Lecture Notes in Electrical Engineering 216

Zhicai Zhong
Editor

Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012

Volume 1

Springer

Lecture Notes in Electrical Engineering

Volume 216

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Volume 1

Springer

Editor
Zhicai Zhong
Chongqing
People's Republic of China

ISSN 1876-1100 ISSN 1876-1119 (electronic)
ISBN 978-1-4471-4855-5 ISBN 978-1-4471-4856-2 (eBook)
DOI 10.1007/978-1-4471-4856-2
Springer London Heidelberg New York Dordrecht

Library of Congress Control Number: 2012956302

Preface

Welcome to the proceedings of the 2nd International Conference on Information Engineering and Applications (IEA 2012), which was held in Chongqing, China, October 26–28, 2012.

As future generation information engineering, information technology and applications have become specialized. Information engineering and applications including computer engineering, electrical engineering, communication technology, information computing, service engineering, business intelligence, information education, intelligent system and applications are growing on an ever-increasing scale and heterogeneity, and becoming overly complex. The complexity is getting more critical along with the growing applications. To cope with the growth and information, engineering and applications focus on intelligent, self-manageable, scalable information systems, engineering and applications to the maximum extent possible without human intervention or guidance.

Information engineering and applications is the field of study concerned with constructing information computing, intelligent system, mathematical models, numerical solution techniques and using computers and other electronic devices to analyze and solve natural scientific, social scientific, and engineering problems. In practical use, it is typically the application of computer simulation, intelligent system, Internet, communication technology, information computing, information education, applications and other forms of information engineering to problems in various scientific disciplines and engineering. Information engineering and applications is an important underpinning for techniques used in information and computational science and there are many unresolved problems worth studying.

The IEA 2012 conference provided a forum for engineers and scientists in academia, industry and government to address the most innovative research and development including technical challenges and social, legal, political and economic issues, and to present and discuss their ideas, results, work-in-progress and experience on all aspects of information engineering and applications.

There was a very large number of paper submissions (1845), and all submissions were reviewed by at least three Program or Technical Committee members or external reviewers. It was extremely difficult to select the presentations for the

conference because there were so many excellent and interesting submissions. In order to allocate as many papers as possible and keep the high quality of the conference, we finally decided to accept 542 papers for presentations, reflecting a 29.4 % acceptance rate. We believe that all of these papers and topics not only provided novel ideas, new results, work-in-progress and state-of-the-art techniques in this field, but also stimulated the future research activities in the area of information engineering and applications.

The exciting program for this conference was the result of the hard and excellent work of many others, such as Program and Technical Committee members, External Reviewers and Publication Chairs under a very tight schedule. We are also grateful to the members of the Local Organizing Committee for supporting us in handling so many organizational tasks, and to the keynote speakers for accepting to come to the conference with enthusiasm. Last but not least, we hope you enjoy the conference program, and the beautiful attractions of Chongqing, China.

October 2012

Yan Ma
Qingsheng Zhu
Shizhong Yang
General and Program Chairs, IEA 2012

Organization

IEA 2012 was organized by Chongqing Normal University, Chongqing Computer Society, Chongqing Copious Prachanda Cultural Exchange Services Company, Chongqing University, Chongqing University of Science and Technology, Yangtze Normal University, Chongqing University of Arts and Sciences, and sponsored by the National Science Foundation of China, Shanghai Jiao Tong University. It was held in cooperation with *Lecture Notes in Electrical Engineering* (LNEE) of Springer.

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Part I
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Chapter 1
Mechanical Engineering Vocational English Education Based on ESP Theory

Yili Feng

Abstract Mechanical engineering English education plays an indispensable role in higher vocational colleges. According to the basic requirements and purposes of higher vocational foreign language teaching and the principle of college-enterprise cooperation and work–study combination, this paper analyzes the present situation and problems. To these problems, from such three aspects as the teaching staff, the construction of teaching material and the teaching methods, the paper attempts to reform mechanical engineering English education based on ESP in order to further deepen the "five-cohesion and ten-docking" personnel training mode proposed by China's higher vocational English education.

Keywords ESP theory · Mechanical engineering English · Higher vocational education · Teaching reform

1.1 Introduction

Foreign language education plays an important part in higher vocational education. China's higher vocational English education has made a great progress in the late 30 years of efforts. It comes to be perfect [1]. Vocational skills' training has become a foothold of vocational English teaching reform, and a standard to judge whether higher vocational English teaching reform succeeds or fails.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_1,

Along with the development of science and technology and the progress of human society, mechanical industry has made further development. Most achievements, such as mechanical products and equipments, instruction manual and specification, are written in English, which requires the higher vocational college students, who will be the future mechanical industry workers, to own a solid knowledge base in mechanical engineering English, reading simple mechanical engineering English literature and understanding the latest trends of the frontier development in mechanical industry field throughout the world. Mechanical engineering English teaching is more than expansion of fundamental English teaching; it is a combination practice of common English knowledge, ESP theory and mechanical knowledge, the purpose of which is to cultivate the higher vocational students' comprehensive skills.

1.2 Characteristics of Mechanical Engineering English

Mechanical engineering English is an English language description of mechanical engineering development and special equipments. It includes the simple machinery, simple circuit, engineering drawing, engineering material, engineering mechanics, injection molding, hydraulic and pneumatic system, robot technology and so forth. Mechanical engineering English must be objective and accurate, and it has such characters as specialty and applicability, which is closely related to its terminologies, abbreviations and specific expressions. In addition, Mechanical engineering English articles have their own unique features, such as style, grammar, vocabulary, rhetoric, translation and commonly used symbol formula. It owns objectivity, accuracy and conciseness. Mechanical engineering English shows both science and technology style and communication style. As for higher vocational education, mechanical engineering English belongs to ESP category. Its task is to improve the students' English knowledge and boost their skills to cope with his future profession.

1.3 ESP Theory

ESP is the abbreviation of English for specific Purposes. In the book The Linguistic Science and Language Teaching Halliday, McIntosh and Strevens believe that English is for civil servants; for policemen; for officials of the law; for dispensers and nurses; for specialists in agriculture; for engineers and fitters [2]. Hutchinson and Waters think that ESP is an approach to language in which all the decisions as to content and method are based on the learner's reason for learning [3]. ESP is a language course in which the content and aims of the course are fixed by the specific needs of a particular group of learners, says Richards and Schmidt [4]. According to the experts' definition, ESP is opened based on the specific purpose and specific learners' need, its purpose is to train the students' skills in the

future work environment. ESP study highlights the students' orientation and their professional requirements. It features specific teaching aims and special teaching materials. Moreover, there are three distinct characteristics about ESP teaching reform in higher vocational English education. They are authenticity, demand analysis, including "target needs" and "learning needs," and students' orientation, stressing various students-oriented teaching activities. The purpose of ESP teaching reform is to guide the students to understand and use standard vocational English correctly and effectively.

1.4 Present Situation and Issues

1.4.1 Lack of Well-Qualified Teachers

ESP theory requires teachers to have higher English level and professional knowledge. Take mechanical engineering English as an example. On one side, Mechanical engineering English teachers master general English language knowledge. On the other side, they own mechanical engineering knowledge. However, according to the author's investigation, at present, in higher vocational colleges, special English courses are usually taught by professional teachers or public English teachers, respectively. There is a problem that professional teachers lack basic skills in English teaching, and public English teachers are short of professional knowledge. Thus, professional teachers instruct students to translate the texts and then do the exercises; meanwhile, public English teachers cannot express terms accurately, having difficulties in teaching professional knowledge. This leads to disjointing professional knowledge from English teaching, causing poor teaching effect. Furthermore, most professional teachers have different English levels, the good and bad being intermingled, and their substandard pronunciation may mislead students to make serious mistakes.

1.4.2 Unpractical Teaching Material

Teaching material is also a problem to reform mechanical engineering English education in higher vocational colleges. At the moment, the officially published higher vocational mechanical engineering English teaching materials are not many. The well-designed textbooks only for higher vocational students are much fewer. Only a few of them are also edited by mechanical professional teachers. Teaching content has such defects as more randomness and sidedness. What is more, as for mechanical engineering English, a foreign language tools, the edition of the teaching content does not conform to the rules of language learning. Some teaching materials are too simple, which does not make known the latest

information and the development trends in the mechanical engineering field, while other teaching materials are too special, which is beyond the higher vocational foreign language teaching such requirement as the applicable principle of "sufficient usage degree" and beyond the higher vocational students' abilities. Besides, at present most mechanical English teaching materials still go on to adopt the traditional modes, for instance, the "text-word-note-exercises-grammar-reading materials" mode. Such type of teaching materials cannot reveal the particularity and practical utility of the ESP teaching theory, and it cannot meet employment-oriented education demands either.

1.4.3 Unchanged Teaching Methods

At present, a lot of special teachers do not pay much attention to the course teaching. They believe that professional English teaching method is the way of "reading + translating" of professional articles. In the process of teaching, with teacher-centered mode, they teach only translation of some terms. As for the complete articles, they themselves translate sentence by sentence, paragraph by paragraph. Other teachers let students translate first and then make some guidance. As far as the analysis of the structure, writing style and professional terms and unique terminological expressions are concerned; the explanation is hardly ever made. Such teaching approach and means utterly break away from the real mechanical industrial practice and development. Moreover, at present, although higher vocational colleges offer a few professional English teaching classes, in most cases, the course begins to be taught at the fourth or fifth term. It is too short. At the same time, several other professional courses are opened, thus, the students have heavy schoolwork burden. On the other hand, facing the pressure of graduation and employment, the students have no time or energy to study professional English. Few practical courses and deficient skill training are the problems too. All in all, it seems that teachers never teach and students never learn.

1.5 Exploration Into Mechanical Engineering Vocational English Teaching

1.5.1 Boost Teacher's "Double Competency" Quality

Teachers play a leading role in teaching process. A group of teachers with both higher English proficiency and professional knowledge pledge to boost the implementation of ESP teaching. Qualified teachers should have the sense of lifelong learning. They should inspire themselves with constantly updated knowledge, longing to study more. The present rapid development of higher

vocational education put forward much higher and more urgent request for higher vocational college teachers. It requires them to assure themselves that what their teaching can bring into correspondence with the requirements of the social development and industrial development. Meanwhile, they make sure that language, as a special use tool as well as a communication tool, should serve for a certain domain and for the students' future work.

Well-qualified mechanical engineering English teachers need to have qualified English teachers' quality, and have a firm mechanical engineering professional knowledge as well, being familiar with mechanical engineering theories and practice. What is more important, they should be gradually good at combining English teaching methods with professional teaching methods together, trying to teach whatever the students need. Some figures show that at present, the proportion of English teachers endowed with "double competency" quality in professional English teaching is comparatively low. Quite a few professional English teachers are badly in need of professional knowledge training in order to improve their "double competency" quality. Only by this way can they adjust themselves to the requirements of higher vocational English teaching [1]. There are some approaches designed for professional English teachers to improve their "double competency" quality. For example, some higher vocational colleges adopt preferential policies to encourage English teachers to study by themselves, listen to some professional classes, attend some classes for advanced studies and so on. Cooperation with professional teachers is also an effective and efficient way. It will benefit them to learn from each other in classroom teaching, teaching approaches, material collection. Some higher vocational colleges with good conditions can also be regularly or irregularly to invite some experts on mechanical engineering to give some professional lectures, training and instructing the vocational English teacher and helping them to find problems and then solve problems, to finally improve their professional knowledge. This way can help vocational English teachers make a great progress both in the professional English classroom teaching and practice and make them quickly become qualified teachers with "double competency" quality, and eventually ensure mechanical engineering English teaching reform to go on smoothly.

1.5.2 Enhance the Edition of Teaching Material

The construction of teaching material is a basis to achieve some teaching goals. Higher vocational English teaching materials shall be edited according to different professional requirements, reflecting different professional characteristics and their own unique knowledge structures, meeting different professional students' demands for goals and study. Research shows that higher vocational professional English teaching material should be edited under the guidance of with work-integrated learning and competency-based principles, and work task considered. The content of English textbooks should be selected and designed in favor of students' vocational knowledge. And the structures of public English textbook

should be organized by work-related task links so that students can develop their communicative ability in the work place [5]. Dudley-Evans and St. John require the course designers and the teachers to think highly of the students' present English language proficiency and to analyze their learning difficulties and obstacles so as to find out their gaps and differences. Furthermore, based on the findings, teachers sift some materials and edit the corresponding teaching materials to meet the students' needs [6]. This also means that higher vocational English teaching need not adopt a unified textbook. Each higher vocational college has a right to choose some appropriate teaching content endowed with its own characteristics and professional features according to its actual conditions. Take mechanical engineering vocational English as an example. The selection of the teaching material should not only meet the demands of mechanical engineering industry, but it should cope with the relationship between the principle of "necessity and sufficiency" at the present and "shift and availability" for the future development. It aims at the reality of "teaching according to the demands." At the same time, it is considered to modularize the curricula so as to make common English module, ESP module and mechanical module integrated effectively.

Besides, to the teaching material, teachers should regularly have a theoretical discussion and make a practice evaluation. The evaluation standard of professional English teaching material in higher vocational colleges should comply with such three dimensions as the language material, form and value, which will promote teaching and learning to change from "knowledge conception" to "ability conception" and then to "post skill conception". That is to say, it lays stress on the students' actual differences and on the balance development of five basic language skills. And according to the theory of "practicality and sufficiency," the teachers research and analyze each professional characteristic of teaching materials, paying attention to the teaching material's instrumentality, applicability and availability.

1.5.3 Innovate Teaching Pedagogy, Focusing on Training

Advanced teaching methods are effective to increase the students' study enthusiasm, encourage them to think actively and stimulate their potentials. Firstly, vocational English based on ESP is a tool language integrating scientific and technological information and communication skills. Its teaching attaches importance to English language training in workplace. ESP teaching should take such a teaching mode as alteration of working and learning, task driven, project orientation and classroom-practice base integration. According to the course content and the students' characteristics, teachers can also flexibly use some teaching methods, such as case analysis, cooperation study, role-play in order to guide the students to think and practice actively. It is also acceptable and popular to adopt modern education technology and virtual technology, which helps to set up an analog teaching environment, such as virtual companies, virtual enterprises and virtual society, so as to further improve the teaching quality [1].

Secondly, with respect to mechanical engineering English teaching, ESP theory consistently implements the "student-centered" principle in classroom teaching. It means that teaching methods may not be predetermined but have some flexibility. According to different teaching content and students, teachers can apply different approaches. Inside-and-outside school practice base is a good place to create a real language environment and to effectively motivate the students' learning enthusiasm; guiding students' self-directed learning with the help of rich network resources is another good approach, which helps the students to understand the developing frontier knowledge of the mechanical discipline; Meanwhile, in the inside-and-outside school training activities, ESP teaching put emphasis on the cooperation patterns, the features of which are not only a cooperative learning mode of the students, but also a cooperative teaching mode organized by both ESP teachers and professional teachers. Such cooperation can truly promote the students' vocational skills in computer English education, and finally make the "application-orientation" ESP teaching into reality.

Finally, the paper takes task-based teaching mode as an example. Task-based teaching mode is firstly established in some real tasks. Secondly, in the design of the tasks, we have to be sure that all of the adopted materials are authentic, and that the tasks are devised on the basis of the step-down technique. Finally, the chain of the tasks must be designed both naturally and workably. Through the hands-on practice, the students will acquire some information and apply it to the real workplace. Such method integrating teaching, learning and training will really broaden the students' horizon, stimulate their study enthusiasm and make them play their leading role. On the other hand, it also helps them to acquire more professional knowledge and strengthen their vocational skills. And then, it will eventually shorten the distance between the students and the industry, making the "zero distance" into reality.

1.6 Summary

The applicability-orientation ESP theory is run through mechanical engineering vocational English. First of all, the curriculum is designed to satisfy the students' English learning objective and meet the demands for their future work. Secondly, in the teaching way, the task-driven teaching mode is mainly adopted. In class, the teachers play the role of observer and the role of judge, while the students become real learners and centers. Besides, in the choice of teaching material, in view of the students' diversities and their work needs, it reveals that the higher vocational English education has such characteristics as communicativeness, instrumentality, humanism and practicality to entirely achieve the "zero distance" between the students and the industry. Flexible application of ESP theory is only one effective way of implementing the "five-cohesion and ten-docking" policy.

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Chapter 2
Efficient Teaching Reform Scheme of Aerobic Course

Li Zun

Abstract To promote the teaching quality of aerobic curriculum for physical education majors in Chengdu Sport University and enhancing the role that aerobics plays in the training of Chinese physical education professionals. Based on the guiding ideology of modern Chinese higher education, adhering to the training program of Chinese physical education professionals, this paper refers to the teaching target of Chinese aerobic curriculum and begins with the present teaching situation of aerobic curriculum for physical education majors in Chengdu Sport University to look into existing problems in the university, with the help of such research methods as literature review, comparative analysis, interview, and logic analysis. Meanwhile, ways to the teaching reform of aerobic curriculum are pointed out.

Keywords China · Chengdu Sport University · Physical education major · Aerobic curriculum · Teaching status quo · Reform

2.1 Introduction

With the continuous improvement of aerobics theoretical system, the various demands of society to experts on aerobics, the contents on aerobics curriculum of Chinese physical education are changing. During this period, the teaching program undergo amends three times, which provide scientific evidence for the improvement and innovation of aerobic theoretical system and technological

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_2,

system [1]. Since 1990, it has been 20 years when physical education subject in Chengdu Sport University build aerobics curriculum, which is not well developed after his peak time. The author thinks that the most important fact is the attention degree of school and the rationality of setting-up of curriculum and the influence of teaching experience and ideas of teacher. This paper through analysis of teaching program of undergraduate aerobic curriculum in 2000 and 2008 in Chengdu Sport University, and the research and interview of the students major in aerobics in 1996 and 2000, finds the problem existing in reforming of aerobic curriculum in order to provide reference for the foundation of scientific contents of aerobics curriculum of physical education in Chengdu Sport University and in the same time to provide foundation to the build aerobics curriculum.

2.2 Object and Methods of Study

2.2.1 Object of Study

The object is students and teachers in grade 1996 and 2000 in aerobics and the present teaching situation of Chengdu Sport University.

2.2.2 Method of Study

Literature research method: The method of study this paper applied includes studying teaching schedule of Chengdu Sport University's education, the related materials of teaching leading principles and text in different versions during different time of Chengdu Sport University in physical education.

Method of comparative analysis: In the course of the study uses the method of comparative research, Chengdu Sport University since 1990 on physical education Aerobics Specialized Course in different periods of aerobics teaching content, course and students' special athletic level are compared between each period, analysis of teaching contents, and teaching hour's distribution effect.

Interviewing method: Mainly using telephone interviews and face-to-face interview, level 1996, level 2000 of the Chengdu Sport University, 2006 physical education of aerobics instructors and 32 graduate students on Aerobics Curriculum for training, technology transfer, such as improving the quality of the special effects for a visit, listen to their opinions and suggestions.

Logic analysis: Induction, deduction, by analogy, comprehensive thinking form, to the actual data and the existing literature to the logic analysis.

2.3 Present Situation of Teaching in Chengdu Sport University

2.3.1 Inconsistencies Between Teaching Objectives and "Two Targets"

"Two kinds of goal" is our country teaching guidelines of common higher education undergraduate professional school sports of all kinds of main course (hereinafter referred to as the "outline") aerobic class target and Chengdu sports institute "sports education undergraduate teaching plan" (hereinafter referred to as the "plan") aerobics course goal. In 2004, issued by the ministry of education, the outline of the aerobics in the overall goal of the course for positioning is to make the students master the basic theory of aerobic class knowledge, technology and skills, which has engaged in the school sports education and have had the calisthenics teaching and organize activities ability, and have used aerobics means and methods in guiding social sports activities in my ability. In 2008, Chengdu Sport University "plan" sets the goal for the sports education professional teaching: teaching content should be on the basis of professional course, expanding and deepening our interpretation of the basic theory of the sports knowledge, techniques and tactics, teaching method and physical training, psychological training, technology and tactical training method, and the movement of the competition rules, the referee method, etc. Teaching should strengthen training factors and to develop students' teaching and training ability, competition organization ability and working ability [2]. Therefore, as a professional sport the aerobics should based on specialist courses also answer with "two targets" to develop the teaching work.

However, looking at Chengdu Sport University physical education specialty's 2008 version of aerobics specialist teaching program, we found that the aerobics specialist courses teaching outline of turned into "gymnastics class specialist courses teaching outline, total class for 328 h". This program of aerobics specialist course's objective task are as follows: systematically learn and grasp the outline specified the gymnastics and aerobics basic theoretical knowledge and all kinds of basic technology, master will learn the basic technical movement; a large expansion form training, pedal gymnastics, calisthenics, Latin setting-up exercise, combat gymnastics, street dance, dance cheerleaders, jazz dance, and other social need fitness plate content. Graduate should master teaching content and reach the athletics gymnastics or an aerobics athlete level.

From this program, the author puts forward some questions: (1) Why do aerobics specialist courses become gymnastics class specialist courses, but don't develop an aerobics specialist talent? (2) Why the program is a reflection of the teaching content key and not the competitive aerobics content? (3) Why is required for graduation in the possessive less gymnastics or calisthenics teaching content of the project and required students to pass competitive level 2 players and referees standards? (4) The Chengdu sports institute of physical education major specialist courses is the

purpose of training "professional" or "public" type talent? (5) With so little time of class, how to complete such a rich teaching content, and how to cultivate the students' professional ability and competition level? (6) How the outline realizes the purpose of the task of the outline of the aerobics stipulated in the overall goal of the course and Chengdu Sport University in the plan of the professional sports education for the teaching of aerobics goals? Through these questions, obviously, the Chengdu Sport University calisthenics' teaching goal could not answer these questions well. The author thinks, at present, the Chengdu Sport University calisthenics teaching goal and actual specialist courses "two targets" requirement is not consistent, even a few stray from the path.

2.3.2 The Deviation Between Teaching Content and the Training of "Multi-skill Practical Talents"

Through the four stages in Chengdu sports institute of 1990–2011 of aerobics specialist courses teaching content's setting-up, we can see, in the exploring stage (1990–1995), Chengdu Sport University course syllabus provisions of aerobics specialist course's teaching content is made according to the state physical culture the aerobics competition rules, promulgated in 1989, are the three major elements of teaching. One is to reflect the characteristics of aerobics exercise action; the second is with the provisions of the body quality, difficult movement, and the four types of difficulty movement of deformation (such as push-ups can deformation for fall cubits push-ups, single arm push-ups, push-ups push-up, high kick can change for Pian leg, cover leg); the third is made in the basis of rules of the single, double of creating routines. In strengthening the competitive level stage (1996–2000), Chengdu Sport University course syllabus provisions of aerobics specialist course teaching content around the aerobics exercise the ability, aerobics quality, aerobics difficulty movement. With reference to the international competition, the stage calisthenics rule in China will be difficulty movement by four types of increased to six types: A dynamic force, static strength, C B of jump (explosive), D kick (dynamic power), E balance, F flexibility. In the two hold combined with stage (2001–2007), Chengdu Sport University calisthenics teaching content specialist courses is mainly about the aerobics class player provisions action and national aerobics public training standards level provisions movement.

We can see the three stages in the 1990–2007 period, the Chengdu Sport University fitness course for the teaching of content creation is carried out around the aerobics, and the aerobics competitive level of students is higher in both competitions at all levels to achieve better results, while aerobics students can quickly achieve a good conversion of the special; and in the areas of work, it can reflect the higher level of expertise. At present, Chengdu Sport University Physical Education Teaching Aerobics mainly by competitive gymnastics (gymnastics two), Aerobics (three provisions sports action), fitness plate (step aerobics, fitness ball, hip-hop,

dance, friends exercise, jazz dance, kickboxing), experimental teaching aerobics (gymnastics) theory of the composition. In the teaching content as the aerobics content of teaching and training students, apparently there are two problems: First, functional disorder, which is such a diversity of teaching material as the main aerobics courses teaching content, it is difficult to truly play the main course features aerobics and effect; the second is it is not professional, and student aerobics' knowledge, technology and skills could not reach the requirements of specialist courses.

2.3.3 Stressed Class Reduce Teaching Quality and Student's Professional Level

Chengdu sports institute of physical education in the professional course constitution, aerobics, as a main teaching content, realize sports education professional talent training is the target and serviceable. Aerobics course belongs to basic sports education, putting aerobics sports education into the basis of professional course category is valuable. So far, gymnastics majors less and less, or even face fault cases; aerobics majors and still have a larger base. Through the survey of the Chengdu sports institute department heads, calisthenics teachers, graduated students, the conclusion is as follows: generally, we think that the aerobics to develop the students' comprehensive quality plays an important role in the sports education and is a good mean to realize the target of talent cultivation. So, in aerobics course teaching, we should put more effort in aerobics basic action and difficulty movement spends [3]. Through the Chengdu Sport University level 2008 aerobics major's interviews, we found that: students think that their own aerobics special level is not high, whether practice or finding a job has a certain difficulty and I hope later Chengdu Sport University aerobics specialist course can pay attention to students' special teaching training ability and sports level. This shows that teachers and students try to achieve aerobics sports talents training target.

The currently used the 2008 version of the gymnastics course teaching outline, calisthenics teaching is 328 h, but in aerobics course, it is only count 20 % of the athletics gymnastics, 20 % of competitive aerobics, 24 % of the plate, 25 % of the fitness of the comprehensive experimental teaching, 11 % of gymnastics and aerobics theory of teaching contents, in fact aerobics technology and theory teaching hours accounted for less than 30 %. Without a doubt, accounts for less than 30 % of the aerobics specialist courses of calisthenics teaching content to guarantee teachers have enough teaching time, it is hard to ensure that students master calisthenics teaching and training methods, organization and competition, etc. This is clearly an aerobics specialist in the teaching of a test because the aerobics is a high quality requirement on the skill, the sports, and specialist courses in order to develop the purpose and a higher level of the students (relatively). So, in the aerobics specialist course teaching process, it greatly reduces the teachers'

teaching quality and students' special level, and it will reduce the students' professional level so as to restrict the Chengdu Sport University calisthenics teaching and training and sports level.

2.3.4 *"The Goal is Differ," "Content Deviation" and "Class Extrusion" Led to the Impotency of the Teaching Effect*

The author investigated the Chengdu sports institute of 1996 grade, 2000 grade, 2006 grade aerobics majors and aerobics instructor of the investigation found that the calisthenics teachers think through the aerobics teaching training the overall development of the quality of the students, and the training of the students' organization, coordination, team, management ability development also has a certain effect. Students think through the aerobics studio, to be able to develop the sensitivity of the body, coordination and flexibility, strength quality, so for professional skills of the formation and project migration has good effect. In summary, the calisthenics teaching training to develop the students' comprehensive quality has a strong effect. But for a variety of reasons, this effect is not significant, and relatively single [4].

As stated above, the problem is the teaching goal and two targets are not consistent in professional sports aerobics specialist courses. And teaching contents deviates training phase, which reduces the class extrusion teaching quality and students' professional level. These problems are directly affect the aerobics specialist course teaching effect, and the teaching effect on the quality of the final reflect students, the students' professional knowledge, technology and skills, the most important students' teaching ability, training organization ability and competition ability, special sports level, and the competitive level in each big game only can be better reflected, teaching effect is also a way to show one of the important factors. However, is Chengdu sports institute of physical education major aerobics specialist course talent exactly a kind of effective?

In order to find out its reality effect in the Chengdu sports institute of aerobics specialist courses on talent's cultivation, the author finds statistics between 1991 and 2010 Chengdu Sport University aerobics majors match result, which can show from 1991 to 2010 and between the Chengdu Sport University aerobics majors in all competitions of the achievements and the performance of the work after obtaining, gone from a "winner" to "failure" of the process. More important, the competitive level at present is lower, so that the students are lack of aerobics specialist course learning enthusiasm and initiative and the students' competitive level is not high, the teaching and the training work ability, competition organization and the referee work ability are not strong.

2.4 Aerobics Specialist Teaching Reform Proposals of Chengdu Sports Institute

2.4.1 Reconstruction Teaching Task for the Realization of Aerobics Specialist Courses Target Support Form

With the aerobics course teaching, we can develop the students' professional skills to the formation of the body of closely related quality (strength, flexibility, sensitivity and coordination ability quality, etc.), teaching training ability and special competitive level. So, in aerobics teaching actual process, we should give full play to the function of the aerobics, focus on developing students' special quality and through the classroom teaching way targeted the cultivation of the students' teaching ability training, and to work out a urged teachers' and students' active completion of task of teaching evaluation system, including specific assessment content, method, standard, aerobics specialist courses for the realization of the target formation support.

2.4.2 Ramming the Teaching Content, Reaching Teaching Means and to Improve the Students' Professional Technology Level

The "three basic level" outstanding calisthenics teaching contents are the aerobics basic skills, basic quality, the basic difficulty of teaching. Basic technology including basic attitude, gymnastics the unit, is to realize the transition of space action change connection movements of training. Basic quality is strengthening quality, flexibility quality. Through the new teaching content and teaching means, we could cultivate the students' professional quality and ability and improve the students' professional technology level. Therefore, we should consider the course teaching goal of aerobics specialist, and improve sports education cultivation plan for development of students. And we should choose the quality and ability of effective content and the means of aerobics specialized.

2.4.3 "Teach" Combination Provides Chengdu Sport University Aerobics Course with Construction and Development Provided Protection

Following the idea that we should enhance the students' teaching and training, the referee's ability and special sports level, we should enhance the specialist courses teaching to promote the competitive level race format to improve the teaching quality. Because the strategy work principle and actively will speed up the mass

calisthenics, competitive calisthenics teaching competition and competitive game activities, so as to promote public coordination and sustainable development.

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Chapter 3
Online Entrepreneurship and E-Commerce Experimental Teaching

Daijiang Chen, Juanjuan Chen and Yujiao Wang

Abstract The rapid development of IT technology generates enormous opportunities for young college students to start their own businesses; hence, experimental teaching model is encouraged among various colleges to cultivate students and their practical abilities, and they might use what they learn to find their motives in cyber market. This paper aims to research the colleges who are applying the experimental teaching model and their students, then by questionnaire investigates them and those who have experiments in starting own businesses and then statistically processes the data to analyze the indicator system which might improve the online entrepreneurship-driven experimental teaching model. Finally, the factor structure is modified.

Keywords Online entrepreneurship · E-commerce · Experimental teaching model · Factor analysis

3.1 Introduction

E-commerce is a brand new business model based on network technology, which is characterized by digital transactions among businesses. Since the end of last century till present, E-commerce major is developing very quickly in high

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_3,

education, and experimental teaching is emphasized because of the importance to cultivate students and their practical skills. According to the curriculum, it is accepted that academic courses account for the most part of it and experimental courses are relatively inadequate. This paper will discuss how online entrepreneurship will improve E-commerce and its experimental teaching, so as to find out the key factors that influence the teaching. The main purpose of this paper is to discuss the rational teaching model for high education and improve the comprehensive quality of graduates.

3.2 Research Background

Many scholars have researched this area of online entrepreneurship and E-commerce experimental teaching; however, most of them focus on the success determinants for online entrepreneurship. Professor Zhang in his paper [1] talks about major factors which impact online entrepreneurship of college students; they are personal ability and external condition. Moreover, personal ability includes personal innovation, teamwork, executive ability and personal skills; external conditions include national policy, financial resource, market opportunity and social education.

There are literatures researching hardware and software applied in E-commerce experimental teaching, Su [2] proposes some rationalized suggestions for improving teaching resources, such as teaching environment, teaching method and curriculum. However, there have rare empirical studies about online entrepreneurship and its impact on experimental teaching. Viewing that, this paper will apply factor analysis to discuss the mechanism how online entrepreneurship may improve E-commerce education.

Present E-commerce experimental teaching model. E-commerce experimental teaching is defined as follows: by the guidance of theoretical knowledge, students are educated by various practical experiments to improve their experimental knowledge, techniques and overall qualities [3]. Experimental teaching has close relationship with theoretical teaching on one hand; they are independent on the other hand; as a key chain in high education, experimental teaching compensates theoretical teaching, which is very important to improve students and their practical skills, moreover cultivate their innovative motives and abilities [4].

3.2.1 Current Teaching Environment

As far as we know, many colleges have spent a large amount of money in equipping E-commerce laboratory with various equipments and software; however, they are not willing to spend money on laboratory maintenance or software upgrade. As a consequence, most laboratories are just one-time investment and lack of advanced teaching environment, which will impede the academic education. Students might not able to learn up-to-date techniques and knowledge.

3.2.2 Current Status of Experimental Teaching

Generally, there are four different types of E-commerce experiments, they are given as follows.

1. Learn by experience: includes sand table simulation, E-commerce system simulation and E-logistics management experiments.
2. Learn by operation: includes webpage design and programming.
3. Learn by entrepreneurship: includes website designing and maintenance.
4. Learn by comprehensive experiment: includes internship in business and online entrepreneurship.

Students are encouraged to follow fixed module in experimental studies, and they have no motives to innovate in those experiments as there are no standards to evaluate their efforts. So in practice, students just imitate teachers and follow steps written in textbooks, which is a mechanical process and hence has no impact on students' practical skills.

3.2.3 Current Status of Teaching Methodology

Giving lectures are most common in E-commerce classes, when teacher speak and students listen or take notes. However, E-commerce is a comprehensive subject combing knowledge of computer technology, E-marketing and project management. Simply giving lectures are not adequate for better understanding the developing situation of E-commerce. Moreover, not every teacher has degree in E-commerce, and most of them have no cooperation with real E-businesses, so they are not skillful in teaching and instruction. Unfortunately, we have to say that the most E-commerce teachers have poor teaching methodology and are lack of practical cooperation skills (accounts for 44 %) [5]. Because of the context, less academic support can be offered to students.

3.2.4 Current Teaching Results

According to our understanding, the E-commerce curriculum has various courses, providing different knowledge to students. But most Chinese students have passive studying motives, so they would rather follow than be creative in those courses, so their innovative ability are poor in general.

3.3 Empirical Study Overview

3.3.1 Sample Selection and Data Collection

200 questionnaires are sent out to E-commerce students in three universities, and 173 were retrieved, the retrieve rate is 86.6 %; the number of valid questionnaires are 154. We will collect the data from questionnaires for further research.

The investigation questions are designed to understand how E-commerce majored students regard online entrepreneurship as a new experimental teaching method and its impact on E-commerce education. We use 5-point Likert scale to measure interviewees' attitudes toward different questions; first point represents strongly disagree, second point represents disagree, third point represents neutral, fourth point represents agree and fifth point represents strongly agree.

3.3.2 Data Analysis

The results are shown in Figs. 3.1 to 3.4 and Table 3.1, KMO value is 0.908 and Bartlett's sphericity test $P = 0.000$ (less than 0.001), which indicates that we can apply exploratory factor analysis to conduct research. Choose elements whose eigenvalue are greater than 1, and then we got two principle components, and accumulative contribution equals 60.520 %. We consider selecting the third component, whose eigenvalue is slightly less than 1, and then we can better explain the results. The value of accumulative consistency of corrected items shows how the psychological homogeneity of this question with other questions; here, the value of xg4 is less than 0.40, which indicates this item has poor relationship with other 13 items, so it was deleted. The fifth column of deleted Cornbach's Alph shows that the greater the alpha values the more similar of behavior characters.

Fig. 3.1 Test of KM and Bartlett

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.908
Bartlett 's Test of Sphericity	Approx. Chi-square	1123.434
	df	78
	Sig.	.000

Dimension	Notation	Explanation
Teaching Environment	TE1	online entrepreneurship requires better laboratory equipments
	TE2	online entrepreneurship requires advanced software
	TE3	online entrepreneurship requires proficient network experimental laboratory
Experiments	EX1	online entrepreneurship requires clear experimental curriculum
	EX2	online entrepreneurship requires attention to cultivate the ability to start a e-business
	EX3	online entrepreneurship requires students involvement in practical activities, so as to improve the innovative ability
Teachers Team	TT1	online entrepreneurship enriches teachers of their experience and skills
	TT2	online entrepreneurship helps teachers to focus more on experimental teaching, so as to integrate theory with experiment
	TT3	online entrepreneurship helps to improve teaching methodology
	TT4	online entrepreneurship helps to optimize teachers' team
Subject Effect	SE1	online entrepreneurship stimulates students interests and enthusiasm to start a E-business
	SE2	online entrepreneurship improves students of their innovations and practical skills
	SE3	online entrepreneurship broadens job selection channels
	SE4	online entrepreneurship helps to increase income for students

Fig. 3.2 Indicator system of online entrepreneurship in promoting E-commerce experimental teaching

Component	Initial eigenvalue			Square Sum Loading			Rotation
	Total	Variance (%)	Accumulation (%)	Total	Variance (%)	Accumulation (%)	Total
1	6.713	51.640	51.640	6.713	51.640	51.640	5.178
2	1.284	9.880	61.520	1.284	9.880	61.520	4.519
3	.922	7.092	68.612	.922	7.092	68.612	1.462
4	.703	5.410	74.022	.703	5.410	74.022	4.387
5	.614	4.725	78.747				
6	.532	4.095	82.842				
7	.439	3.380	86.222				
8	.410	3.155	89.376				
...							

Fig. 3.3 Sample transaction data (per month) total variance explained

Table 3.1 Reliability test results

	Scale mean of deleted items	Scale variance of deleted items	Corrected item total	Cronbach's alpha	a
TE1	51.19	84.746	0.638	0.909	0.909
TE2	51.06	87.075	0.555	0.912	
TE3	51.14	86.524	0.602	0.91	
EX1	51.05	84.233	0.72	0.906	
TT1	50.97	84.738	0.674	0.907	0.906
TT2	50.78	84.918	0.734	0.905	
TT3	50.97	84.554	0.707	0.906	
TT4	51.07	86.001	0.641	0.909	
SE1	50.76	84.89	0.688	0.907	0.908
SE2	50.61	87.573	0.67	0.908	
SE3	50.69	87.105	0.639	0.909	

Fig. 3.4 Factor loading results

	Components		
	1	2	3
TE1		.863	
TE2		.849	
TE3		.833	.
EX1		.660	
EX2			.733
EX3			.835
TT1	.713		
TT2	.726		
TT3	.856		
TT4	.872		
SE1			.709
SE2			.820
SE3			.758

3.3.3 Result Analysis

3.3.3.1 Factor Structure Modification

By standard Kaiser oblique rotation, it shows that three factor loadings are rotated to principal element 2 and principal element 3, which could be explained that the E-commerce experimental teaching indicator system is reduced from four dimensions (i.e., teaching environment, experimental teaching, teachers team and subject effect) to three new dimensions (i.e., teaching environment, teachers team and comprehensive ability). The exploratory analysis shows that the improvement of experimental teaching has been achieved.

3.3.3.2 Factor Explanation and Reliability Analysis

1. Teaching environment is defined by how well the equipments, the software, the upgrade rate and the experiment content. The Cronbach's alpha is 0.909, which shows good consistency.
2. Teachers' team is the guarantee of better experimental teaching, and online entrepreneurship could help to consolidate the theoretical knowledge and deepen the understanding. The Cronbach's alpha is 0.906, which shows good consistency.
3. Comprehensive ability is defined as the overall quality of E-commerce students, which are greatly improved after the introduction of online entrepreneurship. The Cronbach's alpha is 0.908, which shows good consistency.

3.3.3.3 Explanation of Deleted Factors

The reason that some indicators are deleted in the result is because that the questionnaire is designed by our personal judgment, and those indicators were assigned to different groups. However, out empirical result shows that EX1 should be grouped into teaching environment dimension, and EX2 and EX3 should be grouped into comprehensive ability dimension. SE4 failed in the reliability test as its value is less than 0.4000, which indicates it is not suitable for factor analysis.

3.4 Summary

This paper is an empirical study to explore and testify the influence of online entrepreneurship on the E-commerce experimental teaching indicator system. The result shows that at this stage, online entrepreneurship has impact on three dimensions, which are teaching environment, teachers' team and comprehensive ability. Also, it is necessary for colleges to consider including online entrepreneurship into E-commerce experimental teaching and related reforms. In doing so, E-commerce graduates could fulfill more responsibilities in their jobs and satisfy the developing needs.

Acknowledgments This paper is sponsored by the research project of Chongqing Higher Education Reform (102313), and this research is funded by high-quality course of Chongqing Normal University (Electronic Commerce). This paper is an empirical study to explore and testify the influence of online entrepreneurship on the E-commerce experiment.

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Chapter 4
Personalized Teaching Model Based on Moodle Platform

Yang Xiaoqiong, Yang Guoqing and Zheng Zeng

Abstract Moodle's designing concept, free and open-source characteristics and its rich functions have provided a guarantee for the smooth implementation of the personalized teaching model, but before putting it into practice, we must take into consideration the learning styles of the students. On the basis of examining the strengths of the Moodle platform and the characteristics of the students' learning styles, this paper explores the theoretical basis and connotations of the personalized teaching, and then conducts a further study on the implementation of personalized teaching model from the perspectives of curriculum, course content, teaching methods, extra-curricular activities and evaluation system.

Keywords Moodle · Personalized teaching model · Learning style

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_4,

4.1 The Advantages of Moodle Platform

College English curriculum requirements [1] requires that colleges and universities should take full advantage of modern information technology, adopt English teaching models based on computer and classroom, and hence improve the single teaching mode dominated by the teacher. The new teaching model should make the English teaching and learning, to a certain extent, free from the restrictions of time and place, and develop toward the direction of personalized and independent learning. Since our university became one of the 180 College English teaching reform institutions in 2004, we have conducted a constant exploration and reform on college English teaching concepts, teaching methods, course content and teaching modes, and meanwhile we have established New Horizon College English Platform, New Era College English Platform, Lancoo English online, foreign language online, and Moodle community. Among these platforms, Moodle community has been extremely popular with the teachers and the students. Compared with other teaching platforms such as the platforms created by Oracle and Microsoft or other e-learning platforms, the Moodle platform has the following advantages.

4.1.1 Designing Philosophy of Moodle

Moodle is an abbreviation for the modular object-oriented dynamic learning environment [2], whose designing philosophy is based on the theory of social constructivism, which puts an emphasis on the cognitive concept of experience-based learning. Moodle is practicing what the theory is advocating, that is, in teaching and learning activities, the educators and learners are of equal importance, and they influence each other and collaborate with each other, during which they construct knowledge and create new knowledge based on existing experience. "The social constructivist epistemology has great effects on me because it regards learning as a social activity and focuses on the learning results when actively creating the learning resources for others", said Dr. Martin Dougiamas (2003), the founder of Moodle and the Australian educator and computer scientist. Moodle's people-oriented and user-centered designing ideas help to stimulate the users' interest and enthusiasm in learning [3].

4.1.2 The Characteristics of Moodle

Moodle is a free source e-learning software platform, also known as a course management system, learning management system, or virtual learning environment

(VLE). As of December 2011 it had a user base of 72,177 registered and verified sites, serving 57,112,669 users in 5.8 million courses.

As free course management system software, the users can free download and install it on any platform that supports PHP [4]. The installation process is simple and only needs a database (and can be shared). After installation, Moodle provides an administrator account with the highest privileges. Thanks to Moodle's open-source characteristics, the administrator can use the software source code to fully understand how Moodle was designed and functioned, and can modify the source code, and also can adjust interface to increase or decrease function modules in accordance with the demand. Because Moodle platform supports unlimited creation of the course catalog, the administrator may at any time create, move, download and modify the curriculum and may add and remove the curriculum-related resources and activities.

Because of its ease to learn to operate, the average teachers will be able to grasp the basic operation and editing of Moodle only after a short period of training, and apply Moodle to their own courses teaching to change the traditional teacher-centered teaching mode and to make up for the shortcomings by the traditional classroom and improve teaching effectiveness.

4.1.3 Abundant Functions of Moodle

As the software package of courses and web sites established on the Internet, Moodle has modules covering the main features of common network teaching platform, research network teaching platform as well as resource-based network teaching platform [5], such modules as those of course management, teaching blog, course introduction, teaching arrangements, teachers' information, Q & A discussions, course assignments, chatting, voting, forums, quizzes (online testing), resources (courseware, lesson plans, personal resources, resource sharing), questionnaire survey, interactive evaluation and personal learning process. The multi-function modules of Moodle platform and its rich resources and activities can guarantee the effective conduction of personalized teaching model.

4.2 Study on the Students' Learning Styles

The analysis and research on the learner's learning styles is an important factor in the effective implementation of personalized teaching. Due to the different emphasis on learning styles, so far, the scholars have yet to reach a consensus on the definition. For example, Keefe defines the learning style as "cognitive,

affective, and physiological traits that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". Reid claims that learning styles are internally based on individual's personal characteristics, often not perceived or used consciously, which are the basis for the intake and understanding of new information [6].

According to the different definitions of learning styles by different scholars, we can summarize the characteristics of learning styles as follows. It involves perception, cognition, conceptualization, affection and behavior, and includes social, cultural, psychological, physiological, cognitive, emotional, motivation and other factors. Learners have their own personal tendencies in the learning process and this tendency is the characteristics manifested in the mutual interaction of the learning factors affecting the learning results, showing the uniqueness and consistency in different scenarios. Thus, to improve teaching effectiveness, the teachers must conduct in-depth understanding of the students' different learning styles and accordingly improve their teaching methods and teaching strategies for students with different learning styles [7].

There are different tools to measure learning styles in Second Language Acquisition, but different tools take different perspectives, such as the Jackson personality inventory, the Myers–Briggs type indicator (MBTI) and perceptual learning style preferences questionnaire (PLSPQ). However, generally speaking, in the online teaching environment, the existing studies are mostly using Reid's PLSPQ, and therefore the learners' learning style needs further study.

Since Moodle's designing philosophy is based on constructivist theory, and Honey and Mumford's [6] classification on the learning styles is on experiential learning, their learning style model can be more appropriate to study the learning styles of students in the Moodle platform environment. Honey and Mumford's learning style model, built on the work of Kolb's experiential learning model, but enjoying considerable uptake in educational circles, includes four stages: having the experience, reviewing the experience, concluding from the experience and planning the next steps. Under Honey and Mumford system, there are four learning styles-activist, reflector, theorist and pragmatist, each of which can be determined through Honey and Mumford test, namely, the learning styles questionnaire (LSQ) test.

Because Moodle's built-in questionnaire module can not be edited to suit the demands, the administrator needs to add the functionality of the new survey by downloading the compressed package of questionnaires and installing it under the appropriate directory, and then add the "Honey and Mumford LSQ". The questionnaire usually takes the students about 10–20 min to complete. The individual can compare his results with the standard marks and receive his preferred learning style almost immediately [8]. These results would help the individual look for developmental suggestions to improve present results and create a personal development plan with the guidance of the teacher.

4.3 Theoretical Basis and Connotations of Personalized Teaching

4.3.1 Theoretical Basis of Personalized Teaching

Personalized teaching (personalized instruction) is a combination of such theories as humanism learning theory [9], the theory of social constructivism and multiple intelligences theory, and it is the development trend of the teaching reform.

Humanism learning theory is built on the humanistic psychology, whose representatives are American psychologists Maslow [8] and Rogers [10]. It has proposed the concept of teaching objectives of unifying the knowledge and emotions, the concept of meaningful free learning and the concept of student-centered teaching model. Humanism learning theory also advocates that real learning should be based on the "integrity" of a human to enable the students to become perfect and useful; the learning process is one of his own potential development, personal growth and self-realization; learning principle should be based on the respect for learners, learners' wishes, feelings and needs and teaching activities should be student-oriented so that the students can perceive the relationship between the self development and the learning content and learn by doing.

Constructivism is a branch of cognitive psychology school with Piaget, Kornberg, Vygotsky, Bruner as the main representative. The theory is rich in its contents and put emphasis on the learners' initiatives, social and situational interactions. Meanwhile it advocates that teaching and learning activities should be student-centered, stressing the students' initiative to explore and discover the knowledge, and to conduct an active construction of knowledge, and it points out that the teacher's role is a loyal supporter and an active help and guide of the students in constructing the knowledge. The theory also divides learning levels into primary learning and advanced learning level [4].

The theory of Multiple Intelligences, including a total of 8 intelligent areas, is proposed by Howard Gardner [3]. It claims that different people have different combination of intelligence. During teaching, the teachers should take into account every student's different intelligence and select the most suitable methods to teach the students. Meanwhile, the teachers should care and guide the students and help the students develop their potentials and cultivate the students' intelligence of self-retrospection.

4.3.2 Connotations of Personalized Teaching

Personalized teaching is the teaching fully manifesting the learners' learning styles and its connotations involves the teaching content and the forms of teaching and personalized learning. Specifically speaking, the teaching activities need to be implemented for a given teaching purposes in accordance with each student's

personality, interests, strengths and to fully develop each student's personality; with the same objectives, the teaching methods can have some alternatives such as in the individual, group or collective forms; in personalized teaching, the students can give full play to their learning autonomy, give full consideration to their own interests, wishes and needs [10].

Moodle-based personalized teaching is a combination of personalized teaching theory with Moodle platform, whose idea can be summarized as follows: the teaching and learning process should be learner-centered, making use of such learning elements as the scenarios, collaboration, conversation and resources to design the learning resources, learning strategies, cognitive tools to meet the learner's needs through the analysis of learners' knowledge, cognitive characteristics and background, and give full play to the learner's initiative and innovative spirit, and finally effectively fulfill the meaning construction of the current knowledge [11].

Personalized teaching model, based on the full excavation and analysis on the learners' learning characteristics, can provide personalized teaching methods, course content and learning resources in accordance with their characteristics and can avoid the shortcomings of the traditional cramming method of teaching. Besides, it focuses on the learners' personality differences and personality development, encouraging the students to arrange their own learning progress and independently choose learning content, and also spurring students on, on the basis of the original experience, to actively explore and construct the knowledge under the guidance of the teachers according to their learning characteristics.

4.4 Implementation of Moodle-Based Personalized Teaching Model

4.4.1 Personalization and Diversification of University English Curriculum System

The single or incomplete curriculum system of many universities is far from being able to meet the diverse needs of students, and impedes the achievement of the goals of college English teaching reform and the education reform process. Therefore, in order to truly implement the personalized teaching model, the university should establish a personalized and diversified curriculum system for college English and college English optional courses respectively based on the analysis of its teaching resources and orientation, as well as the diversification of social needs and the needs of students [12]. For example, the students can be divided into two categories, advanced English learners and average English learners, according to their English scores of college entrance examination and their majors. And meanwhile, students of different classes should use different materials and different teaching methods. Besides, the university should provide

the optional courses for those students with higher English levels, such as advanced English reading, language and culture, business English and so on.

Personalized and diversified curriculum system will make the teachers clearly understand their teaching purposes, select the appropriate teaching contents and rely on the Moodle platform to set different goals in the teaching process for students with different English levels, interests and learning styles, and finally improve teaching effectiveness. Meanwhile, the students are allowed to choose different learning contents and goals according to their own learning characteristics, and then complete the appropriate English learning content, and successfully achieve the set objectives set gradually. There is no doubt that this emphasis on the differences of teaching goals will mobilize the students' initiative and enthusiasm in learning.

4.4.2 Personalization of Teaching Methods

Moodle is a good platform for the teachers to personalize their teaching methods. On the basis of analysis and study of students' learning styles, English language proficiency, interests, and professional characteristics, the teachers can design and edit their teaching materials, and post them to the Moodle course management module or coursework module, using the curriculum notification module to notify the students of the learning tasks. In the learning process, the students can find a suitable mode of learning for their own learning styles. Besides, the teachers can offer the students one-to-one guidance through chatting, forums, blog and wiki modules or through e-mail.

Since Moodle provides a convenient and easy grouping tool, the teachers can group the students by taking the students' different learning styles, personality or other factors, encouraging the students to get involved in group discussion, and introducing competition system into the team cooperative learning, so that all the team members will have a strong sense of responsibility and team spirit.

4.4.3 Personalization of Extra-Curriculum Activities

Extra-curriculum activities play an indispensable role in stimulating the students' interest in learning and in improving their English proficiency. Moodle modules have provided an ideal platform for carrying out personalized extra-curriculum activities. On the one hand, teachers can take full advantage of the moodle platform to establish the system of extra-curriculum activities through the combination of the real classroom and the traditional college English extra-curriculum activities to create a good English learning atmosphere on campus and fully develop the students' English proficiency, such as holding Moodle English culture festivals (including English drama competition, recitation contest, speech contest, song

contest, the English book club, etc.), founding the English Magazine and English Corner on the Moodle. On the other hand, the students can be encouraged to make full use of the Moodle platform for self-presentation, such as uploading a personal report, dialogue exercises, role play or interview activities, and other related audio, video, paper materials, or they exchange ideas through the chat, blogs, forums and other modules with teachers and other learning partners at any time.

4.4.4 Personalization and Diversification of Evaluation System

In the Moodle-based teaching, it is of great significance to conduct a personalized and diversified assessment on the students' learning. For example, the assessment plays a role in the formation of two-way feedback mechanism between teachers and students, and it can guide and motivate the students to learn and finally to improve the learners' learning effectiveness and it also can optimize the network education.

Considering the characteristics of the personalized teaching and the students' learning process, personalized teaching evaluation methods include the following seven aspects: personality analysis, contract evaluation, self-evaluation, the dossier evaluation, peer assessment, parents and teachers' evaluation, and achievement exhibition such as presentations. The teachers can make full use of the functions of the Moodle learning records tracking, a dual evaluation module and peer evaluation to track and analyze the students' online behaviors, to explore the relationship of the learners' behavior and the learning, and conduct a reasonable evaluation of the learner through a variety of factors.

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Chapter 5
E-Commerce Undergraduate Training Mode

Lei Lei

Abstract Nowadays, modern division of labor is becoming increasingly clear. How do we deal with the embarrassing situation that the e-commerce major students have learned extensive but shallow knowledge? The only solution is to cultivate the application-oriented e-commerce talented person based on universities, which could improve the employment rate of electric commerce major students. From the perspective of students, this paper intends to recommend that all universities should take actions as circumstances permit and integrate all kinds of resources according to the wishes of the students. It discusses a brand new training mode for the application-oriented e-commerce undergraduate talents from the view of training direction and innovation management.

Keywords E-commerce · Training mode · Employment

5.1 The Situation of Development of E-Commerce and the Need for E-Commerce Majors

Nowadays, E-commerce has been adopted as a new life-style by many companies, among which the famous ones are Alibaba, CTRP-US, VANCL, Jingdong Shang City, electronic banking, online booking and etc. In March 2012, the 12th 5-year plan was settled. The document pointed out that during the 11th 5-year plan E-commerce was popularized among small-and-medium-sized enterprises.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_5,

In 2010, the rate of trading online and network market had reached 42.1 % among small-and-medium-sized enterprises, and individual network sale had reached 0.161 billion with the total trading volume up to 513.1 billion, which make up 3.3 % of the overall retail sales of social consumption products. These statistics are showing us that E-commerce in our country is developing in a steady step and made great achievements during the last 5 years [1]. Besides, the documents also pointed out that our aim of this 5 years is to double the volume of online business to exceed 1.8 billion, among which online business between enterprises over 1.5 billion. Online purchase and online sales respectively occupies 50 and 20 %. The online supply chain of big enterprises should be established and some giant enterprises should be able to cooperate internationally. Small-and-medium-sized enterprises that often use E-commerce should make up at least 60 % of this kind of enterprise. The volume of retail transaction should exceed 3000 billion yuan, making up 9 % of the overall retail sales of social consumption products. Mobile e-commerce transaction volume and number of users reached the world leading level. In order to realize this, a large number of qualified personnel are needed. For E-commerce are special, qualified personnel of this field sharing the characteristics of versatility and diversity? The versatility requires that the qualified personnel should have a full understanding of the nature and needs of business practice, and what's more important is the ability to use theories to guide practice which means to choose proper methods according to business requirement, thus achieving the purpose of profit. Diversity is important because E-commerce is popular among many fields. Although the EC personnel are not necessary to be proficient in every field, they should have a general knowledge of them. Well, what are the qualities that qualified EC personnel should own? According to the common classification, the popular EC personnel in job market fall into 3 groups [2–4].

5.2 Main Cultivation Mode of Electronic Commerce in Universities and the Advantages and Disadvantages

Improving the employment quality and market adaptability of EC majors is urgent and the way out are to cultivate applied talent of electronic business affairs in colleges and universities. In present days, EC training mode in universities can be classified into the following:

(1) Business management as the main mode of training. This model takes business management as the direction, that's Strengthen the management of curriculum. Take China University of Mining and Technology as an example, graduates can be in the electronic commerce practical business management in all types of enterprises and institutions and also can be engaged in government departments, universities, research institutes.
(2) Logistics management as the main mode of training. This model in electronic commerce logistics management as the direction, i.e., to strengthen the

economic, management, logistics basic knowledge education, focusing on training students' ability of business activities. For example, the University of Electronic Science and technology, outstanding logistics, supply chain management and services characteristics, students are required to master the modern enterprise management, logistics and supply chain management, service management, graduates in the logistics and modern service enterprises, manufacturing enterprises, software and network enterprises and government agencies engaged in electronic business and information management, logistics and supply chain management and service management.

(3) Based on the educate mode of subjectively of e-commerce technology application towards the direction of e-commerce technology application, the main research activities of electronic commerce technology support system, focusing on training students' computer technology, communication technology and network technology application ability. Such as the Nanjing Agricultural University, aims to train as business manager, electronic commerce manager, web site development and design planning manager as well as the government, enterprises and institutions of advanced network management responsibilities of high-quality talents.

(4) Comprehensive education training mode. This model integrated information flow, logistics, capital flow all three knowledge module, to achieve a wide caliber, composite curriculum goal of Education. Such as the Northwestern University, Guizhou University. In addition, most schools also began to further comprehensive education training mode development, cultivating the compound talent of electronic business affairs.

However the above mode all exist some shortcomings:

(1) Professional personnel training direction is not clear, professional positioning is not clear. This not clear, not only department classification, but also the students on their own position, teachers for students to grasp.

(2) Students practice ability is poor. The current domestic universities generally adopts the practice teaching mode, there are two main ways: one is the software teaching. Mainly around the electronic commerce the teaching courses, in a simulated business environment, by special software to practical operation. Two is the outside school practice. Is mainly composed by the off-campus training base for practicing?

The two teaching methods in electronic commerce teaching all have distinct characteristics and improve students' practical ability, but also have obvious deficiencies:

First, lacking of teaching software.

It is a rapid development of network information era, simulation software development, there is a time lag promotion to the final link when students use, the new network technology, payment tools, transaction, management regulations are emerging, software cannot achieve the synchronization, so that students master the

practical skills always far away to requirements, cannot let the students meet the requirements of the market.

Software teaching environment have too much emphasis on process, rigid contents, lacking of the business and marketing ability analysis. At the same time, the simulation teaching project cannot compare with the real business; student's lack of get on with the market changing processing ability, therefore, students cannot really understand the connotation and essence of electronic commerce.

Simulation software and teaching content are consistent, they break up seriously, lacking of teaching knowledge application integration. The students' electronic commerce management level cannot get increased.

Second, base outside the school lacking of real education.

Businesses involved in management, trade, marketing and other large information data relating to its business secret, unwilling to let the student have too much intervention, resulting in the student's internship only superficial study of major knowledge and professional ability is far away from requirement. General according to business needs, let students repeat an operation of a work or do some chores.

Teaching organization is difficult. The extracurricular enterprise willing to accept interns each unit is generally not more than 10, so the students dispersed, communicate less, participate in the enthusiasm is not high.

Each enterprise internship content of inconsistency, lead the eventual internship appraisal standard to different level, some even no practice can also get a higher academic achievement.

The school and the enterprise's system is different, too little communication, eventually leading to cooperation only a form, did not achieve a win–win situation.

Based on the current electronic commerce practice teaching insufficiency, proposed the present e-commerce undergraduate program for reform are imminent.

Application of electronic commerce talent cultivation mode.

5.3 Electronic Commerce Employment Direction and Related Courses Classified

In the current academic circles of application oriented undergraduate talent cultivation mode of electronic commerce research and discussion, mostly based on the school or teacher's perspective, this paper considers that the electronic commerce applied undergraduate talents, should contain two parties, namely the teacher and student. Traditional studies lacking of students' evaluation. As a student to consider, they are mostly concerned about the employment direction and position. From the past ten year's electronic commerce employment statistics, the relation curriculum can be shown in Table 5.1 [5–8].

Table 5.1 Professional category

Main direction of culture	Main course (in addition to the public course)	Future employment enterprises or post
Technical direction	Website SEO optimization, webpage design and making, the security of electronic commerce, electronic commerce law	Electronic commerce company technical department or unit of electronic commerce department
Customer service orientation	The telephone marketing, relationship marketing, customer relationship management	Engaged in customer service work
Logistics direction	Introduction to logistics, procurement theory and strategy, logistics management, logistics cost management, distribution center operation and management, electronic commerce law	Logistics company, express company or e-commerce company distribution department
Financial direction	Electronic banking, financial markets, money and banking, securities and investment, risk management	Banks, securities companies, financial companies
Accounting orientation	Accounting, financial management, audit, asset evaluation	Accounting firm or corporate accounting positions
Management orientation	Management, human resource management, organizational behavior, management psychology	Various enterprises and management positions
Marketing orientation	Marketing, market research and forecasting, network marketing	Marketing management, sales of reserve managers and other
National public orientation		Enterprises, village officials, and transferring students

5.3.1 The Solution to Professional Personnel Training and Professional Orientation Unclear

(1) To make students have a clear self-recognition and grasp some direction of proposal

First, it is recommended that students enrolled early, set up to resolve e-commerce professional training courses, to make the students have an overall view of the professional nature of the current state of development, future trends, and our emphasis on areas of expertise.

The second is the curriculum for each course should have a detailed explanation, such as: course name, class, selected textbooks, classroom teachers, biased towards the direction of the theory and practice, for which direction of student choice.

Tell each student professional orientation, as well as previous students' career orientation (or just above the icon mentioned in the eight directions), for example, previous to a direction of the employment situation, the current, the future employment situation of prediction, what preparations should do and courses choice, as well as practice opportunities. Only have a clear understanding of each direction, shall they have a specific circumstances of a plan for their 4 years of university life, to devise strategies, winning thousands of miles.

(2) Proposals for improving the teachers to grasping the point of students

In traditional education, the teacher response for teaching do not stay in the office makes the students and teacher communication objective cannot be timely and efficiently. The mentality of students the teacher can understand, much less to teach students in accordance with their aptitude. The teacher's response for student management often does not understand the major market and the students' adaptation to the situation. This article suggested that in educating the electronic commerce major students, constructing efficient three party communication platform, namely teaching teachers, student teachers and students of the barrier-free communication platform. Quickly reach a dynamic information exchange. This article suggested in the students whose major is electronic commerce, constructing efficient three party communication platform, namely teaching teachers, student teachers, students and barrier-free communication platform between these three. Quickly reach a dynamic information exchange.

The scheme for improving students practical. Reform of current experiment course, open laboratory; the development of network teaching and the market fusion online venture project. Independent undertaking project—"shops online". Based on taobao.com, Chongqing net as the C2C platform; ShopEx independent shop online, Ecshop independent shop online, Wdwd shop for free, Maifou, iShopEx independent shop UNITA and other sites for B2C platform, start the project of College Students' "shops online", every students have to complete the

"shop" in the early establishment of work in one single year, and manage to university graduation.

This project are combine with the foundation course "introduction to electronic commerce" and "computer network technology". The cooperation of enterprises with business projects.

To help local enterprises product and do business promotion project.

Cooperate with Ali institution, through market research to choose a suitable network marketing enterprise product or service, help local small enterprises to develop products and online trade, product and business in China and even the world promote entrepreneurial projects. Realization the objection of helping enterprises to sell products on the web, business promotion, wide marketing. The project mainly combines the core courses "marketing", "network marketing", "international trade".

To help local enterprises to build and maintain the business project.

Cooperate with Chongqing local small and medium enterprises, to provide advice, recommendations and to assist in the design of enterprise website program, and also can help to achieve enterprise information dissemination and maintenance. This project mainly combine core curriculum "webpage design and making" "enterprise and electronic business affairs management" "Javascript" "program design of electronic commerce system design and site construction". Constructing the "e-commerce real room", make the students' War drill simulation of battlefield. Above the original electronic commerce laboratory basis, in the construction of a "e-commerce real room", the construction of the experimental platform build for open laboratory, students can realize designing a variety of projects and programmers in this platform. Mainly has: business meetings, business communication, business planning, webpage design and making, online trading, online business forum, enterprise information market information retrieval, publishing and other functions, thereby widening the electronic commerce and related students entrepreneurial space, realize the classroom and the market combination.

(3) The rebuilding of practice system

Different training directions of schools, based on the electronic commerce student employment, establish the strategic partnership with the enterprises. Schools and enterprises jointly develop intern selection and cultivation method, which can be divided into different stages of enterprises to participate in practical activities without having to wait for the senior after passing the exams. It can timely send their own understanding of the theoretical knowledge into practice, and it can shorten the adaption period of the students' entering the community even to the "zero adaption period" effect by training the students' practice abilities on time.

5.3.2 The High Adaption Between Science Technology Management and Teaching Management

In order to make the students adapt to the market demands, we might introduce the social management model into the science technology management, to ensure that the students can conduct "real time practice", and the science technology management can copy the company management and simulate its operation except the cooperation with the enterprises. The roles which teachers, tutors and students correspond respectively will make the daily teaching and the situation of exception management as the company project management. The students in school will be able to experience the enterprise's management system and model, so as to improve their social adaptability.

5.4 The End

Talent shortage has become the most fundamental and the most pressing problems on the E-commerce development in China. Electronic commerce talents orientation and training is concerned universally and the electronic commerce talented person innovation training is particularly important. This paper puts forward a new electronic commerce application oriented undergraduate talent training plan from the direction of employment, training module and promoting the practical teaching and other aspects. Solid students' "practical, complex, diversified" professional core competencies, to cultivate students' ability to solve practical problems, in order to entering the workforce "zero adapting period", can be quickly cut into the practical engineering application type talents "wedge".

Acknowledgments The authors are grateful for the anonymous reviewers who made constructive comments. This work is sponsored by Chongqing Board of Education (NO: 102313).

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Chapter 6
Information Literacy Composition and Training Strategies of University Teaching Administrator

Xiu-ying Li

Abstract The twenty-first century is the information society, so it is necessary to have a high level of the information literacy and establish informationalized teaching management concept for university teaching administrators. This paper tries, based on the analysis of the information literacy composition of university teaching administrators and training importance, to put forward the training strategies of the information literacy for university teaching administrators.

Keywords University teaching administration · Education informationization · Information literacy · Necessity · Training strategies

6.1 Introduction

The university teaching administration is a school management with the combination of administrative and academic management, which bears the task to ensure the orderly operation of teaching, complete educational goals and achieve the three main objectives of the teaching, researches and social services and is the fundamental core to improve the quality of teaching [1]. The university teaching administrators make planning, organizing, supervision and control to the teaching in order to ensure efficient and orderly operation of the teaching system. Ministry of Education points out clearly that the education informationization should promote education modernization. During the process of achieving education

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_6,

informationization, the university should take the initiative to use the information technology to improve the management level and the efficiency of management, improve the overall level of work, cultivate and bring up with innovative spirit and practice ability of high quality talents. To adapt the need of the modern and scientific teaching administration, it becomes more important to foster and improve administrator's information literacy.

6.2 The Connotation of University Teaching Administrators' Information Literacy

Information literacy was first proposed by Paul Zurkowski in 1974, the chairman of American Information Industry Association [2]. Information literacy is the ability to retrieve from a variety of information sources, evaluate and use information and is the life skills for the works to master in the information society. With the development and application of the information technology, people pay more attention to the importance of information literacy. Teaching administrators' information literacy includes the following: to realize that complete and accurate information is the basis of the wise decision, to make retrieval strategy according to the information needs, to use retrieval technology to search information, to evaluate the information, to achieve new information to the original knowledge structure according to the practical use and to use the information in the critical thinking, problem solving and the process of the communication in order to make scientific decision and regulation [3]. It includes three main aspects, information knowledge, information consciousness and information capability.

Information knowledge is the theory, common sense and method about the information. Information knowledge is the basis of information literacy and how much knowledge one masters is directly related to how strong teaching administrators have information consciousness and information ability [4]. University teaching administrators need to use a variety of communication tools to communicate and exchange with teachers and students, which requires the teaching administrators to understand the computer system knowledge, network knowledge and multimedia knowledge and to grasp the information processing, inquiry, acquisition, transmission, evaluation and information of knowledge innovation. Master information system operation rules and the matters needing attention better. Please prevent the leak when using all information and data. Using the Internet to collect information, people should comply with relevant laws and regulations and ethics and protect others' intellectual property. So, people should study relevant state laws and regulations and the knowledge of intellectual property rights.

Information consciousness is a reflection form of teaching administrators' ideas about the information and is also the confidence and interest to read information, search information and use information under the information environments.

Information consciousness is a reflection of information sensitivity, and this sensitivity makes the person determine the nature and scope of the needed information, know when to need specific information and clearly express information needs. The survival of mankind is not only a natural survival, but also a social survival. University teaching administrators take several social roles such as leader, communicators, coordinator, service, decision makers, which ask them to have a strong information consciousness. In the performance of the planning, organizing, leading and control basic functions, administrators should maintain readiness and judgment about the new information and determine the need for information, actively explore and collect the information related to his own work, make sound decisions based on the problem of information demand, and the ability to judge extraction and development and make good use of the information to, in order to better service to his own work.

Information ability is the core of the information literacy, which is the ability to survive for people in the information age. It shows people's ability to obtain information, process the information and create new information with information equipment and information resources. University teaching administrators' information ability includes that one is the ability to use information tools. It requires that people can use text browser, a search engine and e-mail and other modern tools and use the modern office automation information processing software, remote communication tools and other information technology skills. The second one is the ability to identify and handle information. Along with the development of the education information, according to own actual need and specific requirements, teaching administrators need to make use of the scientific methods from outside information carrier to extract valuable information to improve the use of the valuable information through the information out, screening, reorganization, identification and evaluation. Through the appropriate analysis, administrators will guide practical work with the information to be discovered and captured in order to improve the management efficiency. The third one is the ability to create and transmit information. Administrators innovate information obtained, transmit the new information to others in an appropriate way and communicate with others to promote rising of new knowledge and new thought.

6.3 The Necessity of Training University Teaching Administrators' Information Literacy

Under the intensive information environment, teaching administrators' information behavior and information literacy have the important influence on teaching administration information. The working nature and professional characteristics of university teaching administrators require them to have good information literacy.

6.3.1 Cultivating Teaching Administrators' Information Literacy is Helpful to Improve the Management Efficiency

The higher education popularity makes the expansion of university teaching scale, which causes a series of qualitative changes such as higher education ideas, functions, management, entrance and selection. With the increase in management range and management levels, the teaching management work required is continuously improving. The pursuit of efficiency is the center of management activities and the starting point of all management work. The rapid growth of the information requires teaching administrators to take full advantage of modern information technology in the process of teaching management, which can be used to select, store, process and transmit information, and analyze and evaluate data information in order to promote information exchange. It is the basis of efficient decision to strengthen the idea of the information share and full participation in the decision making, improve the flexibility of the organization and strengthen the staff's conscience of participation and cooperation. At the same time, it can save the man power and material resources, reduce the cost of work and improve the efficiency of management.

6.3.2 Cultivating Teaching Administrators' Information Literacy is Helpful to Improve the Quality of Teaching

The human being has full access to the information age; information increasingly becomes the most decisive factor in the most active social fields. The world famous future scientist Arwen Toffler predicts "who masters information and controls the network can master the whole world." The information age puts the new life and vitality to the education and has a profound impact on education so that it put forward higher request to the education. Training the talents with good information literacy has become the inevitable trend in the present education reform. Higher education needs to adapt to the requirements of information society and cultivate students with the ability to gain information, use information and develop information, that is, to say, the innovative talents should have the information literacy, so that they can strengthen the country's competitiveness in the international society. Therefore, good quality of the information literacy is the need of cultivating creative talents. University teaching administrators must take the mission of fostering the talent, improving education teaching quality and improving their own level of information literacy.

6.3.3 Cultivating Teaching Administrators' Information Literacy is Helpful to Management Innovation

The role of the administrators is to come out the initiative and creativity of "people" and "community" through management. To realize scientific and effective management requires teaching managers to have new ideas and creative thought. Information is the basis of modern management and leader's decision. Teaching administrators must have lots of information resources to make school training objectives and talent training scheme and combine the information with the relevant law and regulation, integrate new information with the original knowledge system, put forward new plan based on information feedback, make the scientific decision based on the test of information products to form the goal and the plan, and realize innovation on management thought, management system and management technology. In the process of information transferring and use, it makes the full play of the school function in order to realize the school's development. Good information literacy for teaching administrators is necessary to realize management innovation.

6.3.4 Cultivating Teaching Administrators' Information Literacy is Helpful to Promote Education Informationization

Education informationization is a major adjustment for traditional higher education system and is the basis of education modernization. University teaching administrators are the main organizers and practitioners in teaching activities and the important power to promote education informationization construction. Educational administration system, office automation system and other systems provide informationization support and at the same time ask teaching administrators to improve quality of the information literacy. The information technology and the information service connect organically as users of the system put forward the needs of the system related to relevant business to change into the practical needs of systems and show the accurate demands to systems. Teaching administrators are familiar with information management business process, straighten out the teaching management mechanism, establish unimpeded information channels and realize the technology innovation and service innovation. To improve the teaching literacy of teaching administrators is to make not only environmental performance and the need of teaching resources, but necessary demand to promote higher education informationization. University teaching administrators should improve the information literacy with knowledge sharing, cooperation and research and codevelopment, develop actively the production and transmission of new knowledge, new technology and new thoughts, strengthen the communication and cooperation between the universities and promote the development of the whole community.

6.4 Training Strategies of University Teaching Administrators' Information Literacy

In the twenty-first century, university teaching management is the field of information and intensive knowledge, and with the deepening of education informationization level, teaching administrators should try to raise the level of their information literacy to adapt to the development and requirements of the times.

6.4.1 Creating the Informationization Atmosphere and Shaping the Information Organization Culture

Organization culture is a special kind of culture tendency to the organization management field and is the combination to guarantee organization behavior rationality and normative, strengthen the organization cohesive force and endurance and promote the organization growth and development of the ideology. Building up a good information environment and shaping the information organization culture is to develop and improve the material base of the teaching administrators' information literacy. They should set up a group of design information and knowledge management system, set up the system of the information and knowledge management, make feasible development planning about information management and knowledge management, make the atmosphere of information and knowledge sharing in internal organization, and make the administrators realize the importance of informationization to the school, so as to make the preparation on public opinion. Through the establishment of information society values and organization culture mode, it can strengthen the identity of members and motivate managers' fulfillment, so as to improve the management efficiency.

6.4.2 Updating the Teaching Management Concept, Strengthening the Information Consciousness and Cultivation of the Information Concept

It is the key to increase the efficiency of the teaching management that teaching administrators show the enthusiasm, initiative and creativity. Choosing the correct values is the primary strategic issue to shape the information society. Teaching administrators should be brave to accept the challenge of times, update the teaching management idea, set up the informationization teaching management concept, accept actively new thoughts and concepts at work or study, study and apply information technology willingly from the consciousness and form the

consciousness and habits to use information technology to solve the practical issues. They should actively raise working ability in the digital environment to adapt to the information teaching. Information environment has an important effect on people's formation and development on information consciousness. Building up a good information environment is the material guarantee to improve the teaching administrators' information concept. The software commonly used and enough computers can make the guarantee that Internet network information technology is widely penetrated to the whole process of teaching management, establish a safety, advanced and perfect technical platform and realize the teaching management network and intelligent information processing.

6.4.3 Regularly Open the Training to Information Literacy and Information Technology

According to the school's practical situation and the need of teaching administration, it should take advantage of the rich information resources in the higher school and the professional talents insist the direction to master knowledge, the principle to develop capacity, the purpose of proficient use and make the training plans which use the methods to regular training, professional study to provide various kinds of training approaches to information literacy and information technology. The focus of training is the actual operation ability and especially for a comprehensive introduction to various information systems for administrators, in order to make them to master the management proficiently as soon as possible and become leaders to construct school's informationization. In order to strengthen the teaching administrators' confidence to learn, let each teaching administrators position their own information literacy level. Based on the actual, a modular content training system is adopted, which is divided into a module of the basic knowledge and new progress, a module of information retrieval, a module of network operating application and a module of software commonly used in order to make sure that every teaching administrators can promote their literacy compared with the other community in the same level. The long-term support security mechanism is established to ensure teaching administrators can get the help and guidance from the information technology department in time when meeting the problems at work [5].

In the society with science and technology information, network, knowledge and the globalization, information literacy has become the basic survival ability for every member in society. We should improve the quality of the teaching administrators' information literacy to promote the development of the education career and even the entire social economy and culture.

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Chapter 7
Research of Art Education in High Normal Schools

Lihua Ma and Qiushi Huang

Abstract With the improvement of people's living standard, people's pursuit of beauty is more and more high. At present, from primary school to high school, the reform of arts curriculum has been fully implemented; various arts training institutions also emerge in an endless stream on the society. In this condition, the art education of high normal school is less adapted to the social development, and it is imperative to analyze its current situation and give the corresponding countermeasure. In this paper, it firstly analyzes the social environment and the education target about the current normal art education, then discusses problems and countermeasures about art education of high normal schools from four aspects, finally discusses the quality that teachers should have in art education of high normal schools.

Keywords Arts education in normal universities · Current situation · Analysis of countermeasures

7.1 Introduction

The arts play an important role in enriching people's inner feelings and developing imagination, creativity and comprehension [1, 2]. Art education is an important component to improve the artistic accomplishments [3]. For the fine arts education major in the normal universities, it is mainly to train the primary and secondary

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_7,

school art teachers. The quality of the normal university students' art learning not only affects itself but also affects art education effect of a generation even a few generations.

7.1.1 The Social Environment of the Fine Arts Education in Normal Universities

Our educational system is set up with the help of the Soviet Union. Each curriculum is in accordance with the Soviet model, and art education is no exception. In the 1950s and 1960s of the last century, the art education is mainly to improve students' skills [4, 5]. The main content is to master the skills and theories in the process of learning. This kind of education has continued ever since. With the development of science and technology, the traditional education mode can not meet the current needs of the society. At the end of the last century, the training of art education is no longer skill based, but converted to develop students' creative thinking abroad. Under this background, China's fine arts education in the normal universities is changed accordingly. It must be reformed to meet the demands of The Times.

7.1.2 The Target of the Fine Arts Education in Normal Universities

In China, the main training objectives of the fine arts education major in the normal universities are to provide art educators for primary and secondary schools. With the development of the society and popularization of higher education, quite a lot of students are not engaged in teaching after graduation. It is put forward higher goals and requirements of the training targets of the fine arts education in the normal universities. During the process of education, it is not only for its art education but also for improving humanities quality and professional skills of the students. Let students master the frontiers of knowledge of the art education theory as much as possible.

7.1.3 The Art Education in the Information Age

With the rapid development of information technology, art is not only asking people to paint on paper, but also the art work can use their computers to unfold the authors in people's front in the way of the Internet, television, advertising and

so on. While using these tools, it is also requires students to have a certain esthetic ideas. We should find out the outstanding works to improve students' artistic accomplishments in the visual banquet of dazzling network.

7.1.4 The Art Education in the Multicultural

Since we implemented the reform and opening-up policy, we have suffered the impact of the world's different cultures. We authenticate the foreign cultural and absorb the advanced cultural achievements on the basis of carrying forward the Chinese excellent traditional culture. In the process of culture shock, art plays an important role on the heritage of cultural as a special language.

7.2 The Analysis of the Advanced Normal Art Education Problems and Its Countermeasures

7.2.1 Emphasize Pedagogy

No matter what extent the social develop, the primary task of the normal schools is to train a large number of primary and secondary school teachers. Art education is the cradle of the art teachers for the primary and secondary schools. We need to have a clear understanding which is the fine arts education major in the normal universities and is not to train artists, painters and artists. In addition, normal schools are mainly to train primary and secondary school teachers rather than professional art training staff. So, in the education process, it is mainly to cultivate students' understanding and awareness of beauty which is also an important part of quality education. It plays a positive role in all-round development of students.

At present, China's normal schools are mainly to train students' skills and art theoretical knowledge for art education major, especially skills training. Students spend most of time on exercising the skills and techniques. Therefore, the practical ability of art teacher majors' students is relatively high. At the same time, the varieties of skills contests which are organized by schools and competent authorities are relating to the practice. It is in some way to stimulate the students' enthusiasm in the skills training. In universities, the total number of classes is fixed. When you keep all your energies to practice, it needs to sacrifice the time of theoretical study. Thus, school art teachers who affect students to become a qualified primary or secondary should have the theoretical knowledge. After a student goes to work, it is not what he can draw, but what should he teach students. At present, primary and secondary schools have advocated in raising the quality

education to break the traditional spoon-feeding education. So, it needs to guide the students to do what rather than hand-holding in the process of primary and secondary education.

In normal college, many students focus on raising the level of English and painting while ignoring the learning and exercising of the humanistic quality in the learning process. They think that so long as their professional skills have been improved; there is no problem to teach students in primary and high schools. In the teaching certificate, as long as he passes the test, he can engage in the teaching work. If he just understand this, he is completely wrong.

In recent years, the fine arts education major in the normal universities makes a series of reforms. It adds the computer art, computer design and modern educational technology to the curriculum system. At the same time, the educational nature curriculum is set to be compulsory course. It has played a positive role in improving students' educational theory.

7.2.2 To Strengthen Our Contacts with Primary and Secondary Art Education

At present, the graduates of the fine arts education major in the normal universities unable to enter into the role successfully which cannot assume the role of teachers after they get into primary and secondary schools. Disjointed phenomenon is appeared. This is mainly due to many normal colleges take the previous education mode while turning a blind eye to the new school curriculum standards for state specified.

At present, China's art education all layouts the painted objects in the classroom and the students draw according to the objects. Then, they hand in their works to the teachers to review. They are in the passive acceptance, and there is no active participation. It greatly limits the students' thinking skills and creativity in the process of learning. After a long period of four-year study, students have remained in this education state. They work to primary and secondary schools after graduation. In the process of teaching, this method is also applied to the primary and secondary school students invisibly. For the primary school students who don't have any art strength, the result can be imagined. At the same time, the present primary and secondary schools have been emphasizing quality education to develop students' creativity and capacity of active seeking knowledge. During the learning process, the creativity of the students who passing a long period of normal education is basically zero. It is impossible to let the graduates who don't have any creativity to guide primary and secondary school students and to develop their creativity and imagination.

7.2.3 To Strengthen Educational Practice

In China, many people think that the teaching is the easy profession to enter. They think that it is a very simple matter which is nothing more than to observe the aged teachers' behavior and language and then repeat them. The persons who think the teachers are to implant knowledge to students in class are ignoring the complexity and difficulty of the education. They pay less attention to educational practice. They believe that as long as they learn English well and the drawing level is increased, they will be able to an excellent primary and secondary school art teachers. This requires the fine arts education major in the normal universities to strengthen the education of students in terms of ideology firstly. While let the students do the educational practice and the increase the educational practice classes corresponding during the usual learning process. At present, our normal colleges for educational practice courses are divided into two parts: probationary stage and practice stage. In the probationary stage, it is mainly to prepare lessons, write lesson plans and try to speak through observing and listening to the experienced teachers 'class and under the guidance of aged teachers. It is mainly to engage in a period of practical education work to the primary and secondary schools, after completion of the internship, schools and instructors gives their evaluation. However, due to the large number of students and leaks in management which exist in the primary and secondary schools, students in the internship generally be used as substitute teachers and they cannot get some reasonable proposal and evaluation after the internship. This has caused the students cannot blend in the teachers' role in a long term in the real teaching process after graduation.

In view of the above problems, it needs to adopt the whole educational practice mode to clear the goal of the internship and to change the education concepts in mind. We need to reflect and summarize their advantages and disadvantages in the process of practice and to establish the idea of lifelong education. We should combine with the actual situation of the school, find out the right mode of education.

7.2.4 To Keep Pace with the Times

With the development of the technology, a variety of camera equipment provides people with dazzling visual impact. It makes people to understand the art with a further development. At present, we can know and see the different styles around the world through various media. The art is not only limited in a small area but also to be the enjoyment rights of whole citizens.

At present, people can use the traditional tools for the creation of art and take advantage of new high-tech means to create and disseminate the art. Now, we can watch a variety of art exhibitions which are hold all over the world through the Internet and television. Technology has a huge impact on the development of art. It provides a broader platform for the communication between teachers and students.

Distance education and BBS have become the new methods and means of communication between teachers and students. It not only breaks time and space limitation of students' learning but also encourages the teachers' work.

7.2.5 To Strengthen the Training of University Teachers

Nowadays, art teachers of normal schools are mostly come from the professional art schools or socially distinguished artists. These people have a strong theoretical foundation for the art but less of proficient on their education. For them, treating students with artists' vision and cultivating every student to be artists as them is the success of education. So, it needs to emphasize the practice of skills and painting skills during the teaching process. As time passes, it forms a single teaching method which mode is relatively rigid. The mode of teachers to teach students is still used in class. They pay much more emphasis on drawing skills, thus ignore the students' innovation ability and thinking. At the same time currently the number of students is relatively more, it cannot reach every aspect of the students and popularize during the teaching process. On the other hand, art education of primary and secondary schools has never been involved by these people. University students or social personnel have been facing during the process of teaching. They are lacking of students' thinking mode and education understanding that is seriously out of schools' educational practice.

So, the ultimate goal of teachers who are teaching lessons of the fine arts education major in the normal universities is to train students to be qualified teachers of primary and secondary schools. They are able to guide pupils to carry out basic painting, handmade and other related courses to improve students' practical ability, creative thinking and esthetic concepts.

7.3 The Qualities Should Be Required by Teachers of the Art Education Program in Normal Colleges

7.3.1 Loving Art Education

Only a person loves this career from his heart can he really make achievements in the area. In China, the teacher's wage levels are relatively low. In society, due to the development of the art industry is not perfect in China, many art talents cannot stand in the society through the sale and purchase of the works. They have to engage in the teaching profession. This forms a huge contrast. On the one hand, they do not want to stay in the teaching industry and they want to be well-known painters or artists by publishing art works. On the other hand, there is no proper opportunity or relatively high works. They have to blend in teacher industry.

Because of this case, many people who engaged in art education don't love the teachers. They bring their dissatisfaction to class invisible during the teaching process. This will cause huge adverse impact on students. This concept is also deeply to stimulate the students of the normal colleges.

At present, scientific advancement makes people's words and deeds spreading faster and wider. This requires teachers to set an example first. The teachers should show a positive image for their students to guide them in a right way. Art has no borders. The artists are pursuing of freedom constantly, so it is even more important to be a model of virtue.

7.3.2 Clearing the Educational Objective

It is different to precede art teaching between normal schools and professional schools. If the concept of advanced normal art education' pedagogic is not fully understood, even if a person is quite love art education and pay a amount of labor, ultimately the effect is not particularly good. So, it needs to have regular learning for the normal schools' art teachers to educate and reform them in mind. No matter how high level they have, it needs to let them to understand the true meaning of pedagogic. So, they can teach and educate better.

7.3.3 Requiring Some Operational Capacity

The above two have stressed the importance of being a model of virtue and pedagogic of teachers. After clear the attitude, the operational capacity of teachers should be improved. Educating students and studying art in school are inseparable from the profound knowledge of art and superb skills.

In colleges, teachers' self-learning ability is more important. They cannot just rely on the communications which are organized by schools and forum. Only by learning actively, enriching their own knowledge systems and updating their knowledge structure can they competent to art education.

7.4 Summary

In this paper, we have studied the fine arts education in the normal universities. First, we analyze the social environment and target of the fine arts education in the normal universities. We describe art education of the information era and multi-cultural. Then, we discuss the current situation and countermeasures of the fine arts education in the normal universities from four aspects. Finally, we give some contents which should be mastered by an excellent advanced normal art

education's educator. Due to space limitations, it is hard to avoid weakness. I hope that the interested readers can make critique and correction. We can discuss and study together. We will work hard for the beautiful tomorrow of fine arts education in the normal universities to create much more excellent art talents.

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Chapter 8
Error Factors and Monitoring Strategy in College Teaching Administration

Min Jie

Abstract By applying the human factor engineering into the research, the educational management errors are divided into systemic error, human error and random error. On the basis of analyzing the formation mechanism of educational management errors, it is proposed that the management system for the error prevention and error monitoring should be established so as to effectively reduce the occurrences and the negative effect of errors, and improve the quality of educational administration.

Keywords Human factor engineering · Educational administration errors · Error prevention · Error monitoring

8.1 CLC: G471.7 Document Code: A

In recent years, along with our country's higher education enrollment expansion, college students, campus number showing a rising trend, thus college teaching management staff workload and working difficulty increases, the complex features of the work of educational administration in universities will be more prominent. This requires us to adopt a more effective job behavior in daily management in order to avoid various mistakes. Educational management error is the root of work stress, teaching quality problems and the teaching accident, which are the important issues affect the normal teaching order. Because the error may lead to a variety of adverse consequences, long-term, universities have taken various

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_8,

preventive measures to eliminate the error, but educational management error still exists everywhere. In this article, with the application of human factor engineering method, the educational management mistakes are divided into systemic error, human error and random error; by analyzing the formation mechanism of educational management errors, it presents that only establishing error prevention and error monitoring management can effectively reduce the number of errors and the negative effect, and improve the quality of teaching administration.

8.2 Educational Management Error Types

The so-called educational management mistake means that it does contrary to the planned educational administration management or it does not comply with the normal teaching management system target, thereby preventing the education teaching goal or task behavior [1]. The management of teaching in university is of great subjectivity because of its characteristics of big workload, pressing and complicated matters. According to the error characteristics of educational administration, the application of human factor engineering can be divided into the following three categories:

Systemic error: Due to the educational administration management system itself, such as rules and regulations, work flow cannot adapt to the rapid development of changes in the teaching management requirements, which inevitably leads to the generated error in management system. For example, some students cannot resist or select the course due to the course code transformation.

Human error means that staff is aware of the harm or potential harm behavior, and not well cooperated in the process of educational management. Though the frequency of man-made error is not high, it has extremely high concealment, and once happens it will bring bad influence.

Random errors: It happens in the management process due to the psychological, physiological and environmental factors; the staff produces unconsciousness human error for completing an assignment due to personal reasons of them—such as family disputes, the unexpected blow, illness, lack of sleep, resulting in work errors such as inattention, fatigue and weariness, lack of the normal ability to judge things; or as a result of the bad work attitude, low technical skill and the noisy working environment. If the management facilities are backward, it will also cause random errors such as staff negligence; unverified adjustment of classroom use which led to conflict; failure to timely submit correctly ordering of textbook materials, which cause wrong order and leakage of textbooks, and the students cannot timely receive needed materials during the new semester; unconscious human errors in the management process occurs most often, which will have some impact on normal teaching order, although such errors cannot be avoided, but as the educational management workers, we should take effective measures to reduce such errors. The error may lead to a variety of adverse consequences, long-term; people always try various devices to eliminate errors in the emergence of work.

But in the complicated environment, errors are always everywhere; the objective facts make people think it impossible to completely eliminate the error. Because error is inevitable, people begin to pay attention to analyze the error causes, try to objectively understand the error generation mechanism, prevent the foresight ability of errors, enhance error processing capacity and to reduce the negative impact of the error to the minimum.

8.3 Mechanism Analysis of Administration Errors

The cause of educational management error factors are perplexing, its mechanism is not yet fully analyzed. General speaking, it has both objective and subjective reasons, among them; the subjective factors play a major role. The subjective factors include the people's physiological and psychological factors, while external factors include management factors, environmental factors and so on.

The subjective factors mean human factors that include physical and mental capabilities.

Circadian rhythms: Physiological changes have great influence on people's thinking and behavior, if it is not properly treated, it may make the employee's be in a state of disorder. Everyone has a rhythm regulation system; it is easy to produce the phenomenon of fatigue during the low period work. The intellectual, emotional and physical changes are high or low, it represents sinusoidal function law according to statistics, and the cycle is 33 days, 28 days and 23 days [2]. Let T be the employee's days of age I, F, S, respectively, stand for intellectual, emotional and physical changes, then the relationship between them is as follows:

$$I = T - 33INT(T/33) \tag{8.1}$$

$$F = T - 28INT(T/28) \tag{8.2}$$

$$S = T - 23INT(T/23) \tag{8.3}$$

According to the expressions (8.1)–(8.3), we can see that the intellectual, emotional and physical strength are periodic. It makes people may be in disorder on a few days. If staff works in a state of fatigue or illness, it is prone to make random error.

Psychological problems: Because people generally exist some harmful personalities, such as habitual psychology, psychological paralysis, fluky psychology, psychological stress, conceit, if handled improperly, it may also induce disorder for human thought and cause random error.

Level of consciousness: The non-standard behavior of the managers themselves, such as lacking of sense of responsibility, is negligent, not obey to the rules and regulations. Such error is often a collective reflection of culture, the collective culture forgives this non-standardized work style, so that the rules and regulations and work procedures being subsisted by emotion.

Technology ability: Educational administration personnel lack the necessary education management theory knowledge, they also do not know scientific management methods, and their problem solving ability is not strong, which leads to the management effect cannot reach the anticipated result.

8.4 Objective Factors

Management factors: The result of systemic errors occurs when there is a gap between educational administration management system structure itself, rules and regulations, work flow and the demand of practical work. Such as the educational administration management system structure is not reasonable, personnel does not reach the designated position, unreasonable division of labor, responsibility is not clear, resulting vacancy, imposition, offside phenomenon in management; personnel training mode, curriculum system reform, and the relevant teaching management regulations failed to keep pace with the times to update, it is hard to find the corresponding regulations system to regulate the management in the process of the new situation and the new problem, and lead to the emergence of "vacuum" region; restrictions and fault for educational administration management information system, cause relevant information cannot be promptly, smoothly be delivered to lower levels; the specific working process is not standardized, maneuverability is poor, leading to the chaos phenomenon in management; moreover, the discipline of regulation is not timely treated in the management process, it will also lead to mistakes in educational management.

Environmental factors: If the management facilities or equipment and the working environment cannot meet the requirements, it will lead to the error, such as the backward of facilities management, which cannot satisfy the mass data processing requirements; poor working platform design will also make people easy to produce error, such as the dim lights, noisy workplace environment, the busy trivial affairs and the abnormal change of climate.

8.5 Research on the Transfer of Human Errors

If we consider the people as a system, various causes of human error factors can be set for several states; working status always changes when people affected by physiological, psychological and environmental factors. The people in the working state are set into three levels: normal state (S_0), the metastable state (S_1) and a state of disorder (S_2). The first hypothesis is human error rate constant in these three states (the human error rate can be understood as the state average) are K_1, K_2, K_3; secondly, if any two state shifted, state transfer rate and recovery rate are constant: M_1, M_2, m S_0 and S_3, respectively, by S_1, S_2, S_2, S_0 transfer rate, L_1, L_2, L_3,

respectively, by S_1, S_0, S_2, S_1, S_2, S_0 recovery rate; $F_1(T)$, $F_2(T)$, $F_3(T)$, respectively, in S_0, S_1, S_2, human error failure rate; $P_0(T)$, $P_1(T)$, $P_2(T)$, respectively, in S_0, S_1, S_2, work reliability.

Based on the markov process chain, we can obtain the following equation:

$$P_0(t)[1 + (K_1 + m_1 + m_3)] = P_1(t)L_1 + P_2(t)L_3 \tag{8.4}$$

$$P_1(t)[1 + (K_2 + m_2 + L_1)] = P_0(t)m_1 + P_2(t)L_2 \tag{8.5}$$

$$P_2(t)[1 + (K_3 + L_2 + L_3)] = P_1(t)m_2 + P_0(t)m_3 \tag{8.6}$$

With the probabilities of $P_0(T)$, $P_1(T)$, $P_2(T)$, we can get the solution of expressions (8.4)–(8.6) as following [2]:

$$P(t) = P_0(t) + P_1(t) + P_2(t) \tag{8.7}$$

People working reliability will be changing with the person working state transfer, so when we evaluated an educational management system, the human factor should be considered; it must put the person's element and human reliability system as an important index for assessing, truly be "people-oriented," so as to effectively improve the management efficiency and reduce human error.

8.6 Current Error Management in Colleges

In fact, administration errors are important sources of producing work stress and teaching accidents; large and frequent occurrence of these would cause serious interference in normal teaching management for colleges and universities; and its S_0 normal state S_1 metastable S_2 disorder state: m_1 m_2 m_3, k_1 k_2 k_3, L_1 L_2 L_3 $F_1(t)$ $F_2(t)$ $F_3(t)$; harmfulness has already been widely recognized. In the process of teaching management, many colleges and universities have developed "The Interim Provisions of teaching and teaching management error and accident cognizance and treatment," which clearly defines the bad management and problem behaviors in the teaching management and puts forward various treatment measures. Considering the treatment of teaching management error, it mainly has three forms.

One is the reflection of self-examination, which mandates responsibility person to write a note and check, and be criticized in the responsible department. The second is the administrative processing type: according to the degree of accident, the responsible person is given a criticism, administrative warning or demerit; the third is the economic punishment type: according to the accident, the responsible person will be deducted wages for 1 month to one year. If the responsible person has different opinions he or she has the right of appeal. To recognized errors, we should fill out the error form and delivery it to the academic affairs for the record [3]. At present, the provisions of mistake processing do good to prevent the teaching management errors, but because the rules expressly defined wrong

liability, for fear of criticism, economic sanctions and effect appraisal, title evaluation, management personnel prone to hide it, which leave the hidden trouble for the later work.

8.7 Regulation Strategy for Reducing Administration Error

8.7.1 Error Prevention Strategy

The error prevention strategy refers to avoid any adverse consequences by trying to prevent errors in the process of the work, so as to reach the aim or complete a task [4]. For possible errors, we must have the foresight, through adopting effective preventive strategies to reduce errors.

According to the requirement of school teaching management, to set up a reasonable teaching management mechanism, make the job responsibilities clear, strengthen management so as the information can be smoothly communicated. We must work out a specification, strong operability and standard operating procedures. Revise timely for the sound management rules and regulations, and establish and perfect the implementation. Through the establishment of a sound implementation of the supervision mechanism to discover and correct irregularities, eliminate hidden mistake in management.

Avoid human errors occur. By strengthening the construction of educational administration personnel, improving the integral quality of the team. Create a positive work environment, form a good humanities environment, to stimulate the staff's group consciousness, so as to greatly reduce the error brought about by human for uncooperative.

Reduce the generation of random error. Random error is the most frequently error which occurs in educational management, according to statistics; it is an unconscious human error which account for 80 %; it has a great relationship with the mental state, body condition, the working environment. To reduce the random error generation, first of all, we should concern with personnel's psychological and physical conditions, through active guidance, make them in a normal state, avoid depression, physical discomfort which results in work errors; secondly, to improve the working environment, advocate "people-oriented" concept and ensure them to maintain good working condition and working passion. A good working environment, on the one hand, it can improve the work efficiency; on the other hand, it ensures physical and mental health for staff, making them keep healthy balance even under great pressure and reduce the possibility of error.

8.7.2 Error Management Strategy

Application of error management strategy to analyze on the occurrence of errors can cultivate employee's error handling capacity, reduce or even eliminate adverse consequences by errors.

Set up the "no punitive" error reporting system. For educational administration errors, it should be reported immediately, the management authority must deal with it soon so as to bring negative influence to the least. For the people who have as active reporting and timely treatment, they would not be punished, which plays a beneficial role to create a relaxed environment and promote the staff to have an open discussion and communication about the error. "No punitive" error reporting system, overcoming the misunderstanding concept of "more work and more trouble, less work and less trouble, do not work do not wrong," while it will arouse the enthusiasm of staff management.

Regularly organize management through analysis of typical cases, error prevention training, draw lessons from mistakes, learn to acquire knowledge, enhance the spirit of exploration.

By means of error management strategies to improve the educational management system, establish a sound management rules and regulations. Through the comprehensive evaluation to analyze the cause of error, and timely detect the defects in the management and constantly revise management system, improve the management system, thus forming a scientific teaching management system. Educational management error is inevitable, but as educational management workers, we should not avoid, hide, but should actively face it. On the one hand, we should establish a perfect error prevention system to reduce error rate, improve the safety and quality of service in educational management system; on the other hand, through effective management strategies for error, to detect error causes and treatment methods, improve error prevention system, reduce the possibility of error again. Only develop the error prevention and error monitoring and management simultaneously can we reduce the number of errors, the negative effect, and improve the teaching management level and quality.

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Chapter 9
Teaching Management Analysis on Sports Club in Colleges of Vocational Education

Jing Chen

Abstract To explore the teaching management on sports club in colleges of vocational education, this study used literature review, expert interview, questionnaires survey, and statistic analysis methods, it came into the following findings: (a) the sports events do not meet the need of the students in the college of vocation education, (b) school sports facilities and equipment cannot meet the teaching management on sports club mode, and (c) teaching in sports club mode needs the physical education owns more skill. In order to resolve this problem, the author suggests the following: (a) school authorities and local government should endeavor to complement the effort of the teachers with enough funds in the culture of improvisation in the bid to providing needed infrastructural materials so as to improve physical education teacher and (b) training and re-training programmers should be conducted regularly for teachers to facilitate improvement on sports skills.

Keywords Sports club · Colleges of vocational education · Teaching management · Physical education · Sports facilities and equipment

9.1 Introduction

A sports club or sport club, sometimes called athletics club or sports association, is a club for the purpose of playing one or more sports. As we known sports clubs range from organizations whose members play together, unpaid, and may play

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_9,

other similar clubs on occasion, watched mostly by family and friends, to large commercial organizations with professional players or amateur which have teams which regularly compete against those of other clubs and attract sometimes very large crowds of paying spectators. Clubs may be dedicated to a single sport, or to several (multi-sport club). The term athletics club is sometimes used for a general sports club rather than one dedicated to athletics proper [1].

Teaching management is the act of getting students together to accomplish desired teaching goals and objectives using available teaching resources efficiently and effectively. Teaching management comprises teaching planning, teaching organizing, teaching, teaching leading or directing, and controlling a teaching organization (a group of one or more people or entities) or effort for the purpose of accomplishing a goal. Resourcing encompasses the deployment and manipulation of human resources, financial resources, technological resources, and natural resources. Since teaching organizations can be viewed as systems, management can also be defined as human action, including design, to facilitate the production of useful outcomes from a system [2].

A college of vocational education (or trade education or career education), providing vocational education, is a school in which students are taught the skills needed to perform a particular job. Traditionally, colleges of vocational education have not existed to further education in the sense of liberal arts, but rather to teach only job-specific skills, and as such have been better considered to be institutions devoted to training, not education. That purely vocational focus began changing in the 1990s toward a broader preparation that develops the academic and technical skills of students, as well as the colleges of vocational education.

With the deepening of the reform of higher school, the teaching goal, task, and mode, etc. are changing. Some teaching concept, idea, modes are coming into appearance, such as, open classroom model, happy sports and physical education model, hierarchical option model, sports club option model. In general, as we known, there are two typical teaching patterns in physical education teaching: one is traditional teaching model, in which the teacher dominated the key role; its goal is to give students some information. The other one is sports club model, in which the students play a key role; they can select the sports events according to their favorites. The latter model is popularizing in general higher education, as well as the college of vocational education [3, 4].

In comparison with colleges and universities, colleges of vocational education have its own character. In order to better deepening teaching reform, understanding the current situation in colleges of vocational education and the student's requirements is a radical issue. Therefore, this author aims to make a survey on some teachers and students in colleges of vocational education, through analyzing the survey data, and this author revealed the advantage and disadvantage of teaching management analysis on sports club in colleges of vocational education. The findings of study can provided some suggestions on related management department and researcher.

9.2 Participants and Method

9.2.1 Participants

This survey was performed in three colleges of vocational education in Deyang, Sichuan: Sichuan College of Architectural Technology, Sichuan Engineering Technical College, and Sichuan Aerospace Polytechnic. 231 students were voluntarily participated in this study. 231 questionnaires were used. After gathering and analyzing these questionnaires, the study got 225 valid questionnaires, and the percentage of valid questionnaire was 97.4 %.

9.2.2 Contents of the Survey

The questionnaire contained the following questions:

Which sports events do you like and can it meet your requirement (if you choose this sports event, you can attend this class)?

Do you think the sports classes have fewer or more events than you expected and your suggestion?

Do you think your school's equipment and sports fields are short to meet the need of sports activities?

Do you think physical education teachers' skill meet the sports activities?

9.2.3 Statistical Analysis

Data from the questionnaires were collected and analyzed with SPSS 16.0 for Windows. The data gathered were analyzed using frequency count and percentages. Three research assistants were used for distribution and collection of questionnaire.

9.3 Results and Analysis

9.3.1 Sports Events Required Situation and Ratio of Meeting Requirement

From Table 9.1 listed below, as we seen, it indicated that the traditional event, such as track and field events, football, basketball, can meet student's requirement. But some event, such as swimming, badminton, cannot meet student's requirement. In this study, we find out that the students do not like some traditional events, such as field and track events.

Table 9.1 Ratios of student's favorite sports events and meeting requirement

Sports events	Like (%)	Meet requirement (%)
Sporting dance	45	85
Swimming	35	87
Badminton	42	52
Tennis	38	68
Football	46	100
Basketball	24	100
Volleyball	13	100
Track and field	13	100
Martial art	32	89
Gym	25	100

Table 9.2 Expected sports events

Sports events	Percentage
Swimming	67
Tennis	45
Rock climbing	23
Orienteering	32
Golf	11
Boxing	21
Taekwondo	32

9.3.2 Expected Sports Events

According to the survey data, many students expected some modern sports events, such as swimming, tennis, rocket climbing, orienteering, and hip-hop. These sports events do not list on the sports classes in some colleges; the reason is that the sports facilities and equipment are short or there are no teacher can teach it (Table 9.2).

9.3.3 School Sports Facilities and Equipment Situation

In the survey questionnaire and interview with physical education teachers and students, the data indicated that school sports facilities and equipment are short, the satisfaction degree of both teachers and students were low. Not only the students but also the teachers complain the school sports facilities and equipment. In our survey, the data showed that there are no swimming pool or tennis courts in some colleges; however, these sports events are favorite for many students, so local government and colleges should put more funds on the building of school sports facilities and equipment.

Table 9.3 Satisfaction degree of school sports facilities and equipment

Category	Satisfaction	Dissatisfaction	Uncertain
Teacher	45	50	5
Student	30	67	3

Table 9.4 Satisfaction degree of physical education teachers' skill

Category	Satisfaction	Dissatisfaction	Uncertain
Skill level[1]	55	42	3
Events level[2]	43	52	5

[1] The degree of skill in a particular sport of a physical education teacher
[2] How many events a PE teaching master, such as a teacher know how to play tennis, football, table tennis

9.3.4 Physical Education Teachers' Skill Situation

In the interview with students, many students companied that the physical education teachers' skills do not meet the modern college's need. As shown in Table 9.3, the satisfaction degree of physical education teachers' skill is low, especially, they do not satisfy the events level, namely, they reckoned that many physical education teachers do not understand the modern or popular sports events, such as hip-hop, rock climbing, and tennis (Table 9.4).

9.3.5 Advantage and Disadvantage of Sports Club Mode Teaching in Colleges of Vocational Education

9.3.5.1 Sports Club Mode Teaching in Colleges of Vocational Education Background and Trend

Traditional physical education focus on the teaching of knowledge, neglect to stimulate students' interest and personality; and therefore, it splits the connection between curricular activities and extra-curricular activities, and it can cause the college physical education away from the development of abilities. Traditional physical education is technical teaching, and thus focuses on sports skills, but not respects the students' physical needs, the selectivity of students is small, and the interest and enthusiasm are not high.

According to the discussion above, the traditional physical education teaching has some shortcoming, the new sports club mode teaching should be adapted and the reform of physical education should be carried out without hesitation.

9.3.5.2 Advantage and Disadvantage of Sports Club Mode Teaching

As we know, students are the key factor in sports club teaching mode; this mode respects choose of students and meets the requirement of students; and therefore, it can make students more interesting in physical activities. At the same time, it can improve the individual sports abilities. For example, the students can play some events which he/she never played but desired to play; he/she also can select the events which he masters.

In sports club mode, according to teacher's abilities to arrange the classes, if certain teacher is poor in sports skill or teaching behavior, then, the students maybe do not choose his class; it will improve teacher's enthusiasm on improvement and perfection of their teaching method and sports skill. Therefore, it is benefit for the reform of teaching.

9.3.5.3 Disadvantages of Sports Club Mode Teaching

The disadvantage of sports club mode teaching is obvious: it needs more sports facilities and equipment, in most colleges the present sports facilities and equipment cannot meet this requirement. The requirement of physical education teachers is more strictly, the teacher of some modern events is short, and teachers of some traditional events are superfluous. In order to resolve these problems, teachers in the field of physical education should encourage the skills of improvisation using the local resource available in their environment to satisfy the quest for knowledge through the adoptive ability to produce facilities and equipment at low profile for teaching process. School authorities and local government should endeavor to complement the effort of the teachers with enough funds in the culture of improvisation in the bid to providing needed infrastructural materials so as to improve physical education teacher. Training and re-training programmers should be conducted regularly for teachers to facilitate improvement on sports skills.

Another problem is the teaching management system; in the traditional physical education teaching, the courses are arranged according to grade and class, but, in the sports club mode, there are no difference among grades and classes. And the traditional management system should be changed, but, now, many colleges adopt two modes, so it gives heavy burden to teaching management personnel.

9.4 Conclusion

According to the discussion mentioned above, the author revealed some findings came to as follows:

Teaching management on sports club in colleges of vocational education has some bottleneck, such as the sports facilities and equipment are short and not meet the need of sports activities.

The physical education teachers' sports skills focus on the traditional events, such as field and track events, football, basketball, and volleyball.

Some more sports events, such as rocket climbing and orienteering, should be added to physical education classes.

Overall, there are many problems in the teaching management of sports club mode in colleges of vocational education. The authors reckoned that in order to resolve various conflicts, a mixed teaching mode, that is, traditional and sports club teaching mode should be executed in the physical education. And the sports club mode plays the key role in physical education.

Meanwhile, in order to carry out the sports club teaching rapidly, the author recommended the following methods:

Teachers in the field of physical education should encourage the skills of using the local resource available in their environment to satisfy the quest for knowledge through the adoptive ability to produce facilities and equipment at low profile for teaching process.

School authorities and local government should endeavor to complement the effort of the teachers with enough funds in the culture of improvisation in the bid to providing needed infrastructural materials so as to improve physical education teacher.

Training and re-training programmers should be conducted regularly for teachers to facilitate improvement on sports skills.

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Chapter 10
Research of Mathematics Learning Strategy in the Occupation Education

Yan Yu

Abstract Toward the research of mathematics learning strategy in the occupation education, mathematics as cultural foundation course provides the necessary knowledge for professional courses and directly or indirectly affects students' mastery of professional courses in vocational education, so it is imperative to improve mathematics academic performance. In this article, learning strategies are analyzed, the importance of mathematical learning strategies is described, and the way of mathematics learning strategies is given.

Keywords Vocational education · Mathematics · Learning strategies

10.1 Introduction

As for students of vocational schools, the foundation of the basic course is relatively weak [1, 2]. Because the mathematics is a relatively high theoretical course, the teaching contents cannot be completed within the scheduled course time, which are caused by many reasons [3]. For example, some individuals do not work hard, and some do not grasp the correct way to learn [4]. During teaching the mathematics, the teacher constantly stresses the importance of mathematics, however, students has not found the importance in learning professional courses. After many times, the students will think mathematics will not work at the major courses, and even be fed up with studying. What is worse, the students may repel mathematics which will lead to a vicious cycle.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_10,

10.2 Theories on Mathematics Learning Strategies

10.2.1 The Definition of Learning Strategies

There are a lot of descriptions about the definition of learning strategies at home and abroad. Some focus on the mastery on learning methods. Some focus on learning control skills. Some describe the establishment of learning programs, and some also describe the effective learning rules and techniques. On the basis of these theoretical studies, we make the following definition: In learning process, following specific steps, rules and procedures, we will perform mathematics in the dynamic way to achieve the goal of improving scores.

10.2.2 Features of Mathematics Learning Strategies

10.2.2.1 Explicit and Implicit

To improve students' math scores, a series of learning activities which are obvious are needed. These learning activities can change the students' inner mental activities and enable students to become more proactive.

10.2.2.2 Comprehensiveness and Holistic

During learning mathematics, there are a variety of methods to stimulate students' learning enthusiasm, meanwhile optimize the learning goals. The method to help students learn better is not single, but to synthesize multiple methods together. These methods or activities eventually form an integrated whole.

10.2.2.3 Regulation and Selectivity

In teaching activities, the students are the main. So, learning strategy is to help students regulate and control themselves in learning activities. Each student is an independent-thinking individual. Students are not the same, and they are different, so the choice of learning methods is different. To teach students on the basis of the actual situation of the students, so that students' mathematics learning can be improved furthest.

10.2.3 Elements of Mathematics Learning Strategies

Mathematics learning is a gradual process, so the mathematics learning strategies are consisted by the three levels as described below:

10.2.3.1 Metacognition

Metacognition refers to people's awareness of their knowledge. This ability, to some extent, can compensate for the lack of intelligence. After students understand the metacognition, it is clear for them to know, in the process of learning new knowledge, when and where to learn and what kinds of learning strategies to choose from, on the basis of which, to find new learning methods to improve the efficiency of mathematics learning and to compensate the deficiencies on their own memory or understanding.

10.2.3.2 Metacognition Monitoring

A good learning strategy needs to be improved by a series of process, such as to monitor, to adjust and to modify, so infinitely close to the intended target. It mainly consists of such steps as planning, monitoring, evaluation, adjustment, amendment, review and summary.

10.2.3.3 Learning Methods

Mathematics learning strategies are consisted by a number of learning methods. Grasping the correct or appropriate learning methods can help students improve the efficiency of obtaining mathematical knowledge and skills. Learning higher mathematics can gradually develop students' abstract ability, logical reasoning ability, spatial imagination, self-learning ability and innovation ability, and make students have higher-skilled computing power and the ability to analyze and to solve the problem by applying the integrated mathematical methods.

10.3 The Importance of Mathematics Learning Strategies in Vocational Education

10.3.1 The Need of New Curriculum Reform

The current mode of education has a material changes. It has been transformed from traditional mode to enable students to learn and remember into the process of students' self-understanding, self-active learning and aiming to develop students'

sustainable development. The core of the new curriculum contents is to offer students a quality education. Do not request students to memorize a lot of knowledge, base on the overall quality of the students, and emphasize the improvements of learning skills and emotions and other aspects. It also make students learn the ability of self-exploration, cooperation and exchange and practice to change the teacher-centered teaching model, and to form an effective teaching model in which students participate in teaching activities.

10.3.2 The Need of Students' High Learning Efficiency and Interest

The performance of vocational school students in cultural studies is relatively poor, especially in mathematics. To lower the teaching objectives so as to strengthen students' confidence in mathematics education activities will aggravate students' inferiority. The reason why vocational school students do not learn mathematics better is not the problem of intelligence and poor foundation, but the students are lack of motive to study well. Students cannot pay all their attention on their studies, in addition, they lack correct learning approach. At the same time, a large part of students insist that mathematics in the learning process cannot help them learn professional courses, and also do not have any relevance to the future work, thus they lose their enthusiasm on mathematics. In the teaching process, mathematics teachers always stress how important math is, but in the teaching practices do not contact the professional curriculum with mathematics effectively, which makes words feeble and is unable to resonate in the hearts of students, so that to improve the efficiency of learning just like water without root.

In the process of learning mathematics, we understand the concept of derivative, understand the meaning of the geometry, can calculate tangents and normal of curve, and can use the derivative to find the maximum and minimum of the function. If we, in the process of learning, let students keep working on mathematical formula calculations, then the student may be trapped into a sea of titles. Students which are not interested in math will repel math more intensively. In the process of learning, if we contact the mathematics with the professional courses as much as possible, the students' interest will be greatly improved. Suppose we are having a class for the students of mechanical engineering. In the process of major study or practice, it is essential for the students to process some products, and at that time, we need to use math. Here, we make the following examples to explain the application of mathematics in professional courses.

Title: To make a rectangular open container which has a square bottom, and the volume is 108 cubic meters. How to make the materials to save most?

Solution: regard the length of bottom as x, height as h, and materials as y.

$$x^2 h = 108,\ h = \frac{108}{x^2} \tag{10.1}$$

$$y = x^2 + 4xh = x^2 + 4x\frac{108}{x^2} = x^2 + \frac{432}{x^2} \tag{10.2}$$

$$y' = 2x + \frac{-432}{x^2} = \frac{2x^3 - 432}{x^2} \tag{10.3}$$

Order $y' = 0$, get $2(x^3 - 216) = 0 \Rightarrow x = 6$

And because $x > 6, y' > 0; x < 6, y' < 0$, so $x = 6, y = 108$ is the minimum, meanwhile $h = 3$.

So, the bottom length is 6 m, the height is 3 m, which is the best choice.

10.3.3 The Need of Improving Teaching

In the process of mathematics teaching, mathematics teachers have such complaints that mathematics differ from other subjects and are pure theory. Except to explain the definitions and principals, teachers will allow students to do the titles again and again. There is no other way. Some want to extend extra-curricular knowledge to students, but there is no content to speak of. As for teachers, they should reform in conjunction with the contents of this course in order to enhance students 'interest in learning, regard increasing students' initiative and enthusiasm as teaching target. Teachers cannot push all responsibilities to the students. The idea that the main reason for students' poor learning is that the students do not learn hard, anyway, they have taught students all contents in the book, is incorrect.

To enable students to have a happy and efficient learning environment and to make students at different levels gain much in the process of teaching. In explaining the calculus, for example, to regard the following as a prelude, rather than stating the importance of calculus at the beginning of the class, then that is a lot of the explanations of the definition, and first you can explain the history of the calculus.

For example, calculus became a subject in the seventeenth century; however, the idea of differential and integral has been produced in ancient times. At 3BC, the ancient Greek mathematician and mechanical expert—Archimedes (BC 287 $\sim$ 212) has already mentioned the calculus in his book which is the measurement of the circle and on the ball and cylindrical, and he has implied the idea of modern integral in his studying and solving the problem of the parabola under the bow area, the ball and the spherical cap area, the area under the spiral and rotating hyperbolic volume. As the basis for the limit theory of the calculus, in ancient times, there has had very detailed discussions on the calculus, such as Zhuangzi, a book written by Zhuang Zhou, "the world chapter" with "one foot Chui, Sun whichever half, Jesus Christ inexhaustible." Three Kingdoms Period, Liu Hui in his cyclotomic surgery, with cut indemnity fine, the loss of indemnity less the cut of the cut that cannot be cut, fit and round and nothing to lose men. To regard curve as a linear type whose edge increases infinitely. The area of a circle is the area of an infinite number of triangles, and these can be regarded as the masterpieces of the typical limit thinking. Italian mathematician Cavalieri, who published the book Continuous

Inseparable Geometry in 1635, regarded the curve as an infinite number of line segments (not component). These make up the mental preparations made for the birth of calculus.

This can not only transfer students' attention to learn mathematics, but also can let the students know the deeds of the ancient mathematicians and thus can strengthen their love on Chinese civilization.

10.4 Ways of Cultivating Mathematics Learning Strategies

10.4.1 To Enhance Interest and Improve the Motivation

A person with strong ambition and higher degree of concern on a matter, then it is possible to achieve a higher score, which is same as mathematics learning. To make students obtain fun from the mathematics learning process continually, and students will spend much more time and energy in mathematics learning and continue to correct their own errors and incorrect learning methods to choose the appropriate and correct learning strategies, and then to achieve better results.

You need a lot of abstract thinking on studying math, which is also the reason why a lot of students do not like mathematical. In the learning process, our students like memorizing mechanically, but not like thinking. This is not conducive to the mathematics learning, at the same time also deviates from quality education our country advocates. To carry forward the spirit of democracy in the mathematics classroom, to free students to show their imagination and to mobilize, the classroom atmosphere are very beneficial for improving students' learning motivation.

10.4.2 To Cultivate the Scientific Learning Patterns

Because of the long-term indoctrination education model, students in the learning process rely too much on teachers. Many students, in the mathematics learning process, memorize the definition and principles in the books clearly, at the same time grasp the titles that the teacher teaches in the classroom well, and the small tests' results are good, but are faced with a formal examination, the results will be very unsatisfactory, and do not achieve the desired objectives. This is mainly related to the learning patterns. Such students, in their normal learning, use their memory excessively so that they have no real understanding on the definitions and principles mentioned in the mathematics. When the subject they do is not seen, and there is not the same type of math problems in their memory, then you will not know what to do.

In mathematics learning process, encouraging students to adopt different learning approaches to learn new knowledge is also the main contents of mathematics learning strategies. At present, the mathematics learning methods have mainly the following kinds: inquiry-based learning, cooperative learning and independent learning.

10.4.3 To Focus on the Cultivation of Conventional Mathematics Learning Strategies

There are lots of learning strategies, including problem-solving strategies, discovery strategies, accept–introspection–replicable strategies and induction and generalization strategies and others. Mathematical content is relatively extensive. You should use different learning strategies in the different aspects, which can obtain the desired results. Therefore, teachers in the teaching of courses should not only show the detailed analysis on the contents, but mainly promote students to master new learning strategies.

10.5 Conclusion

With the study on mathematics learning strategies for vocational education expanding, the article gives the example of some of my insights and practical process. But due to limited space, this article is not fully extended to give a detailed discourse on mathematics learning strategies. I hope the interested reader will do further research and analysis on the basis of this article.

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Chapter 11
Computer-Aided Designed Net-Teaching Platform for Tennis Teaching

Kai Zhang

Abstract As the rapid development of tennis in China's universities, traditional sports teaching methods cannot meet the demands of learning tennis. Under the circumstances, this paper has made an exhaustive study on the effects of computer-aided designed teaching platform for tennis teaching. It has also integrated tennis teaching with web-based instruction, which has largely improved the former teaching mode. According to the results of the study, with the help of this web-based teaching platform, modern tennis teaching form has become increasingly various, making the learning process of students even more targeted, practical, and advanced.

Keywords Computer-aided design · Net platform · Tennis teaching

11.1 Introduction

With the deepened development of Chinese education reform, more diversified teaching forms are needed by Chinese universities in respect that traditional teaching conception and teaching mode are inadaptable of the current situation of education. As one of the major physical courses in universities, tennis courses play an important role in physical training curriculum. Therefore, there is emerging a new problem demanding prompt solution of how to complete the teaching task with limited time.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_11,

In the course of tennis teaching, we should combine the demands of teaching content and teaching tasks with web-based teaching platform, aiming at making students understand the knowledge and content of tennis teaching [1]. The activation of more senses in human body to participate in learning process is in favor of developing cognitive ability of students, enriching their learning methods, and ensuring favorable teaching effect [2].

11.2 Definition of Web-Based Teaching Platform

Web-based teaching platform, known as web-based teaching supported platform, can be used in a broad and a narrow sense. To say from the abroad sense, it is composed of hardware equipment and facilities supporting web-based teaching platform. That is to say, web-based teaching platform can be divided into two sectors: hardware teaching platform and software teaching platform. On the other hand, to say from the narrow sense, web-based teaching platform is a software system providing comprehensive supportive service on the basis of Internet [3].

The main teaching modules of computer-aided designed net-teaching platform are curriculum introductions, teaching programs, teaching arrangements, and information of teachers, teaching video files, question-answering discussions, assignments, questionnaires, teaching notes, curriculum management, curriculum lists, teaching blogs, and scheduling program [4].

11.3 Adverse Factors of Traditional Teaching Mode May Influence Tennis Teaching

11.3.1 Unitary Teaching Method and Backward Teaching Conception

In traditional physical practice courses, teachers only relied on past teaching experience, or even copied predecessors' obsolete teaching conception, which cannot keep pace with demands of modern time and the thoughts of teaching reform. Moreover, the unitary and inflexible teaching methods lead to tedium atmosphere in class, poor enthusiasm in studying, and unfavorable teaching effect.

11.3.2 There are Limitations for Teachers Who are Not Specialized in Tennis Teaching Tennis

During the process of tennis technique teaching, "listening" and "seeing" are the ways of recognizing techniques, in which "seeing" is the main resource of

acquiring information. Teacher ought to have relatively exquisite level of basic skills and demonstrating capacity, or else normative demonstration is hard to achieve. Therefore, teachers should strengthen exercise of basic skills and improve the accuracy of demonstrating basic skills, otherwise a tiny error may badly influence the image of teachers in students' eye, leading to a discount of activity and interest of learning tennis.

11.3.3 Techniques of Superior Difficulty are on the Edge of Absence of Demonstration

In the course of tennis teaching, teachers will encounter highly difficult techniques which are hard to be demonstrated, such as volleying forehand and backhand drive, or top spin. Students find it hard to comprehend and acquire the essential of techniques in a short time, or rather establish completed image of action. Therefore, teachers have to explain repeatedly in class, which achieve half the results with twice the effort.

11.3.4 The Quality of Teachers' Demonstration will Downgrade with the Growth of Age

The growth of age must cause bad influence to the quality of teachers' demonstration. Moreover, with the improvement of material conditions and living standards, a plenty of teachers have encountered with growth of weight and rapid degradation of expressing ability when showing actions, which cause the reduction of demonstration quality. Therefore, teachers will try to avoid techniques which are hard to demonstrate on purpose, which directly causes the unity of teaching content and badly influence the comprehensive development of students.

11.4 The Advantages of Net-Teaching Platform for Tennis Teaching Compared with Traditional Teaching Mode

The utilization of net-teaching platform in tennis teaching can be changed according to different demands of teaching content and teaching tasks. We should rationally select and apply modern instructional media, combine information sent through multisenses with media of feedback regulation and control, and implement the modern methods into the whole process of teaching in class in order to optimize teaching process [5].

11.5 The Advantages of Tennis Teaching Aided by Net-Teaching Platform

11.5.1 Tennis Teaching Aided by Net-Teaching Platform Can Comprehensively Guide Student Learning

Teachers can organize and arrange teaching content and process by modern net-teaching platform and optimize teaching content so as to make teaching process organized, normalized, and accurate. Teachers can also carry out teaching activities by realizing man–machine conversations on the basis of computers containing a wealth of information.

11.5.2 Improve Quality of Tennis Teaching Aided by Net-Teaching Platform

Most of tennis techniques are completed in the combination of hitting pace, and strong coherence is among the connection of techniques. Therefore, even if the teachers are wise in expressing, the abstract and undistinguishable features of tennis techniques are hard to explain, and even if the teachers are good at demonstrating, the technical difficulties and important steps are hard to demonstrate in pauses. In this case, teachers should spend long time to explain or demonstrate technique difficulties and finally end up with little achievements.

The most obvious features of net-teaching platform are the prominence of tennis technique difficulties and moreover give visual perception to students and show micro motions of technique difficulties will largely raise the efficiency of technique teaching, which is hard to imagine before the application of net-teaching platform. For example, the technique difficulties of forehand action and continuous hitting action can be divided and demonstrated by static frames, where students can apperceive the whole process of actions and understand essential and features of exercise.

11.5.3 Aided by the Utilization of Net-Teaching Platform, Students Can Accomplish Self-Learning and Self-Correct

Teachers publicize the information on teaching content, technique videos, and analysis of key points, so that students not only can learn in class, but also review afterward and prepare new techniques in advance, which can help to enhance the effect of learning.

When students' inaccurate actions are being corrected by teachers in traditional ways, they may hardly recognize the mistakes in their actions. This kind of communication barriers can only be solved by repeated practice with patient instructions, in which students must waste a lot of time and effort. On the contrary, with the help of net-teaching platform, students can record their actions by mobile phone or video recorder and watch it repeatedly from multi-media equipment, in order to be conscious of the difference of their own actions and the actions of professional players, and then rectify their errors [6]. Correcting mistakes by net-teaching platform is superior to any other methods.

11.5.4 To Activate the Interest of Students and Raise Learning Efficiency by Tennis Teaching Aided by Net-Teaching Platform

Interest is the best teacher, and studying without interest is the absence of wisdom and inspiration. As the cognitive disposition, stable interest can optimize psychological activities and make observation keener, enrich imagination, and enhance the willpower of overcoming difficulties, in order to largely increase efficiency of learning. As a result of the tediousness of traditional tennis teaching, it can hardly eliminate negative psychological condition in learning process. Therefore, to activate the enthusiasm in learning is the key of enhance learning effect, and dynamic forms of tennis teaching aided by net-teaching platform can help sustain positive psychological conditions, activate the appetite for further knowledge, and raise efficiency of learning.

11.5.5 Tennis Teaching Aided by Net-Teaching Platform Can Cultivate Innovative Thinking and Observation Ability

The advantage of tennis teaching aided by net-teaching platform is mainly the provision of visual image and motive or static images, which can help students develop their observation ability and space imaginative capacity and activate the observation desire of students with the changing process of images. Observation is the only way of recognizing the expression form of tennis playing, motion methods and features of techniques, and then, students can find and resolve problems in observation in that tennis technique is the external expression of human body.

11.5.6 The Utilization of Tennis Teaching Aided by Net-Teaching Platform Can Benefit the Launching of Autonomous Learning

The common feature of traditional teaching method is the over-pursuit of teaching efficiency, whereas there are large differences in intelligence level, physical quality, and physical basis among students, so that the demands of learning cannot be met, and to a certain extent confine the development of physical teaching.

Tennis teaching aided by net-teaching platform adopts several combination forms and structures of information unfolding, such as anti-linear reticulated structure, which is convenient for teacher controlling teaching process. Moreover, the foremost feature of tennis teaching aided by net-teaching platform is the undivided relation of man–machine conversations, by which students can determine the appropriate levels and teaching content according to their real conditions.

For instance, some students can experience the rhythm of techniques, some can recognize their shortage in the decomposition of tennis techniques, and some can jumpily select proper levels of tennis learning process, which sufficiently embody the conception of individual teaching according to respective conditions and lay solid foundation of controlling studying schedule in autonomous learning.

11.6 The Function of Tennis Teaching Aided by Net-Teaching Platform Should Be Clearly Recognized and Blind Canonization Should Be Avoided

Traditional teaching methods are being combined with net-teaching aiding platform. On the basis of correct cognition and conforming to the law of cognition and principle of enlightening, operating and thinking capability should be cultivated. We ought to spur students actively participating in teaching process and enhance the artistic level of tennis teaching aided by net-teaching platform under the guidance of scientific senses and policies.

In conclusion, the modern teaching method, net-teaching platform will play an important role in the process of tennis teaching to enhance quality of tennis technique curriculum and raise the efficiency of teaching. We are not the early countries to get net-teaching platform started; therefore, there may be irrational places in the practice. We should dialectically and correctly face various forms of net-teaching platform and find its combination points with traditional teaching methods, so as to bring the modern features into play and try to avoid its shortcomings.

As an emerging teaching technique, teaching aided by net-teaching platform will promote the development of education and educational skills. In the course of

practice, teachers should conclude and improve the features of the new methods, exert its beneficial functions, and serve to physical education by innovative educational work.

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Part II
Electrical Engineering and Applications

Chapter 12
Research on Contactless IC Card Simulation Technology

Jinlong Lu, Longsen Xu and Maolin Zhang

Abstract This paper presents a card simulation technology. We used the embedded device to simulate the contactless IC card data integrity, data security, initialization-on/anti-collision, main logic control, command set, read/write control and memory so as to implement the simulation of contactless IC card. Based on the simulated card, we designed the test system to test the IC card reader of AFC system. It solved the fundamental problem IC card reader test confronted which is the big inconvenience brought by the manual operation and the great cost of material resources. Experimental results show that the method which using simulated IC card to test IC card reader is efficient and reliable.

Keywords Card simulation · IC card reader · Embedded device

12.1 Introduction

Contactless IC card is the ticket media of Automatic Fare Collection (AFC) system, and contactless IC card reader is the interface between the AFC system and passengers [1]. The contactless IC card reader is widely used in selling tickets, entry gate and outbound ticket. The stability and reliability of IC card reader is the foundation for the AFC system; therefore, the test for the reader is essential for AFC system. Nowadays, people usually use the hand-held cards to test the reader of AFC system, which requires the IC card as a test input. This kind of test is

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_12,

facing the incomplete coverage, low efficiency, high cost, low accuracy and other problems like this.

This paper presents a new method to test reader of AFC system, which based on IC card simulation technology, say, using embedded device to simulate contactless IC card. By using the simulated cards to test reader, we can achieve a full coverage, efficient and accurate test result.

12.2 Related Work

Contactless IC card, also known as radio frequency card, is consisted of the chip and induction coils. It is packed in a standard size card so as to protect the chip and the antenna from exposure to the air [2]. Contactless IC card combines RFID technology and IC technology together, to solve the problems of passive (no power supply in the card) and avoid contact, so contactless IC card is a major breakthrough in the IC card field. The most prevalent IC card is MIFARE Ultralight, which is made by NXP Company, and it is also the contactless IC card we will simulate in this paper.

Proxmark 3 was originally developed by Jonathan Westhues and released under the terms of GPL, which is arguably the most powerful device currently available for researching, RFID and NFC systems. A powerful processor, Field-Programmable Gate Array (FPGA) and custom firmware allow it to meet the demanding communication timing requirements imposed by various RFID systems. The device targets low- and high-frequency systems operating at 125, 134 and 13.56 MHz. We will use Proxmark 3 to simulate contactless IC card, because it can meet the card timing requirements.

12.3 The Implement of Simulation IC Card

The description for device and function of simulation IC card. The IC card simulation device is comprised of three sections: hardware, operation system and firmware.

Hardware Hardware is comprised of the RF interface and LC coils. The main functions of the RF interface are the RF signal data rate control, modulation, bit representation and coding etc. While LC coils' main function is to transmit and receive signals, RF interface corresponds with the contactless IC card ISO/IEC 14443-3 Type A. Communication signal interface, thus it can simulate the contactless IC card RF interface layer behavior.

Operation system Embedded Linux operation system is responsible for managing the hardware and software resources.

Firmware Firmware is the central component of IC card simulation device which performs the simulation of data integrity, data security, initialization/

anti-collision, main logical control, command set, read/write control and memory control.

Data integrity simulation In order to ensure the integrity of data transferred between card reader and contactless IC card, we use 16-bit CRC verify for each block and add parity bit check for each byte.

Data security simulation To achieve contactless IC card chip data security, we use the general global unique serial number which cannot be modified, together with a series of authorization, encryption and decryption of information.

When we use card reader to read serial number of simulation IC card and take the serial number as encryption operator to encryption and decryption, it will be like a real IC card, because we establish a set of serial numbers to simulate unique serial number of the global, which real exist.

The most important measures to ensure data security are the authorization and encryption/decryption of information. MIFARE Ultralight card does not have information authorization, or encryption and decryption functions, but through the locking mechanism and the OTP write mechanism, it can implement a simple data security feature.

Initialization/anti-collision simulation In order to make a real-time detection of IC Cards, a reader shall send repeated REQA commands and search the response ATQA commands, the process also known as polling [3]. An intelligent anti-collision function enables simultaneous multicard operation. The anti-collision algorithm individually selects each card and ensures correct execution of a transaction with the selected card without data corruption from other cards in the field.

Main logic control simulation. The function of main logic control is comprised of accomplishment of transport protocol, the preservation of states of IC card authorization, read/write and encryption, the management and call of each module, which are all after anti-collision process [4].

MIFARE Ultralight chip. Its main logic function is to achieve data transmission under ACTIVE state.

Command set simulation. The simulation of command set should accomplish the following three tasks:

Decoding the received information and identifying the instructions and obtaining instruction parameters according to the instruction code [5].

Performing the appropriate action combined with the communication status of contactless IC card and contents of instruction.

Encoding the commands and data, which will be send, transferring them to radio frequency, the interface layer, and sending them out.

Read and write control simulation Contactless IC card reader control refers to the management and control of the authority to read and write on card memory. The control of MIFARE Ultralight cards' read and write is comprised of lock bytes and one time programmable (OTP) bytes.

IFARE Ultralight card only possesses 512-bit memory space organized in 16 pages with 4 bytes per page, which is comprised of serial number; lock byte and user data section. The memory structures of Mifare Ultralight are shown in Fig. 12.1.

Page address		Byte number			
Decimal	Hex	0	1	2	3
0	00h	serial number			
1	01h	serial number			
2	02h	serial number	internal	lock bytes	lock bytes
3	03h	OTP	OTP	OTP	OTP
4 to 15	04h to 0Fh	user memory			

Fig. 12.1 Structure of memory of MIFARE Ultralight

12.4 Advantages of Simulated IC Card

Switching among many IC cards Simulation contactless IC card uses the dynamic loading memory content to separate the chip logic from card memory, through loading different memory images, and can achieve the card switching function. There are three advantages of simulated card as follows: the reset of unrecoverable operation, error card simulation and failure rate low.

12.5 The Solution to Test Reader

The test framework The test framework of IC card reader is consist of test system and tested system which is based on IC card simulation technology. The system under test is the subsystem which is from the layer of RF interface to the layer of API interfaces of the reader system, or from the layer of RF interface to the layer of application of the reader system. The testing system is composed of the library of test case, test execution, coder/decoder, the first adapter and the second adapter, as Fig. 12.2.

Test case the test case is the simplified process of AFC system Entry Gate which read the card balance, minus 2 yuan and writes back.

The Table 12.1 shows the detail information of the test case.

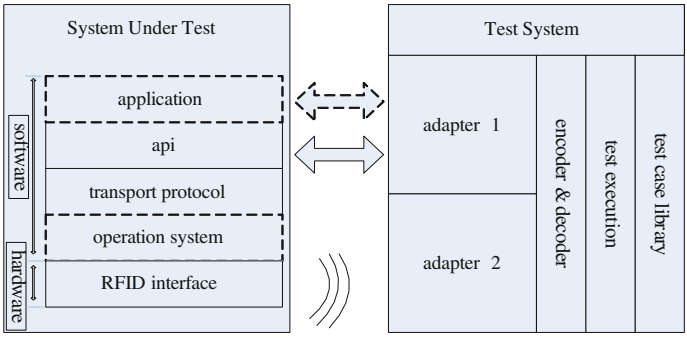

Fig. 12.2 Testing framework

Table 12.1 Description of the test case

Step	Description	Input	Expected results
1	Loading the image of the card	Image of the card(DMP)	Ok
2	Starting simulating	–	Ok
3	Reader connecting to simulated card	–	Ok
4	Reading the card balance	Address of the balance	Balance > 0
5	Writing balance back to the card	Current balance-2	Ok
6	Closing the connection between reader and simulated card	–	Ok
7	Stop simulating and getting the image of the card	–	_DMP

Fig. 12.3 Test report

Analysis of test results The test report Fig. 12.3 consists of name and time, which graphically display in detail each step of the test case execution.

Experiments show that the AFC system simulation testing platform supports SCL3711 reader typical test case design, development and implementation of the whole process, which is based on the IC card simulation technology.

According to the time stamp information of the test report that test case execution, we can calculate the execution time of the test sample is less than 3 s, which is far more efficient than manual testing.

12.6 Conclusions

In order to ensure the stable and reliable of AFC system, IC card reader of AFC system needs rigorous test, which needs manual operation. We put forward card simulation technology to simulate contactless IC card and use embedded device to implement the idea. Using the simulated IC card, we design test framework and test case to test IC card reader, and the test results proved the method is feasible and efficient.

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Chapter 13
Research on Input-Series and Output-Parallel DC/DC Transformer

Bugen Wang and Xianjin Zhang

Abstract The input-series and output-parallel (ISOP) converters, which consist of multiple low-voltage and low-power modules, are very attractive in the high input voltage. In this paper, an ISOP DC/DC transformer, based on non-resonant full-bridge DC transformer modules, is proposed. The main factors, which influence the input voltage sharing, such as duty cycles, switching frequencies and periods, and turn ratios in each module, are analyzed in detail for guiding designing an ISOP DC/DC transformer in practical applications. Finally, experimental results of an ISOP DC/DC transformer are given to verify the analysis.

Keywords DC transformer · Input-series output-parallel · Voltage sharing · Full-bridge converter

13.1 Introduction

DC transformer, which is a DC converter without output filter, runs under near 100 % duty ratio to maximize the efficiency and power density [1]. The topologies of DC transformers usually have two types of non-resonant circuits and resonant circuits [2]. Especially in the resonant circuits, the power devices can operate in zero-current switching and zero-voltage switching manners. But in high-voltage and high-power applications, the weight and volume of resonant components are not negligible, and non-resonant DC transformers are more practical [2].

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_13,

In high-voltage applications, it is very difficult to choose suitable power devices. In order to reduce the voltage stress of the power device, multi-level technology may be better selected [3, 4]. And another method is series technology via low-voltage and low-power modules [5, 6]. The advantages of the technology include the following: standardization of the module leads to reduction in manufacturing cost and time, power converters are easily reconfigured to support varying input–output specifications, and possibly higher efficiency and power density can be realized.

The challenge of the series topology is series voltage sharing. A three loop control strategy is introduced for sharing input voltage in ISOP converters [5]; the relationship between the input voltage sharing and output current sharing was researched, and it was pointed out that if the input voltages are sharing, the output currents are automatically sharing [6]. In order to reduce control loops, common-duty-ratio control method was also introduced in ISOP converters [7].

In this paper, an ISOP DC/DC transformer consisting of two non-resonant full-bridge DC transformers [8] is presented and the factors influencing input voltage sharing, such as switching frequency, leakage inductance (including series inductor at first side), duty ratios and turn ratios, are analyzed. Finally, a prototype, which may deal with 1 kW power, is fabricated to illustrate the analysis.

13.2 An ISOP DC/DC Transformer

13.2.1 Non-Resonant Full-Bridge DC Transformer Module

The non-resonant full-bridge DC transformer module [8] is shown in Fig. 13.1a, where the C_o is very large to keep the output voltage U_{CO} constant. The simplified input current i_{ini} and first side current i_{Lr} of the transformer T_r are shown in Fig. 13.1b, where T is switching period, D is duty ratio. Under steady state, the input current (i_{ini}) average value I_{ini}, the output current I_o, the input voltage U_{Cin} and the U_{CO} can be illustrated by Eqs. (13.1) and (13.2), where n is a turn ratio N_p/N_s.

$$U_{CO} \approx \frac{U_{Cin}}{n} - \frac{4I_o L_r}{n^2 D^2 T} \tag{13.1}$$

$$I_{ini} \approx \frac{(U_{Cin} - nU_{CO}) \times D^2 T}{4L_r} \tag{13.2}$$

From Eqs. (13.1) and (13.2), it can be concluded that I_{ini}, U_{CO}, L_r, D and T are closely interrelated and that the voltage U_{CO} will fall when the current I_o increases. In order to achieve the hard external characteristic, the inductance L_r must be as small as possible and the duty ratio D is also as large as possible.

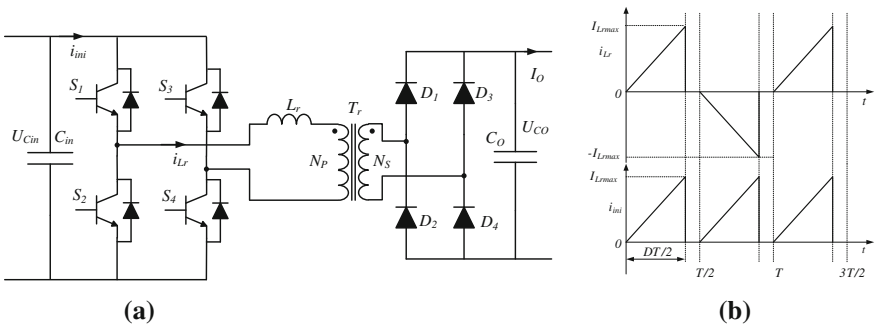

Fig. 13.1 DC transformer module and first side current and the input current

13.2.2 ISOP DC/DC Transformer

An ISOP DC/DC transformer, which consists of two non-resonant full-bridge DC transformer modules, is shown in Fig. 13.2. At steady state, because the input-divided capacitors' voltages U_{C1} and U_{C2} keep constant, the average currents of going through the capacitors C_1 and C_2 are zero, that is, the input current average values I_{in1} and I_{in2} of each module are equal.

From the Eq. (13.2), the Eq. (13.3) will be got, where n_1 (N_{p1}/N_{s1}) and n_2 (N_{p2}/N_{s2}) are turn ratios, D_1 and D_2 are duty ratios, and T_1 and T_2 are the period.

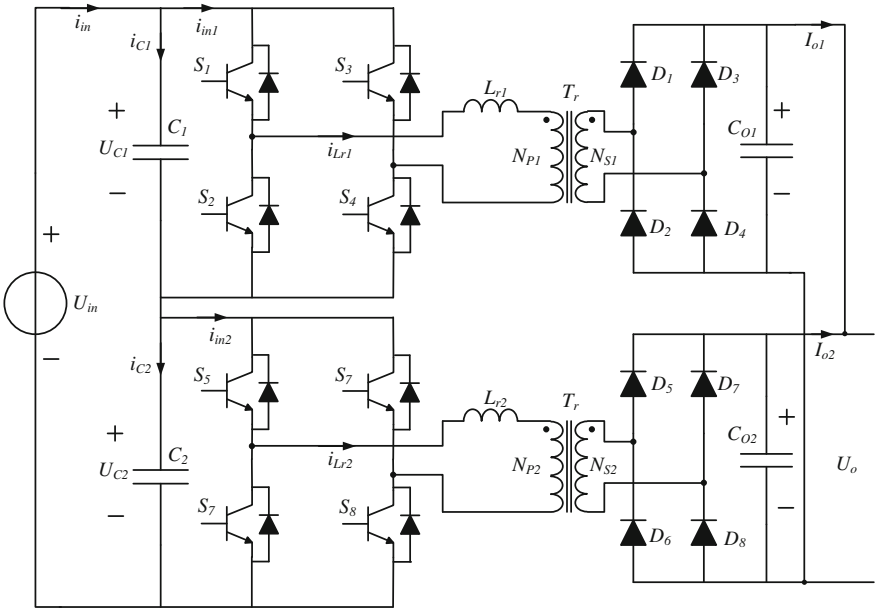

Fig. 13.2 ISOP DC/DC transformer

$$I_{in} = I_{in1} = \frac{(U_{C1} - n_1 U_O) \times D_1^2 T_1}{4L_{r1}} = I_{in2} = \frac{(U_{C2} - n_2 U_O) \times D_2^2 T_2}{4L_{r2}} \tag{13.3}$$

From the Eq. (13.3), the different value ΔU between U_{C1} and U_{C2} is expressed by

$$\Delta U = U_{C1} - U_{C2} = 4I_{in} \times \left(\frac{L_{r1}}{D_1^2 T_1} - \frac{L_{r2}}{D_2^2 T_2} \right) + U_O(n_1 - n_2) \tag{13.4}$$

From the Eq. (13.4), it is concluded that the input voltage of each module will be shared if these factors, such as the first side inductances, duty ratios, periods, and turn ratios, are equal, respectively. At the same time, it is known that the input capacitors do not affect the input voltage sharing. Because these factors are not absolutely equal in practical applications, the input voltage no-sharing is always inevitable.

13.3 The Analysis of Influencing Input Voltage Sharing Factors

From the Eq. (13.4), the Eq. (13.5) is obtained when the n_1 and n_2, L_{r1} and L_{r2}, and T_1 and T_2 are identical, respectively. As seen, the input voltage of the smaller duty-ratio module is greater than that of the bigger duty-ratio module.

$$\Delta U = U_{C1} - U_{C2} = \frac{4L_{r2} I_{in}}{T_2} \times \left(\frac{1}{D_1^2} - \frac{1}{D_2^2} \right) \tag{13.5}$$

When the n_1 and n_2, D_1 and D_2, and T_1 and T_2 are the same, the ΔU is given in the Eq. (13.6) derived from the Eq. (13.4). From the Eq. (13.6), the input voltage of the larger first side inductor is more than that of the smaller first side inductance.

$$\Delta U = U_{C1} - U_{C2} = \frac{4I_{in}}{D_2^2 T_2} \times (L_{r1} - L_{r2}) \tag{13.6}$$

When the n_1 and n_2, D_1 and D_2, and L_{r1} and L_{r2} are identical, respectively, the ΔU is also obtained in the (13.7) derived from (13.4). From the Eq. (13.7), the input voltage of lower period is obviously larger than that of the higher period.

$$\Delta U = U_{C1} - U_{C2} = \frac{4L_{r2} I_{in}}{D_2^2} \times \left(\frac{1}{T_1} - \frac{1}{T_2} \right) \tag{13.7}$$

From the Eqs. (13.5–13.7), the ΔU will increase when the input current I_{in} rises, which is caused by the output power increasing.

When the D_1 and D_2, L_{r1} and L_{r2}, and T_1 and T_2 are equal, the ΔU is shown in the Eq. (13.8) derived from (13.4). From the Eq. (13.8), it can be seen that the input voltage of the larger turn ratio is greater than that of the smaller turn ratio.

Combining the Eqs. (13.1) and (13.8), the ΔU will decrease when the output power rises, which causes the output voltage U_o to reduce.

$$\Delta U = U_{C1} - U_{C2} = U_O(n_1 - n_2) \tag{13.8}$$

13.4 Experimental Verifications

To verify the analysis, an ISOP DC/DC transformer is built in a lab. The leakage inductances L_{r1} and L_{r2} are 89.2 and 88.4 μH under the frequency 20 kHz, and the n_1 and n_2 are 86:9. The switching frequency f_1 and the duty ratio D_1 of the module1 are 21.20 kHz and 0.96, and the switching frequency f_2 and the duty ratio D_2 of the module2 are 20.60 kHz and 0.96, respectively, when they have the same parameters. The capacitors C_1 and C_2 are 330 μF, respectively, and the output capacitor ($C_{O1} + C_{O2}$) is 9,400 μF. The experimental results with the same parameters, different duty ratios, different first side inductors, and different switching frequencies are given below, respectively.

The experimental waveforms with all the same parameters are shown in Fig. 13.4a when the voltage U_{C1}, U_{C2}, U_o and the current I_o are 303.2, 303.1, 27.7 V and 26.0 A, respectively, where u_{g1} and u_{g2} are the driving signals of the modules 1 and 2. The experimental data are listed in Table 13.3. From the Fig. 13.3a, it can be seen that the currents i_{Lr1} and i_{Lr2} are similar. From the Table 13.1, it is concluded that the ISOP DC/DC transformer can get better voltage sharing when all parameters have the same parameters.

All the parameters are the same except for D_2 being changed into 0.8. The experimental waveforms are in Fig. 13.3b when the voltages U_{C1}, U_{C2}, U_o and the current I_o are 299.8, 303.1, 27.9 V and 20.7 A, respectively. The data are shown in Table 13.2. From the Fig. 13.3b, we can see that because the input current average value of each module is the same, the slope of the first side current i_{Lr2} is larger than that of the current i_{Lr2}. It is distinctly consistent with the Eq. (13.3).

As seen from the Table 13.2, we can get that the input voltage U_{C2} with smaller duty ratio is greater than the input voltage U_{C1} with larger duty ratio, and that the

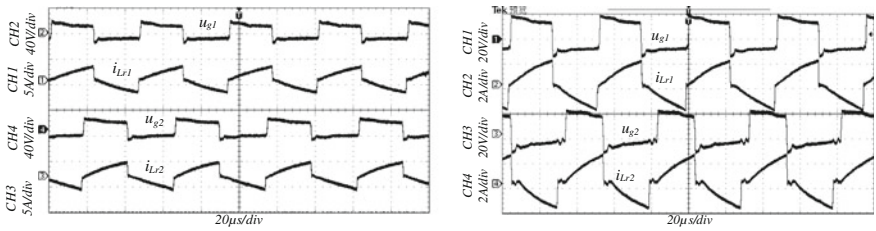

Fig. 13.3 The experimental waveforms with the same nominal value and different duty ratios

Table 13.1 Experimental data with the same parameters

U_{C1} (V)	U_{C2} (V)	U_{C1}–U_{C2} (V)	U_O (V)	I_O (A)
299.5	299.3	0.2	28.9	6.7
293.4	293.1	0.3	27.3	16.5
291.1	290.3	0.8	26.2	28.3

Table 13.2 Experimental data with the different duty ratios

U_{C1} (V)	U_{C2} (V)	U_{C1}–U_{C2} (V)	U_O (V)	I_O (A)
302.5	304.1	−1.6	29.4	5.7
299.7	301.9	−2.2	28.3	16.2
298.1	302.2	−4.1	27.3	27.8

ΔU is more and larger along with the current I_o increasing. The experimental results are obviously similar to the Eq. (13.5).

The parameters' values are the same except for adding an excess inductor 60 μH at the first side of the isolated transformer of the module 2. The experimental waveforms are shown in Fig. 13.4a when the voltages U_{C1}, U_{C2}, U_o and the current I_o are 299.4, 308.7, 28.1 V and 22.0 A, respectively, and the experimental data are listed in Table 13.4.

From the Fig. 13.4a, the slope of the current i_{Lr2} is the same as the slope of the current i_{Lr1} under the same switching frequency and duty ratio. It is clearly in accord with the Eq. (13.7). In Table 13.3, it can be seen that the U_{C2} is more than the U_{C1} and that the ΔU is also more and more large along with the current I_o rising. The experimental results also illustrate the Eq. (13.6) perfectly.

The parameters' values are the same except for switching frequency f_2 being changed into 26.10 kHz. Figure 13.4b gives the experimental waveforms when the voltages U_{C1}, U_{C2}, U_o and the current I_o are 293.1, 297.8, 27.4 V and 21.6 A, respectively. And the experimental data are shown in Table 13.4.

From the Fig. 13.4b, it can be got that the slope of i_{Lr2} is larger than that of i_{Lr1} under the same duty ratio. It is also compatible with the Eq. (13.6). In Table 13.4,

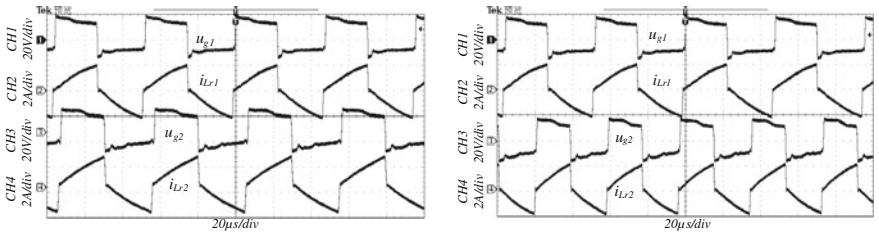

Fig. 13.4 The experimental waveforms with different first side inductors and different switching frequencies

Table 13.3 Experimental data with the different first side inductances

U_{C1} (V)	U_{C2} (V)	U_{C1}–U_{C2} (V)	U_O (V)	I_O (A)
303.1	305.3	−2.2	29.5	6.1
298.9	304.5	−5.6	28.2	16.5
297.1	308.7	−11.6	27.4	28.0

Table 13.4 Experimental data with the different switching frequencies

U_{C1} (V)	U_{C2} (V)	U_{C1}–U_{C2} (V)	U_O (V)	I_O (A)
298.4	300.7	−2.3	28.9	5.74
295.1	298.7	−3.6	27.9	16.54
288.6	295.5	−6.9	26.7	26.0

we can get that the U_{C2} is larger than the U_{C1} under the frequency f_2 higher than the f_1 and that the ΔU is more and more large when the current I_o rises. The experimental results are also apparently fit with the Eq. (13.7).

13.5 Conclusions

In this paper, an ISOP DC/DC transformer based on non-resonant full-bridge DC transformer modules is proposed, and the main factors of influencing the input voltage sharing are studied particularly. The analyses show that the duty ratio, the first side inductance, the switching frequency and the turn ratio are main factors that affect the input voltage sharing. Finally, experimental results were given to verify the analyses. At the same time, it is pointed out that a good voltage sharing may be got when the all parameters have the same normal value.

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Chapter 14
An Effective Equalization Based On Fuzzy Logic for Series Moduled Battery Strings

Shumei Zhang, Yishan Cai, Jiaxi Qiang and Lin Yang

Abstract In the lithium-ion batteries for electric vehicle applications, the battery equalizer is required to enhance life time and guarantee safety. A simple technique that provides effective equalization in terms of battery voltage for a series string of battery cells is presented in this paper. The advantages of accurate equalization are very substantial and include reduced damage to battery cells in the stack and a dramatic increase in battery life. The main circuit technique of two-level DC/DC converters substantially simplifies the structure. Moreover, fuzzy logic equalizing algorithm effectively enhances the uniformity of batteries. The operational principles and design considerations of the proposed equalizer are presented, and equalization performance is verified by the prototype with 6 Ah lithium-ion batteries.

Keywords Electric vehicle · Battery equalizer · Two-level DC/DC converters · Fuzzy logic equalizing algorithm · Uniformity of batteries

14.1 Introduction

Nowadays, electric and hybrid electric vehicles (EVs and HEVs) use lithium-ion batteries which are moduled in series packs to store energy for propulsion due to its high energy density and low self-discharge rate [1, 2]. However, since the cell voltage of lithium-ion battery is low about 4 V, the series moduled battery string is

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_14,

required for driving a high-voltage electric motor in EV and HEV [3]. Nevertheless, when the batteries of string are repeatedly charged or discharged, the charge imbalance of the batteries occurs since internal impedance of each battery is not purely identical [4, 5]. When these unbalanced batteries are left in use without any control such as charge equalization, the energy storage capacity decreases severely and, in the worst case, they may explode or fire [5]. Thus, charge equalization for a series moduled battery is necessary to prevent these phenomena and extend the life time of the batteries [6].

Therefore, to avoid the possible risks and enhance the battery lifetime, the equalization method for lithium-ion battery strings is significantly necessary, which divided into two categories: passive equalization and active equalization.

A passive equalization technique is also known as dissipative equalization technique because a dissipative element moduled as a shunt is used to bypass or drain extra energy from a cell. In a resistive shunt equalization technique [7], the resistors moduled as a shunt element across each cell should be of the same value. Therefore, a strong cell dissipates more power across the resistor than a weak cell, and they get balanced with time. In an analog shunt equalization technique [8], a transistor is used as a shunt element, and the break down voltage of a zener diode acts a reference voltage for each cell, that is the voltage level where the bypass circuit turns on. A voltage comparator circuit can be used to switch the transistor.

An active equalization technique is also called a non-dissipative equalization technique because this method utilizes the active or non-dissipative elements to transfer the energy from one cell to another. In a switched capacitor method, a capacitor is frequently switched between the neighboring cells. If there is a difference in voltage between the two neighboring cells, then charge transfer takes place from the strong cell to the weak cell with the help of a common capacitor them. The disadvantages with this method are that the cells in a stack are equalized with their neighbors but not with respect to reference voltage, and the time taken to equalize is long. A switched reactor equalization technique method is the same as the switched capacitor technique, but uses a reactor instead of capacitor for charge equalization. In a resonant equalization technique, a resonant circuit composed of L and C components in parallel is used to achieve the charge equalization by transferring the energy between neighboring cells. A common bus moduled to all the DC/DC converters as in [7] is useful for energy transfer from a strong cell at any position in the stack to a weak cell at any position. A DC/DC converter block monitors the individual cell voltages and compares with a reference voltage during charging. When a cell voltage reaches its reference, the cell is bypassed and energy is transferred to the main bus via the DC/DC converter. From the main bus, the energy bypassed is directed to a weak cell in the stack. During discharging, the energy is transferred from a strong cell to a weak cell through the main bus using bidirectional DC/DC converters. Kutkut and Divan presented three different multi winding transformer methods for charge equalization.

The effective equalization system is proposed on the basis of DC/DC converters topology integrated with fuzzy logic equalizing algorithm. The simple and reliable

architecture as well as the active and efficient arithmetic substantially eliminates the degradation and improves the lifespan of the battery.

The paper is organized as follows. The equalization system architecture design is introduced in Sect. 14.2. In Sect. 14.3, the active fuzzy logic equalization algorithm is presented. Certifications of simulation and experiment are demonstrated in the Sect. 14.4. Finally, the conclusions relating to the novel efficient equalization technique are given in the Sect. 14.5.

14.2 Equalization System Architecture Design

In this paper, the battery string is modularized into M groups, and each group has K cells. The proposed equalizer showed in Fig. 14.1 consists of the three parts; the first stage DC/DC converter, the second stage DC/DC converter, and selection switch modules. The first stage converter steps down high voltage of the battery string to about 10 V. This stage is simply implemented by using the conventional flyback converter. The main work of this stage is to supply equalization power to the second stage modules. The second stage converter, constructed in each module, does make the charging current. The second stage is also constructed by the flyback converter. Lastly, the selection switch module consists of the bi-directional MOSFET to make a current path between second stage DC/DC converter and the selected battery cell.

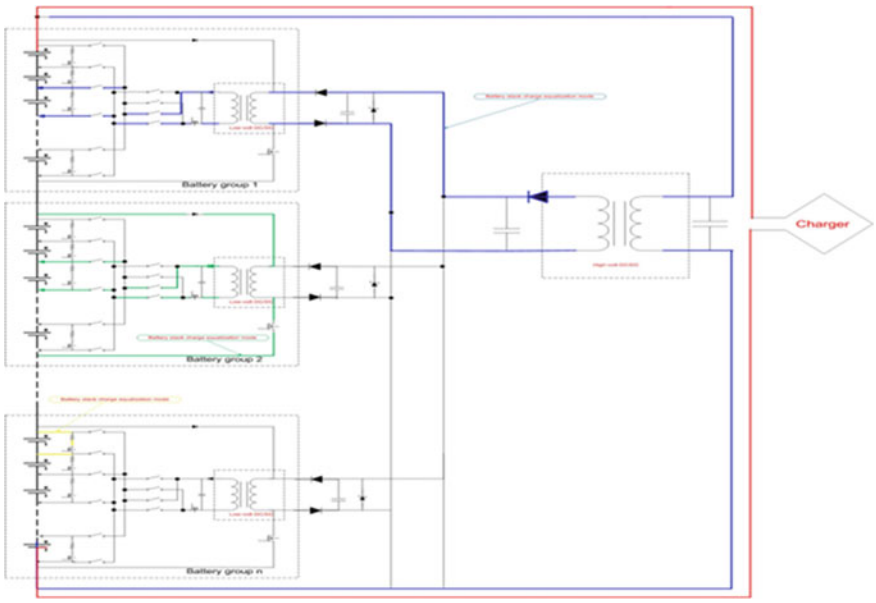

Fig. 14.1 The system architecture design

In the proposed equalizer, balance is archived by three basic equalization mode specified as follows:

1. Battery stack charge equalization mode: In this mode, the first stage DC/DC converter and the second stage DC/DC converter are both turned on. This stage transfers the equalization current from the battery pack to the input terminal of the second stage converter. Therefore, by collaborating on the second stage converter with the selection switch mode, the first stage converter can provide the equalization current to battery cell of the lowest voltage value as shown with blue lines of Fig. 14.1.
2. Battery group charge equalization mode: in this mode, only the second stage DC/DC converter is turned on. This stage transfers the equalization current from battery group which including the lowest voltage battery cell to the lowest one illustrated green lines of Fig. 14.1.
3. Battery cell discharge equalization mode: in this mode, the power MOSFET which parallel with the commanded high-voltage battery cell is turned on. This stage transfers the equalization current from the commanded battery cell to heat by resistor demonstrated with yellow lines of Fig. 14.1. Although energy dissipation is accompanied with the equalization process, it is time-saving especially in the presence of few extremely high-voltage battery cells, consequently improves the flexibility and extendibility of the system.

14.3 Fuzzy Logic Equalization Algorithm

In view of literature of control, fuzzy logic is absolutely an effective approach to problem of multivariate, nonlinear, and time-varying. A fuzzy logic controller (FLC) is employed to regulate the equalizing current of the proposed equalization. FLC (shown in Fig. 14.2) consists of four parts:

- Rule base, this is the core of fuzzy controller.
- Inference mechanism, which can simulate the expert in the process of using the knowledge to translate the input and make decision. According to fuzzy input, it can seek and use corresponding rules to draw fuzzy output.

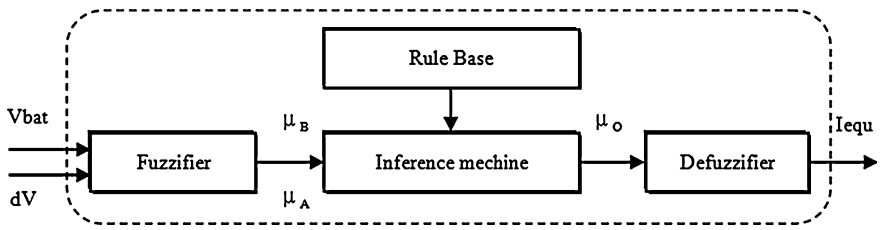

Fig. 14.2 Block diagram of the FLC

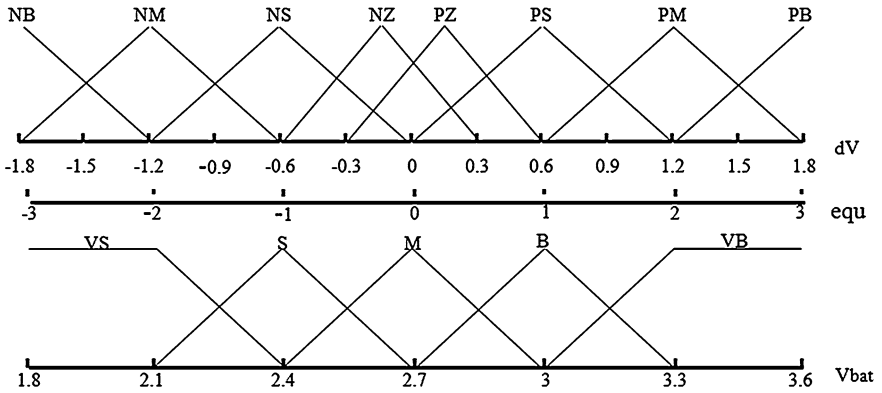

Fig. 14.3 Membership functions for the equalization strategy

- Fuzzification.
- Defuzzification by the center of gravity approach in this paper.

There are two inputs in the FLC, each input is the average voltage difference between battery module and battery stack. The numerical inputs are converted into linguistic fuzzy sets by the fuzzifier. The linguistic control values are generated in the inference machine based on the input fuzzy values and the pre-constructed rule base. The linguistic inference results are converted into numerical output by the defuzzifier. Figure 14.3 shows a set of membership functions for the equalizing strategy in the proposed scheme. Based on the cell balancing control strategies in this battery equalization technology, the fuzzy control rules in the battery equalization scheme are shown in Table 14.1.

14.4 Certifications of Simulation and Experiment

A simulation model is developed for the proposed active charge equalization topology using MATLAB/SIMULINK to test functionality of the proposed system indicated in Fig. 14.4. The scheme of the proposed control strategy contains three important units.

Table 14.1 The rule base in the proposed FC controller

Iequ		dV							
		NB	NM	NS	NZ	PZ	PS	PM	PB
Vbat	VB	NZ	NZ	NS	NS	NM	NM	NB	NB
	B	PZ	NZ	NZ	NS	NS	NM	NM	NB
	M	PS	PZ	NZ	NZ	NS	NS	NM	NM
	S	PM	PS	PZ	NZ	NZ	NS	NS	NM
	VS	PB	PM	PS	PZ	NZ	NZ	NZ	NS

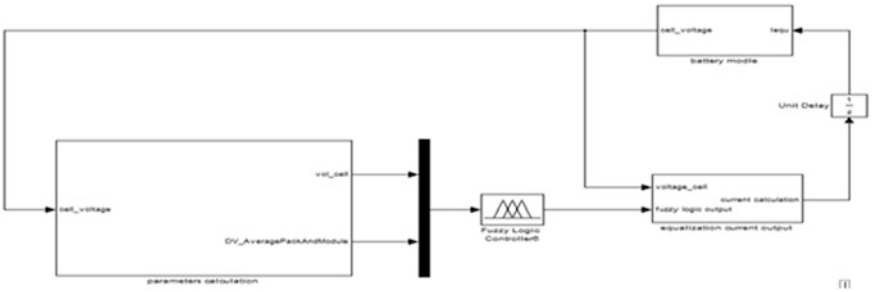

Fig. 14.4 The diagram of the FC controller on battery equalization

The parameters calculation is to obtain the necessary information for FC controller input. The equalization circuit has been incorporated for a stack of 25 lithium-ion batteries by constructing the RC battery model. Additionally, the final equalizing current is guaranteed by cell voltage for safety.

The parameters used for realization of the prototype are described in Table 14.2.

The simulation results show that the proposed equalization algorithm has outstanding cell balancing performance compared with charge/discharge only equalization shown in Table 14.3. In the table, the equalization time and the corresponding equalization target voltage are both clarified. As to the small discharge current, the energy dissipation is greatly reduced. However, the advantage of time-saving is of extreme importance.

Table 14.2 The cell voltage of M × K series moduled battery (mV)

MK	1	2	3	4	5
1	1,800	2,000	2,200	2,400	2,600
2	3,600	3,400	3,200	3,000	2,800
3	1,900	2,100	2,300	2,500	2,700
4	2,700	2,900	3,100	3,300	3,500
5	1,800	2,400	2,800	3,200	3,600

Table 14.3 The comparison of the proposed equalization with others

Equalization mode	Charge only	Discharge only	Proposed equalization
Equalization target (mV)	2,830	1,800	2,780
Equalization time (min)	168	238	102

14.5 Conclusions

Equalization is an indispensable module in the management of the series moduled batteries. This paper introduces the particularity and the application prosperity of the lithium-ion battery. Then, system architecture design and the FC equalization algorithm are specified respectively. With the proposed control strategy, the equalization time could be abbreviated greatly. At last, the simulation and the corresponding results manifest the effectiveness of this topology and the control method. All the results are helpful for further study on charging equalization technique.

In the future, we will also considerate the energy loss on other electronic components. Meanwhile, the equalizing strategy among multi cells is also to be further studied. In addition, the proposed equalizer will be put into practice to test its robustness in practice.

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Chapter 15
Performance Analysis and Experimental Validation of GBAS Based on the Optimal Hatch Filter

Zhenggang Huang

Abstract The introduction of Differential GPS (DGPS) into application improves the position accuracy, which leads to the po‘ssibility for the use of GPS into precise approach. However, the accuracy and integrity of DGPS are limited due to the influence of ionosphere error including both the spatial and temporary gradient. They also bring in some extra error due to the effect of ionosphere temporal and spatial gradient based on the analysis of this error, a new algorithm is formulated to design optimal Hatch filter whose smoothing window width varies flexibly with the satellite elevation, ionosphere variation and distance from the user to the reference station. Through the application of the method to GBAS and the comparison to the performance of traditional Hatch filter based GBAS, it reveals that the improved GBAS is more robust for the challenge of ionosphere storm.

Keywords Optimal Hatch filter · GBAS · Ionosphere gradient · Availability

15.1 Introduction

Recently, the main problem of ground-based augment system (GBAS) lies in that, though carrier-smoothing filter and local differential GPS (LDGPS) improve the accuracy of the pseudorange by reducing the noise in the pseudorange and eliminating most common error between the user and the reference station, respectively, they also bring in some extra error due to the effect of ionosphere temporal

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_15,

and spatial gradient [1, 2]. Especially under the ionosphere anomaly condition, if not take addition action, there will be a huge integrity risk [3, 4] when considering the original error due to the spatial gradient and the additional error through the carrier smoothing [5].

In this paper, we will analyze the extra error due to ionosphere temporal and spatial gradient in the Hatch filter process, and an analytical expression of the whole extra error due to ionosphere is derived. Then, based on the analysis of this extra error due to ionosphere gradients and considering the smoothing noise, we derive DMRS of differential correction error. Finally, we develop a new optimal Hatch Filter called optimal Hatch filer, which can minimize differential correction error in GBAS. Then, an improved GBAS architecture is given based on optimal Hatch Filter to mitigate the influence of ionosphere for CAT III [6] approach. And the performance analysis and experimental validation between traditional GBAS and improved GBAS for the aspect of the precision and availability are presented.

15.2 Analysis of the Additional Error

15.2.1 Single-Frequency Hatch Filter

The single-frequency carrier-smoothing filter [7] uses the code measurement and the carrier measurement. The process is expressed as follows:

$$p_s(k) = \frac{1}{N_S} p(k) + \frac{N_s - 1}{N_s}(p_s(k-1) + \phi(k) - \phi(k-1)), N_s = \frac{\tau_s}{T_s} \tag{15.1}$$

Here, τ_s indicates the filter time constant, T_s the sample interval, p the code measurement andϕ the carrier phase measurement, p_s the smoothing code measurement.

As the effect of the ionosphere spatial and temporal gradient, there will be a bias adding to the smoothing code measurement. We can investigate the effect by the following method

$$\begin{aligned} p(k) &= r(k) + I(k) + \varepsilon(k) \\ \phi(k) &= r(k) - I(k) + N(k) + \eta(k) \end{aligned} \tag{15.2}$$

where, r indicates the common components between code measurements and carrier measurement, including actual distance, clock offsets and troposphere delay. I is the ionosphere component, ε is the random noise on code measurement (thermal noise and multipath) and η is the random noise on carrier measurement.

By the same way, we express the smoothing code measurement as

$$p_s(k) = r(k) + I(k) + \theta(k) \tag{15.3}$$

where θ is the error of smoothing code measurement?

With a little rearrangement, the above equation can be approximated as a continuous expression

$$\frac{\partial \theta}{\partial t} = -\frac{\theta}{\tau} - 2\frac{\partial I}{\partial t} - 2v\frac{\partial I}{\partial r} + \frac{\varepsilon}{\tau_s} \tag{15.3}$$

$$\theta = e^{-\frac{t}{\tau_s}}\left\{\theta_0 - \int_{t'=0}^{t} e^{\frac{t'}{\tau_s}}\left(2\frac{\partial I}{\partial t'} + 2v\frac{\partial I}{\partial r} - \frac{\varepsilon}{\tau_s}\right)dt'\right\} \tag{15.4}$$

It is obvious that this error relates with velocity of user, ionosphere spatial gradient and temporal gradient.

15.2.2 The Effect of Temporal Gradient and Spatial Gradient

In the analysis, we express the ionosphere temporal gradient and spatial gradient as $\frac{\partial I}{\partial t} = k_1, \frac{\partial I}{\partial r} = k_2$.

When neglecting the other factor including the multipath, the spatial gradient and initial value, we obtain the effect of temporal gradient on the carrier-smoothing process, which can be described as follows:

$$\theta = -e^{-\frac{t}{\tau_s}} \int_{t'=0}^{t} e^{\frac{t'}{\tau_s}} 2\frac{\partial I}{\partial t'}dt' = -e^{-\frac{t}{\tau_s}} \int_{t'=0}^{t} e^{\frac{t'}{\tau_s}} 2k_1 dt' = 2(1 - e^{-\frac{t}{\tau_s}})k_1 \tag{15.5}$$

It shows that the filter error asymptotically approaches a constant offset equal to negative two times temporal gradient, times the time constant, which can be expressed by using the following equation when it comes to a steady state.

$$\theta_{steady}^{temp} = -2\tau_s k_1 \tag{15.6}$$

We can derive the steady state of the spatial gradient effect with the same method; it can be expressed as the following equation $\theta_{steady}^{spatial} = -2\tau_s v k_2$.

This equation shows us that spatial gradient affects user with higher velocity such as an aircraft more, and it exerts no effect on the still user.

15.2.3 User Error Due to Ionosphere Gradients in GBAS

According to the analysis of the ionosphere characteristics induced error in carrier-smoothing process, the additional error related with ionosphere gradient in GBAS can be described as the following equation

$$\Delta I(t,x) = I_a(t) - I_b(t) = ob\{-2\tau_a k_1 + 2\tau_b k_1 - 2\tau_a v k_2 + x k_2\} \tag{15.7}$$

where *Ob* indicates the oblique factor, τ_a is user filter constant, and τ_b is reference filter constant, v indicates the speed of user and x is the distance from user to reference station.

15.3 The Optimal Hatch Filter

In order to find the optimal time constant, the calculation of the differential error DRMS is the prerequisite. The noise of the differential correction for the user can be described as below: $N(t) = N_a(t) - N_b(t)$.

Here, N_a is the user smoothing noise and N_b is the reference smoothing noise. Assuming that the noise of both original measurements is equal, we obtain the following equation: $\sigma_N^2 = \sigma_{N_a}^2 + \sigma_{N_b}^2 = \left(\frac{1}{2k_a} + \frac{1}{2k_b}\right)\sigma_p^2 + 2\sigma_\phi^2$.

The whole error after the differential process can be described as follows:

$$\delta p(t) = N(t) + \Delta I(t,x) \tag{15.8}$$

Therefore, we can obtain the DRMS value of the user pseudorange which has been processed through smoothing and differential correct.

In order to reduce the error in differential correction, we should properly select the value of τ_a and τ_b to minimize DRMS. So, we take DRMS to $DRMS(\tau_a, \tau_b)$. Then, τ_a and τ_b will satisfy the following equations:

$$\begin{aligned} DRMS &= E(\delta p^T \delta p) = 2\sigma_\phi^2 + \left(\frac{1}{2\tau_a} + \frac{1}{2\tau_b}\right)\sigma_p^2 \\ &\quad + ob^2(2(\tau_b - \tau_a)k_1 - 2\tau_a v k_2 + x k_2)^2 \\ \frac{\partial DRMS(\tau_a,\tau_b)}{\partial \tau_a} &= -\frac{\sigma_p^2}{2\tau_a^2} + 2ob^2(2(\tau_b - \tau_a)k_1 - 2\tau_a v k_2 + x k_2)(-2k_1 - 2k_2 v) = 0 \\ \frac{\partial DRMS(\tau_a,\tau_b)}{\partial \tau_b} &= -\frac{\sigma_p^2}{2\tau_b^2} + 2ob^2(2(\tau_b - \tau_a)k_1 - 2\tau_a v k_2 + x k_2)(2k_1) = 0 \end{aligned} \tag{15.9}$$

When $k_1 + k_2 v < 0$, there are τ_a and τ_b existed to satisfy the above equations. So, the result satisfies the following equations $(k_1 + k_2 v)\tau_a^2 = -k_1\tau_b^2$

$$\tau_b^3 + \frac{x k_2}{2(\sqrt{-k_1(k_1 + v k_2)} + k_1)}\tau_b^2 - \frac{\sigma_p^2}{16 k_1 ob^2(\sqrt{-k_1(k_1 + v k_2)} + k_1)} = 0 \tag{15.10}$$

It is obviously that it should have a minimum, so the optimal time constants are the best values for the differential process to reduce its error.

Then, we can obtain the following optimal time constants:

$$\begin{aligned}
\tau_b &= \sqrt[3]{\frac{1}{2}\left(-q_b + \sqrt{q_b^2 + 4p_b^3}\right)} + \sqrt[3]{\frac{1}{2}\left(-q_b - \sqrt{q_b^2 + 4p_b^3}\right)} + \frac{1}{3} \\
p_b &= -\frac{1}{9}\left(\frac{xk_2}{2(\sqrt{-k_1(k_1 + k_2 v)} + k_1)}\right)^2 \\
q_b &= \frac{2}{27}\left(\frac{xk_2}{2(\sqrt{-k_1(k_1 + k_2 v)} + k_1)}\right)^3 - \frac{\sigma_p^2}{16k_1 ob^2(\sqrt{-k_1(k_1 + k_2 v)} + k_1)} \\
\tau_a &= \sqrt{\frac{-k_1}{k_1 + k_2 v}}\tau_b
\end{aligned} \tag{15.11}$$

When $k_1 + k_2 v = 0$, neither τ_a nor τ_b satisfies the equation; however, DRMS can be still minimized $DRMS = 2\sigma_\phi^2 + \left(\frac{1}{2\tau_a} + \frac{1}{2\tau_b}\right)\sigma_p^2 + ob^2(2\tau_b k_1 + xk_2)^2$

Then, we can obtain the following results:

$$\begin{aligned}
&\tau_a \to \infty \\
&\tau_b = \sqrt[3]{\frac{1}{2}(-q_b + \sqrt{q_b^2 + 4p_b^3})} + \sqrt[3]{\frac{1}{2}(-q_b - \sqrt{q_b^2 + 4p_b^3})} + \frac{1}{3} \\
&p_b = -\frac{1}{9}\left(\frac{xk_2}{2k_1}\right)^2 \\
&q_b = \frac{2}{27}\left(\frac{xk_2}{2k_1}\right)^3 - \frac{\sigma_p^2}{16k_1^2 ob^2}
\end{aligned} \tag{15.12}$$

When $k_1 + k_2 v > 0$, DRMS reaches its minim if and satisfy the following equations:

$$(2k_1 + 2vk_2)\tau_a - 2k_1\tau_b + xk_2 = 0, \tau_a \to \infty, \tau_b \to \infty \tag{15.13}$$

15.4 Performance Analysis of the Improved GBAS

The working process of the ground-based augment system is shown as Fig. 15.1.

As the optimal Hatch filter is designed under the ionosphere storm condition, this method would not be used to GBAS when no ionosphere anomaly happens. As a result, the improved GBAS would be a hybrid system, that is, when no ionosphere anomaly happens, the improved GBAS would be a traditional GBAS; when ionosphere anomaly happens, the filter would change to the optimal Hatch filter.

This paper evaluates the performance of the improved GBAS by two aspects: precision and availability. We have carried out some simulation to verify the

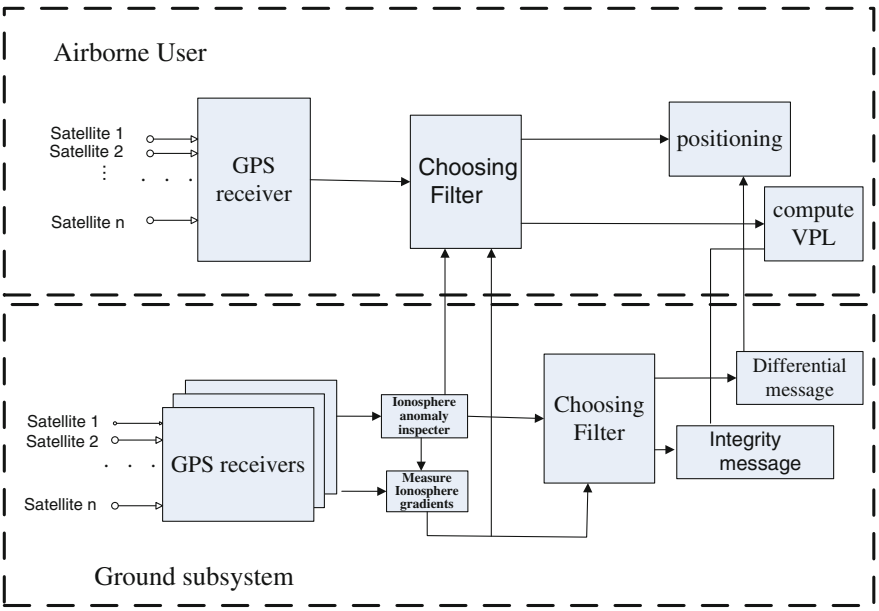

Fig. 15.1 The improved GBAS architecture

performance of the improved GBAS. In the simulation, we compare the performance of the improved GBAS to traditional GBAS using classic Hatch filter with different time constants, which are set with such values, 100, 200, 400 and 800 s. We assume reference station locates at (40.014, 116.533, 33.877) in the ECEF coordination. The ionosphere temporal gradient is 0.08 mm/s, the ionosphere

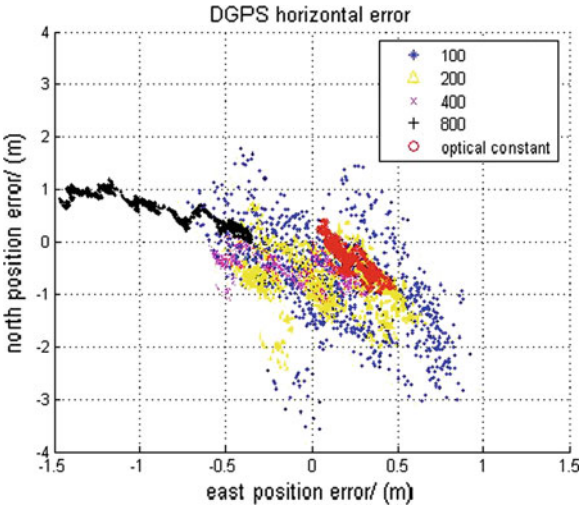

Fig. 15.2 Horizontal error using different methods

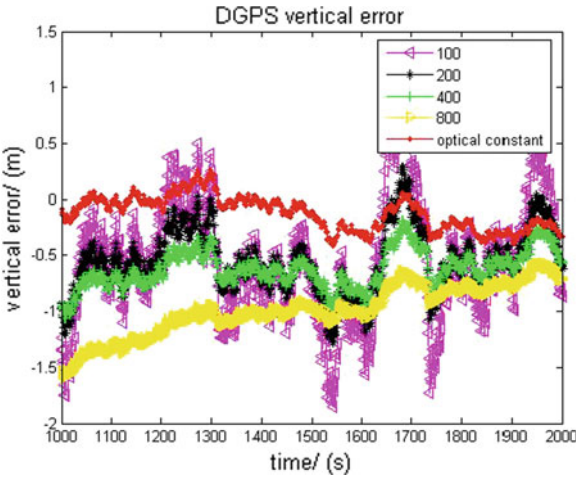

Fig. 15.3 Vertical error using different methods

spatial gradient is 6 mm/km, and the velocity of the user is −20 m/s. The user went into the reference station from the distance of 20 km east of the station.

As mentioned before, distance from user to the reference station, elevation angle and ionosphere gradient are important factors that decide the optimal constants.

From Figs. 15.2 and 15.3, we can see that the horizontal and vertical errors after applying this new optimal Hatch filter are much closer to zero. It illustrates that position accuracy with optimal method is better than classic Hatch filter. In order to compare the position error more clearly, we calculate the DRMS of position error. The result is shown in Table 15.1.

Under the ionosphere anomaly condition, we have simulated and evaluated the long-term average availability of the improved GBAS located in such airports as Beijing, Harbin, Kunming, Lhasa, Sanya, Shanghai and Urumqi. We assume noise of the ground reference station to satisfy the GAD-C level. To fulfill the requirement of CAT II III approach for GBAS, the alarm level (AL) is set with value of 5.3 m; the figure and table below show the simulation result.

From the Fig. 15.4 and Table 15.2, we can see that the availability of the improved GBAS is finer comparing to traditional GBAS. It illustrates that the improved GBAS would behave better under ionosphere anomaly condition.

Table 15.1 Positioning error using different methods

DMRS/m	Constant 100	Constant 200	Constant 400	Constant 800	Optimal constant
Horizontal	0.659	0.644	0.393	0.612	0.214
Vertical	0.49	0.526	0.56	0.812	0.14

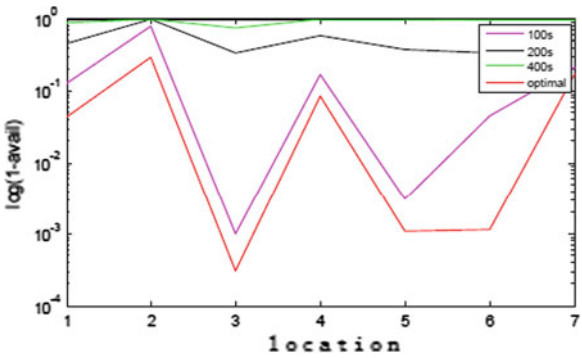

Fig. 15.4 The availability using different methods (AL = 5.3 m)

Table 15.2 The availability using different methods (AL = 5.3 m)

	Beijing	Harbin	Kunming	Lhasa	Sanya	Shanghai	Urumqi
100 s	0.8726	0.2072	0.9990	0.8298	0.9969	0.9546	0.7875
200 s	0.5402	0	0.6646	0.4149	0.6213	0.6638	0.4981
400 s	0.1242	0	0.2475	0	0	0.0414	0.0415
Optimal	0.9565	0.7039	0.9997	0.9151	0.9989	0.9988	0.8319

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Chapter 16
PCB Print-Oriented Filling Algorithm

Zhuang Chen, Yen Qian Wang, Hui Jiang and Yu Qin Jing

Abstract The paper proposed threshold-based adaptive filling algorithm for Gerber rasterizing. Based on high-precision requirements of Gerber, the original filling algorithm is applied to the PCB printer. For the error produced in traditional algorithm, the new algorithm being improved is more suitable for Gerber. Experiment shows that the new algorithm is faster and has high efficiency for Gerber rasterizing compared with original. It helps to enhance the quality of PCB printing and promote the PCB printing industry.

Keywords: Graphics, region filling, gerber · PCB

16.1 Introduction

With the rapid development of electronic technology, equipment and technology are advancing by leaps and bounds for the Printed Circuit Board (PCB) industry. In particular, based on the technology of "private" and "super ink-jet", print head and the special ink used to improve and breakthrough, we can now get the line width of 3–5 μm [1]. These technologies, processes and application conditions maturing provide the foundation and guarantee for the ink-jet printing technology applications and promotion in the PCB field. The production requirement of the

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_16,

PCB industry is increasingly high overall, mainly in the production efficiency and precision. In order to meet the demand of the society, the PCB industry must improve production efficiency. So it can make the technology of digital ink-jet printing promotion in PCB industry.

The production process of the PCB ink-jet printing is divided into six steps, as shown in Fig. 16.1. Without manual intervention in the process of PCB fabrication and taking generally 1–2 min on total, the jet printing and ink curing work at the same time, so it saves a lot of time. Compared with the traditional PCB screen printing, ink-jet printing technology has many significant advantages such as it greatly simplify the PCB producing processes, small size, and short cycle, low cost, environmentally friendly. The digital ink-jet printing technology improved the accuracy of the interlayer matching and graphics printing and greatly improves the efficiency and quality of the circuit board production; thus, it must be the trend that "digital ink-jet printing technology" is bound to achieve industrialization [2].

Rasterization of vector graphics translated the vector graphics elements into an image matrix with the certain line width, so that the image in the display and printing will be a unified expression. Vector graphics are composed of points, line segments, arcs, fold line and area filling. In the rasterization, the area filling is complex, so the filling efficiency and quality directly is the key of the rasterizer. In this article, firstly, we try to apply the original scan line algorithm to Gerber rasterizing. Then, for the errors and low efficiency of the algorithm, we improve the rasterization algorithm applying to Gerber files. At last, according to the resolution accuracy requirements of customers, we maximize the improvement of the quality of the rasterized graphics and the efficiency of the Gerber.

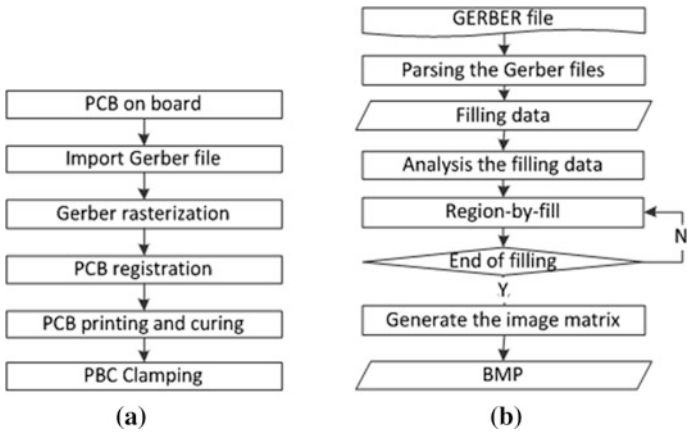

Fig. 16.1 **a** PCB ink-jet printing process. **b** Gerber rasterizing

16.2 Rasterization of Area Filling

16.2.1 Gerber Files

Being an industry standard data files of RS-274X, Gerber files are widely used in PCB manufacturing. The area filling in the Gerber files has a special mark. As following a brief overview of the area filling in the Gerber file, shown in Table 16.1.

Gerber sentence of Table 16.1 descript as graphics in Fig. 16.2a [3]. For example, we can simply understand the usage of the Gerber statement. Gerber is a set of standardized data formats, which contains many other statements and detailed usage. Filling that described in Table 16.1 is a simple connected region, but there are many complex connected areas in Gerber files, as shown in Fig. 16.2b. It is the most important element of area filling. This paper makes the complex connected region as focus and describes in detail the improvement of the region filling algorithm.

Table 16.1 Gerber statement

Gerber sentence	Meaning
G04 Example*	G04 means note, similar "//" in C
%FSLAX23Y23*%	Format statement, X23Y23 means that axis X and Y has two integer and three decimal
%MOIN*%	In inches
%SFA1.0B1.0*%	Coordinate zoom is 1.0, that is, no scaling
%ADD10C, 0.010*%	Define a circular code as diameter is 0.01 inch. D number is 10
G36*	Filling begin
X6000Y2000D02*	Start point
X6000Y3000D01*	D01 means drawing
X10000Y3000D01*	
Y10000Y2000D01*	
X6000Y2000D01*	End point, same with start point
G37*	Filling end
M02*	File end

Fig. 16.2 **a** The Gerber example, **b** complex connected region

16.2.2 The Gerber Rasterizing

Rasterizing is the most important process in PCB producing, and the accuracy of the images generated will impact on the final print. As being developed areas of industry, the technology of PCB ink-jet printing is designed as four steps in this paper:

1. Parsing the Gerber files. According to Gerber grammar, making the filling data store to specified location in Gerber files.
2. Analysis the filling data. Statistics the data matrix size set the fill parameters.
3. Region-by-fill. Call the fill function, filling one by one.
4. Generate the image matrix. As filling completed, it will get the image matrix.

16.3 Improved Region Filling Algorithm

16.3.1 Analysis of the Original Algorithm

As one of the most important elements of Gerber, the efficiency and the precision of area filling have an important impact on rasterizer. The current filling algorithm is mainly divided into two categories: the scan line filling algorithm [4, 5] and seed filling algorithm [6]. The former mainly make use of the continuity of the scan line and filling in the order of scan line; the latter mainly make use of the continuity of the graphics space and starting a seed point from the internal coherence of the test point. However, the seed filling uses a lot of access to the stack; it wastes a lot of space and repeat, so the seed filling algorithm is extremely inefficient [7–9].

The scan line filling algorithm generally consists of four steps.

1. Intersection. Traversing the whole scan lines, calculate the intersection of scan lines with multilateral regional and generate the intersection list.
2. Sorting. Traversing the intersection list, sort the intersection of each row with the size of x.
3. Paired. Each scan line of the intersection paired and form filling interval.
4. Filling. Fill the interval.

Because of precision requirements of the industrial design, assuming that the minimum distance between two points is 20 μm, as the Gerber rasterize as the resolution of 360, 720, 1440 DPI, we can get the distance of two pixels for 70.56, 35.28, 17.64 μm. As shown in Fig. 16.3, each square represents one pixel and outline of records is to be filled polygons. As in Fig. 16.3a, if rasterizing for 1440 DPI, the two pixels distance for 17.64 μm, so any two points are in the different pixels; in Fig. 16.3b to be rasterized by 720 DPI, there are two points fall in the same pixels, such as C and D, E and F, I and J. The Scan line algorithm will

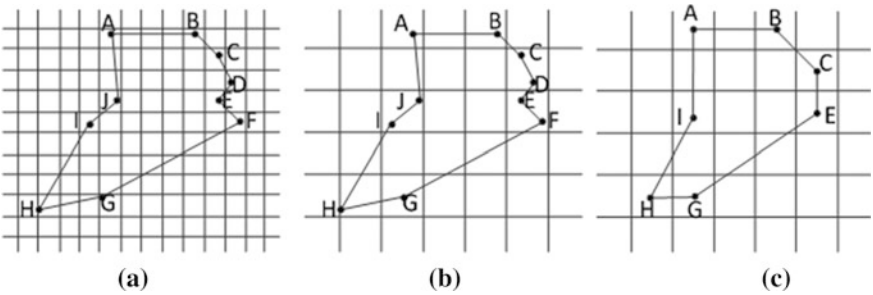

Fig. 16.3 The distance of two pixels for **a** 70.56 μm, **b** 35.28 μm, **c** 17.64 μm

Table 16.2 Resolution and threshold value corresponds to several

DPI	Threshold α
360	70.56
720	35.28
1440	17.64

lead to the error of statistics, the number of the intersection, and finally, filling with failure.

In this paper, for the disadvantage of the scan line fill algorithm in the Gerber rasterizing, it will improve the scan line filling algorithm and form algorithm effectively for any filled shape in Gerber.

16.3.2 Threshold-Based Adaptive Filling Algorithm

Threshold According to the resolution of the system, it will calculate the most appropriate threshold for rasterizing. Resolution and threshold value corresponds to several frequently used as shown in Table 16.2. Threshold can be calculated as α.

$$\alpha = 25.4 * 1000/\text{DPI} \tag{16.1}$$

As the threshold is based on user-selected resolution, and judging the coordinates of Fig. 16.3b, we will get the simplified coordinate, as shown in Fig. 16.3c.

Threshold-based adaptive filling algorithm According to the resolution of the system, the threshold will filter out the unnecessary data in the list as scan. It will improve the efficiency of the implementation of the algorithm and also improve the correct rate of Gerber rasterizing.

The algorithm defined in the edge node structure as follows:

Among

x_{min}	Δx	y_{max}	next

X_{min}	Intersection of the coordinates of the current scan line and the edge;
Δx	Increments of X as Y increased 1;
Y_{max}	The highest scan line intersects with the edge;
Next	Next edge

Threshold-based adaptive filling algorithm:

1. Initialize. Set the ordered-edge-list (*NET*) empty and calculate threshold α;
2. Judge by threshold. Scan point list, the first coordinate of points is denoted by the *PRE*, and the second coordinate is denoted by the *TEMP*, then calculate the Euclidean distance *DIST* of the two points *PRE* and *TEMP*. If the *DIST* is less than or equal to α, the current node the *TEMP* should be ignored, and the third coordinate of points is denoted by *TEMP*; if the *DIST* greater than α, then *PRE* and *TEMP* is denoted by the side of the *ET*, and add to the *NET* linked list. Finally, generate the ordered-edge-list.
3. Construct active edge table. Scan ordered-edge-list *NET*, and construct the active edge table *AET*;
4. Paired. Get the intersection from the *AET* and pair for filling interval, then fill the interval;
5. If $y = yi + 1$, then $x = xi + 1/k$. Modify nodes of *AET* in the intersection of the X-coordinate. If the corresponding edge table ET is not empty, we should insert the nodes into *AET*, and forming of the new *AET*;
6. If *AET* is not empty, then turn (3); otherwise the end.

In order to facilitate the active edge table, the establishment and update, we should construct an edge table ET for each scan line, and store it in the side of the scan line first. In other words, if the lower endpoint of the edge is y_{min}, the edge will store in the scan line of y_{min}.

For improving the speed, assuming that the X-coordinate of the intersection of the current scan line and the edge of a polygon is xi, the intersection of the next scan line and the edge does not need to recalculate while increase Δx. For $ax + by + c = 0$, $\Delta x = -b/a$ is a constant. Using the incremental method, we need to calculate the range of intersect of one edge with scan lines to delete it from the active edge table. The key point of the algorithm is getting the right intersection of scan line and the regional contour.

16.4 Algorithm Analysis

The threshold-based adaptive filling algorithm is divided into six steps in the rasterizing process, and it is relatively fast and impressive effect. As follow, PCB actual plate graphics fill in the following experiment and, respectively, for a precision fill area and hollow fill area graph.

Fig. 16.4 Filling the area for high-accuracy **a** the point spacing of the Gerber files record is less than the threshold **b** achieve the purpose of rasterization

Fig. 16.5 Contains more than hollow area

Fig. 16.6 Image fill

Figure 16.4 is the filling the area for high-accuracy. If the point spacing of the Gerber files record is less than the threshold, the original algorithm will fill error, as shown in Fig. 16.4a. The effect of the improved filling algorithm is right and achieves the purpose of rasterization, as shown in Fig. 16.4b.

Figure 16.5 contains more than hollow area and the original algorithm cannot correctly filled, as shown in Fig. 16.5a. The filling effect of the new algorithm achieves the purpose of correct rasterization, closing to the original vector graphics, as shown in Fig. 16.5b.

According to the requirements of customer rasterizing by threshold, it is appropriate to simplify the part of the coordinate points of the Gerber files to achieve the purpose of increasing efficiency, the efficiency test as shown in Table 16.3.

The experiment shows that the filling effect of the improved algorithm is greatly superior to the original filling algorithm and the practicality of the new algorithm is quite high.

Table 16.3 Test compare

Number	Size (pixel)	Origin algorithm (ms)	New algorithm (ms)
Figure 16.4	1073 × 300	2	2
Figure 16.5	3029 × 400	310	102
Figure 16.6	6060 × 2201	12307	2047

16.5 Summary

In this paper, the threshold-based adaptive filling algorithm simplified the Gerber for accuracy requirements, so to ensure the correct filling, it greatly shortened the time of rasterization. The new filling algorithm had been applied to the Gerber. Practice has proved that the new algorithm is accurate for polygon region in variety of Gerber and it will get great value and market prospects.

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Chapter 17
A Circuit Structure and the Test Method of High Voltage DC Circuit Breaker

Guang-Ping Yao and Qi Dong

Abstract Introduce a method of using auxiliary oscillator circuit connected the break of the circuit. DC current can be interrupted by the break of AC current circuit breaker according to the principle of the current zero-crossing occurred by superimposed current. The features and the circuit structure of the breaker based on above-mentioned principle as well as the calculation method of key parameters are introduced in detail. This paper at the same time discusses about the forms of the experimental circuit for testing and verifying the capability of interrupting DC current on the circuit. Especially, the scheme of the equivalent test circuit of imitation DC power supply was proposed which based on storage energy with the capacitor and the experimental operational timing diagram, simulation waveforms and the experimental waveforms are given. Ultra-high voltage direct current (UHVDC) transfer switching formed based on same principle used in UHVDC transmission project was recommended.

Keywords High voltage direct current circuit breaker · Ultra-high voltage direct current transfer switching · Ultra-high voltage direct current transmission · Oscillation circuit · Zero-crossing · Test circuit

17.1 Introduction

AC circuit breaker can't be directly used for breaking direct current as we know, because the break arc is not easily extinguished with the direct current have no natural zero-crossing, Especially how to realize the high voltage, ultra-high

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_17,

voltage direct current system breaks DC current has been the technical problems troubled people. In recent years HVDC transmission technology in our country get fast development, and it's the development direction of long-distance transmission of electricity in the world. At present our country has being setting up the UHVDC converter station rely mainly on the location equipments, DC circuit breaker is one of the important equipments within UHVDC converter station projects, change operation modes of DC system or remove DC side fault [1, 2] is its main function, the key technology of Ultra-high voltage DC circuit breaker is only mastered by few foreign companies, so development of UHVDC circuit breaker (or switch high-voltage direct current) has been a priority and it is necessary for the research on Technology of DC Circuit Breaker. Combined with the current level of UHVDC transmission project in our country, the basic parameters for the DC Circuit Breaker discussed in this paper are as follows: rated break current 5,000 A DC; break recovery voltage 120 kV peak [3, 4].

17.2 The Basic Principles of DC Circuit Breakers Based on AC Circuit Breaker

Figure 17.1 shows the circuital construction of the DC circuit breaker based on the AC circuit breaker components, BT1 and BT2 are breaks of the SF6 circuit breaker (double break in series), LO is the induction coil, CO is the capacitor, MO is the arrester, which constitute a DC circuit breaker.

When the circuit breaker's contacts separate, the DC current occurred arc between the contacts, the behavior of arc voltage is unstable, and the higher the arc voltage with the contact distance was extended, while the circuit breaker contacts

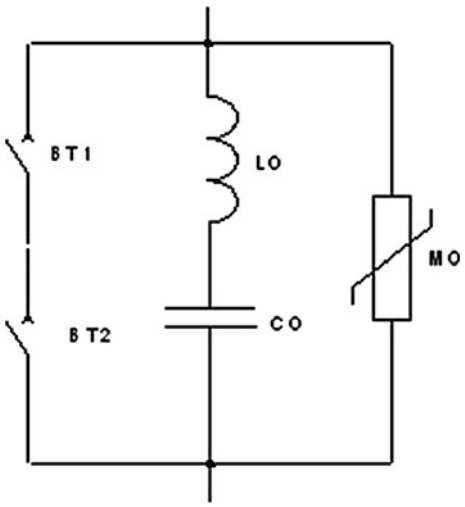

Fig. 17.1 Main circuit of DC circuit breaker and auxiliary

and branch of LO-CO form resonant loop, the resonant current occurred depending on the arc between the circuit breaker contacts, the resonant current is the AC current, the current and the DC current superimpose on the break of the circuit breaker, the greater the resonant current with the contact distance was extended, DC current will completely offset when the resonant current peak is equal to the value of the magnitude of DC current, so there have been zero-crossing on the break of circuit breaker cause that the arc off, then realize the purpose of breaking DC current. LO-CO has branch known as the auxiliary oscillation circuit. MO is metal oxide arrester (MOA), to absorb the remaining energy of the loop when the DC current is break [5].

Figure 17.2 shows simulation waveform of the break current (Iarc) and the current (If) of auxiliary oscillation circuit. Low-frequency part of simulation waveform is caused by attenuating oscillation which is occurred by LS and CS.

LO-CO is the series resonant circuit, circuit breaker provide the energy equivalenting to the source, that will increase inductance of the LO and capacity of CO if resonant circuit's natural resonant frequency were set too low, and this will inevitably increase the device size and cost.

If the resonant frequency is too high, after arc is extinguished, the rate of rise of recovery voltage du/dt is too large, it is possible to re-arc, and it is not conducive to breaking. Taken together, 1–2 kHz is suitable for the natural resonant frequency. From the perspective of rate of rise of recovery voltage ($\frac{du}{dt} = \frac{I_d}{CO}$, Id is DC current), 15–50 μF is a good selection for CO. If CO is set to equal to 30 μF, the resonant frequency is equal to 1.7 kHz, based on the principles of L-C resonant: resonant frequency $f_o = \frac{1}{2\pi\sqrt{\text{LoCo}}} = 1.7\,\text{kHz}$, obtained LO = 300 μH. MOA can be used for absorbing the energy of equivalent inductance of circuit, the residual voltage is 120 kv on MOA. Energy of MOA should be decided based on the current of DC circuit and the equivalent inductance.

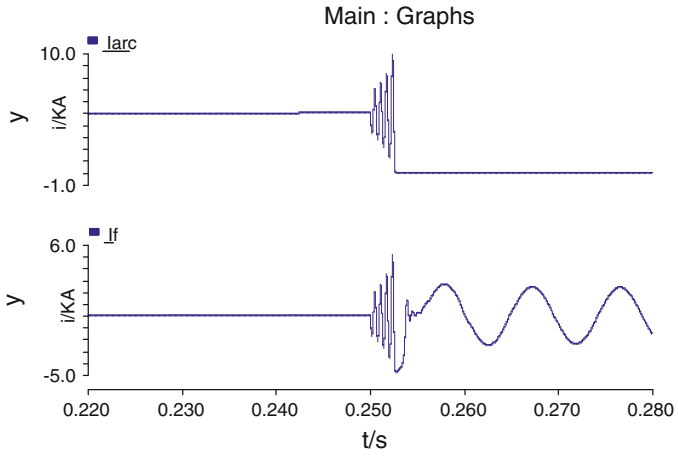

Fig. 17.2 Simulation waveform of break current (*Iarc*) oscillation current (*If*)

17.3 Test Circuit

The task of testing circuit is to provide the DC circuit breaker (test sample) an equivalent actual DC power source, this equivalent DC power source should be able to provide three essential functions: (a) Provide an adjustable break current for the test product to satisfy the request of rated break current, and has the allowance. (b) Provide recovery voltage after arc is extinguished to meet the requirements of break recovery voltage. (c) From the perspective of power, the analog DC power supply should be a suitable pulsed power supply, that there should be storage areas to avoid drawing high energy from the power grid directly.

Based on the above considerations, the main experiment circuit programs include: analog DC source, circuit breakers, test product (DC transfer switch), a measurement device.

Figure 17.3 shows the main experiment circuit, the analog DC source is to the left of dotted line, the breaker of test products is to the right of dotted line. CG is constant current charging device which is made of full controlled three-phase bridge rectifier circuit of thyristor. CS is capacitor for the energy storage, LS is inductor for the energy storage. CG, CS, LS constitutes analog DC source, VD1 is the dividers. CS stored energy to provide test products enough DC current, LS stored energy to provide the break of test products adequate recovery voltage. In Fig. 17.3, BP is the circuit breakers for protection. DC circuit breakers of test products is made by the following components: BT1, BT2 are the breaks (UHV AC SF6 circuit breakers are double breaks in series); LO and CO are components of auxiliary self-excited oscillation circuit; MO is zinc oxide (Zno) arrester; CT1–CT4 is the Hall current transducer; VD2 is the resistance–capacitance dividers.

At the beginning of the experiment, BT1, BT2 and BP are on the open state, CG the constant current charge the unit of energy storage capacitor, when voltage reaches the preset, control system will automatically blockade all the trigger pulse of all the thyristor bridge arms of full controlled rectifier bridge within CG, stopping charge. Then close BT1, BT2 synchronously, (BP is still on the open state) at this time CG-LS-BT1-BT2 constitute a resonant circuit, the current in LS increases sinusoidally, at the same time arc occur on BT1, BT2 breaks and the arc stimulate the LO, CO auxiliary oscillation circuit to start oscillate, DC current superimpose with the oscillating current on the BT1, BT2 break, the higher arc voltage with the contact distance was extended, the oscillation strengthened further, when the peak of oscillating current equal to the amplitude of DC current, all DC current will be offset by oscillations current, there have been zero current on break, arc current is off, thus breaking the DC current. Since then the energy in LS start transfer to CO from LO, voltage on CO continues to rise, this voltage provide break recovery voltage. When the voltage on CO reaches the action voltage of MO arrester, the current in LS flows to the surge arrester, that is the energy in the inductor LS is absorbed by arresters. When the energy in LS drops after a certain level, the voltage on CO is lower than the action voltage of MO arrester, CS-LS-LO-CO constitutes free damping resonance until the energy in CS is greatly

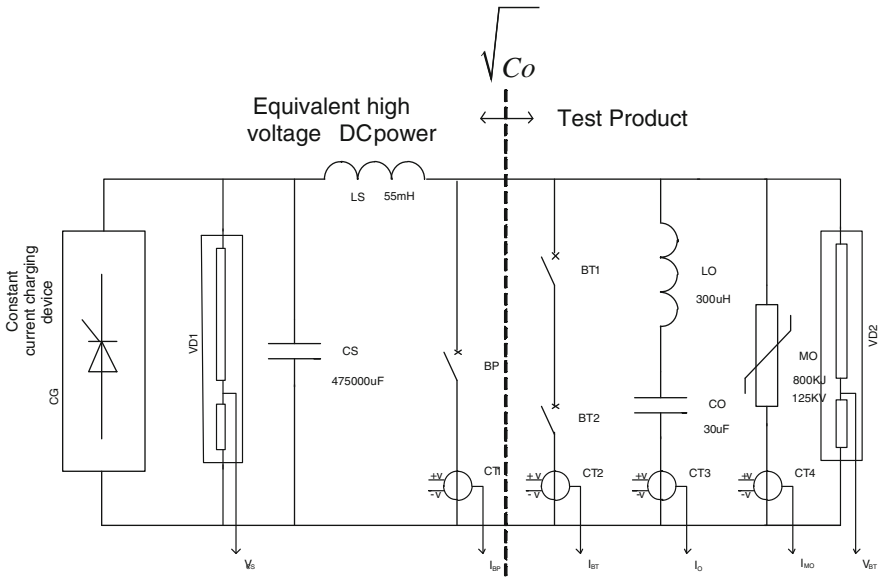

Fig. 17.3 Principle of experimental circuit

depleted. Circuit breaker BP close to make the energy in LS go bypass only when the test items can not break DC current, to avoid the excessive ablation on the break of test items. (Circuit breaker BP is provided only in experiment circuit).

When the break of test products is closed, approximately 5,000 A direct current IB will pass LS, According to the energy formula, this moment the energy stored in LS is $W_L = \frac{1}{2}\mathrm{Ls}I_b^2$. The energy in LS exchanges to CO after the arc is extinguished, namely: $\mathrm{L_sI_b^2} = \mathrm{CoV_{Co}^2}, \mathrm{V_{Co}} = \sqrt{\frac{\mathrm{Ls}}{\mathrm{Co}}} \cdot \mathrm{I_b}$

At this time VCo is the recovery voltage Vb after the arc is extinguished, considering that allowance should be left, it's properly that the peak of voltage should be 1.8 times the rated break recovery voltage, that is: VCo $\geq$ 216 kV (In fact arrester absorb the overall part of the rated break recovery voltage) namely: $\mathrm{Ls} = \frac{\mathrm{V_{Co}^2 \cdot Co}}{\mathrm{I_b^2}}$. It's known that the value of Ib is 5,000 A, Co is 30 μF, VCo is 216 kV, obtained Ls is 55 mH (For the purpose of calculation, we can loosely think of the current in LS as still 5,000 A when the arc is extinguished).

CS on one hand stores energy, on the other hand when the TB1, TB2 is closed, CS and LS form low-frequency oscillations, the lower the oscillation frequency, the better for the test, the more able to reflect the authenticity of the DC power supply. However, if the oscillation frequency is too low, it is bound to increase a lot of capacitance, In principle, the period of low-frequency oscillations Ts is much larger than arcing time. Arcing time is about 20 ms, it is proper that Ts $\geq$ 200 ms.

According to this: $Ts = 2\pi\sqrt{LsCs} \geq 200\,ms$, known LS = 55 mH, obtained CS ≥ 18,000 μF by calculation. In order to make Ts as long as possible, to minimize the impact of energy loss on authenticity of experiment which caused by loop resistance and fracture arcing, the cycle of low-frequency oscillations should be raised to a second, that is Ts = 1 s, then the total capacity of capacitor CS is about 470,000 μF, frequency of low-frequency oscillation is about 1 Hz. This is the ideal frequency.

When LS, CS parameters are determined, the height of voltage on CS determines the amplitude of the current in the LS on the resonant. Due to rated break current is about 5,000 A, which is the peak current ILSM in LS, according to the formula $CsVcs^2 = LsI_{LSM}^2$, obtained the maximum charging voltage on capacitor CS is 1.7 kV. In order to leave allowance, the highest charging voltage of the constant current charging device ought to be able to reach 2 kV. The energy stored in LS is the maximum energy which arrester can absorb, obtained 687 kJ by calculation, take the arrester of 800 kJ^{-1} MJ with the residual voltage 120 kV.

Constant current charging devices use full- controlled six-pulse bridge rectifier circuit of thyristor; the constant charging current can be 2–3 A. The maximum output voltage is 2 kV.

17.4 Conclusion

The experiments are carried out in strict compliance with the timing sequence. Figure 17.4 shows the timing sequence in time for experimental operation.

The operation of the experiment system indicate that the 5.3 kA DC current breaking reliable and repeatable. Figure 17.5 is the waveform of process from arc occurred to arc extinguished. Figure 17.6 shows the recovery voltage the break withstands when arc is extinguished.

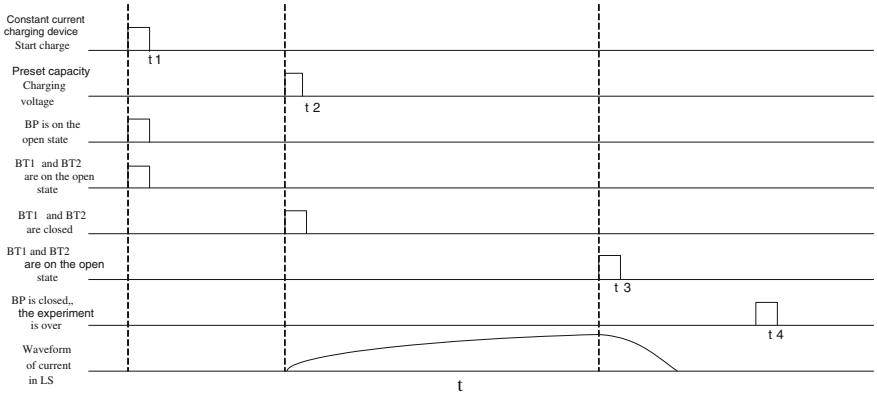

Fig. 17.4 Timing sequence in time for experimental operation

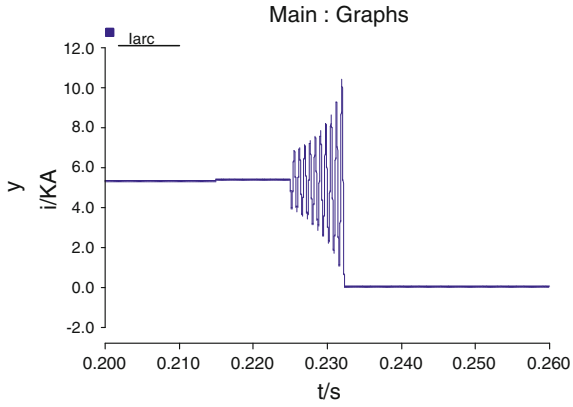

Fig. 17.5 Current waveform on the break

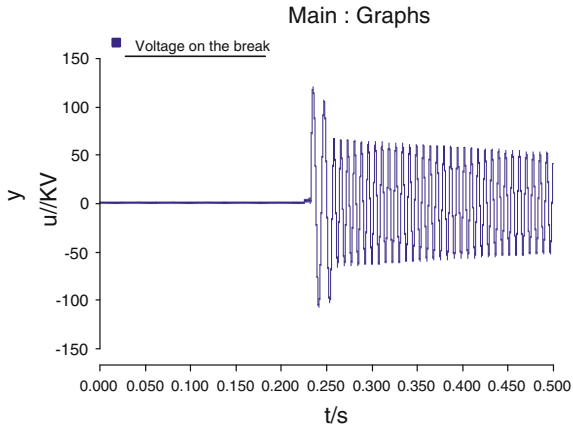

Fig. 17.6 Voltage waveform on the break

The experiment circuits discussed in this article, provide a feasible scheme to the experiment of the circuit breaker of high voltage breaking DC current, it has two advantages. (a) Due to the capacitance and inductance ways of storing energy, the test circuit doesn't need to be provided the high energy directly by the power grid, avoiding the impact influence to the power grid and it also sharply reduced equipment investment and manufacturing difficulty. (b) The process of circuit work meets the needs of large current of break of circuit breaker and the break recovery voltage.

Discussion in this article and the results of the experiment provide some schemes of economic and feasible technology and relevant evidences for the research on high-voltage DC circuit breaker and ultra-high voltage DC transfer switch, performance testing, inspection and related research.

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Chapter 18
A New Sinusoidal Phase Modulation Interferometry

Ying-Chun Ran, Guo-Tian He, Yan Ma, Ying-Ying Qi and Song Wang

Abstract Sinusoidal phase modulation (SPM) interferometer is a time phase modulation method, which has strong anti-jamming ability and needs higher CCD frame rate, so ordinary CCD do not meet the requirement. This article proposed a new interval sampling based on SPM. When SPM modulating signal frequency was 200 Hz, preset sampling frequency was 2,000 Hz; area array CCD with 182 Hz frame rate only collected an interference image in a modulation cycle, and then, these collected images are processed using 2,000 Hz CCD frame rate, thereby reducing the CCD frame rate. This article processed simulation and extracted phase principle values of interference images with filtering method, and by joining main interference signal in the work environment, the error analysis proved that interval sampling could improve the anti-jamming ability of SPM interferometer in the measurement of object surface topography.

Keywords Interferometer · Sinusoidal phase modulation · Interval sampling

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_18,

18.1 Introduction

Osami Sasaki and others made a sinusoidal phase modulation (SPM) interferometer in 1986 [1, 2], which had an adhesive piezoelectric ceramic (PZT) on the back of the mirror in reference light path reached SPM for reference light beam by exerting a sinusoidal voltage on the PZT and then got the physical quantities through the analysis of the interference signal. SPM can be divided into three modulations: PZT modulation, optical and thermal modulation and current modulation [3, 4]. SPM interferometer has advantages of a simple structure, high precision, strong anti-jamming ability and so on, which has a wide application in the measurement of displacement, vibration, surface topography, micro-angle and so on [5–7]. When the traditional SPM interferometer technique is applied to a surface topography measurement [8–10], modulating signal frequency is dozens of Hz at least, sampling frequency at least several times of the modulating signal frequency [11–13] and requires high-speed CCD to [14] capture interference signal [15]. The price of high-speed CCD is very expensive, so it limits the application of sinusoidal phase interferometer in object surface topography measurement. Many people realized that high-speed sampling with a low-speed CCD usually improves CCD drive frequency and reduces the image pixels [16]. Improving CCD drive frequency directly will make the CCD to acquire images with a lot of noise; it cannot improve CCD drive frequency directly and significantly faster. Reducing the image pixels will reduce the resolution of interference images and lead to insufficient spatial sampling rate. When measuring large object surface topography or more markedly changed object appearance, the measurement error is very large and severe and also results in the recovery of surface topography of a measured object incorrectly. This article presented a method of image acquisition and processing, which did not need to reduce the image pixels per frame and was able to significantly improve the sampling frequency of SPM interferometer.

18.2 Principle

Measured object was motionless in object surface topography measurement; the frequency and amplitude for sinusoidal modulated signal was certain in the SPM interferometer; the formed interference images had a periodic variation with the modulating signal. CCD could collect images in continuous modulation cycle.

This article performed precision interval sampling on interference images. It captured the first frame at a time in the first modulation cycle and then captured the second frame at the same time in the second modulation cycle and so on; sampling interval is greater than one modulation signal cycle. When the collected images reach the required number, then these images would be processed at the preset sampling frequency and object surface topography was measured.

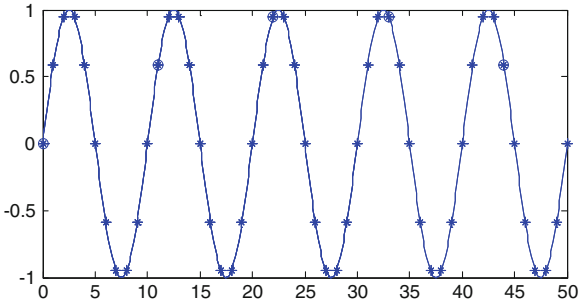

Fig. 18.1 CCD interval sampling time diagram

Each modulation period sampling points $n = f_s/f_c, f_c$ was modulation frequency, and f_s was the preset sampling frequency. In the interval sampling method between the neighboring two samplings, there were n points in CCD interval sampling time diagram that is shown in Fig. 18.1.

Asterisks indicated normal sampling moments, captured 10 points for each modulation signal cycle. Circled asterisk indicated interval sampling moments, once for each modulation cycle. The time interval by interval sampling was 11 times as much as the time interval by continuous sampling.

18.3 The Simulation of Interval Sampling and the Analysis of Anti-Jamming Ability

18.3.1 The Simulation of Interval Sampling

This article adopted filtering to deal with interference signals. The center wavelength of semiconductor laser was set at 800 nm, modulation depth Z was 2.33, modulating signal frequency was 200 Hz, sampling frequency was 2,000 Hz, and cutoff frequency of low-pass filter was 20 Hz.

Figure 18.2 shows topography simulation image measured by interval sampling. CCD frame rate was 182 Hz, collecting 101 images costs 0.56 s. Excluding all kinds of interference and error, one can get the measurement accuracy of 2,000 Hz CCD frame rate while reducing errors associated with low-pass filter.

18.3.2 The Analysis of Anti-Jamming Ability

Interferometer was in the working environment with inevitable environmental vibration; its energy was concentrated in lower than 100 Hz spectrum, the peak value at 30 Hz around. Therefore, this article joined 30 Hz sinusoidal oscillation signal to analyze the anti-jamming ability of interval sampling.

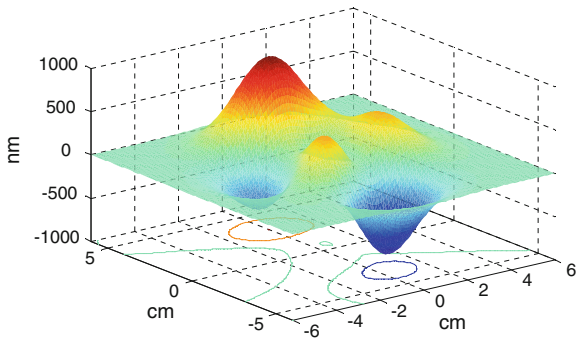

Fig. 18.2 Topography simulation image measured by interval sampling

External vibration would vary the optical path difference between two beams of light, thus affecting the measurement accuracy. If all external vibration signals were used to change the optical path difference, joined sinusoidal vibration signal was $d(t) = 100\sin(2\pi ft)$ nm; the amplitude of vibration signal was 100 nm; the frequency of vibration signal was 30 Hz.

The interference signal was given by:

$$s(t) = s_1 + s_0\cos[z\cos(\omega_c t + \theta) + \alpha + d(t)] \tag{18.1}$$

Then, this article measured surface topography images by interval sampling and traditional SPM method as shown in Fig. 18.3 when the radial vibration interference signal was joined.

In Fig. 18.3, figure on the left shows the measurement of the 200 Hz sampling frequency, that is, 200 Hz CCD frame rate, and figure on the right shows the measurement of the 2,000 Hz sampling frequency using interval sampling only

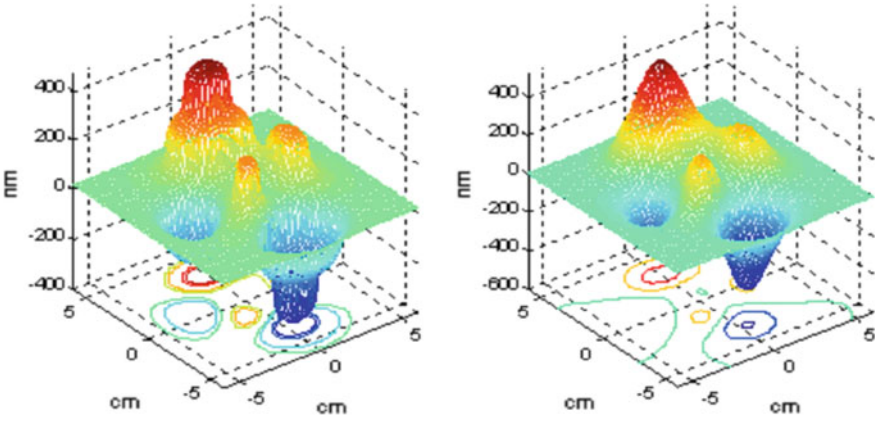

Fig. 18.3 Comparing images by interval sampling and traditional SPM method with radial vibration interference signal

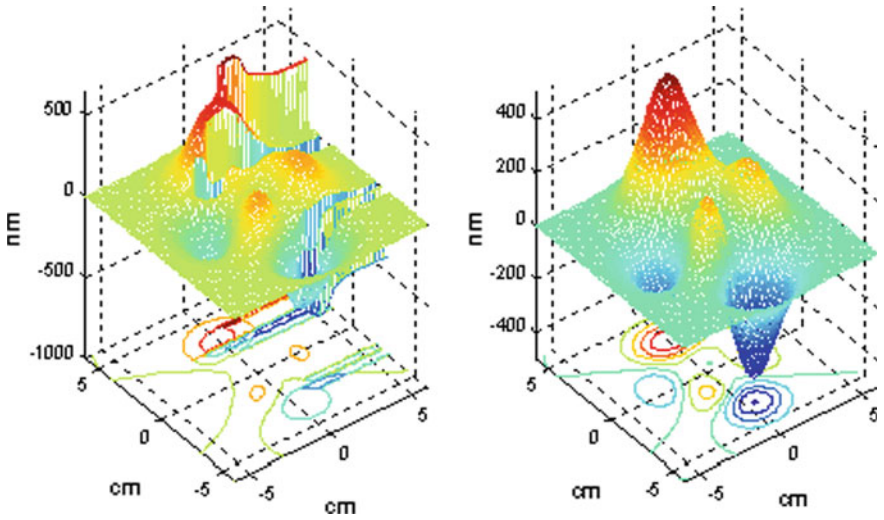

Fig. 18.4 Comparing images measured by interval sampling and traditional SPM method with vibration interference signal in the CCD plane

with the 182 Hz CCD frame rate. As can be seen from the figure, the figure on the left was distorted largely, but the right figure was very close to measured image with no vibration and less distortion.

External vibration would also cause the displacement phenomenon of interference images acquired by CCD. Joining in-plane vibration, CCD acquired the interference signals corresponding to the other parts of the surface that resulted in the error. CCD pixels were 100×100, by joining the interference signals of sinusoidal vibration in both horizontal and vertical direction in CCD plane, and interference amplitude was the third point in the adjacent direction of the acquisition. Then, this article measured the surface topography images by interval sampling and traditional SPM method as shown in Fig. 18.4 when the two-dimensional vibration interference signal was joined.

From Fig. 18.3, we could see that the left figure had many errors, and there were some points of discontinuity in high fluctuations, which led directly to phase unwrapping errors; the right figure was measured by interval sampling, and image distortion is smaller so all the above proved that the interval sampling could significantly improve the anti-jamming ability of the SPM Interferometer with the same low-speed CCD.

18.4 Conclusion

This article presented an interval sampling based on SPM, when the CCD frame rate could not satisfy the requirement, one can also use the high modulation frequency. While the interval sampling method required 2,000 Hz CCD frame

rate, this method needed only 182 Hz CCD frame rate. By joining the interference signal, simulation and comparative studies found that the interval sampling with the 182 Hz CCD frame rate had stronger anti-jamming capability than the traditional SPM method with the 200 Hz CCD frame rate. In the absence of suitable high-speed CCD, interval sampling can be an effective compromise method.

Acknowledgments This paper got the following project supports: the national 863 project "major projects with high intelligent analysis instrument online and complete system key technology research and product development" items (2012 AA040603), Chongqing major projects "high temperature flue gas more than high precision components online intelligent monitoring system research" (cstc2011ggC70001) and Chongqing municipal education commission–funded project (KJ110601, KJ100605, KJ090820). Through this, authors wish to thank all.

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Chapter 19
Automobile PEPS Low-Frequency Automatic Calibration System's Accomplishment

Xiaoping Jiang, Jun Deng, Lunpeng Liu and Yuanyuan Liang

Abstract For no keys into the start of the system and the electromagnetic compatibility problem, this paper designed and realized based on the platform of the electromagnetic field surrounding LabView car distribution shows the function and complete automatic control, manual walk control and the coordination work with acquisition part. Car passive entry and passive start (PEPS) low-frequency automatic calibration system can realize the whole process of automation and visualization, this paper, based on the Matlab platform design database data extraction and 3D display function, and the Matlab platform called LabView the function design and commissioning of the final, and finally from the point of view of the simulation are given the whole car model 3D magnetic field distribution shown figure, reflect the car model field around the change trend of the electromagnetic field size and, without keys into the start of the actual testing system and put forward the suggestions reference.

Keywords Automatic calibration · Mechanical arm · Three-dimensional electromagnetic field display

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_19,

19.1 Introduction

Car passive entry and passive start (PEPS) system, using RFID technology, through the car owners carries intelligent key label to the introduction of automatic switch door lock and start of the engine. PEPS system only requires the car near and not the key chain or smart card from pocket or purse out of. As long as pulling a doorknob of the driving car can activate the radio frequency identification transceiver awakening the pattern, this time the radio frequency identification transceiver will scan the surrounding area, to identify, looking for the key or the smart CARDS embedded in the radio frequency identification chips specific ID code. Once found, security will determine whether this chip is legal and decide whether to open the door once the owner identity is confirmed, and the system will verify whether the keys in the car, if in words, just click on the dashboard button to start the car [1]. Intelligent system is the car keys and intelligence information, electronic reflected, improves the security of the whole vehicle, comfort and reliability and has extremely huge market prospect and the potential benefits, so the no keys into the PEPS has very important research value.

19.2 Car PEPS Low-Frequency Automatic Calibration System

Low-frequency calibration system includes software and hardware part; software part mainly consists of a serial port receiving module, mechanical arm to be automatic measurement modules, space distribution of the electromagnetic field and mechanical arm displaying module driver totally of four main modules, and hardware part includes the part of the field test module, mechanical arm and industrial PC. The field test module through a serial port RS232 and industrial PC connected mechanical arm through the PCI interface card.

19.3 Electromagnetic Field Distribution Display Systems

19.3.1 Car PEPS Model Calibration Area

Smart labels in the outside of the electromagnetic blind area or a car in existing in the environment with PEPS system communication frequency close to electromagnetic interference is not working. This paper's key point is how to control the mechanical arm walking routes and complete the above four areas of the field strength of the electromagnetic field measurement and shows the whole area and the key area of the field strength as shown in Fig. 19.1.

The purpose of this program is to realize the distribution of the electromagnetic field car space 3D display. Automatic measurement modules finally get a database of measurement results, it stores the each test point value of the field, and the

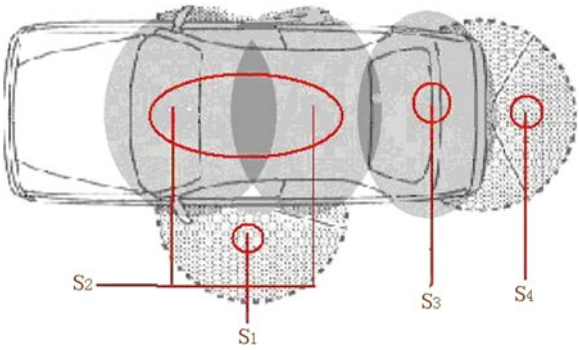

Fig. 19.1 PEPS on the outside of the LF signal blind area signal (the actual)

program's mission is to read data in the database of the field and electromagnetic field data of 3D visualization. The program not only should be able to read the correct measurement results and also convert the data to facilitate processing of the available data, but must be able to give space electromagnetic field distribution and man–machine interface, technical personnel in the distribution of the electromagnetic field observation analysis characteristics.

19.3.2 Electromagnetic Field Distribution Shows the System Frame

Electromagnetic field distribution display system is mainly divided into two parts; the first part is to drive mechanical arm of the above four areas magnetic field data's collection and deposit in the database. The second part is to read database data in the Matlab workbench, and the controllable man–machine interface of the LabView workbench could send data to Matlab platform to finish some part or the whole electromagnetic field data to 3D visualization as shown in Fig. 19.2.

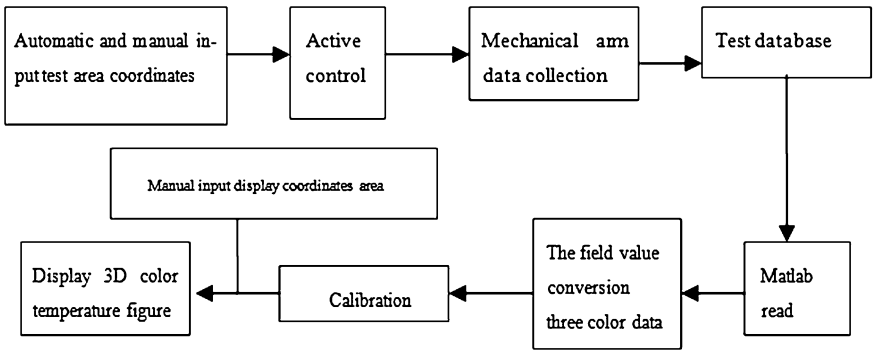

Fig. 19.2 Electromagnetic field distribution system frame

19.3.3 Mechanical Arm Driver Modules

Mechanical arm driver module is mainly responsible for the control of mechanical arm walk, through the program to control servo motor to realize the operation of the stem movement. Driver module manufacturer is offered by car. With dynamic link library form to give users, providing development interface functions includes the following: equipment initialization, move specified axis, the axis moves to the original position, speed, get set specified shaft axis state, equipment specified closed, etc.

The application to the dynamical link library implements mechanical arms control; first of all, through the member function Get Drive () to obtain the device object and then calling Auto Init () initialization equipment, equipment after initialization can be called the corresponding member for the function of realization of mechanical arm to control and test device object after the close to disconnection and connection of mechanical arm [2].

19.3.4 Mechanical Arms to be Automatic Calibration Module

This module is the whole system for the most important module; the main purpose is to be able to drive mechanical arm of the target area of the field data collection and to store it in the database file. In the system of automatic calibration process, mechanical arm finished the test point measurement; so, how to control the mechanical arm through all the test point is a key question; this involves testing path, and we generate test path through the database to solve this problem, and in the whole models in some special point, but cannot be included in the four key areas, so must also be manual measuring process.

19.3.5 The Design Method of Measurement Path

The main task of the mechanical arm automatic measurement module is to produce the measuring path database, and it can be read. The walk of controlling mechanical arm records the corresponding values to the measurement results field in the database. In the interface, it can display full time the sampling points above the position of the data and information (such as 3D coordinates of the field and value) and realizes the test point tracking.

Generations of testing the database of the path: Fig. 19.1 has introduced PEPS on the outside of the LF signal blind area; it could simulate each test area into cuboids' structure, in order to make the measurement of mechanical arm fast for the data of the whole car, and it must be designed good mechanical arm walk path. Mechanical arm get out of the first coordinate generation of measurement path

database and then move to the corresponding position, get the field data, take out the next position and move to the coordinates of the corresponding position, and so on complete the cuboids' individual test area measurement, move on to the next area of measurement, and complete the measurement of the whole vehicles.

For a single area, we first after *x*–*y* according to the order of the *z* again, that can be considered as the face of the line-plane-body measurement in order to complete a cuboids' measurement of the area of the field measurement of V. We use the cuboids' main diagonal line on the starting point and end point to determine the position of the cuboids'. The two o'clock position is the user interface in manual input set. And then, the user specified walk step length of mechanical arm, and you can get all the needs of the whole cuboids' area value of measurement. Mechanical arm extraction of the coordinates can be completed, and we set the field data collection function. So, from a measurement area to another measuring area, mechanical arm that may wingspan is not enough, for example, see Fig. 19.3, *S*1–*S*4, or *S*1–*S*2 (*S*1, *S*2 on the outside in the car). So, the order of measuring area must also be set, for example, measurement for *S*1-*S*2-*S*3-*S*4, only reasonable plan for the beginning and the end of each area, and the test area has test sequence, can cause the mechanical arm moving process simple and will not touch the car's shell.

As already mentioned, mechanical arm is fixed, so from a measurement area to another for the zone will only turn car or make a turn, then this area of mechanical arm compared with the fixed position is changed. It must be able to finish the coordinate transformation in the program so that it does not need testers to coordinate change every time. Car can make sure the two directions every time that can be seen as 90° or 180° of rotation. Take Fig. 19.3 for example.

First measured in *S*1, and then the car after 180° level rotary, corresponding to the fixed in *S*1 of mechanical arm, originally in the area within the *S*2 any point (x, y) will be mapped to (x', y') place. It can be found in the graph, as long as controlling the car model of the focus point (x_0, y_0) unchanged, the car is in accordance with a point for rotating angle, in the area of each point can according to this point to ask out after turn of coordinates. The above available:

$$\begin{cases} x' = 2x_0 - x \\ y' = 2y_0 - y \end{cases} \tag{19.1}$$

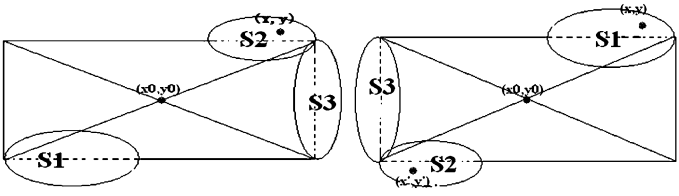

Fig. 19.3 The model car horizontally rotating 180°

19.3.6 Test Path Generation of Database

This paper completed test path generation of database mainly by VC++. Piece of regional test data table records the path in the area of each test point coordinates, and mechanical arm in accordance with the contract shall be in accordance with the data in storage order of sequence through the corresponding test points [3]. Here, one key issue is that when to record data, make coordinate system, and match the value of the field. Mechanical arm reach the corresponding position and stop the recording timing of the test data; so, in the program realization, it should take corresponding strategy that confirmed data record this time.

19.3.7 Test Point Tracking and Data Show

System requires operator interfaces to display the current test point position at all times, in order to achieve the simulated results. We use OpenGL library to achieve the purpose of virtual reality. Open Graphics Library (OpenGL) is a specification which defines a cross-programming language and cross-platform programming interface, and it is used in 3D images. OpenGL is a professional graphics programming interface, and it is powerful called convenient bottom graph library.

(1) Body model display

OpenGL library supports three-dimensional model of the reading and displays 3Ds format, and 3Ds model format is used frequently in one of the model file. First of all, the model transformation into 3Ds format, with VC++ program, using OpenGL provides written reading and the function model shows program will read car model and display on the 3D display interface.

(2) The test point display

Measuring test module to get coordinates can be made after test point tracking module, and test point will be shown in 3D graphics after processed.

(3) LabView and VC++

This part of the program is the core of the written reading with VC6.0, including database of reading and writing operation, and the mechanical arm drive module shows the test point displayed, and program integration and interface is written by LabView, so how to embed VC into LabView well is the key to the question, especially the realization of the virtual reality. In order to achieve the purpose, VC program will be integrated into the ActiveX control, through the LabView controlling ActiveX, embedding the controls seamless into LabView, and it can easily visit the properties of ActiveX, realizing the communication with VC6.0 and LabView well [4].

The test point tracking displays rendering as shown in Fig. 19.4. In the chart, the red dot is to calibrate the field strength of the electromagnetic field which is the point.

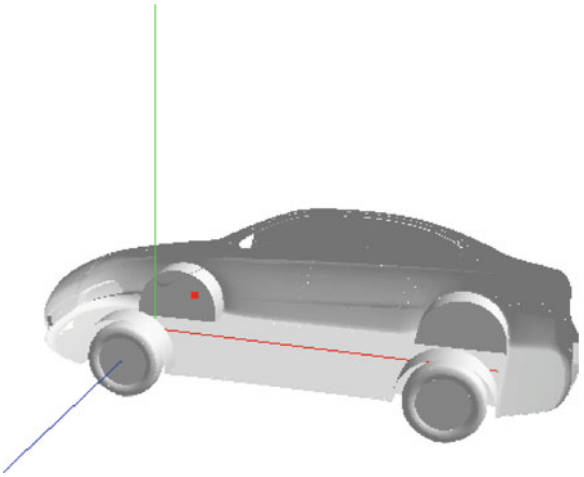

Fig. 19.4 Car 3Ds into model test point's show rendering

19.4 The Figure of the Planar Distribution Field Results

The planar distribution field is mainly used in the Matlab to complete 3D data visualization, and it can set Matlab nodes to call Matlab procedure in LabView, basic interface is mainly to complete the operation personnel controllable that chose to display the way and in different areas of the function [5].

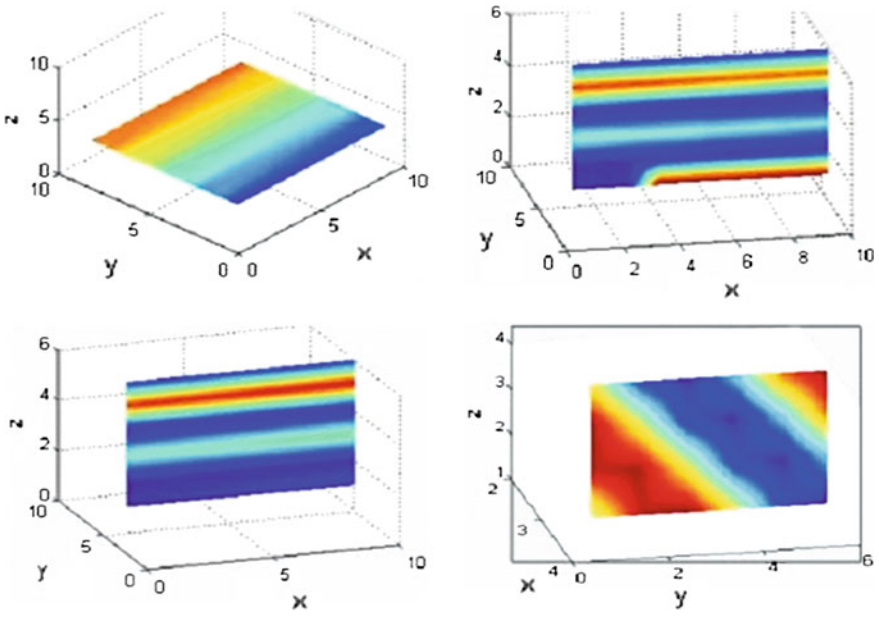

Fig. 19.5 **a** Car door $z = 3$. **b** Car backseat $y = 4$. **c** Car front seat $y = 5$. **d** Car platform $x = 3$

Figure 19.5, respectively, shows car door $z = 3$, the backseat $y = 4$, the front seat $y = 5$ and platform $x = 3$ of the magnetic field intensity distribution.

19.5 Conclusions

As PEPS system as important applications of automobile electronic system, the problem of emcee cannot be ignored, it has become a more and more important research direction, and this is not just because of the automotive electronic components of mutual interference and external environment of the electromagnetic field strong interference factors. LabView as the typical representative of virtual instrument fully combines advantages that are according its' own needs to make instruments and giving full play to the strong data processing functions in computer. The Matlab are powerful data operation and drawing functions that can guarantee the correctness and reliability of the algorithm.

This paper was based on which put forward and realized display system based on the LabView car platform of the electromagnetic field surrounding distribution, in order to get use of analysis the system basis of electromagnetic compatibility. After the completion of the program, electromagnetic field distribution could be tested and verified, and it is able to play a guidance and assistance role of solving the problem of electromagnetic compatibility.

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Chapter 20
Study on Intelligent Grid-Connected Controller for Offshore Distributed Wind Power System

Huaqiang Zhang, Jinzhu Dou and Wei Sun

Abstract A kind of new topological structure of grid-connected Z-source inverter used in offshore wind power generation control system is proposed. And its operational principle of the improved Z-source inverter is analyzed. An implementation method of fixed shoot-through step-up ratio control with Space Vector Pulse Width Modulation (SVPWM) system is studied. The mathematical model of three-phase voltage source PWM inverter in the three-phase static coordinate system and two-phase rotation coordinate system is built. The control strategy of fixing Z-network capacitor voltage and decoupled controlling *d*–*q*-axis current is used to realize unity power factor grid-connected. The results of simulation verify its correctness of theoretical analysis and validity of control method.

Keywords Distributed wind power generation · Improved Z-source inverter · Intelligent grid-connected · Simulation

20.1 Introduction

Compared with wind energy source in the land, offshore wind energy source has bigger wind energy content and little wind shear, and offshore wind power generation does not occupy land resources, so offshore wind power generation becomes focus of study. In the wind power system, a topology is the permanent magnet synchronous generator connecting with uncontrollable rectifier through the PWM inverter to realize grid-connected. This topology leaves out the heavy gear

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_20,

box and has simple structure and low cost. When the wind speed is low, to add a boost, circuit between rectifier and inverter is necessary for normal operation of system. But this reduces the system efficiency and increase the cost of the system.

As a new type of power electronics device, the three-phase Z-source inverter has a lot of advantages such as flexible buck/boost control, high anti-electromagnetic interference ability, and high-efficiency single stage structure. But, there are also some disadvantages such as big start impulse current and high steady-state Z-network capacitor voltage. Therefore, an improved Z-source inverter is proposed to restrain impulse current and reduce steady-state Z-network capacitor voltage effectively [1, 2]. The control policy of stable Z-network capacitor voltage and decoupled *d*–*q*-axis current for the improved Z-source inverter is proposed and verified by the MATLAB/SIMULINK simulation model in this paper [3, 4].

20.2 Operational Principle of Improved Z-Source Inverter

20.2.1 Topological Structure of Improved Z-Source Inverter

Figure 20.1 shows the circuit topology of the improved Z-source inverter. Compared with the traditional voltage type inverter, the improved Z-source inverter has not only eight switch vectors, but also has a shoot-through zero vector state. When the DC voltage is added to the load, this kind of inverter has six non-zero voltage vectors. When the load is short-circuit by three above or below switch tubes, it has two zero voltage vectors. When the switch tubes of the same bridge arm are open at the same time, the improved Z-source inverter operates on shoot-through zero voltage vector state, but it is not allowed for the traditional one. This kind of novel inverter uses shoot-through zero voltage vector to realize the function of boost. When the inverter bridge operates on shoot-through zero voltage vector state, bridge arm is short-circuited, and the equivalent circuit shows in Fig. 20.2a. When the inverter bridge operates on six non-zero voltage vector states, the inverter bridge arm can be regarded as current source. When the inverter bridge operates on two zero voltage vector states, the inverter bridge arm can be regarded as a zero current source. Equivalent circuit of eight kinds of non-shoot-through stages for the inverter shows in Fig. 20.2b. Compared with traditional Z-source inverter, the difference is the position change in Z-network and Inverter Bridge. The advantage is greatly reducing Z-source network capacitance voltage in the same DC peak voltage.

Considering the two inductance and capacitance has the same values, respectively; therefore,

$$V_{C1} = V_{C2} = V_C, \quad v_{L1} = v_{L2} = v_L \tag{20.1}$$

As seen in Fig. 20.2a, when the inverter is in the shoot-through state, we can get

$$v_L = V_C + V_{\mathrm{dc}}, \quad v_i = 0 \tag{20.2}$$

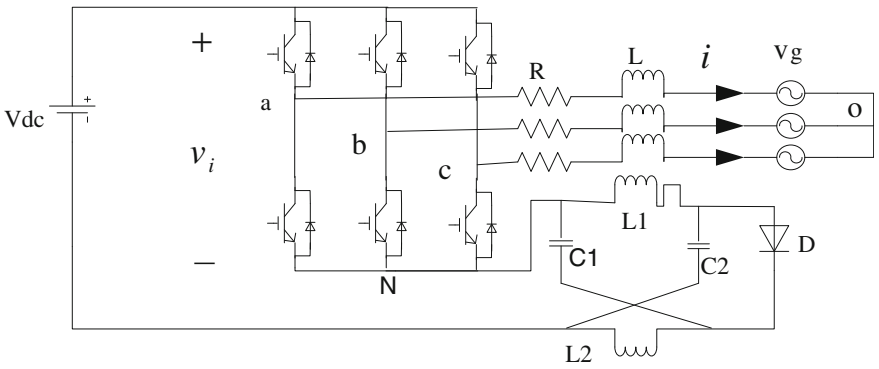

Fig. 20.1 The improved Z-source inverter topological structure

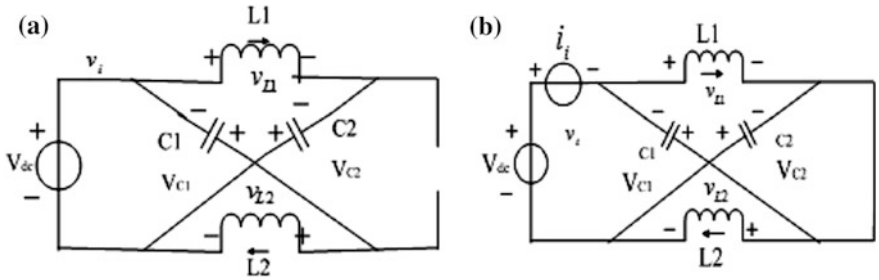

Fig. 20.2 Equivalent circuit of improved Z-source inverter. **a** Shoot-through state. **b** Non shoot-through state

When the inverter is in the non-shoot-through state, as seen in Fig. 20.2b, the following equation can be derived as

$$v_L = -V_C, \quad v_i = 2V_C + V_{\mathrm{dc}} \tag{20.3}$$

As the average of steady-state inductance current is zero, so

$$\frac{V_C}{V_{\mathrm{dc}}} = \frac{D}{1-2D} \tag{20.4}$$

DC chain peak voltage can be expressed as

$$v_i = \frac{1}{1-2D} V_{DC} = BV_{\mathrm{dc}} \tag{20.5}$$

where D—shoot-through duty ratio, B—boost factor.

Output phase voltage amplitude is

$$v_g = \frac{MB}{2} V_{\mathrm{dc}} \tag{20.6}$$

where M—inverter modulation factor.

Compared with traditional Z-source inverter, the difference is the position change of Z-network and Inverter Bridge. The advantage is greatly reducing Z-source network capacitance voltage in the same DC peak voltage and buffering starting current.

20.2.2 Fixed Shoot-Through Duty Ratio Boost Control

In this paper, fixed shoot-through duty ratio boost control is applied. This kind of method insert shoot-through zero vector into the commutation moment of above and below switch tubes, making the switch frequency invariant. Because Space Vector Pulse Width Modulation (SVPWM) modulation system has a lot of advantages such as constant switch frequency, high content of phase voltage fundamental wave, so it is especially suitable for wind power generation system of low wind speed state [5, 6].

In the SVPWM control method with shoot-through zero vector, the above and below switch tubes state of the same bridge arm is irregular. For the three switch tubes of the above arm, switching time is

$$\begin{cases} t_1 = (T - T_1 - T_2)/4 - T_0/6 \\ t_2 = t_1 + T_1/2 + T_0/6 \\ t_3 = t_2 + T_2/2 + T_0/6 \end{cases} \tag{20.7}$$

For the three switch tubes of the below arm, switching time is

$$\begin{cases} t_1 = (T - T_1 - T_2)/4 \\ t_2 = t_1 + T_1/2 + T_0/6 \\ t_3 = t_2 + T_2/2 + T_0/6 \end{cases} \tag{20.8}$$

As shown in Fig. 20.3, shoot-through zero vector is inserted into traditional zero vectors, and switch frequency does not increase [7, 8]. And now, shoot-through duty ratio D and inverter modulation factor M meet Eq. (20.9). When Z-source network input voltage and inverter output voltage are decided, inverter modulation factor M and shoot-through duty ratio D can be calculated by this equation [9].

$$\begin{cases} M \le \dfrac{2v_g}{3\sqrt{3}v_g - 2V_{dc}} \\ D \ge \dfrac{6\sqrt{3}v_g - 6V_{dc}}{12\sqrt{3}v_g - 8V_{dc}} \end{cases} \tag{20.9}$$

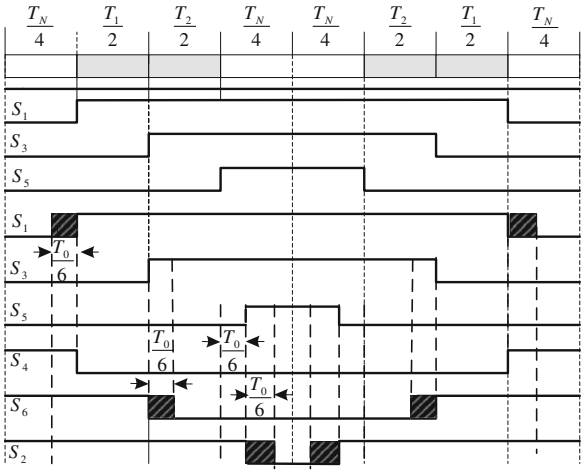

Fig. 20.3 SVPWM waveform with shoot-through zero vectors

20.3 Grid-Connected Study for Improved Z-Source Inverter

20.3.1 Grid-Connected Control Strategy

In order to realize grid-connected, the inverter output voltage amplitude phase and frequency should be the same as power grid. When the inverter works at grid-connected situation, the power grid can be regarded as an infinite capacity of AC voltage source, the inverter is connected with power grid directly, and the connection point voltage is fixed, so the power quality is decided by output current quality. In order to achieve grid-connected operation, it is necessary to control inverter output current tracking network voltage. Because the traditional PWM inverter current control strategy applies to improved Z-source inverter, so the current inner ring can use direct current control [10, 11].

As shown in Fig. 20.1, the mathematical model of grid-connected inverter in three-phase static coordinate system is

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = R \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + L \begin{bmatrix} \frac{di_a}{dt} \\ \frac{di_b}{dt} \\ \frac{di_c}{dt} \end{bmatrix} + \begin{bmatrix} v_{ga} \\ v_{gb} \\ v_{gc} \end{bmatrix} \tag{20.10}$$

When d-axis of d–q coordinate system coincides with network voltage vector by Clark and Park transformation, the mathematical model of grid-connected inverter in two-phase rotation coordinate system is

$$\begin{cases} v_d = L\frac{di_d}{dt} + Ri_d + v_{gd} - \omega Li_q \\ v_q = L\frac{di_q}{dt} + Ri_q + v_{gq} + \omega Li_d \end{cases} \tag{20.11}$$

When the current PI regulator is adopted, the above equation changes to

$$\begin{cases} v_d = (K_p + \frac{K_i}{s})(i_d^* - i_d) + v_{gd} - \omega Li_q \\ v_q = (K_p + \frac{K_i}{s})(i_q^* - i_q) + v_{gq} + \omega Li_d \end{cases} \tag{20.12}$$

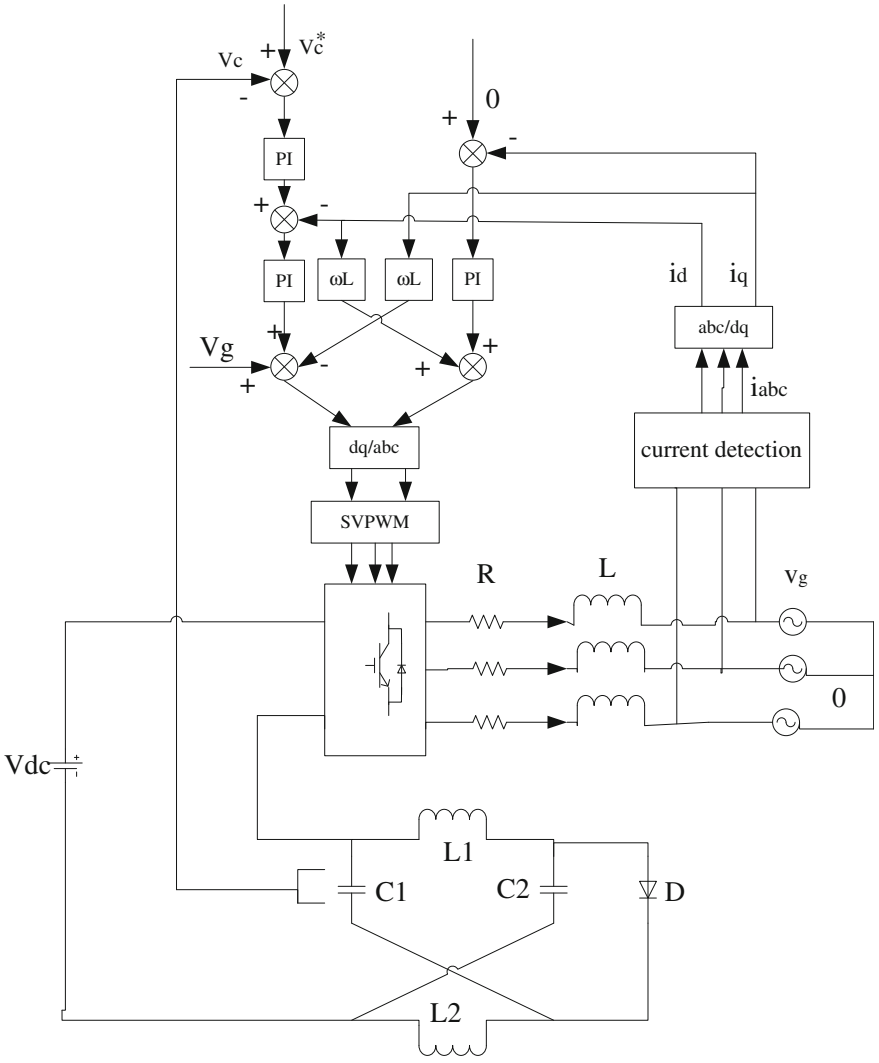

Fig. 20.4 Grid-connected control diagram of improved Z-source inverter

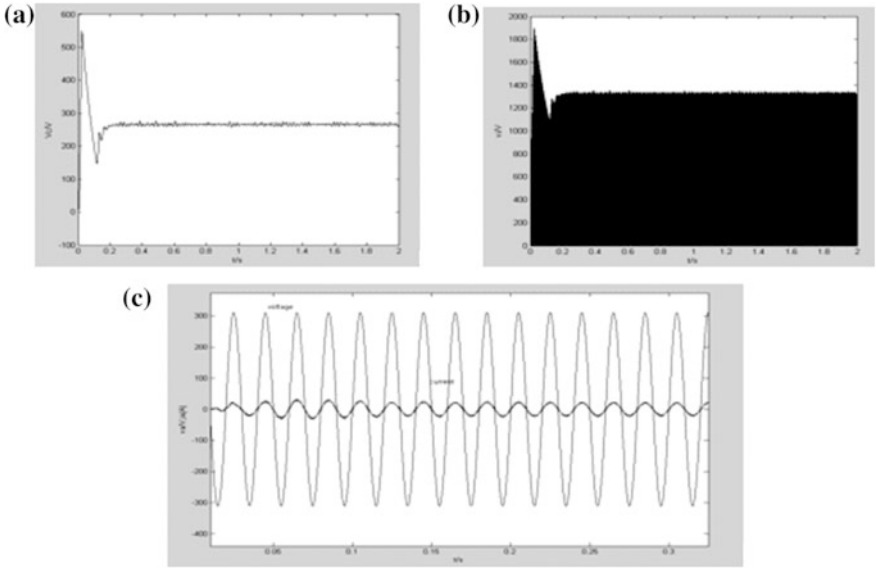

Fig. 20.5 Simulation results. **a** Z-source network capaciatance voltage. **b** Inverter input dc chain peak voltage. **c** Voltage and current waveform of phase A

K_p proportional gain;
K_i integral gain;
i_d^*, i_q^* current references values.

20.3.2 Grid-Connected Simulation Analysis

In order to confirm the correctness of the above analysis and control strategy, the control diagram as shown in Fig. 20.4 is adopted for simulation analysis. The simulation circuit parameters were as follows:

$$v_g = 311V\,, V_{dc} = 800V\,, L_1 = L_2 = 8e-3H\,, L = 1e-2H$$
$$R = 12\Omega\,, D = 0.2\,, C_1 = C_2 = 3e-3F\,, V_C^* = 266.67V$$

The simulation results are shown as Fig. 20.5.

Figure 20.5a shows that Z-source network capacitance voltage is near 266 V steadily. Figure 20.5b shows that inverter input DC chain peak voltage is near 1,333 V steadily. In the Fig. 20.5c, voltage and current have the same frequency and phase, and in the simulation model, voltage and current on line

side have the same positive direction, so the simulation results show that the wind power generation system realizes the unity power factor grid-connected operation.

20.4 Conclusion

This paper presents a new topology of offshore wind power. A new kind of improved Z-source inverter is applied in direct-drive PMSM wind generation system. The simulation model is built by MATLAB/SIMULINK, and SVPWM modulation strategy is used to realize fixed shoot-through duty ratio boost control. The voltage outer loop stabilizes the Z-source network capacitance voltage, and the current inner loop achieves decoupled controlling of d–q-axis current. The control purpose of unity power factor grid-connected is realized.

Acknowledgments This paper was supported by Shandong Science and Technology Fund (2011GGH20411) and Shandong Excellent Young Scientist Research Award Fund (BS2010NJ001).

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Chapter 21
Cancelable Palm Print Templates Using Gabor Representations and Random Measure

Weidong Gu, Hengjian Li and LianHai Wang

Abstract Palm print template security is an important issue in a real biometric system because compromised templates cannot be revoked and reissued. To tackle these problems, in this paper, by measuring the Gabor-based palm print image with a chaotic random matrix, we propose a palm print template protection scheme with provable security and acceptable recognition performance. Firstly, the Gabor is employed to convolute with preprocessed palm print image. Then, to generate the binary cancelable template, the obtained Gabor representation is compared with a chaotic random matrix. The random measure can improve the template's discriminability. Therefore, the proposed algorithm not only protects the template but also has better performance. The experimental results on Hong Kong PolyU palm print database show that the proposed approach can achieve zero equal error rate (EER) and has large cancel ability.

Keywords Biometric recognition · Palm print template protection · Chaotic number · Random measure

21.1 Introduction

Biometric recognition is one of the most promising approaches in a variety of security applications because of its reliable, robust and convenient way [1]. Compared with the other physical characteristics, palm print authentication has

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_21,

several advantages: (1) low-resolution imaging; (2) low intrusiveness; (3) stable line features and (4) high user acceptance. It has played important roles in the application of public security, access control, forensic, banking, etc. [2]. With the growing number of applications using biometrics, there is a rising concern about the security and privacy of the biometric data itself. However, unlike credit cards, which can be revoked and reissued, biometric template of an individual has a limited number of useful biometric traits and cannot be modified (invariance of life). Once these biometric data are compromised, it is impossible to have a replacement since everyone has a unique biometric. And they may reveal sensitive information about personality and health, such as simian crease, which can be processed and distributed without the users' authorization [3]. Therefore, security and privacy of the users have been attracted more and more researchers' interest in palm print recognition performance.

To deal with these security and privacy issues, there are currently many research efforts toward protecting biometric systems against possible attacks which has been established at their vulnerable 8 points in [4]. In essence, the adopted security measures should be able to enhance biometric system resilience against attacks while allowing the matching to be performed efficiently. The straightforward solution to protect template is to apply a traditional data encryption algorithm (such as DES or AES) on the biometric template; however, due to the intra-class variations in biometric data, a small change in the raw biometric template will result in a completely different encryption form, as the data encryption algorithm required. Therefore, performing the marching process cannot be directly implemented in the encrypted domain. Before the matching process, they need to decrypted, and the privacy leak of the original template is possible [5].

To overcome this matching problem, a commonly proposed approach is not to store the original biometric template. Instead, a transformed version of the original template is stored, named cancelable biometric template [4]. For palm print-based authentication system, the idea of cancelable palm print biometric has been introduced in, which can protect the original palm print template as well as revoke and reissue novel template when the old ones are lost or stolen [6, 7]. In order to solve the intra-class template variation problem while maintaining the template, in this paper, a novel cancelable palm print template is generated by measuring the Gabor-based palm print image with a chaotic random matrix. The basic idea is to transform a real value palm print feature vector into a binary feature vector using a chaotic random matrix (the chaotic cipher has application in biometric security [8, 9]).

The rest of paper is organized as follows. In Sect. 21.2, the different biometric template protection solutions which have been investigated in the recent years are analyzed. The proposed approach for the protection of sequence-based palm print templates is illustrated in Sect. 21.3, and its security analysis is outlined in Sect. 21.4. Finally, some conclusions are drawn in Sect. 21.5.

21.2 Biometric Template Security for Palm Print Template

A biometric system can be roughly sketched as that in Fig. 21.1. As discussed in [4] and also shown in Fig. 21.1, eight possible vulnerable points have been identified and addressed systematically in a biometric system.

It consists of a sensor module, a feature extractor module, a matcher, a database and an application device which is driven to be the matcher output [4].

Among the eight attacks, the biometric templates generated by the feature extractor module, which are stored in the database or matched against previously stored templates, are the promising threat attack points. The main reason is that there is a strong linkage between user's irrevocable biometric templates and his identity. Consequently, a number of biometric template protection algorithms have been reported to overcome the security and privacy problems. There are many template protection schemes in the literature, and they are broadly classified into two categories [10]: biometric cryptosystems and feature transformation approaches.

It has been suggested that a biometric template protection algorithm should satisfy the following three requirements: (1) Security: it should be computationally hard to reconstruct the original biometric template from the transformed biometric template [8]. (2) Discriminability: the discriminability of the original biometric template should not be degraded after the transformation. (3) Cancel ability (revocability + diversity): if the transformed biometric template is stolen or lost, the algorithm should be able to generate another transformed template of an individual for different applications. The cancelable biometrics can hide private information.

To protect private information in palm prints, databases store encrypted templates because the line features can be reconstructed from raw palm pint templates. Cancelable biometrics matches with the transform domain, while traditional encryption techniques require decryption before matching. A common method to get cancelable biometric template is using random projection algorithm [11, 12]. However, these methods would degrade the original biometric performance.

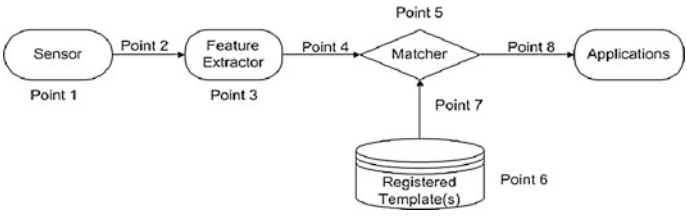

Fig. 21.1 Eight vulnerable points in a typical biometric system

21.3 Cancelable Palm Print Verification Using Random Measure

The ultimate purpose of the proposed cancelable palm print recognition system can be mainly divided into the following steps, as illustrated in Fig. 21.2.

Step 1: For reliable feature measurements, the gaps between the fingers as reference points to determine a coordinate system are used to extract the region part of a palm print image.

Step 2: The preprocessed palm print image is convoluted by a Gabor filter.

$$O(\theta) = \overline{G}(\theta_p) * I(x, y) \tag{21.1}$$

where "*" is an operator of convolution and I (x, y) is a preprocessed palm print image. The Gabor $G(\theta_p)$ is an effective tool for palm print texture analysis [2] and can be represented as:

$$G(x, y, u, \sigma, \theta_p) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right) \times \exp\left[2\pi ui\left(x\cos\theta_p + y\sin\theta_p\right)\right] \tag{21.2}$$

To make it more robust against brightness, a discrete Gabor filter is turned to zero direct current (DC) with the application of the following formula:

$$\overline{G}(x, y, u, \sigma, \theta_p) = G(x, y, u, \sigma, \theta_p) - \frac{\sum_{i=-n}^{n}\sum_{i=-n}^{n} G(x, y, u, \sigma, \theta_p)}{(2n+1)^2} \tag{21.3}$$

where (2n + 1) is the size of the filter. (u, σ, θ_p) are the Gabor filter parameters

Step 3: Given an initial seed S_0, using the following piecewise linear chaotic map to generate the random number, the distribution of the random follows uniform distribution [13].

$$s_{n+1} = F(s_n, p) = \begin{cases} s_n/p, & 0 \le s_n < p \\ 0, & s_n = 0.5 \\ (s_n - p)/(0.5 - p), & p \le s_n < 0.5 \\ 0, & s_n = 0.5 \\ F(1 - s_n, p), & 0.5 < s_n < 1.0 \end{cases} \tag{21.4}$$

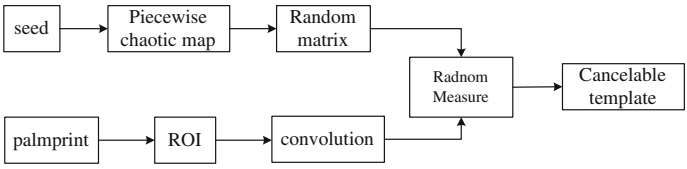

Fig. 21.2 Block diagram of the proposed cancelable template generation algorithm

where s_0 is the initial state and $s_0 \in (0, 1)$; p is the control parameter and $p \in (0, 0.5)$. It has the following characters: (1) the system is chaotic, and output signals in determined segment meet with periodicity, mixing property and determinacy. (2) The distribution is unique uniform invariant distribution.

Step 4: Coding scheme: The sample point in the filtered image is coded to two bits, by the following inequalities,

$$\begin{cases} t_r = 1 & if\ \mathrm{Re}[O] \geq s_n \\ t_r = 0 & if\ \mathrm{Re}[O] < s_n \\ t_i = 1 & if\ \mathrm{Im}[O] \geq s_{n+1} \\ t_i = 0 & if\ \mathrm{Im}[O] < s_{n+1} \end{cases} \tag{21.5}$$

Using this coding method, only the phase information in palm print images is stored in the feature vector. Figure 21.3 shows the feature generation cancelable palm print template.

Step 5: The matching scores are then calculated by the Hamming distance to measure the most similarity to test the cancelable palm print template set.

Firstly, since the main objective of the protection biometrics scheme is to provide cancelable ability, in our proposed scheme, a novel different chaotic random matrix would generate a different cancelable palm print template. Second, during measuring with a random matrix, the matching distances of intra-class are reduced, while the distances of inter-class are increased. Also, this provides an additional protection. At the same time, the cancelable palm print template can improve the describing ability in different class because of the randomness enhancement. Different applications require different sets of parameters in the random matrix. In our proposed scheme, we can generate a novel cancelable palm

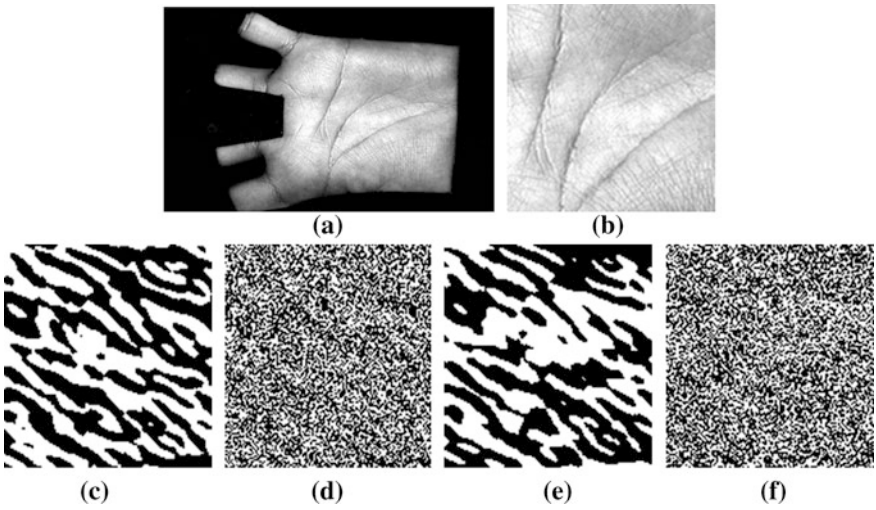

Fig. 21.3 **a** Original palm print image. **b** ROI parts of the palm print image. **c** Real part of palm code. **d** Real part of random code. **e** Imagery part of palm code. **f** Imagery part of random code

print template just with a different initial parameter or control parameter, and therefore, the secure palm print templates of an individual in different applications will be different. In turn, the cross-matching across databases will not be feasible. Moreover, the secure palm print template can be canceled and reissued by changing the chaotic parameters.

21.4 Experimental Results

21.4.1 Palm Print Database

In PolyU palm print database, there are 600 gray-scale images captured from 100 different palms by a CCD-based device (http://www.comp.polyu.edu.hk/ biometrics). Six samples from each palm are collected in two sessions: the first three samples were captured in the first session, and the other three samples were captured in the second session. The average time interval between these two sessions was two months. The size of all the images in the database was 384 $\times$ 284 with a resolution of 75 dpi. In our experiments, a central part (128 $\times$ 128) of each image is extracted for further processing. To evaluate the separation between the genuine and the impostor distributions, the discriminating index d′ (d prime) is computed to measure how well the non-match score probability density and the match score probability density are separated. The discriminating index d′ is defined as [14]:

$$d = \frac{|\mu_1 - \mu_2|}{\sqrt{\left(\sigma_1^2 + \sigma_2^2\right) \div 2}} \tag{21.6}$$

where μ_1 and σ_1 are the mean and variance of the match scores of the genuine populations, respectively; μ_2 andσ_2 are the mean and variance of the match scores of the impostor populations, respectively.

21.4.2 Experimental Performance

Figure 21.4 gives the ROC curves using the sum rule under different number of filters. The mean and variance of the intra-class and inter-class matching scores are also included in Table 21.1. From the Fig. 21.4 and Table 21.1, we can see that the verification performance using the random matrix is better than that of the palm code. Compared with the original genuine/impostor distributions, the distributions using the random matrix have smaller intra-matching scores, while the distributions using matching all-together strategy have larger inter-matching scores. Both of them can improve the authentication accuracy. As illustrated in Table 21.1, the improvement of d prime also demonstrates this point.

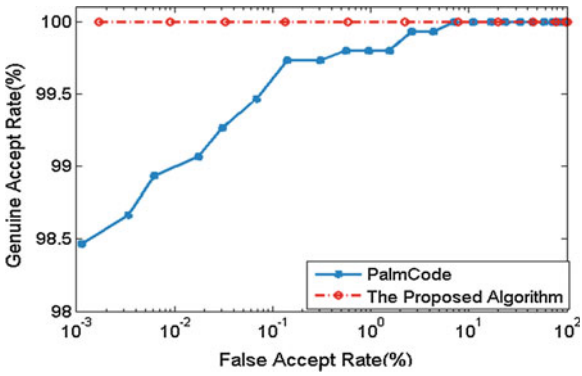

Fig. 21.4 ROC curve of different verification algorithm, including the palm code [2] and the proposed cancelable algorithm

Table 21.1 Performance of different palm print verification and the energy of every spread range target cell

	Intra-class		Inter-class		EER (%)	d prime
	Mean	Variance	Mean	Variance		
Palm code	0.2323	3.483×10^{-3}	0.4503	2.6065×10^{-4}	0.27	5.0396
Proposed algorithm	0.0671	8.4256×10^{-4}	0.4750	4.2449×10^{-5}	0	19.3901

From the Fig. 21.5a, the proposed cancelable palm print authentication algorithm can obtain zero equal error rate (EER) and yield clean separation of the genuine and impostor populations as illustrated in Fig. 21.5b. Hence, the FAR can be eliminated without suffering from the increased occurrence of the FRR. From the Fig. 21.5b, the mean value of intra-class has dramatically reduced from 0.2323 to 0.0671. The mean value of inter-class has increased from 0.4503 to 0.4750. All these properties show that the proposed scheme has more discriminative power.

21.4.3 Cancel Ability of the Proposed Authentication System

To generate cancelable palm print templates based on matrix random, we use a chaotic cipher to generate the random number. Thus, the capability of reissuing a palm print template is characterized by the key space of the employed chaotic system. Numerical experiments show that the PWCL has uniform distribution. The key space size is the total number of different keys. A good cancelable template scheme is one in which the cancelable templates are completely sensitive to all the secret keys, and the ability to reissue templates is sufficiently large to make brute-force attacks infeasible. There is one initial parameter s_0 and a control parameter p in (4); therefore, the key space in the PWCL is 10^{30}, which is enough to resist brute-force attacks.

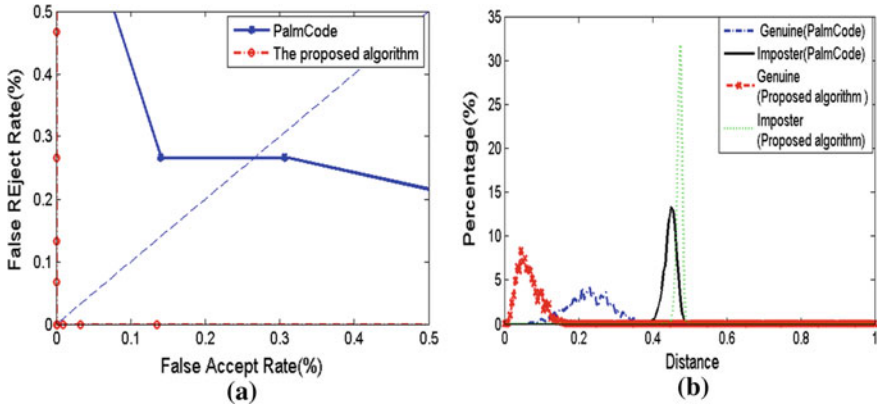

Fig. 21.5 **a** EERs of different verification algorithm, **b** Distribution of matching distance

21.5 Discussion and Conclusion

Based on the random measure, a novel palm print template protection scheme is presented in this paper. The random measure, which is generated from chaotic cipher, can be employed to provide cancel ability. Therefore, this scheme protects the template. On the other hand, the randomness is also able to increase the template describing ability. And the performance can be guaranteed. However, in our proposed scheme, only one single method is employed to protect the palm print template. There are other security risks in the scheme. In the future, we will combine the biometric cryptosystem, such as fuzzy vault and fuzzy commitment to improve the cancel ability and security of the biometric authentication system.

Acknowledgments The authors are very grateful to the anonymous referees for their helpful comments. This work was supported by grants by National Natural Science Foundation of China (No. 61070163), by the Shandong Province Outstanding Research Award Fund for Young Scientists of China (BS2011DX034) and by the Shandong Natural Science Foundation (ZR2011FQ030).

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Part III
Bioinformatics and Applications

Chapter 22
Automatic Interface Generation Algorithm Based on the Features of Colorectal Cancer Medical Record

Xiufeng Liu

Abstract In view of the limitations of popular automatic interface generation technologies in medical record management system of colorectal cancer, this paper presents a new automatic interface generation algorithm in terms of features of colorectal cancer medical record. This algorithm realized automatic interface generation control which was bound with data fields in database, also realized the basic functions such as adding, deleting, checking and altering and so on. It was testified that this algorithm can save 70 % developing time when comparing with manual method when applying it in the development of medical record management system of colorectal. This algorithm is also suitable for other medical data management system which has same data features.

Keywords Automatic interface · Colorectal cancer · Management system · Data binding

22.1 Introduction

Colorectal Cancer Medical Record Management System is an important tool for collecting medical records of patients with colorectal cancer, constructing data warehouse of colorectal cancer and processing the data mining of postoperative survival period of patients with colorectal cancer. Different from the traditional electronic medical record which base on structured design, the colorectal cancer

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_22,

Medical Record Management System is mainly used to acquire medical data. Due to this reason, the data characteristics determined that the traditional software develop method is not applicable to the development of the Medical Record Management System, and meanwhile, a rapid development method of automatic interface generation should be introduced for the goal of rapid collection of medical data. However, different automatic interface generation technology has a great influence on the development efficiency of the system. Thus it is vital to choose or design one kind of automatic interface generation technology that meets the characteristics of colorectal cancer medical data.

22.2 The Data Characteristics of Colorectal Cancer Medical Record Management System

As for present, most of the domestic hospitals still use paper medical records, and lack unified electronic medical data specification. The core professional data is extremely incomplete and non-standard. Thus the data management and statistical analysis becomes very complicated, medical data exchanges and sharing between hospitals cannot be accomplished, and the clinical data mining is difficult. The structure of medical record of colorectal cancer needs to standardize, and medical information system should be built.

Under normal circumstances, a relatively complete medical record of patient with colorectal cancer includes basic data of patients, disease assessment data, preoperative treatments data, surgical case data, postoperative treatment data, clinical observation data, pathological results and follow-up records, and other modules. Each module also may be divided into multiple record sets, each record set also contains a number of clinical indicators, each indicator may consist of several components. For instance, in the case of the property "Preoperative Treatment TNM Stage", "TNM Stage" consists of T, N and M. Also there may be multiple indicators combined to display one same pathological feature, for instance, the "mass width" and "mass height" of positive features is used to indicate the size of mass. In addition, in the past medical record of colorectal cancer, the main storage is related to indicators of Western medicine, the percentage of Chinese medicine is relatively small. Therefore, the system hopes to introduce the clinical application of indicators of Chinese medicine in addition to medical record of Western medicine, as a reference. However, it takes time to select and identify the Chinese medicine indicators, while we hope to acquire the data in the meantime. Thus the system was required to quickly adapt to the changing requirements of the clinical indicators. In response, the system should have the application of rapid generation, and should meet the characteristics of colorectal cancer medical record data.

22.3 Popular Automatic Interface Generation Technology and Its Limitations

22.3.1 Overview of Popular Automatic Interface Generation Technology

Nowadays, popular automatic generation technology is mainly divided into two broad categories: the Web software user interface (WUI) and desktop software graphical user interface (GUI). WUI usually use three-tier structure system, a more typical application is the MVC model [1], through the hierarchical structure, the model making the large amount of data processing on the server side, and the client only have to display data in tabular form, achieving a good separation of business processes and data display, thus improved the system's maintainability and scalability. This design pattern is applicable to more complex business processes and information system involved in multi-user operating [2]. On the other hand, the GUI is usually task-oriented, focusing on one or more specific operation tasks for the layout, interface element setup, layout, shortcut keys are all set to make the more efficient completion of the task [3], such as the typical library management system, patient charges system, etc. Taking into account that the colorectal cancer Medical Record Management System is only open to specific users, business process is relatively simple and requires rapid development, so the system will use the GUI automatically interface generation technology.

In the GUI automatic interface generation technology, most are based on XML technology. The main principle is based on a database table field described by XML configuration interface file, and then read the XML document using the interface generation engine and according to their descriptions, create interface elements and make the layout then display interface. For the systems need to complete the automatic storage, we need to define an event listener class to monitor the user operation may happen on the interface. This is for the achievement of the automatic storage of data; this function is also carried out by the XML configuration file [4]. On this basis, some academics have suggested function-model-presentation (FMP) interaction model, through the introduction of XML, we make archive storage of the original FMP model information and all information of interface generation, and then use the interface generation engine for parsing XML documents and generate object code, which can well realize the reuse of the interface descriptions information, thus generate different target language in different platforms [5].

In addition, there have been a variety of interface model and the corresponding interface development environment in software development, such as UML [6]. Through a combination of different abstraction levels of declarative model, UML can provide development methods and supporting technologies in the whole process from the interactive task analysis to the final interface code generation.

22.3.2 Its Limitations in the Medical Record Management System

As for automatic generation technology based on XML technologies, an XML file is needed to define, then make the configuration according to the database fields, interface layout, and monitor events. This is mainly used in systems whose demands don't change often once determined, such as network management system [7], cluster resource management system [8] and other non-medical systems. Due to the data colorectal cancer systems where data table field is not easy to identify, this approach requires constant changes in data tables, and modifies in the XML file, thus is not only inefficient, but also prone to error. Although XML automatic generation tools can be applied, but medical data have a number of one-to-many or many-to-one relationships, the new XML also need to modify the configuration to reflect the relationship between data. What's more, a new XML must be newly generated after each change, and the previous custom configuration will be overwritten. Therefore, this application is relatively rare in the Medical Record Management System. And for interface generation tools using declarative models such as UML models, we need to model the system prior to development, the program generated by the model will become bloated and difficult to maintain and update, and the complexity of the model and environmental adaptation also determined it's difficult to promotion, showing that it is not suitable for the development of Medical Record Management System. Therefore, in this paper we propose a brand-new algorithm which can realize automatic dynamic interface generation and the basic management operation according to database table structures and their changes, then at last quickly realize an information management system that meets the characteristics of colorectal cancer record.

22.4 Interface Generation Algorithm Based on the Features of Colorectal Cancer Medical Record

22.4.1 Algorithm Objectives

Automatic interface generation algorithm is based on the features of medical record of colorectal cancer. The algorithm requires an interface control that binds to the data field and can automatically generate the layout, which is automatically generated based on one specified data table structure, and requires to realize the basic database operation such as adding, deleting, searching and altering and so on.

22.4.2 Algorithm Design

22.4.2.1 Algorithm General Description

1. Acquire table field names and field types according to the data table structure.
2. Traverse the table field; call control generation algorithm and database operation statement generation algorithm according to field names and field types.
3. If the user triggers data operation events, perform database operations and call the data source binding function.

22.4.2.2 Control Generation Algorithm Based on Table Field

1. Generate the corresponding user controls according to the field names and field types, such as in Visual Studio 2008, the char variable corresponds to TextBox control, Boolean variable to CheckBox control, the time variable to DatetimePicker control, etc., and binds the control to the corresponding field.
2. Determine the number of rows and columns of table according to the number of table fields and make the panel layout in the form of table.
3. Clear layout panel and re-load all controls.

22.4.2.3 Database Operation Statement Generation Algorithm

1. Generate the corresponding statement of database insert according to the field names and field types, such as insert into Table 1 (Field 1, Field 2 … Field n) and set modified flag isInsert as true.
2. If the user performs a database operation, then determine whether it's insert operation, if so, traverse all the fields in the table, make a completion of insert statements; Otherwise, the user will perform a modify operation, set isInsert as false, and then traverse all table field and generate the update statement.
3. If isInsert is true, then execute insert statement, otherwise, perform the update statement.

22.4.3 Algorithm Application in the Medical Record Management System

22.4.3.1 Development Environment

This algorithm is realized with Visual Studio 2008, using C# language. Background database is Microsoft Access 2003, the corresponding database operation class is AccessDB.cs. This class encapsulates the definition for operations of

database connection, add, delete, search and modify, close, generate DataSet and DataTable, and acquire the name of all tables in the database.

22.4.3.2 Function Description

Use a tree structure to display the various modules and the record set under the modules of the colorectal cancer system, each record set correspond to one data table. When a record rally point is selected from the tree structure, the interface will show the data list corresponding to this record set in the form of DataGridView, and display the user controls that are already set, the value of each control is the field value corresponding to the current selected row in DataGridView. The data of current row can be modified and deleted, new records for the record set can also be added. The operation button to activate the add, delete, search and modify events of database are all common controls, it can display the data table according to the currently displayed corresponding record set, thus eliminated the need for defining separate sets of buttons for each record set.

22.4.3.3 Algorithm Realization

1. We use the tree structure to display the various modules of the colorectal cancer system and the record set under each module. In order to reflect this relationship, the system adds a data management table to store the data table name and the respective modules information. Therefore, when we need to the display the tree structure, just call FillTree method, traverse this data table and populate TreeView control.
2. Select the tree node and according to the Text property of the tree node, dynamically load the GetLoadInfo method.
3. In the record set corresponding to the current tree node, we can realize the operation of add, modify, and delete to the data table, in which the add and modify operations are completed in two steps, first step is to click the "Add" or "Modify" button, and then input the new data; second step is to click the "Save" button, having the data updated to the database. However delete operation only need to select the records in the current DataGridView, and then click the "Delete" button to delete the selected record.

22.5 Experiment Results Analysis

The Medical Record Management System used the manual approach to manufacture interfaces one by one on Visual Studio in the early time of development, which took an amount of time, however generated a lot of mistakes. The most severe problem of the manual manufacture process is the duplication work of

Table 22.1 Comparison of hand mode and automatic mode on time

	Interface making (Min)	Grouping adjusting (Min)	Data access (Min)	Total
Hand mode	30		30	60
Auto mode	6	10	2	18

obtaining and copying data from forms will have to be taken, the names of the forms are varied, and when multiple acquisition statement are listed, it is easy to have typos or miss some of the forms. Such errors will not display until debugging, thus greatly decreases the efficiency of development. Basic patient information collection, for example, as the form having the fewest fields in the system, the form requires users to enter a total of 29 form items. After the application of the automatic interface generation algorithm, the development of such form just took some 18 min of time, saving up to 70 % time compared to manual method. Low level errors such as wrong variable names are also prevented. The comparison of hand mode and automatic mode on time is as shown in Table 22.1.

22.6 Conclusion

This paper describes an automatic interface generation algorithm and its realization based on the features of colorectal cancer medical record. The algorithm directly manipulates the database, and does not need the XML file to obtain configuration information. Control displaying, data binding, and data updating are all realized through the program. One significant characteristic of the algorithm is when changes happens in the database table structure, as long as no changes happen in the data table, the program will not require additional modifications to rebuild the interface according to the database. Even the number of data table changes, only corresponding table names and their respective modules in the data management table are needed to be modified; the program does not require any changes. Thus the algorithm can well meet the features of Colorectal Cancer Medical Record Management System. It can also be applied to medical data management system with similar data characteristics, such as prescription management system, traditional Chinese medicine dialectical system, etc.

Acknowledgments This paper is supported by Guangdong Province Medical Research Foundation Project of Science and Technology, China (A2010209), and Guangdong Province Technology Project in Social Development Field of Guangdong Provincial Department of Science and Technology, China (201102).

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Chapter 23
Agricultural Flood Disaster Control Based on Information Technology

YuRong Yu, Hua Xiao and Wei-chen Hao

Abstract Agricultural information is the combination of traditional agricultural management modes and modern high-tech means, and is also the effective way in which information technology permeated to agricultural field. Agricultural information technology will play an important role in promoting future agricultural production and technological progress as a whole. With the application and development of satellite Remote Sensing technology (RS), Geographical Information System technology (GIS) and Global Positioning System technology (GPS) in the agricultural disaster field, especially the rapid application and achievement obtained in agricultural flood disaster control, 3S technology has been proved to be playing a special role in deeply exploring agricultural flood information, improving utilization efficiency of agricultural flood information and guiding agricultural production.

Keywords Disaster control · Agricultural flood · Information technology · Development · Application

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_23,

23.1 The Status of Flood Control

Combating floods is a major issue for us to protect and strengthen agriculture, and it is also the only way of the ecological, economic, social, scientific development human beings. With the progress of human society, our way to prevent and response to floods has undergone many changes. Here, we mainly divide the ideas and techniques of combating floods into two categories, traditional defense methods and modern flood protection. The traditional flood control is a passive defense, it more lies in that the disaster is unpredictable and the behavior of flood fighting occurs after the disaster, and the disasters bring serious economic losses to agriculture and other productive activities. However, the modern flood control is more a kind of active control; it applies high-tech methods and stresses prevention and a variety of non-engineering measures to avoid risks as much as possible.

In the historical period, along with social progress, the human ability to regulate and control the floods increases, but the hazard of floods is still increasing. In a very long period of time, human's responses to floods reflect a passive form of defense, due to the technological level and limitations of understanding nature, the adopted defense thinking is based on the accumulation of the experience, and its means and emergency mode is also more extensive and single, the major flood prevention measures generally include building dams and embankments, dredging, flood discharge, flood diversion and flood diversion etc. From the story of Dayu's Flood Control which has spread far and wide, we can see: in the distant ancient times, humans already have the course of the struggle with the flood. This flood control has portrayed a prototype for the concept of flood control in the historical period; the core idea of Dayu's Flood Control is to open water channels and introduce the flood into the sea through the river channels, so as to achieve the purpose of flood control. In Western Han Dynasty, since the period of Emperor Hanwu, the Yellow River continuously flooded in the lower reaches; Jia-rang put forward three plans of harnessing the Yellow River which has been regarded as the earliest planning for controlling Yellow River handed down from ancient times. The most confirmed specific program of the plans is to reroute the Yellow River to the west and make it to flow northward into the sea in the spacious area between the Yellow River and the west foot of the Taihang Mountains at that time, the principle of this approach is roughly the same with that of Dayu's approach, they are both to introduce the flood to unmanned areas or areas which have small impacts on economy by rerouting flood way. During historical period, there is still a common practice that increases the height of the embankment to resist the flood, this approach was more obvious in the Northern and Southern Dynasties, due to the development of Yangtze River Basin was greater at that time, the reclamation of land from the lake increased, ecological destruction was massive, the focus of flood control was a passive emergency, people limited the flooding threat to farmland and themselves by evading the flood and increasing the height of the embankments [1].

Although the traditional flood control measures and means has played a crucial role in a certain period of time, the shortcomings rendered and exposed are also very distinctive. First: the risks brought by such a defense to the agricultural and economic activities are great, the flood itself is a natural disaster of great contingency, its occurrence has the great unpredictability, the passive of defending brings the corresponding increase of the risk; second: the effectiveness of this defense is low, the economic cost arising from the defense is too large, and the control effect is difficult to reach the initial goal.

Since the traditional means of flood control has exposed many shortcomings, and there is an urgent need to strengthen and improve the means of flood control, with the continually advance of modern civilization, the contradictions between the human production and the flood continuously highlight, and what new ideas and means do we have to deal with the flood disaster? Judging from the specific measures taken by China and other regions of the world, the concepts and ideas of the flood control evolves as the following trends: they evolve from the large-scale engineering flood control to the conjoint flood control which combines engineering and non-engineering, from embarking on controlling natural flood alone to making efforts to adjust and standardize the social development to adapt to the laws of nature, from coping with flood in isolation and passively to coping with flood in association and actively and even using the flood.

Recently, the construction of embankments and dams is in the ascendant, they have played a great role in the flood control. After the completion of the Yongding River Guanting reservoir, the water damage loss avoided in Beijing, Tianjin, Hebei by storing a large flood is more than the entire investment in the reservoir. The small, medium and large reservoirs which are studded on the trunk stream and tributaries of Yellow River Basin and the big embankment construction on main stream of lower reaches have achieved the safety of the Yellow River for 60 years. The downstream flood control standard is also raised as Xiaolangdi Reservoir has been built up and put into operation, it can store and adjust a thousand-year to million-year catastrophic flood, so that people can have sufficient time to dredge River and strengthen dike on downstream. The river dams of the middle and lower reaches of the Yangtze River have also been heightening and thickening and strengthening several times, the Jingjiang flood diversion project in 1950s has initially increased the flood control standard of Jianghan Plain, after the completion of the Three Gorges Reservoir, it stored the catastrophic flood of the upper reaches of the Yangtze River, so that it's possible to shift flood peak of the Xiang River, Han River, Gan River and other big tributaries of the middle reaches, thus the greater flood can be avoided [2].

Brazil features an abundant rainfall, it has numerous rivers and lakes, it is also the country that floods occur with relatively high probability, the flood control measures of Brazil have certain characteristics, and this is worth our inquisitiveness and critical thinking. Brazil's flood control has engineering measures and non-engineering measures, but more are non-engineering measures. Non-engineering measures include flood-plain areas protection, guiding land use by risk zoning, early warning, forecasting and flood insurance. Brazil's practice shows

that the non-engineering measures save more investment than engineering measures and they can reduce the repair and maintenance costs and benefit the environment, and they are sustainable.

At present, we have entered the information technology era of rapid development, the system technology supported by a variety of information means, communication systems and data acquisition tools has been widely used in various social areas, therefore, the flood control has come into a stage of systematic control. In a long-term vision for the future, the full support of the system will run through the whole process of flood control. At the beginning of its formation, the system will help us analyze the causes tightly and precisely, and statistic and calculate the various elements of the factor effectively; in the formation process, we will monitor the flood dynamically, jointly, continuously, and call the model rapidly and timely to make decisions reaction; after the flood disaster has occurred, there will be an optimal emergency alternative which can minimize the loss and even change the harm into benefit, and we can transform the energy generated by flood into other forms of energy thus to benefit the society. Take United States for example, the means which the United States used to defend and control flood are very advanced, the core of the flood control of the United States is the prevention, sudden flood research, radar warning, flood forecasting, flood quantify forecast, the basin oriented probable river flood forecasting and the flood warning system are important research results of United States in the field of flood forecasting. As the system predicts the flood accurately, the best opportunity for defending flood can be achieved in the very beginning of the chain of flood control.

23.2 The Development and Application of Information Technology in Agricultural Flood Disaster Control

Combining modern information technology with agricultural flood disaster control and building data-sharing, multi-layered business collaboration unified agricultural spatial decision support system is a core of this study. We mainly study on using the online multidimensional variable technology to realize the agricultural spatial data storage and update in the online environment and using the multi-source heterogeneous data integration technology to realize the effective integration of the modeling and multi-level and multi-type spatiotemporal data of the flood disaster; and doing agriculture flood disaster spatial decision analysis on this basis. Management department can base on the analysis results to analyzing accurately and monitoring the current affairs and situation of the flood disaster and to make a fast and scientific making-decision analysis, this has facilitated the improvement of the management and decision-making mode, and this provides a sufficient decision basis for agricultural flood defense management department [3].

Informatization means the progress in the economic and social activities, which is to develop and use information resources more effectively, and to promote economic development and social progress and make the proportion of information economic value added in GNP gradually increase until to play a dominant role through the widespread use of IT and electronic information equipment. Its content includes: information infrastructure, information technology, information industry, and the information application and information services. IT is the key enabling technology which grows fastest today and has the strongest permeability and has been used most widely, it is a powerful engine of improving the economic growth and the dissemination and application process of knowledge. IT innovation and development, and its application in various fields of economy and society plays a fundamental strategic role in supporting innovative activities in all sectors and improving national economic efficiency and resolving resource environmental constraints.

The development of 3S integration technology, intelligent systems and programming techniques provides a long-term power and guarantee for the development of the agricultural flood spatial decision system. Remote sensing technology (RS) interprets and analyzes the phenomenon and targets of surface by observing electromagnetic, this uses the electromagnetic characteristic of the surface features, i.e., "all objects, due to the different types and environmental conditions, and thus has the characteristic of reflection or radiation of different wavelengths of electromagnetic waves", it is a technology which uses the objects' inherent characteristic of reflecting or radiating electromagnetic to identify objects and the environmental conditions of objects by observing electromagnetic waves. Global positioning system (GPS) is one of the navigation technologies which use Artificial Earth Satellites for point measurement, its full name is the NAVSTAR/GPS, and it is developed and established by the U.S. military organization, it is implemented from 1973 and completed in the early 1990s. The GPS system consists of three parts: the space segment—the GPS satellite constellation; ground control segment—the ground control system; user equipment—GPS signal receiver, it plays an increasingly important role in the object dynamic, precise positioning, tracking and monitoring. Geographical information system (GIS) is a system used to analyze and display spatial data, it is generally integrated with RS technology in its data utilization and software implementation, so that, in a remote sensing and GIS integrated system, remote sensing data is the important information source of GIS, GIS can be used as a powerful tool for remote sensing image interpretation, specifically, GIS is taken as an image processing tool, and remote sensing data is taken as an information source of GIS. Intelligent systems and programming techniques benefit integrating and analyzing a variety of business data in a network environment, in order to establish the various models and achieve the efficient management of multi-type, multi-scale, multi-temporal state facilities object information [4].

23.3 Conclusion

Domestic and international researches showed that agricultural flood disaster control based on 3S had made great achievements. However, 3S technology had been used to solve the problems only as technology auxiliary means in most researches, which led to some problems in information technology application. Achievement of systematic study on information technology application was rare. The next step is to uniform technology models and system framework to guide agricultural flood disaster information utilization. The purpose was to seek application mechanism of information technology integration on agricultural flood disaster control, to improve the widely guidance and reality popularization to different agricultural disaster, thereby to improve the efficiency and effectiveness of agricultural flood disaster field, it has great significance to agriculture increasing yields, and peasant increased revenues.

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Chapter 24
Study on Training Postgraduate Students Majoring in Management Science and Engineering

Zhijian Wang

Abstract The scale of postgraduate education in China is increasing rapidly in recent years, which brings the challenge of avoiding training quality reduction. Current researches on postgraduate education problems are investigated, and the outcomes are classified into two types. The principles to define postgraduate education goal scientifically in Management Science and Engineering (MSE) are presented, and the processes to formulate reasonable training program are suggested. Also the defects of traditional tutorial system are analyzed and several improved multi tutors systems are suggested.

Keywords Training postgraduate · Students majoring · Management science and engineering

24.1 Introduction

A well beginning for the postgraduate students' education weighs heavily with the positive development of that subject. For a new approved program for master degree, the key is to set up a set of effective training mechanisms so as to make sure qualified postgraduates of the specified specialty are educated, and we should pay attention to this from the very beginning.

The scale of postgraduate students training in China increases rapidly in recent years, there is growing recognition from universities and employer that we should pay more attention to improve the quality of education. How to train postgraduate

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_24,

students effectively is always a hot topic widely researched by many educators during the education reform. Many researchers have investigated different problems and situations during students educating, and suggested different training modes at different angles. We mainly research the educating students majoring in Management Science and Engineering (MSE) in this paper. Current achievements in this field mainly include two aspects as below.

(1) Subject orientation and employment demand analysis: Starting with factors that influence the formation and development of MSE discipline, Mei investigates the way in which MSE discipline forms and develops, and sets up concepts of modern MSE discipline and a MSE discipline system [1]. Ma suggests that the primary characteristic of MSE is mainly about 3 perspectives, and managerial science and engineering is the nearest discipline to the science, engineering science and techno logical science, therefore, it appears more comprehensive [2]. Zhang introduces the establishment of American Professional Science Masters [3].
(2) The study of current problems in students' education and exploration of training model: Chen believes that postgraduates education accelerate scientific research and knowledge innovation, it enhance social service, he uses Jishou university as an example and puts forward some suggestions about how to improve postgraduates cultivation [4]. Based on the review of the studies on the relationship between tutor and graduate student, Li summarizes the domestic and foreign scholars' researches from different views such as the relationship's nature, type, influence factors, problems and countermeasures to improve relations between tutors and students [5], etc. Zou analyzes the essence of education innovation, divides the innovation into theory innovation and method innovation. He proposes that the innovative ability of master graduate in management science and engineer should stress on method innovation, and discusses the ways to cultivate innovative ability of students [6]. Li believes that education model is a summary of the organizational methods and corresponsive strategies in the process of education conducting, it concerns the fixing of education target, curricular arrangement, teaching program, faculty requirement and quality guarantee system. The questions to be answered are what to educate, how to educate and so on. He compares the domestic and overseas postgraduate education models from different aspects including development process, education characteristics, conducting mechanism and so on [7].

24.2 Training Goal Definitions

The definition of training goal for a certain subject is the basis to train students. Usually in a training goal, the type of talents the students are assumed to be, the skills and basic essences the students are assumed to possess, and the possible jobs the students are assumed to be engaged in the future are defined in advance. As for

the specialized field of MSE in universities in China, we tend to orientate towards training students understanding methodologies, theories and related technologies in management science. This type of orientation reflects the demand for higher education in our country, but it doesn't demonstrate the characteristic of different universities at all. In addition master of engineering education predominantly trains persons with application ability, and so management class master of engineering education should stress on forming the ability to solve practical management problems related with engineering technology.

Deviate from master of engineering, master of science aims to train students as higher level research talent in principle and it is a transition degree corresponding to research posts, so research talent is the target of master of science education and research ability is stressed for such students.

The master program of MSE cultivates students and awards them the degree of scientific master in engineering or management, and following factors should be taken into account: (1) No matter recognize from the viewpoint of engineering or management, MSE is a subject where application is stressed greatly; (2) For a new program for postgraduate, as the first time step of enrolling new students, usually the source of students will not be an idea situation.

For example, a local university is with economy, management and law as its core subjects, maybe its engineering subject is not so powerful but it truly has its advantages in the field of information management and information system, this is a field which needs a lot of practice. For these reason it is not suitable for MSE in this university to aim at training students for purely academic research. So a scientific and reasonable training goal definition is the first and key step of the development of an academic program.

24.3 Formulating Reasonable Training Program

Postgraduate training program is the specific practice to put the training goal into effect. The training plan works as not only the primary teaching file for student education and degree award, but also the foundation for quality control, inspection and evaluation. The training programs center on the realization of training goal. To decide the degree courses, subject research direction, development, advantage and characteristic are important factors to be taken into account. Scientific dissertation whole process management is hoped. To study and define course scheme and teaching plan for the subject of MSE is the condition-prerequisite of carrying student education.

Theory and practice should both be paid attention to in curriculum provision. Core courses of MSE include management, economics, operational research, modern computer networks, etc. Usually the core courses design might be influenced by subject direction, for example, advanced information management system and data mining can be arranged for direction of information management, while business intelligence and information security should be arranged for direction of E-commerce. Methodology courses should be required, such as system

engineering, decision method and model, predication method, analysis and design of management information system, etc.

Selection of dissertation topic should link closely with development frontiers of MSE and trace hot issues in studies of problems calling for immediate solution. Systemic concepts are required during course arrangement, and entirety optimization of vertical and horizontal combination also helps to reach an idea result. From the horizontal run, course teaching of postgraduate should be accompanied by other training measures such as scientific research, social practice and so on; from a vertical perspective, postgraduate education should be joined together with courses of undergraduate stage, a step-down method is suggested here. An imparting teaching method aims to impart knowledge to student, while the postgraduate course teaching should change to a kind of researching teaching which aims at training the students' ability of bringing forth new ideas, so the interactive and enlightening teaching mode, lecture mode teaching and discussing mode teaching should be encouraged.

All postgraduate courses have a common and fundamental goal, namely to serve for cultivation of high-level talents. A scientific courses arrangement of postgraduate is the premise and guarantee of high quantity education. Cultivating the ability of knowledge acquisition for students should be emphasized, so that they can effectively update their obtained knowledge constantly in order to satisfy the science development and real application.

In order to guarantee the flexibility and knowledge space for both teachers and students, basic subjects, especially basic theoretical courses should be fewer but better. We can expand the knowledge to MSE related subjects; the arrangement should reflect the original knowledge structure of MSE as well as widen the vision. As the effective media for culturing personality for students, optional course should pay close attention to the latest development of science and technology in today's world, and do their best to be multiple and agile. Some MSE related, crossed field courses or new peripheral discipline courses help to broaden students' horizons and thoughts.

24.4 New Type Tutorial System

MSE is an interdisciplinary subject concerning theory, method, technology and knowledge from many different fields including management, economics and computer science. For a new master program it is usually enrolls limited number of students, even sometimes the number of qualified teachers is great that that of students in the early stages.

Over more than the above-mentioned, we can explore the improvement of traditional single tutor pattern. The shortcoming of single tutor pattern is that it is easy to lead to a limited radius of knowledge for students, and it is not easy to replace a tutor even in some special occasion, sometimes it becomes one of drift.

Collective culture seems to be an effective pattern, for example a dual-tutor model or a tutors group model. (1) For dual-tutor model, another tutor from related

subject is assigned to cooperate with the original tutor, this help to overcome the deficiency of knowledge limitation brought by only one tutor model, and it also brings a stimulus to intersect cross. (2) The second type of dual-tutor model is to engage a salted expert from enterprise, this helps to train the student's practice ability. (3) The original tutor cooperates with a group in the same field or from different field, the collectivity of tutors discuss questions with students. This pattern is in fact a development of the previous two models.

24.5 Conclusion

Researching those sixty-four-dollar questions influencing subject' development helps to establish a good basis for that subject, such research should be based on practical situation of MSE in a university and should be carried at the very beginning of the subject development. The research of training goal and training program for MSE also brings important significance for other subject. The tutorial system innovation research may help to accumulate experience for other subject problems research.

Acknowledgments The paper is supported by the Eleventh-Five Year Education Plan Project of Guangdong Province (Grant No. 2010tjk143), Natural Science Foundation of Guangdong Province (Grant No. S2011010001546 and 10151032001000003). Open Research Foundation of Guangdong Key Lab of Electronic Commerce (Grant No. 2011GDECOF05). This paper is also supported by following projects of Guangdong University of Business Studies: Innovative Team Project, Graduate Education Reform Research Project and Education Reform Project of Information Science School.

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Chapter 25
Non-Invasive Ankle Brachial Index Measurement Based on Pulse Wave

Nan-quan Zhou

Abstract To find a new algorithm for non-invasively detecting ankle brachial index (ABI) by synchronous acquisition of four limbs pulse wave signals and cuff pressure-wave signals based on waveform character method and amplitude coefficient method in priority rule. The turning point was judged in certain range by calculating the difference of adjoining pulse waves and their relative ratio based on priority rule. The method settled the problem of misjudgement of the turning point before systolic blood pressure (SBP) and around average pressure. Many cases analyses and lots of clinical tests proved the algorithm effective and reliable. ABI is a handy and dependable predictor of atherosclerosis; it is associated with conventional risk factors such as age, blood pressure, and so on.

Keywords Ankle brachial index (ABI) · Systolic blood pressure (SBP) · Arteriosclerosis · Priority rule

25.1 Introduction

When blood flows in the arteries of human body, blood pressure between lower extremity arteries and upper limb artery has significant difference. Clinically, a new cardiovascular hemodynamic parameter is defined because of this difference: ankle brachial index (ABI), this parameter is the ratio of systolic blood pressure (SBP) between dorsal pedal artery and upper arm artery [1]. ABI not only can be applied to diagnose peripheral arterial disease (PAD) [2], but also to detect

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_25,

coronary atherosclerosis, aortic valve calcification, mitral valve calcification, rheumatoid arthritis. It is a strong predictor in cardiovascular events and mortality [3, 4]. Therefore, accurately measuring ABI accurately for prevention and diagnosis of cardiovascular disease has significant value [5, 6]. Based on waveform character method and amplitude coefficient method in priority rule, a new algorithm for non-invasively detecting ABI is presented by synchronous acquisition of four limbs pulse wave signals and cuff pressure wave signals in this paper.

25.2 Detection of Ankle Brachial Index

ABI is the ratio of SBP of lower limbs ankle artery and upper brachial artery. The measurement principle of SBP for under ankle and upper arm is same, so the measurement of SBP is emphatically introduced in this paper.

The measurement for limbs SBP is based on oscillometric principles in this paper. At present there are many assessment standards to detect SBP based on oscillometric, but not an acknowledged criterion. Different blood pressure monitors use different criterions. Feature point method is a basal method of blood pressure measurement. It searches some dissimilarity of SBP from waveform of the pulse wave and determines blood pressure. Measurement of blood pressure influences on its precision in feature point method for such reasons that decided feature of waveform cannot adapt to otherness of individual and that cannot choose feature of waveform well and truly. For example, the first jump of the pulse wave corresponds to start up of the artery when it closes for being pressed in the method of determining the nature. It is a certain theory basic that the first jump is judged as SBP. It can measure tiny undulation even if cuff pressure is higher than SBP. But appearance of the first jump is not always very obvious in practice, and influences on judgment of SBP. At the same time waveform of the pulse wave is different from individual. It takes some difficulty to judgment of SBP for sometimes peak value happens again.

We start with method of determining the nature basing on difference arithmetic in researching arithmetic of blood pressure and find some difference bordering upon amplitude of pulse wave, then thinks the most margin point as breaking one. It is absolute value that is measured by the method of difference arithmetic in change of the pulse wave. In experiment and observing we find that absolute change of amplitude in the pulse wave is larger than other near the average pressure. It brings us some miscarriage of justice on measuring breaking point only in the method of difference arithmetic. With a view to the characteristic that amplitude of the pulse wave is smaller near SBP and amplitude of the pulse wave is larger near the average pressure, we conjecture with a bold hand that we maybe can work out the question that a point near the average pressure is taken as breaking one in error in the method of difference ratio. Many experiments and research prove our conjectural correctness. The method of difference ratio which is put forward is to work out difference bordering upon amplitude of pulse wave and

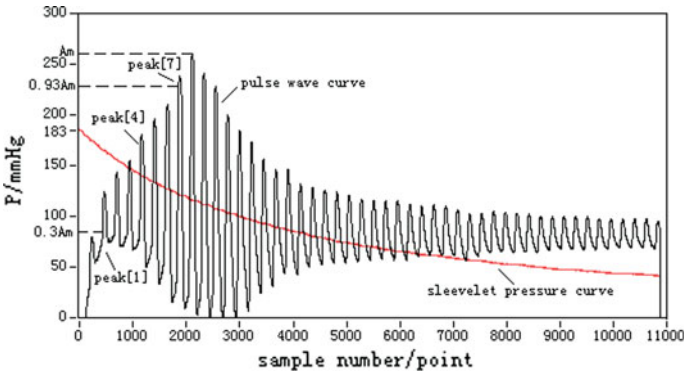

Fig. 25.1 Pulse waveform and cuff pressure-wave during the period of deflation

their relative ratio (that is to say we compare difference of the amplitude with amplitude of the front pulse wave in theirs) and determine a breaking point in priority method. We find out that the method of difference ratio can work out the question that a point near the average pressure is taken as breaking one in error, but it brings some new questions at the same time in experiment. SBP determined is always higher in practice only in the method of difference ratio. It is a reason that amplitude of pulse wave before SBP is smaller and difference bordering upon amplitude of pulse wave is larger. In order to seek the best method of determining blood pressure, we recur to some other theories. We get some illumination from the characteristic of pulse wave in amplitude characteristic ratios method. In this way the pulse wave amplitude corresponding to SBP is related to the ratio of the largest amplitude. The ratio is 0.3–0.93 in SBP. Considering these rules, many cases analysis and clinic experiments, we put forward a new method to determine SBP based on coefficient difference ratio priority method. Figure 25.1 shows the comparison results of SBP by difference method, difference ratio priority method and coefficient difference ratio priority method.

Peak [1] the SBP point according to difference ratio priority method; peak [4]: the SBP point according to coefficient difference ratio priority method; Peak [7]: the SBP point according to difference method.

The waveform of a critical hypertension patients in Fig. 25.1 (sex: male, age: 69, height: 171 cm, weight: 66 kg), analysis results is as follows (Table 25.1).

25.3 Clinical Study

25.3.1 Relationship Between ABI and Coronary Atherosclerosis

According to the guidelines of ACC/AHA coronary arteriography, 208 patients (male 123, female 85, age 62.06 $\pm$ 8.27) participated in normal coronary angiography, there

Table 25.1 The results of three methods

Method	SBP (mm Hg)	Normal range of SBP
Difference method	121	$90 \leq SBP \leq 140$ mm Hg
Difference ratio priority method	164	
Coefficient difference ratio priority method	143	

are 121 patients with coronary arterial lesion (one-vessel stenosis group: 42, two-vessel stenosis group: 44, three-vessel stenosis group: 35) and others without coronary arterial lesion. At the same time ABI is detected for all candidates. Table 25.2 shows the analysis results: ABI have significant difference ($P < 0.001$) between normal group and coronary arterial lesion group, and ABI have significant difference ($P < 0.001$) among one-vessel stenosis group, two-vessel stenosis group and three-vessel stenosis group. The more serious coronary arterial lesion is, the smaller ABI is. The pearsonion correlation coefficient of coronary arteriography integration and ABI is -0.752 ($P < 0.001$), the higher coronary arteriography integration is, the smaller ABI is, ABI has reverse correlation with coronary arteriography integration, the reduction of ABI shows that coronary arterial lesion is more serious, so ABI can predict the severity of coronary artery lesions.

25.3.2 Analysis of Correlation Between ABI and Age

Before correlation analysis, we first verify whether ABI and age are both of normal distribution. Single-sample tests of Kolmogorov–Smirnov show that they are in line with the normal distribution. Figure 25.2 shows pearsonion correlation analysis and scatterplot chart analysis of ABI and age.

ABI is negative correlation with age ($r = -0.608$, $P < 0.01$), it verifies the fact that artery occlusion degree is more serious as he gets older.

Table 25.2 Comparison of coronary angiography score and ABI in different abnormal coronary angiography groups ($\overline{x} \pm s$)

Group	n	Coronary angiography score	ABI
Normal group	87	0.51 ± 0.82	1.24 ± 0.05
One-vessel stenosis group	42	26.23 ± 17.78	0.97 ± 0.03*
Two-vessel stenosis group	44	32.54 ± 15.22	0.91 ± 0.08*#
Three-vessel stenosis group	35	52.41 ± 23.63	0.88 ± 0.11*#+

* $P < 0.001$, as compared with normal group; # $P < 0.001$, as compared with one-vessel stenosis group; + $P < 0.001$, as compared with two-vessel stenosis group

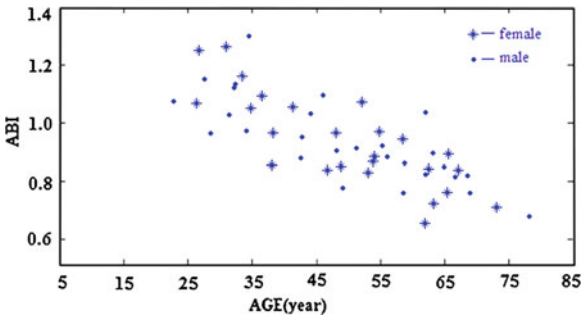

Fig. 25.2 The distribution map between *ABI* and *age*

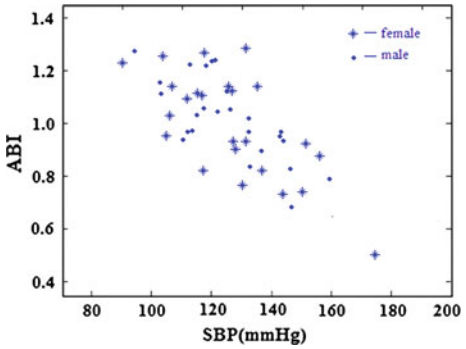

Fig. 25.3 The distribution map between *ABI* and *SBP*

25.3.3 Analysis of Correlation Between ABI and SBP

First we verify that SBP and ABI are both of normal distribution. Figure 25.3 shows pearsonion correlation analysis and scatterplot chart analysis of ABI and SBP.

Data processing shows that markedly negative correlation between ABI and SBP are presented ($r = -0.734$, $p < 0.01$). It verifies the fact that artery occlusion degree is more serious as ABI reduces.

25.4 Conclusion

In this paper the measurement of ABI is as simple as regular blood pressure measurement, it has many advantages such as repeatability and non-invasive, therefore, can be used in the clinic of general, also suitable for large-scale crowd PAD routine screening for diseases, so as to reduce the harm of artery atherosclerotic disease.

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Chapter 26
Analyze the Superiority of HEV Based on Systems Science

Ting Yan, Bin Yan, Yanqing Hu, Zhang Shumei and Lin Yang

Abstract This paper selects the dual-clutch type of parallel hybrid vehicles to run vehicle simulation in the China city bus typical driving condition and displays the curves of major parameters of main components such as the engine and the electric motor. Meanwhile, it compares the fuel consumption, acceleration performance and climbing ability of HEV system with conventional car system and obtains the superiority of HEV system in terms of the vehicle dynamic performance and fuel economy. The purpose of this paper is to analyze the science rationality from the point of systems and subsystems and whole emergence referred to Systems Science theory through the simulation.

Keywords Hybrid electric vehicle · Systems Science · Whole emergence · Simulation

26.1 Introduction

Hybrid electric vehicle is referring to the mixed type of electric cars with more than one kind of energy converter to provide drive power. It integrates the low-emission character of the electric car and enhances the advantage of high specific power and specific energy of oil fuel at the same time. So, it has notable improvements in emission performance and fuel economy of the traditional internal combustion engine. It also increases the life mileage of electric vehicles

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_26,

and meets the comprehensive requirements of low emission, low oil consumption and high ratio of performance at the same time.

Systems Science is a new comprehensive branch of science that centers on systems thinking and synthesizes contents of multiple subjects. This paper mainly involves the relationship between system and subsystem and whole emergence in Systems Science. Subsystem refers to a part of elements that connects each other closely in some way in the form of groups with relative independence and integrity. The relationship between system and subsystem is that of including and included. Subsystems perform their own functions and contribute their power to realize functions of the whole system together. Some new properties which subsystems do not possess of will come out when subsystems form a whole system. We call this kind of properties as the whole emergence.

In the hybrid system, components such as engine, electric motor, battery pack and gearbox can be considered as independent subsystems. They finish their own tasks, collaborate with each other to achieve the power needs of the vehicle and aim to decrease the fuel consumption and improve dynamic performance. The whole emergence can also be reflected by the superiority of the hybrid system.

26.2 Control Strategy of the Hybrid System

To make the various components operate orderly and achieve the power demand target, it needs to develop a matching control strategy, which can be expressed as the following points:

When system starts up, the ISG motor works as a driving motor in a short period of time to accelerate the internal combustion engine to reach its idle speed, and then, engine starts cylinder combustion process, and then, the clutch combines and driving cycle begins.

When the car is in motion, if the battery SOC is lower than its maximum limit value, the ISG converts to generator state to charge the battery pack, but if the battery SOC is equal to or greater than the limit value, ISG do not charge the battery.

The ISG generally only just starts in the process of hard acceleration or hill climbing and assists the engine by providing power required to accelerate. And when during the general driving condition, the car is only driven by a small displacement engine and engine charges the battery pack as battery SOC is low to a certain extent, which further enhances the rate of engine load. When during the deceleration process, the battery pack absorbs the braking energy and charge itself.

Working in the mode that engine directly drives vehicle as much as possible, which the energy consumption is relatively cost-effective. The engine operation state tends to the steady state more, the better the fuel consumption and emissions performance.

Since many problems are found in the actual operation, depending only on the basic strategy is not enough. So, we need to develop more supplementary strategies particularly:

Optimizing energy allocation strategy: Distribute torque into engine and motor in accordance with the best efficiency of the system, while no acceleration is required.

SOC balance and consumption strategy: Based on the objective need, keep the balance of SOC or allow consuming SOC to save fuel and to improve fuel economy.

Parking and charging strategy: When the car stops, charge battery according to SOC.

Parking and stopping engine strategy: Reduce unnecessary fuel consumption.

Regenerative braking strategy: When the car brakes, regenerate power to recover kinetic energy of the vehicle and improve energy efficiency.

Fault diagnosis strategy: Diagnose the electronic control system and high-voltage system and take remedial measures if necessary.

Electronically controlled clutch control strategy: During the braking process, realize the function of not changing the gear position to neutral position while parking by controlling the electronic control clutch to separate, which can prolong the time and improve the efficiency of braking energy recovery; during the pure electric starting or low-speed driving process, control the electronically controlled clutch to separate to avoid the engine operating in high fuel consumption rate and low engine load areas and to avoid dragging down the engine. This can improve the driving energy efficiency.

26.3 Preparations for System Simulation

26.3.1 Parameters of Components

26.3.1.1 Parameters of Vehicle

Parameters of vehicle and gearbox are shown in Tables 26.1 and 26.2.

Table 26.1 Parameters of vehicle

Vehicle glinder mass	Vehicle max mass	Wheelbase	Coefficient of aerodynamic drag	Frontal area
12400 kg	18000 kg	6.1 m	0.58	6.89 m^2

Table 26.2 Gear ratios of gearbox and final ratio

Gear	1	2	3	4	5	Final ratio
Gear ratio	6.9	4.13	2.45	1.49	1	4.875

26.3.1.2 Parameters of Engine

HEV engines require certain amount of driving power and enough dynamic performance to meet the HEV power performance requirements. What is more, engines must cooperate with electric motors to provide HEV maximum power and make HEV reach or get close to the dynamic performance level of the conventional car (Table 26.3).

26.3.1.3 Parameters of Motor and Battery Pack

The main parameters of the motor are speed and power. Its peak power plus engine peak power shall meet the power requirements of the maximum speed of the vehicle. The main characteristic of the parallel hybrid electric vehicle is taking engine as the primary source to output power to drive the vehicle. The battery drives the motor to provide auxiliary power. The car decelerates or brakes to charge the battery. According to the structure and principle of the parallel HEV, the power of the motor can be a little smaller.

This paper selects the motor of which the peak power is 100 kw, the peak efficiency is 0.96, the quality is 120 kg, the maximum current is 400 A, and the minimum voltage is 250 V.

This paper chooses the NiMH battery as the battery pack. Its basic parameters are in Table 26.4.

26.3.2 Drive Cycle of the Simulation

To comprehensively and objectively analyze the performance advantages of dual-clutch HEV, it needs to simulate the conventional and hybrid vehicles in an extraordinary typical driving condition separately. So, we should take some characteristics of the urban road condition into account when we choose the simulated driving condition, including good quality of road surface, starting up the

Table 26.3 Parameters of engine

Cylinder diameter/stroke	Displacement	Fire order	Rated torque/speed	Max power/speed
110 mm/135 mm	5.13 L	1–3–4–2	780 Nm/1,500 rpm	151 kW/2,300 rpm

Table 26.4 Basic parameters of cell

Peak power	Max/min voltage	Rated voltage	Rated capacity	Coulomb efficiency	Number of a module
3.3 kw	15.675/ 9.135 V	13.4 V	40 Ah	0.85	29

vehicle is easy to take place while on a ramp, the average speed is not high, and engine load rate changes quite often. Therefore, we cannot just select a normal driving condition. Finally, we select the China city bus typical driving condition.

26.3.3 Simulation Software

ADvanced Vehicle SimulatOR (ADVISOR) is simulation software developed by the U.S. National Renewable Energy Laboratory (NREL). It is developed in order to match the "PNGV" program proposed by the United States. Traditional vehicles, electric vehicles, hybrid vehicles and fuel cell vehicles can be simulated quickly by ADVISOR. What is more, it has good readability and maintainability, and it can be further developed and researched. It works under MATLAB/Simulink environment.

26.4 Simulation Results and Analysis

By loading parameters of all components and driving condition, we can obtain simulation results according to the control strategy through simulation made by ADVISOR. The maps of SOC value, output torque and speed of engine, and output torque and speed of motor are shown in order as below. These parameters vary with the time of driving condition (Fig. 26.1).

Meanwhile, in order to highlight the superiority of hybrid vehicles in dynamic performance and economic performance, we arrange comparison tests for conventional vehicles particularly. We select the six-cylinder conventional vehicle of which peak power is 192 kw, which is almost equal to the output power of the hybrid vehicle. Similarly, the driving condition and other parameters of components keep the same with the hybrid vehicle. The simulation results of engine output torque and speed are shown in order in Fig. 26.2.

Except listing the curves of significant parameters of the main components, we make a table to compare the performance of hybrid and conventional vehicle, as shown in Table 26.5.

The dynamic data include time spent to accelerate from 0 to 70 km/h and 30 to 70 km/h, maximum speed and maximum acceleration the vehicle can reach. The economic data include fuel consumption of three cases of accessory torque: with air conditioner, without air conditioner, and without any accessories.

Through comparatively analyzing the fuel economy and the dynamic performance results of the hybrid system and the conventional vehicle, we can discover that the fuel economy of the hybrid vehicle has been greatly improved compared with the conventional vehicle. The increase rates of three cases of accessory torque are all more than 30 %. However, the dynamic results are more or less the same due to the output power of both the two vehicles are quite close.

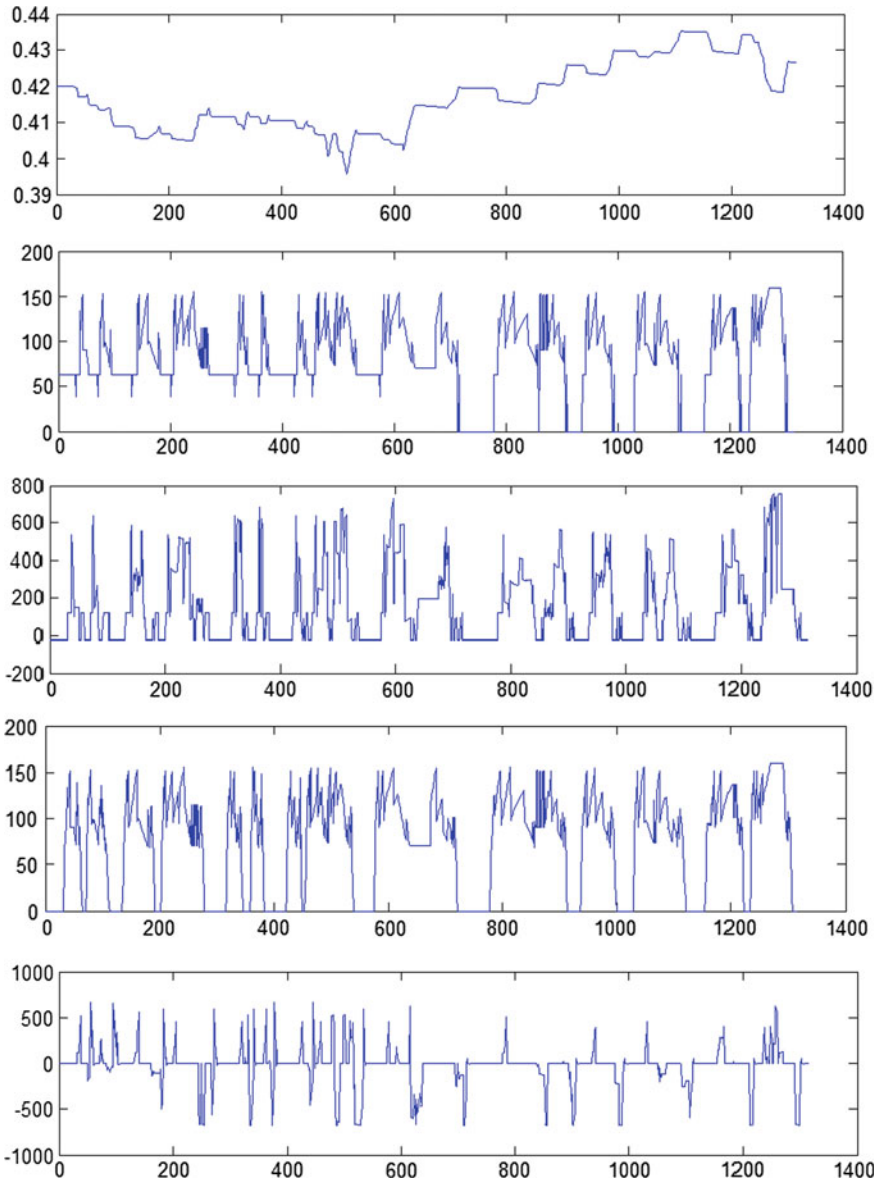

Fig. 26.1 The maps of relative parameters of engine and motor

From the point of Systems Science to analyze the superiority of the hybrid electric vehicle, the reason why the economic result of HEV is obviously better than the conventional vehicle is the "positive but not plus" system effect. The total system can produce properties that subsystems do not possess. In short, the whole is greater than its parts. The motor and the engine can be seen as subsystems to

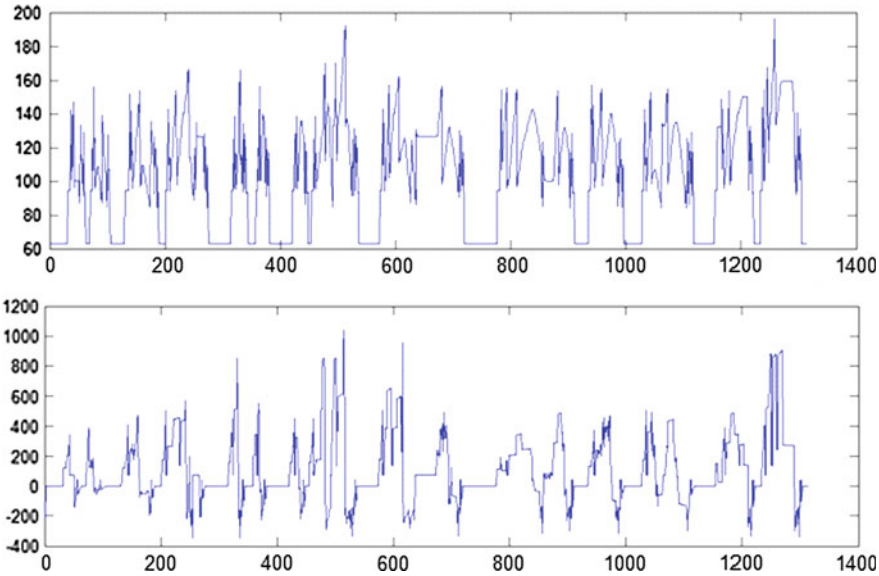

Fig. 26.2 The maps of engine output torque and speed

Table 26.5 Comparison of simulation results

	Conventional	hybrid
0–70 km/h acceleration time (s)	25.1	25.7
30–70 km/h acceleration time (s)	19.8	19.3
Maximum speed (km/h)	98.5	94.2
Maximum acceleration (m/s^2)	2.7	3.1
Grade ability (%)	34.2	32.8
Fuel economy with air conditioner (L/100 km)	50	33.1
Fuel economy without air conditioner (L/100 km)	46.8	30.6
Fuel economy without any accessories (L/100 km)	40.2	25.7

output torque to the vehicle, respectively. The total demanded torque is obtained by combining these two output torques. But when the engine and the motor work together in a hybrid electric system, some new functions would come out, which conventional vehicles or electric vehicles do not have by applying HEV control strategy, such as the functions of motor assistance to accelerate, hybrid driven mode, pure electric driven mode and pure engine driven mode. These new functions can make engine always work in a high-efficiency area. And motor can play the role of power assistance. Because of short reaction time of motor, it will help to follow up the power requirements promptly. As a result, HEV can achieve required driving power and reduce fuel consumption simultaneously, but its dynamic performance would not weaken. Although conventional vehicles can reach power requirements quite well, it does not have the features of high efficiency, zero

emission and zero fuel consumption of motor; pure electric vehicles are lack of high-energy density of engine, and the requirements of battery pack and infrastructure are critical, which makes it not widely applied. The hybrid system combines the advantages of both and in the meantime produces new properties which is good for fuel economy thanks to the whole emergence. So, it is widely used and developed pretty well.

As for the reason why the whole emergence appeals in the hybrid system, it can be explained based on the theory of Systems Science. Emergence is the effect of system integration. System organizations combine together orderly to form an ordered structure, and it will produce organizational effects. The more complex the organizations are, the more complex the emergence they produce. And when components benefit and complement each other, it will result in positive emergence effect; otherwise, negative emergence would come about. Thus, engine, motor, battery and other components in the hybrid system are operated according to a certain orders and rules, and they constitute an ordered structure, which is complex and mutually beneficial. As a result, complex emergence effect shows up.

26.5 Conclusion

This paper selects hybrid vehicles and conventional vehicles with the same parameters to run performance simulation under the same driving condition. The results show that the fuel economy of the hybrid vehicle is obviously much better than the conventional vehicle. The increase rate can reach more than 30 %. This phenomenon can be explained from the perspective of Systems Science. Due to the orderly collaboration and integration of the various components in the hybrid system, the total system will produce properties and modes which subsystems do not possess. This "positive but not plus" effect can make the engine operate in high efficiency and low fuel consumption areas and let motor assist to provide auxiliary power. It makes meeting the power needs while reducing fuel consumption possible. Conventional vehicle and pure electric vehicle do not have this kind of advantages of hybrid vehicles. This can also embody the emergence concept of Systems Science.

Chapter 27
An Evaluation Model of Stroke Rehabilitation

Wen Ji, Jianhui Wang, Xiaoke Fang and Shusheng Gu

Abstract At present, the evaluation of stroke rehabilitation is mainly based on physician's experience and evaluates the degree of one of function injury for motor function, nerve function, and activities of daily living. There is no a quantitative method. Therefore, the evaluation model of stroke rehabilitation is proposed and evaluates the condition of stroke patients quantitatively. Experimental results show that the evaluation model of stroke rehabilitation correlates well with the Fugl-Meyer assessment, which indicates that the model is effective.

Keywords Rehabilitation evaluation · Evaluation model of stroke rehabilitation · Rehabilitation evaluation indicator

27.1 Introduction

Stroke, also known as cerebrovascular accident, is a limited brain dysfunction, suddenly caused by cerebral vascular disease, and is a clinical syndrome which can last more than 24 h or caused death. With the aging of the world have become increasingly prominent, and the number of cardiovascular and cerebrovascular disease are increasing, thousands of people are deprived of one or more of exercise capacity. The motor deficit has seriously affected their quality of life and brought a heavy burden on society and family [1]. The rehabilitation of stroke patients has been widespread concern. Also, rehabilitation evaluation which is the premise of rehabilitation estimates functional status and potential ability of patients. Therefore,

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_27,

rehabilitation evaluation has a great significance on stroke patients, their family, and our society.

At present, evaluation of stroke rehabilitation at home and abroad is mainly physician, which provide the corresponding single clinical scale (including simple Fugl-Meyer assessment scale, functional independence measure scale, and China stroke scale) scores [2, 3] and estimate the degree of stroke patients' function (including motor function, nerve function, and activities of daily living) injury. There is no a quantitative method [4, 5]. So, the current research focusses on the design and development of quantitative evaluation of motor function devices and methods. Recently, there is no research in our country, but in foreign countries, they have developed a number of automatic evaluation devices [6, 7], which can quantitatively evaluate the coordination and restricted motion of upper shoulder and elbow joint after brain injury. However, these devices can evaluate certain single motor function quantitatively. Thus, this paper establishes an evaluation model to achieve a quantitative evaluation of the patient.

27.2 Common Stroke Rehabilitation Evaluation Methods

At present, rehabilitation evaluation of stroke patients is commonly used clinical scales, which include simple Fugl-Meyer assessment scale [8, 9], functional independence measure scale, and neurological injury clinical scale for stroke patients [10]. These scales are used to evaluate motor function, nerve function, and activities of daily living of stroke patients.

(1) Impaired limb assessment method of motor function.

Simple Fugl-Meyer assessment scale, which included two parts: upper and lower limbs, evaluates the motor function of the shoulder, elbow, wrist, hand and hip, knee, ankle, respectively, and upper and lower limbs of the tendon reflexes and coordination. The total score is 100, in which the total score of upper limb is 66. The score of simple Fugl-Meyer assessment of upper limb function and clinical significance is shown in Table 27.1.

Table 27.1 Score of simple Fugl-Meyer assessment of upper limb function and clinical significance

Score of upper limb motor function	Grade	Clinical significance
<26	1	Severe movement disorder
26–50	2	Apparent movement disorder
51–61	3	Moderate movement disorder
62–65	4	Mild movement disorder
66	5	Normal

Table 27.2 Score of China stroke scale and clinical significance

Score of China stroke scale	Grade	Clinical significance
0–15	1	Mild neurological defect
16–30	2	Moderate neurological defect
31–45	3	Severe neurological defect

Table 27.3 Score of functional independence measure and clinical significance

Score of functional independence	Grade	Clinical significance
18	1	Totally dependent
19–35	2	Very severe dependence
36–53	3	Severe dependence
54–71	4	Moderate dependence
72–89	5	Mild dependence
90–107	6	Very mild dependence
108–125	7	Largely independent
126	8	Completely independent

(2) The assessment method of nerve function.

In China stroke scale, the highest score is 45 and the lowest score is 0. The score of China stroke scale and clinical significance is shown in Table 27.2.

(3) The assessment method of activities of daily living.

Functional independence measure (FIM): FIM includes self-care activities, sphincter control, transfers, travel, communication, and social cognition. There are thirteen moveable daily living skills and five cognitive activities of daily living. Score using 7-point scale, that is each activity's highest score is 7, lowest score is 1. The highest total score is 126, the lowest is 18. Score is given according to the degree of independence to patients, the needs of auxiliary equipment, and the quantity of help. The score of functional independence measure and clinical significance is shown in Table 27.3.

These three common stroke rehabilitation evaluation methods are used to evaluate the degree of stroke patients' functional impairment, but cannot evaluate quantitatively. Thus, it is need to build a comprehensive and quantitative evaluation model of stroke rehabilitation.

27.3 The Establishment of Evaluation Model of Stroke Rehabilitation

Rehabilitation medicine indicated that the rehabilitation of stroke patients is not only related with the recovery of motor function, but also with nerve function and activities of daily living. For now, the evaluation of stroke rehabilitation is mainly

based on physiatrists' practical experience which evaluates the physical, mental, and speech aspects. The physical evaluation includes limb motor function, activity of joint motion, muscle spasms, balance, reflexes, sensation, daily living skills, and so on. The mental evaluation is mainly including intelligence and emotion of stroke patients. The speech evaluation is to examine aphasia and dysarthria of the patient.

Considering that the evaluation of stroke rehabilitation has no quantitative method. Thus, the establishment of an evaluation model of stroke rehabilitation is very important. For now, the method of modeling mainly includes linear, nonlinear, and the combination of linear and nonlinear [11]. The calculation process of linear method is simple, which applies to the situation of independent evaluation indicators, and is not sensitive to the difference in evaluation object. The nonlinear method applies to the situation of associated evaluation indicators and is sensitive to the difference in evaluation object. The combination method has the advantages of the linear and nonlinear method, but the calculation process is complex.

The purpose of the rehabilitation evaluation is to evaluate the condition of stroke patients and to highlight the different conditions of the patients. Also, the stroke patients' functional condition affects each other, which including their physical, mental and speech aspects, and so on. It means that their functional condition has a strong correlation. Considering the feature of the method of modeling, this paper uses the nonlinear method to establish an evaluation model of stroke rehabilitation according to the condition of stroke patients. Their condition includes muscle spasm, balance, limb motor function, speech, daily living skills, social cognition, and reflection activities. The model in this paper is:

$$y = \prod_{j=1}^{n} x_j^{w_j} \tag{27.1}$$

In formula (27.1), y is the value of the evaluation model of stroke rehabilitation (or stroke patients), x_j is the rehabilitation evaluation indicator ($x_j \geq 1$), w_j is the weight of evaluation indicator x_j, $w_j \geq 0 (j = 1, 2, \ldots, n)$, $\sum_{j=1}^{n} w_j = 1$, n is the number of rehabilitation evaluation indicator. Considering the physical, mental, and speech aspects of stroke evaluation, and clinical stroke rehabilitation evaluation methods, this paper chooses the indicator's number n is 3.

27.4 Evaluation Indicators' Pretreatment

From Tables 27.1, 27.2, and 27.3, the evaluation indicators have "very large" indicator and "very small" indicator, and the overall score of these indicators is different. Before the establishment of the evaluation model of stroke rehabilitation, the first step is to make these indicators consistent and standardized, that is to make them pretreatment. Otherwise, it will not be able to determine the value y of

Table 27.4 Standardization results of simple Fugl-Meyer assessment of upper limb function and clinical significance

Score of upper limb motor function	Standardized motor score	Grade	Clinical significance
<26	<40	1	Severe movement disorder
26–50	40–76	2	Apparent movement disorder
51–61	77–93	3	Moderate movement disorder
62–65	94–98	4	Mild movement disorder
66	100	5	Normal

Table 27.5 Standardization results of neurological function score for stroke patients and clinical significance

Score of China stroke scale	Standardized neurological function score	Grade	Clinical significance
31–45	0–33	1	Severe neurological defect
16–30	34–67	2	Moderate neurological defect
0–15	68–100	3	Mild neurological defect

evaluation model of stroke rehabilitation which is the bigger the better and it also cannot determine the patient's condition. Therefore, it is prior to make these indicators pretreatment.

(1) Consistency of evaluation indicator

As simple Fugl-Meyer assessment indicator and functional independence assessment indicator are "very large" indicators, but the china stroke indicator is a "very small" indicator. Change the china stroke indicator into a "very large" indicator, then these rehabilitation evaluation indicators are "very large" indicators.

(2) Standardization of evaluation indicator

Due to the overall indicator score of simple Fugl-Meyer assessment of upper limb function indicator, china neurological function indicator, and functional independence measure indicator exists differences, these three indicators should be standardized in order to make sure that the rehabilitation evaluation process is fair. There is no difference in dimension among these indicators, so the scores of these three indicators should be correspondingly zooming in or out. And then these three indicators will be standardized, and the overall score of these three indicators is one hundred.

Results of evaluation indicators' pretreatment are shown in Tables 27.4, 27.5, and 27.6.

Table 27.6 Standardization results of functional independence measure and clinical significance

Score of functional independence	Standardized functional independence score	Grade	Clinical significance
18	14	1	Totally dependent
19–35	15–28	2	Very severe dependence
36–53	29–42	3	Severe dependence
54–71	43–56	4	Moderate dependence
72–89	57–70	5	Mild dependence
90–107	71–85	6	Very mild dependence
108–125	86–99	7	Largely independent
126	100	8	Completely independent

After the pretreatment, according to the value of y to determine the patient's condition, the greater the y, the stroke patient's condition more light, the smaller the y, the condition of stroke patients more severe.

27.5 Model Validation of the Evaluation Model of Stroke Rehabilitation

In the process of establishing the evaluation model of stroke rehabilitation, it needs to determine the weight factor of evaluation indicators. Using the Delphi method to calculate the factor, after calculation, the factor of Fugl-Meyer assessment of upper limb function indicator, China neurological function indicator, and functional independence measure indicator are 0.4448, 0.2428, and 0.3124, respectively. Substituting the value of these weight factors into the evaluation model 27.1, we can then obtain the evaluation model of stroke rehabilitation.

From the rehabilitation center of Liaoning Province, selected ten groups were studied. Each group includes six patients. These patients understood the purpose and process of experiment. The tested people and their guardians agreed to participate in testing. Group A comprises 4 males and 2 females; average age is 47.2 ($\pm$19.4), of which 3 cases of traumatic brain injury, 2 cases of cerebral hemorrhage, and cerebral infarction in 1 case.

The values of Group A of the evaluation model of stroke rehabilitation and Fugl-Meyer score are shown in Fig 27.1.

When testing the other nine groups, their graph of the evaluation model value and Fugl-Meyer score is similar to the graph of group A. Experimental result indicates that the correlation coefficient ρ is 0.8807 between the value of the evaluation model of stroke rehabilitation and Fugl-Meyer score. This shows that the evaluation result of using the evaluation model of stroke rehabilitation and traditional Fugl-Meyer had a strong correlation. Then, the model in this paper is valid.

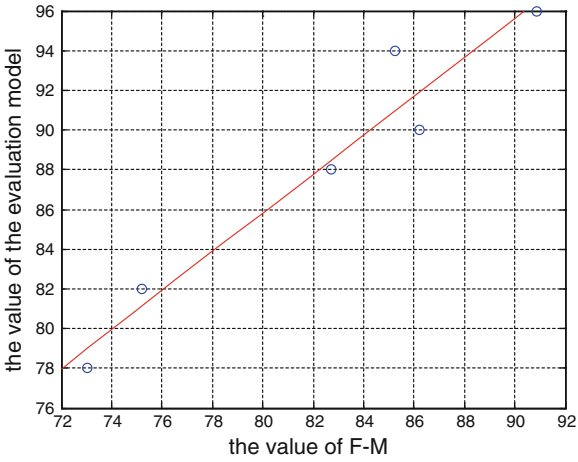

Fig. 27.1 Graph of the evaluation model value and Fugl-Meyer score of group A

27.6 Conclusion

Combining the medical knowledge of stroke rehabilitation, this paper proposed an evaluation model of stroke rehabilitation, which can substitute for traditional evaluation method, and can quantitatively evaluate the stroke patients. The experimental result shows that the model was effective. The model provides the basis for developing a scientific rehabilitation training program, which can guide the rehabilitation robot to train stroke patients.

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Chapter 28
Pediatric Clinical Nursing Management Information System

Song Li and He Guotian

Abstract In this paper, the use of software engineering prototyping ideas using rapid development tools is to design a system test version. This version can be used to demonstrate and evaluate user. With this beta version to refine their needs, system developers tap the needs of users with this beta version, system test version to improve on this basis, the final user needs quick management information system development methodology to meet the information management needs of pediatric clinical care information system. In short, the system will eventually provide the pediatric an effective platform for a health care quality assessment and performance appraisal.

Keywords Pediatric · Subsystem process · Database design

28.1 Introduction

Pediatric care information management system is an important branch of modern medical informatics [1, 2]. The course of development and current status of hospital information management system for study at home and abroad according to the needs and development of hospital information management system [3, 4] (HIS), based on combined pediatric information system characteristics and architecture of

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_28,

pediatric nursing process, the expert care model and management restructuring and optimization, and pediatric information management system database and the module, has been optimized [4, 5]. Nursing management information subsystem and nursing expert management information subsystem were studied in [6, 7].

This paper will study the system administrators, children and families and the entire information system.

In this paper, we use the prototyping and modular design, and designing pediatric care information management system with the modular design, Programming Visual FoxPro 6.0, concrete realization of pediatric care information systems.

28.2 The System Administrator Subsystem Process

The system administrator subsystem structure is shown in Fig. 28.1. Landing algorithm is shown in Fig. 28.2.

In order to facilitate system maintenance, pediatric information management system has also set up a user login log, record user login time and their operation [8, 9]. In order to strengthen the confidentiality of the system, this study proposes a dynamic password technology, the user can set a password in the login manager subsystem algorithm; system password set by the user of the cryptographic algorithms and random identification number to determine, so each ID is not the same to increase the security of the system.

28.3 Database Design

The database is inter-related data collection which is based on the organization stored together, the best way it can at least repeat as a variety of application services. The data are stored independent of the use of the application [10, 11]. The database can be said that is a warehouse to store useful information, the re-organization of the document, in order to minimize duplication of data in each file, and enhance the mutual relations between files and file records, and to achieve rational organization and sharing of data. In this study, the database library contains the Table 28.1:

Table ek_admin Fig structure. The detailed design is shown in Table 28.1.

The Fig ek_pgb Fig structure. The detailed design is shown in Fig. 28.3.

The Fig ek_hbb Fig structure the detailed design is shown in Fig. 28.4.

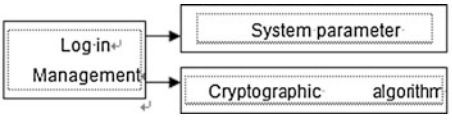

Fig. 28.1 Log management subsystem chart

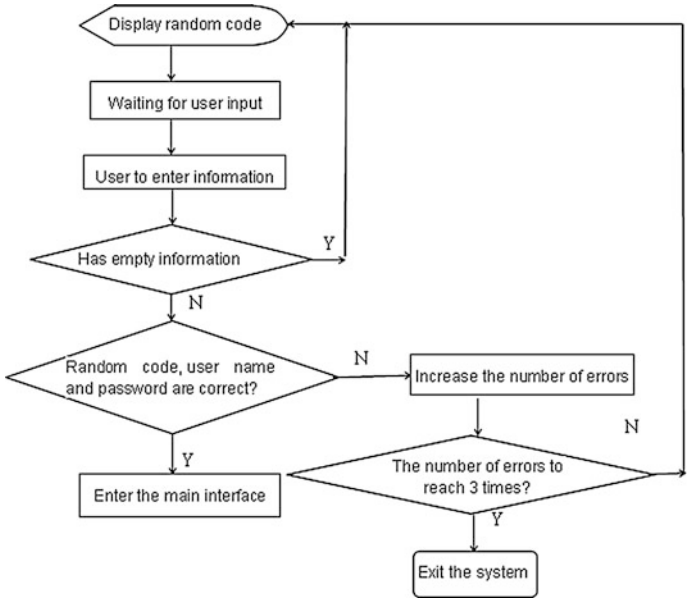

Fig. 28.2 The user registration process

Table 28.1 Ek_admin (system information Fig)

Field name	Data types	Length	Explain
Number	AutoNumber	15	AutoNumber
Admin name	Text	6	The system administrator login user name
Admin password	Text	6	System administrator login password
Department name	Text	6	Delegated to a department of the hospital
Designer	Text	6	Designer name
Sn	Text	8	Authorization number
System name	Text	6	System number
V	Text	6	Version number
Ip	Text	10	Last login IP system administrator
Time	Date and time	19	Last login time of the system administrator

The Fig ek_cyb Fig structure the detailed design is shown in Fig. 28.5.
Fig ek_ huli_huanzhe Fig structure the detailed design is shown in Fig. 28.6.
Fig ek_ huanzhe Fig structure the detailed design is shown in Fig. 28.7.
Fig ek_ the huli the Fig structure detailed design as shown in Fig. 28.8.
Fig ek_ zuanjia Fig structure the detailed design is shown in Fig. 28.9.

Field Name	Data types	Length	Explain
nurseid	Text	6	Nursing staff ID
patient and sididid	Text	6	Patients and their families ID
hosipitalbed	Data	2	Bed No.
name	Text	8	Patient name
sex	Text	2	Gender
age	Data	3	Age
hosipitalzation number	Text	15	Hospital number
address	Text	50	Home address
admission time	Date and time	19	Admission time
admission diagnose	M	10	Into the Divisiondiagnosis
nuring class	Text	2	Care level
Admission way	Text	10	Admission manner
past case	Text	20	Past medical history
past Medcine irritability	Text	20	History of drug allergy
telephone	Text	11	Contact
body temperature	Data	4	Body temperature
breath	Text value	4	Breathing
pulse	Data	3	Pulse

Fig. 28.3 Ek_pgb (children admitted to hospital evaluation form)

28.4 Environment Configuration

Windows Server 2003 is Microsoft's server operating system. The server uses Windows 2003 Server software implementation and management of the entire network system. The software is flexible and easy to use, easy to expand, to the greatest extent possible to meet the functional requirements of the pediatric network.

Visual FoxPro is a relational database management system and is the most flexible, most powerful database management system. It has a long and glorious history of the development. Start-up when the FoxBASE product of Fox Software, Inc., "Fox" (the international programming community, it's called) is a reliable, convenient and efficient programmer's database products. Joined with the Rushmore technology, the SQL statement, WYSIWYG development of reports, screen tools, the world is not a product, such as the Visual FoxPro run as it is unique.

This section is main from the user's login subsystem, and care information subsystem, department management subsystem, the care experts subsystem, children and family subsystems, medical personnel subsystem, system, system management subsystem to tell the story of a specific implementation of the system. Start of clinical pediatric care information management system will appear.

Field Name	Numeric types	Length	Explain
hosipital bed	AutoNum ber	4	The number of beds, the primary key
name	Text	6	Name
hosipitalzation number	Text	15	Hospital number
nuring grade	Text	2	Care Level
datetime	Date and time	19	Date
body temperature	Value	4	Body temperature
pulse	Value	3	Pulse
Value	Value	4	Breathing
blood pressure	Value	3	Blood pressure
state of illness and pharmacotherapeutics	Remarks	4	Condition and drug treatment
treatment fee	Numeric	8	Treatment costs
nuring fee	Numeric	8	nurse
drug fee	Numeric	8	Drug charges
total	Numeric	9	Total

Fig. 28.4 Ek_hbb (children care record Fig)

Field Name	Numeric types	Length	Explain
hosipitalbed	AutoNum ber	15	The number of beds, the primary key
name	Text	6	Name
hosipitalzation number	Text	15	Hospital number
admission date	Date of Type	10	Date of Admission
hosiptal out date	Date of Type	10	Date of discharge
nodule	Remarks	10	Discharge summary
health edification	Remarks	10	Health Education
liability nurse sign	Text	6	Primary nurse signature
head nurse sign	Text	6	Matron signature

Fig. 28.5 Ek_cyb (children discharged from the assessment form)

Field Name	Types of data values	Length	Explain
group number	AutoNumber	5	Number of the care team and patient relations, primary key
nurseid	Text	6	Nurses (Nurse ID)
patientid	Text	6	Patient ID

Fig. 28.6 Ek_ huli_huanzhe (care groups and children with relational Figs)

Field Name	Data types	Length	Explain
hosipitalbed	Text	15	The patient's bed number
patientpw	Text	6	Password to log in patients
patient name	Text	6	The patient's name
ip	Text	6	Patient last login IP
time	Date and time	19	Patients with the last login time

Fig. 28.7 Ek_ huanzhe (children information sheet)

Field Name	Data types	Length	Explain
numbering	AutoNumber	6	Nursing staff ID, primary key (the nurses login user name)
hosipitalbed	Text	6	Bed No.
nursepw	Text	6	The name of the nursing staff
nurse name	Text	6	Patient last login IP
ip	Text	6	The nurses last login IP
time	Date and time	19	Nurses last login time

Fig. 28.8 Ek_ huli (nursing information Fig)

Click on the above page, automatically enters the user login screen.

When a user puts in his or her name, password, authentication code, the system automatically logs on to the specified user interface. According to their competence in the main interface, the user can enter the appropriate subsystem.

This subsystem is the main user login management and data backup functions.

Care specialist hlzj landing into the care expert's subsystem. This subsystem is mainly care information database, expert advice, expert education, and expert research and management.

Field Name	Data types	Length	Explain
name	Text	6	Nurse Specialist ID (nursing experts login user name)
sex	Text	2	Gender
speciality	Remarks	10	Specialty
ip	Text	6	Nursing expert's last login IP
time	Date and time	19	Care expert's last landing
target name	Text	6	Consultation with the object name
contents	Remarks	M	Advisory content
remarks	Remarks	M	Conclusion

Fig. 28.9 Ek_ zuanjia (pediatric care expert's information Fig)

Matron hsz landing, the department management subsystem. This subsystem is mainly for medicines management, materials management, watch keeping arrangements, personnel management, payroll management, career planning.

Nurses hlry landing into the nursing information management subsystem *t* subsystem care information entry (admission assessment, nursing records, etc.) modify, delete, electronic medical records, query, statistics (for medical expenses, care and disease statistics), nursing classification and ward allocation internal information, print and other functions.

The medical staff ys landing, the medical personnel subsystem.

This subsystem is mainly patient information (electronic medical records, patient inquiries, patient costs), expert research, duty inquiries, individual wages query function.

Children and families of guest login access to children and their families subsystems.

The subsystem for electronic medical records inquiries, expert advice, education experts, expert selection, and the cost of query functions.

28.5 Conclusion

In this paper, we use the software engineering prototyping ideas and use rapid development tools to design a system test version. This version can be used to demonstrate and evaluate user with the help of this test version to refine their own needs. System developers digging the needs of users with this beta version, based on it, system test version can be improved, and the final user needs quick management information system development methodology. Developed to meet the information management needs of pediatric clinical care information system. And with part of the program source code.

The system optimizes the process of pediatric care, improves the staff‘s productivity, and reduces the medical records lost, mistakes, regulatory and other issues. Pediatrics run the information management system, leading to master the various indicators of quantity, quality, effectiveness, efficiency, management and is conducive to strengthening the management of pediatric and guide the development of pediatric health. Based on assessment and evaluation of individuals engaged in medical work, we can improve the operational capacity. In short, this system will eventually provide for the pediatric effective platform for a health care quality assessment and performance appraisal.

Acknowledgments This paper gets the following project support, the national 863 project “major projects with high intelligent analysis instrument online and complete system key technology research and product development” items (2012 AA040603), Chongqing major projects “high temperature flue gas more than high precision components online intelligent monitoring system research” (cstc2011ggC70001) Chongqing municipal education commission funded project (KJ110601,KJ100605,KJ090820) in this to say thank you all.

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Chapter 29
Requirements Analysis of the Pediatric Clinical Nursing Information Management System

Song Li, He Guotian and Xu Zeyu

Abstract The overall needs of pediatric care information system were defined and analyzed in the paper (the needs of hospital management, the needs of pediatric management, the needs of pediatricians, the needs of pediatric care experts, the needs of pediatric nurses, the needs of maintenance personnel, the needs of children and family), based on HIS system of the theoretical analysis and related technologies. Propose a client/server design pattern to design a chart of pediatric information management. The specific design of the pediatric care information, the pediatric department management, patient and families, leadership/doctor queries, and other pediatric care information management function modules were given in the paper. The pediatric health care processes, the matron information flow, were studied and realized. The subsystem has greatly simplified the management of clinical pediatric care, reduced costs, and has great significant to clinical pediatric care information management.

Keywords Requirements analysis · Pediatric care information management · Ideas and goals

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_29,

29.1 Introduction

With the development of nursing, care model has changed from the disease that was centered to patient-centered systematic care [1], children's health concepts, services and requirements of social needs for pediatric care have changed dramatically, pediatric care connotation, service areas and service objects are constant extension, pediatric nurses undertake more and more professional responsibility [2]. Combined with the aspects of unique characteristics of the physical and psychological, and pediatric disease special in pathology, diagnosis, treatment, prognosis and prevention, known as the "dummy subjects", the disease broke acute, deteriorated fast, high mortality, dosage small, carefully translated when dosing; noisy working environment, heavy workload [3]; parents' high expectations for pediatric care, the nurse-patient both prone to disputes, easy to form a strong psychological pressure to nurses [4]. The pediatric care information management systems, scientific and standardized care process, and nursing expert subsystem were built to ensure care scientifically, reduce errors and nurse–patient conflicts, and to provide appropriate and necessary care for patient and parents [5]. Therefore, the pediatric care information management system was particularly important in pediatric nursing resources allocate and expert care and has important theoretical value and practical significance [6].

29.2 Development Ideas and Goals

The pediatric care information management system was designed by pediatric care expert model, which includes conventional management subsystem, personnel management subsystem, and nursing expert subsystems. By discussing the design and implement of the system, using the interactive response technology and modular design method, a pediatric care information management system was built based on Visual FoxPro 6.0 and Windows XP technologies. Combining with the concept, structure and system integration of the basic principles and methods of the information management systems development, a variety of technique integration research was completed based on the nursing information management system model. The process in the pre-system model organization has become flexible, and information and data can interchange with the system, and various security measures were provided for the system.

29.3 Requirements Analysis and Design of the Pediatric Information System

29.3.1 System Requirements Analysis

The pediatric information management system should be divided into the following aspects:

The demand for the hospital-level management personnel: (1) basic information about patient; (2) basic inquiries information of the medical staff; (3) provident information of various documents; (4) wage inquiry; (5) equipment *q* inquiry; (6) management information inquiry.

The demand for pediatric management: (1) basic information about patient; (2) basic information of health care workers; (3) provident information of various documents; (4) drug inquiry; (5) equipment inquiry; (6) emissions classify; (7) pediatric management information entry and revision of hospital-level management information, pediatric information, attendance; (8) patient discharged settlement; (9) complete the medical staff wage calculation, statistics, and payment, according to the medical staff positions, visits, workload, length of service, job title.

The demand for pediatrician: (1) basic information about patient; (2) basic information of health care workers; (3) provident information of various documents; (4) drug inquiry; (5) equipment inquiry; (6) inquiry the wage of the doctors themselves according to their position, visits, workload, length of service, job title.

The demand for pediatric care experts: (1) basic information about patient; (2) basic inquiries information of the medical staff; (3) provident information of various documents; (4) wage inquiry; (5) equipment inquiry; (6) management information inquiry; (7) develop a specific care plan, modify the lower-level nursing program; (8) note nursing training news and related information; (9) on-site or online consultation; care experts in their own post (10) inquire the wage of the experts themselves according to their position, visits, workload, length of service, job title.

The demand for pediatric nurses: (1) store patient information, medical staff information, provident information of various documents, for the corresponding staff query; (2) patient admitted to hospital/discharge register; (3) determine patient care level, arrangements for nurses; (4) kind of single care plan; (5) the format of doctor; (6) medicine management, including drugs withdraw lists, drugs payment records, drug storage lists; (7) equipment management; (8) timely update, statistic and automatic processing of various inventory information; (9) inquiry management information; (10) update, statistics, automatic processing various documents, certificates and records, according to actual needs; (11) timely updates and statistical information for medical personnel, and obtained other data according to the statistics, such as nursing position, visits, workload, length of service, job title, query wage; (12) inquire the wage of the nurses themselves according to their position, visits, workload, length of service, job title.

The demand for system maintenance: including data backup, recovery and correction of erroneous data.

The demand for children and families: (1) reduce medical treatment time; (2) inquire the cost; (3) the doctor–patient communication should be immediately; (4) provide various medical treatment guide; (5) consultation of condition and health.

29.3.2 System Analysis and Modular Design

29.3.2.1 The Overall Design Ideas

HIS products nowadays were basically not involved in the hospital management, optimize the use, and improve the quality of care, social and economic benefits and competitiveness. The system used client/server (C/S) design mode, shown in Fig. 29.1.

Patient used terminal only has sent and received functions to reduce costs. Health care workers used terminal have data processing function, which can reduce the data transmission on the Internet, improve data processing speed. The main task of patient client application was: to provide the interface for user to interact with the database, to submit requests to the database server and receive information from it, to perform application logic required for client application data. The system according to business needs to determine the number of the pediatric client, initially only has 65 terminal units distributed in various departments, now have more than 90 terminal units, with the applications and the expansion of business scope of the hospital.

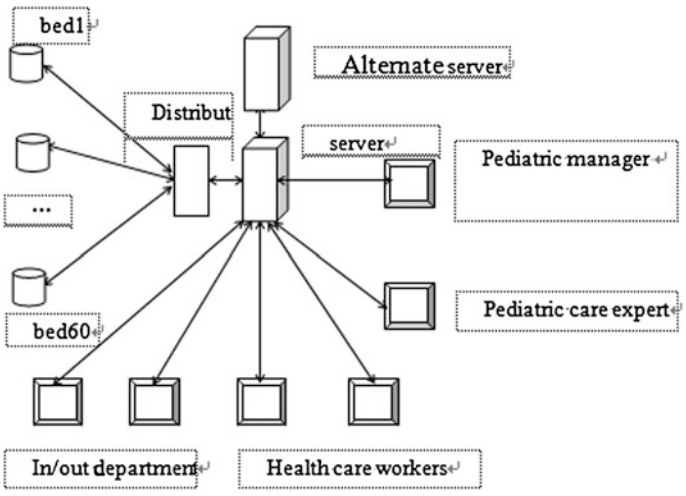

Fig. 29.1 C/S mode pediatric information management chart

29.3.2.2 Systems Analysis and Design

Client Analysis From analysis and research, the key issue of pediatric care information management system framework mode and care expert subsystem, the detailed design of all key steps was given in the system using modular design concept. The system mainly oriented to three types client: system administrator, medical staff, patients and their families. The system administrator could add routine care management process, the evaluation method and system information; medical staff could manage the patient care information, choose to add, modify, delete, query patients information, statistic patient-related costs, view nursing and related content; patients and their families could check their own information and consult to nursing experts.

The client login process mainly achieves the following functions: check password correctness; enter the system if password checks successfully; an error message appears if unsuccessful, the processing of unsuccessful times over a certain number (for example three times).

Modular Division Pediatric care process analysis and function description pediatric care process analysis pediatric care processes are shown in Fig. 29.2.

Children or their family first registered, and then the pediatric clinic checked or examined the patient to give the outcome of the diagnosis, prescription, or transfer to hospital, such as prescription, payment, receive medicine, treatment, and end. According to the patient card sent by the out-patient department to the pediatric patient registration, if needed go to hospital, pay advance money, arrange care level, specify nurses, check diagnosis, and related consult, cured through the discharge.

Function description According to the pediatric care business scope, pediatric information management was roughly divided into the follow aspects:

Pediatric inpatient register: registry information for patient with health insurance and non-insurance. Patient information with health insurance registry to the front-end health care; manage the ward and beds for patients; determine the care level and allocate nurses; deposit management, manage pay, fill or back of the deposit; print patient list; query the situation of patients admitted to hospital.

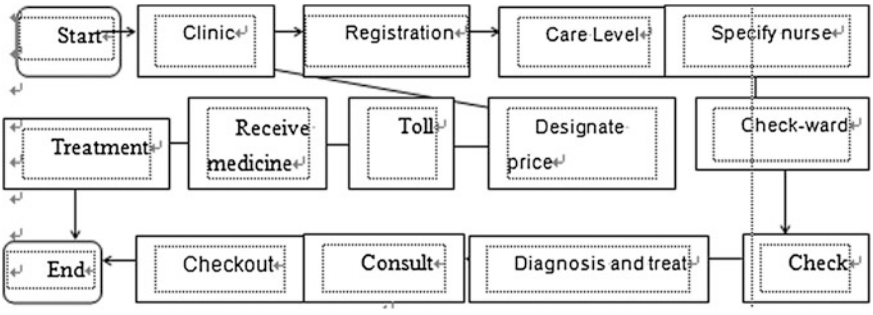

Fig. 29.2 Pediatric flow chart

Hospital settlement: settlement and pre-settlement costs by the patients in the hospital, statistic and check various costs according to separate invoice; patients discharge with no fees and re-settlement; inquiry detailed cost; Print and manage invoice.

Hospitalization and cost management of patients: provide expenses entry, modify, delete, and query functions; the medical advice function; pediatric children discharged notice to the settlement chamber; the cost of pre-nodal at any time function; clinic approval function; departments or bed chosen function; print drugs and injection shill: departments benefit accounting functions.

Patients in hospital with prescription processing functions: medicine management; query and statistics of drug costs information; prescription statistics; collar drugs/drug withdrawal function; classified management of drugs inventory; inventory functions nurse–patient communication function: provide inquiry functions.

Work flow and function description of the nursing expert function description: pediatrician classify and rescue critical patients; develop care plans; inquiry relevant information and medical advice of patients; modify the lower nurse care plan; rounds record; counseling records; education record; research record; data collection and management; care quality assessment.

Management processes and function description of matron.

The matron was the leader of daily care and the guide of the nursing skills. With relevant investigations, matron's main work was daily management (accounting for 85 %), technical guidance only points percent. The matron management subsystem for pediatric leader, which combined the information of medical and department management, providing query and statistics of the general operational aspects with a flexible search and query method, combined data tables and statistics chart, to help pediatrics' management and decision-making.

Matron management structure diagram shown in Fig. 29.3.

Demarcation and Design of Modules Pediatric information was the main line to establish the feature set for the local system, based on universal principles, and the entire feature set was divided into core feature set and extensive feature set in this study. Core feature set development was the key point, and expansion feature set was developed according to various needs. The information system could

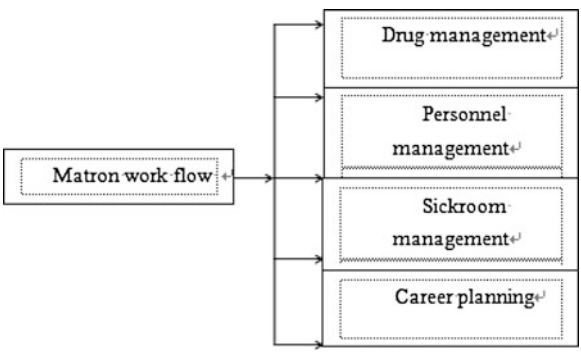

Fig. 29.3 Matron management structure chart

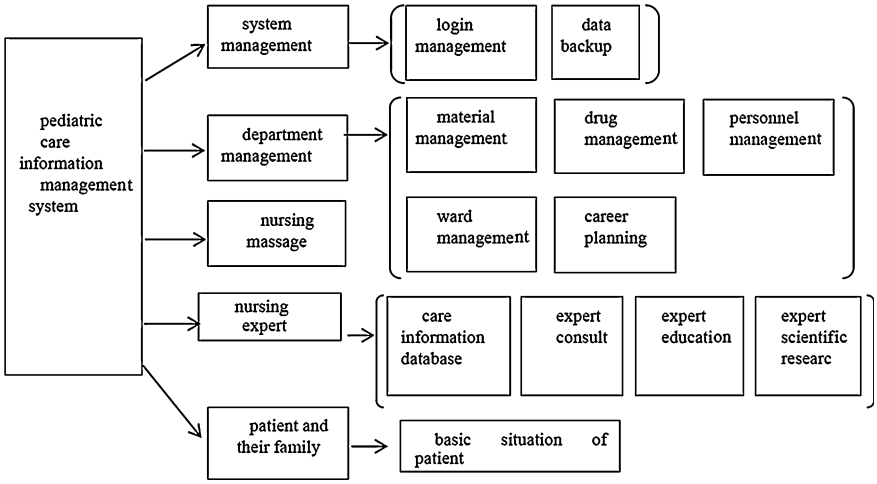

Fig. 29.4 The main structure chart of pediatric care information management system

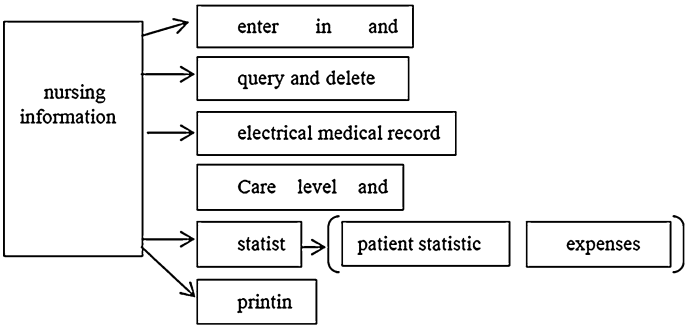

Fig. 29.5 Nursing subsystem structure chart of pediatric nursing information

increase or decrease by the size of the pediatric scale. Based on the above considerations, the whole system was divided into some subsystems: system administration, pediatric nursing management, nursing expert management, patients and their families, each subsystem was divided into different function modules. The structure was shown in Figs. 29.4 and 29.5.

29.4 Summary

The overall needs of the pediatric care information system were defined and analyzed, by using HIS system theoretical analysis and related technologies, which including hospital management needs, pediatric management needs, pediatricians needs, pediatric care experts needs, pediatric nurses needs, maintenance personnel

needs, patients and their family needs, etc. A structure chart of pediatric information management was given by client/server design mode. The specific design of many functional modules was given, such as pediatric care information, pediatric department management, patients and their families, leader/doctor query. Pediatric medical flow and head nurse work flow were also studied in this paper.

Acknowledgments This paper gets the following project support, the national 863 project "major projects with high intelligent analysis instrument online and complete system key technology research and product development" items (2012 AA040603), Chongqing major projects "high temperature flue gas more than high precision components online intelligent monitoring system research" (cstc2011ggC70001) Chongqing municipal education commission funded project(KJ110601, KJ100605, KJ090820) in this to say thank you all.

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Chapter 30
Efficient Management Method of Pediatric Nursing

Song Li, He Guotian and Xu Zeyu

Abstract There are many deficiencies in the process of transfer, admissions and treatment of traditional pediatric care. According to BPR-based theory, we propose a new type of pediatric care management processes; it makes up for the limitations of traditional pediatric care, provides more comprehensive and specific care services, greatly enhances the care quality and efficiency, saves processing time and expands services. It is truly people-oriented, personalized service that makes care more systematic, standardized and scientific.

Keywords Pediatric nursing · Nursing process · Process reengineering

30.1 Introduction

As the hospital system, medical technology, capital and other resources are homogeneous [1, 2], the focus of health institution competition is organizational structure, operational mechanisms and other factors on the process instead of production from the service, supply, marketing and technical areas [3, 4]. In the United States, Dr. Michaelttammer and Campy proposed "BPR" (Business Process

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_30,

Reengineering) that is an improvement process in the operating philosophy in 1990 [5, 6]. It redesigned and reintegrated systematically the original processes to increase valuable content, reducing the worthless content. The theory which has improved operation quality, operational efficiency, and reduced operating costs is one of the latest management theories in the 1990s [7, 8]. We introduce "BPR" to hospital management to improve our level, and it is great significance to synchronize with the development of the world's advanced hospital management level [9, 10].

30.2 The Traditional Pediatric Care Management Processes

Currently, our country's mainly pediatric care management is the traditional pediatric clinical care management process which is far from satisfying the need of clinical care [11]. With changing of the medical model, it is necessary to complement and complete traditional care management processes.

As shown in Fig. 30.1, the computer is only used as prescription processing and financial settlement of the traditional pediatric management. Physician–patient communication is not two-way communication but nurses communicate with patients. It does not meet modern nursing management and personalized service requirements. There are many problems of traditional pediatric care, as following:

1. It is a disease-centered model which does not care about children's need with psychological, social factors, etc. In this case, it is difficult to diagnosis the disease of children;
2. The purpose of nursing is not caring for children but simply care for diseases;
3. The nursing process is just caring diseases and lack of interaction between nurses and patients;
4. There is not health education; the services which children were received are limited;
5. For traditional management, this is unreasonable that the ward is only divided into neonatal (0–28 days) and normal children (28 days –14 years), while the classification method is not specific for normal children with large age span [12].

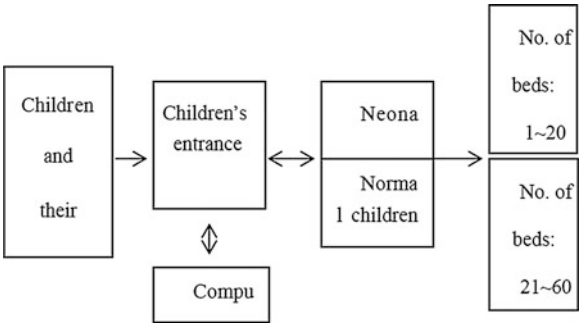

Fig. 30.1 Traditional pediatric care flow chart

Owing to the specificity of pediatric care, there are many potential risks in all aspects of the work, such as in transfer, admissions, treatment and so on. Therefore, we need to understand and analyze the traditional pediatric care in all aspects, and then improve the traditional pediatric care process and propose a better one.

30.3 Study of Modern Pediatric Care Management Processes

There are many defects in traditional pediatric care, and even probably occurs medical disputes. Based on modern philosophy of pediatric care, we put forward a modern pediatric care management process which compensates for the limitations of traditional pediatric care. There are three characteristics of the modern pediatric care management process, as following:

1. It is based on "biological–psychological–social" model.

Traditional pediatric care is disease-centered care, and the modern pediatric care is patient-centered care. The modern pediatric care is systematic and scientific which provides patients with physical, mental, social care and wide range of services. We could be clearly and systematically aware of the overall situation of nursing care and then diagnose accurately the diseases. We also could adjust the care measures according to implementation results and patients' needs.

2. Children are encouraged and assisted in nursing care, and this kind of nursing care could enhance the effect of nursing activities.

According to overall nursing care, if we increase health education content and promote the health of nursing care, then we will reduce the incidence of diseases. There is a pediatric nursing information management system. And then, nurses, doctors, nursing specialists, patients and their families can exchange their information with the system.

3. The pediatric wards are subdivision.

There is a watershed when child is 3 years old. It is very different about the probability of illness and infection disease categories when children are younger than 3 years old and older than 3 years old, then we divide the ward of general patients into ward of neonatal, infant ward and general one.

Nursing care process depends on schedule, execution qualified nursing staff and the comfortable environment. In this study, we divide the wards of general patients into infant wards, preschool wards and school-age wards in the light of the BPR theory and methods. In order to meet the patient needs, we set four entrances, consulting and guiding. We manage and schedule nurses and set up with a call system in wards and in duty offices by computer. The structure is shown in Fig. 30.2.

Figure 30.2 represents computer technology in the modern pediatric care plays an important role; it is not only used in prescription management, financial

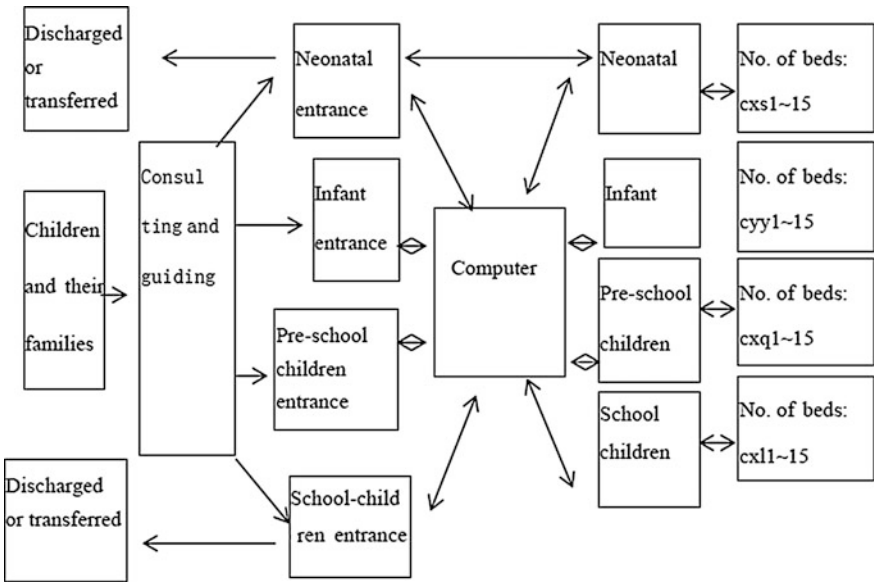

Fig. 30.2 The modern pediatric care flow chart

settlement, but also fixed the level of care, assigned bed number, arrangement nurses, nursing care, nurse–patient communication medium, automatic scheduling, consulting and so on. The system can also select children's songs, play games and tell stories. Children are happy to accept treatment in this kind of warm environment. We apply the modern pediatric care to Chongqing Municipal People's Hospital. Table 30.1 shows the difference between traditional pediatric care and modern pediatric care.

Table 30.1 shows the traditional pediatric care adopts functional approach model. Nurses are arranged randomly not considering its position and job content in this model. In this kind of model, there is no clear objective, scope of responsibility and nurse–patient communication time. The model wastes a lot of resources. For example, nursing staff spend a lot of time to repeat manual labor. Under the same number of beds and care workers conditions, the nurse–patient

Table 30.1 Contrast between traditional pediatric care and modern pediatric care

Category	Nurses/ person	Beds	Care team	Beds per team	Nurse–patient communication time/ minutes per day	Call number/ times	Efficiency/ %
Traditional pediatric care	12	60	2	30	20.1	16.2 ± 6.27	
New pediatric care	12	60	4	15	44.22	35.9 ± 7.34	51.2

communication time of modern pediatric care is about 1.2 times that of traditional one, and the call number of children is over one times, and the efficiency has improved 51.2 %. Through process reengineering, it ensures that patients are accompany with two nurses (including holidays) when patients admission and discharged from hospital. The modern pediatric care is "children-centric" concept which is satisfied with patient in processes and time. Meanwhile, the modern pediatric care process model bring modern computer technology and intelligent technology into play, which has saved daily nursing time and expanded the range of services. It is truly people-oriented, personalized service.

30.4 Summary

According to the "Business Process Reengineering" management theory, there are many defects in the traditional pediatric care management process, and then we propose a modern pediatric care management process. Modern pediatric care management process which provides more comprehensive and specific care services have resolved the defects of traditional pediatric care. Modern pediatric care management process greatly enhances quality and efficiency of care, saves processing time for routine care and expands the range of services. It is truly people-oriented, personalized service that makes care more systematic, standardized and scientific.

Acknowledgments This paper get the following project support, the national 863 project "major projects with high intelligent analysis instrument online and complete system key technology research and product development" items (2012 AA040603), Chongqing major projects "high temperature flue gas more than high precision components online intelligent monitoring system research" (cstc2011ggC70001), Chongqing municipal education commission funded project (KJ110601, KJ100605, KJ090820) in this to say thank you all.

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Chapter 31
Design of Pediatric Nursing Experts Subsystem

Song Li, Guotian He and Zeyu Xu

Abstract Information technology subsystem of pediatric care experts is an important part of clinical pediatric care management information system. We studied the model of pediatric care experts and its subsystem. We focus on the ability of pediatric care experts, the duties of pediatric care experts, the organization and implementation process and the informational implementation process of pediatric experts care. The practice shows that the subsystem has a major role to improve the clinical pediatric care information management.

Keywords Pediatric care · Information system · Pediatric · Subsystem

31.1 Introduction

The information technology subsystem of Pediatric care experts is an important part of clinical pediatric care management information system [1, 2]. With the rapid development of medical science and people's increasing health needs, the level of nurse caring must be improved [3]. In order to establish a simple and practical clinical pediatric care subsystem, we establish a kind of pediatric care mode in this chapter according to development status pediatric care expert model of CNS [4].

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_31,

Katherine De Witt, the care authority, for the first time put forward the concept of care specialists (nursing specialist) in 1900 and pointed out that modern civilization and scientific requirements for the nursing work to further improving asked for emergence of care specialists [5, 6]. In the 1980s, the United Kingdom, [7] Singapore and other countries have trained a number of CNS [7, 8]. There is no domestic specialist system [9]. The clinical nurse specialist was studied in domestic in 2001. To this end, we will study in pediatric care expert mode and information systems.

31.2 Subjects

Research has shown that the number of experts is generally in the 15–50 persons. Requirements for the research are as follows: (1) they engage in pediatric care, education, management, research more than 10 years; (2) intermediate technical titles or above titles, college degree or above; (3) involved in pediatric care, education or management; and (4) pediatric care experts.

Basis on the selected standards and the geographical distribution (we did not involve Hong Kong, Macao and Taiwan regions in this study), we finally have selected 37 experts, which are in the field of clinical care management and nursing research, throughout 37 regions, involving 37 tertiary level in the above hospital. We have recovered 35 valid questionnaires. The basic information about experts has shown in Table 31.1.

From Table 31.1, we conducted a survey of seven aspects. The Experts including elderly, middle-aged and youth work in the field of pediatric care more than a decade [10, 11]. From the point of degree and educational background view, there are middle-aged and youth experts who are quick thinking, having new knowledge structure and working in the forefront of pediatric and experienced, knowledgeable elderly pediatric experts. On account of worked, managed and educated in care for a long-term, the experts have deeper theoretical knowledge, practical experience and higher academic level. Therefore, their opinions are representative and authoritative, and then, the conclusion is convincing in light of the experts views.

31.3 Contents and Method

31.3.1 Research

Through literature review, we determined the requirements on the ability of clinical pediatric care experts according to panel discussions and expert interviews. (1) Literature: we sorted the literature of the last two decades through retrieval CNKI

Table 31.1 The basic information about experts ($n = 35$)

Projects and structural		Number of people	Percentage (%)
The age of nursing experts	30–40:	8	22.9
	40–50:	21	60
	>50:	6	17.1
The work experience of nursing experts	11–20:	20	57.1
	21–30:	12	34.3
	>30:	3	8.6
The title of nursing experts	Charge nurse	3	8.6
	Deputy director of nursing	21	60
	Director of nursing	12	34.3
The educational background of nursing experts	Specialist	2	5.7
	Undergraduate	18	51.4
	Graduate	15	42,9
The degree of nursing experts	Bachelor	17	48.6
	Master	14	40
	Doctor	1	2.9
The nature of work of nursing experts	Clinical care	14	40
	Care management	16	45.7
	Nursing research	3	8.6
	Nursing education	2	5.7
Tutor life	0–5	19	54.3
	6–10	11	31.4
	>10	1	2.9

database, Wan Fang database and foreign databases. (2) Panel discussion: Invited a several pediatrician discussion with department members who are non-pediatric health care workers, and then, we determined the initial indicators required by the clinical competence of pediatric care experts. (3) Interviews with experts: we consulted and discussed face-to-face the initial indicators with the doctors teaching in re-large nursing college and management experts. We modified the corresponding indicators on the basis of the survey result and determined indicators required by the clinical competence of pediatric care experts. Finally, we have produced the questionnaire which included practical ability, expert guidance, training, advisory capacity, research capacity, clinical and professional leadership skills, ability to cooperate, ethical decision-making capacity and 30 classification ability. The correlation coefficients are shown in Table 31.2.

Table 31.2 The quantization level of indicators of the importance, familiarity and judgment

Category	Grade				
	Grade 5	Grade4	Grade3	Grade 2	Grade 1
The importance index	5	4	3	2	1
Familiarity factor $C1$	1	0.8	0.6	0.4	0.2
Academic attainments $C2$	1.0	0.8–0.9	0.5–0.7	0.3–0.4	0.2
Foundation of judgment	Practical experience		0.4	0.3	0.2
	Theoretical analysis		0.3	0.2	0.1
	Reference to domestic and international data		0.2	0.1	0.05
	Intuitive		0.1	0.1	0.05
	Total		1.0	0.7	0.4

31.3.2 The Authority of the Research Methods and Research Objects, and the Credibility of the Contents

We issued 37 questionnaires and reclaimed 35 valid questionnaires, and the effective rate was 94.6 %. Investigations on expert questionnaires were carried out by recycling of the questionnaires. SPSS statistical software was used for statistical analysis to calculate the mean and standard deviation and perform q test and t test.

The authority of consulting experts (coefficient q) is determined by the three factors: Familiarity factor with the survey questions ($C1$), Academic attainments ($C2$), the indicators, main basis for judgment ($C3$). Expert academic achievement is divided into five grades: primary grade is defined as the first grade and its coefficient is 0.2; intermediate professional titles. Academic or specialist qualification is defined as the second grade and its coefficient is 0.3. Intermediate grade, master degree or doctor degree, is also defined as second grade and its coefficient is 0.4. Associate professors, academic or specialist qualification is defined as third grade and its coefficient is 0.5. Associate professors with master degree is also defined as third grade and its coefficient is 0.6. Associate professors and doctor degree is defined as third grade and its coefficient is 0.7. Senior professional title and academic or specialist qualification is defined as fourth grade and its coefficient is 0.8. Senior professional title and master degree is also defined as forth grade and its coefficient is 0.9. Senior professional title and doctor degree is defined as fifth grade and its coefficient is 1.0. Intuition is classified a few grades based on consultants' information and author's experience. The authority expresses authority coefficient (Ca). Ca is bigger and the information is more valuable, and the result is more reliable. The formula is $\mathrm{Ca} = (C1 + C2 + C3)/3$. The authority of the coefficient q is between 0.72 and 1.00, and the overall authority of the coefficient q is 0.87 according to questionnaires. Generally speaking, when the authority of the coefficient q is bigger than 0.70, the result is acceptable. From the results, this study has higher authority, thence the result is credible.

In this study, the stability of questionnaire is shown by internal consistency (Cranach's a coefficient). The reliability coefficient is bigger, and the reliability is higher. Many scholars hold that when the coefficient is bigger than 0.8, the questionnaire is credible and stable. The coefficient is 0.91 for this survey, and the overall authority of the coefficient is 0.87. Therefore, this questionnaire is credible and stable.

31.3.3 Clinical Competence Expectation by Consulting Experts in Pediatric Care Experts

Consultant and pediatric care experts modify prepared ability index and then survey second time. The results are shown in Table 31.3.

Table 31.3 shows, the majority of pediatricians believe that the basic ability is very important. The expectations of 10 basic ability proposed by experts is statistically significant ($P < 0.05$), and the coefficient of variation is less than 0.20. We make a Q test in 10 basic expectations of the ability and compare every two proposed clinical abilities. The expectations of the care experts include neonatal care, pediatric nursing management, routine pediatric care and clinical ability. The P value is not statistically significant ($P > 0.05$). From this, all of them agree that pediatric care specialists should have pediatric clinical nursing skills, management ability and vision. This view indicates our current nursing situation and contradiction between nurses and patients. There are a few factors: the overall quality of nursing staff is low for enrollment; most of them are secondary school students or adult colleges; parents of children irrational in the period of social transition.

The important percentage of nutrition care capacity and clinical communication skills is more than 90 %. It needs different nutrition in different child's growing stage. For example, 4–6-year-old children are in rapid growth and development of the language movement ability, and their body building bones, teeth, muscles and blood. They require large amount of nutrient, energy, protein, vitamins and minerals to fit the need for growth and development. They grow rapidly for 7–12-year-old children. Then, it is important to supply comprehensive and proportion of suitable nutrition. Adequacy of nutrition is not only relating to children's growth and physical health and intellectual development, but also improving the learning situation. Clinical communication skills, especially the ability communicating with the patients, are the basic skills. 94.2 % of the experts believe that the clinical communication skills are the basic quality in care nursing.

It is not statistically significant ($P > 0.05$) to compare with pediatric caring research, pediatric nursing education capacity, child psychology, nursing ability and pediatric care capacity each other. Both the points of children's psychological care capacity and pediatric care capacity are lower than 4.50. Teaching ability and research ability have higher expectations. 85.3 % of the experts believe that teaching ability should be the basic ability of the pediatric CNS. 72.1 % of experts

Table 31.3 The importance results of basic clinical ability ($n = 35$)

Basic ability	Very important (%)	Most important (%)	Important (%)	Less important (%)	Unimportant (%)	Average expectations $x = \bar{x} \pm s$	Coefficient of variation
Newborn care	96.1	3.9	0	0	0	4.95 ± 0.39	0.078
Routine pediatric care	93.8	6.2	0	0	0	4.96 ± 0.26	0.052
Children's nutritional care	66.7	30.5	3.3	0	0	4.66 ± 0.45	0.097
Children's psychological care	52.1	16.8	25.6	2.6	2.9	4.43 ± 0.57	0.129
Pediatric care capacity	15.4	23.7	46.1	12.2	2.6	4.35 ± 0.85	0.171
Clinical communication skills	72.3	16.7	5.2	5.8	0	4.75 ± 0.71	0.149
Clinical ability to foresee	78.5	21.5	0	0	0	4.89 ± 0.69	0.141
Pediatric care management	95.4	4.6	0	0	0	4.97 ± 0.46	0.092
Pediatric nursing education	25.3	46.8	13.2	10.8	4.9	4.68 ± 0.48	0.102
Pediatric nursing research	43.3	37.8	8.5	10.4	0	4.57 ± 0.37	0.081
Pediatric care consultation	56.1	23.5	12.6	6.7	1.1	4.82 ± 0.51	
Community care capacity	32.81	12.90	22.57	23.41	8.31	4.71 ± 0.78	

Note $P < 0.05$

believe that the 5 classification capabilities are important. This is a high level in pediatric CNS area, and the dissemination of knowledge to others is an important manifestation. Health guidance provided by clients and professional acknowledge spread by peers are the basic capacities in the pediatric CNS. 81.1 % of experts believe that access to information, research topic selection and writing skills are basic research capability.

31.3.4 The Expected Results of the Classification Ability of Pediatric CNS

We have been interviewed and surveyed 87 experts from, Chongqing, Chengdu, Shanghai, Xi'an, Beijing, Lanzhou, Guangzhou, Nanjing, Jinan, Hangzhou, Wuhan and other areas in 2009 (clinical care, nursing management, nursing education). Such we have gotten CNS capabilities as shown in Table 31.4 according to the literature and survey methods:

Experts sort the expectations of the business capacity: the ability of routine pediatric care > neonatal care capacity > nutritional care capacity > clinical communication skills > Children's psychological care capacity > their own quality > pediatrics human caring ability > clinical vision > pediatric nursing education capacity > pediatric nursing research capacity > pediatric care management capabilities > pediatric care advisory capacity > pediatric community nursing capacity. Instructions are consistent with the actual situation. Compared with Hong Kong, Hong Kong experts pay more attention on the teaching ability of the CNS and t community care capacity than the mainland. In this paper, community care capacity is less than 4.00. Some experts believe that community care capacity should be detached from CNS operational capacity. The variation coefficient of routine pediatric care, newborn care capacity and nutritional care capacity are 0–0.10, that is to say, the three basic abilities are more important than others in CNS. Human pediatric care capacity, clinical vision in pediatric nursing education capacity, pediatric care research capacity and pediatric care management capacity are in line with modern nursing development. In particular, the vision clinical ability pays an important role in dealing with emergencies and reducing medical disputes. These results indicate that the clinical pediatric care is the most basic and important capacity, which is the requirements of the CNS occupational characteristics and the foundation of further development of nursing education, nursing research and nursing management.

The variation coefficient of 13 operational capacities is 0–0.20 (except the ability of community care). If the coefficient is less than 0.20, it indicates that expert advice is uniform. If the coefficient is more than 0.20, it indicates large differences of expert opinion.

Table 31.4 The expected results of the classification ability of pediatric CNS ($x = \bar{x} \pm s$)

Classification ability	The average expectations	Coefficient of variation
1 Newborn care capacity:	4.96 ± 0.27	0.05
(a) Daily neonatal care;		
(b) Nursing ability of common diseases		
(c) High-risk child care capacity		
(d) Newborn care diagnostic capabilities		
2 Routine pediatric care capacity:	4.98 ± 0.12	0.02
(a) Pediatric surgical expertise		
(b) Pediatric surgery-based care operation		
(c) Pediatric-specialized care operation		
(d) Rescue with the ability		
(e) Observation and diagnostic capabilities		
(f) The ability to solve difficult problems		
(g) Self-development capacity		
3 Nutritional care capacity:	4.92 ± 0.35	0.07
(a) Children with the diagnosis of malnutrition;		
(b) The care of children with malnutrition		
4 Children's psychological care capacity:	4.85 ± 0.61	0.13
(a) Children with psychological and behavioral;		
(b) Psychological development in children;		
(c) Children with psychological care		
5 Human pediatric care capacity:	4.71 ± 0.69	0.15
(a) The concept of humane care;		
(b) Humane care ability;		
(c) Perception of humane care		
6 Clinical communication skills:	4.86 ± 0.52	0.11
(a) Interaction ritual;		
(b) The language of communication;		
(c) Communication skills		
7 The clinical vision:	4.69 ± 0.93	0.20
(a) The development of pediatric disease foresight;		
(b) Nurses state to assess the force;		
(c) Incident handling capacity		
8 Pediatric care management capabilities:	4.24 ± 0.85	0.20
(a) The nursing management;		
(b) The care and quality control capabilities;		
(c) Coordination capacity		
9 Pediatric nursing education capacity:	4.61 ± 0.57	0.12
(a) Teaching ability;		
(b) Children with health education capacity;		
(c) Family health education capacity;		
(d) Educational evaluation capacity		

(continued)

Table 31.4 (continued)

Classification ability	The average expectations	Coefficient of variation
10 Pediatric nursing research capacity: (a) Ability to obtain information; (b) Research and design capability; (c) Statistical analysis capabilities; (d) Thesis writing skills; (e) Published; (f) Assume the subject; (g) Innovation capability	4.57 ± 0.52	0.11
11 Pediatric care advisory capacity: (a) Newborn care; (b) Child health; (c) Children fed; (d) Prevention and treatment of common diseases frequently occurring; (e) Children with post-discharge health care and advice	4.48 ± 0.56	0.13
12 The pediatric community nursing capacity: (a) Children's community nursing knowledge; (b) Assessment of children's health; (c) Children's chronic disease care; (d) Children with disabilities care	3.82 ± 0.94	0.25
13 Their own qualities: (a) Education; (b) Knowledge of the law; (c) Prevention of cruelty to children; (d) Love the nursing work; (e) Sense of responsibility and compassion; (f) Work attitude; (g) Good health; (h) Self-regulating capacity; (i) Aggressive; (j) Teamwork;	4.73 ± 0.46	0.10

31.4 Responsibilities of Pediatric Care Experts and the Implementation Process

31.4.1 Responsibilities of Pediatric Care Specialists

For the above research, pediatric CNS duties are as follows:

1. Pediatric clinical practice is the main functions of the pediatric CNS.
2. Pediatric Nursing Research.

3. Nursing teaching knowledge and information of pediatric CNS impart to the children, their families and colleagues through clinical practice, research and consultation activities.
4. Nursing consultation.
5. Care management.
6. Social and psychological treatment.
7. Advanced nursing skills
8. Advanced medical skills for the process of organization and implementation.

In this study, we determine care specialists working structure shown in Fig. 31.1.

According to the pediatric characteristics, this study proposes expert pediatric care for newborns, infant and child care experts, preschool care specialists, school-age care specialists, pediatric nutrition care specialists, pediatric mental care specialists, pediatric care personnel education experts and pediatric consulting care specialists.

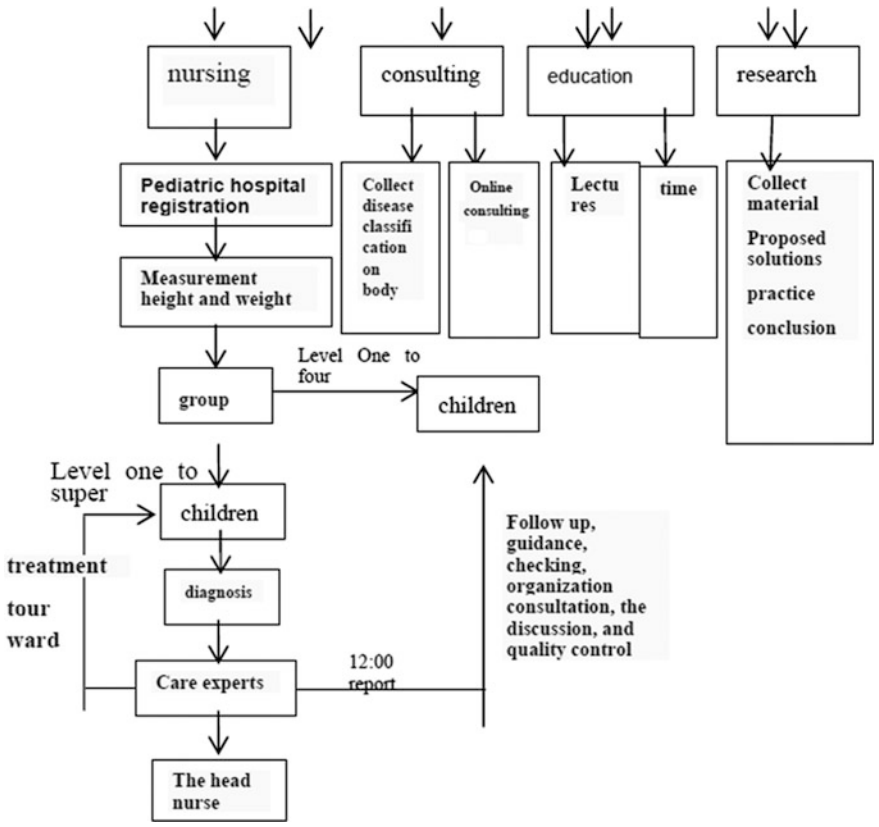

Fig. 31.1 Flowchart of care expert working

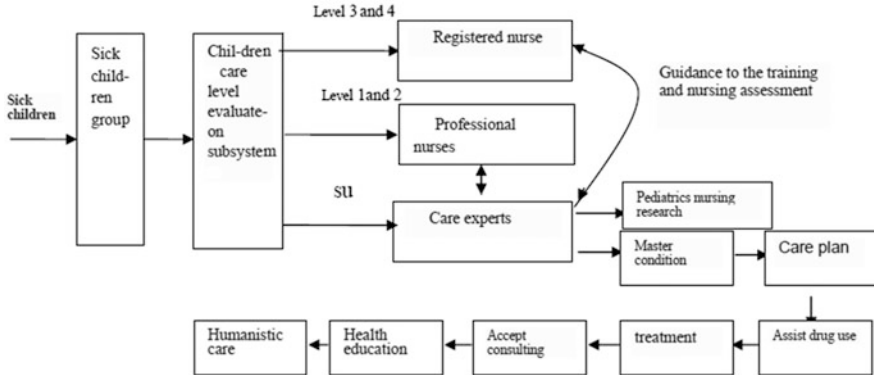

Fig. 31.2 Information flowchart of pediatric care expert care

Pediatric care expert consultation group is composed with the nurse leader and nursing specialists, experienced clinical nurses. We have organized regular expert meetings and summed up the preliminary work. Finally, we developed the best care plan and the standard of care processes. We organized lecture two times every month. Experts comment pediatrics nursing care, pediatric care and the direction of development.

31.4.2 Information Flow of Pediatric Care Expert

The process of pediatric care experts is a series of logical and orderly care to completing care task. It is shown in Fig. 31.2.

31.5 Summary

We studied clinical pediatric care information in this paper. The main subjects were the mode of pediatric care, specialist care and pediatric care expert subsystem. We focused on the pediatric care ability, duties and organization of pediatric care experts and the implementation process of pediatric experts care information management processes.

Acknowledgments The authors would like to acknowledge the support of the following projects: the national 863 project "major projects with high intelligent analysis instrument online and complete system key technology research and product development" items (2012 AA040603), Chongqing major projects "high temperature flue gas more than high precision components online intelligent monitoring system research" (cstc2011ggC70001) and Chongqing municipal education commission funded project (KJ110601, KJ100605, KJ090820).

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Chapter 32
Stochastic Credit Contagion Model for Enterprise Group

Lei Xiao, Li Li and Jiawen Xiao

Abstract Enterprise group's credit risk has obviously infectious character because of its large number of companies, complex share relation and invisible associated business. The number of low credit rating companies within enterprise group and its variance directly reflects credit contagion trend in group. Combined with graph theory and epidemiological point of view, this paper firstly analyzed credit risk contagion process in group, then proposed a stochastic credit contagion model for enterprise group and gave an example for its application. In order to get the way of controlling infection, we took sensitivity analysis for principal parameters. Our results showed that reducing risk correlation degree and risk inflectional coefficient was effective to prevent credit contagion.

Keywords Enterprise group · Stochastic credit contagion model · Credit risk correlation degree

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_32,

32.1 Introduction

Enterprise groups have always been large lending customers of commercial bank in China. Meanwhile, group companies are generally "leading enterprise" in a particular region or industry. The development of enterprise groups makes great contributions to the local economy and the development of industry. But, in recent years, some large enterprise groups, such as Delong, Jiangsu Rail, Huayuan and so on, have successively appeared financial crisis, involving a huge amount of loans and bank losses.

However, the complexity and variability of enterprise group's credit risk management are inherent. In China, enterprise group is not often a separate legal entity, but a large-scale economic union of several companies and institutions with the link of property rights, technology and business contract (see [1–3]). Usually, the default of a member within the group will cause another member or a series of companies default, showing the chain reaction of credit default and forming "domino effect" or "crisis spillover effect". Because of the infection characteristics of the enterprise group's credit risk, it is difficult for risk managers to grasp the future trend of group's overall credit risk. Thus, they always missed the best time of preventing risk, and it ultimately lead to an overall default or even serious consequences. Initiators are always some low credit rating and poor quality companies. Therefore, dynamically grasping the variety of number of such enterprises in group explores the main factors affecting the change and pursuant to find the way of preventing credit risk infection would be helpful for the overall credit risk management of enterprise group.

At present, research on the credit contagion is still in its infancy. Related study of enterprise group's credit risk in our country proposed by Chen and Zhou [4, 5]. Based on Structural model and Reduced-Form model respectively, they took theoretical analysis of credit contagion process for parent–subsidiary companies and associated firms under the control of the same parent company [4, 5]. Yet, the scope of their study is limited to two corporations. Davis and Lo [6, 7] studied the transmission of credit risk in bond portfolio, which pioneered probability model for credit contagion. But, assumptions are very rigor. David [8] is the first researcher who used copula function in the correlation analysis of credit risk infection. Giesecke and Weber [9] pointed out that the breach of critical level and their connected incomplete information were the source of credit contagion. Giesecke [10] applied multi-dimensional structure to describe an economy and modeled credit contagion process in order to discuss aggregate loss. Schönbuche [11] believed that there was no direct link between defaults, just because the information effect led to risk infection and established information driven model for credit contagion. But so far, study of credit contagion is still at a nascent stage, and lack dynamic infection model to depict the change number of low credit rating companies for enterprise group.

According to the economic union feature of enterprise group, this article used the change number of higher credit risk companies to describe credit risk infection

trend within enterprise group. Firstly, enterprise group can be seen as a graph which has member companies as its vertices. Secondly, combined with epidemic model and took into account the random interference of infection process, it applied mechanism analysis to establish stochastic credit contagion model for enterprise group, which can describe the dynamic risk transmission process among group members.

This paper is organized as follows: Sect. 32.2 builds stochastic contagion model. It first proposes the hypothesis, then derives the relationship between the number of credit abnormal companies in the group and time, and analyzes its trend over time. Section 32.3 provides example and numerical simulation, including sensitivity analysis of principal parameters in stochastic model, and puts forward the prevention measures for credit contagion within group. Section 32.4 presents the conclusion.

32.2 Dynamic Contagion Model

32.2.1 Assumption

Without loss of generality, the basic assumptions are as follows:

1. For simplicity, assume the total number of member companies in enterprise group, N, unchanged during [0, T].
2. For any time $t \in [0, T]$, according to credit rating or default probability of company, member companies within enterprise group are divided into two categories: one, called normal credit company, consists of higher credit rating or low default probability firms whose default probability is less than a specified threshold P. Note the total number of such companies as $S(t)$. The other is abnormal credit company whose default probability is higher than the previous threshold P, and their total number is $I(t)$. P $(0 < P < 1)$ is determined by manager's risk tolerance.
3. Assume that abnormal credit company can be transformed to normal credit firm, while after that it still can be transmitted into abnormal credit company. Let μ be recovered rate in per unit time.

32.2.2 Basic Credit Contagion Model

Let n-number enterprise group as a graph called Group's Network diagram. Vertices in the graph represent member companies. The edge connecting two vertices means credit contagion relation between those two member firms, such as equity relationship, associated guarantees, managing scheduling and credit

contracts. These direct contacts are likely to become channels of credit risk infection. The number of edges connected to one vertex is defined as the degree of this vertex (see [12]).

Definition 1 Define credit risk correlation degree k for Group's network diagram by $k = \sum_{l=1}^{N} \frac{E_l}{N(N-1)}$, $(0 \le k \le 1)$, where $E_l (l = 1, 2, \ldots, N)$ is the degree of lth vertex.

Obviously, the higher credit risk correlation degree, the greater possibility of infection among members. With the epidemiological theory, this article takes mechanism analysis of credit contagion within enterprise group as follows (see [13]).

During study period [0,T], contact infection probability between abnormal credit company and other company for every time is β_0. For convenient discussion, this paper will not discuss the influence of member heterogeneity to risk infection and assume β_0 as a constant. Here, contact infection means that a normal credit company becomes the abnormal credit company by direct relation.

One abnormal credit company directly contacts other member companies U times per unit time. $\beta_0 U$ is the effective contact rate. Thus, average effective contact rate of each abnormal credit company is$\beta_0 U \frac{S}{N}$. Due to the total number of abnormal credit firms, that is, I, the number of companies infected by all abnormal credit corporations in per unit time is $\beta_0 U \frac{S}{N} I$, that is, infection rate is $\beta_0 U \frac{S}{N} I$.

Assume U is proportional to group network average correlation degree $\sum_{l=1}^{N} \frac{E_l}{N}$, and the coefficient is a, that is, $U = a \sum_{l=1}^{N} \frac{E_l}{N} = a(N-1)k$, where the value of a can be estimated by historical data. Let $\beta = \beta_0 a(N-1)$, the infection rate is $\beta = \beta_0 a(N-1)$. We call β as risk inflectional coefficient, it is proportional to β_0. From assumption (32.1) to (32.3), we get credit risk contagion model for enterprise group as:

$$\begin{cases} \frac{\mathrm{d}I}{\mathrm{d}t} = \beta k \frac{S}{N} I - \mu I \\ N = S(t) + I(t) \end{cases} \tag{32.1}$$

Simplified to

$$\frac{\mathrm{d}I}{\mathrm{d}t} = (\beta k - \mu) I - \beta \frac{k}{N} I^2 \tag{32.2}$$

Note the total number of firms in enterprise group N is unchanged during the period. Let $i = \frac{I}{N}$, the proportion of abnormal credit companies, then $\mathrm{d}i = \frac{\mathrm{d}I}{N}$, with Eq. (32.2), we have

$$\frac{\mathrm{d}i}{\mathrm{d}t} = (\beta k - \mu) i - \beta k i^2 \tag{32.3}$$

32.2.3 Stochastic Credit Contagion Model

For cross-regional and cross industrial pluralistic business strategy, credit risk infection process within enterprise group is always suffered by random disturbance, and the infection rate has stochastic volatility. Suppose random disturbance is a white noise, replace β with $\beta + \rho\xi(t)$ in Eq. (32.3), $\xi(t)$ is a white noise with zero mean and one volatility, and ρ is constant representing random disturbance strength through the infection process. Now, we have stochastic credit contagion model:

$$\mathrm{d}i = [(\beta k - \mu)i - \beta k i^2]\mathrm{d}t + \rho k(1 - i)i\mathrm{d}W \tag{32.4}$$

where W is standard Brown Motion.

32.3 Numerical Results

32.3.1 Numerical Methods

The numerical methods of stochastic differential equation are generally Euler–Maruyama approximation, Runge–Kutta approach, Milstein approximation and so on (see [14]). In this paper, we employ Milstein approximation to estimate the numerical solution of Eq. (32.4). The specific steps of the algorithm are as follows:

Step 1 For given time T, divide the period $[0, T]$ into n equal piles and take $\delta = \frac{T}{n}$, then $0 = t_0 < t_1 < \cdots < t_n = T$.

Step 2 By Milstein approximation principles, stochastic differential Eq. (32.4) has the following recursive formula:

$$\begin{aligned} i(m+1,j) &= i(m,j) + f(i(m,j))\Delta t_m + g(i(m,j))\xi_m \\ &\quad + \frac{1}{2}g(i(m,j))g'(i(m,j))(\xi_m^2 - \Delta t_m) \\ &\quad (m = 1, 2, ..., n,\ j = 1, 2, ..., M) \end{aligned} \tag{32.5}$$

With $f(i(m,j)) = (\beta k - \mu)i(m,j) - \beta k[i(m,j)]^2$, $g(i(m,j)) = \rho k(1 - i(m,j))$ $i(m,j)$.

Independent identically distributed variables $\{\xi_m\}$ obey the law of normal distribution $N(0, \delta)$. $i(0) = i_0$, m and j stand for time nodes and path number. n is the number of time nodes and M is the number of sample paths. When $j = 1$, first generate n random number obeying the normal distribution $N(0, \delta)$. Second substitute them into (32.5) and then get a sample path satisfied the Eq. (32.4).

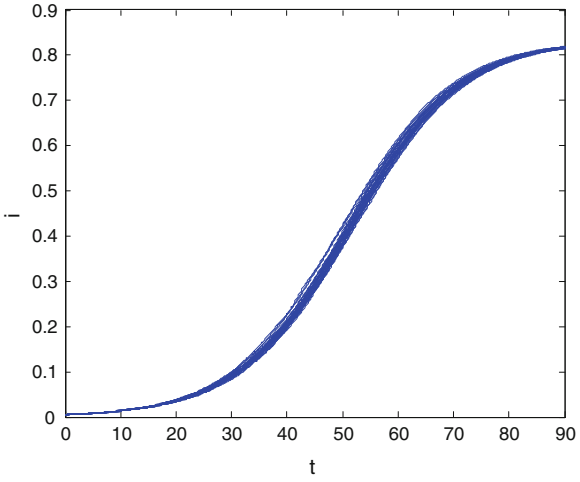


Fig. 32.1 Prediction of I

Step 3 Repeat step 1 and step 2 for $M - 1$ times, and we have sample paths for $j = 2 \ldots M$.

32.3.2 Example

Assume that the initial proportion of abnormal credit companies in group is 0.05 %. Other parameters are assumed as follows: $\beta = 6$, $k = 0.02$, $\rho = 0.5$, $\mu = 0.02$, $n = 9000$, $T = 90$ days, $M = 30$. Applying above simulation method, the prediction of the proportion of abnormal credit companies in group within the next 90 days is shown as in Fig. 32.1, where t represents time and i represent the proportion of abnormal credit companies. It is not hard to see that predicted proportion grows rapidly from 0.1 to about 0.73 during the next 30–70 days. Furthermore, in the same period, the trading range of abnormal credit proportion affected by random disturbance is significantly higher than the rest of other time intervals. This shows that credit contagion process within group is in rapid increase stage during the interval [30, 70] and is subject to random interference. Therefore, presentational credit contagion treatment should be executed in the first 30 days in order to effectively reduce risk's "negative spillover effect".

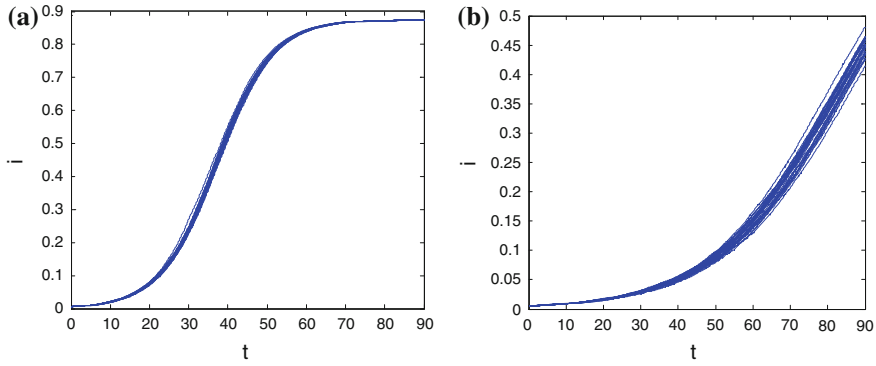


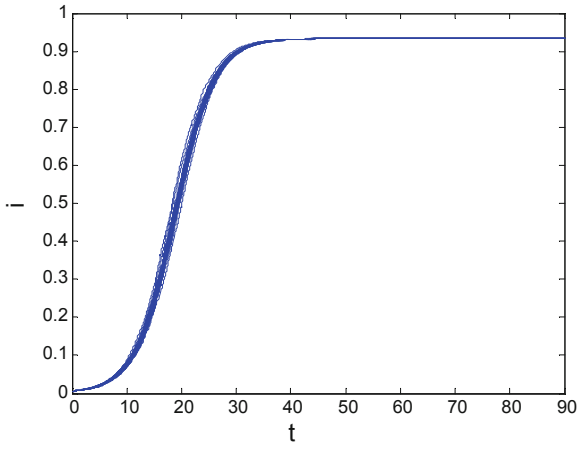
Fig. 32.2 **a** $\beta = 8$, **b** $\beta = 4$

32.3.3 Sensitivity Analysis

32.3.3.1 Risk Inflectional Coefficient β

Assume the other parameters unchanged, change the contact infection probability β_0 to make risk inflectional coefficient β rise to $\beta = 8$ or drop to $\beta = 4$ as reported in Fig. 32.2. Although the abnormal credit proportion shows an upward trend, the arriving time of proportion meets fixed value in Fig. 32.2a is significantly earlier than the counterparty in Fig. 32.1. And Fig. 32.2b has the similar conclusion. That means the greater risk inflectional coefficient, the earlier arrival of default peak.

Fig. 32.3 $k = 0.05$



32.3.3.2 Credit Risk Correlation Degree *k*

In Fig. 32.3, $\beta = 6, k = 0.05$. Compared with Fig. 32.1, with the increase of credit risk correlation degree, the rapid growth period of abnormal credit proportion is in advance to $[10, 30]$ and the length of interval shorts from 40 to 20 days. Therefore, the spread of credit risk can be controlled by reducing risk correlation degree.

32.4 Conclusions

In this paper, we grasp the feature of economic union of enterprise group and use graph theory and epidemiology research methods to construct stochastic credit contagion model for enterprise group. From the simulation results, we find that parameters such as β, k play important roles in the proportional valuation of abnormal credit companies. As the initial attempt of credit contagion for enterprise group, we assume unchanged group size and only consider the proportion of abnormal credit companies as sticking point. We do not deeply analyze the variation of nodes number in group network diagram, equity relationships among companies, related transaction and other factors on the infection of credit risk. It will be our further research.

Acknowledgments This research is supported by National Natural Science Foundation of China (70971015, 11061041), Natural Science Fund of Yunnan Province (2010ZC063, 2010ZC079) and Scientific Research Foundation of Yunnan Province Education Office (2011C109).

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Chapter 33
Research of Data Mining on the Post-Treatment Survival Period Prediction of Colorectal Cancer

Xiufeng Liu and Zhenhu Chen

Abstract This paper highlighted the basic situation of colorectal cancer and introduced the key technologies of data mining, then summarized medical applications of data mining technologies, and finally discussed the use of data mining technology in cancer, especially colorectal cancer research. Prospect of data mining prediction in post-treatment of colorectal cancer has been proposed.

Keywords Data mining · Survival period prediction · Colorectal cancer

33.1 Introduction

The adoption of varied data mining algorithms in medical treatments and prognosis analyses is an important research content of medical applications of data mining. In the past, the researches on diagnosis and treatment of diseases, especially of cancers, mainly relied on the biological and medical analyses [1, 2]. With the rapid development of information technology, there is a sharp increase in the data accumulation. Data mining techniques are thus playing a more and more important role in data analysis and knowledge discovery in database (KDD). Meanwhile, such techniques are widely used in bio-informatics science and medicine related fields, to name a

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_33,

few, auxiliary diagnosis and treatment of diseases, research and development of new drugs and medicine, information analysis of electronic medical records, spectrum analysis of traditional chinese medicine (TCM), DNA and molecular structure analysis and so forth. Furthermore, the predictive analytics based on "preventive treatment" idea has become a hot topic in medical applications of data mining.

Since the research of data mining technologies in medicine related fields would turn out to be an important reference and aid to our research in constructing a predicting model of colorectal cancer, systematic analysis and synthesis of medical applications of data mining are conducted to support the further study in the paper. And we also make an expectation for data mining in colorectal cancer research.

33.2 Colorectal Cancer

Colorectal cancer, also called colon cancer or large bowel cancer, includes cancerous growths in the colon, rectum and appendix. With 655,000 deaths worldwide per year, it is the fourth most common form of cancer in the United States and the third leading cause of cancer-related death in the Western world. Many colorectal cancers are thought to arise from adenomatous polyps in the colon. These mushroom-shaped growths are usually benign, but some may develop into cancer over time. The majority of the time, the diagnosis of localized colon cancer is through colonoscopy. Therapy is usually through surgery, which in many cases is followed by chemotherapy.

33.3 Key Technologies of Data Mining

Data mining, the extraction of hidden predictive information from large databases, is a powerful new technology with great potential to help companies focus on the most important information in their data warehouses [3]. Data mining mainly involves four classes of task: Classification, Clustering, Regression and Association rule learning. Classification refers to arranging the data into predefined groups [4]. Its common algorithms include Decision Tree Learning, Nearest Neighbor, naive Bayesian classification and Neural Network. Clustering is like classification but the groups are not predefined; thus, the algorithm will try to group similar items together [5]. Regression attempts to find a function which models the data with least errors. Association rule learning searches for relationships between variables [6].

33.4 Medical Applications of Data Mining

In recent years, many research attempts in data mining are focused on the field of medicine, thus greatly improved the analysis and processing ability of medical information. We summarized the medical applications of data mining technology at domestic and abroad which include several aspects as follows.

33.4.1 Auxiliary Diagnosis of a Particular Disease

Auxiliary diagnosis of a particular disease using data mining technologies includes prediction of the effectiveness of surgical procedures, medical tests and medications, and discovery of relationships among clinical and pathological data or personal information, for instance, age, sex and dietetic habits. There are many similar researches abroad, from the application of nerve network and association rules in breast cancer [7], to rough set theory in lung cancer [8], to the application of decision tree and genetic algorithms in pathology [9].

In China, researches of data mining have opened up a new era in the auxiliary diagnosis of specific diseases. There are several data models built by data mining technology. Take the building of solitary pulmonary nodules model, for example, it mainly uses classification and regression tree (CART), plus the artificial neural networks (CNN) technology [10]. Data mining methods such as logistic regression and decision tree are also employed to classify the data of coronary heart disease (CHD) [11]. Besides, data mining techniques find themselves usages throughout medical fields in bacillary dysentery [12], type2 diabetes [13], deficiency syndrome of spleen [14] and other diseases.

33.4.2 The Applications in TCM Data Pre-Processing

The development progress of TCM has seen a long history. Accordingly, experts of the past ages all over the nation accumulated a great amount of experiences in disease diagnosis, making formula and other aspects. In order to systematize these experiences and make guidance for clinical work, these raw data of TCM are supposed to be organized. At present, the applications concerning TCM data pre-processing mainly include normalization for formula, dose, diseases separation and so forth. This can be done by adopting data reduction techniques, clustering techniques, fuzzy set theory and other methods. Chromatographic analysis of TCM, association rules and graphic intelligent research on formula compositions, combination of Chinese herbal formula, researches on the absence of the nature of herbal drugs prediction and others are the hot research fields in China.

33.4.3 Application of Medical Information System

In 2002, a survey conducted by China's Health Ministry on 6,921 hospitals showed that 85 % of the hospital information systems are management information systems which focus on the central task of financial accounting, and they mean little to improve the quality of clinical treatment and medical research. However, there were only 10 to 15 % of the hospitals began to explore and build clinic information system (CIS) which made doctor workstation as a core and build picture archiving and communication systems (PACS), which is also a developing trend of medical information system. Medical data warehouse and data mining technology are of great help in auxiliary diagnosis and treatment and medical research. Recently, in China, researches in this field mainly include applications of hospital infection management [15], hospital decision support systems [16], electronic patient record system [17], PACS system [18] and information systems based on a specific disease, such as gallstone [19]. The applications of data mining in medical information system in western countries also include quality management of hospitals and telemedicine platform. This type of application combines the data mining technology with information management system which makes decision-making functions available.

33.5 Applications of Data Mining in Cancers

33.5.1 Applications of Data Mining in Other Cancers

Applications of data mining in cancers mainly involve the application of association rules in data analysis of patients with liver cancer [20], data mining software researches on diagnosis of prostate cancer [21], researches on related gene of cervical cancer [22], cluster analysis on related gene of lung cancer [23], study on prognosis of esophageal squamous cell carcinoma [24] and so on.

33.5.2 Application of Data Mining in Colorectal Cancer

In China, studies on diagnosis and treatment of colorectal cancer are mainly from biological and medical aspects of view. The use of data mining techniques only focuses on early diagnosis of colorectal cancer, including classification technology [25], clustering method and researches on new improved algorithms [26]. Being a trial and beginning of relating application of data mining in colorectal cancer, it has a preliminary medicinal effect, and the results of the research are premature, thus cannot be extensively used in clinic. Limited to early diagnosis of colorectal cancer, this type of researches makes little evaluation of prognosis and the effect of

high-risk group. By comparison, researches in this field have been carried out abroad which mainly include the analysis of serum samples of patients with rectal cancer by data mining techniques, in order to predict adjuvant radiation and chemotherapy reaction of local-advanced rectal cancer histology and predict 5-year survival rate of patients with colorectal cancer [27, 28].

33.6 Conclusion

There is never any doubt that medical applications of data mining technology are becoming more and more important. Typical applications are focused on clinical medicine, bioinformatics, basic medicine and traditional Chinese herbs. Researches on cancers are not rare, however; achievements in analysis of colorectal cancer prognosis still leave something to be desired. Therefore, constructing prediction system of colorectal cancer with data mining technology and preventing disease of high-risk group are of very important realistic meaning.

Acknowledgments This paper is supported by Guangdong Province Medical Research Foundation Project of Science and Technology, China (A2010209), and Guangdong Province Technology Project in Social Development Field of Guangdong Provincial Department of Science and Technology, China (201102).

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Part IV
Computer Simulation and Modeling

Chapter 34
A Group-Based Dynamic Framed Slotted ALOHA Anticollision Algorithm for Single Reader RFID System

Jutao Hao, Qingkui Chen and Xiaolian Yan

Abstract Radio frequency identification (RFID) technologies have revolutionized the asset tracking industry, with applications ranging from automated check out to monitoring the medication intakes of elderlies. There are two challenges for the frame-slotted ALOHA algorithms in (RFID). The first challenge is estimating unknown tag-set size accurately; the second challenge is improving the efficiency of the arbitration process so that it uses less time slots to read all tags. A novel anticollision technique is proposed to maximize identification performance in slotted ALOHA-based (RFID) systems. The performances of these protocols are evaluated, and it is verified that this protocols outperform the traditional frame-slotted ALOHA protocols.

Keywords Anticollision · Framed ALOHA · Radio frequency identification (RFID) · Tag estimate

34.1 Introduction

Recently, radio frequency identification (RFID) attracts attention as an alternative to the bar code in the distribution industry, supply chain and banking sector. This is because RFID system that has advantages of contactless type and can hold more data than the bar code.

An RFID system consists of radio frequency (RF) tags attached to objects that need to be identified and one or more electromagnetic readers. Tags can be active

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_34,

or passive. Active tags have storage capabilities and are provided with power sources for computing and transmitting data. Due to the complexity and cost of mounting a power source onto a tag, active tags are not practical for use with disposable consumer products. Passive tags instead rely only on RF energy induced by the electromagnetic waves emitted by the reader and can have limited storage functionality.

In a simple RFID communication sequence, the reader emits radio frequency waves. Passive tags, which received these waves, are also receiving energy to begin sending their stored data. Active tags have their own power sources.

In an RFID system, when numerous tags are present at the same time in the interrogation zone of a single reader, the system requires an anticollision algorithm to read tags' ID or data from individual tags. Collision problem can affect the identification process by the long time that should be spent and by the low accuracy of tags identification. Although many algorithms have been proposed to solve this problem, a large part of them suffer from the long delay time or the high cost and complexity. RFID anticollision protocols can be categorized into tree-based and ALOHA-based ones.

Tree-based algorithms resolve collisions by muting subsets of tags that are involved in a collision. Successively muting larger subsets finally leads to successful transmission of a tag's identification. Tree-based tag anticollision protocols can have a longer identification delay than slotted ALOHA-based ones, but they are able to avoid the so-called tag starvation, in which a tag may not be identified for a long time when involved in repeated collisions. Among tree-based protocols, there are binary search protocols [1] and query tree protocols [2]. In binary search protocols (BS for short), [3] the reader performs identification by recursively splitting the set of answering tags.

The basic framed slotted ALOHA protocol [4] uses a fixed frame size and does not change the size during the process of tag identification. In this protocol, the reader transmits to tags the frame size and each tag generates a random number j not larger than the frame size and then transmits in the jth slot of the frame. With a fixed size of the frame, if there are too many tags, most slots will have a collision. On the contrary, there are many wasted time slots, if a large size of the frame is used with a small number of tags. The dynamic framed slotted ALOHA (DFSA) [5] protocol changes the frame size dynamically. To date, there are several surveys on anticollision protocols [6] and [7].

Tree slotted ALOHA (TSA) [8, 9], an enhanced FSA protocol, uses a tree structure during the identification process. The root node of the tree denotes a frame to be transmitted in the first read round. Each tag remembers the slot number they used to transmit. At the end of a read round, if there were collisions, the reader starts a new reading cycle for each collided slot. This corresponds to adding new nodes to the tree. Each tag has a counter to remember its position in the tree. Each time a collision occurs, a new node is inserted onto the tree, and another reading cycle is initiated. The whole process is repeated until a cycle is collision free. TSA's strength lies in generating a new frame for each colliding slot, which avoids any remix of colliding tags.

TSA is based on the assumption that the number of tags in each collision slot is equal. However, the actual situation is not the case. This problem also exists in paper [10]. Our work is based on DFSA and makes an improvement based on above two works.

34.2 Related Work

34.2.1 Tree Slotted ALOHA

TSA deals with collisions more efficiently by using a different way of grouping tags that are queried in the same frame. After the first frame, a new set of "child" frames is allocated, each devoted to solving the collisions which have occurred in a given slot of the first frame. Only the (few) tags which transmitted in that slot participate in the corresponding frame. The approach is repeated: If collisions occur in one of the frames allocated to solve collisions (say, frame i), new frames are allocated to solve such collisions (one for each collision slot in frame i). This is possible by estimating the number of tags colliding in each slot, and then allocating a properly sized frame to solve the collisions which have occurred in such slot. More precisely, if n_i is the estimated number of transmitting tags in reading cycle i (computed using Chebyshev's inequality), c_1^i the number of identified tags during the ith cycle, and c_k^i the number of slots with collisions, then the frame size of the $(i+1)$th reading cycle is given by $l_{i+1} = \left\lfloor (n_i - c_1^i)/c_k^i \right\rfloor$.

TSA's strength lies in generating a new frame for each colliding slot, which avoids any remix of colliding tags. However, tag estimation remains a weak point.

34.2.2 Collision-Group-Based Anticollision Algorithm

Each CGA loop has two reading cycles. In the first cycle, the reader sends R_1 including frame size to all tags. On receiving R_1, the active tags answer at their randomly selected time slots. The reader observes the reading results and updates the collision status Δ. If the number of collision $c_i \neq 0$, the reader performs the estimation algorithm to derive $\widetilde{n}$ and set group frame size f_g to min (128), max $(\left\lceil \widetilde{n}/c \right\rceil, 2)$. The frame size of second cycle is set to $c_i \times f_g$.

In the second cycle, the reader sends R_2 including group frame size f_g and collision status to all tags. On receiving, each active tag calculates its *collision group number* by summing up 1's from the first bit to γth bit in Δ; tag randomly selects a number x in $[1, \ldots, f_g]$ and transmits its ID in a time slot ω, where $\omega = f_g * (q-1) + x$. The reader observes the reading results. If the number of collisions $c_{i+1} \neq 0$, the frame size for the next iteration is set to $\min(128, \max((\widetilde{n} - s_i - s_{i+1}), 2))$. And s_i is the

number of occupied slots. The reader continues the arbitration process until no collision occurs.

No matter TSA or CGA, they are all based on the assumption that the number of tags in each collision slot is equal. As described in CGA, tags in the same collision slot are reallocated into a subframe. The performance of the algorithm may be degraded greatly when the number of tags in each collision slot varies considerably. Meanwhile, if the number of tags in each collision is small, a small frame may Increase the overhead.

34.3 Proposed Anticollision Algorithm

In DFSA, frame size is automatically adjusted after each frame. It is important for the frame size N value not be so far from tag's population value n. This requires making tag's population estimate operation that can be done by exploiting the outcomes of the previous frame information for the next frame sizing.

At each reading cycle, we obtain a triple $< c_0, c_1, c_k >$ quantifying the empty or idle slots, success slots and slots with collisions, respectively. According to Chebyshev's inequality, the outcome of a random experiment involving a random variable X is most likely near the expected value of X. By using this property to compute the distance between the effective results $< c_0, c_1, c_k >$ and the expected results $< a_0, a_1, a_k >$ of a reading cycle, respectively, and by minimizing such a distance, defined in Eq. (34.1), it is possible to estimate the number of tags n that are transmitted in such a cycle.

$$\varepsilon(N, c_0, c_1, c_k) = \min_{n} \left| \begin{pmatrix} a_0^{N,n} \\ a_1^{N,n} \\ a_k^{N,n} \end{pmatrix} - \begin{pmatrix} c_0 \\ c_1 \\ c_k \end{pmatrix} \right|, \quad k \geq 2 \tag{34.1}$$

When the reader uses a frame size equal to N, and the number of responding tags is n, the expected value of number of slots with r responding tags is given by

$$a_r^{N,n} = N \times \binom{n}{r} \left(\frac{1}{n}\right)^r \left(1 - \frac{1}{n}\right)^{n-r} \tag{34.2}$$

The number of success slots is given by

$$a_1^{N,n} = n\left(1 - \frac{1}{n}\right)^{n-1} \tag{34.3}$$

The number of expected empty is defined by

$$a_0^{N,n} = N\left(1 - \frac{1}{N}\right)^{n} \tag{34.4}$$

Therefore, the number of slots with collision is given by

$$a_k^{N,n} = N - a_1^{N,n} - a_0^{N,n} \tag{34.5}$$

Most commonly the bounded values $c_1 + 2c_k$ and $2(c_1 + 2c_k)$ are adopted as possible representative values for the number of tags.

When the number of tags and the frame size are approximately the same, the system efficiency becomes the maximum. Our algorithm starts with blindly partitioning the tags and probes the first subset of tags for estimation on the tag population. Once the estimation is obtained, the remaining subsets of tags are repartitioned into an optimum number of subsets that yields maximum throughput.

The system is initialized with an initial frame size of l_0. The partition process begins by broadcasting a partition message $P<\gamma_i>$ to the tags. The role of this message is to tell the tags how many subgroups should be partitioned into. When tags receive message P, each of them generates a random number in the range of 1 to γ_i. Next, the reader broadcasts a request message $R<l_0, s>$, which informs tags in the sth subgroup that in the next round the frame size is l_0.

Once receiving message R, each tag in the subgroup s selects its response slot by generating a random number in the range $[1, l_0]$ and transmits its ID in such a slot.

According to the responds of tags, the reader makes a decision whether to repartition or not. Repartitioning occurs whenever the following situations are happened.

$$\frac{c_k}{l_0} - \frac{a_k^{l_0}}{l_0} > \varepsilon \tag{34.6}$$

When Eq. (34.6) is satisfied, the tag set will be partitioned into $2\gamma_i$ subgroups.

Once a frame is completed without repartitioning, we get a rough estimate of the number of tags in the first subgroup, and the size of the entire tag population can be inferred.

The number of groups is calculated as follows:

$$\gamma_{opt} = \frac{The \quad number \quad of \quad tags}{the \quad frame \quad size} \tag{34.7}$$

The identification process includes several stages. In the first reading cycle, the reader broadcasts a request message $R_1<l_i, s>$, which informs tags in the sth subgroup that in the next round the frame size is l_i. Tags in the subgroup answer at their randomly selected time slots γ_i within $[1, 2, \ldots l_i]$. The reader observes the reading result and updates the frame length in the next cycle.

$$l_{i+1} = n^i - c_1^i \tag{34.8}$$

where $n^i$and c_1^i are the estimation according to Eq. (34.1) and the number of slots with collision related to reading cycle i.

In the second cycle, the reader sends $R_2<l_{i+1}, g_{i+1}>$ including frame size in the next reading cycle and the number of collision slots in the first cycle, where

$g_{i+1} = \left\lfloor c_1^i / m \right\rfloor$ denotes how many collision slots will be incorporated into a subframe.

Once receiving R_2, each tag randomly selects a number x in $[1...u_{i+1}]$ and transmits its ID in a time slot $\gamma_{i+1} = \gamma_i \% g_{i+1} * u_{i+1} + x$, where $u_{i+1} = l_{i+1}/g_{i+1}$.

From the definition of γ_{i+1}, we can see that tags in the same collision slot will be reallocated into one subframe. Furthermore, the combination of several collision slots can overcome t tag uneven distribution problem.

34.4 Performance Analysis

To evaluate the performance of the proposed algorithm, we have performed extensive simulations. Two primary performance metrics in our experiments are the average throughput and average identification time. The average throughput is defined as a ratio of the number of tags to the number of slots used to read the tags. The average identification time is the number of slots used to identify all the tags.

The effect of the different values of m to the read performance was firstly examined. Figure 34.1 shows the simulation results with different values of m when the number of tags varies from 300 to 1,000. This experiment shows that due to the uneven distribution of tags in each collision slot, a higher throughput can be obtained by using a higher m value.

In the second experiment, the proposed algorithm was compared with CGA [10] and EDFSA in the performance of the average identification time, as shown in

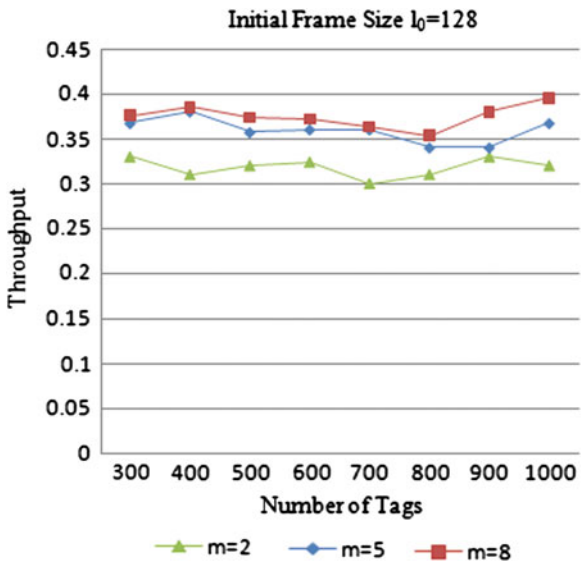

Fig. 34.1 Comparison of the simulation results with different m values

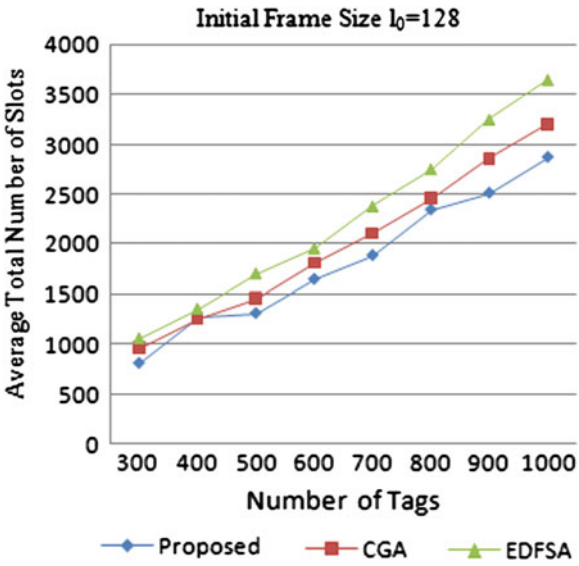

Fig. 34.2 Comparison of the simulation results for CGA, EDFSA and the proposed method

Fig. 34.2. Our proposed anticollision algorithm can effectively solve and use less time slots to read all tags.

34.5 Conclusion

In this work, we proposed a novel anticollision algorithm that utilizes the partitioning technique. The proposed estimation algorithm has low average estimation errors in a high tag density environment. Our proposed anticollision algorithm can effectively solve and use less time slots to read all tags. The simulation results show that proposed algorithms outperform others.

Acknowledgments This work was supported by the National Nature Science Foundation of China (Grant No. 60970012), Shanghai Key Science and Technology Project in Information Technology Field (Grant No. 09511501000), Shanghai Key Science and Technology Project (Grant No. 09220502800), Shanghai leading academic discipline project (Grant No. S30501) and Innovation Program of Shanghai Municipal Education Commission (Grant No. 10YZ102).

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Chapter 35
Numerical Simulations of Two Dimensional Mixed Flows of Buoyant and Thermocapillary Convection in Crystal Growth

Huan Mei, Zhong Zeng, Zhouhua Qiu, Liping Yao and Liang Li

Abstract Two dimensional mixed flows of buoyant and thermocapillary convection are investigated by the spectral element method (SEM). The Navier–Stokes equations are solved based on a spectral element discretization with Chebyshev and Legendre polynomials. The semi-implicit time-splitting method is employed for temporal discretization. Finally, the SEM is applied to solve two dimensional mixed flows of buoyant and thermocapillary convection. After qualitative and quantitative comparisons between the SEM and finite volume method (FVM), it is found that the numerical solutions agree closely with the reference data. In addition, exhaustive sources of errors are given. These numerical results reveal that incompressible fluid flow with free surface can be accurately solved by the SEM.

Keywords Spectral element method · Buoyant convection · Thermocapillary flow · Semi-implicit time-splitting method · Chebyshev polynomials · Legendre polynomials · Free surface

35.1 Introduction

Study on crystal growth is of great significance for electron and communication industry. As experimental study on hydrodynamic process of semiconductor melt is difficult, numerical simulation becomes a main research approach. Now

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_35,

Czochralski method [1, 2] and floating zone technique [3, 4] are dominant in crystal growth technique, but Czochralski method cannot avoid melt contamination, which is disadvantageous to grow high-quality crystal. At present, the purest single crystals are generally produced by floating zone method, where convection in crystal growth is mainly driven by buoyant force and surface tension. Actually, both of the two forces have a great deal to do with the quality of growing crystal, so it is necessary to study buoyant and thermocapillary convection.

Relative to traditional finite element method (FEM), finite difference method (FDM) and finite volume method (FVM), the SEM, initially presented for fluid dynamics by Petera [5], showed faster convergence and higher accuracy and was therefore adopted in this paper. The SEM combines the generality of the FEM with the accuracy of spectral methods [5], and it can be used for solving problems in complex domains. Actually, the SEM has been applied to a broad range of problems so as to hold the balance in fluid dynamics. The first monograph about applications of the SEM in computational fluid dynamics was written by Karniadakis [6]. Qin and Chen [7, 8] used spectral element and time-splitting methods to solve natural convection and lid-driven flow in square cavity, respectively, and the numerical solutions agreed well with the benchmark simulations. Minev [9] used a spectral element splitting algorithm for thermally driven flow problems. Gjesdal [10] gave the benchmark solutions of natural convection in square and tall cavities. As for thermocapillary convection, Lee-Wing [11, 12] and Bodard [13] employed a Legendre spectral element method to solve problem of falling liquid films in which free surface deforms with time. Besides, Lee-Wing solved steady thermocapillary convection. However, applications of the SEM to crystal growth are few despite the fact that both of them have been greatly studied, respectively. Here, a two dimensional mixed flow of buoyant and thermocapillary convection is solved based on floating zone method.

35.2 Mathematical Model

Figure 35.1 shows the geometrical model of floating half zone. The constant temperatures of upper and lower walls are T_m and T_c, respectively. The free surface is non-deformable. The free surface and left wall are adiabatic from the environmental gas. The free surface is regarded as a linear function of the temperature with $\sigma = \sigma_0 - \sigma_k(T - T_c)$, where σ_k is the surface tension coefficient. The liquid is considered as a Newtonian fluid. We use the scales H, $\mu H/(\sigma_k \Delta T)$, $\sigma_k \Delta T/\mu$, $\rho(\sigma_k \Delta T/\mu)^2$ for length, time, velocity and pressure, respectively, where μ is the constant dynamic viscosity and ρ the density. The normalized temperature is $T^* = (T - T_c)/\Delta T$, where $\Delta T = T_m - T_c$. Based on the Boussinesq approximation, the dimensionless governing equations for fluid flow driven by buoyant force and unbalanced surface tension in square cavity can be written as:

$$\nabla \cdot \mathbf{u} = 0 \tag{35.1}$$

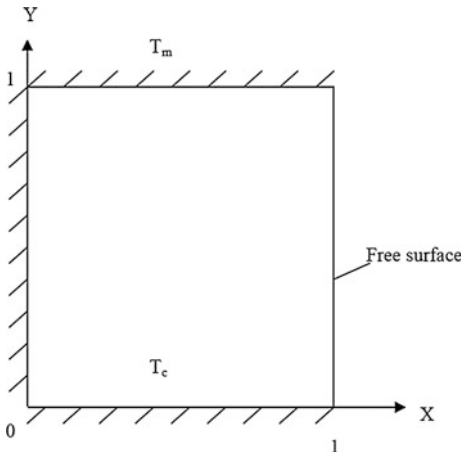

Fig. 35.1 Geometrical model

$$\partial \mathbf{u}/\partial t + \mathbf{u} \cdot \nabla \mathbf{u} = -\nabla p + \nabla^2 \mathbf{u}/\mathrm{Re} + \mathrm{Gr} \cdot T\mathbf{e}_y/(\mathrm{Re})^2 \tag{35.2}$$

$$\partial T/\partial t + \mathbf{u} \cdot \nabla T = \nabla^2 T/(\mathrm{Pr} \cdot \mathrm{Re}) \tag{35.3}$$

where $\mathbf{u}$, p, T represents the dimensionless velocity vector (u, v), pressure and temperature, respectively. Re, Gr and Pr are defined as $\mathrm{Re} = \sigma_k H \Delta T / \rho v^2$, $\mathrm{Gr} = g\beta \Delta T H^3 / v^2$, $\mathrm{Pr} = v/\kappa$ $(v = \mu/\rho)$, where g is the acceleration of gravity, β the thermal expansion coefficient, and κ the thermal diffusivity. The corresponding boundary conditions are as follows: $x = 0$ $u = v = 0$, $\partial T/\partial x = 0$; $x = 1$: $\partial \mathrm{v}/\partial x = -\partial \mathrm{T}/\partial y$, $\mathrm{u} = 0$, $\partial \mathrm{T}/\partial \mathrm{x} = 0$; $y = 0$: $u = v = 0$, $T_c = 0$; $y = 1$: $u = v = 0$, $T_m = 1$.

35.3 Spatial Discretization and Time Discretization

Spatial discretization. The spatial discretization is based on SEM [9, 10]. The computational domain is divided into non-overlapping quadrilateral elements. Then, two dimensional variations can be written as Lagrange interpolation polynomials, that is,

$$u_N(\xi, \eta) = \sum_{j=0}^{N_\xi} \sum_{k=0}^{N_\eta} u_{\mathrm{jk}} h_j(\xi) h_k(\eta) \tag{35.4}$$

where $h_j(\xi_\mathrm{i}) = \delta_{\mathrm{ij}}$, $h_j(\eta_\mathrm{i}) = \delta_{\mathrm{ij}}$, ξ_i and η_i are Chebyshev-Gauss-Lobatto (CGL) or Legendre-Gauss-Lobatto (LGL) points for numerical integration. As in [6, 7], the formulation of Helmholtz equation is:

$$\nabla^2 u - \lambda^2 u = f, \text{ in } \Omega \tag{35.5}$$

$$u = 0, \text{ on } \Gamma_1 \tag{35.6}$$

$$\partial u/\partial \mathbf{n} = g, \text{ on } \Gamma_2 \tag{35.7}$$

where f and g are the functions of x and y; $\mathbf{n}$ is the normal unit vector Γ_2; Ω represents the computational domain, while Γ_1 and Γ_2 represent the boundaries. Then, the weak formulation of Eq. (35.5) is:

$$\iint_{\Omega} \nabla u \cdot \nabla v \mathrm{d}x\mathrm{d}y + \iint_{\Omega} \lambda^2 uv \mathrm{d}x\mathrm{d}y = \iint_{\Omega} fv \mathrm{d}x\mathrm{d}y + \int_{\Gamma_2} gv \mathrm{d}S \tag{35.8}$$

where v is a trial function. Both u and v are discreted using spectral spatial discretization as in Eq. (35.4). Then, the discretized form of Eq. (35.8) for ith element can be derived:

$$\sum_{j=0}^{N_\xi^i} \sum_{k=0}^{N_\eta^i} u_{jk}^i C_{\mathrm{jkpq}^i} = \sum_{j=0}^{N_\xi^i} \sum_{k=0}^{N_\eta^i} F_{jk}^i B_{\mathrm{jkpq}^i} \tag{35.9}$$

where $p = 0, \ldots, N_\xi^i$; $q = 0, \ldots, N_\eta^i$; C_{jkpq}^i and B_{jkpq^i} are the coefficient matrices and f, g are included in F_{jk}^i as in [7]. The global discretized form of Eq. (35.5) is assembled from Eq. (35.9).

Time discretization. The semi-implicit time-splitting method [7] is used to discrete Navier–Stokes equations, which can be split into three parts, that is, advective terms, viscous terms and pressure terms. A second-order Adams–Bashforth explicit scheme is applied to the non-linear terms, and a second-order Crank–Nicolson implicit scheme for the linear terms. Inserting the buoyant term into the advective term, the Eqs. (35.2) and (35.3) can be split into three sub-steps:

$$\begin{aligned}(\hat{\mathbf{u}} - \mathbf{u}^n)/\Delta t = &-3\left[-\mathbf{u} \cdot \nabla \mathbf{u} + \mathrm{Gr} \cdot T\mathbf{e}_y/(\mathrm{Re})^2\right]^n/2 \\ &+ \left[-\mathbf{u} \cdot \nabla \mathbf{u} + \mathrm{Gr} \cdot T\mathbf{e}_y/(\mathrm{Re})^2\right]^{n-1}/2\end{aligned} \tag{35.10}$$

$$\left(\hat{T} - T^n\right)/\Delta t = -3(-\mathbf{u} \cdot \nabla T)^n/2 + (-\mathbf{u} \cdot \nabla T)^{n-1}/2 \tag{35.11}$$

$$\left(\hat{\hat{\mathbf{u}}} - \hat{\mathbf{u}}\right)/\Delta t = -\nabla p^{n+1}, \hat{\hat{T}} = \hat{T} \tag{35.12}$$

$$\left(\mathbf{u}^{n+1} - \hat{\hat{\mathbf{u}}}\right)/\Delta t = \left[\left(\nabla^2 \mathbf{u}\right)^{n+1} + \left(\nabla^2 \mathbf{u}\right)^n\right]/(2\mathrm{Re}) \tag{35.13}$$

$$\left(T^{n+1} - \hat{\hat{T}}\right)/\Delta t = \left[\left(\nabla^2 T\right)^{n+1} + \left(\nabla^2 T\right)^n\right]/(2\,\mathrm{Pr} \cdot \mathrm{Re}) \tag{35.14}$$

where n represents the time step; $\hat{\mathbf{u}}$, $\hat{\hat{\mathbf{u}}}$ represent the intermediate velocity fields, $\hat{T}$ and $\hat{\hat{T}}$ the intermediate temperatures. Three Helmholtz equations and a Poisson equation can be obtained and then solved by the SEM.

35.4 Results and Discussion

Two dimensional mixed flows of buoyant and thermocapillary convection. The basic parameters are $\mathrm{Gr} = 1000$, $\mathrm{Pr} = 1.0$, $\mathrm{Re} = 100$, and the computational domain is divided into 4×4 elements. Both degrees of Chebyshev and Legendre polynomials are 10 with $\Delta t = 0.5$. The velocities of flow field are zero at initial time and grow to steady along with time. For comparison, the solutions of FVM are based on the SIMPLE algorithm with a second-order upwind scheme. The streamlines pattern and temperature field for them are shown in Figs. 35.2 and 35.3, and the velocity and temperature at the free surface are given in Fig. 35.4.

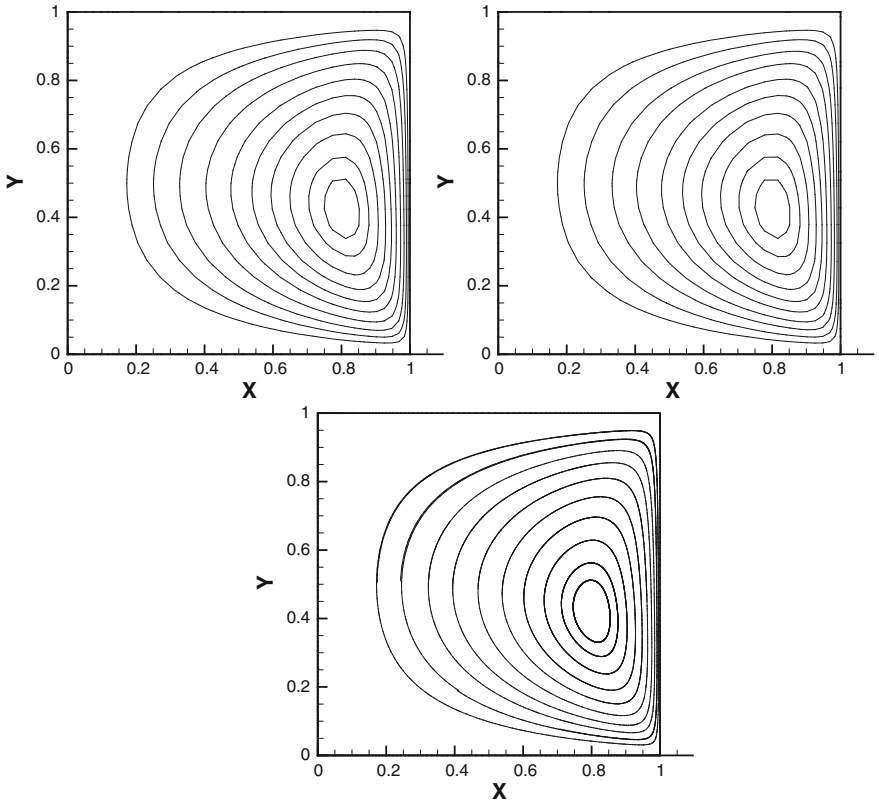

Fig. 35.2 Streamlines pattern: Legendre (*left*), Chebyshev (*middle*), FVM (*right*)

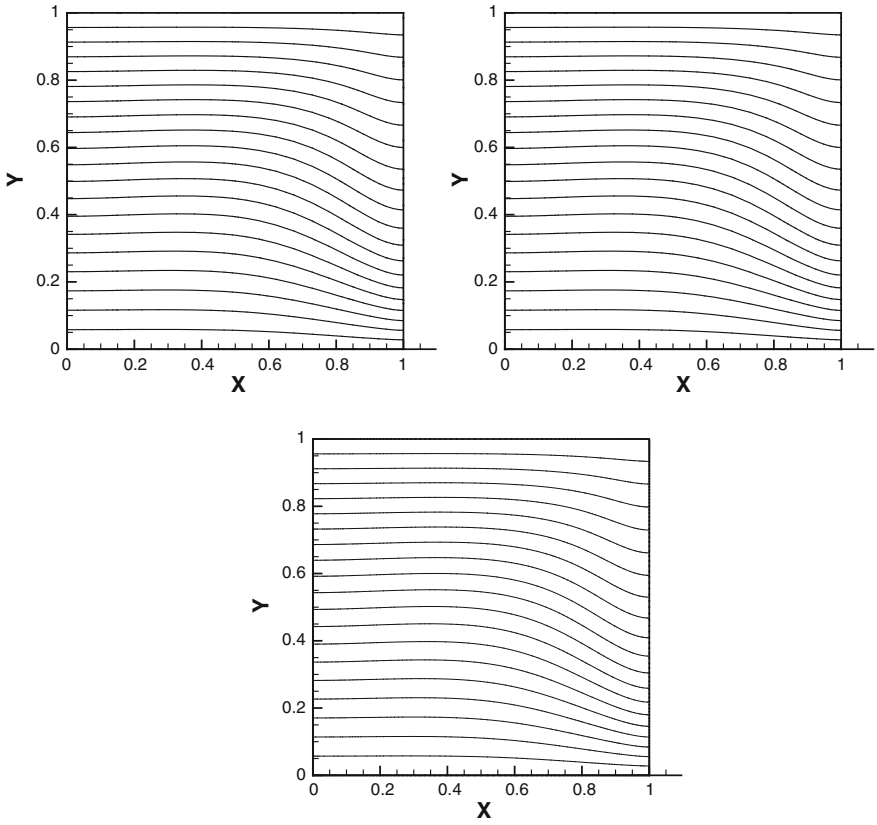

Fig. 35.3 Temperature fields: Legendre (*left*), Chebyshev (*middle*), FVM (*right*)

In the qualitative analysis, the streamlines pattern, temperature fields, the velocity and temperature at the free surface for the two schemes agree well with those of the FVM. In order to better understand the spectral accuracy, a comparison of quantitative analysis is conducted between the SEM and FVM in Table 35.1. In Table 35.1, $u_{\max}$ and $v_{\max}$ stand for the maximal dimensionless velocities in the x and y directions, and $\mathrm{Nu}_{\max}$ and $\mathrm{Nu}_{\min}$ stand for the maximal and minimal dimensionless Nusselt numbers at the hot wall. $\overline{\mathrm{Nu}}$ is the medial Nusselt number. The relative formulations can be seen in Ref. [7].

From Table 35.1, a little difference between the SEM and FVM can be observed. The difference between the solutions from Chebyshev and Legendre polynomials can be negligible. The maximal relative error is 1.9 % for $\mathrm{Nu}_{\max}$.

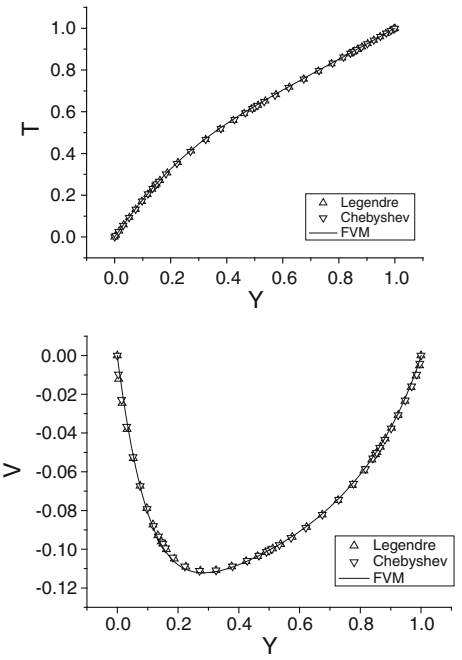

Fig. 35.4 Temperature (*left*) and velocity (*right*) on free surface

Table 35.1 Comparison of quantitative analysis between SEM and FVM

	Methods		
	Legendre	Chebyshev	FVM
u_{max}	2.3189096E−2	2.3173064E−2	2.3220399E−2
y	0.83845	0.841435	0.839589
v_{max}	1.9122756E−2	1.9118827E−2	1.92350E−2
x	0.623242	0.620922	0.637328
$\overline{Nu}$	1.0755	1.0752	1.0598
Nu_{max}	1.1757	1.1756	1.1536
x	0.376758	0.379078	0.362672
Nu_{min}	0.7671	0.7671	0.7595
x	1.0	1.0	0.995626

The reasons for the differences of the SEM and FVM may be mainly as follows. The first is the accuracy of the method itself. In fact, the accuracy of the FVM is second-order. But in SEM, the accuracy of time discretization is second-order,

while that of space discretization is tenth-order. Theoretically, the SEM is more accurate than FVM. As for the two schemes of the SEM, the Chebyshev polynomial is explicit, while the Legendre polynomial is implicit, so the stability of the latter is better than that of former. Second, the grids of the two methods are different. Specifically, 101×101 mesh are used for the FVM while 41×41 for SEM. Maybe the node in the position where variables reach their maximal values has not been arranged, for example, $u_{\max}$ and its position. Lastly, the computational error of the machine itself cannot be avoided.

35.5 Conclusion

The numerical results in this paper show the capability of the SEM to compute accurately solutions of incompressible fluid flow with free surface. The numerical solutions of two dimensional mixed flows of buoyant and thermocapillary convection have been obtained and compared with those of the FVM. Sources of errors are analyzed in several aspects. All of the errors are in an acceptable range. Finally, the accuracy of SEM improves our confidence in the method as a tool to explore more complicated flow as well as stability analysis.

Acknowledgment This work is supported by the National Natural Science Foundation of China (Grant No. 10872222), Chongqing Natural Science Foundation (Grant No. 2009BB4207) and Fundamental Research Funds for the Central Universities (No. CDJXS10 241103).

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Chapter 36
Long-Term Effective Control Mode of Science and Technology Innovation in Equipment Manufacturing Industry

Hua Zou, Tian Chen and Airu Sun

Abstract This research, concerning long-term monitoring mode of technology innovation of equipment manufacturing industry through the methods of analyzing long-term mode elements, discusses the function and position of elements and describes the mechanisms and principles of the mode of long-term operation. The purpose of this article is to achieve the development of science and technology innovation. The three long-term effective control modes of science and technology innovation and their interactions are the creation of this research which is seldom discussed in detail in other related research. The result is that the government should well play its role in the process of monitoring and guiding the enterprises to pursue the long-term technology innovation achieving by conducting the three long-term effective control modes.

Keywords Equipment manufacturing industry · Science and technology innovation · Long-term control mode

36.1 Introduction

In recent years, China's equipment manufacturing industry improves technology innovation ability to mark its big progress of itself. But compared with developed countries, the innovation system of science and technology in China's equipment manufacturing industry is not perfect; the subjects of innovation cannot fully play their role in the process of technology innovation. And service and support from

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_36,

the public service platform are in shortage. All of these result in backwardness of equipment manufacturing industry in China which should be attached enough attention to.

36.2 The Analysis on the Components of Long-Term Effective Control Mode of Technology Innovation

Long-term effective control mode of technology innovation in equipment manufacturing industry includes the executers and monitors of the long-term effective control mode; monitors include: enterprise, government, high education institutions, scientific and technological research institutions, scientific and technological innovation agencies, etc.

36.2.1 The Executers of Long-Term Effective Control Mode

In order to make the long-term effective control mode of science and technology innovation in equipment manufacturing industry run smoothly, the executors of a long-term effective control mode should have the authority and the ability to reasonably predict the future development direction. So to some provinces or territories, they should found control institutions to regulate the manufacturing industry which should directly supervised by control department of the government. This kind of control institutions should have the following functions: One is to allocate resources reasonably. The other one is to conduct policy measures of equipment manufacturing technology innovation according to the demands and the third is to have the control ability [1], which can timely amend the deviation during the technology innovation, as shown in Fig. 36.1.

At the same time, to make the control and monitoring departments responsible to the technology innovation of equipment manufacturing industry, the government can put the performance of the technology innovation of equipment manufacturing industry development into consideration as the leading indicators of political performance appraisal; and regularly pose some training to the relative leaders of the relative organization to reinforce the executive ability of the relative leaders when they work.

36.2.2 The Objects of the Long-Term Effective Control Mode

The monitored objects of the long-term control mode of technology innovation of equipment manufacturing industry include the monitors from equipment

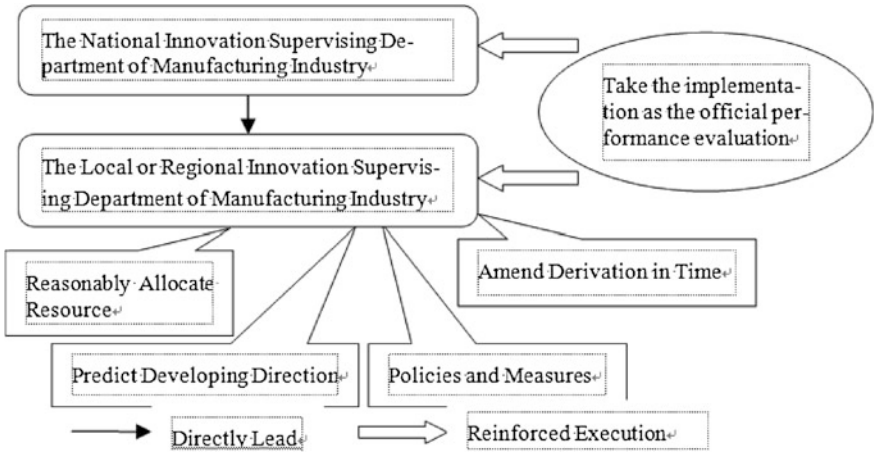

Fig. 36.1 Execution of long-term control mode

manufacturing enterprises, governments, universities and research institutes and scientific and technological innovation service. The executors of the long-term effective control modes in the equipment manufacturing industry, through rational allocation of resources, forecasting the future development direction, formulating policy measures and correcting deviations, ensure that the monitored objects fully play their roles on the basis of a unified management [2].

36.3 The Interaction Relationships Among Monitored Objects

The control department of the technology innovation of equipment manufacturing industry by means of monitor and control on the equipment manufacturing enterprises, governments, universities and research institutions, as well as the institutions of scientific and technological innovation service, enhances the relationship and interaction between the subjects of innovation process as shown in Fig. 36.2, constructing a system of combination of enterprise–education–research and technology innovating.

Technology innovation system in equipment manufacturing, the monitoring objects must fully play their roles and be clear about the status of every monitoring object [3]. That means to cultivate and maintain the dominant position of the enterprises in technology innovation, to strengthen the leading status of the government, to force the university and research institutions to perform their basic and important role in this process and to continuously improve the middle status institutions that technology innovation service agencies' level of service.

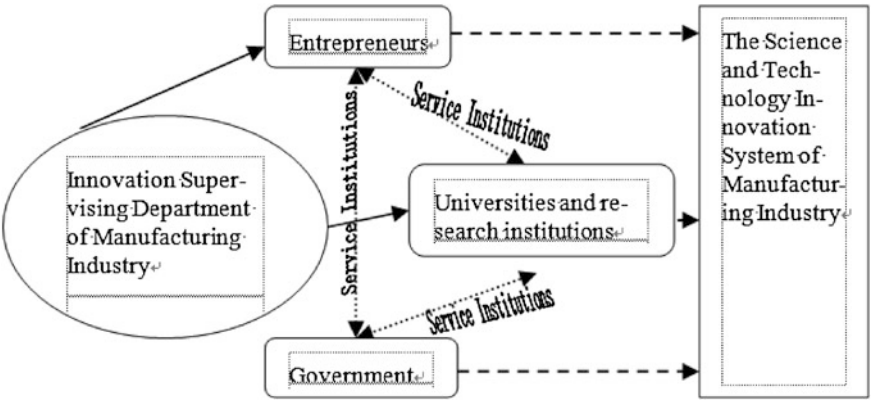

Fig. 36.2 Interaction between control objects

36.3.1 The Dominant Position of the Enterprises on Technology Innovation

Equipment manufacturing enterprise is playing a dominant role in new technology innovation system [4]. What is more, the reasons are: firstly, equipment manufacturing enterprises, in the process of producing, operating and value adding can directly interfere into the market and can easily grasp the change and news of the market, even more can acquire the potential needs and developing tendency in advance so that to make the manufacturing innovation more targeted and precise to the market's demand. Secondly, innovation of science and technology at the same time is also needed by the equipment manufacturing enterprise's own development and growth as the saying that "Science and technology are the first productive forces," especially for technology-intensive equipment manufacturing enterprises, if they want to lead in the market, holding the commanding point in technology is the only way out in order to win in the competition, as shown in Fig. 36.3.

36.3.2 Leading Position of the Government in the Technology Innovation

In the equipment manufacturing industry, the government put itself in a leading position in the technology innovation system which combines enterprise–education–research together. Basically it is because that the government has the ability to guide and support the innovation elements clustering toward enterprises, to push the technology fruits transformation into production power and also to implement and encourage the legal and policy supporting system, incentive mechanism and market environment of the technology innovation and industrialization of the fruits of the technology [5], as shown in Fig. 36.4.

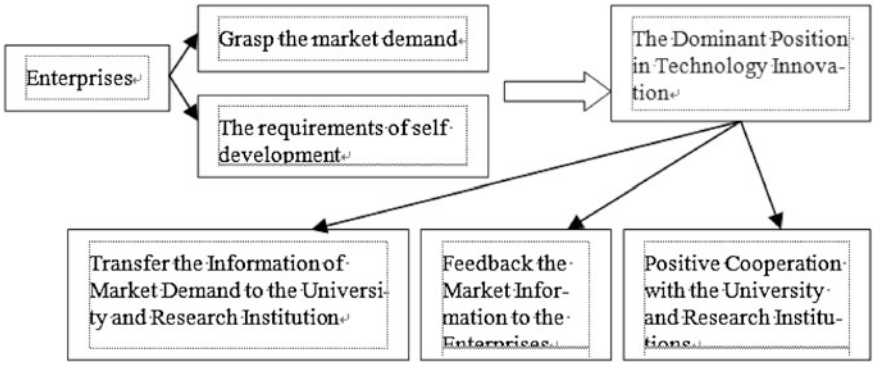

Fig. 36.3 The dominant position of enterprises in science and technology innovation

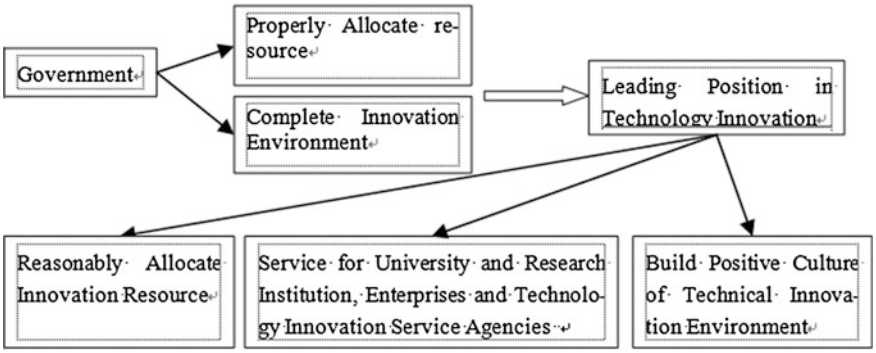

Fig. 36.4 The leading position of government in science and technology innovation

36.3.3 The Fundamental Position of Universities and Research Institutions in Science and Technology Innovation

Universities and research institutions are playing important roles and are in a fundamental position in science and technology innovation of equipment manufacturing industry. Universities and research institutions constantly generate new knowledge.

New technologies bearing the function of education and training in sci-tech innovation of equipment manufacturing industry; and conducting reorganization of knowledge and promoting technology diffusion in innovation system of science and technology combination with equipment manufacturing as an enterprises' incubator.

36.3.4 The Medium Position of the Service institutions in the Technology Innovation

In the technology innovation system, integrated of enterprise–education–research in equipment manufacturing industry, scientific and technological innovation service in an intermediate position, is the main auxiliary technology innovation, science and technology innovation system in the construction of combination of production, teaching and research, play the role of bond and bridge, to constantly raise the level of scientific and technological innovation of services.

36.4 Long-Term Effective Control Modes of Technology Innovation of Manufacturing Industry

The long-term effective control mode of technology innovation can be concluded: to ensure the collaboration and cooperation between the enterprises, government, university, research institution and technology innovation service agencies. Under the innovation system of the combination of the enterprise–education–research, relative institutions should build an R&D platform, technology innovation service platform and industrialization platform for the manufacturing industry [6]. By this means, the whole release purpose of the sum of the whole is greater than the parts' functions simply added together and the objective of improving the technology innovation ability of the manufacturing industry as shown in Fig. 36.5:

36.4.1 Science and Technology R&D Base Control Mode

Technology R&D base control mode is originated and based on the R&D platform which supports the technology innovation of the equipment manufacturing industry. Moreover, innovation service platform, as a support, lays innovation foundation for its industrialization as shown in Fig. 36.6.

36.4.2 Industrialization Driving Control Mode

Industrialization drive control mode can make the research achievements transfer and diffuse effectively into productivity consequently drive the R&D constantly innovation activities. In the process, the R&D platform is needed to let the innovation achievements flow to the industrialization platform, thereby the innovation service platform is needed also so that to ensure the coordination and

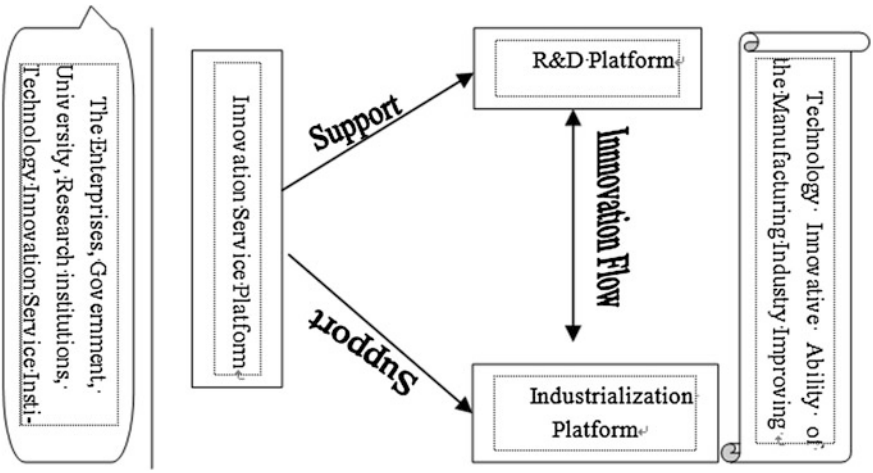

Fig. 36.5 Overall operating mode for long-term monitoring

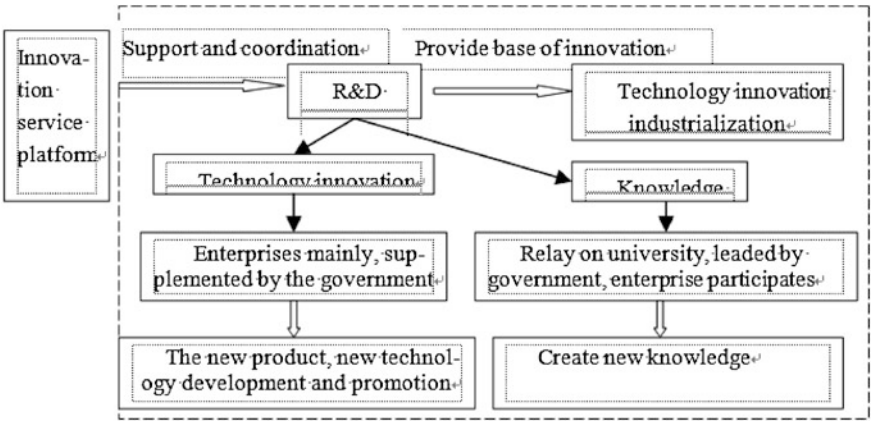

Fig. 36.6 R&D base control mode

communication during the innovation achievements flowing in and out of the innovation achievements into and out of, as shown in Fig. 36.7.

36.4.3 Innovation Service Support Control Mode

Innovation service support control mode is based on innovation service platform as the core, through improving the service quality of innovation service platform to

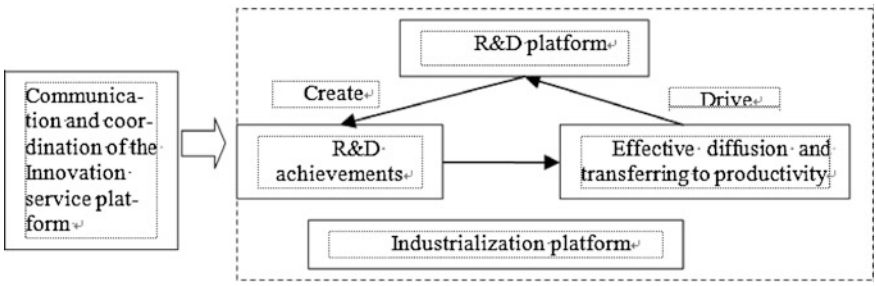

Fig. 36.7 Industry driving control mode

make the way of production and industrialization of new achievements easier and smoother, thus to push the development of the innovation activities of the equipment manufacturing industry.

36.5 Conclusion

R&D base control mode, industrialization driving control mode and innovation service support control mode need to have the government as main cooperator embodied with policies and regulations' protection and support. The government, through establishing completed science and technology innovation incentive policy and regulation, in the process of mutual cooperation of all the platforms, plays the overall planning, coordinating and controlling role in promoting the development of the cause of science and technology innovation and improves science and technology innovation ability and level in the equipment manufacturing industry in China.

Acknowledgments This work was financially supported by Liaoning Provincial Department of Science and Technology Project (Grant No. 2009401038) and Project of Shenyang Science and Technology Department (Grant No. 1091199-5-00).

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Chapter 37
An Efficient Modeling Approach for Real-Time Monitoring System with Metadata Hierarchy

Zheng Yi Yang and Shi Long Wang

Abstract Real-time data access of a monitoring system is necessary for evaluation of its capacity to interact with real environments. A novel data organization and access model (NDOAM) is presented to the real-time monitoring system based on the metadata hierarchy. This model takes advantage of real-time database in main memory, mapping to the sensor data for equipment status. The model needs to maintain only little amount of information, and front application could quickly access real-time and historical data with the metadata mapping. At the same time, the complexity of the data mapping process is quite low. Simulation results show that the model improve the performance of data access, significantly decrease the number of I/O. Compared with traditional data organization and access model (TDOAM), it shows that the model actively supports distributed environment and the open industry standards, has a good effect on the environment of a large-scale real-time data objects compared with the existed models.

Keywords Real-time systems · Monitoring · Metadata mapping · Sensor data collection

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_37,

37.1 Introduction

Real-time monitoring system may be used in a variety of event-driven applications where the system is activated in response to a critical change in the observed phenomena [1]. Once an event is detected, frequent and periodic updates from the sensors to the sink are needed. Sensor data here are very time-sensitive, and a real-time communication process needs to be in place to ensure timely data delivery. In the real-time monitoring system over the production, the great majority and variety of the monitored objects and the large amount of data about the description of the equipment state which is mapped in the application program as the memory data result in the complicated, closely related and rapidly changing memory data [2]. For example, in the production process, there are many kinds of mechanical equipments and electronic components, and they belong to different fields such as power monitoring and equipment monitoring. Besides, each point refers to different digital quantity, analog quantity and pulse quantity, which makes data management very complicated. With the increased demand for real-time data storage and processing in the real-time monitoring system and with the increasing complicated application of them, the traditional real-time data processing method based on the file cannot meet the demand.

This paper presents a data model of the real-time monitoring system based on the metadata in the hierarchic structure. It meets the real-time demand based on hierarchical mapping can take advantage of the traditional files model and memory mode, keep the logic and semantic aspects of the real-time data and historical data, transmit information effectively, and as a result it better meets the demand for the safety, cross-platform data sharing, high performance and expansibility.

37.2 The System Model

The real-time data are the data that are collected on the spot in the process control system, and they are one or several pieces of latest data in the database, because of the small number of the data, they can be obtained from internal storage [3]. The historical data include all other data except the real-time data, and they can be got from the real-time database and are related to time and they describe the monitored state at a certain point of time [4]. Although the inquiry into historical data does not demand so much instantaneity as real-time data, it helps when it coincides with what is going on in the outer system, and its response to the inquiry has to be efficient and rapid, because the historical data are an objective description of the present outer system. Figure 37.1 shows the structure.

The real-time data are obtained from site equipments through communication program by the real-time monitoring system, and are then processed before it is filmed directly in the form of diagram on the computer screen. On the other hand, it is controlled or adjusted by the controlled data to I/O equipment in response to

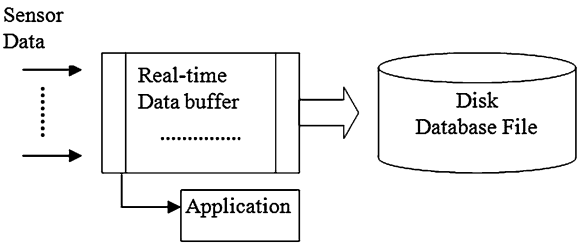

Fig. 37.1 The existing system of data storage system structure

configuration requirements and the operator's instructions. In the real-time monitoring system, the real-time and historical databases provide data for real-time data collecting, computing, historical data storage and search, procession and storage of the warnings and the I/O data connection. The real-time and historical databases also bridge the graphic interface program and the statements program for their communication and data share with each other. This paper use multi-layer metadata mapping model, integrate real-time database and historical database and obtain data from the terminal to provide corresponding interface for the system application, as shown in Fig. 37.2.

This model is a kind of system based on the file-type historical data and internal storage-type real-time data in the open database interface access control system. And the file-type historical data and internal storage-type real-time data are read by visiting database. Accessing to the real-time data is recorded in the form of the metadata registration directory. The real-time data got this way are transmitted to the corresponding visit module automatically by visiting registration directory to meet the instantaneity. But the historical data do not involve so much instantaneity, it employs the asynchronous way: request–response pattern.

The data abstraction module is used to abstract the historical data, real-time data and relational database data in the real-time monitoring system, and meanwhile, it will abstract original data flow collected on the spot into the equal presentation corresponding to the real-time data. It also abstracts the file-type historical data into a historical data table which is similar to the relational

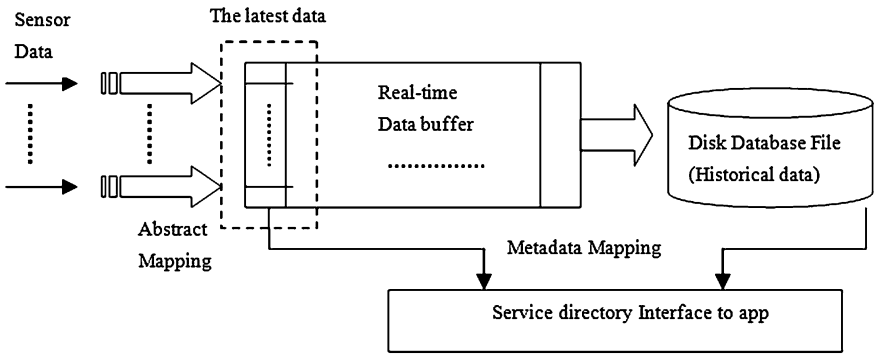

Fig. 37.2 Structure of the real-time monitoring mapping data based on two layers

database. Abstracting memory-type real-time data into real-time data table is the base that real-time monitoring system database interface provides data for the external application.

The data integration module is used to provide file-type historical data and memory-type real-time data in the system for the real-time monitoring system database interface, to preliminarily process and optimize the original data that have been abstracted and to provide data support for the system's access to data interface through metadata mapping. The data integration layer is the core of the metadata service components.

The data access interface module is used to provide standardized database driver, file-type historical data and internal storage-type real-time data in order to realize the real-time data access.

As numerical values collected at varied points of time are different, vector I ($V[i]$) may denote the numerical value at the point of time I. And $V[i..j]$ denotes a series data collected from the time point I to the time point J. D_i denotes the data at a certain point marked by i. The state collected at the time point j can be shown in the Formula (37.1)

$$V_j = \text{state}\left(Dj^{i1}, Dj^{i2}, \ldots, Dj^{ik}, j \in [p, q]\right) \tag{37.1}$$

where $[p, q]$ denotes the time interval between the time point p and the time point q, and C_{as} stands for the data collected and processed in the interval, and D stands for the time interval supplied by the monitoring system and data. As shown in the Formula (37.2),

$$C_{\text{as}} = \sum_{j=p}^{q} V_j = \sum \text{state}(Dj) \tag{37.2}$$

where T denotes the latest time point, if $q = t$ and the data range from C_{as}, which is referred to as the real-time data process performance of the real-time monitoring system is the real-time data of the system. The data beyond the time duration $V_i(i < p)$ can be mapped and written into the historical database for the future inquiry and analysis.

37.3 Design of the Real-Time Data Collection and Storage System

The data management model is responsible for the abstraction of the real-time-detected data, the transformation and transfer between original data, real-time data and the historical data. The real-time data can be visited from the outside system through mapping. The real-time data after the time node can be changed into historical data and stored. It can also be visited from the outside system. The access to real-time data and the historical data is operated through metadata

mapping. The real-time data are served in the systems assigned in the service directory for the graphics display, data process and alarm remind. The historical data can be displayed and analyzed after the visit from the outside.

37.3.1 Metadata of the Monitoring System

Metadata includes various maintenance information, inclusive of attribute metadata, node metadata and service description metadata. It mainly works to describe the data information and provide a kind of standardized format data for the metadata mapping system. Metadata are the description of the comprehensive management abstract data when transferred between the real-time database and the historical database. Metadata can provide data service support for the interface visit to the application program after the procession of the metadata, real-time data and the historical data.

We can use the metadata technology and service-oriented metadata technique to establish the unified data and function model, shield off the data format differences and ultimately establish the integrated grading metadata model. The work flow is as follows: the data storage and service node consist of node data at different points of time. The real-time data stem from monitoring the original data. The historical database derives from the real-time data. The metadata management and data output service are conducted through the metadata management service components.

(1) Abstract-level metadata

Abstract level works to describe the original data from the hardware equipment and collects the node information and the original data from the different monitoring points at the different points of time. It also works to map the original data into the metadata available for the physical layer through abstraction.

(2) Physical layer metadata.

Physical layer describes two objects: storage system and data set. The metadata for the description of physical feature of the storage system are defined as the storage system metadata. It is mainly composed of real-time-recorded metadata and the historical document metadata. Real-time-recorded metadata describes the real-time node information and the real-time data information of the node. Data set metadata mainly work to describe the input and output information of the different data sets between various modules on different levels, inclusive of the data set logo, system symbols and the mapping in the course of the communication between different models. Schema mapping describes the match up between the local model of the data set and the logic view objects. Through schema mapping, the model supports the transparency when visiting the different data set and shields the changes in the physical layer without any change in the outside when the changes with the model take place.

(3) Interface service layer metadata

Description of the interface service layer metadata is carried out in a certain application area. There may be several areas in the model. All the interface service layer metadata are related to the certain application area, and thus, they are called application metadata. The information provided by interface service layer data set is described by classification. Every data set corresponds to a certain category and the data set asked by the business customers are available if the category of the designated data set is visited.

The necessary registration service for the exchange between the different nodes is conducted through the standardized and unified data and function interface. It is only a standardized metadata service component in the form. It is used to exchange, process and issue the information in the system. It is also responsible for the service for the outside system.

37.3.2 Data Arrangement and Mapping

In the course of data storage, it is assumed that the memory capacity is designed to be S, bit width of the check data i is M_i, and the storage of each check point (several assessments) is $S_k = \sum_{i=0}^{n} M_i = \{M_{k0}, M_{k1}, \ldots, M_{kn-1}\}$.

Based on real-time monitoring metadata, the monitored object's data can be shared with the real-time data and the historical data through the unified visit. It can also achieve real-time data packaging and components processing and realize the management and share of the metadata through the standardized visit of the components.

Given the complexity, the real-time data should be stored on its own. The historical data from the real-time data, the alarm information and the state information can be treated as the attribute data, and thus the integration storage can be achieved. The metadata service components are composed of user access layer, data integration layer, directory service layer and transparent data access layer.

The system metadata model involves description of the relationship between the objects in the three abstract levels for the accuracy of the mapping and exchange in the different resources levels [5]. Here are the relationships as follows: (1) the mapping of the real-time data collection objects into the data set. The data set with same logic attribute may provide different information in the acute application environment. So the data set with same logic structure are abstracted as the same real-time data collection object. (2) The mapping of data set to real-time data and historical data. When the real-time data set is changed into real-time data and historical data, the relationship between data can be further classified as dependence, quotation, etc. The support to such relationships is of help for the realization of sorting the data organization and simplicity of view construction because the logic relationship between the real-time data set, real-time database

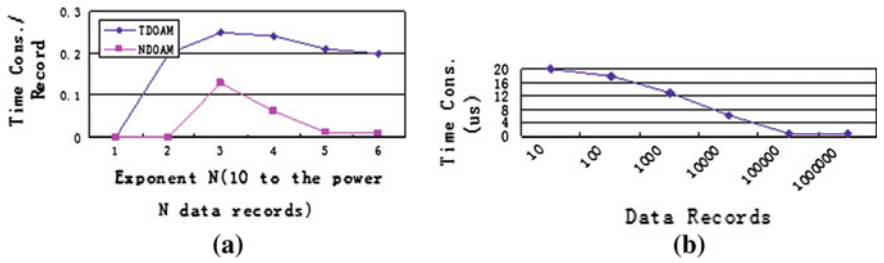

Fig. 37.3 Time consumption performance comparison. **a** Compare with TDOAM. **b** Access time for every record

and historical database is common with all the views of the quoted objects. (3) The mapping of the data access interface to data set and database. In fact, data access interface is the result of the combined operation of one or more data or database objects. The mapping of data access interface to data set and database is just the description of the relationship between the data access interface and the real-time data set and the relationship between data access interface and the historical database.

37.4 Performance Evaluation

The objective of the performance study is to validate our proposed architecture and evaluate and compare its performance against existing architectures under different conditions using simulation. To further study the effectiveness of the architecture, we also evaluate it on a variety of conditions.

We first study the applications containing multiple layers where users in Si can access all the data. In the simulation, we ignored time consumption of obtaining the record. The novel model was compared with traditional model. The reported results were observed from multiple and independent simulation runs, with initial conditions and parameters. We can find the results from Fig. 37.3 that with the increase in record data, the NDOAM's time consumption is increased slower than TDOAM's. This result denotes that the data arrangement and mapping method of NDOAM are better than TDOAM.

37.5 Conclusion

Integrated storage of the detected data in the real-time monitoring system, establishment of the management and sharing model achieve primary solution to the technical problems concerning the sharing and exchange of information data.

The study classifies the real-time data, shields off the differences between the checked real-time state information and the real-time database and the history database in structure and format through metadata. It makes the existing data share break away from the limit and restrictions from the specific monitoring systems and platforms.

The application of the new system model in the real-time monitoring system and its real-time data analysis and process can help to find the problems in the operation and make the right controlling decisions and ultimately guarantee the safe production process. It can also help to meet the need of the application software for the real-time data, improve our users' access for the historical data, their experience of analysis and study.

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Chapter 38
Research of Tow Class Supply Chain with a Retailer-led Under Demand Uncertainty Based on Game Theory

Yang Li, Lei Cong and Weixiang Guo

Abstract The two-class retailer-led supply chain equilibrium model is established under demand uncertainty in this paper. The conclusion can be verified that the enterprises of the supply chain can achieve the optimal total profit as well as individual income through cooperation based on the Stackelberg game theory. In order to maintain the stable cooperation between enterprises of the supply chain, applying cooperation mechanism with buy-back contract can realize the win–win state on supply chain enterprises.

Keywords Demand uncertainty · Game theory · Supply coordination

38.1 Introduction

Good supply chain management can significantly reduce the chain of transactions between companies cost of the entire supply chain to achieve profit maximization problem of the distribution of profits that also attracted wide attention. Yong Long and Xiutai Yang established game model under an uncertain environment, and the use of Choquet expected utility theory to solve the problem of income distribution alliance will enable analysis of more realistic models [1]. Leigang, Lin, and Qinhai establish a consultative-based pricing model for the distribution of profits. According to the main factor of influencing the demand this model determined the plate sides profit distribution factor value, and based on the cooperation model, they discussed both the repeated game in different situations [2]. Huiping and

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_38,

Rongqiu used the ratio of different Stackelberg game analysis on the impact of both partners' profit and profit rate of change based on different speed range, and range from preferences finds their cooperation interval; a new division ratio for profits distribution was obtained according to the cooperation interval—40 % for retailers and 60% for manufacturers [3].

Although the supply chain game has researched a lot, but about under uncertain demand equilibrium model study is less[4–6]. This paper discusses the requirements under conditions of uncertainty, the retailer-led supply chain through two buy-back contract of cooperation mechanisms, to achieve a win–win business chain [7, 8].

38.2 Model Assumptions and Symbols

This paper establishes a two-stage supply chain model, by an upstream manufacturer and a downstream retailer. Market demand is stochastic and the demand information is only be mastered by the dominant retailer. The market demand on one hand is influenced by the sales price and is strictly decreasing function of sales price, on the other hand, by the influence of random factors. That is, $Q = Q_1(p) + Q_2$, in which $Q_1(p)$ and Q_2 can be interpreted to determine the needs of some parts, and random demand, assuming demand for Q_2 is a positive random continuous variable, and the demand for goods at a price is determined by the value of a certain percentage above the uniform floating, that is, Q_2 is subject to $U(0, d)$ uniform distribution $(d > 0)$; the distribution function density function is as follows:

$$f(x) = \begin{cases} \frac{1}{d} & x \in (0, d) \\ 0 & \text{other} \end{cases} \tag{38.1}$$

Retailers know that Q_1, but do not know the true value of Q_2, only know the probability distribution of demand.

Model variable declaration:

π_M Manufacturer profits;
π_R Retailer profits;
C_M Manufacturers manufacturing cost per unit of product;
C_{R1} Retailers storage per unit of product over-cost;
C_{R2} Retailer shortage cost per unit of product;
w The manufacturer's products wholesale to retailers, including $C_M < w$;
p The retailer's retail price

38.3 Non-cooperative Game Equilibrium Analysis-Stackelberg Equilibrium

Because the retailer is the core of supply chain, companies, manufacturers, and retailers in the Stackelberg game in the first retailer make decisions, according to retailers and manufacturers to make their own decision making. Making the order,

First, the retailer gives the first-order quantity Q;

Then, the manufacturer observed Q and selected the wholesale price w.

At this point, the manufacturer's profit:

$$\pi_M = (w - C_M)Q \tag{38.2}$$

For retailers, the ability to determine a sales cycle determines the market demand, while demand can be observed in a random probability distribution $f(x)$ of x, and $Q_1(p) = Q_0 - b_p$.

When the random order quantity is not less than random demand, that is, $x \leq Q_2$, the sales cycle is not the end of each unit of product sold to retailers bear some cost savings over C_{R1}, at this time, the retailer's profit:

$$\pi_{R1} = \sum_{0}^{Q_2} [p(Q_1 + x) - w(Q_1 + Q_2) - (Q_2 - x)C_{R1}]f(x) \tag{38.3}$$

When the random order quantity is less than random demand, that is, $x > Q_2$, at the end of the sale cycle, the retailer need to take certain stock loss C_{R2} for each unit of product, at this time, the retailer's profit:

$$\pi_{R2} = \sum_{Q_2}^{+\infty} [p(Q_1 + Q_2) - w(Q_1 + Q_2) - (x - Q_2)C_{R2}]f(x) \tag{38.4}$$

Therefore, the retailer's profit:

$$\begin{aligned}
\pi_R = \pi_{R1} + \pi_{R2} = &\sum_{0}^{Q_2} [p(Q_1 + x) - w(Q_1 + Q_2) - (Q_2 - x)C_{R1}]f(x) \\
&+ \sum_{Q_2}^{+\infty} [p(Q_1 + Q_2) - w(Q_1 + Q_2) - (x - Q_2)C_{R2}]f(x) \\
&\int_0^{Q_2} [p(Q_1 + x) - (Q_2 - x)C_{R1}]f(x)dx \\
&+ \int^{\int_{Q_2}^{+\infty}} [p(Q_1 + Q_2) - (x - Q_2)C_{R2}]f(x)dx - w(Q_1 + Q_2) \\
&= (Q_0 + Q_2 - bp)(p - w) + \left(Q_2 - \frac{d}{2}\right)C_{R2} - \frac{Q_2^2(C_{R1} + C_{R2} + p)}{2d}
\end{aligned} \tag{38.5}$$

Using Eq. (38.4) for p and Q_2, respectively, we find the first derivative and make them equal to zero:

$$\frac{\partial \pi_R}{\partial p} = Q_0 + Q_2 - 2bp + bw + \frac{Q_2^2}{2d} = 0 \tag{38.6}$$

$$\frac{\partial \pi_R}{\partial Q_2} = \frac{C_{R1} Q_2}{d} - (p + C_{R2})\left(1 - \frac{Q_2}{d}\right) + w = 0 \tag{38.7}$$

By Eqs. (38.5) and (38.6), we can solve for the optimal value of p and Q_2, which will be retail-led supply chain Stackelberg equilibrium solution $\left(p^*, Q_2^*\right)$. Because the expression is too complex to list the expression here, specific numerical solution is only be solved in the example.

At this point, the total profit of the supply chain:

$$\pi = \pi_R + \pi_M = (Q_0 + Q_2 - bp)(p - C_M) + \left(Q_2 - \frac{d}{2}\right) C_{R2} - \frac{Q_2^2 (C_{R1} + C_{R2} + p)}{2d} \tag{38.8}$$

38.4 Cooperative Game Equilibrium Analysis

Stackelberg model is used to get a balanced solution, in equilibrium without any unilateral interest driven to change their decision to change strategy if the price changes will be to lower earnings. However, the equilibrium state is not necessarily optimal Pareto, benefit will be improved if members of the supply chain are cooperative and trust each other. The premise of the cooperation is that cooperation benefits are more than uncooperative.

Assuming that manufacturers and retailers jointly determine the sales price p' to make the whole supply chain and to maximize the return, the manufacturer participates in the sales channels available to retailers to buy back the remaining product in the sales end of the agreement and repurchase price of the wholesale price certain multiples, that is, $\alpha w (0 < \alpha < 1)$.

When the random order quantity is not less than random demand, that is, $x \leq Q_2$, the manufacturer of the end of the sales cycle to αw repurchase price per unit of product is not sold, then retailer profits:

$$\pi'_{R1} = \sum_{0}^{Q_2} [p(Q_1 + x) - w(Q_1 + Q_2) + \alpha w(Q_2 - x)] f(x) \tag{38.9}$$

When the random order quantity is less than random demand, that is, $x > Q_2$, the sales cycle for the end of each unit of product retailers to take some stock

losses C_{R2}, retailer profits at this time:

$$\pi_{R2}^{'} = \sum_{Q_2}^{+\infty} [p(Q_1 + Q_2) - w(Q_1 + Q_2) - (x - Q_2)C_{R2}]f(x) \tag{38.10}$$

Therefore, the retailer's expected profit:

$$\pi_{R}^{'} = \pi_{R1}^{'} + \pi_{R2}^{'} = (Q_0 + Q_2 - bp)(p - w) + \left(Q_2 - \frac{d}{2}\right)C_{R2} - \frac{Q_2^2(C_{R1} + p - \alpha w)}{2d} \tag{38.11}$$

Manufacturers' expected profit is as follows:

$$\begin{aligned}\pi_{M}^{'} &= (w - C_M)(Q_1 + Q_2) - \sum_{0}^{Q_2} [p(Q_1 + x) - w(Q_1 + Q_2) + \alpha w(Q_2 - x)]f(x) \\ &= \frac{(2Q_0 + Q_2 - 2bp)(p - w) - (1 - \alpha)Q_2 w}{2d} + (Q_0 + Q_2 - bp)(w - C_M)\end{aligned} \tag{38.12}$$

Total supply chain profits are as follows:

$$\pi^{'} = \pi_{R}^{'} + \pi_{M}^{'} = (Q_0 + Q_2 - bp)(p - C_M) + \left(Q_2 - \frac{d}{2}\right)C_{R2} - \frac{Q_2^2(C_{R2} + 2w - 2\alpha w) - Q_2(Q_0 - bp)(p - w)}{2d} \tag{38.13}$$

Retailers are given according to the manufacturer repurchase price, starting from the supply chain as a whole, determine the best selling price, making the overall supply chain to maximize profits, so that more members of the supply chain profit improvement.

Equation (38.12) for p and Q_2, respectively, finds the first derivative and makes them equal to zero:

$$\begin{cases} \frac{\partial \pi^{'}}{\partial Q_2} = C_{R2} - C_M + p - \frac{2Q_2(C_{R2} + 2w - 2\alpha w) - (p - w)(Q_0 - bp)}{2d} = 0 \\ \frac{\partial \pi^{'}}{\partial p} = Q_0 + Q_2 + bC_M - 2bp + \frac{Q_2(Q_0 - 2bp + bw)}{2d} = 0 \end{cases} \tag{38.14}$$

Eq. (38.13) will get be an equilibrium solution $\left(p^*, Q_2^*\right)$ in the condition of buy-back contract. Similarly the expression is too complex to list here, a specific numerical solution is also given in the example.

38.5 Example Analysis

There are many examples about the dominant retailers in the supply chain, such as large retailers like Carrefour and its suppliers; this article also has Carrefour and its suppliers to supply chain as an example, to analyze the validation of this chapter in the model.

For example, the Carrefour and Dairy Industry Co., Ltd. Jiamusi Shuoye, Jiamusi Shuoye Co., Ltd. sell red dates yogurt by Carrefour hypermarket. For simplicity, giving the free handling of each parameter, known in a sales cycle, the maximum market demand $Q_0 = 2000$, the market sales price elasticity $b = 30$, that is, part of the market to determine demand for $Q_1 = 2000 - 30p$, Q_2 is a positive random demand continuous variables, and the yogurt demand is determined by the price at a value above a certain percentage of uniform floating, that is, Q_2 obey $U(0, 25)$ uniform distribution, the density function is:

$$f(x) = \begin{cases} \frac{1}{25} & x \in (0, 25) \\ 0 & \text{other} \end{cases} \tag{38.15}$$

Dairy Industry Co., Ltd. Jiamusi Shuoye produces a box of red dates yogurt to pay the cost of production $C_M = 10$ and wholesale to Carrefour at the price $w = 20$. Carrefour places selling price p sales to consumers, as Carrefour does not know the exact values of Q_2, so the unit causes the storage costs $C_{R1} = 15$, due to stock shortages resulting in unit cost of $C_{R2} = 20$. The two sides reached a buy-back contract in cooperation model, and the Dairy Industry Co., Ltd. Jiamusi Shuoye repurchases the unsold yogurt of Carrefour at the price $\alpha w = 20\alpha\,(0 < \alpha < 1)$ in the sales end.

Through the above equations Tables 38.1 and 38.2 can be obtained.

Table 38.1 Decision making under the non-cooperative model

Q	p	π_M	π_R	π
703.18	43.69	7030.88	16573.20	23604.08

Table 38.2 Decision making under the buy-back contract cooperation model

α	$p^{'}$	$Q^{'}$	$\pi_M^{'}$	$\pi_M^{'}$	$\pi^{'}$
0.1	42.84	731.74	7972.08	16481.26	24453.34
0.2	42.91	730.94	7972.69	16501.53	24474.22
0.3	42.99	730.07	7962.98	16523.30	24486.28
0.4	43.07	727.07	7956.98	16544.35	24501.33
0.5	43.15	729.24	7956.68	16563.98	24520.66
0.6 ★	43.24 ★	729.18 ★	7953.16 ★	16580.17 ★	24533.33 ★
0.7	43.33	729.79	7961.52	16418.87	24380.39
0.8	43.42	731.34	7979.91	16367.59	24347.50
0.9	43.51	734.3	8014.92	16534.87	24549.79

By comparing Tables 38.1 and 38.2, in the repurchase contract, the supply chain overall profits are higher than the non-cooperation, but in most of the decision making, Dairy Industry Co., Ltd. Jiamusi Shuoye's profits are increased, while Carrefour's profits are increased but not as high as uncooperative, making the program a win–win only one (as marked "★" in Table 38.2). When the repurchase price is 0.6 times the wholesale price, Dairy Industry Co., Ltd. Jiamusi Shuoye's profits, Carrefour's profits, and the supply chain overall profits are higher than the non-cooperation that reaches a win–win.

38.6 Conclusion

Based on Stackelberg game ideas, this article set up two supply chains equilibrium model under the conditions of uncertainty in demand, verifying that the supply chain can be achieved through cooperation, the optimal supply chain, and their overall income gain of the best, and through a buy-back contract cooperation mechanisms, to achieve supply chain corporate earnings that substantially cover a supply chain to achieve a win–win.

Acknowledgments The authors are grateful to the helpful comment by the anonymous referees. The authors also thank the financial support of the Fundamental Research Funds for the Central Universities (Grant No. DL10BB05).

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Chapter 39
E-Loyalty Simulation Based on Hidden Markov Model

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Abstract With the rapid development of E-retailing business, customer loyalty management becomes more important to E-retailers. However, E-loyalty is not observable from the perspective of merchants, there should have data mining before recognizing and grouping consumers. Moreover, the evolution process of customer loyalty shows dynamic, stochastic and non-after-effect characteristics, which can be called as a Markov process. The paper explores how Hidden Markov model can be applied on E-loyalty researches. Combining with K-mean clustering method, this paper builds the HMM-based E-loyalty simulation model, including transition matrix of customer loyalty and transaction behavior. Detailed experimental results are given in the last part.

Keywords Hidden Markov model · Customer E-loyalty · K-means clustering · Electronic Commerce

39.1 Introduction

By the end of 2012, analysts estimate that consumers will be spending over $400 billion in online transactions [1]. However, the competition in cyber marketplace is fierce too. As for E-retailers, it is a cost-effective and highly efficient way to build relationships with loyal customers by various management activities.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_39,

According to Griffin [2], the customer loyalty is defined as the repeated purchasing frequency of customer, as a consequence driven by customers' preference of certain band name. Customer loyalty has drawn a lot of research interests; the empirical study by Laurn and Lin [3] suggests that the four dimensions of customer trust, satisfaction, perceived value and commitment will have positive impact on customer loyalty; among them, the commitment dimension has the strongest impact. Gefen [4] proposed that the E-customer loyalty is intervened by factors of service quality, trust, switching cost and perceived risk. Some research [5] shows that in traditional industries, the customer retained rate being increased to 5 %, the profitability increased to 25 %.

From the perspective of E-retailers, it is significant to introduce artificial intelligent technology to explore the customer loyalty management by data mining, so as to realize the temporal loyalty recognition and management.

As loyalty state cannot be observed, which is hidden, but the transaction behavior can be treated as the output of certain loyalty, so we can use the Hidden Markov model (HMM) theory to research E-loyalty. HMM is a finite-state machine that is also a doubly stochastic process involving two levels of uncertainty: a random process associated with each state, and a Markov chain, which characterizes the probabilistic relationship between the states in terms of how likely one state is to follow another.

The paper is organized as follows: we first briefly explain the working principle of HMM, giving the notations and terms. Then, we model the customer behavior using K-mean clustering method from sample data, building the output signals for HMM. After classifying E-loyalty, we describe the learning process of loyalty HMM parameters, transition probability matrix and emission matrix. Finally, detailed experimental results and conclusion are presented.

39.2 HMM Background

HMM is a variant of a finite-state machine having a set of hidden states, an output observations, transition probabilities, emission probabilities and initial state probabilities [7]. The current state, here which is loyalty, is not observable. Instead, each state produces an output with a certain probability. Given the HMM parameters, we can find the most likely sequence of hidden states which could have generated a given output sequence; moreover, we can predict and intervene the future output.

As mentioned above, E-loyalty is not visible to observers and is randomly generated by the transaction contact at time t; the evolution process of customer loyalty shows dynamic, stochastic and non-after-effect Markov characteristics. The transaction details, such as amount, frequency and item catalog, can be represented as the underlying finite Markov chain, which is customer loyalty process. Hence, we feel that HMM is an ideal choice for addressing the problem and so as to better manage customer loyalty. An HMM can be defined by the following.

An HMM includes two stochastic processes, we denote the set of states $S = \{S_1, S_2, \ldots, S_N\}$, where $S_i, i = 1, 2, \ldots, N$ is an individual state. The state at instant time t is denoted as q_t. Denote the set of symbols $V = \{v_1, v_2, \ldots, v_M\}$, where M is the number of distinct observation symbols per state. The observation symbols correspond to the physical output of the system being modeled.

We use the notation $\lambda = \{\pi, A, B\}$ to define an HMM, A represents the state transition probability matrix, where $A = \{a_{ij}\}, a_{ij} = P(q_{t+1} = S_j | q_t = S_i)$, representing the probabilities to go from state i at time t to state j at time $t + 1$, $0 \le a_{ij} \le 1, \sum_{\substack{i,j=1 \\ i \ne j}}^{N} a_{ij} = 1; 1 \le i \le N, 1 \le j \le N; t = 1, 2, \ldots$

B is the observation symbol probability matrix, also called as emission matrix, which represents the likelihood of a certain observation v_k when the model is in state S_i, where $b_i(k) = P(v_k | S_j), 1 \le i \le N, 1 \le k \le M, \sum_{k=1}^{M} b_i(k) = 1$.

π is the prior probabilities matrix, denoted as $\pi = [\pi_i]$, where $\pi_i = P(q_1 = S_i), 1 \le i \le N, \sum_{i-1}^{N} \pi_i = 1$.

The observation sequence is $O = \{O_1, O_2, \ldots, O_R\}$; each observation $O_t, t = 1, \ldots, R$ is one of the symbols from and R is the number of observations in the sequence.

A complete specification of an HMM requires the estimation of two model parameters N and M, and three probability distributions A, B, π.

39.3 HMM-Based E-Loyalty Evaluation Model

Traditionally, businesses divide customers to different groups from the strategic point of view, and this segmentation method is comparatively simple and static. Meanwhile, online customers will change their behavior pattern from time to time due to variation of their needs and different marketing stimulations from marketplace, hence will switch from segmentation to another [6]. The customer data mainly include three categories: the first is description information, the second is affiliation information, and the third is transaction information itself. Moreover, transaction information, such as date of purchase, product price, purchases frequency, can truly reflect their shopping behavior; E-businesses can easily collect these real-time information and save them for data mining. This paper will adopt the transaction information as the base to produce observation symbols V for HMM. We choose the following three nonlinear correlated key transaction indicators at the first step; they are average transaction value per month, purchase frequency per month and items purchased per month. Then, we will apply K-mean clustering method and try to find out the purchasing pattern of sample web site.

In data mining, K-means clustering is a method of cluster analysis which aims to partition n observations into K clusters in which each observation belongs to the cluster with the nearest mean. The objective function is given as $e^2 = \sum_{j=1}^{k}$

Table 39.1 Sample transaction data (per month)

	Average amount X	Frequency Y	Categories Z
No. 0001	420	8	3
No. 0002	183	5	7
…	…	…	…
No. 1,200	3,150	19	22

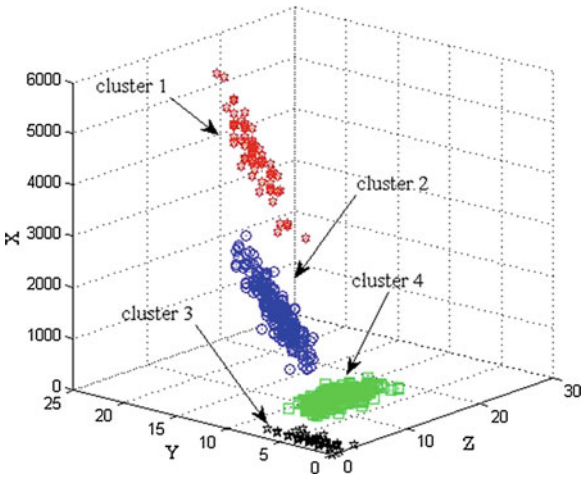

Fig. 39.1 Three-dimensional K-means clustering output

$\sum_{i=1}^{n_j} \left\| y_i^{(j)} - z_j \right\|^2$, where $\left\| y_i^{(j)} - z_j \right\|$ is a chosen distance measure between a data point $y_i^{(j)}$ and the cluster center z_j is an indicator of the distance of the n data points from their respective cluster centers.

Here, we set $K = 4$ and then use MATLAB as a tool to process the sample data in Table 39.1, the clusters are shown in Fig. 39.1 and Table 39.2.

Cluster 1: Routiner, whose average spending amount, number of frequency and transaction category varieties are at the high level, representing the purchase behavior characterized as routine and loyalty.

Cluster 2: Simplifier, whose average spending per month is high but the frequency and category varieties are relatively low, they only show interests to certain products and repeat purchase every month, representing the transaction behavior driven by mainly by convenience.

Cluster 3: Bargainer, whose average monthly amount, frequency and category varieties are all at low level, representing low interests of online shopping or low financial ability?

Cluster 4: Group buyer, whose monthly spending is moderately high, but the frequency and varieties are low, representing the accidental purchase behavior or group purchase behavior.

Consider there are three levels of online customers' loyalty to E-retailer, and they are all hidden to E-retailers, so we can treat these three levels as the hidden

Table 39.2 Output of K-means clustering algorithm

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Transaction behavior	Routiner	Simplifier	Bargainer	Group purchaser
z_j	(3500,21,20)	(1700,13,9)	(31,2,1)	(720,5,4)
Percentage (%)	5	27	35	33

states in the HMM. They are low loyalty (given as l), medium loyalty (given as m) and high loyalty (given as h), so the HMM state set is $\{l, m, h\}$. Now, we start training the HMM. The training algorithm has the following steps: (1) initialization of HMM parameters, (2) forward procedure and (3) backward procedure. For training the HMM, we convert the consumer's transaction behavior into observation symbols and form sequences out of them. At the end of the training phase, we get an HMM $\lambda = (A, B, \pi)$ corresponding to the sample E-retailer.

39.4 Numerical Examples and Analysis

After HMM training step, the parameter estimation is given as follows:

$$A = \begin{array}{c|ccc} & l & m & h \\ l & 0.42 & 0.35 & 0.23 \\ m & 0.32 & 0.38 & 0.3 \\ h & 0.23 & 0.42 & 0.35 \end{array} \quad B = \begin{array}{c|cccc} & C_1 & C_2 & C_3 & C_4 \\ l & 0.1 & 0.5 & 0.3 & \\ m & 0.3 & 0.2 & 0.3 & 0.2 \\ h & 0.4 & 0.2 & 0.1 & 0.3 \end{array} \quad \pi_0 = (0.52, 0.27, 0.21)$$

Since we have the HMM $\lambda = (A, B, \pi)$, now we will give several numerical examples to show how the HMM works for online customer loyalty management.

Take another example to exemplify the HMM of its application in managing customer loyalty.

Take the observation timescale $t = 10$, retrieve the transaction data to generate the observed signals. Here, we have $t = 10$, and the consumption behaviors in the past 10 months are given in the signal set $O' = (C_4, C_3, C_4, C_3, C_4, C_3, C_2, C_2, C_1, C_1)$

Then, we run MATLAB, the result is given as follows:

```
prior2 = [0.52 0.27 0.21];
transmat2 = [0.42 0.35 0.23;0.32 0.38 0.3;0.23 0.42 0.35];
obsmat2 = [0.2 0.1 0.5 0.3;0.3 0.2 0.3 0.2;0.4 0.2 0.1 0.3];
data2 = [4 4 4 3 4 3 2 3 1 1];
obslik = multinomial_prob(data2,obsmat2);
path = viterbi_path(prior2,transmat2,obslik)
```

The output of the HMM is given as follows:

$$S = \{S_1 = 1, S_2 = 1, S_3 = 1, S_4 = 1, S_5 = 3, S_6 = 2, S_7 = 2, S_8 = 2, S_9 = 2, S_{10} = 2\}$$

According to the calculation of HMM, this customer has developed a stable loyalty level with E-retailer, which is to say, in the recent 5 months, the customer's loyalty stays on the medium level. This is important information for merchant to put focus on this kind of customer with target marketing techniques, instead of focus on low loyalty customers, knowing that the former kind has much lower customer retention cost and acquisition cost than the later kind. If E-retailer can calculate every customer's loyalty level and categorize them into different groups, then take specific marketing tools to meet various needs for each group. For example, if customers are predicted to belong to the high loyalty group, by understanding their purchase pattern, then E-mail marketing technique can be applied to recommend high value commodities to entice them staying with the E-retailer, or stimulate them with bonus to use social network techniques such as Twitter or Micro-blog to spread marketing information.

39.5 Conclusions and Discussion

In this paper, we have proposed an application of HMM in online customer loyalty management. The different steps are represented as the underlying stochastic process of an HMM. We have developed the purchase patterns as the observation symbols, whereas the customer loyalty level to be the hidden states of the HMM. Here, we applied the K-means algorithm to distinguish various transaction data into purchase pattern; from the sample website, we choose 100 customers of 1,200 sets of data to develop the benchmarks. Then, we use numerical examples to explain the usage of HMM and relate the results with marketing purpose. The major contributions of this paper can be summarized as that a well-defined representation for the prediction of the potential customer loyalty, which is proposed with the Hidden Markov model. In the future, we will research the HMM with greater customer data and develop software to realize simultaneous customer loyalty management for online retailers.

Acknowledgments This paper is sponsored by the Bilingual Course Foundation of Chongqing Normal University.

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Chapter 40
Real-Time Simulation of Fireworks Based on CUDA and Particle System

Gang Liu, Fuyan Liu and Fangjie Tao

Abstract There are two performance bottlenecks in fireworks simulation using traditional particle system that utilizes CPU to update particle properties. First, the efficiency is low using CPU to update the property of each particle. Second, CPU will transfer each updated data every time to GPU for rendering, which causes too frequent communication between CPU and GPU. This paper introduces a new particle system method for fireworks simulation based on compute unified device architecture (CUDA). The method uses parallel threads of CUDA to update the particle properties. It reduces the frequent communication between CPU and GPU by graphics interoperability of CUDA and OpenGL. The field experiment shows that the rendering speed of fireworks simulation is accelerated using CUDA. The rendering effect can meet the real-time requirement of video game and virtual reality.

Keywords Particle system · Fireworks · CUDA · Texture mapping

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_40,

40.1 Introduction

The simulation of the natural objects such as clouds, fireworks, large-scale sea surface has been the focus of computer graphics research. Those objects have fuzzy boundaries and keep changing over time, which makes the traditional rendering method hard to simulate. In 1983, Reeves introduced the simulation of fuzzy objects based on particle systems [1]. His method had very good randomness and dynamic nature, which made it then a widely used tool for simulation of natural objects. However, due to the ineffective CPU processing of each particle's property and frequent communication between CPU and GPU, the particle system based object simulation has the bottleneck of real-time rendering.

In 2007, NVIDIA introduced compute unified device architecture (CUDA), a software–hardware system that utilizes GPU as data parallel computing unit. The GPU architecture that supports CUDA has been significantly improved; making the CUDA architecture is more suitable for the purpose GPU parallel computing. First, using a unified processing architecture can be more efficient use of computing resources distributed in the vertex shader and fragment shader. Second, introduction of on-chip shared memory supports random writes and communication between threads [2]. This platform provides users with a simple CUDA C programming interface, reducing the complexity of the complexity of the GPU programming. Meanwhile, using the unit form of organization benefit to the program run in parallel computing in the hardware greatly improves the computation speed.

This article uses the CUDA threads in parallel to update the properties of the particles. According to graphics interoperability between CUDA and OpenGL, to reduce the frequent transfer of data between the CPU and GPU, and effective solution to traditional CPU-based particle system pyrotechnic simulation bottlenecks.

40.2 Principles of Particle System

The particle system is the boundary formed by many small particles as the basic elements of fuzzy systems. To simulate different natural features, you can use different types of elementary particles, such as point particles, the ray particles and the surface particles [3].

In general, different particles have different properties, such as the initial direction of emission of particle, the initial color. Particles in the system have different properties, such as location, size, color, speed, acceleration. Each particle in the system has a "birth," "aging" and "death" three stages in this process, the particle properties change over time. Abstract of motion of the particles in the natural scene, according to particle system properties and particle properties to control the motion of particles to simulate natural scenes [4]. Particle system workflow is shown in Fig. 40.1.

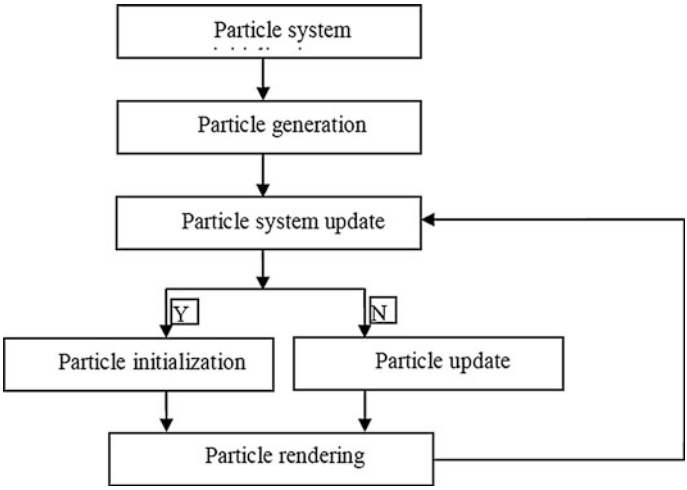

Fig. 40.1 Workflow of the particle system

40.3 Fireworks Particle System Model

Firework simulation, the main task is to update fireworks particle system, as well as the properties of the particles in the system. Simulate different types of fireworks, the abstract law of motion of different firework particles, each particle is then given as the initial property, and then update the particle properties according to the mechanical analysis of the particle.

40.3.1 Fireworks Particles and System Properties

To define a fireworks particle class, all the fireworks particle properties are a number variable of the class of fireworks particles [5].

Class C Particle:

{Position, Velocity, Acceleration, fAlpha, fAlpha Change, Color, Color Change, fSize Change, fDie Age, fAge}.

The properties of fireworks particle include position, velocity, acceleration, alpha value, alpha rate, color, the color change rate, size and the current value of life. Which the particle position, velocity, acceleration is the three-dimensional vector.

Define a fireworks system class, as follows:

Class C Particle System:

{Emitter Position, Max Creation Deviation, Standard Emit Direction, Max Emit Direction Deviation fMin Emit Speed, fMax Emit Speed, Acceleration Direction …}

Fireworks system attributes include the location of the particle emitter, launch the biggest change in the scope of the position, the initial direction of emission, the emission direction of the maximum range, the minimum rate of fire, direction.

40.3.2 Peony Type of Fireworks Simulation

Different varieties of fireworks in the discharge, the color of the fireworks particles, the degree of light and dark, as well as the shape after the explosion are not the same, especially the shape after the fireworks explosion is vastly different. However, using computer simulation fireworks discharge; these can adjust the properties of particles to achieve. In this paper, according to CUDA parallel is used to accelerate rendering of the particles to achieve a real-time simulation of the firework.

Entire peony fireworks display process is divided into two stages before the explosion and after the explosion. First, a firework particle launched from the ground, explosion when the particle will death. Second, off particle death point as explosion point, generating a large number of particle emitted to the surrounding constitute peony shape. The peony firework contour similar to a spherical, by polar coordinates to initialize the initial velocity of the particle direction, and then given the speed of the approximate size. Direction of the velocity is given as follows:

```
m_pParticles [i]. m_Velocity. x = sin (phi) * cos (theta);
m_pParticles [i]. m_Velocity. y = cos (phi);
m_pParticles [i]. m_Velocity. z = sin (phi) * sin (theta);
```

where phi is the center of the sphere to the spherical point where the ray and Y-axis positive angle, theta is the spherical point in XOZ plane projection point with the center of the sphere of connection with the X-axis positive angle.

40.4 The Key Technology of Fireworks Simulation

In order to realistic simulation the firework, use of firework texture mapping making the particles is more realistic. Use the Billboard technical sight direction perpendicular to the plane always firework texture will not change the line of sight to the firework texture into flakes.

40.4.1 Texture Mapping Technology

The use of texture mapping can generate realistic images, and the implementation cost is relatively small. Texture mapping techniques, including the following steps:

1. Create a texture object and specify a texture for it.
2. To determine the texture how to apply to each pixel.
3. Enable the texture mapping function.
4. Draw the scene; offer the texture coordinates and geometric coordinates.

Use traditional methods to simulate the display of firework, particles will consume a lot of time and resources. When the number of particles is too low, the simulate of the effect of distortion. Excessive number of particles, real time is affected [6]. Using the square as the primitives of the firework particle, TGA format firework texture (Fig. 40.2) is mapped to the square on the use of texture mapping techniques.

40.4.2 Billboard Technology

Billboard is a technology that when texture mapping or point of view after rotation, the texture maps always face the observer. The idea is that putting a static image as a texture to a simple geometric plane and then pan around the object itself, rotate the plane depending on the location of the viewpoint transformation, so that the point of view is always orthogonal to the plane [7]. Draw each firework particle, real-time calculation of particle facets relative to the direction of the point of view, by multiplying the rotation matrix that can be the particle facets to the viewpoint's location.

40.5 CUDA Parallel Acceleration

CUDA is a parallel programming model and soft environment. It is traditional for graphics rendering GPU for general purpose computing and gives full play to the GPU in the huge advantage of parallel computing. The basic idea is that of the CUDA programming: the program is divided into host-side program and device-

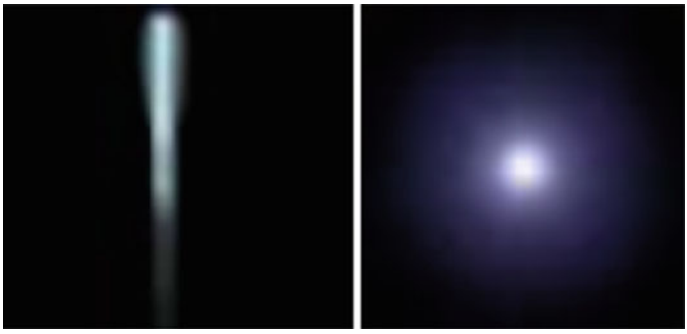

Fig. 40.2 Firework texture

side program [8]. First, allocate memory on the host side and device side, then taking the calculate data transmitted by the host side to the device side, calculation is done by the device side to return the host side. Under the CUDA architecture, thread is the smallest data execution unit, multiple threads consist a thread block, the thread in each thread block can communicate, and multiple threads block consists a thread grid. The two threading model can increase the number of processing units. The relationship between the thread grid, thread block and thread is shown in Fig. 40.3.

In the rendering of a large number of particles, the traditional CPU serial updates the particle properties, low efficiency. For each particle is assigned a parallel thread to update each particle properties, improve efficiency. In this experiment, the particles are independent, so using one-dimensional threads and thread blocks is more convenient.

Designed as follows:

Dim 3 blocks (128, 1, 1); //each thread block has 128 threads

Dim 3 grid (Num Particles/128, 1, 1); //number of thread blocks are Num Particles/128

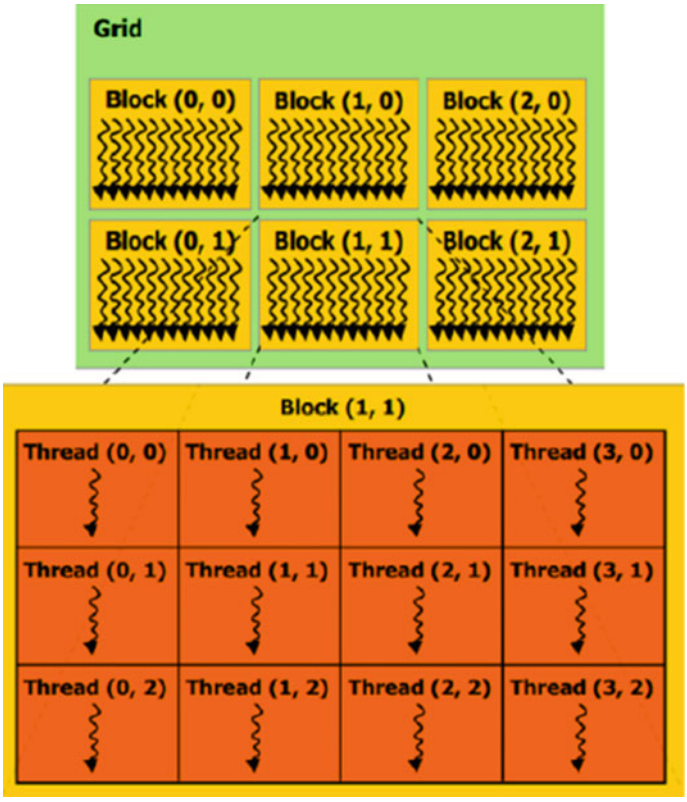

Fig. 40.3 Grid of thread blocks

The core function is Update Kernel <<<grid, block>>> (d_data, time pass);

For one-dimensional thread block, the thread ID and storage space index mapping are as follows:

x = threaded x. x + block Id x. x * block Dim.x;

Each particle will be assigned to a thread, the order of the particles created in the order corresponding to thread index.

The interoperability capabilities of CUDA and OpenGL, respectively, through handle buffer object and resource operations of the same memory space are used. After the update is complete when each frame of particle properties, OpenGL through handle buffer object remove the particle data to render [9], reduce the frequent transfer of data between the CPU and GPU to improve the rendering speed.

40.6 Result

Experimental platform: Intel (R) CPU T2370 1.73 GHz, memory 3 GB, graphics card Ge Force 8,400 GS, 0.80 GHz, video memory 128 MB, computing power 1.1, compilation environment Visual Studio 2010, API OpenGL 2.0. Implementation peony pyrotechnic effect is as follows in Fig. 40.4.

Table 40.1 shows the CPU and CUDA platform to simulate the frame rate of the different number of firework particles. Simulating of 5,000 particles, the FPS of CPU platform is 17, the CUDA is 56 FPS rendering speed more than three times to CPU, meet the requirements of real time. When the number of particle is 12,000, the FPS of CPU is 9, the picture is not smooth, the CUDA platform is 39 FPS, and

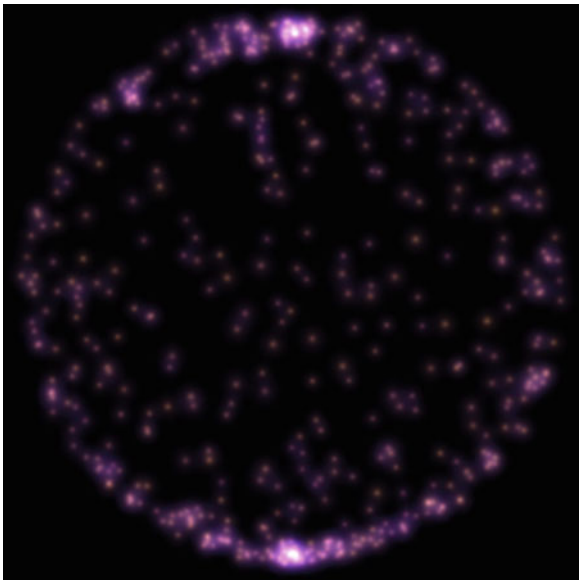

Fig. 40.4 Peony firework

Table 40.1 CPU and CUDA' FPS

Particle number	CPU/FPS	CUDA/FPS
300	62	95
5,000	17	56
12,000	9	39

the picture is smooth. The number of particles increased from 300 to 12,000, CPU rendering speed down 7 times, and the CUDA platform rendering speed only decreased by less than 3 times. Thus, using CUDA platform to accelerate operations, the real-time simulation was improved.

40.7 Conclusion

This paper describes the fireworks discharge simulation using particle systems. It also shows how to do the modeling and rendering of peony-type fireworks. In order to achieve the realistic visual effects, the texture mapping and Billboard technology are applied. In order to get the real-time simulation, the CUDA platform is used to accelerate the rendering of the fireworks particles. As shown from the experiment results, the simulation methods introduced in this paper can accelerate the data computing and improve the real-time fireworks simulation. The future study directions include modeling of more variety of fireworks, increasing the smoke effects in the fireworks discharge to achieve a more realistic simulation, and optimizing the parallel acceleration of CUDA so as to improve further the real-time efficiency of simulation.

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Chapter 41
Industrial Robot Simulation Based on OpenGL

Yan Ma, Tian-ping Dong, Xiaohong Lan, Lunp-eng Liu and Guo-tian He

Abstract In the background of simulation system and industrial robot, this paper described the application features of OpenGL and focused on the design and implementation of simulation system of industrial robot. Then, we need to study the application and key technology of OpenGL in graphical simulation system and to explore the implementation method of the system. Finally, the disadvantages of OpenGL in specific industrial robot simulation system were described, and to achieve good results further improved measures were proposed in this paper.

Keywords Industrial robot · Simulation · OpenGL

41.1 Introduction

Robot is an attractive topic and researchers have been studied it several decades. It has obtained a great development and been applied in various economy fields, especially in modern industrial production, robot has become an indispensable assistant for it can perform many work which human beings could not be done, such as deep-sea exploration, aerospace applications, automotive welding, and so on. In the framework of research and design robot, graphic simulation system

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_41,

plays a very important role and been widely applied in various fields for it is a safe, reliable, flexible, and convenient tool [1]. Graphic simulation system has some significant advantages. In addition, users can select the appropriate type robotic according to the specific job based on graphical simulation technology.

Intuitively, a powerful and efficient development tool, known as OpenGL which is the most convenient and practical tool, is needed to develop robot graphic simulation system.

The rest of the paper is structured as follows. Section 2 presents the research of industrial robot simulation. Section 3 describes the application features of OpenGL. It presents simulation system and 3D industrial robot model. In Sect. 4, we report on the application and key technology of OpenGL in industrial robot graphic simulation; and Sects. 5 and 6 conclude.

41.2 The Research of Industrial Robot Simulation

According to the rapid development of artificial intelligence (AI), the technology and function of robot has been significantly enhanced, such as the mobile robot, the improved visual and tactile technology of robot, and so on. Recently, a large number of robots have been applied in various fields, and the industrial robots were the most widely used in practice. Industrial robot was proposed since the early 1960s, it has been widely applied in industrial field during the 40 years development. Fully automated welding process of welding robot is a hotspot for the wide employment and fast development of welding robot in automotive industries. At present, the robotic welding production lines were introduced by the major car manufacturers of various countries which has been become a crucial competition. Meanwhile, there is a trend of developing a wide range of robotic machines according as diffusing the robot technology, such as sensor technology, intelligent technology, control technology, etc., and these technologies are penetrated into other files.

Current production and application of industrial robot are more mature in developed foreign countries, such as Japan, North America, Europe, Korea, and so on. These industrial robots are mainly employed for automobile, motorcycle, engineering machinery, electronics, home appliances, and chemical industry, which deal with those complex operations, such as welding, assembly, handling, processing, spraying, palletizing, and so on. Since the 1970s, some researchers, from foreign universities and research institutes, have been focused on robot parameters, the coordination of robot positioned and researched robot offline programming and simulation technology, then developed a prototype system. In China, industrial robot mainly used in automobile, recycle, engineering machinery, railway locomotives, and other major industries. The welding robot is the largest and also the first user is automobile manufactories. Recently, the robots in China mainly have three categories: Japanese robots, European robots, and domestic robots. And robots from the SIASUN are the most popular in China.

Generally, we employ Windows platform to develop robot simulation; and object-oriented programming method is used in the robot design process of geometric model and the simulation program. When we design simulation model, the problem model is obtained by detail analysis the object-oriented method which contributes to simulation and solution space model of robot. Hence, we choose the object-oriented programming Visual C++ 6.0 and OpenGL simulation programming as our development tool in this paper. As Visual C++ 6.0 closely integrates object-oriented analysis (OOA), object-oriented design (OOD), and object programming (OOP), it produces a more effective method for large and complex object-oriented application programming than traditional process-oriented programming. Thus, the principle of robot simulation system is shown in Fig. 41.1

41.3 The Application Features of OpenGL

Open graphics library (OpenGL), 3D computer graphics software interface, was developed by SGI for the standard of graphics workstations. It aims at drawing 2D or 3D object into a frame buffer. The object is defined as a series of vertex or pixel, the vertex and pixels usually be used to describe geometric objects and images, respectively. Then, OpenGL make data convert to pixels with some processing, and these pixels can form the eventual display graphics in the frame buffer [2]. All OpenGL interfaces are open and can be applied to various hardware platforms and operating systems. Then, users can create 3D color images of high-quality static and dynamic which close to the ray tracing with effectively employ OpenGL [3, 4]. Thus, the application features of OpenGL are:

(1) OpenGL is independence on the hardware platform. OpenGL is software interface which independent on hardware. Intuitively, source code which without modify, can be run on different operating systems of personal computers and workstations. Thus, OpenGL has good portability.

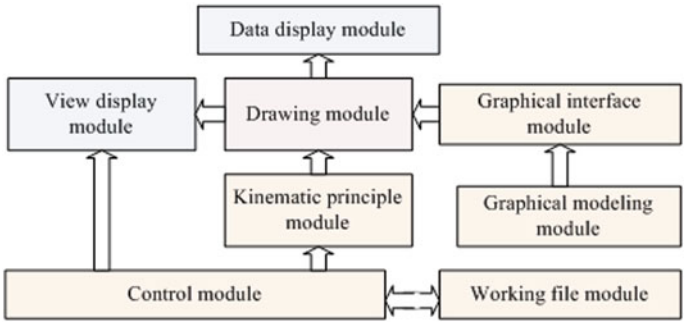

Fig. 41.1 The schematic figure of simulation system

(2) Offline programming. According to the working mechanism of OpenGL is client/server mode, it is transparent to network. Thus, OpenGL is convenient to operate in the remote network environment.
(3) Dynamic Link. In Visual C++ 6.0, we can compile dynamic link library for other procedures call by the interface of OpenGL and Windows system using the MFC class library.

Owing to the enhancement in hardware performance and the development of the operating system, the overall performance of computer has exceeded over early workstation. Because of OpenGL has been integrated into the Windows, users either develop OpenGL application procedures in Windows environment, or can easily transplant procedures of existing workstations on Windows. Therefore, it is convenient to achieve interactive and high-quality 3D graphics based on Visual C++ and OpenGL graphics library on PC [5]. Certainly, high-efficiency and low-cost robot simulation system is rapidly developed according to the further development of hardware and software.

This paper addressed the robot simulation system based on OpenGL on PC, and achieved good result in theoretical and practice. The simulation result of the system graph is shown in Fig. 41.2.

41.4 Simulation System

41.4.1 Virtual Simulation Environment

The simulation system includes three basic elements: model, system, and computer. And the basic activities, which contract these basic elements, are simulation modeling, system modeling, and simulation. These relationships are shown as follows: (Fig. 41.3)

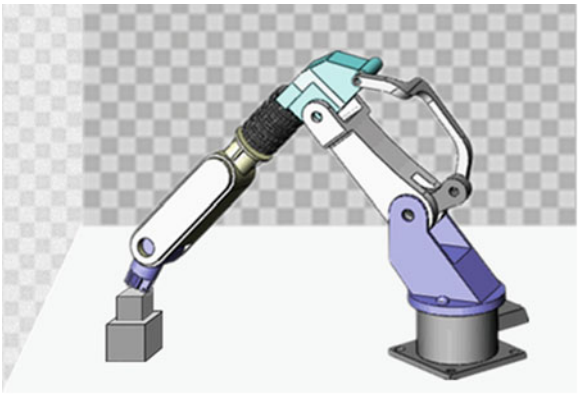

Fig. 41.2 The simulation results of robot model

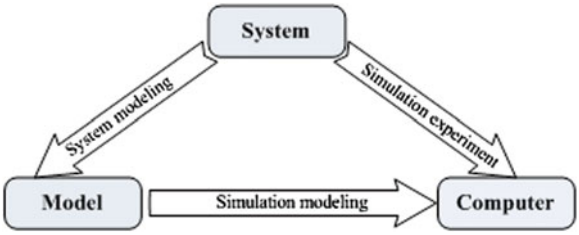

Fig. 41.3 The three elements and three basic activities of simulation system

We note that OpenGL provides a 3D graphics standard with good compatibility and it aims at ignoring the development tools for developers. OpenGL only focuses on the work itself without regarding to hardware and software, and only to modeling, lighting, rendering, set based on the basic knowledge of image [6]. Usually, developers employ the OpenGL graphics library to build 3D visual model based on the robot simulation system.

However, OpenGL is a pure API; we need to build a basic application framework. And the application framework is developed by following methods.

(1) Setting the OpenGL basic library

First, we import OpenGL library to Visual C++ 6.0 and installation configuration files, such as DLL files, LIB files, H header files, and so on. Then, an executable program of single document type is constructed by MFC class library. Finally, adding OpenGL header files in View.h file. The code in View.h file can be written as follows:

```
#include "gl\gl.h"
#include "glu\glu.h"
```

(2) Add variables, functions, and message response

In this step, we need to add member functions, variables and message response to the class View.

(3) Setting pixel format

OpenGL draws graphics and displays graphics with rendering context, instead of device context of Windows. A key part of the rendering context is setting pixel format. When we use drawing operation of OpenGL, in fact, we operate the device pixel. The data are transferred into pixels on OpenGL, when pixel format of Windows is necessarily known, then storing these pixels to frame buffer. Usually, PIXELFORMATDESCRIPTOR is used to set pixel format which includes color mode, color bits, cache settings, and depth buffer bits.

(4) Rendering description table

We construct the rendering description with function Myfirst ().

(5) Setting viewpoint and view-field

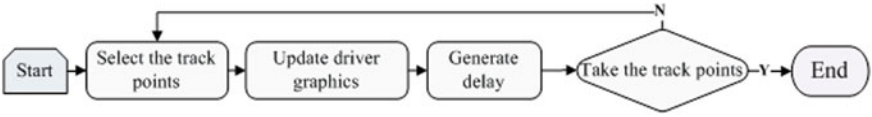

Fig. 41.4 The flowchart of 3D animation effects

Setting viewpoint and view-field and changing view-field with function Myfirst () and message response function Onsize (), respectively.

(6) Setting window background

Generally, we set window background using function OnDraw ().

Obviously, the basic program framework was built after the above steps, then we can draw graphics with function MyDraw () in class View. In order to efficiently develop OpenGL, we rather set the built OpenGL framework into the options of development project based on the special function of VC++ 6.0, than repeatedly develop the above steps, thus greatly enhance the development efficiency.

41.4.2 3D Industrial Robot Model

Intuitively, setting virtual work space and drawing robot graphics with function MyDraw () in class View. Shreiner et al. proposed 3D industrial robot model with the basic drawing graphics program function on OpenGL platform [7].

The industrial robot effect is displayed by the update planning trajectory graphics. In order to achieve the program, determining the point of the planning trajectory is the first step. Then, solving the joint angles of each trajectory interpolation point and updating the window with graphical program interface, which can obtain the dynamic display. The flowchart of 3D industrial robot model is described in Fig 41.4.

41.5 Application and Key Technology of OpenGL

41.5.1 OpenGL Application in Industrial Robot Graphic Simulation

It is easy to achieve the industrial robot graphical modeling with the powerful OpenGL 3D graphics function [8]. We have simple industrial robot graphical model in Fig. 41.5.

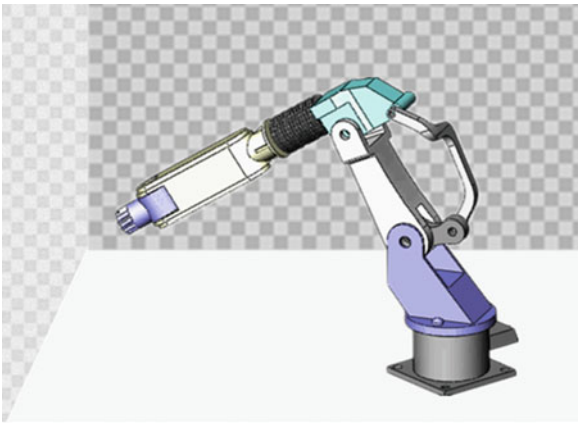

Fig. 41.5 The simple robot model

The advantages of OpenGL clearly outperform Windows graphical device interface (GDI), such as setting the material and light, using the function directly construct 3D polyhedron and setting projection parameters of 3D polyhedron. Therefore, we can directly call the function itself to develop industrial robot modules. Instead of users design algorithm to calculate the projection which project each vertex of 3D polyhedron onto 2D plane, we only focus on the 3D polyhedron coordinate parameters in actual 3D space, and draw image and realistic 3D polyhedron which have light and surface texture. Moreover, OpenGL also has advantage both the choice of projection and the observation position of observers. On one hand, users can set projection function, which enables users to select parallel projection or perspective projection, and set projection angle. On the other hand, it produces a function, which makes any entity rotate around or translate along any straight line in space. Thus, observers can easily observe robot state from different angles and different line of sight. Considering the real-time and smooth animation, in addition, we generate a new image in PC memory, then copying the new image to a certain region of the screen. Use of OpenGL device work of the independent bitmap (DIB) and double buffer can solve the above problem. It is easy to use the OpenGL, a class OpenGL is created and its code is encapsulated in practice programming.

41.5.2 OpenGL Key Technology in Industrial Robot Graphic Simulation

Unfortunately, OpenGL has some limitations in practice implementation process for it only provides some sample graph drawing orders. It is difficult to construct complex graphs. For solve this problem, we introduce the Open Inventor, 3D Studio, and Virtual Reality.

Open Inventor is object-oriented tool package based on OpenGL, it provides not only the object and the application method for constructing interactive 3D graphics, but also the preconstructed object, the interactive built-in event model and advanced applications for creating and editing 3D scene.

In addition, 3D Studio from AutoDesk and Virtual Reality from Visual Software are used to construct industrial robot model, and they are a beneficial application additive of Open Inventor. We aim at studying the data file format for saving 3D model and developing software system which corresponds to the interface of model data file based on the above two software. Necessarily, the software system is demanded to read model parameters from the data files and implement the model. Therefore, the implemented model is match to system graphics algorithm.

Unfortunately, the speed of drawing 3D graphics with OpenGL is not always ideal. At this point, we must take further measures to improve the drawing speed. According to OpenGL is based on the client/sever, its running speed on Windows NT is about 30 % higher than which on Windows 98. Thus, it is a good measure that the system is transplanted to Windows NT. In addition, there is certain independence between drawing graphics and collecting and sending data. As well as considering to make full use of multithreaded or distributed operating systems to enhance system speed.

41.6 Conclusion

According to continuous development of the robotics research, the application fields of robotic automation control will become an increasingly widespread. And it brings more significant economic and social benefits. Industrial robot simulation applications based on OpenGL is feasible in practice and achieves the desired results. This method has some advantages, such as it is mastered easily, reduced development costs, improved development speed, good extensibility, etc. And OpenGL has a certain reference in other fields. When we deal with large-scale high-quality, high-resolution, and high-brush graphics based on interaction between hardware and software in the system, we can obtain the efficient display.

It is worth emphasizing that industrial robotic automation control is still in the industrial production initial stage, and it must be simultaneously developed with the corresponding mechanical industry and computer. However, the development of industrial robots will face many problems, such as new structures and new materials are required in robot production, robotic automation control systems need to develop current sensor and control technology, to plan the optimal operating path of robot and to improve human–computer interaction technology of the robot control system, etc. Obviously, with the development of computer technology, artificial intelligence, sensor technology, communications technology, and other key technologies of industrial robots and automation control, robot

automation technology will play a key role in realizing industrial unmanned production in the future.

Acknowledgments This work is sponsored by Chongqing Higher Education Educational Reform (NO: 102118) and Chongqing Education Committee (KJ090809).

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Part V
Grid Computing and Cloud Computing

Chapter 42
Provisioning Virtual Educational Resources Based on Private Cloud

Guoxiang Zhong and Tangming Yuan

Abstract Nowadays, "cloud computing" has become an increasingly popular term. Many researchers are attracted in promoting education development through cloud computing technology. Virtualization is the core of the construction of an educational resources platform based on cloud computing. This paper focuses on the provisioning virtual educational resources through private cloud with particular concerns with security, QoS, and lifelong learning. Related work in the area is discussed, on the basis of which principles of educational resources development are proposed. The paper also provides an analysis of the services provided by the virtual educational resources platform and proposes a novel platform architecture for private cloud-based virtual educational resources.

Keywords Private cloud · Educational resources · Virtualization · Architecture

42.1 Introduction

Since the WWW was launched, open educational resources have rapidly become freely available [1]. The available materials, however, are of widely varying quality. The majority of the materials neither promotes enhanced learning nor incorporates the latest technological and pedagogical advances. The lack of quality

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_42,

assurance for open educational resources is impeding the quality enhancement of modern education.

The recent advance in "cloud computing" provides a new opportunity in sharing high-quality educational resources. Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms, and application software). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a paper—use model in which guarantees are offered by the infrastructure provider by means of customized SLAs [2]. Educational institutions, however, may not be willing to run mission-critical applications in a public cloud and send sensitive resources to the cloud for processing and storage for reasons of security. They prefer having their teaching activities conducted even when the Internet and cloud are offline or the network communication is slow. The advances of multicore technology and desktop supercomputer make this possible. For reasons of security, QoS, and lifelong learning discussed above, private cloud for educational resources platform is a more preferred choice.

Virtualization is the core of the construction of educational resources platform. Virtual data capture the relationship between data, programs, and computations and prescribe various abstractions [3]. The role of virtualization in clouds is emphasized by identifying it as a key component [2]; moreover, clouds have been defined just as virtualized hardware and software plus the previous monitoring and provisioning technologies. The chief interest of this paper is provisioning virtual educational resources through a private cloud. The remainder of this paper is organized as follows. We start with a review and discussions of the related work in the area of virtualization of educational resources based private cloud. In light of the review and discussions, the principles of educational resources development are then proposed. After that, we analyze the requirements for the services provided by the virtual educational resources platform. We finally propose a novel platform architecture for private cloud-based virtual educational resources.

42.2 Related Work

Open educational resources include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge. They reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others. Virtualization technology enables multiple virtual machines as guest operating systems to run concurrently and independently on a single physical machine. Virtualization and cloud computing can help to reduce the hardware and maintenance costs, improve the resource availability, and ease the deployment of new services. Virtual educational resource can be defined as an open source, on-demand remote access, dynamic assemblage, and high-quality

resource, and it has a centralized virtualization management and distributed data storage, and can be accessed at any time and from any location through a simple e-device with a connection to the Internet.

With the rapid development of cloud computing and its strengths, there has been increasing research on the virtualization of educational resource recently. Bala [4], for example, provides an analysis of the importance of Open Source Software in cloud computing, and argues that security is one of the critical issues. Chieu et al. [5] present a novel architecture for the dynamic scaling of Web applications based on thresholds in a virtualized cloud computing environment. Ercan [6] provides an infrastructure model with the intension to meet the needs of the administrative staff (including student affairs, finance and accounting, purchasing and procurement, etc.), and education, training, and research related needs of the students and academic staff especially those who work in the educational institutions. Li et al. [7] describe a virtualized data center through virtual computing lab. Deng et al. [8] illustrate the key steps to build a private cloud in order to improve the efficiency of configuration management of the training laboratories. Hu et al. [9] investigate how the two key enabling techniques of cloud computing: system virtualization and Web service could be applied to create an agile computer aided learning environments with improved cost-efficiency.

Despite the work discussed above, the architecture and services in the virtualization of educational resources have not been investigated in depth. Although there are a number of projects concerned with [5, 6], but they do not consider the construction and implementation of educational resources and cloud computing together [7, 8]. The following sections will cater for this.

42.3 Principles of Educational Resources Development

The purpose of development of educational resources is for the enhancement of teaching and learning. That is to say, it is for the study of the learner, so the development of educational resources must follow the following principles.

42.3.1 Adhering to Cognitive Theory

More recent theories have focused on ways to help students internalize that information in a way that makes it both personally meaningful and applicable to new situations. Traditionally, human cognition has been seen and studied as existing solely “inside” a person, irrelevant to the social, physical, and artifactual context in which cognition takes place. Researchers re-examine the nature of cognition and proposes that a clearer understanding of human cognition would be achieved if it were conceptualized and studied as distributed among individuals, knowledge is socially constructed through collaborative efforts toward shared

objectives within cultural surroundings, and that information is processed among individuals and the tools and artifacts provided by culture [10]. The concept of situated learning is to emphasize that the learner must apply knowledge to the real occurrence and the environment through active exploration and operations in order to construct knowledge, and therefore learn the knowledge and skills in a real application scenario.

Sweller's research in learner's cognitive load in problem solving reveals that traditional problem-solving method too much emphasizes on problem-solving skills where learners have to use a lot of cognitive memory capacity [10]. As a result, learners have no extra cognitive capacity left to engage in learning. If a lot of information is stored in the short-term memory, it is easy to cause "excessive" cognitive load. According to working memory theory, human working memory capacity is very limited. If the pending message and its internal elements are highly interactive and cross-referencing is required in order to understand it, excessive cognitive load will lead to greater difficulties in learning. By applying cognitive load theory, it is hoped that the design of an effective teaching and learning environment can lead to better learning outcomes, and a good learning environment which can reduce the waste of intellectual resources and increase learning [11].

42.3.2 High Quality

"Digital Educational Information Resource Service" refers to educational informationization service system supported by the modern education technology, computer technology, information technology, and communication technology. It is a user-oriented model of digital educational information resources. The educational material should be of high quality. The concept of high quality relates to the following questions. How to build theory and practice of multiple functional modules, and principles of design and development in educational material? How to build a teaching type of educational material? How to formulate construction standards for educational resources database with reference to relevant state documents and their own advantages and features? How to build interactive platforms for users of educational resources? High quality also means high quality of the sharing platform. The sharing platform should feature digitalization, webifying, intelligentization, and multimedization. Currently, most platform development highly integrates digital instructional resources and follows instructional, scientific, open, applied, hierarchy, and economical features. The platform should be able to aggregate and customize educational resources effectively. The platform should also provide data concerning searching rate, guarantee the protection of intellectual property rights and interactive applications of resources.

42.3.3 Multiple Abstract Levels

The service based on virtual educational resources should cover such levels as technology, ideology, design methods, and integration. It can play in an orderly and organic manner to change into a content-intensive one. And it can categorize and dynamically track the educational resources in a private cloud through an intelligent agent. That is to say, the service must serve different purposes, for example, the cognitive domains of learners include knowledge, comprehension, application, analysis, synthesis, evaluation, every cognitive object has special requirements for educational resources; and the teaching methods of teachers include presenting method, practice method, discovery method, and strengthen method, etc., every teaching method also has special requirements for educational resources. In general, it should provide the information for users searching and keeping track of resources.

42.3.4 Unified Standard

According to educational theories, standardized paths include document format, selection of storage medium, reserve strategies in normative framework for storage and management. Furthermore, how to carry out the basic content, mechanism, policy development, mechanisms of organization, coordination, evaluation, management, and service mechanism will be involved based on the analysis of features of digital educational information resource.

42.4 Services Provided by the Virtual Education Resources Platform

Should the principles discussed in the previous section be applied, the virtual education resources platform would provide better services. Virtualization can be regarded as a mapping from educational resources to users' needs. The applications appear to the users as if they were running simultaneously and all the available resources in a private cloud could be used by the user. Virtualization provides the necessary abstraction, which can be united as a pool of educational resources and educational resource overlays can be built on top of them. Virtualization enables all applications to be encapsulated such that they can be configured, deployed, started, migrated, suspended, resumed, and stopped, and thus provides better security, manageability and isolation. As a result of the consolidation of server and application where multiple applications can be run on the

same server, educational resources can be utilized more efficiently. Various applications can be dynamically configured and the educational resources be aggregated. Virtualization allows quick recovery from unplanned outages, as virtual environments can be backed up and migrated with no interruption in service. Resource provisioning, monitoring, and maintenance can be automated, and common resources can be cached and reused.

42.5 Architecture of Virtualization for Educational Resources Based Private Cloud

Virtualization captures the relationship among educational resources. It prescribes various abstractions that the private cloud can provide three kinds of transparency. The first type is location transparency where resources can be requested without regard to resource location, a distributed metadata catalog is engaged to keep track of the locations of each piece of resource (along with its replicas) across cloud sites, and privacy and access control are enforced. The second type is materialization transparency where resources can be either recomputed on the fly or transferred upon request, depending on the availability of the resources and the cost to recompute. And the third type is representation transparency where resources can be consumed and produced no matter what their actual physical formats and storage are, resources are mapped into some abstract structural representation and manipulated in that way.

42.5.1 The Conceptual Model

According to the idea that the next-generation internet computing will take the triangle model as shown in Fig. 42.1 [3], the authors propose that the virtual educational resources platform should be constructed based on a private cloud on the ground that education is a special service which concerns security, QoS, and lifelong learning. Internet computing will be centralized around educational resources, clouding computing as well as client computing. Cloud computing and client computing will coexist and evolve hand in hand, while educational resources management (such as mapping, partitioning, querying, movement, caching, replication) will become more important for both cloud computing and client computing with the increase of resource-intensive applications.

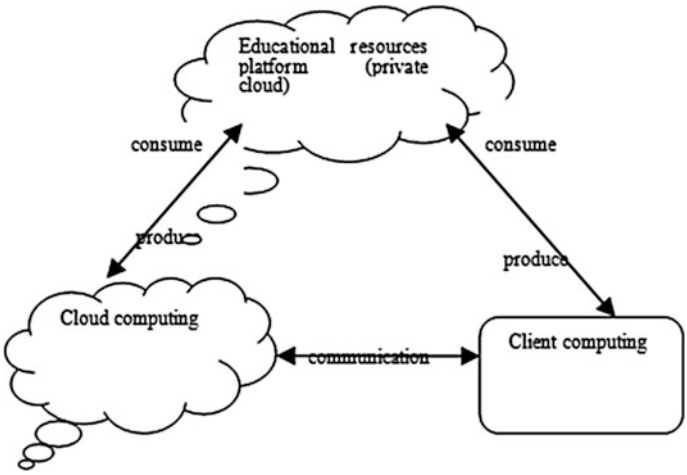

Fig. 42.1 The conceptual model

42.5.2 Hierarchical Architecture

To realize the ideas discussed in Sects. 42.3 and 42.4 comments, the hierarchical architecture of educational resources platform is proposed and illustrated in Fig. 42.2.

The virtualization platform of educational resources is designed with six layers: physical layer, virtual layer, information layer, executing layer, common service layer, and application layer. Physical layer includes the hardware, software, and the all sorts of educational resources. Virtual layer enhances the transparency of hardware by virtualization, and realizes fine-grained management of educational resources. Virtual layer as an educational pool on the physical layer, it eliminates the differences among physical machines and provides basic educational resources dynamically. For provisioning different levels educational resources met the requirements of end users, we propose that the educational resources are abstracted by two kinds of keywords, the first kind of keywords is knowledge domain, and the second kind of keywords is cognitive and teaching domain.

Information layer provides functions of educational fabric for persistence. It manages the storage of virtual machine images, content entities, ontology, and metadata. It also provides community for subject information. Executing layer is responsible for providing specific types of capabilities. It includes provisor, monitor, and load balancing. These components jointly manage and maintain the educational resources pool in the virtual layer. The provisor module sets up a plan for providing best educational resources by analyzing context information transferred by user and information of educational resource, it then schedules educational resources according to the plan.

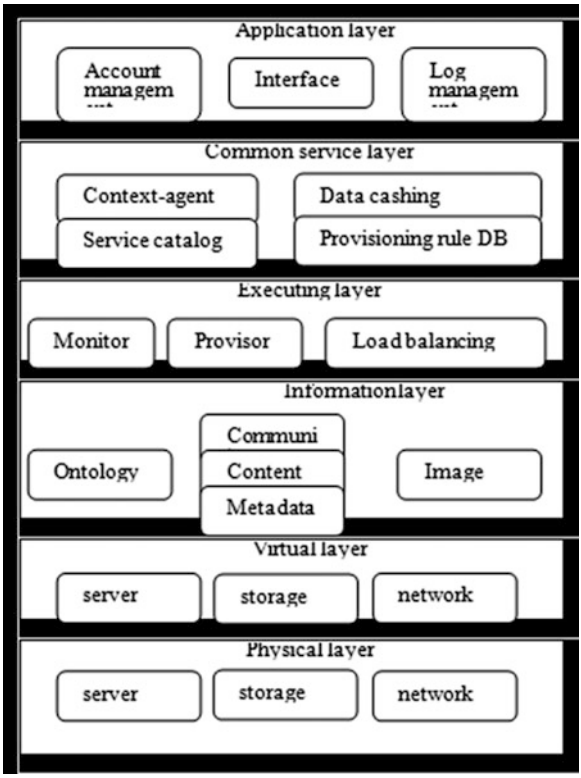

Fig. 42.2 Hierarchical architecture

Common service layer provides reusable common information for the higher layers. It includes context-agent, service catalog, and provisioning rule DB, and also provides data-cashing service. Context-agent is responsible for understanding a variety of context information and inferring it. For example, it can collect context information and modeling it, inferring context information, and responsible for understanding what user's situation is. The service catalog module stores the service information that will be used by the users. Provisioning rule database stores rules for providing best provisioning process to use context information and educational resources. Application layer is the entry-portal into virtualization platform for educational resources based on a private cloud. It provides function interfaces and interaction interfaces, and also manages the account and log information.

42.5.3 Logical Realization

The virtual platform for educational resources is realized by the processes illustrated in Fig. 42.3.

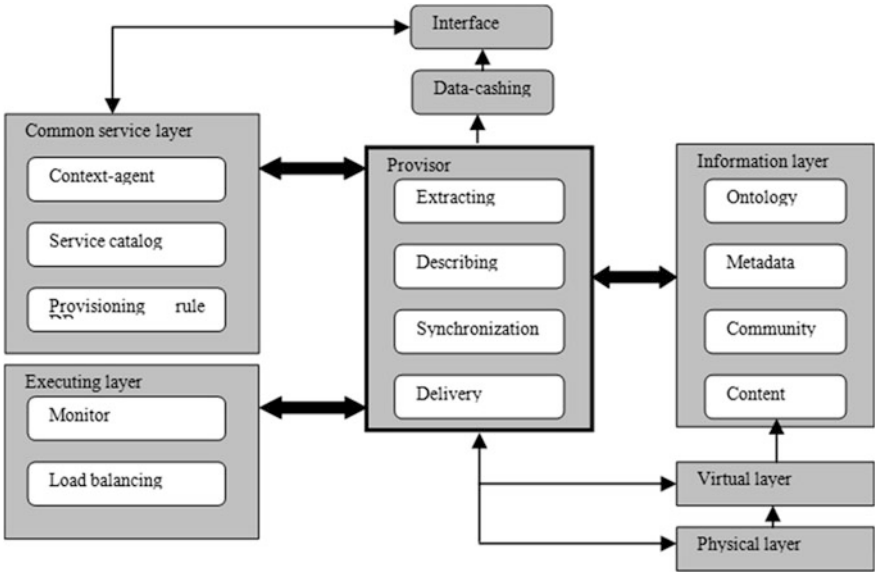

Fig. 42.3 Logical architecture

The context-agent module consists of the user situation and the physical situation. It includes static factors and dynamic factors that describe the hybrid situation. And it deals with the context objects and the relations among them. Since the context-agent module considers the characteristics of each user individually, such as learners' knowledge interests, needs, expertise, and experiences, it can provide highly customized and relevant learning resources to each user.

Supported by the information of ontology and its metadata, community, and content modules, the educational resources push is accurately executed. And supported by the functions offered through service catalog, provisioning rule DB, monitor, and load balancing, data-cashing modules, the speed of transmission is very high. The logic realization process is described as follows.

The Extracting module is the process of refining educational resources in the virtual layer through a variety of sensors from user situation and physical situation information based on the context-agent model. The context-agent model is used to filter information from the sensing information. The filtered information is analyzed to determine the user preferences.

The Describing module is mainly responsible for representing the educational resource in the form of resource number, time, memory, type, and supported application types. The description is needed for educational resources delivery, because resource number specifies the educational resource in the virtual layer.

Synchronization has two steps. The first step is content synchronization which is the synchronization among the virtual layer in resource number. And the second synchronization is device Synchronization which performs the process of synchronization between devices in the physical layer.

The Delivery module is executed for user after the educational resources are adapted and device and content are synchronized. As for the content delivery, the situation will be used. It links the contents and devices so users can use the educational resources at their device. It uses the physical situation information to find the related details of the contents and devices. The related details for the contents are time, memory, type and their application types. The related details for device are process speed, memory, screen size, and supported interface types for the terminal. The details of terminal indicate the information about available resources in the current device. If the details of a device and contents are of the same or compatible type, a link can be established and the contents are delivered to the device.

42.6 Conclusions

The construction of educational resources platform based cloud computing has a number of challenging issues to be solved. The virtualization of educational resources is one of them. We have argued that the educational resources platform should be constructed based on private cloud for reasons of security, QoS, and lifelong learning. Four principles namely cognitive theory, high quality, multiple abstract levels, and unified standard have been proposed for the construction of private cloud-based educational resources. Aiming at a private cloud-based virtual educational resources platform, we have proposed a triangular conceptual model, put forward a six-layer hierarchical architecture and analyze the logical realization process. It is anticipated that the work will contribute to the development of cloud-based educational resources.

We are currently investigating means to evaluate the proposed architecture. We are also planning to investigate how to provide monitoring, provenance, and aggregation of private cloud-based virtual educational resource platform.

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Chapter 43
A Dynamic Load Balancing Approach Based on the Remaining Storage Capacity for Mass Storage Systems

Jian Zhang, Shujuan Zhang, Xingyu Zhang, Yilin Lu and Shaochun Wu

Abstract In the mass storage system, load balancing becomes a key issue. The people proposed the load balancing method in the past only to consider the load of the node. In this paper, we propose the load balancing method based on the remaining storage capacity. The method considers the load and the node's remaining storage capacity of the node. By analyzing the load-control model, this paper presents a hybrid control model. Each level uses the different balance strategy. The model can timely spread the load. To collect information consumes few resources. The simulation results show that the approach can markedly reduce the overall response time and balance the global load.

Keywords: Load balancing · Mass storage · Dynamic migration · Remaining storage capacity

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_43,

43.1 Introduction

With the development of the search engines and electronic commerce, the amount of storage data increase quickly. The traditional storage system includes direct attached storage; network attached storage and storage area networks. They cannot meet the needs to store the massive data. Owing to the development of network technology, grid computing, distributed file systems, clustering technologies, and storage virtualization technology, it leads to the emergence of object-oriented storage and cloud storage. Cloud Storage is good to meet the demand for massive storage. Cloud storage provides services access to and store massive data. Users can purchase services according to his requirements. Services have the flexibility, inexpensive, and high performance. Massive storage has a variety of different performance storage devices. The data are stored in different devices. If the task is focused access to a storage device, this device is likely to cause the overload and other equipment is idle. Dynamic load balancing method can effectively use the resources of the system and balance the load between nodes. It reduces the response time and improves system performance.

In this paper, we propose the load balancing method based on the remaining storage capacity. The method uses a hybrid structure model using two layers of load balancing strategies. The lower layer manages the local load information. The upper layer manages the compressed load information. This will not only be able to timely balance local load, the scheduler can balance the global load in the upper. This model is not a bottleneck. It spends small resources to improve overall system performance. By analyzing the load index, we propose the method of the remaining storage capacity. The method considers the load and the node's remaining storage capacity of the node. According to the different hotspots of the data, it uses two strategies that include migrating and replicating data to reduce the load. The remainder of this paper is organized as follows. In Sect. 43.2, we describe the related research. Section 43.3 briefly presents a hybrid control strategy for load balancing. Section 43.4 presents the calculation of the remaining storage capacity. Section 43.5 describes calculating hotspots of the logic unit. Section 43.6 describes the experiment and analysis. We conclude this paper in Sect. 43.7.

43.2 Related Research

Kalogeraki, Melliar-Smith, and Moser proposed dynamic migration algorithms for distributed object systems [1]. They present the Cooling and Hot-Spot migration algorithms. The eternal resource management system monitors the situation of accessing to the object, collects load information, and dynamically balances the load between nodes. Migration algorithm will avoid a single node failure to improve the effectiveness of the system. Zhipeng Tan and Dan Feng proposed dynamic replication strategies for object storage systems [2]. The replication can

effectively reduce the access latency and bandwidth consumption. By creating multiple copies of a hotspot data, it balances the system load and can improve reliability. By collecting the size of the object, the frequency, the transmission time, and the network bandwidth, it computes the number of copies to create. The method reduces the system response time, but also increases the resource consumption to maintain data copies. Anirban Mondal, Kazuo Goda, and Masaru Kitsuregawa proposed the load balancing via migration and replication in spatial grids [3]. They use dynamic load balancing in spatial grids via data migration/replication to prevent degradation in system performance owing to severe load imbalance among the nodes. The Google File System uses load balancing strategy [4]. The master server periodically balanced the load by changing the number of copies. It checks the current copy of the distribution. It moves the copy to get a better space.

43.3 A Hybrid Control Model for Load Balancing

The centralized control model statistics the load information on the global and disperses global load. With the expansion of the system scales, a single control node is prone to bottlenecks. The model does not consider that the control node can not assume too large information interaction. The distributed control model has no centralized control node in the system. All nodes interact with other nodes to balance the global load. But it cannot be timely to balance the load. We propose a hybrid control model. The system control node is divided into a two-tier structure. The local control node in lower layer balances the local load. The control node in upper layer collects the compressed load information of the global node cluster and the total amount of remaining storage capacity. It selects the sending and receiving node cluster. In the selected node cluster, then it selects the appropriate sending and receiving nodes. A control node in lower layer manages the two node cluster. A node cluster belongs to the two control node in lower layer. Node cluster can be iterated to distribute the load. A hybrid control model for load balancing follows Fig. 43.1.

Partial treatment process is as follows:

1. Two storage node clusters submitted to the load information and the remaining storage capacity what the lower layer control node manages.
2. The control node in lower layer selects the node of the maximum load information as the sending node.
3. The sending node selects logical unit data to choose to migrate or copy data.
4. According to the number of accepting nodes, it selects the corresponding number of the comparatively large remaining storage capacity of the node.
5. Starting the replication or migration.

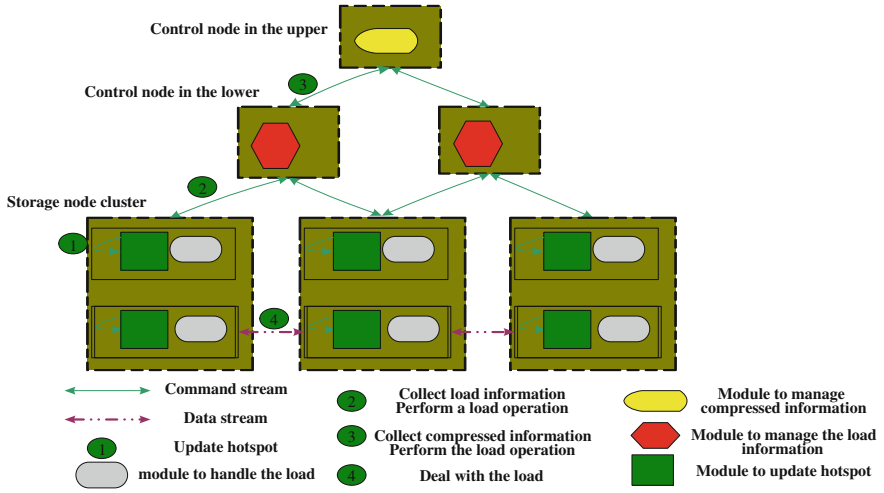

Fig. 43.1 A hybrid control model for load balancing

The global process is as follows:

1. The upper control node collects the compressed load information and the total remaining storage capability of each lower layer control node.
2. Selecting the sending and receiving node cluster sent to two control nodes in lower layer.
3. Two control nodes in lower layer deal with the local load.

43.4 The Calculation of the Remaining Storage Capacity

Most network storage systems use different load parameters. Different load parameters affect the load balancing. The simple parameters can play a very good effect. The single indicators can reflect the load conditions, but it does not fully reflect the load. The load comprehensive assessment values further deal with the load indicators [5]. The calculation formula is as follows.

$$\text{load}_i = \sqrt[3]{(w_1 \times \text{cpu}_i)^3 + (w_2 \times \text{mem}_i)^3 + (w_3 \times io_i)^3 + (w_4 \times \text{len}_i)^3} \quad (w_1 + w_2 + w_3 + w_4 = 1) \tag{43.1}$$

Cpu_i is the CPU utilization. Mem_i is the memory utilization. Io_i is the io utilization. Len_i is the length of the task queue. load_i is the node load. Selecting the sending node can select a node of the largest load value. If it chooses to the accepting node of a small load, it may not be able to select the ideal node.

Therefore, it is necessary to consider the remaining storage capacity and the node at light loads. The formula of the remaining storage capacity is as follows.

$$\text{remainder}_i = \text{total}_i - \text{load}_i \tag{43.2}$$

total_i is the total processing capacity. load_i is the node load. Remainder_i is the remaining storage capacity.

43.5 Calculating Hotspots of the Logic Unit

The selected data must be the principally affected load. If the task uniformly accesses to the data where the hotspots are basically the same inside the node, we use the strategy of migrating the data. If tasks centralized access to part of the data where it has relatively high hotspots, we use a replication strategy to disperse the load. Migrating (replicating) data of the operation is based on logical unit (LUN). The size of the data element is fixed, while the size of the LUN is not a certain value. Selecting the logical unit does not associate with other data. Migrating (replicating) operation has the stability. It does not cause the waste of other storage resources. Calculating hotspots of the logic unit includes hotspots of files. The length of the logical unit is not fixed. It contains a different amount of data. Each file affects hotspots of the logical unit. When the method calculates the hotspots of the file, it needs to take into account the sequence and frequency of accessing the file. The initial condition, the heat of the file is zero. The farther access to the generated heat will continue to decay. The current access generates the heat. The formula for calculating the file heat is as follows:

$$D_0(F_j) = 0 \tag{43.3}$$

$$D_{i+1}(F_j) = D_i(F_j) \times e^{-\sigma(t_{i+1}-t_i)} + w \times \text{Vit}(j, i+1); (0 < w < 1; 0 < \sigma) \tag{43.4}$$

I am the time period. J is the file. Vit (j, i) is the visiting frequency. W is the weight. σ is the recession factor. The above two formulas can reflect a long-term stable trend of the file being accessed. The heat of the file and the weights determine the heat of the logical unit. Calculating the heat of the logical unit is as follows:

$$D(\text{LUN}_k) = \sum_{i=1}^{M} D(F_i) \times w_i; (0 < i <= M, i, M \in N^*) \tag{43.5}$$

D (F_i) is the heat of the file. W is the weight.

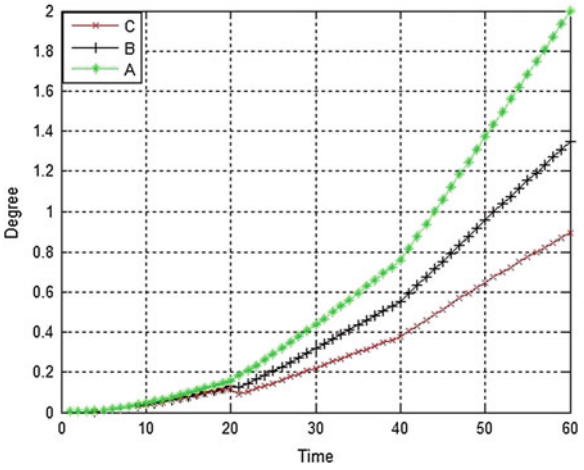

Fig. 43.2 The balancing degree of three cases

43.6 Experiments and Analysis

The experiment tests three cases and compares their performance. (1) It uses the local control strategy and a common load balancing method. (2) It uses a hybrid control strategy in this paper. But it does not consider selecting the high heat logical unit and the remaining storage capacity of the node. (3) It uses a load balancing method of this article.

Experiment 1 is as follows. The experiment initializes the system. It continues to increase I/O tasks. Twenty and 40 time points have the peak of the I/O task. The experimental results are shown in Fig. 43.2. Before 20 time points, the system is idle. The balancing degree of B is less than A. The main reason is that B uses a hybrid load balancing strategy. From the comparison of B and C, the balancing

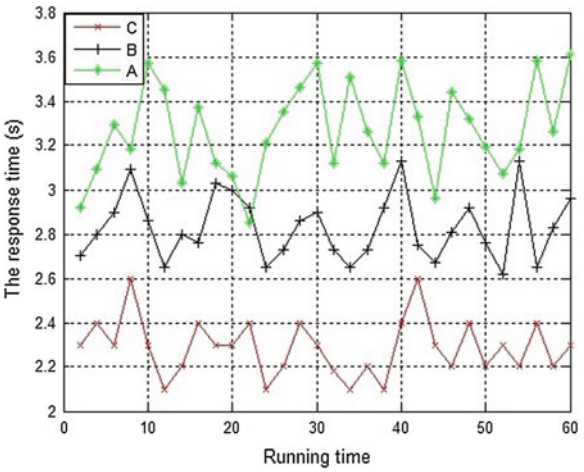

Fig. 43.3 The response time of three cases

degree of C increases slowly and stable. The main reason is to select the logical unit of the high heat.

Experiment 2 is as follows. It compares the response time of three cases. The experimental results are shown in Fig. 43.3. In the case of C, the response time of the system is the fastest. From the comparison, the system response time is reduced accordingly. They reduce the range of 13.40, 19.08 %. From the comparison of C and B, the response time to reduce by 19.08 %. It is the main reason that the C replicates the logical unit. Multiple copies can be close to provide accessing services to reduce the number of visits and time.

43.7 Conclusions

This article analyzes the distributed control model and centralized control model. We propose the hybrid control model for massive storage features. The upper collects compressed information, while the lower collects the load information of storage nodes. It is timely to reduce the global load. The receiving node has a lot of the remaining storage capacity. The method considers the load and the node's remaining storage capacity of the node. Computing the heat of the logical unit, so that it mainly impacts the node load. The experimental results show that we propose the load balancing method can effectively balance the load on the system and reduce the response time.

Acknowledgments This work was financially supported by Shanghai Leading Academic Discipline Project (Project Number: J50103), the Natural Science Foundation of Shanghai Municipality of China under Grant No. 08ZR1408400.

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Chapter 44
Supply Chain Network Equilibrium Under Risk

Gui-Tao Zhang, Jin-Song Hu, Hao Sun, Yan Zhou and Chun-Long Zhao

Abstract In this paper, we developed a model of supply chain network, in which both physical and B2C electronic transactions were used by manufacturers and the manufacturers' risk was considered. The model comprised various decision makers including manufacturers, retailers, and consumers. And the demands associated with the consumers were random. We formulated the equilibrium state of the network by finite-dimensional variational inequality theory. In turn, the logarithmic–quadratic proximal prediction–correction algorithm was designed to calculate the network equilibrium pattern. Several numerical examples were given to illustrate the impact of price ceiling, production capacity constraints, and risk upon the network equilibrium prices and product shipments. The results show that when considering a binding price ceiling on competitive markets, the total profit of manufacturers, and the retailers will decrease.

Keywords: Variational inequalities · Dual channel · Risk · Price rigidities

44.1 Introduction

In today's modern economics, the competition patterns among enterprises are mainly expressed as the competition among supply chains. The threats to the performance of supply chain include human disruptions such as epidemics, as well as natural ones like earthquake. Such factors of threats have brought much more

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_44,

stress and requirement for the analysis and formulation of the risk consisting in supply chain network.

The seminal paper by Nagurney et al. [1] whose research focused on the supply chain network equilibrium with deterministic market demand has triggered a variety of studies on the SCNE models. Dong et al. [2] studied SCNE including manufacturer and retailer with stochastic demand. The multitiered supply chain network model with B2B e-commerce and demand side risk was presented by Nagurney et al. [3]. Meng et al. [4] developed SCNE model with the manufacturers' production capacity constraints, but they assumed that the market demand was deterministic and they only considered physical distribution channels. Yang et al. [5] developed a closed-loop supply chain network which included recovery centers. Younes [6], in contrast, proposed a modeling framework to analyze the optimal behavior of supply chain players by using the new purchasing strategies and considering the capacity constraints of manufacturers.

However, the literatures mentioned above neglected the production capacity constraints except Meng et al. [4] and Hamdouch [6]. Actually, any manufacturing facility should have the production capacity constraints.

In addition, in some cases such as some monopoly industries or after some unexpected events, the market demands and subsequently, the product price will fluctuate mightily. Thus, in order to protect the interests of consumers, the government often intervenes in the market by means of price rigidities. Here, unlike the preceding papers, we consider the price intervention and manufacturers production capacity constraints so as to investigate the supply chain network equilibrium with manufacturers' risk and dual channels.

44.2 Supply Chain Network Equilibrium Models

In this section, we begin to develop the supply chain network model. The multicriteria decision makers of manufacturers are concerned not only with profit maximization but also with risk minimization.

The links in the supply chain network in Fig. 44.1 include physical links and Internet links to allow for e-commerce transactions. We denote a typical manufacturer by i, a typical retailer by j, and a typical demand market by k. It is assumed that both the manufacturers and the retailers are the selfish profit maximizers.

44.2.1 The Equilibrium of the Manufacturer Market

Let q_i denote the non-negative production output of manufacturer i, group the production output of all manufacturers into the column vector $q \in R_+^m$. The product

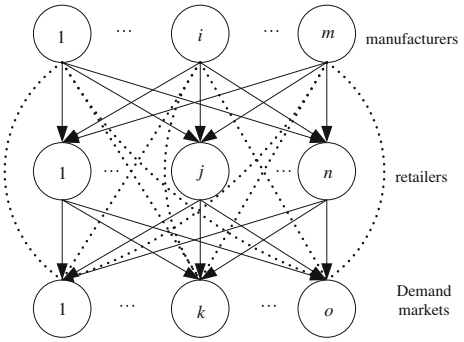

Fig. 44.1 The structure of dual channel supply chain network

shipment between a manufacturer i and a retailer j is denoted by q_{ij}, the product shipments between all pairs of manufacturers and retailers are grouped into the column vector $Q^1 \in R_+^{mn}$. The product shipments from manufacturer i to demand market k is denoted by q_{ik}^e, we group these product shipments into the column vector $Q^2 \in R_+^{mo}$. Let ρ_{ij} represent the price charged for the product by manufacturer i to retailer j who has transacted, and let ρ_{ik}^e denote price charged for the product by manufacturer i to the consumer of market k. Let C_i denote the upper bound of the production level for the manufacturer i.

It is assumed that each manufacturer i is faced with a production cost function $f_i(q)$. The transaction cost associated with manufacturer i transacting with retailer j is denoted by $c_{ij}(q_{ij})$, and the transaction cost associated with manufacturer i transacting with demand market k is denoted by $c_{ik}(q_{ik}^e)$.

In addition to the criterion of profit maximization we also assume that each manufacturer is concerned with risk minimization. Risk function is denoted by $r_i(Q^1, Q^2)$, $\forall i$. Each manufacturer i associates a non-negative weight α_i with the risk minimization criterion.

Owing to we assume that the manufacturers compete in a noncooperative fashion. Also we presume that the production cost functions and the transaction cost functions and the risk functions for each manufacturer are continuous and convex. The optimal conditions for all manufacturers can be described as the following inequality: determine the optimal $(q^*, Q^{1*}, Q^{2*}) \in \Omega^M$, satisfying

$$\begin{aligned}
&\sum_{i=1}^{m} \frac{\partial f_i(q^*)}{\partial q_i}\left[q_i - q_i^*\right] + \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial c_{ij}(q_{ij}^*)}{\partial q_{ij}} - \rho_{ij}^* + \alpha_i \frac{r_i(Q^{1*}, Q^{2*})}{\partial q_{ij}}\right] \\
&\times \left[q_{ij} - q_{ij}^* + \sum_{i=1}^{m}\sum_{k=1}^{o}\left[\frac{\partial c_{ik}\left(q_{ik}^{e*}\right)}{\partial q_{ik}^e} - \rho_i^{e*} + \alpha_i \frac{r_i(Q^{1*}, Q^{2*})}{\partial q_{ik}^e}\right]\right. \\
&\left.\times \left[q_{ik}^e - q_{ik}^{e*} \geq 0, \forall \left(q, Q^1, Q^2\right) \in \Omega^M\right.\right. \qquad (44.1)
\end{aligned}$$

where $\Omega_i^M = \left\{(q, Q^1, Q^2) \in R_+^{m+mn+mo} \middle| \sum_{j=1}^{n} q_{ij} + \sum_{k=1}^{o} q_{ik}^e \leq q_i, q_i \leq c_i\right\}$

44.2.2 The Equilibrium of the Retailer Market

The retailers, in turn, are involved in transactions both with the manufacturers as well as with the consumers. Let q_{jk} denote the amount of the product purchased by consumers in the market k from the retailer j, and group these shipment quantities into the column vector $Q^3 \in R_+^{no}$. We suppose that $\hat{d}_j(\rho_j)$ is the demand for the product at the demand price of ρ_j at retail outlet j, where $\hat{d}_j(\rho_j)$ is a random variable with a density function of $\phi_j(x;\rho_j)$, with ρ_j serving as a parameter. Let $\Phi_j(x;\rho_k) = \int_0^x \phi_j(x;\rho_j)\mathrm{d}x$ be the probability distribution function of $\hat{d}_j(\rho_j)$. Let $s_j = \sum_{i=1}^m q_{ij}$, in turn, denote the total supply at retailer j that he obtains from all the manufacturers, and group these purchased amount into the column vector $s \in R_+^n$. Then, retailer j can sell to the consumers no more than the minimum of his supply or demand, that is, the actual sale of j cannot exceed $\min\{s_j, \hat{d}_j\}$. A retailer j is faced with what we term a handling cost, which may include, for example, the display and storage cost associated with the product. Let c_j denote this cost. In order to model competition among retailers, holding cost of a retailer is a function of how much of the product he has obtained from the various manufacturers, i.e., $c_j = c_j(s)$, $\forall j$. We also assume that $c_j(s)$ is continuous and convex. $\lambda_j^+ (>0)$ and $\lambda_j^- (>0)$ are the unit penalty of having excess supply at retail output j and the unit penalty of having excess demand respectively.

Given s_j, for retailer j, expected sales, inventory and shortage amounts are scalar functions of s_j and ρ_j. In particular, let $S_j(s_j,\rho_j)$, $H_j(s_j,\rho_j)$ and $Q_j(s_j,\rho_j)$ denote these values respectively.

As mentioned above, we assume that the retailers compete in a noncooperative manner so each retailers maximizes his profits, in the condition of given the actions of the other retailers. The optimality conditions for all the retailers satisfy the variational inequality: determine the optimal $(s^*, Q^{2*}, Q^{3*}) \in \Omega^R$, satisfying

$$\sum_{j=1}^{n}\left[\left(\rho_j^* + \lambda_j^+ + \lambda_j^-\right)\Phi_j\left(s_j^*, \rho_j^*\right) - \rho_j^* - \lambda_j^- + \partial c_j(s^*)/\partial s_j\right] \times \left[s_j - s_j^*\right] + \sum_{j=1}^{n}\sum_{i=1}^{m}\rho_{ij}^*\left[q_{ij} - q_{ij}^*\right] \geq 0 \quad \forall\left(s, Q^2, Q^3\right) \in R_+^{n+mn} \tag{44.2}$$

where $\Omega^R = \left\{(s, Q^2, Q^3) \in R_+^{n+mn} | s_j = \sum_{i=1}^m q_{ij}, \forall j\right\}$

44.2.3 The Equilibrium of the Demand Market

In order to protect the benefit of consumers, the government often intervenes in the market by means of price ceiling. Let $\bar{\rho}$ denote the price ceiling of product by government. Supposing that the market demand satisfied is independent by

physical and B2C transactions. Introducing the notation $s_i = \sum_{k=1}^{o} q_{ik}^e$, $\forall i$. represent the volume purchased by demand market k from all manufacturers, group s_i of all demand markets into the column vector $s^e \in R_+^m$. Owing to ρ_i^e denoting the price charged for the product by manufacturer i to the consumer of market, group ρ_i^e of all manufacturers into the column vector $\rho^e \in R_+^m$.

Hence, equilibrium conditions of demand market can be expressed as: determine $(\rho^*, \rho^{e*}) \in \Omega^C$, satisfying

$$\sum_{j=1}^{n}\left[s_j^* - \tilde{\tilde{d}}_j\left(\rho_j^*\right)\right] \times \left[\rho_j - \rho_j^*\right] + \sum_{i=1}^{m}\left[s_i^* - \tilde{\tilde{d}}_i\left(\rho_i^{e*}\right)\right] \times \left[\rho_i^e - \rho_i^{e*}\right] \geq 0, \quad \forall \rho, \rho^e \in R_+^{n+m} \tag{44.3}$$

where $\Omega^C = \left\{\rho \in R_+^n,\ \rho^e \in R_+^m | \rho_j \leq \bar{\rho},\ \forall j;\ \rho_i^e \leq \bar{\rho},\ \forall i\right\}$

44.2.4 The Equilibrium Condition of the Supply Chain Network

Theorem A product shipment and price pattern $(q^*, Q^{1*}, Q^{2*}, Q^{3*}, s^*, \rho^*, s^{e*}, \rho^{e*}) \in \Omega$ is an equilibrium pattern of the supply chain network model of with production capacity constraints and price rigidities, iff it satisfies the variational inequality problem given by: determine $(q^*, Q^{1*}, Q^{2*}, Q^{3*}, s^*, \rho^*, s^{e*}, \rho^{e*}) \in \Omega$, satisfying

$$\begin{aligned}
&\sum_{i=1}^{m} \frac{\partial f_i(q^*)}{\partial q_i}[q_i - q_i^*] + \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial c_{ij}(q_{ij}^*)}{\partial q_{ij}} + \alpha_i \frac{\partial r_i(Q^{1*}, Q^{2*})}{\partial q_{ij}}\right][q_{ij} - q_{ij}^*] \\
&\quad + \left[\sum_{i=1}^{m}\sum_{k=1}^{o} \frac{\partial c_{ik}(q_{ik}^{e*})}{\partial q_{ik}^e} - \rho_i^e + \alpha_i \frac{\partial r_i(Q^{1*}, Q^{2*})}{\partial q_{ik}^e}\right][q_{ik}^e - q_{ik}^{e*}] \\
&\quad \sum_{j=1}^{n}\left[(\rho_j^* + \lambda_j^+ + \lambda_j^-)P_j(s_j^*, \rho_j^*) - \rho_j^* - \lambda_j^- + \frac{\partial c_j(s^*)}{\partial s_j}\right][s_k - s_k^*] \\
&+ \sum_{j=1}^{n}\left[s_j^* - \tilde{\tilde{d}}_j(\rho_j^*)\right] \times [\rho_j - \rho_j^*] + \sum_{i=1}^{m}\left[s_i^* - \tilde{\tilde{d}}_i(\rho_i^*)\right] \times [\rho_i^e - \rho_i^{e*}] \geq 0 \\
&\qquad \forall (q, Q^1, Q^2, Q^3, s, \rho, s, \rho^e) \in \Omega
\end{aligned} \tag{44.4}$$

where $\Omega = \Omega^M \times \Omega^D \times \Omega^R \times \Omega^C$, Let $\lambda \in R_+^m$, $\delta \in R_+^m$, $\gamma \in R^n$, $\upsilon \in R_+^n$, $\eta \in R_+^n$, $\theta \in R_+^m$ and $\omega \in R_+^m$ denote the Lagrangian multipliers column vector with respect to the constraints respectively.

44.3 The Solving Algorithm for SCNE

The feasible domain of VI (4) is defined on polyhedral a set of non-negative orthant, a novel logarithmic–quadratic proximal prediction–correction (LQP-PC) method developed can be employed for solving the corresponding VI (4).

Let row vector function F_1, F_2, F_3, F_4, F_5 and F_6 represent the vectors before the multiple signs. Hence, in terms of vector notations, VI (4) can be rewritten as follows, determine $(q^*, Q^{1*}, Q^{2*}, Q^{3*}, s^*, \rho^*, s^{e*}, \rho^{e*}) \in \Omega$, such that

$$F_1 \times (q - q^*) + F_2 \times \left(Q^1 - Q^{1*}\right) + F_3 \times \left(Q^2 - Q^{2*}\right) + F_4 \times (s - s^*) + F_5 \times (\rho - \rho^*) + F_6 \times (\rho^e - \rho^{e*}) \geq 0 \, \forall \left(q, Q^1, Q^2, Q^3, s, \rho, s^e, \rho^e\right) \in \Omega \tag{44.5}$$

where Ω is the constraint sets and has the vector pattern

$$\Omega = \left\{ \begin{array}{c} (q, Q^1, Q^2, Q^3) \in R_+^{m+\mathrm{mn}+\mathrm{mo}+\mathrm{om}} \\ (s, \rho, s^e, \rho^e) \in R_+^{n+n+m+m} \end{array} \middle| \begin{array}{c} A_0 q \leq C, A_1 Q^1 + A_2 Q^2 \leq A_0 q, A_4 Q^3 \leq A_3 Q^1 \\ A_5 Q^1 = A_6 s, A_6 \rho \leq \bar{\rho}, A_7 Q^2 = A_8 s^e, A_8 \rho^e \leq \bar{\rho} \end{array} \right\} \tag{44.6}$$

Group all column vectors $q, Q^1, Q^2, Q^3, s, \rho, \rho^e$ into a column vector x, in turn, group all column vectors $C, q, Q^1, s, \bar{\rho}, s^e, \bar{\rho}$ into a column vector b, and construct A by $A_1 \ldots A_8$ satisfying $A^T x \leq b$, group all column vectors $\lambda, \delta, \gamma, \upsilon, \eta, \theta, \omega$ into a column vector y, finally, group all column vectors $F_1, F_2, F_3, F_4, F_5, F_6$ into a column vector $f(x)$.

44.4 Numerical Examples

In this section, considering a supply chain network includes two manufacturers, two retailers, and two demand markets. In all the examples, we assume that the demands associated with the retailer outlets follow a uniform distribution. Hence, we assume that the random demand $\hat{d}_k(\rho_k)$, of retailer k, have the pattern of $\hat{d}_k(\rho_k) \sim [0, b_k/\rho_k]$, $b_k = 100$, $k = 1, 2$.

Also assume the demands satisfied by e-commerce have the pattern of $\hat{d}_k(\rho_k^e) \sim [0, b_k^e/\rho_k^e]$, $b_k^e = 10$, $k = 1, 2$.

The maximal production capacity of each manufacturer is $c_1 = c_2 = 1$; the production cost functions for the manufacturers are given by: $f_1(q) = 2.5q_1^2 + q_1 q_2 + 2q_1$, $f_2(q) = 2.5q_2^2 + q_1 q_2 + 2q_2$.

We assume that the risk functions of manufacturers are given by:

$$r_i = \left(\sum\nolimits_{j=1}^{n} q_{\mathrm{ij}} + \sum\nolimits_{k=1}^{o} q_{\mathrm{ik}}^e - 2\right)^2, \text{ for } i = 1, 2.$$

The transaction cost functions faced by the manufacturers and associated with the retailers and with the transacting electronically with the consumers are given by:

$c_{ij}(q_{ij}) = 0.5q_{ij}^2 + 3.5q_{ij}$, for $i = 1, 2; j = 1, 2$ and $c_{ik}(q_{ik}^e) = 0.5q_{ik}^{e2} + 5q_{ik}^e$, for $i = 1, 2$; $k = 1, 2$.

The handling costs of the retailers, in turn, are given by: $c_k(s) = 0.5s_k^2$, Set the unit costs of excess supply and excess demand, $\lambda_k^+ = \lambda_k^-$=1, for $k = 1, 2$.

Set the parameters used in LQP-PC method, β=1, ν=1, η=0.9, μ=0.1, $\gamma = 1.8$, $r = 2$ and $\varepsilon = 10^{-8}$, respectively.

Implementing the LQP-PC method for the example yields the equilibrium solutions of the SCNE model with and without production capacity constraints, with respect to the price ceiling, with the risk level of $\alpha = 0$ and $\alpha = 0.4$, respectively, and the results are shown in Table 44.1.

According to Table 44.1 associated with $C_1 = C_2 = \infty$ we can observe that in the absence of the production capacity constraints and the price rigidities, there is no shortage of product in demand markets, i.e., $\sum_{k=1}^{2} v_k = 0$. When we set the price ceiling $(\bar{\rho}_k)_{1\times 2}$ below the equilibrium price, the total demand amount $\sum_{k=1}^{2} d_k$ increases, then, shortage of products appears in demand markets, i.e., $\sum_{k=1}^{2} v_k > 0$, and the total profit $\sum_{i=1}^{2} M_i + \sum_{j=1}^{2} R_j$ of manufacturers and retailers decreases. However, the price of e-commerce is below the price of physical channel. When the manufacturers consider the different risk levels, the production volume of manufacturers and the various shipments increase, the profit of manufactures also increases, however, the total profit of supply chain does not change significantly. The production volume satisfies the constraints of $q_i = \sum_{j=1}^{2} q_{ij} + \sum_{k=1}^{2} q_{ik}^e$.

Comparison of $C_1 = C_2 = \infty$ and $C_1 = C_2 = 1$ in Table 44.1 shows that when setting the maximal production capacity $C_1 = C_2 = 1$ of manufacturers, the equilibrium price of products without the price ceiling is higher than that without the production capacity constraints; when setting the price ceiling, The price ceiling is equal to the price of demand markets. In addition, it is very interesting to see that the equilibrium profit subject to the production capacity constraints is

Table 44.1 Solutions of the SCNE model

	$C_1 = C_2 = \infty$				$C_1 = C_2 = 1$			
	$\alpha = 0$		$\alpha = 0.4$		$\alpha = 0$		$\alpha = 0.4$	
	$\bar{\rho} = \infty$	$\bar{\rho}_i = 25$	$\bar{\rho} = \infty$	$\bar{\rho}_i = 25$	$\bar{\rho} = \infty$	$\bar{\rho}_i = 25$	$\bar{\rho} = \infty$	$\bar{\rho}_i = 25$
$(\rho_{ik}^e)_{2\times 2}$	17.314	16.813	17.163	16.655	30.276	21.304	30.276	21.304
$(\rho_k)_{1\times 2}$	35.558	25.00	35.285	25.00	59.891	25.00	59.891	25.00
$(v_k)_{1\times 2}$	0.000	0.687	0.000	0.663	0.000	1.235	0.000	1.235
M_i	19.562	18.215	19.336	18.085	26.874	17.847	26.874	17.847
R_j	12.786	4.684	12.796	4.883	12.431	0.270	12.431	0.270
$\sum M_i + \sum R_j$	32.347	22.899	32.175	22.968	39.305	18.116	39.305	18.116

higher than that without any production capacity constraints. This phenomenon is due to the market competition in case where given production capacity will raise the supply price between manufacturers, retailers, and demand markets. We can see that the product shortage $\left(\sum_{k=1}^{2} v_k\right)$ is higher with the production capacity constraints than that without any production capacity constraints. When setting the maximal production capacity of manufacturers $C_1 = C_2 = 1$, the risk level of manufacturers has no effect, that is, the manufacturers are not sensitive to risk level.

44.5 Conclusions

This paper has proposed a general dual channel supply chain model with production capacity constraints and the price rigidities, which is formulated by the VI and solved by the LQP-PC method. More generally, the proposed SCNE model is an experimental tool, with the different certain parameters which may help to analyze various conditions and to answer the questions how to develop the supply chain in the long run. Thus, this paper may be useful to decision makers and the policy makers in handling the long-term strategic management of supply chain under the uncertain and disruption circumstances.

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Chapter 45
Emergency Logistics Distribution Optimization Model and Algorithm in Disaster Chain

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Abstract Emergency logistics distribution of disasters and accidents is an effective means to reduce the loss of lives and property. On the condition of meeting the timeliness requirement of emergency logistics, the study of emergency logistics distribution can rationally schedule vehicle, substantially reduce the vehicle allocation time and the logistical cost. Through the analysis of the characteristics of rescue emergency logistics, the system structure of emergency logistics distribution is proposed. After the material distribution optimization model for emergency logistics is established, an improved genetic algorithm is designed to solve this problem. In improved genetic algorithm, the best individual reservations, roulette selection, blend crossover, and blend mutation have been adopted to avoid premature convergence and enhance the process efficiency. A numeric example is presented to validate the feasibility and effectiveness of the model and its algorithm.

Keywords: Emergency logistics · Logistics distribution · Optimization model · Genetic algorithm · Disaster

45.1 Introduction

In recent years, a lot of large-scale public emergencies frequently occurred in China, such as the crises of SARS in 2003, the poison gas leak of Chongqing and the water pollution of Songhua River in 2005, the Avian Influenza, the south snow disaster in the beginning of 2008 [1], the Wenchuan Earthquake, the influenza A

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_45,

virus subtype H1N1 in 2008, and so on, which resulted in gigantic loses. The emergency logistics system is a special logistic action in order to provide the emergency supplies to the incidents.

Kem ball-Cook and Stephenson [2] first proposed the importance of logistics management when transporting relief materials in order to improve transport efficiency. Eldessouki [3] studied the emergency supplies distribution problems for the objective of minimizing transportation costs under different constraint conditions. Dai and Da [4] presented the model of multiresource emergency problem according to the characteristics of multiresource and multigarage problem and obtained the solution by citing the concept of continuous feasible and using the results of single resource problem. Liu and He [5] studied the emergency supplies scheduling problems with multigarage on the constraint condition of material requirement. According to the characteristics of consecutive emergency, an emergency model aiming at minimizing the succor nodes was established respectively under the precondition of best emergency in response to times and the restriction periods. Kejun and Wang [6] classified the burst events in the process of logistics and distribution as three categories: the effect on the state of goods, vehicles and the state of the road status raised the static, dynamic, and the functional model based on burst events. Zhang et al. [7] proposed a multiobjective multiperiod emergency logistics model to deal with Split-delivery Vehicle Routing Problem (SDVRP), and aimed to minimize the unsatisfied demand, total delivery time and supply unbalance among demanders. Sen Chen et al. [8] considered the repair of the destroyed roadways from the view of transformation between material relief and the delay of logistics distribution, and gets the best solution according to the purpose of the decision maker through roadway network and vehicle routing combinative optimization.

45.2 Emergency Logistics Distribution System Structure

Assume that emergency supplies have been transported to the railway stations, airports, and docks which are located in the affected areas through railway, air, water carriage, and other methods. Therefore, the railway stations, airports, and docks are treated as emergency supplies warehouses. What this paper studies is the process that the emergency supplies are transported from various warehouses including local storehouses, railway stations, airports, and docks to affected sites by dispatching vehicles available at disaster bursting areas.

The emergency logistics distribution system is a chart of three-layer structure. The first layer is garages, all vehicles needed with different types set out from this layer and the number of the vehicles has known in advance. The second layer is emergency supplies warehouses, including local storehouses at all levels, railway stations, airports, and docks. There are several categories of emergency supplies and their quantity at each storehouse is known and does not change during the emergency respond periods. The bottom layer is the disaster sites, namely, the

destination of the whole emergency logistics distribution. Once the disaster bursts, each disaster site will generate certain number of emergency supply demands for every type of emergency supplies after disaster assessment, and each emergency supply warehouse will deploy certain numbers of vehicles according to the demands of the affected areas to deliver the emergency supplies. There only exists vehicle flows between the first layer and the second layer without material flows. That is to say, the vehicles are running empty and on single orientation, transport from garages to emergency supply warehouses and not return to garages during the emergency respond times. There are both vehicle flows and material flows between the second layer and third layer, the material flows from the second to the third is one-way, while vehicles are in two-ways between the two levels. When vehicles arrive at the disaster sites, they do not return to the garage immediately but wait at the disaster site for new orders. Once there is a new assignment they will return to material warehouses to deliver the emergency supplies again. Thus, there are two states after the vehicles transport from material warehouses to disaster sites, one is waiting at the disaster site for new order, the other is returning to the emergency supplies warehouses to begin next distribution after receiving a new assignment and, as the dotted line in Fig. 45.1, the vehicles are running converse empty.

As a result, there are material flows or vehicle flows between the two layers, but nodes at the same level have nothing to do with one another. On one hand, because there need large quantities emergency supplies after burst disaster, it is the same with general business logistics which often combine with small quantities. On the other hand, it reflects the characteristic that the emergency logistics distribution is oriented by the demand of disaster sites, which aims at meeting the need of the disaster sites and shortens the distribution time as soon as possible in order to cut down the losses of affected areas and the vehicle running costs. Vehicles can be used continuously in the whole distribution system, namely, they flow repeatedly between the second layer and third layer until all disaster sites meet their needs.

45.3 Emergency Logistics Distribution Optimization Model

45.3.1 Problem Assumptions

Based on the analysis of emergency logistics distribution system, we make the following definitions and descriptions about the emergency relief supplies transport network model:

There are several emergency commodity supply nodes and demand nodes, the supply and demand quantities at each node have known beforehand, and the overall supplies is greater than or equal the overall demands.

More than one kind of emergency material need delivering, all of them have different weight, volume, and loading and unloading efficiency, suppose the loading efficiency at supply nodes is equal to the unloading efficiency at demand nodes.

There is more than one garage, each garage may have several types of vehicles, all the vehicles are sufficient for emergency logistics distribution and each vehicle has a serial number to mark it.

Vehicle only load one kind emergency material each task.

Each disaster site can be served by several vehicles.

Vehicles need not return to starting node (garage) immediately after finishing a distribution assignment but wait at the disaster site for next order.

Nodes at the same level have nothing to do with one another and there are neither vehicle flows nor material flows.

45.3.2 Mathematical Model

1. Sign Definitions

Sets:$D = \{D_1, D_2, \ldots, D_m\}$, Set of demand nodes; $G = \{G_1, G_2, \ldots, G_p\}$, Set of emergency supply types; $S = \{S_1, S_2, \ldots, S_n\}$, Set of supply nodes; $K = \{K_1, K_2, \ldots, K_k\}$, Set of garages; $L = \{L_1, L_2, \ldots, L_l\}$, Set of vehicles; $E = \{(k, i)(i,j) | k \in K, i \in S, j \in D\}$, Set of sides.

Emergency supplies parameters: w_g, Unit weight of emergency supplies g; c_g, Unit volume of emergency supplies g; t_g, Loading or unloading unit emergency supplies g time.

Vehicle parameters: cap_l, The load weight of vehicle l; V_l, The volume of vehicle l; v_l, The velocity of vehicle l.

Distance parameters: d_{ki}, Distance between garages and supply nodes; d_{ij}, Distance between supply nodes and demand nodes.

Decision variables: x_{lijg}: Amount of emergency supplies type g traversing arc (i, j) using vehicle l

$$y_{\text{lki}} = \begin{cases} 1 & \text{vehicle } l \text{ traversing arc}(i,j) \\ 0 & \text{otherwise} \end{cases}$$

$l \in L, k \in K, i \in S$

$$y_{\text{lij}} = \begin{cases} 1 & \text{vehicle } l \text{ traversing arc}(i,j) \\ 0 & \text{otherwise} \end{cases}$$

$l \in L, i \in S, j \in D$

$$z_{lijg} = \begin{cases} 1 & \text{vehicle } l \text{ with commodity type } g \text{ traversing arc}(i,j) \\ 0 & \text{otherwise} \end{cases}$$

$l \in L$, $i \in S$, $j \in D$, $g \in G$

2. Objective Function

$$\begin{aligned} \min T = & \sum_{l\in L}\sum_{i\in S}\sum_{j\in D}\sum_{g\in G} t_g \bullet x_{\mathrm{lijg}} \bullet y_{\mathrm{li}} \bullet z_{\mathrm{lijg}} \\ & + \sum_{l\in L}\sum_{k\in K}\sum_{i\in S}\frac{d_{\mathrm{ki}}}{v_l} y_{\mathrm{lki}} + \sum_{l\in L}\sum_{i\in S}\sum_{j\in D}\sum_{g\in G} t_g \bullet x_{\mathrm{lijg}} y_{\mathrm{lj}} \bullet z_{\mathrm{lijg}} \\ & + \sum_{l\in L}\sum_{i\in S}\sum_{j\in D}\frac{d_{\mathrm{ij}}}{v_l} y_{\mathrm{lij}} \end{aligned} \tag{45.1}$$

3. Constraint Conditions

$$x_{\mathrm{lijg}} \bullet c_g \le V_l \tag{45.2}$$

$$x_{\mathrm{lijg}} \bullet w_g \le \mathrm{cap}_l \tag{45.3}$$

$$\sum_{i\in S} y_{\mathrm{lki}} = 1 \tag{45.4}$$

$$\sum_{g\in G} z_{\mathrm{lijg}} = 1 \tag{45.5}$$

$$y_{\mathrm{lki}} \in \{0,1\} \left\langle y_{\mathrm{lij}} \in \{0,1\},\ z_{\mathrm{lijg}} \in \{0,1\},\ y_{\mathrm{li}} \in \{0,1\},\ y_{\mathrm{lj}} \in \{0,1\} \right\rangle \tag{45.6}$$

4. Model Explanation

The objective of this model is to minimize the total vehicle running time to meet the needs of affected areas, which includes the vehicle running time from garages to emergency supplies storehouses, the time from emergency supply storehouses to disaster sites, and the emergency supplies loading time at storehouses and unloading time at disaster nodes.

Expression (1) stands for the emergency supplies loading time at supply nodes, the vehicle running time from garages to emergency supplies storehouses, the emergency supplies unloading time at demand nodes, and the time from emergency supply storehouses to demand nodes. Constraint (2) shows the volume of loading emergency supplies each vehicle every time cannot excessive the vehicle largest volume. Constraint (3) shows that the weight of loading emergency supplies each vehicle every time cannot excessive the vehicle largest dwt. Constraint (4) denote that vehicles setting out from garages can only arrive at one emergency

commodity supply nodes once a time, that is to say, they flow on single orientation without circle between the first layer and the second layer. Constraint (5) shows that each vehicle can only load one type emergency supplies from supply nodes to demand nodes, Constraint (6) expresses 0–1 integer.

45.4 The Solution Model with Improved Genetic Algorithm

45.4.1 Genetic Coding

This chapter adopts the improved natural coding methods, a chromosome on behalf of a program of transport emergency supplies. A chromosome makes up of two substrings, and the first substring has a gene which means the series number of vehicle. If there are K vehicles, the change range of the first gene value is the natural number between one and K. The second substring has $3n$ gene, "n" means the assignment number of the vehicle. For example, the vehicle marked two owned by garage three transports emergency supplies type G_2 from supply node I_1 to demand node J_3, then arrives at the supply node I_2 delivery the emergency supplies G_2 to demand node J_2, namely, K_3-I_1-G_2-J_3-I_2-G_2-J_2, if expressed by gene is 3-1-2-3-2-2-2. The $(3n-1)$th gene means the series number of emergency supplies storehouse, the $3n$th gene means the series number of emergency supplies type, the $(3n + 1)$th gene means the series number of disaster nodes. The gene segments of all vehicles rank by paralleling connection from small number to large number according the order and make up of a chromosome.

45.4.2 Initial Population

The Push Forward Insertion Heuristic (PFIH) has been frequently used by many researchers with this purpose [9]. In this paper, a modified PFIH is applied. The total randomized choice is used to define the first customer to be inserted in each new route. That is necessary to produce distinguished individuals in the first GA generation. After the first customer has been randomly selected, the second one will be the one with the minimal insertion cost. Each feasible customer position in the route in construction is evaluated. A new route is created only if no more customer feasible insertions are possible.

45.4.3 Fitness Function

Fitness is used to evaluate the individual's adaptation degree to the environment, the greater adaptation degree of the individual, the greater probability of passing

down to next generation [10]. The lower individuals run the other way round. The function of evaluating the individual's adaptive degree is called fitness function. Because this chapter is aiming at minimizing the time so we need to switch the objective function into fitness function, general to take the following form:

$F(x) = M - f(x)$, M is a big number; $f(x)$ is the objective function.

45.4.4 Selection Operation

Selection is one of the key steps of genetic algorithm, it decides which individual can be passed down to next generation. Common methods of selection are Roulette, Stochastic, and Tournament. Selection algorithm uses a selection strategy that combines the best individual reservations and roulette. M chromosomes in each generation are arranged according to descending fitness, ranked first in the chromosome which has high adaptation can be directly copied to next generation, The next generation remaining chromosome selects again using roulette wheel selection method. It ensures that the best chromosomes in each generation have been preserved and participate petition in the next generation, reduce the search time of algorithm effectively.

45.4.5 Crossover Operation

Crossover means the reorganization and exchange of two parents, aiming at generating a new individual with higher adaptation degree value. Common methods of crossover are single point, two point, and uniform crossover [11]. This algorithm uses the single point, arithmetical, and heuristic crossover. Its overall crossing number proportion is 3:4:3. Thereby, it retains the male excellent genes and greatly increases the population average performance in the evolutionary process.

45.4.6 Mutation Operation

Mutation means randomly changing of the value of gene at any position, its aim is to improve the local search capabilities and maintain the diversity of groups and prevent premature. The probability of change named mutation probability. Common methods of mutation are basic position, reverse, and uniform mutation [12]. This algorithm takes the uniform, combined boundary, and nonuniform mutation, and the total variation percentage in the number is 3:3:4. This can prevent excellent genes in variability being damaged, but also introduce a new gene for the population on the local optimal solutions.

45.5 Experimental Analysis

Assume that a disaster burst in a certain place, and four nodes need emergency supplies, which are marked as J_1, J_2, J_3, J_4. A large part of emergency supplies have arrived at the local airport and railway station by air and train, added with a local storehouse amounts to three emergency commodity supply nodes, which are noted as I_1, I_2, I_3. The ministry of civil affairs can recruit totally 20 vehicles which are distributed randomly in three garages marked as K_1, K_2, K_3. There are four kinds of emergency supplies: tents, quilts, drinking water, and food, marked as G_1, G_2, G_3, and G_4, Tables 45.1, 45.2, 45.3, 45.4, 45.5 provide some relevant information.

The initial population is 20, crossover probability is 0.75, mutation probability is 0.1, and the max generation is 500. Using the improved genetic algorithm, as shown in Table 45.6, the shortest time is 15.27 h in emergency logistics distribution.

Table 45.1 Vehicles parameters

Vehicle	Garage	Volume (m^3)	Dwt (t)	Speed (km/h)
1	K_2	45	7	35
2	K_1	34	5	50
3	K_2	27	3	55
4	K_3	40	6	40
5	K_1	40	6	40
6	K_2	27	3	55
7	K_3	34	5	45
8	K_2	40	5	45
9	K_1	34	5	45
10	K_2	40	5	45
11	K_3	40	6	40
12	K_1	30	4	50
13	K_2	27	3	55
14	K_3	27	3	55
15	K_1	30	4	50

Table 45.2 Emergency supplies parameters

Supplies	Tent	Quilt	Food	Clothes
Weight (kg)	20	5	20	10
Volume (m_3)	0.7	0.15	1.2	0.3
Load efficiency (m)	0.2	0.1	0.2	0.1

Table 45.3 Demand quantities in every disaster site

Disaster site	Tent	Quilt	Food	Clothes
J_1	400	800	500	300
J_2	600	1,100	800	400
J_3	400	700	400	350
J_4	500	1,000	500	450

Table 45.4 Supply quantities in every reserve node

Supply node	Tent	Quilt	Food	Clothes
I_1	600	1,100	1,000	500
I_2	800	1,400	600	600
I_3	800	1,300	800	600

Table 45.5 The distance between every node

Distance (km)	I_1	I_2	I_3	J_1	J_2	J_3	J_4
K_1	50	65	75				
K_2	65	55	85				
K_3	75	85	65				
I_1				65	55	75	85
I_2				75	65	60	70
I_3				15	85	55	65

Table 45.6 Result

Vehicle	Garage	Route	Best value	Mean value
1	K_2	2-2-4-1-1-3		
2	K_1	1-2-2-3-1-2		
3	K_2	2-4-3-2-3-4-3-1-3		
4	K_3	3-3-2-2-1-3		
5	K_1	1-2-4		
6	K_2	2-1-3-3-1-3-3-1-2-2-2-3		
7	K_3	3-3-4-3-1-3		
8	K_2	2-1-3-3-1-3-2-4-3-1-4-3	15.27 h	17.12 h
9	K_1	1-1-3-2-2-4-1-4-3		
10	K_2	3-1-3-3-4-1-2-2-3		
11	K_3	3-3-1-1-3-1-1-3-1		
12	K_1	1-1-4-1-1-3-2-1-3-2-1-3		
13	K_2	2-2-3-2-2-3		
14	K_3	2-4-3-1-1-3-2-2-1-1-3-2		
15	K_1	1-1-3-2-2-3-1-1-3-3-4-2		

45.6 Conclusion

This paper discussed the characteristics of rescue emergency logistics when disaster bursts, designed the system structure of emergency logistic distribution, and established an optimization model, with an aim to minimize the total vehicle running time. Then, an improved genetic algorithm is designed to solve the model, and a numerical example is presented to show the effectiveness and feasibility of this algorithm. As a result, the model and its algorithm are suitable for solving logistic distribution optimization under practical large-scale emergency logistics.

Acknowledgments This paper is supported by the Science and technology research projects in Chongqing Commission of Education (No. KJ100611).

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Chapter 46
Research on Campus M-Learning Based on Cloud Computing

Lun-peng Liu, Yan Ma, Tian-ping Dong and Wen-shu Duan

Abstract With the rapid development of educational information technology, M-learning has already become a new learning method, which has obvious advantages in education and teaching. With cloud computing coming, high-performance computing, mass storage, and convenient services will be around in every aspect of our lives, and this undoubtedly provides a good foundation and platform for the research and development on M-learning. This paper constructs campus M-learning platform under the support of cloud computing and design several modes of campus mobile learning based on the cloud computing in order to help the development of campus M-learning.

Keywords Cloud computing · Campus M-learning · M-learning mode

46.1 Introduction

In recent years, with the development of computer and network technology, as well as the popularity of the various intelligent mobile terminals, M-learning as a new learning method emerges as the times require. M-learning is a complex which contains wireless communication, computer network, mobile terminal as well as a variety of data storage and processing. However, in a previous campus various

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_46,

technical reasons hinder the development of M-learning, instead cloud computing can provide technical support. Then in the support of cloud computing, bottleneck problem in campus M-learning can be solved, which will promote the better and faster development of the campus M-learning.

46.2 Overview of the Campus M-Learning

46.2.1 The Definition of M-Learning

M-learning is essentially based on wireless communication technology, the computer network, and multimedia technology, uses intelligent devices, such as mobile phone, personal digital assistant PDA, notebook computer, to carry out the interactive teaching activities, education, science, and technology information exchange conveniently and flexibly [1]. With the characteristics, such as taking their ease, whenever and wherever possible, away the traditional classroom condition's constraining, learners free themselves from the puzzlement of space, learn more actively.

46.2.2 The Analysis of the Campus M-Learning's Development and Current Situation

September 27, 2004, Intel, cooperating with China Education and CERNET, announced the launch of "Chinese Wireless University Plan" to promote the application of M-learning and wireless technology in the 100 top-grade universities in China. September, 2005, in the meeting of China's University Wireless Forum, Peking University, University of Hong Kong and National Taiwan University, as cross-strait three representative universities, their thoughts and methods of campus wireless network development attracted public attention [2]. With all the university continuing research and promotion, the research of M-learning in our country is gradually increasing. From E-learning to M-learning, the purpose of the research is to develop and use the advanced learning resources, and then promote the effectiveness of learners' learning optimization.

The present campus M-learning mode mainly includes two types: one is the M-learning based on the short message service; another is M-learning through wireless network and intelligent terminal [3]. The current mobile learning modes have many problems, like the lack of technical support with the teaching concept, the poor data transmission rate, the lack of learning resources, limited capacity of using the mobile terminal processing that make very difficult to use widely M-learning in the campus.

46.2.3 Cloud Computing Provides the Support for Campus M-Learning

Cloud Computing is a new method of using resources on the Internet, can provide the calculation on demand for public users through heterogeneous, autonomous service on the Internet. In essence, cloud computing service is a basic public service provided through the Internet, and users can resource acquisition, storage and compute through cloud service [4].

The development of cloud computing is not limited to the PC, along with the vigorous development of mobile Internet, cloud computing service, based on mobile phone and other mobile terminal, has emerged. With the further development of cloud computing technology and the further mature and perfect of mobile Internet devices related, mobile cloud computing services will develop rapidly in the world, which will create a new mobile learning environment. In the campus environment based on cloud computing, Wi-Fi, Bluetooth, and other wireless communication technologies support extremely convenient. Individual data processing will gradually migrate to the "cloud" and the clouds can store massive M-learning resources, and provide the learner for strong processing power, greatly reduce the mobile equipment requirements. The benefits of cloud computing on the campus M-learning mode produce tremendous influence and provide effective support for the campus M-learning platform, also make the problem that the campus M-learning has ever faced be smoothly done or easily solved.

46.3 Research on Campus M-Learning Under the Support of Cloud Computing

46.3.1 Establish the Campus M-Learning Platform Based on Cloud Computing

46.3.1.1 The Physical Layer

Under the cloud computing environment, the physical layer includes computer cluster, network interconnection apparatus, database resources, as well as all kinds of learning resource database free in network. Computer cluster only partly provides learners with super computing power, most simply provides the storage function. In campus, there are large quantities of scrap computer, which do not fit the requirement of the times for single use, but they are completely feasible as the platform of the physical layer. This not only in economy saves the costs in building cloud platform, and uses the old and useless resources campus rationally.

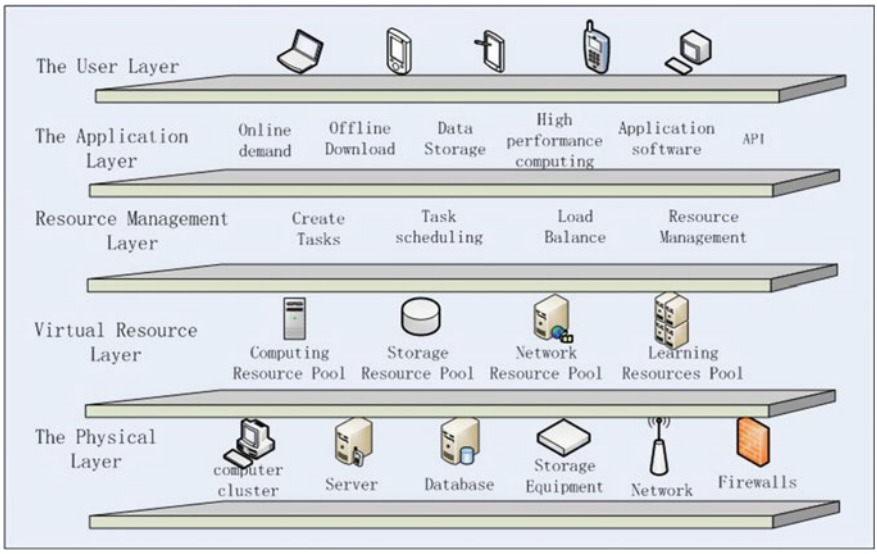

Fig. 46.1 The campus M-learning platform based on cloud computing

Under support of the cloud computing, this papers designs a campus mobile learning model, as shown in Fig. 46.1.

46.3.1.2 Virtual Resource Layer

In cloud computing, virtualization is a key technology. Use of virtual technology can make hardware and software services, learning resources into a virtual resource pool, and the users get high performance computing, data storage space, download, and application of learning resources through the network from the virtual resource layer.

46.3.1.3 Resource Management Layer

Resource management layer is core management layer designed by campus M-learning platform based on cloud computing, which is responsible for resource management on the M-learning platform. On one hand, manage task submitted by users. The task the user submitted is created to different image files and deploys to each node according system design. The layer dispatches timely according to the load status of each node in the task of processing, seals the task on the node loading much larger, and transfers to the idle or insufficient system. On the other hand, manage the system resource, including screening and upload learning resource, the user information management, and network maintenance.

46.3.1.4 The Application Layer

The application layer provides the entrances of using various services conveniently for every learner. Through a mobile network access users can enjoy online on-demand, offline download, data storage, high-performance computing, application software, and other services. At the same time, it can use portability and other characteristics of the cloud computing platform, to provide API port for the access of other clouds server, which cannot only expand more resources and service support for the campus, but also can realize the sharing of resources between different universities.

46.3.1.5 The User Layer

In the campus M-learning mode, the mobile equipment the user holding must be able to log into the Web browser. According to the statistical data shows, in the campus, using rate of mobile devices such as mobile phone, notebook computer, is approaching to that of a traditional desktop computer. With the popularity of mobile equipment intelligent, for campus M-learning mode, the client can mainly achieve the using function of the cloud platform service.

46.3.2 Take Students as Centered and Establish Individualized Campus M-Learning Mode

At present, the three main cloud computing service models including: software as a service (SAAS), platform as a service (PAAS), and infrastructure as a service (IAAS), as shown in Fig. 46.2, thus in the campus mobile learning platform supported by cloud computing that can be divided into three basic models:

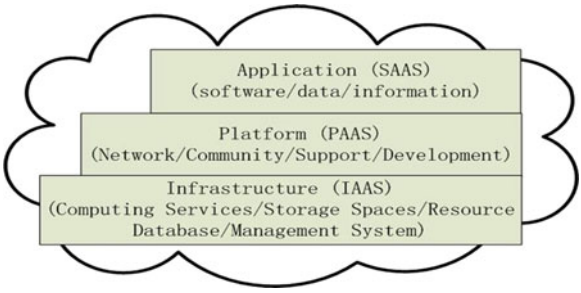

Fig. 46.2 Cloud computing service model for the campus M-learning

46.3.2.1 Personal Autonomous Learning Mode Based on Learning Resources

In the cloud server, the teaching management sets up mobile learning resource and mobile learning support tools for learners. M-learning resource database includes: video live, demand, download courseware, text material, and so on. In the process of moving teaching, the teacher can set up teaching question–answer system and establish doubt inquires for learners.

The learners can choose the suitable way or method to go on personalized autonomous learning at their own favorite time and place [5]. For example, through the smart phones students can download learning courseware in the campus lawn and also can watch the video live in network coverage areas.

This mode takes students as the main body of learning through the students independent learning to finish learning goals. Students can choose their own favorite learning tools to learn and the learners are completely free in time, space, methods, and the thought as well. Teachers can set the beginning and the end of the mobile learning time for students, and the students also can learn video from demanding, download learning courseware and text material to arrange study time freely, if there is a problem, they can query question–answer system that can support the interact online mode and offline mode to teachers, etc.

46.3.2.2 The Team Cooperation Study Mode Based on Network Platform

In the M-learning, learners can through team cooperation conduct discussions to study. The participants can constitute freely according to oneself circumstance, using their different characteristics for complementary in order to achieve the best effect of learning. For example, the students in a dormitory can spontaneously organize up through the mobile device to extend study or the students who join the activity at the same time can complete the course assignments altogether.

Establish a social network platform in campus mobile Internet, the teachers and students use real name for registration, the network platform provide the Weibo, the Blog, QQ, and other social network software so that the learners can make full use of network platform to realize group cooperative study and share their learning resources, learning experiences, and learning results in the process of learning. Learners create a certain professional learning community through team cooperation ways, and study different domain knowledge, individual to individual, personal to team, group to group, and other diversified ways of communication. This open campus mobile learning model not only makes learners' learning effect more apparent, but also is beneficial to the diversity of the students' knowledge.

46.3.2.3 The Virtual Community Learning Mode Based on the Infrastructure

In campus, M-learning platform based on cloud computing includes high-performance computing services and mass storage spaces. It is helpful to integrate the

current huge teaching resources of the network, providing the high performance of online learning for learners, such as live broadcast a university teaching video online and provide real-time interactive services. Cloud server can continually upgrade hardware and storage space that can provides a basic guarantee for teaching managers to set up the capacity of super learning resource, offers a strong support to develop various teaching activities for teachers in the virtual community.

The virtual community learning mode with high-performance infrastructure supports the intelligent campus M-learning services, such as building a learning management system, Knowledge retrieval system, exam assessment system, virtual classroom system and so on, so that many learning activities for students can be in virtualization of environments. Cloud servers may also establish a centralized cloud data management, security management, charging management, and provide a convenient for learners to learn or live, such as learners can query through the clouds database more quickly, retrieve and edit learning resources that is needed, which also can get what they need from the virtual machine and the storage resources to load the application. The virtual campus M-learning mode not only provides students with convenient campus study life, but also can eliminate the education resources between different universities gap to a certain extent.

46.3.3 Play the Advantages of Clouds and Promote the Sharing of Resources

Under the support of cloud computing, all campuses can establish their own cloud service platform, and through the wireless network environment provide the M-learning system service for learners [6]. In the educational concept of the resources sharing, various colleges and universities can set the educational public cloud altogether, providing the public education resource for universities and enterprises. Besides, all the society, provide the resource and tool services for the education public cloud to create a mobile learning mode that is a all-round, multilevel, wide-field mode in education industry, as shown in Fig. 46.3. Building

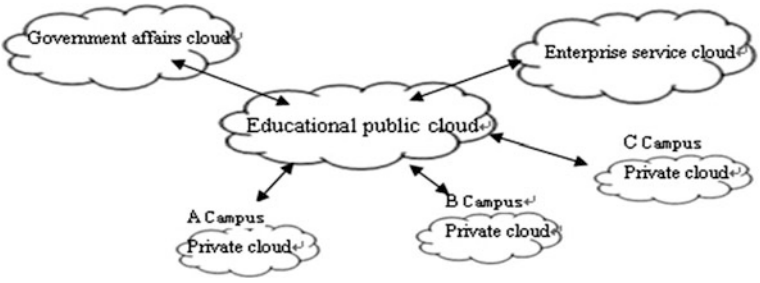

Fig. 46.3 A basic model of resource sharing platform

the whole Internet service system based on cloud computing is what promotes the sharing of resources and avoid the "island cloud".

46.4 Conclusion

With the rapid development of the cloud computing technology, campus M-learning as a study method with the feasibility in development and design, which is not isolated, but as a new way of learning. How to combine with the traditional ways of learning and improve the student's enthusiasm of active learning is also the focus of M-learning research. M-learning mode needs apply the classroom study, network study, and experimental study comprehensively to play its own advantages and promotes learners to improve the learning performance better. In addition, in order to realize the aim of education socialization and lifelong education, research and development the whole society M-learning mode is imperative, it needs more study concept and related technical support.

Acknowledgments This work is sponsored by Chongqing Higher Education Educational Reform (NO: 102118) and Chongqing Education Committee (KJ090809).

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Chapter 47
Industrialized Development of Chinese Broad-Sensed Gymnastics

Li Zun

Abstract Purposes are to explore the healthy development angle, theory, and method of the Chinese gymnastics. Based on the practical situation for gymnastic development in the process of Chinese construction of a sport power, this paper employs such approaches as the literature review, expert consultation, and logical analysis to research the broad-sensed gymnastics. It is proposed that Chinese broad-sensed gymnastics should be developed in an industrialized way. Meanwhile, the necessity and feasibility for the industrialized development of the broad-sensed gymnastics are further discussed. Research findings indicate that the industrialized development of the broad-sensed gymnastics is highly necessary and feasible and it is a must for Chinese broad-sensed gymnastics to overcome the practical development predicament. Finally, tentative suggestions are given concerning the further research on relevant issues.

Keywords Broad-sensed gymnastics · Industrialized · Feasibility · Necessity · China

47.1 Introduction

The broad-sensed gymnastics as a general concept to cover any events closely related to gymnastics, including Olympic and non-Olympic gymnastic events. The concept designation assumes a double significance. For one thing, it finds an ideal niche for those events that have long been wandering away from gymnastics and lays a theoretical foundation for the orderly development of gymnastics. For another, it

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_47,

clarifies the connotation and denotation of gymnastics and makes a unified planning for the complex gymnastic events to offer some ideas for gymnastic sustainable development. Thus, the problem of how to develop gymnastics in an industrialized way is directly turned into one of how to develop the broad-sensed gymnastics in an industrialized way. Through researching and checking documents, the thesis writer finds that up till now no direct research has been done on the broad-sensed gymnastics. At home and abroad, no basic theories and approaches for the industry of the broad-sensed gymnastics are offered. However, the practical experience of sports powers in developing their sports industries shows that sports powers are judged not by the number of number of medals they gain in athletic sports but by the development level of their sports public causes and the economic returns generated by their sports industries and the development of sports events can be secured amid the fierce survival competition only with the guarantee of adequate reserve talents and strong economic conditions. The level of sports industrial development is a major standard to judge the level of a country's sports cause.

Such experience offers useful advice and help as well as referential and feasible ideas and means for the industrialized development of the broad-sensed gymnastics. It goes without saying that the industrialized level of the broad-sensed gymnastics is the major standard to judge the development level of a country's gymnastic cause. The operation and development of the broad-sensed gymnastics have certain effects on the development of the gymnastic events, the improvement of people's living quality, or the promulgation of the gymnastic spirit and the promotion of economic development whatever. They offer direct guidance to the deepened reform and exert positive influence on the sustainable development of Chinese broad-sensed gymnastics, and meanwhile make certain contribution to propelling the construction of a sports power and the overall construction of the comparatively well-off society.

47.2 Designation of the Concept for the Broad-Sensed Industrialization

At present, a quite large number of Chinese equate the development of the broad-sensed gymnastic industry to the industrialization of the broad-sensed gymnastics [1]. The industrialization of the broad-sensed gymnastics, in effect, is gymnastic commercialization, meaning that the broad-sensed gymnastic cause is totally thrust into the market arms and its survival and development are determined by the market demand, which, in turn, is a misunderstanding itself. The industrialization of Chinese broad-sensed gymnastics actually means to base itself on the original gymnastic cause to reform according to the market demand the profitable part and transform according to the input–output principle the nonprofitable part in the original gymnastic cause through the gradual transformation of the mechanism and under the guidance of the market.

The industrialization of the broad-sensed gymnastics is a market-oriented process to create a complete and systematic industry with such links combined in the broad-sensed gymnastic service product chain as production, circulation, exchange, and consumption.

Generally speaking, if a given industry wants to be developed, first and forest, certain production scale must be reached to secure its survival [2]. Once the industry is formed, it needs to be developed amid the motivation to generate profits and the pressure to survive competition. If the industry wants to be developed, the industrial major business must engage itself in industrial expansion by various means to become mature and prosperous, further rendering the industry a pillar one in the national economy. There are two basic means to promote the evolution of the broad-sensed gymnastic industry from infancy into maturity and prosperity. One is government-planned, while the other is market-oriented. It is proved both in theory and in practice that the latter is more effective. In the process of the broad-sensed gymnastic industrialized development, the government will promote the process of the broad-sensed gymnastic industrialization through issuing policies related to the structure, organization, technology, and zone of the broad-sensed gymnastic industry. Of course, a small part of the broad-sensed gymnastic service products are private ones, with the major part being public ones. In terms of availability, private products are mutually exclusive, while such public products are not as the broad-sensed gymnastic public fitness centers and the dissemination of the broad-sensed gymnastics. As a result, unlike the private products of the broad-sensed gymnastics, the public products cannot be supplied by the market; instead, they should be supplied by the government to make up for the market deficiency and improve efficiency and maintain fairness. In the process of the broad-sensed gymnastic industrialization, product supply means should not be limited to market orientation; instead, they should be extended to include government planning, and the combination of government planning and market orientation.

47.3 Necessity of the Broad-Sensed Industrialized Development

47.3.1 Necessary Demand of the Sports Industrial Development to the Broad-Sensed Gymnastic Industrialization

At present, the annual output value of the worldwide sports industry amounts to 400 billion US$, constituting one to three percentages of the GDP. It also develops with a 2 % annual growth rate. The annual output value of the worldwide football industry reaches 200 billion US$, exceeding that of worldwide auto industry. America is the birth place for sports industrialization. American sports industry holds a dominant position in American economy. In 2002, the overall revenue

generated by American sports industry amounted to 213 billion US$. The figure was twice that of American auto industry and makes 3 % of American GDP. It can be seen that the sports industry plays a very important role in the economic development. Compared with developed countries, Chinese sports industrialization enjoys a rather late start. Fortunately, China has a large population and a broad sports market and limitless development potential. In 1998, the overall output value of Chinese sports industry amounted to 140 billion RMB, constituting 0.6 % of the GDP. Although a gap exists between China's figure of 0.6 % and developed country's figures of 1–3 %, it implies large room of and limitless potential for the development of Chinese sports industry [3]; the successful bidding of Beijing for the 2008 Olympic Games attracts huge investment worth of 280 billion US$ amply manifests investors' hot pursuit of the huge profits generated by the sports industry. The rapid development of the sports industry raises new demands to the development of the broad-sensed gymnastic industrialization. In order to smoothly propel the development of the broad-sensed gymnastic industrialization, the broad-sensed gymnastic industry can be combined with industries with large connections to drive the development of such manufacturing industries as textile, machinery, electronic production, and food processing and the development of such relevant industries as media, securities, commercial, lottery, filming, and catering.

47.3.2 Natural Process of the Broad-Sensed Gymnastic Industrialization in Its Own Development

At present, it is a salient problem that many leaders and gymnastic workers have not freed themselves from the bondage that gymnastics used to a public welfare cause and they still devote themselves to pursue the same development condition and culture for the gymnastic cause. They are lacking in economic and social knowledge related to the broad-sensed gymnastics, which is bound to hinder the industrialization process of the broad-sensed gymnastics. Another attention-deserving problem is that many people have a partial understanding of the market orientation for the broad-sensed gymnastics and lack foresight in predicating the demand of the personnel market and the demand of the gymnastic industry. To make matters worse, the public are biased against the industrialized development of the broad-sensed gymnastics, generally maintaining that the industrialized development of the broad-sensed gymnastics actually means the maximization of economic profits, the establishment of the market orientation and the commercialization of gymnastics, which defiles the original purpose and function of the broad-sensed gymnastic events. In brief, the public develop a vague idea on the concept of the broad-sensed gymnastics and an unclear understanding of the classification and hierarchy of the broad-sensed gymnastic events. As a result, there exist only rudimentary statistical index and the evaluation system for the broad-sensed gymnastic industry. The evaluation index of the industry responsible

department is reminiscent of the evolution index for the sports industry. The monitoring system for internal assessment and evaluation is not established. The statistical evaluation system for the broad-sensed gymnastic industry still makes a weak link. There is still a research void in the theory and practice on the broad-sensed gymnastic industry. Practical industrial evaluation standards are hard to make. Industrialization level for such broad-sensed gymnastic events as cheer dance and line dance is generally low. The above-mentioned problems have seriously hindered the development process of the broad-sensed gymnastic industrialization, making it a must to reform the conception and innovate the mechanism to overcome the difficulty confronting the current development of the broad-sensed gymnastic industrialization. This process, in effect, is also a process for the ever development and innovation of the broad-sensed gymnastics.

47.3.3 Satisfaction of the Ever-Increasing Public Sports Demand and Life Orientation for the Broad-Sensed Gymnastic Industrialization

The constant development of modern economy, culture, science, and technology endows people with a deeper understanding of the health-oriented lifestyle. People's understanding of life health is ever increasing while enjoying various material possessions and spiritual comforts provided by modern civilization to their life. The modern living awareness to pursue health is also changing people's traditional way of living and consumption as well as their value outlooks. Outside the time spent on social production and practice, people spend time and money in pursuing health and longevity as well as fitness and entertainment by means of sports recreation and exercise, which has become an important task in modern people's spare time. The old people have an outstanding demand for sports. According to a survey conducted in Shanghai in 2009, sports population constitutes 32 % of the 12 million residents, with the rate of sports population of the middle-aged or old people reaching 59 %, due to their strong demand for fitness, body enhancement and aging resistance. The Number one goal for most people is to postpone the aging process. The middle-aged and old people have strong preference for the fitness programs. They largely prefer such events in the broad-sensed gymnastics as fitness dance, aerobics, line dance, and health-protecting gymnastics [4]. The increase in the broad-sensed gymnastic population leads to a corresponding increase in the product demand, which is bound to promote the further development of Chinese broad-sensed gymnastic industry. The development of the broad-sensed gymnastic industry is in line with the value outlook of the extended sports consumers, for it not only opens up the broad market to cater to people's sports consumption but also meets modern people's psychological demand for the healthy, civil and graceful lifestyle. When people consciously feel the pulse of the broad-sensed gymnastics, they will be transformed into

consumption activities under the guidance and influence of modern market economy [5]. The development of the broad-sensed gymnastic industrialization is in the interest of the sports demand and value outlook for a large number of modern consumers.

47.4 Feasibility of the Development of the Broad-Sensed Gymnastic Industrialization

47.4.1 Favorable Public Support

Most broad-sensed gymnastic events enjoy nationwide popularity. They praise truth, virtue, and beauty in current society and stimulate people's endless appreciation and longing for beautiful mind and happy life in an active and lively way pleasant to public ear and eye; thus, they are deeply loved by the public. Meanwhile, they have great potential for economic development. A good case in point can be provided by such gymnastic events as line dance, cheer dance and street dance. They have comparatively good public support and economic value as they absorb social fashionable elements and reflect the age spirit of the middle-aged and old people. Consequently, programs to train instructors for these gymnastic events are also held and sometimes competitions on these events are hosted by the relevant government administrative departments or the relevant gymnastic associations, organizations, and clubs, which is conducive to the promotion of the broad-sensed gymnastics and the generation of economic returns for the host [6]. Some people's willingness to participate in the events, together with other people's labor in hosing the competitions, helps to enlist the broad public support. However, the economic value of the broad-sensed gymnastic events have not been uniformly recognized and long been ignored. In a sense, only when the broad-sensed gymnastic events are developed and promoted as an industry then their potential pluralistic can be exploited.

47.4.2 Rich Event Resources

Resources for the broad-sensed gymnastic industry are rich and monopolized. In the first place, the fact can testify to the rich resources for the broad-sensed gymnastics that such events as cheer dance, line dance, aerobics, street dance, broadcast exercise, fitness dance, and parkour have a strong flavor of performing arts, a wide range of public support and a close contact with life as well as strong economic potential. Such unique and rich event resources provide a good stage and strong prop for the development of the broad-sensed gymnastic industrialization. In the second place, the unique event resources for the broad-sensed gymnastics nurture performances and competitions, fitness and recreation activities and

training and consultation programs that can be carried out in such different places as urban communities, plazas, parks and fitness clubs, rural grasslands and courtyards, school playgrounds, and factor lots. The performance stage is no longer the best place for such sports as cheer dance, line dance, street dance, broadcast exercise, fitness dance, and aerobics. In the third place, the broad-sensed gymnastic culture has unique charm. A good case in point is the adventurous artistic gymnastics, trampoline, acrobatic gymnastics and parkour, the graceful and attractive rhythmic gymnastics, the exciting and passionate aerobics, the cheerful cheer dance, the leisurely and entertaining line dance, the characteristic street dance, the useful and practical broadcast gymnastics and fitness dance. They are closely related to life, representing strong epoch and cultural characteristics of the broad-sensed gymnastics and the unique advantage in the development of the broad-sensed gymnastic industrialization.

47.4.3 Forceful Policy Guarantee

In March, 1996, the Fourth Session of the Eighth National People's Congress approved the proposal "The Ninth Five-Year Plan for National Economy and Social Development and the Prospective Target and Blueprint for the Year of 2010" [7]. It is pointed out in the proposal that the sports management mechanism should be further reformed and associations and clubs should be founded to manage certain sports events, forming a pattern of the country and the society working together to develop the sports cause and steering the sports cause on the course of socialization and industrialization. In 2010, the Gymnastic Administrative Center under the General Administration of Sport of China combines gymnastic Olympic events and non-Olympic events. "Department of Gymnastics", "Department of Trampoline", and "Department of Rhythmic Gymnastics" are formed to manage gymnastic Olympic events and the non-Olympic events are regulated into the unified "Cause Development Department" to collaboratively publicize, promote and popularize gymnastics [8]. In April, 2010, the successful performance of "Gymnastic World Champions Are in DuJiangyan" offers a ready and available model for the development of the broad-sensed gymnastic industrialization. These policies offer incentive to the healthy growth of the broad-sensed gymnastic industry and form a comparatively systematic theoretical system and provide the policy guarantee for the development of the broad-sensed gymnastic industrialization.

47.5 Conclusions and Suggestions

The broad-sensed gymnastic industrialized development is necessary. It is a necessary demand raised by the sports cause development to the broad-sensed gymnastic industrial updating and a natural process in the own development of the

broad-sensed gymnastics as well as the requirement of the public demand, the ever-increasing sports demand, and the life orientation demand. The broad-sensed gymnastic industrialized development is feasible. It not only boasts strong public support and rich event resources but also enjoys forceful policy guarantee and sound infrastructural facilities. These advantages and conditions offer direct incentive to the broad-sensed gymnastic industrialized development.

In the process of the broad-sensed gymnastic industrialized development, people's physiological and psychological traits as well as interests and needs should be taken into consideration and different broad-sensed gymnastic events should be selected for different groups according to their different needs. Various means like training programs, performances, and video programs can be explored to cater to people's physical and psychological needs and the industrialization of leisure and entertainment.

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Chapter 48
Study on Adaptive SPM Displacement Measurement

Guo-tian He, Ying-chun Ran, Ying-ying Qi, Ming Li and De-sheng Zhang

Abstract This article designed a sinusoidal phase modulation (SPM) interferometer for the precision measurement of object displacement. By using low-pass filters to deal with interference signals, the sine and cosine values of phase in the measured object displacement were got. Then the sine and cosine values of phase divided each other, got its arctangent, and processed one-dimensional phase unwrapping to get the measured object displacement. The Interferometer had high measurement accuracy and strong anti-jamming ability; every measurement was the ratio of two values got by two filtering, the effects of the amplitude of interference signal AC component, circuit amplification, the light-intensity of interference signal, and attenuation of filter on the signal and other factors on the measurement results need not be considered. The circuit structure of the Interferometer was designed to be simple.

Keywords Interferometer · Sinusoidal phase modulation · Filtering · Displacement measurement

48.1 Introduction

Along with the rapid development and application of precision instruments, the demands on displacement and angular deflection of the various mechanical components were increasingly high [1–3]. Photoelectric detection technology with

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_48,

the advantages of high precision and stability, simple structure, quick detection speed, real-time nondestructive testing, had been widely applied [4–6]. In recent years, as the rapid development of laser diode (LD), it had been widely applied in SPM [7–9]. Interferometer due to these unique advantages of a small size, wavelength-tunable, better coherence and stability, and so on [10–12]. Sinusoidal phase modulation Interferometer can make LD output the laser of wavelength that changed with the sine rule by inputting sinusoidal modulation signal to LD, and realized sinusoidal phase modulation for interference signal, greatly simplifying the structure of Interferometer compared to conventional Interferometer [13–15]. Song and Xiangzhao Wang et al. in Shanghai Institute of Optics and Fine Mechanics designed a semiconductor laser interference measuring instrument for real-time measurement of the object small vibration [1]. The measurement instrument first can get the sine value of vibration signal, and then got the arcsine value of the sine value to calculate the sine object small vibration. The measurement scope of the instrument was small, needed to accurately calculate the amplitude of interference signal AC component, [16] the amplification times of amplification circuit, signal attenuation of filter, and other related quantities, made it difficult to guarantee the measurement accuracy.

This article processed SPM interference signal by filtering method, the measurement results were the ratio of two values got by two filtering, offsetting the AC amplitude of interference signal and the amplification times of circuit such as physical quantities. The Interferometer with the advantages of high measurement accuracy and phase unwrapping algorithm, while guaranteeing measurement accuracy, greatly expanded the measuring range of Interferometer.

48.2 Principles

The principle diagram of SPM Interferometer for object displacement measurement was shown as Fig. 48.1. The Optical part of the system is the Twyman–Green Interferometer. The system used LD as light source, get the directed parallel light through lens L, then became two beam parallel light by Min beam device BS, one beam parallel light of which as reference light beam was irradiated to reference mirror M, the other beam parallel light of which was irradiated to measured vibration object with reflection mirror, the light range difference of two beam light was $2D_0$. The reflected light beam of Reference mirror M and the reflected light beam of measured vibration object interfered in each other, forming interference fringes.

The dash part in Fig. 48.1 was completed in the single chip microcopy (SCM), which was a STM32 SCM with 72 MHz ARM core. The STM32 SCM outputted the digital signals folded by $a\cos\omega_c t$ sine-modulated signal and DC signal using timer, which were converted into voltage signals in a row through D/A, and then after V/I converted to the currents of AC and DC superposition for LD power supply, the optical path and the laser from LD whose wavelength changed with the sine rule, composed the SPM interferometer. At the same time, the interference

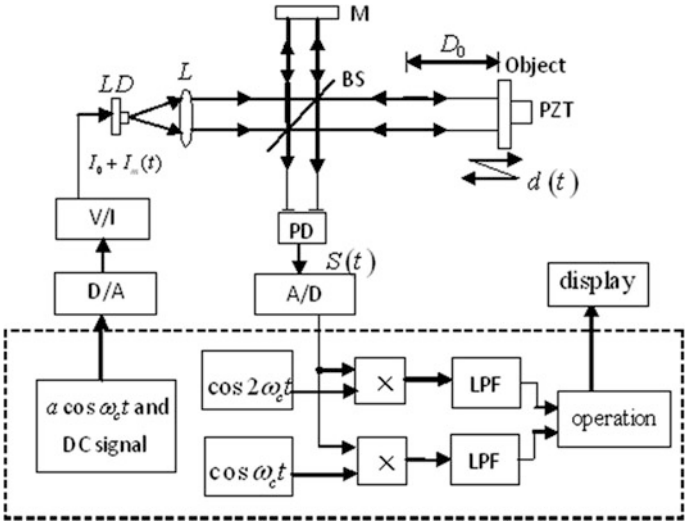

Fig. 48.1 Vibration and displacement measurement principle diagram based on SPM interferometer

signals collected in the PD circuit, via the preamplifier and A/D, were converted to a digital signal and transmitted to the SCM. The SCM also produced cos $\omega_c t$ and cos $2\,\omega_c t$ these two sine signal, whose amplitudes were same and initial phases were zero. The phase of cos $\omega_c t$ and the phase of a cos $\omega_c t$ where same We can multiply cos $\omega_c t$ and cos2 $\omega_c t$ by the collected interference signal $S(t)$ respectively, and filter them through corresponding low-pass filters, filter modulation signal, the signal after filtering only consist the cosine value of the displacement and known constants. The two-channel signals were divided by each other, and found their tangent and arctangent value, and then got the object displacement. If the object displacement was relatively large, the measurement result we got was the truncated primary phase value, we need to process one-dimensional phase unwrapping and recover the initial phase that was the measured object actual displacement.

The current that Laser inputted was:

$$I(t) = I_0 + I_m(t) \tag{48.1}$$

of which I_0 was direct current that a Laser needed for normal work for determining the center wavelength of Laser; $I_m(t) = a$ cos $\omega_c t$ was the LD sinusoidal modulated current; I_0 and $I_m(t)$ together drove LD, making the Laser output laser whose wavelength changed with the sine rule, the wavelength was $\beta I_m(t)$, β was LD wavelength modulation coefficient.

The interference signal that photodiode PD received was:

$$S(t) = S_1 + S_0 \cos[z \cos \omega_c t + a(t)] \tag{48.2}$$

S_1 was the DC component of interference signal, S_0 was the amplitude of the interference signal AC component. z was the modulation depth of sinusoidal phase, $z = -4\pi a\beta D_0/\lambda_0^2$ $a(t) = a_0 + a_d(t)$ a_0 was the initial phase determined by the initial optical path difference $2D_0$, $\alpha_0 = (4\pi/\lambda_0)D_0$.

$a_d(t)$ was object phase variation introducing Displacement determined by the displacement $d(t)$, $d(t)$ Because of object displacement variation in a certain time, which was independent of initial displacement, so here a_0 and a_0 would be merged to? $a(t)$.

Interfering signal was:

$$S(t) = S_1 + S_0\left\{\begin{array}{r}\cos[a(t)]\cdot[J_0(z) - 2J_2(z)\cos(2\omega_c t) + 2J_4(z)\cos(4\omega_c t) - \cdots] \\ -\sin[a(t)]\cdot[2J_1(z)\cos(\omega_c t) - 2J_3(z)\cos(3\omega_c t) + \cdots]\end{array}\right\} \quad (48.3)$$

$S(t)$ was multiplied by the modulation signal $a\cos(\omega_c t)$, then through a low-pass filter, and after filtering got the modulation signal

$$S_{f1} = -a\,S_0 J_1(z)\sin a(t)\sin a(t) = -\frac{S_{f1}}{aS_0 J_1(z)} \quad (48.4)$$

$S(t)$ was also multiplied by the twice times frequency modulation signal $a\cos(2\omega_c t)$, then through a low-pass filter, and after filtering got the modulation signal $a\cos(2\omega_c t)$.

$$\cos a(t) = -\frac{S_{f2}}{aS_0 J_2(z)} \quad (48.5)$$

The truncated phase was:

$$\Phi = a\tan 2[\sin a(t), \cos a(t)] \quad (48.6)$$

When the object's displacement was less than half a wavelength, displacement value is $\Phi/2$. When the object's displacement was more than half a wavelength, measured phase value was the main value of interference phase in the range of $[-\pi, +\pi]$, In order to get the true displacement, must recover the initial continuous phase from the truncated phase. On the premise of meeting the SyQuest sampling theorem, using one-dimensional phase unwrapping technology, truncated phase plus or minus 2π, then we can accurately recover the initial continuous phase.

48.3 Simulation and Error Analysis

This simulation set LD Center wavelength for 800 nm, modulation depth for 2.33, modulation signal frequency for 1 kHz, sampling frequency for 10 kHz, filter cutoff frequency for 100 Hz. Sinusoidal displacement signal was inputted, whose frequency and amplitude was 10 Hz and 180 nm, respectively, the outputted displacement signal was shown in Fig. 48.2.

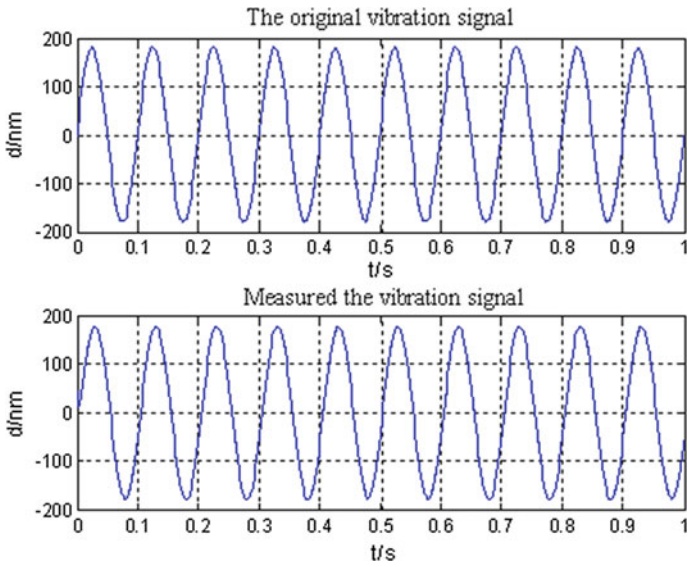

Fig. 48.2 The simulation diagram for measuring microdisplacement based on SPM Interferometer

As can be seen from the Fig. 48.2, the measured displacement signal was very consistent with the initial displacement signal. The amplitude of inputted sinusoidal displacement signal was 180 nm. During the measuring process using FIR low-pass filter, there would be a delay, delay time was 5 ms. Increasing the sampling frequency or decreasing filter order can decrease the delay time to realize real time measurement of object displacement.

Error analysis showed that the measured peak–peak value error was 0.0145 nm, the expected value error was 0.0006 nm, variance was 0.0003 nm^2, and standard deviation was 0.0183 nm.

Displacement signal was set to the linear displacement of 0–50 um; the measurement result was shown as Fig. 48.3.

The map at the top of Fig. 48.3 showed the inputted displacement, the map at the bottom of Fig. 48.3 showed the measurements without the phase unwrapping. The measured displacement was truncated to the saw tooth wave within $[-200, +200$ nm$]$, so we need to process one-dimensional phase unwrapping for the measured displacement as to recover the initial phase that was the actual displacement.

Then the map down Fig. 48.3 was processed one-dimensional phase unwrapping, the measurement results was shown as Fig. 48.4. As can be seen from the Fig. 48.4 the measured displacement was 0 for 0–0.2 s, that showed the object didn't move; during the time of 0.2–0.8 s, the measured displacement linearly increased from 0 to 50 um, represented the object moved at a constant speed in a

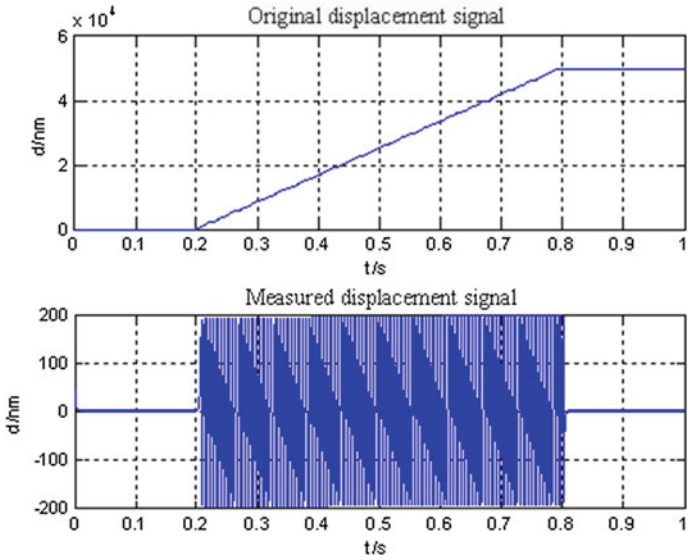

Fig. 48.3 The displacement simulation diagram without the phase unwrapping using SPM interferometry

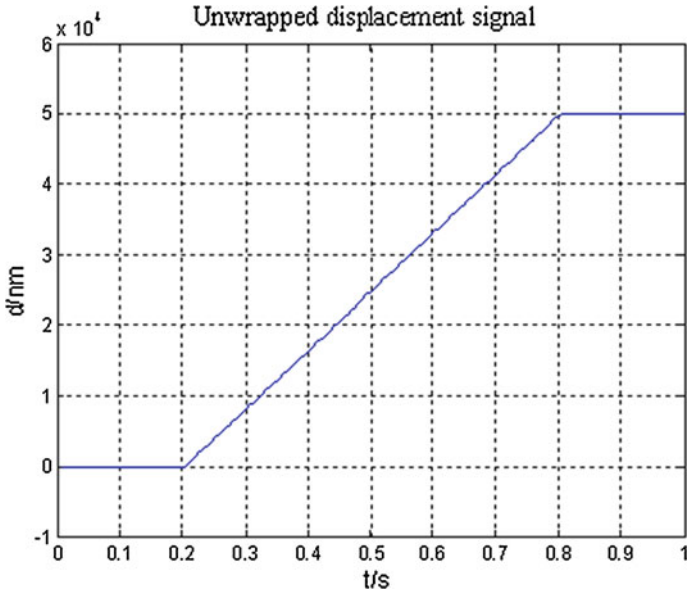

Fig. 48.4 The object displacement simulation diagram with the phase unwrapping

straight line, movement distance was 50 um; during the time of 0.8–1 s, the measured displacement maintained 50 um, represented the object stranded still after moving 50 um.

Error analysis showed that the error was 0.0058 nm and the relative error was $1.16 \times 10^{-9}\,\%$ when the total displacement was 50 um.

48.4 Conclusion

This article designed a sinusoidal phase modulation (SPM) Interferometer for the precision measurement of object displacement. The simulation and error analysis proved the Interferometer had high measuring accuracy. The Interferometer can filter out the DC component and offset the AC component in interfering signal through twice filtering for every measurement using a low pass filter; at the same time it had strong anti-jamming ability and high measurement accuracy, the circuit amplification and attenuation of filter did not affect the measurement result.

Acknowledgments This paper gets the following project support, the national 863 project "major projects with high intelligent analysis instrument online and complete system key technology research and product development" items (2012 AA040603), Chongqing major projects "high temperature flue gas more than high precision components online intelligent monitoring system research" (cstc2011ggC70001), Chongqing municipal education commission funded project (KJ110601,KJ100605,KJ090820) in this to say thank you all.

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Chapter 49
QoS-Constrained Resource Scheduling in Grid Computing

Fujian Qin

Abstract Efficient quality of service QoS management is critical for computational grid to meet heterogeneity and dynamics of resources and users' requirements. Aimed at the QoS requirement for resource, QoS-constrained resource scheduling algorithm is proposed. All the tasks are needed to be associated with four QoS dimensions, namely time, reliability, security, and cost. It is implemented and the advantages of the new algorithm are investigated in a grid simulator called Grid Sim after the simulator has been expanded. The results of the simulation experiments show that this new scheduling algorithm effectively achieves load balancing of resources with comprehensive advantages in time efficiency, and solution accuracy compared to the other two algorithms. The approach can reduce data access latency, decrease bandwidth consumption, and distribute storage site load. It can be applied to resource scheduling in grid computing.

Keywords Grid · Quality of service (QoS) · Resource scheduling algorithm

49.1 Introduction

Grid computing is becoming a popular way of providing high-performance computing for many data intensive, scientific applications [1, 2]. It integrates scattered clusters, servers, storages, and networks in different geographic position to form a virtual super computer. Grid computing is a form of distributed system

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_49,

where in computing resources are shared across networks, such as high-performance computing power, expensive experiment equipment, and other rare resources [3]. Because of the characters of dynamic, distributed, and different requirements to resources asked by applications running in the Grid Systems, it makes the resource management and scheduling very complex [4]. With the development of grid computing, dealing with the data distribution requires a resource management and scheduling which is faster and more effective for parallel applications in order to reduce task's running time and increases the throughput of the grid system. Hence, resource management and scheduling are integrated components of grid computing, especially the research of task scheduling algorithm, playing a very important role in all the research of grid computing.

In resource management and scheduling, one allocates the submitted manufacturing tasks or resource service requests to appropriate resources within the shortest time and highest benefit to both resource provider and consumer. The resource consumers have various requirements, objectives, and demand patterns, which may require different types and levels of Quality of Service (QoS). Computational grid's resource management and scheduling must deal with various demands from consumers and providers. The way to achieve it is to search the qualified resource service, according to a user's QoS requirements, and realize the mapping from QoS requirements to resource capabilities. Thus, it is important for the grid computing to support scheduling strategy in accordance with QoS policy. The scheduler in the grid environment needs to consider the QoS to get a better match between applications and resources. In this case, QoS-constrained resource scheduling algorithm is proposed and discussed. It turned out that the algorithm implement is a feasible option which takes time and cost constraint and other factors into account. It can allocate application tasks to appropriate resources based on the user's QoS requirement of time, security, reliability, and cost constraint.

49.2 Related Works

Recently, QoS-based resource management and scheduling has been the subject of many research studies. In [1], QoS for network is integrated to make a better match among different levels of QoS request/supply. Dŏgan et al. consider the problem of scheduling a set of independent tasks with multiple QoS requirements [2]. Ding et al. provide a flexible way of QoS-based scheduling in which makespan and service ratio can be traded off by adjusting the preference factor in a local objective function [3]. Lee et al. use resource–utility functions in a QoS management framework with the goal to maximize the total utility of the system [4]. He et al. introduce the matching of the QoS request and service between the tasks and hosts based on the conventional Min–Min algorithm [1]. Li Chunlin et al. defines another three QoS parameters, cost, deadline, and reliability, with utility

function for each dimension and uses a market model to maximize the global utility [5]. Nam and Youn et al. propose a Quorum-based resource management scheme, which resource Quorum includes middleware entity and also network entity, both can satisfy requirements of application QoS. They suggest a heuristic configuration algorithm in order to optimize performance and usage cost of Resource Quorum [6, 7]. The multiobjective task scheduling problem with multi-QoS constraints is transformed to the general multiobjective combinatorial problem in [8] and an evolutionary algorithm is put forward to solve it. Golconda et al. develop a model with multi-QoS constraints and compares five scheduling heuristics based on that model [9]. Ghosh et al. [10] present scalable QoS optimization algorithms for allocating resources to tasks in a multiprocessor environment. The algorithms are extensions of Q-RAM (QoS-based resource allocation model), can select a QoS operating point, the number of replicas for fault tolerance and the processors on which to run the replicas so as to maximize overall system QoS. All of the above algorithms consider the QoS-based resource scheduling problem from different points of view. In this paper, economic grid QoS-constrained scheduling algorithm is studied.

In this paper, our design is to develop a high-throughput computing scheduling algorithm. We consider scheduling finite resources to satisfy the QoS needs of various grid users. Each task is associated with a benefit function which depends on the finish time of that task, cost of that execution task, and reliability. We build grid resource management, where grid resource users and providers can buy and sell computing resource based on an underlying economic architecture. The agents of the system interact by offering to buy or sell commodities at given prices.

49.3 Grid Resource Management System Model

49.3.1 Resource Scheduling Framework

We design a resource scheduling framework, which consists of three levels: user level, scheduler level, and resource level (as shown in Fig. 49.1). The resource level is the underlying grid resource. Each resource gives its computation capacity and information. The user level is the grid user. Each user expresses their requirements in the form of tasks. The scheduler level is the grid resource management and scheduling system. Through resource scheduling mechanism or policy, users have access to various resources.

There are three key players in the resource scheduling framework:

Resource Provider: it is defined as an entity which shares some particular physical resource within the context of a grid. Given the currently available resources in grid system is m, the grid resource collection R = {R1, R2…Rm}, where resources Ri = {PEs, MIPS, Bandwidth}, the elements of the collection represent the number of processor, the performance of the processor performance, and the available network bandwidth.

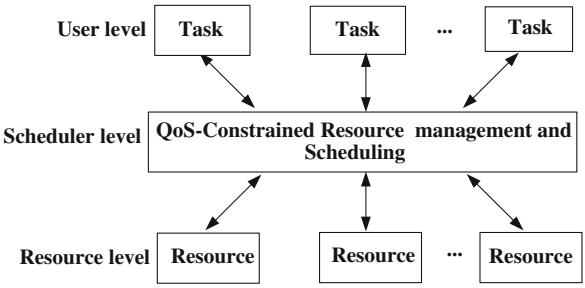

Fig. 49.1 Resource scheduling framework

Resource scheduler: it is responsible for selecting those resources that meet the deadline and budget constraints along with optimization requirements and task assignment. Resource scheduler must make best effort decisions and then submit the tasks to the hosts selected, generally as a user. The scheduler is a mediator between the grid resource user and provider. It can provide the ability to specify resources, obtain quick turnaround for consumer, and receive reliable allocation of resources with all sorts of information gathered by resource discovery.

Resource user: it expresses their requirements in the form of tasks. Each user has a queue of tasks it wishes to execute. Defined a set of scheduled tasks:T = {T1, T2…Tm}, which represents a scheduled task Ti, and Ti = {Length, MIPS, Bandwidth, Deadline}. The meaning of parameter is the length of the grid task, users deadlines demand, the demand for bandwidth, and processing power of CPU MIPS respectively.

49.3.2 QoS Model Requirements

A task executing on a grid system can have a number of QoS requirements that need to be satisfied. It is heterogeneity and dynamics of the grid that make QoS problems in grid environment challenging. Our QoS model is composed of multiple dimensions. Resource selecting is constrained by multiple-QoS metrics such as time, cost, quality, security, reliability, and so on, shown as in the Fig. 49.2.

Time (*T*): it is a common and universal measure of performance. Without loss of generality, the time parameter of a machine is defined as the actual completion time of task running on it. The time can be broken down into three parts that include: transmission time, computation time, and delay time.

Cost (*C*): it represents the cost associated with the execution of grid tasks. Task cost is the cost incurred when a task *t* is executed. Especially, computation resource cost and bandwidth resource cost are ignored. Different resources demands may require different cost. The cost can be broken down into two parts that include: computation cost and bandwidth cost.

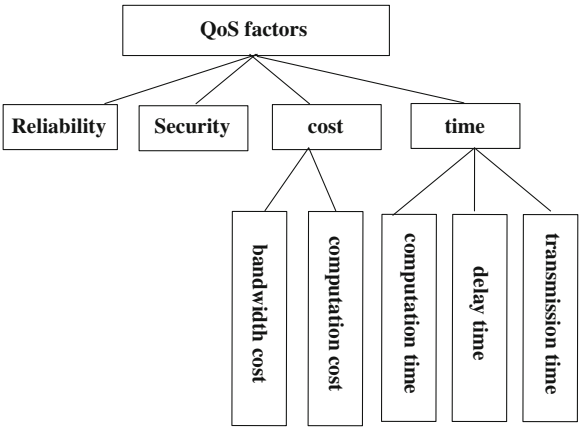

Fig. 49.2 Packet QoS model requirements

Security (*S*): it is defined to be the security level it needs. Each user may require different levels of security for their task and data in a large-scale distributed computing system.

Reliability (*R*): it is defined to be the probability that the task can be completed successfully. A long-time running task may experience failures during its execution, resulting in the wasting of system resources and poor overall performance. Hence, a user may want some reasonable degree of reliability for its task in order to minimize the adverse effects of failures.

Time (*T*), Cost (*C*), Security (*S*), and Reliability (*R*) are considered as the QoS dimensions of a task. As a result, the QoS model of task i can be formulated as Qi = [*T*, *C*, *S*, *R*].

49.4 Grid Task Scheduling Algorithm

From the user point of view, we propose a scheduling strategy for the scheduler.

The expected time *ET* (*Ti*, *Rj*) of task *Ti* on resource *Rj* is defined as the amount of time taken by *Rj* to execute *Ti* given that *Rj* has no load when *Ti* is assigned. The expected time cannot be given directly to the quantitative value of their specific needs calculated by the corresponding value. Therefore, it is defined as follows:

1. ET (Ti, Rj) = Computation time + transmission time + delay time.
2. Computation time = Computational tasks/CPU speed.
3. Transmission time = Data Size/network bandwidth.

The Cost *C* (Ti, Rj) of task Ti on resource Rj is defined as the amount of cost taken by Rj to execute Ti. The Cost *C* (ti, *e*) can be estimated as follows:

C (Ti, Rj) = computation cost + bandwidth cost

The Reliability (Ti) of task Ti is defined to be the probability that the task Ti can be completed successfully.

The Security (Ti) of task Ti is defined to be the security level for the task Ti.

The Cost F of task Ti is an upper bound on the total service cost paid by user.

The uTi is an upper bound on the total completion time.

The scheduling algorithm is considering the QoS constraints when send tasks. Given Q (Ti) = $a \times$ (uTi – ET (Ti, Rj)) + $b \times$ ($F - C$ (Ti, Rj)) + $c \times$ Reliability (Ti) + $d \times$ Security (Ti), where $a + b + c + d = 1, 0 \leq a, b, c, d \leq 1$, a, b, c, d denote the weight assigned to expected time, cost and reliability, security, respectively.

The weight a, b, c, and d indicate that the task requirements degree of four constraints. Scheduling algorithm takes into account the different tasks which demand different resources in the implementation of grid system. According to the demands of the user tasks, the weight a, b, c, and d are set.

While a task with no QoS request can be executed on both high QoS and low QoS resources, a task that requests a high QoS service can only be executed on a resource providing high quality of service. Thus, it is possible for low QoS tasks to occupy high QoS resources while high QoS tasks wait as low QoS resources remain idle. To overcome this shortcoming, we propose the Scheduling algorithm to take the QoS matching into consideration while scheduling.

Step1: {for each task Ti in T = {T1, T2,…, Tm}

{for each resource Rj in R = {R1, R2,…, Rm}
Q (Ti, Rj) = $a \times$ (uTi – ET (Ti, Rj)) + $b \times$ (F–C (Ti, Rj)) + $c \times$ Reliability (Ti) + $d \times$ Security (Ti)
endfor}
endfor}

Step2: {Sort resources by the increasing order of Q (Ti, Rj)}
Step3: {Do until all tasks in T are scheduled

{for each task Ti in T find the highest Q (Ti, Rj) and the corresponding resource
find the task Ti with the maximum highest Q (Ti, Rj)
assign task Ti to Rj that gives it the maximum highest Q (Ti, Rj)
delete Ti from T}
endfor}
enddo}

49.5 Performance Studies

Simulation studies are carried out to evaluate the performance of QoS-Constrained resource scheduling algorithm. We devise other two resource scheduling schemes to compare with QoS-Constrained resource scheduling algorithm in terms of task

completion time. The algorithm one allocates better CPU capabilities than network capabilities to the grid task. The algorithm two randomly allocates network capacity and computation capacity satisfying the minimum QoS requirements to grid task, the new algorithm uses our algorithm. Compared with other two task scheduling algorithm, task completion time our algorithm is shown in Fig. 49.3.

In order to evaluate the performance of QoS-Constrained grid resource scheduling algorithm, the Grid Sim simulation tool is used. This toolkit provides basic functions for the simulation of distributed applications in grid environments. In our experimental testing, we change the number of tasks in the Grid system from 100 to 700. The bandwidths of all links are uniformly distributed between 1 and 200 Mbps. Processor capacity varies from 10 to 100 per time unit, each node' computing delay varies from 1 to 20 per time unit. To characterize various grid resource usage, the simulation abstract both time and resource usage. The resource cost can be expressed in grid dollar that can be defined as processing cost per MIPS.

Figure 49.3 shows that the new QoS-Constrained grid resource scheduling algorithm performs better than the algorithms one and two in terms of the completion time. From the results in Fig. 49.3, for both three algorithms, smaller grid size leads to faster completion times. Our algorithm considers both optimal network resource and CPU allocation, so it has better completion times.

QoS scheduling algorithm adopts both application-centric and resource-centric scheduling objective function aim to optimize the performance of each individual grid user and the performance of the grid resources. It cannot only satisfy the diverse requirements of QoS with different preference from the user perspectives, but also improve the resource utilization rate from the system perspectives. The algorithm is compared with others based on the quality of the prediction formulated by inaccurate information.

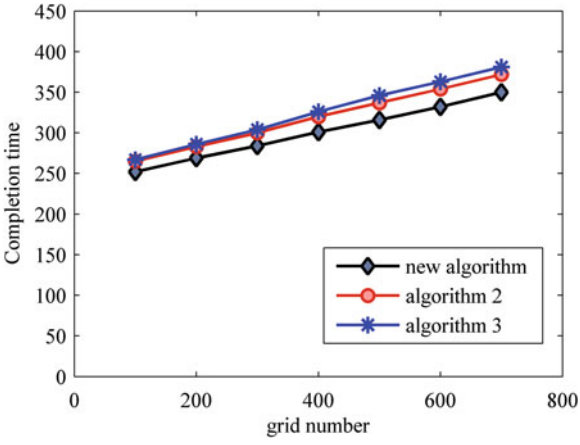

Fig. 49.3 Comparison of completion time

49.6 Conclusion

This study is motivated from the fact that while users with diverse QoS requirements will be having access to a grid computing system, a QoS-Constrained scheduling algorithm is needed not only for meeting users' QoS requirements but also for utilizing the system resources more efficiently. Through the experiments, we have verified the advantages of the algorithm. And it shows that the algorithm can find the most suitable resources and improve resource discovery efficiency. It involves less overhead and leads to better completion times than the other two algorithms.

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Chapter 50
Ontology-Based Energy Model in Smart Home

Shoukun Xu, Jun Qi and Zhenghua Ma

Abstract At present, people are in the pursuit of household intelligent control, at the same time, they start to focus on the comfort and energy saving in household environment. This paper based on the FIPA ontology standard, a kind of intelligent household energy saving model is established, the system of various kinds of agent module are analyzed, and a concrete plan to design energy control is provided. By introducing ordered weighted average operator (OWA), the problem that the system can maximize the customer comfort with minimum power consumption is solved.

Keywords Smart home · Energy saving · Ontology

50.1 Introduction

With the popularity of equipments intellectualization and their price decrease, people begin to considering home comfort requirements gradually. Household appliances bring much convenient and comfort to people's lives, while it causes the invisible environmental pollution and some diseases. In order to improve the convenience and economy in the household life, establishing an energy saving environmental application integrated model has become an important research direction in intelligent space, whose purpose is to make equipments get intelligent control in the space, at the same time, still can reach the purpose of saving energy.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_50,

To establish such an energy saving model, the first problem to solve is how to describe the smart home. There are kinds of intelligent household information, and their classification ways are different due to various classifications included data type, function, household appliances in traditional way. However, it has not been formed a unified standards, the reason is that pervasive devices in smart home exist heterogeneous devices and communications. In order to solve this problem, ontology is introduced in the paper to describe smart home. Context [1] is the set of environmental states and settings that either determines an application's behavior or in which an application event occurs and is interesting to the user. Domo ML [2] is one of the first projects to propose an ontology-based household device model. While it successfully provides taxonomy of different household appliances, Domo ML fails to address the energy behavior of the facilities. The second appliance integration project is called DogOnt [3] and can be seen as an advancement of the taxonomy described in Domo ML. It reuses certain parts of the Domo ML ontology, tries to overcome limitations of Domo ML and gives a compact and complete ontological representation of household goods including states, functionality, and a basic notion of the building environment. Additionally, DogOnt starts to address the issue of heterogeneity in home, but energy-related issues are still not specifically referred in the ontology. In a recent publication [4], the authors present their energy domain extension to the original DogOnt domain ontology. In their approach, they only consider the energy consumption but did not provide users active choice, which means men, machines, and things are not all connected. Based on this, a based-on ontology energy model in smart home (OEMSH) is proposed, aiming to set up a standard smart home context model that can maximize the customer comfort with minimum power consumption, realizing the energy automation management in smart home.

50.2 OEMSH Module Design

Partial FIPA standards are used in the OEMSH, FIPA standard is an international organization of company and academic institutions active in the field of Agent, whose goal is to interoperability work out relevant software standards between heterogeneous Agent and Agent systems. New knowledge concept definition, attributes, and the relationship between classes are defined based on original FIPA standard. Multiagent system (MAS) is an organic system composed of multiple intelligence Agents, which makes it more powerful processing than a single Agent. Because MAS has characteristics such as responsiveness, autonomy, objectives, learning, cooperation, and coordination, it can realize different unit control and management, and the whole organic mix by the communication and cooperation of different agents. According to the FIPA agent Management Ontology description, agent contains agent identifier and agent services.

As shown in Fig. 50.1, OEMSH is divided into four main agent modules; each agent is composed of multiple independent function modules. They are the

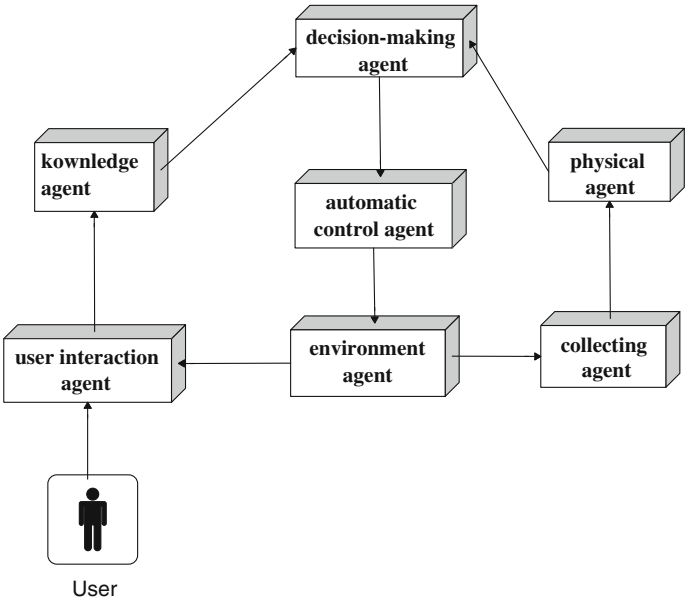

Fig. 50.1 OEMSH system frame model

automatic control agent, the user interaction agent, the decision-making agent, the physical agent.

1. The User interaction agent: user can register personal information, and then the user interaction agent acquires user information, deposits in the knowledge agent, finally provides for decision-making agent.
2. The Automatic control agent: control home energy switch, decides to use the number of time, flow direction, and degree of energy according to the decision of the decision-making agent, and provides energy conversion.
3. The Physical agent: monitors and gathers environment information, and provides for the decision-making agent.
4. The Decision-making agent: set the value of the weight of environment parameters through regulating system multiple agents, and take user preferences into account, resulting in household energy priority.

50.2.1 The Automatic Control Agent

The Automatic control agent is divided into two kinds, namely: the energy control agent and the energy conversion agent. The energy control agent is used in the power switch control household appliances, such as the temperature of the air conditioning, the brightness of the light, lampblack emissions, so as to achieve the minimum of carbon dioxide and other harmful gas emissions, and monitor the flow

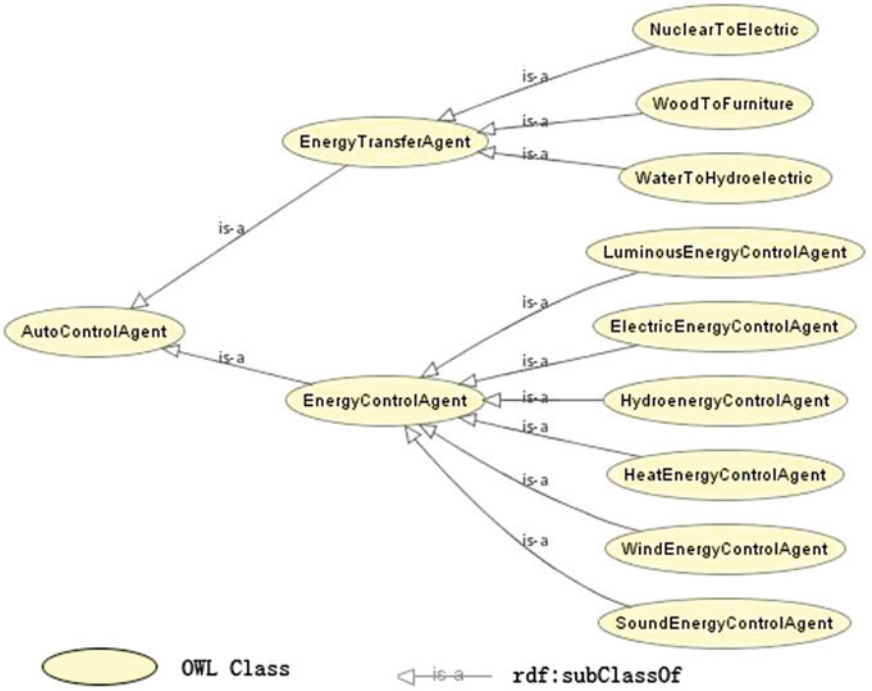

Fig. 50.2 Automatic control agent ontology model

of energy. Energy conversion agent is used to convert water, light, coal, and other energy into household energy.

In order to model an energy saving system, a classification of energy types is needed. The classification has to describe the domain of smart homes with respect to modeled energy types. In OEMSH, energy divides into primary energy and secondary energy [5], and primary energy is divided into final energy and useful energy, as shown in Fig. 50.2. Primary energy sources include nonrenewable energy and renewable energy. Nonrenewable energy, for example, is crude oil, raw coal, and natural gas. Final energy is very few. Therefore, from the point of view of energy saving, we use secondary sources as far as possible, such as wind, hydro, sound energy, etc.

According to the FIPA Device Ontology, automatic control module includes device information and device type. Energy control agent module is divided into water energy control agent, wind energy control agent, electric energy control agent, thermal control agent, sound energy control agent, and light energy control agent, and each of them is responsible for controlling the corresponding household devices, for example, water energy control agent controls household faucet switch, toilet water, washing machine; wind energy control agent controls electric fan speed knob, hair dryer switch; light energy control agent is used to control lighting equipment such as incandescent lamp in home. The energy transfer agent is

responsible for transferring terminal energy and secondary energy into home resources consumption, for example, nuclear energy is transferred into electrical energy, water is transferred into water electricity, wood is transferred into furniture, etc.

50.2.2 The Decision-Making Agent

The decision-making agent is the core of the OEMSH. Compared with other agents, the decision-making agent has more complex logic and reasoning ability, managing high-level user's needs by the decision of the reasonable energy distribution. The decision-making agent set household energy priority through analyzing and evaluating information collected from the physical agent, user comfort play an important role in this process. The decision-making agent set and monitor indoor environment, further so it can manage power consumption of household devices more effectively. For example, a user set intensity of light of environment in a certain period of time, and the process is shown below. First, this message will be passed to the decision-making agent, and take series weight calculations. Second, the result is compared with other environmental parameters in weight. Third, the decision-making agent informs the automatic control agent to adjust household appliances, such as dim the lights, higher temperature, etc. Finally, this message will be retained in the knowledge agent, providing for the system learning.

According to the Air Conditioning system (HVAC), OEMSH signs environment quality with four elements which are temperature, humidity, light intensity, and air quality, ordered weighted average operator (OWA) is used in OEMSH to compute the weight of parameters according to user preferences or the system default distribution. OWA operator mathematical model [6] description as follows:

$$\mathrm{OWA}\ (a_1, a_2, \ldots, a_n) = \sum_{j=1}^{n} w_j b_j,\ n = \mathrm{T, H,\ L, A} \tag{50.1}$$

$$a_n = \max\left(\min\left(\frac{N - a_{n1}}{a_{n2} - a_{n1}}, 1, \frac{a_{n4} - N}{a_{n4} - a_{n3}}\right),\ 0\right) \tag{50.2}$$

$$a_{n1} = \frac{a_{n2}}{1.05} \tag{50.3}$$

$$a_{n4} = \frac{a_{n3}}{0.95} \tag{50.4}$$

In which OWA function is the representation of the overall comfort value, which falls in the range of [0, 1]. $w = (w_1, w_2, \ldots, w_n)^T$ is the OWA associated weighted vector, and b_j is the no. j largest elements in a set of data, n represent the value of indoor real-time temperature, humidity, light intensity and air quality,

respectively, measured by the physical agent. $[a_2,\ a_3]$ is the environmental comfort range set by the user [7], If the user does not set, environmental parameters will be selected by the system randomly in the standard scope.

In order to obtain the OWA weight ω, a basic unit-interval monotonic (BUM) function is introduced as follows:

$$f(y) = y^r (0 \le r \le 10) \tag{50.5}$$

$$w_j = f\left(\frac{j}{n}\right) - f\left(\frac{j-1}{n}\right),\ j = 1, 2, 3, 4 \tag{50.6}$$

The implementation for the decision-making agent calculating weights of environmental parameter in OEMSH can be described as follows:

Step 1 Determine value of the temperature T, the humidity H, the light intensity L, and air quality A.

Step 2 System accepts four environmental comfort parameters, which are the temperature T, the humidity H, the light intensity L, and the air quality A according to user's preferences.

Step 3: If the user does not set environmental comfort parameters, then set by the system according to the standard range.

Step 4 Determine the r of the BUM function.

Step 5 According to the given parameters, calculate $a_1, a_2, ..., a_n$ from formula (50.2), (50.3), and (50.4), and then calculate w_1, w_2, w_3 by formula (50.5) finally take into formula (50.1) to draw the biggest comfort weights.

50.2.3 The Physical Agent

As shown in Fig. 50.3, physical layer in the OEMSH can be divided into the hardware agent and the family gateway agent, in which hardware agent can be divided into three categories: the household appliances equipment agent, the execute equipment agent, and the sensing and perception equipment agent. The family network agent can be divided into the external access network agent, the family gateway agent, and the family internal network agent.

The home appliance agent is a kind device mainly can meet the demand of the people family living, mainly with the common life household equipment. Such as TV, computers, air conditioning, water heater, washing machine, dishwasher, etc. The execution agent contains wireless control devices and switch devices. Wireless control devices are easily used to manage wireless devices in the smart home. Switch devices are controlled by the automatic control agent. Sensor and perception device agent mainly includes some sensors, such as light sensor, sound sensor, temperature sensor, and humidity sensor, etc., which is used to collect indoor water, electricity, gas and energy consumption information of home

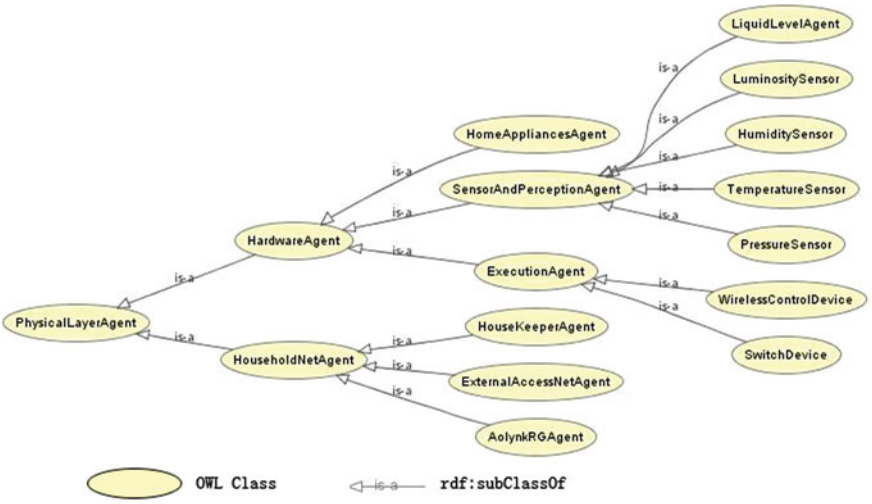

Fig. 50.3 The physical agent ontology model

appliances, it also can monitor the temperature, humidity, light intensity, air quality in the surrounding environment. Hardware agent chooses FIPA Device Ontology and FIPA Audio/Visual Entertainment and Broadcasting Ontology to describe, and adds the description of sensors, wireless device.

The external access net agent tries to solve the internet and internal network in smart home. It can provide bidirectional high-speed connection for home networks through the external access, realizing real-time reliable data transmission in internal and external network. The information of household appliances and equipment are interconnected together by family internal network. By this way, family internal network can realize collaborative work [8].

50.2.4 The User Interaction Agent

The user interaction agent mainly realizes interaction between user and system. Based on user Interface description in FIPA Device Ontology, the user interaction agent includes screen, audio input and output. In OEMSH, a user can register, modify personal information through registration interface, and the information is submitted to the knowledge agent. In the process of interaction with the user, the user interaction agent is responsible for recording attribute, habits, interest, and position of different users. It also adds learning and memorial function based on the FIPA device ontology, for example, the user interaction agent can conjecture user's preferences at a certain time and a certain position according to environment parameters the user set.

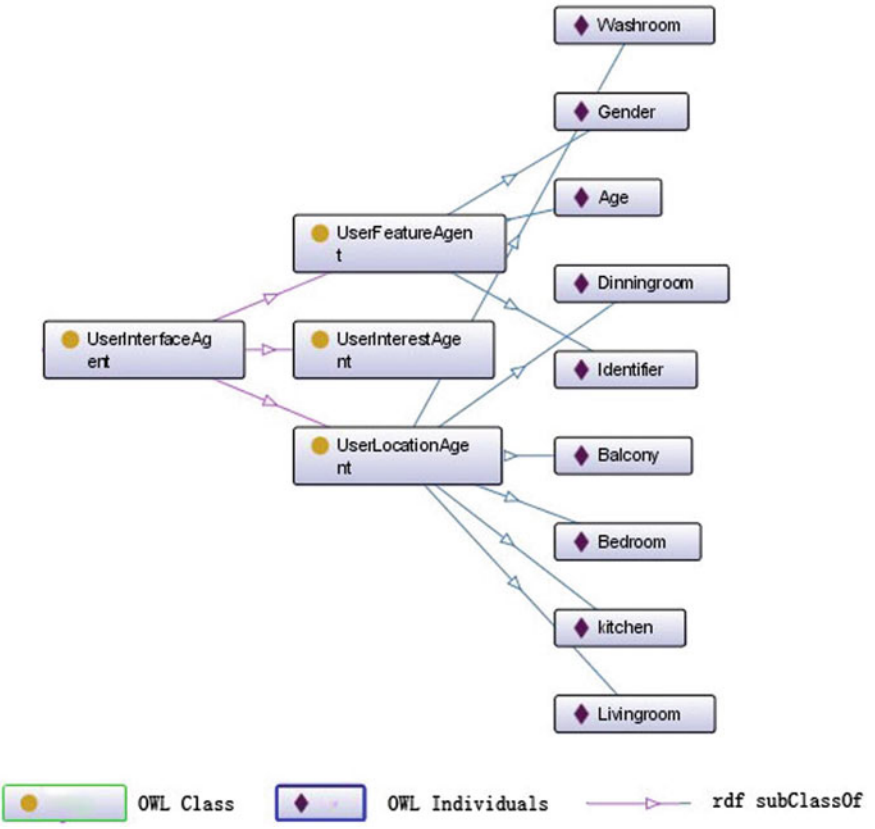

Fig. 50.4 User interaction agent ontology model

As shown in Fig. 50.4, the user interaction agent is divided into the user's preference agent, the user characteristics agent, and the user position agent. The user characteristics agent is responsible for recording user's personal attribute such as age, gender, identity, and so on. The user position agent can locate a certain space in the home, such as sitting room or kitchen. The user's preference agent analyzes and study user's habit by combining with a series of parameters such as user's location, time, and history records.

50.3 The Simulation Results

MATLAB is used to simulate algorithm in the decision-making agent. Figure 50.5 shows the result of indoor environment parameters set according to OWA operator. The parameters are specified as: the comfortable temperature zones are [64.4, 75.2] (K), standard relative humidity zones are [0.45, 0.75] (RH), the excellent air

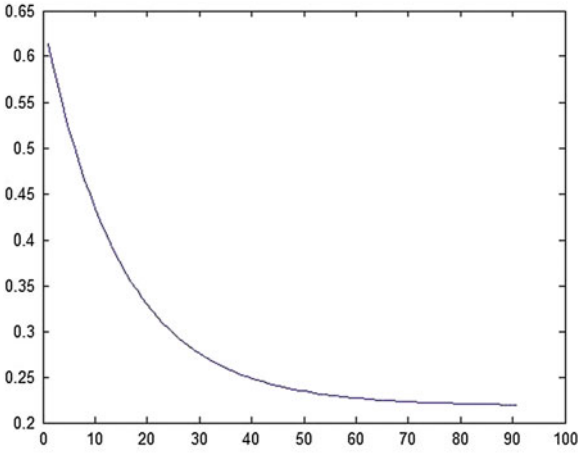

Fig. 50.5 Environment parameters set by system

quality zones are [780, 820] (PPM), suitable for indoor reading light intensity zones are [350, 750] (LUX). With 0.1 for step length selecting 100 points, we can see that the function is drab descending function, and when the r in [0, 1] maximize the weight. In this circumstance, temperature, humidity, light intensity and air quality weight values are as follows: 0.0000, 0.0010, 0.2051, and 0.0133. Thus from this team of data, the priority is $L > A > H > T$.

User also can set comfort environmental parameters. Random users comfortable parameters are selected, temperature zones are defined as [60, 80] (K), relative humidity zones are [0.4, 0.6] (RH), air quality zones are [800, 820] (PPM), and indoor light intensity zones are [500, 800] (LUX). The weight values of temperature, humidity, light intensity, and air quality are respectively: 0.0000, 0.0010, 0.4483, 0.0553, and priority are $A > L > H > T$. We can see that the results are different from system's one, proving that the result of the system may not be able to meet each user's needs. Thus, it can drew this conclusion that OWA operator is has certain feasibility applied with energy saving and optimization in smart home application.

50.4 Conclusions

This paper discusses a topic based on ontology smart home model from the view of energy saving with FIPA ontology standard. The model divides into four main children models, defined as: the automatic control agent, the user interaction agent, the decision-making agent, and the physical agent. Based on the user's preferences, it focuses on OWA operator to calculate weight values in the decision-making agent, and it is proved by the experiment that the model can maximize the user's comfort with minimum power consumption.

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Chapter 51
Research on Cloud Computing

Huajie Wang and Yan Meng

Abstract Cloud computing is a new term emerged in recent years. Although it is a new thing, it has developed fast and received significant attention from more and more people. Because data is the processing object of the cloud computing system, data storage and management are critical for cloud computing systems, thus they are very valuable research areas for researchers. First, this chapter introduces the concept and characteristics of cloud computing, and puts forward a concept of cloud computing based on own understanding. Then, this paper analyzes Google's two data storage and management technologies—GFS and BigTable, and discusses the Map-Reduce programming model. Finally, we outlook the development trend of cloud computing and point out the problems it consists.

Keywords Cloud computing · Data storage · Data management · Programming model

51.1 Introduction

In recent years, cloud computing is undoubtedly one of the most hotspots. In 2006, Google put forward the idea—cloud computing first. In the same year, Google launched the "Google 101 Plan" and presented the concept and theories of cloud computing. Subsequently, many famous IT enterprises put the cloud plan on their

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_51,

agenda, such as Amazon's AWS [1], IBM's "Blue Cloud" program, Microsoft's Windows Azure plan, and so on. All of these confirm the commercial value of cloud computing. The academia also set off a wave of researching cloud computing. With promotions them, preliminary cloud computing products have been put into use, but cloud computing is still developing and its relevant technologies are not very mature now.

51.2 The Concept of Cloud Computing

Cloud computing is a fusion of network technology and traditional computer technologies such as grid computing, distributed computing, parallel computing, network storage, and so on. It is a new commercialized computational model. The understanding of cloud computing is still evolving and there is no standard definitions until now.

Ian Foster, the senior scientist of American Argonne National Laboratory defined cloud computing in this way. He thinks cloud computing is a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet [2].

The definition of Wikipedia: the user can simply use storage, computing power, or specially crafted development environments, without having to worry how this works internally. Cloud computing is a systems architecture model for Internet-based computing. It is the development and use of computer technology on the Internet [3].

Based on personal understanding, the definition this paper gives is as follows: cloud computing is a Web-based and super-computing mode, which combines grid computing, parallel computing, distributed computing, data storage and management technologies, network technology, and so on. It provides hardware, data storage, software resources, calculation and analysis to users as service and allows users to purchase their needed services through the Internet. Users have no necessity to understand the details of the technology. Cloud computing splits massive data and calculation into numerous small pieces of data and calculation. Computer group which are composed by a number of computers returns the results to users after searching, calculating, and analyzing.

51.3 The Characteristics of Cloud Computing

Compared to traditional way of storing and managing data, the way used by the cloud computing environment have many new features.

First, we can purchase needed service in a more flexible way. Users can choose their needed services flexibly and only pay for the services they enjoy. They no longer need to purchase new hardware and software resources when their demand changes.

Second, enterprises can deal with quantity of sudden visits well in the cloud computing environment; Enterprises can mobilize computing and storage resources in the cloud at any time to deal with the unexpected situations.

Third, the cloud service provider is responsible for upgrading storage devices and managing data. Cloud service providers guarantee the security of data by using some storage mechanism.

Fourth, cloud storage has high reliability. The cloud service provider adopts the way of distributed storage and redundant storage to ensure that the services they provide are reliable.

Finally, the cloud computing system is easy to extend. The cloud service provider can develop new cloud services constantly according to the changing demands to expand functions of the cloud computing system.

51.4 Key Technologies of Cloud Computing

Because the core issue of cloud computing is how to store and manage massive data, so the key technologies of cloud computing mainly refer to the technologies of how to store and manage data in the cloud efficiently. In addition, cloud computing also needs supports of some other technologies. For example, it needs distributed and parallel programming technology to achieve task scheduling and tasks' parallel execution. It also needs virtualization technology to realize the dynamic allocation of resources on servers.

51.4.1 The Data Storage Technology

To ensure the reliability and availability of data, cloud computing adopts the distributed storage mode. It also takes the redundant storage way (save several copies of the same file) to ensure the reliability of data. This section will take Google's GFS as an example to introduce typical storage technology used by cloud computing.

GFS usually save three copies for each chunk—one is the main block and others are replications. In order to ensure the consistency of them, all modifications should be done on all copies. Programs access the chunks by first querying the Master server for the locations of desired chunks, then accessing the aim chunk servers according to the locations to obtain desired chunks. In this way, the Master server can avoid jam when there are many reading and writing operations occuring at the same time. The procedure of writing data to GFS is as follows [4].

1. The client-side sends requests to the Master server. If the client wants to add new data, the Master server will allocate new storage space on chunk servers. If the client-side just wants to modify existing data, the Master server will search for locations of the chunk servers where the desired file is stored.
2. The Master server returns locations of the main chunk and other replications to the client.
3. The client sends data to chunk servers where the main chunk and other duplications are stored after it get authorizations from the Master server.
4. The client sends writing requests to the Master server after all the data has been sent. The Master server is responsible for writing data to all the copies.
5. Chunk servers send message to the Master server after all the writing operations have been finished.
6. Finally, the Master server replies to the client that writing operations have been completed.

51.4.2 The Data Management Technology

The data management technology used by cloud computing must be able to manage large-scale data efficiently because the cloud computing system needs to process and analyze large data sets. In the cloud computing environment, the frequency of reading operations is far greater than that of updating operations. The main task of the cloud computing system is reading data from servers and then making a lot of data analysis. Therefore, data are often saved by column storage in the cloud computing system. This section will take Google's BigTable as an example to introduce management technology in cloud computing [5].

BigTable is divided into three parts. (1) The Master server. It is responsible for assigning tasks to the Tablet servers to make them reach load balancing, monitoring the state of the Tablet server, collecting garbage chunks, and so on. (2) The Tablet server. It is responsible for handling the reading and writing requests of the Tablet and dividing big Tablet into small segments. (3) A library that is linked to every client. The basic architecture of BigTable is shown in Fig. 51.1 [6].

51.4.3 The Programming Model

In order to let users write programs to accomplish specific purposes by using programming models and make services provided by the cloud platform are easy to access for users, the programming model adopted by the cloud computing system must be very simple and it should also ensure that the complex parallel execution and task scheduling in the background are transparent to users and programmers. Most of the cloud computing systems use a very simple distributed

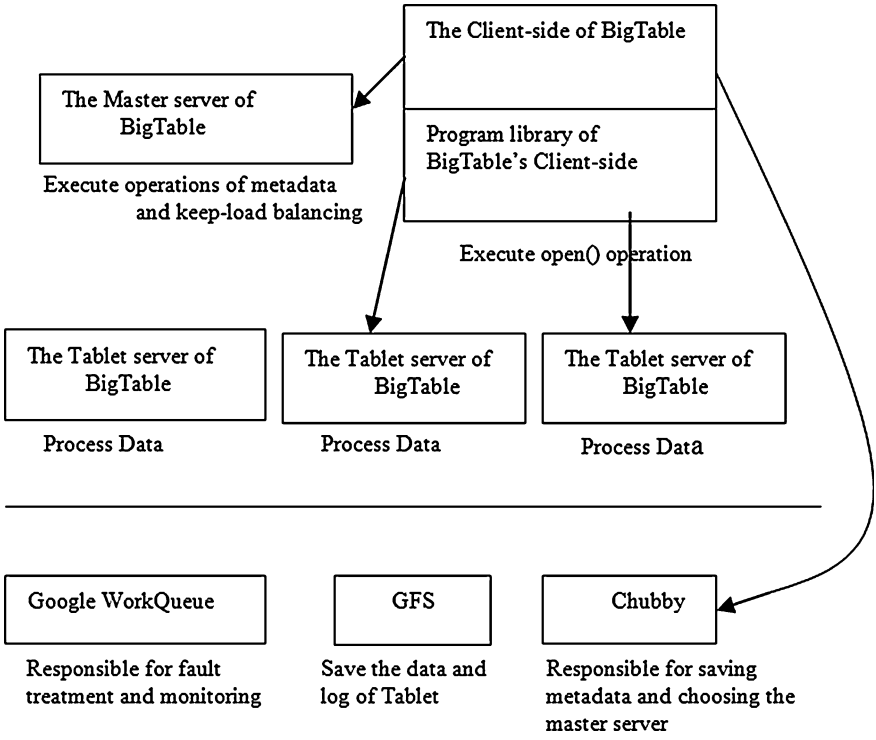

Fig. 51.1 The basic architecture of BigTable

programming model called Map-Reduce. Map-Reduce is mainly used for parallel computing and the scheduling and processing of parallel tasks.

When we use Map-Reduce, we need to define two functions—Map and Reduce. In the Map function, we specify how to process each data chunk. In the Reduce function, we define how to reduce the middle result that the Map function produces. The executing procedure are as follows: the Master server takes the input, divides it into smaller data segments, and distributes them to several servers to execute Map function in parallel. The Reduce function is then applied in parallel to each group, which in turn produces a collection of values. Each Reduce call typically produces either one value or an empty return.

51.5 The Development Trend of Cloud Computing

Cloud computing has broad development prospects and its related technologies are developing rapidly. The developing trend of cloud computing is building large-scale bottom infrastructure which can be closely integrated with applications. Because the existing cloud computing systems often have some defects, so

designing new cloud storage and cloud management system is an urgent problem that is need to be solved. In addition, cloud computing is often used in a variety of different scenarios, so we need to optimize the cloud systems according to different application scenarios. Therefore, cloud computing still has a long way to go.

51.6 Conclusions

Cloud computing is a new commercial computational model. The cloud service company builds the storage and computing center, and then people can get services in the cloud easily through the Internet. The resource-sharing and application mode cloud computing brings are bound to provide a wider market for cloud computing. But cloud computing still has some problems, such as the security and availability of data. These problems will be solved step by step with the research and application of the academic and business circle. The related technologies of cloud computing will be more and more mature. In the near future, I believe that cloud computing will play an important role in a growing number of applications and make our life more convenient.

Acknowledgments This work is supported by Shandong Provincial Natural Science Foundation, China under project number ZR2010FL009. The authors also would like to express appreciation to the anonymous reviewers for their helpful comments on improving the paper.

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Chapter 52
Study on Objects Ordering for Manufacturing Cloud Platform

Jing Xu and Pinglu Chen

Abstract In order to improve its ability of fast response to replying the economic globalization and product diversification, the higher demands are put forward in computing rapidly and sharing effectively. The manufacturing cloud platform is born at the proper moment. It is important to carry out ordering of manufacturing cloud platform to realize data management perfectly. On the basis of analyzing the connotation of ordering, the ordering system for objects oriented to manufacturing cloud platform is proposed. The key technologies are elaborated which including the technology of rationalization, modularization, normalization, organization, standardization, and so on. It is indicated that the ordering for manufacturing cloud platform is convenient to share resources, improve the efficiency of enterprise personnel. It is the guide of implementation for information in future.

Keywords Manufacturing cloud · Ordering · Cloud platform · Cloud service

52.1 Introduction

The enterprise competition core has come up with great changes caused by economic globalization and information from products and simple services to solutions and values [1]. In order to adapt the competitive environment, the rapid responses and innovation abilities must be promoted for the manufacturing enterprises to meet the diversified requirements. Consequently, the technology of cloud manufacturing has been one of the key research problems in recent years.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_52,

Based on the idea of cloud computing, cloud manufacturing makes use of the information technologies to realize manufacturing resources sharing highly in order to avoid their waste. It is an important reflection toward a low carbon economy. The objective of cloud manufacturing is the provision of services for life cycle. These services may be readily accessible, reliable, and used as needed [2]. Constructing the manufacturing cloud platform is the way to achieve the goal of premise. The platform is used to share the public services of manufacturing sources for which the cooperation has come true between manufacturing resources and services.

For the small and medium enterprises, they do not need to purchase the servers and deploy network architecture as long as they are joined in manufacturing cloud platform. Immediately, they may have enjoyed services throughout the manufacturing cloud platform. For example, most of application systems would be applied conveniently such as ERP, CRM, PDM, OA, etc. Meanwhile, the key business may be deposited in the private cloud, so that it is easy to balance the cost and security. For the medium and large enterprises, the biggest challenge is how to integrate the heterogeneous hardware and software in cross-region. The manufacturing cloud platform provides the best solutions to solve the above problems.

In the era of cloud services, users may attempt any applications you want in any time or any place without any limits. The data gap must be broke among cloud platform in order to achieve interacting between data and applications. Thus, the ordering of data or objects in manufacturing cloud platform become more and more important to offer better cloud services and share the cloud resources preferably.

52.2 Manufacturing Cloud Platform

The manufacturing cloud is a dynamic cloud-service center. It is composed of a large number of cloud-services according to certain rules. The manufacturing cloud may supply application services throughout product life cycle wholly. At the same time, the users enjoy the reliable, cheap, and high-quality services joyfully [3].

The hierarchy of manufacturing cloud is proposed by Zhang [3] including the layer of resources, resource awareness, resource virtual access, core services, transport network, terminal application, and so on.

Definition: Manufacturing Cloud Platform. Manufacturing cloud platform is a set which it is composed of a series of general and reusable manufacturing resources and manufacturing services. These objects were combined flexibly and hierarchically. The manufacturing cloud platform can reflect the relations of objects clearly which have the characteristics of flexibility and variability as follows.

The objects composed of manufacturing cloud platform are independent which they have specific functions.

The manufacturing cloud platform adopts the pattern of composition flexibly. Based on the customized requirements of enterprises or users, the manufacturing resources and services are configured with freedom.

The objects of manufacturing cloud platform are requested to own higher degree of standardization.

The manufacturing cloud platform would adapt the idea of modern design methodology to meet the demands of mass customization better.

52.3 The Ordering System for Manufacturing Cloud Platform

The manufacturing cloud platform is the basis of developing, designing and manufacturing in the enterprises. These resources are not be accumulated simply while their relations between manufacturing resources and services are formed as an organic whole. The ways of organization and management for objects in the manufacturing cloud platform would affect objects reusing effectively. It is important to implementing ordering of manufacturing cloud platform to offer more and better services.

52.3.1 The Connotation of Ordering

Ordering is known as methodization which is the process of objects organization according to certain rules and methods through some tools and technologies. Reorganizing the disorder data is the aim of ordering to convenient for storage, retrieval, and informatization [4]. Ordering is consisted of rationalization, modularization, normalization, organization, standardization, and so on. It is shown by Table 52.1.

Table 52.1 The connotation of ordering

Concept	Connotation
Rationalization	Based on the idea of total optimization, rationalization is the theory and method to reorganize reasonably resources, information, processes and so on [5]
Modularization	Under the guidance of system perspectives, modularization is the process of decomposition and combination [6]
Normalization	During the course of normalization, the objects definition and contents description are guaranteed correctly and uniformly on the basis of some specifications, methods and technologies [7]
Organization	The relations of objects are discovered through organization in some forms.
Standardization	Standardization draws up some rules for current problems and potential problems in a certain range implementation which they are applied commonly and repeatedly [8]

52.3.2 The Framework of Ordering System for Manufacturing Cloud Platform

Ordering is system engineering for manufacturing cloud platform. Stood on the point of view of ordering, rationalization, modularization, normalization, organization, and standardization is the fragments of ordering. The correlations are existed in them shown in Fig. 52.1. Rationalization and modularization are the methods to seek the orderly rules of objects for manufacturing cloud platform. Normalization, organization, and standardization are the methods to describe the orderly rules for manufacturing cloud platform. They propel the implementation process of ordering from different aspects.

The manufacturing cloud platform is a compatible environment for all application systems. It is important that the technology system is supported for manufacturing cloud platform to reuse objects effectively and optimize designing processes.

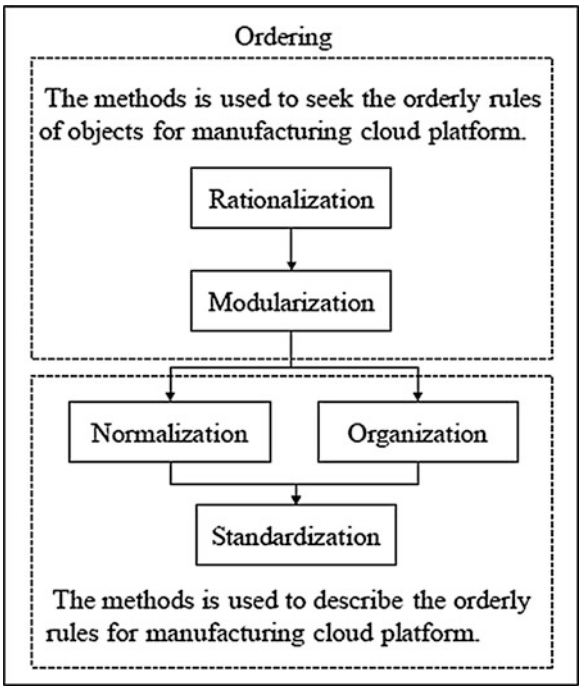

Fig. 52.1 The correlations of ordering

52.4 The Key Technologies of Ordering for Manufacturing Cloud Platform

The key technologies are applied to realize the above methods including the technology of rationalization, modularization, normalization, organization, standardization, and so on.

52.4.1 The Technologies of Rationalization

In order to achieve the rationalization of data ordering implementation, the first step is the planning of manufacturing cloud platform systematically. The process of rationalization for manufacturing cloud platform may contain the disposal of data description and procedure ordering. The rationalization of data description is the technology countered to analyze the management characteristics, technical characteristics, and relational characteristics of objects for manufacturing cloud platform. The rationalization of procedure ordering means the settings of ordering process and the sequence of process are developed rationality analysis.

52.4.2 The Technologies of Modularization

The essence of modularization is a design concept by means of decomposing and combining to meet diversified requirements. The main technology of modularization includes module division, module evaluation, module decoupling, module configuration, module deformation, and so on.

On account of functional decomposition, the division of modules has come true through assisting cluster analysis, matrix analysis, heuristic algorithm, and so on. After the modules are obtained, it is necessary to evaluate the modules such as structure evaluation of modules and hierarchy evaluation. In order to realize module decoupling, it is combined with contradiction matrix by TRIZ and axiomatic design. The main concentration of module configuration is in the expression of deployment knowledge, modeling, and configuration problem solving. The technology of module deformation is the adaptable design for actual demands in fact. The parameters of module are changed by means of module library and tabular layouts of article characteristics to form product model satisfied customer's requirements.

52.4.3 The Technologies of Normalization

The description of objects and models are normalized in the manufacturing cloud platform. During the course of normalization, the normative system and the corresponding database are established. The description information of objects contains attributes and characteristics in the normalization such as name, code, etc. The modeling normalization of objects conducts the specification about modeling principles, modeling system, and model description. The normalized objects and information are saved into databases in categories which they include name dictionary, attributes/characteristics pool, parts library, parameter library, and so on.

52.4.4 The Technologies of Organization

Organization is known as the process to describe the relations of objects of manufacturing cloud platform throughout some structures such as classification structure, product main structure, and order product structure. The classification structure shows the relations of objects with the help of the classification characteristics in manufacturing cloud platform. Each kind of objects has only a classification tree. The product main structure is used to express the product composition in a product family or product line which is composed of variant master record, part master record, and configuration rules. Based on the relations of assembly, the order product structure represents the correlations between parts and related objects to meet different demands.

52.4.5 The Technologies of Standardization

The standard system of digitization and related standards are built during the course of standardization for manufacturing cloud platform which instructs the ordering implement. There are two main standards as technical standards and administrative standards. The process of standardization is made up of multiple steps which include formulating standards, the implementation of standards, and information feedback. The process of standardization is not a simple process chain rather than process network interweaved by many process chains. The standards are modified and improved constantly to propel the standardization for manufacturing cloud platform moved forward.

52.5 Conclusion

Stood on the point of view of the definition of manufacturing cloud platform, the ordering system is proposed. Aimed at the requirements of information sharing, some key technologies are presented which included rationalization, modularization, normalization, organization, and standardization.

It is further pointed out that object ordering was a technology established in the enterprise global. Throughout the product life cycle, the ordering technology involved many application systems of the enterprise. In future, the focus of research would be put into the ordering solutions for enterprise actual in manufacturing cloud platform.

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Chapter 53
Mobile Learning in the Cloud

Sheng Juan and Dai Fu Jun

Abstract With the Rapid knowledge updating in the twenty-first century, and the rapid development of mobile devices, more and more people are willing to choice mobile learning, because traditional mobile learning has many limitations, so this paper describes the prospects of mobile learning under cloud computing platform, discusses structural design of a mobile learning system based on cloud computing, etc.

Keywords Cloud computing · Mobile learning · Education model · Education resources

53.1 Introduction

Life-long learning now has become more and more people's necessity. In this background, whether students or the general public hopes to achieve learning anytime and anywhere in a style which is more free, more individual, and more diverse. Mobile learning as digital learning (E-learning) branch, which has increasingly got the attention of people, gradually became new hotspot in education technology and related field. Due to small size, slow network transmission, limited educational information resources, and the high price for mobile devices and network price in contrast, mobile learning may be prevented at a certain degree.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_53,

The arrival of the era of cloud computing provides a new development prospects for mobile learning, the user in the clouds will more easily reach their desire to achieve knowledge anytime and anywhere

53.2 The Mobile Learning Mode and Limitations Based on Internet

53.2.1 The Mobile Learning Mode Based on Internet

According to different application technology and Communication protocol, the mobile learning mode based on internet is usually divided into two kinds: mobile learning mode based on short message of short messaging service (SMS) [1], the mode based on WAP resource site. Short message's length is up to 140 bytes. The mode is mainly used in learning activities of insufficient data telecommunications. For example, Learners can receive notice and learn conceptual knowledge fragments and so on from school. The other kind of mode is browse WAP site. Learners can browse, search, and download all kinds of learning resource as ordinary internet users by mobile phone.

53.2.2 The Mobile Learning Mode Limitation

Although in the existing conditions, users can use SMS or browse WAP site to complete mobile learning, but the mode through short message lacks real-time interactivity, learners are usually accepted service message passively from service machine. Short message in sending and receiving process is often affected by uncertain factors, sometimes learners need wait for enough long time, sometimes they perhaps never can receive the message what they need; the second mode of browsing WAP site still has strong limitations. Although the education resources in the Internet are very rich, but much mobile equipment cannot only support HTTP protocol which is widely used in accessing to Internet, most of which are only support WAP protocol. The WAP protocol has many defects in now, such as its lower data transfer rate especially for the multimedia data transmission, and its high cost, all of these make learners' learning efficiency is not high. The existing shortcomings of mobile learning mode make it hard to form the popularization of mobile learning trend. People are in urgency of changing the mode of mobile learning.

53.3 The Mobile Learning Prospect in "Cloud"

Cloud computing is a supercomputing model based on Web. The principles of cloud computing is to integrate all kinds of resource which is stored in the personal computer, mobile phones, and other devices to a large number of information and processor resources together for collaborative work. Data and computing resources are managed by professional providers of cloud computing services. Thus, users no longer need to worry about system crash data loss, virus attack, and so on; Cloud computing provides the ideal solutions for mobile learning, its main advantage displays in the following aspects.

53.3.1 Cloud Computing Provides the Most Abundant Education Information Resources

The essential starting point of cloud computing is the information fusion, storage, and service sharing through the network, educators can integrate the educational resource in greatest degree [2]. In the cloud computing era, education resources provided by educators who come from all world scope will converge to the storage server of "clouds". Cloud computing platform shifts resources to the "cloud", cloud computing platforms are designed to unify management of network connections and scheduling in a large number of compute resources, which forms a pool of computing resources on-demand services to the user. Learners do not have to concern many questions; such as resources achieved from where, provided by whom. For learners, the use of "cloud" data resources, computing power is something like the use of "water" and "electric", which makes mobile learning more quick and easy to obtain learning resources. What educators just have to do is adjusting education resources, classifying management, and establishing corresponding access rules. What learners want to do is entering the keywords, choosing study content, achieving the education resources from all over the world. Everything learners do is just easy as they use search engine. At the same time, in the learning process, learners and educators can also make some additional modify and supplement to existing learning content under the established rule, which can make education resource more and more rich. Mobile learning system based on cloud computing meets the users gets rich, real-time, and accurate study content demand. At the same time in the learning process the system provides real-time learning support, and can support students well in cooperative learning and circumstances learning.

53.3.2 Cloud Computing has a Low Requirement on Mobile Learning

At present, the problems of mobile learning devices are still important factors restricting the development and popularity of mobile learning. Most of the mobile equipment does not support the HTTP protocol, which can only access WAP protocol based on the server, multimedia resources transmissions are restricted. Emergence of cloud computing technologies provides a good solution to these problems under Cloud computing, all data are stored and processed in the "cloud", its powerful calculation ability is not only much faster than personal computers, but also can cope with the task of data processing that some personal computers could not finish. Cloud computing can gather the abundant memory, storage, and computing power that exists in the distributed computers into a virtual resources pool. Learners can employ the cloud services simply by a mobile phone on the internet.

53.3.3 Cloud Computing Can Provide More Personalized Environment

Adoption of cloud computing as the platform for mobile learning has three main reasons. The most important is that it can help learners manage their learning content and process. Second, it can provide support for learners to set their own learning goals. Third, it can communicate with others in the process of learning, also can join into groups and have a suitable environment to practice social skills [3].

According to Coombs' definition, mobile learning can go on daily in the home and neighborhood, behind the school and on the play field, in the workplace, marketplace, library, and museum; this kind of spontaneous, unstructured learning may not make learners realize that learning is taking place when they interact with learning materials [4].

53.4 Structure Design of Mobile Learning System Based on Cloud Computing

Cloud computing as an important support in the mobile learning, which has nonsubstitutable advantages over traditional networks such as model, blog platform. Its unique advantage provides favorable conditions for mobile learning, which make mobile learning more charming. Autonomous learning based on cloud computing emphasizes on learner-centered study, fully embodies the learner autonomy and initiative, and gives learners a strong sense of motivation and strong interest in learning. Cloud computing provides a virtual learning environment, which allows learners and learning resources are divided in time and space,

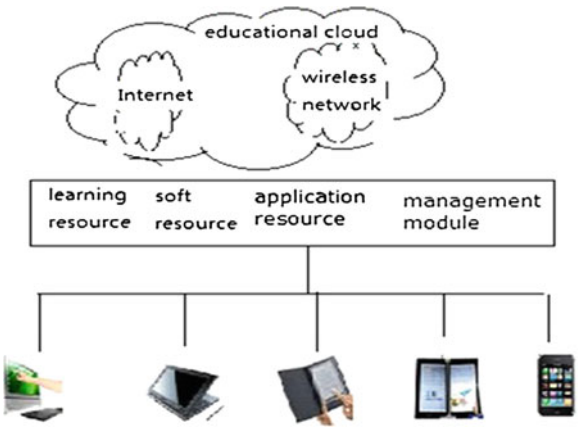

Fig. 53.1 Structure of mobile learning system

learners can choose their learning content according to their time and place, this kind of learning method has many advantages such as learning real-time, interactivity, flexibility.

Mobile learning system based on cloud computing consists of four major sections, which are the mobile terminal, mobile communications networks or wireless networks, network platform based on three-layer structure, and cloud computing platforms, as shown in Fig. 53.1.

53.4.1 Mobile Terminal

Mobile terminal provides content to users of the system; it is the user terminal of the whole system, as a vehicle to interact with the system for users [5]. Support equipment for mobile terminal can be a cell phone, PDA, and other mobile devices. Mobile terminal does not need a lot of configuration [6]; it can just be a normal device. Client applications or software do not need to be prepared in advance, because the "cloud" can provide all needed software, so that when users need to use a software application, they can download directly from the cloud. They also need not maintain mobile devices, do some operations such as installs, downloads, upgrades, etc. they need not to worry about their systems being attacked by virus because the entire mobile device is unified to maintain by clouds, learners just need to have concern about just when and what to learn.

53.4.2 Mobile Communications Networks or Wireless Networks

Users use mobile terminal platform to communicate with the network via mobile communications network or a wireless network. Because of scalability in the cloud is very strong, existing network resources can be joined in "cloud", which can

reduce the financial and time investment, and realize the true share in all kinds of resources [7].

53.4.3 Network Platform Based on Three-Layer Structure

It is the basis for the system as a whole. Its role is to identify the user require of service and then to call-related services interface provided through a cloud computing platform [5]. The platform is a system of a bracket. It does not include specific data content; it submits its various businesses to cloud computing platforms via the interface.

53.4.4 Cloud Computing Platforms

Cloud computing platform is the core part of the system and final execution of the function modules of the system as a whole. It is a computing platform which is able to provide dynamic resource pool, virtualization, and high-availability [8]. Cloud computing involves several levels hierarchy as shown in Fig. 53.2.

The level hierarchy from the bottom to up is:

IaaS

IaaS is the infrastructure (computing resources and storage) as a service for rent; it provides virtualization of computing resource, storage resource, and network resource. This mode is essential cloud computing based on the IT framework [9].

PaaS

PaaS include the operating system and the specific application of the required service [9].

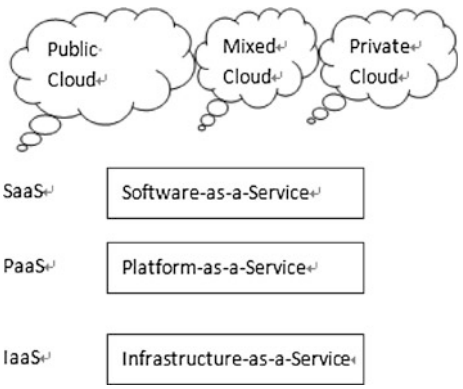

Fig. 53.2 Level hierarchy of cloud computing

SaaS

Software as a service (SAAS) is a type of cloud services. All the application services such as office, video-on-demand, and learning software will be stored in the cloud, Software or application provided can be rented for user and the user can select as they need [10].

All resources and capabilities that the user needs are converged on the cloud platform. Service which users needs through the interface connects with the cloud computing platform, all processed by the cloud computing platform, data will pass on users after being processed by interface. Learners can easily study. For example, a foreign language enthusiast can found listening and reading materials he needed through the platform; a program fan can configure hardware he needed through the platform without purchasing or installing new equipment in his home; A teacher can view homework submitted by student through the platform; A busy and forgetful person can always find his last recorded part in order to start a new learning, and more.

53.5 Conclusions

Cloud computing technology in mobile learning is still in its early stages of exploration, but as more scientific and technological workers are in hot pursuit of cloud computing technology, cloud computing will become more and more mature. Combination of cloud computing and mobile learning will enable mobile learning applications to be content-rich; a broader, more powerful development can be seen. Cloud computing is the future of mobile learning environments and platforms; "Cloud computing" will support and promote the development of mobile learning.

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Part VI
Semantic Grid and Natural Language Processing

Chapter 54
A Novel Apriori Algorithm Based on Cross Linker

Xiaohong Li and Jin Shang

Abstract Based on the analysis of the Apriori algorithm from the perspectives of time complexity and memory complexity, a novel algorithm was proposed. The proposed algorithm defined a cross-linker structure firstly and then used this structure to substitute the array description of the transactions database. The cross linker structure shortened the length of the objects linked; thus, it reduced the algorithm's time cost. The cross-linker structure did not save the candidates of frequent itemset also; thus, it reduced the algorithm's memory cost. The experiments show that the proposed algorithm's performances are comparable.

Keywords Apriori algorithm · Cross linker · Itemset

54.1 Introduction

Association rules reflect the relationships between itemset among a large amount of data. Its mining is an important field of data mining. Two steps are included in association rules mining [1, 2]. The first step is to produce the frequent itemset from transaction database, whose minimal support probability is greater than a initial threshold. The next is to construct the valuable rules from frequent itemset

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_54,

produced. In this process, the first step of producing is the most important. The time cost of this step determines the algorithm's time complexity.

Apriori algorithm and its improved algorithms were proposed in prior works. In 1993, Classic Apriori algorithm was proposed firstly by Agrawal R. In 1994, AprioriTid and Apriori Hybrid algorithms were put forward [3, 4]. In the next years, some other algorithms based on Apriori were explored [5, 6]. Among all these algorithms, two problems existed. One is the time cost to calculate the candidate itemset [7, 8]. Another is that multiple scanning of transaction database is needed to match the pattern among candidate itemset [9]. Two problems are the kernel point of association rules mining.

A Novel algorithm is proposed based on the studying of some Apriori algorithms. There are many structures to describe the transaction database, such as tree, array, vertical binary string and horizontal binary string, etc. Every structure has its own attributes. Through comparison of these structures, cross linker is defined and used to describe the database. The candidate frequent itemset does not need to save by using cross linker in the mining procedure. Thus, the proposed algorithm's performance is improved. The algorithm is compared with traditional Apriori and AprioriTid from aspects of time cost and space cost in the paper final part.

54.2 Related Works

Apriori algorithm uses successive recursion method. First of all, transaction database was scanned so that frequent itemset 1 produced: L_1. Then the candidate frequent itemset C_k would be constructed. C_k was obtained by apriori_gen function. The function executed the linking operation or pruning operation to the member of L_{k-1}. After that, the support of every candidate frequent itemset was calculated and compared to a minimum support which user defined. When the support is greater than the minimum, the itemset should merge to frequent itemset k: L_k. The algorithm will end at the time when there are no candidate frequent itemset produced. Finally, all the frequent itemset will be merged.

For further discussion, it is necessary to analysis the performances of Apriori algorithm. Let N is the record number of transaction database D, T is the largest length of the record. Then the first scanning time of D is $O(T \times N)$. In every step, the time cost of linking operation, pruning operation, and scanning operation are $O(|L_{k-1}| \times |L_{k-1}|)$, $O(|C_k|)$ and $O(N \times |C_k|)$, respectively. Therefore, the total time cost of Apriori algorithm is

$$O(T \times N|) + \sum_{k \geq 2} (O(|L_{k-1}| \times |L_{k-1}|) + O(|C_k|) + O(N \times |C_k|)) \qquad (54.1)$$

Because the algorithm is recursive, the main time cost of the algorithm above is the time caused by two tasks below. One is time to produce frequent itemset 2 and 3. Another is the time to count candidate frequent itemset C_2 and C_3. In fact, frequent

itemset 2 is produced based on the linking and pruning operations to L_1. Frequent itemset 3 is produced based on L_2. Due to $|L_i| > |L_j|$ $(2 \leq i, j \leq k, i < j)$, so the main time cost result is reasonable.

From the description algorithm above, the space cost of the algorithm is

$$O(|L_1|) + \sum_{k \geq 2} (O(|C_k|) + O(|L_k|)) \tag{54.2}$$

To improve the algorithm's performance, two ways may be selected. One is reducing the number of linking operation so that the scanning time could be reduced. Another is do not save the candidate frequent itemset so that the memory occupation become less. From this point of view, the cross linker to describe transaction records will be emerged.

54.3 The Proposed Algorithm

54.3.1 Cross-Linker Structure

Some formal descriptions should be defined before further cross-linker structure is defined. We suppose

Let $I = \{i_1, i_2, \ldots, i_m\}$ is the whole itemset, where i_l $(1 \leq l \leq m)$ represents a particular item, and m is the number of items.

Let $U = \{x_1, x_2, \ldots, x_n\}$ represent the transaction set, where x_l $(1 \leq l \leq n)$ denotes a particular transaction, and n is the number of transactions in database.

Let $T = \{t_1, t_2, \ldots, t_n\}$ is the set of transaction identity, where t_l $(1 \leq l \leq n)$ is the identity of a particular transaction x_i. t_l is corresponding to x_l one by one.

Let $C = \{C_1, C_2, \ldots, C_n\}$ is the transaction itemset, where $C_i \subseteq I$ $(1 \leq i \leq n)$ represents a particular itemset.

Follow these suppositions, we could define

(1) Every transaction's combination method is defined as $A = T \cup C$.
(2) Transaction database is defined as $D = (U, A)$. Which means transaction database D is composed of transactions U and U's relationships.
(3) After that, we define cross linker as $M = (U^T, A, V, f)$. Where U^Trepresents the array transposition of U.

$$V = \{ < i_k, t_j > | i_k \in I, t_j \in T, k = 1, 2, \ldots, m, j = 1, 2, \ldots, n\} \tag{54.3}$$

Represents the middle nodes set, whose element $< i_k, t_j >$ is composed of every item i_k from C and every identity t_j from T. f is a mapping function, which is defined as: $f : C \times T \rightarrow V$.

Suppose that there is a transaction database. After the preprocessing of this transaction, its pattern could be described as < Transaction ID, Item 1, Item 2…>, where Item 1 and Item 2 etc. represent item name of transaction. Item means are

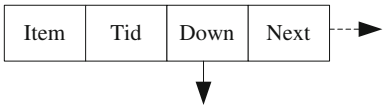

Fig. 54.1 Node structure of cross linker

ordered in an ascending manner by its item ID. An example of this transaction is described as: Tid 1 = {I2, I3, I5, I6}, Tid 2 = {I2, I3, I5}, Tid 3 = {I3, I5, I6}, Tid 4 = {I1, I6}, Tid 5 = {I3, I4, I5, I6}, Tid 6 = {I1, I5}, Tid 7 = {I2, I5}, and Tid 8 = {I5, I6}.

To build a cross-linker structure, we defined the node structure firstly. Node structure is composed of four elements illustrated in Fig. 54.1. This structure indicates where the item of Tid will go. Dashed arrow indicates the next item this item linked horizontally. Solid line arrow indicates the next Tid of this item linked vertically. If "Down" or "Next" is equal to zero, that means this item is terminal. In other words, this situation means no item or no Tid is linked to this item.

Based on the node structure, a cross-linker structure is built which is shown in Fig. 54.1. Head table of item, head table of Tid, and the cross node are the main parts of the cross linker structure. Head table of item is used to indicate an item's beginning transaction. Head table of Tid is used to indicate a transaction's beginning item. Node locates in the cross position of this structure. Communication between nodes is achieved by node's "Down" and "Next" points.

Three attributes existed in this structure. First, there is no node which is dependent. It means any node should relate to head table of item and head table of Tid. The next, all the nodes in a row connected by "Next" pointer correspond to a transactions' itemset in database, and all the nodes in column connected by "Down" pointer correspond to the support of an item. The end, the cross linker structure describes transaction database is whole and enough. Which means all the information used in further data mining exist in this structure.

For example, the transaction of Tid = 1 could be described as <1,I2,I3,I5,I6>. Four items called I2, I3, I5 and I6 are included in this transaction, and they are connected by every item's "Next" pointer in order. In other hand, I2 in transaction 1, 2 and 7 are connected by "Down" pointer. The item support of I2 is 3 because I2 occurred 3 times in transaction database. Fig. 54.2. For example, the transaction of Tid = 1 could be described as <1,I2,I3,I5,I6>. Four items called I2, I3, I5 and I6 are included in this transaction, and they are connected by every item's "Next" pointer in order. In other hand, I2 in transaction 1, 2 and 7 are connected by "Down" pointer. The item support of I2 is 3 because I2 occurred 3 times in transaction database.

54.3.2 Improved Apriori Algorithm

Based on cross linker structure, frequent itemset's mining becomes some operations to cross linker from the scanning to transaction database. First of all, every item's support should be calculated through the scanning of "Down" pointer

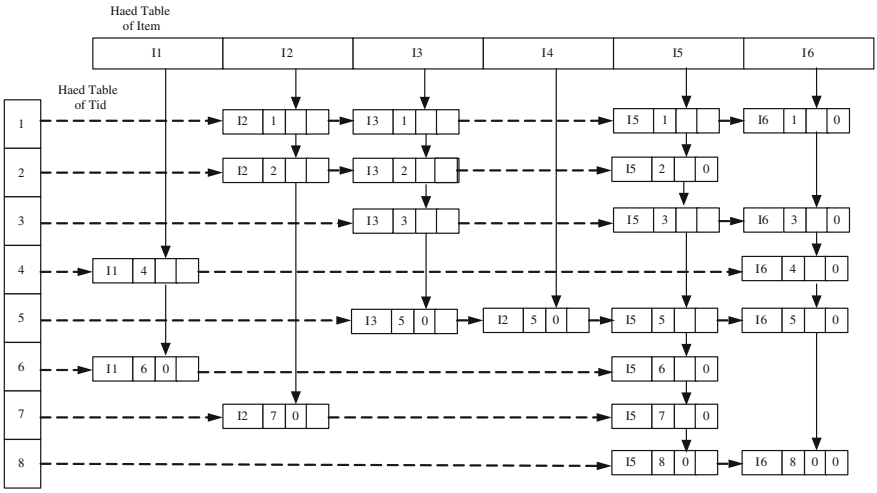

Fig. 54.2 The structure of cross linker

included in every node. Next, every item's support is compared to Minsup which is a threshold of support. Frequent itemset L_1 could be produced from these items whose support is greater than Minsup. Then, frequent itemset L_k is constructed from L_{k-1}. Two nodes of L_{k-1} are combined arbitrarily to a new composition. After the composition is pruned, the composition's support is calculated. If the calculated value is greater than Minsup, this composition will be combined to frequent itemset L_k.

An example of cross linker structure is illustrated by Fig. 54.3. Every node in this structure is composed of two elements. One is the item pointer and another is the next node pointer. When the linking operations are performed on L_1, any two items in the node are combined to each other to build the new composition whose length is 2. For example, <I2> and <I3> in Fig. 54.3 are combined to <I2, I3>. When the linking operations are performed on L_2, new compositions whose length is 3 are built from these compositions whose length is 2.

From the discussion above, the proposed Apriori algorithm could be described by pseudo codes as below. Functions my_gen and prunc are the linking and pruning functions which are the same as the traditional Apriori algorithm.

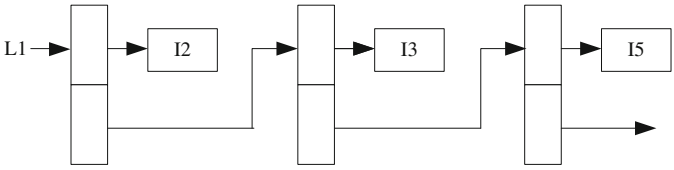

Fig. 54.3 Frequent itemset 1

Function check_c is used to check whether c is inserted into L_k. Function count_c is used to calculate the support of the composition c.

Input: cross linker M, minimum support threshold Minsup.

Output: frequent itemset L.

1. L_1 = find_1 (M, Minsup);
2. for ($k = 2$; $L_{k-1} \neq \phi$; k++) do {
3. for ($p = L_{k-1}$; $p!$ = NULL; $p = p->$ next) do {
4. for ($q = p->$ next; $q!$ = NULL; $q = q->$ next) do{
5. 5. c = my_gen(p,q); //itemset combination of node p and q
6. if (prunc (L_{k-1}, c)&&check_c (L_k, c))
7. continue; //return to the loop by q
8. count = count_c(M,c);
9. if (count $\geq$ Minsup)
10. insert (L_k, c); }}} //the composition c is inserted to L_k
11. Answer = $\bigcup_k L_k$;

54.3.3 Analysis on the Proposed Algorithm

Let N be the records of transaction database, and T be the most length of record. In the proposed algorithm, the time complexity of function find_1, the linking operation, the printing operation and scanning/counting are $O(T \times N)$, $O(\frac{|L_{k-1}| \times |L_{k-1}-1|}{2})$, $O(|C_k|)$ and $O(N \times |C_k|)$, respectively. Compared to the traditional Apriori's time cost $O(|L_{k-1}| \times |L_{k-1}|)$, it is the same level of time complexity. But, because of the number of linking operations is decreased; the proposed algorithm's convergence speed is increased. So that the proposed algorithm could save some time than the traditional algorithm when the program is running.

The proposed algorithm could save much more space than the traditional. The proposed algorithm just needs the space to save frequent itemset L_k, does not need the space to save the candidate frequent itemset C_k. So its space complexity is $O(|L_1|) + \sum_{k\geq 2} O(|L_k|)$. Compared to the traditional algorithm's space complexity $O(|L_1|) + \sum_{k\geq 2} (O(|C_k|) + O(|L_k|))$, total space of $\sum_{k\geq 2} O(|C_k|)$ are saved.

54.4 Experiments

To verify the performance of the proposed new algorithm, the Apriori algorithm, AprioriTid algorithm, and the proposed New_Apriori algorithm are programmed by VC6.0. The test data is coming from the Chinese stock of 320 enterprises in July–December, 2011. The data mining is Boolean association rule mining, and performed by single layer and single dimension. The result of the experiments is

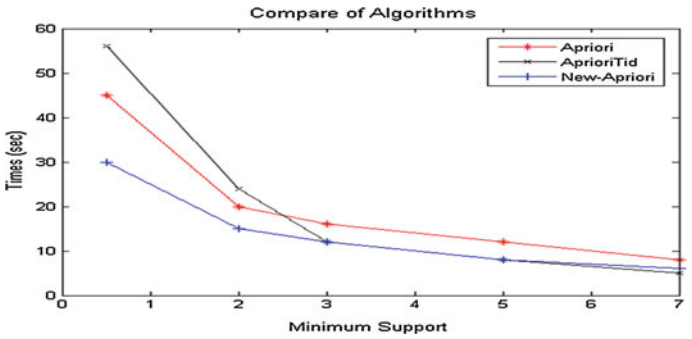

Fig. 54.4 Performance comparison of apriori algorithm and its improved algorithms

illustrated in Fig. 54.4. Whatever the support is, New_Apriori's time cost curve is below the Apriori's. Further calculation demonstrates that New_Apriori could save up to 25 % time than Apriori. When the support is small, New_Apriori has the minimum time cost. When the support becomes bigger, New_Apriori and AprioriTid have the same time cost almost. Actually, AprioriTid includes the linking and pruning time cost of $\overline{C}_k$. But the New_Apriori does not include. When the support is small, there are many members in $\overline{C}_k$. Thus AprioriTid need more time to link and prun. With the support increasing, members in $\overline{C}_k$ become less and less, the time to link and prun becomes less and less. Therefore, time cost of AprioriTid becomes less and less with the increasing of support.

54.5 Conclusion

Based on the definition of cross-linker structure, a Novel Apriori algorithm is proposed. The proposed algorithm does not need to scan the whole transaction database when the itemsets are linking or pruning. Therefore, the time cost is decreased than traditional. The proposed algorithm does not need to store the candidate frequent itemset. Therefore, the space complexity of this algorithm is decreased than traditional.

Acknowledgments This work was supported by the Science and Technology Research Project of Chongqing Education Committee (Grant No. KJ110629).

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Chapter 55
Research on Evolution Mechanism of Supply Chain Flexibility Based on Environmental Uncertainty

Yibing Qi, Quanxi Li, Lixin Diao and Jiansong Sun

Abstract In order to respond to environmental uncertainty, deep understanding, flexibility, and analysis of evolution of supply chain flexibility in changeable demand environment is the primary goal in supply chain management. With the continuous updation of technology and various customers' requirements, supply chain flexibility has received increasing attention by practitioners as well as researchers. This paper analyzed the concept of supply chain flexibility evolution and division of the flexibility capacity of supply chain. Then it presented the construction stages and evolution factors of the supply chain flexibility. Due to the timeliness and dynamics of supply chain flexibility, supply chain has to dynamically adjust and real-time monitor the degree of flexibility. Finally, this paper established the evolution mechanism and evolution framework of supply chain flexibility, which is essential to construct an effective supply chain and has deep theoretical and practical values.

Keywords Supply chain flexibility · Environmental uncertainty · Evolution · Mechanism

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_55,

55.1 Introduction

With the continuous development of technology and changing consumer's demands, there are various uncertainties in supply chain environment, which increase the complexity of supply chain management [1]. Flexibility has been considered to be a good means to react uncertainty which has received considerable attention by scholarship.

As supply chain environment is highly dynamic and complex, it is objective need to research supply chain flexibility from the perspective of evolution. To this purpose, this paper researches on the concept and mechanism of the development of supply chain flexibility from the perspective of dynamic and evolution, that fills the gaps in this field.

55.2 Concept of Supply Chain Flexibility Evolution

Flexibility is a dynamic concept. In this paper, supply chain flexibility refers to the ability and robustness to react the environmental uncertainties [1]. For the high level of environmental uncertainty, supply chain and its environment related in a certain period constitute the supply chain niche. In this state, supply chain has a certain level of flexibility. As the environment changes, the supply chain flexibility has to adjust to coordinate the environment [2], which form supply chain flexibility evolution.

The definition of supply chain flexibility evolution in this paper is that the flexible ability of supply chain to make a proper adjustment according to the environmental of uncertainty degree, which highlights the matching process between the flexible ability and uncertainty degree.

55.3 Evolution Flexible Capacity and Status of the Supply Chain

Environment changes and uncertainties are the original sources of supply chain flexibility, and how to evolve is affected by many factors.

55.3.1 Evolution Flexible Capacity of the Supply Chain

The level of flexible capacity of supply chain relies on its internal and external environmental uncertainty degree [3]. We can divide the flexible capacity of supply chain into three levels: buffer capacity, adaptive capacity, and innovation capacity as shown in Fig. 55.1.

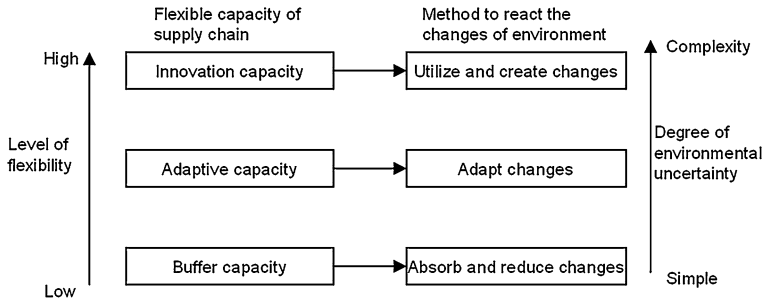

Fig. 55.1 Division of the flexible capacity of supply chain

The division of flexible capacity of supply chain is put forward from the perspective of dynamic, and the level of flexibility must be matched with environmental uncertainty [4].

Buffer capacity refers to the supply chain through its own features and functions to perceive the changes of the external environment, and through the existing flexibility level to overcome the impact of the external environment on itself [5].

Adaptive capacity refers to the ability of the supply chain system to adapt to the changes of environmental uncertainty quickly with its basic characteristics [6], via transforming and selecting its flexible strategies of the supply chain to react to the environmental changes.

Innovation capacity refers to the ability of supply chain system to affect and react to the changes of the external environment uncertainties. When the environmental changes exceed the scope of the existing flexibility of the supply chain, the system will take the initiative to change itself and the external environment to avoid the system breakdown [5].

55.3.2 Flexible Status of the Supply Chain

This capacity division is the foundation of research on the evolution of supply chain flexibility. From the perspective of dynamic, it presents a conscious strategic selection as the environment changes; from the perspective of behavior, it presents a process of evolution [7]. Therefore, we can name the capacity of the three overall as action flexibility. From the static point of view, different flexibility level reflects various states. This paper classified the flexible status into potential flexibility, realistic flexibility, and demand flexibility.

The above classification of the flexible status represents redundant degree of supply chain flexibility system relative to the environmental uncertainty.

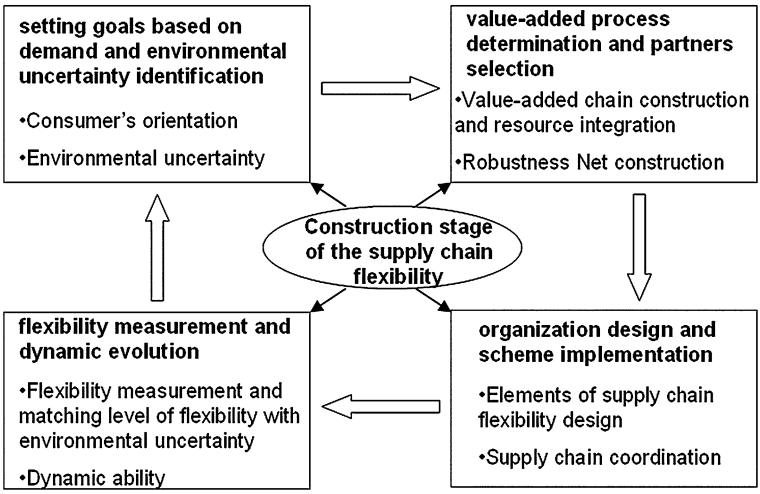

Fig. 55.2 Construction stages of the supply chain flexibility

55.4 Construction Stages and Evolution Factors of the Supply Chain Flexibility

55.4.1 Construction Process of the Supply Chain Flexibility

Supply chain flexibility construction is a systematical project. The core company plays an important role in the period of constructing the consumer-oriented supply chain flexibility, which represents that the core company needs to not only identify the special consumer's demand, but also to integrate the resources according to the degree of the environmental uncertainty [8]. Based on the object of this thesis and the analysis of flexibility classification, the construction process of the supply chain flexibility is divided into four stages: setting goals based on demand and environmental uncertainty identification, value-added process determination and partners selection, organization design and scheme implementation, and flexibility measurement and dynamic evolution. As shown in Fig. 55.2.

55.4.2 Evolution Factors of the Supply Chain Flexibility

55.4.2.1 Dynamic Capacity Factors

From the perspective of value-added chain and business system, core enterprise is an important node in the whole value chain [9]. Its dynamic capability is the guarantee of supply chain to obtain flexibility, rapid response to the market

demands and the environmental changes is one of the crucial factors [10], [7]. Through the above analysis, the dynamic capability is defined as: the ability of the core enterprise through the knowledge, resources, process, and other elements to continuously create new demand and integrate the new value chain. Dynamic capability can be measured by three elements.

Environmental insight and customer value oriented identification While the core enterprise has been environmental insight and accurately and timely grasping the customers' demands that means the company has already found a way forward, so as to shorten the supply chain responding time, gain the advantages of competition, get more loyal customers [11], and improve the efficiency of the whole supply chain [6].

Value chain reconfiguration and integration ability Complex and turbulent environment forces the supply chain to adjust its structure based on the changeable demand to adapt to the environmental uncertainty and business needs [3]. Therefore, reconfiguration and integration ability is essential for supply chain to construct flexibility.

Learning ability Organizational learning ability is the important means to gain a strategic innovation; strategy innovation requires the organization to continuously explore and learn the new ways.

55.4.2.2 Adaptability Factors

Supply chain is a coordinated complex system. In terms of construction and improvement of supply chain flexibility, elements of system and its coordination degree is also a crucial factor [12]. Through the above analysis, the article presents three elements affected supply chain coordination [11].

Management synergy Management synergy is the highest level of the supply chain adaptability, which mainly includes the values of enterprises integration, development target unification, and collaborative decisions making and standards unification.

Information synergy Information synergy refers to the information transformation among the organizations in the supply chain in order to sharing information, which can effectively weaken the butterfly effect, make enterprise better order decision [9]. Information sharing and supply chain coordination mechanism is the important strategy to improve supply chain performance.

Business synergy Business synergy refers to the application of some coordination mechanism to coordinate the operation of business based on the information synergy, which is the information synergetic application in management.

55.5 Evolution Principle and Framework of the Supply Chain Flexibility

55.5.1 Evolution Principle of the Supply Chain Flexibility Based on the Environmental Uncertainty

Based on the research scope of supply chain and the definition of the supply chain flexibility, several principles are presented for constructing supply chain flexibility.

Real-time sensing principle As the evolution of supply chain flexibility is the result of joint action between supply chain environmental uncertainty and its own capacity, the real-time and accurate perceived environment uncertainty is the key and premise to the evolution of supply chain flexibility.

Dynamic control principle Supply chain must real-time identify the environmental uncertainty and measure the supply chain flexibility to adapt to the external changes.

Contingency principle The evolution of supply chain flexibility should also follow this principle to properly balance between flexible level and uncertainty degree.

55.5.2 Evolution Mechanism and Framework of Supply Chain Flexibility

Previous articles researched on flexibility mostly focused on the internal system; it is appropriate for the isolated and closed system. But supply chain is an open and complex system constantly exchanging information, energy, and materials between organizations and external environment. Therefore, from a brand-new angle of view this paper presents the evolution mechanism of supply chain flexibility, as shown in Fig. 55.3.

Evolution of supply chain flexibility, starting at supply chain environmental perception, is the process of apperceiving and recognizing the environment changes [6]. Perceptible degree of environmental uncertainty is the level of supply chain flexibility needed, which is namely the demand flexibility. The supply chain can draw a reasonable strategy, via comparing the demand flexibility with realistic flexibility and potential flexibility.

The formation of supply chain flexibility is a process of progressive development and accumulation. In this process, supply chain adjusted constantly to achieve the relative balance between the ontology supply chain system resources possessed flexibility and external environmental uncertainties. If the changes break this balance, it drives a new evolution of supply chain flexibility. According to the above analysis, we can build an evolution framework of supply chain flexibility as shown in Fig. 55.4.

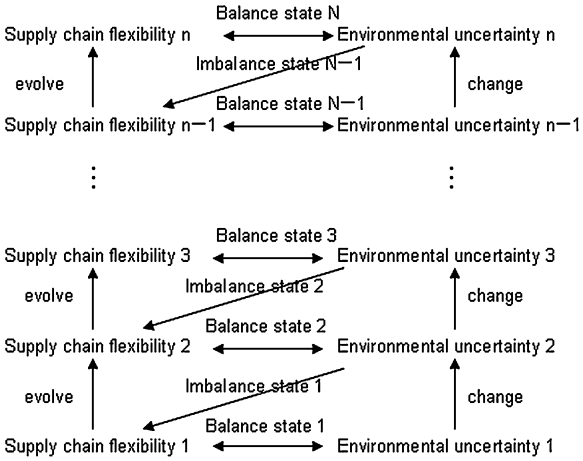

Fig. 55.3 Evolution mechanism of supply chain flexibility

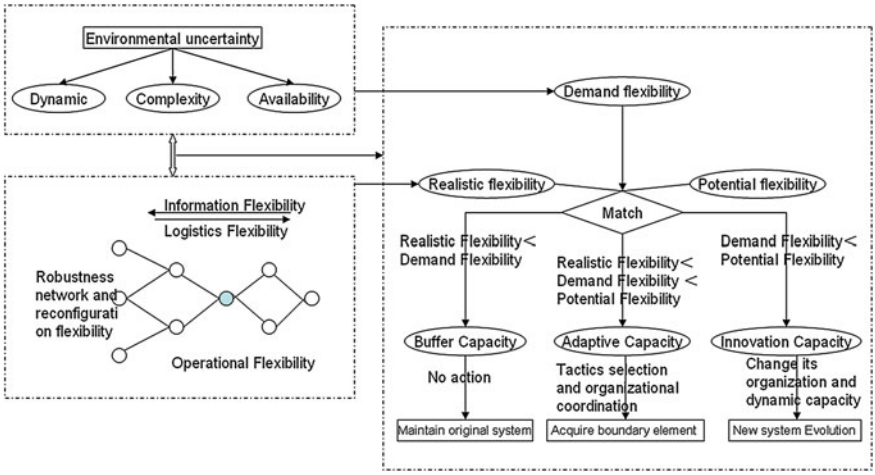

Fig. 55.4 Evolution framework of supply chain flexibility

55.6 Conclusion

Flexibility is a relative concept, the ability of system to response to the environmental changes, and such ability is relative to the environmental uncertainty. Therefore, supply chain should perceive environmental uncertainty to make appropriate adjustment, and match the environmental uncertainty, so that the supply chain system can get a maximum efficiency. This requires supply chain not only to enhance the environmental changes in perception, but also to pay more attention to the adaptability and match the degree between supply chain flexibility

and uncertainties, which will enhance the ability of supply chain to respond the external environment via adjusting supply chain flexibility by its dynamic ability and supply chain synergy.

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Chapter 56
Research on the Developing Strategies of Zhejiang Producer Services: Based on the Perspective of the Provincial Comparation of Zhejiang Province and Jiangsu Province

Rudan Chen and Minghua Han

Abstract Producer service is an important component in the modern service industry, and has become one of the key factors in the development of economy. This paper mainly compares the current situation between Zhejiang and Jiangsu producer service in three aspects: added value, structure, and employee proportion, then it finds that the producer services in Jiangsu develop much better than Zhejiang's. After then this paper does a deep analysis on the existing problems of Zhejiang producer service, and on the basis of these existing problems it puts forward some related suggestion to the developing strategies of Zhejiang producer service.

Keywords: Producer service · Provincial comparison · Developing strategies

56.1 Introduction

Producer service has been a very important factor in the economic development which has significant strategic meaning in improving economic and social efficiency, promoting economic structure optimization, and furthering the transformation of economic growth pattern and realizing the sustainable development. As it is so important for economic development, many Chinese and foreign scholars have made a lot of research. Foreign scholar Martinelli think, Producer service should includes many activities such as resource allocation and material circulation related activities, manufacturing organization and management

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_56,

related activities, and the production itself the related activities and so on [1]; Chinese scholars think producer service is the service industry that directly or indirectly provides middle service for production process, it involves mutual transfer and management of information collection, processing, and exchanging, and its main service object is the business organization and management agencies [2, 3]. In the research on relationship between producer service and manufacturing industry, foreign scholars Dilek Cetindament Karaomerioglu and Bo Carlaaon think [4, 5], producer service plays a complement and supporting role to manufacturing industry, so it can be viewed as a whole with the manufacturing integration [6]; While based on the lessons drawn from foreign research, Chinese scholars consider that producer service should serve the manufacturing industry, and it has managing, promoting, and strategic functions. Service outsourcing is the breakthrough of the development of producer service. It can know from the related research about producer service from home and abroad, the emerging and developing of producer service is the embodying of deepening labor division and improving specialization, the development of producer service will contribute to the rapid development of economy. Zhejiang is one of the provinces that develops producer service earlier, in the recent years, under the leadership of Zhejiang Government and mutual efforts of each producer service industry, zhejiang producer service develops rapidly in every aspects. But there still exists a lot of problems, and compared to jiangsu, jiangsu producer service is more better than zhejiang. So based on the comparison between zhejiang and jiangsu producer service, this paper wants to point out the problems that exist in zhejiang producer service by comparison and then puts forward some developing advice.

56.2 Comparison of Current Development Between Zhejiang and Jiangsu Producer Service

According to the "The People's Republic of national economic and social development of the eleventh five-year plan" issued by China, producer service can be divided into five parts: transportation, modern logistics, financial service, information service, and business services. And according to the report, the producer service mainly toward manufacturing service industry, including transportation, storage and the postal service; financial industry; information transmission, computer service and software; lease and business service industry; Scientific research technical services and geological survey. In the comparison, this paper mainly uses added value, structure, and employees proportion of producer service.

56.2.1 Comparison of Producer Services' Added Value

As shown in Table 56.1, Zhejiang producer service's added value presents a rising trend from 2007 to 2010, and in 2010 the added value is 468.375 billion yuan, increasing about 152.61 % compared with year 2005, so in general it presents a good state; while compared to Jiangsu province, Zhejiang producer service's developing speed is slower. In the year 2010, Jiangsu's added value was 571.301 billion yuan which increased about 191.02 % than in 2005 and is 38.41 % more than zhenjiang's. While in 2005, the added value of the two provinces are similar, Zhejiang was 185.416 billion yuan, Jiangsu was 196.31 billion yuan; the gap is only 10 billion yuan, but by 2010 the gap widened to nearly 103 billion. Zhejiang's added values of transportation, storage, and the postal service; scientific research, technical services, and geological survey; information transmission, computer service and software; financial industry; and lease and business service industry were 72.83, 56.36, 65.83, 176.74, and 62.24 %; And jiangsu, were 92.06, 161.71, 65.09, 183.95, and 149.55 %. From the above data, it can know no matter producer service's added value or each service industry's, Jiangsu province was more than Zhenjiang province.

56.2.2 Comparison of the Structure of Producer Service Industry

As shown in Table 56.2, in 2007 zhejiang producer service's added value was 3216.95 billion yuan, including transportation, storage, and the postal service accounted for 27.71 %; scientific research, technical services, and geological survey accounted for 6.38 %; information transmission, computer service, and software accounted for 16.76 %; the proportion of the financial industry is 37.02 %, and leasing and business service industry accounted for 12.13 %. While jiangsu's added value was 196.31 billion yuan, the proportion were 37.75, 6.01, 16.25, 28.65, and 11.34 %. In 2010, zhejiang producer service's added value was 468.375 billion yuan, including transportation, storage, and the postal service accounted for 22.99 %; scientific research, technical services, and geological survey accounted for 5.01 %; information transmission, computer service, and software accounted for 12.69 %; The proportion of the financial industry which was still the biggest even almost half was 49.67 %, and leasing and business service industry accounted for 9.63 %. While Jiangsu's added value was 571.301 billion yuan, the proportion was 30.95, 6.39, 110.59, 36.85, and 15.20 %.

Table 56.1 Comparison of Zhejiang and Jiangsu producer service added value in 2007–2010

Unit: hundred million yuan	2007		2008		2009		2010	
	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu
Producer service	2916.58	3216.95	3550.52	3924.92	3852.76	4411.31	4683.75	5713.01
Transportation, storage and the postal service	748.61	1039.46	843.2	1346.26	888.02	1423.25	1076.67	1768.3
Scientific research, technical services, and geological survey	164.01	154.90	182.85	271.66	185.04	308.84	234.87	365.17
Information transmission, computer service and software	442.69	455.75	482.28	503.63	515.4	526.52	594.55	605.28
Financial industry	1251.43	1202.1	1653.45	1298.48	1899.33	1596.98	2326.58	2105.92
Leasing and business service industry	309.84	364.73	388.74	504.89	364.97	555.72	451.08	868.34

Table 56.2 Comparison of the structure of producer service industry in 2007–2010

	2007 (%)		2008 (%)		2009 (%)		2010 (%)	
	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu
Transportation, storage, and the postal service	25.67	32.31	23.75	34.30	23.05	32.26	22.99	30.95
Scientific research, technical services, and geological survey	5.62	4.82	5.15	6.92	4.80	7.00	5.01	6.39
Information transmission, computer service, and software	15.18	14.17	13.58	12.83	13.38	11.94	12.69	10.59
Financial industry	42.91	37.37	46.57	33.08	49.30	36.20	49.67	36.86
Leasing and business service industry	10.62	11.34	10.95	12.86	9.47	12.60	9.63	15.20

56.2.3 Comparison of Producer Services' Employees Proportion

As shown in the Table 56.3, in 2005 the proportions of zhejiang producer service's employees were 59.44, 5.01, 10.75, 9.07, and 15.73 %, while jiangsu's were 44.16, 12.21, 7.77, 23.75, and 12.11 %. After several years, zhejiang province formed a relatively reasonable structure, the proportions were 48.23, 6.88, 15.48, 10.06, and 19.34 %, but jiangsu's was more reasonable when compared to zhejiang, the proportions were 30.29, 12.61, 10.53, 14.56, and 32.02 %.

56.3 Enlightment of Zhejiang by Provincial Comparison

Through the comparison of Zhejiang and Jiangsu province, Zhejiang producer service developed very quickly, but still there existed some questions, which seriously impeded the development of Zhejiang producer service.

Table 56.3 Comparison of producer service's employee's proportion in 2007–2010

	2007 (%)		2008 (%)		2009 (%)		2010 (%)	
	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu	Zhejiang	Jiangsu
Transportation, storage, and the postal service	47.07	42.78	50.76	32.38	47.72	31.59	48.23	30.29
Scientific research, technical services, and geological survey	5.43	12.36	5.44	9.97	6.27	10.37	6.88	12.61
Information transmission, computer service, and software	22.87	8.36	20.91	15.25	19.87	14.99	15.48	10.53
Financial industry	7.87	24.58	9.95	11.81	9.82	12.10	10.06	14.56
Leasing and business service industry	16.75	11.93	12.93	30.59	16.32	30.96	19.34	32.02

56.3.1 The Developing Speed of Producer Service was Still Slow

In 2007, the gross of zhejiang produce service was 185.416 billion yuan, while jiangsu's was 196.31 billion yuan; the gap between two provinces was not large but it was only 10.894 billion yuan. But in the year 2010, the gap became very large, the gross of zhejiang producer service was 468.375 billion yuan, and jiangsu's 571.301 billion yuan, the gap became 102.926 billion yuan, which was more than 10 times of the gap between two provinces in 2005. It was clearly seen from the data that from 2005 to 2010 zhejiang producer service developed greatly, but the developing speed was slower than Jiangsu's.

56.3.2 The Structure of Producer Service Developed Unbalanced

In 2007, transportation, storage, and the postal service took up about 27.71 % of Zhejiang producer service, scientific research, technical services, and geological survey took up about 6.38 %, information transmission, computer service, and software took up about 16.76 %, financial industry took up about 37.02 % and leasing and business service industry was about 12.13 %. While Jiangsu's proportion were 37.75, 6.01, 16.25, 28.65, and 11.34 %. The proportions of technical services and geological survey and information transmission, computer service and software were

similar, but financial industry and transportation, storage, and the postal service were very different: the proportion of transportation, storage, and the postal service in Zhejiang was smaller than Jiangsu's, but was larger than Jiangsu's in financial industry. But in 2010, the data showed that the development of Zhejiang producer service formed a bad layout, financial industry took up about 49.67 %, others were 22.99, 5.01, 12.69, and 9.63 %; while jiangsu province formed a more reasonable structure in 2010, it had changed the situation of transportation, storage, and the postal service took up the largest. And its proportion was 30.95, 6.39, 10.59, 36.86, and 15.20 %. This could explain that the structure of the producer services in Zhejiang province is very unreasonable, the specific performance was financial industry occupied a large proportion, while other were too small.

56.3.3 Employment Structure and Work Efficiency Are Not Optimal

In 2007, the percentage of employment in transportation, storage, and the postal service almost took 60 % of total employment in producer service, other four added up to was only 40 %. Although the percentage had changed in some way in 2010, the situation was not changed, the percentage of employment in transportation, storage, and the postal service stills took up about 50 %. While in 2005, Jiangsu province's the employment of transportation, storage, and the postal service was about 45 %, but in 2010 it formed a good structure, transportation, storage, and the postal service and leasing and business service industry took up about 30 %, respectively, others roughly equally.

So compared to jiangsu, the employment structure in zhenjiang was not optimal, it needs to be developed urgently; meanwhile there also existed the problem of efficiency of working staff in some industries. In 2005, the percentage of employment in transportation, storage, and the postal service was about 59.44 %, but the added value was only 27.71 %, but the financial industrial only took up 9.07 %, the added value was about 37.02 %. The same thing happened in 2007–2010. From the above data, it can be seen that the working efficiency was low; a lot of human resources were wasted in some industries, while some other industries lack human resource to develop.

56.4 Advices on Developing Strategies of Zhejiang Producer Service

In recent years, under the leadership of Zhejiang Government and mutual efforts of each producer service industry, zhejiang producer service greatly improved in both its added value and developing speed, but in current zhejiang producer service

there exists some problems: developing speed was relatively slower, the industry structure of producer service developed was unbalanced, and the employment structure was not optimal. Therefore, Zhejiang producer service should adopt related developing strategies to solve these problems.

56.4.1 Creating a Sound External Environment for the Development of Producer Service

The development of producer service needs a good material environment, including information facilities, business building, and traffic facilities, etc., while at the same time it needs sound system, legal, and policy environment. In order to regulate the development of zhejiang producer service, some related departments in zhejiang should further improve laws and regulations, lower the barriers to entry into industry, open channels to attract advanced productive elements into producer service departments, improve the degree of competition in the industry, eliminate various arbitrary charge phenomenon in the internal producer service, and establish a standardized system.

56.4.2 Joint Development

Promoting the integration of service and manufacturing industry, boosting the urbanization to help and serve economy, and stimulating domestic demand by living service industry. It should encourage the focus of industrial competition to change from "product and technology" to "used in service", the industrial developing strategy changes from "produce drive" to "customer drive". Zhejiang should develop financial industry which has great growth potential and strong impetus function to promote the modernization of service. And Zhejiang's manufacturing industry has a good foundation; it has formed a lot of manufacturing industry clusters. So producer service should makes full use of that advantage to make the industrial cluster as its foothold, and according to the characters of many small enterprises in industry cluster and big common demand, it should provide social and professional productive service in order to develop zhenjiang producer service rapidly.

56.4.3 Optimized Structure and Layout

From the data of 2010, it can be seen that the structure of zhenjiang producer service is very unreasonable, financial industrial almost took up 50 %, it was not a reasonable development for zhenjiang producer service in that way. For that

reason zhejiang should developing other four industries rapidly on the basis of continuing to develop financial industrial in order to optimize the structure of producer service. At the same time, zhejiang should follow the direction points of service to do space layout, and according to the industrial characteristics of service and zhejiang's regional differences, zhejiang should have an overall plan which not only avoids repeated construction and uneven, but also prevents excessive competition and resources waste, what is more, it should improve the resource; space allocation efficiency and organization degree in the maximum, so as to realize webified of productive service and promote the agglomeration of producer service. At present, jiangsu's agglomeration zone have already had central business district, creative industry park, science and technology and pioneering park, software park, modern logistics park, and products trading market and service outsourcing, etc. And in the future, it will continue to build a lot of service agglomeration zones with distinct characteristics, ecological coordination, and novel form and complete functions. So Zhejiang province should get some good experience from Jiangsu's good layout, and then based on that zhenjiang can plan a distinctive layout of producer service which suits itself well.

56.4.4 Speeding Up the Training of Producer Service Talent and Improving the Quality of Employees

There existed low working efficiency in some zhenjiang producer service, so it wasted a lot of human resources. The main reason caused that situation is the low quality of employees who cannot finish work with high efficiency. So Zhejiang should make every effort to improve the quality of employees in producer service and make it an internal mechanism. On the one hand, it should further promote to create high level talent team, improve talent selection system, and attract talent from various channels; on the other hand, zhejiang should issue a series of related policies to attract foreign excellent talent who major at producer service, strength the exchange between China and abroad, and gradually improve the mechanism of talent's train and supply.

56.5 Conclusion

Above all these years, zhejiang producer service got certain development, but when compared to jiangsu, there existed some problems: developing speed was relatively slower, the industry structure of producer service developed was unbalanced, and employment structure was not optimal which seriously affected zhejiang producer service's rapid development, and if these problems are not solved, zhejiang will not develop its producer service rapidly.

Acknowledgments This project was supported by scientific research of Zhejiang provincial education department.

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Chapter 57
Research on Storage Handling Based on Petri Net and Flexsim

Li Xiang

Abstract In order to improve the efficiency of storage handling process, put forward the analytical method based on combining the Petri net modeling and Flexsim simulation. Firstly, the method uses Petri net for modeling to find problems in the process. Secondly, it uses Flexsim for entity simulation to make the system bottleneck clear at a glance. Finally, it achieves the purpose of optimization system through the modification of system parameters. The simulation results show that the method can find the system bottleneck more easily compared with the traditional method, with a visual effect, and can accurately reflect the handling process condition.

Keywords Storage handling · Modeling · Simulation

57.1 Introduction

Storage handling process refers to using storehouse or site to handle and distribute goods [1]. In order to design a reasonable storage handling process, we often use object-oriented modeling technology, but the object-oriented model is a modeling method based on graphic representation; it lacks a strong math tool for the analysis and the correct verification of the model, lacks an effective analysis and test method for the system after modeling, and lacks abstraction and accuracy because its many concepts are being close to nature.

This paper introduces Petri net which has a strict mathematical definition into storage handling model and analyzes system bottleneck by means of Petri net for analysis and modeling. At the same time, it uses the discrete virtual simulation

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_57,

software Flexsim to make physical simulation for the storage handling process, and puts forward an improvement plan, optimizing the storage handling system structure, to improve the system efficiency.

57.2 Petri Net Modeling and Flexsim Simulation

57.2.1 Definition of Petri Net

Petri net, a combination model which can be represented with graphs, is mainly used to study the system organization structure and the dynamic behavior, and focuses on the change of various states that may happen in the system and the relationship between changes. Petri net is intuitive, easy to understand and easy to use, with a superior original place for describing and analyzing the process. Its digraph is expressed as: PN = (P, T, I, O, M_0), here $P = \{p_1, p_2, p_3,\ldots, p_n\}$ is called finite library of the collection, $T = \{t_1, t_2, t_3,\ldots, t_n\}$ is called finite set of transitions, I is the input arcs; O is the output arcs; M is Petri net marking, and M_0 represents the initial state of system [2]. The basic Petri net marking structure is as shown in Fig. 57.1.

57.2.2 Modeling Process and Procedure of Petri Net

The modeling process of Petri net combining the object-oriented methods [3] and the specific modeling procedure is as follows:

1. Clarify the design requirements of system. Before system modeling, understand the main functions of the system and the demand of system function as completely as possible.
2. Determine the object, and establish the object model. Use object-oriented modeling method to list the name, property, method, and operation of the object.
3. Mark the relationship between the objects. Clarify the behavior in each object and relation with other objects, mainly used to indicate the interaction between objects.

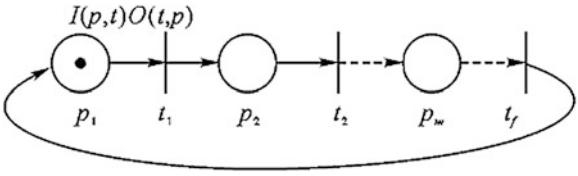

Fig. 57.1 Basic petri net structure

4. Establish the initial system model. Use object-oriented Petri net syntax to explain the process, and set up the system model.
5. Optimize the initial model. Optimize the above model, and repeat 2–4 steps, to establish the optimization model.
6. Integrate the model to establish a Petri net of the whole system. According to the finally marked object and their relationship, establish Petri net of the whole system.
7. Analyze the model and determine its integrity. The most outstanding characteristic of Petri net is that it can make syntax analysis for modeling to reduce mistakes. Judge the validity and integrity of the model through analyzing the model.
8. Design the system in detail. Carry on the detailed design of system on the basis. If step 7 has a satisfactory result, or turning to step 2, repeat the process behind, until model is correct and complete.

57.2.3 Flexsim Profile

Flexsim is discrete event system simulation software with the function of three-dimensional display of using object-oriented technology, which is researched and developed by American Flexsim Software Production Company [4]. It is the first simulation software that has integrated C++ IDE and compiler in the graphical modeling environment. Flexsim can visually describe the whole process, and clearly find the problems existing in the design process; so it can be widely used in modeling, simulation of industrial production, and realizing the business process visualization [5].

57.3 Analysis of Handling Case Based on Petri Net and Flexsim

57.3.1 Storage Handling Process Instance

In the handling process, suppose there are three conveyers in the storehouse: M_1, M_2, and M_3, four forklifts: W_1, W_2, W_3, and W_4, and a high-altitude conveyer belt Y_1. The whole handling process is divided into two stages for transportation, the first stage is that high-altitude conveyer M_1 and M_2 transport goods, respectively; the second stage is that high-altitude M_3 transports the goods transported by M_1 and M_2. Through simulation analysis, Petri net simulation of this system is as shown in Fig. 57.2, and the definition of library and change is as shown in Table 57.1.

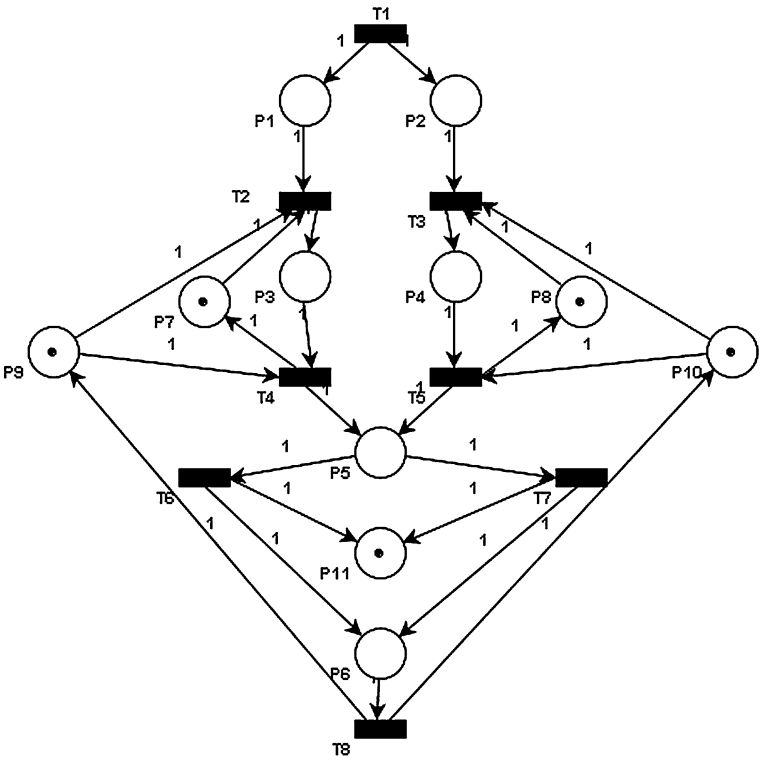

Fig. 57.2 Handling process descriptions

57.3.2 Physical Simulation of Petri Net Model in Flexsim

Change the above Petri net model into three-dimensional simulation figure in Flexsim, as shown in Fig. 57.3. If we suppose the working time is 8 h a day (28,800 s), the consumed time of each process is as shown in Tables 57.2 and 57.3.

57.3.3 Analysis of Simulation Result

To optimize the storage handling process, firstly find the bottleneck in the handling process. We can see the problems existing in the current processes from the simulation report of system modeling:

1. Equipment utilization rate of W_3 and W_4 is low, only 50 %.
2. Task completion rate of Y_1 is lower, only 44.4 %.
3. Equipment utilization rate of M_3 is lower, only 44.4 %.

Table 57.1 Library and changes

Name	Event meaning	Name	Event meaning
P_1	M_1 ready	T_1	Goods arrive
P_2	M_2 ready	T_2	Forklift truck W_1 loads the goods onto M_1
P_3	M_1 transportation	T_3	Forklift truck W_2 loads the goods onto M_2
P_4	M_2 transportation	T_4	Forklift truck W_3 loads the goods onto M_1
P_5	M_3 ready	T_5	Forklift truck W_4 loads the goods onto M_1
P_6	M_3 transportation	T_6	Load the goods transported by M_1 onto M_3
P_7	M_1 available	T_7	Load the goods transported by M_2 onto M_3
P_8	M_2 available	T_8	Unload the goods and complete the output
P_9	W_1 available		
P_{10}	W_2 available		
P_{11}	M_3 available		

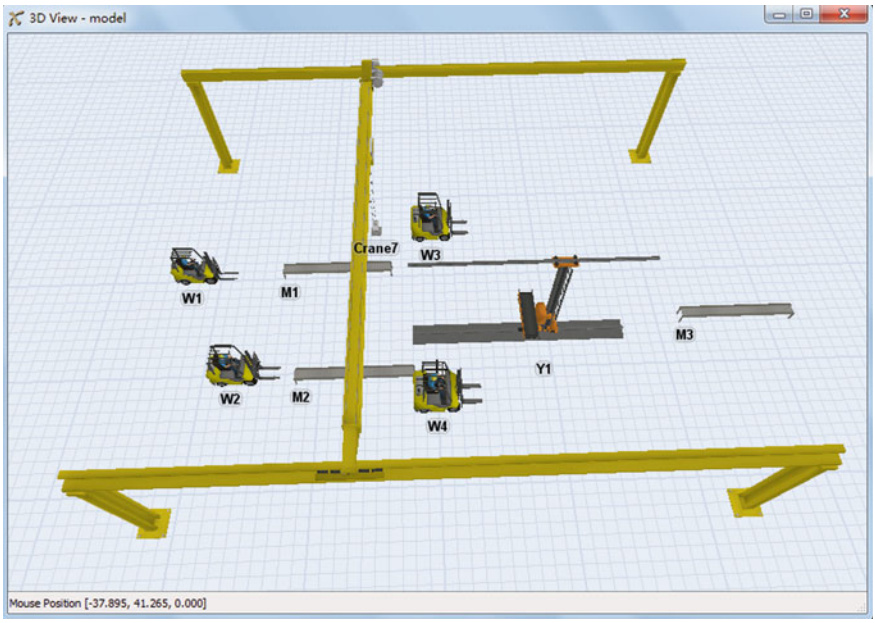

Fig. 57.3 Establish three-dimensional simulation figure of handling process in flexsim

57.3.4 Improvement Design of Handling Process

Aimed at the problems existing in the current handling process, put forward an optimization scheme and solution:

1. First must eliminate the system bottleneck Y_1, to improve the task completion rate of high-altitude transmission link.

Table 57.2 Time-consuming table of handling process

Process name	Time (s)
One round trip time of forklift W_1–M_1	80
One round trip time of forklift W_2–M_2	80
One round trip time of forklift W_3–M_3	40
One round trip time of forklift W_4–M_4	40
Transmission time of conveyer M_1 for single room goods	60
Transmission time of conveyer M_2 for single room goods	60
Transmission time of conveyer M_3 for single room goods	40
Transmission time of high-altitude conveyer belt Y_1 for single room goods	90

Table 57.3 Simulation report of handling process

Simulation entity	Input number	Output number	Maximum output number	Equipment utilization (%)	Task completion rate (%)
W1	360	360	360	100	100
W2	360	360	360	100	100
M1	360	360	480	75	100
M2	360	360	480	75	100
W3	360	360	720	50	100
W4	360	360	720	50	100
Y1	720	320	320	100	44.4
M3	320	320	720	44.4	100

2. Balance the working beat of each process in the system, and improve each equipment utilization rate, to prevent too much state being free.

Specific improvement measures:

1. On the basis of the existing high-altitude conveyer belt Y_1, add a high-altitude conveyer belt Y_2.
2. Reduce the existing two forklifts of W_3 and W_4 to one, keeping only W_3.

57.3.5 Optimization Simulation Results

According to the optimization scheme of the above process, establish the simulation model, as shown in Fig. 57.4, and output the simulation results of the optimization scheme, as shown in Table 57.4.

From Table 57.4, after increasing Y_2 and reducing W_4, double the equipment utilization rate of W_3 and M_3 in the storage handling process, and also double the task completion rate Y_1 at the same time. Through the above modeling simulation process, we can quickly find the problems existing in the storage handling process, and put forward an optimization design scheme and find a solution to improve the efficiency of system by analyzing the system bottleneck.

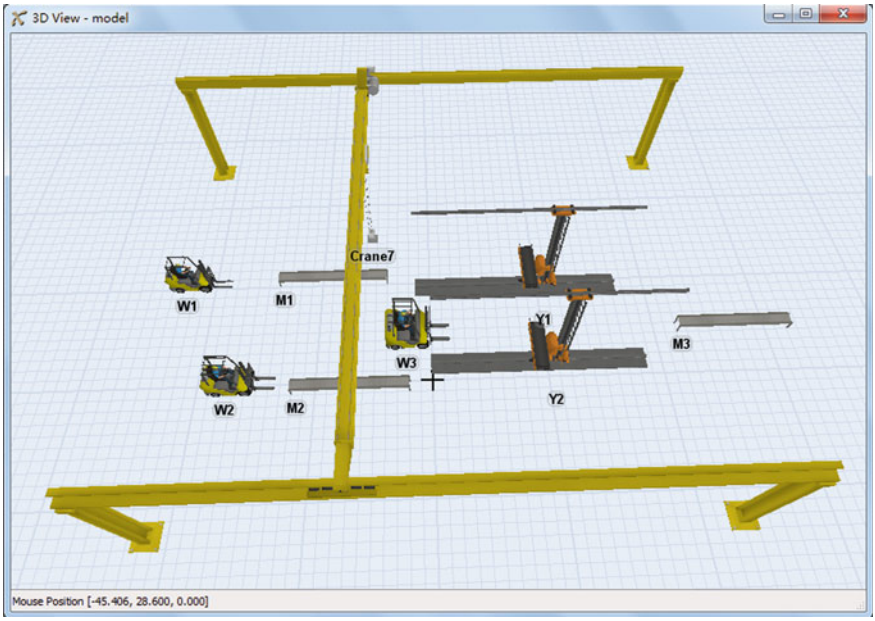

Fig. 57.4 Three-dimensional simulation figure after optimization

Table 57.4 Optimization simulation report of handling process

Simulation entity	Input number	Output number	Maximum output number	Equipment utilization (%)	Task completion rate (%)
W1	360	360	360	100	100
W2	360	360	360	100	100
M1	360	360	480	75	100
M2	360	360	480	75	100
W3	720	720	720	100	100
Y1	360	320	320	100	88.8
Y2	360	320	320	100	88.8
M3	640	640	720	88.8	100

57.4 Conclusions

Based on analyzing the influence factors of storage handling process, use Petri net to realize modeling for the storage handling process, then make physical simulation through three-dimensional simulation software Flexsim to make the bottleneck of system design be clear at a glance, and finally achieve the purpose of optimizing system by modifying the parameters. The simulation results show that

this method has a higher mathematics reasoning basis compared with the traditional methods, and its result is intuitive and easy to understand; so it is a feasible storage handling process analysis method.

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Chapter 58
Study on Spatial Structure of National Park in Southwest China

Yanling Jiang, Zhaofeng Gao and Enfu Tang

Abstract This paper provides the classification of statistics on the number and location of heritage-based attractions such as state-level scenic spots, national geology parks, national forest parks, and national nature reserves in five territories including Sichuan, Guizhou, Yunnan, Chongqing, and Tibet Autonomous Region. Integration of data models including space model theory and geographical proximity and geographic concentration of the use of the model are used in quantitative analysis of distribution of these tourist attractions. Finally, relevant conclusions are drawn with a view to regional integration in the tourism development process and able to provide a useful proposal for the relevant decision-making departments.

Keywords Spatial structure · Regional tourism integration · Tourism development

58.1 Introduction

In this paper, the selected five southwestern provinces, municipalities, and autonomous regions are Sichuan, Chongqing, Guizhou, Yunnan, and Tibet. The five provincial administrative regions adjacent to each other, all feature a variety of climatic characteristics of biological populations and natural resources.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_58,

Moreover, the location, traffic distribution, natural conditions, tourist resources, and domain combinations are highly correlated, strongly complementary, and combined in a good manner [1]. China has no uniform national parks, but it has a large number of various parks and protected areas (spots) that are named with the word "State" and designated by the State Council and departments, so select this scenic area, national forest parks, national geological Park, national Nature Reserve for the study, which are key ecological items listed in the national "Eleventh Five-Year plan", "Twelfth Five-Year" plan, and "National Planning for the Main Functional Areas" [2] as the prohibited development area.

Located in China's southwest, Sichuan Province, Chongqing Municipality, Guizhou Province, Yunnan Province, and Tibet Autonomous Region have a total area of about 3,107,600 km^2, accounting for 32.4 % of China's land area. According to the sixth census data, five provincial administrative regions have a total of 193 million people, accounting for 14.08 % of China's total population. The vast Southwest is where ethnic minorities are concentrated, with the full range of tourist resources, accounting for 99 % of the national tourism resource types [3]. Western tourism in the region started late, and the development is lagging behind. This is reflected by the overall low level of coordination between the space which may force regions, cities, and attractions, as well as a large regional disparities and imbalances of provincial development. To achieve leapfrog development its tourism must give full play to the western natural resources, the establishment of tourism economic characteristics, and the formation of large-scale mass tourism and the creation of the whole western edge [4].

At present, research on the regional structure and space integration of travel space are mostly concentrated in urban tourist attractions [5], travel behavior of residents [6], and spatial structure in specific tourist areas [7], but fewer on the southwest region for in terms of the tourism spatial structure.

58.2 Relevant Theoretical Basis

Spatial structure of regional tourism is a nonlinear structure, involving the contents that are quite complex. Foreign scholars have proposed many models and quantitative research methods, such as location theory and fractal geometry method [8]. And from the tourism planning perspective, in-depth studies have been carried out on the spatial structure of tourist attractions. Domestic research is concentrated in several areas: The overall spatial form, the urban recreational business district, urban rim recreation and the spatial distribution of tourist facilities [9]. In addition, some scholars also used the nonsymmetry model of monopolistic competition [10], the geographical proximity model and the geographic concentration data model in their exploration on the spatial structure of tourist attractions from different perspectives.

58.2.1 Spatial Integration

The space integration theory was put forward by the American scholar Friedman in his book: *Regional Development Policy*. From the perspective of space travel, he believes that space travel includes three basic elements, i.e. tourist destination, tourist places, and travel channels, while tourist destinations are interacting to form a tourist area. To study the integration of space tourism refers to clarify the composition of the various tourist regions, as well as the relationships between tourist attractions and these three elements. Therefore, the regional tourism planning and management of tourist areas require a clear understanding of the tourist area as a whole, where all elements are interrelated in-between, one element changed may lead to the change of others.

58.2.2 Theoretical Research on Spatial Structure of Tourism

Tourism is a marginal academic discipline being highly inclusive, involving geography, geology, urban planning, economics, and many other disciplines and fields. Many theories used in the study on the spatial structure of tourist attractions also draw on research methods in other disciplines.

58.2.2.1 Theory of Growth Pole

The theory of growth pole was put forward by the French economist Francois Perroux; it is applied to nonbalanced regional economic development [11]. Its main contents are: It is virtually impossible for a country to achieve the balanced regional development and economic growth is usually passed from one or more growth centers to other areas or departments. Therefore, in the process of regional development, a specific geographic space should be chosen as the growth center to promote the development of the surrounding area. However, the growth pole theory in practice will produce two different effects: one is the positive effect that growth centers can drive and promote common development of the surrounding area; and the negative effect, i.e., a growth pole in rapid development will occupy around resources, which will restrict the development and growth of the surrounding area. In addition, the number and size of a regional growth pole in a certain territory will also affect the development within the region.

58.2.2.2 Theory of Core-Edge

The theory of core-edge was systematically put forward by the US geographer J. R. Friedman in 1966. It is a theory used to explain the relationship between regions on economic development and the evolutional model of regional spatial

structure [12]. The theory says that in the regional development process, the core development area and the edge area have an unequal relationship between them; core area of development and prosperity will have a leading and dominant role for the edge area. But also in the development process, the status of core area and that of the edge area would be converted under certain conditions, resulting in the formation of a new core area and edge area, thus promoting the development of other regions. The spatial layout of the tourist areas may introduce the core-edge theory. Based on the tourism resources and location advantages, etc., a core area may be identified to drive the edge area's development around the core area.

58.3 Model Introduction and Data Analysis

58.3.1 Analysis of Geographic Concentration

The model of geographic concentration is used to calculate the distribution of tourist attractions in all of the small areas that constitute a large area. The formula is as follows:

$$G = 100 \times \sqrt{\sum_{i=1}^{n} \left(\frac{x_i}{T}\right)^2} \tag{1}$$

Here, G is for index of geographic concentration, X_i for the number of tourist attractions in No. I small area, and T, the total number of tourist attractions in a large region. G values are in the range of: $1 \leq G \geq 100$. The greater the value, the higher the concentration of tourist attractions, and the smaller the value, the more dispersed distribution of tourist attractions.

This paper is to explore the five provincial administrative regions in southwestern China with a view to their type of and number of tourist attractions as indicated in the Table 58.1.

Table 58.1 Statistic numbers of various types of national parks in southwest China's five provincial-level administrative regions

Province	National geological park	National forest park	National scenic area	National nature reserve	Total
Guizhou	8	13	18	8	47
Sichuan	14	28	14	23	79
Tibet	3	3	3	9	18
Yunnan	8	25	12	16	61
Chongqing	6	21	6	3	36
Total	39	90	53	59	241

Note Statistics as of August 31, 2011

The above five provincial administrative regions have their own number and total number of 241 national parks, which is taken into the above formula and calculated as $G = 23.49$. If the 241 national parks are evenly distributed in the five provincial administrative regions, the theoretical value can be obtained as $G = 21.56$. From the actual value being greater than the theoretical value, we can see the uneven distribution of national parks in the five provincial administrative regions.

58.3.2 Calculation and Analysis of the Gini Coefficient

Gini coefficient was defined by the Italian economist Gini in the early twentieth century, an index that uses the Lorenz curve to determine the fairness of income distribution. In economic geography, the Gini coefficient can be used to measure the spatial distribution of variation. As the Gini coefficient is used to calculate the spatial distribution of tourist attractions, and its formula is as follows:

$$H = -\sum_{i=l}^{N} p_i \ln p_i,\ H_m = \ln N \tag{58.2}$$

$$G_i n_i = \frac{H}{H_m},\ C = 1 - G_i n_i \tag{58.3}$$

Here, N is the number of regions, P_i is ratio of the number of No. i region accounting for the number of all the scenic spots, Gini is the coefficient value, and C, the uniformity of the distribution of tourist attractions. Gini coefficient is a ratio of values between 0 and 1. Larger values indicate that the distribution area have a small balance, that is, the more concentrated; the smaller value means the greater balance in the distribution of tourist attractions, that is, the more uniform distribution. The large value of C represents the area being more evenly distributed.

After resorting the data in Table 58.1, the number of national parks in the provincial administrative regions have a ratio with the total number of national parks in the above five provinces and regions, we get P_i, where $N = 5$, Gini coefficient is calculated as 0.938, and C value of 0.618. It can be seen from the results, with the Gini coefficient as amendment and supplementation to the model of geographic concentration, the distribution of national parks has a small balance in the five provincial-level administrative regions in the southwest of China. In other words, the more concentration can be found in the distribution of national parks.

58.3.3 Calculation and Analysis of the Scale Index

Scale index is used to calculate the percentage of scenic areas in each region. The greater degree of the scale indicates that the elements in a large scale within such small area. On the contrary, it would be a size smaller. Scale index is calculated as follows:

$$G_i = \frac{n_i}{A_i} \tag{58.4}$$

Here, G_i is scale index, n_i is the number of scenic spots in No. i area, and A_i is the area of No. i area. The index used in the model of the scale of the target area on the spatial structure that reflects the size of area in various regions.

By taking the data in the provincial administrative area and the number of national parks into the above formula, we calculated the values of G_i for the various provinces, autonomous regions, with the results shown in Table 58.2.

As shown in the results of Table 58.2, the size of Chongqing has the largest index, and the Tibet Autonomous Region is the smallest, and the size of Guizhou Province in the middle level, compared to Sichuan and Yunnan provinces with a smaller scale degree, lower than the average value 2.07.

In terms of the number of the national parks, Sichuan and Yunnan both outnumbered the average, and Tibet, only 30 % more than average. Figure 58.1 is produced using ArcMap as the national park map in five southwest provincial administrative regions, it can be more visual to display the distribution: In Chongqing, Guizhou Province, the national parks are relatively evenly distributed; Yunnan is larger, where 61 national parks are found, but with less density and being relatively sparse; national parks in Sichuan Province are mainly in Sichuan Basin and less in western Sichuan plain. This may be due to the higher altitude of the region, where climate and geological conditions are variable, and local economic development is lagging behind, resulting in the reporting and approval of national parks not being able to keep up with the pace; in the vast Qinghai-Tibet plateau is featured by bad weather, extremely fragile ecosystem, sparsely populated addition to more intensive distribution around Lhasa, the rest are scattered in the vast plateau. Its national parks have the least number among the five boroughs. This shows that the Tibet Autonomous Region has more great tourism potential to be discovered, and rare animals and plants and their habitats need to be effectively protected.

Table 58.2 Data, number of national parks, and the values of G_i for the various provinces and autonomous regions

Municipality, province, and autonomous region	n_i	A_i (1000 km^2)	G_i
Guizhou	47	1,762	2.67
Sichuan	79	485	1.63
Tibet	18	12,284	0.15
Yunnan	61	394	1.55
Chongqing	36	824	4.37
Average	48.2	——	2.07

Note The table data for the provinces, the municipality and autonomous region are based on the results from the central government portal

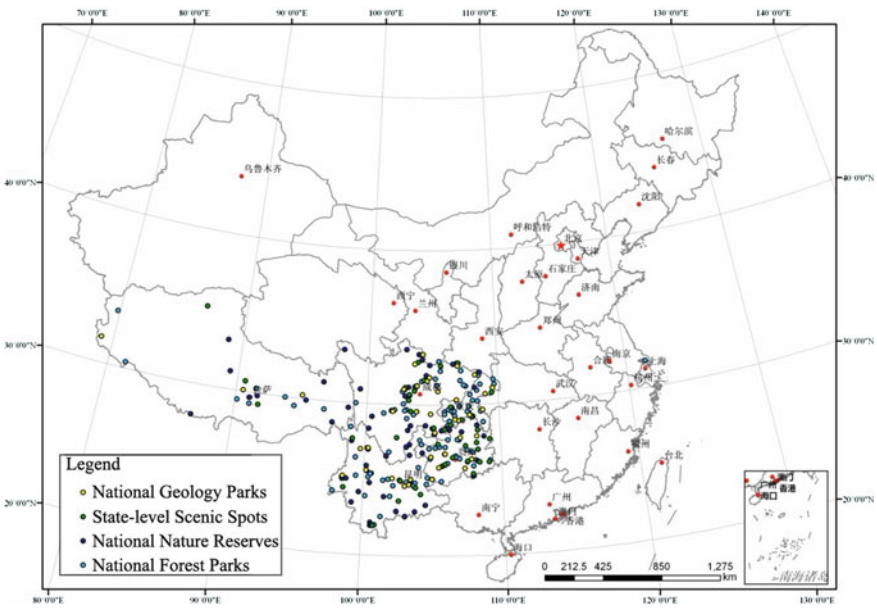

Fig. 58.1 Distribution of national parks in five southwestern provincial administrative

58.4 Conclusions and Recommendations

Based on the above quantitative calculation of the spatial structure's model, index, and the analysis results, we can see that the national parks are relatively concentrated in five provinces in western China, municipalities, and autonomous regions, such as in Chongqing, Guizhou, eastern Sichuan, and in Yunnan Province, where the domestic tourism industry is more mature as a leader region, has a smaller degree. Western Sichuan plateau and Tibet region, due to their special geographical conditions, economic development lagging behind, have a large blank area in the region reserved for the distribution of national parks, and it has not been protected and utilized.

Therefore, the author made the following recommendations on the establishment, construction of national parks, and the tourism in the five provincial administrative regions of southwestern China.

Focus is made on cultivating the tourism growth pole and the core area to drive the surrounding regional development. It can be seen from the data analysis that eastern Sichuan Province, Chongqing Municipality, and Guizhou Province, all have a greater degree of the scale, where national parks are distributed more intensively. Scattered distribution of national parks in Yunnan Province, due to more mature development of tourism has produced a more significant role in promoting the local economy. Therefore, it is strongly recommended to rely on the airport and transportation hub, a growth pole can be cultivated in the western

region of Sichuan Province and central Tibet for the establishment of the core area of tourism development; thus, the formation of radiation effects on the surrounding area to drive the development of the surrounding tourism and related industries, where tourism income can be used to protect the establishment and operation of national parks. National park tourism in Chongqing Municipality and Guizhou Province, regardless of the development being not mature enough, should also designate the appropriate core development area to play an exemplary role.

More efforts should be made on the landscape and ecological protection in Tibet. The vast Tibetan region is considered the last refuge of mankind, humble, and charming. The local economic development is far from that in eastern and central regions, local authorities also have not enough emphasis on the construction of national parks. National Park has an important function in the declaration of state sovereignty to increase national pride and identity, and can have better protection and utilization of resources and landscape. The relevant state ministries and commissions should give certain macroeconomic policy preferences and financial support for Tibet with respect to the establishment, construction, and operation of national parks.

China has abundant tourism resources in the western region, but the economy is relatively backward, so national park tourism can be developed to drive the development of tourism with the help of the brands of national parks. Our national parks are designated and managed by the departments, and they have not yet formed a coherent development trend. In addition, different types of national park boundaries are unclear and overlapped. This is inconsistent with management objectives, resulting in a certain amount of chaos to be further to solve. Also it is required to continue to explore other issues related to the spatial correlation structure and income of tourist attractions.

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Chapter 59
Research on GIS 3D Visualization Based on ArcGIS and SketchUp

Yurong Mu and Huiying Gao

Abstract Many specialized agencies start to do basic research of 3D GIS, and a lot of prototypes of 3D GIS were developed today. But, due to most of the traditional modeling software have many defects. So the method of ArcGIS combined with SketchUp is brought forward as a new idea in GIS 3D visualization because ArcGIS has powerful spatial analysis functions, while SketchUp is easy to learn and models quickly. This paper summarized the research status both home and abroad, discussed the application of the technology in various fields, analyzed its advantages and disadvantages, and then explored the development prospect of it.

Keywords ArcGIS · SketchUp · GIS · 3D visualization

59.1 Introduction

With 3D GIS becoming increasingly prevalent, the demand from users is on the increase too: 3D GIS should not only achieve the 3D displaying, but also the spatial analyzing functions. However, the traditional 3D modeling software attached to the specialized modeling and displaying platform generally does not have the function of analysis or conjoint analysis with 2D GIS features. The naissance of SketchUp ESRI makes the joint modeling of ArcGIS and SketchUp become a reality, thereby providing a new way for the development of 3D GIS. Firstly, the ArcGIS software has powerful function of spatial analyzing. Secondly,

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_59,

SketchUp can model rapidly in such fields as architecture, gardens, landscape, interior design, industrial design, and so on, with material and texture to the models. Last but not least, ArcGIS offers interfaces to the SketchUp. So data interchanges easily between them thus laying a foundation for the accurate modeling and spatial analyzing functions of 3D GIS. When analyzed the research status and both the advantages and disadvantages of it, this paper explored the development trend of 3D GIS.

59.2 Research Status of GIS 3D Visualization

3D visualization of GIS, as an important development orientation of GIS, has been a research hotspot [1] since the late 1980s. In 1989, Professor Turner [2] hosted the first specialized meeting of the 3D visualization system supported by the North Atlantic Treaty Organization (NATO), which marked the comprehensive launching of the 3D visualization research. In 1996, the International Map Association and the Association for Computing Machinery SIGGAPH group made a interdisciplinary collaboration, and developed an action plan [3] called "CartoProject", aimed to explore how can the theory and technology of the computer graphics field be effectively applied to the field such as spatial data visualization, desktop virtual reality, cartography, and so on. Henceforth, because of the motive force of demand and the development of computer system, 3D GIS visualization became a research focus gradually. At present, the international community set up many specialized agencies [4] to do basic study in 3D GIS. Moreover, a large number of academic papers about 3D GIS were published, and mass of prototype systems of 3D GIS were developed, which promoted the application of the 3D GIS technology in various fields like mineral resource management, digital cities and so on.

However, due to the restriction of spatial database technology, 3D modeling software and GIS software, the development of 3D GIS system has encountered a lot of difficulties, for example, high professional knowledge requirements; modeling software is hard to learn; complex modeling process; poor spatial analyzing functions. While SketchUp software is easy to learn with low requirements of professional knowledge. It allows creating, displaying, and modifying 3D texture model in a relatively quick and easy way. At the same time, ArcGIS software has powerful spatial analyzing capabilities, and could exchange data with SketchUp via SketchUp ESRI plugin. Therefore, SketchUp professionals can create accurate 3D textured models based on ArcGIS, while ArcGIS professionals can model using the 3D Analyst extension with the SketchUp models as 3D symbols, or import MultiPatch data which is exported from SketchUp. In summary, the method of ArcGIS combined with SketchUp is a new way to realize 3D GIS visualization, and is attracting more and more researchers' attention.

59.3 Methodology of the ArcGIS Combined with SketchUp Modeling Technology

59.3.1 Main Modeling Software

The main modeling tools are ArcGIS software, SketchUp software. While they interact via the SketchUp ESRI plugin their features are as follows [5].

1. ArcGIS software.

ArcMap is a data processing platform with the function of edit, display, query, and analysis to the map; ArcCatalog is a layer manager, mainly used to manage spatial data storage and database design as well as the metadata record, review, and management; ArcScene is a platform for 3D scene. It projects all the data to the spatial reference of current scene, and the scene in ArcScene displays plane projection. So it is suitable for the scene of small area.

2. Google SketchUp software.

SketchUp software is simple ostensibly, but in fact powerful. It can form a program sketch quickly, as well as build, display, and edit the 3D models very soon. SketchUp software is suitable for buildings modeling, and the model file is very small, which is saving disk space and easy to transmit.

59.3.2 Modeling with ArcGIS and SketchUp

As a new modeling method of 3D visualization, the modeling method decides the complexity of the modeling process. So we describe the principles of the method in the following aspects:

1. Modeling methods.

There are three ways to create 3D models [6]: Property stretching, establishing with 3D symbols, and importing MultiPatch type data. The method of property stretching is rarely used in ArcGIS. Besides, though such method as establishing with 3D symbols and importing MultiPatch type data all can create 3D models, but the shape of the 3D models generated by the same universal symbol are identical. So the second method could not simulate the real situation. While 3D models generated by the type of the MultiPatch collections are different, possessing their own attribute information and being independent of each other. Therefore, in most cases, we use the method of importing MultiPatch type data to create 3D models. This paper mainly explores the method of importing MultiPatch type data to create 3D model as well.

2. Modeling process [7].

Firstly, the vector data is loaded into ArcMap. When the coordinate system is set and all elements are endowed with height value, the elements to be modeled will be selected, and then imported into SketchUp via SketchUp ESRI plugin. Secondly, elements are modeled and rendered. In this step, we should pay attention to the amount of the data, because the larger the amount the slower the operational speed. When models are created completely, we export them out as MultiPatch (*. mdb) type data. Thirdly, models are imported and reprocessed in the ArcScene. Finally, browse the realistic 3D scene in ArcExplorer or Google Earth.

59.4 Domestic and International Research Status

Although the international community set up a number of specialized agencies for basic research of 3D GIS visualization, and has developed many 3D GIS visualization prototype systems, but due to the restriction of spatial database technology, 3D modeling software, GIS software and so on, 3D GIS development encountered a lot of problems. As a new method of 3D GIS modeling, ArcGIS combined with SketchUp attracts more and more researcher's attention. The following passage is exploring the domestic and international research status of this method.

59.4.1 International Research Status

Since the issuance of SketchUp ESRI plugin, the research of ArcGIS combined with SketchUp 3D visualization method flourishes in many fields. Alaa et al. [8] took the first step of 3D virtual campus system supported by the technology, while Rodríguez et al. [9] using that method produced the land use change model and achieved good results. In the same year, the TAMS project [10] explored by the college of Engineering and Computer Science at the University of Tennessee in Chattanooga, established a 3D model of the city via the approach, so that we can communicate with the public and obtain data in real time in the city disaster emergency evacuation. And in the MedIsolae-3D project [11], a state-of-the art WebGIS technology project cofunded by the European Commission under the eContentplus Community Initiative Programme, they created 3D model on the Mediterranean coast using the method, which promoted the development of 3D map. Pichai et al. [12] established the 3D diffusion model of the Thai highway noise in the building on the basis of highway noise model with the help of the technology. Jason et al. [13] studied the 3D city model to prevent Terrorism Sniper hazards. So the method took the first step on terror prevention. Chanikarn et al. [14] studied the impact of the trees to the residential buildings' day lighting. BOBEK [15] from Czech Republic created a detailed 3D data model in that way to explore the methods of heritage protection. Kalli et al. [16] explored the 3D modeling of the cadastre in Greece, which contributed much to the development of 3D cadastre.

59.4.2 Domestic Research Status

This method of ArcGIS combined with SketchUp was widely used not only in foreign countries, but also in China. Wang [17] modeled the ancient village with the method. While based on the method, He [18] proposed a new idea to develop the 3D pipe network. Wang Cheng-fang [19] applied it in urban planning field. Deng et al. [5] setting Jilin University as an example, discussed the method of creating virtual campus in that way. Liu [20] studied the 3D modeling of the digital defense with the method. Almost at the same time, Xu et al. [21] introduced the technology of developing virtual 3D landscape through the approach of ArcGIS combined with SketchUp. Wu et al. [2] applied the technology to the vegetable base planning. In the same year, due to the frequent coal accidents and the high-risk of rescue, through joint research, Jia et al. [22–24] realized the 3D visualization of the coal ream and the roadway, and made functions of the rescue robot positioning, navigation, trace analysis, and best rescue path selection come true. Deng et al. [5] and Zhou [25] realized the district 3D visualization with the method. Liu [6] reproduced the 3D panorama of the study area, with topography map, aerial photos, forest map, and photos photographed by the model airplane as material and ArcGIS combined with SketchUp as modeling method, then studied the spatial structure and competition status of the forest.

In recent years, ArcGIS combined with SketchUp 3D modeling technology has become a hotspot both at home and abroad. In the country, many scholars explored this method in such fields as district 3D modeling, virtual campus, city 3D visualization, 3D landscape, mine disasters rescue, culture heritage protection, and digital defense and so on. Abroad, researchers of various domains explored this method in the areas like highway noise hazards analysis, land-use change, emergency communication system, virtual campus, digital city, heritage protection, counter-terrorism, 3D cadastre, and so on. ArcGIS combined with SketchUp 3D modeling technique makes the 3D visualization simple, precise, and functional, which have a significant impact on the future GIS 3D visualization.

59.5 Advantages and Disadvantages of the Technology

59.5.1 Advantages of the Technology

Due to the restriction of spatial database technology, 3D modeling software and GIS software, the development of 3D GIS system has encountered a lot of difficulties, for example, high professional knowledge requirements; modeling software is hard to learn; complex modeling process; and poor spatial analyzing functions.

While SketchUp is a convenient [26], easy-to-use, yet powerful 3D modeling software with free mass data resource in the Google Earth as a basis. Moreover, ArcGIS has powerful spatial analyzing functions. So the method of ArcGIS

combined with Sketchup improved modeling efficiency and reduced the restriction to the professionals, generally reduced the cost of the 3D modeling. Thus it is a new bright spot in the 3D visualization realm in recent years, and has demonstrated great prospect.

59.5.2 Disadvantages of the Technology

Although ArcGIS combined with SketchUp technology has many advantages, but as a 3D modeling approach, it also has some inadequacies.

For example, this method is relatively limited in space [19]. If the scope of the visualization is too large, the operational speed will be greatly reduced; at the same time, the precision of the 3D models are subject to the restriction of the operational efficiency. The higher the detail degree, the lower operating efficiency [19]; And when imported into ArcSence software, the SketchUp model often produces distortion [27] using the noninherent material; Furthermore, due to the SketchUp software lacking some advanced features like some other professional modeling software [27], the computer runs slowly when the amount of data increases; Though MutiPatch type can store some data, the efficiency is relatively low. So the storage and fast processing [28] of the 3D multivariate data is a problem; So currently, due to the restriction of the development technology and database technology, the spatial analyzing function [28] of the 3D visualization system is poor; moreover, because 3D data obtained in real time will waste a lot of time and manpower, the low-cost access of 3D data is a problem [28] in 3D visualization; and last but not least, the popularity of the 3D visualization is limited by the broadband penetration [19].

Though, the technology has such inadequacies, but as a new way of 3D modeling, it also is applied in many fields and guides the development direction of 3D GIS.

59.6 Summary and Scope

Wide use of the 3D visualization is an inevitable requirement for the development of GIS industry. Because the method of ArcGIS combined with SketchUp GIS 3D visualization modeling is easy-to-learn, relatively high precision, and low cost, it is studied by a majority of research workers home and abroad. Now it has been applied to the areas such as landform landscape simulation, cultural heritage protection, digital defense, district 3D visualization, virtual campus, digital city, and so on. However, due to such factors as the imperfect spatial database technology, 3D data acquisition difficulties, low level development of software and hardware and so on, this technology still cannot be used in a wide range of area currently. Nonetheless, what the technology brings to us is not a simple 3D modeling method. It guides GIS 3D visualization technology toward simplification, humane, and simultaneously pointed out the direction for the development of the GIS 3D visualization technology.

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Chapter 60
A Trust Evaluation Method for Distributed Components

Yonghao Wang and Guangping Zeng

Abstract If the applications are built by reusing the distributed components, the quality and development efficiency of applications can be significantly improved. However, it is very difficult to select the components with high Quality of Service (QoS) and security because of the openness and dynamics of Internet. Existing trust models are usually established on base of the historical interaction experience among software entities, and are not entirely suitable for the distributed components with strict requirements on QoS. On account of the problem, a trust evaluation method appropriate to distributed components is presented. The method not only meets the subjective and fuzzy characteristics of trust by being based on fuzzy logic theory, but also helps to solve the problems of selecting trusted components in open network by comprehensively considering the QoS and historical interaction experience.

Keywords Trust evaluation · Distributed component · Fuzzy logic · Quality of service

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_60, © Springer-Verlag London 2013

60.1 Introduction

With the deepening study of software engineering, the continuous improvement of software technology, and the rapid development of Internet technology, the CORBA, DCOM and EJB as the representative of the distributed component technology also have got rapid development; especially the emergence of Web Services makes increasing number of reusable distributed components. While internetware [1, 2], a new software form based on Internet [3], provides the broader space for the further application of distributed components. But how to select the distributed components with high Quality of Service (QoS) and security for reusing, which becomes a new research topic? Because the components are widely distributed in diverse, open and dynamic Internet nodes, these components are unpredictable in QoS and safety.

According to real-life experience, it is an effective method to use the trust relationship for solving the problem. By evaluating the trust level of the distributed components [4, 5], the QoS, security and reliability can be measured out, and the trusted components can be selected. At present, lots of research institutions and scholars at home and abroad have put forward some trust models for evaluating software entities, including Beth model [5], Jøsang model [6], TEM model [7], DTME model [8], etc. These models divide the trust into direct trust and recommendation trust, provide such logic operators as recommendation and combination, and are based on the historical interaction experience in evaluation basis of trust. These provide a great reference on evaluating the trust level of distributed components, and also include defects. The most important is that their evaluation are based on nothing more than a consideration of historical interaction experience, without considering QoS, which is very important for components. In addition, when modeling subjective trust, these models usually use the probability statistics or mathematics statistics method, which is equivalent to regard the subjectivity and uncertainty of trust as randomness, and is clearly incompatible with the inherent characteristics of trust.

Therefore, the paper presents a new method of evaluating trust for distributed components, which is based on the subjective and fuzzy characteristics of trust, uses the fuzzy logic theory, regards the QoS of distributed components as the evaluation basis, uses the successful and failure number of historical interaction experience to calculate the regulator factor of trust level, and at final evaluate the trust level of the components.

60.2 Description of Trust

The trust is a subjective judgment in fact, and has the characteristics of subjectivity, uncertainty and fuzziness. Fuzzy theory is put forward by the Zadeh in 1965, and can be used to describe and deal with fuzzy concepts and object.

Therefore, with the help of fuzzy membership and fuzzy linguistic variable in fuzzy theory, the fuzziness of trust can be studied well in quantity, thereby enabling trust model more realistic.

According to the definition by Zadeh in [9], if there is any element of x in the domain of U, existing a number of $A(x) \in [0,1]$ in response to it, it claims that A is the fuzzy set in U, and regards $A(x)$ as the membership of x on A. When x changes in U, $A(x)$ is a function, and is called the membership function of A. The membership of $A(x)$ is closer to 1, which means that the degree of x belonging to A is higher. On the contrary, $A(x)$ is closer to 0, this indicates that the degree of x belonging to A is lower.

Fuzzy linguistic variable is a kind of variable whose domain of data is the word or sentence described in natural language or artificial language. Although the words or sentences are not exact with the value, the fuzzy linguistic variables can be expressed as the phenomenon and concepts which are fuzzy, complex, and can't accurately be described in terms.

The trust obviously meets these characteristics, which can be described by use of the fuzzy linguistic variables. At first, multiple fuzzy sub-sets, T_j ($j = 1,2,3,\ldots, M$), are defined to represent the sub-sets with different trust level, that is to use discrete scale $\{1,2,3,\ldots, M\}$ to describe the level of trust. Meantime, T_j is named with natural language, which can give it an intuitive and practical significance. For example, when M is equal to five, T_j can be defined as follows:

T_1 the sub-set of complete distrust;
T_2 the sub-set of distrust;
T_3 the sub-set of basic trust;
T_4 the sub-set of trust;
T_5 the sub-set of complete trust.

Because fuzzy linguistic variable, the trust, has five sub-sets, it often can't be accurately determined their belonging to which of sub-sets. This means that various fuzzy sets aren't an exclusive relationship with one or the other, so that you can use the vector consisting of membership of various fuzzy sets to represent this object. The formalized trust vector is expressed as $V = \{v_0,v_1,\ldots,v_M\}$, where v_j is the membership of x_i to T_j.

60.3 Direct Trust

60.3.1 Comprehensive Evaluation of Trust

Fuzzy comprehensive evaluation is a quantitative evaluation mode based on fuzzy mathematics, and makes an overall evaluation on the objects by using fuzzy sets concepts and considering various factors related to the object.

Although trust is a kind of subjective judgments, the establishment of trust relationship must be based on objective facts. The trust relationships among

distributed components are the same as people, and should establish on the certain objective facts, where the objective facts are the QoS of these components. QoS consists of a set of attributes, the papers [10] have studied the QoS model appropriate to web service, and put forward an attribute set including response time, throughput, reliability, availability, accuracy, security, etc. This chapter [11] has presented a component quality model named Component QoS Mode (CQSM), which consists of a set of QoS dimension describing the component of service quality, and the service quality dimension consists of the QoS attributes.

Therefore, the trust relationships among distributed components not only have the nature of fuzziness, but also are composed of multiple sub-factors. Fuzzy comprehensive evaluation method can be used to make a comprehensive evaluation of the trust. The basic process is as follows:

(1) Determining the evaluation factor set of trust, E = {e1, e2… en}. Here e_i is the attribute of QoS. Because different applications have different requirements in QoS, the number and type of attribute should be determined according to specific requirements.
(2) Determining the evaluation set of trust. According to the content above, m can be set to five, which means to define such five sub-sets as complete distrust, distrust, basic trust, trust, complete trust. It also enables to be redefined according to actual needs.
(3) Establishing the factor evaluation matrix. By building the fuzzy map between factor set E and evaluation set D, the matrix element r_{ij} can be gotten.
(4) Determining the weight allocation of various factors. Different weights must be given under the influence of various factors on the extent of the object. The weight should follow the objectivity, orientation and measurable principles.
(5) Executing the fuzzy comprehensive evaluation, and getting the trust vector. The formalized representation is as follows:

$$(v_0, v_1 \ldots v_M) = (w_1, w_2 \ldots w_n).\left(R_{ij}\right)_{n \times M} \tag{60.1}$$

where "." represents the fuzzy transformation, operators can be determined according to the specific situation, and common operators include Zadeh, Einstein operator, etc.

60.3.2 Regulatory Factor of Trust Level

Trust relationship is not static, and will change with the increase of the interaction number. If the number of successful interaction is more than that of failure interaction, the trust relationship will deepen. Otherwise, the trust relationship will diminish.

The trust vector gotten by fuzzy comprehensive evaluation is static; because it is completely based on the collection of QoS of components before, and can't reflect the dynamic change. The trust level should be adjusted dynamically

according to the interaction situation. Therefore, a regulatory factor of trust level should be used to adjust the trust level dynamically, which can be gotten on the basis of the number of successful and failure interaction. Assuming that the total interaction number of component A and component B is M times, where the number of successful interaction is N times, the regulator factor of trust level can be quantified on $\delta = \frac{N}{M}, \delta \in [0, 1]$. After being adjusted by regulatory factor of trust level, the trust vector can be formally expressed as:

$$V' = (v_0, v_1, \ldots, v_M)\delta = (\delta v_0, \delta v_1, \ldots, \delta v_M) \tag{60.2}$$

60.4 Recommendation Trust

In a large distributed system, it is difficult to obtain knowledge about every component in the network, let alone first hand knowledge and experience of them. So it is necessary to have another type of trust except for the direct trust, which is the recommendation trust. The recommendation trusts can also be divided into single-path and multi-paths recommendation trust.

60.4.1 Single-Path Recommendation Trust

Single-path recommendation trust is as shown in Fig. 60.1, where i is an evaluators, j is an evaluated object, and $p_s (s = 1, 2, \ldots, n)$ is the intermediate recommender. The process of recommendation is the process of transferring trust information. When the component i need to cooperate with the component j, because i isn't familiar with the j, then i asks other cooperated components for help i. Selects a component with higher trust level (for example p_1), and submits a request to it, if the component p_1 cannot complete the requested task, and will continue to pass the task, until finding a component (for example, p_n) having a direct trust relationship with j. Then p_n transfers the trust evaluation on j back to p_1 step by step, the final recommendation information given by p_1 combines the recommendation information of all recommenders in the path.

When calculating the recommendation trust level, assuming that the recommendation trust level of p_1 on i is RT_1, that of p_2 on p_1 is RT_2, and so on, that of p_n on p_{n-1} is RT_n, and the direct trust level of p_n on j is DT, then the final trust level of i on j can be expressed as in formalization:

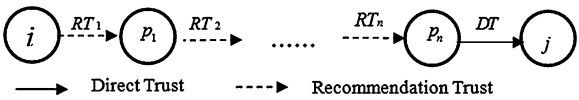

Fig. 60.1 Single-path trust recommendation network topology

$$T_{ij} = RT_1 \times RT_2 \times \ldots \times RT_n \times DT \tag{60.3}$$

As $RT_i(\mathrm{i} = 1, 2, \ldots, \mathrm{n})$ means the trust level of recommendation information, has little relation with the QoS of recommender itself, and mainly depends on the historical interaction between two components, RT_i can be replaced with regulatory factor of trust level between p_i and p_{i-1}. DT of p_n on j can be gotten by calculating the QoS of j directly. Because of $RT_i \in [0, 1]$, the formula also reflects the characteristics that the recommendation trust level will gradually decline with the growth of trust chain.

60.4.2 Multi-Paths Recommendation Trust

There are probably multi recommendation paths between evaluator and evaluated object. Evaluator needs to merge this recommendation information to acquire the real trust level. The multi-paths trust recommendation network topology is just shown as Fig. 60.2. In the figure, i is the evaluator, j is the evaluated object, and p_i and q_i are the recommenders in various paths.

When merging the recommendation information in the multi recommendation paths, the recommendation results may incompletely be consistent because of the complexity of trust network, sometimes quite the contrary. When little of malicious components in some transmission paths raise or lower the real trust information of the evaluated object intentionally, its recommendation information maybe conflict with other recommendation information. If these are merged directly, the result is probably unreliable.

Therefore, by using the fuzzy clustering analysis method [12], all the recommendation trusts are divided into trust type or distrust type according to the cut-off matrix with $\lambda = 0.5$, which are respectively represented with *TRUST* and *DISTRUST*.

In the acquisition of fuzzy similar matrix, the absolute value subtraction method can be used here:

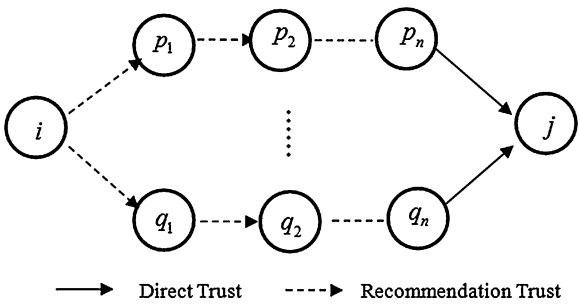

Fig. 60.2 Multi-paths trust recommendation network topology

$$r_{ij} = 1 - c\sum_{k=1}^{m}\left|X_{ik} - X_{jk}\right| \tag{60.4}$$

In the formula, c should be appropriately selected, so that r_{ij} can be in $[0, 1]$ and decentralized.

After acquiring the *TRUST* and *DISTRUST*, the fuzzy reasoning rules of knowledge can be defined as follows:

(1) If the number in *TRUST* is much more than that in *DISTRUST*, *DISTRUST* will be abandoned, and weighted average only is used to the trust information in *TRUST*;
(2) If the number in *DISTRUST* is much more than that in *TRUST*, the whole recommendation process must be abandoned;
(3) If the number in *TRUST* and *DISTRUST* has little difference, weighted average can be used to all the trust information in *TRUST* and *DISTRUST*.

The recommendation information through the fuzzy reasoning rules gets comprehensive multiple entities recommended information and references various opinions extensively, which can effectively restrain the vandalism of malicious recommendation entity and improve the accuracy of the trust model evaluation.

60.5 Conclusion

The trust evaluation method for distributed components presented by the paper better reflects the subjective and fuzzy characteristics of trust by comprehensively using the methods of membership, fuzzy linguistic variables, fuzzy comprehensive evaluation, and fuzzy clustering analysis in fuzzy logic theory. Meantime, the method regards the QoS of components as the basis of trust evaluation and the historical interaction experience as the regulator factor of trust level, which ensure the evaluated trust level can comprehensively reflect the QoS and security of components. The method provides an effective solution for selecting trusted distributed components.

Acknowledgments We thank the National High Technology Research and Development Program of China (863 Program) (No.2009AA01Z119) and the National Natural Science Foundation of China (No.60973065) for partially supporting our research work.

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Chapter 61
Improved Diamond Search Algorithm

Xiujuan Sun, Deyun Yang and Yingkun Hou

Abstract In order to improve the accuracy and speed of template matching, the paper presented a new fast search algorithm and called it the improved diamond search (IDS) algorithm. Through analyzing and carrying out several main search algorithms, the center-biased of motion field was taken into consideration in whole process. In addition, IDS algorithm added rough location and enhanced halfway-stop procedures to speed up convergence. Lots of vehicle tracking experiments show that the search performance of IDS algorithm is moderate. Moreover, contrastive experiments prove that IDS algorithm achieves faster search speed, supplying more effective technical support for template matching.

Keywords Improved diamond search algorithm · Motion vector · Rough location

61.1 Introduction

Owing to relatively simple calculation and strong robustness, template matching technology has been applied in numerous fields, for example object tracking. However, simple template matching algorithm has the following weakness: firstly, computation amount rapidly increases with the increasing of the template scale or

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_61,

search scope; secondly, it cannot adapt to scale change of the target in image; and thirdly, because the template cannot steadily update with target shape deformation or interfere, it is vulnerable to lead to the template drift, even tracking failure [1]. Aiming at the computation amount problem, researchers have put forward many solutions. In the literature [2], several fast search algorithms were introduced in details, such as three-step search (TSS), four steps search (FSS), new three-step search (NTSS), and diamond search (DS), etc. But these algorithms have their own problems about search performance or speed, so they are hard to be used in reality.

In order to solve the above question, this paper puts forward the improved diamond search (IDS) algorithm. The algorithm combines merits of TSS, NTSS, and DS algorithms, and increases the search speed on the basic of ensuring the search performance. Contrast experiments shows the IDS algorithm has better tolerance for trajectory change than TSS algorithm, and realize nearly global optimum.

61.2 Three Conventional Fast Search Algorithms

The studies showed, size and shape of the search patterns not only influence the speed of motion estimation, but directly affect the performance of algorithms [3]. In this section, we further prove the point by analyzing TSS, NTSS, and DS algorithms.

61.2.1 TSS Algorithm and NTSS Algorithm

TSS algorithm [4] completes the search by only three square patterns of different step lengths. It is simple to calculate and quick to converge. Unfortunately, the step length in the first step is so big that it is apt to mislead the search direction and fall into the local optimum. In addition, when the motion vector (MV) is small, it is inaccurate and inefficient. Algorithm theory is shown in Fig. 61.1.

NTSS algorithm [5] taking center-biased of motion field into consideration, adds 3×3 square patterns in the first step of TSS algorithm, just as Fig. 61.2a. With the help of the patterns, NTSS gets better search performance. In addition, NTSS algorithm designs halfway-stop technique, which makes it have faster convergence when the MV is not large. However, when the MV is large, for example Fig. 61.2b, NTSS needs more search positions than TSS.

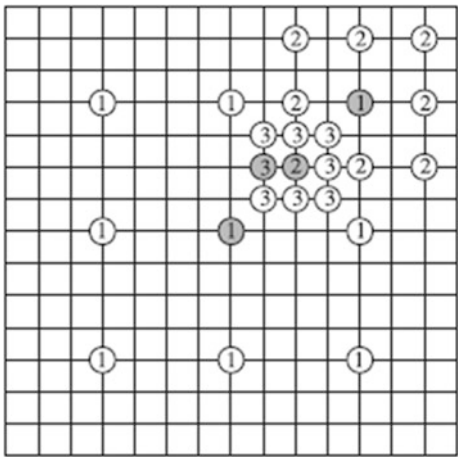

Fig. 61.1 TSS algorithm theory

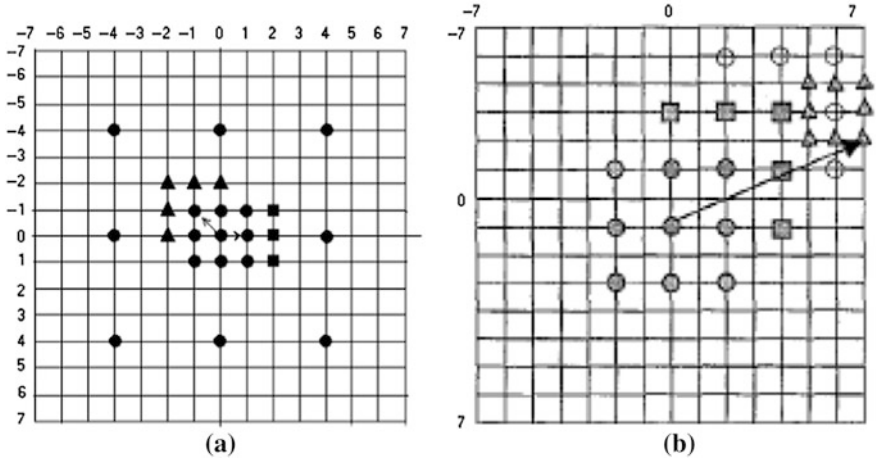

Fig. 61.2 The sample figures of NTSS algorithm. **a** The case of small MV. **b** The case of large MV

61.2.2 DS Algorithm

DS algorithm [6] successively uses large diamond search pattern (LDSP) and small diamond search pattern (SDSP). The algorithm has its own characteristics [3]: firstly, the diamond patterns have so strong correlation that calculate only three or five new search positions in each temple motion, which reduces the computation amount of DS algorithm; secondly, iterative processes enlarge the search scope to help DS algorithm achieve nearly global optimum. But compared with FSS

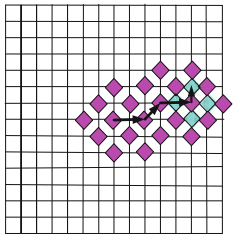

Fig. 61.3 DS algorithm theory

algorithm or TSS algorithm, its convergence speed is slow. Figure 61.3 shows the algorithm theory.

61.3 Improved Diamond Search Algorithm

Because the total calculation amount in matching algorithm is decided by calculation amount of the used matching criterion and the number of search positions, it is necessary to reduce the number of search positions to the greatest extent. Of course, it is quite important to guarantee the matching performance. Therefore, this paper presents a new fast search algorithm, i.e., IDS algorithm. Its principle is displayed in Fig. 61.4.

61.3.1 IDS Algorithm Description

For an $M \times N$ object, the object function of search algorithm is showed in Eq. 61.1.

$$E(u,v) = \sum_{i=1}^{M-1} \sum_{j=1}^{N-1} |f_{t-r}(i+u, j+v) - f_t(i,j)| - W < u, v < W \qquad (61.1)$$

where u, v is the candidate motion vector, $f_{t-r}(\cdot, \cdot)$ and $f_t(\cdot, \cdot)$ refer to pixels of $(\cdot, \cdot)$ in a previous frame and current frame that are to be compared, and W is the maximal motion in vertical and horizontal directions.

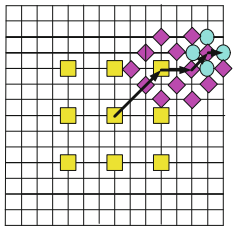

Fig. 61.4 IDS algorithm theory. The *yellow* pattern is square pattern, the *pinkish red* ones are LDSP, the *black* one is the SDSP, and the *arrow* indicates the search direction

The specific steps of IDS algorithm are as follows:

Rough location of search direction,

Search 7 × 7 square pattern in the current frame to find out the optimal solution of the objective function;

If the optimal solution is the center of pattern, search 3 × 3 square pattern around the center to find out the optimal solution of the objective function. Stop the search; (The first enhanced halfway-stop)

If the optimal solution is a neighbor of pattern and the similarity is larger than threshold, replace the center with the optimal solution, and search 3 × 3 square pattern around the new center to find out the optimal solution of the objective function. Stop the search; (The second enhanced halfway-stop)

Otherwise, replace the center with the solution. The rough location is over. Turn to step 2;

Shrunk search pattern to 5 × 5 LDSP, and find out the optimal solution of the objective function;

If the optimal solution is the center, turn to step 3;

If the optimal solution is on the edge of search scope, turn to step 3; (The iteration is terminated ahead of schedule)

Otherwise, replace the center with the optimal solution, apply LDSP again, and turn to step 3;

Shrunk search pattern to 3 × 3 SDSP, and find out the optimal solution of the objective function. Now the optimal solution is the final MV. Searching is over.

61.3.2 IDS Algorithm Analysis

It is easy to prove that IDS algorithm guarantees the search performance. IDS algorithm mainly relies on DS algorithm which reaches nearly global optimal. Taking fast convergence of TSS algorithm and center-biased of NTSS algorithm into consideration, this paper sets square pattern as the initial search pattern. Different from TSS algorithm, the step of square pattern is shrunken to 3. Because considering the center-biased of motion field, the initial pattern can not only supply rough location for diamond search, but also reduce the probability of wrong search direction. In the whole process, the center-biased of motion field is considered to stop the search at the suited time. If the optimal solution is the center of pattern, the probability of MV around it is extreme high. So execute once enhanced halfway-stop and stop the search. If the optimal solution is on the edge of pattern and the similarity is sufficiently large, the probability of MV around it is also very high. We carry out enhanced halfway-stop and stop the search. Otherwise, remove the pattern center to the optimal solution. The rough location is over. Studies showed that the probability of MV being enclosed in central 5 × 5 area is very high [4], so the MV maybe smaller than 2 after rough location. In order to avoid inefficiency of LDSP when the MV is smaller than the step, this paper uses

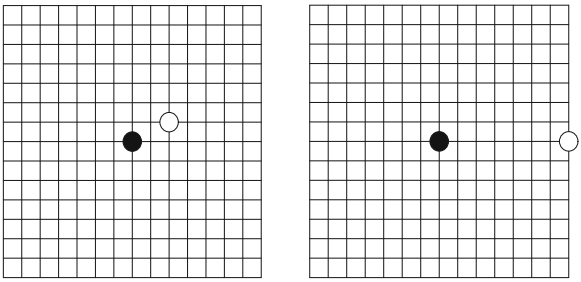

Fig. 61.5 Two sample charts. **a** The case of small MV. **b** The case of large MV. The *black* point is the center of search scope, and the *white* point is the target point

twice LDSP at most. Finally, the SDSP which has relatively complemented positions of LDSP is used to stop the search.

The used 3×3 square patterns in two enhanced halfway-stops are designed to improve the motion estimation performance under ensuring the MV candidate range.

Compare the computation amounts of FS (the full search), TSS, NTSS, DS, and IDS algorithms to prove the efficiency of IDS algorithm. Whatever the case, FS need search $15 \times 15 = 225$ positions; TSS need search $9 + 8 + 8 = 25$ positions. When the target point is far from the center, for example the white position in Fig. 61.5a, MV is small, NTSS algorithm needs $9 + 8 + 5 = 22$ positions, and DS algorithm needs 16–22 positions while IDS needs $9 + 8 = 17$ positions. When the MV is zero, for example the black position in Fig. 61.5a, NTSS needs $9 + 8 = 17$ positions, and DS algorithm needs $9 + 4 = 13$ positions while IDS needs $9 + 8 = 17$ positions. When the MV is large, for example the white position in Fig. 61.5b, NTSS needs $9 + 8 + 8 + 8 = 33$ positions, and DS algorithm needs $9 + 5 + 5 + 4 + 4 = 27$ positions, while IDS needs $9 + 8 + 5 + 3 = 25$ positions. As a whole, IDS algorithm needs fewer search positions than the others.

In effect, the number of search positions demanded in IDS algorithm can be calculated by Eq. 61.2.

$$L = 17P_1 + 21P_2 + 24P_3 + 25(1 - P_1 - P_2 - P_3) \tag{61.2}$$

where P_1 is the probability of occurring enhanced halfway-stops; P_2 is the probability of occurring once LDSP; P_3 is the probability of LDSP moving along diagonal direction. These probabilities depend on the MV.

The number of reduced positions is limited, but the significance is immense. The computation amount issuing from matching is large at each search position, so the reduced calculation amount of just these positions is enormous. Visibly, IDS algorithm remits the computation pressure of template matching.

61.3.3 Experimental Result and Analysis

The proposed algorithm has been tested in various vehicle tracking experiments. In addition, this paper compared it with FS, TSS, NTSS, and DS algorithms. Experimental results proved the efficiency and robustness of the proposed algorithm.

In experimental environment of this paper, the computer configuration is: Intel Pentium CPU 1.86 GHz processor, 1G memory, Microsoft Windows XP Professional operating system, Matlab R2009a compile software, and video image size of 768 × 578 pixels.

Template matching algorithm based on Gaussian scale-space [1] was used to track vehicles under trajectory change. Then compare FS, TSS, NTSS, DS, and IDS algorithms by tracking results. The 2, 68, 95, and 302 frames are shown in Fig. 61.6. The target occurred trajectory change in the whole procedure, especially in the 68–95 frames. The tracking results of NTSS and DS algorithms are similar to IDS algorithm, and omitted. Experimental result shows, when the trajectory undergoes large change, tracking algorithm based on TSS is not moderate and apt to track failure while tracking algorithm based on IDS is not influenced by trajectory change. The reason is that trajectory's change can lead to target's MV change in the image. Before the mobile turn, MV is large, and TSS algorithm can achieve good tracking; after the mobile turn, the motion direction is nearly parallel to light axle of video, MV is so small that TSS algorithm performance descend. But IDS algorithm is not limited by MV, and keeps good search performance.

The drift situation contrast diagram of the experiment is shown in Fig. 61.7. Obviously, the proposed algorithm is much better at dealing with the trajectory

Fig. 61.6 Mobile tracking under trajectory change, the first row is the result used TSS algorithm; the second row is the result used IDS algorithm. The *red* box indicates tracking success while the *green* box indicates tracking failure

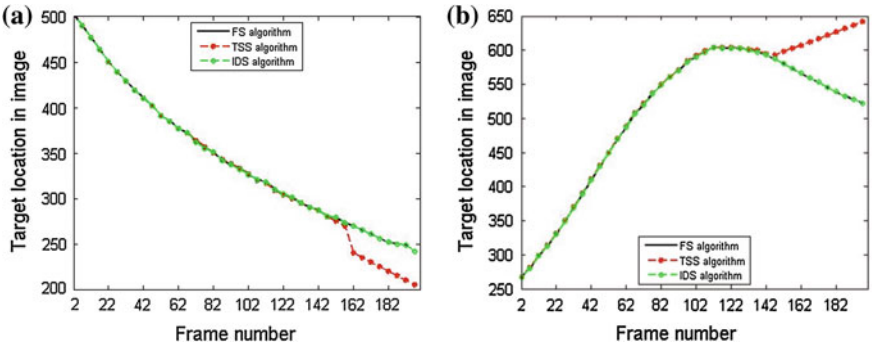

Fig. 61.7 The drift situation contrast diagram. **a** The target's location on X-axis. **b** The target's location on Y-axis

Table 61.1 Mean consuming time of different search algorithms

Algorithm	Average consuming time (s/frame)
FS	2.2201
TSS	0.2397
NTSS	0.2497
DS	0.2412
IDS	0.1925

change than the others. When the trajectory has large change, we can see that the performance of IDS algorithm is similar to FS algorithm.

Search algorithms are different not only in search performance, but also in search speed. Table 61.1 describes contrast result. Obviously, IDS algorithm really brings about faster convergence than other search algorithms.

61.4 Conclusion

For the sake of solving the calculation problem of template matching, this paper put forward the IDS algorithm. Experiments have proved its abilities in both search performance and speed. However, the proposed algorithm cannot realize the global optimum like FS algorithm. Further work will lay out in this respect.

Acknowledgments This work was supported by the National Nature Science Foundation of China (61072148).

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Chapter 62
Study on Gait Adaptation in Slips and Falls Based on Fluctuation of the Center of Mass

HaiLong Su, JunXia Zhang, Hui Zheng and Jun Hu

Abstract To inquire into the frequent slips and falls in older adults of myasthenic lower extremities in detail, a method was proposed that could analyze the process of slips and falls with the modified peak of required coefficient of friction (RCOF) and the amplitude of the body center of mass (COM). This method can be used to rapidly detect parameters in each gait cycle, and analyze every instantaneous balance status during walking. According to the results, the key point thresholds of slips and falls have been judged and verified and the theoretical groundwork for slips and falls' gaits has been established. By comparing the experimental data between no myasthenia and myasthenics, myasthenic older people's gaits became more and more unstable because of the weak ability of neuromuscular control. Because of it, slips and falls more easily occur on myasthenia older people. The experimental data show that the method can well and effectively reveal the process of slips and falls.

Keywords Slips and falls · Gait adaptation · Center of mass · Fluctuation

62.1 Introduction

Falls are a major threat to the independence and quality of life of older adults. Fearful of such an outcome, older adults often restrict their activity to avoid the risk of falling. Unfortunately, this very behavior actually increases the risk of falling by causing loss of muscle and strength.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_62,

With age, normal adults, especially the elderly people will be decreased muscle strength and reduced joint activity. In particular, lower limb's muscle strength decrease leads to insufficient balance and gait instability and it will have a direct impact on human activity, resulting in the risk of slipping. Special consideration is given to people of age 65 or older because this is the population of adults at highest risk for falls [1]. And indoors fallings in old adults also occurred in the regular activities of the room, such as bedroom and kitchen.

According to statistics, for the 57 million persons injured in 1985, the cost amounts to $157.6 billion, or $2,772 per injured person [2]. While the study in 1994, Englander, who updated the data of fall damage for each person to spend $7,399, which falls in the elderly population throughout the United States, the total cost of the damage is 202 billion dollars [3]. Fall that can cause brain damage, soft tissue injuries, fractures, dislocations, and other injuries, is a matter of paying attention to the issue of elderly care.

Much research has been done on gait and balance control in the older adult population. Tang [4] compared the old and the young people's, the different reactions produced when slipping during walking, and found that slow reaction time and muscle strength of older people who are more likely to cause a slip and fall are major factors. Meyer [5] focuses on dynamic stability. In dynamic stability, both the base of support and COM are in motion, and effective balance function is required. Kemoun [6] investigated the kinematic and kinetic characteristics of walking in healthy nonfaller elderly in order to develop predictive parameters for falls and found that subclinical gait parameters occur in older people. Didomenico [7] and Droegemeier [8] studied on the relationship between the displacement of the heel touching the ground after slipping and the subjective evaluation of events. Yang [9] studied on human balance strategy of trans-femoral prosthesis users during slip gait and its application. Under summary of the work done, the dynamic model of the lower limb with Kane equation was proposed and gave the calculation method of the amendment maximum slipping friction coefficient during the process of the body balance adjustment, slip, and fall response factors.

62.2 Model

The lower limb is composed of hipbone, thighbone, patella, shankbone, fibula and foot bones, including the three largest joints of human body (hip, knee, and ankle joints). The human hip joint is the largest and one of the most stable joints and also is a typical ball mortar joint.

The lower limb musculoskeletal model is 3-link and 3-rotation-freedom joint model. Assuming that the lower limb was in uniform motion relative to the inertial reference system during the experiment, that is $\dot{x}_s = \dot{y}_s = \text{const}$. Then it has 6 degrees of freedom, and hip is 3, knee is 1, ankle is 2. The motion parameters of the lower extremity walking model was defined in Fig. 62.1, and (x_s, y_s) is the generalized coordinates of the lower limbs and torso center of ball and socket joint connecting,

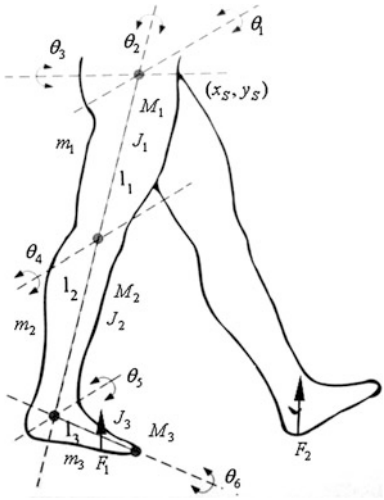

Fig. 62.1 Kinematic parameters of lower limb

respectively, thigh, calf, and ankle joint angles. $\theta_i (i = 1, 2, \ldots, 6)$ are generalized coordinates of the thigh, leg, and foot joint ankle. $m_i, l_i, J_i (i = 1, 2, 3)$ are the quality, length, and moment of inertia of thigh, leg, and foot. The dynamic equations of walking model by Lagrange kinetic equation will be established [10, 11].

$$J(q)\ddot{q} = B(q, \dot{q}, G, M, F) \tag{62.1}$$

where $J(q) \in R^{6\times 6}$ is the inertia matrix for the lower limb. $q = [\theta_1, \theta_2, \theta_3, \theta_4, \theta_5, \theta_6]^T$ is the generalized coordinates for the 6 degrees of freedom array, and $G = [m_1 g, m_2 g, m_3 g]^T$ is the mass matrix for the lower extremity. $F = [F_1, F_2]^T$ is the matrix of the ground reaction force from force platform and $M = [M_1, M_2, M_3]^T$ are the driving torques within the joints. Taking into account human walking is the periodic motion between left and right led alternately, as listed above kinetic equation suits to the left leg (Fig. 62.1).

62.3 Slip and Fall Motion

There are two phases during people's walking, including slip and fall. In order to obtain the kinetic parameters, Kane equation and the generalized velocity of joint angle are used to facilitate the kinetic equations. The Kane equation based on the human lower limb during waling bionic model, and the parameters are as follows: (1) the subscript L and R represent the left and right led, H, K and A, respectively, the hip joint, knee joint, and ankle joint; (2) C_r represents the centroid of each rod; (3) let the hip rotation center of the orthogonal unit vector $h_i (i = 1, 2, 3)$, and their definition are uniform to the inertial reference system O. There are a group of

orthogonal unit vectors (k_{Li}, k_{Ri}, a_{Li}, a_{Ri}, e_{Li} and e_{Ri} $(i = 1, 2, 3)$), while subscript 1 unit vector pointing the direction of rod length.

Assuming the distance between 3-rod centroid and the joint rotation center is r_1, r_2 and r_3, respectively, the walking kinetic equation could be obtained according to Kane equation.

Because of both sides of the legs being similar with kinetic equations, the left leg side of the equation is to be written only. Selecting three generalized velocity as follows.

$$u_h = \dot{\theta}_{HL},\ u_k = \dot{\theta}_{KL},\ u_a = \dot{\theta}_{AL} \tag{62.2}$$

Thigh, leg, and foot-rod angular velocity, respectively,

$$\omega_h = u_h h_3 \quad \omega_k = u_k k_{L3} \tag{62.3}$$

Containing the generalized active force (torque), the generalized inertia force (torque), and the ground reaction force (moment) from force platform, the Kane dynamic equations are

$$\begin{cases} \sum_{r=1}^{4} F_{C_r}^{(r)} + F_{C_r}^{*(r)} = 0 \\ \sum_{r=1}^{4} M_{C_r}^{(r)} + M_{C_r}^{*(r)} = 0 \end{cases} \tag{62.4}$$

where, $F_{C_r}^{(r)}$ and $F_{C_r}^{*(r)}$ are the joint generalized active force and the generalized inertia force suffered on the centroid C_r, and $M_{C_r}^{(r)}$ and $M_{C_r}^{*(r)}$ are the joint active torque and generalized moment torque of inertia suffered on the centroid C_r. According to Eq. (62.4) to determine the three unknowns u_h, u_k and u_a, so while walking the instantaneous state of motion, any data can be determined from the above equations.

62.3.1 Slipping Process

Slip is required to estimate by the sliding friction coefficient (Required coefficient of friction, f_{RCOF}), and its peak value is the maximum friction coefficient ($f_{\mathrm{RCOF_{max}}}$). Maximum friction coefficient is the course of normal walking, slipping does not occur in the case of foot and the ground must be able to provide the maximum coefficient of friction. It is completely determined by the characteristics of human gait, and ground conditions nothing. When the ground can provide more than $f_{\mathrm{RCOF_{max}}}$ real friction coefficient, slipping occurs, while no slipping. $f_{\mathrm{RCOF_{max}}}$ may reflect in the gait characteristics of integrated ground reaction force, moreover it can serve as a slip risk criterion.

According to the 3-rod walking model, a modified formula was used to calculate to RCOF of the left leg during walking [9].

$$f_{\mathrm{RCOF}_{\max}} = \max\left(\frac{F_2 \cdot e_{L2}}{F_{C_{L3}} \cdot e_{L1}}\right) \tag{62.5}$$

$$f_{\mathrm{REAL}_{\max}} = \max\left(\frac{F_2 \cdot e_{L2}}{m_3 g \cdot e_{L1}}\right) \tag{62.6}$$

where, F_2 is the GRF of the left foot and $F_{C_{L3}}$ is the inner joint driving force of the left foot-rod. e_{L1} and e_{L2} are the unit vectors of the left foot-rod end, respectively. The formulas contain the angle relationship between the foot-rod and GRF, ankle dorsiflexion, so it could reflect the critical state about body posture parameters when slipping and falling.

62.3.2 COM Characteristic

Human walking process is a dynamic equilibrium at all times maintain the instantaneous process, so people's COM will show the fluctuation of changes during walking. But the stable COM changes during walking for the individual, there is a defined range. As the nervous system, there is a big delay from the feedback received (0.15–0.25 s), the human foot center of pressure (COP, Center of plantar) and COM control coordination between the joint stiffness is accomplished, with the stiffness control joint angle changing start immediately. Almost simultaneously with the COP and COM to move, and the amplitude of COP movement greater than the COM's, the difference with the level of acceleration is proportional to the COM. Because COM and hip rotation center can be seen as rigid connection during the walking process, COM could be calculated by the hip rotation center.

$$\begin{cases} v_{C_{L3}} = r_1 u_h h_1 + r_1 u_h h_2 + r_2 u_k a_{L2} + r_3 u_a e_{L2} \\ F_{C_{L3}} = \dfrac{\partial v_{C_{L3}}}{\partial u_a} \cdot m_3 g \end{cases} \tag{62.7}$$

where, $r_i (i = 1, 2, 3)$ is the distance between thigh-rod, leg-rod, and foot-rod and each joint rotation center. $F_{C_{L3}}$ is the generalized active force (including force platform reaction force) of the foot-rod 2. The relationship between any transient ground reaction force and absolute speed of the hip joint center could be obtained by Formula (62.7). On the basis, corresponding to different individuals walking the COM position will be appropriately compensated, we can derive any instantaneous value of COM.

Table 62.1 Comparison of f_{RCOF} and f_{REAL}

		$f_{RCOF_{max}}$	$f_{REAL_{max}}$
Normal	Stance phase	0.141	0.153
	Swing phase	0.102	0.128
	Begin slipping	–	–
Myasthenia	Stance phase	0.131	0.149
	Swing phase	0.102	0.121
	Begin slipping	–	0.086

62.4 Experiment

A laboratory study was conducted to examine gait changes associated with aging and the effect of these changes on initiation of slips and frequency of falls utilizing newly defined biomechanical parameters of slips and falls. A total of 56 participants (42 male and 14 female, average age 64.52 and min 60, max 72) from two groups (nonfaller and five or more minor slips at least in the past year) walked around a straight track at a comfortable pace wearing a safety harness.

From Table 62.1, the comparison experimental data of the two group's fiction coefficient are shown. Because of the myasthenia lower limb, older adults' gaits have been affected and could be more prone to slip and fall compared with the normal elderly.

Because of the elderly' muscle weakness decrease in neuromuscular control, according to Table 62.2, gaits of these elderly are tend to be unstable and the ability to balance recovery is becoming to gradually descend after slips and falls. Figure 62.2 shows the value of y_{COM} fluctuation of two groups of subjects in a gait cycle. The value of COM fluctuations are larger than the normal elderly indicating that part of the swing phase is more difficult to control gait body posture. When the stance phase and the swing phase alternating, especially in the early swing phase (0.25–0.42 s after starting), the longitudinal gait fluctuations are bigger. Taking

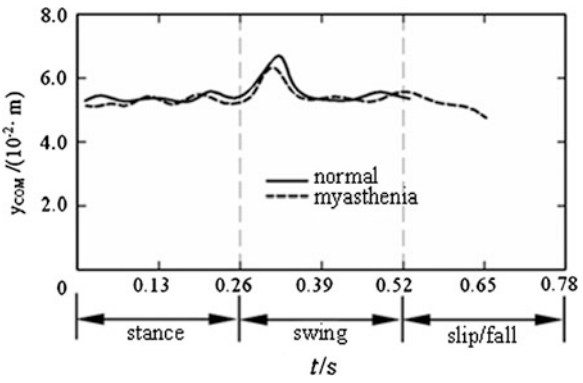

Fig. 62.2 Gait characteristic of y_{COM}

Table 62.2 COM changes during walking

Gait cycle		COM_{min}	COM_{max}
Normal	Stance phase (m)	0.0156	0.0168
	Swing phase (m)	0.0375	0.0445
Myasthenia	Stance phase (m)	0.0160	0.0182
	Swing phase (m)	0.0413	0.0440

into account $f_{RCOF_{max}} > f_{REAL_{max}}$, silps and falls begin at this time for the myasthenia old adults.

62.5 Conclusion

Based on analyzing the slips and falls between lower extremity normal old adults and myasthenia, a dynamic walking model aiming at the slips and falls phenomena was established and a new calculation method that could determine RCOF was proposed. The equation of COM position was derived by the dynamic model, besides the experimental data were gained to verify the dynamic model. In conclusion, the maximum RCOF can be analyzed to judge and predict the slips and falls; however, the whole body COM characteristic during walking provide a theoretical reference to slips and falls events. To better predict slips and falls, factors influencing recovery of slips and falls should be examined.

Acknowledgments Funding for this project was provided by Natural Science Foundation of Tianjin (No. 11JCYBJC05700 and 10JCYBJC06800) and the National Natural Science Foundation (No. 50975204).

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Chapter 63
Anticounterfeiting Structural Designs of Liquor Packaging Based on Product Semantics

Xinglong Hu, Taolin Ma and Congcong Zhao

Abstract Based on product semantics, this paper puts forward an innovative design idea, called "Trademark Simulation". Following the guidance of product semantics, through the appropriate aided design software of the packaging, the anticounterfeiting structures of liquor packaging have been achieved. Finally, program analysis, evaluation, and related dimensions of semantic computing have been finished. This paper provides a reference for the application of product semantics in the packaging design of specific product and broadens the design ideas.

Keywords Liquor packaging · Anticounterfeit · Product semantics · Product design · Structure design

63.1 Introduction

Product semantics study the Symbolic features of the artifact's morphology and how to apply this in industrial designs [1]. Products stimulate the human senses through a variety of symbolic language, and then through information processing to produce the impression of the product in the brain. The product design process is processing and integration of these symbols, such as material, shape, color, and thus we can obtain a product with functional and spiritual values [2]. Shape, color, and material having their own emotional characteristics, put them together can produce different feelings. Product designers should in-depth study of ergonomics,

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_63,

materials, technology, markets, and corporate culture, which can help us mix those design elements in a best way to show the emotional characteristics [3]. The other hand, we must clearly know there are a lot of counterfeit cigarettes, fake food, and fake drinks in the market. The white wine is special goods, it is with high tax and consumed in a large quantities. Law-breakers, in order to seek illegal interests, manufacture false goods to escape the national tax, while harming the consumers in interests and mentally, so anticounterfeiting is urgent.

63.2 The Anticounterfeiting Structural Designs of Liquor Packaging Based on Product Semantics

63.2.1 Bottle Shape and Size Design

Capacity [4]. The nominal capacity is the capacity of the bottle container should have when filling to filling standard line at the temperature of 20 °C, This article set 500 ml as the nominal capacity.

Headspace capacities refer with: Eq. 63.1:

$$V_{\mathrm{h}} = K_V V \tag{63.1}$$

Check the under Table 63.1, $K_v = 3$ %, by the formula: $V_h = 500 \times 3$ % $= 15$ ml.

Mouthful capacity V_0 is the capacity of the contents filling to the plane of the bottle mouth.

Refer with: Eq. 63.2:

$$V_0 = V + V_h + V_s \tag{63.2}$$

V_s—Cork volume (plug-shaped bottle has V_s)

$V_0 = 500 + 15 + 0 = 515$ ml.

Bottle radius. The inside size of radius is R, thickness is T, taken as 4 cm, arc approximate a straight line, the bottom has been slashed is negligible, Fig. 63.1 shadow area can be approximated as the area of the fan-shaped ABC.

$$\mathrm{AB} = \mathrm{AC} = \sqrt{3}R,$$

$$S = \frac{\sqrt{3}}{2}R^2 + \frac{1}{3}\pi \mathrm{R}^2,$$

Table 63.1 Part of the bottle headspace value Kv [%]

Contents	Beer	Spirits	Carbonated drinks	Noncarbonated beverages	Juice	Alcoholic cosmetics
Headspace	4	3	4	2	2	4

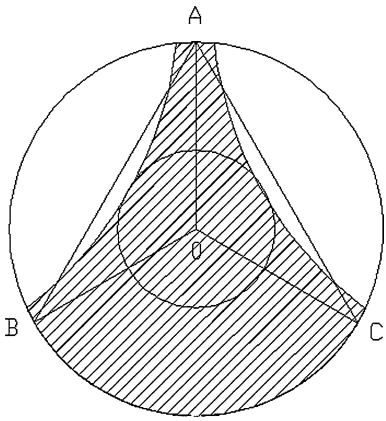


Fig. 63.1 Bottle cutaway view

$$V_o = S \times T, \quad T = 4\text{cm},$$

$$515\text{cm}^3 = \left[\frac{\sqrt{3}}{2}R^2 + \frac{1}{3}\pi R^2\right] \times 4, \quad R \approx 8\text{cm}.$$

Bottle thickness. This design uses glass material; the weight of the glass container determines the design size, if the wall thickness is too large, resulting in heat consumption has increased considerably, and stress in the sidewall, so the container will deform when remolding and cooling. In other words, the wall thickness does not improve the strength of the container, but increase bottle weight, to extend the production cycle, resulting in product defects. Glass container wall thickness should be uniform, if we need wall thickness changes in structure, should use the gentle arc over [4]. Take the sidewall of 5 mm, the diameter of the bottle $D_0 = 170$ mm, width $B_0 = 50$ mm.

Bottom thickness and fillet. Bottom fillet depends on binding mode of the forming mold and the bottom die [4]. In this design, bottom lie perpendicular to the axis of bottle, fillet transition to bottle at a level, we should choose the size of the data in Table 63.2. According to these data, we can avoid the bottom concave (Fig. 63.2).

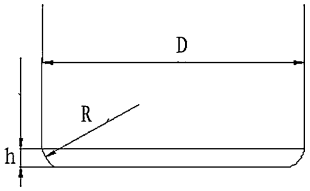
$D_0 = 170$, $B_0 = 50$, take the middle value, $h = 5.50$ mm, $R = 8.75$ mm.

Combination of the bottle shape, the bottom length is about 2/5 of the bottle outside diameter, so the long of the bottle bottom is 68 mm.

Table 63.2 Bottom size Unit: mm

D	0–20	30	40	50	.....	150	160	170	180	.....
h	1.25	1.50	1.00	1.50	.....	7.50	8.00	8.50	9.00	.....
R	1.00	1.75	3.50	4.25	.....	11.75	11.50	13.25	14.00	.....

Fig. 63.2 Bottom size



Bottle mouth size. Reference to the "packaging structure design", bottle mouth select LA-type, the size of the mouth is LA30-20, outer diameter 30 mm, height 20 mm, and neck connection diameter 28 mm.

The diameter of cap equal to bottle width of B0, 50 mm.

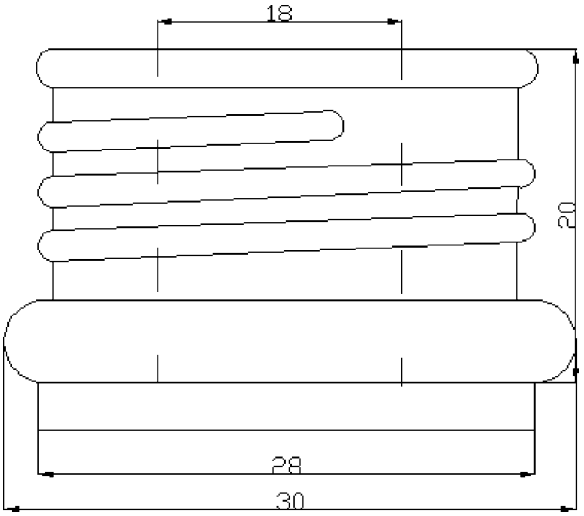
Set the height of the bottom of bottleneck to the top of cap is 38 mm.

The total height of the bottle $H_0 = 38 + \sqrt{85^2 - 14^2} + \sqrt{85^2 - 34^2} =$ 200 mm (Figs. 63.3 and 63.4).

63.2.2 Box Shape and Size Design

The thickness of the thermoplastic container is critical: too big to waste materials, increase costs, but also to extend the molding time, in general the thickness increases each time the cooling time will increase four times; too small, the material flow resistance increases, and prone to shrinkage, depression, bubbles, and other defects, the minimum thickness should meet the requirements of stiffness and strength, able to stand shock and vibration caused by the demolding machine, able to stand the clamping force in the assembly, the wall thickness should be uniform to avoid warpage, and the corner thickness should not be a big difference from the

Fig. 63.3 The LA bottle



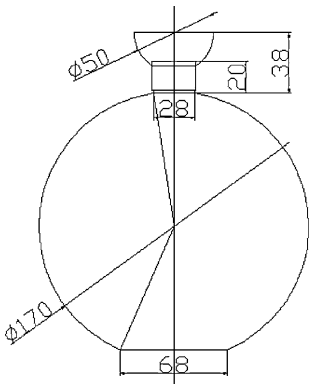


Fig. 63.4 Size calculation

wall, to use the rounded transition [4]. A thermoplastic container can be thinnest up to 0.25 mm, but generally should not be less than 0.6–0.9 mm, usually take 2–4 mm [4]. Here we take the thickness of 3 mm (Fig. 63.5).

$D_0 = 170$ mm, $H_0 = 200$ mm, $T_0 = 50$ mm, the inner wall from the wine is 5 mm, for the box $Li = 180$ mm, and $Bi = 60$ mm. According to the mechanical properties and esthetics, the cushion thickness is 35 mm, the cap of the packaging is semicircular, and diameter $L_0 = 186$ mm (Figs. 63.6, 63.7 and 63.8).

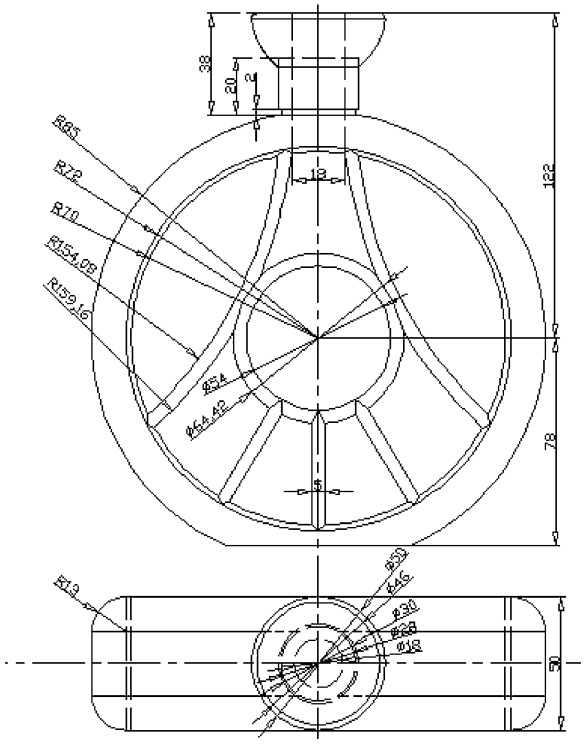


Fig. 63.5 Bottle manufacturing size

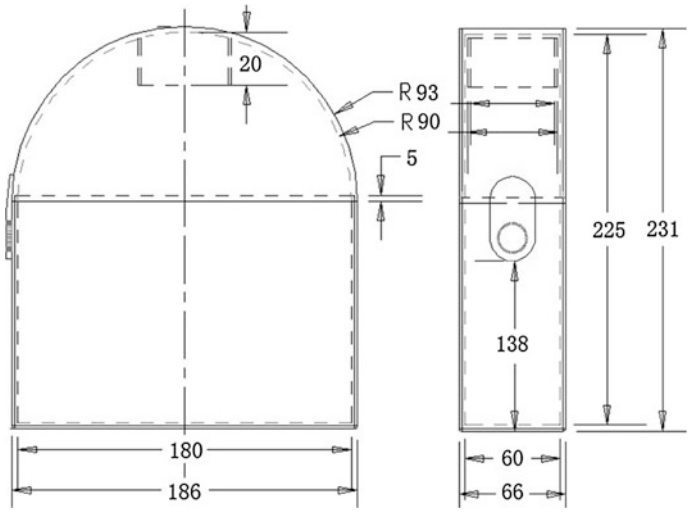


Fig. 63.6 Box manufacturing size

Fig. 63.7 Cushion size

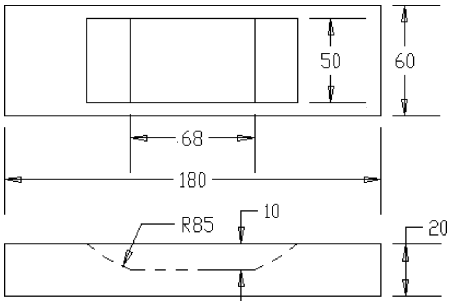
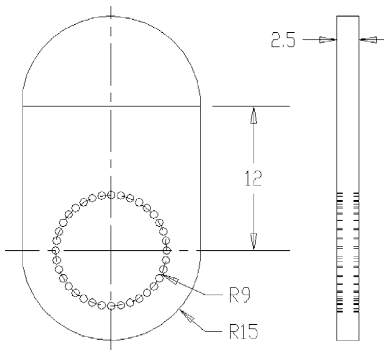


Fig. 63.8 Security stickers size



63.3 Analysis

63.3.1 Bottle Analysis

Material analysis. Glass, one of the most common packaging materials of bottles, has stable chemical properties, high barrier properties, good usability and security, and changing shape and ease of molding.

Shape analysis. This paper presents the design concept is "mock trademark", the design of Wuliangye trademark shape bottle based on this idea, Wuliangye itself is a symbol of a quality and identity. The bottle shape is similar to the Chinese traditional flat pot, function and operation is essentially the same. The hollow place is very suitable for handing. The bottle-shaped rather like a full moon, symbolizes reunion auspicious. The lid designed to semicircular, the overall looks stable but not rigid. The easy to pull ring design reference to the trademark shape, corresponding to the bottle.

63.3.2 Box Analysis

Material analysis. PET material is safe, innovative, low cost, plasticity, can finishing out the different surface texture to enhance the decorative of packaging, compact and lightweight shape meet consumers need. Transparent material is facilitating the identification of security identifier for the user, to improve the safety of drinking, and easy to shelf display.

Shape analysis. Because of the plasticity characteristics of the PET material, we can manufacture dome lid. Round and square are two of the most basic geometry, round with soft and satisfactory view, square with straight and generous, reflecting the perfect combination of strong and soft.

Function analysis. The box is a rectangle, reduce the losses caused by dumping, and easy to transport and store, and using the one-time destruction security structure. When the packaging is not open, the upper semicircle of plastic stickers is glued to the lid, circular portion stick on the box body, and the rest is not connected with the box. When opening, pull the edge of sticker at the under semicircular, along the easy-open structure to open the box. When we want the box to be closed again, we can fasten the pull ring and the circular portion.

Ergonomics analysis. This transparent wine package, suitable installed by hand bag. The wine's easy-open structure is easy to operate, and easy to shelf display.

63.4 Summary

Based on product semantics, this paper puts forward an innovative design idea, called "Trademark Simulation". Following the guidance of product semantics, select the appropriate materials, through the appropriate aided design software of the packaging, the anticounterfeiting structures of liquor packaging have been achieved. Finally, program analysis, evaluation, and related dimensions of semantic computing have been finished. This paper provides a reference for the application of product semantics in the packaging design of specific product and broadens the design ideas.

I do not have a system learning of product semantics, theoretical knowledge in this area is still very lacking so the use is not very skilled. As a packaging designer, what we need to do is to meet consumers expect semantics.

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Chapter 64
Product Quality Management in ATO Supply Chain Based on Quality Tracing

Yu-yu Li and Bo Huang

Abstract Considering that the final product manufacturer is the core enterprise of assemble-to-order (ATO) supply chain and quality tracing is used to control the quality of suppliers' components, a quality control model of ATO supply chain based on quality tracing is established, the theory analysis is conducted, and the best quality control mechanism (including component procurement price, the coefficient of supplier compensation) for the final product manufacturer is therefore obtained, as a result the self-interested supplier would choose the quality level set by the final product manufacturer, whose profit would be maximized.

Keywords Assemble-to-order (ATO) · Supply chain · Product quality tracing · Mechanism design

64.1 Introduction

With the competition between enterprises turned into the competition based on time and customer needs, providing customized products for customers and improving the response speed of final product became important methods for enterprises to seek competitive advantage. Assemble-to-order (ATO) became one of the modes of production that enterprise would give first priority due to

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_64,

its quick response to markets [1]. ATO production was characterized by assembling procured component directly to final products. Therefore, component quality control played an important role in final product quality. Russell and Thomas used models to analyze the behavior of buyers and sellers through how quality maintenance contract affects the quality of product [2]. Reyniers and Tapiero established the quality control models to suppliers base on internal information punishment by manufacturers under the condition of unilateral moral hazard. The result showed that the punishment to suppliers will cause them consciously to select the best quality level [3]. Reyniers and Tapiero established corresponding game model considering that manufacturers used price rebate and sales margin to control the quality of suppliers [4]. Bauman set up preliminary quality control model and obtained the optimal and suboptimal conditions and utilities of models when the suppliers and manufacturers were risk averters [5]. Chen made a research on how to apply quality assurance to control the product quality under the condition of Integrated Supply Chain base on the Nash Equilibrium Research chosen by the behavior of both buyers and sellers and two-level decision method applied [6]. Lim established component quality control models under the condition of incomplete information and studied the quality control under the condition of two compensation plans (price rebate and margin strategy) [7]. Zhang and Hua studied how manufacturers control suppliers' product quality level through sampling inspection and carried out corresponding checking scheme [8].

Recently, more and more enterprises had obtained great benefits by adding feedback quality control base on product quality tracing besides preincident survey. Deasy pointed out that quality tracing was an effective product quality control in dairy industry [9]. Jansen-Vullers made a research on the recording and tracing methods of product quality information in food industry [10]. Scramlin studied the quality tracing problem of fresh pork [11]. There were fewer studies on the product quality tracing in manufacturing, such as, Smith discussed the problems in the project of small cars in GM base on pacing [12]. Balachandran and Radhakrishnan established a unilateral quality control model of suppliers and manufacturers and analyzed the effects of quality control by the implementation of product quality tracing under the two conditions of unilateral moral hazard and double moral hazard.

Actually, one of the most prominent features of the ATO manufacturing was that component was directly assembled into the final product without being processed by manufacturers. When the final products had quality problem, it was easy to for manufacturers to take the responsibility by quality tracing; that is, quality tracing was a quality control method suitable for the ATO system. So lots of ATO manufacturers made quality control by further using the quality tracing on the basis of strengthening close cooperation with suppliers and jointly expanding the quality assurance and improvement. At present, for example, the DELL Company confirmed the NVIDIA's graphics quality issues by quality tracing and shouldered corresponding responsibility when its 10 laptops confronted with quality issues.

Thus, considering that ATO supply chain is composed of one core enterprise (the final product manufacturer, also ATO producer) and many component suppliers, and the final product manufacturer uses product quality tracing to control the quality of suppliers, a quality control model of ATO supply chain based on quality tracing is developed to design the quality control mechanism to urge suppliers and manufacturers to yield products or components base on the quality level agreed by them beforehand.

64.2 Problem Descriptions and Symbol Definitions

ATO supply chain was composed of one final product manufacturer and many component suppliers, among which final product manufacturer was the core enterprise who would procure component from suppliers to sell final product to customers through assembly processing by order.

The assumptions mentioned in this paper are as follows:

Assumption 1 The final product manufacturer is the core enterprise of the ATO supply chain and suppliers and final product manufacturers both are neutral risk.

Assumption 2 An independent third party should carry out product quality tracing to determine who should be responsible for the quality to ensure the justice and fairness of the quality tracing. If it are the responsibility of the suppliers, then they should first refund the component prices to the manufacturer and pay appropriate compensation, which would be a certain multiple of the return loss of the manufacturer.

Assumption 3 ATO supply chain participants are difficult to fully observe the practical actions of other participants, that is, the quality level or detection level (because these parameters are random variables fluctuating around a mean), or unable to present evidence even being observed.

Assumption 4 When customers return goods, the final product manufacture would suffer certain costs (such as the costs incurred in the return process, reputation rebuilding, and customers' compensation). Therefore, the return losses suffered by final product manufacturer were the total sum of sales price and the cost of returns.

Symbol definitions in this paper are as follows: n is the number of component suppliers; s_i is the procurement price of the components i, $i = 1, 2,\ldots, n$; q_i is the number i supplier's quality level, i.e. the possibility of qualified products, $i = 1, 2,\ldots, n$; P is the sales price of the final product; p is the production quality level of the final product manufacturer; r is the manufacturer's cost of returned goods when the final product has quality issues; w_i is the compensation coefficient of supplier i, that is, the supplier i will compensate $w_i\ (P + r)$ to the manufacturer when shouldered quality responsibility.

64.3 Model Establishing

There are two production processes in ATO supply chain: first, the production and processing of component by each component supplier, second, the final product manufacture's assembly processing of the final product by component. When suppliers produced component, they would select their own production quality level q_i, $q_i \in (0, 1]$. In order to provide component of this quality level, suppliers should bear the quality cost of raw materials costs, manufacturing costs, and prevention and appraisal costs and so on. Its quality cost function was $S_i(q_i)$, and $S_i'(q_i) > 0$, $S_i''(q_i) > 0$, $S_i'(q_i = 1) = \infty$, $i = 1, 2, \ldots, n$. The final product manufacturer selected certain production quality level by assembly processing of component into final product. If the quality level was $p \in (0, 1]$, the quality cost function of final product manufacturer would be $M(p)$, and $M'(p) > 0$, $M''(p) > 0$, $M'(p = 1) = \infty$, among which if $S_i'(q_i) > 0$, the quality cost would raise with the improvement of quality level and if $S_i''(q_i) > 0$, the marginal utility of quality costs would decrease, that is, with the increase of quality level, the quality cost to upgrade unit quality level increased and if $S_i'(1) = \infty$, the slope possibility would be ∞ when the quality cost function infinitely closed to 1, the cost would also be ∞, so did the $M(p)$.

The expected payoff of ATO supply chain was defined to be:

$$R(q_i, p) = P - (P + r)\left(1 - q\prod_{i=1}^{n} q_i\right) - S_i(q_i) - M(p) \tag{64.1}$$

When the sold final product has quality issues, an independent third party should make product quality tracing and determine who should take responsibility of quality. The quality tracing testing had errors and there was a possibility that the party with quality conformance should take the responsibility. Proposition $a_{ij} \in [0, 1]$ is the possibility of quality responsibility that i supplier takes for j supplier(i, $j = 1, 2,\ldots, n$, when $j = i$, a_{ii} was the possibility the suppliers should be responsible for), $h_i \in [0, 1]$ is the possibility of quality responsibility that i supplier takes for manufacturer ($i = 1, 2,\ldots, n$). So it could be seen that the possibility of quality responsibility that supplier i should bear is

$$\mu_i(q_i, q_j, p) = \sum_{j=1}^{n} \left[a_{ij}(1 - q_j)\right] + h_i(1 - p),\ i = 1, 2, \ldots, n \tag{64.2}$$

$$\sum_{i=1}^{n} a_{ij} \le 1, \sum_{i=1}^{n} h_i \le 1$$

As the final product manufacturer in advance paid the compensation to the customer and took the return loss, so it was unnecessary to calculate the probability of quality responsibility of the manufacturers.

When the final product has quality issues, the final product manufacturer would firstly bear the return loss $P + r$, P is the price of final product, r is the return cost, including the cost in the exchange process, costs of reputation restoring, cost of lawsuits and so on, among which costs of reputation restoring included the costs compensated to the customers by manufacturers when confronted with quality issues and the advertising costs paid for reputation restoring. This paper would take this as an exogenous variable into consideration. If the suppliers should take the responsibility through the quality tracing, then the suppliers would pay $s_i + w_i(P + r)$ compensation to the manufacturers, while s_i was the procurement price of the component and $w_i(P + r)$ was the penalty cost from manufacturers to suppliers.

Thus, the expected payoff of number i supplier was defined to be

$$R_i(q_i, p) = s_i - [s_i + w_i(P + r)]\mu_i - S_i(q_i) \tag{64.3}$$

As the final product manufacturer was the core enterprise of ATO supply chain, and being a fully rational person, the enterprise would select component procurement price and other variables when designing the quality control mechanism to make the actual profits of the suppliers exactly equal to its retained earnings while the retained earnings of each supplier were fixed constants. Therefore, maximum profits to final product manufacturer were equivalent to maximum profits to the ATO supply chain; that is, a maximum profit to ATO supply chain was the decision-making goal. As a result, the expected payoff of final product manufacturer was defined to be

$$R_m(q_i, p) = R(q_i, p) - \sum \pi_i \tag{64.4}$$

While π_i $(i = 1, 2, \ldots, n)$ was the retained income of number i component supplier, which was the lower limit of income set by the suppliers.

64.4 Mechanism Design

Before the production, the final product manufacturer and component suppliers would sign a cooperation agreement for maximum profits of ATO supply chain, for which the two sides needed to determine quality level and detection level to be obtained, respectively. So the ATO supply chain is faced with the following planning issues:

$$\underset{q_i, p}{\text{Max}}\ R(q_i, p) \tag{64.5}$$

$$\text{s.t}\,\text{Max}\,R(q_i, p) \geq \sum \pi_i + \pi_m \geq 0 \tag{64.6}$$

$$0 \leq \{q_i, p\} \leq 1 \tag{64.7}$$

Formula (64.6) was the participation constraint of ATO supply chain, π_m was the retained income of final product manufacturer, which is the lower limit of income set by final product manufacturer, formula (64.6) showed that only when the maximum profit of ATO supply chain was not less than the total retained income of suppliers and final product manufacturer, the suppliers or final product manufacturer would be able to participate in the production of ATO supply chain, who would then start producing. The quality level q_i^*, p^* with the maximum ATO supply chain profits and detection level, respectively, satisfied those when the solution of the first-order partial derivatives equals to 0.

$$\frac{\partial R(q_i, p)}{\partial q_i} = (P + r)p \prod_{j=1, j\neq i}^{n} q_j' - S_i'(q_i) = 0 \tag{64.8}$$

$$\frac{\partial R(q_i, p)}{\partial p} = (P + r)p \prod_{i=1}^{n} q_i' - M'(p) = 0 \tag{64.9}$$

Simultaneously solve formula (64.8) and (64.9), and then you could get the quality level q_i^* and p^* when the profits of ATO supply chain were maximized.

When the profit of ATO supply chain is maximized, so is the final product manufacturer, therefore, if the supplier selected quality level q_i^*, final product manufacturer would automatically select quality level p^*, that is, p^* is the dominant strategy of the manufacturer. As the cooperation contract between supplier and manufacturer was an "incomplete contract", so suppliers, as a fully rational person, would have a strong incentive to breach component quality level and select appropriate component quality level to maximize their own profits. In order to enable suppliers to automatically use q_i^*, it was necessary for the final product manufacturer to design a quality control mechanism, identify the component procurement price as well as variables of penalty cost when component had quality issues to urge the component suppliers, driven by self-serving, to provide components by selecting quality level q_i^*. After ATO supply chain determined the optimal quality level q_i^* and p^*, the final product manufacturer needed to determine component procurement price Mi and compensation coefficient w so that under the condition of participation constraint and incentive compatibility, the suppliers, driven by self-serving, would use the quality level q_i^* to maximize the profits of the final product manufacturers, that is, the final product manufacturer was faced with the following issues:

$$R_i\left(q_i^*, q_{-i}^*, p^*, s_j^*, w_j^*\right) = \pi_i \geq 0, i = 1, 2, \ldots, n, j = 1, 2, \ldots, n \tag{64.10}$$

$$\left.\frac{\partial R_i\left(q_i, q_{-i}^*, p^*, s_j^*, w_j^*\right)}{\partial q_i}\right|_{q_i = q_i^*} = 0, i = 1, 2, \ldots, n, j = 1, 2, \ldots, n \tag{64.11}$$

$$\text{s.t}\left\{s_j^*, w_j^*\right\} \geq 0, j = 1, 2, \ldots, n \tag{64.12}$$

Formula (64.10) is the participation constraint of suppliers, q_{-i}^* was the optimal quality level set of suppliers besides supplier i ($i = 1, 2, \ldots, n$), formula (64.10) showed that the final product manufacturers would select component procurement price s_j^* and compensation proportion w_j^* ($j = 1, 2, \ldots, n$) to make profits of quality level q_i^* selected by supplier i equal to the retained income, so supplier i would select to participate in the production of ATO supply chain. Formula (64.11) is incentive compatibility constraint of supplier i, that is, under the conditions of procurement price s_j^*, compensation proportion w_j^*, testing strategy θ^* and other supply quality level q_{-i}^* signed with the manufacturer, supplier i would select quality level q_i^* to make its anticipated profit maximized. Therefore, supplier i would voluntarily select q_i^* as its quality level.

Proposition 1 *ATO supply chain had the unique optimal solution* $\left(s_i^*, w_i^*\right)$*, where* $s_i^* = \pi_i + S_i\left(q_i^*\right) + \frac{\mu_i\left(q_i^*, q_{-i}^*, q^*\right)}{a_{ii}} S_i'\left(q_i^*\right)$ *and* $w_i^* = \frac{S_i'\left(q_i^*\right)}{(P+r)a_{ii}}$*, to make the supplier i select the quality level* q_i^* *(* $i = 1, 2, \ldots, n$*) as its dominant strategy, that is, supplier i would voluntarily select* q_i^* *production component.*

Proof Solving (64.11), we can get

$$w_i^* = \frac{S_i'\left(q_i^*\right)}{(P+r)a_{ii}},\ i = 1, 2, \cdots, n \tag{64.13}$$

Solving (64.13) and (64.10), we can get

$$s_i^* = \pi_i + S_i\left(q_i^*\right) + \frac{\mu_i\left(q_i^*, q_{-i}^*, q^*\right)}{a_{ii}} S_i'\left(q_i^*\right),\ i = 1, 2, \ldots, n \tag{64.14}$$

So, under the contract of $\left(s_i^*, w_i^*\right)$, the participation constraint and incentive compatibility constraint of supplier i are both satisfied, supplier i would voluntarily select q_i^* production component.

64.5 Conclusions

Product quality tracing helped the downstream enterprises to strengthen the quality control of the upstream enterprises and improve product quality and profits of the downstream enterprises. Considering that quality tracing to make quality control for the component suppliers was applied by the ATO manufacturer, a quality control model of ATO supply chain based on quality tracing was established, the theory analyses is conducted, and the optimal component procurement price, the coefficient of supplier compensation, that is, the incentive mechanism is therefore obtained, as a result, the suppliers are stimulated to voluntarily select the optimal quality level and the profit of manufacturer is maximized.

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Part VII
Artificial Intelligence

Chapter 65
Transductive Binary Classification with Local–Global Learning Regularizer

Jia Lv

Abstract This paper presents local–global regularizer for transductive binary classification problem. Based upon the neighborhood region, local learning regularizer is constructed to make the label of each data that have the desired property. Global learning regularizer is built to smooth the labels of the data in order to lessen the insufficient training of the local regularizer. To achieve the objective of transductive classification problem, an objective function is constructed by combining together the local learning regularizer, the global learning regularizer, as well as the loss risk term. Thus, the transductive classification approach can be obtained at the end. Comparative classification experiments on some benchmark datasets validate the effectiveness of the presented approach.

Keywords Transductive classification · Binary · Local–global · Learning

65.1 Introduction

Recently, semisupervised learning has been receiving more attention in machine learning and pattern recognition [1, 2]. Semi-supervised learning can be categorized into two classes [3]: transductive learning and inductive learning. A learner is transductive if it only works on the labeled and unlabeled training data, and cannot handle unseen data. Inductive learners can naturally handle unseen data.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_65,

It has been noted that the local learning algorithms usually demonstrate better empirical results since it is hard to find a unique function which has a good predictability in the whole data space. However, in spite of its empirical success, one problem for local learning is that the size of the data used to train a local classifier is usually small, which usually leads to the classifier not to be sufficiently trained. Literature [4, 5] proposes a general learning framework using local and global regularization for supervised learning, unsupervised learning and semisupervised learning. A global regularizer is added to penalize the smoothness of the data labels for the sake of alleviating the insufficient training of the local classifiers. Therefore, motivated by such a general learning framework, as far as transductive learning is concerned, we present a transductive classification approach with local–global regularizer. Comparative classification experiments on some datasets illustrate the feasibility and effectiveness of this approach.

65.2 Transductive Binary Classification Problem

Given a set of n data points $T = \{(x_1, y_1), \ldots, (x_l, y_l)\} \cup \{x_{l+1}, \ldots, x_n\}$, where $x_i \in$ Rd is a d-dimensional input vector for the ith data points, the first l data points are labeled and $y_i \in \{-1, +1\}$ denotes the class label for x_i, $i = 1,\ldots,l$, the remaining $n - l$ data points are unlabeled [3, 4]. The goal is to label the given unlabeled instances $x_{l+1}, \ldots, x_n$ on all data instances.

Most semi-supervised classification can be roughly addressed as the following optimization problem [5, 6].

$$\min_F \left(F^T RF + (F - Y)^T D(F - Y)\right) \tag{65.1}$$

where $F = (f_1, f_2, \ldots, f_n)^T \in R^n$ is the vector of real valued solution, R is the regularization matrix, $Y = (y_1, \ldots, y_n)^T$ is the class label vector of data points, $y_i \in \{-1, +1\}$, $i = 1, \ldots, l$, $y_i = 0$ is initial class label corresponding to x_i, $i = l + 1, \ldots, n$, $D \in R^{n \times n}$ is a diagonal matrix and its ith diagonal element D_{ii} is as follows: $D_{ii} = D_l > 0$, $i = 1,\ldots,l$, $D_{ii} = D_u \geqq 0$, $i = l + 1, \ldots, n$. The first term $F^T RF$ in the objective function, it is called regularizer that specifies the desirable properties of f_i, and the second term $(F - Y)^T D(F - Y)$ is just similar to the square loss function that restricts that f_i should be close to y_i, $i = 1 \ldots \underline{n}$.

The problem (65.1) is an unconstrained optimization problem [7, 8], so its solution can be obtained by

$$F = (R + D)^{-1} DY. \tag{65.2}$$

Class labels of the unlabeled data $x_{l+1},\ldots,x_n$ are computed as follows:

$$y_i = sign(f_i), \; i = l + 1, \ldots, n \tag{65.3}$$

where the sign function sign(f) is defined as sign(f_i) = 1 if $f_i \geq 0$ else sign(f_i) = -1 if $f_i < 0$, for $i = 1,\ldots,n$.

65.3 The Algorithm

65.3.1 Local Learning Regularizer

A global learning machine trains the classifier using the whole data set as the training set, such as SVM, while local learning is presented to construct models based on the local neighborhood information of each data. Recent research has demonstrated that such a local learning strategy is superior to global learning, especially on datasets that are not evenly distributed [11, 12]. However, there are a small amount of labeled data and lots of unlabeled data in semisupervised classification. If local learning method is used directly, it is possible that the method cannot be satisfied because of a few or even no labeled data in the local region. This case has been reasonably resolved by Local Learning Regularization method (LL_Reg) [9, 10].

It is obvious that the nature of local learning is that a given test instance is well estimated only by its adjacent data points. Using the notation in the problem (65.1), for any x_i, $i = 1\ldots n$, the value of f_i can be well evaluated based on the data points located in the vicinity of x_i. The value of f_i should be similar to the output of the model that is trained locally with the data points $\{(x_j, f_j)\}(x_j \in N_i)$, where N_i denotes the set of neighboring data points of x_i. Linear model is employed in local learning model as follows:

$$g_i(x) = w_i^T(x - x_i) + b_i,\ \forall x \in N_i \subset R^d \tag{65.4}$$

where $w_i \in R^d$, $b_i \in R$, $i = 1,\ldots,n$. To find the linear model, the optimization problem based on this model is required to solve as follows:

$$\min_{w_i \in R^d, b_i \in R} \lambda \|w_i\|^2 + \sum_{x_j \in N_i} \left(w_i^T(x_j - x_i) + b_i - f_j\right)^2 \tag{65.5}$$

So the first term in the problem (65.1) is naturally replaced with $\sum_{i=1}^{n} (f_i - g_i(x_i))^2$ and it can be written in a compact form as:

$$\|F - G\|^2, G = (g_1(x_1), \ldots, g_n(x_n))^T \tag{65.6}$$

For each x_i, $i = 1,\ldots,n$, n_i is the number of instances in N_i, $X_i = (x_j - x_i)_{d \times n_i} \in R^{d \times n_i}$, $x_j \in N_i$, $w_i \in R^d$, $b_i \in R$, $e = (1, \ldots, 1)^T \in R^{n_i}$, I is the identity matrix of order n_i, $F_i = (f_j)_{x_j \in N_i}^T \in R^{n_i}$, then the linear model $g_i(x_i) = \alpha_i^T F_i$, where

$$\alpha_i^T = \frac{e^T - e^T X_i^T X_i \left(\lambda I + X_i^T X_i\right)^{-1}}{n_i - e^T X_i^T X_i (\lambda I + X_i^T X_i)^{-1} e} \tag{65.7}$$

In the above equation, α_i is only related to X_i and is irrelevant to f_j. Thus α_i can be extended to the matrix $A = (a_{ij}) \in R^{n\times n}$, if $x_j \in N_i$, then $a_{ij} = \alpha_{ij}$, otherwise $a_{ij} = 0$. $G = AF$ is got, and $\|F - G\|^2$ is transformed into $F^T(I - A)^T(I - A)F$, I is the identity matrix of order n, therefore R of the first term in the problem (65.1) is just the following local learning regularizer:

$$R = (I - A)^T(I - A) \tag{65.8}$$

65.3.2 Global Learning Regularizer

Literature [6] proposes a general geometric framework for semisupervised learning called manifold regularization, which searches for an optimal classification function f minimizing the following objective function

$$\sum_{i=1}^{l} L(y_i, f(x_i, w)) + \gamma_A \|f\|_F^2 + \gamma_1 \|f\|_I^2 \tag{65.9}$$

where $L(.,.)$ is the loss function? $\|f\|_F$ is the induced norm of f in the functional space F, $\|f\|_I$ reflects the intrinsic geometric information of the marginal distribution $p(x)$. Since in the semisupervised learning scenario, there are only very small portions of labeled data, which are not enough to train a good learner by minimizing the former two terms of (65.9). Therefore, we need some prior knowledge to guide us to learn a good f. What $p(x)$ reflects is just such type of prior information. Moreover, it is usually assumed that there is a direct relationship between $p(x)$ and $p(y|x)$, i.e. if two data points x_1 and x_2 are close in the intrinsic geometry of $p(x)$, then the conditional distributions $p(y|x_1)$ and $p(y|x_2)$ should be similar. That is, $p(y|x)$ should very smoothly along the geodesics in the intrinsic geometry of $p(x)$ [5]. Specifically, $\|f\|_I^2$ can have the following form [6]

$$\|f\|_I^2 = \int_{x\in M} \|\nabla_M f\|^2 \mathrm{d}p(x) \tag{65.10}$$

where M represents the low-dimensional data manifold, $\nabla_M f$ denotes the gradient of f with respect to M. intuitively, $\|f\|_I^2$ measures how f varies on M, i.e. the smoothness of f. And $\|f\|_I^2$ can further be approximated by [6]

$$\|f\|_I^2 = \frac{\gamma_I}{n^2} \sum_{i,j} \big(f(x_i) - f(x_j)\big)^2 W_{ij} = \frac{\gamma_I}{n^2} F^T L F \tag{65.11}$$

where n is the total number of data points, and W_{ij} are the edge weights in the data adjacency graph, and L is as follows:

$$L = D - W \in R^{n\times n} \tag{65.12}$$

where L is the graph Laplacian where W is the graph weight matrix with its (i, j)th entry $W(i,j) = w_{ij}$, and D is a diagonal matrix whose diagonal element D_{ii} is the sum of the ith row of W, i.e. $D_{ii} = \sum_{j=1}^{n} w_{ij},\ i = 1, \ldots, n$. Thus, the global learning regularizer is just the same form as (65.11).

65.3.3 The Algorithm

The problem can be addressed as follows:

$$\min_{F}\left(F^T RF + (F-Y)^T D(F-Y) + \frac{\gamma_I}{n^2} F^T LF\right) \tag{65.13}$$

Where the first term is local learning regularizer which make f have the desired properties, the second term is a loss term which will be minimized to make the predicted labels and the initial labels sufficiently close on the labeled data points, and the third term is global learning regularizer which smoothes the data labels.

The optimization solution of the problem (65.13) can be got

$$F = \left(R + D + \frac{\gamma_I}{n^2} L\right)^{-1} DY \tag{65.14}$$

where R and L are calculated by (65.8) and (65.12) respectively

The algorithm framework can be described as follows:

1. Given the training dataset T and proper parameters D_l, D_u, λ, γ_I and the neighborhood size K.
2. Compute R by (65.8).
3. Compute L by (65.12).
4. Calculate F by (65.14).
5. Determine the class labels y_{l+1}, …, y_n by (65.3).

65.4 Experimental Results

Six benchmark datasets are used in our experiments, the datasets consist of three parts: diabetes, Breast, Ionosphere are from UCI machine learning repository, digit1, USPS are from image datasets, G241c is one of the toy datasets. Descriptions of these datasets are given in Table 65.1.

Besides this algorithm, LL_Reg, Lap_Reg and NLap_Reg [10] are also implemented for experimental comparison. Lap_Reg-based transductive classification algorithm (Lap_Reg) and NLap_Reg-based transductive classification algorithm (NLap_Reg) are obtained by replacing R in the optimization solution (65.2) with $D - W$ and $I - D^{-1/2}WD^{-1/2}$, respectively.

Table 65.1 Description of the datasets

Datasets	Classes	Sizes	Features
Diabetes	2	768	8
Breast	2	683	10
Ionosphere	2	351	34
Digit1	2	1500	241
USPS	2	1500	241
G241c	2	1500	241

Table 65.2 The average correction rates (%) and standard deviations (%) comparison

Lap_Reg	NLap_Reg	LL_Reg	LG_Reg
67.20 ± 2.54	68.07 ± 2.71	72.37 ± 2.40	74.61 ± 1.33
96.75 ± 1.87	96.60 ± 1.65	97.00 ± 1.13	98.00 ± 0.87
72.74 ± 2.46	66.29 ± 2.55	75.44 ± 2.04	77.18 ± 1.53
96.98 ± 0.84	97.09 ± 0.59	97.37 ± 0.66	97.15 ± 1.10
92.91 ± 1.66	95.40 ± 1.45	96.33 ± 0.92	98.71 ± 1.04
61.00 ± 2.23	55.00 ± 3.92	78.64 ± 3.67	78.35 ± 1.20

For four algorithms, their optimal parameters are set by LOO error from some grids introduced in the following: 10 % of each dataset is randomly chosen as labeled data points, $K \in \{5, 10, 20, 50, 100\}$, $D_l \in \{0.1, 1, 10, 100\}$, $D_u = 10^{-6}$, $\lambda \in \{0.1, 1, 10, 100\}$, $\delta \in \{1/2\text{^}6, 1/2\text{^}5, \ldots, 2\text{^}5, 2\text{^}6\}$, $\gamma_I \in \{0.1, 1, 10, 100\}$.

The average classification correction rates and standard deviations of 50 independent runs are presented in Table 65.2, and the best results are highlighted in bold face. As can be seen from Table 65.2, we can observe that LG_Reg is remarkably superior to Lap_Reg, NLap_Reg and LL_Reg on the datasets except digit1 and G241c, while LG_Reg is close to LL_Reg on the two datasets.

65.5 Conclusions

We have developed the transductive classification approach with local–global regularizer in our work. The objective function of the transductive classification problem consists of three parts: the first part is the loss risk term, the second part is the local learning regularizer, and the third part is the global learning regularizer. The local regularizer can make the label of each data reflect its desired property, and the global regularizer can alleviate the insufficient training of the local classifier. The experimental results show the superiority of the novel algorithm.

Acknowledgments This work was supported by the National Natural Science foundation of China (Grant No.10971223, No.11071252, No. 70921061) and the Project Foundation of Chongqing Municipal Education Committee (Grant No. KJ120628).

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Chapter 66
Research of Household Savings Prediction Based on SVM and K-CV

Li Xiang

Abstract In order to improve the prediction accuracy of household savings, this paper puts forward a household savings model based on support vector machine (SVM) and K-fold cross-validation (K-CV). First, it builds the sample of the historical data on household savings. Second, it pretreats the sample data, including normalized and principal component analysis (PCA) dimensionality reduction process. Third, it uses K-CV to select the optimal parameters. Fourth, it uses the best parameters to train the training set data. Finally, it predicts and analyzes the predictive set data and establishes the prediction model. The experimental results show that the prediction method of household savings has a higher accuracy than traditional method and has high generalization ability.

Keywords Support vector machine · K-fold cross-validation · Household savings

66.1 Introduction

Household savings is a kind of typical time series data, influenced and affected by economy, policy, and many other factors, with dynamic and high nonlinear characteristics, so the key for household savings prediction is the algorithm selection of prediction. In the current economic field, main prediction methods contain time series model, Carl Mambo model, and neural network model. These several prediction methods have their own advantages and disadvantages: time series model as a prediction method based on linear data cannot describe

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_66,

accurately the nonlinear changing regularity of household savings, so its prediction accuracy is not high. Carl Mambo model is an improvement for multiple linear regressions, with a higher selectivity of criterion predictors and higher prediction accuracy, but this model needs large number of matrix and vector arithmetic, with a complex algorithm and a cumbersome application. Neural network model has good nonlinear approximation ability, which is the main method of predicting the current financial data, but this model is based on a large number of learning samples, inadequate sample will lead to a lower prediction result.

Support vector machine (SVM) has an obvious advantage in handling high nonlinear classification, regression, and other practical problems, which is an important method to solve "curse of dimensionality" and "over fitting" [1]. LibSVM as a software package of SVM pattern recognition and regression that is developed by Professor Jen from Taiwan University etc. can solve C-SVC, nu-SVC, epsilon-SVR, nu-SVR, and other problems [2].

Aiming at this problem that the prediction accuracy of current household savings is low, this paper proposes a model of SVM savings prediction based on K-CV and this model uses LibSVM to link the influencing factors of household savings, uses the K-CV method finding the optimal parameters to improve the prediction accuracy of household savings. And a replication experiment is done for it with Chinese residents' calendar year savings data, to verify the validity of this model.

66.2 Theory of Household Savings Prediction

Prediction of household savings uses past and present savings data and each index factor affecting the household savings for analysis, and then uses certain prediction theory, method, and model to predict the future household savings. Because the household savings is affected by society, economy, technology, and other many factors, it has a high nonlinear characteristics and a higher redundancy between data, the traditional prediction method is difficult to predict accurately this complex nonlinear data, which will lead to low prediction accuracy, and cannot meet the requirements of household savings prediction.

This paper uses first PCA method to select the factor that greatly affects the household savings, and eliminate the high redundancy between data, and then uses K-CV to optimize parameters of SVM and build the learning model, finally obtain the prediction results. This model combining the excellent parameters optimization ability of K-CV and the excellent nonlinear function prediction ability of SVM, effectively improves the accuracy of house savings prediction.

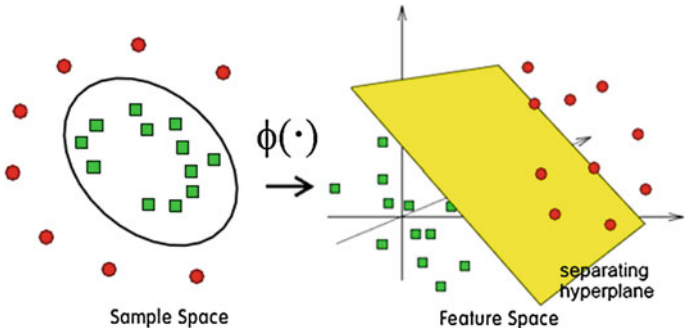

Fig. 66.1 Mapping schematic diagram from sample space to feature space

66.3 Household Savings Prediction of SVM Based on K-CV

66.3.1 SVM Principle

The principle of SVM is to establish a classification hyperplane as a decision surface, making the separation edge between positive cases and counter cases is maximized. According to the input data, SVM prediction finds the nonlinear mapping function: $\phi(x)$: $R^d \rightarrow F$ mapping to the output space. And then it makes the linear estimates in the higher dimensional feature space [3].

The estimation function is $f(x) = \sum_{i=1}^{n} (a_i - a_i^*)K(x_i, x) + b$, $K(x_i, x)$ represents the kernel function of SVM. It is mapping principle as shown in Fig. 66.1.

In the process of calculating $f(x)$, do not need to calculate the weight vector or the numerical nonlinear mapping $\phi(x)$, and just need to calculate a_i, a_i^* and $K(x_i, x)$, which well avoids the curse of dimensionality in the higher dimensional data.

66.3.2 The Selection of Optimal Parameters Searching Methods

SVM needs to call related parameters (mainly penalty parameter c and kernel function parameter g) when solving regression problems, and can use the cross-validation CV to obtain optimal parameters c and g [4]. Common methods of CV contain Hold-Out Method, K-fold cross-validation (K-CV), and leave-one-out cross-validation (LOO-CV).

Hold-Out Method divides the original data into groups randomly, and the classification accuracy of final test set is highly related to the original data group, so the results gained from this method are not sufficiently convincing.

The number of model that LOO-CV needs to build is the same as the sample number of original data, and when the sample number of original data is much

larger, LOO-CV will be difficult in the actual operation, with a higher computing cost [5].

K-CV divides the training sample set into K mutually disjoint subsets randomly, and the size of each subset is roughly equal. Use k−1 training subsets establish a regression model for a set of given parameters, and use the last remaining subset MSE to evaluate the performance of parameters. Repeat K times according to the above process, so each subset will have a chance to be tested, use the average value of MSE gained from k iterations to estimate expecting generalization error, and choose an optimal parameters finally. K-CV can effectively avoid an over fitting and under fitting, the achieved result is more persuasive, so this paper chooses K-CV method.

66.3.3 The Process of SVM Household Savings Prediction Based on K-CV

Using SVM model based on K-CV to predict household savings, first make a principal component analysis (PCA) for the input index that affects household savings, to eliminate the redundancy correlation between indexes; second, reduce dimensions for the input vector, to get the main composition that affects household savings; third, use the got main component as the input of SVM to study and get the optimal SVM prediction model; and finally predict the prediction set, to get the predicted value of household savings, the process is as shown in Fig. 66.3.

66.4 Simulation Research

66.4.1 The Selection of Sample Data

This paper selects urban and rural residents' saving deposit (Y) from 1991 to 2009 for predicting replication experiment, the major influential element are GDP (X1, a hundred million Yuan), urban per capita disposable income (X2, Yuan), urban per capita nonproductive expenditure (X3, Yuan), the 1-year savings deposit interest rate (X4, %), urban and rural consumer price index (last year = 100), (X5, Yuan), price indices of investment in fixed assets (last year = 100), (X5, Yuan). According to the "China Statistical Yearbook", get the original data of each index, see Table 66.1.

Table 66.1 Resident total saving deposits and index factor, 1991–2009

Years	Y	X_1	X_2	X_3	X_4	X_5	X_6
2009	260771.7	340506.9	17175	12265	2.25	99.3	97.6
2008	217885.4	314045.4	15780.76	11242.9	2.25	105.9	108.9
2007	172534.2	265810.3	13785.81	9997.47	4.14	104.8	103.9
2006	161587.3	216314.4	11759.45	8696.55	2.52	101.5	101.5
2005	141051.0	184937.4	10493	7942.88	2.52	101.8	101.6
2004	119555.4	159878.3	9421.6	7182.1	2.25	103.9	105.6
2003	103617.3	135822.8	8472.2	6510.94	1.98	101.2	102.2
2002	86910.6	120332.7	7702.8	6029.88	1.98	99.2	100.2
2001	73762.4	109655.2	6859.6	5309.01	2.25	100.7	100.4
2000	64332.4	99214.6	6280	4998	2.25	100.4	101.1
1999	59621.8	89677.1	5854	4615.91	3.78	98.6	99.6
1998	53407.5	84402.3	5425.1	4331.61	4.77	99.2	99.8
1997	46279.8	78973.0	5160.3	4185.64	5.67	102.8	101.7
1996	38520.8	71176.6	4838.9	3919.47	7.47	108.3	104.0
1995	29662.3	60793.7	4283	3537.57	10.98	117.1	105.9
1994	21518.8	48197.9	3496.2	2851.34	10.98	124.1	110.4
1993	15203.5	35333.9	2577.4	2110.81	7.56	114.7	126.6
1992	11757.3	26923.5	2026.6	1671.73	7.56	106.4	115.3
1991	9244.9	21781.5	1700.6	1453.81	10.08	103.4	109.5

66.4.2 The Establishment of Household Savings Prediction Model Based on LibSVM

Select the household savings data of 1991–2004 years as 14 training samples, and select the household savings data of 2005–2009 as five test samples. This paper chooses K-CV method to determine the parameters, and constantly adjusts the parameters c and g, finally chooses Best $c = 5.278$, Best $g = 0.57435$ with the smallest error (mse) as the optimal parameter, Best mse $= 0.00019164$, to get the SVM prediction model. The specific results of parameter selection (contour map and 3D view) are as shown in Figs. 66.2 and 66.3.

According to the prediction model, fit training the household savings of 1991–2004, with the fitting effect of training set as shown in Fig. 66.4, and the fitting effect of test set as shown in Fig. 66.5.

66.4.3 Results Analysis

We can see from Table 66.2, the model after learning through SVM can be used to predict the residents' total saving deposits well, and the relative error is controlled within 2.5 %. Through this model, we can quickly and more accurately predict the impact of the change of impact factor on household savings; thus, it is a feasible and effective prediction method of household savings.

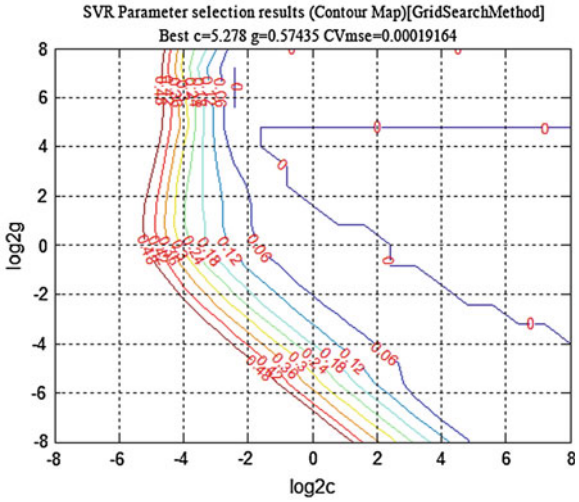

Fig. 66.2 Contour map of parameter selection

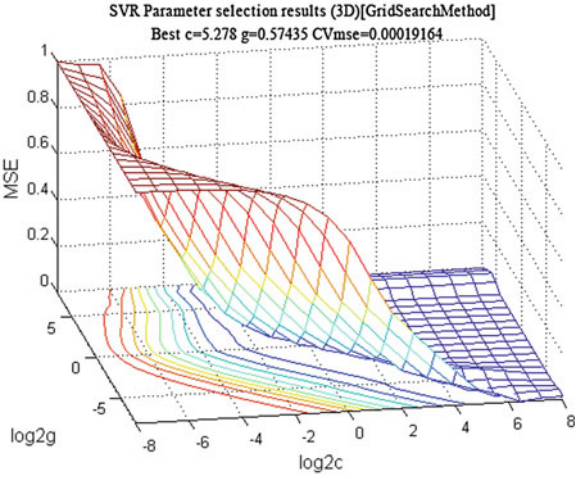

Fig. 66.3 3D view of parameter selection

In order to validate the relative merits of the model that this paper has put forward, do the contrast test, and the reference model is: SVM, BP neural network (BPNN), the analysis result of each model prediction is as shown in Table 66.3.

We can see from Table 66.3, the SVM prediction result based on K-CV that this paper has proposed has a minimum percentage in the average error of all reference models, and its fitting degree of the predicted value and the actual value

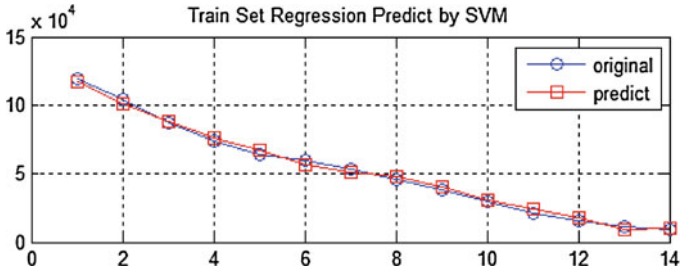

Fig. 66.4 Fitting effect of training set

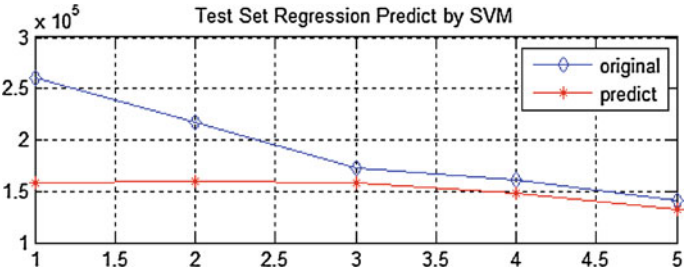

Fig. 66.5 Fitting effect of test set

Table 66.2 Prediction results of SVM model

Years	Actual value	Predicted value	Absolute error	Relative error (%)
2009	260771.7	262223.5	1451.80	0.56
2008	217885.4	214365.4	−3520.00	−1.62
2007	172534.2	176752.3	4218.10	2.44
2006	161587.3	163865.7	2278.40	1.41
2005	141051.0	140365.6	−685.40	−0.49

Table 66.3 Result of each model prediction

Years	Actual value	SVM	BPNN	K-CV SVM
2009	260771.7	267236.5	266423.1	262223.5
2008	217885.4	212763.2	217691.5	214365.4
2007	172534.2	181345.3	179214.2	176752.3
2006	161587.3	169941.6	167654.8	163865.7
2005	141051.0	139821.8	146515.2	140365.6
Average error (%)		1.91	2.72	0.46

is the highest. This shows this model of household savings prediction has a higher accuracy and a high efficiency, so it is a feasible and effective method of household savings prediction.

66.5 Conclusions

Household savings is a complex nonlinear time series data, related to per capita disposable income, per capita consumer spending, 1-year savings deposit interest rate, and other factors, and the traditional method is difficult to establish an accurate mathematical model. SVM is very suitable for modeling and prediction of nonlinear time series, and can reflect well the changing trends of the residents' total saving deposits. This paper uses the residents' calendar year total saving deposits in our country for empirical experiment, and the experimental result shows that, the prediction accuracy of SVM prediction method based on K-CV is higher than every reference model, with a more ideal result, so this method is practical and feasible in household savings prediction.

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Chapter 67
Fuzzy SVM with a New Fuzzy Membership Function Based on Gray Relational Grade

Wan Mei Tang, Yi Zhang and Ping Wang

Abstract In dealing with the two-class classification problems, the traditional support vector machine (SVM) often cannot achieve good classification accuracy when outliers exist in the training data set. The fuzzy support vector machine (FSVM) can resolve this problem with an appropriate fuzzy membership for each data point. The effect of the outliers can be effectively reduced when the classification problem is solved. In this paper, gray relational analysis (GRA) is employed to search for gray relational grade (GRG) which can be used to describe the relationships between the data attributes and to determine the important samples that significantly influence some defined objectives. A new fuzzy membership function for the FSVM is calculated based on the GRG. This method can distinguish the support vectors and the outliers effectively. Experimental results show that this approach contributes greatly to the reduction of the effect of the outliers and significantly improves the classification accuracy and generalization.

Keywords Support vector machine · Fuzzy support vector machine · Fuzzy membership function · Two-class problems · Gray relational analysis · Gray relational grade

67.1 Introduction

The theory of support vector machines (SVMs) was first introduced by Vapnik and was developed from the theory of structural risk minimization [1]. The SVM learning algorithm has drawn much attention due to its higher performance in

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_67,

pattern recognition and function regression than that of the traditional tools [2]. For linearly separable cases, the SVM is to find the separating hyperplane that maximizes the margin between two classes in the input space; otherwise the SVM uses kernel functions to transform the samples from different classes to a higher dimensional feature space and separates them with a hyperplane that maximizes the margin between two classes in the feature space. Classification with SVM is formulated as quadratic programming (QP) problems which can be solved efficiently by using many well-documented optimization algorithms.

Although definitions vary, an outlier is generally considered to be a data point that is far away from its own class. Possible sources of outliers are recording and measurement errors. In dealing with the Two-Class classification problems, the SVM with outliers in the training data set will lead to the reduction of the classification accuracy. This effect of outliers is described as follows: If one training sample is detected as an outlier, it is very likely to fall in one class, but actually it falls in the opposite class. In this case, the classical SVM training algorithm will make the decision boundary severely deviate from the optimal hyperplane because SVM is very sensitive to outliers [3].

When traditional SVM is used to solve a Two-Class classification problem, each training sample is treated equally and assigned to only one class. However, in many applications, some training samples, such as the outliers, may not be exactly assigned to one of these two classes, which is the effect of the outliers. To solve this problem, some techniques have been found to tackle the outlier problem. In Ref. [4], candidate vectors selection is proposed to find the outliers. In Ref. [5], a central SVM method is proposed to use the class centers in building the SVM. In Ref. [6], an adaptive margin SVM is developed in the utilization of adaptive margins for each training pattern. In Ref. [7], the original input space is mapped into a normalized feature space to increase the stability against the noise. Fuzzy support vector machine (FSVM) [8] which is developed on the theory of the SVM is another effective method to solve the outlier problem. In fact, the importance of each sample to the decision surface is different. In FSVM, each input sample is given a fuzzy membership which denotes the attitude of the corresponding sample toward one class; the different input points can make different contributions to the learning of the decision surface. In order to decrease the effect of those outliers, we assign each data point in the training data set with a membership and sum the deviations weighted by their memberships. If one sample is detected as an outlier, it is assigned with a low membership, so its contribution to total error term decreases. In this paper, by using gray relational grade (GRG), a new fuzzy membership function for FSVM is presented. It shows that the proposed method enhances the FSVM in reducing the effect of the outliers and significantly improves the classification accuracy and generalization.

The SVM and the FSVM can be used to solve the Two-Class problem as well as the Multi-Class problem. The classification problem mentioned in this paper is confined to the Two-Class problem, although the proposed method in this paper can also be applied to the Multi-Class problem.

67.2 SVM and FSVM

In this section, the theory of the SVM and the FSVM in dealing with classification problems is briefly reviewed. Further detailed description is in Ref. [1, 4].

67.2.1 SVM

Suppose there is a set of training data of l data points $\{(x_1, y_1), (x_2, y_2), \ldots, (x_l, y_l)\}$ where $x_i \in R^d$ is the ith input vector and $y_i \in \{+1, -1\}$ is the corresponding class label. When the samples are linear separable, the SVM can separate them with the largest margin between the two classes without any wrong separated points. The hyperplane could be represented as $w \cdot x_i + b = 0$. It can classify a sample point x_i according to the following function:

$$f(x_i) = \text{sign}(w \cdot x_i + b) = \begin{cases} +1, & if \quad y_i = +1 \\ -1, & if \quad y_i = -1 \end{cases} \tag{67.1}$$

This can be achieved by solving the following quadratic program:

$$\begin{cases} \min & \frac{1}{2}\|w\|^2 \\ \text{s.t.} & y_i(x_i \cdot w + b) \geq 1, \quad i = 1, 2, \ldots, l. \end{cases} \tag{67.2}$$

where w is the weight vector and $b \in R$ is the threshold value. For a nonlinearly separable case, it is not possible to satisfy all constrains in (67.2). Thus, slack variables $\xi_i, i \in \{1, 2, \ldots, l\}$ are introduced to measure the amount of violation of the constraints. The QP problem becomes:

$$\begin{cases} \min & \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{l} \xi_i \\ \text{s.t.} & y_i(w^T \cdot x_i + b) \geq 1 - \xi_i, \quad i = 1, 2, \ldots, l \\ \text{and} & \xi_i \geq 0, \quad i = 1, 2, \ldots, l. \end{cases}$$

where C is a parameter which must be determined beforehand to define the cost of constraint violation, and the larger C means a higher penalty which is assigned to empirical errors? Tuning this parameter can make balance between margin maximization and classification violation.

However, in most cases, the searching of suitable hyperplane in an input space is too restrictive to be of practical use. Hence, the solution to this situation is mapping the input space into a higher dimension feature space and searching the optimal hyperplane in this feature space by using a nonlinear function $\varphi(x) : R^d \rightarrow H$. To solve the QP problem, the function $K(\cdot, \cdot)$ called *kernel function* is only needed, which is an inner product about φ in feature space, that is, $K(x_i, x_j) = \langle \varphi(x_i), \varphi(x_j) \rangle$, and the explicit formulation of φ is not needed. *Kernel* function must satisfy Mercer's condition [9]. With the karush–kuhn–tucker (KKT)

conditions and Lagrange multiplier method, the following equivalent dual problem can be formed:

$$\begin{cases} \min & \frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l} y_i y_j \alpha_i \alpha_j K(x_i, x_j) - \sum_{j=1}^{l} \alpha_j \\ \text{s.t.} & \sum_{i=1}^{l} \alpha_i y_i = 0 \\ \text{and} & 0 \le \alpha_i \le C, \quad i = 1, 2, \ldots, l. \end{cases}$$

where $\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_l)$ is the vector of nonnegative Lagrange multipliers. There is one Lagrange multiplier for each training sample. The training samples for which the Lagrange multiplier is nonzero are called support vectors.

Through the kernel trick, SVM can deal with the classification in the nonlinear case easily. Some commonly used kernel functions are polynomial, sigmoid, and Gaussian functions.

67.2.2 Fuzzy SVM

In the classical SVM, each training sample belongs to either of the two classes. However, in many applications, some training samples, such as the outliers, may not completely belong to either of the two classes, and each training sample does not have the same importance to the decision surface. To solve this problem, Lin proposed the theory of FSVM in Ref. [4] on the basis of classical SVM, and introduced fuzzy membership to each input point of SVM. Different memberships represent different contributions to the construction of the decision surface. The noises or the outliers are made to have lower fuzzy membership in order to reduce their effects. Suppose the training samples are $S = \{(x_i, y_i, s_i) | i = 1, 2, \ldots, l\}$, where each $x_i \in R^d$ is a training sample and $y_i \in \{+1, -1\}$ represents its class label, $s_i (i = 1, 2, \ldots, l)$ is a fuzzy membership which satisfies $r \le s_i \le 1$ with a sufficiently small constant$r > 0$.

Thus, the quadratic problem for classification can be described as follows:

$$\begin{cases} \min & \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{l} s_i \xi_i \\ \text{s.t.} & y_i(w^T \cdot \varphi(x_i) + b) \ge 1 - \xi_i, \quad i = 1, 2, \ldots, l \\ \text{and} & \xi_i \ge 0, i = 1, 2, \ldots, l. \end{cases} \tag{67.3}$$

where C is a penalty parameter which must be determined beforehand to define the cost of constraint violation. Since the fuzzy membership s_i is the attitude of the corresponding point x_i toward one class and the parameter ξ_i is a measure of error in the SVM, the term $s_i \xi_i$ can be seen as a measure of error with different weights. It is noted that a smaller s_i can reduce the effect of the parameter ξ_i in problem (67.5) so that the corresponding point x_i can be treated as less important. The way

to solve problem (67.5) is the same as the classical SVM only with a little difference from Ref. [4].

67.3 Gray Theory and Gray Relational Analysis

Gray system (GS) is the system of which part of the information is known and the other part of information is unknown. Gray relational analysis (GRA) is a new method of analysis which has been proposed in the GS theory and it is founded by Professor Deng. GRA is based on geometrical mathematics which complies with the principles of normality, symmetry, entirety, and proximity. GRA is suitable for solving complicated inter-relationships between multiple factors and variables and has been successfully applied on cluster analysis, robot path planning, project selection, prediction analysis, performance evaluation, and factor-effect evaluation, and multiple criteria decision [10]. The GRG is also a distance measure whose value is within the interval (0, 1). For a given reference sequence and a given set of comparative sequences, GRA can be used to determine the GRG between the reference and each comparative sequence in the given set. Then the best comparative sequence is the one having the largest GRG. Detailed explanation about GRA method is presented in the following section.

67.3.1 Gray Relational Coefficient

Let $X = \{X_i | i \in \{0, 1, 2, \ldots, n\}\}$ be a space sequence. X_i is a sample of the system, and its value at the kth item in the sequence is $x_i(k)$, $k = 1, 2, \ldots, m$. If we denote the reference sequence by $X_0 = \{x_0(1), x_0(2), \ldots, x_0(m)\}$ and the comparative sequences by $X_i = \{x_i(1), x_i(2), \ldots, x_i(m)\}$, $i = 1, 2, \ldots, n$. Then the gray relational coefficient between X_0 and X_i at the kth item is defined to be

$$\xi_i(k) = \frac{\min\limits_i \min\limits_k |x_0(k) - x_i(k)| + \rho \max\limits_i \max\limits_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max\limits_i \max\limits_k |x_0(k) - x_i(k)|} \tag{67.4}$$

where ρ is known as a distinguishing coefficient with $\rho \in [0, 1]$. Normally, let $\rho = 0.5$, the purpose of which is to weaken the effect of $\max\limits_i \max\limits_k |x_0(k) - x_i(k)|$ when it gets too big, and enlarges the difference significance of the relational coefficient. $\xi_i(k)$ Reflects the degree of closeness between the two comparing sequences at $k, 0 < \xi_i(k) \leq 1$.

67.3.2 Gray Relational Grade

In reality, GRA compares relations of sequences in their appropriate metric spaces. If two sequences agree at all points, then their gray relational coefficient is 1 everywhere, and therefore their GRG should be 1. From this view, the relational grade of two comparing sequence can be quantified by the mean value of their gray relational coefficients; i.e.,

$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k)$, here, $\xi_i(k)\,(k = 1, 2, \ldots, n)$ is designated as the GRG between X_0 and X_i.

67.3.3 Gray Relational Ordering

In relational analysis, the practical meaning of the numerical values of gray relational grades between elements is not absolutely important, while the gray relational ordering between them yields more subtle information. If $\gamma_i > \gamma_j$, we say X_i to X_0 is better than X_j to X_0. If$\gamma_i < \gamma_j$, we say X_i to X_0 is worse than X_j to X_0. If $\gamma_i = \gamma_j$, we say X_i to X_0 is worth equally this X_j to X_0.

67.4 A New Fuzzy Membership Function in FSVM

In this section, a new fuzzy membership function for the FSVM is proposed based on GRA. The proposed method can do better than that of Ref. [6] in reducing the effect of the outliers for linear separable cases and significantly improves the classification accuracy and generalization.

Suppose that there is a set of training samples $S = \{(x_1, y_1, s_1), (x_2, y_2, s_2), \ldots, (x_l, y_l, s_l)\}$, denoting a set as $Q = \{x_i | (x_i, y_i, s_i) \in S\}$, $Q^+ = \{x_i | x_i \in Q,\ y_i = +1\}$, $Q^- = \{x_i | x_i \in Q \text{ and } y_i = -1\}$. Let $l_1 = |Q^+|$, $l_2 = |Q^-|$, $l = |Q|$. It is clear that $Q = Q^+ \cup Q^-$, $Q^+ \cap Q^- = \varphi$, $l = l_1 + l_2$. Denote the mean of class Q^+ as x^+_{cen} and the mean of class Q^- as x^-_{cen}. i.e.,

$$\begin{aligned} x^+_{\text{cen}} &= \frac{1}{l_1}\sum_{x_i^+ \in Q^+} x_i^+ \\ x^-_{\text{cen}} &= \frac{1}{l_2}\sum_{x_i^- \in Q^-} x_i^- \end{aligned} \tag{67.5}$$

For the class Q^+, we denote the reference sequence by $x_0 = x^+_{\text{cen}}$, and the comparative sequence by $x_i = x_i^+ \in Q^+$, calculating GRG γ_i^+. Based on γ_i^+, the fuzzy membership s_i^+ of each sample point $x_i^+ \in Q^+$ can be calculated as follows.

$s_i^+ = \frac{\gamma_i^+}{\max(\gamma_i^+) + \delta}$, where $\delta > 0$ is a sufficiently small constant to avoid the case $s_i^+ = 1$.

For the class Q^-, we denote the reference sequence by $x_0 = x_{\text{cen}}^-$, and the comparative sequence by $x_i = x_i^- \in Q^-$, calculating GRG γ_i^-. Based on γ_i^-, the fuzzy membership s_i^- of each sample point $x_i^- \in Q^-$ can be calculated as follows.

$s_i^- = \frac{\gamma_i^-}{\max(\gamma_i^-) + \delta}$, where $\delta > 0$ is a sufficiently small constant to avoid the case $s_i^- = 1$.

So the fuzzy membership s_i of each sample point x_i is defined as:

$$s_i = \begin{cases} s_i^+ & if \quad y_i = +1 \\ s_i^- & if \quad y_i = -1 \end{cases} \tag{67.6}$$

The FSVM with the above membership function can achieve good performance because it can distinguish the support vectors and the outliers effectively for the linear classification problem, and therefore reduce the effect of the outliers.

67.5 Experiments

In order to illustrate the effectiveness of the proposed algorithm with the new membership function, the performance of the FSVM-2 with the new fuzzy membership is compared with the results of the FSVM-1 on artificial data and real data.

67.5.1 Experiments with Artificial Data

To visualize the experimental results, we randomly generate some samples with some given outlier points in $R^6 \times \{+1, -1\}$ to test the proposed method. There are 200 points in the data set in which 120 points are selected as training samples and the remaining 80 points for testing. In the training set, 60 points including six outliers belong to one class and the other points including three outliers belong to another. The Gaussian RBF kernel function and different selections of the regularization parameters have been used for the training to compare the performance of the FSVM-2 with the FSVM-1.

Table 67.1 lists the experimental results obtained with the FSVM-1 and the FSVM-2 on the artificial data. It can be seen that, although the FSVM-1 is competent, the FSVM-2 outperformed the FSVM-1. We can find that FSVM-2 performs more stable than FSVM-1 when the penalty parameter C varies from 10 to 1,000 and it has better generalization performance. All these experimental results illustrate that the new method proposed in this paper has better performance in reducing the effect of the outliers. In the tables, Rate 1 denotes the probability of

Table 67.1 Experimental results of the FSVM-1 and the FSVM-2 on the artificial data with Gaussian RBF kernel function (width = 2)

C	FSVM-1			FSVM-2		
	SVs	Rate 1 (%)	Rate 2 (%)	SVs	Rate 1 (%)	Rate 2 (%)
10	43 (35.8 %)	97.5	93.8	44 (36.7 %)	98.3	93.8
50	42 (35.0 %)	99.2	93.8	44 (36.7 %)	99.3	93.8
100	40 (33.3 %)	100	92.5	44 (36.7 %)	99.3	93.8
300	38 (31.7 %)	100	91.3	44 (36.7 %)	99.3	93.8
400	38 (31.7 %)	100	91.3	44 (36.7 %)	99.3	93.8
500	38 (31.7 %)	100	91.3	44 (36.7 %)	99.3	93.8
600	38 (31.7 %)	100	91.3	44 (36.7 %)	99.3	93.8
1,000	38 (31.7 %)	100	91.3	44 (36.7 %)	99.3	93.8

Table 67.2 Experimental results of the FSVM-1 and the FSVM-2 on the Monk's data sets

Kernel	C	FSVM-1			FSVM-2		
		SVs	Rate 1 (%)	Rate 2 (%)	SVs	Rate 1 (%)	R ate2 (%)
Gaussian (width = 2)	10	40 (32.8 %)	80.3	77.7	34 (28.3 %)	95.9	92.4
	50	31 (25.4 %)	93.4	84.8	36 (33.0 %)	99.2	94.2
	100	25 (20.5 %)	92.6	84.3	33 (27.5 %)	100	92.4
	500	39 (32.0 %)	91.0	83.5	30 (25.0 %)	100	91.9
Polynomial ($c = 1$, $p = 2$)	10	48 (39.3 %)	81.1	78.1	26 (21.7 %)	82.8	83.8
	120	27 (22.1 %)	83.6	80.3	18 (15.0 %)	75.4	76.2
	250	33 (27.0 %)	89.3	81.2	18 (15.0 %)	75.4	76.2
	800	42 (34.4 %)	82.2	79.6	18 (15.0 %)	75.4	76.2

correct classification on training set, Rate 2 denotes the probability of correct classification on test set, and SVs denotes the number of the support vectors and their percentage in the training set.

67.5.2 Experiments with Real Data

We choose the data sets of UCI Repository (http://www.ics.uci.edu/) to show the effect of the method. The Monk's problems are chosen from the database to test the proposed method. Each sample is represented by six discrete-valued attributes. To compare the proposed FSVM-2 with algorithm FSVM-1, experiments will be performed with the third training and testing data set from the database of the Monk's problems, for only this data set of the Monk's problem has 5 % noise among the samples. Table 67.2 lists the experimental results of the algorithm of the FSVM-1 and the FSVM-2 using Gaussian RBF kernel and polynomial kernel, respectively. The parameters of the SVM kernel (Gaussian width and polynomial kernel parameters) by DTREG (http://www.dtreg.com/svm.htm) (DTREG

provides two methods for finding optimal parameter values, that is, a grid search and a pattern search). In this paper, we use the method of the grid search.

Table 67.2 shows that, when using Gaussian kernel, the FSVM-2 with the new fuzzy membership function outperforms the FSVM-1.

67.6 Conclusions

Choosing an appropriate fuzzy membership function for a given problem is very important to solve classification problem with the FSVM. Different membership functions have different effects to the algorithm. A new fuzzy membership function for the FSVM is proposed based on the GRG in this paper. FSVM with the proposed fuzzy membership function can achieve better performance in reducing the effects of the outliers, which is better than the existing method of. Experimental results show the effectiveness of the present method in this paper.

Acknowledgments This work is partially supported by the National Natural Science Foundation of China (Grant No. 10771228), the Natural Science Foundation Project of CQ CSTC (Grant No. CSTC, 2010BB2090), Education Commission project Research Foundation of Chongqing (No. KJ110617, No. 50, No. KJ120628), PR China, and the Program for Innovative Research Team in Higher Educational Institutions of Chongqing, P. R China.

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Chapter 68
A Novel Multi-Labels Classification Algorithm

Qing Ai, Ji Zhao and Yuping Qin

Abstract For the problem of multi-labels classification, a multi-labels maximal-margin minimal-volume hypersphere support vector machine (SVM) is proposed by this paper. Use 1-a-r maximal-margin minimal-volume hypersphere SVM to train sub-classifiers, obtain membership vector of the sample to be classified according to the classifiers. At last give the labels that the sample to be classified belongs to according to the membership vector. The experimental results show that the algorithm has higher classification performance compared with the other multi-labels classification algorithms.

Keywords Multi-labels · Maximal-margin minimal-volume hypersphere support vector machine · Membership function

68.1 Introduction

Support vector machine (SVM) which was based on statistical learning theory was a new classification technique [1]. According to the limited samples, the best compromise between the complexity of model and the ability of learning was

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_68,

obtained by SVM. Because of its excellent generation ability, it had been widely used in many fields [2, 3] and had got better result [4].

SVM was two-class classifier and had many excellent training algorithms. To solve the problem of multi-class classification, people always decomposed it to a series of two-class classification problems. The main solutions included one against rest (1-a-r) [5], pairwise classification (1-a-1) [6], directed acyclic graphs SVM (DAGSVM) [7] and so on. But it was required by the algorithms that each training sample belonged to single-label and only single-label was labelled for a sample to be classified. However, most of samples are multi-labels in nature. For example, news for 911 is both the military news and the political news. For the problem of multi-labels classification, the old algorithms of multi-class classification cannot solve. A multi-labels classification algorithm based on DAGSVM was proposed by Ref. [8]. Based on DAGSVM and fuzzy theory, the fuzzy decision hyperplane was used to multi-label samples by the algorithm. For solving multi-labels classification, two algorithms based on SVM were also proposed by Ref. [9]. The first method used 1-a-1 to train sub-classifiers, for the sample to be classified, sub-classifiers were used to obtain membership matrix, and then according to the sum of every line of membership matrix, confirm the labels that the sample belonged to. The second method used 1-a-r to train sub-classifiers, for the sample to be classified, sub-classifiers were used to obtain the membership vector, according to the membership vector, confirm the labels that the sample belongs to. It was shown that two algorithms of Ref. [9] have better performance, compared with the algorithm of Ref. [8], the other multi-labels classification algorithm based on hypersphere SVM was proposed by Ref. [10]. The hypersphere SVM was used to obtain each hypersphere, the distances from the sample to be classified to center of each hypersphere is computed, according to the distances, the membership vector was gotten, at last give the labels that the sample to be classified belongs to according to the membership vector. Based on maximal classification margin of SVM and minimal description volume of support vector data description, a maximal-margin minimal-volume hypersphere SVM was proposed by Ref. [11]. Two different concentric hypersphere was built in the model, positive samples were packed in small hypersphere and negative samples were excluded outside large hypersphere. The margin of two hypersphere was maximized by the objective function of model. The maximization of margin and the minimization of volume were realized and the classification performance was improved. For multi-labels classification, a multi-labels maximal-margin minimal-volume hypersphere SVM is proposed by this paper. The experimental results show that the algorithm has higher performance on average precision, average recall, and average $F1$, compared with the other multi-labels classification algorithms.

The rest of this paper is organized as follows: In Sect. 68.2, a brief review of maximal-margin minimal-volume hypersphere SVM is given. In Sect. 68.3, a multi-labels maximal-margin minimal-volume hypersphere SVM is discussed in detail. In Sect. 68.4, experimental result is given in standard datasets. Finally, conclusions are outlined.

68.2 Maximal-Margin Minimal-Volume Hypersphere Support Vector Machine

Given sample set $\{x_i, y_i\}$, $i = 1, 2 \ldots$ n, $x_i \in R^d$, $y_i \in \{-1, 1\}$. x_i^+ is positive training sample and x_j^- is negative training sample. It is supposed that there exists two concentric hyperspheres S_1 and S_2, the center of two concentric hyperspheres is c. S_1 is small hypersphere and radius is R_1, S_2 is large hypersphere and radius is R_2, $R_2 \geq R_1$. The positive samples are packed in S_1 and the negative samples are excluded outside large hypersphere S_2. The mathematic model of maximal-margin minimal-volume hypersphere SVM is formulated as follows [11]:

$$\max_{R_1, R_2, c, \xi_i, \xi_j} R_2^2 - MR_1^2 - C_+ \sum_i \xi_i^+ - C_- \sum_j \xi_j^- \tag{68.1}$$

$$\text{s.t. } \left\| x_i^+ - c \right\|^2 \leq R_1^2 + \xi_i^+ \tag{68.2}$$

$$\left\| x_j^- - c \right\|^2 \geq R_2^2 - \xi_j^- \tag{68.3}$$

$$R_2^2 - R_1^2 \geq 0,\ \xi_i \geq 0,\ \xi_j \geq 0,\ \forall i, \forall j \tag{68.4}$$

where ξ_i^+ and ξ_j^- are slack variables, C_+ and C_- are penalty parameters. The parameter M (M > 0, M $\neq$ 1) is used to compromise between R_2^2 and R_1^2.

The dual optimal problem is obtained as follows:

$$\begin{aligned} \min_{\alpha} & -\sum_i x_i^+ \cdot {x_i}^+ + \sum_j x_j^- \cdot x_j^- + \frac{1}{M-1} \sum_{i,l} \alpha_i^+ \alpha_l^+ (x_i^+ \cdot x_l^+) \\ & + \frac{1}{M-1} \sum_{i,l} \alpha_i^+ \alpha_l^+ (x_i^+ \cdot x_l^+) + \frac{1}{M-1} \sum_{j,k} \alpha_j^- \alpha_k^- (x_j^- \cdot x_k^-) \end{aligned} \tag{68.5}$$

$$\text{s.t. } \sum_i \alpha_i^+ - \sum_j \alpha_j^- = M - 1 \tag{68.6}$$

$$\sum_i \alpha_i^+ \geq M \tag{68.7}$$

$$0 \leq \alpha_i^+ \leq C_+,\ 0 \leq \alpha_j^- \leq C_- \tag{68.8}$$

Solve dual problem (68.5)–(68.8) and get optimal solution α_i^+ and α_j^-. When $0 < \alpha_i^+ < C_+$, x_i^+ is called support vector of hypersphere S_1; when $0 < \alpha_j^- < C_-$, x_j^- is called support vector of hypersphere S_2.

68.3 Multi-Labels Maximal-Margin Minimal-Volume Hypersphere Support Vector Machine

Given multi-labels training sample set $\{x_i, E_i\}_{i=1}^{l}$ and kernel function $K(x_i, x_j)$, where $x_i \in R^n$, $E_i = \{y_{ij}\}_{j=1}^{p}$, $y_{ij} \in \{1, 2, 3, \ldots, q\}$. q is the number of categories of the training set. P ($\leq q$) is the number of the categories of the sample x_i. $K(x_i, x_j)$ corresponds to inner product in feature space, namely, $K(x_i, x_j) = g(x_i) \cdot g(x_j)$, where g: $X \mapsto Z$ is a transformation that projects input space to feature space. For the training samples, use 1-a-r to train sub-classifiers $H_i(c_i, R_i^+, R_i^-)$ ($i = 1, 2, \ldots q$), where H_i is two different concentric hyperspheres that are obtained by training maximal-margin minimal-volume hypersphere SVM with all of the samples in the ith class with positive labels and all other samples with negative labels, samples of the ith class are packed in small hypersphere, and all other samples are excluded outside large hypersphere. The inner hypersphere of $H_i(c_i, R_i^+, R_i^-)$ is represented by $H_i(c_i, R_i^+)$ and the outer hypersphere of $H_i(c_i, R_i^+, R_i^-)$ is represented by $H_i(c_i, R_i^-)$, where c_i is the center of the two different concentric hypersphere, R_i^+ is radius of inner hypersphere and R_i^+ is radius of outer hypersphere.

Definition 1 The membership functions of the sample x to be classified for $H_i(c_i, R_i^+)$ and $H_i(c_i, R_i^-)$ are respectively defined as follows:

$$m_i^+(x) = 1 - d_i(x)/R_i^+ \tag{68.9}$$

$$m_i^-(x) = 1 - d_i(x)/R_i^- \tag{68.10}$$

where $d_i(x) = \|x - c_i\|$.

Definition 2 The membership of the sample x to be classified for $H_i(c_i, R_i^+, R_i^-)$ is defined as follows:

$$m_i(x) = (m_i^+(x) + m_i^-(x))/2 \tag{68.11}$$

From Eq. (68.11), obtain membership vector as follows:

$$M(x) = \begin{pmatrix} m_1(x) \\ \vdots \\ m_q(x) \end{pmatrix} \tag{68.12}$$

Given weight $\kappa\,(0 < \kappa \leq 1)$. It is supposed that there exists $m_i(x) > 0$, if $m_i(x) \geq \kappa \times MAX(m_i(x))$, x to be classified belongs to the ith label. Otherwise all $m_i(x) < 0$, if $d_i(x) = MIN(d_j(x))$, x to be classified belongs to the ith label.

The algorithm is described in detail as follows:

Step 1 Given the sample to be classified x and weight κ;
Step 2 Get membership matrix $M(x)$ of the sample to be classified x according to Eq. (68.11);
Step 3 There exists $m_i(x) > 0$, goto step 5; else goto step 6;
Step 4 If $m_i(x) \geq \kappa \times MAX(m_i(x))$, x to be classified belongs to the ith label. Goto step 6;
Step 5 If $d_i(x) = MIN(d_j(x))$, x to be classified belongs to the ith label. Goto step 6;
Step 6 The End.

68.4 Experiments

Experiments are made on standard data sets scene that includes six classes ($q = 6$), 2,407 samples and maximum of the number of labels of each sample is three ($p = 3$). 1,211 samples are used as training set and the rest are used as testing set.

The macro-average precision, macro-average recall, and macro-average $F1$ [8] of the algorithm for different κ are given in Fig. 68.1, where kernel function is Radial basis function (RBF) $\mathrm{K}(\mathrm{x}, \mathrm{y}) = e^{-0.25\|x-y\|^2}$, the parameter of system $C_+ = C_- = 100$ and $M = 32$. In Fig. 68.1, when κ smaller, macro-average precision is lower, and macro-average recall is higher. With the increment of κ, macro-average precision is enhanced and macro-average recall is lowed. When macro-average precision is equal to macro-average recall, macro-average $F1$ is maximal, namely, the performance of the algorithm is the best. In other words, at this point the average performance of system is the best. The experiment offers the rule to select κ, namely, the point that macro-average precision is equal to macro-average recall should be selected. A number of experiments have showed that κ is the best between 0.75 and 0.95.

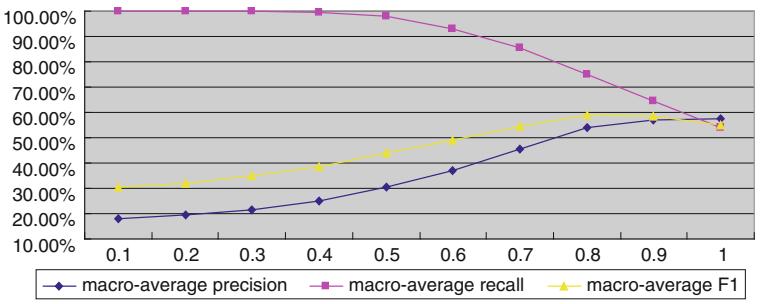

Fig. 68.1 The macro-average precision, macro-average recall, and macro-average $F1$ of the algorithm for different κ

Table 68.1 The results of comparing multi-labels maximal-margin minimal-volume hypersphere SVM with the other multi-labels classification algorithms

Algorithms	Macro-average precision (%)	Macro-average recall (%)	Macro-average $F1$ (%)
The algorithm proposed by Ref. [8]	43.13	46.82	43.62
The algorithm proposed by Ref. [9](1-a-1)	45.23	48.65	46.87
The algorithm proposed by Ref. [9](1-a-r)	44.17	47.63	45.83
The algorithm proposed by Ref. [10]	49.45	90.93	58.30
The algorithm proposed by this paper	55.90	70.23	59.0

Table 68.2 The parameters

Parameters	C	v	M	γ	θ	τ	κ
Algorithm proposed by Ref. [8]	2	–	–	1/32	0.7	–	–
Algorithm proposed by Ref. [9](1-a-1)	2	–	–	1/32	0.7	–	–
The algorithm proposed by Ref. [9](1-a-r)	2	–	–	1/32	0.4	–	–
Algorithm proposed by Ref. [10]	–	1/16	–	1/8	–	0.7	–
Algorithm proposed by this paper	16	–	32	1/4	–	–	0.85

The results of comparing multi-labels maximal-margin minimal-volume hypersphere SVM with the multi-labels classification algorithms of Refs. [8–10] are presented in Table 68.1, where kernel functions are RBF $K(x, y) = e^{-\gamma\|x-y\|^2}$, the parameters C_+, C_-, M and κ mentioned in this paper, C and θ mentioned in Refs. [8, 9], v and τ mentioned in Ref. [10] is presented in Table 68.2. As Table 68.1 shows, the algorithm has higher macro-average precision, macro-average recall, and macro-average $F1$, compared with the other multi-labels classification algorithms.

68.5 Conclusions

Based on maximal-margin minimal-volume hypersphere SVM and fuzzy theory, novel multi-labels classification algorithm is proposed by this paper. The experimental results show that the algorithm compared with the other multi-labels classification algorithms has better performance. Therefore, it is a more practical algorithm to deal with multi-labels classification. In the future work, we will focus on finding more intelligent algorithms which is used for selecting parameters κ that is given according to experience.

Acknowledgments This study is partly supported by the National Natural Science Foundation of China (No. 60603023), and the education committee project of Liaoning province in China (No. 2010076).

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Chapter 69
Parameter Optimization for SVM Classification Based on NGA

H. S. Qin, Y. Wei and S. H. Zeng

Abstract This paper described the principle of Support Vector Machine (SVM), analyzed the influence of kernel parameters on its classification performance, and proposed the SVM classification performance fitness function using a new leave-one-out. Due to the Niche Genetic Algorithm (NGA) which avoids the premature situation and better maintains the diversity of solution, shared fitness function is defined based on fitness function with the hamming distance between two individuals. Then, constructed the choice operation, intersect operation, and aberrance operation. Finally, the simulations show that our parameters optimization algorithm is effective and practical, using samples produced by three test methods and in UCI data set.

Keywords Support vector machine · Parameter optimization · Niche genetic algorithm · Shared fitness function

69.1 Introduction

Since support vector machine (SVM), as a new statistical learning method, was proposed by Vapnik in 1990s [1]. It has obtained a great development and been applied in various fields in recent years, such as pattern recognition, fault diagnosis, network intrusion, bioinformatics, and agricultural-informatics and so on. SVM outperform in learning speed and generalization compared with traditional statistical classification, especially in the case of small sample and nonlinear.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_69,

In order to enhance the classification accuracy of SVM, researchers focused on how to optimize its parameters.

Many scholars have made a significant contribution to research the method of optimizing SVM parameters and find a lot of effective algorithms. Staelin et al. [2] chose the RBF kernel function parameters and the penalty parameters by the experimental design method which greatly reduced the search scope. Aydin et al. [3] presented develop a multi-objective artificial immune algorithm to solve this problem and voided these parameters are selected by trial and error or human's experience. The kernel and structural parameters were optimized by kernel calibration coefficients and expected training error, respectively. However, it has neither efficiency compute nor integration into the genetic algorithm [4]. Sun [5] proposed feature extraction of SVM with niche genetic algorithm (NGA) and principal component analysis (PCA) which no parameter optimization. Liu [6] addressed adaptive GA-SVM parameter optimization with automatically adjusting probability using fitness and despite parameter C. Automatically search the optimal parameter values of SVM based on niches genetic algorithm which search region is defined as the determined range [7]. Another algorithm were not optimizing genetic operators [8–12]. The simple genetic algorithms have some disadvantages, such as premature convergence, non-global convergence, and convergence weakness in later, which cannot maintain the diversity of solution and is good at searching the global optimal solution.

This paper formulated parameter optimization of SVM for classification based on NGA and constructed the fitness function of SVM classification by improvement leave-one, it enhanced SVM generalization. Then, parameter optimization with NGA which constructed a share function based on Hamming distance between the individual. The experimental results testify that the proposed algorithm is effective and practical.

The rest of the paper is structured as follows. Section 69.2 presents the framework of support vector machine. It presents our main contribution in Sect. 69.3 and proposes the new parameter optimization algorithm, we report on the empirical results in Sects. 69. 4 and 69.5 concludes.

69.2 The SVM Framework

Support vector machine (SVM) framework focus on finding a nonlinear mapping ϕ between input space and output space for samples in low-dimensional are mapping to high-dimensional feature space F. Hence, nonlinear samples in input space can be distinguished in F. Then, we can construct an optimal hyperplane for approximating the desired results. Set the training set $S = (x_1, y_1), \ldots, (x_l, y_l)$, $x \in R^n, y \in \{+1, -1\}$, where l and n can be defined as the training samples and dimensionality, respectively. y is the binary classification. There is classification hyperplane, as known $w^T x + b = 0$, can correctly separate the training samples if

samples can be separated in feature space F. We now aim at finding the optimization problem of the classification hyperplane.

$$\begin{aligned} \min\ \ & \Phi(w) = ||w||^2/2 \\ \text{s.t.}\ \ & y(w^T x + b) \geq 1 \end{aligned} \tag{69.1}$$

where w and b are weight and offset, respectively. When we obtain the minimum $||w||^2/2$, that is to say, we find the optimal hyperplane.

However, the samples cannot be separated in F which create a certain number of misclassified samples. In order to solve the problem, slack variable ξ is introduced and the optimization problem is rewritten as:

$$\begin{aligned} & \min \tfrac{1}{2}||w||^2 + C\sum_{i=1}^{l}\left(\xi_i + \xi_i^*\right) \\ & \text{s.t. } y_i[w^T \Phi(x_i) + b] \geq 1 - \xi_i \\ & \xi_i, \xi_i^* \geq 0, \quad i = 1, 2, \ldots, n \end{aligned} \tag{69.2}$$

where penalty parameter is $C(C > 0)$. The proportion of confidence intervals and empirical risk is adjusted in feature space by C, which aim at finding the best generalization of SVM. And C is larger, the empirical error has more punishment. When the complexity of machine learning is large and its experience risk value is smaller, which well give rise to overlearning, otherwise known as the less learning.

Calculating the derivatives of the Lagrangian with respect to primal variables w, b, ξ_i, ξ_i^* and setting these derivatives to zero, then we arrive at the follow dual problem of (69.2):

$$\begin{aligned} & \min \tfrac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l} y_i y_j a_i a_j k(x_i, x_j) - \sum_{i=1}^{l} a_i \\ & \text{s.t.} \sum_{i=1}^{l} y_i a_i = 0 \\ & \quad 0 \leq a_i \leq C, \quad i = 1, 2, ..., n \end{aligned} \tag{69.3}$$

where $k(x_i, x_j) = \left(\Phi(x_i), \Phi(x_j)\right)$, Kernel methods only deal with the kernel function $k(x_i, x_j)$ rather than the explicit form of ϕ which efficiently avoid the complex inner product and the design of machine itself (feature space). We can obtain the optimal solution a_i^* by solving (69.3) and the support vector is $0 < a_i^* < C$. Then, the optimization classification function of SVM becomes:

$$f(x) = \text{sgn}\left(\sum_{i=1}^{l} y_i a_i^* k(x_i, x_j) + b^*\right) \tag{69.4}$$

where $b^* = y_i - \sum_{i=1}^{l} y_i a_i^* k(x_i, x_j)$. Due to the outperformance of radial basis kernel function, as known $k(x_i, x_j) = \exp(\frac{-||x_i - x_j||}{\sigma^2})$, RBF function is selected as the parameters optimization of SVM classifier in this paper.

69.3 Parameters Optimization Based on Niche Genetic Algorithm

From the above analysis, the classification performance of SVM is impacted by parameters σ^2 and C, and has influence on the distribution complexity of samples and the proportion of confidence intervals and empirical risk, respectively. Therefore, in order to receive the best generalization of SVM, we must first select the appropriate σ^2 to make samples are mapped to F, and then we acquire optimal ratio of confidence intervals and empirical risk with adjusting parameter C. Wang et al. [10]. proposed optimize RBF kernel parameter σ based on Fisher criterion. Li et al. [11] addressed the fitness evaluation of the validation error. Optimizing the parameters σ^2 and C based on shared function using NGA is presented by this paper. A series of simulation experiments demonstrate that the proposed algorithm outperforms SVM in classification accuracies and achieves more efficiency and practice.

69.3.1 Encode

The improved SVM classifier aim at solving high-dimensional and high-accuracy successive function optimization problem, so floating-point coding is selected in the algorithm in which individual chromosomes are represented by a float within a range, and the individual coding length is equivalent to the number of variables. The method efficiently enhance computing speed and accuracy, and avoid some problem of binary coding, such as the larger coding length, the inferior performance, and accuracy of genetic algorithm caused by repetitively encoding and decoding.

69.3.2 Fitness Function

In this paper, we evaluate the classification performance of SVM with new leave-one-out, known as NLOO. In NLOO method, l samples were divided into d groups, where every group is represented by $D_i, i = 1, 2, \ldots, d$. Consider one group as testing samples and the remainder $d-1$ groups as the training samples. Then, we obtain the evaluation function of the i sample by the reciprocal of error sum squares about the result output of d groups with SVM classifier and objective function. The sample is more useful when F_i becomes larger, then more generalization of SVM classifier. The fitness function is:

$$F_i = \frac{1}{\sum_{j=1}^{d} \sum_{(x_i, y_i \in D_j)} (y_i - f(x_i))^2 + \alpha} \tag{69.5}$$

In order to avoid the denominator approximates zero and set as constant, and $\sum_{(x_i,y_i\in D_j)}(y_i - f(x_i))^2$ represents the error sum squares about SVM output and objective function.

69.3.3 Niche Genetic Algorithm

The NGA avoids the premature situation and better maintains the diversity of solution compare with these sample genetic algorithms. We achieve the algorithm by shared function using Hamming distance between the individual samples [9]. The Hamming distance is defined as:

$$sh_{ij} = ||d_i - d_j|| = \sqrt{(\sigma_i^2 - \sigma_j^2)^2 - (C_i^2 - C_j^2)^2} \tag{69.6}$$

where d_i and d_j denote the i individual and the j individual in population, respectively. Hence, the shared function rewrite as:

$$SF_i = F_i / \sum_{j=1}^{N} sh_{ij} \tag{69.7}$$

where N is the number of population and $\sum_{j=1}^{N} sh_{ij}$ is defined as the sharing measure of the i individual, When the distance between two individuals is less L, the individual fitness whose the shared function is small will be multiplied by C where C is relatively small, is smaller. So the individual well be likely eliminated in the last evolution. Therefore, to maintain the diversity of population for there is only a fine individual within L. And a certain distance is existed in each individual so that these individuals can spread in feature space. Then, we achieve the niche elimination algorithm.

69.3.4 The Choice Operation, Intersect Operation, and Aberrance Operation

Intuitively, the choice operation is defined as the individual well be genetic or eliminated in the next generation based on individual fitness. According to (69.5–69.7), we calculate the individual shared fitness function SF_i. Then, the choice probability P_i is computed as:

$$P_i = SF_i / \sum_{j=1}^{N} SF_j \tag{69.8}$$

Consider the roulette wheel selection, the rotary wheel is divided into N parts and each regards as $2\pi P_i$. Firstly, setting a fixed point and begin to turn the wheel. The selected individual is that pointed part when the wheel is stopped. Obviously,

the larger probability of selected individual whose P_i is relatively large. Setting $P1$, $P2$ as chosen two parents of individuals, the intersect operation is

$$\begin{aligned} P1 &= P_c P1 + (1 - P_c)P2 \\ P2 &= P_c P2 + (1 - P_c)P1 \end{aligned} \tag{69.9}$$

where P_c is weight coefficient and it belongs to random number between 0 and 1. The aberrance operation is executed by changing the individual step, giving P_m as the aberrance probability and it belongs to random number between 0 and 1. The aberrance operation formula as following:

$$P = P + P_m(P_{\max} - P_{\min}) \tag{69.10}$$

where P respects intersected individual, $P_{\max}$ and $P_{\min}$ are the maximum and minimum of the search space.

69.3.5 The Parameters Optimization Algorithm

In this paper, the outline of the proposed algorithm is shown in Algorithm 1, and the termination criterion of the algorithm is: maximum number of iteration has been reached G generation or the best individual of population has no improvement in several generations.

Algorithm 1— The parameters optimization algorithm	
Input	The training sample set $S = \{(x_1, y_1), (x_2, y_2), \ldots, (x_m, y_m), x \in R^n, y \in \{-1, +1\}\}$
Initialization	Randomly generated initial population by x, and code using floating-point
Algorithm	While the stopping criterion not meet repeat Step1: evaluate the performance of SVM classifier with NLOO, calculate the individual fitness function F_i with (69.5) Step2: calculate the shared fitness SF_i with (69.6) Step3: introduce NGA and generate the new generation population with P_i, P_c, P_m and (69.8), (69.9), (69.10)
Output	The result of SVM binary classification

69.4 The Simulation Experiment

In the simulation experiment, we randomly select three UCI datasets, such as German, Heart, and Sonar, to evaluate the efficiency of proposed algorithm. With every experiment, simulated data set consists of an independent training set and an independent testing set in which 50 % of the samples are randomly selected as the training set and the randomly data are used for test.

Table 69.1 Simulation study configurations and results

Data	Data dimension	Classification accuracy %		
		PO-NGA	PO-SGA	PO-SVM
German	20	68.48	67.20	64.20
Heart	13	75.30	74.40	71.18
Sonar	60	80.20	77.70	75.26

In order to validate the performance of our presented algorithm, three methods are simulated: (1) The parameters optimization based on NGA, as PO-NGA; (2) parameters optimization using simple genetic algorithm [11], as PO-SGA; (3) parameters optimization using standard SVM and setting the empirical parameters, as PO-SVM, where $C = 100$, $\sigma_1 = \sigma_2 = 1$.

Observed from Table 69.1, the average classification accuracy of independent experiment proves that parameters optimization based on NGA clearly outperforms the simple genetic algorithm. And search range of parameters optimization is greatly reduced by our proposed algorithm compared with standard SVM. The result denotes that our method is more effective and practical.

69.5 Conclusion

In this paper, we can conclude following two respects by the above analysis.

(a) Analyze the impact of classification performance by SVM parameters σ^2 and C. We can better evaluate the SVM classifier generalization with fitness function using the new leave-one-out.
(b) The parameters optimization based on shared function NGA for SVM is proposed, this method can adaptively optimize SVM parameters and effectively avoid the chose blindness through the human experience. Then, constructed the choice operation, intersect operation and aberrance operation. The average classification accuracy and search capability of algorithm clearly outperforms the simple genetic algorithm and standard SVM.

Acknowledgments The work was supposed by the Scientific Research Foundation of the Chongqing Municipal Education Commission, China (No. KJ090823 and No. KJ110632), Natural Science Foundation of Chongqing, China (No. cstc2011jjA40008), and the Foundation of the Chongqing Normal University, China (No. 11XLB047).

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Chapter 70
Ground Nephogram Classification Based on Gabor Wavelet and SVM

Hanguang Li and Qi Wang

Abstract Techniques called feature extraction and pattern recognition are implemented for nephogram representation and recognition. In this approach, the Gabor wavelets are used to extract features of ground nephograms. The principal component analysis (PCA) is applied on the Gabor transformed matrices to reduce the dimensions of these features. Finally by using these features, we can train support vector machine (SVM) classifiers for classifying cloud types. After finishing training, we can use these trained SVM classifiers to classify these cloud types. During these experiments, we used different Kernels and parameters for comparison. Experiment results indicated that the solution proposed in this paper was able to get a good accurate rate which was higher than the solution using Haar-like features and AdaBoost algorithm.

Keywords Gabor wavelet · Texture features · SVM · PCA · Ground nephogram classification

70.1 Introduction

Clouds affect the energy balance of the earth by means of absorbing and scattering radiation, and they have notable influences on global climate. It is very important to monitor clouds [1]. Yang et al. used the method of texture analysis to extract

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_70,

characteristic parameter and judged from statistic pattern recognition [2]. Zhang et al. used feature extraction based on co-occurrence matrices, and neural network classifiers for identifying cloud types in test images [3].

Gabor wavelet is a powerful texture analysis tool [4]. The ground nephogram has a rich texture, and is suitable for feature extraction using Gabor wavelet. Support vector machine (SVM) is an useful tool for classification. It was first applied in classifying Two Class problems, and may be extended to multiclass classification problems. Zhang presented an algorithm and implementation of image classification based on SVM [5]. Luo used SVM classifiers for classification of remotely sensed imagery [6]. In this paper, we combined these two technologies, and put forward a new solution of ground nephogram classification. We achieved good results.

70.2 Gabor Wavelet Extracts Texture Features

Gabor wavelet transform has particular advantages in the image texture analysis. Mutelo et al. studied two-dimensional (2D) Gabor features for face recognition [7]. Zhang et al. extracted texture feature by using Gabor wavelet [8].

70.2.1 Gabor Wavelet

The Kernel of Gabor wavelet: $\varphi_{\mu,v}(z) = \frac{\|k_{\mu,v}\|^2}{\sigma^2} e^{-\|k_{\mu,v}\|^2 \|z\|^2 / 2\sigma^2} \left(e^{ik_{\mu,v}z} - e^{-\sigma^2/2} \right)$ where μ and V are the direction and the scale of Gabor kernel, $z = (x, y)$, operator $\|\bullet\|$ means standard operation, wave vector.

$$k_{\mu,v} = k_v e^{i\Phi_\mu} \tag{70.1}$$

where $k_v = k_{\max}/f^v$, $_\mu = \pi\mu/8$. $k_{\max}$ is the maximum frequency of central frequencies of the active band filter. f is interval factor of the kernel [9].

Wavelet kernel can be generated by the wave vector in (70.1). $\| k \|$ controls the width of the Gaussian window and the wavelength of the sine wave. Φ controls the direction of the filter. σ defines the ratio of Gaussian window width and wavelength. For digital images, Gabor wavelet usually samples at five scales $v \in \{0,\ldots,4\}$ and eight directions $\mu \in \{0,\ldots,7\}$ on the condition that the parameters $\boldsymbol{\sigma}$ equals to 2π, $k_{\max}$ equals to $\pi/2$, and f equals to $\sqrt{2}$ [10]. The choice of scale is very important. It cannot present the local feature of the image when the scale is too big, and can be affected by the noise when the scale is too small. In this paper, we choose three scales and eight directions so that we can achieve twenty-four filters.

70.2.2 Ground Nephogram Texture Features by Using Gabor Wavelet

The Gabor features of one ground nephogram are convolution result of the image and the Gabor wavelet. $I(z)$ means the image, its Gabor feature:

$$X_{\mu,v}(z) = I(z) * \varphi_{\mu,v}(z) \tag{70.2}$$

where $\varphi_{\mu,v}(z)$ is the Gabor kernel, $X_{\mu,v}(z)$ means the convolution results of the Gabor kernel at scale V and direction μ [11].

70.2.3 Principal Component Analysis

PCA method can retain the main feature on the premise of reducing feature dimensions. PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system. This is done by using only the first few principal components so that the dimensionality of the transformed data is reduced [12]. For example image $I(z)$ is an $N \times N$ matrix; we get a sample after standardizing the image, and the covariance matrix of the samples:

$$S_t = \sum_{i=1}^{M} ((xi - \alpha)(x_i - \alpha)^T) \tag{70.3}$$

where x_i denotes the ith sample vector, $\alpha = \frac{1}{M}\sum_{i=1}^{M} x_i$ is the mean vectors of the samples, M is the total number of samples, S_t is the covariance matrix which can be transformed to a diagonal matrix: $P^{-1}S_tP = diag[\lambda_1, \lambda_2, \cdots, \lambda_N]$

Where P is the orthogonal transformation matrix $\lambda_n n = 1, 2, \cdots, N)$ is the eigenvalue of S_t and $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_N \geq 0$, λ_n corresponds to the orthogonal normalized eigenvectors $\alpha_{\boldsymbol{n}}$. $\alpha_1, \alpha_2, \ldots, \alpha_N$ can constitute the orthogonal basis in space $\Re^N$, in this space the sample of this image can be represented as follows:

$$x_i = \sum_{n=1}^{N} x_i(n)\alpha_n \tag{70.4}$$

We can use the first $r(r, N)$ eigenvalues corresponding to the eigenvectors as principal components. Then x_i is projected to the subspace of the orthogonal space $P_{\boldsymbol{i}} = [\alpha_1, \alpha_2, \ldots, \alpha_{\boldsymbol{r}}]^T \bullet x_i$.

Where $P_{\mathrm{i}} = x_i(1), x_i(2), \ldots, x_i(r)$ is a set of coordinates coefficients which indicates the position of x_i in the new space. We can use P_i as the eigenvectors for classification [13].

70.3 Classifier Based on SVM

SVM are a group of supervised learning methods that can be applied to classification or regression. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on.

70.3.1 The Linearly Separable Case

The problem can be solved by searching the maximum marginal hyperplane which has the largest distance between positive examples and negative examples. For 2D linear separable problems, define classification line H which separates two classes of samples successfully. $H1$ and $H2$ are straight lines paralleling H, and contain samples which are nearest to line H. The distance between $H1$ and $H2$ is called classification interval. So the optimum classification line not only can separate two classes but also has the largest classification interval.

Given data set $D = \{(X_1, y_1), (X_2, y_2), \ldots, (X_{|D|}, y_{|D|})\}$, where X_i is training set, y_i is its label, $y_i \in \{+1, -1\}$.

Marginal hyperplane can be defined as:

$$W \bullet X + b = 0. \tag{70.5}$$

Where W is weight, $W = \{w_\infty, w_\in, \ldots, w_n\}$, n is the number of attributes, b is bias. X means the values of attributes $X = (x_1, x_2, \ldots, x_n)$. We can change (70.5) as follows: $\sum_{i=0}^{n} w_i \bullet x_i + b = 0$.

Adjust bias b, we can define $H1$ and $H2$:

$$H_1 : \sum_{i=0}^{n} w_i \bullet x_i + b \geq 1$$

$$H_2 : \sum_{i=0}^{n} w_i \bullet x_i + b \leq -1 \tag{70.6}$$

That is to say, the points above $H1$ belong to class of +1, and the points below $H2$ belong to class of -1. Actually training the SVM is a constrained quadratic optimization problem. According to the Lagrangian formula, the maximum marginal hyperplane can be rewritten in the decision boundary:

$$d(X^T) = \sum_{i=1}^{l} y_i \alpha_i X_i X^T + b_0 \tag{70.7}$$

where y_i the label of support vector is X_i, X^T is test set, α_i and b_0 are parameters which are determined automatically by the SVM algorithm, l is the number of support vectors.

70.3.2 The Linearly Nonseparable Case

Classification of ground nephogram is a linearly nonseparable problem. According to the pattern recognition theory, we can change a linearly nonseparable problem into a linearly separable one by mapping it into a high-dimensional space. So the problem becomes linearly separable in the high-dimensional space. The problem is solved. We can use Kernels $K(X_i, X_j)$ which can map input into a high-dimensional space for classification. Here are three common Kernels.

Polynomial: $K(X_i, X_j) = (X_i \bullet X_j + 1)^h$

Gaussian (radial-basis function network): $K(X_i, X_j) = e^{-\|X_i - X_j\|^2 / 2\sigma^2}$

Sigmoid: $K(X_i, X_j) = \tanh(\kappa X_i \bullet X_j - \delta)$

70.3.3 Multiclass SVM

We have discussed Two Class classification SVM including linearly separable case and linearly nonseparable case. For multiclass classification problems, SVM can be achieved by combining Two Class classifications together. Usually there are two strategies.

One-versus-rest.

In this strategy, each step of the classification will separate one from the other. For example, if there are M classes, we need to train M classifiers.

One-versus-one.

In this strategy, each step of the classification will separate any two classes. For example, if there are M classes, we need to train $M(M-1)/2$ classifiers.

In this paper, we use LIBSVM providing by Chih et al. [14] and one-versus-one strategy.

70.4 Results and Analysis of Experiments

According to the programs discussed above, some experiments were done to test the algorithm. The experiments include two parts, training and classifying. Figure 70.1 is the framework of the experiments. The training samples used in the experiments were 64 × 64 pixels grayness images.

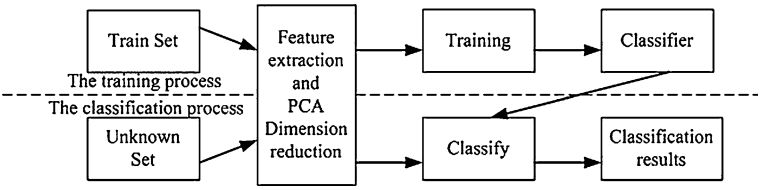

Fig. 70.1 Framework of ground nephogram classifying system

Fig. 70.2 One of the samples in experiments

Table 70.1 Results of haar-like features and adaboost algorithm

Class of nephogram	Accurate rate (%)
Cu cong	45
Ns	50
Actra	45
Cc	40

In the experiments, we use four common types of cloud such as Cumulus congestus, Nimbostratus, Altostratus translucidus, and Cirrocumulus. During the training process, there are 200 nephograms for each type of clouds as positive samples and 20 nephograms as testing samples. One of the samples is shown in Fig. 70.2.

Kernels and parameters values used in the experiments and results are shown in Tables 70.1, 70.2, and 70.3.

Making an analysis of the results, the choices of different Kernels and parameters values have an effect on the recognition rate. So we need to select the appropriate parameters according to the conditions of different experiments. Experimental results show the experiment scheme in this paper has a high accuracy. But there are still errors in classification. It is mainly attributable to the anomalous structure of clouds. And the limitations of the samples have some bad influence.

Table 70.2 Polynomial kernels and the results

Class of nephogram	Accurate rate			
	$h = 1$ (%)	$h = 2$ (%)	$h = 3$ (%)	$h = 4$ (%)
Cu cong	85	80	80	75
Ns	80	80	85	80
Actra	85	80	85	90
Cc	90	85	75	85

Table 70.3 Gaussian radial-basis function network kernels and the results

Class of nephogram	Accurate rate			
	$\sigma = 2$ (%)	$\sigma = 3$ (%)	$\sigma = 4$ (%)	$\sigma = 5$ (%)
Cu cong	85	85	80	80
Ns	80	85	85	85
Actra	75	85	80	85
Cc	80	85	85	75

70.5 Conclusion

SVM is a very effective classification method. Experiment scheme based on Gabor wavelet and SVM is proposed in this paper. Experimental results indicate that the scheme is practicable. Future research will focus on a more powerful analysis of feature extraction and the choices of different Kernels and parameters values.

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Chapter 71
Face Recognition by Nonsubsampled Contourlet Transform and Support Vector Machine

Yuehao Wang

Abstract This paper proposed a new face recognition method based on nonsubsampled contourlet transform (NSCT) and component-based support vector machine (SVM). This approach takes technological advantages of both SVM for classification and the NSCT for facial feature extraction. We named the new method combining the nonsampled contourlet transform and SVM as NSCT-SVM. The experimental results on ORL and MIT-CBCL face database demonstrate that our face recognition method is effective and competitive.

Keywords Face recognition · Nonsubsampled contourlet transform (NSCT) · Support vector machine (SVM)

71.1 Introduction

Face recognition, which offers a nonintrusive and the most natural way of personal identification, is one of the most successful biometric methods [1]. It has attracted significant attention of the researchers in computer vision, image/video analysis and understanding, machine learning, etc. especially since the past 20 years, it has been widely used in several applications such as video surveillance, security access control systems, human–computer intelligent interaction, biometrics [2], etc.

Many new technologies and theories behind face recognition are still emerging [1, 2]. The most popular approaches applied in face recognition include PCA, LDA, ICA, LPP, Elastic Graph Matching, HMM, etc. [3, 4]. One kind of most

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_71,

popular face recognition algorithms generally contain two most basic face recognition process stages, the feature extraction and the classification.

Inspired by the literatures in reference, we propose a new method mainly based on the combination of nonsubsampled contourlet transform (NSCT) [5] for facial feature extraction and support vector machine (SVM) [3, 4] for classification. The contributions of this paper include the following aspects: (1) SVM is successfully applied to face recognition by using the nonsampled contourlet transform as the facial feature representation; (2) the NSCT are used to represent the whole face in a computable dimensional space. The method is evaluated on two famous face image databases, ORL and MIT-CBCL [6], and the experimental results show that the new method is more effective.

The paper is organized as follows. In the next section, we briefly describe the history of multi-resolution analysis tools development, especially on the recently most successful progress of this area, NSCT [8]. Section 71.3 describes the SVM technology used in our method. Experiment results are summarized in Sect. 71.4 followed by discussions and conclusions in Sect. 71.5.

71.2 Nonsubsampled Contourlet Transform

Wavelet transform [7] has been proven to be effective in image processing but is not optimal in capturing the two-dimensional (2D) singularities found in images. To incorporated directionality and multi-resolution, and hence, could more efficiently capture feature in images. To incorporated directionality and multi-resolution, and hence, could more efficiently capture feature in images, several transforms have been proposed for image signals.

As a new progress of multi-resolution analysis, unlike traditional wavelet transform, contourlet transform (CT) is proposed in [5] to represent 2D singularities, which is composed of Laplacian pyramid (LP) and directional filter bank (DFB). The transform can represent curve more sparsely due to its directionality and anisotropy.

However, there exists frequency aliasing in the process of CT. In order to eliminate the frequency aliasing, enhance directional selectivity and shift-invariance, and NSCT is proposed in [8] based on nonsubsampled pyramid decomposition and nonsubsampled filter banks (NSFB).

Figure 71.1 gives the illustration of the NSCT. An overview of NSCT is shown in Fig. 71.1a. The structure composed of a bank of filters splitting the 2D frequency plane in the sub-bands is illustrated in Fig. 71.1b, respectively.

Basically, NSCT is more efficient than other multi-resolution analysis in image processing due to its multi-scale, multi-direction, anisotropy, and shift-invariance. Therefore, we perform multi-scale decomposition on the facial image to get low frequency component as the effective facial component in our method.

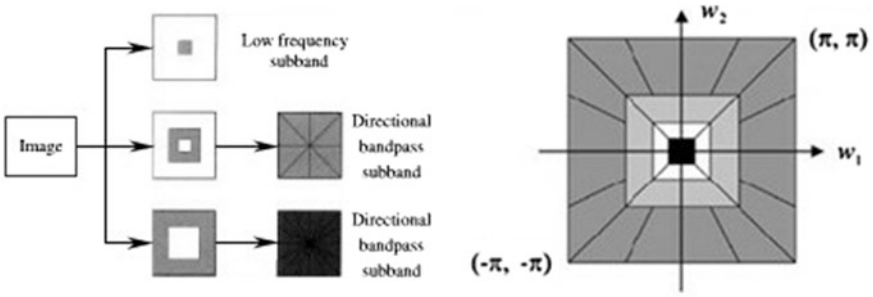

Fig. 71.1 NSCT **a** NSFB structure that implements the NSCT. **b** Idealized frequency partitioning obtained with the proposed structure

71.3 Support Vector Machine

A SVM [9] is a machine learning method in statistics and computer science for a set of related supervised learning methods that analyze data and recognize patterns. It is widely used for classification and regression analysis, and most important, SVM has also been greatly developed and widely applied in classification and pattern recognition ever since its invention. SVM has the capacity to handle nonlinear separable data and it is basically a hyperplane classifier:

$$S(x) = < w, b > \ + b \tag{71.1}$$

SVM aimed at solving the two class problem. As the decision function of SVM is only based on the dot product of the input feature vector with the SVM and it has no requirements on the dimension of the feature vector, therefore, features with any dimension can be fed into SVM theoretically.

Based on the SVM theory, once the nonsubsampled contourlet have been identified, they can be used to extract face features for training and recognition. Since the NSCT are selected using intra-person and extra-person space discrimination criteria, a natural choice should be the boosting algorithm learned strong classifier, namely boosted classifier (BC) [10]. Compared with BC, in this paper, we use the SVM for the classification step, and it outperforms the BC in the experiment on ORL and MIT-CBCL face data base. The proposed face recognition framework is illustrated below: (a) Use the log operation as the pre-processing step of the facial images; (b) Use NSCT to get the low frequency part of the facial image as the NSCT feature; (c) Use the SVM for classification.

71.4 Experimental Results

In this section we evaluate the new method and compare this method with PCA [1] and BC [10]. The face database we used in the experiment is ORL face database and MIT-CBCL face database.

The first face database we used was the Cambridge ORL face database. The ORL face database contains 40 distinct persons. (Fig. 71.2).

In our experiment on the ORL database, we randomly selected 200 samples, that is to say, 5 for each individual as the training set, from which we trained models. The testing sets were constructed with the remained images.

The second face database we used was the MIT-CBCL face database. The MIT-CBCL face database contains face images of 10 persons. Each person consists of 200 images. There are variations of pose (up to about 30° of rotation in depth), person's hairstyle and orientation. And different lighting conditions and background have been used during image acquisition. Ten images of one person in MIT-CBCL are demonstrated in Fig. 71.3.

In our experiment, since the original image size in MIT-CBCL database is 115×115, 100×100, or 82×82, we resized all the images to 100×100. Then we randomly selected 40 samples out of 200 images for each individual as the training set, while the remaining images constructed the testing set.

The recognition performances obtained by new method, BC and PCA method on ORL and MIT-CBCL face database is showed in Tables 71.1 and 71.2.

Table 71.1 shows the results obtained by each algorithm in ORL and MIT-CBCL face database while Table 71.2 shows recognition rate by applying new method, BC and PCA method average over two face database, respectively. From Tables 71.1 and 71.2, we can see that our algorithm has a little better performance than BC and PCA.

Fig. 71.2 Some examples of the ORL face database

Fig. 71.3 Images of one person in MIT-CBCL face database

Table 71.1 Recognition performances obtained by new method, BC and PCA method on ORL and MIT-CBCL face database

Face database	Our method (%)	BC (%)	PCA (%)
ORL	94.8	91.1	88.5
MIT-CBCL	92.7	89.3	85.7

Table 71.2 Recognition accurate obtained by new method, BC and PCA algorithm average over ORL and MIT-CBCL face database

	Our method (%)	BC (%)	PCA (%)
Average	93.75	90.2	87.1

71.5 Conclusions and Future Work

The proposed face recognition method combines some methodologies used before. Since we use the SVM to classify the nonsampled contourlet facial feature, we named the method combining the nonsampled contourlet face features and SVM as NSCT-SVM. The experiment results indicate that the method is robust and more effective compared to some traditional algorithms. In the future we will continue to focus on improving the robustness and the application of recent progress on multi-resolution analysis theory.

Acknowledgments This work was supported by the Funds of Chongqing University of Arts and Sciences (100242).

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Chapter 72
Use Fuzzy SVM Mining Customers' Opinion Trends from Their Feedbacks

Deli Zhu

Abstract Developed a prediction model based on customers' feedbacks. Customers' feedbacks are collected by asking to assign one most suitable class labels to each product sample. After analyzing form feature of product samples and collecting customers' evaluation data, a fuzzy SVM model is constructed. Two standard kernel functions including polynomial kernel and Gaussian kernel are used and compared their performance. The experimental results show that the performance of Gaussian kernel model is better than polynomial model.

Keywords Customers' feedback · Multiclass fuzzy SVM · Opinion mining

72.1 Introduction

Customers often make choices in the marketplace according to the perceived product attributes. Based on this idea, product samples are assumed to be distinguished by customers and classified into different groups. The managerial decisions can be made more effectively by identifying the relative importance attached to various product attributes [1]. Take the mobile phone design for example, class labels, such as sports, simplicity, female, plain, and business, etc., are used to describe different product divisions provided in the marketplace. Although there exist other product characteristics may affect customers' subjective perceptions (brand, price, etc.), this paper mainly emphasize on the factors only in product

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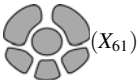
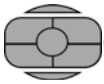
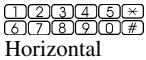
Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_72,

form design. Other marketing strategies which may influence the decision of customers are beyond the scope of this study.

72.2 Collect Customers' Feedbacks Data About Product Feature

We collect totally 36 mobile phones from Chongqing market in 2011. Form features of each product sample were determining one unified representation. Product form features are often mixed with two kinds of attributes denoted as "discrete" or "continuous" type. Continuous attributes such as length and proportion often have some kind of scale or can be measured and the domain of variable is continuous without interruption. Continuous attributes were recorded directly [2]. Discrete attributes denote categorical choices among fixed number of variables, such as

Table 72.1 Complete list of product features used in this study

	Form features	Type	Attributes
Body	Length (X_1)	Continuous	None
	Width (X_2)	Continuous	None
	Thickness (X_3)	Continuous	None
	Volume (X_4)	Continuous	None
	Type (X_5)	Discrete	 Block body (X_{51})  Flip body (X_{52})  Slide body (X_{53})
Function button	Type (X_6)	Discrete	 (X_{61}) (X_{62})  (X_{63})
	Style (X_7)	Discrete	 Round (X_{71})  Square (X_{72})  (X_{73})
Number button	Shape (X_8)	Discrete	 Circular (X_{81})  Regular (X_{82})  Asymmetric (X_{83})
	Arrangement (X_9)	Discrete	 Square (X_{91})  Vertical (X_{92})  Horizontal (X_{93})

types of texture, material used in parts etc. A complete list of all product form features is shown in Table 72.1

72.3 Translate the Collected Data to Suit SVM

Since SVM requires that each data sample be represented as a vector of real numbers, discrete attributes can be represented as integer number [3]. Taking a three-category attribute "circle, rectangle, triangle" for example, it can be coded as [1–3]. As for continuous attributes, because kernel values usually depend on the inner products of feature vectors, e.g., linear kernel and polynomial kernel, large attribute values might cause numerical problems. Continuous attributes are linearly scaled to the range [0, 1] to avoid numerical difficulties during calculation [4].

Mobile phone design has been selected to demonstrate the proposed methodology. Table 72.2 shows a part of product samples used in this study. The set of $S_i(i = 1, 2, \ldots, 10)$ represents a part of product samples to be analyzed; the set of $X_i(i = 1, 2, \ldots, 6)$ denotes the product form feature attributes; and the set of $Y_i(i = 1, 2, \ldots, 5)$ represents the class labels; μ_i is the membership value of the +1 class label of each product sample S_i. For the sake of simplicity only six product form features are listed in the example of Table 72.2.

$$\begin{aligned} X &= \{X_1, X_2, X_3, X_4, X_5, X_6\} \\ &= \{\text{body} - \text{length}, \text{body} - \text{width}, \text{body} - \text{thickness}, \text{body} - \text{volume}, \\ &\quad \text{body} - \text{type}, \text{function} - \text{button} - \text{type}\} \end{aligned}$$

Five class labels are used to describe customers' subjective perceptions of mobile phone design. These class labels list as follows:

Table 72.2 Part of training product samples for mobile phone design

Product samples (S)	Product form features (X)						Class labels and membership values (Y, μ)					
	X_1	X_2	X_3	X_4	X_5	X_6	Y_1	Y_2	Y_3	Y_4	Y_5	μ
S_1	0.75	0.45	0.72	0.62	2	3	−1	−1	−1	**+1**	−1	0.5
S_2	0.67	0.43	0.64	0.47	3	3	−1	−1	**+1**	−1	−1	0.8
S_3	0.79	0.42	0.57	0.48	1	3	**+1**	−1	−1	−1	−1	0.5
S_4	0.75	0.44	0.6	0.5	3	3	−1	−1	−1	**+1**	−1	0.6
S_5	0.67	0.42	0.77	0.54	2	2	−1	−1	**+1**	−1	−1	0.6
S_6	0.72	0.48	0.53	0.47	2	3	−1	−1	−1	**+1**	−1	0.9
S_7	1	0.44	0.56	0.63	1	1	−1	−1	**+1**	−1	−1	0.7
S_8	0.77	0.45	0.81	0.71	2	1	−1	−1	**+1**	−1	−1	1
S_9	0.75	0.45	0.72	0.62	2	3	−1	−1	**+1**	−1	−1	0.6
S_{10}	0.67	0.43	0.64	0.47	3	3	−1	−1	**+1**	−1	−1	0.8

$$Y = \{Y_1, Y_2, Y_3, Y_4, Y_5\}$$
$$= \{\text{sports, simplicity, female, plain, business}\}$$

Take product sample S_1 as example, the consumer choose label Y_4 "plain" and the attitude of Y_4 is $\mu = 0.5$. Part of training product samples for mobile phone design is shown in Table 72.2.

In this study, each product sample is assigned as a class label to formulate a multiclass classification problem. This problem is then divided into a series of OVO SVM subproblems. The objective of multiclass classification is to correctly discriminate these classes from each other and each OVO problem is addressed by a two different class labels (e.g., sports versus simplicity). Each classifier uses the fuzzy SVM to define a hyperplane that best separates product samples into two classes. Each test sample is sequentially presented to each of the $5 \times (5-1)/2 = 10$ OVO classifiers and can be predicted to which label it belong to, based on the OVO classifier having the largest vote.

72.4 Construct Multiclass Fuzzy SVM Model and Choose Optimal Parameters

Since the number of product samples is limited, it is important to obtain best generalization performance and reduce the overfitting problem. Practical implementation is to partition these data samples into training data and testing data. Various partition strategies have been proposed including leave-one-out cross-validation, k-fold cross-validation, repeated random subsampling, and bootstrapping [5]. In this study, 5-fold cross-validation is used to choose optimal parameters. The whole training samples are randomly divided into five subsets of approximately equal size. Each multiclass model is trained using $5 - 1 = 4$ subsets and tested using the remaining subset. Training is repeated five times and the average testing error rates for all the five subset that are not included in the training data is calculated.

The performance of SVM model is heavily dependent on the regulation parameter CC and the parameter of chosen kernel function. Take the Gaussian kernel for example; each binary classifier requires the selection of two parameters, which are the regularization parameter C and kernel parameter σ^2. C and σ^2 of each classifier within the multiclass model are set to be the same for calculation efficiency. Since cross validation may be very time-consuming, a two-step grid search is conducted to find the optimal hyperparameter pair. In the first step, a coarse grid search is taken using the following set of values: $C = \left\{10^{-3}, \ldots, 10^{3}\right\}$ and $\sigma^2 = \left\{10^{-3}, \ldots, 10^{3}\right\}$. Thus 49 combinations of C and σ^2 are tried in this step. An optimal pair (C_0, σ_0^2) is selected from the coarse grid search. In the second step, a fine grid search is conducted around (C_0, σ_0^2), where

$$C = \{0.2C_0, 0.4C_0, \ldots, 0.8C_0, C_0, 2C_0, 4C_0, \ldots, 8C_0\},$$

and

$$\sigma^2 = \left\{0.2\sigma_0^2, 0.4\sigma_0^2, \ldots, 0.8\sigma_0^2, \sigma_0^2, 2\sigma_0^2, 4\sigma_0^2, \ldots, 8\sigma_0^2\right\}.$$

All together, 81 combinations of C and σ^2 are tried in this step. The optimal hyper parameter pair is selected from this fine search. Likewise, the same two-step grid search is repeated on polynomial kernel. For polynomial kernel, the coarse grid of polynomial is taken as $C = \left\{10^{-3}, \ldots, 10^3\right\}$ and $\rho = \{1, 2, \ldots, 5\}$. When (C_0, ρ_0) is determined, the range of the fine grid search is as

$$C = \{0.2C_0, 0.4C_0, \ldots, 0.8C_0, C_0, 2C_0, 4C_0, \ldots, 8C_0\},$$

and

$$\rho = \{0.2\rho_0, 0.4\rho_0, \ldots, 0.8\rho_0, \rho_0, 1.2\rho_0, 1.4\rho_0, \ldots, 1.8\rho_0\}.$$

After comparing the performance of all training models using different kernel functions and parameters, the best combination of parameters obtained by cross-validation is used to build the multiclass fuzzy SVM model.

72.5 Training Effect of Different Kernel Functions

The training effects of polynomial kernel and Gaussian kernel are investigated with the whole product samples. Average training accuracies of kernel functions and the corresponding parameters are shown in Fig. 72.1.

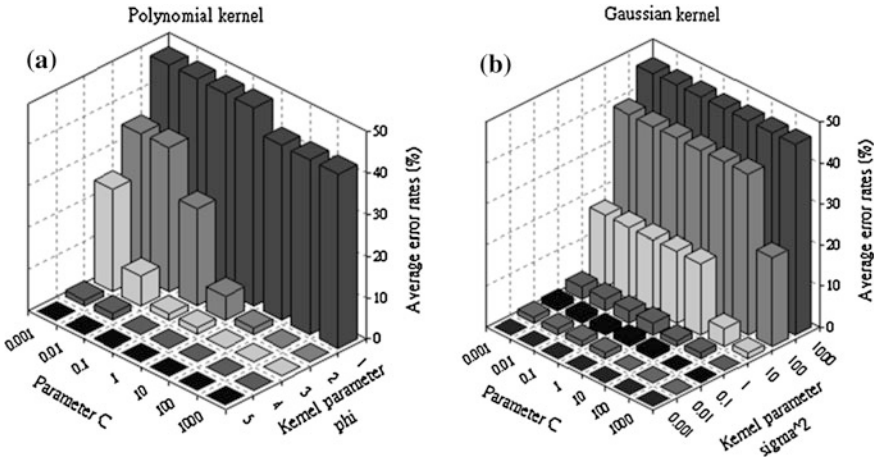


Fig. 72.1 Average training accuracies using **a** polynomial kernel and **b** Gaussian kernel

For polynomial kernel in Fig. 72.1a, the average error rates of linear kernel for all parameter C were all larger than 40 %. When $p = 2$, the regulating effect of parameter C was most obvious. As the decrease of parameter C from 1,000 to 0.001, the average error rate increased from 0 to 34.8 %. This is due to the parameter C that can adjust the margin of optimal hyperplane. Since training with smaller C will result in larger margin, training error can also be increased. The parameter C had similar regulating effect when $p = 3$. However, the training error rate increased more drastically than $p = 2$. although the training accuracies of polynomial kernel $(p > 1)$ were all superior to linear kernel, they might suffer from the problem of overfitting and had poor generalization ability [6].

For Gaussian kernel in Fig. 72.1b, the regulating effect of parameter C was less pronounced than polynomial kernel for all kernel parameters σ. It has been reported that too large and too small value of σ both lead to poor generalization performance. Our results exhibited similar effects of σ. For larger value of σ, such as $\sigma^2 > 10$, all training data were regarded as one data. In a consequence, the training model cannot recognize new data and the training error rate is very high. On the other hand, for smaller value of σ, such as $\sigma^2 < 10$, all training data were regarded as support vectors and they can be separated correctly. The training error rate declined extremely. However, for untrained data, the training model may not give good result due to overfitting problem.

In general, the linear kernel performed worse than nonlinear kernels. The polynomial kernel and Gaussian kernel are capable to nonlinearly map the training samples into higher dimensional space unlike linear kernel, thus they can handle the case when the relation between product form features and class labels is nonlinear. Since every single kernel function has different properties and generalization performance, the advantages of different kernel functions can be combined by using their mixture [7]. In addition, there exist some theorems which can help to build kernel functions that take into consideration the domain knowledge (Barzilay and Brailovsky 1999) [8], these issues are beyond the scope of this paper.

72.6 Conclusion and Future Works

In this paper, an approach based on multiclass fuzzy SVM is proposed to develop a prediction model of customers' preferences. The OVO multiclass fuzzy SVM model can deal with the nonlinear relationship between product form features by introducing kernel function. The optimal training parameters were determined by a two-step cross-validation process. According to the experimental results of mobile phone design, the optimal training model was obtained by choosing the Gaussian kernel model with lowest average error rates 72.4 % of cross-validation. The parameter set (C, σ^2) of the optimal training model was $(40, 4)$. The optimal Gaussian kernel model training with all product samples also had very high

accuracy of 98.6 %. In a consequence, the Gaussian kernel model is superior to the polynomial model. The result is consistent with the fact that Gaussian kernel is popular and commonly used in many applications due to its good features.

Since our case study was developed based on mobile phone design and used relative small amount of product form features, the form features of different product samples, such as consumer electronics, furniture, car design, etc., may have different characteristics to consider with. A more comprehensive collection of different product samples is needed to study the effectiveness of the proposed multiclass fuzzy SVM model. Extending standard kernel functions such as polynomial kernel and Gaussian kernel by considering the characteristics of product form features is also a very interesting issue and requires further study.

Acknowledgments This work is supported by younger's funds 'of ChongQing Normal University (2011XLQ25) and Natural Science Foundation of ChongQing (General) (cstc2012jjA1303).

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Chapter 73
A New Method for Ranking Canonical Intuitionistic Fuzzy Numbers

Zuming Peng and Qiang Chen

Abstract In this paper, we consider the ranking problem of canonical intuitionistic fuzzy numbers. First, the concepts of canonical intuitionistic fuzzy numbers and fuzzy cut sets are defined, and the relation between generalized fuzzy numbers and canonical intuitionistic fuzzy numbers are studied. Next, the concept of Center index and Radius index of canonical intuitionistic fuzzy numbers which based on fuzzy cut sets are introduced, and the ranking index with the degree of optimism of decision maker for canonical intuitionistic fuzzy numbers is defined. Then a new ranking method based on ranking index is developed. Finally, to illustrate the validity of the proposed method, two numerical examples are presented, the results of the numerical examples show that the new method is reasonable and effective.

Keywords Fuzzy sets · Intuitionistic fuzzy numbers · Fuzzy cut sets · Ranking

73.1 Introduction

Since the fuzzy set theory was introduced by Zadeh [1] in 1965, Fuzzy set theory is used widely in various fields, as approximate reasoning, data analysis, artificial intelligence, and decision making, etc. However, there are many real life problems that the fuzzy sets theory cannot compatible to deal with. To overcome the

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_73,

shortcoming of fuzzy set theory, intuitionistic fuzzy sets were introduced as an extension of fuzzy sets by Atanassov [2] in 1986. Intuitionistic fuzzy sets may express more abundant and flexible information as compared with the fuzzy sets for which characterized by a membership function and a nonmembership function. Many researchers have investigated intuitionistic sets theory and its application to several fields such as decision making [3, 4], pattern recognition [5, 6], image processing [7, 8]. For the fuzzy multiple criteria decision making problems, the degree of satisfaction and nonsatisfaction of each alternative with respect to a set of criteria is often represented by an intuitionistic fuzzy number (IFN), so the problem that how to set the ranking of intuitionistic fuzzy numbers is very important. Recently, the research on ranking intuitionistic fuzzy numbers as follow, Mitchell introduced a ranking method based on statistical viewpoint and interpret each intuitionistic fuzzy number as an ensemble of ordinary fuzzy numbers. Nayagam et al. [9] described IFN of a special type and introduced a method based on scoring function. Grzegrorzewski [10] proposed the expected value and ordering method for intuitionistic fuzzy numbers by using the expected interval of intuitionistic fuzzy numbers. Wang and Zhang [11] defined the trapezoidal IFN and gave a ranking method which transformed the ranking of trapezoidal IFN into the ranking of interval numbers. Li [12] presented a ranking method which is developed on the basis of a ratio of the value index to the ambiguity index. But, ranking intuitionistic fuzzy number is a complex and difficult task, so in this paper, we want to introduce a new method for ranking intuitionistic fuzzy numbers.

73.2 Preliminaries

Assume that X is the universe of discourse, A fuzzy sets A on X is given by A. Zadeh as $A = \{(x, \mu_A(x))|x \in X\}$, where $\mu_A(x) : X \to . [0, 1]$ and $\mu_A(x)$ is called membership function of fuzzy sets A. In this paper, we denote $F(X)$ as the set of all fuzzy sets in X.

Definition 1 [12] A generalized fuzzy number is a fuzzy subset on R (real number) with membership function $\mu_A(x)$ is represented by

$$\mu_A(x) = \begin{cases} \mu_A^L(x) & a \le x \le b \\ \omega & b \le x \le c \\ \mu_A^R(x) & c \le x \le d \\ 0 & \text{otherwise} \end{cases},$$

where $\mu_A^L : [a, b] \to [0, \omega]$ is continuous and strictly increasing, $\mu_A^R : [a, b] \to [0, \omega]$ is continuous and strictly decreasing.

An intuitionistic fuzzy sets (IFS) A on X is given by Atanassov [1] as $A = \{(x, t_A(x), f_A(x))|x \in X\}$, where $t_A(x) : X \to [0, 1], f_A(x) : X \to [0, 1]$, with the

condition $0 \le t_A(x) + f_A(x) \le 1$. The numbers $t_A(x)$ and $f_A(x)$ denote the degree of membership and nonmembership of X to A, respectively, $\pi_A(x) = 1 - t_A(x) - f_A(x)$ be called hesitancy degree of x to A. In this paper, we denote $IFSs(X)$ as the set of all IFS in X.

Definition 2 [12] An intuitionistic fuzzy number is an intuitionistic fuzzy set A on R with membership function and nonmembership function are represented as.

$$t_A(x) = \begin{cases} t_A^L(x) & a \le x \le b \\ u & b \le x \le c \\ t_A^R(x) & c \le x \le d \\ 0 & \text{otherwise} \end{cases}, \quad f_A(x) = \begin{cases} f_A^L(x) & a_1 \le x \le b_1 \\ \upsilon & b_1 \le x \le c_1 \\ f_A^R(x) & c_1 \le x \le d_1 \\ 0 & \text{otherwise} \end{cases},$$

respectively, $0 \le t_A(x) + f_A(x) \le 1$, where $t_A^L : [a, b] \to [0, u]$ is continuous and strictly increasing, $t_A^R : [c, d] \to [0, u]$ is continuous and strictly decreasing, $f_A^L : [a_1, b_1] \to [\upsilon, 1]$ is continuous and strictly decreasing, $f_A^L : [c_1, d_1] \to [\upsilon, 1]$ is continuous and strictly decreasing.

Definition 3 A canonical intuitionistic fuzzy number A is an intuitionistic fuzzy number with membership function and nonmembership function as follows

$$t_A(x) = \begin{cases} t_A^L(x) & a \le x \le b \\ u & b \le x \le c \\ t_A^R(x) & c \le x \le d \\ 0 & \text{otherwise} \end{cases}, \quad f_A(x) = \begin{cases} f_A^L(x) & a \le x \le b \\ \upsilon & b \le x \le c \\ f_A^R(x) & c \le x \le d \\ 0 & \text{otherwise} \end{cases},$$

respectively, and $\forall x \in R$, $0 \le t_A(x) + f_A(x) \le 1$, where $t_A^L : [a, b] \to [0, u]$ is continuous and strictly increasing, $t_A^R : [c, d] \to [0, u]$ is continuous and strictly decreasing, $f_A^L : [a, b] \to [\upsilon, 1]$ is continuous and strictly decreasing, $f_A^L : [c, d] \to [\upsilon, 1]$ is continuous and strictly decreasing. For convenience, a canonical intuitionistic fuzzy number A can be represented by $(a, b, c, d; u, \upsilon)$.

Definition 4 Intuitionistic fuzzy number A is a canonical intuitionistic fuzzy number if its membership function and nonmembership function are given as

$$t_A(x) = \begin{cases} u\dfrac{x-a}{b-a} & a \le x \le b \\ u & b \le x \le c \\ u\dfrac{x-d}{c-d} & c \le x \le d \\ 0 & \text{otherwise} \end{cases}, \quad f_A(x) = \begin{cases} (\upsilon - 1)\dfrac{x-a}{b-a} + 1 & a \le x \le b \\ \upsilon & b \le x \le c \\ (\upsilon - 1)\dfrac{x-d}{c-d} + 1 & c \le x \le d \\ 0 & \text{otherwise} \end{cases},$$

respectively, then the canonical intuitionistic fuzzy number be called canonical intuitionistic trapezoidal fuzzy number. Where $a, b, c, d \in R$, and $u \geq 0, \upsilon \geq 0$, $u + \upsilon \leq 1$. If $u + \upsilon = 1$, then the generalized trapezoidal fuzzy numbers are considered as special cases of the canonical intuitionistic trapezoidal fuzzy numbers.

73.3 Proposed Approach

73.3.1 Fuzzy Cut Sets

Definition 5 Let $A \in \mathrm{IFSs}(X), \lambda \in [0,1]$, the fuzzy $\lambda-$cut set of an intuitionistic fuzzy set A is defined by $A_\lambda = \{(x, \mu_A(x)) | \mu_A(x) = t_A(x) + (1-\lambda)\pi_A(x), x \in X\}$.

Definition 6 Let $A \in F(X), \lambda \in [0,1]$, the product between $\lambda$and A is defined by $\lambda A = \{(x, \mu_A(x), (1 - \mu_A(x) - \lambda) \vee 0) | x \in X\}$.

Theorem *Let* $A \in IFSs(X), \lambda \in [0,1]$, *then* $A = \underset{\lambda \in [0,1]}{\cap} \lambda A_\lambda$

Proof

$$\begin{aligned}\left[\underset{\lambda\in[0,1]}{\cap}\lambda A_\lambda\right](x) &= \underset{0\leq\lambda\leq 1}{\wedge}\lambda A_\lambda(x)\\ &= \left(t_A(x)\right)_{\underset{0\leq\lambda\leq 1}{\vee}\left[\max\{f_A(x)+\lambda(\pi_A(x)-1),0\}\right]}\\ &= (t_A(x), f_A(x)) = A(x)\end{aligned}$$

Then $A = \underset{\lambda \in [0,1]}{\cap} \lambda A_\lambda$.

Remark 1 Let A be a canonical intuitionistic fuzzy number with membership function and nonmembership function as follows:

$$t_A(x) = \begin{cases} t_A^L(x) & a \leq x \leq b \\ u & b \leq x \leq c \\ t_A^R(x) & c \leq x \leq d \\ 0 & \text{otherwise} \end{cases}, \quad f_A(x) = \begin{cases} f_A^L(x) & a \leq x \leq b \\ \upsilon & b \leq x \leq c \\ f_A^R(x) & c \leq x \leq d \\ 0 & \text{otherwise} \end{cases},$$

then A_λ is a generalized fuzzy number, and its membership function can be represented as follows:

$$\mu_{A_\lambda}(x) = \begin{cases} \lambda t_A^L(x) + (1-\lambda) f_A^L(x) & a \leq x \leq b \\ \lambda u + (1-\lambda)\upsilon & b \leq x \leq c \\ \lambda t_A^R(x) + (1-\lambda) f_A^R(x) & c \leq x \leq d \\ 0 & \text{otherwise} \end{cases}.$$

Remark 2 Let A be a fuzzy number, then $\lambda \mathrm{A} = \{(x, \mu_A(x),\ (1 - \mu_A(x) - \lambda) \vee 0) | x \in X\}$ is an intuitionistic fuzzy number.

73.3.2 The New Ranking Method

For a generalized fuzzy number A, since $\mu_A^L : [a, b] \to [0, \omega]$ is continuous and strictly increasing, then the inverse function of $\mu_A^L(x)$ exists, similarly, the inverse function of μ_A^R exists. The inverse functions of μ_A^L, μ_A^R are denoted by v_A^L, v_A^R, respectively. Then the $\alpha-$ cut set of A is an interval $\left[v_A^L(\alpha), v_A^R(\alpha)\right]$, where $0 < \alpha \leq \omega$. In this paper, the $\alpha-$ cut set of A is denoted by A_α, namely, $A_\alpha = \left[v_A^L(\alpha), v_A^R(\alpha)\right]$.

Definition 7 The Center and Radius of generalized fuzzy number A are defined as follows:

$$m_F(A) = 2\int_0^\omega \alpha \frac{v_A^L(\alpha) + v_A^R(\alpha)}{2} \mathrm{d}\alpha,\ \varpi_F(A) = 2\int_0^\omega \alpha \frac{v_A^R(\alpha) - v_A^L(\alpha)}{2} \mathrm{d}\alpha,$$

respectively. Where $0 < \alpha \leq \omega$.

If we assume $m_I(A_\alpha) = 0,\ \varpi_F(A) = 0$ on the condition $\omega < \alpha \leq 1$, then the Center and Radius of generalized fuzzy number A can be written as follows:

$$m_F(A) = 2\int_0^1 \alpha \mathrm{m}_I(A_\alpha) \mathrm{d}\alpha,\ \varpi_F(A) = 2\int_0^1 \alpha \varpi_I(A_\alpha) \mathrm{d}\alpha,$$

respectively.

Definition 8 The Center index and Radius index of a canonical intuitionistic fuzzy number are defined as follows:

$$m_{\mathrm{CIF}}(A) = \int_0^1 \alpha \mathrm{m}_F(A_\lambda) d\lambda,\ \varpi_{\mathrm{CIF}}(A) = \int_0^1 \alpha \varpi_F(A_\lambda) d\lambda,$$

respectively.

Remark 3 Let $A = (a, b, c, d; u, \upsilon)$ be a canonical intuitionistic trapezoidal fuzzy number, then

$$m_{\mathrm{CIF}}(A) = \frac{a + 2b + 2c + d}{6}\left[\frac{(u + \upsilon - 1)^2}{3} + (1 - \upsilon)^2 + (1 - \upsilon)(u + \upsilon - 1)\right],$$

$$m_{\mathrm{CIF}}(A) = \frac{-a - 2b + 2c + d}{6}\left[\frac{(u + \upsilon - 1)^2}{3} + (1 - \upsilon)^2 + (1 - \upsilon)(u + \upsilon - 1)\right],$$

respectively.

Definition 9 Let $A = (a, b, c, d; u, \upsilon)$ be a canonical intuitionistic fuzzy number, the ranking index of A is defined by

$$r(A) = m_{\mathrm{CIF}}(A) + \frac{\theta}{1 + \varpi_{\mathrm{CIF}}(A)},$$

where $\theta \in [0, 1]$. The choice of the parameter θ reflects the degree of optimism of a decision maker. A lager value of θ indicates a higher degree of optimism.

Assume that there are n canonical intuitionistic fuzzy numbers A_1, A_2,…, and A_n to be ranked, the proposed method for ranking canonical intuitionistic fuzzy numbers is shown as follows:

Step1: Compute $m_{CIF}(A_i)$, $\varpi_{\mathrm{CIF}}(A_i)(i = 1, 2, \ldots, n)$, respectively.

Step2: Compute ranking index $r(A_i)$ $(i = 1, 2, \ldots, n)$, respectively.

Step3: Ranking the n canonical intuitionistic fuzzy number according to non-increasing order of $r(A_i)$ $(i = 1, 2, \ldots, n)$.

73.4 Numerical Examples

Example 1 Consider three canonical intuitionistic triangular fuzzy numbers $A_1 = (0.592, 0.774, 0.774, 0.910; 0.6, 0.4), A_2 = (0.769, 0.903, 0.903, 1; 0.4, 0.5)$, $A_3 = (0.653, 0.849, 0.849, 0.956; 0.5, 0.2)$.

By the ranking approach developed in this paper. The results are shown in Table 73.1. From Table 73.1, for a pessimistic decision maker with $\theta = 0$, the ranking order is $A_3 \succ A_1 \succ A_2$. For a moderate decision maker with $\theta = 0.5$, the ranking order is $A_3 \succ A_1 \succ A_2$, the result coincides with the one presented in Li's method [12]. For a optimistic decision maker with $\theta = 1$, the ranking order is $A_3 \succ A_2 \succ A_1$. The result coincides with the one presented in Li's method [12].

Example 2 Consider the canonical intuitionistic triangular fuzzy numbers $A_1 = (3, 5, 5, 7; 0.6, 0.4)$, $A_2 = (3, 5, 5, 7; 0.5, 0.3)$, canonical intuitionistic trapezoidal fuzzy numbers $A_3 = (5, 7, 9, 10; 0.5, 0.3)$, $A = (5, 7, 9, 10; 0.5, 0.3)$, canonical intuitionistic fuzzy $A_4 = (5, 7, 9, 10; 0.5, 0.4)$ with membership function and nonmembership function as follows.

$$t_A(x) = \begin{cases} 0.125(x-5)^2 & 5 \le x \le 7 \\ 0.5 & 7 \le x \le 9 \\ 0.5(x-10)^2 & 9 \le x \le 10 \\ 0 & \text{otherwise} \end{cases}, \quad f_A(x) = \begin{cases} 0.15(x-7)^2 + 0.4 & 5 \le x \le 7 \\ 0.4 & 7 \le x \le 9 \\ 0.6(x-9)^2 + 0.4 & 9 \le x \le 10 \\ 1 & \text{otherwise} \end{cases},$$

respectively.

Table 73.1 The ranking index value of proposed method in example 1

θ	A_1	A_2	A_3	Ranking order
0	0.276	0.182	0.359	$A_3 \succ A_1 \succ A_2$
0.5	0.533	0.491	0.582	$A_3 \succ A_1 \succ A_2$
1	0.789	0.800	0.805	$A_3 \succ A_2 \succ A_1$

Table 73.2 The ranking index value of proposed method in example 2

θ	A_1	A_2	A_3	A_4	A_5	Ranking order
0	1.800	1.517	2.820	2.376	2.371	$A_4 \succ A_5 \succ A_3 \succ A_1 \succ A_2$
0.5	1.869	1.597	2.861	2.423	2.712	$A_3 \succ A_5 \succ A_4 \succ A_1 \succ A_2$
1	1.938	1.676	2.901	2.471	3.052	$A_5 \succ A_3 \succ A_4 \succ A_1 \succ A_2$

By the ranking approach developed in this paper. The ranking results are shown in Table 73.2. For a pessimistic decision maker with $\theta = 0$, the ranking order is $A_4 \succ A_5 \succ A_3 \succ A_1 \succ A_2$. For a moderate decision maker with $\theta = 0.5$, the ranking order is $A_3 \succ A_5 \succ A_4 \succ A_1 \succ A_2$. For a optimistic maker with $\theta = 1$, the ranking order is $A_5 \succ A_3 \succ A_4 \succ A_1 \succ A_2$.

73.5 Conclusion

This paper defined the ranking index of the canonical intuitionistic fuzzy numbers which based on fuzzy cut sets. Then a new ranking method was proposed. Numerical example results show that the proposed ranking method not only can rank canonical intuitionistic fuzzy numbers, but can also rank generalized fuzzy numbers, and show that the proposed method is effective.

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Part VIII
Mathematics and Computation

Chapter 74
Sparse Recovery and Compressive Sampling Based on FFT and DWT

Maoling Peng, Shanxiong Chen and Guanglin Yu

Abstract When the signal in a transform domain is sparse or compressible, it could be projected to low-dimensional vector utilizing measurement matrix. This projection maintains the information required by reconstructing signal. By research about the basic theories for compressed sensing, this article adopted FFT and DWT as the transform matrix Φ respectively, the random matrix as the sampling φ, then analyzed the coherence among them in addition to the sparsity of the sampling signals, explored further the ability of the two methods for recovering signals.

Keywords Sparse recovery · Incoherence · FFT · Reconstructing signals

74.1 Introduction

Sparse recovery could not only realize the collection of signals with the sampling frequency below the Nyquist sampling frequency but also recover the signals effectively. Since Donoho and others [1, 2] put forward Compressed Sensing that provided a method able to be comprehensively applied for collecting compressed signals and rendering the collected data with less redundancy [3], the researches on

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_74,

compressed sensing had started and attracted more and more people joining the studying team.

Based on the existing researches in the theory of compressed sensing, this article analyzed the sparsity of signal sampling and the reconstructing method, focusing on the incoherence between the orthogonal transforming matrix ϕ and the stochastic matrix Φ constructed by Fourier transformation and wavelet transformation as well as the sparsity of the obtained sampling signals, and recovered the signals with the method of orthogonal matching pursuit.

74.2 Basic Theories of Compressed Sensing

Conduct mathematical operation of projection for the signal $x \in R^{N\times 1}$ with a linear measuring matrix $\Phi \in R^{M\times N}$ $(M < N)$

$$y_{M\times 1} = \Phi_{M\times N} x_{N\times 1} \tag{74.1}$$

Y is the signal collected. Now the problem is to get x recovered from the signal y. If $M < N$, then we need to solve an underdetermined equation which could result in many groups of solutions and even obtain basic set of solutions. Is there a method that can get a sole solution for x? Here orthogonal transformation could be conducted on the original signal x and get:

$$s = \phi x \tag{74.2}$$

S is the sparse expression of the signal. Substituting the Eq. (74.2) into the Eq. (74.1) could get:

$$y = \Phi\phi^H s = \Theta s \tag{74.3}$$

where $\Theta = \Phi\phi^H$, and this is still an underdetermined equation, but under some restrictive conditions s could be obtained by solving the equation y through the following equation:

$$\hat{s} = \arg\ \min||s||_0, \quad s.t.y = \Phi\phi^H s \tag{74.4}$$

$\|\cdot\|_0$ is the 0-normal number for the vector which indicates the number of the nonzero elements in the vector, that is to say, the underdetermined equation could result in the solution of s when the vector s is in the most sparse state. Of course it is a NP problem to find the solution of the 0-normal number, and Tao cooperated with Candés to expand the issue of the 0-normal number into the 1-normal number, which reduced the difficulty for finding the solution. Moreover, they also illustrated the Restricted Isometry Property (RIP) that must be satisfied by the sensing matrix Θ [4]. Define the restricted isometry constant $\delta_k \in (0, 1)$of Θ for

the sparse signal s of any K as the minimum value for the constitution of the following formula:

$$(1-\delta_k)\|s\|_2^2 \le \|\Theta s\|_2^2 \le (1+\delta_k)\|s\|_2^2 \tag{74.5}$$

74.3 Theory of Coherence

Suppose $\tilde{\Phi}, \phi \in R^{N\times N}$ are a pair of orthogonal transforming matrixes, that is to say, $\tilde{\Phi}\tilde{\Phi}' = \mathrm{I}$ and $\phi\phi' = \mathrm{I}$, among which $\tilde{\Phi}$ is a signal measuring matrix while φ is a signal transforming matrix and both of them are used for the sparse expression of the signals. Suppose $\tilde{\Theta} = \tilde{\Phi}\varphi$, then the coherence of $\tilde{\Phi}$ and φ could be defined as [5, 6]:

$$\mu(\tilde{\Phi}, \varphi) = \max_{1\le i,j\le n} \left| <\tilde{\Phi}_i, \varphi_j> \right| \tag{74.6}$$

In this equation, $\tilde{\Phi}_i, \varphi_j$ could be used as the row vector and volume vector of $\tilde{\Phi}, \varphi$ respectively, and because $\tilde{\Phi}, \varphi$ are a pair of orthogonal transforming matrixes so $\tilde{\Theta} = \tilde{\Phi}\varphi$ is also a orthogonal transforming matrix. According to the knowledge about linear algebra, we could know that $\mu(\tilde{\Phi}, \varphi) \in [1/\sqrt{n}, 1]$. When the measuring matrix $\tilde{\Phi}$ is a unit matrix, the coherence reaches the maximum degree of $\mu = 1$ and $\tilde{\Phi}$ is the most coherent or completely incoherent with φ. If at this moment important information inside the compressible signals needs to be figured out, sensing data equivalent to the original data should be collected during which the compressed sensing method is degraded to be a routine method for collecting signals.

In fact most of the coherences among the matrixes are not 1, for example, the coherence between the impulse function and the Fourier transform is $1/\sqrt{n}$ and the coherence between the impulse function and the sinusoidal trace is also $1/\sqrt{n}$; while the coherence between the stochastic matrix and an orthogonal matrix is also very low, so stochastic project is often used as the method for collecting data in compressed sensing. The theory of coherence shows that incoherent orthogonal matrix is helpful for efficient compressed sampling and reconstructing signals [7, 8].

74.4 Experiments and Analyses

Fast Fourier transformation (FFT) and Discrete Wave Transformation (DWT) had been applied in these experiments to construct the transforming matrix ϕ and the stochastic matrix was adopted as the measuring matrix Φ because the coherences

between stochastic matrix and many matrixes are all rather low. Twenty times of measurement were conducted during the experiments resulting in twenty stochastic matrixes and various sampling matrixes, and then recovery was conducted. We measured the coherence between ϕ and Φ, the sparsity of the sampling data, as well as the value of PSNR after the data were recovered.

74.4.1 Coherence

The matrix $A = \Phi\varphi$ is not necessarily orthogonal, so we adopted the Schmidt orthogonalization method to ensure A as an orthogonal matrix and then calculated its coherence with the formula $\mu(\widetilde{\Phi}, \varphi) = \max_{1 \le i,j \le n} \left| < \widetilde{\Phi}_i, \varphi_j > \right|$. The bigger the value of the coherence is, the higher the degree of the coherence will become and the more the measurements will be needed for recovering the signals.

74.4.2 Signal Recovery

In order to test the ability of whom for recovering images with the sampling signals, the method of orthogonal matching pursuit was applied to realize the reconstruction of the original images. Figure 74.1 shows that the FFT and DWT methods have been used to produce the transforming matrix and the PSNR value of the recovered image was obtained by recovering the image after the samples were compressed. From this figure it could be seen that the DWT method is better than FFT.

Further analysis reveals that the coherence of the method of DWT shown in Fig. 74.2 is higher than that of FFT, and some theories prove that the higher the

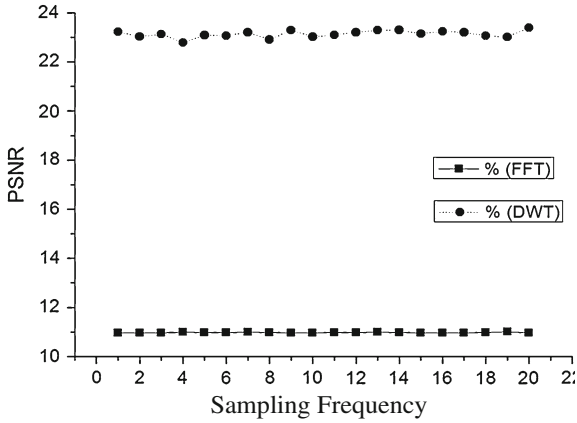

Fig. 74.1 PSNR values of recovered signals by constructing the matrix ϕ though FFT and DWT

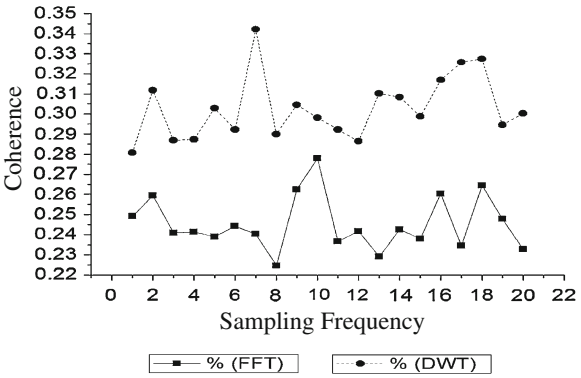

Fig. 74.2 Coherence between ϕ and Φ constructed by FFT and DWT

coherence between the transforming matrix ϕ and the measuring matrix $\tilde{\Phi}$ is, the more the data needed for recovering signals are needed to be collected. However, when signals were collected through the methods of DWT and FFT in the experiments, both the Ms, the measuring frequencies, were set as 190, that is to say, DWT was adopted as the transforming matrix ϕ, which had lower requirements than FFT but could achieve better effects on signal recovery. If the coherence between it and the measuring matrix could be further reduced, then much less sampling signals are needed for the recovery of the original images.

74.5 Conclusion

The novelty of the compressed sensing theory lies in that much less samples than those needed according to the traditional Nyquist sampling theory are needed for reconstructing the original signals precisely or in high probability. The sampling frequency is no longer limited by the bandwidth of the signal, while it is dependent on the sparsity of the signal as well as the incoherence between the sampling matrix and the transforming matrix to a great extent. Based on the researches of the basic theories for compressed sensing, this article adopted FFT plus DWT as the Φ and the stochastic matrix as the sampling φ, then analyzed the coherence among them in addition to the sparsity of the sampling signals and the ability of the two methods for recovering signals.

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Chapter 75
Linear Regression Method-Based Data Mining in Vehicle Maintenance

Xiaohong Meng, Yan Qu, Yongtao Zhou and Peng Liu

Abstract Based on linear regression method, the large amount maintenance data of a certain type of vehicle were extracted. The iron content of every engine oil accelerated as the working time grew up linearly. The curve of $K < 0.87$ flattens out, which means the iron content is increasing slowly with the growth of engine working time, and the frequency of changing the lubricant should be cut. The curve of $K > 0.87$ is steep, which means the iron content is increasing rapidly with the growth of engine working time, and the frequency of changing the lubricant should be added.

Keywords Engine · Data mining · Linear regression · Maintenance

75.1 Introduction

The large amount of historical data was accumulated in the process of using and maintaining various types of vehicles. But many of the recessive knowledge and links between data are not fully understood by people, which causes great resources waste. The data mining is a process that the recessive, unknown, and potential useful information and knowledge are extracted from vast, incomplete, noisy, blurry, and random actually applied data. The research of data mining in domestic and international is always the research of various fields hot spots. At present all the advanced data mining tool provides various data mining algorithms and possesses their own feature and application direction [1–6]. For example, there are hundreds of data mining type based on neural network, which contains machine learning method (including decision trees, rule induction, genetic algorithm, rough set, and so on) and statistics method etc.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_75,

75.2 Recording and Processing Maintenance Data of Vehicle Engine

The diversified data mining method can be adopted flexibly according to the difference of requirement and using. Due to the limitation of the thesis length, this paper quoted a small part of the spectral monitoring data for a certain vehicle engine from Dec. 1998 to Feb. 2003, using linear regression for the data mining.

It is possible to hypothesize that the trouble courses of different vehicle engine are of the same type because these vehicles are working under the same condition. During the working time of engine, the irregular spectral analysis is used to detect and archive the iron and Pb content of the lubricant. The engine can be regarded as a new one after recommissioned that caused by fault maintenance and regularly serviced, which satisfies the hypothesis of "as good as new".

Data recording includes engine number, detection date, length of service, metal ion concentration and update of each time, the failure or preventative maintenance. This kind of historical data is various. This paper here to extract some timetable monitoring records of four engines. Based on the hypothesis of "as good as new", thirteen groups of data for the four engines are measured after a major renovation. Six groups of these thirteen groups have broken down, and seven groups of them stopped working caused by preventative maintenance. Meanwhile, their exists five groups of engine spectral data with similar type. These engines are maintained aperiodically by changing the lubricant during the process of working. The results of data analysis are summarized in Table 75.1 (Because the data sheet takes up a large part of space, small amount of data are taken for example. No. 1 engine cut out the data among events. Another engines only cut out the beginning and ending event data.)

The metal ion content of the lubricant can be regard as 0 after changing the lubricant each time. Because the metal ion content of the lubricant is 0 after changing the lubricant each time, the data of iron content and engine running time are obtained in Table 75.2 after accumulating the raw data of Table 75.1. (Because the data sheet takes up a large part of space, part of the data of No. 1 engine is taken for example here.)

The data of Tables 75.1 and 75.2 are random. Table 75.3 is the iron data that is show in every 500 h by data fitting. (Here takes part of the data of No. 1 engine for example.)

75.3 The Maintenance Data Mining of Certain Vehicle Engine

Wear is the major cause of equipment failure, and about 80 % equipment failures are caused by wear [7]. The certain vehicle is a kind of heavy-lift vehicles. At present, the preventative maintenance measure of changing the lubricant is adopted, which plays the effect of retaining the vehicle transportation function.

Table 75.1 The lubricant spectral raw data of certain vehicle engine

Engine no.	Date	Running time (h)	Event	Content of iron (ppm)
J–1	12/30/98	0	B	0
	……	……	*	……
	2/14/99	1,028	*	11
	2/14/99	1,028	OC	0
	……	……	……	……
	4/23/00	10,524	EF	25
	4/24/00	10,524	B	0
	5/8/00	10,886	*	12
	3/9/03	32,335	ES	2
	……	……	……	……
J–2	1/19/99	0	B	0
	……	……	……	……
	3/12/03	32,214	*ES	2
J–3	3/14/00	0	B	0
	……	……	……	……
	2/21/03	22,917	*ES	12
J–4	4/15/00	0	B	0
	……	……	……	……
	2/27/03	21,688	*ES	3

Note 1 B New engine start working, * Lubricant detection, *OC* Lubricant maintenance, *EF* Fault, *ES* Terminate due to preventative maintenance
Note 2 Iron Iron ion concentration; Pb–Pb ion concentration, in PPm
Note 3 The metal ion content of the lubricant can be regarded as 0 after changing the lubricant each time. (similarly hereinafter)

Table 75.2 The lubricant spectral accumulated data of certain vehicle engine

Engine no.	Running time (h)	Event	Content of iron (ppm)	Accumulated content of iron (ppm)
F-1	0	B	0	0
	33	*	2	2
	……	……	……	……
	10,524	EF	25	119
	10,524	B	0	0
	……	……	……	……
	22,706	ES	3	109
	22,706	B	0	0
	……	……	……	……
	32,335	ES	2	56

Figure 75.1 is a relation curve of the relationship between the first stoppage occurring time and iron changing for four similar certain vehicle engines, which shows the iron content within every engine oil accelerated as the working time grew up linearly. Therefore, the linear regression method is used. The data that the running time and the change of iron content of the four engines is extracted in table and shown in Fig. 75.2.

Table 75.3 The lubricant spectral data of launch vehicle engine

Engine no.	Event	Running time (h)	Accumulated content of iron (ppm)
F-1	B	0	0
		500	12.68
	……	……	……
	EF	10,500	119
	B	0	0
		500	16.01
	……	……	……
	ES	12,000	107.76
	B	0	0
		500	6.70
	……	……	……
		9,500	55.58

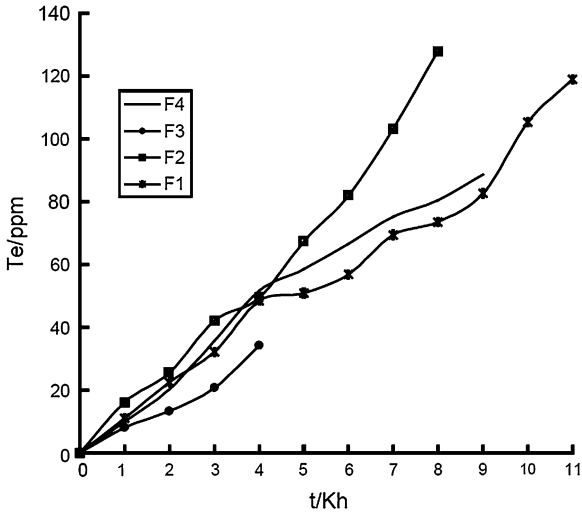

Fig. 75.1 The iron changing curve of the four engines from using to first failure

It can be seen from the Fig. 75.2 that the iron content of the lubricant accelerated as the working time grew up linearly. Every curve represents that the iron content varies with the engine working time.

These data are made use of rational analysis to find out the data law of the figure. In other words, a list of representative data is found out from a cluster of data to research the distributive regularity of these data.

It can be seen that all the curve mostly close to a line P, and make it for

$$y = kx + b \tag{75.1}$$

$$C = a \pm kt \tag{75.2}$$

There: C-concentration of ferric ion[ppm], t-running time of engine [Kh], k-slope, a-constant.

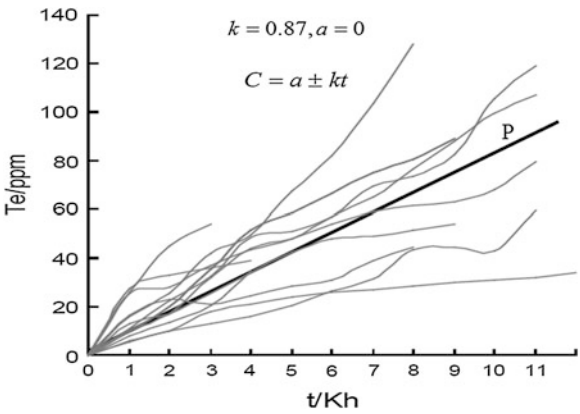

Fig. 75.2 The lubricant monitor curve of launch vehicle engine

If a series of data of the known two variables (t, C) are

$$\begin{array}{ll} t & t_1\, t_2 \ldots\ldots t_n \\ c & C_1\, C_2 \ldots\ldots C_n \end{array}$$

a and k are dominated by the equations as below:

$$\begin{cases} \frac{1}{n}\sum_{i=1}^{n} C_i = a \pm k\left(\frac{1}{n}\sum_{i=1}^{n} t_i\right) \\ \frac{1}{n-1}\sum_{i=1}^{n-1} C_i = a \pm k\left(\frac{1}{n-1}\sum_{i=1}^{n-1} t_i\right) \end{cases} \tag{75.3}$$

The deviation between the line and the ordinate of all points is

$$v_i = C_i - (a \pm kt_i) \tag{75.4}$$

Find the representative point from all curve, and substituting it into (75.2). A large number of experimental data prove that

$$k = 0.87,\ a = 0 \tag{75.5}$$

75.4 Conclusion

In Fig. 75.2, the line P represented by formula (75.5) is the data distributive regularity that is excavated from the large amount of experimental data. The important purpose is to divide the the curve of iron content into top and bottom sections. When the curve (the wear condition of engine) lies under the P, the value of k is smaller. $k < 0.87$. The more the curve of Fig. 75.2 flattens out, the iron content is increasing more slowly with the growth of engine working time, and the frequency of changing the lubricant should be cut. When the curve (the wear

condition of engine) lies above the P, the value of k is higher. $k > 0.87$. The curve of Fig. 75.2 is steep, which means the iron content is increasing rapidly with the growth of engine working time, and the frequency of changing the lubricant should be added. At the same time, the data represented by the curve (Fig. 75.2) can guide people to assess the function of engine and maintenance practice.

Above the P have two steep and short curves in Fig. 75.2, which shows the engine represented by this two curves had failed at not yet preventative maintenance (changing the lubricant) time. This further demonstrates the utility of data mining method. Method of linear regression can be applied to the data mining and analysis in the similar case of practice, which can shorten the time of changing

According to the dynamic monitoring data (the lubricant monitoring data) of the wear condition of certain vehicle engine, the linear regression is used to excavate and analyze data to confirm the time of changing the lubricant. It can make maintenance more economical and efficient on condition that the function of engine can be guaranteed, and provide a basis for the preventative maintenance decision based on the actual state of engine.

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Chapter 76
Optimization of Tolerance Allocation with Consideration of Assembly Deformation and Quality Loss

Jiao Chen, Yuan Li and Jianfeng Yu

Abstract Quality loss displays the role of importance in production. The less quality loss, the better characteristic of assembly appeared. In order for minimum quality loss, there exists a large amount of optimal models of tolerance allocation. However, the consideration of influence of assembly deformation is not introduced into these models. In aircraft assembly, thin-walled parts are tending to deform, while the parts of this type ubiquity have their existence in aircraft. Because of this, we have to take into account the assembly deformation in optimizing the tolerance allocation scheme. In this paper, we fist analyze the transfer relation of assembly deformation, then construct the optimal model of tolerance allocation with the consideration of assembly deformation and quality loss, finally, a case study of this methodology is introduced to verify this model.

Keywords Optimization · Tolerance allocation · Assembly deformation · Quality loss · Model

76.1 Introduction

Tolerance is the allowable variation of the nominal dimension in the process of part manufacturing and assembly. The tighter the tolerance, the more of the machining cost, although the best quality of assembly; in contrast, the looser the tolerance, the more quality loss of assembly, although the less of the machining

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_76,

cost. Many researchers represent optimal model based on manufacturing cost and quality loss, in order to balance the trade-off between their relations [1, 2]. However, in aircraft assembly, the principal element we concentrate on is the characteristic and quality of assembly, rather than the manufacturing cost. Hence, the optimal model previously mentioned is incomplete appropriate for aircraft assembly. There are masses of thin-walled parts in aircraft, which have the heavy curvature and the numerous joint relations with each other when assembled together and can be readily generating the deformation by the interaction forces. In fact, the optimal model without the consideration of deformation may result in the much more quality loss. For example, when we ignore the deformation, some tolerance allocation scheme may conclude the best the assembly characteristic and the minimum quality loss, nevertheless, when we consider the deformation, this scheme may result the great quality loss, or even worse, the closed-loop beyond the allowable variation and the loss of assembly functionality. Consequently, analyze the effect of assembly deformation on optimal tolerance allocation has practical significance. This paper is on the basis of quality loss model, resolve the minimum quality loss in the existence of deformation, deduce the optimal model based on the deformation and quality loss, and, finally, proceed with the verification of this model via an instance [3].

76.2 Quality Loss Function

Quality loss is the extent of loss for the society after the completion of the production. The quality loss function is as follows [4]:

$$L(y) = k(y - y_t)^2 \tag{76.1}$$

where y and y_t is actual and target value, respectively, and k is a quality loss coefficient. Suppose the deviation of the actual value from its target is w, the quality loss is A, and then the coefficient k is determined by $k = A/w^2$. Suppose the tolerance of closed-loop is T, the tolerance of composing-loop is $T_i (1 < i < N)$, where N the quantity of the composing-loop count is, and then the closed-loop and composing-loops have the following relationship:

$$s^2T^2 = \sum_{i=1}^{N} q_i^2 s_i^2 T_i^2 \tag{76.2}$$

where s represents the distribution coefficient, T represents the tolerance of closed-loop, q_i represents the transfer ratio which is due to the impact of composing-loop applied to the closed-loop, s_i represents the distribution coefficient of composing-loop, and T_i represents the tolerance of composing-loop. According to Eq. 76.1, the quality loss function of closed-loop can be simplified as $L(T) = kT^2$, where $k = A/w^2$. In a similar manner, we can derivate the quality loss of composing-

loop, which is $L(T_i) = k_i T_i^2$, where $k_i = A_i / w_i^2$. Since the dimension of closed-loop in assembly is dependent on the composing-loops, consequently, we conclude that the quality loss of closed-loop can be represented, using the tolerance of composing-loops, as follows:

$$L(T) = kT^2 = \sum_{i=1}^{N} k_i T_i^2 \tag{76.3}$$

Integrate Eqs. 76.2 and 76.3 together, we may derivate the optimal model of tolerance allocation based on the minimum quality loss objective, where Eq. 76.2 is the condition of optimization, Eq. 76.3 is the target function of optimization. For completeness, we rewrite Eqs. 76.2 and 76.3 in combination as follows:

$$\begin{cases} L(T_i) = \sum_{i=1}^{N} k_i T_i^2 \\ \text{st: } s^2 T^2 = \sum_{i=1}^{N} q_i^2 s_i^2 T_i^2 \end{cases} \tag{76.4}$$

76.3 Basic Concepts of Assembly Deformation

In this section, we will concentrate on the mechanism of assembly deformation, and take some insights into the interpretation of this concept. For better understanding, we focus on a simple example shown in Fig. 76.1.

In Fig. 76.1a, the dimension chain is $l_3 = l_1 + l_2$, where l_3 represents closed-loop, l_1 and l_2 are composing-loops. In Fig. 76.1b, there exist deformation on part

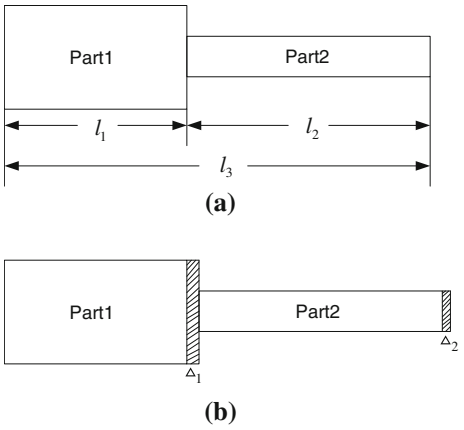

Fig. 76.1 Graphical interpretation of assembly deformation

1 and part 2, which is Δ_1 and Δ_2, respectively. Suppose Δ_3 is the overall assembly deformation, then the following deformation relationship satisfied:

$$\Delta_3 = \Delta_1 + \Delta_2 \tag{76.5}$$

From Eq. 76.5, we conclude that the closed-loop deformation is dependent on its composing-loops deformation. Hence, if the closed-loop deformation exceeds the allowable tolerance, this assembly will lose its functionality. From the preceding discussion, we can draw a conclusion that the assembly deformation exactly have influence on the assembly characteristic. Because of this influence, we have to consider deformation, specially in aircraft assembly, where exist many of thin-walled parts, which extremely tend to deform even tiny forces applied to them. Consider Fig. 76.1b again, the composing-loops deformation exactly determines the closed-loop deformation, which conclude that the composing-loops deformation have direct influence on quality loss of assembly. In general, the exact relationship between closed-loop and composing-loops deformation is as follows [5]:

$$\Delta = \sum_{i=1}^{N} \varepsilon_i \Delta_i \tag{76.6}$$

where ε_i represents the deformation coefficient, which is the degree of contribution of composing-loop deformation for the closed-loop deformation, Δ and Δ_i represents the closed-loop and composing-loop deformation, respectively.

76.4 Optimal Model Based on Deformation and Quality Loss

We will construct the optimal model of tolerance allocation from the conclusion of preceding sections discussed. In the former section, we conclude that the deformation influences the quality loss of assembly, especially when it increases the quality loss, or decreases the assembly characteristic, the product may lose its functionality. For this reason, it is necessary to consider the deformation when optimizing the tolerance model on the objective of minimum quality loss. Equation 76.4 can be interpreted as the process of given the optimal condition, which is the second expression of Eq. 76.4, solve for the tolerance of composing-loops where, in this case, the quality loss is in its minimum value based on the first expression of Eq. 76.4. This optimization, however, without the consideration of deformation, i.e., the parts are ideal. For this and the former reasons discussed in preceding section, the improvement of optimal problem, i.e., Eq. 76.4 is essential for practical application. Suppose the quality loss is $L^{'}$ with the consideration of deformation. In this case, the quality loss function can be deduced as follows:

$$L^{'}(T^{'}) = kT^{'2} = \sum_{i=1}^{N} k_i T_i^{'2} \tag{76.7}$$

We have indicated that the quality loss is the deviation of the actual value from the target value. Similarly, the deformation is the deviation of its ideal state, i.e., the target value. Consequently, when consider deformation, the overall deviation of the target value is the summation of actual value (which ignores the deformation influence) and deformation (the notation of which is △). Usage of this conclusion, the following relationship satisfies:

$$T^{'} = T + \Delta \tag{76.8}$$

where $T^{'}$ represents the overall deviation in practical case, T represents the overall deviation in ideal case, and Δ represents the overall deformation. In a similar fashion, for composing-loops, the following relationship satisfies:

$$T_i^{'} = T_i + \Delta_i \tag{76.9}$$

where $T_i^{'}$ represents the composing-loop deviation in practical case, T_i represents the composing-loop deviation in ideal case, and Δ_i represents the composing-loop deformation. Substitution of Eqs. 76.8 and 76.9 into Eq. 76.7, the modified quality loss function for practical application just as follows:

$$L^{'}(T) = k(T+\Delta)^2 = \sum_{i=1}^{N} k_i (T_i + \Delta_i)^2 \tag{76.10}$$

Equation 76.10 is the improved quality loss function with the consideration of the assembly deformation appropriate for practical application. Consequently, the target function of the optimization problem stated before is replaced by Eq. 76.10, i.e., the solution of the minimum quality loss of Eq. 76.3 is converted into the solution of Eq. 76.10. Since quality loss function modified, the conditions of the optimization problem must improved. Recall that the tolerance relationship between closed-loop and composing-loops constructs the conditions of the optimization problem. Comparison of Eqs. 76.3 and 76.10, we observe that both of each have identical variables T and T_i. Hence, the condition in Eq. 76.4 is equally appropriate for Eq. 76.10. Further, only this condition is insufficient, because of the inclusion of variables Δ and Δ_i in Eq. 76.10. From the former discussion, Eq. 76.6 represents the relationship between closed-loop deformation and composing-loops deformation, which constraint these variables. Because of this, Eq. 76.6 is another condition of the optimization problem, together with the preceding condition, constraint the optimal solution of Eq. 76.10. As a consequence, for completeness and clarity, we summarize the optimal model of tolerance allocation with consideration of deformation as follows:

$$\begin{cases} L^{'}(T) = k(T+\Delta)^2 = \sum_{i=1}^{N} k_i(T_i + \Delta_i)^2 \\ \text{st1: } s^2T^2 = \sum_{i=1}^{N} q_i^2 s_i^2 T_i^2 \\ \text{st2: } \triangle = \sum_{i=1}^{N} \varepsilon_i \triangle_i \end{cases} \tag{76.11}$$

76.5 Case Study

In order for the verification of the improved optimal model, we study a simply example illustrated in Fig. 76.2. The assembly component in the figure designed using CATIA, which is a type of CAD software, is the component of cabin door of some aircraft. Suppose the distribution of closed-loop and composing-loops obey the normal distribution, so that the distribution coefficient q and $q_i$identically equal constant 1. The basic information of closed-loop and composing-loops is listed in Table 76.1. In Table 76.1, P_1–P_8 represents the composing-loops of the component, while the P_9 represents the closed-loop of the component. The computation result of the optimal tolerance and quality loss are listed in Table 76.2, where we exploit both the improved and original model for comparison. From Table 76.2 we conclude that the overall quality loss using the improved model is less than that using the original model, although some composing-loops' quality loss of improved model are more than that of original model.

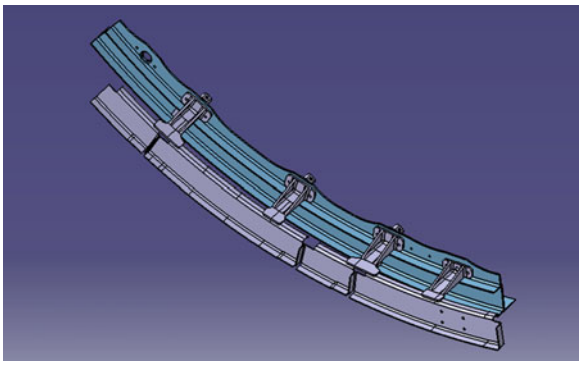

Fig. 76.2 Use case for verification

Table 76.1 Basic information of closed-loop and composing-loops

No.	Nominal dimension	Tolerance	Deformation
P_1	50.8	0.50	0.11
P_2	75.7	0.65	0.23
P_3	38.0	0.23	0.09
P_4	200.0	0.45	0.23
P_5	97.4	0.33	0.11
P_6	158.4	0.70	0.12
P_7	32.4	0.15	0.05
P_8	56.7	0.45	0.10
P_9	136.0	0.30	0.13

Table 76.2 Comparison of result based on improved and original models

No.	Improved model		Original model	
	Optimized tolerance	Quality loss	Optimized tolerance	Quality loss
P_1	0.3221	37.22	0.4656	48.35
P_2	0.2310	5.43	0.4500	3.12
P_3	0.0932	4.32	0.1839	1.21
P_4	0.2132	56.93	0.3765	78.35
P_5	0.1039	45.92	0.3198	35.13
P_6	0.3398	9.82	0.5600	10.12
P_7	0.0500	6.54	0.1350	8.92
P_8	0.1897	9.38	0.3500	10.83
P_9	0.1021	175.56	0.2317	196.03

76.6 Conclusion

This paper discussed the optimal model of tolerance allocation based on the quality loss, especially with the consideration of assembly deformation. We explored the improved model in the case of deformation effect. This model, however, is more appropriate for practical application. Finally, we take an instance for comparison of this model with the original model which based on quality loss only. From this comparison, we conclude that the improved model has less quality loss for overall assembly.

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Chapter 77
Efficient Mixed-Norm Multiple Kernel Learning

Yan Wei, Han-shu Qin and Shao-hua Zeng

Abstract Multiple kernels learning (MKL) is a hot topic in the current kernel machine learning field which aims at find a convexity linear combination of based kernels. Current MKL methods encourage spare kernel coefficients combination, unfortunately, when features encode orthogonal data, spareness tends to select only a few kernels, and may discards useful information which lead to poor generalization performance. In this paper, we presented an efficient multiple kernels learning method based on mix-norm in which sparseness and nonsparseness can be compromised using a mixing regularization. Both SVM and MKL could be regarded as special cases of EMNMKL. Then, we developed a rapid gradient descent algorithm to deal with the problem. Simulation experiment results show that the EMNMKL rapidly converges and the average testing accuracy demonstrates that EMNMKL algorithm clearly outperforms SVM and MKL.

Keywords Multiple kernel learning · Mix-norm · Mixing regularization · Gradient descent algorithm

77.1 Introduction

Multiple kernels learning (MKL) is a new attractive topic in the current kernel machine learning field. Multiple kernel learning attends to search for a combination of base kernel functions (matrices) that maximizes a generalized performance measure, it turns out that the combine multiple kernel can meet some

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_77,

practical requirements such as large scale problem, high dimension or un-normalized data, heterogeneous information, nonflat distribution of samples, etc. Wang et al. [1] proposed multiple kernel learning methods and analyzed MKL methods with the corresponding characteristics and disadvantages. Mehmet and Alpaydın [2] gave a taxonomy of and review several multiple kernel learning algorithms. Rakotomamonjy et al. [3] addressed the Simple MKL, and it has been applied in a number of domains, such as extraction image feature [4], economic forecast [5], stock market price forecast, [6] and so on.

A large number of researchers apply themselves to deal with kernel fusion problem and have given some efficiency algorithms. In order to make the MKL approach solve large-scale problem, Wang et al. [7] proposed an adaptive sequence learning algorithm based on the kernel target alignment heuristics, it has better performance and stability in regression precision and classification accuracy. Rakotomamonjy et al. [8] addressed the MKL through an adaptive 2-norm regularization formulation. Group lasso was introduced by Xu et al. [9], who also provided a unified solution for the entire family of l_p-MKL. Intuitively, Sparseness is being regarded as one of the key features in machine learning [10], sparse solutions makes sense when the expected number of useful kernels is small. Sparseness is good when these kernels already contain a couple of good features that alone capture almost all of the characteristic traits of the problem. In other words, it implies that features are highly redundant. Unfortunately, sparseness do not always perform well in practice problems [11], when the features inherently include orthogonal information, enforcing sparseness may lead to discarding useful information and as a result, degradation of generalization performance. Recent approaches to MKL avoid discarding information either by incorporating an additional constraint l_p ($p > 1$) to meet nonspareness [9, 11] or by a mixing norm to compromise sparsity and nonsparsity [12, 13].

In this paper, we formulate an efficient mixed-norm multiple kernel learning (EMNMKL), it aims at compromising sparseness and nonsparseness in the situations to achieve more efficient multiple kernel learning. According as l_p-norm ($p > 1$) is more popularize rather than l_2-norm, EMNMKL makes use of a mixing regulation function, in other words, EMNMKL combines l_1-norm and l_p-norm with $p > 1$. In order to obtain efficiently EMNMKL, we develop a rapid gradient descent algorithm which significantly reduces the computation cost. A series of simulation experiment shows that the EMNMKL converges rapidly and its efficiency compares favorably with SVM and other MKL algorithms.

The rest of the paper is structured as follows. Section 77.2 presents the framework of multiple kernel learning and the theoretical analysis of existing approaches to MKL. It presents our main contribution in Sect. 77.3, we report on the empirical results in Sects. 77.4 and 77.5 concludes.

77.2 Multiple Kernel Learning

In this paper, we focus on binary classification problem. Support that data set $S = \{(x_1, y_1), (x_2, y_2), \ldots, (x_m, y_m), X \in R^n, y \in \{-1, +1\}\}$, where $x_i \in X$ denote the training samples and y denote the label for the data points in X. In kernel methods, the data is mapped into a Hilbert space through the mapping $\Phi : X \mapsto H$. Aim of kernel algorithm is to find the solution of the learning problem which has a linear form:

$$f(x) = \left\langle \sum_{i=1}^{n} \alpha_i \Phi(x), \Phi(x_i) \right\rangle = \sum_{i=1}^{n} \alpha_i K(x, x_i) \tag{77.1}$$

where kernel function is defined as the inner product in $H : K(x, x_i) = \langle \Phi(x), \Phi(x_i) \rangle$. Kernel methods only deal with $K(\cdot, \cdot)$ instead of the explicit form of mapping Φ. So kernel function avoids complex inner product, as well as avoids to design the feature space (learning machine) itself.

The framework, known as multiple kernel learning (MKL), considers a group of mapping $\Phi_m : X \mapsto H_m$ and every mapping gives rise to a reproducing kernel K_m of H_m given by $K_m(x, x_i) = \langle \Phi(x), \Phi(x_i) \rangle_{H_m}$. Giving weights $\mu_1, \mu_2, \ldots, \mu_M$ to these mappings and stacking them simultaneously, such that the kernel function has the following forms:

$$\begin{aligned} K'(x, x_i) &= \langle \Phi(x), \Phi(x_i) \rangle \\ &= \mu_1 \langle \Phi_1(x), \Phi_1(x_i) \rangle + \mu_2 \langle \Phi_2(x), \Phi_2(x_i) \rangle + \cdots + \mu_M \langle \Phi_M(x), \Phi_M(x_i) \rangle \\ &= \sum_{m=1}^{M} \mu_m \langle \Phi_m(x), \Phi_m(x_i) \rangle = \sum_{m=1}^{M} \mu_m K_m(x, x_i) \end{aligned} \tag{77.2}$$

where the composite feature mapping $\Phi(x)$ and weight vector ω have a block structure $\Phi(x) = \left(\sqrt{\mu_1}\Phi_1(x)^T, \sqrt{\mu_2}\Phi_2(x)^T, \ldots, \sqrt{\mu_M}\Phi_M(x)^T\right)^T$ and $\varpi = \left(\varpi_1^T, \varpi_2^T, \ldots, \varpi_m^T\right)$ respectively. According to the formulation of support vector machine, the MKL problem is equivalent to the following optimization form:

$$\begin{aligned} \min \quad & \frac{1}{2}\left(\sum_{m=1}^{M} \|\varpi_m\|\right)^2 + C\sum_{i=1}^{n} \xi_i \\ \text{w.r.t.} \quad & \varpi = \left(\varpi_1^T, \varpi_2^T, \ldots, \varpi_M^T\right)^T \in R^{c_1} \times R^{c_2} \times \cdots \times R^{c_M}, b \in R, \xi_i \in R_+ \\ \text{s.t.} \quad & y_i\left(\sum_{m=1}^{M} \varpi_m \Phi_m(x_i) + b\right) \geq 1 - \xi_i \end{aligned} \tag{77.3}$$

where $X = R^{c_1} \times R^{c_2} \times \cdots \times R^{c_M}$ and $H_m = R^{c_m}$. Thus, the kernels $\{K_1, K_2, \ldots, K_M\}$ can be viewed as defined on $\{R^{c_1}, R^{c_2}, \ldots, R^{c_M}\}$, respectively. Then the decision function of binary classification problem becomes:

$$\begin{aligned} f(x) &= \langle \omega, \Phi(x) \rangle + b = \sum_{m=1}^{M} \sqrt{\mu_m} \varpi_m \Phi_m(x) + b \\ &= \sum_{i=1}^{n} \left(\alpha_i y_i \sum_{m=1}^{M} \mu_m K_m(x, x_i) \right) + b \end{aligned} \tag{77.4}$$

77.3 Efficient Mixed-Norm Multiple Kernel Learning Algorithm

Using l_p-norm ($p > 1$) to encourage nonsparse was proposed in multiple kernel learning [10, 14], the approach can be equivalent by incorporating the constraint $\|\mu\|_p \leq 1$. The nonconvexity of the resulting optimization problem is not inherent and can be easily solved by a variable substitution $\omega_m := \sqrt{\mu_m} \varpi_m$. Thus, the primal optimization problem of binary classification can be rewritten as:

$$\begin{aligned} \min_{\mu, \omega, b, \xi} \quad & \frac{1}{2} \sum_{m=1}^{M} \frac{\|\omega_m\|^2}{\mu_m} + C \sum_{i=1}^{n} \xi_i \\ \text{s.t.} \quad & y_i \left(\sum_{m=1}^{M} \omega_m \Phi_m(x_i) + b \right) \geq 1 - \xi_i;\ \xi, \mu \geq 0; \|\mu\|_p \leq 1 \end{aligned} \tag{77.5}$$

Sparseness is being regarded as one of the key features in machine learning for it can efficiently simplify the underlying data representation. Ordinarily, we use l_1 constraint to encourage sparse, also known as the simplex constraint, which can lead to a sparse solution. Unfortunately, l_1-norm MKL do not always acquired outperform in practice. In this paper, we proposed a mix-norm regularized MKL, it introduced a tuning parameter θ to compromise between sparseness and nonsparseness, where $\theta \in (0, 1)$. That is to say, it represents nonsparseness by incorporating the constraint $\|\mu\|_p \leq 1$ and weights on each kernel matrix with l_1-norm constraint to encourage sparseness. Hence, the efficient mix-norm multiple kernel learning algorithm (EMNMKL) is presented by this paper which has the follow form:

$$\begin{aligned} \min_{\mu, \omega, b, \xi} \quad & \frac{1}{2}(1 - \theta) \left(\sum_{m=1}^{M} \|\omega_m\| \right)^2 + \frac{1}{2} \theta \sum_{m=1}^{M} \frac{\|\omega_m\|^2}{\mu_m} + C \sum_{i=1}^{n} \xi_i \\ \text{w.r.t.} \quad & \omega = \left(\omega_1^T, \omega_2^T, \ldots, \omega_M^T \right)^T \in R^{c_1} \times R^{c_2} \times \cdots \times R^{c_M}, b \in R, \xi_i \in R_+ \\ \text{s.t.} \quad & y_i \left(\sum_{m=1}^{M} \omega_m \Phi_m(x_i) + b \right) \geq 1 - \xi_i; \xi, \mu \geq 0; \quad \|\mu\|_p \leq 1 \end{aligned} \tag{77.6}$$

In EMNMKL framework, the compromise between sparseness and non-sparseness is controlled by parameter θ which is computed by cross-validation. When θ is relatively small, the l_1-norm term becomes the main part of (77.6) and in this case, sparseness is encouraged. When θ approaches to 0, EMNMKL degenerates into MKL. When θ is relatively large, the l_p-norm term becomes the main part of (77.6) and in this case, nonsparseness is well denoted. When θ approaches to 1, EMNMKL degenerates into extending SVM.

In order to compute the optimal value of (77.6), we apply Lagrange's theorem incorporates the constraints into the optimize problem of (77.6) by introducing nonnegative Lagrangian multipliers $\alpha_i, \beta_i \geq 0$, so the Lagrangian problem can be written as:

$$\begin{aligned} L = &\frac{1}{2}(1-\theta)\left(\sum_{m=1}^{M}\|\omega_m\|\right)^2 + \frac{1}{2}\theta\sum_{m=1}^{M}\frac{\|\omega_m\|^2}{\mu_m} + C\sum_{i=1}^{n}\xi_i \\ &- \sum_{i=1}^{n}\alpha_i\left(y_i\left(\sum_{m=1}^{M}\omega_m\Phi_m(x_i)+b\right)-1+\xi_i\right) - \sum_{i=1}^{n}\beta_i\xi_i \end{aligned} \tag{77.7}$$

Calculating the derivatives of the Lagrangian with respect to primal variables ω_m, ξ_i, b and setting these derivatives to zero, then we arrive at the follow dual problem:

$$\begin{aligned} &\max\ 1^T\alpha - \frac{1}{2}\alpha^T y^T\left(\sum_{m=1}^{M}\frac{\mu_m}{\mu_m-\theta\mu_m+\theta}K_m\right)\alpha y \\ &\text{s.t. } \alpha^{\mathrm{T}}\mathrm{y}=0;\ 0\leq\alpha\leq\mathrm{C} \end{aligned} \tag{77.8}$$

Algorithm 1—efficiency elastic multiple kernel learning algorithm	
Input	The training sample set $S=\{(x_1,y_1),(x_2,y_2),\ldots,(x_m,y_m), X\in R^n, y\in\{-1,+1\}\}$
Initialization	To set $t=1$ and $\mu_m^t=\frac{1}{M}$ for $m=1,2,\ldots,M$
Algorithm	While the stopping criterion not meet do
	Stept 1: solve SVM problem $K=\sum_{m=1}^{M}\frac{\mu_m^t}{\mu_m^t-\theta\mu_m^t+\theta}K_m$ and obtain the optimal solution α^*
	Step 2: calculate gradient $\frac{\partial L}{\partial\mu_m}\big\vert_{\mu=\mu^t}=-\frac{1}{2}\alpha^{*T}y^T\frac{\theta}{(\mu_m-\theta\mu_m+\theta)^2}K_m\alpha^*y$
	Step 3: compute descent direction ∇L_t and optimal step size θ_t, and update μ with $\mu^{t+1}\leftarrow\mu^t+\theta_t\nabla L_t$.
	Step 4: $t=t+1$
Output	The result of SVM binary classification

We can solve the optimal value of the optimize problem with any SVM algorithm. Then, let us calculate the derivatives of $L(\mu)$ as following:

$$\frac{\partial L}{\partial \mu_m}\Big|_{\mu=\mu^*} = -\frac{1}{2}\alpha^{*T} y^T \frac{\theta}{(\mu_m - \theta\mu_m + \theta)^2} K_m \alpha^* y \tag{77.9}$$

where α^* is optimal solution at $\mu = \mu^*$. In this paper, the outline of the proposed algorithm is shown in Algorithm 1. The descent direction represents by ∇L_t, and the optimal step θ_t is calculated using Armijo's rule which ensures global convergence. The stopping criterion is determined by either maximum number of iterations or duality gap.

77.4 The Simulation Experiment

In the simulation experiment, we randomly select three UCI datasets, such as SPECT Heart, Breast Cancer and Iris, to evaluate the efficiency of EMNMKL algorithm. With every experiment, simulated data set consists of an independent training set and an independent testing set. In order to compute two tune parameters, we adopt Gaussian kernels and use 10-fold cross-validation on a grid. Then, the base kernel matrices are generated by Gaussian kernels with 15 different bandwidths $\{2^{-3}, 2^{-2}, \ldots, 2^{11}\}$ on all variables and each single variable. Note that the training data have been normalized to zero mean and unit variance, and the testing data are also normalized using the mean and variance of training data. For each experiment, the termination criterion of the proposed algorithm can be either based on the maximal number of iterations or the duality gap.

In Table 77.1, columns 3–6 represent the number of samples for positive and negative training/testing, respectively. Columns 7–8 show the testing accuracy of

Table 77.1 Simulation results

Algorithm	Databases	N_ptrain	N_ntrain	N_ptest	N_ntest	A_pos%	A_neg%	A_test%	θ
SVM	SPECT heart	40	40	172	15	57.58	33.32	55.63	1
	Iris	50	50	100	50	55.10	46.25	51.75	1
	Breast cancer	60	60	250	36	49.92	53.38	50.36	1
MKL	SPECT heart	40	40	172	15	75.68	52.33	73.81	0
	Iris	50	50	100	50	77.30	69.25	74.42	0
	Breast cancer	40	40	250	36	74.92	78.30	73.35	0
EMNMKL	SPECT heart	40	40	172	15	77.56	53.42	75.62	0.4
	Iris	50	50	100	50	78.20	69.55	74.32	0.5
	Breast cancer	40	40	250	36	72.54	81.25	73.64	0.6

positive samples and negative samples respectively. And column 9 is testing accuracy.

77.5 Conclusion

In this paper, we have proposed an efficient mix-norm multiple kernel learning algorithms by combining l_1-norm and l_p-norm with $p > 1$. By the above analysis, the following conclusions can be drawn.

1. The EMNMKL algorithm makes use of a mix-norm regularization function to compromise sparseness and nonsparseness. And the compromise between sparseness and nonsparseness is controlled by parameter θ, when θ is relatively small, l_1-norm encourage sparsity. On the other hand, When θ is relatively large, the l_p-norm makes nonsparsity be well denoted. Therefore, SVM and MKL can be regarded as a special case of EMNMKL by the tune parameter θ.
2. In order to obtain efficiently algorithm, we develop a rapid gradient descent algorithm which significantly reduces the computation cost. The above result of simulation show that the average testing accuracy of independent experiment proves that EMNMKL algorithm clearly outperforms SVM and MKL. And our presented algorithm has rapid convergence.

The MKL still deserve deep study. Our algorithm now only focuses on binary classification problems. We well research regression and multiple-scale of EMNMKL and theoretical analysis of its convergence will be carried out in the future.

Acknowledgments The work was supposed by the Scientific Research Foundation of the Chongqing Municipal Education Commission, China (No.KJ090823&No.KJ110632), Natureal Science Foundation of Chongqing, China (No.cstc2011jjA40008), and the Foundation of the Chongqing Normal University, China (No.11XLB047).

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Chapter 78
Impact of Product Attributes and Reputation Mechanism on Customer Intention

Y. M. Liu

Abstract Online shopping in China has been growing rapidly in recent years. This paper examined customers' motivation to spread review after online shopping. Based on Chinese context and relevant literature research, this paper discussed first the impact of different product attribute, satisfaction degree, and online reputation mechanism on customers' review spreading intention in China, then built the research model and developed hypotheses. And next, hypotheses were tested by the data from Xidian university students. The result showed that reputation as a top reviewer did not have a significant impact on customers' intention to spread eWOM, however, high "a helpful review" radio drives a customer to provide eWOM significantly. The results also indicate that dissatisfied feelings and experience attributes drive customers to provide an online review significantly.

Keywords Online review · Product attributes · Reputation mechanism

78.1 Introduction

Online shopping in China has been growing rapidly in recent years. Online consumer product review, a form of electronic word-of-mouth (eWOM), has been researched intensively because of its significant influence on the consumer purchase decisions and on the sale performance of online shop. To date, most previous research has only limited research on the impact of online reviews in specific product categories or different industries in China or in other countries [1, 2]. In practice, however, not all customers submit online reviews. Reviewing a product

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_78,

online would probably cost customers' time and efforts. So we should explore the motivation that customer share their purchase experience with strangers. In this paper, we focus on this issue to examine the internal and external factors that drive customers to spread online reviews. Based on the relative literature review, we build our research model and develop hypotheses. Then we empirically test the research model and report the findings of our empirical study. And finally, we discuss implications for both research and practice. And we intend to make some contributions to marketing literatures. This paper extends online reviews research to impact of different product attribute and online reputation mechanism on customers' review spreading intention. The findings of this study also will help online honest sellers make better marketing strategies to improve the sale performance by more persuasive online reviews.

78.2 Literature Review

Dichter [3] identified four motivations that drive customer to provide only positive WOM: product-involvement, self-involvement, other-involvement, and message involvement. In another study, Sundaram et al. [4] explored the motivations underlying both negative WOM and positive WOM communication. In the online shopping context, however, Hennig-Thurau et al. [5] suggest that the primary factors leading to eWOM behavior are consumers' desire for social interaction, desire for economic incentives, their concern for other consumers, and the potential to enhance their own self-worth. Building on the social psychology literature, Cheung et al. [6] identified that reputation, sense of belonging and enjoyment of helping other consumers significantly related to consumers' eWOM intention. Picazo-Vela et al. [7] investigated that attitude, perceived pressure, neuroticism, and conscientiousness significantly drive an individual's intention to spread an online review. Prior researches mainly focus on the internal factor from customer perspective. In this study, we extend to the external factor, product attributes and website reputation mechanism, and examine how those factors to influence customer eWOM intention.

78.2.1 Product Attributes

Previous studies have analyzed the relationship between product and online reviews. Products can be divided into search attributes, experience attributes, credence attributes by the level of information asymmetry. Search attributes can be determined by inspection of consumer prior to purchase, for example, some electronic products. Experience attributes are not determined prior to purchase unless customers try and experience the product personally [8, 9], such as the clothing. Credence attributes include the confidentiality of the customers' banking

information. In this paper, we only examine the search and experience product because few credence product is sold online and we just study this issue on the online context. Senecal have researched that the type of product had a significant influence on the propensity to follow product recommendations and the result showed that experience products' recommendations were more influential than search products' recommendations. Park showed that the impact of negative eWOM on the eWOM effect is greater for experience goods than for search goods. Moldovan examined how product originality and usefulness generate WOM and found that consumers spread more WOM about original products [10–12], but the valence of what they say depends on the usefulness of the product. Most prior researches focus on the impact of some product characteristics on online reviews effectiveness. However, little research examined the impact of product attributes on online reviews spreading behaviors.

78.2.2 Reputation Mechanism

Reputation mechanism, which report users' feedback on historical transactions, is particularly important to build trust between sellers and buyers in online transaction website. Most business websites provide reputation feedback mechanism for transactional trader. Previous researches focus on the trust issue. However, only Cheung et al. [13] examined the relationship between reputation and eWOM spreading intention and found that reputation is significantly related to consumers' eWOM intention. In that research, reputation is defined that consumers gain an informal recognition and establish themselves as experts. In this paper, online reputation mechanism for consumer is those that a seller reviews consumers' trade behaviors after purchase or that receivers give a feedback to the reviews provided by one consumer. And another reputation mechanism for seller is those that a consumer reviews sellers' trade behaviors post purchase and products sold by this seller. Most prior research argued how reputation mechanism for a seller influences trust or sales, and few researchers examined whether reputation for consumers would have impact on consumer behaviors. In this paper, we analyze the impact of reputation mechanisms for customer's review on the customer's intention to post a review.

78.3 Research Model and Hypotheses Development

In this section, we develop our theoretical framework on the literatures we discuss above, and then propose the hypotheses [14]. In this study, we use the intention definition in Picazo-Vela's research which defined "intention as an individual's willingness to provide an online review", as shown in Fig. 78.1.

Most transactional websites develop a mechanism that reviews readers could judge and feedback whether a review is helpful or not. So every product review a

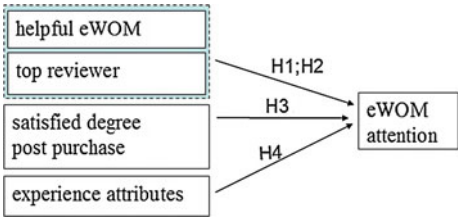

Fig. 78.1 The research model and hypothesized relationships for the study

customer spreads online post purchase would get a radio of helpful. In this paper, the research model was examined using a sample of Amazon.cn, one of most successful transaction website in China [15, 16]. The question "Was this review helpful to you?" follows each posted review and a review receiver chooses one of two response options: "Yes" and "No". The dependent variable (helpfulness) on the whole review content top listed by Amazon.cn was calculated by dividing the number of people who voted that they found the review helpful by the total number who submitted votes for that review. On the other hand, every reviewer is ranked into different classes, such as "the top reviewers".

Individuals tend to get a high reputation by spreading online review. In other words, reviewers have a tendency to get high level feedback of "helpful" online review. So this leads to the following hypothesis,

Hypothesis 1: Reputation as a top reviewer will have a positive effect on customers' intention to provide an online review.

Hypothesis 2: Reputation as a helpful review will have a positive effect on customers' intention to provide an online review.

Prior research has found that consumers will be more motivated to post their reviews to express their feelings if they are very satisfied or very dissatisfied. A customer with neither dissatisfied nor satisfied shopping experience is not significantly motivated to provide reviews online. However, Hu did not examine the different impact on customers' motivation to post reviews between satisfied customers and dissatisfied ones. Based on balance theory, dissatisfied customer would like to express negative feelings to lessen frustration and reduce anxiety. In the other words, a customer with unsuccessful consumption experience tends to share negative emotions with others. Hence, we propose in this paper,

Hypothesis 3: Dissatisfied feelings will have a more significant effect on customers' intention on provide an online review than satisfied ones do.

Most previous online review research choose a movie, hospitality and tourism industry, or a restaurant as objective used to empirically test hypothesis, and then draw a conclusion. Those two kinds of product belong to experience product. A customer tends to give others his/her own experiences or opinions about product quality after he/she actually use this type of product. However, a customer could judge search product quality by information provided online or offline. Individuals do not tend to review products any more after they purchase and experience them. Hence,

Hypothesis 4: Experience attributes will have a positive effect on customers' intention on provide an online review.

78.4 Research Method

78.4.1 Samples and Measurements

To ensure enough content validity, a survey questionnaire was adopted and modified based on the findings of the literature review, with the exception of reputation measure that was created in this study. We measure intention using three items from Picazo-Vela, satisfaction three items from Spreng, and experience attribute from Krishnan. Five-point rating scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) were used to measure each construct.

We choose university students to participate in this study partly because previous research has identified college students as a major population of internet shoppers, and partly because those samples are easier to get. All the respondents should have the experience of online shopping. The data are collected in two ways. One way is that a printed survey was distributed among students at Xidian University in the China. Two classes' students are randomly chosen to answer the questions. Another way is to distribute questionnaires on a survey website (http://www.sojump.com/) and then to tell students in other universities this link to answer online. This research totally collected 256 responses, but 5 were excluded because of incomplete responses and 13 were excluded because of sequent same answers. So this study collected 238 valid responses for the following data analyses by using SPSS software.

78.4.2 Data Analysis and Research Results

As shown in Table 78.1, the average frequency of online purchases was 1.86 times per month. 51.2 % participants were male. All Cronbach' α coefficients for each construct exceeded the minimum hurdle of 0.60 (0.635 for reputation, 0.651 for satisfied degree, 0.871 for experience attribute, 0.808 for intention). All the level of internal consistency was acceptable. Regression analysis was followed. The significant level of the model had reached 0.000.

Table 78.1 Coefficients of regression analysis

Independent variable[a]	Hypothesis	Standardized coefficients	t-statistic	Sig	Result
A top reviewer	H1	0.019	0.177	0.860	Not supported
A helpful review	H2	0.675	6.399	0.000	Supported
Satisfaction	H3	0.629	6.155	0.000	Supported
Experience attribute	H4	0.645	5.973	0.000	Supported

[a] Dependent variable: intention

78.5 Discussion and Conclusion

Hypothesis 1 was not supported. The results indicate that reputation as a top reviewer did not have a significant impact on customers' intention to spread eWOM. However, hypothesis 2 was supported. High "a helpful review" radio drives a customer to provide eWOM significantly. This was surprising that two types of reputation had different result of regression analysis. Three potential reasons may explain this result. First, a customer that would like to become a top reviewer should buy enough products to provide review after using the product. Second, a customer needs to make lot of effort and spend more time to spread reviews online. Third, top reviewers would not gain so competitive profits that university students cannot focus on the competition with other reviewers.

Hypothesis 3 was supported. The results indicate that dissatisfied feelings will drive customers to provide an online review more significantly than satisfied ones do. Almost all the buyers would like to express his/her own personal feeling (satisfaction or dissatisfaction) by post online reviews. However, negative reviews actually are not obvious more than positive reviews in practice. We explain this by a survey of eBay users in previous research. Zacharia found two phenomena. One is that many customers give positive feedback to a problematic trade; two is that many customers do not leave any feedback because they are afraid of retaliation from sellers. So even if some customers have an intention to post a negative review, they do not change into any actual behaviors.

This study had examined factors that influence a customer's intention to provide an online review. First, product characteristics only limited to experience attribute and search attribute in this paper. We also recommend future research could identify the impact of other product characteristics on an individual's intention to spread an online review. Second, reputation as a top reviewer could not drive a customer to provide a review online. We explained it, but future research could find deeper reasons why customers do not care about this reputation (a top reviewer).

Acknowledgments This research was supported by the Fundamental Research Funds for the Central Universities (72114829; K50510060013), and by the Research of Knowledge Share in Xi'an Cultural Industry (SF1015 (5)).

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Chapter 79
Decreasing Accelerated Gradient Descent Method for Nonnegative Matrix Factorization

Furui Liu

Abstract In this paper, by bringing in a user defined nonnegative control matrix to form a new objective function, I modify the update rules correspondingly and propose a novel decreasing accelerated gradient descent method for nonnegative matrix factorization (DAGDM) which can make the matrix of the decomposition results achieve sparse. The control matrix also contains the weighting information, which puts different weight on different parts of the result matrix to be produced. This will provide a control interface of nonnegative matrix factorization to make a sparse and light basis matrix. Experimental results demonstrate the effectiveness of the proposed method.

Keywords Sparse representation · Matrix factorization · Nonnegative control matrix

79.1 Introduction

Nonnegative matrix factorization (NMF) [1, 2] has been introduced as a useful decomposition in analysis of data. NMF finds an approximate factorization $v \approx WH$ with nonnegative constraint on both factors. This method produces two factors W and H, and they can be viewed as the basis (W) and the encoding (H) factors for their different representation effect. The additive nature of the constraints makes this method different from others such as independent component analysis (ICA) [3] which learns holistic feature from data. The NMF can be interpreted as a part-based representation of data.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_79,

NMF has been successfully used in fields of science such as biomedical applications [4], and face object recognition [5]. The intuitive nature of the method makes it possible to extract additive parts of data set that are highly interpretable, and the result is also a sign of discovering hidden topics and separating useful part features. At the same time, this will reduce the dimensionality of data. The part-based nature is related to a study of sparse representation. Sparse representation attempts to make a sparse result in order to avoid the high degree of overlapping among basis vectors that contradict the intuitive nature of "parts" [6]. These works are to modify the original NMF to enforce sparseness on basis factors, encoding factors or both [7, 8].

Although work has been done to force a sparse result, the sparse constraint is side effect but not an explicit constraint concerned about the objective function, they concentrate on the decomposition result but pay little attention to the control of the weight of different parts of the basis factor. The result is much depending on the initial condition of the factorization which is randomly set. To solve these problems, I propose a novel decreasing accelerated gradient descent method for nonnegative matrix factorization (DAGDM) to make a sparse matrix factorization and bring in a user defined nonnegative control matrix D to contain the weighing information of the basis factor. My method can enforce the factorization result to act correspondingly to the control matrix D, with different D the result will show different coding feature. The main contribution of this paper should be as:

- Combine the "Kullback–Leibler divergence" [9] and square of Frobenius norm together in the objective function to force sparseness in the basis factor W while keeping a better probabilistic interpretation of the data.
- Bring in a nonnegative matrix D to contain the weighing information of the part of W and give the controllable interface to the user to make a sparse and light result.

79.2 Related Work

79.2.1 Nonnegative Matrix Factorization

The method proposed as Nonnegative Matrix Factorization [2] is to find a useful decomposition of the original matrix V.

$$V \approx WH \tag{79.1}$$

where $V \in R^{p\times n}$, $W \in R^{p\times r}$ and $H \in R^{r\times n}$. Basing on the Poisson likelihood, we can get the "KL divergence" to form the objective function as:

$$D(V,\ WH) = \sum_{a=1}^{p}\sum_{b=1}^{n}\left[V_{\mathrm{ab}}\log\frac{V_{\mathrm{ab}}}{(WH)_{\mathrm{ab}}} - V_{\mathrm{ab}} + (WH)_{\mathrm{ab}}\right] \tag{79.2}$$

The update rule is to minimize the objective function $D(V, WH)$ by creating a decreasing sequence, each step the $D(V, WH)$ is to decrease a little. The above function is lower bounded by 0, and vanishes if and only if $V = WH$. It is usually referred as "divergence" from V to WH but not "distance" between them because it is not symmetric in V and WH. It reduces to Kullback–Leibler divergence or relative entropy when $\sum_{ab} V_{ab} = \sum_{ab} (WH)_{ab} = 1$. It can be regarded as normalized probability distributions.

With the gradient descent algorithm and a proper choice of the step size, we get the update rule of the multiplicative method [9]:

$$H_{ab} \leftarrow H_{ab} \frac{\sum_{i=1}^{p} (W_{ia} V_{ib} / \sum_{j=1}^{r} W_{ij} H_{jb})}{\sum_{i=1}^{p} W_{ia}} \tag{79.3}$$

$$W_{cd} \leftarrow W_{cd} \frac{\sum_{i=1}^{n} (H_{di} V_{ci} / \sum_{j=1}^{r} W_{cj} H_{ji})}{\sum_{i=1}^{n} H_{di}} \tag{79.4}$$

This method is easy to code and it has a good performance in practice to generate part-based results, and it is widely used in many areas as I mentioned in the first section.

79.2.2 Nonnegative Matrix Factorization with Sparseness Constraints

A more recent work related to the addition of sparseness constraints to the classical NMF problem is proposed by Hoyer [7]. This method minimizes the Euler distance $E(V, WH) = \|V - WH\|^2$ under the following constraints:

$$\text{Sparseness}\,(W_i) = S_\omega,\ i = 1, 2 \ldots r \tag{79.5}$$

$$\text{Sparseness}\,(H_i) = S_h,\ i = 1, 2 \ldots r \tag{79.6}$$

where W_i is the ith column of W, H_i is the ith row of H, S_ω and S_h are sparseness values for W and H, respectively, and are user-defined parameters. I mention the paper here to carry out the sparseness criteria in the paper which uses a combination of L_1 and L_2 norm of a given vector:

$$\text{Sparseness}\,(x) = \frac{\sqrt{n} - (\sum |x_j|) / \sqrt{\sum x_j^2}}{\sqrt{n-1}} \tag{79.7}$$

N is the dimensionality of the vector x. This criterion also quantifies how much energy of a vector is packaged into only a few components. This function evaluates to 1 if and only if x contains only a single nonzero part, and takes a value 0 if and only if all components are equal, interpolating smoothly between the two extremes.

79.3 My Proposal: Decreasing Accelerated Gradient Descent Method for Nonnegative Matrix Factorization

In this paper, I modify both the objective function and the update rule to form an decreasing accelerated gradient descent method which has an explicit sparseness constraint on the basis matrix W. I bring in a user defined matrix $D \in R^{p\times p}$ to evaluate the degree of sparseness adding to the basis matrix W, at the same time the user can add different weight to different parts of the basis matrix W by giving different values to the parts of D. Adding a square of the Frobenius norm of the matrix DW to the original objective function, I get the new objective function:

$$O = \sum_{a=1}^{p}\sum_{b=1}^{n}\left[V_{ab}\log\frac{V_{ab}}{(WH)_{ab}} - V_{ab} + (WH)_{ab}\right] + \|DW\|_F^2 \tag{79.8}$$

To maintain a smooth process, I preprocess the user input matrix D with some division, that is to say I check all the value of the item of D and select the one with the largest value Dmax, and let $D = D/D\text{max}$, so the largest item of D has been normalized to one. Then I make another division, let $D = D/\lambda\sqrt{p\times r}$, p and r are the dimensions of the matrix W and $\lambda > 1$ is a user-defined regularization parameter. This can maintain the property of smoothness for each step.

To minimize the objective function, the original multiplicative method described in (79.3) and (79.4) can be considered as a gradient descent method [10], and using the similar way, I can give the construction of my gradient descent method, consider the following gradient descent formulas:

$$H_{ab} \leftarrow H_{ab} - \eta_{ab}\frac{\partial}{\partial H_{ab}}O \tag{79.9}$$

$$w_{cd} \leftarrow W_{cd} - v_{cd}\frac{\partial}{\partial W_{cd}}O \tag{79.10}$$

Replace O with the formula in (79.8), the above formula forms:

$$H_{ab} \leftarrow H_{ab} + \eta_{ab}\left[\sum_{i=1}^{p}\frac{V_{ib}W_{ia}}{(WH)_{ib}} - \sum_{i=1}^{p}W_{ia}\right] \tag{79.11}$$

$$W_{cd} \leftarrow W_{cd} + v_{cd}\left[\sum_{j=1}^{n}\frac{V_{cj}H_{dj}}{(WH)_{cj}} - \sum_{j=1}^{n}H_{dj} - 2\times\sum_{i=1}^{p}(DW)_{id}D_{ic}\right] \tag{79.12}$$

To select a step size, forcing:

$$\eta_{ab} = \frac{H_{ab}}{\sum_{i=1}^{p}W_{ia}} \tag{79.13}$$

$$v_{cd} = \frac{w_{cd}}{\sum_{j=1}^{n} H_{dj}} \tag{79.14}$$

Then we get the final update rule:

$$H_{ab} \leftarrow H_{ab} \frac{\sum_{i=1}^{p} (W_{ia} V_{ib} / \sum_{j=1}^{r} W_{ij} H_{jb})}{\sum_{i=1}^{p} W_{ia}} \tag{79.15}$$

$$W_{cd} \leftarrow W_{cd} \left(\frac{\sum_{j=1}^{n} (H_{dj} V_{cj} / \sum_{k=1}^{r} W_{ck} H_{kj}}{\sum_{j=1}^{n} H_{dj}} - 2 \times \frac{\sum_{i=1}^{p} (DW)_{id} D_{ic}}{\sum_{j=1}^{n} H_{dj}} \right) \tag{79.16}$$

If in one step $W_{cd} < 0$, then let $W_{cd} = 0$.

Notice that in one step, the W_{cd} may be less than 0 and conflict with the nonnegative constraint on matrix W, the 0-setting of W_{cd} is necessary. I give the detailed algorithm below:

Algorithm decreasing accelerated gradient descent method for nonnegative matrix factorization
Input D, V, max_iter, r, λ
Output W, H, O
Begin
Calculate p = rows of V, n = columns of V
Randomly set nonnegative matrix $W \in R^{p \times r}$, $H \in R^{r \times n}$
$D = D$ / (Dmax $\times \lambda \sqrt{p \times r}$)
Set iter = 1, $O = \infty$
While not iter > max_iter or converged do
Update H as (15)
Update W as (16)
Check W, if $\exists W_{cd} < 0$, set $W_{cd} = 0$
Calculate O as (8)
iter = iter + 1
End while
End

It is obvious that the update rule for H in (79.15) is the same as (79.3), and we can view this DAGDM to be taking an extra subtraction and decreasing a little more on W_{cd} than the classical method in each step and thus accelerate the decreasing of W_{cd}. Below I will show that DAGDM preserves the nonnegative property.

Theorem *Both of the matrix H and W are nonnegative under the update rule* (79.15) *and* (79.16).

Proof To get this property, I first prove that the matrix W is nonnegative after each update step. We set W_{cd}^{i} to be the item of W at cth row and dth column, and it is the result of the ith updating. For $c \in \{1, 2, \ldots\ldots p\}$, $d \in \{1, 2, \ldots\ldots r\}$, $W_{cd}^{0} \geq 0$. (that is because we set the initial condition of the matrix W to be

nonnegative). Suppose $W_{cd}^{i} \geq 0$, for W_{cd}^{i+1} if $W_{cd}^{i+1} \geq 0$, the nonnegative property is of course preserved; if $W_{cd}^{i+1} < 0$, then the 0-setting rule in (16) will force $W_{cd}^{i+1} = 0$, and because the update rule (79.16) has a factor of W_{cd}, for any $j \geq i+1$, $W_{cd}^{j} = 0$. So this item will always remain 0 on the following steps. Then the whole matrix W is nonnegative. Next we look at the matrix H, W, and V are both nonnegative, and the initial H is also nonnegative, it is obvious that under the iterative update rule (79.15) the H will remain nonnegative.

79.4 Experimental Results

To test the effect of DAGDM for nonnegative matrix factorization, I focus on the sparseness measured by (79.7) and the factorization effects of inputting different control matrix D. The sparseness measure of the matrix W is the average sparseness value of all its vertical vectors.

Sparseness compare: to show a close relationship with engineering application, I use a special filter bank for palmprint verification [11] to test my method. Each filter is a 33 × 33 matrix which can be viewed as $V \in R^{33\times 33}$ with 33 feature vectors. A filter can be defined as:

$$F(\delta_x, \delta_y, \theta) = \left((x')^2 - \delta_x^2\right)\frac{A}{\delta_x^4}\exp\left(-\frac{(x')^2}{2\delta_x^2} - \frac{(y')^2}{2\delta_y^2}\right) \tag{79.17}$$

The parameter definition and more details are available at the paper [11]. I normalize the values of F to make it between 0 and 1. Here I use two different D to give a profile of the efficiency of my work. The first one is D_0, which is a zero matrix. With the D_0 the DAGDM update rule (79.16) is the same as (79.4), and thus it is just the original method. The second one is D_1, which contains all items of value 1. Notice that I select $\lambda = 1.75$, use parameters $(\delta_x, \delta_y, \theta) = (2.4, 6.0, 0)$ to generate the matrix $V \in R^{33\times 33}$ and randomly set initial nonnegative matrix $W \in R^{33\times 10}$, $H \in R^{10\times 33}$ with all items between 0 and 3. The two matrices are marked as $D_0 = \begin{bmatrix} 0 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{bmatrix} D_1 = \begin{bmatrix} 1 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ 1 & \cdots & 1 \end{bmatrix}$ correspondingly. As shown in Fig. 79.1.

The following table compares some statistic results of the 10 vectors of the basis matrix W produced under two control matrices, as shown in Table 79.1.

Factorization effect: As shown in Fig. 79.2, I add two matrices to show the effects, and use the famous ORL dataset which contains different images of each of 40 distinct subjects. The two matrices are an upper and a lower triangle matrix with all nonzero items being 1 correspondingly recoded as $D_2 = \begin{bmatrix} 1 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} D_3 = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 1 & \cdots & 1 \end{bmatrix}$.

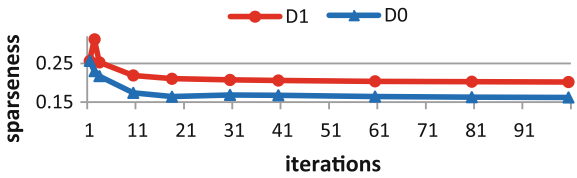

Fig. 79.1 The average sparseness value of all vectors of W varying until the objective function nearly stable. The DAGDM has an "initial-rising" effect to make the W achieve sparse because it produces a large local initial reduction in some part

Table 79.1 Sparseness comparing between two results.

	Average $\sum x_i$	Average $\sum x_i^2$	Average sparseness	Minimum sparseness	Maximum sparseness	0-entry
D_1	2.2695	0.2331	0.2019	0.1498	0.2716	31
D_0	26.7908	29.6767	0.1622	0.0911	0.2308	4

Seen from the table, the DAGDM package much energy into the coding matrix H and produce a light basis matrix W. The 0-entry here is to calculate the total number of items with values less than 10^{-5}

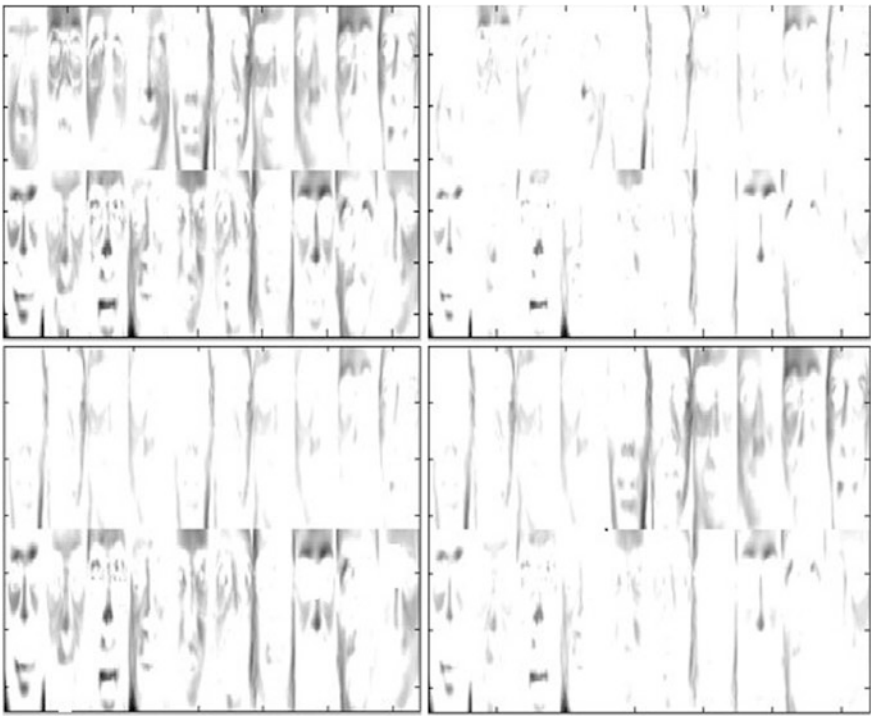

Fig. 79.2 Factorization effect which learns part from the data. It shows different results of DAGDM. I change the gray level to suit the map and use a white-based representation

It is D_0 to D_3 one by one from left to right. The parameter λ may vary for different control matrix to maintain stableness. The results show how the weighting information influences the final coding effect via different control matrix.

79.5 Conclusions

This paper proposes a novel decreasing accelerated gradient descent method for nonnegative matrix factorization (DAGDM) to make a sparse and light basis result matrix. DAGDM also provides an interface for users to control the factorization parameters and get desired results. The encouraging experimental results show that DAGDM has a better performance in sparse achievement than the original NMF and it is effective for matrix decomposition.

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Chapter 80
Symplectic Runge–Kutta Schemes and Variational Integrations of Pendulum Equation

Jiabo Tan

Abstract To preserve the symplecticity property, it is natural to require numerical integration of Hamiltonian systems should be symplectic. The most important classes of symplectic methods are symplectic Runge–Kutta methods and variational integrations. Symplectic Euler method and midpoint rule are the most widely used symplectic Runge–Kutta methods, while the most widely used variational integrations are trapezoidal integration and midpoint-type variational integration. For pendulum equation, which is a model of Hamiltonian systems, we propose symplectic Euler method, midpoint scheme, trapezoidal integration, and midpoint-type variational integration of the model in this paper. At last, it will be proved that symplectic Euler method is equivalent to trapezoidal integration, while midpoint scheme is equivalent to midpoint-type variational integration.

Keywords Hamiltonian systems · Symplecticity · Runge–Kutta method · Variational integration

80.1 Introduction

Let Ω be a domain in the oriented Euclidean space R^{2d} of the point$(p,q) = (p_1,p_2,\ldots p_d;q_1,q_2,\ldots q_d)$. If $H(p,q)$ is a sufficiently smooth real function defined in Ω, then the Hamiltonian system of equations with Hamiltonian $H(p,q)$ is given by

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_80,

$$\begin{cases} \dfrac{\mathrm{d}p_i}{\mathrm{d}t} = -\dfrac{\partial H(p,q)}{\partial q_i} \\ \dfrac{\mathrm{d}q_i}{\mathrm{d}t} = \dfrac{\partial H(p,q)}{\partial p_i} \end{cases}, \quad i = 1, 2, \ldots, d. \tag{80.1}$$

And it is well-known that the solution flow of Hamiltonian system is symplectic, i.e.,

$$\frac{\mathrm{d}}{\mathrm{d}t}(\mathrm{d}p \wedge \mathrm{d}q) = 0. \tag{80.2}$$

So it is natural to require the numerical integration of Hamiltonian systems should preserve the property of symplecticity [1]. The most widely used symplectic numerical methods are symplectic Runge–Kutta schemes and variational integrations.

In this paper, we consider the mathematical pendulum equation

$$\ddot{q}(t) = -\sin q(t) \tag{80.3}$$

And (Eq. 80.3) can also be seen as Hamiltonian systems (Eq. 80.1) with Hamiltonian

$$H(p(t), q(t)) = \frac{1}{2}p(t)^2 - \cos(q(t)) \tag{80.4}$$

Hence the solution flow of (Eq. 80.3) preserves the symplecticity property (Eq. 80.2). In the following sections, we will propose symplectic Runge–Kutta schemes and variational integrations of pendulum equation (Eq. 80.3). At last, it will be proved that the symplectic schemes proposed in different approaches are equivalent.

80.2 Symplectic Runge–Kutta Schemes of Pendulum Equation

The most famous symplectic Runge–Kutta schemes are symplectic Euler method [2] and midpoint rule [3, 4].

The symplectic Euler method for Hamiltonian systems (Eq. 80.1) is given as:

$$\begin{cases} p_{n+1} = p_n - h\dfrac{\partial H}{\partial q}(p_{n+1}, q_n) \\ q_{n+1} = q_n + h\dfrac{\partial H}{\partial p}(p_{n+1}, q_n) \end{cases} \tag{80.5}$$

It is a symplectic method of order 1.

The symplectic midpoint rule for Hamiltonian systems (Eq. 80.1) is given as:

$$\begin{cases} p_{n+1} = p_n - h\dfrac{\partial H}{\partial q}\left(\dfrac{p_n + p_{n+1}}{2}, \dfrac{q_n + q_{n+1}}{2}\right) \\ q_{n+1} = q_n + h\dfrac{\partial H}{\partial p}\left(\dfrac{p_n + p_{n+1}}{2}, \dfrac{q_n + q_{n+1}}{2}\right) \end{cases} \tag{80.6}$$

It is a symplectic method of order 2.

Doing the discretization (Eq. 80.4) of pendulum equation (Eq. 80.3), we have the symplectic Euler scheme of pendulum equation (Eq. 80.3):

$$\begin{cases} p_{n+1} = p_n - h\sin(q_n) \\ q_{n+1} = q_n + hp_{n+1} \end{cases} \tag{80.7}$$

While doing the discretization (Eq. 80.5) of pendulum equation (Eq. 80.3), we have the symplectic midpoint scheme of pendulum equation (Eq. 80.3):

$$\begin{cases} p_{n+1} = p_n - h\sin\left(\dfrac{q_n + q_{n+1}}{2}\right) \\ q_{n+1} = q_n + h\dfrac{p_n + p_{n+1}}{2} \end{cases} \tag{80.8}$$

Variational integrations of pendulum equation.

The Lagrange's equations of motion can be viewed as the Euler–Lagrange equations for the variational problem of extremizing the action integral among all curves $q(t)$ that connect two given points q_0 and q_1:

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial L}{\partial \dot{q}}\right) = \frac{\partial L}{\partial q} \tag{80.9}$$

$$S(q) = \int_{t_0}^{t_1} L(q(t), \dot{q}(t))\,\mathrm{d}t \tag{80.10}$$

$$q(t_0) = q_0, \quad q(t_1) = q_1. \tag{80.11}$$

In fact, assuming $q(t)$ to be external and considering a variation $q(t) + \varepsilon\delta q(t)$ with the same end-points, i.e., with $\delta q(t_0) = \delta q(t_1) = 0$, gives, using a partial integration which leads to (Eq. 80.8). If we introduce the conjugate moment and consider the Hamiltonian it can be proved that the Hamiltonian systems (Eq. 80.1) are equivalent with Lagrange's equations (Eq. 80.8). If we have the discredited action integral with given q_0, q_N, and L_h is the discrete approximation the requirement for an extremely yields the discrete Euler–Lagrange equations for $n = 1, 2, \ldots N-1$. this process gives a numerical integration of (Eq. 80.8) [6]. This process is the so-called variation integrations. The most widely used variation integrations are trapezoidal integration and midpoint-type integration.

$$0 = \frac{\mathrm{d}}{\mathrm{d}\varepsilon}|_{\varepsilon=0} S(q + \varepsilon\delta q) = \int_{t_0}^{t_1}\left(\frac{\partial L}{\partial q}\delta q + \frac{\partial L}{\partial \dot{q}}\delta\dot{q}\right)\mathrm{d}t = \int_{t_0}^{t_1}\left(\frac{\partial L}{\partial q} - \frac{d}{dt}\frac{\partial L}{\partial \dot{q}}\right)\delta q\mathrm{d}t \tag{80.12}$$

$$p = \frac{\partial L}{\partial \dot{q}}(q, \dot{q}) \tag{80.13}$$

$$H = p^T \dot{q} - L(q, \dot{q}) \tag{80.14}$$

$$S_h\left(\{q_n\}_0^N\right) = \sum_{n=0}^{N-1} L_h(q_n, q_{n+1}) \tag{80.15}$$

$$L_h(q_n, q_{n+1}) \approx \int_{t_n}^{t_{n+1}} L(q(t), \dot{q}(t))\, \mathrm{d}t \tag{80.16}$$

$$\frac{\partial S_h}{\partial q_n} = 0 \tag{80.17}$$

$$\frac{\partial L_h}{\partial q_n}(q_{n-1}, q_n) + \frac{\partial L_h}{\partial q_n}(q_n, q_{n+1}) = 0 \tag{80.18}$$

The main idea of trapezoidal variational integration is: choosing L_h by approximating $q(t)$ of (Eq. 80.14) as the linear interpolant of q_n, q_{n+1} and approximating the integral by the trapezoidal rule [5]. This gives and the discrete Euler–Lagrange equation (Eq. 80.16) yields trapezoidal variational integration.

$$L_h(q_n, q_{n+1}) = \frac{h}{2} L\left(q_n, \frac{q_{n+1} - q_n}{h}\right) + \frac{h}{2} L\left(q_{n+1}, \frac{q_{n+1} - q_n}{h}\right) \tag{80.19}$$

The main idea of discrete midpoint-type variational integration is: choosing L_h by approximating $q(t)$ of (Eq. 80.14) as the linear interpolant of q_n, q_{n+1} and approximating the integral by the midpoint rule [6]. This gives $L_h(q_n, q_{n+1}) = hL\left(\frac{q_{n+1} + q_n}{2}, \frac{q_{n+1} - q_n}{h}\right)$ and the discrete Euler–Lagrange equation (Eq. 80.16) yields midpoint-type variational integration.

As for the mathematical pendulum equation (Eq. 80.3), it can be seen as the Lagrange's equation (Eq. 80.8) with $L(q(t), \dot{q}(t)) = \frac{1}{2}\dot{q}(t)^2 + \cos(q(t))$.

The discrete trapezoidal-type Lagrangian of (Eq. 80.3) is:

$$L_h(q_n, q_{n+1}) = \frac{h}{2}\left(\frac{q_{n+1} - q_n}{h}\right)^2 + \frac{h}{2}(\cos(q_n) + \cos(q_{n+1})) \tag{80.20}$$

And the process of (Eq. 80.16) yields the trapezoidal variational integration of pendulum equation (Eq. 80.3):

$$\frac{q_{n+1} - 2q_n + q_{n-1}}{h^2} = -\sin(q_n) \tag{80.21}$$

The discrete midpoint-type Lagrangian of (Eq. 80.3) is:

$$L_h(q_n, q_{n+1}) = \frac{h}{2}\left(\frac{q_{n+1} - q_n}{h}\right)^2 + h\cos\left(\frac{q_n + q_{n+1}}{2}\right) \tag{80.22}$$

And the process of (Eq. 80.16) yields the midpoint-type variational integration of pendulum equation (Eq. 80.3):

$$\frac{q_{n+1} - 2q_n + q_{n-1}}{h^2} = -\frac{1}{2}\left(\sin\left(\frac{q_n + q_{n-1}}{2}\right) + \sin\left(\frac{q_n + q_{n+1}}{2}\right)\right) \tag{80.23}$$

80.3 The Equivalence of Symplectic Runge–Kutta Schemes and Variation Integrations of Pendulum Equation

In this section, we will show the equivalence of symplectic Runge–Kutta schemes and variational integrations.

Theorem 80.1 *For pendulum equation* (Eq. 80.3), *the symplectic Euler scheme* (*Eq*. 80.6) *is equivalent to the trapezoidal variation integration* (*Eq*. 80.17).

Proof From the second equation of (Eq. 80.6), we have

$$p_{n+1} = \frac{q_{n+1} - q_n}{h} \tag{80.24}$$

And also we can get

$$p_n = \frac{q_n - q_{n-1}}{h} \tag{80.25}$$

Put Eqs. (80.19 and 80.20) into the first equation of (Eq. 80.6), we have

$$\frac{q_{n+1} - q_n}{h} = \frac{q_n - q_{n-1}}{h} - h\sin(q_n) \tag{80.26}$$

It is clear that (Eq. 80.21) is equivalent to the trapezoidal variational integration (Eq. 80.17).

Theorem 80.2 For pendulum equation (Eq. 80.3), the midpoint rule (Eq. 80.7) is equivalent to the midpoint-type variational integration (Eq. 80.18).

Proof It is clear that both Eqs. (80.7 and 80.18) are equivalent to the formulas:

$$\begin{cases} v_{n+1/2} = p_n + \dfrac{h}{2}(-\sin\dfrac{q_n+q_{n+1}}{2}), \\ q_{n+1} = q_n + hv_{n+1/2}, \\ p_{n+1} = v_{n+1/2} + \dfrac{h}{2}(-\sin\dfrac{q_n+q_{n+1}}{2}). \end{cases} \tag{80.27}$$

Hence Eqs. (80.7 and 80.18) are equivalent.

Acknowledgments This paper is supported by Funding Project for Science and Technology Program of Beijing Municipal Commission of Education (Application to Biological Information Systems of Model Analysis and Parameter Estimation. No. SQKM201210037001) and Funding Project for Improving Teaching Quality of Beijing Wuzi University.

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Chapter 81
A New Evaluation Method of Guns' Reliability Based on Fuzzy Theory

Changzhi Jia, Yaoxin He, Guangsheng Liu and Tao Huang

Abstract The reliability of guns was related to the building of the evaluation index system of guns which decides the probability of success of the action. By using the fuzzy theory and stratification method, the membership function of the reliability of guns was established. It can be used to judge whether the reliability of use of guns can satisfy the action requisition or not, and its application perspective of this method is presented.

Keywords Reliability · Fuzzy theory · Membership function · Gun

81.1 Introduction

The ability that a product achieves its designed function in limited condition and time is always defined as the reliability of the product. With the development of technology, design for the reliability of a system is more reasonable and perfect than before. To the weapon system, its reliability was related with the process of designing, producing, operating, and other indeterminate factor. It is obvious that if the reliability of the weapon system cannot satisfy the demand of the rules, army's action or operation will be limited in some complexion. By evaluating the reliability and confirming the weakness of weapon system, operating personnel could easily find the indexes of the weapon where needed to be improved, and made the reliability degree of the weapon in a regulated range. So it is important to

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_81,

keep the fight efficiency of the weapon system. And a mount of statistical data and operational experience had opened out that study the reliability of the weapon system and keep it in a good state in time would take less resource than any other service in the using process.

The purpose of studying the evaluation of the reliability of guns is to confirm the weakness of the guns for optimization, which has been realized by making the reliability in a safety threshold range. The high reliability of guns is the foundation to achieve the purpose of exerting its efficiency in the war or other action. By evaluating the reliability of guns, their weakness can be confirmed and the components which need be improved always can be confirmed, which makes the reliability of guns in a reasonable range that could maintain gun in a good state. A modern artillery system comprises firing system, fire-control system, chassis system, safety system, command and communication system and other kit system. So it is indispensable to build membership function of the reliability of the subsystems before confirm the membership function of the reliability of a gun system.

This article established the membership function of the reliability of the subsystems by using the stratification method based on the fuzzy theory, and confirmed the membership function of the whole gun system, and then pointed out whether the reliability degree satisfied the demand or not by using different evaluating indicator functions.

81.2 Computing of the Reliability Degree of a Gun System

1. When the degree of the evaluating factor $v_j \geq a_{\mathrm{ij}}$.

$$\mu_{i1}(x) = \begin{cases} 1 & x \geq a_{i1} \\ \frac{a_{i2}-x}{a_{i2}-a_{i1}} & a_{i1} > x \geq a_{i2} \\ 0 & x < a_{i2} \end{cases}, \quad \mu_{\mathrm{im}}(x) = \begin{cases} \frac{a_{\mathrm{im}-1}}{x} & x \geq a_{\mathrm{im}-1} \\ 1 & a_{\mathrm{im}-1} > x \\ \frac{x}{a_{\mathrm{im}}} & x < a_{\mathrm{im}} \end{cases},$$

$$\mu_{\mathrm{ij}} = \begin{cases} \frac{a_{\mathrm{ij}-1}}{x} & x \geq a_{\mathrm{ij}-1} \\ 1 & a_{\mathrm{ij}-1} > x \geq a_{\mathrm{ij}} \\ \frac{x-a_{\mathrm{ij}+1}}{a_{\mathrm{ij}+1}-a_{\mathrm{im}}} & a_{\mathrm{ij}} > x \geq a_{\mathrm{im}} \\ 0 & x < a_{\mathrm{im}} \end{cases} \tag{81.1}$$

2. When the degree of the evaluating factor $v_j \le a_{\mathrm{ij}}$.

$$\mu_{i1}(x) = \begin{cases} 1 & x \ge a_{i1} \\ \frac{a_{i2}-x}{a_{i2}-a_{i1}} & a_{i1} > x \ge a_{i2} \\ 0 & x < a_{i2} \end{cases}, \quad \mu_{\mathrm{ij}} = \begin{cases} \frac{a_{\mathrm{ij}-1}}{x} & x \ge a_{\mathrm{ij}-1} \\ 1 & a_{\mathrm{ij}-1} > x \ge a_{\mathrm{ij}} \\ \frac{x-a_{\mathrm{ij}+1}}{a_{\mathrm{ij}+1}-a_{\mathrm{im}}} & a_{\mathrm{ij}} > x \ge a_{\mathrm{im}} \\ 0 & x < a_{\mathrm{im}} \end{cases}, \quad \mu_{\mathrm{im}}(x) = \begin{cases} \frac{a_{\mathrm{im}-1}}{x} & x \ge a_{\mathrm{im}-1} \\ 1 & a_{\mathrm{im}-1} > x \\ \frac{x}{a_{\mathrm{im}}} & x < a_{\mathrm{im}} \end{cases} \tag{81.2}$$

To the firing system, it comprises breechblock, recoil equipment, gun turret, gun sight and rammer, and the membership function of the reliability of the recoil equipment is assured. So the degree of reliability of other parts needed to be assured by the expertise. Take the breechblock as an example, it is composed by locking device, launcher, semi-automata, cartridge extractor, trap, and safety equipment. To the locking device: $ui = \{u1, u2\}$, $u1$ and $u2$ separately represent the closing and opening performance of the breechblock. And then an evaluating aggregate was built: $vt = \{v1, v2, v3, v4\}$ where $v1$, $v2$, $v3$, and $v4$ separately represent the different degree which is excellent, nicer, good, and bad. According to the choosing rules of the membership function.

Because there are many parts in the breechblock system, it is complicated to calculate each one's evaluating degree. Thus, this paper simplified the course and gave a same evaluating degree when the part was in the same grade. Table 81.1 shows the degree of the different factors of each evaluation grade.

According to the simplification rule, the formula of the different factor was listed:

$$f_{11}(u_1) = \begin{cases} 1 & u_1 \ge 0.85 \\ \frac{u_1-0.75}{0.1} & 0.75 \le u_1 < 0.85 \\ 0 & u_1 < 0.75 \end{cases} \tag{81.3}$$

Table 81.1 Degree of different factors of each evaluation grade

	The liquid volume of recoil brake (litre)	The pressure of the recuperator (litre)	Others (litre)
Excellent	6.9– 7.0	2.9–3.3	0.85–1
Nicer	6.8–6.9	2.7–2.9	0.75–0.85
Good	6.5–6.8	2.5–2.7	0.6–0.75
Bad	<6.5	<2.5	<0.6

$$f_{12}(u_1) = \begin{cases} \frac{0.85}{u_1} & u_1 \geq 0.85 \\ 1 & 0.85 > u_1 \geq 0.75 \\ \frac{u_1 - 0.6}{0.75 - 0.6} & 0.75 > u_1 \geq 0.6 \\ 0 & 0.6 > u_1 \end{cases} \tag{81.4}$$

$$f_{13}(u_1) = \begin{cases} \frac{0.75}{u_1} & u_1 \geq 0.75 \\ 1 & 0.75 > u_1 \geq 0.6 \\ 0 & u_1 < 0.6 \end{cases} \tag{81.5}$$

$$f_{14}(u_1) = \begin{cases} \frac{0.6}{u_1} & u_1 \geq 0.6 \\ 1 & u_1 < 0.6 \end{cases} \tag{81.6}$$

$$f_{31}(u_3) = \begin{cases} 1 & u_1 \geq 6.9 \\ \frac{u_1 - 6.8}{0.1} & 6.8 \leq u_1 < 6.9 \\ 0 & u_1 < 6.8 \end{cases} \tag{81.7}$$

$$f_{32}(u_3) = \begin{cases} \frac{6.9}{u_1} & u_1 \geq 6.9 \\ 1 & 6.9 > u_1 \geq 6.8 \\ \frac{u_1 - 6.5}{6.8 - 6.5} & 6.8 > u_1 \geq 6.5 \\ 0 & 6.5 > u_1 \end{cases} \tag{81.8}$$

$$f_{33}(u_3) = \begin{cases} \frac{6.8}{u_1} & u_1 \geq 6.8 \\ 1 & 6.8 > u_1 \geq 6.5 \\ 0 & u_1 < 6.5 \end{cases} \tag{81.9}$$

$$f_{34}(u_3) = \begin{cases} \frac{6.5}{u_1} & u_1 \geq 6.5 \\ 1 & u_1 < 6.5 \end{cases} \tag{81.10}$$

$$f_{41}(u_4) = \begin{cases} 1 & u_1 \geq 2.9 \\ \frac{u_1 - 2.7}{0.2} & 2.7 \leq u_1 < 2.9 \\ 0 & u_1 < 2.7 \end{cases} \tag{81.11}$$

$$f_{42}(u_4) = \begin{cases} \frac{2.9}{u_1} & u_1 \geq 2.9 \\ 1 & 2.9 > u_1 \geq 2.7 \\ \frac{u_1 - 2.5}{2.7 - 2.5} & 2.7 > u_1 \geq 2.5 \\ 0 & 2.5 > u_1 \end{cases} \tag{81.12}$$

$$f_{43}(u_4) = \begin{cases} \frac{2.7}{u_1} & u_1 \geq 2.7 \\ 1 & 2.7 > u_1 \geq 2.5 \\ 0 & u_1 < 2.5 \end{cases} \tag{81.13}$$

$$f_{44}(u_4) = \begin{cases} \frac{2.5}{u_1} & u_1 \geq 2.5 \\ 1 & u_1 < 2.5 \end{cases} \tag{81.14}$$

Table 81.2 The scale value of each factor of the locking device

	u_1	u_2
u_1	1	2
u_2	1/2	1

With the expertise: $u_1 = 0.73$, $u_2 = 0.81$, the one-factor evaluation matrix was built:

$$R = \begin{pmatrix} 0 & 0.867 & 1.000 & 0.822 \\ 0.600 & 1.000 & 0.926 & 0.741 \end{pmatrix} \tag{81.15}$$

According to the degree of the reliability, processed the result of the expertise by the analytic hierarchy process, the scale value of each factor of the locking device was assured in Table 81.2.

After normalization, the weighting factor was: $A = \{a_1, a_2\} = \{0.6, 0.4\}$. So the evaluating of reliability of the locking device was:

$$\begin{aligned} B_1 = A \times R &= (0.6 \quad 0.4) \times \begin{pmatrix} 0 & 0.867 & 1 & 0.822 \\ 0.6 & 1 & 0.926 & 0.741 \end{pmatrix} \\ &= (0.614 \quad 0.904 \quad 0.932 \quad 0.783) \end{aligned} \tag{81.16}$$

In the same way, the membership degree of other parts of the breechblock can be got:

Launcher: $B_2 = (0.482\ 0.867\ 0.953\ 0.886)$;

Semi-automata: $B_3 = (0.684\ 0.972\ 0.856\ 0.852)$;

Cartridge extractor: $B_4 = (0.852\ 0.863\ 0.967\ 0.784)$;

Trap: $B_5 = (0.832\ 0.847\ 0.952\ 0.912)$;

Safety equipment: $B_6 = (0.763\ 0.965\ 0.872\ 0.438)$.

Then the weighting factor can be obtained: $A = (0.2 \quad 0.2 \quad 0.15 \quad 0.15 \quad 0.15 \quad 0.10)$. So the evaluating result of reliability of the firing system was:

$$\begin{aligned} B &= A \times R \\ &= (0.2 \quad 0.2 \quad 0.15 \quad 0.15 \quad 0.15 \quad 0.15) \times \begin{pmatrix} 0.240 & 0.920 & 0.971 & 0.790 \\ 0.482 & 0.867 & 0.953 & 0.886 \\ 0.684 & 0.972 & 0.856 & 0.852 \\ 0.852 & 0.863 & 0.967 & 0.784 \\ 0.832 & 0.847 & 0.952 & 0.912 \\ 0.763 & 0.965 & 0.872 & 0.438 \end{pmatrix} \\ &= (0.775 \quad 0.887 \quad 0.936 \quad 0.800) \end{aligned} \tag{81.17}$$

By the same way, the weighting factor of the fire-control system, chassis system, safety system, command and communication system, and other kit system can be computed, it was $A = (0.2 \quad 0.3 \quad 0.1 \quad 0.3 \quad 0.1)$. So the evaluating result of reliability of the gun was

$$W = A \times R = (0.3, 0.2.0.2.0.3) \times \begin{pmatrix} 0.775 & 0.887 & 0.936 & 0.800 \\ 0.782 & 0.753 & 0.811 & 0.763 \\ 0.687 & 0.459 & 0.795 & 0.768 \\ 0.683 & 0.639 & 0.832 & 0.817 \end{pmatrix} \quad (81.18)$$

$$= (\,0.731 \quad 0.700 \quad 0.852 \quad 0.791\,)$$

To the result, according to the maximum membership degree rule, the reliability of the gun was good. Therefore, according to the weighted average rule:

$$Z = \frac{0.731 \times 1 + 0.700 \times 0.8 + 0.852 \times 0.6 + 0.791 \times 0.4}{1 + 0.8 + 0.6 + 0.4} = 0.757 \quad (81.19)$$

It did not reach the threshold of the reliability degree of the gun (0.85), so it should be mended in the weakness.

81.3 Conclusion

The study of the reliability of the use of guns is the foundation of building the evaluation system of the guns performance. This paper introduces the way to use hierarchical method based on the fuzzy theory to compute the degree of reliability of guns, and take the firing system of a gun as an example to expound the material operating process. By the result of the computing, it is easy to make sure if the gun system had a weakness which should be disposed in time. Furthermore, this method presented in this paper can be extended to related application fields.

Acknowledgments This study is supported by the National Natural Science Foundation Grant No. 51175508 and Natural Science Foundation of Hebei Province Grant No. E2012506009.

Chapter 82
Evolution Analysis of Leptospira Interrogans Serova Lai Based on Differential Equation and RANSAC

Xiaofeng Wang

Abstract In this paper, we make a novel analysis of duplicate genes of Leptospira interrogans serovar Lai, which is widely anthropozoonosis, based on differential equation and RANSAC algorithm. To reduce the impact, evolution Analysis for evolution process is particularly important. Through differential equation and RANSAC algorithm, we compare the rates of the nucleotide substitution at replacement and silent sites. The result shows that early in their history for Leptospira interrogans serovar Lai many gene duplicates experience a phase of relaxed purifying selection, subsequently selection constraint gradually increases and eventually tended to the stability.

Keywords Differential equation · RANSAC · Gene duplication · Non synonymous substitution · Synonymous substitution · Leptospira interrogans serova lai

82.1 Introduction

Gene duplication is believed to play a major role in gene evolution. Evolution Analysis based on gene duplication has made significant progress in recent years.

Gene duplication, which includes chromosomal duplication or gene amplification, is any duplication of a region of DNA that contains a gene. Duplications arise from an event termed unequal crossing-over that occurs during meiosis between misaligned homologous chromosomes. The chance of this happening is a

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_82,

function of the degree of sharing of repetitive elements between two chromosomes. In relation to the first copy, the second one of the gene is often free from selective pressure.

In 1936, Bridges reported one of the earliest observations of gene duplication from the doubling of a chromosomal band in a mutant of the fruit fly, which exhibited extreme reduction in eye size [1]. In 1970, Ohno's seminal book, Evolution by Gene Duplication [2], further popularized this idea. It was, however, not until the late 1990s, when many genome sequences were determined and analyzed, that the importance of gene duplication was clearly demonstrated. We can estimate numbers of duplicated genes in completely or nearly completely sequenced genomes of representative bacteria, archaebacteria and eukaryotes. One finds that, in all three domains of life, large proportions of genes were generated by gene duplication.

Leptospirosis is spread from animal urine to humans and is considered to be the most widespread anthropozoonosis in the world. This disease is common in farmers and veterinarians, but can also be transmitted through contaminated water in flooded areas. In particular, Leptospirosis is one of the most important infectious diseases contracted in waterlogging areas and rice paddies. So it is significant to study the characters of Leptospirosis, especially of the study of evolution analysis [3, 4]. Leptospira interrogans serovar lai was originally isolated in 1958 in China Leptospira interrogans serovar lai was identified in China in 1966 as a new serovar of the icterohaemorrhagiae serogroup by cross-absorption tests, which an important zoonosis of worldwide distribution, especially China. So to reduce influence, Evolution Analysis for the evolution process is particularly important.

In this paper, we make an analysis of duplicate genes of Leptospira interro-gans serovar Lai. Using the concept of the gene duplication, we compare the rates of nucleotide substitution at replacement and silent sites, and then perform RANSAC, instead of the least-squares analysis, selective constraint in their history have been showed.

The paper is organized as follows: In Sect. 82.2 we discuss presents an overworks of algorithm and concept about evolution Selection, evolution Selection, RANSAC algorithm etc. The results of evolution analysis using RANSAC algorithm and differential equation is presented in Eq. 82.3 and is discussed in Eq. 82.4.

82.2 Overviews of the Proposed Algorithm

82.2.1 Evolution Selection

The theory of evolution is one of the great intellectual revolutions of human history [5, 6] the duplication of a gene results in an additional copy that is free from selective pressure. One kind of view is that this allows the new copy of the

gene to mutate without deleterious consequence to the organism. This freedom from consequences allows for the mutation of novel genes that could potentially increase the fitness of the organism or code for a new function.

Theory suggests three alternative outcomes in the evolution of duplicate genes [7, 8]: (1) one copy may simply become silenced by degenerative mutations; (2) one copy may acquire a novel function and become preserved by natural selection, with the other copy retaining the original function [9, 10]; or (3) both copies may become partially compromised by mutation accumulation to the point is reduced to the level of the single-copy ancestral gene. Because the vast majority of mutations affecting fitness are deleterious and gene duplicates are generally assumed to be functionally redundant at the time of origin, virtually all models predict that the usual fate of a duplicate-gene pair is the nonfunctionalization of one copy.

82.2.2 RANSAC Algorithm

Our model introduces the Random Sample Consensus (RANSAC) algorithm without using least squares owing to the outliers. [11, 12, 20].

The RANSAC algorithm is an algorithm for robust fitting of models, which was introduced by Fischler and Bolles in 1981 [14]. It is robust in the sense of good tolerance to outliers in the experimental data. It is capable of interpreting and smoothing data containing a significant percentage of gross errors. It is a paradigm using to fit a model to experimental data, it allows interpreting and smoothing data which contain a great number of gross errors and it does not require initial estimates of motion parameters. So RANSAC has an advantage over least squares in this respect.

The standard RANSAC algorithm consists of two steps. First, RANSAC establishes an initial set S of minimum size. Then, a model is built with the help of set S. This will be model M. Next, all elements, which can be approximately modeled by model M, will be collected into set S^*. If the size of set S^* is satisfying, then the algorithm calculates the final estimation M^* (based on set S^*) for the missing parameter and up to it ends. If set S^* is too small, then the algorithm drops its intermediate results, and starts again by establishing a new random set S. When the algorithm is unable to find a suitable consensus set S^*, it can either end in failure or it can give an imprecise estimation based on the largest consensus set found during the operation. In the next sections we will discuss RANSAC for fitting data.

82.2.3 Synonymous and Non-Synonymous Distances

In this paper, we can acquire the selective constraint through comparing rate of synonymous and non-synonymous. Synonymous and non-synonymous distances can be computed by comparing codons between sequences.

Firstly, we acquire evolutionary distance using two parameter models through the differential equation and the Markov process in stochastic process. Through them, we can acquire the evolutionary distance between two sequences as estimated number of changes that have occurred per site.

$$\Delta P(T)/\Delta T = 2\alpha - 4(\alpha+\beta)P(T) - 2(\alpha-\beta)Q(T) \tag{82.1}$$

$$\Delta Q(T)/\Delta T = 4\beta - 8\beta Q(T) \tag{82.2}$$

And we get

$$P(T) = \frac{1}{4} - \frac{1}{2}e^{-4(\alpha+\beta)T} + \frac{1}{4}e^{-8\beta T} \tag{82.3}$$

$$Q(T) = \frac{1}{2} - \frac{1}{2}e^{-8\beta T} \tag{82.4}$$

And then the total number of substitutions per site is

$$D = 2Td = 2\alpha T + 4\beta T \tag{82.5}$$

$$D = -\frac{1}{2}\log_e\left\{(1-2P-Q)\sqrt{1-2Q}\right\} \tag{82.6}$$

We take the number of substitutions per silent site S and the number of substitutions per replacement site R.

82.3 Evolution Analysis

We know, duplicate genes undergo different phases of evolutionary divergence. The traditional approach to inferring the selective constraint on protein evolution focuses on codons, comparing the rates of nucleotide substitution at replacement and silent sites [15–18].

Under the assumption that silent substitutions are largely immune from selection constraint and accumulate at a stochastic rate that is proportional to time [19, 20], we take the number of substitutions per silent site, S and the number of substitutions per replacement site, R. Evolution analysis can be obtained by considering a model in which R declines relative to S, the function between $R$and S is expressed as

$$\frac{dR}{dS} = \frac{1}{a - be^{-ms}} \tag{82.7}$$

Under this model, assuming positive m, the ratio of rates of replacement to silent substitutions initiates with an expected value $1/(a-b)$ at $S = 0$ and declines $1/a$ at $S \to \infty$. Integrating this differential equation, the expected cumulative number of R can be described as a function of S:

Table 82.1 Parameters a, b, m by performing least-squares

	Result	Error
a	7.97	1.90
b	7.81	1.41
m	4.15	6.00

$$R = \frac{1}{am}\left[mS - In\left(\frac{a-b}{a-be^{-mS}}\right)\right] \tag{82.8}$$

The complete set of available gene sequences of Leptospira interrogans serovar Lai was downloaded from Gen-Bank, and then we get pairs of gene duplicates using BLAST and VC, and parameters a, b, m can be estimated by performing RANSAC analysis on the pair-wise gene-specific estimates of R and S (Table 82.1).

In Fig. 82.1, we show that cumulative numbers of observed replacement substitutions per replacement site as a function of the number of silent substitutions per silent site. Each point represents a single pair of gene duplicates. The dashed line denotes the expectation under the neutral model, whereas the solid line is the RANSAC algorithm. For the duplicate genes that we have identified, when $S < 0.05$, there is an often considerable point around the neutral expectation, suggesting that early in the history of Leptospira interrogans serovar Lai, gene duplicates experience a phase of relaxed selection or even accelerated evolution at replacement sites. As shown in Fig. 82.2, the progressive decline of R/S beyond this point reflects a gradual increase in the magnitude of selective constraint. The vast majority of gene duplicates with $S > 0.1$exhibits an R/S ratio.

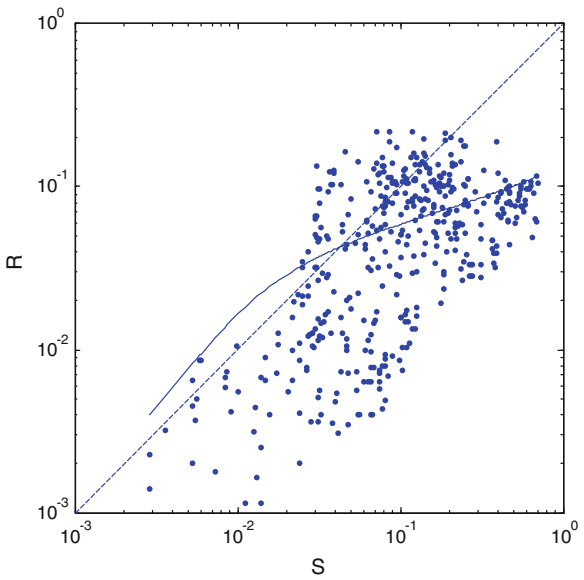

Fig. 82.1 The curves of R-S by performing RANSAC algorithm

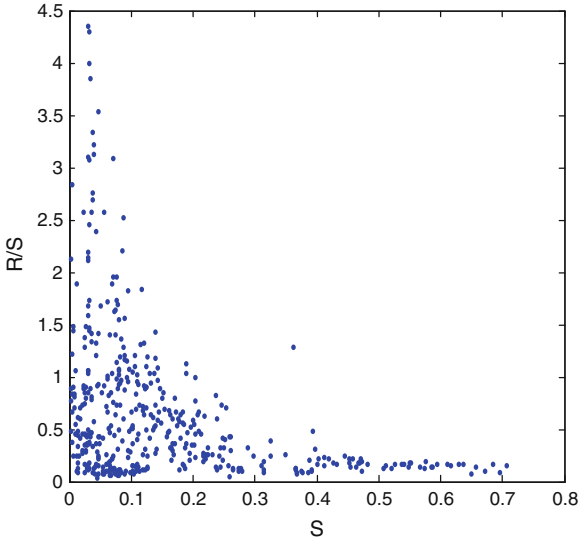

Fig. 82.2 Various R/S ratios

Through the following scatter diagram, we can acquire and deduce selective pressure vary from the divergence time S. Early in their history for Leptospira interrogans serovar Lai, many gene duplicates experience a phase of relaxed purifying selection $S < 0.07$, subsequently selection constraint gradually increases and eventually tended to the stability $S > 0.15$.

So through the above results, we can acquire the selective pressure vary from the divergence time S. If we assumed that the number of silent substitutions increases approximately linearly with time, the relative age-distribution of gene duplicates within a genome can be inferred indirectly from the distribution of S.

82.4 Discussion

Evolutionary distance is very important to the protein evolution of the species, which may contribute to construct phylogenetic trees, estimate divergence time. Leptospira interrogans serovar Lai is one of the most important infectious diseases which is widely distributed in China. To reduce the impact of one, Evolution Analysis for the evolution process is particularly important.

In this paper, we compare the rates of nucleotide substitution at replacement and silent sites based on differential equation and RANSAC algorithm, the result shows that early in their history, $S < 0.05$ many gene duplicates experience a phase of relaxed purifying selection; subsequently selection constraint gradually increases and eventually tended to the stability. Future research will focus on acquiring the number of silent substitutions and the relative age-distribution of gene duplicates can be inferred indirectly from the distribution of S.

Acknowledgments This work is supported by the Science and Technology Foundation of the Education Department of Chongqing (KJ121404), Innovation team of Chongqing University of Science & Technology (1809013) and Research Foundation of Chongqing University of Science & Technology (CK2011Z15).

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Chapter 83
Generalized Laguerre Approximation in Ordinary Differential Equation

Xiao-yong Zhang and Hong-li Jia

Abstract In this paper, generalized Laguerre spectral method for ordinary differential equation is proposed, which is very efficient for long-time numerical simulations of dynamical systems. The global convergence of proposed algorithm is proved. Numerical results demonstrate the spectral accuracy of these new approach and coincide well with theoretical analysis.

Keywords Generalized Laguerre approximation · Spectral method · Ordinary differential equation

83.1 Introduction

Numerous problems in science and engineering are governed by ordinary differential equations [1, 2]. There have been fruitful results on their numerical solutions.

As basic tool, the Runge–Kutta method plays an important role in numerical integrations of ordinary differential equations [3, 4]. We usually designed this kind of numerical schemes in two ways. The first way is based on Taylor's expansion coupled with other techniques. The next is to construct numerical schemes by using collocation approximation [5].

In the existing work, one often used the Legendre-Radua interpolation to design the Runge–Kutta process. However, the Legendre-Radua interpolation is available

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_83,

for finite interval essentially. Conversely, if we use the Laguerre approximation, we can approximate the exact solution on half line. Thereby, the related algorithms might be more appropriate for long-time calculations. In particular, the corresponding Runge–Kutta process possesses the global convergence. As we know, some authors developed the Laguerre approximation with successful applications to spatial approximations of various partial differential equations on the half line and a large class of other related problems but so far, to our knowledge, here is no work concerning the applications of Laguerre spectral approximation to ordinary differential equations.

This paper is for new generalized Laguerre spectral method based on modified generalized Laguerre polynomial. We investigate the generalized Laguerre approximation and propose a new algorithm. This algorithm has several advantages. Firstly, it is easier to be implemented, especially for nonlinear systems. Next, it provides the global numerical solution and the global convergence in certain weighted Sobolev space. Hence, it is very applicable to long-time calculations. Furthermore, by adjusting a parameter involved in the method, we may weaken the conditions on the underlying problems, and so enlarge its applications essentially. We present some numerical results, which demonstrate the spectral accuracy of proposed method and coincide well with analysis.

83.2 Orthogonal Approximation

Let $\Lambda = \{\rho | 0 < \rho < \infty\}$. We define $L^2_\chi(\Lambda) = \left\{ v \middle| \|v\|_{\chi,\Lambda} < \infty \right\}$ with the following inner product and norm $(u,v)_{\chi,\Lambda} = \int_\Lambda uv\chi(\rho)\mathrm{d}\rho$, $\|v\|_{\chi,\Lambda} = (v,v)^{\frac{1}{2}}_{\chi,\Lambda}$.

For any integer m, we define the space $H^m_\chi(\Lambda) = \left\{ v \middle| \frac{\mathrm{d}^l v}{\mathrm{d}\rho^l} \in L^2_\chi(\Lambda), 0 \le l \le m \right\}$

Equipped with the following inner product, semi-norm and norm

$$(u,v)_{m,\chi,\Lambda} = \sum_{0 \le k \le m} \left(\frac{\mathrm{d}^k u}{\mathrm{d}\rho^k}, \frac{\mathrm{d}^k v}{\mathrm{d}\rho^k} \right)_{\chi,\Lambda} \|v\|_{m,\chi,\Lambda} = (v,v)^{\frac{1}{2}}_{m,\chi,\Lambda}, |v|_{m,\chi,\Lambda} = \left\| \frac{\mathrm{d}^m v}{\mathrm{d}\rho^m} \right\|_{\chi,\Lambda}.$$

For any real $r > 0$, the space $H^r_\chi(\Lambda)$ and its norm $\|v\|_{r,\chi,\Lambda}$ are defined by space interpolation as in [1]. In particular, ${}_0H^1_\chi(\Lambda) = \left\{ v \middle| v \in H^1_\chi(\Lambda), v(0) = 0 \right\}$.

Let $\omega_{\alpha,\beta}(\rho) = \rho^\alpha e^{-\beta\rho}, \alpha > -1, \beta > 0$. The generalized Laguerre polynomials of degree l are defined by $L^{(\alpha,\beta)}_1(\rho) = \frac{1}{l!}\rho^{-\alpha}e^{\beta\rho}\frac{\mathrm{d}^l}{\mathrm{d}\rho^l}\left(\rho^{l+\alpha}e^{-\beta\rho}\right), l = 0, 1, 2, \ldots$.

They fulfill the following recurrence relations

$$\frac{\mathrm{d}L^{(\alpha,\beta)}_l(\rho)}{\mathrm{d}\rho} = -\beta \sum_{k=0}^{l-1} L^{(\alpha,\beta)}_k(\rho) \tag{83.1}$$

$$L_l^{(\alpha,\beta)}(0) = \frac{\Gamma(l+\alpha+1)}{\Gamma(\alpha+1)\Gamma(l+1)}, l \geq 0. \tag{83.2}$$

The set of $L_l^{(\alpha,\beta)}(\rho)$ is the orthogonal system, namely,

$$\left(L_l^{(\alpha,\beta)}, L_m^{(\alpha,\beta)}\right)_{\omega_{\alpha,\beta},\Lambda} = \begin{cases} \gamma_l^{(\alpha,\beta)} = \frac{\Gamma(l+\alpha+1)}{\beta^{\alpha+1}\Gamma(l+1)}, l=m \\ 0, \ l \neq m \end{cases}$$

Now, let N be any positive integer and $P_N(\Lambda)$ be the set of all algebraic polynomials of degree at most N. Furthermore, ${}_0P_N(\Lambda) = \{v \in P_N(\Lambda) | v(0) = 0\}$.

For any integer $r > 0$, we introduce the space $A^r_{\alpha,\beta}(\Lambda) = \left\{v \middle| \|v\|_{A^r_{\alpha,\beta,\Lambda}} < \infty\right\}$ equipped with the following semi-norm and norm

$$|v|_{A^r_{\alpha,\beta,\Lambda}} = \left\|\eth^r_\rho v\right\|_{\omega_{\alpha+r,\beta},\Lambda}, \|v\|_{A^r_{\alpha,\beta,\Lambda}} = \left(\sum_{k=0}^{r} |v|^2_{A^k_{\alpha,\beta,\Lambda}}\right)^{\frac{1}{2}}$$

For an real $r > 0$, we define the space $A^r_{\alpha,\beta}(\Lambda)$ and its norm by space interpolation as in [1].

The orthogonal projection $P_{N,\alpha,\beta} : L_{\omega_{\alpha,\beta}}(\Lambda) \to P_N(\Lambda)$ is defined by $(P_{N,\alpha,\beta}v - v, \phi)_{\omega_{\alpha,\beta},\Lambda} = 0, \ \phi \in P_N(\Lambda)$ and ${}_0P^1_{N,\alpha,\beta} : {}_0H^1_{\omega_{\alpha,\beta}}(\Lambda) \to {}_0P_N(\Lambda)$:

$$\left(\frac{\mathrm{d}}{\mathrm{d}\rho}({}_0P^1_{N,\alpha,\beta}v - v), \frac{\mathrm{d}}{\mathrm{d}\rho}\phi\right)_{\omega_{\alpha,\beta},\Lambda} = 0, \ \phi \in {}_0P_N(\Lambda).$$

Similarly, we define the orthogonal projection ${}_0P_{N,\alpha,\beta} : {}_0L_{\omega_{\alpha,\beta}}(\Lambda) \to {}_0P_N(\Lambda)$ as

$$\begin{aligned} &({}_0P_{N,\alpha,\beta}v - v, \phi)_{\omega_{\alpha,\beta},\Lambda} = 0, \ \phi \in {}_0P_N(\Lambda), \ {}_0L_{\omega_{\alpha,\beta}}(\Lambda) \\ &= \left\{v \middle| v \in L_{\omega_{\alpha,\beta}}(\Lambda), v(0) = 0\right\}. \end{aligned}$$

Lemma 2.1 *For any integers* $r \geq 1, v \in_0 H^r_{\omega_{\alpha,\beta}}$, $\left\|{}_0P_{N,\alpha,\beta}v - v\right\|_{\omega_{\alpha,\beta},\Lambda} \leq cN^{\frac{1-r}{2}} \left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|_{A^{r-1}_{\alpha,\beta,\Lambda}}$.

Proof By the projection theorem $\left\|{}_0P_{N,\alpha,\beta}v - v\right\|_{\omega_{\alpha,\beta},\Lambda} \leq \|\phi - v\|_{\omega_{\alpha,\beta},\Lambda}, \ \phi \in_0 P_N(\Lambda)$

Taking $\phi = \int_0^\rho P_{N-1,\alpha,\beta} \frac{\mathrm{d}v}{\mathrm{d}\xi} \mathrm{d}\xi$ in above. Clearly, $\phi \in_0 P_N(\Lambda)$.

A combination of Lemma 2.1 with Lemma 2.2 leads to the desired result.

Lemma 2.2 *For any* $\phi \in P_N(\Lambda)$, *integer* $r \geq 0$, $\|\phi\|^2_{r,\omega_{\alpha,\beta},\Lambda} \leq c(\beta N)^{2r} \|\phi\|^2_{\omega_{\alpha,\beta},\Lambda}$.

The proof sees (cf. [2]).

Now we define $P^{k,0}_N :_0 H^k_{\omega_{\alpha,\beta}}(\Lambda) \to {}_0P^k_N(\Lambda)$, $\int_0^{+\infty} \frac{\mathrm{d}^k\left(v - P^{k,0}_N \mathrm{v}\right)}{\mathrm{d}\rho^k} \frac{\mathrm{d}^k \phi}{\mathrm{d}\rho^k} \omega_{\alpha,\beta} \mathrm{d}\rho = 0$

For $\forall \phi \in {}_0P_N^k(\Lambda)$, where ${}_0P_N^k(\Lambda) = \left\{ \phi \middle| \phi \in P_N(\Lambda), \frac{\mathrm{d}^l \phi(0)}{\mathrm{d}\rho^l} = 0, 0 \le l \le k-1 \right\}$.

Theorem 2.1 *Let k be a positive integer. For any nonnegative real numbers $0 \le r \le k \le s$ there exists a positive constant c depending only on s such that, for any function φ in $A^s_{0,\beta,\Lambda} \cap {}_0 H^k_{\omega_\beta,}$ the following estimate holds*

$$\left\| \varphi - P_N^{k,0}\varphi \right\|_{H^r_{\omega_\beta}} \le cN^{\frac{r-s}{2}} \|\varphi\|_{A^s_{0,\beta,\Lambda}}$$

Proof We first assume that $r = k$ Clearly,

$$\forall \varphi \in {}_0 H^k_{\omega_\beta}, P_N^{k,0}\varphi(\rho) = \int_0^\rho P_{N-1}^{k-1,0} \frac{d\varphi}{d\xi} d\xi \tag{83.3}$$

We note also that $P_N^{1,0}\varphi(\rho) = {}_0P^1_{N,0,\beta}\varphi(\rho)$.

By virtue of (83.3), we obtain the following estimate from Theorem 2.3 of (cf. [3]).

$$\begin{aligned} \left| \varphi - P_N^{k,0}\varphi \right|_{k,\omega_\beta} &= \left| \varphi' - P_{N-1}^{k-1,0}\varphi' \right|_{k-1,\omega_\beta} = \dots \\ &= \left| \frac{d^{k-1}\varphi}{d\rho^{k-1}} - P^{1,0}_{N-k+1} \frac{d^{k-1}\varphi}{d\rho^{k-1}} \right|_{1,\omega_\beta} = \left| \frac{d^{k-1}\varphi}{d\rho^{k-1}} - {}_0P^1_{N-k+1,0,\beta} \frac{d^{k-1}\varphi}{d\rho^{k-1}} \right|_{1,\omega_\beta} \\ &\le c(N-k+1)^{\frac{k-s}{2}} \left\| \frac{d^k\varphi}{d\rho^k} \right\|_{A^{s-k}_{0,\beta,\Lambda}} \le cN^{\frac{k-s}{2}} \|\varphi\|_{A^s_{0,\beta,\Lambda}} \end{aligned} \tag{83.4}$$

Clearly,

$$\beta \int_0^\rho (\varphi - P_N^{k,0}\varphi)^2 \omega_\beta \mathrm{d}y + (\varphi - P_N^{k,0}\varphi)^2 \omega_\beta = 2 \int_0^\rho (\varphi - P_N^{k,0}\varphi) \frac{\mathrm{d}(\varphi - P_N^{k,0}\varphi)}{\mathrm{d}y} \omega_\beta \mathrm{d}y$$

$$\le \frac{\beta}{2} \int_0^\rho (\varphi - P_N^{k,0}\varphi)^2 \omega_\beta \mathrm{d}y + \frac{2}{\beta} \int_0^\rho \left(\frac{\mathrm{d}(\varphi - P_N^{k,0}\varphi)}{\mathrm{d}y} \right)^2 \omega_\beta \mathrm{d}y.$$

Let $\rho \to \infty$ we obtain

$$\int_0^{+\infty} (\varphi - P_N^{k,0}\varphi)^2 \omega_\beta \mathrm{d}y \le \frac{4}{\beta^2} \int_0^{+\infty} \left(\frac{\mathrm{d}(\varphi - P_N^{k,0}\varphi)}{\mathrm{d}y} \right)^2 \omega_\beta \mathrm{d}y \tag{83.5}$$

Combining this estimate with (83.4) yields

$$\left\|\varphi - P_N^{k,0}\varphi\right\|_{H^k_{\omega_\beta}} \le cN^{\frac{k-s}{2}}\|\varphi\|_{A^s_{0,\beta,\Lambda}} \tag{83.6}$$

Next we prove the case $r = 0$. For any g in $L^2_{\omega_\beta}$, we consider the solution χ in ${}_0H^k_{\omega_\beta}$ of the problem $\int_0^{+\infty} \frac{\mathrm{d}^k\chi}{\mathrm{d}\rho^k}\frac{\mathrm{d}^k\psi}{\mathrm{d}\rho^k}\omega_\beta \mathrm{d}\rho = \int_0^{+\infty} g\psi\omega_\beta \mathrm{d}\rho$.

The existence and uniqueness of this solution follow from the Lax–milgram Theorem. Moreover, the regularity tells us that χ belongs to $H^{2k}_{\omega_\beta}(\Lambda)$ and satisfies

$$\|\chi\|_{H^{2k}_{\omega_\beta}} \le c\|g\|_{L^2_{\omega_\beta}} \tag{83.7}$$

Then we compute

$$\begin{aligned}
&\int_0^{+\infty} g(\varphi - P_N^{k,0}\varphi)\,\omega_\beta \mathrm{d}\rho = \int_0^{+\infty} \frac{\mathrm{d}^k(\varphi - P_N^{k,0}\varphi)}{\mathrm{d}\rho^k}\frac{\mathrm{d}^k\chi}{\mathrm{d}\rho^k}\omega_\beta \mathrm{d}\rho \\
&= \int_0^{+\infty} \frac{\mathrm{d}^k(\varphi - P_N^{k,0}\varphi)}{\mathrm{d}\rho^k}\frac{\mathrm{d}^k(\chi - P_N^{k,0}\chi)}{\mathrm{d}\rho^k}\omega_\beta \mathrm{d}\rho \le \left|\varphi - P_N^{k,0}\varphi\right|_{H^k_{\omega_\beta}} \left|\chi - P_N^{k,0}\chi\right|_{H^k_{\omega_\beta}}
\end{aligned} \tag{83.8}$$

Applying twice the estimate for $r = k$, we obtain from (83.7) that

$$\left\|\varphi - P_N^{k,0}\varphi\right\|_{L^2_{\omega_\beta}(\Lambda)} = \sup_{g\in L^2_{\omega_\beta}} \frac{\int_0^{+\infty}(\varphi - P_N^{k,0}\varphi)g\omega_\beta \mathrm{d}\rho}{\|g\|_{L^2_{\omega_\beta}(\Lambda)}} \le cN^{-\frac{s}{2}}\|\varphi\|_{A^s_{0,\rho,\Lambda}} \tag{83.9}$$

This result gives the case of $r = 0$. By space interpolation, we complete the proof.

Next, we introduce a set of polynomials $0 \le l \le k-1$ $\chi_{k,l}$ in $P_{k-1}(\Lambda)$ Which satisfies $\frac{\mathrm{d}^l\chi_{k,l}(0)}{\mathrm{d}\rho^l} = 1$, $\frac{\mathrm{d}^m\chi_{k,l}(0)}{\mathrm{d}\rho^m} = 0, 0 \le m \le k-1, m \ne l$.

For each function φ in $H^k_{\omega_\beta}(\Lambda)$ we define a function $\widetilde{\varphi}$ in ${}_0H^k_{\omega_\beta}(\Lambda)$ by

$$\widetilde{\varphi} = \varphi - \sum_{l=0}^{k-1} \frac{\mathrm{d}^l\varphi(0)}{\mathrm{d}\rho^l}\chi_{k,l}(\rho) \tag{83.10}$$

Now, let $\frac{\mathrm{d}^l\varphi(\rho^*)}{\mathrm{d}\rho^l} = \min\limits_{0\le\rho\le 1/\beta}\left|\frac{\mathrm{d}^l\varphi(\rho)}{\mathrm{d}\rho^l}\right|$, clearly, for any $\rho \in [0, \frac{1}{\beta}]$,

$$\left|\frac{\mathrm{d}^l\varphi(0)}{\mathrm{d}\rho^l}\right| \le \left|\frac{\mathrm{d}^l\varphi(\rho^*)}{\mathrm{d}\rho^l}\right| + \left|\frac{\mathrm{d}^l\varphi(\rho^*)}{\mathrm{d}\rho^l} - \frac{\mathrm{d}^l\varphi(0)}{\mathrm{d}\rho^l}\right| \le \beta \int_0^{\frac{1}{\beta}} \left|\frac{\mathrm{d}^l\varphi(\rho)}{\mathrm{d}\rho^l}\right| \mathrm{d}\rho + \left(\int_0^{\frac{1}{\beta}} e^{\beta_\rho} \mathrm{d}\rho\right)^{\frac{1}{2}} \left\|\frac{d^{l+1}\varphi(\rho)}{\mathrm{d}\rho^{l+1}}\right\|_{L^2_{\omega_\beta}(0,\frac{1}{\beta})}$$

$$\le c\left(\beta^{\frac{1}{2}}\left\|\frac{\mathrm{d}^l\varphi(\rho)}{\mathrm{d}\rho^l}\right\|_{L^2_{\omega_\beta}(0,\frac{1}{\beta})} + c\beta^{-\frac{1}{2}}\left\|\frac{\mathrm{d}^{l+1}\varphi(\rho)}{\mathrm{d}\rho^{l+1}}\right\|_{L^2_{\omega_\beta}(0,\frac{1}{\beta})}\right) \le c\|\varphi\|_{H^k_{\omega_\beta}(\Lambda)}, 0 \le l \le k-1$$

Next, we define $\|\varphi\|_{B^s_{\omega_{0,\beta}}(\Lambda)} = \|\varphi\|_{A^s_{0,\beta}(\Lambda)} + \|\varphi\|_{H^s_{\omega_\beta}(\Lambda)}$.

According to previous formula and (83.10), for any real number s

$$\|\widetilde{\varphi}\|_{A^s_{0,\beta}(\Lambda)} \le c\|\varphi\|_{B^S_{\omega_{0,\beta}}(\Lambda)}$$

Next, set

$$\widetilde{P}^k_N\varphi = P^{k,0}_N\widetilde{\varphi} + \sum_{l=0}^{k-1} \frac{\mathrm{d}^l\varphi(\rho)}{\mathrm{d}\rho^l}\chi_{k,l(\rho)} \tag{83.11}$$

Obviously, $\varphi - \widetilde{P}^k_N\varphi = \widetilde{\varphi} - P^{k,0}_N\widetilde{\varphi}$. Using Theorem 2.1 leads to

$$\left\|\varphi - \widetilde{P}^k_N\varphi\right\|_{H^k_{\omega_\beta}(\Lambda)} = \left\|\widetilde{\varphi} - P^{k,0}_N\widetilde{\varphi}\right\|_{H^k_{\omega_\beta}(\Lambda)} \le cN^{\frac{k-s}{2}}\|\varphi\|_{B^S_{\omega_{0,\beta}}(\Lambda)} \tag{83.12}$$

Next, we define $\widehat{P}^1_N$ as $\widehat{P}^1_N\varphi = {}_0P_{N,0,\beta}\,\widetilde{\varphi} + \varphi(0)$.

By using Lemma (2.1) with $\alpha = 0$ we obtain

$$\left\|\varphi - \widehat{P}^1_N\varphi\right\|_{\omega_\beta,\Lambda} = \left\|\widetilde{\varphi} - {}_0P_{N,0,\beta}\widetilde{\varphi}\right\|_{\omega_\beta,\Lambda} \le cN^{\frac{1-r}{2}}\|\varphi\|_{A^r_{0,\beta}(\Lambda)} \tag{83.13}$$

83.3 Generalized Laguerre Spectral Method

Let $\omega_\beta(\rho) = \omega_{0,\beta}(\rho) = e^{-\beta\rho}$, $\beta > 0$.The generalized Laguerre polynomials

$$L^{(\beta)}_l(\rho) = L^{(0,\beta)}_l(\rho), l \ge 0$$

The set of $L^{(\beta)}_l(\rho)$ is the complete $L^2_{\omega_\beta}(\Lambda)$—orthogonal system, namely,

$$(L^{(\beta)}_l(\rho), L^{(\beta)}_m(\rho))_{\omega_\beta,\Lambda} = \begin{cases} \frac{1}{\beta}, l = m \\ 0, l \ne m \end{cases}.$$

Using (2.2), we derive that $L^{(\beta)}_l(0) = 1, l \ge 0$.

Thus, $\psi_k = L^{(\beta)}_k(\rho) - L^{(\beta)}_{k+1}(\rho), 0 \le k \le N-1$ form the basis of ${}_0P_N(\Lambda)$.

We consider the following problem

$$\begin{cases} \dfrac{\mathrm{d}v}{\mathrm{d}\rho} = f(v(\rho), \rho), \rho \geq 0 \\ v(0) = v_0 \end{cases} \tag{83.14}$$

Next, we construct the numerical scheme. To do this, we approximate v by u_N.

Where $u_N \in P_N(\Lambda)$, $u_N(0) = v_0$. Let $\widehat{u}_1$ be the coefficient of u_N in terms of $L_1^{(\beta)}$. Then $u_N(\rho) = \sum_{l=0}^{N} \widehat{u}_1 L_1^{(\beta)}(\rho)$.

Where $\widehat{u}_1 = \beta(u_N, L_1^{(\beta)})_{\omega_\beta}, 0 \leq 1 \leq N-1, \widehat{u}_{\mathrm{N}} = v_0 - \sum_{1=0}^{N} -1\widehat{u}_1$. By virtue of (83.1),

$$\frac{\mathrm{d}}{\mathrm{d}\rho} u_N(\rho) = \sum_{1=0}^{N} \widehat{u}_1 L_1^{(\beta)}(\rho) = -\beta \sum_{1=0}^{N} \widehat{u}_1 \left(\sum_{m=0}^{1-1} L_m^{(\beta)} \right) = -\beta \sum_{1=0}^{N} L_m^{(\beta)} \left(\sum_{m=0}^{1-1} \widehat{u}_1 \right) \tag{83.15}$$

Due to the orthogonality of $L_1^{(\beta)}$, we deduce that

$$(\mathrm{L}_1^{(\beta)}, \psi_{\mathrm{k}})_{\omega_\beta} = (\mathrm{L}_1^{(\beta)}, \mathrm{L}_{\mathrm{k}}^{(\beta)})_{\omega_\beta} - (\mathrm{L}_1^{(\beta)}, \mathrm{L}_{\mathrm{k}+1}^{(\beta)})_{\omega_\beta} = \begin{cases} \frac{1}{\beta}, & 1 = \mathrm{k} \\ -\frac{1}{\beta}, & 1 = \mathrm{k}+1 \\ 0, & \text{other.} \end{cases} \tag{83.16}$$

A combination of (83.15) and (83.16) leads to

$$\left(\frac{\mathrm{d}}{\mathrm{d}\rho} u_N, \psi_k \right)_{\omega_\beta} = -\sum_{1=k+1}^{N} \widehat{u}_1 + \sum_{1=k+2}^{N} \widehat{u}_1 = \begin{cases} -\widehat{u}_{k+1}, & 0 \leq k \leq N-2 \\ -\widehat{u}_N, & k = N-1. \end{cases} \tag{83.17}$$

We note that $\widehat{u}_N = v_0 - \sum_{l=0}^{N-1} \widehat{u}_1$ then

$$\left(\frac{\mathrm{d}}{\mathrm{d}\rho} u_N, \psi_k \right)_{\omega_\beta} = \begin{cases} -\widehat{u}_{k+1}, & 0 \leq k \leq N-2 \\ \sum_{1=0}^{N-1} \widehat{u}_1 - v_0, & k = N-1. \end{cases} \tag{83.18}$$

Let $a_{k,j} = \begin{cases} -1, j = k+1, 0 \leq k \leq N-2 \\ 1, j = 0, \ldots, N-1, k = N-1. \end{cases}$

$$A^N = \left(a_{\mathrm{k},j}\right)_{N \times N}, B^N = (0, 0, \ldots, 0, 1)^T, \overrightarrow{u}_N = (\widehat{u}_0, \widehat{u}_1, \ldots \widehat{u}_{N-2}, \widehat{u}_{N-1})^T$$

$$\widetilde{f}_k = (f(u_N(\rho), \rho), \psi_k)_{\omega_\beta}, \widetilde{F}^N(u_N) = \left(\widetilde{f}_0, \widetilde{f}_k, \ldots, \widetilde{f}_{N-2}, \widetilde{f}_{N-1}\right)^T.$$

We derive the following spectral scheme for (83.14)

$$\begin{cases} A^N \overrightarrow{u}_N = \widetilde{F}^N(u_N) + v_0 B^N \\ \widehat{u}_N = v_0 - \sum_{1=0}^{N-1} \widehat{u}_1. \end{cases} \tag{83.19}$$

Obviously, the system (83.19) is equivalent to

$$\begin{cases} \dfrac{\mathrm{d}u_N(\rho)}{\mathrm{d}\rho} = f(u_N(\rho), \rho), \rho \geq 0 \\ u_N(0) = v_0. \end{cases} \tag{83.20}$$

Next, we analyze the numerical error of (83.19). To do this, let $E_N = u_N - \widehat{P}_N^1 v$. By definition of $\widehat{P}_N^1$, $E_N(0) = 0$. Using (83.20) yields that

$$\begin{cases} \left(\dfrac{\mathrm{d}}{\mathrm{d}\rho} E_N(\rho), \phi \right)_{\omega_\beta} = (G_{\beta,2}, \phi)_{\omega_\beta} - (G_{\beta,1}, \phi)_{\omega_\beta}, \forall \phi \in {}_0P_N(\Lambda) \right) \\ E_N(0) = 0. \end{cases} \tag{83.21}$$

where $G_{\beta,1} = \dfrac{\mathrm{d}}{\mathrm{d}\rho} \widehat{P}_N^1 v(\rho) - \widehat{P}_N^1 \dfrac{\mathrm{d}v}{\mathrm{d}\rho}, G_{\beta,2} = f(u_N(\rho), \rho) - \widehat{P}_N^1 \dfrac{\mathrm{d}v}{\mathrm{d}\rho}, E_N(\rho) \in {}_0P_N(\Lambda)..$ Taking $\phi = 2E_N$ in (83.21)

$$2\left(E_N, \frac{\mathrm{d}}{\mathrm{d}\rho} E_N \right)_{\omega_\beta} = 2(G_{\beta,2}, E_N)_{\omega_\beta} - 2(G_{\beta,1}, E_N)_{\omega_\beta} = A_{\beta,2} + A_{\beta,1} \tag{83.22}$$

Since $E_N(0) = 0$, integration by parts

$$2(E_N, \frac{\mathrm{d}}{\mathrm{d}\rho} E_N)_{\omega_\beta} = \beta \|E_N\|_{\omega_\beta}^2 \tag{83.23}$$

By using the Cauchy inequality, we derive that

$$\left| A_{\beta,1} \right| \leq 2 \left\| G_{\beta,1} \right\|_{\omega_\beta} \|E_N\|_{\omega_\beta} \leq \varepsilon \|E_N\|_{\omega_\beta}^2 + \frac{1}{\varepsilon} \left\| G_{\beta,1} \right\|_{\omega_\beta}^2 \tag{83.24}$$

Next, we assume that there exists a real number γ such that

$$(f(z_1, \rho) - f(z_{2,}\rho))(z_1 - z_2) \leq \gamma (z_1 - z_2)^2 \tag{83.25}$$

Then

$$\begin{aligned} A_{\beta,2} &= 2(f(u_N, \rho) - \widehat{P}_N^1 \frac{\mathrm{d}v}{\mathrm{d}\rho}, E_N)_{\omega_\beta} \\ &= 2(f(u_N, \rho) - f(\widehat{P}_N^1 v, \rho), E_N)_{\omega_\beta} + 2(f(\widehat{P}_N^1 v, \rho) - f(v, \rho), E_N)_{\omega_\beta} \\ &\quad + 2(\frac{\mathrm{d}v}{\mathrm{d}\rho} - \widehat{P}_N^1 \frac{\mathrm{d}v}{\mathrm{d}\rho}, E_N)_{\omega_\beta} \leq 2\gamma \|E_N\|_{\omega_\beta}^2 + 2\gamma (\widehat{P}_N^1 v - v, E_N)_{\omega_\beta} \\ &\quad + 2(\frac{\mathrm{d}v}{\mathrm{d}\rho} - \widehat{P}_N^1 \frac{\mathrm{d}v}{\mathrm{d}\rho}, E_N)_{\omega_\beta} \end{aligned}$$

According to the above formula, we obtain that

$$\begin{aligned}\left|A_{\beta,2}\right| &\le 2\gamma\|E_N\|^2_{\omega_\beta}+2\gamma\left\|\widehat{P}^1_N v-v\right\|_{\omega_\beta}\|E_N\|_{\omega_\beta}+2\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|_{\omega_\beta}\|E_N\|_{\omega_\beta}\\ &\le (2\gamma+\varepsilon+\varepsilon)\|E_N\|^2_{\omega_\beta}+\frac{\gamma}{\varepsilon}\left\|\widehat{P}^1_N v-v\right\|^2_{\omega_\beta}+\frac{1}{\varepsilon}\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|^2_{\omega_\beta}\end{aligned} \tag{83.26}$$

Substituting (83.23), (83.24), (83.26) into (83.22), we assert that,

$$\beta\|E_N\|^2_{\omega_\beta}\le(2\gamma+3\varepsilon)\|E_N\|^2_{\omega_\beta}+\frac{1}{\varepsilon}\left\|G_{\beta,1}\right\|^2_{\omega_\beta}+\frac{1}{\varepsilon}\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|^2_{\omega_\beta}+\frac{\gamma}{\varepsilon}\left\|\widehat{P}^1_N v-v\right\|^2_{\omega_\beta} \tag{83.27}$$

Let $\delta=2\gamma+3\varepsilon$. By virtue of Lemma 2.5 with $\alpha=0$, we derive that

$$\begin{aligned}(\beta-\delta)\|E_N\|^2_{\omega_\beta} &\le c\left(\left\|\widehat{P}^1_N v-v\right\|^2_{\omega_\beta}+\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|^2_{\omega_\beta}+\left\|\widehat{P}^1_N v-\widetilde{P}^1_N v\right\|^2_{1,\omega_\beta}+\left\|\widetilde{P}^1_N v-v\right\|^2_{1,\omega_\beta}\right)\\ &\le c\left(\left\|\widehat{P}^1_N v-v\right\|^2_{\omega_\beta}+\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|^2_{\omega_\beta}+\left\|\widehat{P}^1_N v-\widetilde{P}^1_N v\right\|^2_{1,\omega_\beta}+\left\|\widetilde{P}^1_N v-v\right\|^2_{1,\omega_\beta}\right)\\ &\le c\left(N^2\left\|\widehat{P}^1_N v-v\right\|^2_{\omega_\beta}+\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}-\widehat{P}^1_N\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|^2_{\omega_\beta}+N^2\left\|\widetilde{P}^1_N v-v\right\|^2_{1,\omega_\beta}\right)\end{aligned}$$

Finally, we obtain the following Theorem

Theorem 3.1. *If* v *belongs to* $A^s_{\omega_{0,\beta}}(\Lambda)\cap H^s_{\omega_\beta}(\Lambda)$, *taking* β *such that* $\beta>\delta$, *by* (83.13) *with* $k=1$ *and (83.14), then*

$$\|E_N\|_{\omega_\beta}\le cN^{\frac{2-s}{2}}\left(\|v\|_{B^s_{\omega_{0,\beta}}(\Lambda)}+\|v\|_{A^{s-1}_{0,\beta,\Lambda}}+\left\|\frac{\mathrm{d}v}{\mathrm{d}\rho}\right\|_{A^{s-1}_{0,\beta,\Lambda}}\right). \tag{83.28}$$

Acknowledgments This research is financially supported by the Fundamental Research Funds for the Central Universities.

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Part IX
Information Management Systems and Software Engineering

Chapter 84
Efficient Scheme of Improving Experience of Student Software Engineering

Guoxiang Zhong and Tangming Yuan

Abstract The main objective of having a team project in the course is to provide students with some experience in working in a team. To ensure the success of team projects, it is important to evenly distribute skills among teams. For an individual team, good intra-team communication is the key to succeed. It is also important to define a fair policy to assess individual team member's contribution. Further, a quality assurance (QA) plan is essential to enhance student team project experience. This paper intends to share our practice of delivering software team projects with an emphasis on team formation metrics, intra-team communication assessing individual contribution and with a focus on the use QA plan. The paper also presents the common problems occurred within a project team and their proposed solutions. It is anticipated that this work will contribute to research in software team projects and teaching practice in software engineering.

Keywords Software engineering · Software team project · Team formation metrics · Intra-team communication · QA plan

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_84,

84.1 Introduction

The main aim behind software engineering course in universities is to teach students how to learn and understand the importance of each phase of the software life cycle, project management, and also the software process so that students are prepared to be able to successfully design and build modern software systems in the future. A common approach of achieving this is to include a team project in the curriculum of the course. Team projects provide students with hand-on experience of a "real" software project in a "real" software environment with the aim of increasing student employability. During a project, a team needs to hold regular project meetings, make decisions, manage group, write reports, and present to client. Team projects also require effective communication and collaboration among the team members in order to succeed. This paper focuses on emphasizing QA plan that helps to enhance the student project team experience. The remainder of this paper is organized as follows. Section 84.2 provides a discussion of related work in teaching of software engineering team projects. Section 84.3 presents and reflects our current practice in teaching software team projects, particularly in the metrics we have proposed to facilitate the team formation, facilities used to enhance intra-team communication, means to assessing individual contribution and the use of the QA framework that has been composed to enhance student software development experience in a team. Based on the analysis of the 2010/2011 software engineering team and individual reports at the University of York, Sect. 84.4 presents the common problems that occur within a software project team and their possible solutions.

84.2 Related Work in Team Projects

Because of the fact that modern software systems are very sophisticated, they can only be developed by a team rather than an individual effort. Therefore there has been increasing research and reports on issues related to the teaching of software engineering team projects. Scott et al. [1] investigated the effect of team dynamics on the classical software engineering phases namely specification, implementation, testing, and evaluation. Gorla and Lam [2] explored the relationship between personality composition of teams and the team performance in small IS teams. Woodfield and Collofello [3] discussed many problems observed in the teaching of team project, for example the evaluation of teams and individuals, project selection, team formation, crisis management, and learning new systems and new information. Wilkins and Lawhead [4] discussed the assessing individual student contributions to a group project, they provided a lot of questions for students, and assessed individual student contributions by his/her simple answering these questions. Reichlmaryr [5] discussed the blended learning techniques in enhancing the student project team experience. Blended learning aims to join the best of

face-to-face classroom learning with the best of online teaching and learning to promote active independent learning and reduce class seat time. Jorgenson et al. [6] discussed the facilitating student project team collaboration by using SEREBRO. SEREBRO couples an idea forum with software project management tools to maintain cohesive interaction between team discussion and resulting work products, such as tasking, documentation, and version control. The goal of SEREBRO is to aggregate a discussion forum with project management tools as an environment of collaboration. In SEREBRO, teams can review decisions, follow work product development and stay on task. Anisetty and Young [7] discussed collaboration problems in conducting group project too, and proposed some solutions for collaboration problems during the requirements, analysis, design and implementation phase.

84.3 Our Practice in Teaching Software Team Projects

This section provides discussions and reflections on our experience in team formation, facilitating intra-team communication, assessing individual contribution, and the use of the QA framework.

84.3.1 Metrics for Team Formation

Although there are a number of advantages of using software team projects, as an academic exercise they are often problematic [8]. One of the many issues with team projects is team formation. Too often some teams have strong engineering skills but individual members were not sufficiently motivated while some other teams struggle with coding while every member felt confident to lead the team. These are typical examples of unsuccessful team formation. Ideally, we would like to create teams with mixed and balanced skills e.g., people-side leadership and communication skills, project management skills and software engineering skills. In practice creating balanced teams is challenging especially when there is a large cohort of students and yet the lecturer does not know them well.

According to DeMarco and Lister's [9] guidelines for creating productive teams, females often play vital roles in making a team gel. Mixed gender is therefore considered as one of the team formation metrics. Further, the increasing internationalization of the student population provides students with opportunities to work in an internationalized environment. Mixed nationality is therefore considered as a further team formation metric. When students are from different cohorts mixed cohorts becomes an important metric. Sometimes mixed supervisors can be considered as a metric as well.

84.3.2 Intra-Team Communication

With team projects a further challenging issue is intra-team communication. As DeMarco and Lister [9] put it, "*project successes stem from good human interactions and project failures stem from poor human interactions*". As our students need to juggle several other courses at the same time and they do not have dedicated offices like professional software engineers, students tend to work at their own convenience and at different locations e.g., their accommodation or labs. This poses a great challenge for team communication. In the past few years a number of software tools have been used to facilitate this. For example SVN, a collaborative software environment, was used to provide each team with an online repository. Student feedback of using SVN is very positive, and as teaching stuff we are pleased to be able to monitor each team's progress via SVN [10]. As well as SVN, we have tried to encourage students to use a departmental Forum to communicate with their peers. However, although a high number of students view the forum, few of them actively contribute. To address this, we are planning to ask students in the future how best to use the forum to support intra-team communication.

84.3.3 Assessing Individual Contribution

Team projects provide students with opportunity to gain experience in a real-life project where software engineers are working together as teams. It helps students to foster both technical skills and nontechnical skills. Despite the above mentioned advantages however, it is difficult to define a fair marking policy to motivate individual team members. On the one hand, Demarco and Lister [9] suggest that joint product ownership prompts good team unity and this implies that each member should receive the same mark for the product as a team. On the other hand, this may not reflect each member's true effort devoted to the project. It does tend to happen each year that a few struggling students depend on their team mates to get through this course. Individual discrimination seems to be equally needed. To achieve the right balance is difficult in practice. We have practised two ways of incorporating an individual component to discriminate individual students. The first is to ask each team to have an open and honest assessment of each individual performance with a fixed average for every team. The second is to ask students to hand in an individual reflective report on their team experience, and students receive different marks for their reports. Both approaches have advantages. The first approach is almost resource free and the second approach encourages student reflective learning. We currently use both approaches for two different cohorts and they both seem work well.

84.3.4 The Use of QA Plan

The quality assurance (QA) plan has been used by the MSc Software Engineering Group Projects within the Department of Computer Science of the University of York. The QA plan was developed following the spirit of the IEEE/ANSI standard [11] for software QA plans and it identifies the operating procedures for all major activities in the Software Engineering Group Project. This plan aims to formalize accepted good practice for the development of software. It consists of those procedures, techniques and tools applied by professionals to ensure that a product meets prespecified standards during a product's development cycle. The first version (1.0) of the plan was launched in September 2001 and nine versions of the standard have been evolved. The latest version (1.8) of the QA plan contains 10 standard documents. The name and a brief description of each document are given below [12, 13].

Technical skills learned Students report that team projects provide them with an excellent exposure to how a project can benefit from adhering to standard QA framework. The teams must follow all the steps and meet the prescribed standards. During the process, students could apply their knowledge learnt from the other modules. They gain a better understanding of the software development model and that a software project often has continuous changing requirements and hence strategies for integrating these changes must be developed. After team projects, students appreciate the standards used to create documents, e.g., requirement specification, design specification, test specification, and maintenance manual. Students also learn to analyze the risks of a project and make a plan to mitigate risks, and conduct software reviews to keep track of the overall software development process. Students also report that they have improved their Java, SQL, XML, and skills in applying UML to a real project use, they have also learned to use some of the other popular tools like JUnit (Testing tool), ANT (development tool), IDE (Eclipse and NetBeans), SVN for collaborative software version control, and TRAC for reporting any issues/bugs discovered in the software. Further, their software engineering knowledge, technical writing and decision making skills have been improved by following the QA framework. The usefulness of the QA framework has been echoed by a number of students as quoted below:

Nontechnical skills learned Students also report that they have learned teamwork spirit and improved their communication skills. It is challenging to work with other people from a different culture background especially most of their native languages are not English. They reflect that it should make every team members have a comfortable feeling that he/she is important part of our team, so that the team cooperation can run smoothly. Students also appreciated that each individual has their own way of thinking, and combining the ideas of such a diverse group can potentially produce good results that could not have been achieved otherwise. Students understand that the ability to work under pressure and tight deadline is very important.

84.4 Common Problems Within a Team

During team projects, an individual team often comes across various problems that need to be handled properly in order to succeed as a team. The problems reported by teams are summarized as follows.

Team management People taken as individuals and people in a team are very different dynamics. While there are many advantages when working in a team there is always the possibility of compatibility issues and issues of conflicting interests. Disagreements may delay decisions and cause hard feelings. So the main role of a team leader would be to that of a facilitator and a provider, to provide the optimum comfortable working environment for resources to extract all the benefits of working as a team. Roles were decided depending upon the different skill set possessed by the individual. This was particularly helpful in cases when unexpected anomalies were occurred and the team was comfortable with adjusting the workload, focusing on problems and solving them quickly so the team could be back on track as soon as possible without affecting the schedule.

Communication and collaboration Because of some culture differences, some misunderstandings happened. Some communication gap problems were faced due to team members having varied level of ease with English. Lack of communication leaves everyone confused and uncertain about progress. All the members should be patient enough and help each other wherever required, one has to respect and to try to understand each other, and one good aspect about working with other people is that they can see things in a different perspective.

Resource unavailable Many hiccups were faced as few of the resources were not available during the initial phase for the project. Unfortunately, however, a lack of technical knowledge and experience meant that a small number of team members were tasked with doing a disproportionately large quantity of work. So the task sheet contained the task allotted for each resource for the very next day thereby keeping all resources up-to-date on their work. There were some difficulties, such as learning new concepts, e.g. model checking, and resolve all the bugs during test phase, but everyone worked hard to overcome them and helped each other out. Lack of documentation about the development lifecycle of the existing software, this made it difficult to discover what team needed to do, they tried to resolve this by documenting their own work professionally so they could share the knowledge gained among themselves.

Time constraints Group problem solving is a relatively slow process compared with working alone, and it requires individuals to come together at an agreed time. Due to estimating technical activities was difficult, time available had to be utilized effectively. So the time sheet was maintained by the team management for the resources to update them weekly, clearly mentioning the hours of work done per task, this gave the management clear idea of the utilization of each individual and also in allotting further task efficiently and also to help in bringing forward the resources lagging behind in their task. Project plan was made considering all risks and effectively distributing time for project. Some teams also booked meeting

room and worked together every week day, they tried to resolve problems by constant revaluation and critical updating on their progress.

Regular meeting Regular meeting process was somewhat time consuming, but it helped in the way that it assured that each member was at the same page at any given time and every misunderstanding regarding the project was resolved quickly. Furthermore, it helped the project go forward by allowing the team to hold some brainstorming sessions that really provided solutions during some challenges that came up.

Change management Change is only constant aspect in a software project. Environments change, client's requirements change, needs from a software change and to manage this change properly is a big challenge. A project team should never let these changes to be random and whimsical otherwise they can very easy get out of control. Students coped with the changes, and analyzed the effects of changes in review meeting and followed QA framework to minimize the impact on the project schedule.

Challenges of QA This project was a very good learning experience which gave an excellent exposure to how a project can benefit from adhering to standard QA framework. Though following QA framework some extra work needs to be required but at the end the product is a much more superior one. So since coding phase started, almost all the team members worked together in one room every week day. When one member had doubts, he could communicate with others and solve his doubts immediately. If one member found defects in the project, he could inform the team directly. To achieve a high quality project, they gathered feedbacks from their clients, and improved their software based on those feedbacks. For example, they gave clients different prototypes of user interface of control table and graphical user interface. After meeting with clients, they knew more about what clients wanted, and provided those functions to clients.

84.5 Some Recommendations

According to our teaching experiences and the performances of and feedbacks from teams and team members, we proposed some recommendations for succeeding software team projects.

Good QA plan is important to a project team and its individuals A good QA plan can improve the quality of the task and the code where documents are written more formal and understandable. Good quality tasks can also help to reduce teammate's pressure because it always takes more time for others to understand a low quality document.

Good division of the tasks Good division of the tasks is very important for a team. Every member must have different roles when the project goes to different stages. The task should be divided clearly. If tasks are not divided clearly, some necessary task may be lost in the process of the project. And dividing task clearly does not mean that each member of the team just does their own share of work, teammates should help each other to finish the task, and this will save time and resources.

Face to face discussion Face to face discussion is most effective way to communicate, no matter what problems the students meet, they can have a meeting to discuss the solution, it is much better than just solving it alone.

Design should be thought clearly before coding Before coding, students should pay attention to design. Design is not just about what the system looks like, how it works and basic structure, system design should go into more details. If design and coding are mixed together, it will cause a lot of trouble for the program. This is because that when change one method is changed, a lot of code should be modified, and it wastes a lot of time and reduces the quality of the code.

Personal sense of responsibility Although a team has QA manager, personal sense of responsibility is really important. Every member of the team must try their best to finish their task before the designated deadline because one task delay may halt the whole project.

Team spirit Every member of the team has their own trouble when they are performing their task. They should help and encourage each other. If one member cannot finish his task for some reasons, the team should share the task with other members and try to complete it, never just wait and blame because it makes no sense to solve the problem.

Systematic and adaptable methodology An effective methodology and a systematic approach must be adopted to accomplish the goals set in the project.

Searching for uncertainties in the project It is very important to understand the uncertainties/risks in the project and hence must always look forward to search for uncertainties/risks and resolve them.

Reusing code It is advisable to devote more time in understanding the code of the exiting application and therefore more code could be reused.

Making a separate plan Making a separate plan or at least a separate task list/check list Specific to different roles (e.g. check list for the project leader, checklist for the QA manager and checklist for the coders) is important, and this would help in concentrating on the area a member is working on.

Strengthen the domain knowledge learning The domain knowledge is also very important for students to elicit the demands of the clients.

84.6 Conclusion

The main objective of having a team project is to provide students with some experience of working in a team. We have reflected our experience in the successful teaching of software team projects at the University of York, particularly in forming teams, facilitating team communication, assessing individual contribution and the use of QA plan. We have also discussed the common problems that occur within a project team and their possible solutions. A number of recommendations have been proposed for the success of a team project. It is hoped that this work will contribute to research and teaching practice in software team projects.

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Chapter 85
Research of New Type Power Quality Monitor System

Xiaohui Sun, Hongmei He, Ai-ning Li and Xin-li Jia

Abstract First the paper expounds power quality problems in power grid. According to the characteristics of the steady state component and the transient component, DSP + ARM structure of electric power quality monitor system is designed. Then the paper mainly introduces the signal acquisition (DSP) part of hardware design: The hardware design includes the voltage signal acquisition, Antioxidant aliasing filter circuit design, A/D circuit design, phase-locked frequency circuit design; Finally power quality monitor system is applied in engineering field. Through a period of time to the monitoring data of test analysis found that new power quality monitor can be good to complete the design requirements, the desired effect for users to fully understand the site electrical energy environment provides scientific data.

Keywords Power quality · DSP + ARM · Signal acquisition

85.1 Introduction

Power quality monitoring is the electric power sector for itself and its key users with the important service, which is also gain power quality information of direct way. In modern power system, power quality problems can be divided into steady state and transient power quality two parts. Steady state power quality problems are waveform distortion for features, including the harmonics and noise, etc. [1].

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_85,

Transient power quality problems usually in the spectrum and transient lasts for features, divided into pulse transient and oscillation transient two kinds. With the rapid development of the electric power industry, steady state power quality such as voltage fluctuation, frequency wave, harmonic, has caused enough attention. At the same time transient power quality problem is becoming more and more serious, such as voltage drop sharply, and short-term phenomenon often occur, has brought great loss to the user [2]. Based on the theory of effective value of traditional monitoring technology because of the time window is too long, the RMS has not only accurate description of the actual power quality problems, so must meet the requirements of the development of the new monitoring technology [3].

85.2 Design of the Power Quality Monitor System

Along with the power and rapid development of industry, power supply both sides pay more and more attention to power quality problems. Power quality indicators includes not only the statistical indicators, such as voltage fluctuation, harmonic analysis, etc.; And emphasizes the requirement of real-time, to ensure that the transient index of the accurate analysis. So power quality monitoring system should include the strong data acquisition, processing, save function, intelligible report system, and general information sharing technology [4].

In this paper the structures of the system hardware platform using the DSP + ARM master slave structure. DSP use US TI introduces the latest TMS320F2812 sample data operation to handle, using DSP digital signal processing speed high strengths to the handle big computational complexity of real-time tasks, and man–machine interface by the Samsung S3C2410 chip company ARM9 series realize, mainly including liquid crystal display, keyboard management, serial communication in time clock control, etc. Be responsible for the system configuration management, ARM human–computer interaction, the communication, etc. data exchange of DSP and ARM is through the serial peripheral interface device (SPI) to realize [5]. The system hardware diagram is shown in Fig. 85.1.

Obviously, Based on DSP signal acquisition and processing of design is the core of the whole system, somewhere; this paper will focus of this part of the design of the hardware.

85.2.1 Voltage and Current Signal Acquisition

Real-time three-phase voltage and three-phase current signal are converted by PT and CT, they can be deal with low level signals, after pretreatment circuit, mainly to complete signal filtration, filter out beyond measurement requirements higher

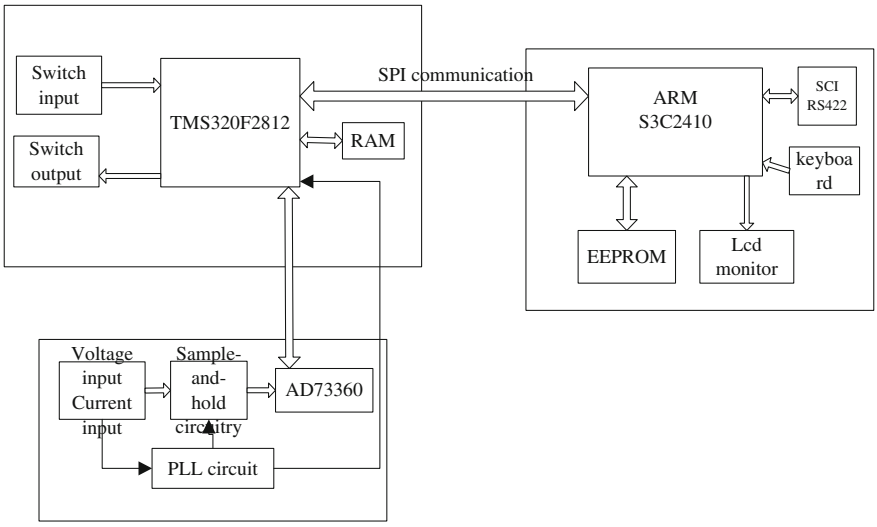


Fig. 85.1 The whole system frame

harmonic. And then the signal is way more synchronous sampling in signal acquisition circuits. And through the communication unit to data processing DSP, and concludes that the power quality parameters.

The voltage signal for use SPT204 current voltage transformer, circuit design as shown in Fig. 85.2. The input voltage after SFCL R1, make rated current through SPT204A voltage transformer primary (former edge) for 2 mA, secondary output (deputy side) will be the same current. Through the operational amplifier function through adjusting the feedback resistance R2 value on the output side to get the required voltage output. Operational amplifier OP07 take the power supply voltage of the 12 V in picture, supply voltage also can be customised according to the specific conditions. The feedback resistance R2 and SFCL R1 is higher than 1 %

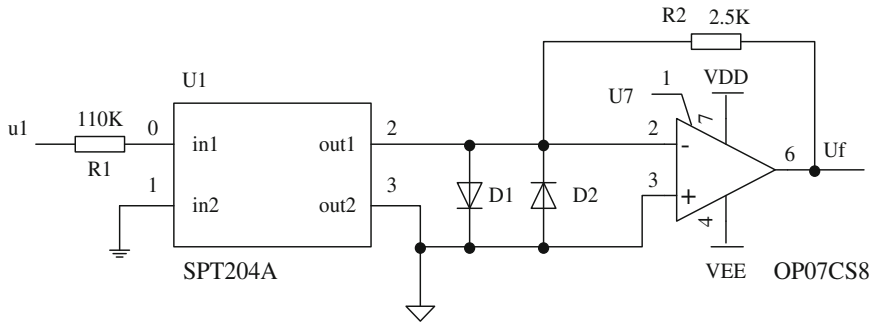


Fig. 85.2 Design of voltage signal gain

accuracy requirement, the temperature coefficient is better than 50 PPM. Recommend using state is 2 mA/2 mA.

Current signal acquisition use SCT254FK current transformer, Circuit design as shown in Fig. 85.3. Input rated current for 5 A, secondary output (deputy edge) current will be 2.5 mA. Through the operational amplifier role, they can adjust the feedback resistance R16 value on the output side to get the required voltage output.

85.2.2 Antialiasing Filter

Signal collected by voltage and current transformer must pass a fight aliasing filter, filter out more than 50 times harmonic. This paper fight aliasing filter adopting second order low-pass filter, circuit design as shown in Fig. 85.4.

To filter out more than 50 times harmonic, take fc for 2,500 Hz. Due to the second order link series will lower cut-off frequency, so practical application ωc will be slightly greater, here take fc for 3,200 Hz. $C2$ approximate to 10/fcuF, take it for 3,300 PF, $C1 \leq \frac{\left[B^2+4C(K-1)\right]C2}{4C}$. The whole system transfer function gain of 1, R3 $= \infty$, R4 $= 0$, namely $K = 1$. Bart WO low-pass filter coefficient B, C in the literature can be investigated, so calculation can be made for 470 pF $C1$, R1–33 k Ω, R2 for 110 k.

85.2.3 A/D Conversion Circuit

The power system of the high order harmonics content relative to the base wave component in is very low. According to the measured data, if using DSP built-in 12 A resolution of the A/D conversion module, consider from the precision of higher harmonic can cause bigger error, so the system selects the 16 resolution of the A/D converter AD73360. AD73360 is A/D conversion chip has six channel analog input, more used in industrial power measurement. Its main characteristic is

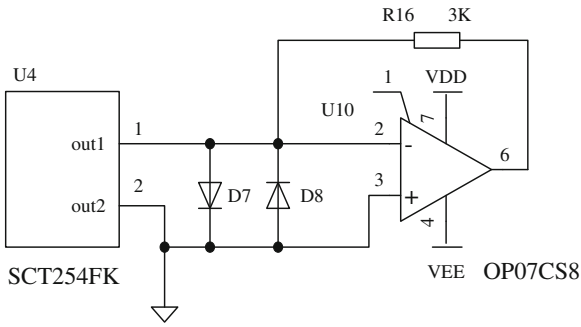


Fig. 85.3 Design of current signal gain

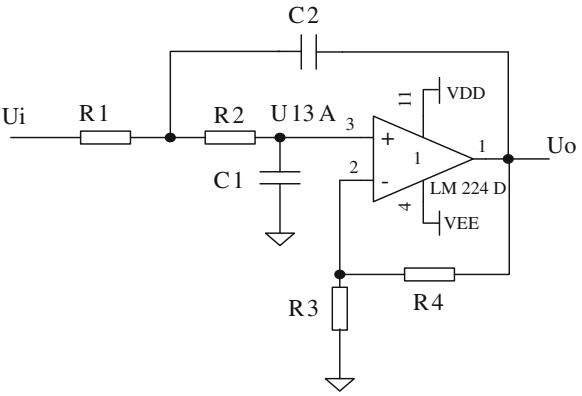


Fig. 85.4 Antioxidant aliasing filter

has six sixteen of the A/D converter, each channel are synchronous sampling to ensure passage between does not exist time delays. So in electric power measurement can be simultaneously in three obtained and three-phase voltage sampling, and don't have to consider the phase delay, make more accurate measurement of electric.

85.2.4 Phase-Locked Frequency Multiplication

In order to guarantee the synchronicity of the sampling, the system USES frequency tracking and times frequency and phase lock technology. Take all the way through the voltage signal zero comparator LM224 grid frequency output tracking of square wave signal, square wave transform circuit as shown in Fig. 85.5.

The square wave signal phase lock loop by 128 times after sampling frequency to keep implement, to ensure that within a week wave sampled 128 points, and then into A/D converter for module conversion, finally using DSP high speed digital signal processing capacity calculation. Because of the actual case,

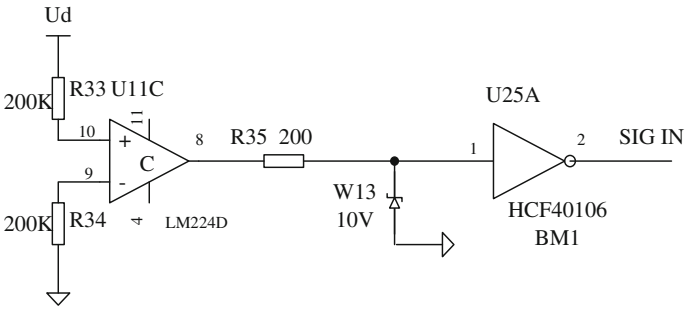


Fig. 85.5 Square-wave circuit

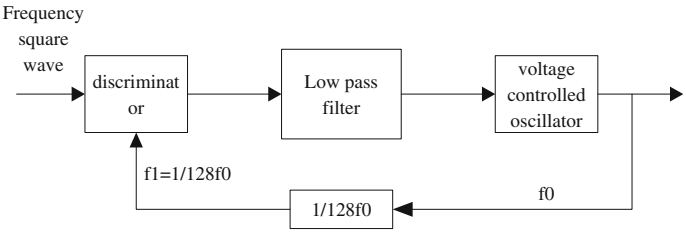
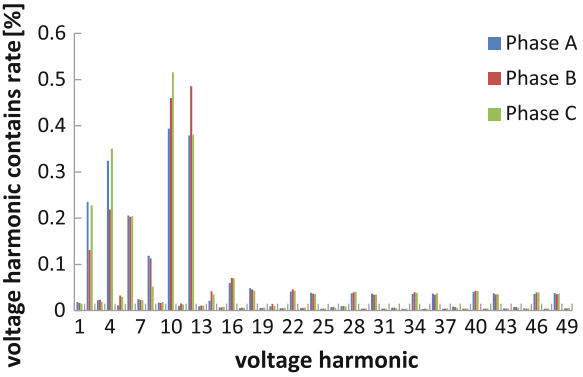


Fig. 85.6 PLL circuit

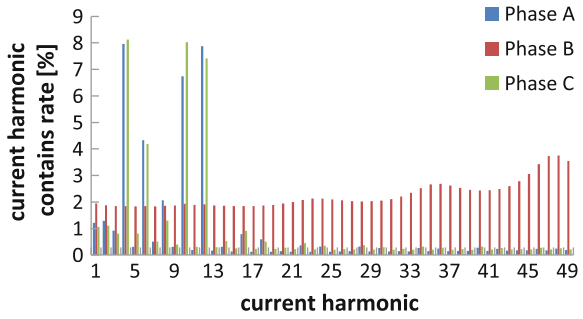
Fig. 85.7 Voltage harmonic histogram



frequency won't have too big wave motion, so the monitor every 15 min by a frequency measurements.

Phase-locked loop circuit is by the CMOS integrated PLL chip CD4046 and 2 slices of four binary addition CD40161 counter composition, principle diagram as shown in Fig. 85.8. Square wave signal SIG IN get by Fig. 85.7 frequency tracking as the input signal, through the internal phase comparator and addition of points CD40161 counter for phase comparison frequency signal, and the control voltage IN internal pressure controlled oscillator VCO of input, the VCO output signal frequency f0 for input frequency fl 128 times. Get the output signal can be used to achieve 128 points per cycle of sampling control (Fig. 85.6).

Fig. 85.8 Current harmonic histogram



85.3 Conclusion

Power quality monitoring devices monitor the three-phase voltages, three-phase current of Dagushan transformer substation Anshan steel group. For a period of time, three phase voltage, three-phase current obtained the harmonic analysis. Calculation gets 2–50 times current harmonic voltage harmonic, containing rate, The results as shown in Figs. 85.7 and 85.8.

According to Fig. 85.7, obviously the result can be seen, an odd number of harmonic contains rate is higher than even higher harmonic contains rate, Among them, the 3, 5, 7, 9, 11, 13 time harmonic content is the most obvious,

According to Fig. 85.8 harmonic current in phase B is different of phase A and phase C. Obviously, there are serious power quality harmonic problem in phase B, Every harmonic current are abnormal state of affairs, circuit should be overhaul in time, found the problem and adopt corresponding measures to reduce the harmonic current. For example, some high-pass filter branch are installed near the harmonic sources to absorb harmonic current; Add static reactive compensation device or says dynamic reactive; From the power supply voltage, line impedance, and the load characteristics find unbalanced three-phase reason, to eliminate them.

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Chapter 86
Establishment of Dynamic Visualization Legend Library in the AutoCAD Environment Based on VBA

Hujun He, Yumei Yan, Cuixia Qu and Yaning Zhao

Abstract According to the existent problems of drawing legend in the production of mine-maps, analyzing on the establishment significance of dynamic visualization legend library, this paper puts forward the concept of dynamic visualization legend library, introduces design ideas, key technologies, and implementation process on the establishment of dynamic visualization mine-maps legend library adapting to mining actual situation in the AutoCAD environment using parametric design method on the basis of VBA language. The establishment of dynamic visualization mine-maps legend library is a relatively effective and feasible method on the basis of AutoCAD VBA, it helps to enhance the efficiency of drawing and ensures the quality of drawing, is worth to further promotion of study.

Keywords Dynamic visualization · Legend library · AutoCAD · VBA

86.1 Introduction

AutoCAD software package is one of the most popular general software package in the world, it has friendly interface, easy operation, quick mapping, high precision, and powerful function to win the praise of people, so it has been used in all

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_86,

walks of life. But AutoCAD as a common drawing system designed can not fully meet the specific requirements of each user. Therefore, customization and secondary development making AutoCAD system to meet the needs of different professional users are necessary. Visual basic for application (VBA) embedded in AutoCAD is secondary development programming languages which is fully object-oriented architecture, it has almost the same development environment and grammar with the VB, with a powerful and easy to learn, it resides in the main house for AutoCAD, so code efficiency is very high, VBA is the preferred language of the AutoCAD second development [1].

When making the mine-maps in order to facilitate reading for others, we often need with the legend, Although the legends are just some color, line work, patterns and symbols, and the corresponding text, they are very complicated disposing by AutoCAD, not only the quality of personnel and technical operations require a higher level, but also affect the drawing efficiency, and are difficult to ensure quality. Thus, standardized of the legends in accordance with the relevant provisions and the establishment of the dynamic visualization legend library are very helpful to improve the efficiency of the mine-maps drawing.

86.2 Dynamic Visualization Legend Library

Legend is a marker and a brief text description which represents various objects and characteristics such as text, patterns, colors and symbols, and other marks, etc. (as the age and color code, pattern and color of lithology, structural elements symbols, symbols and colors of mineral, and other geological phenomena symbol) in the map. Scientific and practical legend can not only improve the quality and practical value of the map, but can also simplify the mapping process, and improve the surface clear and beautiful, to make maps more scientific, practical, and artistic.

Dynamic visual legend library is a database storing and managing legend symbols, the library is to simply observe legend symbols, and it can not only call, retrieve legend symbols in the library under user requirements at any time, but also modify, update or add new symbols in the library. Development of dynamic visual illustration has mainly three purposes: First, the legend symbols can be categorized with the form of a digital atlas and stored in the computer system to realize the legend operations of the query, delete and other items. Second, the existing geological maps legends drawn norms embody in the legend library to make the legend library of geological maps become new standard of user computer-aided drawing. The third is to make the legend drawing and the legend storage organically combine into one, called the online management of the legend [2]. When the operator completes mapping work, the drawing legends now can be added to the legend library.

86.3 Designing Idea of Dynamic Visualization Legend Library

To achieve these goals, we carefully analyze the secondary development of AutoCAD system, and then consider that creating dynamic visual library can be true on the basis of AutoCAD VBA language. Therefore, based on the basis of AutoCAD 2006, we develop dynamic visualization legend library using VBA language, the implement idea of the legend library is as follows:

86.3.1 Storage Legend by Category

In order to conveniently query legend, legend in the legend library should be classified in storage. First, the legend should be classified to make each type of legend have a common feature, with a representative graph as representation of its features. The classification of mine-maps legend is based on mineral and geological professional characteristics and the role of different types of mine-maps in the mineral and geological production management [3, 4], the specific categories shown in Fig. 86.1. Legend should be the first major classification for making each type of legend has a common characteristic. For example, legend library can be divided into strata legend, rock legend, structure legend, exploration engineering legend, hydrogeology legend, etc. And further subdivision, for example, the rock pattern may continue being divided into magmatic rocks legend, metamorphic rocks legend, and sedimentary rocks legend. Construction legend may continue being divided into stratigraphic contact relationship legend, folds legend, and fracture legend, and so on.

86.3.2 Parametric Design of Legend Style

Legend design is right or wrong, which is not only related whether the central content of the maps is outstanding or not, but also directly affects that the quality of the geological outcome is good or bad. According to the requirements of maps

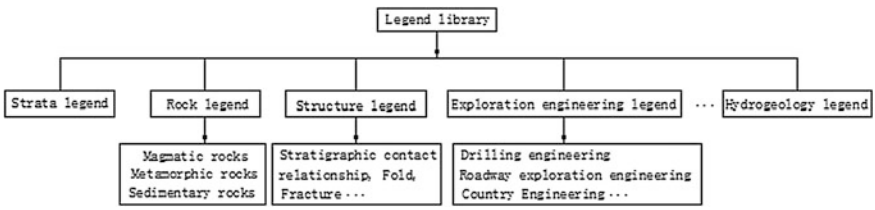

Fig. 86.1 Structure of mine-maps legend library

and the actual situations of drawings, through inputting the parameters (such as the order of legend, the row and column number of legend, the arrangement style of legend, etc.), we can achieve a reasonable layout of the legend.

86.3.3 A Simple, Standardized, Reasonable Design

Under these premise that legend design is in line with existing standards of international and local and combines with the special circumstances of mine, legend combination urges simple, clear, unified naming, and allowing users to glance [5].

86.4 Establishment of Dynamic Visualization Legend Library

86.4.1 Establishment of Legend Block File

First we draw the legend graphics under a certain proportion in the opening AutoCAD, then use the command WBLOCK to define graphics as common DWG legend file, and store it in the corresponding legend folder for the legend name. When drawing a legend, legend box provides specifications for the 12 × 8 mm, the size is 40 × 8 mm after including the back text. Too much text can be written in double lines of text. Coordinates at the left bottom of the legend box is (0,0).

86.4.2 Establishment of Visual Interface

Using visual programming environment of VBA, you can create VBA applications visual interface, When the program is running, users only need to open the legend file, and load the appropriate legend, and input the legend order parameter, you can draw the corresponding legend in AutoCAD. When the basic parameters change, the corresponding graphics have changed.

86.4.3 Legend Preview

To show thumbnails, you must add the AutoCAD DwgThumbnail Control in the form [6, 7]. The “Browse” button’s click event in the form is used to display the standard opening dialog box for accessing the user’s choice, and add the result of choice to the text box. The “List Box” click event in the form is used to displays the specified legend from the list box, while displays the legend thumbnails in the preview thumbnail control.

86.4.4 Design of Legend's Order and Arrangement

Because the size of the legend is relatively fixed, that is just for the different arrangement of the surface; we can fully use parametric design method to complete the layout of the legend in the surface. According to the requirements of maps and the actual situation of drawings, selecting the appropriate arrangement style of the legend, and inputting the parameters such as the row and column number and the interval of the legend etc., we accomplish the rational arrangement of the legend.

86.4.5 Expansion of Legend Library

In the process of adding the legends, if some legends are not found in the legend library, we can add the new symbols according to need. After selecting the "Save" button, it prompts the user for the block point and the name of the legend, and use WBLOCK method to export a DWG file which be saved the corresponding legend library file by the type.

86.5 Conclusions

Dynamic visualization legend library developed in AutoCAD environment using VBA can make the categorized legend symbols to be stored in the computer system in the form of a digital atlas, and according to users' requirements, it will achieve the legend's query, deletion and other items of entry operations, thus it can improve drawing efficiency, and ensure the quality of the drawing, so that is a more effective method and is worthy of further extensive research.

Acknowledgments This work is financially supported by the special fund for basic scientific research of central colleges (CHD2011JC111).

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Chapter 87
Component and Component-Based Software Development

Zhijian Wang, Zhang Chen and Jun Zhang

Abstract To improve software development efficiency, component-based software development method is investigated. The most important attributes of components are analyzed. Components are divided into two types as basic components and process components; key problems in component specification are presented. We also make a comparison between the component in component-based software development and the object in object-oriented environment, and give out some important items in component based software technology.

Keywords Software · Software development · Component

87.1 Introduction

Component-based development (CBD), or component-based software engineering (CBSE), is a reuse-based approach to define, implement components, and compose loosely coupled independent components into systems [1]. CBD is adopted more and more widely in evolutive system developing because it helps to reduce time for system development. By component reassembling and adjusting or by introducing new components for application, software developed is relatively easier to

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DOI: 10.1007/978-1-4471-4856-2_87,

satisfy system requirement modification, and problems met in object-oriented method seems to be overcome [2].

87.2 Component

Generally , an individual software component is a software package, a Web service, or a module that encapsulates a set of related functions or data. In fact the intension of software component is rather rich, there exists much different definition for it and there have been many confusing concepts. Researchers present different views of component from different angles and levels [2, 3]. In a general sense [4, 5], a component refers to a software unit with semantic integrity, they are grammatically correct and have reusable value [6], and they can be recognized clearly in software reuse process. In the standpoint of system structure, a component is the complex of semantic description, communication interfaces and actual codes.

In brief, a component is a program body with certain functions, which is able to work independently or can be assembled with other components in coordination. The use of components has nothing to do with its development or production process. From the level of abstraction, object-oriented technology has reached a class-level reuse, namely code reuse, class plays the role of encapsulation unit. But the scale of reuse granularity in object-oriented technology is still too small because it is not powerful enough to solve the problem of heterogeneous interoperability or to make software reusing more efficient. Component technology upgrades the degree of abstraction into a higher level. A component is a combination of a set of classes, represents the realization of one or more functionalities of a particular service, at the same time it provides users with multiple interfaces. Component definition hides the specific implementation and provides services using only interfaces.

The component model is an abstract description of the components' essential characteristics, and currently researchers internationally have formed a number of component models. Although the objectives and role of these models vary, these reached models separate the component interfaces and implementations effectively, provide the ability of component interact, thus increase the reusing opportunities, and adapt to the needs of large software systems development in the network environment.

87.3 Software Component Classification and Attributes

As an abstract concept, component is not limited to the collection of some methods or a set of business functions. According to their constituent, components can be divided into different granularity groups, they support reuse in different levels.

According to the size of component reuse granularity and concern difference between components, we divided components into process components and basic components.

Process components are reusable components with larger granularity, and such components aim to realize certain autonomous business functions. A process component usually consists of a set of basic components, business processes, user interfaces, and data model, provides relatively independent business functions. Basic components are those reusable components of the smaller granularity, and a basic component aims to complete some type of function and forms the basic elements of process components.

Generally speaking, these two types of components are treated as different types of software components, where each component is defined in a different level of granularity and from different perspectives of a component system.

For different types of components, following attributes should be stressed.

1. Components and their deformation must be able to work correctly, provide useful functions, easy to be understood and easy to be used;
2. Components should be easy to be configured with different parameters in different contexts, in different hardware, in different operating platform and software environment.
3. Components are substitutable, namely a component can replace another if the successor component meets the requirements of the initial component which are expressed via the interfaces. Consequently, components can be replaced with either an updated version or an alternative. If component B provides all what component A provided and uses no more than what component A used, then B can replace A.

Component technology is based on object-oriented technology, so component sometimes looks similar to object in an object-oriented design. They are all used for software reuse, and they are all encapsulated code, but component is not object and there exist great difference between them. First component can be with no inheritance as long as encapsulation should be insisted; Second component is a designing concept has nothing to do with specific programming languages, while object belongs to the concept of programming which is dependent on a specific programming language; finally, data in component are not allowed for direct manipulation while in an object such access operations are allowed.

87.4 Component Specification

Component specification is important for both component users and component developers. For users, the component specification provides a definition of the component interface, because the interface can be accessed, only by part users , the specification should be accurate and complete. For developers, the specification provides the abstract definition of a component's internal structure.

Component specification including component characteristics and component functions, component interface including the definition of part of the component specification and component behavior, a realization of component specification, the instance and the layout of component are all different representation of a component in its life cycle [7].

From the point of view from the component users, the most important feature of the component is that the component's interface and implementation are separated. This separation is different from the separation of declaration and implementation in a programming language or the separation of class definition and class implements in an object-oriented programming language. Component should be independent of its development cycle when be integrated into an application, and component applications updating do not require recompilation or re-connect. Furthermore, functions implemented in a component should only be obtained through its interface, which is particularly important for components published by a third party.

All above items require a complete specification for a component, including function interface, non-functional characteristics such as performance, resource requirements, etc. Component based technology nowadays can manage functional interfaces successfully, but it is not been satisfied with the management of the rest of component specification yet.

A component model is a definition of standards for component implementation, documentation and deployment. Examples of component models include Common Object Request Broker Architecture, COM+ model and so on. The component models specify how interfaces should be defined and elements should be included in an interface definition.

87.5 Component Based Software Technology

Component technology is the deepening of the object-oriented technology which achieve the reuse of software on the binary level and enhance the efficiency of software development. Based on component technology, software systems can be split into relatively independent components, data is exchanged through agreed interfaces, and information is transferred between components.

A component can be written in different languages as long as it meets a set of binary specification.

Following items should be paid attention to in component development:

1. Components obtainment: component production purposively, or extraction of components from the existing system.
2. Component model and component description language: component model reflects the relationship between components and essential characteristics of components, component description language provide accurate description for component model.

3. Component classification, retrieval and assembly: component classification strategy, organization strategy and search strategy, establishment of component library to manage components effectively. Components assembly is to research component assembly mechanisms on the basic of component model, including the run-level assembly and source-code-level assembly.

In a component-oriented software technology, an enterprise software system is represented as a component-based knowledge composition, components forms the basic unit to describe enterprise knowledge instead of many program codes. The basic business processes knowledge in a specific cooperation is often limited, and they are described as a number of components. With the continuous enrichment and completing of enterprise component library, flexible company knowledge systems can be realized relatively easily.

In essence, component can be the encapsulation and reuse of a variety of common knowledge and business knowledge, the component-oriented approach provide a way to record knowledge, namely to realize effective knowledge resources accumulation and reuse for human by component. In component-oriented systems, software production quality and knowledge are improved.

87.6 Conclusion

Component technology is the core technology of software reuse, it has been paid great attention to in recent years in order to obtain rapid development, and it has formed a branch of software engineering disciplinary. Software component technology research will inevitably lead to a change in the way of software production, which will greatly improve the software production efficiency and quality.

Acknowledgments The paper is supported by Natural Science Foundation of Guangdong Province (Grant No. S2011010001546 and 10151032001000003), Open Research Foundation of Guangdong Key Lab of Electronic Commerce (Grant No. 2011GDECOF05) and the Eleventh-Five Year Education Plan Project of Guangdong Province (Grant No. 2010tjk143). This paper is also supported by Innovative Team Project of Guangdong University of Business Studies.

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Chapter 88
Hierarchical Data Deduplication Technology Based on Bloom Filter Array

Jian Zhang, Shujuan Zhang, Yilin Lu, Xingyu Zhang and Shaochun Wu

Abstract In recent years, the data deduplication technology has become a research hotspot. In order to reduce the time and storage space requirements of deduplication technology, we propose a hierarchical deduplication approach which is based on file-level and block-level to eliminate redundant data, and introduce bloom filter (BF) to leach fingerprint to accelerate the search process. In order to further reduce the false positive rate of BF, the concept of bloom filter array (BFA) is applied. The performance results show that this strategy can effectively alleviate the pressure of storage and network transmission, raise the rate of data to be deleted and ensure higher data deduplication speed.

Keywords Hierarchy · BFA · Deduplication technology · Backup

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_88,

88.1 Introduction

In recent years, with the dramatic growth of Internet applications, data storage requirements increase substantially. Many industries provide the storage capacity from dozens of GB to hundreds of TB, even number of PB, so the backup system faces severe challenges [1]. The study found that up to 60 % of the data stored in the backup system is redundant; data deduplication in backup system has become a hot research topic. On the one hand, we use the technology to eliminate same file or block in the backup system to optimize the utilization of storage space; On the other hand we can reduce the amount of data in the network transmission, thereby reducing the energy consumption, network costs and saving network bandwidth for data replication [2]. The analysts believe that deduplication storage industry is one of the most important emerging technologies which will rewrite the economic rules of the storage industry.

This paper describes a hierarchical architecture based on bloom filter array (BFA) for data deduplication in backup system. In this architecture, we can eliminate data redundancy at file-level and chunk-level, and check for duplicate chunks by the bloom filter (BF). Thus the process of identifying duplicate data will be accelerated noticeably. Then we apply the concept of BFA to reduce the false positive rate of BF. The remainder of the paper is organized as follows. In Sect. 88.2, we describe the related research. Section 88.3 briefly presents the new framework of hierarchical eliminates the redundant in the backup system based on BFA. Section 88.4 presents the structural principle and performance analysis of BFA. Section 88.5 describes the experiment and analysis. We conclude this paper in Sect. 88.6.

88.2 Related Research

Tianming Yang and Dan Feng present a fingerprint-based backup method named FBBM [3] which avoids storing duplicate data in the backup system. FBBM adopts file-based backup strategy and uses anchors to divide a file into chunks. Each chunk is indexed by the hash value of its content, which called fingerprint of the chunk. The back-end storage server stores file chunks with write-once policy. Chunks are addressed by the fingerprint of their contents; this guarantees no reduplicate chunks were stored in the system and greatly increases the effective storage capacity of the server. 3DNBS [4] is a data deduplication disk-based network backup system. It also breaks files into variable sized chunks using content-defined chunking (CDC). Chunks may be shared by various files and a file is indexed by an index tree which is also stored as chunks in the storage server. Each chunk is prefixed by a chunk head which stores metadata (fingerprint, storage address, etc.) of the chunk. Meanwhile, a disk-resident hash table is used for global chunk indexing. Two different levels of caches are implemented in the storage server (SS) to speed up the backup process.

Researching on a clustering data deduplication mechanism based on BF [5]. They describe a clustering architecture with multiple nodes and all nodes can do the chunk-level data deduplication in parallel. Then they propose a new technique called "Fingerprint Summary". Each node keeps a compact summary of the chunks' fingerprints of every other node in its memory. When checking for duplicate chunks, each node queries its local chunk hash database and then the Fingerprint Summary if necessary to eliminate inter-node redundant chunks. In this paper, the simple principle is how to improve data deduplication rate and speed. Thus, we propose a hierarchical deduplication based on BFA strategy for the backup system.

88.3 System Architecture

Most of the traditional backup systems use file-level deduplication. This method computing speed is very quick and can detect all the identical files, but cannot detect the same data in different files. In order to save storage space as much as possible, without wasting too many resources, most of the researches or products use chunk-level policy to divide the file into variable sized chunks, and compute the hash of each chunk, then detect duplicate chunks by comparing the hash values of the chunks. This method divides file into block is very complicated, so computing cost is higher. In this paper, the proposed strategy can reduce more redundant data at a higher rate, and then the greater storage space saved.

To design this system, we aim at reducing time and space requirements of data deduplication. To achieve high effectiveness, we do two level data deduplication. First, we check for duplicate files and if there are no identical file fingerprints we perform chunk-level data deduplication. The proposed system also uses BFA to filter fingerprints to improve the search process. Figure 88.1 shows the architecture of the system. In this architecture, backup agent (BA) is a client program installed on the machine to be backed up. When backup a file, BA computes file or chunk's fingerprint and sent all fingerprints of the file to query model (QM) which then responses to BA by requesting file or chunks whose fingerprints not found in SS. QM consists of three parts: meta-data server (MDS) keeps the files' metadata information in SS, including file fingerprint, file name, file size, and all chunks' fingerprints corresponding to each file, BFA filters fingerprint and improve data deduplication performance. Index chunk (IC) including file index and chunk index. SS used to store the backup data.

During the system backup, data deduplication will be processed as followings.

1. BA reads the file *F*, and computes the hash value of *F* with SHA-1 algorithm. Then the file hash value (also called file fingerprint) is delivered to QM.
2. QA checks whether *F* is a duplicate file according to the MDS and BFA.
3. If *F* is a duplicate file, then it is discarded and adds a link to the pointer of *F* in the SS.

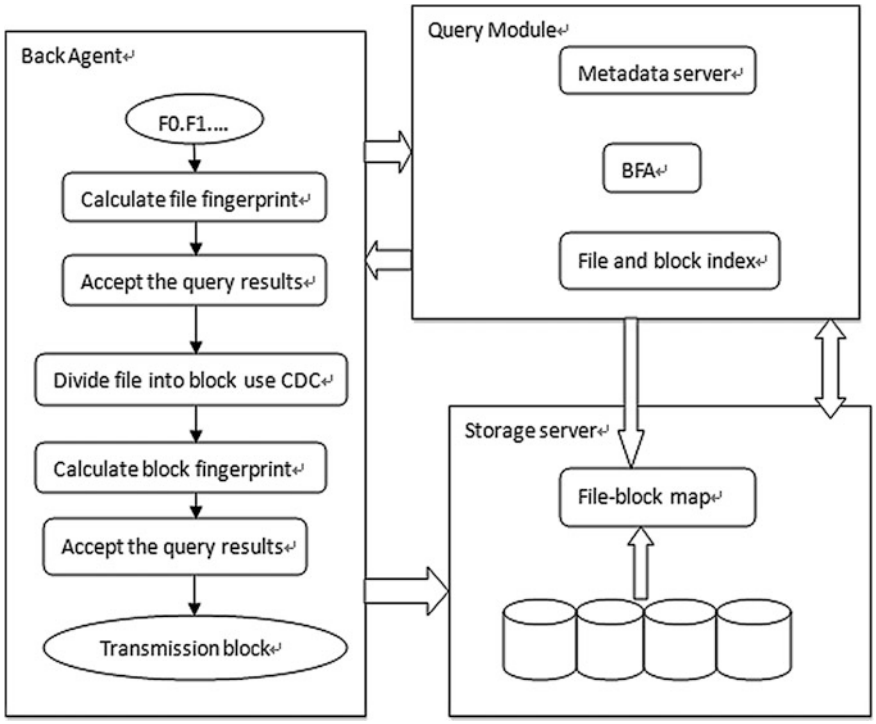

Fig. 88.1 System architecture

4. If not, BA partitions *F* into variable length chunks with CDC method, creates the hash value for every chunk of *F* with SHA-1 algorithm. Chunk fingerprints are delivered to QM.
5. QA checks duplicate chunks, then returns the fingerprints of duplicate chunks to BA. BA discards them and adds links to the pointer of duplicate chunks in the SS.
6. BA then transfers the new chunks to SS, adds chunk fingerprints to BFA.
7. Add fingerprint of *F* to BFA and modify MDS.

88.4 BFA Introduction and Performance Analysis

This paper uses BFA to speed up query process and to improve system performance. All fingerprints of files and chunks which is stored in SS are mapped to BFA, so we can rapidly judge whether a file or data chunk has been backed up to SS.

BF was proposed by Burton Bloom in 1970 [6], and it is a method for representing a set by a bit array to support membership queries. But when we determine

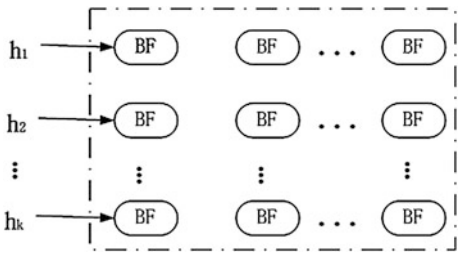

Fig. 88.2 BFA architecture

whether an element belongs to a set or not, we may consider an element not part of the set as the set' member mistakenly. This situation is called false positive.

Backup System requires high security. A number of problems will arise when recording the memberships of all the existing fingerprints using a single BF. First, if the potential number of fingerprints is underestimated, the false positive rate of BF will increase rapidly as the number of fingerprints exceeds the BF capacity, forcing a BF reconstruction. Second, every time a fingerprint is physically removed, resulting in the deletion of an element in BF, the whole BF must be rebuilt. Instead, we employ a BFA which is shown in Fig. 88.2.

Each BF of BFA is a bit array which contains m bits. The number of rows of BFA depends on the number of hash functions, for example if we use k hash functions, BFA' row is k. We divide fingerprints into j groups, so BFA' column is j.

Query fingerprint process is as shown.

1) According to the fingerprint range, determine to query the column.

Each BF of BFA is a bit array which contains m bits. The number of rows of BFA depends on the number of hash functions, for example if we use k hash functions, BFA' row is k. We divide fingerprints into j groups, so BFA' column is j.

Query fingerprint process is as shown.

1. According to the fingerprint range, determine to query the column.
2. Using k hash functions hash fingerprint value, respectively. Then it queries whether each BF in the column corresponding bit is 1.
3. If all corresponding bits are 1, the fingerprint is repeated. Otherwise it is not repeated.

For example, querying fingerprint f. First, according the range of f, we know should query every BF of j column. Second, we use H_1 to compute the hash value of f and query if the corresponding bit of BF_{1j} is 1, use H_2 to compute and query if the corresponding bit of BF_{2j} is 1. Then until use H_k to compute the hash value of f and query if the bit of BF_{kj} is 1. If all bits are 1, f is repeated; as long as there is a 0, f is not in the system.

In this structure, each fingerprint uses different hash function mapped to different BF, so it doesn't have a conflict of interference between different hash function. Even if the irrelevance between the hash functions is not strong, the

impact of the algorithm performance will not be great. In theory, BFA can help significantly reduce the false positive rate of the BF algorithm.

Set the number of random hash function for k, the bit array contains m bits and the elements of the set are n.

1. Elements are mapped to an array: when all elements in the collection are mapped to the array by k hash functions, the probability of one bit is 0 as follows:

$$P0 = (1 - 1/m)^{kn} \tag{88.1}$$

So the false positive rate is:

$$P = (1 - P0)^{\mathrm{k}} = \left(1 - (1 - 1/m)^{kn}\right)^{k} \tag{88.2}$$

2. Elements are mapped to BFA: when all elements in the collection are mapped to one BF of BFA by a hash function, the probability of one bit is 0 as follows:

$$P0' = (1 - 1/m)^{n1} \tag{88.3}$$

So the false positive rate of the whole algorithm is:

$$P' = \left(1 - (1 - 1/m)^{n1}\right)^{k} \tag{88.4}$$

Because n much larger than n_1, by comparison, P is far greater than P', that is the false positive rate of the traditional structure is much larger than BFA's. The algorithm of BFA can further reduce the false positive rate on the basis of the traditional structure, and thus meet the high security of the backup system' requirement.

88.5 Experiment and Analysis

Simulation steps are as follows. Clients randomly launch a certain amount of request of backup files within a time period. Experiments consider three cases. (1) The first case uses the whole file detection (WFD) technology. (2) The second case uses the CDC method. (3) The third case uses the Hierarchical data deduplication technology based on BFA which we proposed in this paper, we denoted by HD.

From Fig. 88.3, we can draw that the redundant data deduplication rates of HD when compared based on WFD algorithm improves 20–60 %, and it is basically the same with the CDC method. From Fig. 88.4, it is very clear that the eliminating

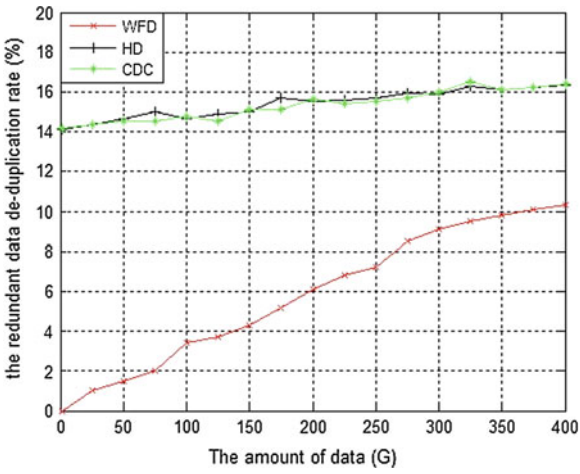

Fig. 88.3 The comparison of the redundant data deduplication rate

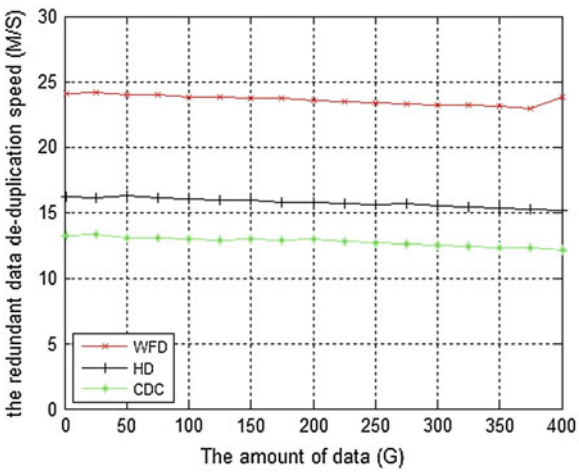

Fig. 88.4 The comparison of the redundant data deduplication speed

redundant data speed of HD is much higher than CDC method, but slightly lower than WFD algorithm. From the above analysis we can conclude that the Hierarchical data deduplication technology base on BFA were proposed not only has a high data deduplication rate but also a high speed.

88.6 Summary

This paper describes a hierarchical data deduplication mechanism which is based on BF. Data deduplication is first done at file-level, and then at chunk-level. Then the file is divided into several chunks and the fingerprint of each chunk is

computed. We use BF to leach the redundant files and chunks in order to accelerate the search process, apply the concept of BFA to reduce its false positive rate in order to meet the high demand of the Backup System on security. From the simulation results, it is concluded that this method can effectively complete the backup requirements and save more storage space.

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Chapter 89
Designing Key-Dependent *S*-Boxes Using Hyperchaotic Chen System

Jun Peng and Shangzhu Jin

Abstract The substitution box (*S*-box) is a very important component of block cryptosystem. In this paper a new method for designing cryptographically key-dependent *S*-boxes using a four-dimensional hyperchaotic Chen system is presented. The results of numerical analysis indicate that all the criteria such as bijection, nonlinearity, SAC, and BIC for designing strong *S*-boxes can be fulfilled, and the *S*-box's sensitivity to the secret key is also satisfied, showing that the proposed method is also suitable for designing block cipher with dynamic *S*-boxes.

Keywords Hyperchaotic chen system · Key-dependent *S*-box · Cryptosystem

89.1 Introduction

The ergodic, mixing, and random-like behavior of chaos, such as sensitivity to initial conditions and control parameters, are used in the design of cryptographic system. As we know, the substitution boxes (*S*-boxes) are core and only nonlinear component of block cryptosystems. Mathematically an *S*-box of size $n \times n$ is a nonlinear map defined as $S : \{0,1\}^n \rightarrow \{0,1\}^n$. Recent research shows that it is a promising direction to use chaos to design *S*-boxes. Tang and Liao et al. [1] presented a new method to obtain cryptographically strong dynamic *S*-boxes based on the iterating discretized chaotic map. Recently, Fatih [2] presented a new design methodology for *S*-Boxes based on continuous-time chaotic Lorenz system.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_89,

Very recently, Wang et al. [3] studied a novel method to design *S*-box using chaotic map and genetic algorithm, where the problem of constructing *S*-box was transformed to a Traveling Salesman Problem.

In this paper, a new method for generating cryptographically key-dependent *S*-boxes based on iterating a four-dimensional hyperchaotic chen system is presented. One of the main motivations for using hyperchaos is that we want to achieve a more sophisticated chaotic sequence to generate the *S*-box.

The remaining part of the paper is organized as follows. The several cryptographic properties that are required to design a "good" $n \times n$ bits *S*-box are first described. Then, a new method for generating key-dependent *S*-boxes is presented. Following that, theoretical analyses and simulation test are provided. Finally, conclusions are drawn.

89.2 Cryptograhic Properties of *S*-Boxes

In general, the following cryptographic properties are widely accepted as the essential properties for "good" *S*-boxes and can be used to evaluate the *S*-box.

89.2.1 Bijection Property

For an *S*-box, the following method is presented to check the bijective property [4]. The Boolean function $f(x) = (f_1, f_2, \ldots, f_n)$ is bijective if it satisfies

$$wt\left(\sum_{i=1}^{n} a_i f_i\right) = 2^{n-1} \tag{89.1}$$

where the $a_i \in \{0, 1\}$, $(a_1, a_2, \ldots, a_n) \neq (0, 0, \ldots, 0)$ and $wt(\cdot)$ is the Hamming weight. The above condition for the boolean function $f(x)$ to be bijective guarantees that any linear combination of f_i has Hamming weight $2^{n-1} (i = 1, 2, \ldots, n)$.

89.2.2 Strict Avalanche Criterion

An *S*-box is said to satisfy the SAC if, whenever a single input bit is complemented, each of the output bits should change with a probability of one half. In [5], the dependence matrix is constructed to ascertain whether a given *S*-box satisfies the strict avalanche criterion. It is expected that the mean value of the dependence matrix is close to 0.5 if the *S*-box satisfies the SAC, that is to say every element in dependence matrix must have a value close to one half.

89.2.3 Nonlinearity Property

The nonlinearity of the Boolean function $f(x)$ can be represented by the Walsh spectrum:

$$N_f = 2^{n-1}(1 - 2^{-n} \max_{\omega \in GF(2^n)} |S_{\langle f \rangle}(\omega)|) \tag{89.2}$$

The Walsh spectrum of $f(x)$ is defined by

$$S_{\langle f \rangle}(\omega) = \sum_{x \in GF(2^n)} (-1)^{f(x) \oplus x \cdot \omega} \tag{89.3}$$

where $\omega \in GF(2^n)$ and $x \cdot \omega$ denotes the dot-product of x and ω.

89.2.4 Output Bit Independence Criterion

This criterion for an *S*-box is first presented by Webster and Tavares [5]. It is another important property that should be satisfied. It means that all avalanche variable couples must be independent for the set of avalanche vectors generated by the inverse of the bits of a single plaintext [2]. Assume the boolean functions in the 8×8 *S*-box are $f_1, f_2, \ldots, f_8$. If f_j and f_k satisfy BIC, $F_i = f_j \oplus f_k$ $(j \neq k, 1 \leq j, k \leq 8)$ should also satisfy nonlinearity and SAC.

89.3 The Method of Designing *S*-Boxes

89.3.1 Hyperchaotic Chen System

Compared with the simple chaotic map, a hyperchaotic system has stronger spatiotemporal complexity and mixture property because of having more than one positive Lyapunov exponent. The inherent merits of hyperchaos form the solid theoretical foundation for excellent *S*-boxes construction.

Research results in [6, 7] indicate that Chen system is a three-order system which can be easily implemented by circuits, and has better three-dimensional dynamical properties in phase space than Lorenz system and Chua's system. Chen system is described by the following system of differential equations [8]:

$$\begin{cases} \dot{x} = a(y - x), \\ \dot{y} = (b - a)x - xz + by, \\ \dot{z} = xy - cz. \end{cases} \tag{89.4}$$

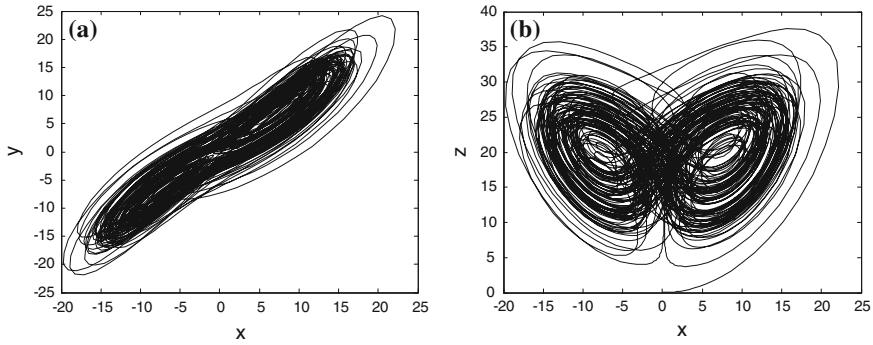

Fig. 89.1 Hyperchaotic attractor of the Chen system on **a** x-y plane **b** x-z plane, respectively

where (x, y, z) are the state variables, and (a, b, c) are control parameters, and when $a = 35$, $b = 28$, $c = 3$, the system is chaotic. By introducing a nonlinear feedback controller to the first equation of system (89.4), the following hyperchaotic system (89.5) is obtained:

$$\begin{cases} \dot{x} = a(y - x) + u, \\ \dot{y} = dx - xz + by, \\ \dot{z} = xy - cz, \\ \dot{u} = yz + ru. \end{cases} \tag{89.5}$$

where (x, y, z, u) are the state variables, and (a, b, c, d, r) are control parameters. When $a = 35$, $b = 12$, $c = 3$, $d = 7$, $0 \leq r \leq 0.085$, the system (89.5) is chaotic, and when $a = 35$, $b = 12$, $c = 3$, $d = 7$, $0.085 < r < 0.798$, the system (89.5) is hyperchaotic. In [9], the author show that system (89.5) has a hyperchaotic attractor with two positive Lyapunov exponents $\lambda_1 = 0.56$, $\lambda_2 = 0.11$ (the other two are $\lambda_3 = 0$ and $\lambda_4 = -26.17$) when $a = 35$, $b = 12$, $c = 3$, $d = 7$, $r = 0.5$. The hyperchaotic attractors with initial conditions (0.02, 0.02, 0.02, 0.02) are shown in Fig. 89.1a, b. The results show that system (89.5) has a strong ability of generating complex hyperchaotic attractors via some simple control inputs.

89.3.2 Description of Designing Key-Dependent 8 × 8 S-Boxes

In this section, we present an approach to construct 8×8 S-box with a 64-bits key. First, the secret key is mapped to the initial condition and control parameter of the hyperchaotic system (89.5); second, iterate the system (89.5) is to generate a hyperchaotic sequence which is subsequently used to construct the S-box. In the system (89.5), we make sure that parameter r is located within $(0.085, 0.798)$ to obtain hyperchaotic sequences. The detail description of designing S-box is as follows:

Step 1. Randomly given a 64-bits key $K = K_1K_2 \ldots K_8$, calculate the following initial condition (x_0, y_0, z_0, u_0) and parameter r of the system (89.5):

$$x_0 = \frac{K_1^{\leq g} \oplus K_2^{\leq g}}{256},\ y_0 = \frac{K_3^{\leq g} \oplus K_4^{\leq g}}{256},\ z_0 = \frac{K_5^{\leq g} \oplus K_6^{\leq g}}{256},\ u_0 = \frac{K_7^{\leq g} \oplus K_8^{\leq g}}{256} \tag{89.6}$$

$$r = d_1 + \frac{(K_1 \oplus K_2 \oplus K_3 \oplus K_4)^{\leq g} \oplus (K_5 \oplus K_6 \oplus K_7 \oplus K_8)^{\leq g} \cdot (d_2 - d_1)}{256} \tag{89.7}$$

where $d_1 = 0.085$, $d_2 = 0.798$, $g = (K_1 + K_2 + \cdots + K_8) \bmod 8$, and symbol $W^{\leq g}$ means cyclic left-shift by g bits of W. Besides, the iteration times of the system (89.5) from the initial value is defined as follow:

$$N = [(K_1 + K_2 + \cdots + K_8)\, mod\, 256]^{\leq g} \tag{89.8}$$

Step 2. Define an integer array S with no items in its initial state.

Step 3. Iterate the system (89.5) for N times from the initial value (x_0, y_0, z_0, u_0) by using fourth-order Runge–Kutta methods. Here, to avoid the transient effect, the first 50 iterations are considered.

Step 4. Assume (x_N, y_N, z_N, u_N) denotes the N-th iteration value of the system (89.5), and let $S^* = \text{floor}(x_N^2 + y_N^2 + z_N^2 + u_N^2) \bmod 256$.

Step 5. If S^* is not in the S, add S^* into S. If S has 256 items, translate S into 8×8 S-box and the process is finished. Otherwise, let (x_N, y_N, z_N, u_N) act as new initial value (x_0, y_0, z_0, u_0) and repeat *Step* 3 to *Step* 5.

As we know, chaotic system (89.5) is extremely sensitive to the initial values and control parameters which are determined by the secret key. Hence, a lot of completely different S-boxes can be generated with a tiny change in the secret key.

89.4 Properties Analysis of the *S*-Boxes

In this section, we construct a key-dependent S-box with a random key1 "J7DyC3a8". According to the algorithm described in above section, an 8×8 S-box is generated and shown in Table 89.1. Then, we randomly select 200 different keys to obtain 200 S-boxes and the properties test results are as follows:

1. All the S-boxes are bijective.

2. Maximum, Minimum, and Average nonlinearity of the S-boxes is 108, 94, and 103.36, respectively (see Fig. 89.2). Especially, 91.50 % of the S-boxes whose nonlinearity are among [100, 108], only 0.50 % are among [94, 95], indicating that most of the S-boxes have a high nonlinearity property.

3. The dependence matrix of the S-box in Table 89.1 is calculated by using the method proposed in [5] and shown in the following, the mean value is 0.5000.

Table 89.1 An 8 × 8 *S*-box generated by proposed algorithm with key1 "J7DyC3a8"

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0	209	115	61	165	42	147	145	194	132	242	123	188	196	218	77	8
1	73	220	118	17	171	206	180	140	138	129	199	69	25	34	148	175
2	28	238	16	185	19	215	198	187	32	107	232	10	253	105	85	201
3	18	205	247	130	114	38	71	231	227	106	210	136	120	97	181	15
4	245	95	99	116	225	141	104	255	248	249	135	134	219	87	79	142
5	35	158	202	207	193	62	168	83	88	41	128	252	53	170	183	212
6	240	101	43	57	55	251	229	144	146	216	161	3	137	67	46	152
7	125	81	234	12	217	143	211	7	166	204	27	72	47	33	213	163
8	36	241	29	89	92	102	113	177	208	236	76	139	254	64	246	44
9	56	109	78	31	98	40	149	133	11	164	122	1	80	117	159	178
a	63	86	21	200	94	24	22	75	173	131	160	243	222	26	214	23
b	153	103	58	179	162	156	51	189	37	119	203	167	54	226	182	223
c	100	190	186	13	124	96	169	110	111	52	2	157	224	49	50	126
d	93	74	45	174	150	59	228	191	5	155	108	84	68	239	82	237
e	192	90	4	195	30	9	127	65	39	112	250	230	14	221	91	176
f	172	184	20	48	235	121	60	197	244	66	154	70	233	151	0	6

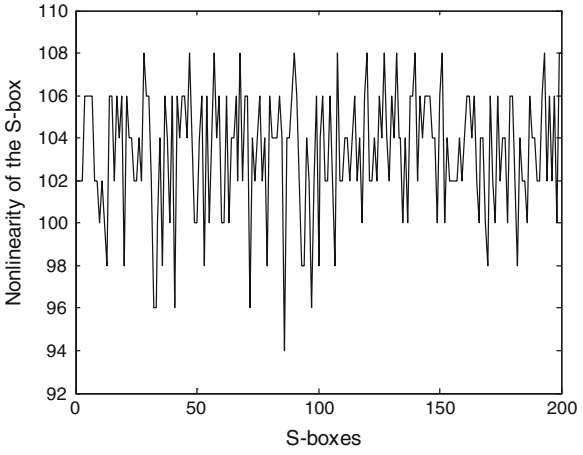

Fig. 89.2 The nonlinearity of the *S*-boxes

$$\begin{bmatrix}
0.5313 & 0.4219 & 0.4531 & 0.5469 & 0.5469 & 0.5313 & 0.5469 & 0.4844 \\
0.5156 & 0.4844 & 0.5469 & 0.5313 & 0.4531 & 0.4688 & 0.4375 & 0.4219 \\
0.5313 & 0.4531 & 0.5781 & 0.5781 & 0.4844 & 0.4688 & 0.4375 & 0.4219 \\
0.5313 & 0.5000 & 0.5000 & 0.4844 & 0.5938 & 0.4531 & 0.4688 & 0.5781 \\
0.4688 & 0.5313 & 0.5156 & 0.4688 & 0.4219 & 0.5156 & 0.5469 & 0.5156 \\
0.4844 & 0.5000 & 0.4375 & 0.4688 & 0.4688 & 0.3906 & 0.5313 & 0.5625 \\
0.4219 & 0.4844 & 0.4688 & 0.4844 & 0.5156 & 0.5625 & 0.4219 & 0.5469 \\
0.5781 & 0.5156 & 0.5000 & 0.4375 & 0.3906 & 0.5781 & 0.5469 & 0.5000
\end{bmatrix}$$

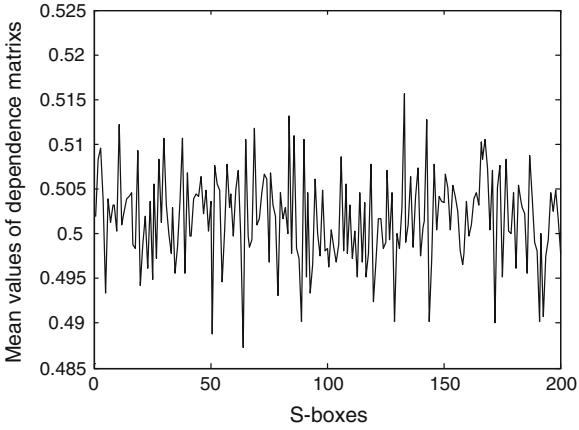

Fig. 89.3 The mean values of dependence matrix of *S*-boxes

Table 89.2 Another 8 × 8 *S*-box generated by proposed algorithm with key2 "J7EyC3a8"

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0	64	187	215	206	235	50	231	224	65	182	203	165	202	94	229	218
1	8	194	41	169	54	222	5	57	162	78	183	96	26	157	11	152
2	25	12	18	120	111	161	38	28	10	213	253	198	155	237	128	4
3	52	71	37	217	153	84	190	56	109	46	251	241	142	134	24	135
4	204	112	23	167	99	66	186	133	101	119	90	158	108	31	80	47
5	160	171	79	239	197	139	9	20	92	143	227	179	245	196	148	48
6	236	35	22	21	184	49	6	2	87	180	75	246	113	212	189	136
7	19	221	105	255	40	207	129	76	201	209	104	122	121	228	45	233
8	141	17	83	89	1	130	70	44	200	192	85	34	42	98	145	68
9	230	63	14	116	100	72	74	30	82	58	205	117	81	240	238	138
a	164	59	247	244	107	73	33	149	7	124	159	140	53	243	29	193
b	32	234	36	77	168	3	214	242	150	39	126	144	51	188	60	137
c	15	211	43	185	93	125	170	225	208	88	55	216	106	178	210	0
d	146	118	156	163	110	191	254	173	114	115	132	62	27	86	250	69
e	195	176	219	181	95	127	175	102	61	123	252	177	174	97	248	151
f	226	223	166	154	13	199	103	232	249	67	91	147	172	220	16	131

We found that all the mean values of the dependence matrixes of 200 *S*-boxes are located within [0.48, 0.52] (see Fig. 89.3), which are close to the ideal value 0.5, indicating that all the *S*-boxes have excellent SAC property.

4. The mean values of nonlinearities of $f_j \oplus f_k$ are greater than 100 and the mean value of dependence matrixes of $f_j \oplus f_k$ are close to 0.5, indicating that all the *S*-boxes approximately fulfill the requirement of BIC property.

5. The correlation coefficients between the *S*-boxes with key1 and key2 are calculated. We can use this to investigate the *S*-box's sensitivity to the secret keys. In here, key1 is set to "J7DyC3a8" and key2 is set to "J7EyC3a8", where only '*D*'

of key1 is changed to '*E*'. The *S*-boxes generated by key1 and key2 are shown in Tables 89.1 and 89.2, respectively, and the correlation coefficient between them is 0.0120, indicating that the *S*-boxes are very sensitive to the keys. Furthermore, the key space of the algorithm is 2^{64}, which is large enough to against the brute-force attack to a great extent.

89.5 Conclusions

In this paper, a new method for generating cryptographically key-dependent *S*-boxes based on hyperchaotic Chen system is presented. The results of numerical analysis on these *S*-boxes obtained by the proposed algorithm have shown that all the cryptographic properties for a strong *S*-box are approximately fulfilled, and the *S*-box's sensitivity to the secret key is also satisfied. Furthermore, since a great deal of *S*-boxes can be obtained easily by our method, it is also suitable for designing block cipher with dynamic *S*-boxes.

Acknowledgments The work described in this paper was supported by the Natural Science Foundation Project of CQ CSTC under Grant No. 2010BB2284; the First Batch of Supporting Program for University Excellent Talents in Chongqing; and Research Project of Chongqing University of Science and Technology under Grant No. CK2011Z17. The authors would like to thank the anonymous reviewers for their valuable suggestions.

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Chapter 90
Designing and Implementation of a RFID-Based VIP Customer Service Information Management System

Zhe Ruan and Aihua Dong

Abstract This paper proposes a VIP Customer Service Information Management (VCSIM) system in a clothing retail store based on RFID technology. In the VCSIM system, the VIP customer is identified when she entering the shop through the RFID tag embedded in her VIP card. The hardware equipment and backstage database in the VCSIM system are illustrated in this paper. It then analyzes the VIP customers' information acquisition and information management functions in the system. Particularly, the realization of automatic customer salutation method using the RFID technology is designed. The proposed RFID-based VCSIM system helps to break away from the traditional mode of "purposeless purchase guide" and avails the customers to experience targeted service with intellectualization and personalization.

Keywords RFID technology · Clothing retail store · Automatic customer salutation · Information acquisition · Information management

90.1 Introduction

With the rapid development of the integration of the world economy, growing demand of clothing consumption and increasingly fierce competition, more and more enterprises have realized that the traditional retail mode could not bring the

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_90,

new benefit growth for own enterprise. In order to have a good hand in the business circle and cater to consumers, each company has been looking for the production, sales and after-sales service mode changes for satisfying the demands of consumers. More and more enterprises have realized the advantage of clothing information management [1].

At the same time, with 30 years of theoretical research and development, radiofrequency identification (RFID) technology has been a new focus of attention in clothing retail industry. The so-called RFID, namely wireless radiofrequency technology, is a noncontact automatic identification technology. No contact can achieve a goal that is automatic target recognition and reads the relevant data through the radiofrequency signal. RFID has realized the noncontact two-way communication, which can support read only work pattern, also can support reading and writing work pattern. It has solved the problem of passive and non-contact, which is a breakthrough in automatic identification field [2]. Therefore, RFID technology application in the clothing retail industry has a greater valuable significance [3–6].

This paper designs a VIP Customer Service Information Management (VCSIM) system in a clothing retail store based on RFID technology. The software is developed with SQL Server 2005 and Microsoft Visual Studio 2005. It realizes the RFID hardware equipment and backstage database communication. In the VCSIM system, the VIP customer is identified when she entering the shop through the RFID tag embedded in her VIP card. In this way, automatic customer salutation, customer information acquisition as well as information management are implemented. The proposed VCSIM system could not only improve the service to the customers but also bring benefits to the clothing retail store.

The rest part of the paper is organized as follows: Part 2 illustrates the frameworks of the proposed VCSIM system. Part 2 defines the function of the VCSIM system. Part 4 introduces the software design of the system. Part 5 designs the algorithms for VIP customer automatic salutation and solves the problem for multiple tags collisions. Part 6 draws the conclusion of the research.

90.2 System Frameworks

The proposed VCSIM system is designed in Client/Server architecture. The software is developed using SQL Server 2005 and VC#. The RFID hardware of the system in UHF frequency named QR4401 are supported from Shanghai Quanray Electronics technology Co., LTD. Figure 90.1 illustrates the layout of the VCSIM system.

In Fig. 90.1, every computer is linked with database server group together in retail store. When the VIP customers come into the clothing retail store, the tag embedded in their VIP cards are trigged. Once the RFID antennas receive the trigged signal, the basic information of the membership card will show in the management center computer as well as the surrounding LED screen. The VIP

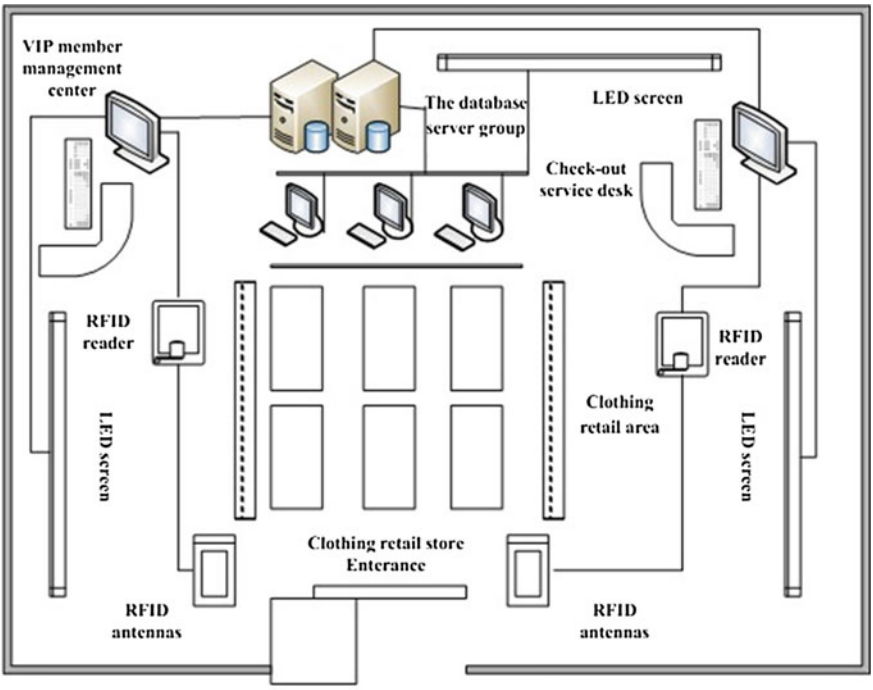

Fig. 90.1 Layout of the VCSIM system

customer is therefore automatic welcomed. At the same time, the clerk can complete the VIP customer information management and maintenance using the management center computer.

90.3 System Function

The VCSIM system could implement the function of customer information collection, management, and maintenance.

90.3.1 Automatic Customer Salutation and Information Acquisition Function

VIP customer is recognized using the RFID technology. When the VIP customers come into the clothing retail store, the tag embedded in their VIP cards are trigged. When customers come into the shop, RFID antennas receive signal, RFID readers can read the portable electronic label information of VIP customers at the gate of

store, all customer information (the name, sex, age, occupation, consumption history, and so on) will be displayed on the surrounding LED screen. The VIP customer is thus automatic welcomed.

90.3.2 VIP Customers Information Management and Maintenance Function

Information management mainly includes VIP member checking out, the membership card management and the basic information management and other functions. The membership card management center can register, update, and delete relevant information for VIP card. The date of routine attention will update to the database server. Also, for VIP card, the system can realize basic discount set according to each member of the total consumption and make VIP enjoy preferential price.

90.4 Systems Software Design

90.4.1 System Software Development Principle

The development of the system interface mainly uses VC#.net language. VC#.net adopts event driven mechanism, has the visualization development environment and the object-oriented program properties, but also it has rich data types and class libraries, at the same time, it can provide a powerful ability of database accessing. Furthermore, the system adopts the way of ADO.NET with the backend database connection. The main technical characteristic of ADO.NET is that it supports disconnected model. It completes this function by two core components (Data Set and Data Provider) [3]. Data Set object is used to save database data in memory. The function of Data Provider is to establish the connection of the Data Set and database, to keep the consistency of the data, and then to manipulate the data by executing SQL commands or storage process [4].

90.4.2 The Development Principle of Backend Database

The database design is the key to the whole system. It needs the system requirement analysis, concept design, database design, relationship model design, integrity and binding design, and internal trigger design. As shown in Fig. 90.2, system data source comes from the basic information of VIP members and goods, it will produce membership information table, in-store members table, sell goods table, commodity information table, and consumption history table, etc. In the logic of the database design, the patterning relationship is given.

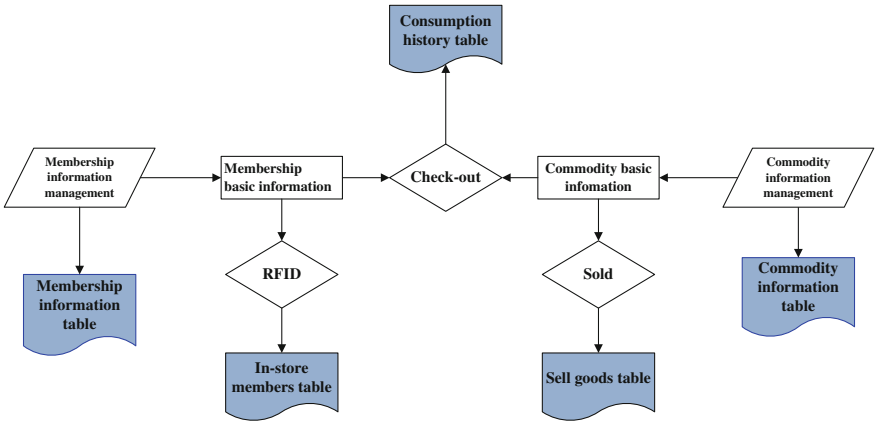

Fig. 90.2 Data flow diagram in VCSIM system

Member consumption history view is made of Customer table, Consumption_ History table, and Item Sold table, which shows members detailed history consumption records; However, member discount view is mapped by Customer table, Consumption_ History table, Item Sold table, and Discount table, which shows all members information including their basic information, the membership card discount, consumption amount, and consumption history.

90.5 System Hardware Configuration and the Realization of Automatic Customer Salutation

90.5.1 Working Principle of RFID Equipment for Reading and Writing

This system has accomplished the work of reading EPC labels mainly through RFID readers. When the initial work completed, it waits for the upper computer instruction then executes the next action of EPC work. RFID readers' initialization mainly includes the basic configuration of RFID readers, such as the configuration of antenna and power. Figure 90.3 shows the flow chart when RFID readers receive the upper computer instructions and its response.

90.5.2 Collision Detection Algorithm of RFID Reader

Figure 90.4 illustrates collision detection algorithm of RFID reader. The algorithm procedures will send equipment power, the way of labels reading, antenna tag number within the scope of the cover, number of the tag antenna and other

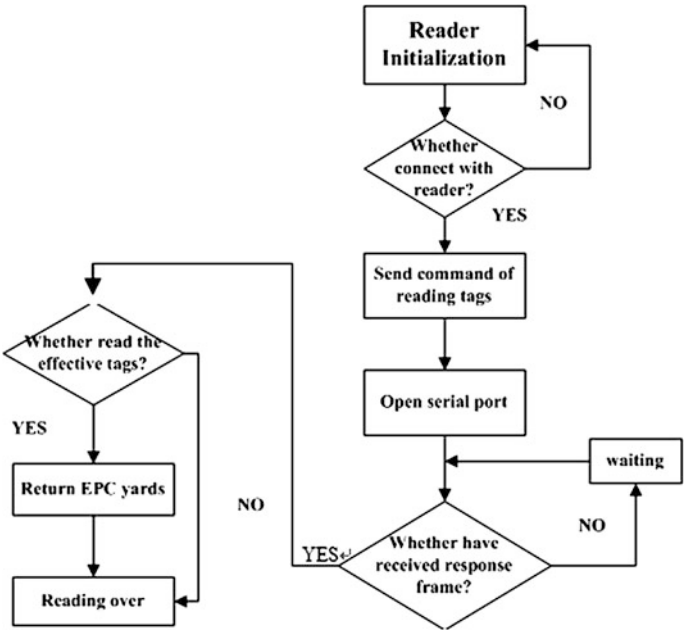

Fig. 90.3 RFID readers working flow

parameters in the command frame. To response the frame, reader will detect the correction of commands execution, get the number of EPC yards, and obtain the antenna number, length of EPC, EPC yards, and other information [5]. Once a full detection process is completed, it will automatically jump into the next command frame sending status.

Since RFID readers can periodically detect RFID tags and the cycle of the read and write is quite short, it may read the same tags repeatedly in a very short time. In order to eliminate the wrong judgment on whether a customer is in or off the store, a collision detection algorithm is designed. If same tags are read repeatedly in 30 s, the system would not carry out any operation. Otherwise, it will further judge whether the customer is still in the store or be away from the store according to the contents of the database.

90.5.3 Solution to Automatic Customer Salutation

When the VIP member enters into the shop, the tag in her VIP member card is read. Then the software will call VIP member basic information database to read in-store member table in which the basic information of all customer are stored. This information includes membership card number, ID number, name, gender, birthday, telephone, E-mail, etc. At the same time, system can read the in-store

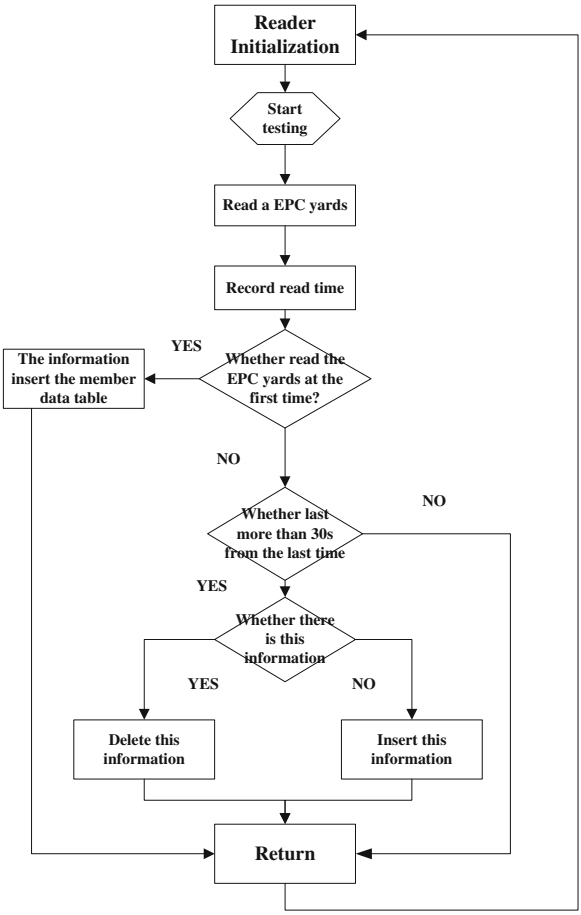

Fig. 90.4 Collision detection algorithm

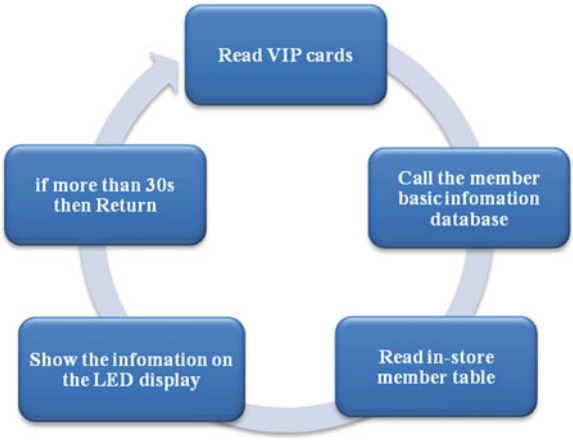

Fig. 90.5 Automatic customer salutation solution

member table, information will be shown around the LED display on both sides. If it is more than 30 s, it will return to detect, circulation the above process as Fig. 90.5 shows.

When more than one customer come into the store, RFID reader will read these customers' information, which shows on both sides of the LED screen in turn. The multielectronic tag collision is solved in system hardware.

90.6 Conclusion

This paper proposes a VCSIM system based on RFID technology in a clothing retail store. It makes clothing retail store more intelligent and provides higher level service to the VIP customers by completing information acquisition, information management, and information maintenance functions. One of the further directions is to embed experts recommend module into the system so as to achieve recommending function for the VIP customers form the view of experts.

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Chapter 91
A Solution of Traffic Problems Based on MapReduce

Yuanhao Wang, Pan Chen, Lei Cheng and Hui Tong

Abstract With the number of cars increasing sharply, traffic becomes a big problem in our daily life. We may think of solving the problem by analyzing the global position system (GPS) data got from cars, but another problem arises, that is, how we can analyze the large-scale data set. The MapReduce programming model is inspired by Google and targets data-intensive parallel computations. This paper presents the results of the situations of several roads at different time and the trends of traffic in each road, after analyzing the huge database by taking a modified velocity–time integration we proposed and run on the MapReduce parallel model. The experiment results show that the algorithm is effective and efficient and the model is efficient to handle with large-scale data set.

Keywords MapReduce · Parallel computation · Traffic problems · GPS · Modified velocity–time model

91.1 Introduction

With the explosion of urbanization throughout the country, a sharply increasing number of cars are shuttling in cities every day and night. However, what comes with the urbanization is traffic jams, and the problem becomes more and more

This research was jointly supported by the Research Innovation Fund for College Student and the School of Science of Beijing University of Posts and Telecommunications, P. R. China.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_91,

obvious and serious. It becomes a problem as how to achieve the velocity of cars in specified roads, which is considered seriously by not only the government, but also our fellow citizens as a reference to solving the traffic jams, car dispatch, emergency evacuation, and other matters in business with traffic and dispatch [1].

In a long period of time, theoretical research and practical application mainly rely on the data collected in the specified road to estimate the average velocity, but the error is obvious and huge. Thanks to the innovation on vehicle identification recent years, global position system (GPS) are installed in urban areas, and the GPS data is easy to be achieved from the scheduling and information service platform. That is to say, we can now make use of those GPS data to estimate the traffic flow efficiently, and this may concern a velocity–time integration model. On the basis of the solution, we consider the practical traffic problem existing in our realistic society and the masses of the GPS data, and take the MapReduce model to deal with that hot potato, and it can easily take care of the billions of record, and is of high efficiency and powerful fault tolerant capability[2].

We will discuss the modified velocity–time integration model, and then verify it in the GPS data of Shenzhen City we collect by using the MapReduce. And then analyze the result and try to find some advantages and disadvantages in our model.

91.2 Modified Velocity–Time Integration Model

Affected by the occasional shield by towers or from the satellite, items related with speed in the GPS data may sometimes switch to zero. But this kind of distortion was not considered in the former speed-time integration model yet. The result is not reasonable.

Coming up with a specific model to analyze those zeros in the speed record of GPS data is one of the crucial parts in the project. True zeros happened when the taxi stops or travels at low speed, while the mistaken ones may emerge due to other indeterminate factors. We can easily eliminate the mistaken zeros as long as we have distinguished each specific state of the taxi already [1–4].

GPS positioning and velocity are of different significance in the basic theory, and the two matters have no direct contact as well. We use features of the position in the GPS data to determine zeros, and improve the precision of the model of the modified speed-time integration model by eliminating the mistaken zeros. The determination is as following:

1. Put in the GPS coordinate point, then begin to judge whether there are more than one fixed positions available before. If yes, go forward to step 2; else, turn to step 6;
2. If the previous GPS coordinate point was already in a stopped state, go forward to step 3; else, turn to step 4;

3. Calculate the distance d_{stop} between the position of current GPS coordinate point and the starting one's. If Eq. (91.1) turn out to be right, which means the car is still stopped, go forward to step 6; else, turn to step 5;

$$d_{\text{stop}} < \text{ce} \tag{91.1}$$

In the mathematical formula, e stands for positioning error; c stands for adjustment coefficient, generally values 2.5.

4. Calculate the largest distance d_{stop} between the position of current GPS coordinate point and the former two points. If formula (91.2) turn out to be right, which means the car is still stopped, go forward to step 6; else, turn to step 5;

$$d_{\max} < \text{ce} \tag{91.2}$$

5. Judge whether the instantaneous velocity of the current GPS coordinate point values zero. If yes, it means they were distortion data and eliminate them then turn to step 6; else, directly go forward to step 6;
6. If the signal of the GPS coordinate point disappears less than 30 min, turn back to step 1; else, the program will pause till the next GPS coordinate point turns out.

We suppose that the taxi runs at a steady speed in the appointed road which we select in the map by GPS with the help of Google Map. After eliminating the mistaken, the effectual data of a single taxi in the road is as follows. The operating range of the taxi among $P_0 \rightarrow P_k$ can be calculated by the modified velocity–time model in this formula [4, 5] .

Position	P_i	$i = 0, 1..k$
the record time	t_i	$i = 0, 1..k$
the instantaneous velocity	v_i	$i = 0, 1..k$

The operating range of the taxi among $P_0 \rightarrow P_k$ can be calculated by the modified velocity–time model in this formula.

$$d_{\text{tra}} = \int_{t_o}^{t_k} \text{vdt} \approx v_0\left(\frac{t_1 - t_0}{2}\right) + \sum_{i=1}^{k-1} \frac{v_i(t_{i+1} - t_{i-1})}{2} + \frac{v_k(t_k - t_{k-1})}{2} \qquad i = 1, 2, \ldots, k-1, k \tag{91.3}$$

However, if the fixed GPS sample interval, $t_{\text{int}}$the formula (91.3) can be simplified as this:

$$d_{\text{tra}} = t_{\text{int}}\left(\frac{v_0}{2} + \sum_{i=1}^{k-1} v_i + \frac{v_k}{2}\right) \tag{91.4}$$

The velocity of a single taxi in the whole road, v_{ind} and the average velocity of the taxis in the road, v_{ave} can be calculated by these two formulas.

$$v_{\text{ind}} = \frac{d_{\text{tra}}}{t_k - t_0} \tag{91.5}$$

$$v_{\text{ave}} = \frac{1}{n}\sum_{j=1}^{n} v_{\text{indj}} \tag{91.6}$$

$j = 1, 2,\ldots,n$, n is the number of the taxis on the road at the sampling time.

91.3 Simulation

Jeffery Dean designs an abstract model called MapReduce, aiming to work on problems with huge numerous datasets. It requires several basic steps: to write down applications, then parallelization, fault-tolerance, data distribution, and load balancing. All miscellaneous matters will be well taken into consideration.

91.3.1 The Model of MapReduce

MapReduce is a framework for processing highly distributable problems across huge datasets using a large number of computers (nodes), collectively referred to as a cluster (if all nodes use the same hardware) or a grid (if the nodes use different hardware). Computational processing can occur on data stored either in a file-system (unstructured) or in a database (structured) [6].

"Map" step The master node takes the input, divides it into smaller subproblems, and distributes them to worker nodes. A worker node may do this again in turn, leading to a multilevel tree structure. The worker node processes the smaller problem, and passes the answer back to its master node.

"Reduce" step The master node then collects the answers to all the subproblems and combines them in some way to form the output—the answer to the problem it was originally trying to solve.

MapReduce allows for distributed processing of the map and reduction operations. Provided each mapping operation is independent of the others, all maps can be performed in parallel—though in practice it is limited by the number of independent data sources and/or the number of CPUs near each source. Similarly, a set of 'reducers' can perform the reduction phase—provided all outputs of the map operation that share the same key are presented to the same reducer at the same time. While this process can often appear inefficient compared to algorithms that are more sequential, MapReduce can be applied to significantly larger datasets than "commodity" servers can handle—a large server farm can use MapReduce to sort a pet byte of data in only a few hours. The parallelism also offers some possibility of recovering from partial failure of servers or storage during the operation: If one mapper or reducer fails, the work can be rescheduled—assuming the input data is still available [5, 7–11].

Table 91.1 Clusters made up by these computers

Type of PC	CPU	Memory	Hard disk
Lenovo Y460	Intel i3 380 M	2G DDR3	500 GB
Lenovo M4300	Intel E4200	4G DDR2	320 GB
Lenovo M4300"	Intel E4200	4G DDR2	320 GB

91.3.2 Calculation Process

The form of our data is time\GPS data\status\velocity. First, we need to extract GPS data from the 12 GB datasets and deliver specific task to each core of the computers in out cluster, while we do not change other messages in the "Map" step. And next, we come to the "Reduce" step. Sending massages of GPS data on the specific road we choose to the cluster in the "Map" step, then based on that, we could select useful data. Deliver tasks to each core again and combine the modified velocity–time integration model. Then we can get the average velocity of the taxis travel on each road that we submit to the computer at first.

Samples of the data style are as follows:

2011/04/18 00:01:31,114.139816, 22.578217,1,24,4
2011/04/18 00:02:01,114.139267, 22.576017,1,27,4,
2011/04/18 00:02:31,114.138748, 22.574682,1,24,4,
…
2011/04/18 00:10:44,114.140984, 22.555134,0,36,3,
…

The "2011/04/18 00:01:31" stands for the time, and the "114.139816, 22.578217" stands for the position massages seen from GPS. The "1" means that the taxi is not available, and "0" means that the taxi is available. The "24" or "27" means the velocity measured by the GPS satellite. The "4" or "3" means the direction the taxi heads in.

The cluster is made up by these computers Table 91.1.

After calculating the average velocity of each road each day, we finally get the average velocity of each road in per hour in only one day. With the help of Mat lab, also called matrix laboratory, which is developed by Math Works, and is a computational software program used in scientific, engineering, and mathematical fields, and other areas of technical computing, we got the trend of each road in each day [12].

In the figures below, ordinate means the speed a taxi travels on the road. The larger the velocity, the worse is the traffic jam. And these will easily help us analyze the traffic condition, and choose a path that will serve our needs.

Table 91.2 GPS information of the road

	Jilong 3rd road	Fuzhong road	Fuzhong 1st road	Fuzhong 3rd road
Initial point	N22.52658	N22.54464	N22.54268	N22.54664
	E114.0641	E114.0563	E114.0563	E114.0562
Stop	N22.52666	N22.54465	N22.54273	N22.54667
Terminal	E114.0680	E114.0582	E114.0605	E114.0582

This shows the different roads we chose, and as is shown, they are very close

Table 91.3 Time needed to process the data

Number of road	Starting time	Ending time	Total float
One	21:23:12,2012.04.08	21:31:56,2012.04.08	8 min 44 s
Two	21:48:25,2012.04.08	21:58:12,2012.04.08	9 min 47 s
Four	22:26:22,2012.04.08	22:37:48,2012.04.08	11 min 26 s

This table shows the time needed to process the procedure

91.3.3 Analysis

In Table 91.3, we find that the total float does not increase sharply with growth of the amount of calculation. And this means that the "Map" Step has a heavy proportion in our experiment, and the communication time between the cluster costs longer time than the productive time. And this means that we can handle with the data of the whole city if the whole GPS data of each road is given. And all these will take only the GPS data of the taxis and that of each road Fig. 91.1.

As shown in the figures, the average velocity of each road varies at different time in a day. The roads we list in Table 91.2 are very close. It is clear that Fuzhong 3rd Road (Figs. 91.2 and 91.3) and Jilong 3rd (Fig. 91.4) Street have low

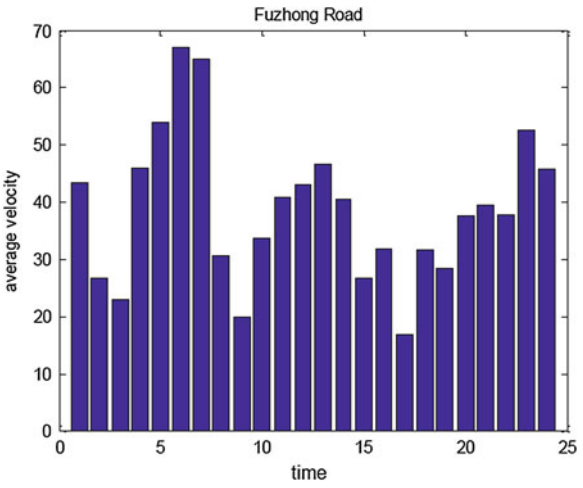

Fig. 91.1 Average velocity of Fuzhong road

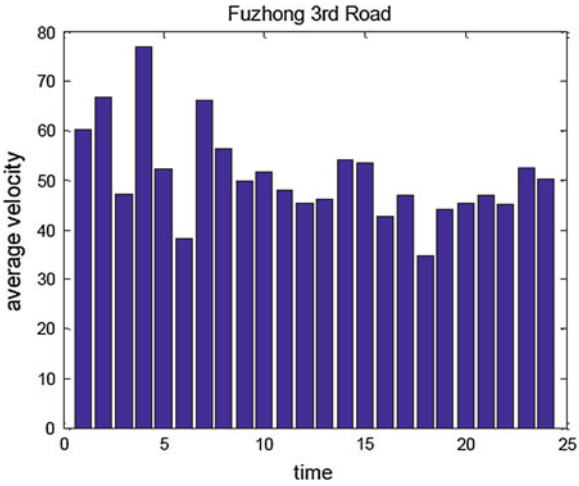

Fig. 91.2 Average velocity of Fuzhong 3rd road

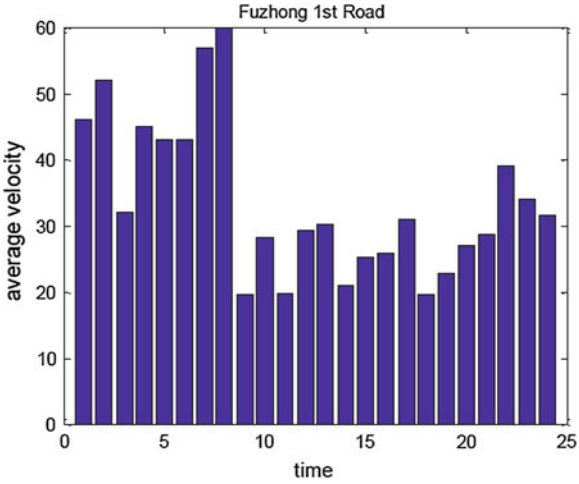

Fig. 91.3 Average velocity of Fuzhong 1st road

vehicle flow, and so the drivers can head into the two roads to avoid the crowd. And the model can be suitable when it comes to other roads and other areas. So when we know the exact average velocity of each road, we can give access to those cars rushing on the relatively uncrowned roads, and thus will reduce the bus traffic pressure. And in that way, the traffic will be conformed again, and the traffic problems will be solved in a great deal, which can be of great help to not only our ordinary people, but also the traffic department, and is meaningful to the emergent dispatch.

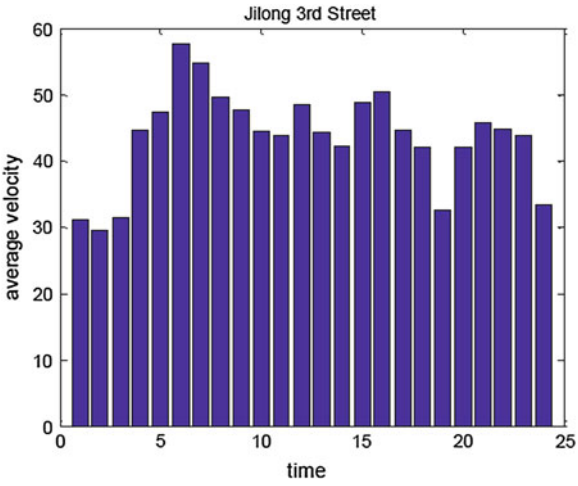

Fig. 91.4 Average velocity of Fuzhong 3rd road

91.4 Conclusion

We find both advantages and disadvantages in our model after analyzing the whole course. First, there are some low points of low velocity, and the speed appears more likely the low speed when we take the modified velocity–time model, which may contributes to the error. Second, if the driver has a good ability of driving and familiar with the roads of the city, the result we get based on our modified velocity–time model may be not smaller but larger than the truth [7].

However, we make use of the advantage of both the model of MapReduce and masses of GPS data from the taxis, and calculate the average velocity in each road based on the model we propose in the paper. Then we get the result in about 12 min, and after a simple analysis, we finally find some proper roads for the driver to head to. We believe the time we need will be less, if we expand our cluster, and the roads we can handle will be more. Then a digital traffic system will take shape. And this will contribute to the car dispatch and traffic management, and help to make our life more beautiful and harmonious. The parallel computation is a trend to deal with masses of data.

Acknowledgments This research was jointly supported by Research Innovation Fund for College Student of Beijing University of Posts and Telecommunications, P. R. China.

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Chapter 92
Security System for Intelligent Residential Quarters

Lianqin Jia

Abstract At present, the intelligent residential areas are found throughout the country, people's security intelligent demand become more and more urgent, the introduction of intelligent means the community security management, is an important problem that must be considered. Combined with practical work experience, the author has discussed a new type of intelligent safety precaution system in this paper.

Keywords Security system · Peripheral protection system · Security intercom system · Emergency call · Anti-theft alarm system

92.1 Introduction

Now, a large number of Intelligent Residential Districts have been built in various provinces and cities in the city, which has brought great convenience to the people's life. At the same time, with the increasing population in the city, the gas, household appliances equipment widely used, great hidden trouble of safety have been caused to the community residents' life and property. Risk mainly includes two aspects, one is theft, robbery, and other malignant cases of public security, the other is due to the damage caused by improper use (such as fire, gas leaking).Therefore, people call for the adoption of effective measures to achieve the security requirements more and more urgently. It is necessary to introduce the intelligent means of security management in the residential area.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_92,

Residential security system mainly includes the Peripheral protection system, Security intercom system, emergency call and anti-theft alarm system.

92.2 The Peripheral Protection System

The Peripheral protection system is the first line of defense to prevent illegal intrusion for the community; the system is mainly used for preventing the district personnel getting into the area without permission, and fully guaranteeing safety for personal and property in the residents.

92.2.1 Components of System Equipment

The main device of the Peripheral protection system includes: long distance active infrared alarm outdoor detectors, zoom to zoom outdoor PTZ [1] camera, alarm control host, video matrix.

92.2.2 Installation of System Equipment

Long distance active infrared alarm outdoor detectors are usually installed in the peripheral wall with the metal box for protection and to prevent illegal malicious damage.

The zoom to zoom outdoor PTZ camera can be mounted in the peripheral wall, or be installed in an appropriate indoor location such as the outer wall of the building, with the use of outdoor special protective cover for protection, with cold, heat, fan, and other functions.

System alarm control host and host matrix are usually installed in the area of security within the center of the control cabinet.

92.2.3 The Peripheral Protection System's Works

Security personnel usually stay in the entrance and exit area to avoid the district personnel to enter the area especially the guard from areas outside the walls of the persons illegally entering. Once unauthorized personnel want to get into the area from outside the walls, the emitted radiation of the alarm detectors will be blocked, resulting in the signal processor in motion, to produce electrical signals to the perimeter protection system of the alarm control host [2], the host sends out sound,

electrical signal notification to the area of security personnel, or community management.

At the same time, the camera will capture images of the alarm places, the host matrix can achieve a variety of control functions, such as camera zoom, aperture opening and closing, focus features, as well as head ‘s about automatic rotation, which provides convenient for security personnel to patrol the scene of the alarm place.

92.3 Security Intercom System

Security intercom system is the second line of defense to prevent the illegal invasion, which is mainly used to prevent personnel within the district without permission from getting into the building, provide full guarantee safety for occupants of the personal and property.

92.3.1 Components of System Equipment

The devices of security intercom system mainly include a residential security talkback host, security management, security intercom intercom extension (or user intercom extension), and electric control door lock.

92.3.2 Installation of System Equipment

The security intercom management host is set in security duty room of the residential property management department. Security talkback host is also called the in front host is installed in the building floor door or entrance wall of building. Security intercom extension also known as user intercom extension is installed in the household door within the vicinity of the wall.

92.3.3 The Security Intercom System’s Works

The security intercom management host door is always in a locking state, which can avoid the personnel without permission to enter the building, at the same time the tenants of the building can use keys access to the building freely. When there is a visitor, guests are required to push the keyboard of the security talkback host outside of the floor according with household’s security intercom extension. The house owners confirm the identity of visitors through the visitor voice or image.

Confirmation can allow visitors entering, resident master use security intercom extension on the lock button, control the building entrance of the electric control door lock opening, then visitors can enter the building.

Residential district property management security departments can monitor through the working condition of the building security intercom system [3] with residential security intercom management host. Residential property management departments and households, households and households can use this system to communicate each other.

92.4 Emergency Call and Anti-theft Alarm System

Emergency call and anti-theft alarm system is another defense line to prevent accidents and prevent illegal intrusion, which is mainly used to find people trespassing (such as theft, robbery), and to send security alarm signals to the tenants and the property management of the residential quarters.

92.4.1 Components of System Equipment

Equipment of the anti-theft alarm system includes residential centralization alarm controller, Menci switch, glass breaking detector, infrared detector, gas detector alarm, emergency button alarm, alarm, etc.

92.4.2 Installation of System Equipment

The centralization alarm controller: set in security duty room of the residential property management department. Alarm controller is always installed in the household door within the vicinity of the wall, so that people of the residential will be easy to do arming and disarming settings.

Magnetic switch: residential perimeter protection is mainly used for magnetic switch [4], magnetic switch installed in the household door, balcony doors and windows. When someone destroys the household door or window while trespassing, Menci switch motion, this motion signal is transmitted to the alarm controller for alarm.

Infrared detector: protection of residential area mainly adopts infrared detector, which is installed in households in room and the main channel of a wall or ceiling. When anyone trespasses, an infrared detector detects temperature of human body to determine whether people is trespassing, at the same time the detected signal is transmitted to the fire alarm controller for alarm, in addition we can set the level and the sensitivity of the detector through the program [5].

Gas alarm detector is always arranged in a kitchen, bathroom, and other location where gas is easy to leak. When the gas leaks, the detectors work immediately, then the detected signal is transmitted to the alarm controller for alarm, in addition we can set the level and the sensitivity of detector.

Emergency button is mainly installed in the master bedroom and living room. When an accident (such as from a trespass or disease) occurs, press the emergency button for emergency call to the small property management security department and the neighborhood.

Alarm bell may be mounted in the interior or the walls or ceilings of the balcony [6]. When the door magnetic switch, infrared detector, and an emergency button send out alarm signal, the alarm bells will make alarm controller sound.

Alarm lamp is installed in the wall out of household door. If the alarm occurs, alarm controller to control the alarm lamp on, the personnel rescue of the district security can quickly fined the alarm tenants through the alarm indication.

Alarm controller can be connected with magnetic switch, infrared detector, gas detector, emergency button, alarm, alarm and telephone.

92.4.3 The Emergency Call and Anti-theft Alarm System's Works

The working condition (full deployment of state, half the deployment of state and disarming state) of the alarm controller and the sector can be controlled by the program according to the need. Alarm controller can receive the alarming signal from the detector, [7] and send alarm signals to control corresponding equipment and according to the procedure linkage, which can also monitor the operation, such as found in the detector malfunction or failure line, then send out a fault alarm signal alarm, and which also has function to alarm when a detector is destroying and the alarm circuit is cut off.

District centralized alarm controller: residential property management security personnel can pass through the district centralization alarm controller to centralized monitoring the working state. If there is an alarm occurs, it can monitor to which households, which detector alarm, then the computer immediately display the information of alarm household, and the alarm content are recorded and printed.

92.5 Working State of Security System Setting

The system has three kinds of operating condition: full deployment of state, half the deployment of state, and a garrison state. We can enter the password to the alarm controller to set the working state about the anti-theft alarm system according to the need.

The full deployment of state applies when nobody is at home; residential perimeter anti-theft alarm equipment (magnetic switch, glass breakage detector) and residential area within protective anti-theft alarm equipment (infrared) are fortified [8].

Half of the deployment of state is suitable for home staff in sleep or rest. Residential perimeter protection burglar alarm equipment (magnetic switch, glass breakage detector) fortification, residential area within a protective anti-theft alarm equipment (infrared) garrison, or according to residential master need some residential area within a protective anti-theft alarm equipment security, part of residential area protection anti-theft alarm device operation.

Garrison State is suitable for someone in your family with activities. Residential perimeter protection burglar alarm equipment (magnetic switch, glass breakage detector) and residential area within a protective anti-theft alarm equipment (infrared detector) are disarmed, when there is trespassing, we can press the emergency button for emergency call, then alarm controller controls the alarm sends out alarm signals, and then inform the community property security department.

92.6 Conclusion

Security system of the modern residential is the most effective and important means to guard against foreign invasion and natural disaster for the family and residential area within the district, which can greatly improve the residents' sense of security. Through the layers of security, surveillance, integrated management, the owners live in the invisible anti-theft network, which is safer and more comfortable rather than physical security network.

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Part X
Project Management and Applications

Chapter 93
Lead–Zinc–Silver Metallogenic Prediction Based on GIS

Yan Sun, Xunlian Wang, Jianping Chen and Xiaoling Liu

Abstract Tuotuo River region lies in one of the most important metallogenic belts in China—Northwest Sanjiang Metallogenic Belt, thus Tuotuo River region can be of very high metal mineral potential. In this research, multisource data sources including geological, geochemical, geophysical, and remotely sensed images were integrated for mineral potential analysis with GIS technology. Using Weights of Evidence method, the metallogenic potential of this area was studied. Six level I, seven level II and nine level III lead–zinc–silver prospective belts were delineated with 83 % of known mineral deposits in them. Because of the belts' similar metallogenic condition with known mineral deposits, they form the most promising zones for new mineral deposits, deserving more and adequate attention in future exploration.

Keywords Sanjiang metallogenic belt · Lead–zinc-silver · GIS · Weights of evidence · Minerogenic prediction

93.1 Introduction

Tuotuo River region is located in Southwest Qinghai Province, P.R.China. Since it lies in one of the most important metallogenic belts in China–Northwest Sanjiang Metallogenic Belt, Tuotuo River region can be of very high metal mineral

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_93,

potential. The region is about 170 km wide and 220 km long with an area about 37,000 km^2. In Tuotuo River district, preliminary analysis on metallogenic patterns and prospect have been launched in recent years, while no comprehensive quantitative study or prediction has been carried out so far. Based on careful analysis on lead–zinc–silver (Pb–Zn–Ag) metallogenic patterns and current achievement of other researchers, GIS technique was employed to combine strata, structures, magmatic rocks, gravity, aeromagnetism, geochemistry, remotely sensed images to look for Pb–Zn–Ag mineralization related information in this region [1, 2].

93.2 Regional Geological Settings

According to the national geotectonic divisions in April 2007, the study area is mainly situated on four Grade 3 geotectonic units, Xijinwulan Lake-Jinsha River-Ailao Mountain ophiolite complex zone (VII_2^4), Cangdu-Lanping double-sided back arc foreland basin (VII_2^6), Kaixinling-Zaduo-Biluo Snow Mountain arc zone (VII_2^7), North Qiangtang Massif (back arc foreland basin) (VII_2^8), which belong to Grade 2 unit Sanjiang Lake Basin System(VII_2) under Grade 1 unit Tibet-Sanjiang Orogenic System (VII).

In the study district, there are basically ordered laminate strata from Carboniferous to Quaternary period with mainly sea-land alternate to face depositions, among which deposit contained strata are usually magma related, such as Permian, Triassic, Luolika Form in Cretaceous period and Wudaoliang Form in Neogene period. In the study area, intruded rocks are mainly Indo-Chinese epoch and Himalayas epoch neutral-acid granite, which have been controlled by mainly northwest and sometimes west-east faults. Magmatic activities were more concentrated in Permian and Triassic period, and few occurred in Jurassic, Cretaceous, and Paleogene–Neogene. Fault structures consist of basically northwest deep/major faults and northeast secondary faults, controlling the forming and distributing of Pb–Zn–Ag mineral deposits in the study area. Metamorphism of Tuotuo River region is relatively strong with tough and fragile dynamo-metamorphic rocks widespread. Hydrothermal alteration phenomena usually happened near major faults in low-medium temperature, contributing to various alterations such as chloritization, epidotization, sericitization, silication, carbonization, gypsum, kaolinization [3].

93.3 Weights of Evidence Approach

Weights of Evidence are a discrete multivariate statistical approach, which was first applied to a nonspatial application in medical diagnosis. Agterberg, Bonham-Carter, etc. have improved this method to predict mineral deposits [4, 5]. Based on Weights

of Evidence theory, districts similar to the geological background of discovered mineral deposits are likely to hold similar types of deposits. Thus, the metallogenic probability for every unit cell of the study area can be worked out. The result of the method is a map of the posterior probability whose value is between 0 and 1, showing the possibility that a unit cell contains a mineral deposit [6, 7].

The weights for each theme in Weights of Evidence approach comprise W+ and W−, C (contrast) is the difference between W+ and W− showing the layer's predictive ability: If $C = 0$, the layer has no predictive function; $C > 0$, the factors' presence in the layer will serve as predictive sign; $C < 0$, the factors' appearance is unfavorable to forming deposits [8].

93.4 Metallogenic Favorable Evidential Themes

Various geological data in the study district has been collected, stored, processed, and managed in MAPGIS, MORPAS, and ENVI. Then this synthesized information was input into MRAS and was dealt with its Weights of Evidence module to calculate the metallogenic probability.

The mineralizing condition and the geological settings information of the mineral deposits have been analyzed, 16 digital evidential themes have been extracted [9].

93.4.1 Favorite Composite Strata

From the statistics of the mineral deposits already discovered and related materials, it is the strata of Permian, Triassic, Luolika Form in Cretaceous and Wudaoliang Form in Neogene period that are in close relation with the formation of lead–zinc–silver mineral deposits. Since the older strata Permian and Triassic could be eroded and deposited down in their near strata, Permian, and Triassic strata were buffered a distance from 1 to 10 km and the adequate distance was selected when the layer's C value is the biggest, with Permian, it is 4 km, and with Triassic, it is 1 km. The composite strata turn out to hold up to 75 % known mineral deposits.

93.4.2 Strata Combination Evidential Theme

Entropy is an approach measuring the amount of information in information theory, reflecting uncertain degree taking place. Generally, the more complicated the geological structural feature, the higher the uncertain degree, and the higher the entropy value. This research adopted the software MORPAS, divided the study area into a 2 * 2 km grid and calculated the strata combination entropy for each

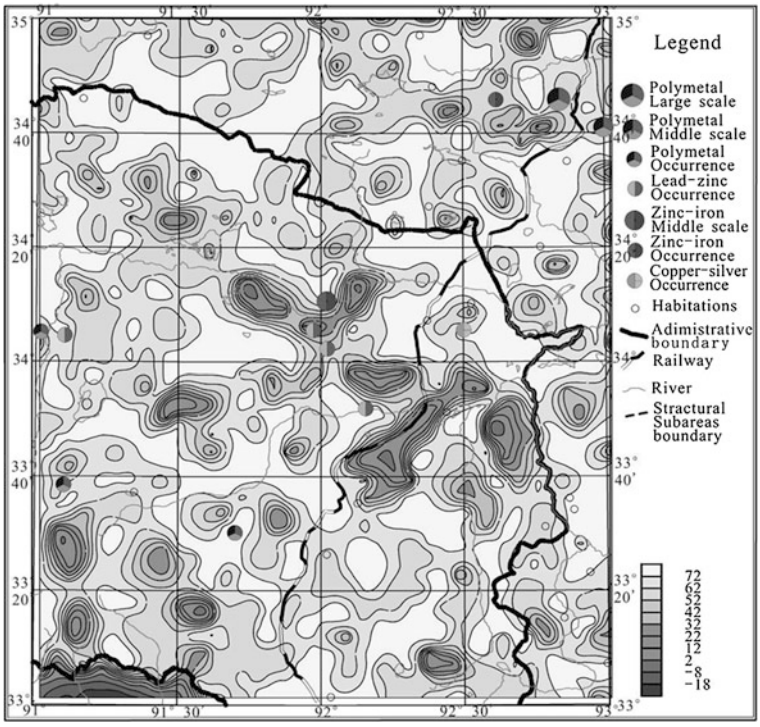

Fig. 93.1 Strata combination entropy isolines with deposits

unit cell. From the known mineral deposit distribution, it can be recognized that hydrotherm type mineral deposits mostly fall into the zones with generally bigger values of entropy, instead of the biggest—the only deposit in the zone holding the biggest entropy is of magma sedimentation type. The districts with the biggest entropy are usually regions with the strongest tectonic activities acting as good guiding passage for mineral, instead of good stowage. By GIS overlap analyzing, in the study district there are 66.7 % of the known mineral deposits falling into the zones with the entropy between 62 and 72 (Fig. 93.1), which can be regarded as one of the evidence themes for hydrotherm type Pb–Zn–Ag mineral deposits.

93.4.3 Fault Evidential Theme

Fault structures have played an important role on deposit forming in the long geologic history. Deep/major faults and secondary faults differ in metallogenic affecting coverage, thus they were buffered at a 1–10 km distance to calculate *C* for each. After the calculation and comparison, for deep/major faults the buffer distance is 3 km with *C* 1.165314 the heaviest in value, while for secondary faults

the buffer distance is 1 km when its C is 0.745599. Thus, 3 km buffered deep/major faults and 1 km buffered secondary faults were selected as one of the favorable evidential themes.

93.4.4 Fault Frequency Theme

Fault frequency is the number of faults in a unit cell, reflecting regional structural complexity. Under the application MORPAS, fault frequency was calculated and the result shows that known mineral deposits mainly fall into the zones with a value between 0.62 and 1.25, not the highest value. Similar to the situation of strata combination entropy, the higher the value of fault frequency, the more complicated the regional structure. Mineral deposits are likely to be situated at places with moderate fault frequency values when the structural complexity is not too high. In the study area, the 2 * 2 km unit cells with 0.62–1.25 pieces of faults are the most favorable positions to hold lead–zinc–silver deposits, which form a predictive evidential theme.

93.4.5 Gravity and Aeromagnetism Abnormity

Through known mineral deposits superposed with gravity and aeromagnetism data, it is found that the known mineral deposits concentrate on gradient change belts of gravity and aeromagnetic field, which are reflection of regional deep/major faults. The zones with gravity value from $-500 * 10^{-5}$ to $-510 * 10^{-5}$ m/s^{-2} and from $-540 * 10^{-5}$ to $-445 * 10^{-5}$ m/s^{-2} and zones with aeromagnetic intensity from -50 to 30 nT are districts with advantage to form lead–zinc–silver deposits.

93.4.6 Metallogenic Favorable Magmatic Bodies

In the study area, the intruded rocks are mainly Indo-Chinese epoch and Himalayas epoch neutral-acid granite having close relations with lead–zinc–silver mineralizing. Aeromagnetic second derivative null value line laws, put forward by Yusheng et al. [10] were employed to reveal concealed magmatic bodies, which together with intruded rocks form predictive evidential themes respectively.

93.4.7 Geochemical Abnormity

Geochemical data have prominent function on predicting. In this research, the lower limit values of lead, zinc, silver, copper, and molybdenum geochemical data

were also decided by C value—the abnormity ranges with the largest C were selected as the evidential themes.

93.4.8 Hydroxyl Alteration Information

This research adopted four remotely sensed TM/ETM images, after removing vegetation, water bodies, salt licks, snow, shades, clouds respectively, three levels of hydroxyl alteration were identified in ENVI. In order to save the weak information in the images, all the processing was executed image by image. Mineral deposits are obviously on or near the extracted hydroxyl alteration, suggesting hydroxyl alteration is valuable for mineral predicting.

93.4.9 Annular Structure Information from Remotely Sensed Images

There are usually numerous annular images on the Earth surface in remotely sensed images, among which the ring image related to geologic processes is called the annular structure. Annular structure and mineralization are often in relatively close relations, especially for those annular structures caused by concealed magma activities. This research utilized the remotely sensed pictures to interpret the concealed annular structures, and recognized some annular structures difficult to discern in routine field work, complementing the conventional geology work effectively.

93.5 Weights of Evidence Model

Weights of Evidence predict model was set up based on the favorable evidence themes, and the weights for each theme were derived (Table 93.1), ready for calculating the posterior probability for each unit cell.

From the predicting model and the analysis above it is clear that: strata in Permian, Triassic, Luolika Form in Cretaceous and Wudaoliang Form in Neogene have close relationship with deposit formation, and also districts in a distance of 4 km from Permian strata and in a distance of 1 km from Triassic strata are likely to hold new deposits because of possible erosion and sedimentation; Indo-Chinese epoch and Himalayas epoch neutral-acid granite are main bodies highly predictive; 3 km buffer of deep/major faults, and 1 km buffer of secondary faults have sure control on mineralizing with northwest faults as the main guiding structures and nearly west-east faults the main stowage structures; Lead–zinc–silver deposits

Table 93.1 Weights of evidence model for lead–zinc–silver prediction in tuotuo river region

No.	Evidential theme names	W+	W−	*C*
1	Favorable strata combination(Permian 4 km buffer, Triassic 1 km buffer, Luolika Form in Cretaceous period and Wudaoliang Form in Neogene period)	0.803135	−0.633038	1.436173
2	Intruded rocks	0.771216	−0.043821	0.815037
3	Strata combination entropy	0.140986	−0.363481	0.504467
4	Deep/major fault 3 km buffer	0.992377	−0.172937	1.165314
5	Secondary fault 1 km buffer	0.616309	−0.129290	0.745599
6	Fault frequency	0.466484	−0.277283	0.743767
7	Aeromagnetism abnormity	0.277358	−0.140966	0.418324
8	Aeromagnetism inferred magmatic bodies	0.482872	−0.108762	0.591634
9	Gravity abnormity	0.752289	−0.783721	1.53601
10	Lead geochemistry abnormity	0.908926	−2.023859	2.932785
11	Zinc geochemistry abnormity	1.383100	−0.987941	2.371041
12	Silver geochemistry abnormity	1.095592	−0.574702	1.670294
13	Copper geochemistry abnormity	0.634690	−0.089822	0.724512
14	Molybdenum geochemistry abnormity	0.803752	−0.243869	1.047621
15	The hydroxyl alteration abnormity	0.228454	−0.378117	0.606571
16	Annular structures	2.071381	−0.070302	2.141683

Note *W*+ evidential theme factors present; *W*− evidential theme factors absent; *C* the degree the evidential layer is correlated with deposit forming

mainly situated at the regions where structural lines intersect but usually not where structural activities are most intensive and the most complicated, which was known from the analysis on strata combination entropy and fault frequency; Lead, zinc, silver geochemistry abnormity layers are extremely predictive with the *C* value exceeding 2, molybdenum geochemistry abnormity is strongly predictive, and the guiding function of copper geochemistry abnormity is moderate; The evidential theme of concealed annular structures interpreted from remotely sensed images has a *C* value exceeding 2, showing clear advantage of prediction; Gravity and aeromagnetic abnormity, aeromagnetic interpreted concealed magmatic bodies, hydroxyl alteration from remotely sensed images also have certain guiding meanings for new lead–zinc–silver mineral deposits [11].

Test of independence of the conditions is essential while employing Weights of Evidence. In a situation that the significance level is 0.05, the above 16 evidential themes meet independence of the conditions except that strata combination entropy evidential theme is not independent with hydroxyl abnormity and lead geochemistry abnormity evidential theme. Considering the strata combination entropy evidential layer is interrelated with hydroxyl abnormity and lead geochemistry abnormity evidential theme, *C* value of the combination entropy layer is relatively lower and the other two evidential themes are independent with each other, from the perspective of efficiency, simplicity and convenience, the researchers decided finally that 15 evidential themes participated in calculating posterior probabilities without the strata entropy evidence layer.

93.6 Results and Appraisement

The comprehensive research has selected 15 evidential themes to calculate posterior probabilities, and 4 levels of posterior probability values were obtained. The statistics reveal that the biggest posterior probabilities are above 0.7, and more than 83 % lead–zinc–silver known mineral deposits fall into cells with the posterior probabilities above level 3.

According to metallogenic belts' distribution, geological background, mineralizing conditions, and the posterior probability values, 3 levels of favorable metallogenic prospective areas were identified: prospective areas level I with posterior probability 0.2–0.74, level II with 0.06–0.2, level III with 0.002–0.06, and 6 prospective areas of level I, 7 prospective areas of level II, and 9 prospective areas of level III were delineated (Fig. 93.2). Among them: metallogenics prospective areas level I from north to south are successively: Zangmaxikong (the area is covered by the icon of Zangmaxikong deposit in Fig. 3), Zonglongba–

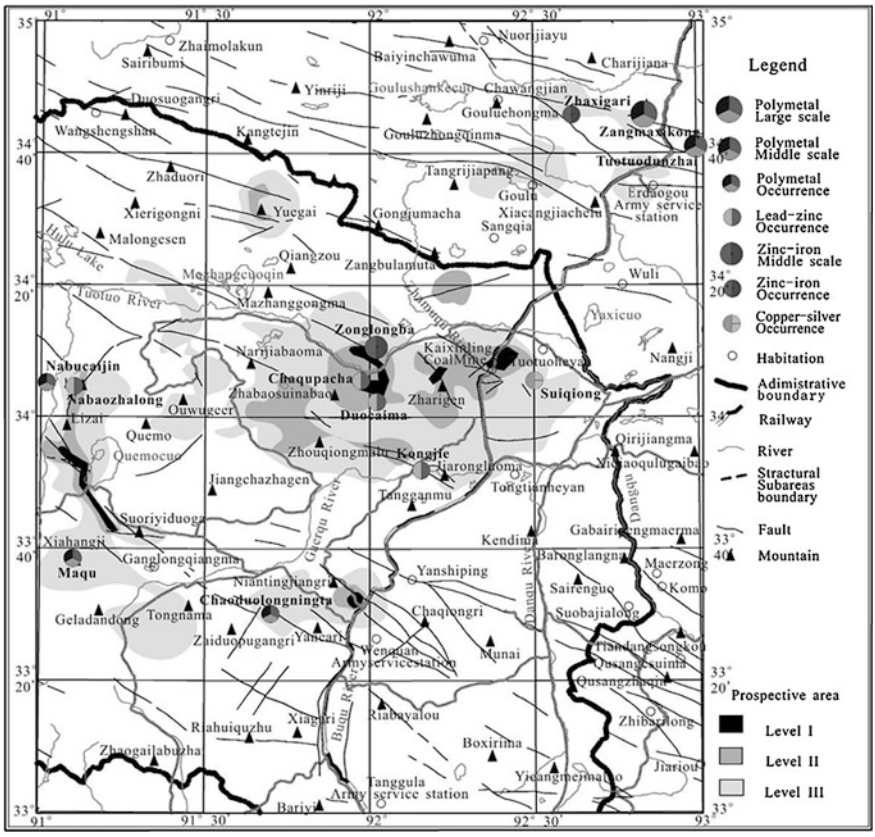

Fig. 93.2 Lead−zinc−silver prospective areas of Tuotuo river region

Duocaima, North of Zharigen, Kaixinling, West of Quemocuo, South of Niantingjiangri, and metallogenics prospective areas level II from north to south are successively: Yuegai, Zharigen-Kaixinling, Chaqupacha, Nabaozhalong, Zhouqiongmalu, South of Niantingjiangri.

The results indicate: (1) More than 80 % of known mineral deposits fall into the identified prospective areas, which supports that the prediction has fully considered the known deposits' metallogenic condition, and the results possess high reliability and considerable accuracy; (2) Through GIS overlap analysis, it is easy to learn that the prospective areas are basically located at the intersection of northwest faults and northeast faults, near the magmatic bodies, the strata in the prospective areas are basically favorable metallogenic strata for new deposits, which demonstrates that lead–zinc-silver deposit formation has been controlled by faults, magma activities and strata; (3) There still have four level I prospective areas, five level II prospective areas and four level III prospective areas without lead–zinc–silver mineral deposits found so far, mainly lying at north of Zharigen, Kaixinling, west of Quemocuo, Yuegai, Zangbulamuta, Zhouqiongmalu, Niantingjiangri, etc. Because of similar metallogenic condition with the known mineral deposits, these prospective areas are greatly promising and should especially be paid more attention to in future exploration.

93.7 Conclusions

The lead–zinc–silver Weights of Evidence predicting model has been set up, which gives a better understanding of the current materials and offer reasonable help for deposit locating.

In this research, six prospective areas of level I, seven prospective areas of level II, nine prospective areas of level III were delineated accommodating 83 % of the known mineral deposits. The results show that on one hand there is considerable resource potential near or around the known deposits, on the other hand, the four level I prospective areas, five level II prospective areas and four level III prospective areas without deposits have similar metellogenic condition with known deposits, deserving paying more attention in future exploration.

From the analysis above, it can be derived that GIS can be employed to analyze information like strata and faults from many perspectives, to extract concealed information from geophysics, geochemistry, and remotely sensed images, to interpret alternation information, and further more, to analyze comprehensively and predict deposits quantitatively. Compared with conventional approaches, prediction based on GIS is more objective, accurate, and efficient.

Acknowledgments Sponsored by a GIS-Based Study on Special Education School Distribution of Beijing.

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Chapter 94
Evaluation System of Landslide Stability in the Three Gorges Reservoir Area

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Abstract This paper, in light of the special geological environment of the remove fall zone of the Three Gorges Reservoir Area and under the premise of thorough consideration of the water influence on the body of disaster, has considered ten typical calculative projects, offered the correspondent load systems acting on the sliding mass, and developed the comprehensive analysis and evaluation system of landslide stability using C++ Builder, which is more convenient and accurate for the analysis and computation of landslide stability, and puts forward a stability evaluation method suitable for the Body of Geological Disaster of Remove Fall Zone in the Three Gorges Reservoir Area.

Keywords C++ builder · Analysis and evaluation system · Stability · The Three Gorges reservoir areas

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_94,

94.1 Introduction

After the hydraulic project of the Three Gorges of the Yangtze River is completed, the water level in front of the dam of the Three Gorges Reservoir Area will be raised from the now several tens of meters to 175 m. Furthermore, because of the needs of preventing floods, the water level of the reservoir area will be adjusted periodically between 175 and 145 m every year. This will inevitably cause the revival of part ancient landslides and the formation of new landslides, which will definitely influence the urban construction, the traffic transportation, the people's life and property security, etc., in the Three Gorges Reservoir Area. Therefore, it is necessary, in view of the specific situations of the Three Gorges Reservoir Area, to analyze thoroughly and systemically the stability of the bank landslide, in order to provide the theoretical basis for coming up with the dredging measure of the bank landslide [1, 2].

The comprehensive analysis and evaluation system of landslide stability is developed using C++ Builder, which is more convenient and accurate for the analysis and computation of landslide stability, and puts forward a stability evaluation method suitable for the Body of Geological Disaster of Remove Fall Zone in the Three Gorges Reservoir Area.

C++ Builder is a fully object-oriented programming tools developed by Inprise. It provides optimal database development tools. C++ Builder provides the data aware components and data access components of maximum productivity to store, compute, and process the data in database, which uses bi-directional database of visualization oriented by components. C++ Builder also provides the best "development tool of distributed application system", which provides more than 25 kinds of visualization database components and can develop rapidly the applications system of Client/Server, Multi-Tier, and WWW [3].

94.2 Special Forces Acting on the Landslide

In this paper, the Three Gorges reservoir landslide is analyzed as the plane sliding; the analysis model of plane sliding is shown in Fig. 94.1. In the light of the special geological environment of the remove fall zone of the Three Gorges Reservoir Area, In addition to the weight of landslide (W, including the other additional load acting on the landslide), the forces (P) act on the bank landslide that include the hydrodynamic pressure (P_d),the hydrostatic pressure (P_s), the uplift pressure (U), and seismic forces (P_z) act on the landslide caused by the change in the rise and fall of the reservoir water level, rainstorm, groundwater, and earthquakes, etc., and the buoyant force (S) acts on the landslide under the reservoir water level. So the total forces are [4]:

$$P = W + P_d + P_s + P_z + S + U \tag{94.1}$$

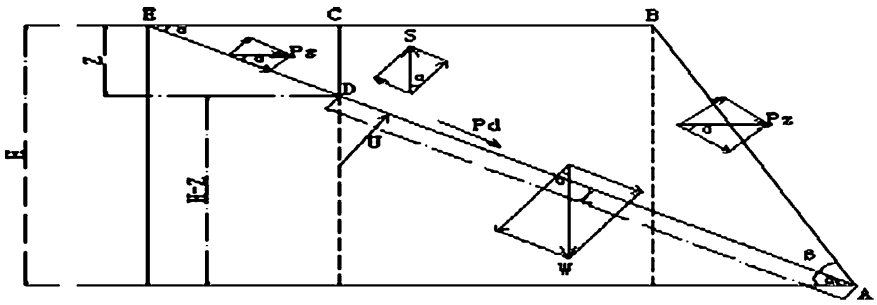

Fig. 94.1 The analysis chart of force acting on plane slide

94.3 Determination of the Computation Projects

The loads acting on the landslide are totally different, and should be treated differently, when the landslide is in different circumstances which include dry season(natural state), raining season (rainstorm or rain for a long period of time), water level (175 m) of the reservoir, earthquake, and water level adjusted from 175 to 145 m. Therefore, this paper should consider fully the influence of these various circumstances on the stability of landslides and summarizes 10 kinds of typical computation projects and their loads when the stability of landslide is analyzed and evaluated. This is shown in Table 94.1.

94.4 Calculation of Stability Coefficient and Stability Evaluation of Landslide

In light of the current status quo and actual project situation, the limit equilibrium method is used to analyze the stability of the bank landslide in this paper. The calculation of the limit equilibrium method is simple, and it can basically reflect the status of the stability of the landslide; the partition of the divided landslide is shown in Fig. 94.2. The stability coefficient (F_s) of landslide is [5]:

$$F_s = \frac{\sum_{i=1}^{n-1}\left(R_i \prod_{j=i}^{n-1}\psi_j\right) + R_n}{\sum_{i=1}^{n-1}\left(T_i \prod_{j=i}^{n-1}\psi_j\right) + T_n} \tag{94.2}$$

Table 94.1 Each calculative project and its loads

Project	Loads
Dry season (natural state)	W
Raining season (rainstorm or rain for a long period of time)	W+Pd+Ps+U
Dry season + water level (175 m) of the reservoir	W+S
Raining season + water level (175 m) of the reservoir	W+Pd+Ps+U+S
Dry season + earthquake	W+Pz
Raining season + earthquake	W+Pd+Ps+Pz+U
Dry season + water level (175 m) of the reservoir + earthquake	W+Pz+S
Raining season + water level (175 m) of the reservoir + earthquake	W+Pd+Ps+Pz+U+S
Dry season + water level lowered from 175 to 145 m	W+Pd+F+S
Raining season + water level lowered from 175 to 145 m	W+Pd+Ps+U+S+F

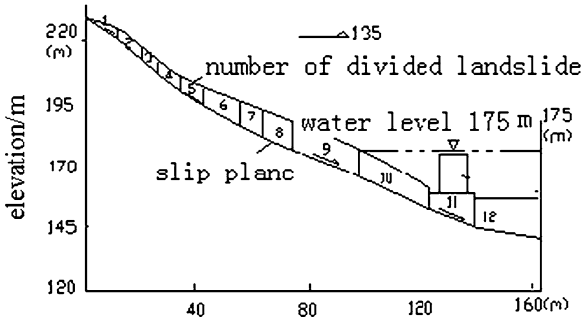

Fig. 94.2 The illustration of a divided landslide

This ψ_j is the transfer coefficient, R_i is the resistance force and T_i is the tangential force of the landslide.

When the stability coefficient (Fs) of landslide, calculated according to the above formula, is greater than 1.05, the body of landslide is in a stable state; when it is in the range of 0.95–1.05, the body of landslide is in a critical steady state, when it is less than 0.95, the body of landslide is temporarily stable or unstable.

94.4.1 Analysis and Evaluation System of Landslide Stability

The comprehensive analysis and evaluation system of landslide stability is developed using C++ Builder in this paper. The stability coefficient and felling thrust is calculated mainly through the establishment of project database in this system. The basic functions of landslide stability analysis and evaluation system is shown in Fig. 94.3.

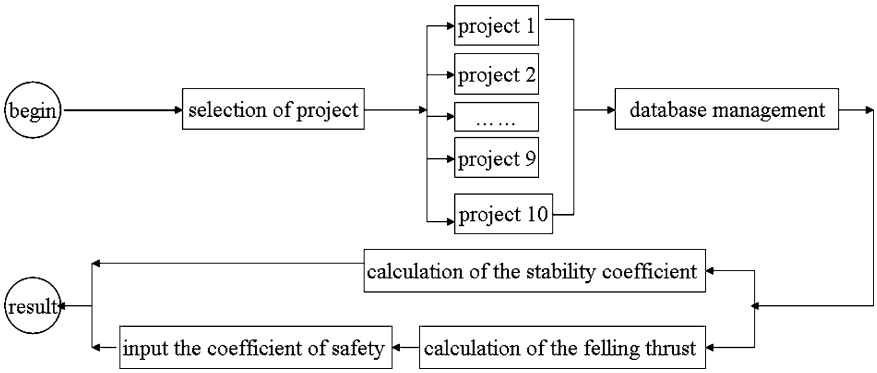

Fig. 94.3 The illustration of analysis and evaluation system of landslide stability

94.5 Calculation of Felling Thrust of Landslide

Some body of landslide, which is non-stable and will definitely influence urban construction such as traffic transportation and people's life and property security, must be renovated. During the renovation process of the landslide, the landslide thrust that acted on the different divided landslides must be analyzed and calculated first, in order to determine the reasonable renovation measures of the landslide. The landslide thrust is calculated using the transfer coefficient method, which is both simple and reasonable. The formula is [6]:

$$E_i = E_{i-1} \cdot \psi + K \cdot T_i - N_i \cdot tg\phi_i - C_i L_i \tag{94.3}$$

where K is the safety coefficient, N_i is the normal force, C_i is the cohesion, L_i is the length of the landslide.

94.6 Project Instance

There are signs of all kinds of deformation and breakage in the MingShan landslide in the Fengdu County Chongqing since the 1970s. The topsoil of some sections produces creep and form a large number of drunkard forests. Recently, the landslide deformation has been intensified, some buildings have been destroyed and the local section has lost stability. Which has threatened more seriously the people's life and property security of the MingShan beauty spot and the foot of the slope resident?

The landslide slip surface is shaped like an arcuate arrow of width 260–430 m, length 110–150 m, slip thickness 1.60–5.10 m, leading edge altitude about 158–176 m, trailing edge altitude about 215–244 m, distribution area 43,910 square meter, and volume about 210,000 cube meter. It belongs to medium-sized shallow

Table 94.2 The computed result of landslide stability coefficinet F_s

Project	Section			
	1	2	3	4
Project 1	1.69	1.60	1.66	1.55
Project 2	1.00	0.91	0.96	0.94
Project 3	1.77	1.47	1.66	1.31
Project 4	1.00	0.89	0.96	0.93
Project 5	1.53	1.42	1.48	1.39
Project 6	0.95	0.85	0.91	0.88
Project 7	1.53	1.31	1.47	1.23
Project 8	0.91	0.80	0.87	0.83
Project 9	1.66	1.46	1.65	1.33
Project 10	1.00	0.86	0.96	0.90

Table 94.3 The computed result of the thrust E_i (KN/m) of each divided landslide in different projects

Section	Calculation blue print				
	Project 2	Project 4	Project 6	Project 8	Project 10
1	0	0	0	0	0
2	74	74	102	102	74
3	169	169	217	217	169
4	247	247	345	345	247
5	348	348	467	467	348
6	415	415	603	603	415
7	696	696	934	934	696
8	815	815	1,077	1,077	815
9	947	947	1,297	1,297	947
10	1,099	1,161	1,537	1,599	1,176
11	873	34	1,296	1,357	944

soil landslide according to the geological prospecting data provided by the 208 Hydrogeology and Engineering geology Crew of Geological Prospecting Primary Company in Chongqing. One of the sections and the compartmentalization of the divided landslide are shown in Fig. 94.3 [7, 8]. The stability coefficient of landslide in the different projects calculated by the analysis and evaluation system developed using C++ Builder is shown in Table 94.2. The value of the felling thrust of one of the sections in different projects calculated by the analysis and evaluation system is shown in Table 94.3.

94.7 Conclusions

This paper, in light of the special geological environment and actual situation of the remove fall zone of the Three Gorges Reservoir Area, puts forward a comprehensive analysis and evaluation system suitable for the stability analysis of the body of landslide in the Three Gorges Reservoir Area, and obtains the following achievements in several aspects that have practical application significance and certain scientific research value:

1. This paper analyzes systematically the forces that acted on the landslide of the Three Gorges Reservoir Area and the force varieties that acted on the divided landslide when the water level changes between 175 and 145 m. It summarizes systematically 10 kinds of typical computation projects and their loads by organic combinations of different kinds of situations, and produces specifically the computational method of the corresponding loads.
2. The comprehensive analysis and evaluation system of landslide stability is developed using C++ Builder which is more convenient and accurate for the analysis and computation of landslide stability.
3. The above comprehensive analysis and evaluation system of landslide stability is applied to the stability analysis of MingSha landslide in Fengdu County Chongqing. The analysis result indicates that the comprehensive analysis and evaluation method of landslide stability put forward in this paper is applicable and feasible to the landslide stability analysis of the Three Gorges Reservoir Area.

Acknowledgments Supported by "Youth Foundation for Chongqing Normal University" (10XLQ04).

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Chapter 95
Demand Model of Tourist Scenic Spots Based on Tourist Total Cost

Hong Zhang

Abstract This article has constructed a travel demand model which groups the tourist total cost of a certain tourist scenic spot based on statistics, instead of using the traditional way to place distances and areas as the dominating factors that influence the tourist demand. However, this method puts the average tourist cost (tourist price) as the chief factor and introduces some other factors that have impacts on the demand of journey to the model, such as tourists' spendable income, time of journey, etc. Meanwhile, the travel demand function will be solved using the econometric model.

Keywords Tourist demand · Model · Factor

95.1 Introduction

As far as the research approach is concerned, the quantitative research for tourist demand forecast has been divided broadly into two stages. The first stage, before the 1990s, was using some traditional quantitative analysis methods, such as Delphi technique method, reasoning method, regression model method,and so on. The second stage is after the 1990s. However, the study of tourism demand is increasingly inclined to use more advanced metering technology, including integrated analysis, error correction model (ECM), vector auto-regression method (VAR), TVP, etc. Regardless of the method used, the purposes are to more accurately grasp the specific impacts of the change in each factor on the scenic

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_95,

tourist demand, so that the relevant departments develop more appropriate tourism policies to regulate the tourism demand. The quantitative study for the domestic tourism demand is developed on the basis of foreign tourism demand forecasting methods, including the introduction of foreign travel demand and interpretation, and foreign empirical analysis of the model to improve the localization or from abroad to reconstruct the idea of building the model on the domestic tourism demand model.

95.2 The Natural Scenery Tourism Demand Model

Demand function is expressed as the market demand of a product and the relationship of its demand influence among the factors. The mathematical formula is expressed as: $Q^d = f(I, P, P_i, T, \ldots)$.

In the type, I is consumer income level, P is the product's price, P_i is related products price of the No. i, T is consumer preference. Similarly, in certain periods, the travel demand function reflects the relationship between consumers' tourism demand and its factors, which is tourism economic research's foundation. The tourism consumption demand of consumers is not only different from the general consumer goods, but also different from other recreational consumption. General merchandise or other recreational consumption usually occurs in the consumer's residence. When such goods are consumed, consumer goods prices are rarely considered beside the cost, such as traveling expenses of purchase commodity, time-consuming, etc., so that the commodity price has become the main influencing factor. But the tourism consumption is different; except for a few tourists in scenic spots, most consumers must consider additional cost when consuming travel goods, including transportation and communication cost, travel catering accommodation cost, opportunity cost of time, and so on, rather than simply consider tourism commodity price (spot entrance ticket price). Because the spot entrance ticket price and the overall tourism spending has been not so important compared with those.

According to the utility theory in economics, in order to achieve the maximum utility, consumers should choose the best mix of goods with the budget constraints, making $\frac{\partial u/\partial x_i}{p_i} = \lambda$, that is to say, consumers should make their money used on a variety of merchandise last yuan bring equal marginal utilities and equal to hold a dollar utility. Thus, the utility that obtained by the rational consumer spending any money must be greater than or equal to its utility held a yuan of money (the law of diminishing marginal utility). For general merchandise, cost of each unit commodity consumers bought is equal to commodity price, therefore, equilibrium condition of consumer utility maximization is: $\lambda =$ the utility obtained by purchasing the last unit commodity/the commodity's price. And for the tourist consumption, additional cost is the main part of tourism spending, so it cannot be ignored, according to the utility theory the law of diminishing marginal utility—

the utility obtained by consumer spending a yuan of money must be greater than or equal to its held a yuan of money, in the tourists' consumption process, all costs are obtained the relevant utility, and part of this utility should be included in the tourists in the scenic tour utility gained, therefore, in the process of travel extra cost tourists spent and price of the entrance tickets have the same effect, both of them are to gain experience through scenic spot. So tourism consumer utility maximization equilibrium conditions should be: $\lambda =$ the utility obtained by purchasing the last unit commodity/the commodity's price.

The above analysis shows that, in order to achieve the maximum effectiveness, rational consumers in the selection of optimal consumption and portfolio, will consciously put the total tourism consumption in the process as the tourist commodity price, rather than the consumption of general merchandise that only consider the spot entrance ticket price. If the tourist in the countryside is homogeneous, namely ignoring the local tourists' consumption habits, effects of cultural tradition on the tourists' consumption, relative to the tourist attractions surrounding tourists, the total cost, during the journey of tourist whose residence away from the scenic spot, can be seen as receiving entrance ticket price for the visitors who reside in attractions. In this way, particular attractions' ticket prices will be a great variability, thus solving the spot entrance ticket price rigidity, but it's difficult to deduce analysis the problem of travel demand function.

This paper model of the travel demand function has a certain degree of difficulty, operability is not strong. Mainly based on the following considerations, First, it is difficult zoning. In general, tourist attractions, the source region is more extensive, even if not foreign tourists to China's land area is so large, divided up more difficult. If the division of the area is too small, the average error of the total travel cost of tourists in the region would be much better if the divided region is too much calculation more difficult. Second, the value of the dependent variable in the sample is too small. Whether you divide the size of the region a single region in the number of specific scenic tourism for the region's total population in terms of minimal, so the regional travel rate as the dependent variable measured analytical error larger, The third is the difference between the larger the total cost of the same region in the same scenic tourist visitors. By region, regardless of division of the area, however, small, this situation will exist. For these reasons, this paper considers the travel demand model can be constructed from the angle of the total travel costs (expenses). Zoning is no longer the source region do not need to change according to different regions of the spatial distance calculating the total cost of travel changes, instead of using the statistical grouping of the tourists' total cost of a particular scenic, direct each group, the average tourism assembly have been deduced tourism demand function. In international tourism, a unit tourism product is generally expressed by the tourist number representation. That is, if a scenic spot in a year receive ten thousand people, that mean providing ten thousand tourism activities for tourists, and selling ten thousand units in the tourism product; therefore, this model is used in each group of tourists travel demand function as the dependent variable is feasible.

95.3 Tourism Total Cost

Due to consumption of tourist commodities in the process, tourists in addition to pay lower ticket price of scenic spots, must also pay such as transportation, meals and other significant additional cost, and occupy time. Therefore, in the new model, this paper substitute tourism total the cost for the scenic spot ticket prices as demand changes in the variables explain the scenic spot. Namely, total travel cost (C) = extra cost (E) + opportunity cost (O) + (P0) ticket price of scenic spots. In which: Extra cost (E) includes transportation, communication, accommodation, food, etc., each point cost and opportunity cost (O) in the course of tourists journey. Opportunity cost (O) means the income brought by tourism activities and occupied time. Computational formula is: tourism opportunity cost = traveling time × the opportunity cost of units time; in that, travel time is the sum that a tourist come and go from the source of traffic time and time consuming in scenic spots.

95.4 Tourism Price

According to total cost tourists spending in visiting tourism attractions, tourists are divided into n groups, and each group statistics the number of tourists; then, according to the survey data to calculate the various tourist total cost. Tourism price refers to groups of tourists average travel cost. Can be expressed as: Tourism price (P_i) = tourists' total cost in I group/the number of tourists in group I, $I = 1, 2,\ldots, n$. Tourists disposable income: tourists' disposable income refers to average disposable income of each group tourists on the base of total cost of division in a scenic spot in tourism tourist groups. The formula expression: Tourists can control income (I_i) = the sum of tourists disposable income in I group/the number of tourists in group I, $I = 1, 2,\ldots, n$.

95.5 Tourism Time

Refers to the average time taken by each group of tourist in attractions. The formula expression: The travel time of tourists in I group/the number of tourists in group I, $I = 1, 2,\ldots, n$. According to the theory of demand, place the tourists' number which divided by total tourism cost as the dependent variable, and put tourist price, disposable income, travel time which had an important impact on the tourism demand as the independent variable. So the grouping travel demand function model is: $D_0 = \beta_0 + \beta_1 P + \beta_2 I + \beta_3 T$.

In type:

D_0 Tourism demand;

P Tourism price;
I Tourist disposable income;
T Total travel time;

The model only express tourism demand of a scenic area in specific tourism price, or the total cost of the tourists in a specific interval, From the tourist total cost into consideration, total costs in a certain scenic spot between tourists are mostly different from each other, thus for a given area, the tourism prices tourists received also have a number of levels, each level of tourism demand consist of a tourism demand. From this perspective, the function of a single tourism demand can be expressed as: $D_0 = \sum_{i=1}^{n} \beta_0 + \beta_1 P_i + \beta_2 I_i + \beta_3 T_i$, ($I = 1, 2, \ldots, n$; n said the group number).

In the type, P_i represents the tourism price, including the extra cost (E_i) the tourists spent to a view spot and the spot entrance ticket price (P_0), inside the function, the additional total cost in I group tourists/the number of tourists in group I, $I = 1, 2,\ldots, n$. If you want to inspect the spot entrance ticket price (P_0) of the tourist demand, you should take $P_i = E_i + P_0$ into the type, obtaining: $D = \sum_{i=1}^{n} (\beta_0 + \beta_1 E_i + \beta_2 I_i + \beta_3 T_i) + \beta_1 P_0$, ($i = 1, 2,\ldots, n$; n said the group number) With E_i, I_i, T_i being known, D is a function of P_0.

95.6 Conclusion

According to the theory of supply and demand, utility theory and other related economic theories as the foundation, on the basis of previous studies on the travel demand model from the total travel cost perspective, the thesis has constructed a new model of tourism demand. The new constructed model not only provides feasible study for similar areas to reach the resources' co-ordination of supply and demand in theory under the guidance of sustainable development, but also supplies a kind of thought for the government to establish a set of management system using government regulation contained administrative means to promote the construction of tourism enterprises, recovering construction of microcosmic main body, etc.

Acknowledgments Thanks to the support of the Guizhou Province science and technology Department Soft science Fund (R [2011] LKC2007).

Chapter 96
LPG Storage Tank Fire and Explosion Accident

Yingchao Dong, Wenhua Song and Fanghua Hu

Abstract The dangers of liquefied petroleum gas (LPG) have been analyzed. The storage tanks of liquefied petroleum gas have been fixed at 20 m^3, and the quantitative analysis of boiling liquid expanding vapor explosion occurring in tank discussed by the model. The results showed that when the distance between the target and the fireball is 14.12–22.32 m, there would be no discomfort with long-term exposure; within 8.00–14.12 m there would be slight pain caused but no blisters; during 5.65–8.00 m there would be moderate damage creating first degree burn/10 s, 10 % deaths/1 min; in the range of 4.61–5.65 m there would be more serious wounds (injuries/10 s, 100 % deaths/1 min); and less than 4.61 m there would be deaths (1 % deaths/10 s, 100 % deaths/l min). In addition, the design of the LPG station, which met the requirements of fire protection, was confirmed and could provide design proposals for the spacing between the related constructions.

Keywords Liquefied petroleum gas · Storage tank · Boiling liquid expanding vapor explosion · Fireball

96.1 Introduction

With worldwide energy shortage, for environmental protection and economic needs, liquefied petroleum gas (LPG), as chemical material and fuel with resource-rich, less pollution, and low prices, is attracting a lot of attention. It has been

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_96,

widely applied in industrial production and daily life. However, because of the flammable nature of LPG, leakage in LPG storage tanks will lead to fire and explosion. Once such accidents happen, the affected area will be broad and serious. It will pose a threat to the buildings around and seriously affect the lives of the people around. This paper focused on predicting LPG tank fire and explosion accidents. The scope and the impact of the accident damage were also analyzed quantitatively.

96.1.1 Risk Analysis of LPG

Propane is the main component of LPG, whose combustion heat value is 2,220 kJ/mol and boiling point is −42.10 °C [1]. Therefore, LPG has a high combustion heat value and low boiling point. It will quickly gasify at a higher temperature. When the LPG decompresses suddenly, the liquid in the tank with a hot state will make the temperature reach a certain level, and then superheated liquid evaporates violently, ultimately causing an explosion. The explosion lower limit for LPG is 5 %, the upper limit 9.65 %, and the smallest ignition energy 0.2–0.3 m. The explosion gas will spread to the surrounding area rapidly, very easily forming explosive gas. Once exposed to an ignition source, it will explode again, called the boiling liquid expanding vapor explosion.

The boiling liquid expanding vapor explosion of LPG is an explosion caused by the sharp gasification of the liquid. The explosion energy comes from the boiling liquid and vapor expansion. The main reason for boiling liquid expanding vapor explosion is when the tank has a large crack, and the tank liquid boils and gasifies. When the container's temperature is too high or surrounded by flames, the LPG will produce high pressure; if the safety valve relief is not timely, it will cause a sharp decline in the tensile strength of the container material, owing to high temperature. When the container cannot receive the set-up pressure, the container will crack by reason of the increasing pressure, then lead to the boiling liquid expanding vapor explosion [2, 3].

The boiling liquid expanding vapor explosion accident may cause explosive shock wave, vessel fragment, and giant fireball heat radiation, resulting in casualties and equipment damage. In this paper, using thermal radiation law, the hazard of LPG liquid expanding vapor explosion was evaluated [4].

96.1.2 Case Situation

There was an LPG storage and distribution station in the industrial district of the town. The station to the southwest side was close to Hollow Fiber Products Co. Ltd. On the south side of the station was a road of width 5 m, with the rest of the surrounding area as open space.

The factory covered an area of 12,000 m^2; the area of construction was 8,600 m^2. The factory was surrounded by a 2 m high solid brick wall enclosure all around. The storage tank area was set up to the southeast of the station; the west side of which was close to the hydrocarbon pumping station and gas cylinder warehouse, North–south layout. Besides, the tank car loading and unloading column was set up to the north of the filling room.

The construction area of the storage tank zone was 480 m^2; the storage tank depot set the four horizontal cylindrical tanks, followed by residue tank, $3^{\#}$, $2^{\#}$ and $1^{\#}$ LPG tank from south to north. The volume of tank was 20 m^3, diameter was 2 m, and maximum storage capacity 16 t. Moreover, the detailed performance data for distance between the $3^{\#}$ tank and stations among buildings is shown in Table 96.1 [5].

The pressure tank equipped with a flammable liquefied petroleum gas, if subjected to external flame baking for a long time, would have its strength to gradually reduce. When the tank intensity decreased to a certain extent, the tank would burst suddenly, leading to pressure reduction, and then liquid would gasify rapidly to cause burning. Consequently, there would be boiling liquid expanding vapor explosion accident taking place. Thus, in order to provide a reference to enhance the safe operation of the LPG storage and distribution station, the scope and size of the consequences for the boiling liquid expanding vapor explosion accident should be researched.

Table 96.1 The distance between the tank and the station outside building

Distance (m)			The tank's distance of standard	The $3^{\#}$ LPG tank's distance
The station	Fire bank toe line	East	3	6
		South		9
		West		6
		North		13
	Hydrocarbon pump		20	24
	Cylinder base		20	30
	The filling room		20	39
	Loading column		20	33
	Fire pool		40	62
	Water pump house		40	80
	Power distribution room		20	80
	The office		30	80
	Enclosing wall	East	20	24
		South		24
		West		116
		North		50
Outside the station	Fiber products factory's wall		30	180
	The road's edge		20	34

It was assumed that the LPG in 3# tanks were all let out during the region, and LPG tank boiling liquid expanding vapor explosion occurs under ideal condition, taking no account of factors such as temperature, wind direction, surrounding environment, and the effect of nearby tank fire and explosion caused by 3# tank.

96.2 Quantity Calculation of LPG Boiling Liquid Expanding Explosion Consequences

96.2.1 Quantitative Calculation Results

The injury distance was calculated by fireball heat radiation calculation model. According to the different heat radiation flux, the heat accepted by the target was calculated (shown in Table 96.2) [6, 7].

96.3 Analysis of the Boiling Liquid Expanding Explosion Calculation Results

Table 96.3 indicates contrast and analysis between four parameters. The four parameters were, the heat radiation flux at the distance between the LPG storage station facilities required by the code for design of the urban gas [5], the heat radiation flux at the distance between the LPG storage station facilities, degrees of damage of the fireball thermal radiation in the required distance, degrees of damage of the fireball thermal radiation [8].

Table 96.2 The evaluation results of 16 t horizontal storage tank fire thermal radiation on human body damage

Radiation heat flux (kW/m^2)	Target distance (m)	Equipment damage	The harm to the human body
37.5	4.61	Equipments were damaged completely	100 % person death/1 min, 1 % person death/10 s
25.0	5.65	In the absence of flame and long time radiation, wood burning minimum energy	100 % person death/1 min, severely person burned/ 10 s
12.5	8.00	A flame, burning wood, the lowest energy of plastic melting	10 % person death/1 min, I-degree burn
4.0	14.12		Cause pain more than 20 s, but it would not blister
1.6	22.32		Have no sense of discomfort after long-term exposure

Table 96.3 The calculation results analysis of tank boiling liquid expanding vapor explosion accident model

From 3 # tank distance (m)		The specification condition to receive radiation heat flux (kW/m^2)	The actual distance to receive heat radiation flux (kW/m^2)	Under the standard distance fireball radiation damage	Under the actual distance fireball radiation damage
Fire bank toe line	East	>37.5	12.5–25.0	Equipments were damaged completely, 100 % person death/ 1 min, 1 % person death/10 s	10 % person death/1 min, I-degree burn, and wood would burn with flame
	South		4.0–12.5		Cause pain more than 20 s, but it would not blister
	West		12.5–25.0		10 % person death/1 min, I-degree burn, and wood would burn with flame
	North		4.0–12.5		Cause pain more than 20 s, but it would not blister
Hydrocarbon pump		1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long
Cylinder base		1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long
The filling room		1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long
Loading column		1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long
Fire pool		<1.6	<1.6	Have no sense of discomfort after long-term exposure	Have no sense of discomfort after long-term exposure
Water pump house		<1.6	<1.6	Have no sense of discomfort after long-term exposure	Have no sense of discomfort after long-term exposure

(continued)

Table 96.3 (continued)

From 3 # tank distance (m)		The specification condition to receive radiation heat flux (kW/m^2)	The actual distance to receive heat radiation flux (kW/m^2)	Under the standard distance fireball radiation damage	Under the actual distance fireball radiation damage
Power distribution room		<1.6	<1.6	Have no sense of discomfort after long-term exposure	Have no sense of discomfort after long-term exposure
The office		<1.6	<1.6	Have no sense of discomfort after long-term exposure	Have no sense of discomfort after long-term exposure
Enclosing wall	East South West North	1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long-term exposure
Fiber products factory's wall		<1.6	<1.6	Have no sense of discomfort after long-term exposure	Have no sense of discomfort after long-term exposure
The road's edge		1.6–4.0	<1.6	Cause pain more than 20 s, but it would not blister	Have no sense of discomfort after long-term exposure

From Table 96.3, some conclusions could be obtained:

(1) Code required the distance from the fire-dike to the storage tank as 3 m, the heat radiation flux greater than 37.5 kW/m^2, the injury degree that "equipments were damaged completely, 100 % person death/1 min, 1 % person death/10 s", considered as unaccepted category. However, during the actual design, the distance between the accident storage tank and fire dike was 6 m, hurt degree was "10 % person death/1 min, I-degree burn, and wood would burn with flame", which were considered as unaccepted category. And when the largest distance between the accident storage tank and fire dike was 9 m, the hurt degree caused by the hot radiation was accepted.

(2) The code required that the distance between the tank to the hydrocarbon pumping house, air bottle storehouse, filling house, loading/unloading pillars, wall of the station area, roads outside the station were 20 m, radiation heat flux was 1.6–4.0 kW/m^2, the degree of injury was that "cause pain more than 20 s, but it would not blister", considered as accepted category. While the actual design distance was greater than 22.32 m, within acceptable range.

(3) Code required that the distance between tanks to the fire water tank, water pumping house, power distribution, office, industrial enterprises were 40, 40,

20, 30, 30 m separately, the thermal radiation flux was less than 1.6 kW/m^2, the degree of injury was that have no sense of discomfort after long-term exposure, within acceptable range, and the actual design distance were acceptable.

96.4 Summary

LPG, as a fire explosive gas, when LPG storage and distribution station had taken some safety measures, but if not pay attention to safety management, there would give birth to the boiling liquid expanding vapor explosion accident. Though simulation on the instance, the calculation results displayed that the no harm radius of the storage tank boiling liquid expanding vapor explosion was 22.32 m, and the liquefied petroleum gas storage and distribution station layout could fully satisfy the safety requirements when the explosion occurred. In addition, the design of the LPG station, which met the requirements of fire protection, was confirmed and could provide design proposals for the spacing between the related constructions. Secondary explosion blast would cause great harm to the station equipment and personnel. Therefore, we should also strengthen the safety management and develop appropriate safety management system and an emergency rescue plan according to the specific circumstances of the station area.

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Chapter 97
Disturbing Signal of Gravimeter Record with National Geodetic Observatory

Guie Tian, Li Jie Song, Ming Li Deng, Xiao Guang Li and Jian Nan Sun

Abstract To improve the further precision of the tidal amplitude factor, it should not only do pretreatment of the superconducting gravity data, but also filter out the further disturbance signal. VAV (Venedikov AP, Amoso J, Vieira R) is new analysis software of solid tide, which used the signal drift model and the iterative method to reject the disturbing signal and it processed the superconducting gravity data Record by National Geodetic Observatory at Wuhan. It manifests that along with increase of iterative time, the mean square deviation of the amplitude factor reduced greatly at the first two or three iterations. MM and MF's amplitude factor fixes gradually in 1.11 after three iterations. It greatly improves the precision of the amplitude factor and provides a basis for better study the Earth's interior and geodynamic phenomena.

Keywords Drift models · Disturbance signal · Amplitude factor · Iterations · VAV tidal analysis software

97.1 Introduction

Under tide-producing force function, the Earth's solid part has periodic deformation called the solid tide. The change of solid tide is very small, which needs sophisticated equipment to be measured [1]. At present, superconducting

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_97,

gravimeter in the determination of the various instruments of the Earth's gravitational field has been recognized by international colleagues as it has the highest precise observation with the best continuity and stability, the lowest noise level, the lowest drift rate. The observation precision of the Superconducting gravimeter's is improved a lot relative to absolute gravimeter, but as the data collection process in the aging computer, lightning stoke, GPS clock cycle overflow and the voltmeter problems caused spikes, jumps, step interfering signals as well as earthquakes, volcanic disturbance signal will cause the exception of the data, reducing the precision of the tidal parameters greatly. At first, preprocessing of the original observational data should be done before the data analysis eliminates, the abnormal signal such as the please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames [2]. This determines the structure of the names in the running heads and the author index.

Sudden jump, step and peak identification; the synthetic gravity tide signal is as replenishment for power outages, earthquakes, and infusion of helium and other factors that lead to short-cycle intermittent. So it is prepared for the data analysis. Figures 97.1 and 97.2 respectively show a diagram of the frequency spectrum of the Wuhan regional long-period tidal and tidal spectrum after tidal pre-processing software.

To improve the further precision of the tidal factor, it should not only do pretreatment of the superconducting gravity data, but also filter out the further disturbance signal [3]. In this paper, new analysis software of solid tide named of VAV, implementing further processing for disturbing signals of the superconducting gravity data, improves the precision of the tidal parameters greatly. After the disturbance signal is filtered out and then through the Atmospheric pressure, Pole motion, Length Of Day correction, the tides of the high-precision factor can be used to study the Earth's internal physical structure and physical distribution characteristics of atmospheric loading and gravity field coupling mechanism, fluid

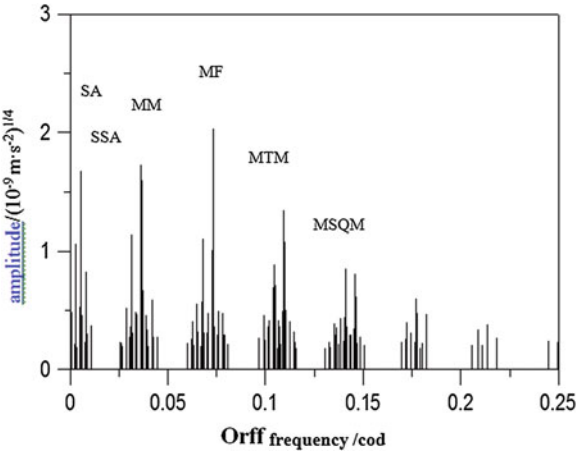

Fig. 97.1 Observed spectrum of the long period tidal gravity waves at Wuhan station

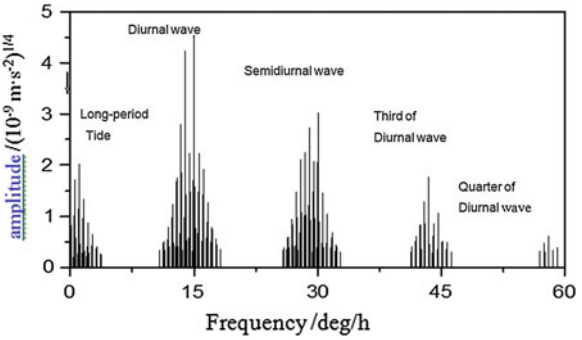

Fig. 97.2 Observed spectrum of the tidal gravity waves at Wuhan station

core near Sun shaking and nuclear mode, the movement of the earth's crust, the Earth's rotation speed of the polar mobile nuclear non-uniformity of geodynamic phenomena.

97.2 Drift Model

To obtain high precision earth tidal parameters, it is essential to filter out the drift and non-tidal waves accurately and effectively in the observational data [4]. Different ways are applied by different software to deal with drift, tidal processing software. So far there are three types: Analyze, Bay tap-G and VAV Software. Analyze Software Solves The Drift Through High-Pass Filter Or Tshebyscheff Polynomial, But If You Simultaneously Want To Solve Long-Period Tidal Parameters And Drift, You Must Use Tshebyscheff Polynomial; Bay tap-G uses a similar iterative method of least squares adjustment to solve the drift, tidal factor, but the heavy workload, computational efficiency is not high. The VAV Software applies stepwise regression model to fit drift [5]. According to Fourier series expansion principle, data filters are divided into every 24 or 24 h integral multiple which is one group of data. In each group within a short time, it is available to use low-order polynomial (less than or equal to 3 orders) to fit the drift. Drifting d (t) in the group data may be represented that as in the formula So (T) is the unknown fitting coefficients, k is the fitting polynomial order. Taking the analyzing long period tidal waves as an example, we usually take $k = 0$, at this time the d $(T + t) = Z_0(T)$ constant, namely the drift is constant within each data segment (Fig. 97.3a), drift changes with T. Figure 97.3b gives that the VAV software has acted drift according to 19th October, 1999 to 17th December, 1999 60 days data observed at National Geodetic Observatory at Wuhan, taking $k = 0$ in the computation drift models. The fig shows that every day's drift is a constant and independent mutually, and makes sure each other for close together two days differs not in a big way, which has fitted the long period non-tidal waves very well.

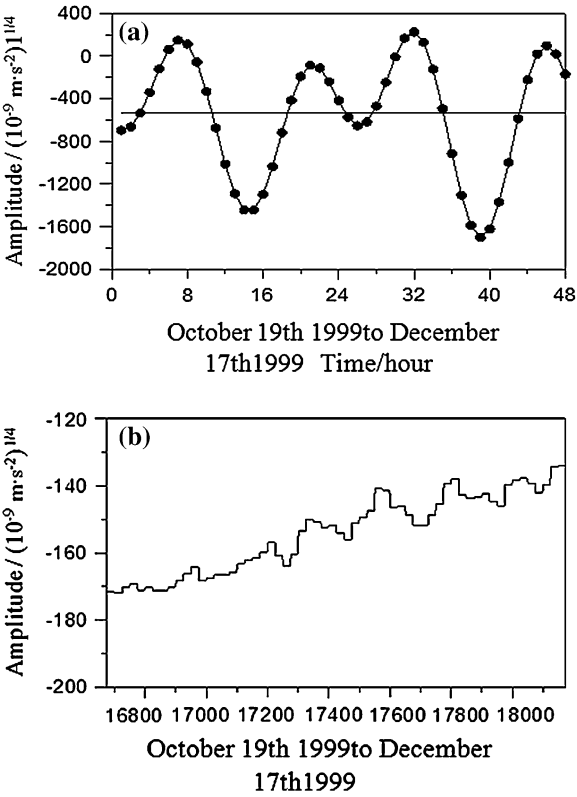

Fig. 97.3 **a** Drift estimated by VAV program it shows 48 day's drift. **b** Drift estimated by VAV program. It shows that the drift tends to a straight line

97.3 The Filtration of Disturbing Signal

VAV earth tide analysis software has a significant feature which is able to detect and remove the disturbance signal that we take the limited mean square error(usually taken as three times mean square error), and multiple iterations to remove the disturbance signal to further improve the precision of the tidal factor [6]. The principle of VAV removal the disturbance signal as follows: tidal data in the filter is divided into many small data segments, after filtering to get the residual $r(T,\Omega)$ of each T data, Ω for each data frequency (circle/day). The mean square deviation (referred to as the MSD, also known as "mean square error") is:

$$\sigma^{\Lambda 2}(\Omega) = \Sigma r^2\ (T,\Omega)\ [2N - 2m(\Omega)] \tag{97.1}$$

In the formula $\overset{\wedge}{\sigma}(\Omega)$ is the mean square error, N is the number of residual integer in Ω frequency, $m(\Omega)$ is the unknown integer in tidal analysis to solve in the Ω frequency, $2N - 2m(\Omega)$ are the degrees of freedom. When it satisfies $r(T,\Omega) > 3\sigma^{\wedge}(\Omega)$ T, Ω corresponding to the tidal signal are filtered, but you need to pay attention to these signals not real to filter out from the observation file, but

rather they are temporarily stored in another file [7]. The next time you do not consider these signals to solve the tidal parameter. And so on, you can remove the disturbance signal through constant iteration of continuous to filter out the residual signal.

This article uses National Geodetic Observatory observed superconducting gravity data to stand on 21st December, 1997 to 30 November, 2002, which has calculated the long period tide parameters Fig. 97.4 clearly gives the respectively frequency is initial residual absolute value in 1 cod (circle/day), 2 cod and 3 cpd. From the comparisons of three figures, you may see that residual amplitude and MSD is gradually decreasing with the frequency adding [8]. Three times themed has reduces from 14.028 nms^{-2} in 1 cpd 4.188 nms^{-2} in 3 cpd. Comparing with three pictures, you can clearly see that the disturbing signal is much bigger when time is 160 and nearby the 1,700 residual amplitude. By amplifying this data further, it is possible to discover the disturbing signal accurately the specific time section, it means that these spots of gravity observed values are inaccurate, existing the unusual data and disturbing signal [9]. This is also breakthrough point of seeking for the data exception, volcano and earthquake signal.

For the above disturbing signal, VAV solid tide analysis software uses the iterative method to filter out in turn. Table 97.1 gives long period tide MM (lunar tide, cycle was 27.5546 days) and MF's (half lunar tide, cycle is 13.6606 days) amplitude factor ands of amplitude factor which it's calculated in iterations 5, grouping 2, and 4 cpd of upper frequency. The result is gutted from the data which is recorded by National Geodetic Observatory at Wuhan [10]. Along with increasing of iteration, MSD of MM and MF tide amplitude factor and phase will be reduce.msd of MM amplitude factor reduces from 0.04272 to 0.02917 nms^{-2} after five iterations, meanwhile's of MF amplitude factor reduces from 0.01871 to 0.01285 nms^{-2}. The amplitude factor fixes gradually down with an increase in iterations, MM and MF amplitude factor fixes gradually in 1.11; Similar to it, MM and MF wave's MSD of phase are also unceasing reduction, and the precision of it is extremely improved. Also you may see that along with increase of iterative time, the scope that the amplitude factor MSD reduces getting smaller because first two

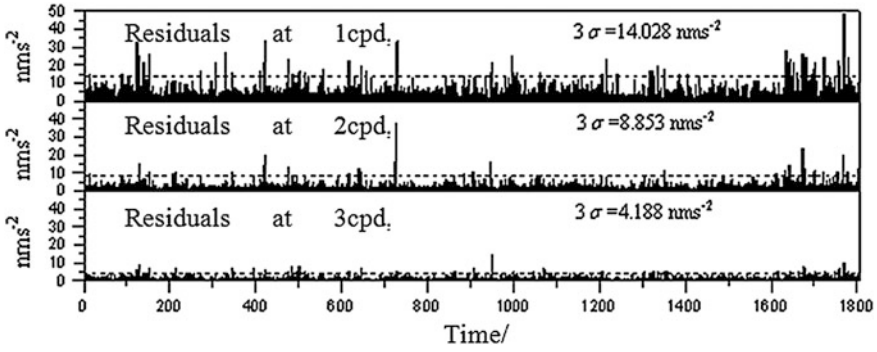

Fig. 97.4 The raw residuals obtained around one to three cpd

Table 97.1 Tidal parameters obtained after having five iterations

Iterations	MM				MF			
	Ampleintrude	MSD-amp	Phase	MSD-phase	Amplitude	MSD-amp	Phase	MSD-phase
00	1.12505	0.04272	1.8281	2.1733	1.10073	0.01871	−0.6865	0.9726
01	1.14690	0.03350	1.2706	1.6647	1.09124	0.01470	0.3573	0.7779
02	1.12282	0.03068	2.8607	1.5503	1.11420	0.01345	1.3063	0.7027
03	1.11277	0.02987	4.0835	1.5167	1.12155	0.01315	1.3024	0.6778
04	1.10514	0.02943	2.7453	1.5012	1.12397	0.01293	1.6195	0.6664
05	1.11418	0.02917	2.3742	1.4762	1.11638	0.01285	1.7919	0.6632

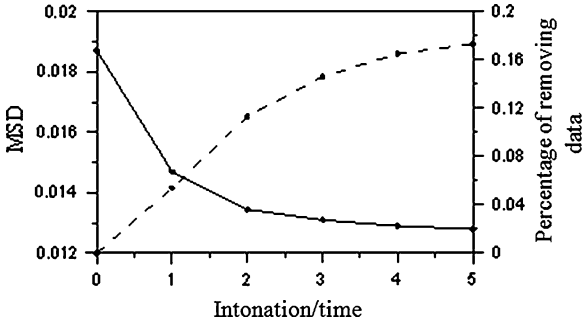

Fig. 97.5 The MSD of MF amplitude factor and rejection data along with the change of iterations

or three iterations is quite mainly remarkable (Fig. 97.5). Therefore usually taking the iteration when the computational process is two is the final solution result.

In order to explain its iterative effect, Fig. 97.5 has separately given the tendency figure of changes of amplitude factor MSD of MF (solid line) and the percentage of rejecting data accepted in this iterative process along with the iterative time (dashed line chart) in Table 97.1. You can clearly see that MSD of MF amplitude factor continuously reduces, and gradually tends to be a straight line from Fig. 97.5 as the increase of iteration times [11]. It reduces 0.00526 nms^{-2} at the latest two iterations and it only reduces 0.00060 nms^{-2} at the last three iterations. The latest two Iterations of increasing the precision of the tidal amplitude factor is most obvious; Along with iterative time increasing, the elimination of the disturbing signal gradually increases, the percentage of rejecting data also gradually reduces. When the iterative time achieves a certain extent, each time the signal of elimination tends to zero.

Iterations has eliminate the disturbing signal, reduce the solution residual and increase the precision of the tidal factor at VAV tidal analysis software, Meanwhile with the increase of iterative time, it makes the atmospheric gravity conductance value much more stable, and achieves equilibrium gradually [12]. This is also further explains that iteration function is very important in filtration disturbing signal. The iterative process may call it is further processing disturbing signal after preprocessing of the observed tidal data.

97.4 Conclusion

VAV tidal analysis software uses the iterative method to analysis the superconducting gravimeter data recorded by the National Geodetic Observatory at Wuhan, which has further rejected the disturbing signal caused by computer aging, thunder stroke, earthquake, volcano, and so on, reducing the theme of tidal amplitude factor and increasing its precision [13]. But to further improve the precision of tidal amplitude factor, it also needs more accurate analysis of factors influencing the residual specific, such as changing of groundwater, changing of temperature, earthquake, annual rainfall, and so on. This is the key point of the next step work study [14].

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Chapter 98
Research on Three-dimensional TV

Jing Li, Peng Zhang and Jing Xia Niu

Abstract Three-dimensional TV is expected to be the next revolution in the TV history. They implemented a 3d TV prototype system with real-time acquisition transmission, and 3d display of dynamic scenes. They developed a distributed scalable architecture to manage the high computation and bandwidth demands. 3d display shows high-resolution stereoscopic color images for multiple viewpoints without special glasses. This is first real time end-to-end 3d TV system with enough views and resolution to provide a truly immersive 3d experience. Japan plans to make this futuristic television a commercial reality by 2020 as part of abroad national project that will bring together researchers from the government, technology companies and academia. The targeted "virtual reality" television would allow people to view high definition images in 3d from any angle, in addition to being able to touch and smell the objects being projected upwards from a screen to the floor.

Keywords 3d · Parallax · Display · Perception

98.1 Introduction

Three-dimensional TV is expected to be the next revolution in the TV history. They implemented a 3d TV prototype system with real-time acquisition transmission, and 3d display of dynamic scenes [1]. They developed a distributed scalable architecture to manage the high computation and bandwidth demands. 3d

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_98,

display shows high-resolution stereoscopic color images for multiple viewpoints without special glasses. This is first real time end-to-end 3d TV system with enough views and resolution to provide a truly immersive 3d experience.

3d television augments the traditional TV technology by showing the viewer not only sequences of 2d images but streams of three-dimensional scene representations [2]. To the viewer at home this will mean a completely new media experience. He will perceive the displayed events in a more immersive way, and he may even get the chance to choose his own viewpoint to watch the displayed events. In the future, three-dimensional movies will become a standard and provide enhanced interactivity options, e.g. by allowing the user to navigate through the scenes [3].

98.2 Scene Capture and Representation for 3DTV

Three-dimensional television starts with acquiring the dynamic, real-world scene in some suitable digital representation. In contrast to conventional TV, however, not only the visual appearance of the scene must be recorded, but 3DTV requires to additionally acquiring also complete shape information in order to enable looking at the scene from different view points [4]. The scientific challenges are twofold: 3d geometry of scenes in motion must be acquired, while the original visual appearance of the scene may not be altered. A number of different technologies have the potential to meet these requirements. On one extreme we find purely image-based approaches using several conventional cameras. Computer vision and computer graphics techniques are then used to describe the recorded scene such that a user can look at it from different angles. On the other extreme we find active holographic techniques. Recent advances in cod and comes imaging technologies show promise to enable direct digital hologram acquisition in the future [5]. Here we provide an overview of the image-based approaches. The conceptually simplest solution to scene capture is to place a camera at each location from which the scene should be looked at and to display the appropriate two views to the human observer. However, this might require an infinite amount of cameras. Typically a set of 2 to 20 cameras are used in a multi-camera recording system which is a calibrated recording setup consisting of cameras delivering synchronized video streams. For calibration, a point light source is moved in the entire space that all the cameras look at. Calibration information like the internal and external parameters (position, orientation, lens information) of the cameras is computed using the recorded videos [6]. Algorithms for automatically calibrating cameras as they record an arbitrary scene are still an active research area. Due to calibration, the location in the camera image of a 3d point of the scene can be computed for all camera images. Using the image coordinates of a 3d point in at least two camera images, the inverse problem can be solved: what are the 3d coordinates of this point? In a first step, feature points like corners are located in a first image. In a second step the location of each feature point using the texture of

the feature point in the first images is located in the other images. This search is simplified by the calibration information which defines for each of the other images just one line in each image where the point has to be located [7]. These feature points may also be tracked over time in order to increase the reliability of the estimated 3d coordinates. As soon as the 3d coordinates of the points of the scene are identified, a 3d surface model of the scene is created. The surface of an object is described using a mesh of polygons where the vertices of the mesh are located at the estimated 3d coordinates. Important alternative representations are triangle meshes, nubs and subdivision surfaces. Subdivision surfaces offer a good compromise between an inherently non-smooth polygonal mesh representation and nubs surfaces which are limited by topological restrictions [8]. Subdivision surfaces allow representation of arbitrary topology and any fine detail with a controllable smoothness. In a final step, the image is projected onto the 3d model defining for each surface patch the look or texture. In advanced systems, the texture of several or all images where the patch can be seen is attached. Hence, each patch has several texture maps enabling a more realistic rendering of the object for different viewpoints. As the number of available images increases, the 3d geometry can be of less precision [9]. There are several approaches of representing an object starting from precise 3d shapes with just one texture up to many images of the object without explicit 3d shape. A 3d model can be rendered from an arbitrary viewpoint using well-known rendering algorithms based on openly, direct 3d or other graphics libraries.

98.3 Coding and Transporting 3d Video

As shown in the previous section there are different data types are used for the different 3d scene representations in the context of 3DTV. Having defined the data, efficient compression and coding is the next block in the 3d video processing chain, and that is the scope of this section. There are many different data compression techniques corresponding to different data representations. For example, there are different techniques for 3d meshes, depth data, multiple view video, etc. [10]. However, the level of maturity varies largely. There is a strong relation to the age, level of maturity and the (commercial) usage of the corresponding data representation.

Holographic signals have so far not been used in multimedia applications, although highly interesting for 3d displays. The commercial relevance of such a data representation is still uncertain. Naturally, compression is not yet studied in detail. This is an open research field where a lot of work would have to be done if such data become relevant.

Multiple description coding and channel adaptation also currently receives significant attention. Here it is shown that improvements are possible for specific application fields if some of the basic coding paradigms of available standard video coding are abandoned [11]. This research direction should be further pursued

with specific focus on 3d video data. As for any type of media, security and rights management is also an important issue for 3d video. Some research has been done for classical 3d models. However, there still needs to be done a lot and for other data this is still an open field. In general conclusion we may state that the very diverse research area of 3d video compression is highly active and relevant at the moment. Market relevance and interest of manufacturers, content providers and users in 3d video systems are growing rapidly. However, there are still important challenges that need to be resolved. One of the goals of the European community funded 3DTV project is to integrate the European research efforts in 3d video compression to ensure a strong European participation in this highly relevant future market.

Determination of the best techniques for transporting 3DTV data over communication networks in real-time requires a thorough investigation of several classical communication techniques together with their adaptation to the unique requirements of this new application. Experiences gained in the early implementations of 3DTV systems, as discussed in the previous sections, are extremely important in reaching a clear understanding of 3DTV transport issues, and therefore must be carefully studied.

The video must be adjusted when the viewer moves around, changing his or her viewpoint of the display. Otherwise, the displayed scene will be quite unrealistic. Particularly for image based techniques; however, this requires transmission of a multitude of views to the end points, multiplying the bandwidth requirements by many factors. Efficient networking techniques for multi-view video delivery over multicast networks are therefore an active research area. Cross layer approaches, where several layers of the communication architecture, from application to physical, are considered together, and jointly optimized, have recently shown to be very successful in 2d applications. Their extension to 3d looks very promising. This approach is particularly important in wireless applications, which may be one of the leading applications of 3DTV, because of the tendency of the wireless operators to feature new applications much earlier than their wired counterparts.

98.4 3DTV Display Technologies

The display is the last, but definitely not least, significant aspect in the development of 3d vision. As has already been outlined, there is a long chain of activity from image acquisition, compression, transmission and reconstruction of 3d images before we get to the display itself. However, the display is the most visible aspect of the 3DTV and is probably the one by which the general public will judge its success. The concept of a three dimensional display has a long and varied history stretching back to the 3d stereo-photographs made in the late 19th century through 3d movies in the 1950's, holography in the 1960 and 1970's and 3d computer graphics and virtual reality of today. Three-dimensional television is a future trend, shown in Table 98.1 and Fig. 98.1, the global three-dimensional

Table 98.1 Worldwide unit shipments preliminary forecast table

Time project	2008	2009	2010	2011	2012
3D RPTV	384	141	30	0	0
3D PDP	237	35	89	1,106	2,748
3D LCD	0	0	37	1,009	3,461

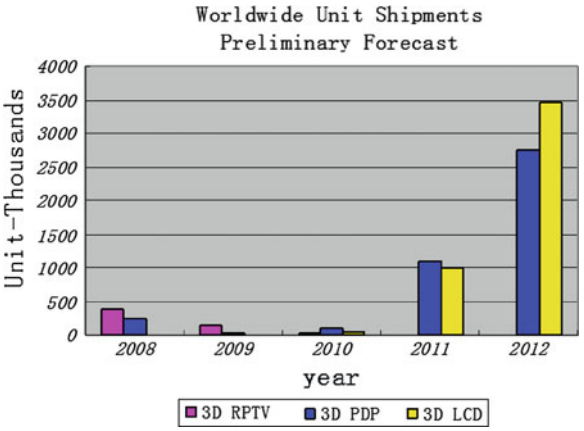

Fig. 98.1 Worldwide unit shipments preliminary forecast

television pre-sale amount. Future, there will be more and more people use the three-dimensional television.

The pursuance of the goal of a full 3d display for TV or other vision applications is an ever expanding field of endeavor. Many approaches have been outlined and discussed, from simple stereo with red/green glasses through to full parallax holography. What technology is applied on a given occasion will largely depend on the application. For example, it maybe that a full parallax, full cooler, interactive holographic display would be used in air traffic control but that an auto stereo-display is more appropriate for low level cad applications. What is clear is that no single approach is likely to dominate and it will be the application which will determine which technology is adopted.

98.5 Conclusions

3DTV techniques have its roots in history. Successful 3DTV systems require a delicate coupling of various technical components, and therefore, multidisciplinary in nature. It is quite possible that future 3DTV systems will have decoupled scene capture and display components, with abstract representation of 3d scenes based on computer graphics tools. Signal processing will convert basic captured 3d scene signals to appropriate signals to drive various kinds of 3DTV displays, ranging from various variants of stereoscopy to well advanced holographic ones. Current research in the field is alive and increasing its momentum.

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Chapter 99
Calculation Model of Fume Temperature During Mine Fire

Xinran Hou, Jinshuang Li and Fusheng Wang

Abstract To judge the influence of fire ventilation pressure on ventilation system stability a fume temperature which is the key factor of determining the value of fire ventilation pressure calculation model has been constructed on the basis of combustion theory and thermodynamics. The construction of model adopted the law of conservation of energy, Boussinesq approximation, Newton cooling theory, and Dalton law, which improved the calculation accuracy of the temperature of mine fire fume and fire ventilation pressure. The model can provide reliable underlying data for ventilation network optimization during mine fire.

Keywords Temperature of fume · Calculation model · Fire ventilation pressure

99.1 Introduction

During mine fire, the temperature of fume rises with the development of the fire, which leads to the reduction in the density of fume, and then produces an effect called "the buoyancy effect" [1, 2]. Fire ventilation pressure is often used as a representation of the value of the buoyancy effect in production. The causation of fire ventilation pressure must have two conditions: fire source and that the outsides of air fumes are vertical or inclined tunnels, so wherever mine fire happens, when

The paper is supported by Science Research Foundation of Hebei United University (project ID: z201206)

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_99,

air fume from fire area flow through vertical or inclined tunnels two different densities of air columns will be formed. The function is contrary to that of natural wind pressure of mine. It can affect the normal ventilation system [3, 4]. Airflow reversal may occur in some tunnels under the influence of fire ventilation pressure to some extent, which adds much to the difficulty of personnel escape and relief work [5, 6]. The temperature of fume is the basic to calculate fire ventilation pressure, so the construction of calculation model of fume temperature is very important to study fire ventilation pressure [7].

99.2 Calculation of Model of Fume Temperature

Taking smoke fume as control volume, the calculation model of fume temperature is constructed using the law of conservation of energy. Supposing that the heat released from fuel combustion would divide into the needed heat of the temperature of smoke fume from T increase T_S and the heat of convective heat transferred from smoke to roadway. In other words, the heat from fuel combustion should be equal to the sum of heat fumes needs and the heat exchange from surrounding rock.

(1) The formation heat of fuel combustion

$$Q_h = h_u \cdot M_F \tag{99.1}$$

where Q_h is the heat during combustion (kJ/h); h_u is the low heat value of fuels (kJ/kg); M_F is the fuel consumption in unit time (kg/h).

h_u, low heat value is the heat generated, without considering the heat released when steam is condensed into water during fuel combustion.

(2) The heat of smoke fume heating required

Supposing that the temperature of smoke fume increases from T to T_S, the formula to calculate heat needed is as follows:

$$Q_P = V \int_{T}^{T_S} C_P \mathrm{dT} \tag{99.2}$$

where Q_P is the heat needed for the increase in temperature of smoke fume from T to T_S(KJ); V is volume of smoke fume (m^3/s); C_P is the specific heat capacity at constant pressure of fume in mine (kJ/(kmol °C)), setting C_{P} = 1 kJ/(kmol °C).

Then we get the following formula (99.3):

$$Q_P = \mathrm{VC}_P(T_s - T) \tag{99.3}$$

To make the problem simpler, adopting the boussinesq approximation, considering that density difference is proportional to temperature difference, and then density variation induced pressure change is very small in comparison to temperature change induced by density change, so pressure change can be ignored, that is:

$$\rho_s = \rho - \rho\beta_T(T_s - T) \tag{99.4}$$

where ρ, ρ_s represents the average density of smoke fume during normal state and mine fire period respectively, (kg/m^3); T, T_s represents the average temperature of smoke fume during normal state and mine fire period respectively, (K); β_T as the expansion coefficient of gas, and to ideal gas, $\beta_T = \frac{1}{T_s}$

If $\beta_T = \frac{1}{T_s}$ we calculate with formula (99.3), and then get:

$$\rho_s = \frac{\mathrm{T}\rho}{T_s}1 \tag{99.5}$$

We can conclude from formula (99.5) that the density of airflow is inversely proportional to the temperature of airflow, therefore when temperature of airflow rises to the highest, its density decreases to the lowest value.

(3) The heat transfer

Convective heat transfer means the heat transfer process between airflow and rock faces when fluids flowing through rock faces of tunnels that have different temperatures. According to Newton's law of cooling, the heat of airflow transfer to rock faces of tunnels in unit time and unit area can be expressed as follows:

$$Q = \alpha\left(t_w - t_f\right) \tag{99.6}$$

where Q means that the heat of airflow transferred to rock faces of tunnels in unit time and unit area (J/(m^{2}s)); α is the convective heat transfer coefficient (J/(m^{2}s °C)); t_w is the temperature of the rock face of tunnel (°C); t_f is the temperature of airflow (°C).

The airflow is a mixture of dry air and steam, supposing that dry air comprises many kinds of gases as a whole, and moist air equals the sum of dry air and steam.

The density of moist air ρ equals the sum of the quality of dry air and steam contained in every choice moist air, that is:

$$\rho = \rho_{d\cdot a} + \rho_v \tag{99.7}$$

where $\rho_{d\cdot a}$ means the density of dry air (kg/m^3); ρ_v means the density of moist air (kg/m^3).

We can regard dry air and steam from moist air as ideal gases, so moist air that comprised of dry air and steam can be represented by ideal gas state equation, that is:

$$\mathrm{Pv} = \mathrm{RT} \tag{99.8}$$

where P is air pressure (Pa); v is the reciprocal of density of air (m^3/kg); T means thermodynamic temperature (K); R is gas constant, and dry air ascertained to be 287 J/(kg·k), steam ascertained to be 461 J/(kg·k).

The pressure of air, namely the pressure of moist air based on Dalton law equals to the sum of dry air partial pressure ($P_{d\cdot a}$) and steam partial pressure (P_v), that is:

$$P = P_{d\cdot a} + P_v \tag{99.9}$$

From formulas (99.7), (99.8) and (99.9), we figure out the relation between density and temperature, that is:

$$T = 0.003484\frac{P}{\rho}\left(1 - \frac{0.378\phi \cdot P_{\text{sat}}}{P}\right),\ T_s = 0.003484\frac{P}{\rho_s}\left(1 - \frac{0.378\phi \cdot P_{\text{sat}}}{P}\right) \tag{99.10}$$

According the conservation of energy law, we obtain that:

$$Q_h = \text{vC}_P(T_s - T) + \alpha(T_w - T_s) = (\text{vC}_P - \alpha)T_s - \text{vC}_P T + \alpha \text{T}_w \tag{99.11}$$

Putting (99.5), (99.10) into (99.11), we get the formula to calculate the temperature of airflow:

$$T_s = \frac{\text{T}\rho\left[Q_h + 0.003484\text{VC}_P\frac{P}{\rho}\left(1 - \frac{0.378\phi\cdot P_{\text{sat}}}{P}\right) - \alpha \text{T}_w\right]}{0.003484\rho\left(\text{VC}_p - \alpha\right)\left(1 - \frac{0.378\phi\cdot P_{\text{sat}}}{P}\right)} \tag{99.12}$$

where T_s is the temperature of mine fire fume (K); T is the temperature of airflow (K); ρ is density of airflow (kg/m^3); Q_h is the heat generated during combustion (kJ/h); V is volume flow (m^3/s); C_p is specific heat capacity at constant pressure of mine airflow (kJ/(kmol °C)); P is the atmospheric pressure (Pa); ϕ is the Relative Humidity; P_{sat} means pressure of saturated moist air (Pa); α is convective heat transfer coefficient (J/(m^2s °C)); T_w is the temperature of tunnel rock face (K).

The value of fire ventilation pressure will continuously change along with the development of fire, and approximate calculation of partial fire ventilation pressure (h_{fr}) produced in well lane is as follows [8]:

$$h_{\text{fr}} = \rho \text{gZ}\frac{\Delta \text{T}}{T_{\text{s}}} \tag{99.13}$$

where h_{fr} means partial fire ventilation pressure (Pa); g is the acceleration of gravity (m/s^2); Z is height difference of roadway two terminals (m); ΔT is increment of air average temperature in mine tunnel before and after the fire (K); Ts is average temperature of mine fire fume in mine tunnel after the fire (K).

Putting (99.12) into (99.13), we obtain the formula of fire ventilation pressure as follows:

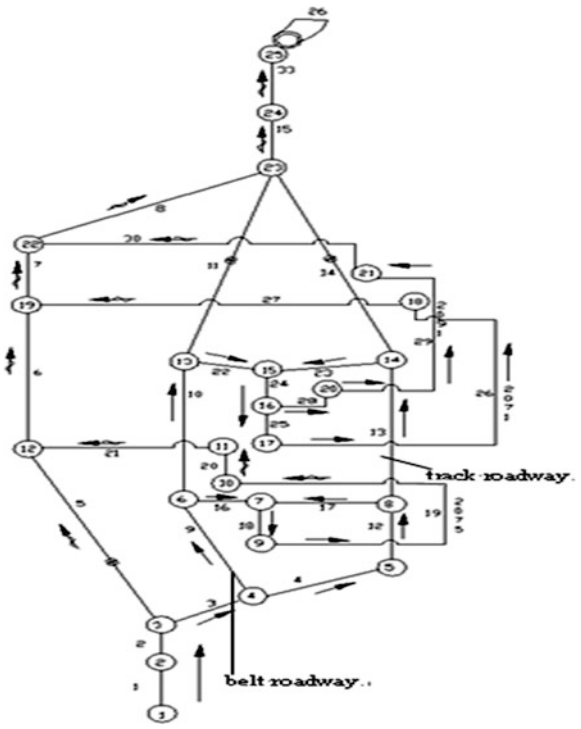

Fig. 99.1 Mine ventilation system

$$h_{\mathrm{fr}} = \rho \mathrm{gz} - \frac{0.003484\rho \mathrm{gz}(v \cdot C_P - \alpha)\left(1 - \frac{0.378\phi \cdot P_{\mathrm{sat}}}{P}\right)}{Q_h + 0.003484v \cdot C_P \frac{P}{\rho}\left(1 - \frac{0.378\phi \cdot P_{\mathrm{sat}}}{P}\right) - \alpha \mathrm{T}_w} \tag{99.14}$$

99.3 Application of Fire Pressure

As shown in Fig. 99.1, the basal areas of track and beltway are 14 m^2, volume flow of mine air is 78.9 m^3/s, Relative Humidity of mine air is 80 %, let the temperature of airflow and tunnel wall be equal before fire occurrence, $T = 296$ K; density of airflow $\rho = 1.2$ kg/m^3. In the complex environment of mine, external-origin fire induced by electric spark and electric spark in mine often ignite belt, and generate plenty of poisonous and harmful gas such as HCl, CO etc., which add very much to the threat of workers, so calculate the ventilation network of the belt roadway [9, 10]. Take an assumption that 4th mouth of belt conveyor roadway in mining area 10, 2nd level which is at weather side of the belt roadway causing fire and then ignite belt that the heat during combustion in 6.3–8.3 × 105 kJ/h, for safety take the maximum value; the height difference of the two terminals of the roadway is 69.1 m, according to formula (99.14) calculate and obtain the maximum value of fire ventilation

pressure generated by the combustion of belt in mine is 633 Pa [11]. By using software for mine ventilation network solution-MFIRE, obtain the result, and shows that three tunnels occur airflow reversal, and obtain the paths of gas spread by analysing (Fig. 99.2), as follows:

(1) Branch 9 → branch 16 → branch 17 → branch 12 → branch 4 → branch 9 → branch 16 → branch 18 → branch 19 → branch 20 → branch 21 → branch 6 → branch 7 → branch 8 → branch 15 → branch 33 then out of the well (affect 2075 working face);
(2) Branch 9 → branch 10 → branch 22 → branch 24 → branch 25 → branch 26 → branch 27 → branch 7 → branch 8 → branch 15 → branch 33 then out of the well (affect 2,071 working face);
(3) Branch 9 → branch 10 → branch 22 → branch 24 → branch 28 → branch 29 → branch 30 → branch 8 → branch 15 → branch 33 then out of the well (affect 2,091 working face).

By anglicizing the result of mine ventilation network calculation we obtain that the influenced areas are very large. Effective measures should be taken to control the fire behavior, and at the same time workers who are threatened should wear

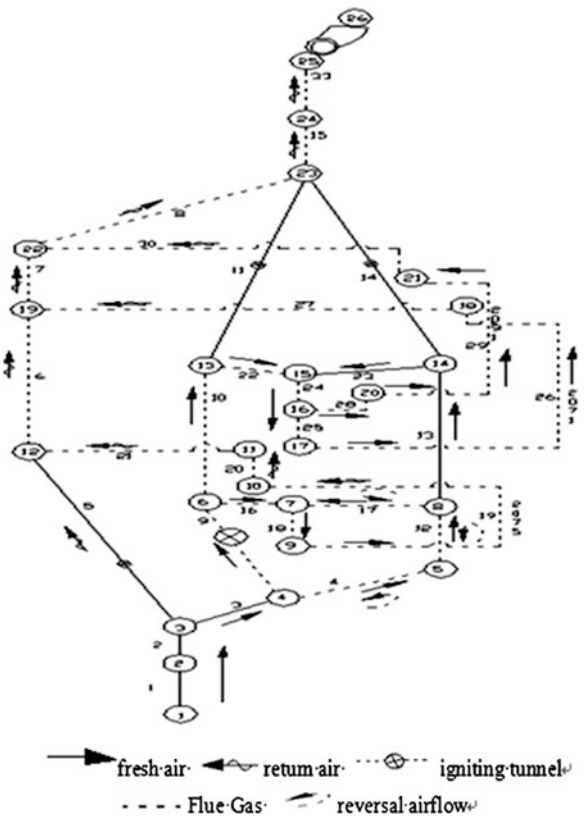

Fig. 99.2 The smoke flow spread of initial fire

self-rescuer, and determine the optimal route for avoiding disaster to escape safety areas according to the route for avoiding disaster made during making the plan of avoiding the disaster before accidents and integrating the actual situation of field, So the results above show that calculation accuracy of fire ventilation pressure is the key restricting factor that affects our judgment of whether the influence scope of flue gas is close to reality during mine fire period.

99.4 Conclusion

(1) The paper shows vividly that fume temperature is the key factor that affects fire pressure through a construction of mathematical measurement model, concludes that species of combustion materials, temperature and density of airflow etc. are all factors affecting fire pressure, and makes the calculation of fire pressure closer to reality;
(2) The mathematical measurement model can improve the accuracy of judgment regarding the influence of fire pressure on the ventilation system stability, which may serve as the scientific basis of taking effective airflow control measures timely and the development of emergency rescue plan, and to reduce the damage of life and property.

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Chapter 100
Smooth Connection of Cubic T-B Spline and Uniform Rational B Spline Curves in Industrial Design

Yali He, Wang Zhao, Shujing Zhao and Jincai Chang

Abstract This article presents a general algorithm for solving cubic TC-B spline curve, and then the expression of the cubic T-B spline. Based on the cubic B-spline basis function, the expression of cubic uniform rational B-spline curve can be derived. Finally, smooth splicing conditions of G^0, G^1, G^2 with the cubic T-B spline and cubic uniform rational B-spline are given. The instance has an important application value in the curve and surface modeling.

Keywords Curve and surface modeling · TC-B spline · T-B spline · Uniform rational B spline · Connect

100.1 Introduction

The spline function proposed by Schoenberg is a method of solving the problem of curve connecting in early industrial design. With the rapid development of computer science and technology, curve surface modeling in CAD/CAM application is increasing widely, such as automobiles, aircraft and shape design, machinery parts processing, etc. In Computer Aided Geometry Design (CAGD), we generally use

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_100,

not only one curve, but composite curves combined by satisfied certain continuity conditions [1]; therefore, the smoothing connection of curves is the key to present a complex combination of curves.

This article mainly studies the connection problem of cubic T-B spline curves and cubic uniform rational B-spline. The T-B spline and B-spline curves are similar in properties [2]; however, the former can accurately express some of the common quadratic curves such as arcs, elliptical arcs, and so on, while the curves expressed by B-spline are in error sometimes. In the connecting process, when the uniform rational B-spline in the condition of control points and nodes have been identified, the weight factor can be used as the parameter to adjust the shape of curves and do not have to adjust the control points [3]. This paper presents a method to solve the expression of cubic TC-B spline using MATLAB, which can save the calculated steps and time.

100.2 The Definition of TC-B Curve

If the constructed TC-B and B-spline curves have similar geometrical properties, then their basis functions must be positive, normative, and the corresponding properties of the endpoint, curve expression [4,5] is:

$$P(t) = \sum_{j=0}^{n} P_j \varphi_{j,n}(t), t \in [0, \alpha], \alpha \in (0, \pi) \text{ therein } \varphi_{j,n}(t) \geq 0 \tag{100.1}$$

$$\sum_{j=0}^{n} \varphi_{j,n}(\mathrm{t}) \equiv 0$$

$$\begin{cases} \varphi_{j,n}(\alpha) = 0, \ j = 0 \\ \varphi_{j,n}(0) = 0, \ j = n \end{cases}$$

$$\begin{cases} \varphi_{j,n}^{(k)}(\alpha) = 0, \ j = 0 \\ \varphi_{j,n}^{(k)}(0) = 0, \ j = n \ \ (1 \leq k < n) \end{cases}$$

$$\varphi_{j,n}(0) = \varphi_{j+1,n}(\alpha).(j = 1, 2, \ldots, n-1)$$

$$\varphi_{j,n}^{(k)}(0) = \varphi_{j+1,n}^{(k)}(\alpha). \quad (j = 1, 2, \ldots, n-1; \quad 1 \leq k < n) \tag{100.2}$$

K is the order of the derivative.
When $n = 2, \varphi_{i,2}(t) = C_{i,0} + C_{i,1} \sin t + C_{i,2} \cos t$.
When $n \geq 3$,

$$\varphi_{i,n} = \begin{cases} \varphi_{i,n-1}(t) + C_{i,n} \cos\left[\frac{n+1}{2}\right] t. & (n \text{ is odd number}) \\ \varphi_{i,n-1}(t) + C_{i,n} \sin\left[\frac{n}{2}\right] t. & (n \text{ is even number}) \end{cases} \tag{100.3}$$

When $n = 3$, we suppose that the basis function of TC-B spline is:

$$\varphi_{i,3}(t) = C_{i,0} + C_{i,1}\sin t + C_{i,2}(\cos t) + C_{i,3}(\cos 2t)$$

$$\begin{cases} \varphi_{0,3}(t) = C_{0,0} + C_{0,1}\sin t + C_{0,2}(\cos t) + C_{0,3}(\cos 2t) \\ \varphi_{1,3}(t) = C_{1,0} + C_{1,1}\sin t + C_{1,2}(\cos t) + C_{1,3}(\cos 2t) \\ \varphi_{2,3}(t) = C_{2,0} + C_{2,1}\sin t + C_{2,2}(\cos t) + C_{2,3}(\cos 2t) \\ \varphi_{3,3}(t) = C_{3,0} + C_{3,1}\sin t + C_{3,2}(\cos t) + C_{3,3}(\cos 2t) \end{cases}$$

Meet the above boundary conditions:

$$\begin{cases} \varphi_0(\alpha) = 0 \\ \varphi_0^{(1)}(\alpha) = 0 \\ \varphi_0^{(2)}(\alpha) = 0 \end{cases}, \begin{cases} \varphi_0(0) = \varphi_1(\alpha) \\ \varphi_0^{(1)}(0) = \varphi_1^{(1)}(\alpha) \\ \varphi_0^{(2)}(0) = \varphi_1^{(2)}(\alpha) \end{cases}, \begin{cases} \varphi_1(0) = \varphi_2(\alpha) \\ \varphi_1^{(1)}(0) = \varphi_2^{(1)}(\alpha) \\ \varphi_1^{(2)}(0) = \varphi_2^{(2)}(\alpha) \end{cases}, \begin{cases} \varphi_2(0) = \varphi_3(\alpha) \\ \varphi_2^{(1)}(0) = \varphi_3^{(1)}(\alpha) \\ \varphi_2^{(2)}(0) = \varphi_3^{(2)}(\alpha) \end{cases}, \begin{cases} \varphi_3(0) = 0 \\ \varphi_3^{(1)}(0) = 0 \\ \varphi_3^{(2)}(0) = 0 \end{cases}$$

$$\varphi_0(t) + \varphi_1(t) + \varphi_2(t) + \varphi_3(t) \equiv 1$$

Obtained system of equations containing 16 equations and 16 unknown numbers:

$$\begin{aligned}
&C_{00} + C_{01}\sin\alpha + C_{02}\cos\alpha + C_{03}\cos 2\alpha = 0 \\
&C_{01}\cos\alpha - C_{02}\sin\alpha - 2C_{03}\sin 2\alpha = 0 \\
&-C_{01}\sin\alpha - C_{02}\cos\alpha - 4C_{03}\cos 2\alpha = 0 \\
&C_{00} + C_{02} + C_{03} - C_{10} - C_{11}\sin\alpha - C_{12}\cos\alpha - C_{13}\cos 2\alpha = 0 \\
&C_{01} - C_{11}\cos\alpha + C_{12}\sin\alpha + 2C_{13}\sin 2\alpha = 0 \\
&-C_{02} - 4C_{03} + C_{11}\sin\alpha + C_{12}\cos\alpha + 4C_{13}\cos 2\alpha = 0 \\
&C_{10} + C_{12} + C_{13} - C_{10} - C_{21}\sin\alpha - C_{22}\cos\alpha - C_{23}\cos 2\alpha = 0 \\
&C_{11} - C_{21}\cos\alpha + C_{22}\sin\alpha + 2C_{23}\sin 2\alpha = 0 \\
&-C_{12} - 4C_{13} + C_{21}\sin\alpha + C_{22}\cos\alpha + 4C_{23}\cos 2\alpha = 0 \\
&C_{20} + C_{22} + C_{23} - C_{20} - C_{31}\sin\alpha - C_{32}\cos\alpha - C_{33}\cos 2\alpha = 0 \\
&C_{21} - C_{31}\cos\alpha + C_{32}\sin\alpha + 2C_{33}\sin 2\alpha = 0 \\
&-C_{22} - 4C_{23} + C_{31}\sin\alpha + C_{32}\cos\alpha + 4C_{33}\cos 2\alpha = 0 \\
&C_{30} + C_{32} + C_{33} = 0;\ C_{31} = 0;\ -C_{32} - 4C_{33} = 0;\ C_{00} + C_{10} + C_{20} + C_{30} - 1 = 0;
\end{aligned}$$

Using MATLAB [6] statement can obtain C_{00},……, C_{30}

S = solve ('c00 + sin (a)*c01 + cos (a)*c02 + cos (2*a)*c03 = 0', 'cos (a)*c01 − sin (a)*c02 − 2*sin (2*a)*c03 = 0', '−sin (a)*c01 − cos (a)*c02 − 4*cos (2*a)*c03 = 0', 'c00 + c02 + c03 − c10 − sin (a)*c11 − cos (a)*c12 − cos (2*a)*c13 = 0', 'c01 − cos (a)*c11 + sin (a)*c12 + 2*sin (2*a)*c13 = 0', '−c02 − 4*c03 + sin (a)*c11 + cos (a)*c12 + 4*cos (2*a)*c13 = 0', 'c10 + c12 + c13 − c20 − sin (a)*c21 − cos (a)*c22 − cos (2*a)*c23 = 0', 'c11 − cos (a)*c21 + sin (a)*c22 + 2*sin (2*a)*c23 = 0', '−c12 − 4*c13 + sin (a)*c21 + cos (a)*c22 + 4*cos (2*a)*c23 = 0', 'c20 + c22 + c23 − c30 − sin (a)*c31 − cos (a)*c32 − cos (2*a)*c33 = 0', 'c21 − cos (a)*c31 + sin (a)*c32 + 2*sin (2*a)*c33 = 0', '−c22 − 4*c23 + sin (a)*c31 + cos (a)*c32 + 4*cos (2*a)*c33 = 0', 'c30 + c32 + c33 = 0', 'c31 = 0', 'c32 + 4*c33 = 0', 'c00 + c10 + c20 +

$c30 = 1$', '$c00$', '$c01$', '$c02$', '$c03$', '$c10$', '$c11$', '$c12$', '$c13$', '$c20$', '$c21$', '$c22$', '$c23$', '$c30$', '$c31$', '$c32$', '$c33$').

disp('$S.c00$'), disp($S.c00$), disp('$S.c01$'), disp($S.c01$), disp('$S.c02$'), disp($S.c02$), disp('$S.c03$'), disp($S.c03$), disp('$S.c10$'), disp($S.c10$), disp('$S.c11$'), disp($S.c11$), disp('$S.c12$'), disp($S.c12$), disp('$S.c13$'), disp($S.c13$), disp('$S.c20$'), disp($S.c20$), disp('$S.c21$'), disp($S.c21$), disp('$S.c22$'), disp($S.c22$), disp('$S.c23$'), disp($S.c23$), disp('$S.c30$'), disp($S.c30$), disp('$S.c31$'), disp($S.c31$), disp('$S.c32$'), disp($S.c32$), disp('$S.c33$'), disp($S.c33$).

Because the solution of equations is very complicated, they are not listed here; the method can obtain the TC-B spline expression when α is of any value.

100.3 Expression of T-B Spline Basis Function and Endpoint Property of the Curve

When $\alpha = \frac{\pi}{2}$, TC-B spline is T-B spline, the expression of T-B spline basis function is as follows:

$$\begin{cases} \varphi_{0,3}(t) = \frac{1}{12}(3 - 4\sin t - \cos 2t) \\ \varphi_{1,3}(t) = \frac{1}{12}(3 + 4\cos t + \cos 2t) \\ \varphi_{2,3}(t) = \frac{1}{12}(3 + 4\sin t - \cos 2t) \\ \varphi_{3,3}(t) = \frac{1}{12}(3 - 4\cos t + \cos 2t) \end{cases} \quad t \in \left[0, \frac{\pi}{2}\right]$$

The expression of T-B spline curves is:

$$T(t) = \varphi_{0,3}(t)q_0 + \varphi_{1,3}(t)q_1 + \varphi_{2,3}(t)q_2 + \varphi_{3,3}(t)q_3$$

$$T\left(\frac{\pi}{2}\right) = \frac{1}{6}q_1 + \frac{2}{3}q_2 + \frac{1}{6}q_3 \tag{100.4}$$

$$T'\left(\frac{\pi}{2}\right) = \frac{1}{3}(q_3 - q_1) \tag{100.5}$$

$$T''\left(\frac{\pi}{2}\right) = \frac{1}{3}(q_1 - q_2) + \frac{1}{3}(q_3 - q_2) \tag{100.6}$$

.

100.4 The Expression of Cubic Uniform Rational B-Spline Basis Function and Endpoint Property of the Curve

According to the expression of cubic B-spline basis functions, the expression of cubic uniform rational B-spline basis functions with h as step length can be deduced

$$u \in [u_{l+3}, u_{l+4}],\ l = 1, 2 \cdots\cdots n-3, u = u_{l+3} + t, t \in [0, h]$$

$$N_{i,3}(u)\begin{cases} \dfrac{(u-u_i)^3}{6h^3}, \\ \dfrac{1}{6h^3}\Big[(u-u_i)^2(u_{i+2}-u)+(u-u_i)(u_{i+3}-u)(u-u_{i+1})+(u_{i+4}-u)(u-u_{i+1})\Big], u \in [u_{i+1}, u_{i+2}] \\ \dfrac{1}{6h^3}\Big[(u-u_i)(u_{i+3}-u)^2+(u-u_{i+1})(u_{i+3}-u)(u_{i+4}-u)+(u_{i+4}-u)^2(u-u_{i+2})\Big], u \in [u_{i+2}, u_{i+3}] \\ \dfrac{(u_{i+4}-u)^3}{6h^3}, u \in [u_{i+3}, u_{i+4}] \end{cases}$$

When $i = l$, then

$$N_{l+1,3}(t) = \frac{(h-t)^3}{6h^3} = \frac{1}{6h^3}(h^3 - 3h^2t + 3ht^2 - t^3)$$

When $i = l + 1$, then

$$\begin{aligned} N_{l+1,3}(t) =& \frac{1}{6h^3}\Big[(2h-h)(h-t)^2 + (t+h)(h-t)(2h-t) + (2h-t)^2h\Big] \\ =& \frac{1}{6h^3}(4h^3 - 6ht^2 + 3t^3) \end{aligned}$$

When $i = l + 2$, then

$$\begin{aligned} N_{l+2,3}(t) =& \frac{1}{6h^3}\Big[(h+t)^2(h-t) + (h+t)(2h-t)t + (3h-t)t^2\Big] \\ =& \frac{1}{6h^3}(h^3 - 3t^3 + 3h^2t + 3ht^2) \end{aligned}$$

When $i = l + 3$, then

$$N_{l+2,3}(t) = \frac{1}{6h^3}(t^3)$$

The expression of cubic uniform rational B-spline curves is as follows:

$$\begin{aligned} R_l(u) &= \frac{\sum_{j=o}^{3}\omega_{l+j}N_{l+j,3}(u)P_{l+j}}{\sum_{j=o}^{3}\omega_{l+j,3}(u)} \\ &= \frac{(h^3 - 3h^2t + 3ht^2 - t^3)\omega_lP_l + (4h^3 - 6ht^2 + 3t^3)\omega_{l+1}P_{l+1} + (h^3 + 3h^2t + 3t^2h - 3t^3)\omega_{l+2}P_{l+2} + t^3\omega_{l+3}P_{l+3}}{(h^3 - 3h^2t + 3ht^2 - t^3)\omega_l + (4h^3 - 6ht^2 + 3t^3)\omega_{l+1} + (h^3 + 3h^2t + 3t^2h - 3t^3)\omega_{l+2} + t^3\omega_{l+3}} \\ R_0(0) &= \frac{\omega_0P_0 + 4\omega_1P_1 + \omega_2P_2}{\omega_0 + 4\omega_1 + \omega_2} \end{aligned} \tag{100.7}$$

$$R_0'(0) = \frac{6\omega_0\omega_2(P_2 - P_0) + 12\omega_1\omega_2(P_2 - P_1) + 12\omega_0\omega_1(P_1 - P_0)}{h(\omega_0 + 4\omega_1 + \omega_2)^2}$$

$$R_0''(0) = \frac{36\omega_0\omega_1(4\omega_1 - \omega_0 + 3\omega_2)(P_0 - P_1) + 36\omega_1\omega_2(4\omega_1 - \omega_2 + 3\omega_0)(P_2 - P_1) + 36\omega_0\omega_2(\omega_2 - \omega_0)(P_2 - P_0)}{h^2(\omega_0 + 4\omega_1 + \omega_2)^3}$$

100.5 Conditions of Smoothing Connection

There are two metrics about the smoothness of connection: One is parametric continuity of curves, that is parametric curves possess n order parameter continuously differentiable at the connection point, so this type of connecting is C^n or n order parameter continuity; the other is called geometric continuity, and only when the two curves segment corresponding arc length parametric have C^n order continuity at the common connection point, then this type of connecting is G^n continuity [7–9]. Geometric continuity more widely used in engineering.

100.5.1 G^0 Smooth Connect Condition

Curves $P(t)$ and $R_1(t)$ have common connection point. According to (100.4) and (100.7):

$$T\left(\frac{\pi}{2}\right) = R_0(0), \text{ that is } \quad \frac{1}{6}q_1 + \frac{2}{3}q_2 + \frac{1}{6}q_3 = \frac{\omega_0 P_0 + 4\omega_1 P_1 + \omega_2 P_2}{\omega_0 + 4\omega_1 + \omega_2}. \quad (100.8)$$

100.5.2 G^1 Smooth Connect Condition

Curves $P(t)$ and $R_1(t)$ must meet the following two conditions: (a) G^0 connection condition; (b) Two curves at the connection point at the common tangent direction.

First, it needs to meet (100.8), also required to meet $P'\left(\frac{\pi}{2}\right) = mR_0'(0)$:

$$\frac{1}{3}(q_3 - q_1) = \frac{6m[\omega_0\omega_2(P_2 - P_0) + 2\omega_1\omega_2(P_2 - P_1) + 2\omega_0\omega_1(P_1 - P_0)]}{h(\omega_0 + 4\omega_1 + \omega_2)^2} \quad (100.9)$$

In ΔP_0P_1P, by the vector triangle rule:

$$(P_2 - P_0) = (P_2 - P_1) - (P_0 - P_1) \quad (100.10)$$

(100.10) into (100.9) can be:

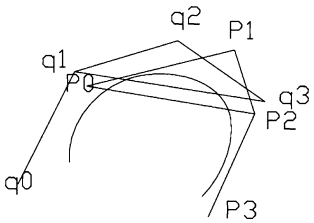

Fig. 100.1 G^1 smooth connection

$$\frac{1}{3}(q_3 - q_1) = \frac{6m[\omega_2(\omega_0 + 2\omega_1)(P_2 - P_1) + \omega_0(\omega_2 + 2\omega_1)(P_1 - P_0)]}{h(\omega_0 + 4\omega_1 + \omega_2)^2} \quad (100.11)$$

q_1q_3 can be linearly represented by P_1P_2 and P_0P, $q_1q_3 \in P_0P_1P_2$ or $q_1q_3//P_0P_1P_2$. Because the two curves have a common connection point, so q_1q_3 and $P_0P_1P_2$ is coplanar (As shown in Figs. 100.1).

100.5.3 G^2 Smooth Connect Condition

Curves $T(t)$ and $R_I(t)$ must to meet the following two conditions: (a) G^I connection condition; (b) Two curves at the connection point curvature equal; (c) Two curves at the connection point, vice normal vector in the same direction.

First should meet (100.11), supposed $k_1(t_0)$ is the curve $T(t)$ curvature at point t_0, and $k_2(t_0)$ is the curve $R(t)$ curvature at point t_0, then according to the curvature of the calculation formula:

$$k_1\left(\frac{\pi}{2}\right) = \frac{\left|T'\left(\frac{\pi}{2}\right) \times T''\left(\frac{\pi}{2}\right)\right|}{\left|T'\left(\frac{\pi}{2}\right)\right|^3} = \frac{\left|\frac{1}{3}(q_3 - q_1) \times \left[\frac{1}{3}(q_3 - q_1) + \frac{2}{3}(q_1 - q_2)\right]\right|}{\left|\frac{1}{3}(q_3 - q_1)\right|^3}$$
$$= \frac{\left|\frac{2}{9}(q_3 - q_1) \times (q_1 - q_2)\right|}{\left|\frac{1}{3}(q_3 - q_1)\right|^3}$$

$$k_2(0) = \frac{|R'(0) \times R''(0)|}{|R'(0)|^3} = \frac{1}{|R'(0)|^3}\left|\left[\frac{6\omega_0\omega_2(P_2 - P_0) + 12\omega_1\omega_2(P_2 - P_1) + 12\omega_0\omega_1(P_1 - P_0)}{h(\omega_0 + 4\omega_1 + \omega_2)^2}\right]\right.$$
$$\left. \times \left[\frac{36\omega_0\omega_1(4\omega_1 - \omega_0 + 3\omega_2)(P_0 - P_1) + 36\omega_1\omega_2(4\omega_1 - \omega_2 + 3\omega_0)(P_2 - P_1) - 36\omega_0\omega_2(\omega_2 - \omega_0)(P_2 - P_0)}{h^2(\omega_0 + 4\omega_1 + \omega_2)^3}\right]\right|$$

In '×', provisions counterclockwise positive direction, the direction of the vector product perpendicular to the plane within two vectors, such as:

$$(P_2 - P_1) \times (P_0 - P_1) = 2S_{\Delta P_0P_1P_2}, (P_2 - P_0) \times (P_2 - P_0)$$
$$= 0, (P_2 - P_0) \times (P_2 - P_0) = 0$$

So: $k_1\left(\frac{\pi}{2}\right) = \frac{\frac{4}{9}S_{\Delta q_1q_2q_3}}{\left|T'\left(\frac{\pi}{2}\right)\right|^3}$, $k_2(0) = \frac{1}{|R'(0)|^3}\left[\frac{432\omega_0\omega_1\omega_2 S_{\Delta P_0P_1P_2}}{h^3(\omega_0+4\omega_1+\omega_2)^3}\right]$.

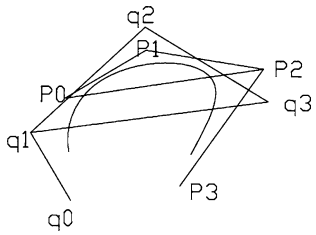

Fig. 100.2 G^2 smooth connection

$$\frac{\frac{4}{9}S_{\Delta q_1 q_2 q_3}}{\left|T'\left(\frac{\pi}{2}\right)\right|^3} = \frac{1}{|R'(0)|^3}\left[\frac{432\omega_0\omega_1\omega_2 S_{\Delta P_0 P_1 P_2}}{h^3(\omega_0+4\omega_1+\omega_2)^3}\right] \tag{100.12}$$

$P'\left(\frac{\pi}{2}\right) = mR_0'(0)$ into (100.12), we can obtain that:

$$\frac{S_{\Delta q_1 q_2 q_3}}{S_{\Delta P_0 P_1 P_2}} = \frac{972m^3\omega_0\omega_1\omega_2}{h^3(\omega_0+4\omega_1+\omega_2)^3} \tag{100.13}$$

In the formula (100.13), in the condition of control points is definite, only need to adjust the weight factor ω_i, So that is established. There is no need to change the location of control points, to satisfy the equation. According to the theory [10] prove from reference article, It could be concluded $q_3 - q_2$ can be linearly expressed by $P_2 - P_0$ and $P_1 - P_0$, therefore $q_2q_3 // P_0P_1P_2$ or $q_2q_3 \in P_0P_1P_2$ combined with conditions $q_1q_3 \in P_0P_1P_2$ or $q_1q_3 // P_0P_1P_2$ in the G^1 continuity, we can obtain $q_1q_2q_3 // P_0P_1P_2$ or $q_1q_2q_3$ and $P_0P_1P_2$ is coplanar, because the common connection point is the intersection between $\Delta q_1q_2q_3$ and $\Delta P_0P_1P_2$, $q_1q_2q_3$ and $P_0P_1P_2$ is coplanar. In other words the six points q_1, q_2, q_3, P_0, P_1, P_2 are coplanar. So the two curves have a common osculating plane (As shown in the Fig. 100.2).

100.6 Conclusion and Outlook

This paper discusses the smoothing connection between the trigonometric and polynomial spline curves, introduced the TC-B spline, T-B spline and uniform rational B-spline often used in computational geometry, and then gave the G^0, G^1, G^2 smooth connection conditions for the two curves, that will help graphic design workers. In our studies, we research the splicing between the polynomial spline curves, and the part of trigonometric spline included in spline curves, which can further consider the splicing between the T-B spline curve and NURBS curves, or between triangular spline surface and polynomial spline surfaces. The order geometric continuity can also be increased from the second order to third order, fourth order, or even to order n. In short, our aim is to make the connection of curves and surfaces smoother and make the graphics more beautiful.

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Chapter 101
Study on Manufacturing Industry Based on VMI

Yuelan Sun

Abstract In the competitive environment of supply chain, the traditional method of inventory management has been unable to meet the needs of enterprise development. In order to solve the problems of supply chain operation efficiency, Vendor managed inventory (VMI) offers new methods. Taking Bosch as a case, the article studied on the concrete implementation of the VMI and the proceeds in China's manufacturing industry, and had come to the conclusion that the VMI can improve the competitiveness of enterprises.

Keywords Vendor managed inventory (VMI) · Supply chain management · Manufacturing industry

101.1 Brief Introduction of Bosch and Its Logistics Operation Mode

Bosch power tools (China) Limited (hereinafter referred to as "Bosch") was established in 1995, the headquarters are located in Hangzhou City, Zhejiang Province. Including Bosch century and annex 3 factories, the company's existing staff comprises more than 3,800 people. Bosch's products mainly include five major categories: handheld power tools, desktop power tools, measuring tools, gardening and power tool accessories. Currently, more than 1,000 products are sold worldwide [1].

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
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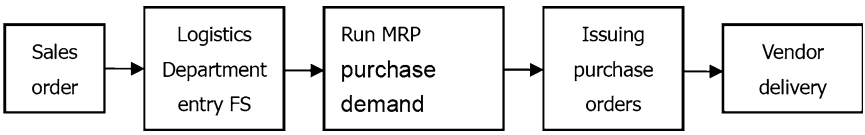

Fig. 101.1 Production materials procurement process

101.2 Bosch Company Logistics Operation Mode

101.2.1 Bosch Logistics System Operation Process

(1) Purchase process of Bosch

According to the functions of every department in organization structure, the entire process of all productive materials from sales orders to materials purchase orders are shown in Fig. 101.1.

In this process [2]:

1. Materials production plan according to sales forecasts and orders determines product demand planning of the company in the future, and then inputs information in the company FS system and assigns production tasks.
2. Logistics material plan according to the product requirement plan issues a purchase order to current components and parts suppliers.
3. In normal circumstances, the supplier according to the requirements of the purchase order delivery time delivery, when the production plan adjust or supplier delivery problems, the materials could not meet the normal requirements of production orders. Logistics department is according to production schedule and lack of materials summary of short of materials information and feedback to the Purchasing Department, by purchasing department for lack of material production processing, contacting vendors for delivery.

101.2.2 Bosch Production Process

Currently, Bosch is using the traditional production mode of operation. In this process, Logistics Department according to customer orders, monthly production plan, weekly production plan, and materials supply assign production, after the completion of production, they are sent into the finished product warehouse of the Logistics Department to be shipped. All processes of production according to the instructions of production, even if before and after the process due to the lack of materials, equipment failures, quality problems, changes or abnormalities has nothing to do with this. Production is continued by the original instruction, which resulted in the output not balanced among the production processes. Therefore, there is a lot of inventory in process among the processes.

Table 101.1 2010, 1–9 month inventory reporting unit: thousand Yuan

Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Raw material inventory	33,721	33,838	32,825	33,124	32,214	33,692	34,383	35,329	35,347
Product inventory	7713.4	9018.9	10,363	11,592	14,740	11,531	12,822	12,960	13,271
Total inventory	41,435	42,857	43,187	44,716	46,954	45,224	47,205	48,290	48,618

Source Bosch finance inventory analysis reports

101.3 Analysis of Logistics Operation Mode in Bosch Currently

The current logistics system of Bosch is inefficient and unstable, taking longer to meet the growing business needs of the company. It mainly shows in the following aspects.

101.3.1 Long Delivery of Parts, Resulting in High Inventory and Slow Turnover

The Bosch 2010, 1–9 month inventory report is shown in Table 101.1.

Bosch inventory turnover days are calculated as follows: inventory turnover days = month end inventory/average consumption of the later two month *30. According to this formula, Bosch company 2010, 1–9 month inventory turnover days is shown in Fig. 101.2.

From Fig. 101.2, Bosch's raw material inventory turnover average days of 199 days, and production of other power tools Bosch Group abroad company inventory turnover average days for about 80 days. The company is relatively slow in inventory turnover, which means a lot of money is to be used by inventory.

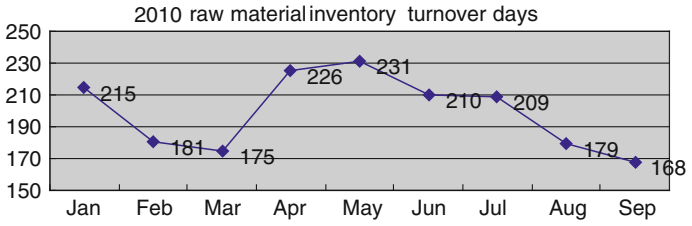

Fig. 101.2 Raw material inventory turnover days of Bosch

Table 101.2 Bosch 2010–2011 logistics cost accounting for sales of the year

Years	Logistics costs/sales %
2010	15
2011	13.5

101.3.2 High Logistics Costs

Due to Bosch qualified supplier evaluation conditions being higher, it results in no local suppliers meeting requirements that can provide these key components. Many key parts such as high-performance steel and carbide knives first need to import the supply radius and the delivery cycles of these parts are long. To meet the need of production and customer orders in time, Bosch can shorten delivery time by air, resulting in high levels of air freight [3]. At the same time due to the inconsistent quality of raw materials from local vendors, a low passing rate of materials, numbers of parts repair many times, they produce high maintenance costs and loss of working costs, leading to high logistics costs. Bosch 2008–2009 logistics cost accounting for sales ratio of the year for example, are as shown in Table 101.2.

This leading level in this index is 5 % in other group companies. Bosch logistics costs are too high, which will directly affect the economic benefit of the company.

101.3.3 Suppliers Do Not Meet Company Requirements of Agile Manufacturing

There are many problems because Bosch company cannot share information with existing suppliers, such as:

- The customer's demand is not clear, upstream suppliers cannot grasp the point of sale data in the lower.
- A large number of spare inventories.
- A long reaction time to customer demand.
- Quantity, packaging, and freight volumn are difficult to grasp.
- Limit the flexibility of supply of secondary suppliers.
- In order to solve the above problems of Bosch Company in logistics system and make logistics management truly become the company's "third profit source", Bosch introduced a new logistics operation mode—Vendor managed inventory (VMI) mode.

101.4 Design and Implement VMI in Bosch

101.4.1 The Design of VMI

Selecte Suppliers Bosch company currently has more than 100 supply chain partners, according to the components of the annual procurement amount and complexity and importance, Bosch classify the vendors by the principles of ABC. For class A and class B suppliers part, Bosch has established the common interests of mutual trust with them through long-term cooperation, so they are willing to establish and maintain strategic partnerships with Bosch.

VMI implementation framework VMI implementation of agreement framework in implementation process should be often to supervision and amendment, the framework agreement which Bosch and suppliers signed contains:

1. Set material ownership transfer time and the both responsibility range, transfer time clearly, distinguish both responsibility, and so effectively ensure the safety stock.
2. Terms of payment, technical support, and information security.
3. Suppliers selection of transport mode and warehouse building, default terms.
4. VMI stock varieties and added plans, VMI organization structure.
5. Inventory levels and control.

It should be set the respective rights and obligations, terms of payment, management fee charged, the remaining material storage location. In the payment way, it determines the consumption of the materials according to the actual materials consumption of workshop.

101.4.2 VMI Implementation

Bosch requires a wide variety of materials, supplier of wide distribution from domestic to abroad. VMI implementation should be based on different time, different stages of choosing the right model of VMI, take VMI mode to a suitable vendor.

First make use of ABC classification, the supplier is determined to be of a class can implement VMI management object, on the Bosch factory in close proximity of suppliers can also be considered, after investigation by the Procurement Department of qualified, a framework agreement is signed as VMI supplier.

VMI supplier will receive the supply item inventory, VMI monitoring tables, including existing inventory information, actual consumption and demand information, the vendor can be based on the monitoring plan shipping information in a table number and time.

Under supplier's feeding system of material delivery directly to the VMI range Bosch. Vendor specialist according to the material stock is responsible for timely replenishment and dealing with emergencies. Quality fail is returned.

Under the model of VMI, Bosch FS every Monday morning on weekend run MRP based supplier of warehouse management information system the latest inventory data, material demand forecasts for the next 16 weeks customer order information into VMI monitoring tables, provided to suppliers via Internet.

Supplier in accordance with Bosch VMI monitoring material requirements and inventory data in a table, combined with the two sides agreed the VMI warehouse of maximum and minimum stock levels, to identify specific delivery time and quantity.

101.5 Bosch VMI Implementation Results

101.5.1 Qualitative Analysis of VMI Implementation Returns

Bosch through the procurement logistics links of implementing VMI in supply chain management, although only at the early stages of implementation, but has experience into VMI management helped the integration of logistics and supply chain as a whole, as well as through the integration of supply chains bring huge economic benefits to the company, and truly benefit from the supply chain.

Compared with traditional logistics mode, after Bosch company implements VMI, logistics cost greatly reduced, while it can reduced stock of funds occupied, it main reflects in following several area:

It greatly reduced parts deficiency material of risk and probability Bosch by Internet of way to suppliers issued 4 months of scroll material needs forecast, and currently in VMI warehouse within placed material of inventory standard, let suppliers by VMI monitoring table Gets information, control supplement cargo time and number, Maintain a certain level of safety stock, ensure the production line to the goods available, enhance the capacity of Bosch manufacture of elastic, improved Bosch on the user's response time and level of service.

The actual realization of zero inventory management of supply chain due to their ownership belong to the vendor and item information in inventory in the inventory management system is a virtual inventory records on the Bosch, Bosch, is a "zero inventory".

Reduce the Bosch Company logistics cost of the workload of the Department of planning and ordering, because the vendor took over the regular complement VMI inventory plans and orders handed down by job function, saves a lot of time and effort, greatly reducing the cost of order management. Logistics officers at the same time as the Bosch VMI warehouse instant control of material, can concentrate on unification of materials, transport, cargo inspection, goods received before the preparatory work, accelerating the process of cargo warehousing, reduces logistics costs.

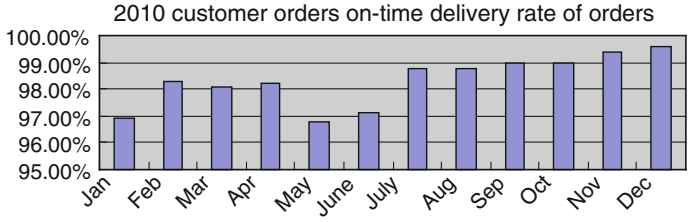

Fig. 101.3 Customer orders on-time delivery rate

101.5.2 Quantitative Analysis of VMI Implementation Benefits

VMI implementation benefits analysis on evaluation index of Bosch company implement. After Bosch company 2010, 9 copies began implementation VMI, inventory level, inventory turnover, customer orders timely delivery rate, important index are occurs has changes:

Because the ownership of material in VMI warehouse belongs to suppliers, before Bosch doesn't use these material, system in the material of book inventory is in suppliers of warehouse within, on Bosch company, is zero inventory, so company of inventory level comparison VMI project implementation Qian has larger reduced. Greatly increase the company's working capital efficiency, reliece the tension of the company's cash flow.

Figure 101.3 is a 2010, 1 customer orders on-time delivery rate chart, it can be seen from the chart: because suppliers of Bosch's material requirements planning more clearly than ever before, through the analysis of material planning and forecasting, vendors can better organization of preparation of raw materials, parts and components of production to guarantee the Bosch customer orders, production requirements.

Some of the company's total inventory a greater proportion of the material there was a noticeable increase in inventory turnover. High inventory turns; it shows capital utilization rate high, less inventory backlog, reduce capital cost of inventory, Enterprise profitability increase. Figure 101.4 is the Bosch Company in September after implementation of VMI, data analysis of inventory turnover days.

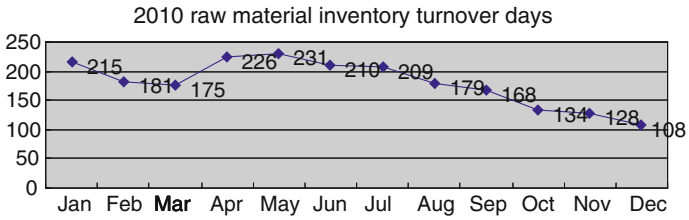

Fig. 101.4 Model of VMI inventory turns

From the above analysis, Bosch can increase benefits through the implementation of VMI, the profit increases from 15,180 to 15,386, but the profits of suppliers decreased, from 43,843 to 43,740; and supply chain total profit has increased, from 59,023 to 59,126. It shows that VMI can improve supply chain performance.

This case that implementing VMI in Bosch in dates: compare with traditional inventory management in manufacturing industry, after the implementation of VMI, it can remove obstacles of communication between up steam and downstream enterprises in supply chain, inventory supply chain enterprise-parts suppliers to manage, it can let go of hands and feet for the core business of manufacturing enterprise development. Compared with downstream enterprise manage its own inventory, supplier in their more experienced product management professional.

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Part XI
Manufacturing Engineering and Management

Chapter 102
Research of Bridge Health Intelligent Detecting Vehicle

Jinbo Song

Abstract China's bridge, the old bridge is a large number of accidents, the bridge when the accident occurred. So it is very important to bridge health monitoring. The current bridge is usually detected in the bridge on the scaffold or suspension of personnel to the bridge bottom artificial detection. These methods have enclosed bridge caused by traffic inconvenience, testing personnel security risks, low work efficiency, large equipment, high cost and problems. In order to overcome the traditional shortcomings of bridge detection method, the project to "fast bridge detection vehicle" "bridge detection vehicle mechanical arm" "intelligent control bridge vehicle detection device". "Bridge detection vehicle support system" and a number of patented technology for the research base, research and development of a bridge health intelligent detecting vehicle. The testing vehicle is in the truck cab mounted computer, in Van right mounting support system (rollover). In the bottom plate of the carriage of the mounting base is arranged on the base, a mechanical arm.

Keywords Bridge health · Intelligent control · Detection vehicle · Reinforcement

102.1 Introduction

Bridge construction is the national important foundation construction of bridge engineering, is the relationship between society and economy to coordinate development of lifeline engineering.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_102,

The bridge of our country faced with numerous international countries bridge the same problem, it is a large number of bridges have entered the ageing stage; some bridges have appeared in various diseases, but all year round to stop operation, great potential safety hazard. In addition, because the original design loads standard and the actual load conditions are not quite the structure safety detection evaluation problem; much bridge bearing capacity is insufficient, the width of the deck does not meet the current requirements of traffic. If not timely detection and elimination of bridge construction, operation safety, is bound to create a huge economic and personal injury, but the unreasonable, premature reformation is a huge economic burden, will cost a lot of money, and caused traffic disruption and many other social problems. Extended overload using a variety of dangerous bridge, old bridge is in a car crash, the bridge when the accident occurred.

Along with the social economy unceasing progress, traffic volume is increasing rapidly, especially the vehicle axle load increases, on the bridge of the increasingly high demand, on bridge damage is also growing, therefore only by scientific and convenient and economic method to more effectively on the existing bridge health of safety testing, to ensure the bridge in the normal life cycle safety. The "12th Five-Year Plan" that the next 5 years basically completed the planning of road network transform, with the new bridge is finished stage by stage, the increase of the number of old bridge, bridge detection and supporting the maintenance and reinforcement content will become the focus of traffic industry project. This graduate output safety, fast, economy of the bridge detection vehicle is very important.

102.2 Similar Products and Technology

The existing bridge detection, mostly artificial detection, conventional testing method is: close traffic scaffold, or use other means to bridge bottom suspension detection testing. This method has many disadvantages, such as: closed to traffic because traffic jams, suspension detection personnel safety risk, the impact of the external environment by many unfavorable factors such as. Due to the above problem of conventional detection methods in practical, safe, economy and other aspects have been unable to meet the existing bridge security detection need fast.

Bridge detection vehicle first appeared in Europe and the United states. The United States of America HYDRA company, Aspen Aerials, Germany MOOG, Italy BARIN Company carried out several years of traditional bridge detection vehicle research and development. Now the equipment technology is very advanced, are used in electronic hydraulic control, and equipped with emergency device, stabilizing device. Italy BARIN Company is currently the main products have AP series, AB series of high-altitude operation car folding arm type bridge detection vehicle and ABC series truss bridge detection vehicle, but all require the use of the hanging basket adopts the artificial detection. Germany MOOG Company has more than 28 years experience in the supply of bridge maintenance

equipment. The main production NIBL series truss bridge detection vehicle is self-propelled and pulling type 2, belong to the nacelle type bridge detection vehicle, need professional high-altitude operations. The United States of America Aspen Aerials company mainly produces folding arm type bridge detection vehicle, the main product models have A-30, A-40, UB-50, A-62, A-75, all of its bridge detection vehicle series can be without installing hydraulic leg and weight of the cases were stable, safe, reliable operation, but still need manual high-altitude.

In the early twentieth century 80 time end at the beginning of 90 time, by the Ministry of transportation highway planning and Design Institute in Beijing crane factory production of type QY-8 automobile crane on the basis of the transformation of design, end in failure, then the domestic and several units developed also failed. In recent years, a number of domestic large-scale construction machinery manufacturers began to engage in bridge detection vehicle development, mainly the Xugong Group, Hunan Baolong, its products and performance can meet the standard of foreign equipment. Group production of the cradle type (folding arm type) of bridge detection vehicle QJ07, QJ12, QJ16, QJ16L, Hunan Baolong special car limited company to develop and produce the truss bridge detection vehicle and Hunan Hengrun high development of limited company launched 16 in truss bridge detection vehicle need artificial operation is detected, operation risk degree large, low working efficiency. But most imported vehicles, expensive. Plus after sale service charges are high, the integrated cost is high.

102.3 Market Prediction and Development Trend

According to the survey, China's bridge detection vehicle "12th Five-Year Plan" takes about 200,000. At present the conventional bridge detection vehicle market price is 300–500 million yuan, due to the larger amount, low detection efficiency, need with artificial reasons in many aspects, the current market has less, the province only Jiangxi province traffic academy purchased 2.

The development of this project of the bridge detection vehicle has the advantages of simple structure, convenient operation, small occupation area, little influence to traffic. After the production cost is about 500,000 yuan, the market prospects are very broad, has great popularization and application value.

At present, domestic and foreign research and development trend of bridge detection vehicle mainly is based on intelligent non artificial detection data acquisition system as the main body, pay attention to the detection of car safety, stability, rapidity, economy.

102.4 The Specific Research Contents and to Resolve Key Technical Problems

102.4.1 Specific Development

The project on "fast bridge detection vehicle", "intelligent control bridge vehicle detection device". "Bridge detection vehicle support system" and a number of patented technology as the previous research results, the economic development zone in Poyang Lake District bridge construction present situation as the object of study, to provide a healthy and rapid detection technology of bridge. It can be solved in bridge detection technology deficiencies, the use of modern imaging, ultrasonic, radar and other equipment, via Bluetooth, infrared wireless transmission technology, the bottom bridge for shot detection, testing personnel directly through the settings on the vehicle display were observed, without carrying the staff to the bridge bottom, thus greatly improve the work efficiency, reduces the requirement of equipment, reducing the size of the device. In the case of bridge closed to traffic on routine functional test, for bridge health life cycle maintenance and repair provide technical reference.

This project is in the project group of researchers digesting, absorbing the most advanced technology of the public, and for its creatively integrated utilization after the successful development of its own technology, l. The main research contents are as follows:

1. The formulation of bridge detection vehicle research and development of the overall solution.
2. The design of detecting vehicle supporting leg, detecting device, detecting a vehicle mechanical arms and other parts of the specific plans and drawings.
3. The study of how in Dongfeng truck on the right side is installed on the frame detection vehicle supporting leg, the carriage bottom plate installed on the base, the base provided with a mechanical arm, the arm is equipped with cameras, radar, ultrasonic and other bridges detection apparatus.
4. In the light of our country current situation of the bridge, making hydraulic transmission mechanical arm intelligent control program, complete the automatic and manual remote information collection.
5. The study of how through infrared, Bluetooth, networking and wireless data transmission technology to realize the mechanical arm, camera, ultrasonic actuator control and operation.
6. As a application of bridge detection vehicle bridge to Jiangxi province for more than 20 years of age old bridge to conduct a comprehensive survey, for detection of bridge peripheral physiognomy investigation, collecting bridge health monitoring data, and archive, according to the survey results, a preliminary classification of bridge type, put forward opinions and budget, as the next step in reinforcement and repair processing to provide more reliable basis, in order to ensure the safety of bridge. According to bridge construction

materials testing results, the bridge structural material current situation analysis, and gives the explicit evaluation. Its focus is on the strength of concrete, steel corrosion and damage of bridge.

102.4.2 To Resolve Key Technical Problems

The main research contents are as follows:

1. The detection of vehicle support to meet the vehicle detection flexibility, stability and safety requirements.
2. The detection device to meet the base support arm requirements.
3. The mechanical arm to facilitate operation of bridge bottom detection.
4. The geological radar to conveniently deck and deck and superstructure of bridge health information collection and the safety decision.
5. The intelligent control system programming to the mechanical arm, camera, ultrasonic devices are controlled effectively, realize the detection data acquisition and transmission.

102.5 The Project Features and Innovations

102.5.1 Project Characteristics

Through infrared, Bluetooth and other wireless data transmission technology in mechanical arm control and operation, has changed the traditional use of high-altitude operation way. The Yeshiva Automotive Technology Service Center in Dongfeng truck equipped with a device testing, bridge detection vehicle supporting leg, radar, ultrasonic testing instruments such as the installation of a reliable, vehicle stability. Adopts the task group patent "intelligent control vehicle detection system", can be of different state of the environment under the bridge of targeted health and safety testing. The stretching device is equipped with independent intellectual property rights of patent technology "bridge detection vehicle mechanical arm", greatly improving the bridge detection range and precision. Adopt traffic safety field of advanced type AC-350EP senior color light suppression type camera, by all apparent crack detection.

As a mechanical arm end with Ounengda type 5,100 color digital ultrasonic detector, a type BS-5040 deck geological ray, the bridge internal health dynamic observation. With the help of hall, is a unit of Jiangxi province transportation engineering archives, the collection data processing analysis, establishing the bridge health archives. The compared with the existing product, the product has clear advantage on the price. 18 m bridge detection vehicle as an example, the

foreign equipment basically in 5,000,000 yuan of above, the domestic equivalent performance equipment price in 3,000,000 yuan, and the product cost is about 500,000 yuan, with strong market competitiveness.

102.5.2 Innovation

In Dongfeng truck equipped with task group to declare the patent "bridge detection vehicle supporting leg", in the process of testing the security and stability of vehicle. The research group of "the patent intelligence control vehicle detection system", without suspension testing personnel, can be in different environment condition of bridge were targeted health safety detection, improves the detection of safety. The stretching device adopts patent "group of task of bridge detection vehicle mechanical arm" (patent number: ZL 201130469701.7), the bridge was a large detection, detection vehicle without the need for frequent mobile. Adopt traffic safety field of advanced type AC-350EP senior color light suppression type camera 6 camera, through all-round apparent crack detection, greatly improving the detection efficiency.

The detection of the use of mechanical arm with Ounengda type 5,100 color digital ultrasonic detector, BS-5040 type geology radar on bridge deck, internal health dynamic observation. I units in Jiangxi province by means of hall of traffic and transportation engineering archives, the collection data processing analysis, establishing the bridge health archives. To reach the technical, economic indicators and social, economic benefit.

102.5.3 Technical Index

Choosing the Dongfeng EQ1096 wagon, and the chassis were modified, with task group of independent research and development of bridge site supporting device (patent has been declared), modified weight 6 tons. The hydraulic activity with 4 degrees of freedom mechanical arm, the original state is 0.8 m high, 6.5 m long arm, working status clear height 8 m, exhibition arm length up to 45 m, according to the Ministry of transport general specification for design of highway bridges and culverts (JTG D62-2004) of the two-way four lane 26 m width less than big, in, small, beam bridge, arch bridge, cable-stayed bridge, suspension bridge, bridge health rapid detection.

The mechanical arm end equipped with already in the field of traffic safety by using 6 AC-350EP advanced color light suppression type camera, the camera integrated 1/2 "SONY EXview HAD CCD chip, the clarity is 540 TVL, minimum illumination 0.0001 Lux F1.2, double filter color to black 600 line, the OSD menu, with high performance light suppression, intelligent tuning, wireless data transmission and other functions can be accurately observed; bridge key parts, apparent status, judge the beam bottom crack length width, forms the image project archives.

As a bridge detection safety driving speed is 60 km/h, detection of mechanical arm stretching state detection rate of 0.1 km/h. Fast bridge detection vehicle under normal operation, every can detect bridge 2–3, and 5–6, the group's research and development of rapid detection of vehicle bridge than conventional detection to improve the efficiency of 8–9 times.

102.5.4 Economic Indicators

But if the first year according to the production 200, priced at 800,000 yuan of computation, then the output value of 16,000,000 yuan, profit 2,880,000 yuan, taxes of 1,600,000 yuan; if second years according to manufacture 300 units of calculation, then the output value of 24,000,000 yuan, profit 4,320,000 yuan, taxes of 2,400,000 yuan; if the first year according to the production of 300 calculation, then the output value of 32,000,000 yuan, profit of 5,760,000 yuan, 3,200,000 yuan of tax.

The press every bridge propping costs 30,000 yuan plan, if every 5 years on the full bridge check, can save support costs 40,000,000 yuan.

102.5.5 Social Results

But without lifting inspection personnel to the bridge detection operation, improves the detection of safety, with potential social benefits.

The detection due to the low cost of equipment, so the bridge was routine testing, improve the running safety of the bridge, will produce enormous social beneficial result.

The project through Research Institute of bridge detection direction teacher 3–5; training in Luqiao is a professional road and Bridge students more than 500 people.

102.5.6 Economic Benefits

It is with Jiangxi province example, according to every bridge propping costs 30,000 yuan plan, if the bridge detection vehicle detection, according to statistics only old bridge three or four bridge can save a support costs 7,980,000 yuan, other bridge health monitoring system can save 16,020,000 yuan support costs. If every 5 years on the full bridge check, can save support costs 40,000,000 yuan.

The result improves the detection personnel safety, and by detecting the hidden elimination of the bridge, will produce enormous economic benefits. Because of the greatly shorten the detection time, does not need to be closed to traffic, will produce greater indirect economic benefit.

102.6 Conclusion

Along with the social economy unceasing development, the traffic volume is increasing rapidly, especially the vehicle axle load increases, on the bridge of the increasingly high demand for bridges, is also growing, so only use the scientific management methods and means, in order to ensure the safety of bridges. This article discusses the bridge health intelligent detecting vehicle as soon as possible can promote traffic industry's rapid development, harmonious society and inject new vitality.

Chapter 103
Contribution of Structure Adjustment to the Energy Conservation and Consumption Reduction in Henan Province

Qingfeng Wang

Abstract This paper applies the contribution calculation model to calculate and analyze the contribution of industrial structure adjustment to unit GDP energy consumption. The result shows that industrial structure adjustment has not caused the unit GDP energy consumption to drop, instead it has created the rise function. Therefore, the government must speed up the industry internal structure adjustment step and take the new industrialization development path, meanwhile, develop the tertiary industry vigorously and enhance service industry proportion, promote industrial structure optimization, and advance positively structure energy conservation in Henan province.

Keywords Industrial structure · Energy conservation and consume reduction · Structure adjustment · Contribution degree

103.1 Introduction

The unit GDP energy consumption in China is not only higher than that in developed countries but also higher than that in many developing countries. According to statistics, China's energy consumed by $100 m GDP is 12.03 million tons standard coal, which is about 5.62 times of German, 3.52 times of America, 1.18 times of India, and 3.28 times of the world average level [1]. However, another fact is China's ownership of energy resources per capita is at a lower level

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_103,

in the world. China's ownership of coal and hydroelectric resources per capita takes only 50 % of the world average level. Therefore, the Chinese government attaches great importance to energy conservation and consumption reduction.

At present, China's energy intensity per unit GDP depends primarily on two factors: the energy consumption level of the industry and the industrial structure [2, 3]. Recently, many scholars have studied deeply on the relationship between energy intensity and industrial structure adjustment [4, 5]. They believe that the irrational industrial structure is the main reason of high energy intensity and energy conservation and consumption reduction can come true mainly by structural adjustment. In 2010, GDP of Henan province reached 2294.3 billion yuan, with a growth of 12.2 % than 2009; meanwhile the energy consumption per 10,000 GDP dropped 5.1 % than 2009. Apparently, the work of energy conservation and consumption reduction has made outstanding achievements. But, how much contributions has the industrial structure adjustment made to saving energy and reducing consumption on earth? What should be done in the future in Henan province? The paper uses the contribution model to analyze this issue according to the related statistical data of 2006–2009, and puts forward some relevant policy advice [6].

103.2 Empirical Examination

103.2.1 The Contribution Calculation Model

At present, adjusting the industrial structure and reducing the energy intensity of industry are the two main ways to make the energy consumption per unit GDP decline. Generally, the following formula is applied to calculate the energy consumption per unit GDP.

$$e = \frac{E}{Y} = \frac{\sum_{i=1}^{3} E_i}{\sum_{i=1}^{3} Y_i} = \frac{\sum_{i=1}^{3} e_i Y_i}{\sum_{i=1}^{3} Y_i} = \sum_{i=1}^{3} e_i y_i \tag{103.1}$$

In the formula, e refers to the energy intensity per unit GDP; E refers to the energy consumption; Y refers to GDP; e_i refers to the energy intensity per unit GDP in industry i; y_i refers to the proportion that the output value of industry i takes in the GDP.

As the formula (103.1) shows, the energy intensity per unit GDP mainly depends on e_i, y_i. The e_i reflects energy utilization efficiency of industries, while y_i reflects the industry structure change. If the base period is fixed, we can use formula 103.2 to calculate how much influence does the industrial structure changes make on the energy consumption level.

$$\left(e_s^n = \frac{\sum_{i=1}^{3} e_i^0 (y_i^n - y_i^0)}{\sum_{i=1}^{3} e_i^n y_i^n - \sum_{i=1}^{3} e_i^0 y_i^0} \right) \tag{103.2}$$

In the formula, e_s^n refers to the share of industrial structure adjustment on the energy intensity per unit GDP; y_i^0 and y_i^n refer separately to the proportion that the output value of the base period and the period n of industry i takes in the GDP e_i^0 and e_i^n refer separately to the energy intensity per unit GDP of industry i in the base period and the period n.

The formula 103.2 shows the role the industrial structure adjustment $y_i^n - y_i^0$ plays in energy consumption reduction with fixed energy utilization efficiency.

103.2.2 Empirical Research of the Contribution Calculation

In order to calculate the contribution that restructuring has made to the energy intensity per unit GDP in Henan, this paper has collected relevant data during 2006–2009, as shown in Table 103.1.

Based on the data of Table 103.1, the annual energy intensity per unit GDP of the three industries is worked out which is shown in Table 103.2.

According to Tables 103.2 and 103.3, we can discover that the achievements in energy conservation and consumption reduction mainly comes from the dramatic decrease of energy intensity of different industries, that is, the great improvement of energy utilization efficiency. Instead, the restructuring not only brings no decrease in energy intensity per unit GDP, but seems to have had the opposite effect. The data in Table 103.3 show that the contribution of restructuring is negative, what is worse, its contribution is as high as breathtaking—85.1 % during 2006–2007. The industrial structure adjustment has made negative effect on the energy consumption reduction.

According to formula 103.2, the contribution which restructuring has made to energy consumption per unit GDP is calculated, as shown in Table 103.3.

Among the three industries, the energy intensity of the secondary industry is the highest. In 2009, its energy intensity per unit GDP is 16,790 tons SCE per

Table 103.1 Relevant data of industrial structure and the industry's energy consumption

Years	Composition of GDP (%)			GDP (100 million yuan)			Energy consumption (10,000 tons of SCE)		
	Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry
2006	17.9	52.1	30.0	1892.0	5514.1	3181.3	461.0	11550.0	2613.0
2007	15.5	54.4	30.1	1891.8	6637.2	3673.0	483.0	13049.0	2703.0
2008	14.8	55.2	30.0	2076.6	7755.8	4224.9	472.0	14591.0	2777.0
2009	14.4	56.9	28.6	2326.7	9169.1	4612.7	478.0	15393.0	2912.0

Table 103.2 Energy intensity per unit GDP in Henan during 2006–2009

Years	The primary industry	The secondary industry	The tertiary industry
2006	0.244	2.095	0.821
2007	0.255	1.966	0.736
2008	0.227	1.881	0.657
2009	0.205	1.679	0.631

Table 103.3 The contribution of restructuring during 2007–2009 in Henan

Years	2006–2007	2007–2008	2008–2009	2006–2009
Contribution	−0.851	−0.215	−0.210	−0.373

100 million yuan, and the energy utilization efficiency had been vastly improved compared with 2006, but the proportion of the total GDP had risen from 52.1 to 56.9 % with an improvement of 4.8 %. Meanwhile, the proportion of the tertiary industry with low energy intensity has not risen, instead declined from 30.0 to 28.6 % with a drop of 1.4 %. Reducing the share of the second industry and improving the proportion of the tertiary industry is an important way to reduce energy consumption. Currently, Henan province is on the accelerated development stage of industrialization and urbanization, and the secondary industry is the mainstay of the economic development. In recent years, the heavy-duty of industrial structure of Henan province is more and more apparent. The leading industries are high energy consumption industries, which is bound to push the energy intensity continuously. In 2009, Henan's heavy industry sector accounted for 69.3 % proportion of above-scale industry. So, it is not very difficult to understand why the contribution of the restructuring is negative.

103.3 Conclusions and Policy Implications

According to the calculation result of contribution, the industrial structure adjustment has a negative effect on the energy conservation in Henan in recent years. Henan province should take measures to accelerate structure adjustment and promote the structure energy-saving actively.

103.3.1 Speed up the Adjustment of Industry Internal Structure and Take the New Industrialization Development Path

Compared with the first industry and the tertiary industry, the secondary industry, especially those heavy industries, have relatively higher energy intensity. We should treat new industrialization as the main direction of structure energy-saving and prompt optimization and upgrading of the secondary industry internal

structure constantly. Compared with the traditional industrialization, the new industrialization is the informative and it can realize a great-leap-forward development. At the same time, it is an industrialization that is able to enhance the capacity for sustainable development. The new industrialization emphasizes the ecological establishment and environment protection, also it stresses on the good relationship between economic growth and the population, resources and environment. It requires us to decline energy consumption, reduce the environment pollution, and enhance the sustainability of economic development.

Henan province should take feasible measures to encourage the development of high and new technology industries, give priority to the information industries that have low energy consumption and significant impetus function to the economic growth. Meanwhile, we should encourage the use of high technology and advancing applicable technical to transform and upgrade traditional industries. In addition, we should further improve the industrial access system, especially heighten "market access" threshold of high energy intensity and high pollution industries. For high energy-consuming industries, we should eliminate the current "surplus" and backward production capacity.

103.3.2 Develop the Tertiary Industry Vigorously and Increase the Proportion of Service Industry Constantly

Compared with the secondary industry, the tertiary industry energy consumption is much lower relatively. The energy intensity per unit GDP of the secondary industry and the tertiary industry are respectively 16,790 and 6,310 tons SCE per 100 million yuan in Henan province in 2009, while the tertiary industry energy intensity is only 37.6 % of the secondary industry. Meanwhile the industrial structure evolution rule shows that, based on the increasing labor productivity of agriculture and industry, the development of the service will be faster and its proportion will also present a fast rising trend. Therefore, in order to reduce the energy consumption, we should not only improve the energy utilization efficiency, but also develop the tertiary industry. The government should make efforts in the planning of key fields in services, broaden and standard the industry access, using fiscal, tax and price policies to support the key areas and new industry in services.

As for Henan, the government should vigorously develop new industries that will have high demand with rise in people's living standards, including real estate, medical and health services, tourism and cultural industries, etc. At the same time, based on Henan's traffic and geographical advantages, we should develop logistics service, business service and other tertiary industry especially. With the development of economy and the improvement of people's living standard, the demands of these industries will increase substantially. What is more, the modern service

industries own high technical content, and less energy consumption and do less harm to the environment, so their accelerated development is bound to push the economic growth and reduce energy intensity per unit GDP.

Acknowledgments The authors thank the science fund project of the Education Department of Henan province "Study on Coordinated Development of the Tertiary Industry in Henan province" (Grant No.2011A790032), "Research of Science and Technology Innovation Platform Network Structure and Development Pattern" (Grant No.12A630059), and the soft science research project of Zhengzhou "Study on Cultivation of the Strategy Emerging Industries in Zhengzhou" (Grant No. 2010RKXYJ176) for supporting this research.

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Chapter 104
Design and Virtual Test of Vibration-Type Digging Shovel

Yonghua Zhang, Wangyun Ning and Yuqing Zhao

Abstract In order to improve the crushing soil effect of potato harvester, a vibration-type digging shovel with the amplitude and frequency adjustable was designed. The kinematic analysis of this vibration digging shovel was performed. A virtual prototyping model was established based on Solid Works and ADAMS software, and mechanical-hydraulic co-simulation was conducted in ADAMS. The virtual test results showed that: the amplitude of digging shovel was directly proportional to the system pressure; at constant system pressure, amplitude was inversely proportional to frequency; the maximum pressure value of the shovel on soil mass was lower than the breaking strength of potatoes.

Keywords Digging shovel · Vibration · Virtual test · ADAMS

104.1 Introduction

The digging shovel of the traction type potato digger is generally of fixed type, mainly suitable for operation in sandy soil or sandy loam. If it is used in clayey soil, the digging resistance will be large, so it will be difficult to break soil and the efficiency of separating potato and soil will be unsatisfactory; moreover, its power requirement is high, as generally being used with a large tractor. In order to

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_104,

overcome the above shortcomings, scholars throughout the world have been studying a vibration-type potato digger and have made certain achievements [1, 2]. The studies indicate that, vibration digging and cutting of soil can result in a remarkable reduction in tractive resistance, decrease in average size of soil mass, and high soil breaking efficiency, and accordingly the efficiency of separating soil and crop is improved [3, 4]. As there are significant differences in the soil characteristics in the potato planting areas, amplitude and frequency of the digging shovel need adjustment upon digging [5]. A vibration-type digging shovel is designed, for which the power is supplied by hydraulic output of the tractor, and the excitation cylinder drives the digging shovel to vibrate, with convenient adjustment in amplitude and frequency; a virtual prototyping model was established based on Solid Works and ADAMS software, mechanical-hydraulic co-simulation was conducted in ADAMS, and the simulation results were analyzed and studied [6].

104.2 Structural Design of Vibration Type Digging Shovel

Since the 3D solid modeling capacity of ADAMS is unsatisfactory, Solid Works is applied to establish the 3D solid model of the vibration type digging shovel of the potato digger, as shown in Fig. 104.1. Table 104.1 shows the main design parameters generated of the vibration-type digging shovel.

At present, a medium or large tractor has two or three hydraulic output devices, which can be used to drive hydraulic agricultural implements. Meanwhile, if driven by hydraulic output of a tractor, the agricultural implement is easy to be controlled and the vibration frequency and amplitude are easy to be adjusted.

The hydraulic system consists of a rotary reversal valve control loop (frequency modulated loop), amplitude modulated loop, two-way hydraulic lock, hand switching valve, and excitation cylinder. See Fig. 104.2. The whole hydraulic system is controlled by the hand switching valve. The vibration digging

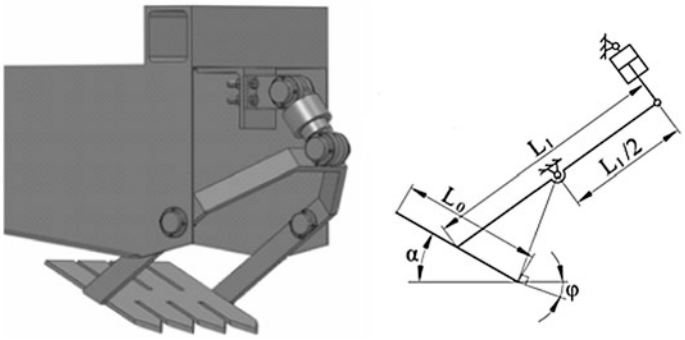

Fig. 104.1 Virtual prototyping model of vibration-type digging shovel

Table 104.1 Design parameters of vibration-type digging shovel

Length of oscillating rod $L1$	Vibration angle of cutting edge φ	Length of shovel $L0$	Inclination angle of shovel face α	Diameter of piston D	Diameter of piston rod d	Stroke of piston S
600 mm	20°	340 mm	30°	80 mm	30 mm	50 mm

components do not work when the valve is closed. In the rotary reversal valve control loop, relief valve I adjusts the working pressure of the hydraulic motor, which drives the rotary reversal valve to rotate and distribute flow to the excitation cylinder, so as to make it rapidly move back and forth. The vibration frequency of excitation cylinder depends on the reversal frequency of the rotary reversal valve driven by the hydraulic motor. Therefore, the cylinder vibration frequency can be controlled through adjusting the governing valve I. The amplitude of excitation cylinder can be adjusted, relying on amplitude modulated loop. The reliefs valve me and the governing valve I control the pressure and flow of the hydraulic oil to the cylinder, and accordingly control the vibration amplitude of the cylinder. In order to ensure that the cylinder piston is fixed in a position when the hydraulic

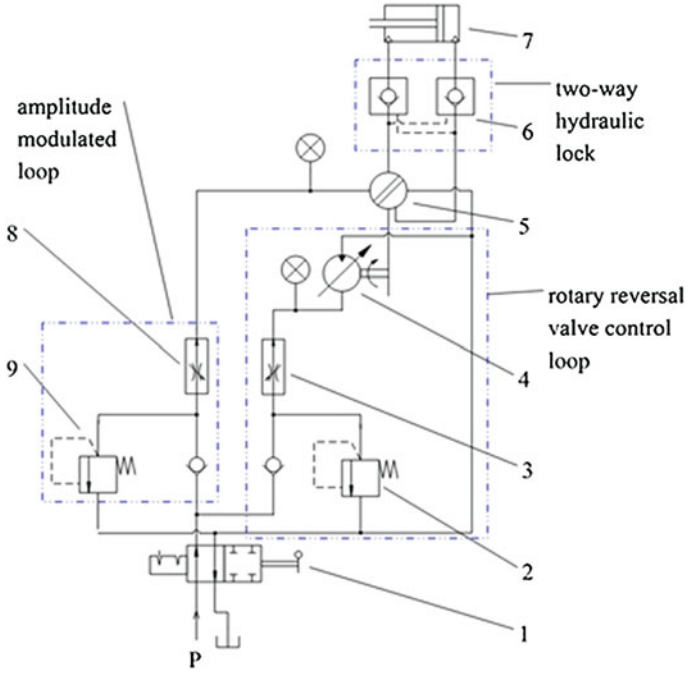

Fig. 104.2 Schematic diagram of hydraulic system *1* hand switching valve, *2* relief valve I, *3* governing valve I, *4* variable hydraulic motor, *5* rotary reversal valve *6* pilot operated check valve, *7* excitation cylinder, *8* governing valve II, *9* relief valve II

system is shut down, two pilot operated check valves are installed at the oil inlet and outlet of the cylinder respectively to form a two-way hydraulic lock.

104.3 Kinematical Analysis of Vibration-Type Digging Shovel

During the vibration digging, the shovel's rotation about a fixed axis and its uniform forward movement jointly result in the movement of digging shovel. For any point at the shovel, as the ratio between its amplitude and its distance from the rotation center is small, the error will be small if the motion is deemed as linear motion. Therefore, the vibration of any point at the shovel can be deemed as oblique linear vibration relative to its heading direction. The vibration angle of any point at the shovel φ is the angle between the moving direction of the point and the horizontal line. When the vibration speed changes to a sine curve, the motion path composed of vibration motion and forward motion is a diagonal sine vibration, as shown in Fig. 104.3. In the figure, P0 → P1 and P3 → P4 is the cutting stage and P1 → P2 → P3 is the lifting stage.

The vibration length l, i.e., length of vibration period, can be obtained based on the forward speed v_m and vibration frequency f: $l = \frac{V_m}{f}$.

The vibration height h of any point at the shovel in vertical movement in the lifting stage can be obtained based on the vibration angle φ and amplitude A:

$$h = 2A \sin \varphi$$

The motion path of any point at the shovel can be expressed with the coordinate equation:

$$\begin{aligned} x &= V_m t + A \cos \varphi \sin \omega t \\ y &= -A \sin \varphi \sin \omega t \end{aligned} \tag{104.1}$$

Where, $\omega = 2\pi f$

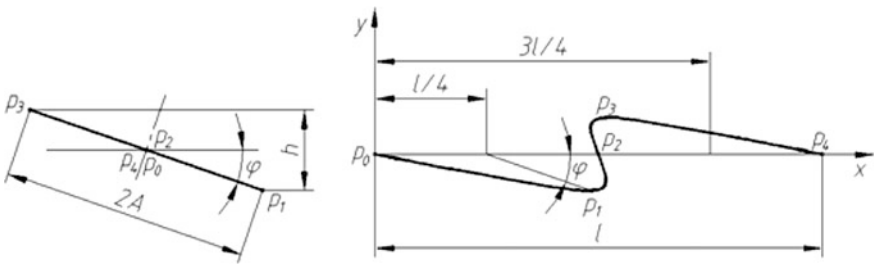

Fig. 104.3 Path of digging shovel

Calculate the derivative of the above formula against time to generate a speed equation:

$$\begin{aligned} V_x &= V_m + A\omega \cos\varphi \cos\omega t \\ V_y &= -A\omega \sin\varphi \cos\omega t \end{aligned} \tag{104.2}$$

The horizontal acceleration a_x and the vertical acceleration a_y are:

$$\begin{aligned} a_x &= -A\omega^2 \cos\varphi \sin\omega t \\ a_y &= A\omega^2 \sin\varphi \sin\omega t \end{aligned} \tag{104.3}$$

When $\sin \omega t = 1$, the acceleration reaches the peak value at the point P_1 and P_3.

$$\begin{aligned} a_{x1} &= -A\omega^2 \cos\varphi \\ a_{y1} &= A\omega^2 \sin\varphi \end{aligned}$$

104.4 Simulation Modeling of Vibration-Type Digging Shovel

104.4.1 Modeling of Virtual Prototype of Mechanical System

Create the model in Solid Works. First create the model of the parts and then create the assembly of components. Export Parasolid doc. from Solid Works software, and import the model of mechanical system into ADAMS environment. Define the material of members and add restrains among members. Define that the horizontal movement speed of the rack is equal to the working speed of the potato digger 1.5 m/s.

104.4.2 Modeling of Virtual Prototype of Hydraulic System

Create the model of hydraulic system with graphic symbols in ADAMS/View. The pressure source of hydraulic system should be set based on the hydraulic output parameters of the supporting tractor. John Deere 904 tractor was employed as the supporting tractor, so the output pressure of the pressure source is set to be 19 Mpa.

Since there is no part of the rotary hydraulic valve in ADAMS/Hydraulics module, equivalent conversion and simplification should be conducted for the actual hydraulic system upon simulation modeling. Considering the rotary reversal valve control loop is to realize the adjustment of vibration frequency, in

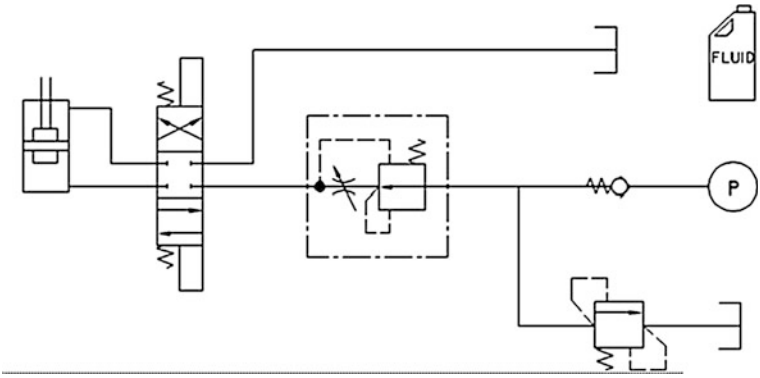

Fig. 104.4 Model of hydraulic system

combination with the output characteristics of the designed rotary reversal valve, the whole rotary reversal valve control loop and the rotary hydraulic valve are simplified into a Directional Control Valve4w3 in ADAMS/Hydraulics, and the movement of valve core should be controlled with sin functions. For instance, if the output speed of hydraulic motor that drives the rotary reversal valve is 600 rpm, i.e., the reversal frequency is 10 Hz, the function of movement control for the valve core is Sin (20 × pi × time). Figure 104.4 shows the model of hydraulic system.

104.5 Simulation Analysis

104.5.1 Relation Between Vibration Frequency and Amplitude

Set the pressure of the relief valve to be 16 MPa. Open the governing valve fully. Set the vibration frequency to be 20, 30, and 40 Hz, and conduct a simulation in 150 steps lasting for 0.1 S. The horizontal displacement curves of the vibration at

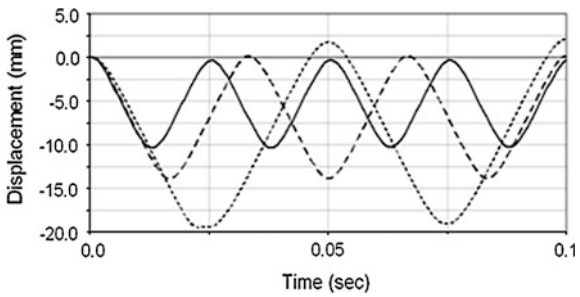

Fig. 104.5 Horizontal displacement of cutting

Table 104.2 Cutting edge amplitude of digging shovel

Vibration frequency (f/S^{-1})	20 Hz	30 Hz	40 Hz
Amplitude (A/mm)	11	7	5

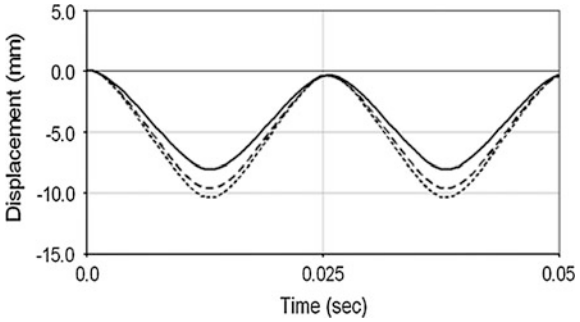

Fig. 104.6 Horizontal displacement of cutting

the cutting edge are shown in Fig. 104.5. The cutting edge amplitude can be calculated with the Eq. (104.1). At a fixed system pressure, the amplitude is inversely proportional to the frequency Table 104.2.

104.5.2 Relation Between System Pressure and Amplitude

The adjustment of the digging shovel amplitude is realized mainly through the control of flow to the excitation cylinder by the governing valve. From the simulation result (Fig. 104.6), it can be found that the horizontal displacement of cutting edge vibration is also related to the system pressure. It indicates that the amplitude is directly proportional to the system pressure provided that the other conditions are unchanged.

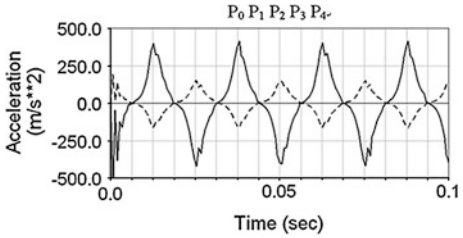

Fig. 104.7 Curves of acceleration at cutting edge

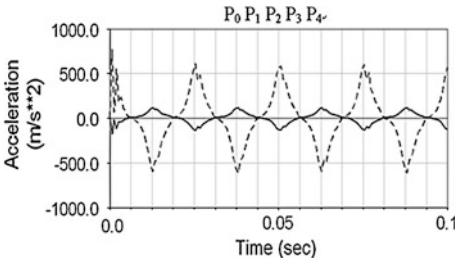

Fig. 104.8 Curves of acceleration at shovel tail

104.5.3 Analysis of Shovel Acceleration

Set the pressure of the relief valve to be 16 MPa. Open the governing valve fully. Set the vibration frequency to be 40 Hz, and conduct a simulation in 150 steps lasting for 0.1 S. The variations of acceleration at the shovel cutting edge and shovel tail are shown in Figs. 104.7 and 104.8. The simulation result indicates that the horizontal acceleration and vertical acceleration vary synchronously and reach the peak value and least value at P_1 and P_3 respectively at the same time. In combination with Fig. 104.3, it can be concluded that the cutting force and effect increase along with the horizontal acceleration; the soil lifting force and effect of the shovel increase along with the vertical acceleration. As the vibration angle at the cutting edge φ is small, the cutting action dominates. The vibration angle at the shovel tail φ is big, so the lifting action dominates.

The resultant acceleration at any point of the shovel at a certain time can be calculated with the horizontal acceleration a_x and vertical acceleration a_y obtained from simulation: $a = \sqrt{(a_x)^2 + (a_y)^2}$.

According to the Newton's second law, the applied force of the shovel at the soil can be calculated: $F = ma$.

Where, m refers to the mass of shovel.

The unit area pressure of the shovel applied on the soil, i.e. pressure p is:

$$p = \frac{F}{S}$$

where, S refers to the area of shovel.

As the maximum resultant acceleration at the shovel tail is greater than the acceleration at the cutting edge, take the former to calculate for the convenience of calculation and analysis. For an actual hydraulic system, the hydraulic output flow of tractor is fixed. The vibration frequency of the shovel depends on the output speed of hydraulic motor; the higher the output speed of hydraulic motor, the greater the flow of consumed hydraulic oil, and the smaller the flow entering the excitation cylinder. In order to reflect the working conditions of the practical hydraulic system more really, the maximum flow of excitation cylinder is restricted in ADAMS simulation, the acceleration at the shovel tail at different

Table 104.3 Maximum pressure of shovel on soil mass

Frequency (f/S^{-1})	10 Hz	20 Hz	30 Hz	40 Hz	50 Hz
Max. flow of cylinder (m^3/S)	0.005	0.0046	0.0042	0.0038	0.0034
Max. pressure (MPa)	0.027	0.037	0.041	0.034	0.029

frequencies are obtained by simulation, and the maximum pressure of the shovel on soil is calculated based on the Eqs. (104.1–104.3). See Table 104.3.

When the vibration frequency is less than 10 Hz, the shovel cannot form continuous vibration digging and cutting; when the vibration frequency is greater than 50 Hz, the amplitude of shovel is less than 2.5 mm and the vibration digging and cutting effects are not obvious. Within the range from 10 to 50 Hz, the maximum pressure of the shovel on soil is lower than the breaking strength of potatoes 1.4 MPa [7] and the damage rate of potato is less than 4 %, reaching the design standard of potato digger [8].

104.6 Conclusions

A vibration-type digging shovel of potato digger was designed, of which the power is supplied by hydraulic output of tractor; a kinematics analysis was made for the vibration-type digging shovel and a virtual prototyping model was established based on ADAMS.

The virtual test indicates that the amplitude of the digging shovel is directly proportional to the system pressure; at a fixed system pressure, the amplitude is inversely proportional to the frequency.

The maximum pressure of the shovel on soil mass is lower than the breaking strength of potato 1.02 MPa and the damage rate of potato is less than 4 %, reaching the design standard of a potato digger.

Acknowledgment This work is supported by the Yunnan Provincial Science and Technology Project (2010ZC087).

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Chapter 105
Cooperation Equilibrium of Industrial Clusters Based on Pricing Game

Xinxia Jiang and Munan Li

Abstract This paper introduces a novel perspective to analyze the mechanism of competition or cooperation based on the pricing game. Through the game analysis of price competition based on incomplete information Cournot model, we found that the cooperation strategy seems to be the better equilibrium of game for the oligopolies in those industrial clusters. In simplified situations of pricing competition game in some industrial clusters, we can argue that those industrial clusters contain more than two oligopolistic enterprises, which can more possibly choose the cooperation strategies for the same consideration of the interests. Then this paper partly explains the tacit behaviors among oligopolistic enterprises of industrial clusters becoming more and more pervasive.

Keywords Industrial cluster · Cournot model · Price competition mechanism · Game theory

105.1 Introduction

In the context of the rapid development of economic globalization and information network technology, competition between nations and regions has intensified, and companies increasingly rely on innovation and integration of internal or external

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_105,

resources. Industrial clusters are generally made of enterprises and other relevant institutions gathering in a relatively small geographical area, being a form of production networks or ecological communities based on the cooperation–competition relationship [1]. The enterprises in the area of industrial clusters generate the scale economic effect by collaboration and communication, which surely plays a role in liquidizing remnant assets, reducing price and transaction costs, stimulating innovation, building a harmonious network, and so on. Its formation can be seen as one of the most effective ways in the collaborative network organization.

Enterprises of industrial clusters give the comparative advantage of revitalizing the stock of assets, reducing price and transaction costs, encouraging business innovation, functional complementation, and building social networks. Since the cluster generated, research on industrial clusters and industrial competitive advantage have also attracted many domestic and foreign scholars and enterprises.

105.2 The Competition–Cooperation Paradigm of Price Game in the Industrial Clusters

According to Bertrand's equilibrium theory, market competition can be achieved even in two oligarchs. In the traditional Cournot's assumptions, the balance strategy is that the most "rational" behavior is to resist the reduction [2]. Chamberlain's conclusion is in general accord with the equilibrium strategies of Cournot. These three price competition strategies tend to set prices by agreement among oligarchs and not taking a strategy of vicious price competition. However, due to incomplete consistency of individual rationality and collective rationality and imperfect information, the static equilibrium does not always happen [3]. For example, before 2008, the market of Chinese mobile communication is contains a typical double oligarchies market. For China Unicom entered the mobile communications market later, so its share in the mobile telephone service market was too low, and cutting-prices unilaterally for competition occurred many times. From 2007 to 2010, the overall general tariff levels of Chinese mobile communications dropped by more than 50 %, basically consistent with Bertrand's assumption. At the same time, the size of the communication market grew by nearly 60 %, and the number of Chinese mobile users maintained the average annual market growth of 13.9 % [4].

105.2.1 Game Strategy of Price Competition

Since the 1990s, the importance of the price-competitive game strategy in cooperation–competition between enterprises has aroused the concerns of scholars all over the world, and has made remarkable achievements. Hotelling modified the basic assumptions of the traditional Cournot model allowing manufacturers to

produce differentiated products rather than homogeneous products, which was the well-known Hotelling Game Model. D' Aspremont [5] proved that there is no equilibrium relationship derived by the Hotelling model when the two enterprises are too close. Collins [6], who dealt with the Hotelling model of the three manufacturers has no equilibrium solution. Diao Xinjun [7] studied the Hotelling model with asymmetric network externalities; first-in-market has first-mover advantage in terms of the equilibrium price, market share and profits. Xu Jiqin [8] constructed a regional innovation system model based on industrial clusters, and took Ningbo City as a precedent. Dong Yong [9] introduced a fractal mathematical model of complex adaptive systems of industrial clusters, and studied the interaction between the main body within the industry cluster with simulation and game method. Weng Han [10] made a detailed analysis of city industry from the view of incomplete information multidimensional game.

105.2.2 The Price-Competitive Strategy and the Cooperation–Competition Trend

Due to spatial aggregation and spillover effect of knowledge and technology, the problem of product homogenization is serious. The enterprises in the cluster not only face competition from clusters of similar enterprises, but also from other regions or other similar clusters such as, in the field of building ceramics, products in Foshan occupy a relatively large share at home, but competition from Jiajiang, Sichuan, Shandong and other places of building ceramics enterprises is still there. Therefore, the price competition within the enterprise of similar enterprises should be considered given, so do market factors of the cluster internal and external.

Presently, domestic research on price-based competition model is more about the electricity market [11, 12], mobile communication market [13, 14], as well as the real estate market [15], all of which have characteristics of typical double-oligarch or Multi-oligarch. Yu and Tan dealt with the cooperation–competition relationship of clusters from the perspective of ecosystem communities, and drew the conclusion that the cooperation of the enterprise cluster is the dominant mode of evolution [16]. Zhou and Deng established a dynamic asymmetric model of competitive equilibrium in a manufacturer cluster based on the evolution game theory of bounded rationality. The model showed that stable cooperation depended on the high rate of the average growth, the high correlation, low homogeneity, high investment, and low cooperation costs [17]. With regard to the theory of complete information static game, the competing mechanism of the industrial cluster was discussed surrounding the upstream and downstream enterprises making the Hengyang steel.

The pricing strategy is one of the main ways of market competition, and as an important industry organization and network organization, the industrial cluster has a competitive advantage in regional development. However, literature based on price competition strategy in the industrial cluster is rare.

105.3 Price Game Based on Incomplete Information Cournot Model

105.3.1 Theoretical Framework of Price Game of Clusters

Cournot Model, known as double oligarch, proposed by the French economist Cournot in 1838, is the earliest version of the Nash equilibrium. The basic assumptions of the Cournot model developed later is as follows. First, only two manufacturers' products A and B sell the same product, and there is no interaction behavior with each other. Second, their cost of production is constant. Third, the demand curve is linear, and both sides have a clear understanding of the market demand. The problem to be solved is how to determine the production when knowing another's production to bring the biggest profit. Nash equilibrium production obtained by solving is

$$\mathrm{q}^* = \left(q_1^*, q_2^*\right) = \left(\frac{1}{3(a + c_2 - 2c_1)}, \frac{1}{3(a + c_1 - 2c_2)}\right) \tag{105.1}$$

However, the basic assumptions of the Cournot model on the complete information static game are inconsistent with the actual economic state. In the normal economic state, there is comparative advantage, commercial confidentiality in various degrees for other companies having difficulty to obtain the accurate information. This paper mainly discusses the industrial price game based on incomplete information.

When all enterprises in the industrial cluster play the price game, strategic variables should be variable sets of multi-enterprises. Let us assume that *i*th product quantity is denoted by q_i, cost function by $C_i(q_i)$, *i*th by product price, and demand function by $P = P(Q) = P(q_i + q_{-i})$. Then *i*th profit function is expressed as $\pi_i = q_i P(q_\mathrm{i} + q_{-\mathrm{i}}) - C_i(q_i), i = 1, 2, \ldots$, equilibrium production $\mathrm{q}^* = \left(q_\mathrm{i}^*, q_{-\mathrm{i}}^*\right)$ as

$$\mathrm{q}_i^* \in \arg\max\, \pi_i\left(q_i, q_{-i}^*\right) = q_i P\left(q_\mathrm{i} + q_{-i}^*\right) - C_i(q_i) \tag{105.2}$$

$$\mathrm{q}_{-i}^* \in \arg\max\, \pi_{-i}\left(q_i^*, q_{-i}\right) = q_{-i} P\left(q_i^* + q_{-i}\right) - C_{-i}(q_{-i}) \tag{105.3}$$

Let the first derivative of the profit function to zero gives the equilibrium production:

$$\frac{\partial \pi_\mathrm{i}}{\partial \mathrm{q}_i} = P(q_i + q_{-i}) + \mathrm{q}_i P'(q_i + q_{-i}) - C_i'(q_i) = 0 \tag{105.4}$$

$$\frac{\partial \pi_{-\mathrm{i}}}{\partial \mathrm{q}_{-i}} = P(q_i + q_{-i}) + \mathrm{q}_{-i} P'(q_i + q_{-i}) - C_{-i}'(q_{-i}) = 0 \tag{105.5}$$

Two reaction functions obtained are:

$$q_i^* = R(q_{-i}), q_{-i}^* = R(q_i) \tag{105.6}$$

This means that the optimal equilibrium production of each enterprise is a function of the production of another enterprise.

105.3.2 Analysis of Product Price Game in the cluster

Price game between enterprises within the same cluster is described as follows: Here discusses how an enterprise to identify product production with other enterprises of the cluster. Specifically, the product price is not only affected by the total amount produced by the enterprise, also by the total amount of homogeneous products in the cluster. What is more, the same product affects the price of different enterprises to a different degree, the following price function can respond to this.

We suppose that the cost function of the homogeneous products in the same cluster is $C_i(q_i) = c_i * q_i$ and the price function is $p_i = a_i - r_i * q_i + h_i * q_{-i}$, in which c_i expressing the marginal cost, p_i expressing the price made by the ith enterprise, a_i expressing the maximum value of price in the ith enterprise, q_i expressing the production made by the ith enterprise, q_{-i} expressing the production made by enterprises except the ith enterprise, r_i expressing in the ith enterprise the influence coefficient of its own product production on its own price, h_i expressing the influence coefficient of product production in other enterprise on price of the ith enterprise. Now enterprises to participating in the price game is simplified into two enterprises of equal strength, and their profit function is

$$\pi_1 = \mathrm{q}_1^*\left[a_1 - r_1^* q_1 + h_1^* q_2\right] - c_1^* q_1$$

$$\pi_2 = \mathrm{q}_2^*\left[a_2 - r_2^* q_2 + h_2^* q_1\right] - c_2^* q_2$$

Here assume that the one and only stable equilibrium exists. Then the profit function meeting these requirements must be concave function, thereby the following functions exist:

$$\begin{cases} \dfrac{\partial \pi_1}{\partial q_1} = 0 & \text{and} \quad \dfrac{\partial \pi_2}{\partial q_2} = 0 \\ \dfrac{\partial^2 \pi_1}{\partial q_1^2} < 0 & \text{and} \quad \dfrac{\partial^2 \pi_2}{\partial q_2^2} < 0 \\ \dfrac{\partial^2 \pi_1}{\partial q_1 \partial q_2} < 0 & \text{and} \quad \dfrac{\partial^2 \pi_2}{\partial q_2 \partial q_1} < 0 \end{cases} \tag{105.7}$$

The equilibrium production for solution is:

$$q^* = (q_1^*, q_2^*) = \left(\frac{2r_2(a_1 - c_1) + h_1(a_2 - c_2)}{4r_1 r_2 - h_1 h_2}, \frac{2r_1(a_2 - c_2) + h_2(a_1 - c_1)}{4r_1 r_2 - h_1 h_2}\right),$$
$$(r_1 > 0, r_2 > 0, h_1 > 0, h_2 > 0) \tag{105.8}$$

The value introduced to the price function we can get the equilibrium price:

$$p^* = \left(p_1^*,\ p_2^*\right) = \left(a_1 - \frac{(2r_1r_2 - h_1h_2)(a_1 - c_1) - r_1h_1(a_2 - c_2)}{4r_1r_2 - h_1h_2}, a_2 - \frac{(2r_1r_2 - h_1h_2)(a_2 - c_2) - r_2h_2(a_1 - c_1)}{4r_1r_2 - h_1h_2}\right), \quad (r_1 > 0,\ r_2 > 0,\ h_1 > 0,\ h_2 > 0) \tag{105.9}$$

And the value introduced to the profit function we can get the equilibrium profit:

$$\pi_1^* = \frac{4r_1r_2^2(a_1 - c_1)^2 + r_1h_1^2(a_2 - c_2)^2 + 4r_1r_2h_1(a_1 - c_1)(a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2}, \quad (r_1 > 0, r_2 > 0, h_1 > 0, h_2 > 0) \tag{105.10}$$

$$\pi_2^* = \frac{4r_2r_1^2(a_2 - c_2)^2 + r_2h_2^2(a_1 - c_1)^2 + 4r_1r_2h_2(a_1 - c_1)(a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2}, \quad (r_1 > 0,\ r_2 > 0,\ h_1 > 0,\ h_2 > 0) \tag{105.11}$$

Then the total profit of the two enterprises is

$$\pi^* = \pi_1^* + \pi_2^* = \frac{4r_1r_2^2(a_1 - c_1)^2 + r_1h_1^2(a_2 - c_2)^2 + 4r_1r_2h_1(a_1 - c_1)(a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2} + \frac{4r_2r_1^2(a_2 - c_2)^2 + r_2h_2^2(a_1 - c_1)^2 + 4r_1r_2h_2(a_1 - c_1)(a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2}, \quad (r_1 > 0,\ r_2 > 0,\ h_1 > 0,\ h_2 > 0) \tag{105.12}$$

These results above are the production, price and profit solution of the Nash equilibrium when enterprises within the cluster play price game, which can analogy to many (i ≥ 3) enterprises, here no longer deducing.

105.3.3 Analyzing Results of Price Game Based on Homogeneous Products in Clusters

From the results above, we can see that the equilibrium production of the enterprise in the clusters is the Eq. (105.13):

$$\left(q_1^*,\ q_2^*\right) = \left(\frac{2r_2(a_1 - c_1) + h_1(a_2 - c_2)}{4r_1r_2 - h_1h_2}, \frac{2r_1(a_2 - c_2) + h_2(a_1 - c_1)}{4r_1r_2 - h_1h_2}\right) \tag{105.13}$$

A significant difference is founded between this value and the outcome got from Cournot Model of complete information, the value of which is the Eq. (105.14).

$$\left(q_1^*,\ q_2^*\right) = \left(\frac{1}{3(a + c_2 - 2c_1)},\ \frac{1}{3(a + c_1 - 2c_2)}\right) \tag{105.14}$$

The equilibrium production normally has much to do with many factors of all enterprises in the cluster involved in the game, which also verified that, each enterprise making price should take into account various factors in the real cluster.

Making observations of the equilibrium profit of enterprise-1:

$$\pi_1^* = \frac{4r_1r_2^2(a_1 - c_1)^2 + r_1h_1^2(a_2 - c_2)^2 + 4r_1r_2h_1^2(a_1 - c_1)\ (a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2} \tag{105.15}$$

We can get that its profit is affected by factors of its own enterprise like a_1, c_1, r_1 and h_1, as well as of opponent like a_2, c_2, r_2 and h_2. In a similar way, the equilibrium profit of enterprise-2 is:

$$\pi_2^* = \frac{4r_2r_1^2(a_2 - c_2)^2 + r_2h_2^2(a_1 - c_1)^2 + 4r_1r_2h_2^2(a_1 - c_1)\ (a_2 - c_2)}{(4r_1r_2 - h_1h_2)^2} \tag{105.16}$$

And its profit is affected by factors of its own enterprise like $a_2\sqrt{b^2 - 4ac}$, c_2, r_2 and h_2.a_1, c_1, r_1 and h_1, as well as of opponent like a_1, c_1, r_1 and h_1. Specifically, we analyze the trend of changes of the equilibrium price. From Eq. (105.17), the equilibrium price of product-1 is

$$p_1^* = a_1 - \frac{(2r_1r_2 - h_1h_2)\ (a_1 - c_1) - r_1h_1(a_2 - c_2)}{4r_1r_2 - h_1h_2} \tag{105.17}$$

The first derivative value is as Eq. 105.18:

$$\frac{\partial p_1^*}{\partial c_1} = \frac{2r_1r_2 - h_1h_2}{4r_1r_2 - h_1h_2},\quad \frac{\partial p_1^*}{\partial c_2} = \frac{\mathrm{r}_1h_1}{4r_1r_2 - h_1h_2} \tag{105.18}$$

We know that, when making price strategy, the enterprise whose goal is to maximize profits first consider the actual status of its own product, namely r_i (expressing in the ith enterprise the influence coefficient of its own product production on its own price) $> h_i$ (expressing the influence coefficient of product production in other enterprise on price of the ith enterprise), written $r_i \succ \mathrm{h}_i$, which can be easily restated as Eqs. (105.19) and (105.20):

$$\frac{\partial p_1^*}{\partial c_1} \succ 0,\ \frac{\partial p_1^*}{\partial c_2} \succ 0 \tag{105.19}$$

The same as enterprise-2:

$$\frac{\partial p_2^*}{\partial c_1} \succ 0,\ \frac{\partial p_2^*}{\partial c_2} \succ 0 \tag{105.20}$$

That is, the equilibrium price of the product changes as: when the cost of the product is constantly on the rise, enterprises of the cluster should choose the higher

price. This idea is also validated the idea of real life when enterprises in the cluster make price strategy.

Analysis of the total profits of the two enterprises, we can see that, to improving the overall income mainly depends on their respective profit level of each enterprise competing with other enterprises. In other words, the more the profit of each enterprise, the better of maximizing their overall profit.

105.4 Conclusions

From the new perspective of game theory, this article based on incomplete information Cournot model uncovers a discussion on the pricing game of one product between two or several enterprises, and obtains the similar conclusions with Ref. [16, 17]. In the same cluster, the optimal strategy of enterprises with elasticity of substitution is to seek a cooperative equilibrium when the market is not saturated, even in the case of the market becoming more and more saturated the scale decreasing, and even diseconomy of scale. Of course, when the market is under extreme circumstances, the game equilibrium of the cluster may be different. This study may partly explain the consultative pricing behavior and the pricing decisions of the approximate oligopolies within the cluster. The analysis of results provides a new idea of the industrial cooperation development, and shows how to make pricing decisions for enterprises.

Acknowledgments This work is partly sponsored by the Soft Science Foundation of Guangdong province of China (No. 2010B070300028) and Yong Teacher Innovation Foundation of Guangdong province of China (No. 2010WYM10048).

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Chapter 106
Research on Product Development Management of Small- and Medium-sized Institute

Yu Xian Zhang, Xiao Shuang Men, Hong Wang and Guo Jian Zhi

Abstract This essay summarized the service features of small- and medium-sized Institutes and planned the solutions of information product data management which is suitable for the development of Institute. It established the product data management structure of small- and medium-sized Institute, and the general framework of product data center. On the basis of this, by standardizing the template of product parts and components, documents, processes signing and control changing, the product development can be ensured to run based on the norm mode of product data management system. Thus, the aim is to standardize the design process, unify data sources, shorten product design period, and improve the innovation capacity of R&D.

Keywords Product data management · Product structure · Configuration management

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_106,

106.1 Introduction

As the market demand trends to personalization, the discrete manufacturing industry develops gradually towards multi-variety and small batch production. Small- and medium-sized Institute engaging in product R&D obtain the required products' information quickly from complex data, then do variant design and new products development using existing products, which is the bottleneck in product information management [1, 2]. Product configuration is the important method for the stage of rapid variant design in the process of customization production. It provides options for customers' personalized requirements on the basis of customizing resources, then sets the products model according to the options which chosen by customer. Therefore, product configuration is the tie to build relations between businesses and potential customers [3, 4]. This essay discussed the information products' configuration management based on the characteristics of small- and medium-sized Institute.

106.2 Service Feature of Small- and Medium-sized Institute

106.2.1 Feature of Product Development Process

The features of product development process to Institute can be illustrated as follows:

1. Single and small batch. The batch product is smaller, basically is single and small batch product, and each product should be managed according to model management.
2. Realized by stages. As development stage, products realized by stages according to scheme design, preliminary design, technical design, construction design, combining with Bearing Factory's production, testing, interaction and service (to complete the design completion), design setting or identification. As research stage, it realized by stages according to scheme design, preliminary design, technical design, construction design, prototype testing and prototype identification, equipment (positive prototype) production and testing and out-Institute identification (quality assessment), equipment interaction and services, design setting or identification, production setting (batch production). The results of each stage should be reviewed after completion.
3. The collaborative design of value chain. Design, equipment, manufacturing located in different places should be committed by different units which require close collaboration in the product development process, and own a huge team to research, design, produce, test and maintain.

106.2.2 Feature of Product Development Organization

Institute's product development organization is function-type organization structure basically. The features of product development organization can be illustrated as follows:

1. Dividing the department by profession. Organizational structure is relatively stable. There are no largely changes following different products. With different tasks undertaken, it assembles group flexibly and has good flexibility and adaptability.
2. Inter-departmental collaborative working. It requires that people in various professions involve in the whole research process, and better breaking down the departmental barriers, developing products in parallel, transmitting information timely, avoiding throw an "over-wall" of product development.
3. The projects are organized by projects, but there are no integrated product development teams in a real sense, which can work together on product development.

106.2.3 Product R&D Aspects

Having digital design capacity, it has already possessed a certain scale in the application on computer aided design, analysis and simulation tools. Some researchers have a good grasp of basic functions of software. In the aspects of application tools design, what need to be strengthened is the designers really master the use of these advanced tools which can be applied skillfully to design works and improve designers' production efficiency.

Personal custody of electronic data files. Electronic documents have been stored in project personnel's computer. The versions of design data are inconsistent. It isn't able to do effective management of various technical data from research process, and the consistency and accuracy of data transmission.

No unified digital innovation management platform. The effective system of knowledge accumulation and management hasn't been established. Inheritable things basically rely on the designers' accumulated experience. Redo it in many cases, which increase research cycle.

106.3 Solutions of Information Product Data Management and Configuration

According to the service features above, information management model was established around product research processes, as shown in Fig. 106.1. By design data management and change control with the core of product configuration structure, top–down gradual control and bottom–up feedback for the entire process of product R&D would be achieved and the truly effective closed-loop management would be realized [5].

106.3.1 Solutions Product Design Process Management

The essential foundation to achieve the effective design process management of information product is unifying design tools, methods, design environment and establishing the consistent design specifications which accord with the unit's actual needs [6].

New product design process is shown in Fig. 106.2.

Product R&D of initial prototype phase and positive prototype phase is similar to concept phase, which gradually evolutes until the product design gets mature and sets interaction.

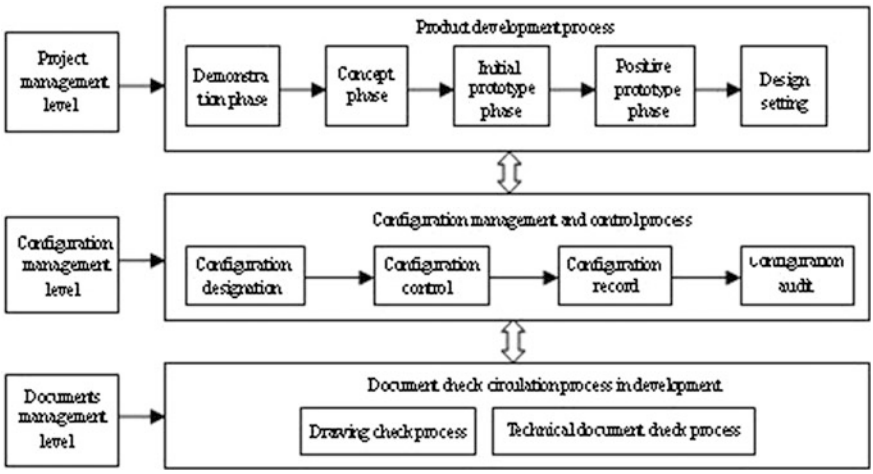

Fig. 106.1 Information data management model

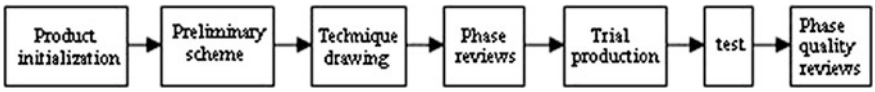

Fig. 106.2 New product design flowchart

106.3.2 Solutions of Product Configuration Management

Product design data is composed by product structures (components and parts etc.), drawing (schematic diagram, assembly drawing and part drawing etc.) and technical documents (research outline, design manual and experimental report etc.). Each design interaction is a specific product configuration, thus it's very important to establish, maintain and manage the product configuration. The configuration management for small and medium sized Institute includes:

1. Define, maintain and manage the products' structure, establish the complete product structure tree and correspond various statements in the product data management system;
2. Ensure the availability, integrity and accuracy of products' BOM data through data electronic audit mechanism;
3. Make reasonable control strategy of data access; ensure the data security while enhance the degree of information sharing;
4. Make engineering drawings according to product structure;
5. Realize the freezing of product configuration in a specific time using the baseline; ensure that the accurate and currently effective BOM statements would be achieved while the products get continuous improvement in research process, and realize the management of product configuration information.

106.3.3 Solutions of Design Audit Process Management

The documents' audit would be managed by electronic process model in the product data management system. First of all, drawing and technical documents are classified based on real needs and quality procedure documents of business, and the clear audit paths are made for different types of documents which will be brought into management specification as a constraints of product data entering into management system. Then different electronic audit work processes are made by different audit path. The participants (proofreaders, inspectors, etc.) in every links of process will be appointed automatically in accordance with the rules or appointed by the designers when submitting drawings and documents. In this way, all types of electronic documents and drawings will be storied, audited, managed

and traced effectively in the product data management system, which would ensure the consistency and integrity for document delivery, shorten the document archive cycle.

106.4 Summary

By making and planning the solution of product data management configuration for small and medium sized Institute, it could improve design efficiency comprehensively, speed up design interaction cycle, improve design quality and increase innovation capability. Compared with existed service management models, this solution has the following advantages:

106.4.1 Drawing and Technical Document Management

Documents are classified by unified principle, and the classification will be a basis to achieve effective management. In the product data management system, documents are managed unified and they are using consistent inquiry mode that both technical documentation and drawing information can be obtained quickly and accurately; all the electronic documents are managed unified by product data management system. To get paper drawings, the drawings are printed unified by print department after audit passing, which is ensured the consistency between electronic and paper documents, and enhanced the ability of archive resources sharing and data reusing; Versions of the documents would be managed unified effectively in product data management system. Retaining the historical records of all the documents' small versions, which ensured the integrity and traceability of enterprise data; the documents use electronic audit flow which could greatly improve working efficiency and controllability.

106.4.2 Technical State Control

Changing after-management to pro-management and emphasizing data predelivery function before formal submission to audit, which make the workers in followed-up intervened in advance to the service process of product R&D, and make evaluation throughout the product R&D process. So as to pre-find that if there are problems and eliminate the phenomenon remedied afterwards. Emphasizes must be made to integrity planning works and inspection of documents integrity in the system and component processes. Electronic management modes which ensure to use the latest changed product data version, combined together with the baseline management models to direct ensure the integrity and accuracy

of product data in this technical state; Also, emphasizes will be made to technical state management based on product structure. All the product data information is organized in accordance with the product structure, and the mechanism combined together with system and component processes which effectively ensure that the integrity of the product structure data could be controlled. At the same time, the above collected information can be extracted directly from the system, which will simplify the unnecessary links of product R&D.

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Chapter 107
Study on Innovative Library Management

Jie Cheng

Abstract The university library must adapt to new forms for faster and better development. Innovation must play an important in university library management. This paper discusses the library management innovation, introduces library management knowledge, analyzes the influence factors of library management, expounds the necessity of library management innovation, improves the management for innovation, and puts forward to improve the innovation of library management ideas and measures, so as to make the library management level of ascension of the whole, implementation spans type develops.

Keywords Library management · Innovation · Ideas · Measures

107.1 Introduction

The twenty-first century is the century of knowledge economy, information and knowledge in promoting economic and social development plays a more and more important role. University library in the higher school in an important position, library work is the important part of school teaching and scientific research work. University library collection amount and quality of service has been regarded as one of the important indexes of university running level and school running conditions. Our library most in from traditional to modern transformation period, the progress of the society, the development of science and technology, the demand of readers, with a fresh outlook requires libraries to adapt and face. The innovation is one of the most important features of the knowledge economy, social development also on the innovation of library management request.

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_107,

107.2 The Concept of Library Management

Library management is based on the library to meet the social needs of readers purpose, through the decision-making, plan, organization, command, coordination and control action, the most reasonable allocation and use the library system of the manpower and material resources, financial resources, so as to maximize the benefits, improve the efficiency of the library, the library to achieve the expected goals, the dynamic process of library to complete the task. Library management by planning, organization, leadership and control method, optimize the allocation of library systems for a variety of resources (human resources, financial resources, information resources) in order to complete the library for the entire school teaching and scientific research service and the service providers—librarian also received a high morale and sense of accomplishment of the activity [1].

107.3 The Main Factors of Affect the Library Management

107.3.1 The Traditional Management Ideas on Reform and Innovation Constraints

The traditional personnel management, there are two modes. One, all in order to work, arranged post is "proceed from work", arouse the work is "because of the need to work," care more than concern for people, emphasize strict management, trenchant rewards, management means heavy form, weight index, weight regulation, lack of flexibility, lack of human touch. Second, any deals of the mu, in some staff background more hall, various management systems implement strict, we keep on good terms, dare not touch sensitive interest issue, cause people rambling, efficiency is low, the phenomenon more disputes over trifles.

Ideological barriers. First of all library circle traditional ideas ingrained, used to close the country to international intercourse, heavy hidden light use, no Shared as a better development and utilization of the collection of library 's effective way, The lack of long-term and macroscopically development vision. Secondly, at present our country national overall culture quality is still low, lack of information exchange use consciousness [2].

107.3.2 The System and Mechanism of Library Management Constraints

China's current management system basically is "intersected, each does things in his own way", the lack of the general overall planning and coordinating division.

In developed countries basically all belong to decentralization dispersion management, that is not a national competent administrative authorities of the library work, Countries for library function just coordination, supervision, provide funds allowance, budget and facilities, of course, the decentralization decentralized management system is established on the perfect legislation basis [3].

The dispersion of management system is resulted in library business work of standardization and non standardization. Many of the library in the internal business work, not strictly enforce the existing national standard or specification files. In the American library association role is bigger, can from professional development Angle to coordinate the development of the library. China's national library association the coordination function is very limited; coordination and cooperation plan because it had no legal effect and administrative effectiveness and often can't thoroughly carry out.

107.4 The Necessity of University Library Management Innovation

107.4.1 External Environment of the Library Management Innovation

University library as a group, in recent years, its external environment changes, including the economic environment and cultural environment, technology environment, industry environment and the needs of the user change, detailed analysis is as follows.

107.4.1.1 The Economic Environment

In the knowledge economy era, the knowledge become as important factor of production and the most important source of economic growth, university library as university teaching and the scientific research of the information center, is to develop the knowledge talented persons base, is also the important pillar of science and technology innovation, In the society of knowledge economy will play more and more important role [4]. University library how to adapt to the requirements of the knowledge economy social environment, make great efforts to realize the information service of the digital and network, intelligent, diversity, actively promote personnel training and innovation of science and technology, is an important subject of its face.

107.4.1.2 The Cultural Environment

In recent years the culture environment of the library also changing, cultural market items with sudden published. In China, for example, in 1981, 214 house press, 25601 kinds of books published, in 2000, press has increased to 565, books published is 143376, In 2005, China press house had 573, the national books were published in 222473. As shown in Figs. 107.1 and 107.2, network literature and electronic literature and so digital resources rapid growth, according to statistics, after 1995 the network electronic journals in total almost doubled every year.

107.4.1.3 The Technology Environment

The modern computer technology, network communication technology and mass storage technology has changed the provide way of the university library collection work means and information resources to information. The digital and network and information of the rapid development of high and new technology, great changes in human, storage, transfer and use information way. Computer technology, the communication network technology, digital technology application of the library to service mode, working and has very greatly changed, and to the library staff the knowledge and skill set the new request. The library needs to increase the electronic computer hardware, software system and operator, request the library staff improve professional technology level, study the new technology, master new technology [5].

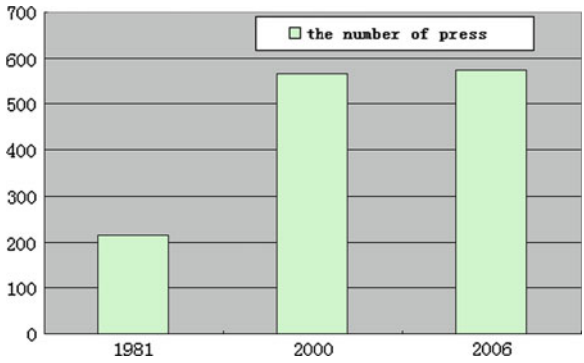

Fig. 107.1 1981–2006 press quantity change

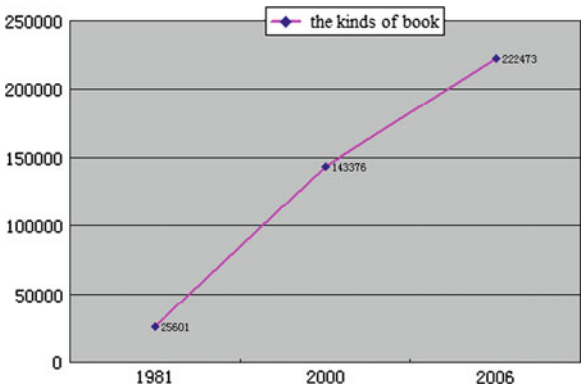

Fig. 107.2 1981–2006 book published quantity changes

107.5 The Significance of the Library Management Innovation

107.5.1 The Needs of Social Development and National Construction

In the twenty-first century modern science and technology is as the core, with the basis of knowledge economy era. Science and technology innovation, knowledge innovation in the development of the social economy plays a more and more important role. The library is the important carrier of social culture, in the social and cultural construction has played a decisive role. Establishing learning society is the inevitable trend of social development, establishing learning society is to is the important means of promote the all-round development, for improving the whole nation, the ideological and ethical standards and scientific and cultural qualities, and promote our country's human resource construction, improve our innovation and competitiveness, Exerting the role of library, so as to promote the development of society, so the library management innovation is must.

107.5.2 The Demand of Learning Society Readers

Twenty-first centuries is the century of lifelong learning. Lifelong education in the library, the public welfare and service to meet the needs of society the inevitable reflect at present, it is an important place for education. The library through the input, storage and output of knowledge, to become the main battlefield of people carry on the lifelong education. Creating the all-round development of people as the center of "learning society" has become the inevitable development of history, is adapted to the economic and social development inevitable product, is also the modern man's own development, ego perfect inevitable requirement.

107.6 The Ideas and Measures of Library Management Innovation

Library management innovation in Chinese characteristic theories as guide, core is to seek truth from facts, focus on the future, based on present, in the library existing conditions, the effective use of resources, including human resources, funding, equipment, technology and so on, and the existing theory and practice experience, arrange as a whole, the realization of library coordination, implementation benefit is the greatest.

107.6.1 The Innovation of the Idea and Thought

Management idea, concept innovation, is the premise for all management innovation. The library should live, should develop, above all should innovate, and must renew idea. In order to adapt to the knowledge innovation and the future development of the library need.

Library management concepts first must change. Face the rapid structural changes and rapid development of the times. A good library management must establish innovation consciousness, not by the conservative; have the courage to break through the old tradition. According to the objective law of the development of the library itself and the era of knowledge economy on library in university needs to formulate right development strategy and management mode, For does not adapt the management mechanism, must try to reform, must study constantly repeated continuous improvement. In the continuation of the process of reform will bring real innovation, make qualitative leap in university library [6].

107.6.2 Strategy Innovation

In recent years, more and more colleges and universities library began to pay attention to strategy and planning. Our country present university library changeful strategy evolved into simple goal setting, but often overlooked strategy implementation and control. So we propose to carry out the innovation of strategy. Mainly is for the importance of high-tech development strategy, *f* and strategic innovation of logic.

107.6.2.1 Pay Attention to High-Tech Development Strategy

The era of knowledge economy, university library information institution, in the information industry, library faces various kinds of information service, enterprises and institutions increasingly fierce competition. While the network such as

the Internet to provide people with access to information the direct pathway, also for Librarians' traditional role challenges. At the same time, the changes in the environment, it will bring about many opportunities for development.

107.6.2.2 Strategic Logic Innovation

The so-called strategic logic refers to the design strategy in with what kind of logic thinking to think. University library can follow the external and internal environment, one of the main reasons to meet the different requirements of readers is that the library managers with an innovative strategy for logical thinking. They can accord the university library the external environment and the libraries own development characteristic with different logic to design strategies.

107.6.3 Cultural Innovation

Since twentieth century, the traditional library is in ceaseless change. New technology environmental influence on the library is more comprehensive, the work mode of library, service mode, organization, collection development, role and mode of operation, has a strong impact on. Therefore, the library organization culture is in adjustment and transformation.

107.6.3.1 Build the Team Culture

Network environment library organizational culture must be good at absorbing other cultural accomplishment, to construct the reasonable, excellent culture. The team culture spirit is the important content of modern organization. Library construction team culture is not a short duration of time. Since the original tissue culture has sufficient stability, at any time for change will be the traditional old cultural obstacles. Library is for long time efforts to gradually form.

107.6.3.2 Foster People-oriented Culture

The library existence is to satisfy people, university library exists to meet the "all kinds of people"—the reader to knowledge, information needs, it is with the reason for existence and development of library. The library is to establish "people-oriented" values, to implement "people-oriented" management mode depends on the support of culture. Common value orientation of the library for managers and readers into is the deepest consideration. The management

personnel in the fully achieve its development, realize the value at the same time, will be more loyal to the cause of the collective and the future development of the library.

107.7 Conclusion

Economic globalization and digital network in the university library is a double challenge. Our library is from a socialist planned economy to socialist market economy transition period, where we are confronted with more pressure and challenge on how to improve the management of management innovation, which is the key to solve all problems. It can be predicted that in the near future, our university library can cause development bottleneck in the management, personnel, and so called "soft factors". So we must carry on the management innovation, faster and more efficiently to improve our management level.

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Chapter 108
Multi-Information Integration System of Aircraft Ground Concentrated De-icing

Liwen Wang, Hongzhen Yang and Bin Chen

Abstract Aiming at solving the problem of information dispersed, hysteresis even lost in the process of aircraft ground concentrated de-icing which reduces the efficiency and safety of aircraft ground de-icing. A multi-information integration system of the whole process of the aircraft ground concentrated de-icing is designed in this paper, which describes the architecture and the function of the information integration system, proposes the hardware structure and implementation of software of the database server and the monitoring terminal. The experimental results show that the system can collect and show the information of the whole process of aircraft ground de-icing properly and provide an efficient monitoring platform for aircraft ground concentrated de-icing.

Keywords Aircraft · Ground concentrated de-icing · Multi-information integration system

108.1 Introduction

With the development of China's civil aviation industry [1, 2], the number of flights at major airport increase rapidly, which is bound to be delayed or canceled when it encounter snow and cold weather, resulting in huge economic losses even safety accidents. In order to guarantee that flight can function normally, the aircraft must be de-iced in half an hour before taking off. To improve the efficiency of de-icing, management staffs need to know the status of de-icing equipments, de-icing

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_108,

operators and other information so that they can dispatch and command all the de-icing resource according to the actual situation to ensure the de-icing is efficient and reliable. Concentrated de-icing has been adopted by most airports currently, however, it is difficult to achieve the comprehensive arrangement and unified management of de-icing resources because of hysteresis and inefficiency in the transmission of information in the de-icing process so that there are shortcomings such as low efficiency, high operating costs and not full utilization of de-icing resource. To solve this problem, a multi-information integration system of the whole process of the aircraft ground concentrated de-icing is designed in this paper.

108.2 The Overall Scheme of Multi-information Integration System

This paper introduces the design of overall architecture and the data flow of the multi-information integration system of the whole process of the aircraft ground concentrated de-icing.

108.2.1 The Overall Architecture Design of System

The multi-information integration system of the whole process of the aircraft ground concentrated de-icing consists of ice accretion prediction unit, the database server, monitoring terminals, display terminals and data collection terminal installed in the de-icing equipment parts, which is able to achieve the integration of related system application, data sharing, real-time information display and interaction during the de-icing process and establish a process-oriented information service platform, which help dispatch and command the aircraft concentrated de-icing process to improve the efficiency and safety of de-icing process. The architecture of the system is shown in Fig. 108.1.

When the system is running, the personnel of airlines and airport in the monitor terminal provide flight information and weather information for the database server, the ice accretion prediction unit will predict ice accretion according to meteorological information and the data collection terminals will collect information of de-icing equipment including the status and current location of de-icing equipment, temperature and margin of the de-icing fluids and other information, and then the information are sent to the database server through the GPRS wireless network [3–6] and will be shown on the display terminal of de-icing resources and GIS [7–12] which shows the current location of de-icing equipment in real-time. The management staff in the monitoring terminal will command de-icing resource according to the above information to ensure the safety and efficiency of de-icing process.

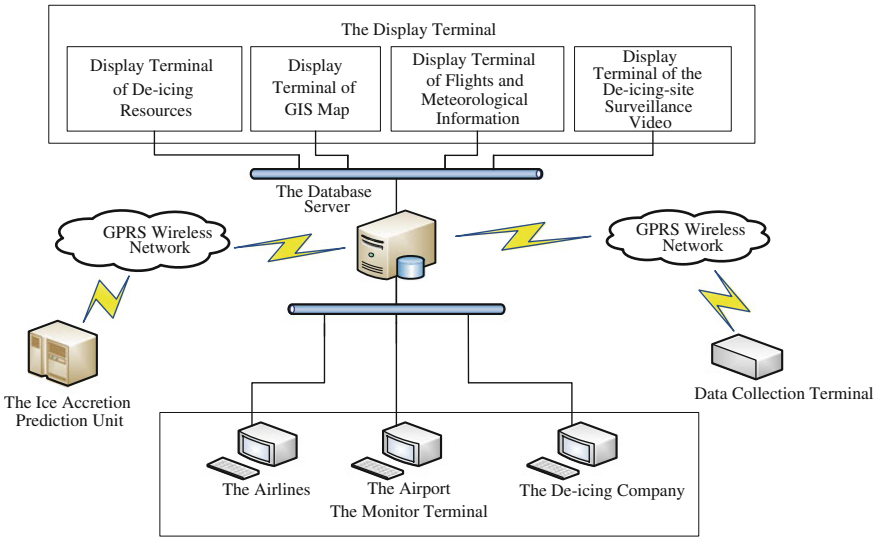

Fig. 108.1 The architecture of the system

108.2.2 Data Flow of the System

The multi-information integration system of the whole process of the aircraft ground concentrated de-icing need to obtain sufficient data and information so that the management staff can arrange de-icing resource reasonable according to the actual situation, and improve the efficiency and safety of de-icing process and ensure the safety and normal operation of flight. The data flow of the system is shown in Fig. 108.2.

As is shown in Fig. 108.2, the database server is responsible for the management and maintenance of the data. The database server accepts the real-time data sent by the monitor terminal and send real-time and historical data in the database to the monitor terminal and display terminals at the same time. And the query and display of data is implemented by the monitor terminal and display terminal.

108.3 The Database Design of the System

As the data storage and manipulation part of the whole system, the performance of database will have direct impact on the performance of the whole system when in practical service [13]. In the process of designing the database, the data access and safety should be considered and minimize the storage of redundant data at the same time to ensure the database will perform efficiently.

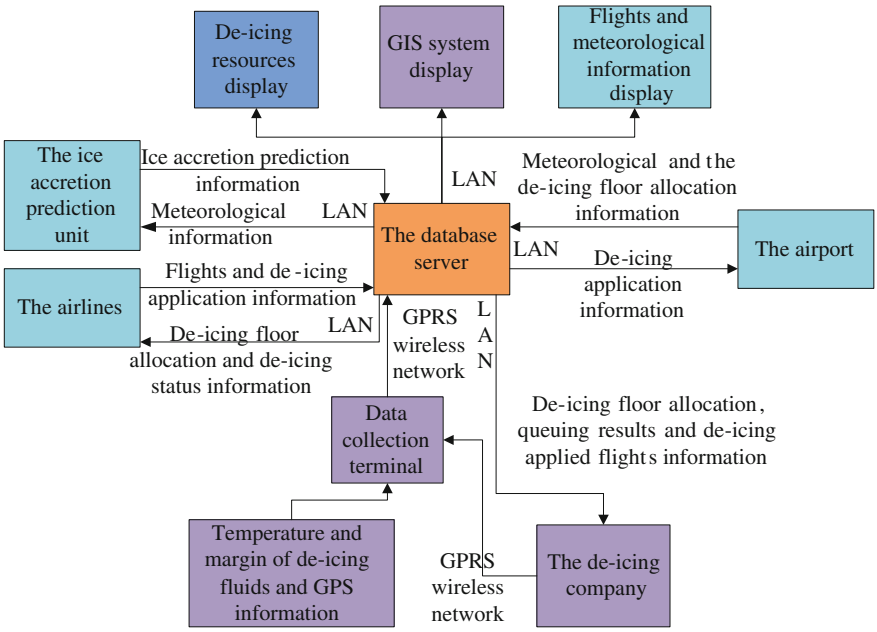

Fig. 108.2 The data flow of the system

According to the system requirements, the database should be able to support the following functions:

Record various properties of the de-icing equipment, such as the number of device, operators, and the status of device, temperature and margin of de-icing fluids contained in the device and so on;

Record various properties of the flight, such as the number of the flight, aircraft type, the de-icing time of the flight, de-icing status of the flight and so on;

Facilitate the command and dispatch work of management staff, make sure they can check the information mentioned above in real-time, provide a reference for their command and control.

According to the requirements mentioned above, the E-R diagram of database is designed as it is shown in Fig. 108.3.

The data table and the relationship between them can be abstracted according to the system database E-R diagram, which is shown in Fig. 108.4.

The meaning of the character in Fig. 108.4 is shown in Table 108.1.

108.4 The Software Development of the Monitor Terminal

The monitoring terminal is the core part for the management staff to monitor and control the whole process of the aircraft concentrated de-icing which convert every link of the de-icing process into the concrete data and graphics displayed on the

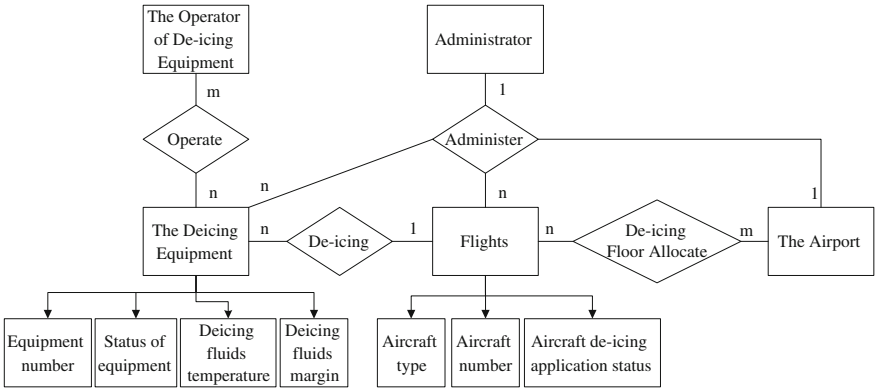

Fig. 108.3 The E-R diagram of database

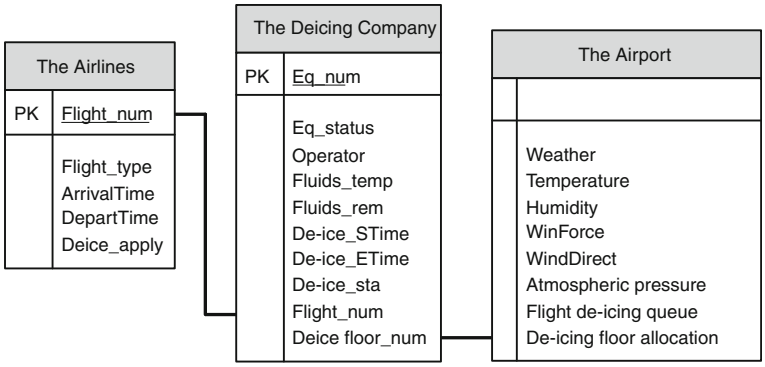

Fig. 108.4 The table of database

screen. The main function of the monitoring terminal is to satisfy the requirements of querying and monitoring of the information of the de-icing resource claimed by different users such as de-icing companies, airlines and airports. According to the request of the system, the monitoring terminal is developed in client/server mode [5, 14] in which the tasks are completed by the client and server respectively. The most typical application of this model is the database technology. The database server in the client/server mode database system is huge and abstract, however, the client can own a small database for the user's request, if the client's database is able to meet the data request, it will give the result directly to the user, and otherwise it will invoke the server to handle the request. When users invoke the resources of server, the clients sent request to the server, and analyze the results sent back by the server and then display the result to users. The system using the client/server mode has very strong function of representing the data and can

Table 108.1 The meaning of the character in database table

Character	Meaning	Character	Meaning
Flight_num	The number of flight	De-ice_ETime	End time of de-icing
Flight_type	The type of flight	De-ice_sta	Status of de-icing
ArrivalTime	Arrival time of flight	Deice flloor_num	The number of deice floor
DepartTime	Depart time of flight	Weather	The weather of environment
Deice_apply	Apply for de-icing	Temperature	The temperature of environment
Eq_num	The number of deicing equipment	Humidity	The humidity of environment
Eq_status	The status of deicing equipment	Winforce	The force of wind
Operator	The operator of deicing equipment	WindDirect	The direct of wind
Fluids_temp	The temperature of deicing fluids	Atmospheric pressure	The atmospheric pressure
Fluids_rem	The margin of deicing fluids	Flight de-icing queue	The queuing result of flights which apply for deicing
De-ice_STime	Start time of de-icing	De-icing floor allocation	The allocation result of deicing floor

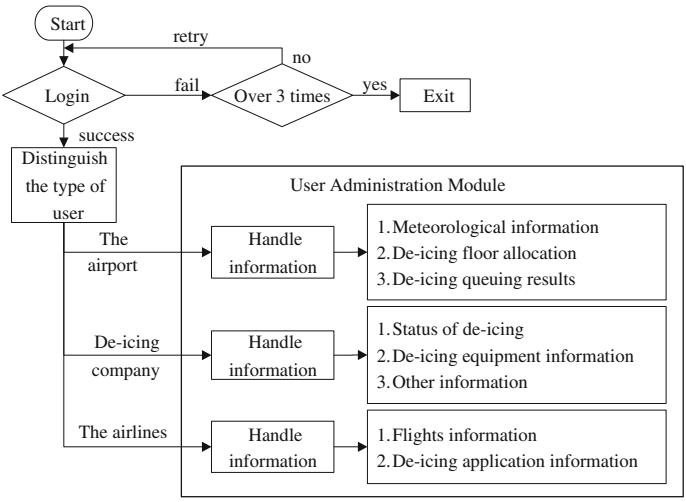

Fig. 108.5 The software flowchart of the monitor terminal

achieve complex data acquisition, data processing and realistic data real-time monitoring. The software flow chart of the monitor terminal is shown in Fig. 108.5.

108.5 Summary

A multi-information integration system of the whole process of the aircraft ground concentrated de-icing is designed in this paper, the design of critical component of the system such as the ice accretion prediction unit, the database server, monitoring terminals, display terminals and data collection terminal installed in the de-icing equipment parts is also proposed in this paper. The system proposed in this paper can achieve multi-source information monitoring and processing and help the de-icing management staff achieve reasonable and fully utilized of de-icing resources, improve the efficiency of aircraft ground deicing, and guarantee the safety of aircraft concentrated de-icing at the same time.

Acknowledgments This work was financially supported by the Joint Funds of the Natural Science Foundation of China and Civil Aviation Administration of China (Grant No. 60939001), Civil Aviation Administration of China Fund (Grant No. 60932016) and National Key Technology Research and Development Program of China (Grant No. 2012BAG04B02).

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Chapter 109
User Experience-Oriented Hierarchical Mechanism of Industrial Design

Dong Zeng and Dan Chen

Abstract This paper puts forward a scientific industrial design method-oriented user experience (UE). Combined with investigation and UE relative theory, this thesis considers industrial design knowledge composed of five layers such as strategy, value, structure, framework, and representation. This hierarchical relationship is a mechanism of top–down decision from concepts to details. Due to delivery of knowledge among layers, the system of knowledge nodes is built. Through knowledge input and output in each node, the resolution of industrial design gradually becomes clear. With the study of practical application, the hierarchical knowledge mechanism-oriented UE efficiently comprehends and reuses valuable information and easily finds out product innovation gap.

Keywords User experience · Industrial design · Design method · Knowledge

109.1 Introduction

In the field of industrial design, the satisfaction of user experience (UE) is gradually playing a crucial role in the improvement of product usability and competitiveness. Knowledge is regarded as the biggest intangible asset in corporations or design teams [1]. Aimed at maximization of economic benefit and sustainable development, the effective knowledge management could provide support for

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2_109,

product design to aid design decision-making, share across-specialty knowledge, and develop design scheme [2]. Thus, how to effectively excavate and extract user knowledge and design knowledge in the process of new product development is the key point.

In the field of knowledge mining, the "thinkaloud analysis" is a method of capturing user psychological information through analyzing words. It can help designers obtain constructive comments from users [3]. Due to the difficulty of capturing user knowledge, some scholars adopt methods of ethnography or anthropology to obtain common features of the goal-users for comprehending their expectations. The classification and definition of user's features are of benefit to develop a cooperative computer system [4]. Owing to more efficiently organized industrial design activity, intelligent computing technologies are applied for evaluation of the esthetic patterns and manufacture cost, such as genetic algorithm, fuzzy computing [5]. This thesis has bought out a hierarchical knowledge mechanism for constructing industrial design process. Based on the five factors of user experience, combined with the social investigation on industrial design activity, we think that the process of product design can be divided as five top–down distinctive layers.

109.2 The Capture of Industrial Design Knowledge

109.2.1 The Knowledge Capture Method

In this thesis, social investigation is used to capture design and user knowledge. There are four phases to capture knowledge.

Step 1: Through case research, individual interview, and questionnaire the whole information in process of design is gathered. Case research is to record the workflow of designer or design team. Individual interview is to aim at the full-experience designer for structure semantic analysis of their development program and relative resource. Through questionnaire, the shortage of knowledge map is easy to find out. The research object of this step is industrial designers.

Step 2: The user knowledge is gathered by the "thinkaloud analysis". The premise of thinkaloud analysis is that users must speak out by words in the human-product interaction. Knowledge engineers could structuralize the user information and conclude the concrete user needs and their weight. In accordance with feedback information from knowledge engineers, designers find out the most suitable gap.

Step 3: Through the literatures investigation, we have compared with general design model [6], design model based on cognition [7], and UE basic factors [8].

Step 4: Through classification and hierarchical structure, a design processing model-oriented UE is built. According to the definition of each UE basic factor, this thesis assembles those activities with similar goals and participators.

Using social investigation, there are two advantages to building processing model. First, because the resource is originated from the practice of design experience, it is more available for analysis and prediction in the design process [9]. Second, the systemic investigation is beneficial to completely comprehend the design background and relative knowledge resources. However, social investigation also has its limitation with place, time, and it is easily affected by uncertain factors.

109.2.2 The Knowledge Representation Model

The industrial design ontology (O) model is a quadruple group, as shown below.

$$O = \langle C, I, R, A_x \rangle \tag{109.1}$$

"C" represents the sets of categories. Every activity in one category has a similar sub-goal or the same study object. According to the UE theory, there are five factors influencing user satisfaction, such as strategy (Sg), value (V), structure (St), framework (F) and representation I. So, the sets C can be described as below.

$$C = \{\mathrm{Sg}, V, \mathrm{St}, F, R\} \tag{109.2}$$

"I" represents the sets of instances in the sets C. "R" represents the relationship sets in the sets C, and the inter-categories relationship can be described as top–down hierarchy. In Eq. 109.2, the Sg is the set of the highest layer about strategy, and the R is the lowest layer of representation. "Ax" represents the axiom sets in the knowledge field of industrial design, and can be used to seriously restrict the attributes and relationships of the sets C.

109.2.3 The Hierarchy Knowledge Processing Oriented UE

The Content of Each Knowledge Hierarchy The industrial design mechanism oriented UE is a top–down and decision-making process from concept to concrete.

In the strategy layer, related knowledge outline is constructed on corporation goals and user demands. So, the knowledge of strategy layer can be described as below. B represents the sets of corporation goals; D represents the sets of user demands. B and D are the sub-sets of Sg in the Eq. 109.2.

$$B = \{b_1, b_2, \ldots, b_i\} \quad i \in n \tag{109.3}$$

$$D = \{d_1, d_2, \ldots, d_j\} \quad j \in n \tag{109.4}$$

Owing to the knowledge outline of strategy originated from two objects such as corporation and users, it can lead to knowledge redundancy. For avoiding this, the

valuation of knowledge points is necessary. Aimed to find out the breakthrough gap, we need to compare with the original product features. As below, F represents the sets of the original product features and S represents the sets of opportunity gaps.

$$F = \{f_1, f_2, \ldots, f_k\} \quad k \in n \tag{109.5}$$

In the valuation layer, for finding out reasonable opportunity gap, we should adopt below operation.

$$S = F \otimes D = \{s_1, s_2, \ldots, s_l\} \quad l \in n \text{ and } S \subseteq D \tag{109.6}$$

"$\otimes$" is a divergent operator and the sets S can't violate the factors of sets B. If the sets S equate null, then the user demands should be gathered again. The destination of knowledge processing in the valuation layer is for designer to understand the project about "what we need to design" and "what we needn't to design".

The Construction of Knowledge Node The knowledge node specifically refers to the basic step of the design process. Owing to industrial design domain ontology includes five hierarchical categories as Eqs. (109.5) and (109.6); they separately represent five knowledge nodes in the design process. Knowledge node system is a treelike configuration. As the treelike distribution of the knowledge node, the knowledge system not only can be easily to eliminate the confusion of concepts and terms, but also its maintainability, scalability and vivacity are ensured. The knowledge node generally is defined as below.

$$\text{Node} = (\text{In}, \text{Out}) \tag{109.7}$$

In represents the sets of concept information about inputting condition; out represents the sets of concept information about outputting goal.

109.3 Practical Application

109.3.1 Design Project

The task is to design for the shape of type WTL-4K centrifuge as Fig. 109.1. The design team consists of one project director, two structure engineers, one marketing specialist, one purchasing specialist and three industrial designers.

Fig. 109.1 WTL-4K centrifuge original shape

109.3.2 The Knowledge Nodes

Knowledge node 1: According to the current market and enterprise situation, after detailed and effective discussion, the design team establishes the specific project about business goal and brand recognition in the phase of strategic design (content see Table 109.1). The experiment of task analysis, observation aimed to understand the operating typical process of the users and oral analysis is applied to analyze the user feeling in the human–computer interaction process. Then the list of user needs is come up with (content see Table 109.2).

(About weight level: L1 and L2 belong to fundamental scope and L3 or above are advanced needs. The weight level is lower, and then the need is more important).

(About the weight levels: the same as in Table 109.1).

Knowledge node 2: After the design team compared the features of original product (as Eq. 109.3) with the factors of the user needs (as Table 109.2), the content of sets S (as Eq. 109.4) can be established as $d3$, $d7$, $d10$ in Table 109.3. Because $d10$ is related to environment protection which needs more the development of technology, the design period would be prolonged. So $d10$ does not conform to the strategic business goal. The $d3$ and the $d7$ are main content of market opportunity gap sets. The output content of this node can be described as "this design project should upgrade its product form, on the premise of user current operate task flow, safely human–machine interaction, conveniently cover plate operation, and legibility brand design."

Table 109.1 The product design goal

Product goal	Factors of the sets B (as Eq. 109.3)	Weight
Business goal	To upgrade product image ($b1$)	L1
	Well and quickly received by the market ($b2$)	L1
Brand identity	Easy to recognize ($b3$)	L3

Table 109.2 List of user needs (brief)

No.	Factors of the sets D (as Eq. 109.4)	Weight
1	The response should be quick and not leave the user waiting too long ($d1$)	L1
2	Well sealed, dustproof and waterproof ($d2$)	L1
3	Operate according to the user task flow ($d3$)	L2
4	Responsive to failure of the machine ($d4$)	L1
5	The cover board must be locked while in function in case of accidents due to opening by mistake ($d5$)	L1
6	The machine must stop once the cover board is opened ($d6$)	L1
7	The cover board must be easy to open and hard to reopen after closure ($d7$)	L1
8	Concise appearance and materials smooth and easy to clean ($d8$)	L2
9	Small in size and fit to the space ($d9$)	L2
10	Environmental protection and energy-saving ($d10$)	L2
11	The operation buttons should be easy to see and handle ($d11$)	L1
12	As user task fails, the machine can give instructions accordingly ($d12$)	L3
13	Device design portable and easy to carry for users ($d13$)	L4
14	Centrifugal rotor can hold test tubes of different types ($d15$)	L4

Table 109.3 The design evaluation

Evaluation object		Value	Weight	Score
UE	Shape upgrade	2.32	0.2	0.464
	Brand recognition	2.12	0.1	0.212
	Operation satisfaction	1.80	0.2	0.360
Structure technology	Structure complexity	−0.46	0.15	−0.075
	Process complexity	0.36	0.15	0.054
Market environment	Cost	−0.50	0.1	−0.05
	The market time principle	0.39	0.1	0.039
Overall score				1.004

Knowledge node 3: According to the output content of node 2, some typical users are invited to participate in the task analysis experiment. Through observing their operation program and recording relevant information, the typical operation process can be described. After analysis, this node can output below points.

When the machine is power-on, running or switch-off, no indicator reminds users;

When user performs operation, cover plate must be remaining open state, meanwhile shaft of hinge form has not jammed institutions;

Micro-tubes should be inconveniently taken out from accessory pocket;

It is no feedback when the cover plate is in the state of closing;

The cover plated jammed institution is made of plastic which easily lead to material tired after long-time usage, so that it effects the use safety.

Knowledge node 4: Case 1–4 as the Fig. 109.2 are silhouette drafts layout by designers and case 0 is the current form. With the team discussion, the sequence of shape change degree from large to small is as (3, 2, 1, 4); the hinge of (3, 4) is

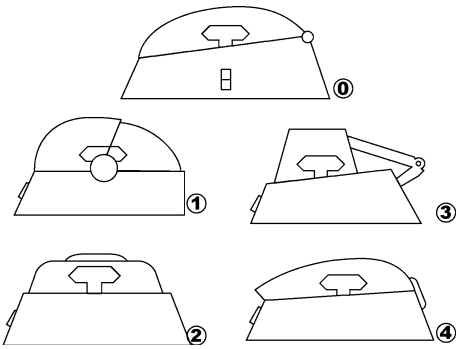

Fig. 109.2 The layout cases of product shape parts

Fig. 109.3 The shape design of 2 layouts

behind the whole shape, and that of 4 is in the middle; the quantity of component parts is as (1, 3, 2, 4) from most to least; the assembly complexity degree is as (1, 3, 4, 2) from easy to hard. After synthesizing above points, the case 2 is chosen to details design.

Knowledge node 5: Figure 109.3 is the final shape of draft 2. The transparent casing is more convenient observe centrifuge operation and micro-tubes state. The operation of machine cover is non-traditional so that it can bring users a new experience. And the shallow water wave shape in the machine cover expresses the meaning of rotating.

Finally, in order to prove the validity of final design, we have invited 7 volunteers to evaluate its shape. Three factors of evaluation are established as UE satisfaction, structure and market environment. Moreover, the weight of evaluation factors should be established by related field experts. In evaluation, we has used "very", "more", "a bit", "general" indicate image scale, so the semantic space can be described as below.

$$[\text{very dissatisfaction}, \text{very satisfaction}] = [-3, 3] \tag{109.8}$$

The statistical value is 1.004 (as Table 109.3). The satisfaction degree expresses a bit.

109.4 Conclusion

Because of the hierarchical relationship of five UE factors, this paper has presented a knowledge mechanism in the field of industrial design. Through investigation of design activity, we have defined the content of each layer. For convenience of knowledge conveying, it is built of five knowledge nodes. Finally, this hierarchical knowledge mechanism has been applied to practical projects. Compared with the traditional design process which emphasizes technology and cost, the design process-oriented UE focus on user study. In addition, this paper only has taken out a commonness of design process-oriented UE. In the next phase, quantitative study on user experience based on psychological perception mode will be conducted.

Acknowledgments This study is supported by "the Fundamental Research Funds for the Central Universities (NO. JGV110775)".

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Z. Zhong (ed.), *Proceedings of the International Conference on Information Engineering and Applications (IEA) 2012*, Lecture Notes in Electrical Engineering 216,
DOI: 10.1007/978-1-4471-4856-2, © Springer-Verlag London 2013