A New Practice Course for Freshmen Using RoboCup Based Small Robots

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1 Introduction

Contemporary engineers need to have the ability not only to freely make use of their professional knowledge and skills, but also to integrate and combine a wide range of knowledge and skills and to build a complex system to solve a problem. But the current educational programs of individual departments (mechanical engineering, electrical engineering, electronic engineering, computer science) are usually designed and performed independently. Therefore it is hard for students to understand how knowledge and technologies of each field are integrated and combined in the objects of the real world. In order to increase student understanding in this area, we propose a new practice course dealing with a completely functional object: a robot.

There are several experiments and practice courses dealing with robots as educational materials. LEGO MINDSTORMS is sometimes used for an introductory course and is acknowledged as efficient educational material [1],[2]. There are also some trials to introduce RoboCup based robots to education in practice [3]–[7], and RoboCup soccer simulation [8],[9]. The first steps in the process of building a robot are more difficult for students than using LEGO MINDSTORMS, because students need to master such tasks as the mechanical process, soldering, and programming. But once they have mastered such tasks, they are better able to try more advanced tasks like adding different type of sensors later.

The Owaribito-CU robot soccer team has competed in RoboCup since 1999. Along the competitions, robots for RoboCup small size league have been developed in one of the extracurricular activities. This year faculty of the team have introduced the construction of a simplified robot to the regular curriculum of the Chubu University college of engineering.

This paper describes the outline of a newly designed practice course for undergraduate engineering students, especially for freshmen. The process and review of the course, which was carried out as five day intensive class in summer vacation, and the analysis of the questionnaire survey for the students after the course are mentioned. Our new course is close to Baltes [4], Anderson [5], and

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DME project in MIT [7] in previous trials. Distinctive features of our course are the realization of inter-departmental education for freshmen without prior knowledge and skills, and compact course work for a short term intensive class.

The course was open to all undergraduate students. It covers not only themes dealing with hardware and software, but also topics in system engineering and the wide range of knowledge and technologies related to several fields. By introducing such a course into the early stages of undergraduate education, we hope to stimulate students to become interested in other fields besides their own specialized fields.

2 A Basic Robot for the Course

Currently we Owaribito-CU team have three wheeled omni directional robots, ball handling devices, and a multi camera vision system. Fig 1 (left) shows our omni-directional robot for the 2004 competition.

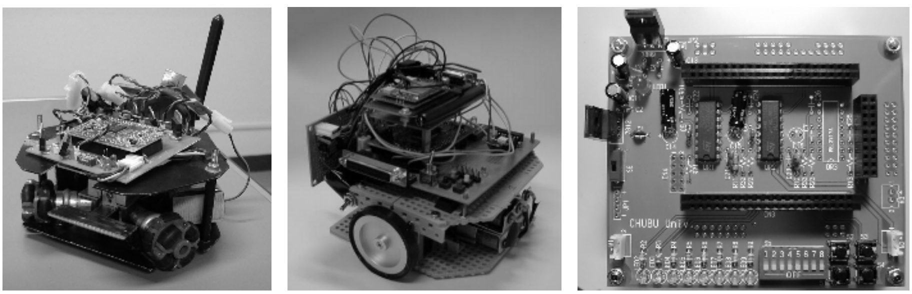

Fig. 1. 2004 omni-directional moving robot for competition (left), prototype of simplified robot (center) and main board (right)

This robot contains expensive motors and a wireless communication board. And it is therefore not suitable for the practice course. The robot which will be constructed by students in the course is a simplified robot. Fig 1 (center) shows the trial piece of the simplified robot. It is easy to construct, even for beginners. Another merit of the basic robot is that it can be constructed at low cost. Already there is a trial to introduce a low cost robot to education in CMU [10].

Our simplified robot for educational use can be constructed for about 330 US dollars per robot including wireless communication function. Required parts (and their cost) are the main board (30 US dollars), wireless communication (90), H8 micro computer (30), motor drive circuit parts (30), DC motor (60), chassis parts (20), tire and wheel (30), battery pack (30), other miscellaneous parts (10). We think total cost is an important factor as educational material, because 30 or more robots are constructed in a course. Keeping costs as low as possible is important in order to continue offering the course in the future.

All parts except the main board are ready-made. Only the main board was newly designed for the course. Fig 1(right) shows the main board. It includes the power supply circuit, motor driver IC, interface to H8 MPU board, switches and LEDs.

Since the construction work is carefully chosen and combined, the robot can be constructed easily within 30 hours by an undergraduate student without any prior knowledge of the robot design and architecture. Once the students experience constructing the robot by themselves, they will have a sense of achievement through the process.

3 A New Practice Course Using RoboCup Based Small Robots

3.1 Aims and Merits of the Course

The aim of the new course is to introduce the fundamental technologies of various engineering fields to freshmen. The course will be a typical example to show how the knowledge and the technologies of many fields are actually applied to build a complex system like a robot. It is expected that students are encouraged to be interested in their field and even non-specialized fields. As another feature of the course, inter-departmental education is realized. Teams are organized by the students from different departments. Making such team produces the chance to communicate with those from other departments, and encourages students' interest in other fields.

Some of the achievements of this course are as follows.

(1) Students can understand the basics, such as the architecture of the robot, driving mechanism, control circuits and programs.
(2) Students can understand how to use various tools.
(3) Students can devise some part of the robot by themselves with their own ideas.
(4) Students have fun constructing a robot and develop their interest in topics in engineering. Students encourage their will to study related subjects.
(5) Students can gain confidence in constructing a robot by themselves.

3.2 Syllabus

Course plan
The course is completed in a five day intensive class with an orientation where a prior explanation of the syllabus is given. We plan to divide the class into teams of students belonging to different departments, and each team constructs its own soccer robot. In order to give an incentive to learn with enjoyment and to construct the robots with interest and enthusiasm, a competition using produced soccer robots is held on the last day of the course.

Schedule
The course is carried out as an appropriate combination of lectures and practices. In order to quickly put into practice the knowledge and information provided

during lectures, the lecture class is assigned in the first half of the day and the practice class is assigned in the latter half. Concerning the first 3 days, the order of contents described below might be re-arranged in rotation for some student teams, because of the size of a class and the limitation of the work place.

the first day
(lecture) Dynamics of Mechanical parts (such as motors, wheels, gears). Behavior of the driving part. How to use machine tools.

(practice) Machine design (shape of chassis, position of electric motor). Evaluation of driving part (regarding speed or torque). Practice using machine tools (cutting out chassis, drilling, bending, smoothing). Test run.

the second day
(lecture) Motor driver IC and circuit. PWM method. Wireless communication. H8 micro processor (A/D converter, D/A converter, peripheral interface). Battery and power supply. How to use tools. Soldering. How to test the circuit.

(practice) Construction of controller circuit. Test operation.

the third day
(lecture) Control program. Programming for wireless communication. USB communication. Process of software development.

(practice) Understanding and tuning the control program. Improvement of the user interface (USB controller). Trial operation.

the 4th day
Construction of robots. Preparation of presentation.

the 5th day
Construction of robots. Final tuning. Team presentation. Competition.

Besides the themes of lecture and practice in the course, it will be possible to include related themes like experiments in logic circuit, how to use an oscilloscope, assembler programming, and so on. In those themes, image processing and AI are especially important research and development themes of RoboCup. Though these themes should be included in the course, they are omitted at present due to time limitations.

Evaluation
Students will be evaluated by writing a paper concerning the skills and knowledge they have learned in the construction process, by completeness and originality of the robots (body, mechanism, circuits, program, and design) they have constructed, by expressiveness of the presentations they have given, and the results they have achieved at the competition. All points mentioned above are individually graded, and the total of them will be used for the evaluation. Students' attitude in the class will be also evaluated in some cases.

3.3 From Preparation to Final Competition

The course textbook was written by faculty and teaching assistants. While the contents of the textbook were limited to only related topics, it had more than

120 pages finally. The textbook was printed and bound prior to the beginning of the course and distributed to participants.

Orientation was held prior to the course to explain the contents of the course and to invite students to the course. All students in the college of engineering can participate this course, but the themes of each day listed in the syllabus are designed mainly for students of the department of mechanical engineering, electrical engineering, electronics and information engineering, and computer science. 81 students registered, while upper limit of participants was 90. Only a few students from outside the above four departments registered.

The course started on August 2nd. To have enough time, the class started at 9:30 and finished at 18:20 everyday. The final day of the course was also the University's "Open Campus" day. Therefore we opened the work room in the morning and the presentation and the competition in the afternoon to the public. Many high school students showed up, and we could make an appeal to them. Fig 2 shows the presentation and competition. Fig 3 shows the examples of robots which students constructed. The parts they used were the same, but the appearance of the robots was different for each teams.

There were some minor problems during construction, but finally all constructed robots worked well. All participants and robots attended the final competition. After the competition, the members of the champion team received a commendation and were given "The Dean of College Cup". They also earned the right to enter "The President Cup" competition in autumn.

Fig. 2. Presentation and competition

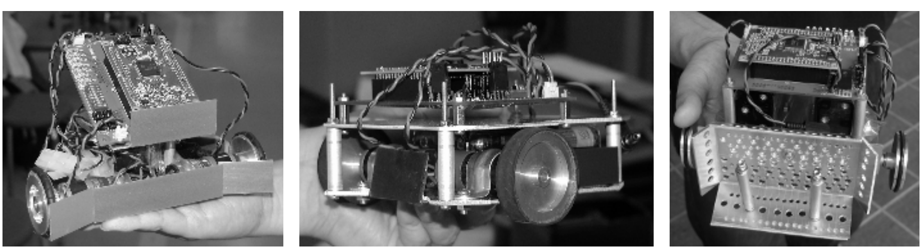

Fig. 3. Examples of robots which students constructed

3.4 Support for Completed Students

After the course, an opportunity to improve their robots is provided for students completing the course. In order to motivate their will to study, we also have "The President Cup" at the university festival in autumn. To the teams who have achieved excellent results in the President Cup, financial assistance for competing in the domestic RoboCup game, "The Japan Open", will be given by the university. Furthermore, if a team wins the Japan Open championship, they will be provided financial assistance to participate in the international RoboCup competition.

4 Questionnaire Survey

We asked course participants to evaluate the course by completing a survey questionnaire on the final day. 74 students (73 male, 1 female) completed the whole course. There were 73 freshmen and one junior. All of them answered the questionnaire. The survey results are found below:

Q1. Part of work in a team: 55 students took charge of work in their own field; for example, students from the mechanical engineering department mainly took charge of mechanical work, and so on.
Q2. Interest in other fields: 71 students answered "Yes". This the result we had hoped for, and it was good that the participants had interest in other fields. The team arrangement policy placing students from different departments on each team may have contributed to the increase in student interest in other fields.
Q3. Team arrangement: 2 students answered that a team should consist of the students from a single department. 72 students approved of the inter-departmental team arrangement. We had hoped that students would make good use of the chance to communicate with students from other fields. and they responded positively to this.
Q4. Knowledge and skills you obtained: Answers were mechanical process, making electronic circuit, software, wireless communication, and so on. Many students answered that they gained knowledge and skills from other fields other than their own specialization, something they do not usually experience in their department course. The confidence which come from such experiences might have influenced the answers. Actually it is hard to understand and make good use of the knowledge and skills of other fields in only five days, but having the confidence based on the experiences will be beneficial for students' future study.
Q5. Was the course worthwhile?: 65 students answered "Yes". 41 students answered "Fully worthwhile". For some students who already have prior experience in building robots or electronic circuits, the contents of the course might be too easy, and they might feel bored. This course is basically designed for freshmen who don't have such experience. For experienced students, a more advanced course should be offered.

Q6. Good or Bad points of the course: There were many kinds of answers, both good and bad. The good points included exchange between students from different fields, fun building a robot, learning a wide variety of fields, and so on. These are also our hopes, and it was good to be evaluated positively by students.

On the other hand, many bad points were also pointed out. They are poor preparation, too busy, classes were too long, end of work of a day was vague, poor tools, and so on. We can understand most of these. Many problems resulted from the fact that this was the first year that the course was offered, and we realize that improvements must be done.

Q7. Work time: 45 students answered "enough", while 28 answered "not enough". We believe the difference in answers is a result of differences in their experiences.

Q8. Independent activity after course: 38 students expressed their hope of independent activity after course. Actually 10 students continued to refine their robots and participated in "The President Cup" competition in autumn. We must continue to support such hopeful students. The problem is keeping the work room reserved for independent activity and also providing parts and tools.

Q9. Do you recommend this course to underclassmen?: 66 students answered "Yes". Many points to improve were pointed out in the previous question, but this answer indicates that many students evaluated the course as worthwhile though not quite satisfactorily.

Q10. Achievement: 67 students answered that they had a sense of achievement.

Q11. What did you make in past?: 60 students answered that they had experience building a plastic model. 20 participants had built a radio controlled car, while 12 participants had made robots. Since the participants are all engineering students, these answers are consistent with expectation.

Q12. Soldering skill: 34 students didn't have ecperience in soldering before they attended this course. 33 of them answered that they obtained soldering skills. Actual experiences were valuable for them.

Q13. Programming in C language: 47 students answered that they understood the program used for robot control, while 26 students answered that they couldn't understand it. Understanding the concept of computer programming requires time and training. Furthermore most participants had not yet taken a class of programming. Therefore if they can't understand the programs it is unavoidable, even though the contents were limited to simple concepts.

Summary of questuonnaire survey

Many participants answered positively to most questions. It is concluded from the answers that the participants evaluated the course as worthwhile though not quite satisfactorily.

Positive points of the course were the exchange between students from different fields , the fun of making a robot, learning a wide variety of fields, and so on. But many points to improve were also pointed out by students. They included poor preparation, too busy, long classes, unclear quitting time, poor tools, and so on. These are areas for improvement. Most participants thought that they obtained knowledge and skills of various fields. They had a sense of achievement.

5 Conclusion

In this paper we have described the new practice course which introduces simplified soccer robots to the undergraduate education. We asked course participants to evaluate the course on the final day. Most participants thought that they obtained knowledge and skills from various fields and that they had a sense of achievement.

This trial is expected to increase the number of students who are interested in the science and technology related to robots. It will be an example of the effectiveness of the RoboCup activity in education.

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