Talents Evaluation Modeling Based on Fuzzy Mathematics

Xiangyang Feng, Zhu Liang(✉), Ran Tao, Youqun Shi, and Ming Zhu

College of Computer Science and Technology, Donghua University, Shanghai, China
{fengxy, taoran, shiyouqun, zhuming}@dhu.edu.cn, 2469607668@qq.com

Abstract. Fuzzy synthetic evaluation is a comprehensive assessment method based on fuzzy mathematics. Using the jurisdiction degree theory in fuzzy mathematics, it transforms qualitative evaluation into quantitative evaluation, and has been widely applied in many fields. In order to make the recruitment process of HRM (Human Resource Management) more systematic and rational, this paper introduces a method to evaluate talents by applying fuzzy synthetic evaluation, and discussed how to implement such mathematical model in our prototype system based on J2EE. Furthermore, the enterprise evaluation process with customizable resume is also proposed in this paper.

Keywords: Fuzzy mathematics · Fuzzy synthetic evaluation · Talent evaluation · HRM · Customizable resume · Recruitment

1 Introduction

Under the increasingly fierce talent competition environment, there is agreement on developing and recruiting talents for major enterprises and companies. The essence of enterprise competition is the competition of human resources. The quality and quantity of talents determine the level and future development of an enterprise. Enterprises need stable talent reserve to survive, while talents need to reflect their self-worth by standing out from many competitors. How to find and employ talents accurately has become the common focus on HRM in recent years.

In order to make HRM more efficient, scientific and systematic, relevant research has been done by domestic and overseas scholars for many years. In the early twentieth century, behavior science theory on HRM grew up with the rapid development of Western industrial society. Labor efficiency evaluation was mainly related to laborer's behavior indicators, such as emotions, needs satisfaction and so on. In the mid-twentieth century, the scope and indicators of talent evaluation were constantly extended and refined based on various test, including intelligence test, ability test, sexual orientation test and achievement test. For instance, Kristof integrated the concepts of human-job matching and proposed an integrated matching model according to the theoretical study of job matching and competency model [1]. Ruban studied how to test whether students' learning abilities are hindered by obstacles through their characteristics, so as to educate different students separately [2]. Kroner et al. used some

L. Uden et al. (Eds.): KMO 2019, CCIS 1027, pp. 135–145, 2019.
https://doi.org/10.1007/978-3-030-21451-7_12

correlation indices to study the validity and reliability of computer simulated intelligence tests [3]. Goodman and Svyantek studied the matching between human and organization from the perspective of organizational performance [4]. Price and others put forward the human resource scale as human resource allocation [5].

In other application areas, such as software evaluation, information security risk assessment, project acceptance assessment, etc., different models have been widely used to evaluate. Evaluation model is the core of evaluation activities. The existing evaluation models mainly include hierarchical decomposition model, threat tree model, intelligent evaluation model and mathematical evaluation model. Mathematical evaluation model quantifies qualitative indicators through fuzzy theory, which solves the problems of single index and vague original information in existing evaluation models. Beynon combined analytic hierarchy process (AHP) and evidence theory to propose a multi-attribute decision-making model of DSAHP, which can not only reduce the number of pairwise judgments and consistency checks, but also solve the decision-making problem under incomplete information [6]. On this basis, Hua et al. further proposed the measurement method of unknown information and decision rule setting strategy of DS-AHP model, and analyzed the specific decision-making effect [7]. On the other hand, three consistency indicators are proposed in paper [8]. By comparing the individual overall preference values with the collective ones, the three indices cannot only provide a reference for judging the decision-making effect of each decision maker, but also reflect the effect of group decision-making to a certain extent.

With the development of computer network technology and database technology, human resource management has become an important part of enterprise information management. In this process, talent evaluation is an important intermediate link and basic work. Talent evaluation is not only a hot issue of concern to enterprises, especially human resources departments, but also a difficult problem faced by human resources departments. Therefore, in view of the effective application of mathematical evaluation model in other fields, it is also of great significance to use mathematical model for human resource management.

In recent years, there have been some advances in talent evaluation methods, and these evaluation index systems and methods are different. In the paper [9], the researcher constructed a new evaluation model of managerial talents for the evaluator. Using the Fuzzy Analytic Hierarchy Process (FAHP) to evaluate, we can obtain information in a more systematic and effective way, and assist related management activities. According to the actual needs of human resources management, along with the gradual maturity of web development technology and database technology, the paper [10] designed and implemented a set of human resources management system based on Struts 2 + Spring + Hibernate (SSH) integrated technology framework.

This paper first discussed the basic concepts of the fuzzy comprehensive evaluation method, then used this method to modelled the talent evaluation and gived the formal definition of the talent evaluation model. This model is also designed and implemented in a software system. In addition, considering the differences of different talents, this model has been improved in the process of implementation, that is to say, enterprises can use self-defined indicators to select the required talents.

2 Fuzzy Synthetic Evaluation

2.1 Basic Concept

Fuzzy mathematics is a mathematical theory and method to study and deal with the phenomenon of fuzziness. The mainstream of the development of fuzzy mathematics is its application. The process of judgment, evaluation, reasoning, decision-making and control by using concepts can be described by means of fuzzy mathematics. For example, fuzzy clustering analysis, fuzzy pattern recognition, fuzzy prediction, fuzzy control and so on. These methods constitute a kind of fuzzy system theory.

Fuzzy synthetic evaluation is a very effective multi-factor decision-making method to make a comprehensive evaluation of things. Fuzzy synthetic evaluation is usually divided into two steps: the first step is single factor evaluation, and the second step is comprehensive evaluation according to all factors. Its advantage is that the mathematical model is simple, easy to grasp, and the evaluation effect of complex problems with multiple factors and multiple levels is better. The characteristic of the fuzzy synthetic evaluation method is that it has a unique evaluation value for the evaluated object and is not affected by the set of objects in which the evaluated object is located. The steps of the model are as follows.

(1) Determining the set of indicators

If each factor u_i makes a single judgment $f(u_i)$, it can be regarded as a U-V fuzzy mapping f, that is:

$$f : U \to H(V) \tag{1}$$

$$u_i| \to f(u_i) \in H(V) \tag{2}$$

From f, a fuzzy linear transformation T_f from U to V can be induced, which is regarded as a mathematical model for the comprehensive evaluation of B by weight W. Therefore, the fuzzy mapping f can induce the fuzzy relation $R_f \in H(U \times V)$, that is, $R_f\left(u_f, v_h\right) = f(u_i)(v_h) = r_{ih}$. R_f can be expressed by a fuzzy matrix $R \in u_{m\times k}$:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1k} \\ r_{21} & r_{22} & & r_{2k} \\ \vdots & & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mk} \end{bmatrix} \tag{3}$$

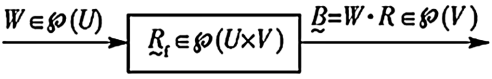
R is called single factor evaluation matrix. Among them, r_{ih} refers to factor x_i, which can be evaluated as the degree of membership of v_i. Specifically, r_{ih} denotes the frequency distribution of factor x_i on comment v_h, which is normalized to satisfy $\sum_{h=1}^{k} r_{ih} = 1$.

(2) Calculating the Value of Fuzzy Comprehensive Evaluation

The fuzzy relation R_f can induce the fuzzy linear transformation T_f from U to V. Thus, *(U, R, V, W)* constitutes a fuzzy comprehensive evaluation model. In order to comprehensively consider the role of each index, the weighted average model is used to calculate the weight W and the fuzzy matrix R. That is, the model M (·, +) is used to calculate the weight W and the fuzzy matrix R. The comprehensive evaluation formula is as follows:

$$B = W \bullet R \tag{4}$$

The function of Formula 4 is similar to a converter, as shown in the figure:



If a weight $W \in H(U)$ is input, a comprehensive judgement is output:

$$B = W \cdot R \in H(V) \tag{5}$$

When $\sum_{h=1}^{k} b_{\mathrm{h}} \neq 1$, it is normalized and $B = (b_1, b_2, \cdots, b_k)$. Each b_k here represents the membership strength corresponding to each evaluation level v_k.

2.2 Formal Representation of Talent Evaluation

In this paper, when fuzzy evaluation is applied to talent evaluation in human resource management, the evaluation process here is usually divided into three steps: first, a set of perfect evaluation index system is established; then, the initial semantic evaluation values of each index are obtained by expert evaluation, test analysis and other methods; finally, the evaluation results are given by calculating the evaluation values of each index. Based on the previous description, this paper formalizes the evaluation problem as follows:

$$E = (U, R, V, W)$$

(1) Factor Set of Talent Evaluation
The factor set of talent evaluation can be set to $U = (u_1, u_2, \cdots, u_n)$, in which u_i is the factor affecting the evaluation object, $i = 1, 2, \cdots, n$. If there are secondary factors, you can set $U_i = (u_{i1}, u_{i2}, \cdots, u_{im})$ for each u_i in U. Apparently m is the number of secondary factors in each category.

(2) Establishing a collection of comments on talent evaluation
Set the comment set to $V = (v_1, v_2, \cdots, v_k)$, in which each v_j is evaluated by one or all factors. Each numerical response in the comprehensive evaluation vector B is the membership strength in different comments.

(3) Fuzzy evaluation transformation matrix
Through the judgment of each factor, the evaluation grade of each factor is given, thus the relationship between evaluation factor and evaluation grade is established, that is, the fuzzy relationship from U to V, which can be described by the fuzzy evaluation transformation matrix R mentioned above.

(4) Weight distribution of each evaluation factor
Let $W = (w_1, w_2, \cdots, w_n)$ is a fuzzy subset of U, which is called weight allocation set, $\sum_{i=1}^{n} w_i = 1$, $w > 0$, w_i indicates the importance of comprehensive evaluation.

3 Model Implementation

3.1 Realization of Self-defined Evaluation Index

Evaluation factor U is a very important link in the whole evaluation process. The factor set mentioned here is the index set that we want to evaluate, with $\mathrm{U} = (\mathrm{u}_1, \mathrm{u}_2, \cdots, \mathrm{u}_n)$ denotes the aspects in which we judge and describe what is being evaluated. It is characterized by a set of several factors and secondary factors. The ultimate goal of the paper's fuzzy evaluation system is to synthetically evaluate the talents through feedback information of job seekers. Therefore, it is necessary to consider the contribution of all the underlying factors to the overall goal.

Enterprises need all kinds of positions in the recruitment process, so the quality of the required talents is different. Even if some studies can give a set of factors and weights, it is difficult to adapt to the differences in different locations. In addition, in the process of fuzzy calculation, if a set of fixed weights is used to calculate, it obviously can not meet the actual situation, so it is difficult to use a set of fuzzy factors and weights to meet the needs of different positions in different enterprises. Therefore, this paper considers the practicability of the system and proposes a customizable fuzzy calculation model.

Taking the recruitment process as an example, in order to avoid evaluating all the objects with a specific evaluation model E (that is, U, R, V and W in E are specific values), we can design a self-customized model of tree structure in the system to achieve fuzzy evaluation. In the three-tier tree structure shown in Fig. 1, enterprise user enterprise constitutes the root node of the tree structure. Because an enterprise can publish many different positions, the child node position of the root node means the different positions belonging to the same enterprise. Each position node has only one child node model. Each model node here represents a complete fuzzy evaluation model E(U, R, V, W). Participants will calculate their own evaluation according to different job types selected, and the corresponding data will be stored separately. Enterprises can design their own set of factors when publishing each location. If the tree structure of Fig. 1 is regarded as the tree structure of the first level, Fig. 2 shows the tree structure nested at the second level in each node model of Fig. 1. As shown in Fig. 2, for each model, it will be customized by enterprise users before it can be used. For each factor, they can also design their own importance, that is, weight values. All applicants for positions can fill in information and participate in the evaluation according to the setting of the enterprise.

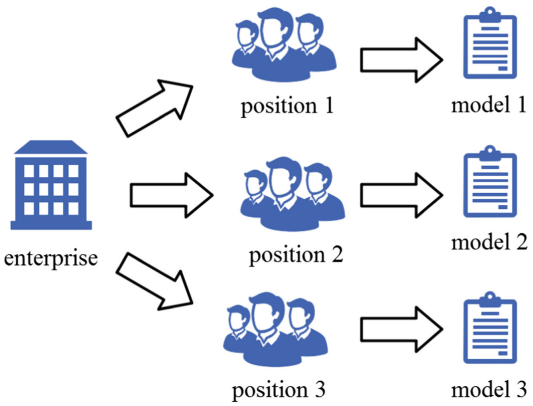


Fig. 1. Customizable model

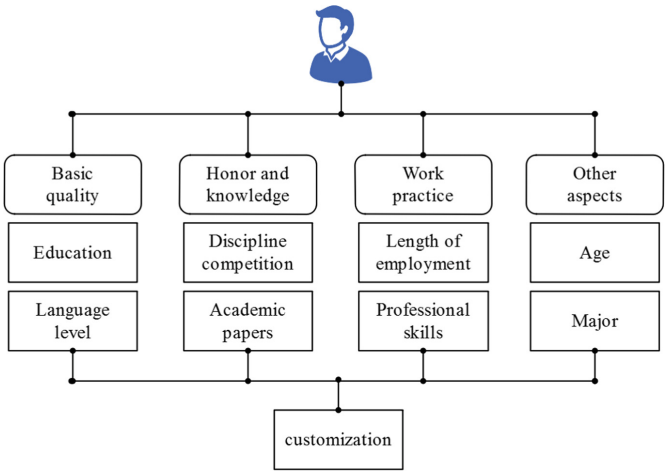


Fig. 2. The customization process of factor set

In the tree structure shown in Fig. 2, the root node represents a deterministic evaluation model. Factor set U is divided into four primary factors in the system: basic information, honor, work experience and other factors. Four primary factors constitute four child nodes under the root node. The new customization factor will be the next layer of child nodes connected in turn. Figure 2 shows the formation of U in the evaluation model.

The model system is based on J2EE platform and is developed with Spring MVC, Spring, MyBatis and other frameworks. The integrated development of framework makes good use of MVC architecture in software development. The process of customizing the evaluation model for enterprise users will be implemented by the view layer in the system, which is also responsible for displaying the evaluation factors for different positions to different participants. The system uses HTML DOM and JavaScript front-end technology to achieve this function. HTML DOM is the HTML

Document Object Model. HTML DOM is a document object model specially applicable to HTML/XHTML. In HTML DOM, everything is a node. DOM is HTML that is regarded as a node tree, and each node has attributes that contain some information about the node. It regards every element in the web page as an object, so that the elements in the web page can also be acquired or edited by computer language. For example, JavaScript can dynamically modify Web pages using HTML DOM.

For a certain added customized factor, the required information includes: name, rank number (i.e. dividing the factor into several ranks), corresponding to each rank of single factor evaluation vector r (r will constitute a row of matrix R in Sect. 2 (2), and secondary weight coefficients. In order to obtain the information input by enterprise users dynamically, the information collected by each user-defined factor can be regarded as a DOM object in the development process. JavaScript is used to write functions to control the increase and deletion of each factor. The number of factors and all factors under each sub-class should also be obtained when accessing page data, so as to facilitate the normalization of weight coefficients. Rationalize and determine the number of rows of the evaluation matrix R.

3.2 Implementation of Evaluation Module

The system will read the data in the database according to the corresponding job type and form different forms if the user starts to evaluate. The form can be filled out by the assessed user or partly by the assessed user and partly by the human resources department of the enterprise. The completed form data will be transferred from the view layer to the model layer under the control layer for calculation, and the results will be returned to the view layer after storing the data. For each evaluation factor, the process of data transmission transfers the marker 1, 2 or 3 which is used to distinguish the grade. The grade here is not relative to the evaluation grade V of the evaluation object, but different grades set by a certain evaluation factor. For example, for the education factor, it can be set as 1 below the undergraduate level, 2 below the undergraduate level, and 3 below the undergraduate level. For master's degree or above, it is 4, which makes it easy to record all data of an evaluation object in the system, and select different but factor evaluation vector r to form evaluation matrix R according to the identification of each factor. If nine factors are customized: age (F1), foreign language (F2), academic background (F3), honor (F4), competition (F5), thesis (F6), specialty (F7), skill (F8) and work experience (F9), then the intermediate data of some people in the system are shown in the Table 1 below. F1–F9 represents the nine different custom evaluation factors mentioned just now:

Table 1. Intermediate results transmitted in the system.

ID	NAME	F1	F2	F3	F4	F5	F6	F7	F8	F9
11	Hexinwei	2	1	2	1	1	2	3	2	1
32	Ronnannan	2	2	3	1	2	2	2	1	3
95	Wangdeshun	1	2	3	4	4	2	3	2	2
122	Liangyuntao	3	4	2	3	2	3	3	4	3
156	Jianghe	3	4	2	4	4	5	4	3	3

Among them, the single factor evaluation vector r and the full weights of the first and second levels can be obtained through Delphi method and Analytic Hierarchy Process (AHP) by a group of human resources management departments or other experts. The relevant evaluation data can be all written into the database, which can realize the systematization of the evaluation process in the future evaluation. At the same time, the system based on MVC is also convenient in updating data and expanding new functions.

The computing module of the evaluation model can be implemented in the Model layer. Spring MVC, as the implementer of the View layer, completes the user's request receiving function. Spring MVC Controller is used as the controller of the whole application to complete the forwarding of user requests and the response to users. MyBatis, as the implementer of DAO layer, completes the functions of adding, deleting, modifying and searching database. Spring will manage the entire application, and the life cycle behavior of all beans will be managed by Spring. That is to say, the creation, initialization, destruction of all objects and the maintenance of the relationship between objects in the whole application are managed by Spring. At the same time, the Model layer in the system will also be implemented through Spring.

The model layer receives the transferred intermediate data, chooses different single factor evaluation vectors r according to the identification of each factor to form the evaluation matrix R, calculates the matrix and stores the necessary results back to the View layer. The logic diagram of the system is as follows (Fig. 3):

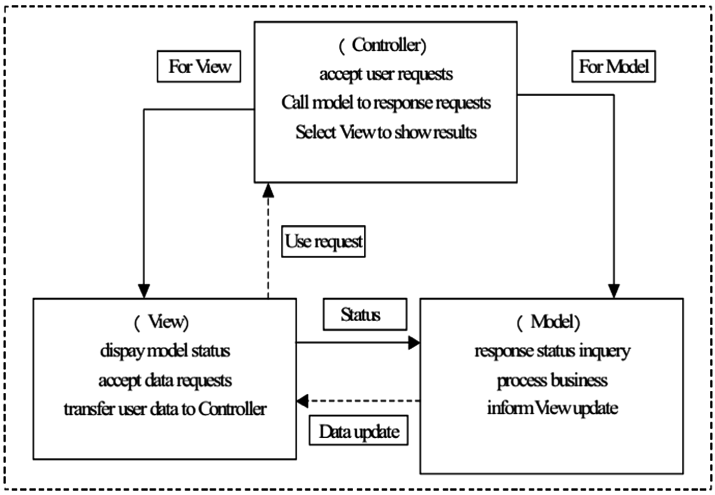


Fig. 3. Logical structure of the system

4 System Performance

Assuming that an enterprise needs to evaluate a job seeker who fills in resume information, specific data have been obtained through Delphi method and Analytic Hierarchy Process (AHP). In the system, the evaluation data can be written into the database in advance, which can realize the systematization of the evaluation process. For example, the data of job seekers can be obtained by filling out forms on the internet. After filling in the data needed for evaluation, the system can automatically evaluate the data. The evaluation and calculation process of the system is as follows:

(1) Delphi method and Analytic Hierarchy Process (AHP) are adopted by an evaluation team composed of human resources department or other experts to obtain relevant data, including single factor evaluation vector r, weight value W, etc., to serve as a reference value for enterprises when issuing new positions. Finally, enterprise users customize the evaluation model according to the type of position.
(2) The participants fill in the form online according to the type of position they choose, and complete the input of the initial data. The system transfers the initial data to the intermediate result data to the evaluation module.
(3) The evaluation matrix R is formed according to the intermediate data, and the final comprehensive evaluation vector B is obtained according to B = W • R. Figure 4 is the result of system evaluation. The column chart shows the value of comprehensive evaluation vector B, the red represents the average value, and the black represents the current value.

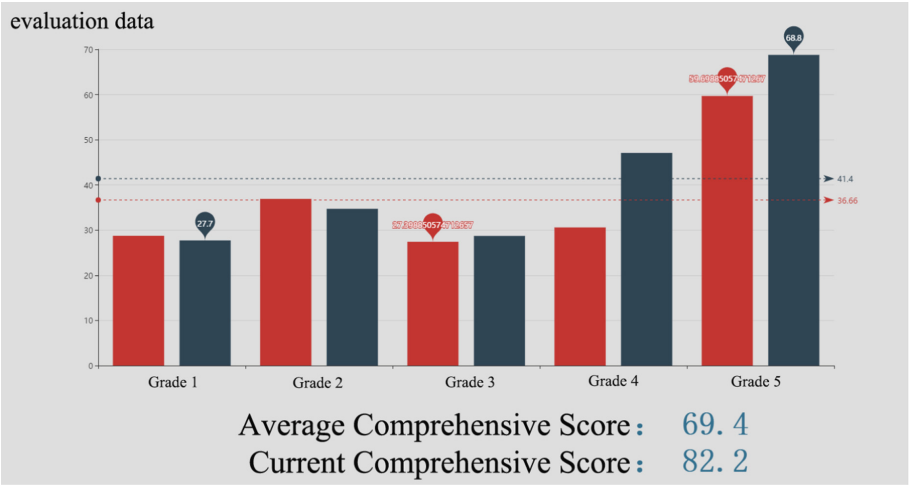


Fig. 4. Individual evaluation results (Color figure online)

B is the user's comprehensive evaluation vector at this time. The semantics of the five grades of the evaluation grade V are: very poor, poor, general, good and excellent. Each value in B represents the membership strength corresponding to different grades

on V. The quantitative values of each element in the comment set are V1 = 40, V2 = 55, V3 = 70, V4 = 85, V5 = 100, and the final evaluation results are between 40 and 100. The closer to 100, the higher the score, and the closer to 40, the lower the score. The final evaluation result score is $N = B^T \cdot V = (B1 \cdot V1 + B2 \cdot V2 + B3 \cdot V3 + B4 \cdot V4 + B5 \cdot V5)$. In this case, the evaluation score is N = 82.2. The calculation results show that the job seeker is in the upper level in the evaluation of the position. The system evaluates 200 objects in a certain position. Some of the evaluation results will be fed back to users in the form of ranking, as shown in the following Fig. 5:

ID	NAME	TIME	SCORE
156	Jianghe	01/04/2019	92.6
32	Rongnannan	01/09/2019	91.0
11	Hexinwei	02/04/2019	90.5
122	Liangyuntao	12/04/2018	88.0
95	Wangdeshun	12/04/2018	87.6

Fig. 5. Sorted results in the system

Enterprise users can use this as a reference for screening after obtaining the ranking results of evaluation under a certain position. At the same time, the system allows enterprise users to change the weights of each index at any time to observe the ranking of job seekers under different weights, which not only reduces the workload of human resources department, but also reflects the comprehensive evaluation value under the influence of multiple factors for reference.

5 Conclusion

Aiming at the disadvantage of selecting resumes only according to one index in the process of Internet recruitment, this paper put forward that fuzzy synthetic evaluation can be applied to the evaluation process of recruitment, and discussed how to use the fuzzy evaluation model to evaluate talents, and designed a J2EE-based fuzzy evaluation model system based on this model. The system used MVC hierarchical structure design framework, which improved the performance of the effectiveness and generality of the system. The experimental results show that the system reduces the workload of enterprise human resources department, solves the problem that too many candidates can only be screened by a single factor, and enables enterprise users to customize the evaluation data. The model structure has good expansibility, and some complex fuzzy evaluation problems can be corrected properly. Other functions of the system, such as user rights management, can be further completed in the future work to make it a more practical system.

References

1. Smith, T.F., Waterman, M.S.: Identification of common molecular subsequences. J. Mol. Biol. **147**(1), 195–197 (1981)
2. Ruban, L.M.: Identification and assessment of gifted students with learning disabilities. Theory Pract. **44**(2), 115–124 (2005)
3. Kroner, S., Plass, J.L., Leutner, D.: Intelligence assessment with computer simulations. Intelligence **33**(4), 347–368 (2005)
4. Goodman, S.A., Svyantek, D.J.: Person–organization fit and contextual performance: do shared values matter. J. Vocat. Behav. **55**(2), 254–275 (1999)
5. Price, J.L.: Handbook of organizational measurement. Int. J. Manpower **18**(4/5/6), 305–558 (254) (1997)
6. Beynon, M., Curry, B., Morgan, P.: The Dempster–Shafer theory of evidence: an alternative approach to multicriteria decision modelling. Omega **28**(1), 37–50 (2000)
7. Hua, Z., Gong, B., Xu, X.: A DS–AHP approach for multi-attribute decision making problem with incomplete information. Expert Syst. Appl. **34**(3), 2221–2227 (2008)
8. Pang, J., Liang, J.: Evaluation of the results of multi-attribute group decision-making with linguistic information. Omega **40**(3), 294–301 (2012)
9. Wu, Y.H.: A study of applying fuzzy analytic hierarchy process on management talent evaluation model. In: IFSA World Congress & Nafips International Conference. IEEE Xplore (2001)
10. Jie, X.: Research on the realization of human resource management system. Adv. Mater. Res. **926-930**, 3930–3933 (2014)