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Research on the Application of Hierarchical Analysis Improved Algorithm in Professional Warning based on Weighted Average and Fuzzy Mathematics

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Abstract

This paper uses fuzzy mathematics theory, and the fuzzy comprehensive evaluation method is applied to the research on admission professional warning fuzzy comprehensive evaluation, combined with the actual situation of the professional warning and admission professional warning evaluation system will be divided into a number of indicators according to the need, establishing the factor set, evaluation set, membership function and weight set, and the comprehensive evaluation of admission professional warning level will be realized. This paper also uses hierarchical analysis method to calculate and evaluate the weight set, and improves the max-min algorithm and the maximum membership degree principle of the evaluation results, proposes a new improved algorithm, and verifies by experiment, and achieves good results. Examples show that the hierarchical analysis improved algorithm based on weighted average fuzzy math has strong operation and good effect, which can be widely used in professional warning.

Keywords: *weighted average, hierarchical analysis improved algorithm, professional warning, application research*

1. Introduction

Fuzzy comprehensive evaluation is based on fuzzy mathematics, one method by using the principle of fuzzy relations, to quantify some factors whose boundary are not clear and difficult to quantify to make a comprehensive evaluation [1]. The comprehensive evaluation of school enrollment professional warning, involves many complex phenomenon and the interaction of many factors, meanwhile, there exist much fuzzy phenomenon and fuzzy concept [2-4] in evaluation. Therefore, in comprehensive evaluation, the fuzzy comprehensive evaluation method is usually used to quantitatively evaluate [5, 6], to evaluate the enrollment professional warning grades, which achieved good results. But the determination of the weights still needs expert knowledge and experience, with certain shortcomings. Thus, this paper uses analytic hierarchy process (AHP) to determine the weight coefficient of each index [7], to make it more reasonable, more practical and easier for quantitative representation, so as to improve the accuracy of the result of fuzzy comprehensive evaluation. In addition, the max-min algorithm often used in fuzzy comprehensive evaluation always loses much information, and with the occasion where the result is not easy to distinguish (*i.e.*, the model failure) [8]. Fuzzy comprehensive evaluation is through construction grade fuzzy subset to quantify fuzzy index which reflects the rated things (that is, determine membership), then to use the fuzzy [9] transform principle to synthesize each index, so as to get the best results.

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2. Evaluation Procedure

2.1 Determine the Factor Domain of Professional Evaluation Object

P evaluation index, $u=\{u_1,u_2,\cdots\cdots,u_p\}$.

2.2 Determine the Level Domain of Professional Warning

$v=\{v_1,v_2,\cdots\cdots,v_p\}$, grade set. Each grade has a corresponding fuzzy subset.

2.3 Establish Fuzzy Relation Matrix R

After establishing professional warning grade fuzzy subset, quantify each evaluated major on each factor $u_i(i=1,2,\cdots\cdots,p)$, that is to say, make sure the membership of evaluated major to grade fuzzy subset $(R|u_i)$, so as to get the fuzzy relation matrix:

$$R=\begin{bmatrix} R|\ u_1 \\ R|\ u_2 \\ \cdots \\ R|\ u_p \end{bmatrix}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix}_{p.m} \tag{1}$$

In matrix R, the element r_{ij} in i cline and j column, means the membership grade of the evaluated major to v_j warning grade fuzzy grade from the perspective of factor u_i. The performance of an evaluated major in one aspect of factor u_i, is described by a fuzzy vector $(R|u_i)=(r_{i1},r_{i2},\cdots\cdots,r_{im})$, while in other evaluation methods, mostly it is described by an index real value. Therefore, from this point of view, fuzzy comprehensive evaluation needs more information.

2.4 Determine the Weight Vector of Evaluation Factors

In fuzzy evaluation, determine the weight vector of evaluation factor: $A=(a_1,a_2,\cdots\cdots,a_p)$. The essence of element a_i in weight vector A is the membership of u_i to fuzzy subset. This paper uses hierarchical analysis method to define the relative importance order among evaluated indexes, so as to define weight coefficient, and normalize it before union, $\sum_{i=1}^{p} a_i=1$, $a_i\geq 0$, $i=1,2,\cdots\cdots,n$.

2.5 Compose the Fuzzy Comprehensive Evaluation Result Vector

Use the appropriate operator to compose A and the R of each evaluated object, and get the fuzzy comprehensive evaluated result vector of each evaluated object B:

$$A\circ R=(a_1,a_2,\cdots\cdots,a_p)\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix}=(b_1,b_2,\cdots\cdots,b_m)=B \tag{2}$$

b_1 is obtained by the j column calculation of A and R, which means the membership of the evaluated object to v_j grade fuzzy subset from an overall perspective.

2.6 Analyze the Fuzzy Comprehensive Evaluation Result Vector

The most commonly used method in practice is the principle of maximum degree of membership, but in some cases the use of it is kind of reluctant, and loss of a lot of information, and even get the some unreasonable evaluation results. Using the method proposed by weighted average grade of membership, this method can be used for multiple rated things and can be sorted according to their hierarchical position.

2.7 Hierarchical Analysis

To calculate the weight is the key of comprehensive evaluation. Hierarchical analysis is an effective method to make sure the weight coefficient, especially for those difficult and complex problems which can't be defined by quantitative index [11]. It divides the factors in a complex problem into organized layer connected to each other and makes them organized, and according to the fuzzy judgment of objectreality, offers quantitative expression on the relative importance of each level, then uses mathematical method to determine the relative importance of orders of all the elements.

2.8 The Procedure of Hierarchical Analysis

Determine the objectives and evaluation factors

$$P \text{ evaluation factors, } u = \{u_1, u_2, \cdots\cdots, u_p\}. \quad (3)$$

2.9 Constructing Judgment Matrix

Judgment of matrix element value reflects people's understanding of each element on the relative importance, by using number 1 - 9 and the countdown scaling method. But when mutual comparison of two factors' importance value can use ratio which has practical significance, we use this ratio to judge matrix corresponding value. Then judgment matrix can be got $S = (u_{ij})_{p \times p}$ c.

2.10 Calculating Judgment Matrix

Use Mathematica software to calculate the maximum eigen value $\lambda_{\max}$ of judgment matrix S on of, and its corresponding eigen vector A, and this vector is the importance order of the evaluation factors, also is the weight distribution.

2.11 Consistency Test

To carry out the consistency test of judgment matrix, it is necessary to calculate consistency index $CI = \frac{\lambda_{\max} - n}{n-1}$, and average random consistency index RI. It constructs 500 sample matrixs by using random method, and construction method uses scale randomly and their to fill the main diagonal triangle of the sample matrix, and each value of The main diagonal always remains 1, the corresponding inverse transpose position uses the reciprocal of the corresponding position random numbers. Then calculate the consistency index value of each random sample matrix,

and calculate the average value of the CI 's mean, the random consistency index RI can be got[12]. When the random consistency ratio $CR = \frac{CI}{RI} < 0.10$, the results of hierarchical analysis sequencing is satisfactory consistency, which means the distribution weight coefficient is reasonable; otherwise, adjust the value judgment matrix elements, and redistribute the value of weight coefficient.

3. The Solution of Model

3.1 The Multilevel Fuzzy Comprehensive Evaluation Index of the Campus Environment and its Sample Data

In the occasion where there are differences among the degree of importance of the evaluation index, the evaluation method of fuzzy mathematics is very useful. There are two methods of fuzzy comprehensive evaluation: one step method (one-time comprehensive evaluation) and multiple steps method (fuzzy evaluation layer by layer). In this paper, the latter method is used [13].

Table 1. The Quantitative Evaluation Standard of Enrollment Professional Early Warning

Evaluation value	enrollment professional early warning	rank
$x_i > 3.5$	First level early warning	$E1$
$2.5 < x_i \le 3.5$	Second level early warning	$E2$
$1.5 < x_i \le 2.5$	Third level early warning	$E3$
$x_i \le 1.5$	Forth level early warning	$E4$

This paper takes the admissions professional quality of a university in Yunnan in past nearly 3 years as an example, a total of 70 professional data as sample, 9 admission batch, more than 20000 times of enrollment population. The evaluation index system of professional quality set consists 6 first level indexes and 19 second level indexes, and index measurement uses the method of Likert measuring Table, with semantic scale can be divided into 4 levels: first level early warning, second level early warning, third level early warning and forth level early warning. The higher the level is, the higher the risk is, and the less ideal the professional is, and it needs to reduce enrollment plan, enrollment of over year next year or stopped recruiting and other substantive measures. In order to facilitate the calculation, we will quantify the semantics scale of subjective evaluation, correspond each early warning and assign them to 4, 3, 2 and 1. Subjective measurement is scaled by forth level semantics scaling. The quantitative evaluation of the standard design is shown in Table 1.

With the help of sampling survey data, shows the application of fuzzy comprehensive evaluation of hierarchy analysis in this aspect. To determine the factors set of evaluation object is just to determine evaluation index. Now from the following several aspects to consider: from the six aspects of the enrollment professional examination, teaching conditions, teaching qualities, teachers, professional quality evaluation and management and professional employment to set 6 first grade evaluation indexes and 19 second level professional evaluation index system of early warning indicators, professional enrollment system the composition is shown in Table 2.

Table 2. Two Grades of Evaluation Factors of Campus Environment Quality and Weighting

Comprehensive index	Evaluation index	weight
A enrollment professional registions(0.202)	a1 percentage of the candidates' first will a2 percentage of transfer will a3 percentage of offer will	0.483 0.228 0.289
B school conditions(0.156)	b1 The student-teacher ratio range b2 percentage of post graduate in professional teachers b3 Administrative teaching offices per student b4 teaching equipment instrument per student b5 books per student	0.203 0.291 0.265 0.141 0.1
C teaching quality(0.165)	c1 curriculum and education c2 professional construction c3 training program c4 education method and learning evaluation c5 practical teaching c6 dissertation and comprehensive training	0.183 0.17 0.191 0.155 0.181 0.12
D teachers quality(0.202)	d1 teaching faculty structure d2teaching faculty education level d3 teaching faculty training	0.217 0.285 0.246
E professional quality evaluation and management(0.202)	e1 ability of moral education e2 ability of PE and arts education e3 professional knowledge and ability e4 evaluation of teachers and students e5 social evaluation	0.217 0.285 0.246 0.111 0.141
F professional employment (0.166)	f1 the occasion of employment rate >70% f2professional employment	0.429 0.571

3.2 The Analytic Hierarchy Process of Solution to the Index Weights

Table 3. Index Weight Algorithm of Professional Early Warning

Input: Evaluate objectset P between evaluation factor set $\mu = \{\mu_1, \mu_2, \mu_3, \mu_4, \mu_5, \mu_6\}$.

Output: Get the index weight $indexw_{i,1}(A)$, $indexw_{i,2}(B)$, $indexw_{i,3}(C)$, $indexw_{i,4}(D)$, $indexw_{i,5}(E)$, $indexw_{i,6}(F)$.

Construct judgment matrix $S = \left(u_{ij}\right)_{p\times p}$, Compute the maximum characteristic root $\lambda_{\max}$,using $\left(u_{ij}\right)_{p\times p}$.

Carry out consistency test of judgment matrix, calculate consistency index $CI = \frac{\lambda_{\max} - n}{n-1}$.

Calculate average random consistency index RI.

If the random consistency rate $CR = \frac{CI}{RI} \prec 0.1$, then get the corresponding characteristic vector of weight coefficient A_0 ,after normalization get A End if

Table 4. Admissions Professional Warning Weighted Average Fuzzy Synthetic Evaluation Algorithm

Input: Evaluation object set the early warning evaluation index of 70 majors of one university in Yunnan(6first level evaluation indexes per each major, 19 second level indexes).

Output: The early warning evaluation scores of each major and the corresponding results.

Calculate the weighted mean $\mathrm{M}(\bullet, \oplus)$ fuzzy composition operator and compose A and R to get fuzzy comprehensive evaluation vector $\mathrm{B}, b_i = \sum_{i=1}^{p}(a_i \cdot r_{ij}) = \min\left(1, \sum_{i=1}^{p} a_i \cdot r_{ij}\right), j = 1, 2, \cdots, m$. b_i, a_i, r_{ij} is membership degree of j, i weight coefficient and i belongs to the membership degree of j.

Calculate the first level index vector $I = \{A_1, B_1, C_1, D_1, E_1, F_1\}$, and get the result and normalize it to get I^1.

Calculate comprehensive evaluation vector A, normalize it to get A'.

Calculate first index evaluation value $\{V_A, V_B, V_C, V_D, V_E, V_F\}$, and evaluate the comprehensive value $V_n = 4 \times A_n + 3 \times B_n + 2 \times C_n + 1 \times D_n$.

Calculate $Max(V_n)$ and get professional early warning evaluation judgment value.

Use the comprehensive evaluation vector A' to get the total comprehensive evaluation value.

Use weight mean principle to calculate membership degree method, and analyze the evaluation results of each evaluation index and get the final conclusion.

4. Comparative Study on Evaluation Methods of Early Warning of Enrollment in Colleges and Universities

Put the 70 major statistical data coming from survey sampling at a university in Yunnan, into the model, and calculate the vector at all levels of the fuzzy comprehensive evaluation.

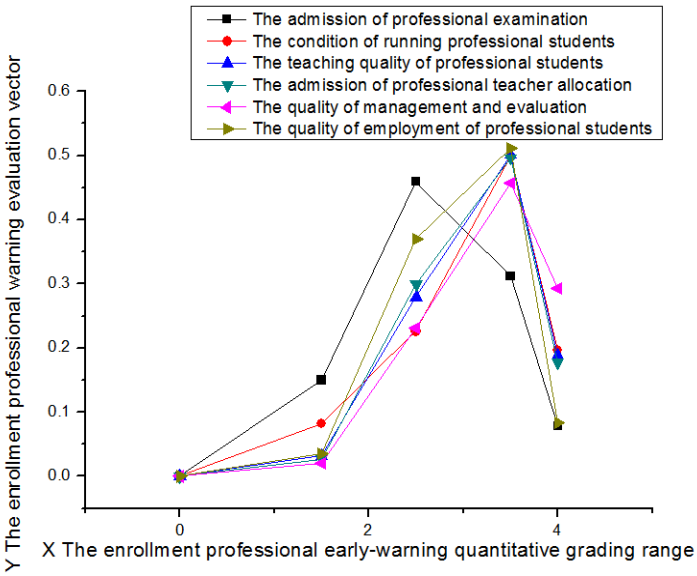

Figure 1. Six Professional Warning First Level Fuzzy Synthesis Evaluation Index Vector Weighted Average

From the analysis of the above calculations, according to Table 2, we can get the professional warning evaluation results of the university is second level $E2$, overall in good condition, part of the professional construction needs to be adjusted. In this paper, the experimental method is adopted in compassion of RSR (Rank-Sun Ratio), PCA (Principal Component Analysis) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) in the loss of information, the results uneasy to resolution, the experimental results were compared the unreasonable.

Table 5. Comparative Research on Evaluation Model of Early Warning Methods of Various Professional

Comparison	This study	BeRSR(2009)	HYPCA(2010a)	QuTOPSIS(2013)
The warning error of Professional information	√	√	---	√
The warning missing of Professional information	√	---	√	---
The results of warning distinguish	Easy	Hard	Hard	Hard
The results of warning	Reasonable	Reasonable	Unreasonable	Unreasonable

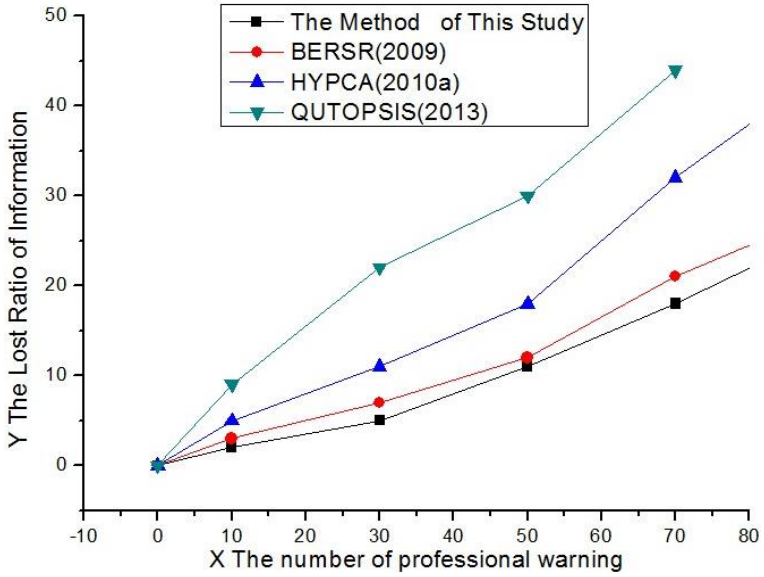

Figure 2. Comparison of Information Loss Rate of Four Commonly Used Warning Methods

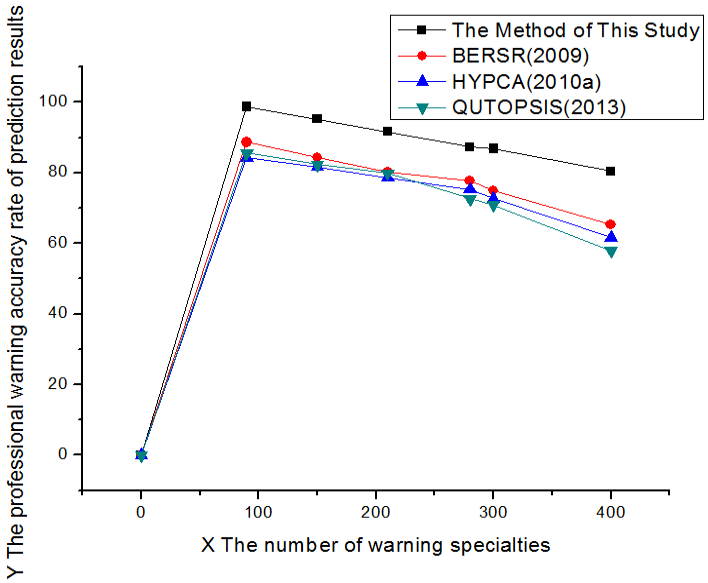

Figure 3. Prediction Accuracy Comparison of Professional Early Warning by Using Four Commonly Used Methods

This paper adopted the method of the maximum membership degree principle, according to the professional warning method, proposed weighted average principle for the evaluation of the grade of membership, and the weighted average principle of the various evaluation indexes and the results were analyzed and compared by experiment. The result by using this method has some differences with the results of principle of maximum membership degree method, but the results are the most similar to actual situation.

5. Conclusion

When the applied fuzzy mathematics evaluates the college admissions professional warning, because of more evaluation indexes, with the commonly used

max-min algorithm, the result always is not easy to distinguish. In this paper, the evaluation of the weighted average was used and achieved good results. In analysis of the fuzzy comprehensive evaluation results, there is the effectiveness problem of the principle of maximum membership degree method. This paper also analyzed the results using the weighted average method, and sorted the multi index comparison, with satisfactory results.

For the determination of weights, most experts think according to their experience that the jamming is serious, resulting in the evaluation results of the entry. This paper uses the analytic hierarchy process to determine the weight by using the fuzzy comprehensive evaluation. This method is very logical, practical and systematic, and can accurately obtain the weight coefficient of each evaluation index. Fuzzy comprehensive evaluation based on AHP method can be used in the research and sorting college early warning evaluation, and the effect is good. In this paper, the set of model fits the actual situation, which is useful for colleges' early warning for professions and optimal integration of existing resources, so as to promote the development of college admissions and professional level and scale; model is easy to solve, which has a good application prospect and popularization value.

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References

[1] H. Yonghong and H. Enhui, "Comprehensive evaluation method", Beijing: Science Press, **(2000)**, pp. 167-188.
[2] Z. Zheng, "Environmental evaluation", Beijing: Higher Education Press, **(2006)**, pp. 155-191.
[3] L. Zuoyong, "Environment quality evaluation principle and method", Beijing: Chemical Industry Press, **(2004)**, pp. 69-133.
[4] Y. Lunbiao, "The fuzzy mathematics theory and application", Guangzhou: South China University of Technology Press, **(2000)**, 67-80.
[5] X. Jijian and L. Chengping, "The method and application of fuzzy mathematics", Wuhan: Huazhong University of Science and Technology Press, **(2000)**, pp. 205-211.
[6] Z. Lin, "Analysis and study of environmental quality evaluation system in colleges and universities", Gansu Science and Technology Press, vol. 22, no. 12, **(2006)**, pp. 120-121.
[7] G. Jun and G. Lunying, "Analytic hierarchy process to determine the index weight", water Contemporary Architecture, vol. 3, no. 1, **(2003)**, pp. 22-23.
[8] L. Angui, Z. Zhihong and M. Yan, "Fuzzy mathematics and its application", Wuhan: Metallurgical Industry Press, **(2003)**, pp. 144-146.
[9] W. Xinzhou, "Fuzzy spatial information processing", Wuhan: Wuhan University press, **(2003)**, pp. 130-131.
[10] L. Shiyong, "Engineering fuzzy mathematics and its application", Harbin: Harbin Institute of Technology Press, **(2004)**, pp. 101-108.
[11] T. Chunsheng, "The theory and method introduction of system engineering", Beijing: National Defence Industry Press, **(2000)**, pp. 185-186.
[12] J. Qiyuan, "Mathematics model", Beijing: Higher Education Press, **(2005)**, pp. 225-231.
[13] N. Xiaoqiu, "The principle and method of fuzzy mathematics", Xuzhou: China University of Mining and Technology Press, **(2014)**, pp. 203-208.

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