Fractional Correlation Distance Method on Course Evaluation

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***Abstract*—Course evaluation is an important and necessary means to improve the level of course. A new course evaluation method based on fractional grey relational distance and analytic hierarchy process (AHP) is proposed in this paper. Firstly, the proportion of the different influence factors can be determined through constructing judging-matrix and calculating-back-to-one and dealing with the checkout of coherence. Secondly, qualitative evaluation indicators are quantified by fractional-order system, and quantitative indicators are processed by idealization and normalization. And then association coefficient is defined. Finally, correlation distance degree is proposed. The new similarity degree reflects the relatedness and the different shape among a selected scheme, the ideal solution and negative ideal solution. Through the application to actual course assessment instance, the results show its practicability and effectiveness.**

***Index Terms*—analytic hierarchy process, fractional, ideal solution, grey relational analysis, Euclidean distance.**

I. INTRODUCTION

Educational assessment, especially higher education evaluation has gradually become an important aspect of education administration at home and abroad. It is education evaluation that can promote the development of education and the realization of educational objectives. Course evaluation is an important part of educational assessment. It is the efficient way that higher education institution realizes the higher education self-perfecting, self-regulation and self-improvement. So it is an important task that establishes a scientific and standardized course evaluation system.

There is more and more research on course evaluation recently. Reference [1] applies a multiple-level growth modeling approach to the long-term stability of students' evaluations of teaching effectiveness. Reference [2] examined the effects of embedding special education instruction into pre-service general education assessment courses. Reference [3] proposed a self-assessment method. Student reactions constituted evidence for final self-evaluation, the summative component of self-assessment, and that must be examined if self-evaluation is to support people learning to teach. Reference [4] indicates course evaluation in medical education. Reference [5] contributes to the conceptual and empirical distinction between appraisals of teaching behavior and self-reported competence acquirement within academic course evaluation. Reference [6] [7] research some course evaluation methods. Course evaluation is a complex systematic process. Some methods did not give details of the assessment data processing, resulting in a lack of convincing results of the evaluation. Some discussion has not given the specific methods. Some methods had not considered the existence of objective weight, so that the result is too subjective.

Fractional grey system theory and AHP are applied for course evaluation in this paper. Indicator system, ideal scheme and correlation distance degree are researched based on many methods. Indicators weight was determined by analytic hierarchy process. It provides a scientific basis for evaluating the quality of course rightly. The detailed evaluation process was described in this paper. This method makes up for insufficiency of a single subjective weighting method. It provides a new thinking and decision-making methods for course evaluation.

The remaining part of this paper is organized as follows. In Sec. II, evaluation indicator system is introduced. In Sec. III, indicators weights can be confirmed by using of AHP. In Sec. IV, evaluating model is built based on the fractional ideal correlation distance degree. In Sec. V, evaluation algorithm is given roughly. In Sec. VI, some practical examples are presented to verify the feasibility of the proposed method. Finally, conclusions are drawn in Sec. VII.

II. EVALUATION INDICATORS

Evaluation index system is basis and measure of evaluation. Course evaluation indicator system is based

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on quality construction connotation request and the goal. It uses of pedagogical theory and surveying principle reasonably. The relevant expert and teaching superintendent are organized in view of in-depth investigations and studies. Evaluation indicator system consists of 5 first-level indicators and 15 second-level indicators in this paper.

Curriculum evaluation indicators are sorted hierarchically. The first layer is the result of course assessment. The second layer is composed of five first-level indicators. It converts course assessment into evaluation on five parts. The third layer is made up of the basic indicators. It shows the most basic decomposition indicators of evaluation system, as shown in Table I.

TABLE I
EVALUATION INDICATORS SYSTEM

Course Evaluation Results	Teaching Force B_1	Course director and main teacher C_{11}
		Teaching troop overall construction and quality C_{12}
		Teaching reform and educational research C_{13}
	Educational Content B_2	Curricular content C_{21}
		Content organization and course outline C_{22}
		Practicing course C_{23}
	Teaching Approaches & Means B_3	Instruction design C_{31}
		Teaching approaches C_{32}
		Teaching means C_{33}
	Teaching Condition B_4	Textbook and related material C_{41}
		Practice teaching condition C_{42}
		Network teaching environment C_{43}
	Teaching Effect B_5	Colleague evaluation C_{51}
		Student ratings of teaching C_{52}
		Video data evaluation C_{53}

Teaching force is the core of course construction and it can not be ignored any time. Educational content, condition, effect, teaching approaches and means will continue to be the evaluation key and highlight the effect of practical application. A more comprehensive indicator system is designed. There is a more comprehensive and clearer understanding of the present curriculum construction through assessment.

III. INDICATORS WEIGHTS

AHP is a multi-criteria decision-making method which proposed by a well-known American, University of Pittsburgh professor T.L.Saaty [8]. AHP method decomposes a complex problem into all relevant indicators. These indicators will be grouped according to hierarchical relationships in order to form an orderly hierarchy. There are goal layer, criteria layer and sub-criteria layer in this method. The multi-attribute weight is measured via pair-wise comparison of indicators. And then the relative importance of each layer index is determined. The results are synthesized and indicators are sorted in relation to the overall importance in hierarchical structure [9]. Then indicators weights can be confirmed based on the AHP.

A. Building Hierarchy Framework

Course evaluation indicators will be designed hierarchically, as shown in Table I.

B. Constructing Judgment Matrix

Judgment matrix is constructed by the decision-makers according to each layer corresponding indicators importance. It is an important part of AHP method to determine comparison matrix. The relative weight of two indicators is expressed by number 1~9 and reciprocal. Number 1 indicates that two indicators a_i and a_j are equally important. Number 3 expresses that a_i is slightly more important than a_j. Number 5 says that a_i is obviously more important than a_j. Number 7 expresses that a_i is very more important than a_j. Number 9 indicates that a_i is absolutely more important than a_j. Even number 2~8 expresses the middle of the above adjacent judgments. And there is $a_{ij} = 1/a_{ji}$.

C. Calculating Criteria Weights

Eigenvalues of comparison matrix can be used to measure the importance of low layer factor relative to upper target. So single-layer sorting can be come down to determine the comparison matrix eigenvalues and eigenvectors.

Consistency index (CI) is provided to measure inconsistency of each pair-wise comparison matrix as well as for the entire hierarchy. The CI is formulated as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{1}$$

where $\lambda_{\max}$ is the maximum eigenvalue, and n is the dimension of matrix. Then average random coincidence indicator (RI) can be found according to the same order matrix in Table II.

TABLE II
RANDOM INDEX

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

Accordingly, the consistency ratio (CR) can be computed with the equation:

$$CR = \frac{CI}{RI} \tag{2}$$

If CR of pair-wise comparison matrix is less than 0.1, the consistency can be acceptable. Or else, comparison matrix must be revised by evaluator.

D. Obtaining Final Ranking

After single-layer indicators are sorted, total sorting also needs to be calculated in order to more clearly express the importance of all the indicators. The final sort order is gone on from top to bottom layer.

E. Consistency Test

In order to judge consistency of goal layer, it is also necessary to carry on consistency check. And comparison matrix is consistent when CR<0.10. Or else, it needs to be modified suitably.

Through the above steps indicator weights have been determined, and it is the basis of assessment.

IV. EVALUATING MODEL

Gray system theory was proposed by Professor Deng Julong in China [10]. Gray relational analysis is an important section of gray system theory. Gray relational analysis does not need the massive samples and the data model distribution. And course evaluating method based on fractional order system and ideal gray correlation distance is proposed in this letter.

A. Fractional Quantification

Some evaluation indicators are qualitative in course evaluation system. First of all, qualitative indicators can be quantized through assigning confidence interval. And fractional order method is also applied to quantize the indicators.

Fractional order model is a powerful tool to describe complex systems[11]. Here the qualitative evaluation results are quantified by fractional-order system. Different levels can be corresponded to the corresponding confidence interval. Each expert is assigned a weight number, which indicates his capability in this area. The quantified evaluation is

$$y = \frac{2d}{c+d} \times \left(\frac{c+d}{2} \right)^{\alpha} \tag{3}$$

where α is weight number of the expert, and confidence interval is [c, d]. The quantified value is provided through fractional processing, and that difference is obvious.

The qualitative indicators of raw data are dealt with fractional quantification processing. Initial evaluation matrix can be gotten.

$$Y = \left(y_{ij} \right)_{m \times n} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix} \tag{4}$$

B. Initial Matrix Idealization

Ideal evaluation matrix is the matrix with the best and the worst reference sequence. Optimal reference sequence is exactly the ideal assessment scheme. Each indicator can achieve the best value in all assessment schemes. The worst reference sequence is negative ideal assessment scheme. And each indicator achieves the worst value. All the indicators are larger-the-better in this paper.

Ideal initial evaluation matrix: In the initial evaluation matrix, the i-th assessment sequence is

$$y_i = \left(y_{i1}, y_{i2}, \cdots, y_{in} \right) \quad i = 1, 2, \cdots, m \tag{5}$$

Optimal reference sequence is

$$y_0^+ = \left(y_{01}, y_{02}, \cdots, y_{0n} \right) \tag{6}$$

where,

$$y_{0j} = \max \left\{ y_{1j}, y_{2j}, \cdots, y_{mj} \right\} \tag{7}$$

And then $Y^+ = \left(y_{ij} \right)_{(m+1)n}$ is ideal initial evaluation matrix, where $i = 0, 1, 2, \cdots, m;\ j = 1, 2, \cdots, n$.

Negative ideal initial evaluation matrix: The worst reference sequence is

$$y_0^- = \left(y_{01}, y_{02}, \cdots, y_{0n} \right) \tag{8}$$

where,

$$y_{0j} = \min \left\{ y_{1j}, y_{2j}, \cdots, y_{mj} \right\} \tag{9}$$

And then $Y^- = \left(y_{ij} \right)_{(m+1)n}$ is negative ideal initial evaluation matrix, where $i = 0, 1, 2, \cdots, m;\ j = 1, 2, \cdots, n$.

C. Ideal Matrix Normalization

Evaluation indicators are processed by non-dimensional analysis in order to eliminate non-commensurable. The different methods can be used for the different ideal matrix.

In ideal initial evaluation matrix, there is

$$p_{ij} = \frac{y_{ij} - \min\limits_{0<i<m} y_{ij}}{\max\limits_{0<i<m} y_{ij} - \min\limits_{0<i<m} y_{ij}} \tag{10}$$

where y_{ij} is initial sequence, $i = 0, 1, 2, \cdots, m;\ j = 1, 2, \cdots, n$.

In negative ideal initial evaluation matrix, there is

$$p_{ij} = \frac{\max\limits_{0<i<m} y_{ij} - y_{ij}}{\max\limits_{0<i<m} y_{ij} - \min\limits_{0<i<m} y_{ij}} \tag{11}$$

where y_{ij} is initial sequence.

Ideal evaluation matrix P^+ and negative ideal evaluation matrix P^- can be gotten through the standardization processing of $Y^{\pm}$.

D. Association Matrix

Data sequence $p_{0j} = \left(p_{01}, p_{02}, \cdots, p_{0n} \right)$ is reference sequence. Data sequences $p_{1j},\ p_{2j},\ \cdots,\ p_{mj}$ are comparison sequences. And $\beta_{ij} = \left| p_{0j} - p_{ij} \right|$. Association coefficient between the j-th reference sequence indicator and j-th indicator of i-th comparison sequence is defined

$$\varepsilon_{ij} = \frac{\min\limits_i \min\limits_j \beta_{ij} + \alpha \max\limits_i \max\limits_j \beta_{ij}}{\beta_{ij} + \alpha \max\limits_i \max\limits_j \beta_{ij}} \tag{12}$$

Where $\alpha \in [0,\ 1]$ is resolution coefficient, which takes 0.5 in this paper.

And then ideal association evaluation matrix and negative ideal association evaluation matrix can be obtained

$$E^+ = \begin{bmatrix} \varepsilon_{01}^+ & \varepsilon_{02}^+ & \cdots & \varepsilon_{0n}^+ \\ \varepsilon_{11}^+ & \varepsilon_{12}^+ & \cdots & \varepsilon_{1n}^+ \\ \varepsilon_{21}^+ & \varepsilon_{22}^+ & \cdots & \varepsilon_{2n}^+ \\ \vdots & \vdots & \ddots & \vdots \\ \varepsilon_{m1}^+ & \varepsilon_{m2}^+ & \cdots & \varepsilon_{mn}^+ \end{bmatrix} \tag{13.a}$$

$$E^- = \begin{bmatrix} \varepsilon_{01}^- & \varepsilon_{02}^- & \cdots & \varepsilon_{0n}^- \\ \varepsilon_{11}^- & \varepsilon_{12}^- & \cdots & \varepsilon_{1n}^- \\ \varepsilon_{21}^- & \varepsilon_{22}^- & \cdots & \varepsilon_{2n}^- \\ \vdots & \vdots & \ddots & \vdots \\ \varepsilon_{m1}^- & \varepsilon_{m2}^- & \cdots & \varepsilon_{mn}^- \end{bmatrix} \quad (13.b)$$

Indicators weight can be determined by the above AHP, and it is $W = (\omega_1, \omega_2, \cdots, \omega_n)$.

The ideal weighted evaluation matrix can be obtained through effecting weight vector on ideal association evaluation matrix.

$$E_w^+ = \begin{bmatrix} \omega_1 & \omega_2 & \cdots & \omega_n \\ \omega_1\varepsilon_{11}^+ & \omega_2\varepsilon_{12}^+ & \cdots & \omega_n\varepsilon_{1n}^+ \\ \omega_1\varepsilon_{21}^+ & \omega_2\varepsilon_{22}^+ & \cdots & \omega_n\varepsilon_{2n}^+ \\ \vdots & \vdots & \ddots & \vdots \\ \omega_1\varepsilon_{m1}^+ & \omega_2\varepsilon_{m2}^+ & \cdots & \omega_n\varepsilon_{mn}^+ \end{bmatrix} \quad (14.a)$$

$$E_w^- = \begin{bmatrix} \omega_1 & \omega_2 & \cdots & \omega_n \\ \omega_1\varepsilon_{11}^- & \omega_2\varepsilon_{12}^- & \cdots & \omega_n\varepsilon_{1n}^- \\ \omega_1\varepsilon_{21}^- & \omega_2\varepsilon_{22}^- & \cdots & \omega_n\varepsilon_{2n}^- \\ \vdots & \vdots & \ddots & \vdots \\ \omega_1\varepsilon_{m1}^- & \omega_2\varepsilon_{m2}^- & \cdots & \omega_n\varepsilon_{mn}^- \end{bmatrix} \quad (14.b)$$

E. Correlation Distance Degree

The first line of the above matrix shows the optimal or the worst reference sequence. The closer with the optimal value, the better the evaluation result. The closer to the worst value, the worst the evaluation result. Euclidean distance is introduced in this paper. In the evaluation matrix, Euclidean distance between comparative sequence and reference sequence is calculated.

$$D_i^{\pm} = \sqrt{\sum_{j=1}^{n} \omega_j^2 \left(\varepsilon_{ij}^{\pm} - 1\right)^2} \quad (15)$$

According to (15), $D_i^{\pm}$ between i-th comparative sequence and the optimal/worst reference sequence can be got. The smaller the value D_i^+, expressed that i-th comparative sequence is closer to the optimal reference sequence. The smaller the value D_i^-, expressed that it is closer to the worst reference sequence. It is obviously that D_i^+ is the smaller the better and D_i^- is the larger the better for i-th comparative sequence. It is best scheme that is closest to the optimum reference sequence, while far away from the worst reference sequence. But in the actual assessment situation, it is often appears the situation as shown in Fig. 1.

It describes evaluation instance with two indicators in Fig. 1, and y^+ and y^- respectively expresses the optimal and the worst reference sequence. Comparative sequence y_1 is closer to the optimal reference sequence y^+ than comparative sequence y_2 in this figure. At the same time y_1 is closer to the worst reference sequence y^- than y_2. Here gray correlation distance degree is defined that indicates quality of comparative sequence.

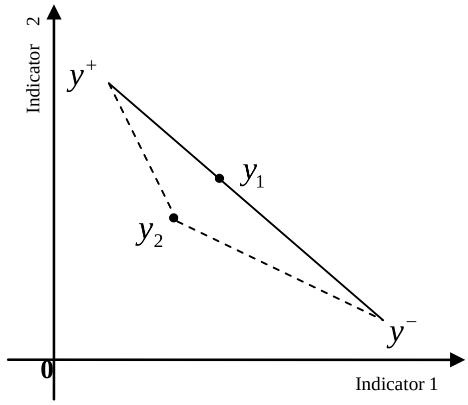

Figure 1. The optimal reference scheme and the worst reference scheme

Definition: The degree of comparative sequence closer to the optimal reference sequence and far away from the worst reference sequence is known as correlation distance degree. It is defined as

$$K_i = \frac{D_i^{+2}}{D_i^{-2} + D_i^{+2}} \quad (16)$$

Comparative sequences are sorted by correlation distance degree from small to large. The comparative sequence with the smaller correlation distance degree is considered a good scheme.

V. ALGORITHM OF GRAY RELATIONAL DISTANCE EVALUATION

According to the above description, course evaluation algorithm proposed in this paper can be summarized as follows:

1) Indicators weights are determined based on AHP;
2) Evaluation indicators are quantized through fractional processing and obtain the initial evaluation matrix;
3) Then ideal initial evaluation matrixes $Y^{\pm}$ are constructed;
4) To eliminate non-commensurable, build ideal evaluation matrix $P^{\pm}$ through the processing of standardization;
5) Compute association coefficient, and structure association evaluation matrix $E^{\pm}$;
6) Ideal weighted evaluation matrix can be acquired based on indicators weights and association evaluation matrix;
7) Calculate Euclidean distance of each scheme according to (15);
8) Then correlation distance degree can be obtained by (16);
9) All schemes are sorted by correlation distance degree from small to large.

VI. EXAMPLE ANALYSIS

Take the recent course assessment of Capital Normal University Information Engineering College as an example. There are four courses selected randomly. Experts give quantifiable estimation results. Assessed values are obtained through equalization and normalization, which are shown as in Table III.

TABLE III. ASSESSMENT VALUE OF FOUR COURSES

Evaluation Indicators	Target			
	C1	C2	C3	C4
Course director and main teacher C_{11}	0.65	0.76	0.65	0.94
Teaching troop overall construction and quality C_{12}	0.77	0.90	0.78	0.95
Teaching reform and educational research C_{13}	0.80	0.69	0.64	0.84
Curricular content C_{21}	0.87	0.80	0.80	0.91
Content organization and course outline C_{22}	0.78	0.78	0.79	0.81
Practicing course C_{23}	0.67	0.59	0.57	0.85
Instruction design C_{31}	0.87	0.79	0.74	0.95
Teaching approaches C_{32}	0.87	0.84	0.78	0.90
Teaching means C_{33}	0.88	0.86	0.77	0.94
Textbook and related material C_{41}	0.81	0.85	0.74	0.91
Practice teaching condition C_{42}	0.83	0.87	0.76	0.85
Network teaching environment C_{43}	0.92	0.86	0.69	0.95
Colleague evaluation C_{51}	0.86	0.88	0.79	0.93
Student ratings of teaching C_{52}	0.78	0.72	0.72	0.84
Video data evaluation C_{53}	0.76	0.76	0.64	0.81

Step 1: Determine weights. In accordance with expert data, six comparison matrixes are constructed. And corresponding CI can be calculated according to maximum eigenvalue of comparison matrix, as shown in Table IV-Ⅸ. They are all acceptable.

TABLE Ⅳ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF INDICATORS

Evaluation indicator	B_1	B_2	B_3	B_4	B_5	weight
B_1	1	1/3	1/3	5	3	0.157
B_2	3	1	1/2	9	4	0.311
B_3	3	2	1	9	4	0.410
B_4	1/5	1/9	1/9	1	1/5	0.031
B_5	1/3	1/4	1/4	5	1	0.091

CR=0.053.

TABLE Ⅴ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF TEACHING FORCE

Teaching Force	C_{11}	C_{12}	C_{13}	weight
C_{11}	1	3.5	1	0.444
C_{12}	1/3.5	1	1/3	0.134
C_{13}	1	3	1	0.422

CR=0.002.

TABLE Ⅵ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF EDUCATIONAL CONTENT

Educational Content	C_{21}	C_{22}	C_{23}	weight
C_{21}	1	3	5	0.637
C_{22}	1/3	1	3	0.258
C_{23}	1/5	1/3	1	0.105

CR=0.037.

TABLE Ⅶ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF TEACHING APPROACHES & MEANS

Teaching Approaches & Means	C_{31}	C_{32}	C_{33}	weight
C_{31}	1	1.5	3	0.475
C_{32}	2/3	1	4	0.399
C_{33}	1/3	1/4	1	0.126

CR=0.052.

TABLE Ⅷ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF TEACHING CONDITION

Teaching Condition	C_{41}	C_{42}	C_{43}	weight
C_{41}	1	1/2	1.25	0.258
C_{42}	2	1	3	0.548
C_{43}	0.8	1/3	1	0.194

CR=0.004.

TABLE Ⅸ
WEIGHTS AND PAIRWISE COMPARISON MATRIX OF TEACHING EFFECT

Teaching Effect	C_{51}	C_{52}	C_{53}	weight
C_{51}	1	1	1.8	0.396
C_{52}	1	1	1.4	0.365
C_{53}	1/1.8	1/1.4	1	0.239

CR=0.006.

So the weight vector of indicators can be decided, W = (0.070, 0.021, 0.066, 0.198, 0.080, 0.033, 0.195, 0.164, 0.052, 0.008, 0.017, 0.006, 0.036, 0.033, 0.021) ^{T}.

Step 2: According to expert quantifiable assessed values, initial evaluation matrix Y can be obtained.

Step 3: Ideal initial evaluation matrix and negative ideal initial evaluation matrix are displayed $Y^{\pm}$.

Step 4: Through the processing of standardization, there are ideal evaluation matrix $P^{\pm}$.

Step 5: In evaluation matrix, there are $\min_i \min_j \beta_{ij} = 0.00$, $\max_i \max_j \beta_{ij} = 1.00$. Ideal association evaluation matrix $E^{\pm}$ can be composed by the association coefficient.

Step 6：According to AHP, the weights of indicators can be decided. W = (0.070, 0.021, 0.066, 0.198, 0.080, 0.033, 0.195, 0.164, 0.052, 0.008, 0.017, 0.006, 0.036, 0.033, 0.021)^T. There are ideal weighted evaluation matrixes $E_w^{\pm}$.

$$Y = \begin{bmatrix} 0.65 & 0.77 & 0.80 & 0.87 & 0.78 & 0.67 & 0.87 & 0.87 & 0.88 & 0.81 & 0.83 & 0.92 & 0.86 & 0.78 & 0.76 \\ 0.76 & 0.90 & 0.69 & 0.80 & 0.78 & 0.59 & 0.79 & 0.84 & 0.86 & 0.85 & 0.87 & 0.86 & 0.88 & 0.72 & 0.76 \\ 0.65 & 0.78 & 0.64 & 0.80 & 0.79 & 0.57 & 0.74 & 0.78 & 0.77 & 0.74 & 0.76 & 0.69 & 0.79 & 0.72 & 0.64 \\ 0.94 & 0.95 & 0.84 & 0.91 & 0.81 & 0.85 & 0.95 & 0.90 & 0.94 & 0.91 & 0.85 & 0.95 & 0.93 & 0.84 & 0.81 \end{bmatrix}$$

$$Y^{+} = \begin{bmatrix} 0.94 & 0.95 & 0.84 & 0.91 & 0.81 & 0.85 & 0.95 & 0.90 & 0.94 & 0.91 & 0.87 & 0.95 & 0.93 & 0.84 & 0.81 \\ 0.65 & 0.77 & 0.80 & 0.87 & 0.78 & 0.67 & 0.87 & 0.87 & 0.88 & 0.81 & 0.83 & 0.92 & 0.86 & 0.78 & 0.76 \\ 0.76 & 0.90 & 0.69 & 0.80 & 0.78 & 0.59 & 0.79 & 0.84 & 0.86 & 0.85 & 0.87 & 0.86 & 0.88 & 0.72 & 0.76 \\ 0.65 & 0.78 & 0.64 & 0.80 & 0.79 & 0.57 & 0.74 & 0.78 & 0.77 & 0.74 & 0.76 & 0.69 & 0.79 & 0.72 & 0.64 \\ 0.94 & 0.95 & 0.84 & 0.91 & 0.81 & 0.85 & 0.95 & 0.90 & 0.94 & 0.91 & 0.85 & 0.95 & 0.93 & 0.84 & 0.81 \end{bmatrix}$$

$$Y^{-} = \begin{bmatrix} 0.65 & 0.77 & 0.64 & 0.80 & 0.78 & 0.57 & 0.74 & 0.78 & 0.77 & 0.74 & 0.76 & 0.69 & 0.79 & 0.72 & 0.64 \\ 0.65 & 0.77 & 0.80 & 0.87 & 0.78 & 0.67 & 0.87 & 0.87 & 0.88 & 0.81 & 0.83 & 0.92 & 0.86 & 0.78 & 0.76 \\ 0.76 & 0.90 & 0.69 & 0.80 & 0.78 & 0.59 & 0.79 & 0.84 & 0.86 & 0.85 & 0.87 & 0.86 & 0.88 & 0.72 & 0.76 \\ 0.65 & 0.78 & 0.64 & 0.80 & 0.79 & 0.57 & 0.74 & 0.78 & 0.77 & 0.74 & 0.76 & 0.69 & 0.79 & 0.72 & 0.64 \\ 0.94 & 0.95 & 0.84 & 0.91 & 0.81 & 0.85 & 0.95 & 0.90 & 0.94 & 0.91 & 0.85 & 0.95 & 0.93 & 0.84 & 0.81 \end{bmatrix}$$

$$P^{+} = \begin{bmatrix} 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.00 & 0.00 & 0.80 & 0.64 & 0.00 & 0.36 & 0.62 & 0.75 & 0.65 & 0.41 & 0.64 & 0.88 & 0.50 & 0.50 & 0.71 \\ 0.38 & 0.72 & 0.25 & 0.00 & 0.00 & 0.07 & 0.24 & 0.50 & 0.53 & 0.65 & 1.00 & 0.65 & 0.64 & 0.00 & 0.71 \\ 0.00 & 0.06 & 0.00 & 0.00 & 0.33 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 0.82 & 1.00 & 1.00 & 1.00 & 1.00 \end{bmatrix}$$

$$P^{-} = \begin{bmatrix} 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 1.00 & 1.00 & 0.20 & 0.36 & 1.00 & 0.64 & 0.38 & 0.25 & 0.35 & 0.59 & 0.36 & 0.12 & 0.50 & 0.50 & 0.29 \\ 0.62 & 0.28 & 0.75 & 1.00 & 1.00 & 0.93 & 0.76 & 0.50 & 0.47 & 0.35 & 0.00 & 0.35 & 0.36 & 1.00 & 0.29 \\ 1.00 & 0.94 & 1.00 & 1.00 & 0.33 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.18 & 0.00 & 0.00 & 0.00 & 0.00 \end{bmatrix}$$

$$E^{+} = \begin{bmatrix} 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.33 & 0.33 & 0.71 & 0.58 & 0.33 & 0.44 & 0.57 & 0.67 & 0.59 & 0.46 & 0.58 & 0.81 & 0.50 & 0.50 & 0.63 \\ 0.45 & 0.64 & 0.40 & 0.33 & 0.33 & 0.35 & 0.40 & 0.50 & 0.52 & 0.59 & 1.00 & 0.59 & 0.58 & 0.33 & 0.63 \\ 0.33 & 0.45 & 0.33 & 0.33 & 0.43 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 \\ 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 0.74 & 1.00 & 1.00 & 1.00 & 1.00 \end{bmatrix}$$

$$E^{-} = \begin{bmatrix} 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 1.00 & 1.00 & 0.38 & 0.44 & 1.00 & 0.58 & 0.45 & 0.40 & 0.43 & 0.55 & 0.44 & 0.36 & 0.50 & 0.50 & 0.41 \\ 0.57 & 0.41 & 0.67 & 1.00 & 1.00 & 0.88 & 0.68 & 0.50 & 0.49 & 0.43 & 0.33 & 0.43 & 0.44 & 1.00 & 0.41 \\ 1.00 & 0.89 & 1.00 & 1.00 & 0.43 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.33 & 0.38 & 0.33 & 0.33 & 0.33 & 0.33 \end{bmatrix}$$

$$E_w^{+} = \begin{bmatrix} 0.070 & 0.021 & 0.066 & 0.198 & 0.080 & 0.033 & 0.195 & 0.164 & 0.052 & 0.008 & 0.017 & 0.006 & 0.036 & 0.033 & 0.021 \\ 0.023 & 0.007 & 0.047 & 0.115 & 0.026 & 0.015 & 0.111 & 0.110 & 0.031 & 0.004 & 0.010 & 0.005 & 0.018 & 0.017 & 0.013 \\ 0.032 & 0.013 & 0.026 & 0.065 & 0.026 & 0.012 & 0.078 & 0.082 & 0.027 & 0.005 & 0.017 & 0.004 & 0.021 & 0.011 & 0.013 \\ 0.023 & 0.009 & 0.022 & 0.065 & 0.034 & 0.011 & 0.064 & 0.054 & 0.017 & 0.003 & 0.006 & 0.002 & 0.012 & 0.011 & 0.007 \\ 0.070 & 0.021 & 0.066 & 0.198 & 0.080 & 0.033 & 0.195 & 0.164 & 0.052 & 0.008 & 0.013 & 0.006 & 0.036 & 0.033 & 0.021 \end{bmatrix}$$

$$E_w^- = \begin{bmatrix} 0.070 & 0.021 & 0.066 & 0.198 & 0.080 & 0.033 & 0.195 & 0.164 & 0.052 & 0.008 & 0.017 & 0.006 & 0.036 & 0.033 & 0.021 \\ 0.070 & 0.021 & 0.025 & 0.087 & 0.080 & 0.019 & 0.088 & 0.066 & 0.022 & 0.004 & 0.007 & 0.002 & 0.018 & 0.017 & 0.009 \\ 0.040 & 0.009 & 0.044 & 0.198 & 0.080 & 0.029 & 0.133 & 0.082 & 0.025 & 0.003 & 0.006 & 0.003 & 0.016 & 0.033 & 0.009 \\ 0.070 & 0.019 & 0.066 & 0.198 & 0.034 & 0.033 & 0.195 & 0.164 & 0.052 & 0.008 & 0.017 & 0.006 & 0.036 & 0.033 & 0.021 \\ 0.023 & 0.007 & 0.022 & 0.065 & 0.026 & 0.011 & 0.064 & 0.054 & 0.017 & 0.003 & 0.006 & 0.002 & 0.012 & 0.011 & 0.007 \end{bmatrix}$$

Step 7: Euclidean distance of each course can be calculated according to (15). $\left(D_1^+\right)^2 = 0.024018$, $\left(D_2^+\right)^2 = 0.045978$, $\left(D_3^+\right)^2 = 0.056482$, $\left(D_4^+\right)^2 = 0.000016$, $\left(D_1^-\right)^2 = 0.037007$, $\left(D_2^-\right)^2 = 0.01354$, $\left(D_3^-\right)^2 = 0.00212$, $\left(D_4^-\right)^2 = 0.057334$.

Step 8: Then correlation distance degree respectively is obtained according to (16). $K_1 = 0.394$, $K_2 = 0.773$, $K_3 = 0.964$, $K_4 = 0.0003$.

Step 9: Four courses are sorted based on the correlation distance degree. It is obviously that C_4 is the best course and C_3 is the worst scheme among four courses.

The results are consistent with the actual situation, and there is more obvious difference in evaluation results. It is clear that the proposed method is practical and effective.

VII. Conclusion

Course evaluation promotes curriculum comprehensive construction and enhances quality of teaching comprehensively. It also promotes curriculum scientific management and standards. It is an important means that the country and society implement monitoring and macroeconomic regulation. It is the efficient way that higher education institution realizes the higher education self-perfecting, the self-regulation and the self-improvement. Course evaluation method based on AHP and fractional grey relational distance is proposed in this paper. The method was applied to actual course assessment instance of Capital Normal University Information Engineering College. And result indicates that this method is highly efficient for solving real-world problems.

References

[1] Herbert W. M. Do university teachers become more effective with experience: a multilevel growth model of students' evaluations of teaching over 13 years. *Journal of Educational Psychology*, vol. 99, no.4, pp. 775-790, 2007.

[2] Kimberlee S B, Lesley A W, Kristin H H, et al. The efficacy of embedding special education instruction in teacher preparation programs in the United States. *Teaching and Teacher Education*, vol. 24 no.8, pp. 2087-2094, 2008.

[3] Catherine M. Assessing self-evaluation in a science methods course: Power, agency, authority and learning. *Teaching and Teacher Education*, vol. 25, no.5, pp.758-766, 2009.

[4] Jennifer R K, Judy A S. Course evaluation in medical education. *Teaching and Teacher Education*, vol.23, no.3, pp.251-264, 2007.

[5] Edith B, Bernhard L. Academic course evaluation: theoretical and empirical distinctions between self-rated gain in competences and satisfaction with teaching behavior. *European Psychologist*, vol.14, no.4, pp.297-306, 2009.

[6] Zhao, Chunna, Li, Yingshun, Luo, Liming: Application of gray relational analysis for course evaluation. *IEEE ICICTA*, pp.758-761, 2010.

[7] Zhao, Chunna, Luo, Liming, Zhao, Yu, Li, Yingshun, Tan, Xiaohui, Xiong, Yeqing. A new course assessment method, *IEEE ICETC*, pp. 4485-4488, 2010.

[8] Saaty T L. *The analytic hierarchy process*. New York: McGraw Hill, Inc, 1980.

[9] Chunna Zhao, Yu Zhao, Xiaohui Tan, Yingshun Li, Liming Luo: Course Evaluation Method Based on Analytic Hierarchy Process, *IEEE CCCM*, pp.318-321, 2010.

[10] J L. *Grey System Theory*. Wuhan: Huazhong University of Science and Technology Press, 1990.

[11] Zhao Chun-Na; Zhang XiangDe; Sun Yan-Rui. Simulation of commensurate fractional order systems. *Journal of System Simulation*, vol.20, no.15, pp.3948-3950, 2008.

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