The Establishment and Realization of Group Decision Comprehensive Evaluation Model Based on Rough Sets

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***Abstract*—In this paper, a comprehensive evaluation model for the group decision is established on the basis of rough sets. Take personnel comprehensiv evaluation for example, a group decision support system is designed and realized in the light of the model database, method database, and human-computer interaction. The model is verified and the corresponding examplesb is provided.**

***Keywords-** group decision-making; rough sets; comprehensive evaluation; GDSS*

I. Research purpose

The group decision-making is the decision-making activities that take groups as the subject. In the collective thinking activity, massive facts show that the cognition level of groups almost reaches the perfect extent with respect to perceiving world. Therefore, group decision-making can be seen frequently in practical area of decision-making ,and that intrigue deeper researchers in the decision-making theory. The researches on group decision-making theory in China mainly are in group decision-making mathematics model method, group decision-making support system (GDSS) and social choice theory. These researches share two common features: firstly, there are lots of articles regarding theory research, whereas is a lack of demonstration articles; secondly, the research and application of the models and methods remain in a single group decision-making method, and is a lack of research on comprehensive group decision-making models that integrate variety of methods. It is implied that the research on group decision-making stay on the academic research phase of concept and laboratory instead of case demonstration phase in china, which is far from mature.

In this paper, the evaluation problem in the group decision- making will be elaborated separately from both model establishment and system design and realization. On one hand, a group decision-making comprehensive evaluation model is established to provide a methodological and technical idea for the integrated application of evaluation methods based on the multilevel, multi-attribute and multi-objective features of decision- making evaluation index system; on the other hand, the design and realization of the group decision-making support system for personnel comprehensive evaluation case will provide a demonstrating case for reference to the research on the GDSS.

II. Research approach

In reality, many evaluation factors of uncertain and multi-attribution issues can only be vaguely evaluated as “excellent”, “good”, “moderate” and “poor”, since many factors features “clear connotation and uncertain extension” and they cannot be precisely defined. In addition, decision-making judge is a subjective behavior and it’s not likely to make a totally correct evaluation. Therefore, the decision-making course has the feature of vagueness.

In this paper, the theory of rough sets will be used to make comprehensive evaluation on decision objects. Using the advantage of rough sets theory in depicting incomplete aspects and uncertainty, attribute reduction, importance analysis, rule generation and the objective and quantitative data mining can be used to analyze imprecise, inconsistent and incomplete information efficiently. The combination of rough sets theory and other comprehensive evaluation theories can complement each other, and make decision-making more scientific and reasonable.

III. Model establishment

A. Establish the evaluation index system

The method of expert consultation is adopted to construct the assessment index system. The steps of specific application consist of defining predictive targets, developing implementation plans, selecting experts of prediction, making investigation forms, evaluating feedback and statistically analyzing and predicting opinions from experts. The author tries to screen out the assessment indices that can comprehensively describe the evaluated objects by means of investigation, expert consultation, collections of feedback and statistical analysis of data.

In order to understand a subject comprehensively and thoroughly, researchers always try to collect as more relevant indices as possible when they study it. Even though the indices could thoroughly and exactly describe a subject after spending massive effort and time to collect the information, the constructed index system might not be helpful for the evaluation work in practical application. Firstly, many indices lead to great calculations. Subsequently, there might be interrelations between indices. That is, indices might share subjects. Therefore, indices should be further refined in order reduce the overlapping parts of indices with appropriate methods.

B. Simplification of indices and Determination of weights of indices with Rough Set Method

In this part, it is describes how to extract core indices to form a simplified index system from massive redundant and interrelated indices, and then determine their weights.

Firstly, the domain of discourse composed of n evaluated objects is U={ $x_1, x_2, x_3, \ldots, x_n$ }. M indices form a set of condition attributes C= { $c_1, c_2, \cdots, c_m$ }, and the results of evaluation comprise the decision attribute set D= { d }. The appraisal ranks {excellent, medium, inferior} are correspondingly {2，1，0}.

Secondly, K experts assess N evaluative objects based on M indices and three appraisal ranks. We assume here that the opinions from K experts have the same importance. And then the average scores of k experts construct a relational data model matrix of $N \times M$ order.

Thirdly, data are discrete. If continuous data exists in the index system, these data should be discretized through discretization methods.

Fourthly, construct a discernibility matrix. In the relational data model matrix, a matrix of order $N \times N$ with different grades of indices is constructed after comparing any two grades of evaluated objects. For example, C_{ij} is an element of row i and column j in the discernibility matrix, it represents a index set of different grades from comparing objects x_i and x_j .

Fifthly, construct a discernibility function. A discernibility matrix is formed after performing a logical disjunction on evaluation indices of C_{ij} , and then performing a conjunction on all C_{ij} . Next, the discernibility function is simplified with absorption law.

Sixthly, determine the indices' weight according to the principle of importance of attributes in Rough Set. In other words, the importance of an index is determined by the change of classification when the index is removed. If the change of classification is large when an index is removed, that means the index is more important and has higher level of weight, vice versa.[1]

Presuming an information system S= (U, A, V, f), and all the first-level indices construct an attribute set A. Besides, Presuming an index $a \in A$, and its importance in attribute A is defined as:

$$sig_{A-\{a\}}\{a\} = I(A) - I(A - \{a\}); \quad (1)$$

$$P \subseteq A, U/P = \{X_1, X_2, ..., X_P\},$$

the amount of information-of-knowledge P is defined as:

$$I(P) = \sum_{i=1}^{m} \frac{|X_i|}{|U|}[1 - \frac{X_i}{|U|}] = 1 - \frac{1}{|U^2|}\sum_{i=1}^{m}|X_i|^2 \quad (2)$$

In the formula, |X| is the radix of set X, and $\frac{|X_i|}{|U|}$ is the probability of the equivalence X_i in set U. Then the importance of the index $a \in A$ in set A is measured by the change of the amount of information when it is removed.

Assuming $a_i \in A = \{a_1, a_2, ..., a_n\}$, and then the weight of the index a_i is determined by the follow formula as：

$$w_{a_i} = \frac{sig_{A-\{a_i\}}(a_i)}{\sum_{j=1}^{n} sig_{A-\{a_j\}}(a_j)} = \frac{I(A) - I(A - \{a_i\})}{nI(A) - \sum_{j=1}^{n} I(A - \{a_j\})} \quad (3)$$

The first-level and second-level indices weight A_1 and A_2 can be determined according to the information system that is constructed by the evaluation results of evaluated objects. Compared to the method AHP that is always used to determine the weight by qualitative index, the application of Rough Set can solves both the problem of blindness that is caused as the experts compare the indices directly without any references, and the problem that the judgment matrix based on experts' results of comparison cannot be verified in the consistency due to the poor consistency. Therefore, the Rough Set that requires experts to score evaluative objects seems to be more practical. In addition, after the indices are simplified by Rough Set, their weights are determined through processing the real data of evaluated objects by mathematical methods, which reflect the amount of information of the indices.

C. Assembly of the integrated evaluation

After a simplified index system is formed and the weights of indices are determined by means of Rough Set method. The evaluation can be done with several multi-attribute decision-making methods for the limited goal. Results of the evaluation can be assembled according to evaluation values (The Linear Weighted Method, etc) or evaluation orders (ELECTRIC, TOPSIS, AHP, etc).

Besides, some other methods can be comprehensively used. For example, the compatibility of among goals of evaluated objects can be analyzed with matter Element Analysis Method ,and the evaluation model can be trained with Neural Network Method, etc.

This article will show the evaluation results that are assembled through both he Linear Weighted Method based on evaluation values and TOSIS Method based on evaluation orders, whose results will be compared.

IV. SYSTEM REALIZATIONS

In this part, a group decision support system of personnel comprehensive evaluation will be designed and realized , the established models will be applied and verified

A. Global design

The system is developed based on B/S mode, and runing in LAN for human resource management case of personnel comprehensive evaluation. Figure 1 is a concept model of system. [2]

The system is controlled by a main-sub system (host by decision-making process controller) ,and the control rules are based on the activity procedure (personnel comprehensive evaluation procedure). The control includes the propulsion of evaluation steps, information interaction of appraisers, backward steps of activities, the organization and coordination of activity (the collection, integration and release of evaluation information), and so on.

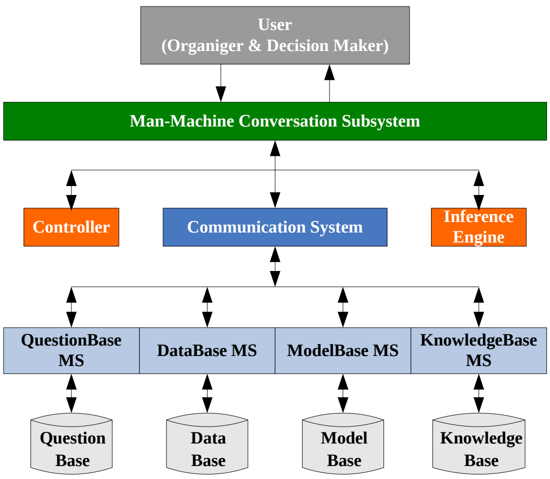

Figure 1. GDSS Concept Model

The system is composed of Data Base, Model Base, Protocol Base, Communication Base, Mail Service Unit, Process Control Unit and Human-Computer Interface, as shown in figure 2.

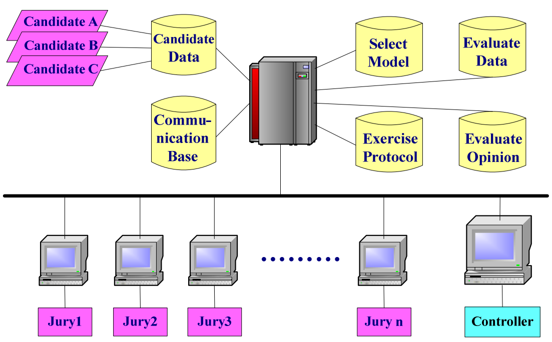

Figure 2. System Structure

B. *Technical architecture*

The system database adopts MySQL5.0 and presentation layer is developed with Html + CSS + XML + JavaScript, logical layer with PHP + Ajax and middle technology with Smarty (a PHP template engine). Among them, the basic function demands in logic layer are mainly realized by PHP and part of higher interactive performance modules are realized with Ajax, such as the instant validation of information, editable data table and SVG image, etc.

C. *Model database design*

The model base of system is composed of model base, model base management system and model dictionary. The decision-makers reach a decision depending on the models in the Model Base via human-computer interaction instead of directly depending on the data in the DB.

The system can select different evaluation models according to different assessment objects. Therefore, with constantly adding new models, the development of model base is gradual. The realization of the model in the system (the presentation, update and authentication techniques of the model) is completed by PHP and Matlab.

Method base design

Decision-makers select data and algorithm from database and method base respectively to realize the combination of data domain algorithm ,and to complete computation then to export the results for a reference in the computational process via human-computer interaction.

The system model performs the processing job mainly by Matlab, and the system function process mainly depends on PHP. Matlab provides program interface to C and Java, however, there is no interface for PHP to directly transfer itself. Since C or Java has difficulties such as interface friendliness or development agility in realizing function process of the system, the transfer between PHP and Matlab becomes the key. During the realization process, C is selected as the middleware between PHP and Matlab to read the input information of users on the human-computer interface via PHP, and then deliver the information to Matlab using C. The results will be returned after completion.

D. *Human-computer design*

The system realizes the separation of presentation layer and logic layer by using Smarty. The top layer of the system, the presentation layer, namely the user interface displayed on client browser, is mainly developed with Html + CSS + XML + JavaScript. The middle layer is Smarty (users will be prevented from visit from this layer, however, this layer is only a middle role for connection instead of the logic backstage of the system); the third layer developed using PHP and Ajax is the core of the system, namely the logic layer. This layer is connected with the presentation layer via Smarty and exchanges data with the database in the bottom layer. The database is in the bottom layer and is separated from the logic layer through relative configuration files such as config.inc in the logic layer.

V. APPLICATION EXAMPLES

As follows, it will demonstrate how to evaluate anchors with the model and system designed in this article. The first step is to select evaluative indices that can describe anchors comprehensively with Expert Consultation Method.

The indices of constructed index system are Language Performance, Paralanguage Performance, Occupation Spirit, Knowledge Skills, Impromptu Performance, Consciousness and Social Investigation.[3]

C1 refers to index Language Performance including standard language, voice condition and expression performance.

C2 refers to index Paralanguage including appearance and behaviors.

C3 refers to index Occupation Spirit that includes self-discipline, social responsibility, professional spirit, team awareness and dedication.

C4 refers to index Knowledge Skills that includes knowledge and additional skills.

C5 refers to index Impromptu Performance that includes enthusiasm, interaction with audiences, audience responses, personal style, and communication accuracy.

C6 refers to Consciousness that includes political, law, and moral consciousness.

C7 refers to Social Investigation that includes audience rating, audience satisfaction, anchors popularity and program reputation.

Firstly, ten anchors constitute a domain of discourse $U=\{x_1,x_2,x_3,\ldots,x_{10}\}$. Seven first-level indices form an attribute set $C=\{c_1,c_2,c_3,c_4,c_5,c_6,c_7\}$. The evaluation results of anchors constitute a decision attribute set $D=\{d\}$. The appraisal rank {excellent, medium, inferior} are correspondingly to {2，1，0}.

Secondly, the main control program of the system creates a marking interface according to the indices from experts. And the five experts score ten anchors' performances according to the seven indices and the three evaluation grades. In addition, the system regards that the opinions of five experts are equally important. Therefore, the average score of five experts is used and rounded here. Finally, the system works out a 10×7 relational matrix as shown in table I:

TABLE I. INFORMATION SYSTEM

	c1	c2	c3	c4	c5	c6	c7	d
x1	2	1	2	1	1	1	1	1
x2	2	2	1	1	2	1	2	2
x3	1	1	2	1	1	2	1	1
x4	1	2	1	2	2	1	2	2
x5	0	0	1	1	0	1	0	0
x6	2	2	0	1	2	0	2	1
x7	0	1	0	1	1	0	1	0
x8	1	0	1	1	0	1	0	0
x9	1	2	0	1	2	0	2	1
x10	1	1	1	1	2	1	2	2

Thirdly, simplify the index system. The system constructs a discernibility matrix according to table I, and the matrix is table II as follows:

TABLE II. DISCERNIBILITY MATRIX

	x1	x2	x3	x4
x1	0	0	0	0
x2	2,3,5,7	0	0	0
x3	1,6	1,2,3,5,6,7	0	0
x4	1,2,3,4,5,7	1,4	2,3,4,5,6,7	0
x5	1,2,3,5,7	1,2,5,7	1,2,3,5,6,7	1,2,4,5,7
x6	2,3,5,6,7	3,6	1,2,3,5,6,7	1,3,4,6
x7	1,3,6	1,2,3,5,6,7	1,3,6	1,2,3,4,5,6,7
x8	1,2,3,5,7	1,2,5,7	2,3,5,6,7	2,4,5,7
x9	1,2,3,5,6,7	1,3,6	2,3,5,6,7	3,4,6
x10	1,3,5,7	1,2	3,5,6,7	2,4

	x5	x6	x7	x8	x9
x1	0	0	0	0	0
x2	0	0	0	0	0
x3	0	0	0	0	0
x4	0	0	0	0	0
x5	0	0	0	0	0
x6	1,2,3,5,6,7	0	0	0	0
x7	2,3,5,6,7	1,2,5,7	0	0	0
x8	1	1,2,3,5,6,7	1,2,3,5,6,7	0	0
x9	1,2,3,5,6,7	1	1,2,5,7	2,3,5,6,7	0
x10	1,2,5,7	1,2,3,6	1,3,5,6,7	2,5,7	2,3,6

(Numbers in TABLE II should be titled ‘C’. For example, 1 indicates C1, 2 indicates C2, etc.)

To build discernibility function according to discernibility matrix and the result is simplified with absorption rate:

$$f=(c1\wedge c2\wedge c3)\vee(c1\wedge c3\wedge c4\wedge c5)\vee(c1\wedge c3\wedge c4\wedge c7)\vee(c1\wedge c2\wedge c6)\vee(c1\wedge c4\wedge c5\wedge c6)\vee(c1\wedge c4\wedge c6\wedge c7)$$

The result shows that the core index of the index set is c1. In another word, the language expression is the most important to anchors as a basic skill. These simplified index sets are equally important. Anyone can be chosen to be a core index system. But the one that has least indices is normally selected. Now experts pick the {c1, c2, c6} (Language Performance, Paralanguage Performance, Consciousness) as the core index system which meets the demands for evaluated objects. This method reduces the amount of evaluation indices effectively.

The final index system is: Language Performance C1 including standard language, voice condition and expression performance; Paralanguage Performance C2 including appearance and behaviors; Consciousness C6 including political, law, and moral consciousness.

Fourthly, determine the weights of indices. The weights of simplified indices can be worked out on the basis of the information system constructed by the evaluation results of anchors.

The equivalence of C/D is {{x1}{x2},{x3},{x4},{x5},{x6},{x7},{x8},{x9},{x10}}.

The equivalence of C-{c1} is {{x1,x10},{x2,x4},{x3},{x5,x8},{x6,x9},{x7}}.

The equivalence of C-{c2} is {{x1,x2},{x3},{x4,x8,x10},{x5},{x6},{x7,x9}}.

The equivalence of C-{c6} is {{x1},{x2,x6},{x3,x7,x10},{x4,x9},{x5},{x8}}.

The calculates weights by the system based on formula 1 and 2 are as follows

$$I(C)=\sum_{i=1}^{10}\frac{|X_i|}{|U|}\left(1-\frac{|X_i|}{|U|}\right)=\frac{1}{10}\times\left(1-\frac{1}{10}\right)\times 10=\frac{9}{10}$$

$$I(C-\{c_1\})=\frac{2}{10}\times\left(1-\frac{2}{10}\right)\times 4+\frac{1}{10}\left(1-\frac{1}{10}\right)\times 2=\frac{82}{100}$$

Likewise, $I(C-\{c_2\})==\frac{80}{100}$ $\quad I(C-\{c_6\})==\frac{80}{100}$

$$w_{c_1}=\frac{sig_{A-|c_1|}}{\sum_{j=1}^{n}sig_{A-|c_j|}(c_j)}=\frac{I(C)-I(C-|c_1|)}{nI(C)-\sum_{j=1}^{n}I(C-|c_j|)}$$

$$=\frac{\frac{9}{10}-\frac{82}{100}}{3\times\frac{9}{10}-(\frac{82}{100}+\frac{80}{100}+\frac{80}{100})}=\frac{2}{7}$$

Likewise, $w_{c_2}=\frac{5}{14}$, $w_{c_6}=\frac{5}{14}$

Fifthly, assembling the composite evaluation. According to the weights of the indices and simplified index values, the system weighs the indices with Linear Weighted Method, [4] and then the scores of comprehensive evaluation of ten anchors are worked out.

$$(0.2857,0.3571,0.3571)\times\begin{bmatrix}2&2&1&1&0&2&0&1&1&1\\1&2&1&2&0&2&1&0&2&1\\1&1&2&1&1&0&0&1&0&1\end{bmatrix}$$
$$=(1.29\quad 1.64\quad 1.36\quad 1.36\quad 0.36\quad 1.29\quad 0.36\quad 0.64\quad 1.00\quad 1.00)$$

We can see that the order of ten anchors is

$$x_2>x_3=x_4>x_1=x_6>x_9=x_{10}>x_8>x_5=x_7$$

The following is order of ten anchors obtained by means of TOPSIS :

$$x_3>x_2>x_4>x_1>x_{10}>x_6>x_9>x_8>x_5>x_7$$

Then we can conclude that the results are nearly the same in two different ways.

VI. CONCLUSIONS

In this paper, a group decision-making comprehensive evaluation model is established based on rough sets. The attribute reduction principle is used in the reductions of indexes, and the attribute importance principle is used in the determination of index weight. In this way, this model simplifies the evaluation process, and outcomes effects caused by human factors of artificial assessment, maintaining objective and accuracy of conclusion. On the basis of the model, a group decision support system of personnel comprehensive evaluation is designed and realized in aspect off model library, method library, database and human-computer interaction, the established model is verified and the corresponding examples are provided too.

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