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The Dynamic Fuzzy Clustering of the Project Stakeholders Demands Information

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Abstract: How to carry out the stakeholders managements effectively, one major issue is to continuously meet the demands of the stakeholders. The purpose of this paper is to clarify the disorganized information of stakeholders demands and correctly deal with it. The paper has expounded on the project stakeholders' demands information, such as fuzziness, randomness, dynamics, diversity and contradictoriness, through the analysis of fuzzy equivalence matrix to find the basic method and procedure of application of fuzzy equivalence relation classification by using the theory of fuzzy mathematics. Based on the fuzzy similarity matrix by using the least squares method derives its transitive closure, and solves the fuzzy clustering problem of fuzzy similarity relation. The paper verifies the effectiveness and feasibility about the dynamic fuzzy clustering of the stakeholders demands information by example, based on the principle of fuzzy clustering, studied the establishment and application of stakeholders' demands information related to dynamic fuzzy clustering models, set the characteristic indexes of project stakeholders demands information classification. Established the relevant theory of fuzzy clustering based on stakeholders demands information fuzzy clustering model, and study the specific implementation steps on how to use the model. These results have practical significance for the classification of managing complex stakeholders' demands information.

Keywords: Demands information, model and application, the dynamic fuzzy clustering, the stakeholders management.

1. INTRODUCTION

In the management of project stakeholders, we need to continuously meet the demands of the stakeholders in order to make them satisfied. Therefore, we need to identify the demands of the stakeholders continuously, and make a classified management. Generally speaking, the demands information of project stakeholders often has the following characteristics [1]:

1. Fuzziness

   The demands of the stakeholders often have no clear boundaries, it is just as a vague description of the language. For example, a very vague description is to demand a certain quality index or a project duration to be better.

2. Randomness

   The project has many stakeholders each part has different demand. And these demands are unsystematic.

3. Dynamic nature

   During the progress of project, the demands of stakeholders will form gradually as situation changes.

   At different stage, the demands of stakeholders are different and these demands are dynamic and variable.

4. Variety

   The demands of stakeholders are various, it could be the demand for tangible products or intangible product; and it may be the demand for project or its own demand.

5. Contradictoriness

   Maybe the demands of stakeholders are contradictory, for example, the project is required to have a good quality and a low price, which is a contradiction of the demands.

Obviously the demands of stakeholders are unsystematic and vague, therefore, it is very important to use the scientific method to classify these demands.

2. THE PROJECT STAKEHOLDERS DEMAND ABOUT DYNAMIC FUZZY CLUSTERING MODELS

2.1. Fuzzy Data Matrix

Assuming that the project stakeholder demands information collection is:

$$A=\{a_1,a_2,\cdots,a_n\} \tag{1}$$

a_1, $a_2\cdots,a_n$ ---The Nth different demand information of project stakeholders.

Demand information classification feature set is:

$$D=\left\{d_1,d_2,\cdots,d_k\right\} \tag{2}$$

d_1, $d_2,\cdots,d_k$ ---According to the demand information to determine the classification of characteristic indexes.

A, D are two non empty set, fuzzy subset of A×D is called into a fuzzy binary relations between A and D. For any elements a in A, any element d in D, A numerical to represent a relationship between A and the degree of D. According to every demand information has the characteristic index of degree, respectively take value in the range [0,1], can get the similar degree between each demand information and the classification index. The fuzzy relation can be represented by the data matrix.

2.2. Fuzzy Equivalence Matrix

If the fuzzy relation on the A can be represented by matrix as [2]:

$$\tilde{S} = (s_{ij})_{m \times n} \tag{3}$$

s_{ij} deputes the size of the relationships between a_i and a_j, respectively take value in the range [0,1]. The matrix which selects a numerical from range of 0-1 to represent the elements are called fuzzy matrix. The matrix possess reflexivity, transitivity, symmetry of fuzzy relations. The fuzzy relation is called fuzzy equivalence relation. When A is a finite set, this class matrix that represent the relation of fuzzy equivalence has the following properties :

Reflexivity: $s_{ij} = 1$, the main diagonal elements of the $\tilde{S}$ was 1;

Transitivity: $\tilde{S} \circ \tilde{S} \subseteq \tilde{S}$;

Symmetry: $s_{ij} = s_{ji}$, the Elements in $\tilde{S}$ are symmetrical by the diagonal.

Matrix $\tilde{S}$ with the above properties are also known as fuzzy equivalence matrix.

The above $\tilde{S} \circ \tilde{S}$ is fuzzy synthetic operation. The definition is:

Assuming fuzzy matrix is: $\tilde{S} = (s_{ij})_{m \times n}, \tilde{Q} = (q_{jk})_{n \times t}$, Synthesis of S and Q is the m × t order fuzzy matrix, written as $\tilde{S} \circ \tilde{Q}$.

$$\tilde{S} \circ \tilde{Q} = (s_{ij}) \circ (q_{jk}) = (p_{ik}) \tag{4}$$

$$p_{ik} = \bigvee_{j=1}^{n} (s_{ij} \wedge q_{jk}) \tag{5}$$

p_{ik} ---is the inner product of the fuzzy vectors that Respectively formed by the row i of $\tilde{S}$ and the column k of $\tilde{Q}$.

By the theory of fuzzy mathematics can lead to the following conclusions: If $\tilde{S}$ is a fuzzy equivalence matrix, then for any digital λ selected between 0 to 1, S_λ is the Boolean matrix which represent the equivalence relations on A. And vice versa. It can be concluded that the classification of the basic methods and steps by using the fuzzy equivalence relation.

1. Appoint $\lambda \in [0,1]$;
2. Solver S_λ;
3. According S_λ to classify A.

when λ is a determined value, there is only one kind of classification corresponding to it. when λ changing, S_λ is also changing. And the classification is changing too. Therefore, this classification has dynamic properties.

2.3. Fuzzy Similar Relation and Fuzzy Clustering

In the reality applications of stakeholder demands information clustering, for fuzzy relation $\tilde{S}$ on A, generally has symmetry and reflexivity. It is difficult to satisfy the transitivity. At this time $\tilde{S}$ is called fuzzy similar relation on A. When the set A is limited, the corresponding matrix called the fuzzy similar matrix. According to the theory of fuzzy mathematics, if the fuzzy similarity relation no transfer relationship, then cannot make the dynamic classification for A. But because the fuzzy similarity relation includes the information of relationships between elements. So after reform, can find a fuzzy equivalence matrix which most similar as it and then classify it. Can seek to prove, the fuzzy similar matrix $\tilde{S}$'s Transitive closure $t(S)$ is fuzzy equivalence matrix. $t(S)$ is the smallest transitive fuzzy matrix which include the fuzzy matrix $\tilde{S}$. so, based on the fuzzy similarity matrix $\tilde{S}$ to solve the transitive closure $t(S)$, then we can solve the fuzzy clustering problem of fuzzy similarity relation.

The following we use square method to solve the transitive closure of fuzzy similar matrix:

1. To calculate $\tilde{S}^2 = \tilde{S} \circ \tilde{S}$ by $\tilde{S}$, if there is no equivalence on $\tilde{S}$, as $\tilde{S}^2 \neq \tilde{S}$, the calculation continues;
2. Calculation of $\tilde{S}^4$ by $\tilde{S}^2$, if $\tilde{S}^4 = \tilde{S}^2 \circ \tilde{S}^2 = \tilde{S}^2$, then The calculation of the $t(S)$ is $\tilde{S}^2$, otherwise, the calculation continues, after a limited number of calculation we will get:

$$\tilde{S}^{2k} \circ \tilde{S}^{2k} = \tilde{S}^{2k} \tag{6}$$

We can get the fuzzy equivalence matrix on A:

$$t(S) = \tilde{S}^{2k} \tag{7}$$

Use $t(S)$ can classify A.

3. THE APPLICATION OF PROJECT STAKEHOLDERS DEMANDS INFORMATION RELATED TO DYNAMIC FUZZY CLUSTERING MODELS

3.1. The Characteristic Indexes of Project Stakeholders Demands Information Classification

Using dynamic fuzzy clustering models to classify the project stakeholders demands information, that is the classification of project stakeholders demands information is above quantitative processing foundation [3]. For this purpose we should use the vector to represent each of the demand information [4]. Each element of the vector represent the values of certain characteristics of demand information.

Characteristic indexes of project stakeholders demands information can be summarized as the following aspects [5]:

1. Functional requirements refers to the performance of the project, such as specification requirements, the structural strength requirements.
2. The requirement of security refers to the process of project implementation and completion of the project to ensure the person and the environment from harm, such as the safety degree of project structure, anti vibration level, fire protection requirements and so on.
3. The demand of temporal aspects refers to the demand for the duration of the project stakeholders.
4. The demand of economic aspects refers to the cost, income and consumption of the project life cycle.
5. The demand of development refers to the influences of future development through the implementation of the project stakeholders.
6. The demand of management coordination refers to the needs of organization, management, communication, and coordination during the implementation process of the project stakeholders.
7. The demand of energy-saving and emission reduction refers to the requirements of the stakeholders to have a energy- saving and emission reduction in the project.
8. The demand of durability refers to the premise of ensuring safety, the age limit can be normal used by the project.
9. The demand of ornamental value refers to the ornamental values of project, such as lighting, modeling, decoration, color, landscape of the project.
10. The demand of environmental coordination refers to whether the project can meet the requirement of the sustainable development, as the environmental influence of the project, and the project influence to the society.

We can set the characteristic index according to the specific situation in practical classification.

3.2. Vector Representation of Project Stakeholders Demands Information

If the set of stakeholder demands information as shown in formula (1)

We can obtain the classification feature set as shown in formula (2) by analyzing the demand information.

We can respectively take a value between 0 to 1 to find the degree of similarity between each requirement information and the classification feature through analyzing the characteristic index of each demand information with.

$$\begin{aligned} X_1 &= (x_{11}, x_{12}, \cdots, x_{1k}) \\ X_2 &= (x_{21}, x_{22}, \cdots, x_{2k}) \\ X_n &= (x_{n1}, x_{n2}, \cdots, x_{nk}) \end{aligned} \tag{8}$$

Then get the data matrix:

$$\begin{bmatrix} x_{11}x_{12}\cdots x_{1k} \\ x_{21}x_{22}\cdots x_{2k} \\ \cdots\cdots\cdots\cdots \\ x_{n1}x_{n2}\cdots x_{nk} \end{bmatrix} \tag{9}$$

x_{ij} --- the degree of similarity between the stakeholders demands information with the characteristic indexes, value range [0,1].

3.3. Building the Dynamic Cluster Model of Stakeholder Demands Information

The purpose of fuzzy clustering is build dynamic cluster model through establish a fuzzy similarity relation $\tilde{S}$. The following is the modeling steps:

1. Determine the characterization data of project stakeholders demands information

Assume $A = \{a_1, a_2, \cdots, a_n\}$ is the set of project stakeholders demands information.

According to the actual situation, Identify mth stakeholder demands information which can describe the characteristic index. Therefore, m data $(x_{i1}, x_{i2}, \cdots, x_{im})$ can be used to characterize any object

2. To calculate the degree of similarity we should determine the degree of similarity s_{ij} between the elements in order to construct the fuzzy similar matrix $\tilde{S}$, that is determine a number in the range [0,1] of objects a_i and a_j, there are several ways to determine s_{ij} just as the following methods [6]:

The similar coefficient method of maximum and minimum.

$$s_{ij} = \frac{\sum_{k=1}^{m}(x_{ik} \wedge x_{jk})}{\sum_{k=1}^{m}(x_{ik} \vee x_{jk})} \tag{10}$$

The similar coefficient method of minimum arithmetic average.

$$s_{ij} = \frac{\sum_{k=1}^{m}(x_{ik} \wedge x_{jk})}{\frac{1}{2}\sum_{k=1}^{m}(x_{ik} + x_{jk})} \tag{11}$$

The similar coefficient method of minimum geometric average.

$$s_{ij} = \frac{\sum_{k=1}^{m}(x_{ik} \wedge x_{jk})}{\sum_{k=1}^{m}\sqrt{x_{ik} \cdot x_{jk}}} \tag{12}$$

Table 1. The table of project stakeholder demands information.

Project Stakeholder	Demand Information	Demand Information Element Code Name
Prospective tenants	Material without harmful impurity The good seismic performance of structures Suitable for use Smooth ground	a_1 a_2 a_3 a_4
Developer	Matching of function and cost Improve the quality Speed up the progress	a_5 a_6 a_7
Design unit	Comply with the design requirements Close collaboration with the contractor	a_8 a_9
Supervising unit	Clear responsibility for security Good cooperation with developers	a_{10} a_{11}
Contractor	Payment in due course Claim for compensation	a_{12} a_{13}

Distance method.

$$s_{ij} = 1 - cd(x_i, x_j) \quad (13)$$

The c of formula (13) --- the properly selected positive to make $0 \le s_{ij} \le 1$

$d(x_i, x_j)$ --- distance, $d(x_i, x_j) = \sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right|$ If

we take the Hamming distance [7].

Grade in the range of [0,1] according to the opinions and experiences of expert and the subjective judgment.

3. Fuzzy classification

If $\tilde{S} \circ \tilde{S} = \tilde{S}$, then $\tilde{S}$ is Fuzzy equivalence relation, take λ from 0 to 1, classified by the S_λ, get a series of dynamic classification, and combined with the reality of the specific circumstances, specify one classification used for actual classification.

If $\tilde{S} \circ \tilde{S} \ne \tilde{S}$, then continue to use square method, through the synthesis of finite time, if $\tilde{S}^{2k} \circ \tilde{S}^{2k} = \tilde{S}^{2k}$, you can use the $\tilde{S}^{2k}$ as the approximate equivalent matrix of $\tilde{S}$, and take a dynamic classification based on $\tilde{S}^{2k}$.

4. THE FUZZY CLUSTER SAMPLE OF PROJECT STAKEHOLDER DEMANDS INFORMATION

In the implementation phase of a housing construction project, we can get the demands informations by identified the demands of stakeholders as shown in Table **1**.

After a preliminary analysis of the demand information can be described by 6 characteristic indexes: Function characteristics (D_1); Safety features (D_2); Time characteristics (D_3); Economic characteristics (D_4); Environmental characteristics (D_5); Management coordination characteristics (D_6). on the basis of the degree of similarity between every demands information and performance index, using the method of expert judgment and fuzzy statistics to take values in the range of [0,1]. The greater the degree of similarity, the greater the values and vice versa. Take the average number of expert opinion as the ultimate value, thus obtained:

$$X_i = \{X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5}, X_{i6}\}$$

X_{i1} --- The value that take from similarity degree between demand information a_i and functional properties D_1;

X_{i2} --- The value that take from similarity degree between demand information a_i and Safety features D_2;

X_{i3} --- The value that take from similarity degree between demand information a_i and Time characteristics D_3;

X_{i4} --- The value that take from similarity degree between demand information a_i and Economic characteristics D_4;

X_{i5} --- The value that take from similarity degree between demand information a_i and Environmental characteristics D_5;

X_{i6} ---The value that take from similarity degree between demand information a_i and Management coordination characteristics D_6.

Get data matrix according to the values :

$$\begin{bmatrix} 0.4 & 0.5 & 0.1 & 0.3 & 0.9 & 0.2 \\ 0.6 & 0.8 & 0.2 & 0.3 & 0.2 & 0.1 \\ 0.6 & 0.4 & 0.3 & 0.4 & 0.2 & 0.2 \\ 0.8 & 0.6 & 0.2 & 0.2 & 0.3 & 0.2 \\ 0.5 & 0.4 & 0.2 & 0.5 & 0.2 & 0.1 \\ 0.8 & 0.5 & 0.2 & 0.3 & 0.4 & 0.2 \\ 0.1 & 0.2 & 0.9 & 0.4 & 0.3 & 0.2 \\ 0.8 & 0.7 & 0.2 & 0.4 & 0.2 & 0.4 \\ 0.2 & 0.3 & 0.2 & 0.3 & 0.1 & 0.9 \\ 0.1 & 0.6 & 0.2 & 0.1 & 0.2 & 0.5 \\ 0.2 & 0.3 & 0.2 & 0.1 & 0.4 & 0.8 \\ 0.2 & 0.3 & 0.4 & 0.7 & 0.2 & 0.6 \\ 0.1 & 0.2 & 0.2 & 0.3 & 0.4 & 0.8 \end{bmatrix}$$

According to the data matrix to construct a fuzzy similarity matrix:

Using the maximum minimum similarity coefficient method to calibrate the similarity between elements.

$$s_{12} = \frac{\sum_{k=1}^{6}(x_{1k} \wedge x_{2k})}{\sum_{k=1}^{6}(x_{1k} \vee x_{2k})}$$

$$= \frac{(x_{11} \wedge x_{21}) + (x_{12} \wedge x_{22}) + (x_{13} \wedge x_{23}) + (x_{14} \wedge x_{24}) + (x_{15} \wedge x_{25}) + (x_{16} \wedge x_{26})}{(x_{11} \vee x_{21}) + (x_{12} \vee x_{22}) + (x_{13} \vee x_{23}) + (x_{14} \vee x_{24}) + (x_{15} \vee x_{25}) + (x_{15} \vee x_{26})}$$

$$= \frac{(0.4 \wedge 0.6) + (0.5 \wedge 0.8) + (0.1 \wedge 0.2) + (0.3 \wedge 0.3) + (0.9 \wedge 0.2) + (0.2 \wedge 0.1)}{(0.4 \vee 0.6) + (0.5 \vee 0.8) + (0.1 \vee 0.2) + (0.3 \vee 0.3) + (0.9 \vee 0.2) + (0.2 \vee 0.1)}$$

$$= \frac{0.4 + 0.5 + 0.1 + 0.3 + 0.2 + 0.1}{0.6 + 0.8 + 0.2 + 0.3 + 0.9 + 0.2} = 0.53$$

We can get the other similarity coefficients in like manner, then build a fuzzy similar matrix as:

$$\tilde{S} = \begin{bmatrix} 1 & 0.53 & 0.52 & 0.57 & 0.47 & 0.66 & 0.36 & 0.50 & 0.38 & 0.29 & 0.42 & 0.37 & 0.42 \\ 0.53 & 1 & 0.73 & 0.73 & 0.54 & 0.70 & 0.34 & 0.75 & 0.40 & 0.31 & 0.35 & 0.41 & 0.35 \\ 0.52 & 0.73 & 1 & 0.59 & 0.57 & 0.57 & 0.47 & 0.67 & 0.43 & 0.34 & 0.39 & 0.52 & 0.39 \\ 0.57 & 0.73 & 0.59 & 1 & 0.47 & 0.92 & 0.38 & 0.79 & 0.39 & 0.34 & 0.43 & 0.41 & 0.39 \\ 0.47 & 0.54 & 0.57 & 0.47 & 1 & 0.50 & 0.40 & 0.50 & 0.41 & 0.32 & 0.37 & 0.61 & 0.37 \\ 0.66 & 0.70 & 0.57 & 0.92 & 0.50 & 1 & 0.41 & 0.76 & 0.42 & 0.33 & 0.47 & 0.41 & 0.47 \\ 0.36 & 0.34 & 0.47 & 0.38 & 0.40 & 0.41 & 1 & 0.36 & 0.37 & 0.37 & 0.37 & 0.50 & 0.46 \\ 0.50 & 0.75 & 0.67 & 0.79 & 0.50 & 0.76 & 0.36 & 1 & 0.47 & 0.39 & 0.42 & 0.50 & 0.44 \\ 0.38 & 0.40 & 0.43 & 0.39 & 0.41 & 0.42 & 0.37 & 0.47 & 1 & 0.71 & 0.74 & 0.63 & 0.74 \\ 0.29 & 0.31 & 0.34 & 0.34 & 0.32 & 0.33 & 0.37 & 0.39 & 0.71 & 1 & 0.50 & 0.54 & 0.50 \\ 0.42 & 0.35 & 0.39 & 0.43 & 0.37 & 0.47 & 0.37 & 0.42 & 0.74 & 0.50 & 1 & 0.57 & 0.82 \\ 0.37 & 0.41 & 0.52 & 0.41 & 0.61 & 0.41 & 0.50 & 0.50 & 0.63 & 0.54 & 0.57 & 1 & 0.57 \\ 0.42 & 0.35 & 0.39 & 0.39 & 0.37 & 0.47 & 0.46 & 0.44 & 0.74 & 0.50 & 0.82 & 0.57 & 1 \end{bmatrix}$$

To calculate the fuzzy equivalent matrix and obtain:

$$t(S) = \tilde{S}^{16} = \tilde{S}^{8} \circ \tilde{S}^{8} = \tilde{S}^{8}$$

$$= \begin{bmatrix} 1 & 0.66 & 0.66 & 0.66 & 0.66 & 0.66 & 0.66 & 0.66 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 1 & 0.73 & 0.75 & 0.73 & 0.75 & 0.70 & 0.75 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.73 & 1 & 0.73 & 0.73 & 0.73 & 0.70 & 0.73 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.75 & 0.73 & 1 & 0.73 & 0.75 & 0.70 & 0.79 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.73 & 0.73 & 0.73 & 1 & 0.73 & 0.70 & 0.73 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.75 & 0.73 & 0.75 & 0.73 & 1 & 0.70 & 0.75 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.70 & 0.70 & 0.70 & 0.70 & 0.70 & 1 & 0.70 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.66 & 0.75 & 0.73 & 0.79 & 0.73 & 0.75 & 0.70 & 1 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 \\ 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 1 & 0.71 & 0.74 & 0.63 & 0.74 \\ 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.71 & 1 & 0.70 & 0.63 & 0.71 \\ 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.74 & 0.70 & 1 & 0.63 & 0.82 \\ 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.63 & 0.63 & 0.63 & 1 & 0.63 \\ 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.61 & 0.74 & 0.71 & 0.82 & 0.63 & 1 \end{bmatrix}$$

According to the fuzzy equivalence relation, take λ from 1 to 0 and classify it by using S_λ.

When $\lambda = 0.73$ Classification by 6:

The demand associated with the functional properties $A_1 = \{a_2, a_3, a_4, a_5, a_6, a_8\}$;

The demand associated with Safety features $A_2 = \{a_{10}\}$;

The demand associated with Time characteristics $A_3 = \{a_7\}$;

The demand associated with Economic characteristics $A_4 = \{a_{12}\}$;

The demand associated with Environmental characteristics $A_5 = \{a_1\}$;

The demand associated with Management coordination characteristics $A_6 = \{a_9, a_{11}, a_{13}\}$.

5. CONCLUSION

Project stakeholders demands information is dynamic and uncertain, it is seems to be out of order if the information is not classified and analyzed. This paper is based on the principle of fuzzy clustering, studied the establishment and application of stakeholders' demands information related to dynamic fuzzy clustering models, set the characteristic indexes of project stakeholders demands information classification. Established the relevant theory of fuzzy clustering based on stakeholders demands information fuzzy clustering model, and study the specific implementation steps on how to use the model. These results have practical significance for the classification of managing complex stakeholders' demands information.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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