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ON UNCERTAIN NODULE FUZZY GRAPH & RESEMBLANCE COEFFICIENTS

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Abstract: To overcome the uncertainty of graph theory, fuzzy graph theory is adopted. Customarily, the imprecise and uncertain data can be effectively evaluated and analyzed by fuzzy graph theory. Fuzzy graph theory can be extended and an uncertain nodule fuzzy graph is originated. As the uncertain nodule is difficult to scrutinize, here the uncertain nodule is changed to a simple fuzzy graph utilizing triangular function group. Moreover, the association within the nodules is analyzed by defining uncertain eventuality table. In this paper, five topics are discussed, (a)innovative triangular function "GKT product", (b) uncertain nodule fuzzy graph, (c) uncertain eventuality table, (d) entropy measures of uncertainty and (e) selection scrutiny of ideal esteem F_{μ_0} in the fuzzy graph series $\left\{F_{\mu}\right\}$. Through the utilization of uncertain nodule fuzzy graph theory, the innovative triangular function and the uncertain eventuality table, the associational architecture of uncertain data is clarified. Based upon the selection procedure in this paper, the ideal esteem F_{μ_0} in the fuzzy graph series $\left\{F_{\mu}\right\}$, and the architectural feature of uncertain nodule fuzzy graph can be found.

Keywords: uncertain nodule fuzzy graph; resemblance coefficients; GKT product; entropy measure of uncertainty

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1. INTRODUCTION

Graph theory is an important way to depict many real world problems. However, graphs have its limitation in expressing the systems properly having uncertain parameters. This proble inspired to define fuzzy graphs. Rosenfeld [1] introduced the concept of fuzzy graphs. Since the world is full of uncertainty so the fuzzy graph occurs in every walk of life.

Graph theory is the study of mathematical objects known as graphs, which consist of vertices (or nodes) connected by edges. Graphs come in a wide variety of different sorts. A graph that may contain multiple edges and graph loops is called a pseudograph [2]. Figure 1 represents the various graph images.

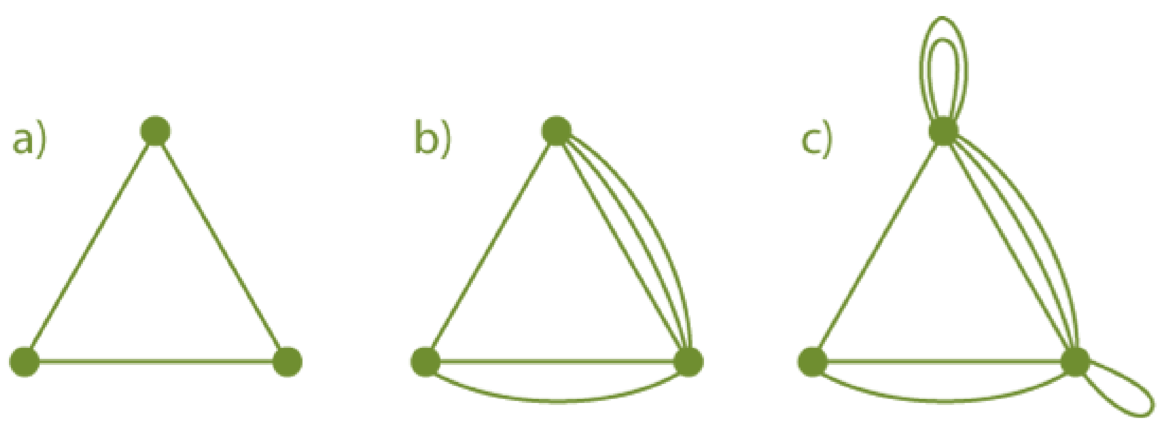

Figure 1: (a) Simple graph, (b) Multigraph and (c) Pseudograph.

The edges of graphs may also be imbibed with directedness. A normal graph in which edges are undirected is said to be undirected [4]. Otherwise, directed [5]. A directed graph in which each edge is given a unique direction is called an oriented graph [6]. A graph or directed graph together with a function which assigns a positive real number to each edge (i.e., an oriented edge-labeled graph) is known as a network [7].

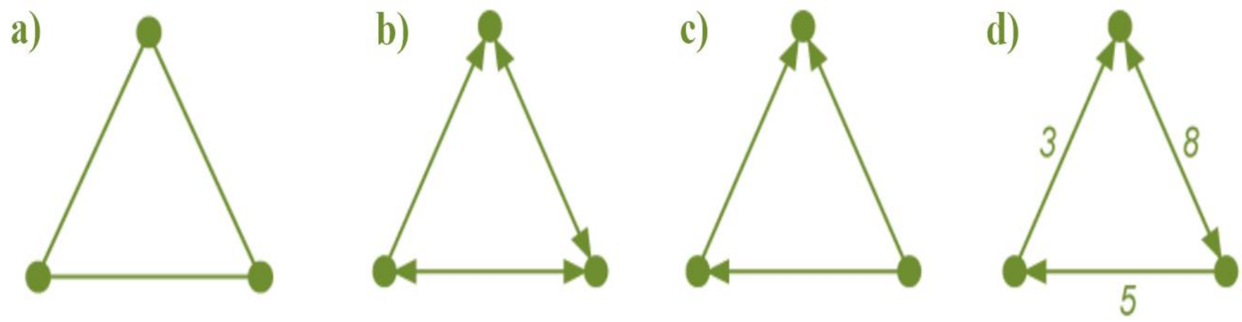

Figure 2: (a) Undirected graph, (b) Directed graph, (c) Oriented graph and (d) Network graph

Fuzzy graphs are very rich topic of applied mathematics, computer science, social sciences, medical sciences, engineering, etc. Fuzzy graph was introduced by Rosenfield in 1975. Fuzzy graphs can be used in traffic light problem, time table scheduling etc. Lots of works on fuzzy graphs have been done by Samanta, Pal, Rashmanlou[8-13] and many others. The operations union, join, Cartesian product and composition on two fuzzy graphs were defined by Mordeson and Peng [14]. Later, Nirmala and Vijaya [15] determined the degree of vertices in the new fuzzy graphs obtained from two fuzzy graphs using the operations Cartesian, tensor, normal product and composition on two fuzzy graphs.

Here in this paper, fuzzy graph theory can be extended and an uncertain nodule fuzzy graph is presented. As the uncertain nodule is difficult to scrutinize, here the uncertain nodule is changed to a simple fuzzy graph utilizing triangular function group. Moreover, the association within the nodules is analyzed by defining uncertain eventuality table.

2. RELATED RESEARCHES

Santisteban and Carcamo [16] stated that similarity measures are necessary to solve many pattern recognition problems. Various similarity measures are categorized in both syntactic and semantic relationships. In this paper we present a new similarity, Unilateral Jaccard Similarity

Coefficient (uJaccard), which doesn't only take into consideration the space among two points but also the semantics among them.

Tao et al. [17] adopted the Geographic Information System (GIS) in this paper, which was used to make the maps of spatial diversity and regionalization of Bambusoideae in County-level of China. The region among genera of Bambusoideae in China was divided into six parts based on similarity coefficient cluster analysis, such as the Tropic-South sub-tropic zone, the south zone, the southeast zone, the Tibet zone, the southwest zone and the Gaoligong mountain zone. The Tropic-South sub-tropic is northward in association with the southwest zone and the Tibet zone by way of the Hengduan Mountain and the western margin of the Sichuan Basin. It is eastward linked to the south zone by the Yangtze River. The Pearl River is an important southern road link between the tropic South sub-tropic zone and the southeast zone.

Ane and partway [18] suggested that facial expression is an essential and impressive means of human contact. This is important connection of information for knowing emotional case and motive. A new study of bit intensity with coefficient feature vector for facial expression recognition proposed in this paper.

Dudarin and Yarushkina [19] presented a novel approach to fuzzy hierarchical clustering of short text fragments in their paper. Nowadays dataset which contains a large and even huge amount of short text fragments becomes quite a common object. Different kinds of short messages, paper or news headers are examples of this kind of objects. Authors have taken another similar object which is a dataset of key process indicators of Strategic Planning System of Russian Federation. In order to reveal structure and thematic variety, fuzzy clustering approach is proposed. Fuzzy graph as a model has been chosen as the most natural view of connected set of words. Finally, hierarchy as a result of clustering obtained as desirable presentation structure of large amount of information.

The above researches recommended the scrutiny of resemblance coefficient is significant in numerous applications. Hence we utilized uncertain nodule fuzzy graph, which is an extension of fuzzy graph theory to scrutinize the resemblance coefficient. As the uncertain nodule is difficult to scrutinize, here the uncertain nodule is changed to a simple fuzzy graph utilizing triangular function group. Moreover, the association within the nodules is analyzed by defining uncertain eventuality table, which is briefly explained in the below section 3.

3. UNCERTAIN NODULE FUZZY GRAPH

Fuzzy graph theory can be extended and an uncertain nodule fuzzy graph is presented. As the uncertain nodule is difficult to scrutinize, here the uncertain nodule is changed to a simple fuzzy graph utilizing triangular function group. Moreover, the association within the nodules is analyzed by defining uncertain eventuality table. In this paper, five topics are discussed, (a) innovative triangular function "GKT product", (b) uncertain nodule fuzzy graph, (c) uncertain eventuality table, (d) entropy measures of uncertainty and (e) selection scrutiny of ideal esteem F_{μ_0} in the fuzzy graph series $\{F_\mu\}$. Through the utilization of uncertain nodule fuzzy graph theory, the innovative triangular function and the uncertain eventuality table, the associational architecture of uncertain data is clarified. Based upon the selection procedure in this paper, the ideal esteem F_{μ_0} in the fuzzy graph series $\{F_\mu\}$, and the architectural feature of uncertain nodule fuzzy graph can be find.

3.1.Triangular function and its group

Triangular function is defined as a binary operation [20] which is represented by:

Description 1 Triangular function is defined as a binary operation

$$a, b \in [0,1] \to T(a,b) \in [0,1]$$

fulfills the succeeding characteristics:

i. Commutability:

$$T(a,b) = T(b,a)$$

ii. Associability:

$$T(a, T(b,c)) = T(T(a,b)c)$$

iii. Monotonability:

$$a \le b, c \le d \Rightarrow T(a,c) \le T(b,d)$$

iv. Edge state of affairs:

$$T(a,0) = 0, T(a,1) = a$$

The characteristic triangular functions are as follows:

i. Rational product:

$$T_R(a,b) = a \wedge b$$

ii. Geometric product:

$$T_G(a,b) = ab$$

iii. Lukaszewicz product:

$$T_L(a,b) = (a + b - 1) \vee 0$$

iv. Harsh product:

$$T_H(a,b) = \begin{cases} 0 & , a \vee b < 1 \\ a \wedge b & , a \vee b = 1 \end{cases}$$

Where $a \vee b$ symbolizes $\max(a,b)$ and $a \wedge b$ symbolizes $\min(a,b)$.

Description 2 Mandate of triangular functions

For 2 triangular functions T_ϕ and T_φ, if the connection

$$T_\phi(a,b) \le T_\varphi(a,b)$$

remains, symbolize the connection with $T_\phi \le T_\varphi$.

To every triangular function T, the connection $T_R \le T \le T_H$ remains always.

Description 3 Triangular function group

To every $\mu \in [a,b]$, while T_μ is triangular function, hence $\{T_\mu\}$ is triangular function which relates T_ϕ with T_φ.

The characteristic triangular function groups are as follows:

A. Dubois product

$$T_\mu(a,b)=\frac{ab}{a\vee b\vee \mu},\mu\in[0,1]$$

B. Weber product

$$T_\mu(a,b)=0\vee\{(1+\mu)(a+b-1)-\mu ab\},\mu\geq -1$$

C. Schweizer product

$$T_\mu(a,b)=\sqrt[\mu]{0\vee(a^2+b^2-1)},\mu>0$$

D. GKT product

$$T_\mu(a,b)=\begin{cases}0 & ,a\vee b<1-\mu \\ a\wedge b & ,a\vee b=1-\mu\end{cases},\mu\in[0,1]$$

and so on.

The connection of characteristic triangular function groups and GKT product can represent as figure 2.

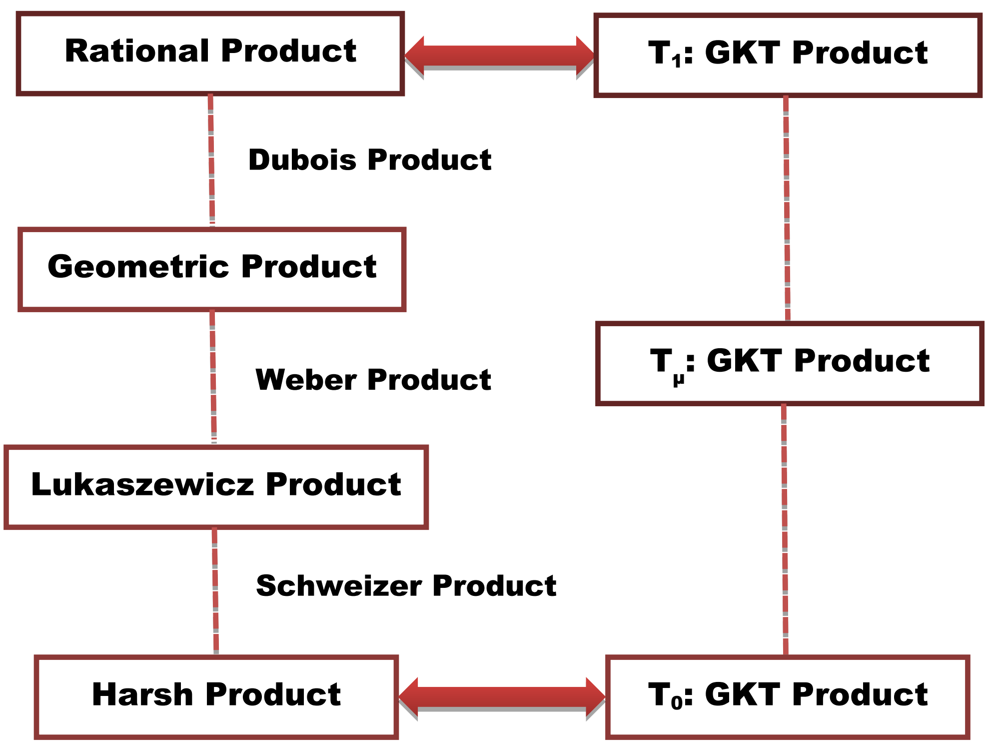

Figure 2: Connection of characteristic triangular function groups

From Figure 1, it can be understanding that Dubois product links “rational product” with “geometric product”, Weber product does “geometric product” with “Lukaszewicz product”, Schweizer product does “Lukaszewicz product” with “drastic product” and GKT product does “rational product” with “harsh product”.

3.1.1 Uncertain nodule fuzzy graph

Description 4 Crunchy nodule fuzzy graph

A crunchy nodule fuzzy graph F [21] can be denoted using

$$F = (U, E) : U = \{u_m\}, E = (e_{mn}), 0 \leq e_{mn} \leq 1$$

Here, U represents a group of nodules and E represents a $r \times r$ matrix. (m, n) constituent e_{mn} of E denotes uncertainty of arc from nodule u_m to nodule u_n.

Description 5 Uncertain nodule fuzzy graph

An uncertain nodule fuzzy graph F [22] can be denoted using

$$F = (U, E) : U = \{v_m / u_m\}, Q = (q_{mn}), 0 \leq v_m, q_{mn} \leq 1$$

Here, U represents a group of nodules and the uncertainty v_m represents the uncertainty of nodule u_m. Q is a $r \times r$ matrix whose (m, n) constituent q_{mn} of E denotes uncertainty of arc from nodule u_m to nodule u_n.

An uncertain nodule fuzzy graph can be demarcated as the uncertainty of the nodules and uncertainty of arcs. Hence, the arrangement of the uncertain nodule fuzzy graph is generally a problematical one.Henceforth the alteration of uncertain nodule fuzzy graph to crunchy nodule fuzzy graph and here a technique for transforming uncertain nodule fuzzy graph to crunchy nodule fuzzy graph is presented.

Description 6 Conversion of uncertain nodule fuzzy graph to crunchy nodule fuzzy graph [22].

An uncertain nodule graph $F = (U, Q)$ is converted to crunchy nodule fuzzy graph $F = (U, Q)$ using the below technique:

Let $F=(U,E):U=\{u_m\},E=(e_{mn}),e_{mn}=T(v_m,q_{mn})$

where the uncertainty e_{mn} of the arc nodule u_m to nodule u_n should be discussed by applying triangular functions.

This uncertain nodule fuzzy graph scrutiny should be smeared to the sociometric scrutiny, guideline scrutiny etc.

3.1.2. Uncertain eventuality table

Description 7 Uncertain eventuality table [23]

Let p and q be two vectors as follows:

$$p=(p_m),q=(q_m),0\le p_m,q_m\le 1,1\le m\le b.$$

Then the uncertain eventuality table of p and q represented consequently:

Table 1: Uncertain eventuality table

$p \setminus q$	1	0	Sum
1	i_{pq}	j_{pq}	$\sum_{h=1}^{r} x_h$
0	k_{pq}	l_{pq}	$r-\sum_{h=1}^{r} x_h$
Sum	$\sum_{h=1}^{r} x_h$	$r-\sum_{h=1}^{r} x_h$	r

$$i_{pq}=\sum_{h=1}^{r} T(p_h,q_h),j_{pq}\ ,j_{pq}=\sum_{h=1}^{r} p_h-i_{pq},$$

$$k_{pq}=\sum_{h=1}^{r} q_h-i_{pq}\ ,l_{pq}=r-\sum_{h=1}^{r} q_h-j_{pq}.$$

Using uncertain eventuality table, resemblance coefficients can be calculated. Certain characteristic resemblance coefficients are

1) Yule

$$r_{pq} = \frac{i_{pq}l_{pq} - j_{pq}k_{pq}}{i_{pq}l_{pq} + j_{pq}k_{pq}}$$

2) Phi

$$r_{pq} = \frac{i_{pq}l_{pq} - j_{pq}k_{pq}}{\sqrt{(i_{pq} + j_{pq})(i_{pq} + k_{pq})(j_{pq} + l_{pq})(k_{pq} + l_{pq})}}$$

3) Ochiai

$$r_{pq} = \frac{i_{pq}}{\sqrt{(i_{pq} + j_{pq})(i_{pq} + k_{pq})}}$$

4) Simpson

$$r_{pq} = \frac{i_{pq}}{\sqrt{(i_{pq} + j_{pq}) \wedge (i_{pq} + k_{pq})}}$$

5) Rogers-Tanimoto

$$r_{pq} = \frac{i_{pq} + l_{pq}}{i_{pq} + 2j_{pq} + 2k_{pq} + l_{pq}}$$

6) Simple Matching

$$r_{pq} = \frac{i_{pq} + l_{pq}}{i_{pq} + j_{pq} + k_{pq} + l_{pq}}$$

7) Russell and Rao

$$r_{pq} = \frac{i_{pq}}{i_{pq} + j_{pq} + k_{pq} + l_{pq}}$$

8) Sorensen-Dice

$$r_{pq} = \frac{2i_{pq}}{2i_{pq} + j_{pq} + k_{pq}}$$

9) Jaccard

$$r_{pq} = \frac{i_{pq}}{i_{pq} + j_{pq} + k_{pq}}$$

etc.

3.1.3Entropy measures of uncertainty

Initially, a function can be defined as

$$S : w \to \Re, w \in W(P)$$

having the below mentioned characteristics [24]:

a) Acuity

$$w(p) = 0 \text{ or } 1 \Leftrightarrow S(w) = 0$$

b) Extremity

$S(w)$ assumes its extreme esteem only if $w(p) \equiv 1/2$.

c) Determination

$$w \prec z \Leftrightarrow S(w) \le S(z)$$

Here, $w \prec z \overset{def}{\Longleftrightarrow} \begin{cases} w(p) \ge z(p), z(p) \ge 1/2 \\ w(p) \ge z(p), z(p) \ge 1/2 \end{cases}$

d) Equilibrium

$$S(w) = S(w^k)\ (w^k = 1 - w)$$

e) Monotonicity

$S(p)$ is monotonically rising over $[0, 1/2]$ and dropping over $[1/2, 1]$.

f) Estimation

$$S(w \vee z) + S(w \wedge z) = S(w) + S(z)$$

The characteristic function is

a. Piecewise linear function

$$D(w) = \begin{cases} 2w, & 0 \le w \le 1/2 \\ 2(1-w), & 1/2 \le w \le 1 \end{cases}$$

b. Quadratic function

$$D(w) = 4w(1-w)$$

c. Shannon function

$$D(w) = -w \log w - (1-w) \log (1-w)$$

Description 8 Entropy of a fuzzy set I

The entropy of I is represented by the summation of functional membership function $\upsilon_I(p_m)$:

$$R(I) = \sum_{m=1}^{r} S(\upsilon_I(p_m))$$

Furthermore, the entropy of the resemblance coefficient is defined using:

Description 9 Entropy of resemblance coefficient

The entropy of resemblance coefficient has been represented as:

$$R(r_{pq}) = \int_0^1 \int_0^1 S(r_{pq})\, dp\, dq$$

For instance,

$$r_{pq} = \frac{i_{pq}}{i_{pq} + j_{pq} + k_{pq}}, T(a,b) = a \wedge b \Rightarrow R(r_{pq}) = 1/2 .$$

3.2. Scrutiny of fuzzy graph

3.2.1Fuzzy graph clustering scrutiny

Fuzzy graph F is represented using

$$F = (U, Q) : U = \{u_m\}, E = (e_{mn})$$

Here, e_{mn} denotes uncertainty of arc nodule u_m to nodule u_n.

For scrutinizing resemblance organization between the nodules present in a graph, equilibrium connection matrix $R = (r_{mn})$.

This equilibrium connection matrix R can be determined through uncertain eventuality table and few resemblance coefficients. Hence an equilibrium connection matrix R can be determined through meek identical resemblance coefficient.

For scrutinizing the clustering organization between nodules, we have its max-min transitive closure $\hat{R} = (\hat{r}_{mn})$ that has been calculated through $\hat{R} = R^r$.

Then, the k-cut matrix R_k for $\hat{R} = (\hat{r}_{mn})$ is defined using,

$$R_k = (r_{mn}^k), r_{mn}^k = \begin{cases} 1, & r_{mn}^k \geq k \\ 0, & r_{mn}^k \leq k \end{cases}, 0 \leq k \leq 1$$

From matrix R_k, the cluster can be defined using $C_{R_k}(m)$.

$$N_k(m) = \{n | r_{mn}^k = 1, 1 \leq n \leq r\}$$

$$C_{R_k}(m) = \{u_n | n \in N_k(m)\}$$

This provides a similarity connection between nodules. Thus the partitioning tree can be constructed by altering the level k of k-cut matrix that denotes the clustering circumstance of nodules in the fuzzy graph [25].

3.2.2. Selection scrutiny of ideal esteem μ_0

Considering the conversion from uncertain nodule fuzzy graph $F=(U,Q)$ to fuzzy graph $F_\mu=(U,Q_\mu)$, uncertain nodule fuzzy graph can be scrutinized through GKT product T_μ.

A series $\{F_\mu\}$ of fuzzy graph has been constructed through transforming the parameter μ. From the series $\{F_\mu\}$, an ideal fuzzy graph F_{μ_0} is selected. After that the procedure for selecting the ideal esteem μ_0 is discussed. For selecting the ideal fuzzy graph F_{μ_0}, two functions $l(\mu)$ and $o(\mu)$ are defined.

Description 10 Length function $l(\mu)$ and connectivity function $o(\mu)$

$$l(\mu)=l\left(E_\mu,R_{k_0}\right)=\frac{1}{r^2-r}\sum_{m=1}^{r}\sum_{n=1}^{r}\left|e_{mn}-r_{mn}^{k_0}\right|$$

$$o(\mu)=o\left(E_\mu\right)=\frac{\chi\left(E_\mu\right)}{r^2-r}$$

Here, $\chi\left(E_\mu\right)=\#\left(\Phi_\mu\right), \Phi_\mu=\left\{e_{mn}^{\mu}\in E_\mu \middle| e_{mn}^{\mu}>0\right\}$.

Also E_μ, R_{k_0} is provide as below:

$$E_\mu=\left(e_{mn}^{\mu}\right),$$

$$e_{mn}^{\mu}=\begin{cases}0 & ,v_m\vee q_{mn}<1-\mu\\ v_m\wedge q_{mn} & ,v_m\vee q_{mn}\geq 1-\mu\end{cases}$$

$$R_{k_0} = \left(r_{mn}^{k_0}\right), r_{mn}^{k_0} = \begin{cases} 1 & \hat{r}_{mn} \geq k_0 \\ 0 & \hat{r}_{mn} < k_0 \end{cases}$$

Here, $l(\mu)$ estimates the characteristics among uncertain nodule fuzzy graph $F_\mu = (U, E_\mu)$ and ideal clustering cut level k_0. If the esteem $l(\mu)$ is high, then F_μ rationally exhibits the characteristics of clustering level k_0. Likewise, $o(\mu)$ estimates the connectivity data of F_μ. If the esteem $o(\mu)$ is high, then F_μ rationally exhibits the characteristics of connectivity data. Then the esteems $l(\mu)$ and $o(\mu)$ are normalized and $e_l(\mu)$ and $e_o(\mu)$ are defined as below:

Description 11 Uncertain Length Function $e_l(\mu)$ and Uncertain Connectivity Function $e_o(\mu)$

$$e_l(\mu) = \frac{l_X - l(\mu)}{l_X - l_x}, e_o(\mu) = \frac{o(\mu) - o_x}{o_X - o_x}$$

Here,

$$l_X = \bigvee_{\mu \in [0,1]} \{l(\mu)\}, \qquad l_x = \bigwedge_{\mu \in [0,1]} \{l(\mu)\},$$

$$o_X = \bigvee_{\mu \in [0,1]} \{o(\mu)\} \text{ and } o_x = \bigwedge_{\mu \in [0,1]} \{o(\mu)\}.$$

Utilizing the extreme selection of uncertain selection, we can rationally identify the ideal esteem μ_0 regarding the series F_{μ_0}.

Description 12 Selection of ideal esteem μ_0

$$e_x(\mu) = e_l(\mu) \wedge e_o(\mu)$$

$$\mu_0 = \wedge \left\{ \mu : e_x(\mu) = \bigvee_{\mu \in [0,1]} e_x(p) \right\}$$

4. CONCLUSION

Fuzzy graph theory can be extended and an uncertain nodule fuzzy graph is presented. As the uncertain nodule is difficult to scrutinize, here the uncertain nodule is changed to a simple fuzzy graph utilizing triangular function group. Moreover, the association within the nodules is analyzed by defining uncertain eventuality table. In this paper, five topics are discussed, (a)innovative triangular function "GKT product", (b) uncertain nodule fuzzy graph, (c) uncertain eventuality table, (d) entropy measures of uncertainty and (e) selection scrutiny of ideal esteem F_{μ_0} in the fuzzy graph series $\{F_\mu\}$. Through the utilization of uncertain nodule fuzzy graph theory, the innovative triangular function and the uncertain eventuality table, the associational architecture of uncertain data is clarified. Based upon the selection procedure in this paper, the ideal esteem F_{μ_0} in the fuzzy graph series $\{F_\mu\}$, and the architectural feature of uncertain nodule fuzzy graph can be find.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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