The Evaluation of Topsis and Fuzzy-Topsis Method for Decision Making System in Data mining

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Abstract - *Due to the growing competition of globalization and fast technological improvements, world markets demand companies to have quality and professional human resources. This can only be achieved by employing potentially adequate personnel. This research presents the fuzzy TOPSIS as the analytical tool that determines the weights of each criterion. Fuzzy theory provides a proper tool to encounter with uncertainties and complex environment. The purpose of this paper is to use the fuzzy TOPSIS method based on fuzzy sets.*

Key Words: Data mining, Decision Making, Fuzzy-Topsis, Topsis.

1. INTRODUCTION

The TOPSIS method was first developed by Hwang and Yoon (Hwang & Yoon, 1981) and ranks the alternatives according to their distances from the ideal and the negative ideal solution, i.e. the best alternative has simultaneously the shortest distance from the ideal solution and the farthest distance from the negative ideal solution. The ideal solution is identified with a hypothetical alternative that has the best values for all considered criteria whereas the negative ideal solution is identified with a hypothetical alternative that has the worst criteria values. In practice, TOPSIS has been successfully applied to solve selection/evaluation problems with a finite number of alternatives [1] because it is intuitive and easy to understand and implement. Furthermore, TOPSIS has a sound logic that represents the rationale of human choice [2] and has been proved to be one of the best methods in addressing the issue of rank reversal. In this paper we extended TOPSIS for KM strategies selection problem because of following reasons and advantages as Shih and his co-operators did for consultant selection problem [3].

- A sound logic that represents the rational of human choice.
- A scalar value that accounts for both the best and worst alternative simultaneously.
- A simple computation process that can be easily programmed into a spreadsheet.
- The performance measures of all alternatives on attributes can be visualized on a polyhedron, at least for any two dimensions.

2. TOPSIS METHOD

A positive ideal solution maximizes the benefit criteria or attributes and minimizes the cost criteria or attributes, whereas a negative ideal solution maximizes the cost criteria or attributes and minimizes the benefit criteria or attributes [3]. The TOPSIS method is expressed in a succession of six steps as follows:

Step 1: Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as follows:

$$r_{ij} = x_{ij} \sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad \text{i =1, 2, ..., m and j = 1, 2, ..., n.}$$

Step 2: Calculate the weighted normalized decision matrix. The weighted normalized value is calculated as follows:

$$v_{ij} = r_{ij} \times w_j \quad \text{i =1, 2,..., m and j = 1, 2, ..., n.} \qquad (1)$$

where w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 3: Determine the ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,...,m\} \qquad (2)$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,...,m\} \qquad (3)$$

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^* = \sqrt{\sum_{j=1}^{m}(v_{ij} - v_j^*)^2},\ j = 1,2,\ldots,m \qquad (4)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m}(v_{ij} - v_j^-)^2},\ j = 1,2,\ldots,m \qquad (5)$$

Step 5: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i with respect to A^* is defined as follows:

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-},\ i = 1,2,\ldots,m \qquad (6)$$

Step 6: Rank the preference order.

3. FUZZY TOPSIS MODEL

The technique called fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) can be used to evaluate multiple alternatives against the selected criteria. In the TOPSIS approach an alternative that is nearest to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values. A detailed description and treatment of TOPSIS is discussed by (TJ, J3) and we have adapted the relevant steps of fuzzy TOPSIS as presented below.

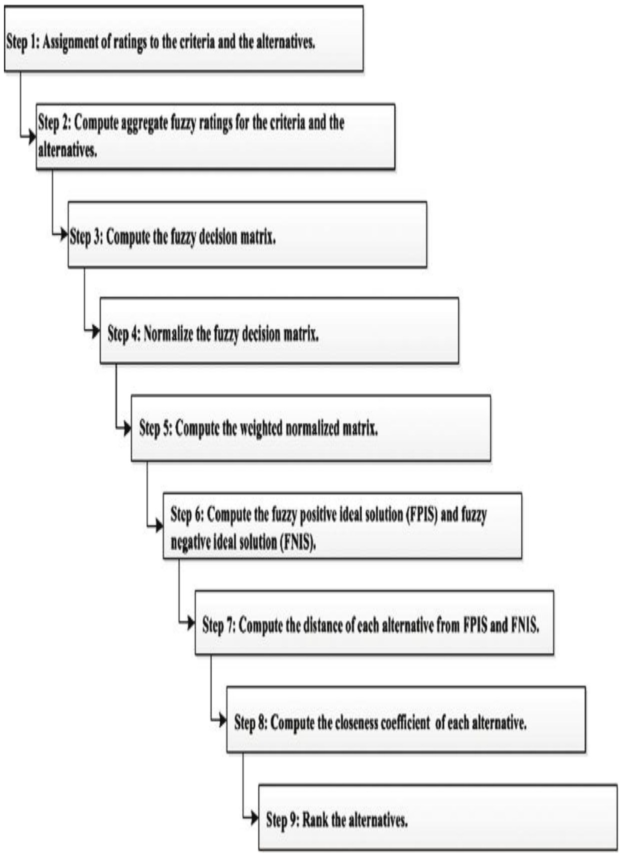

Fig -1: Flow chart of the proposed fuzzy method

The steps of the fuzzy TOPSIS method are following

Step1: In general [18], a typical fuzzy multiple attribute group decision-making problem could be concisely constructed in matrix format as

$$\tilde{\mathbf{D}} = \begin{matrix} & X_1 & X_2 & \cdots & X_n \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{matrix}$$

$$\tilde{w} = (\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n)$$

Where A1,A2,..., Am are possible alternatives to be selected, X1,X2..., Xn denote the evaluation attributes which measure the performance of alternatives, represents the fuzzy performance rating of the ith alternative A_i versus the jth attribute Xj and $\tilde{w}_j$ is the weight of attribute Xj . In this paper, $\tilde{x}_{ij}$; $\tilde{\tilde{x}}_{ij}, \forall i, j$ and $\tilde{w}_j, j$ = 1; 2; : : : ; n are assessed in linguistic terms described by triangular fuzzy numbers, i.e., $\tilde{x}_{ij}$ = (a_{ij}, b_{ij}, c_{ij}), $\tilde{w}_j$ = (w_{j1}, w_{j2}, w_{j3}).

Step2: A group of k experts is established to consider and evaluate the importance weights of the attributes. Supposed that members of the decision group are as follows

$$\mathbf{E} = (E_1, E_2, \ldots, E_k)$$

In addition, different voting power weights are assigned to each group member according to their professional titles, given by

$$\tilde{\lambda} = (\tilde{\lambda}_1, \tilde{\lambda}_2, \ldots, \tilde{\lambda}_k)$$

Where $\tilde{\lambda}_t$ expressed by triangular fuzzy number represents the voting power weight of the tth decision maker.

Step3: The fuzzy collective opinion matrix for all experts can be expressed as

$$\tilde{\mathbf{W}}^* = \begin{matrix} \\ E_1 \\ E_2 \\ \vdots \\ E_k \end{matrix} \begin{matrix} \begin{matrix} X_1 & X_2 & \cdots & X_n \end{matrix} \\ \begin{bmatrix} \tilde{w}^*_{11} & \tilde{w}^*_{12} & \cdots & \tilde{w}^*_{1n} \\ \tilde{w}^*_{21} & \tilde{w}^*_{22} & \cdots & \tilde{w}^*_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{w}^*_{k1} & \tilde{w}^*_{k2} & \cdots & \tilde{w}^*_{kn} \end{bmatrix} \end{matrix}$$

Where $\tilde{w}^*_{tj}$ indicates the fuzzy weight of the jth attribute assessed by the tth evaluator.

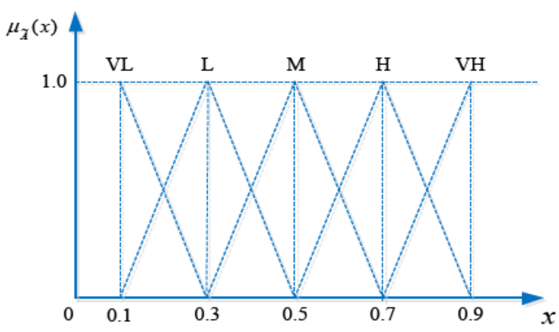

Fig-2. Fuzzy membership function of the linguistic scale

Step4: To integrate all the expert opinions, the following equation is adopted to aggregate the subjective judgements of k experts for obtaining the fuzzy weight $\tilde{w}_j$ of attribute X_j.

$$\tilde{w}_j = \sum_{t=1}^{k} \tilde{\lambda}_t \otimes \tilde{w}^*_{tj}, j = 1, 2, \ldots, n$$

Step5: The normalization of fuzzy decision matrix is performed by applying the linear scale transformation method since it preserves the property that the values of converted triangular fuzzy numbers are within the range [0, 1]. Hence, the normalized fuzzy decision matrix denoted by $\tilde{\mathbf{R}}$ could be identified as

$$\tilde{\mathbf{R}} = [\tilde{r}_{ij}]_{m \times n}, i = 1, 2, \ldots, m; j = 1, 2, \ldots, n$$

$$\tilde{r}_{ij} = \begin{cases} (a_{ij}/c_j^+, b_{ij}/c_j^+, c_{ij}/c_j^+), & j \in J^+ \\ (a_j^-/c_{ij}, a_j^-/b_{ij}, a_j^-/a_{ij}), & j \in J^- \end{cases}$$

Where $c_j^+ = \max_i c_{ij}, a_j^- = \min_i a_{ij},$ J^+ is associated with benefit attributes and J^- is associated with cost attributes.

Step6: The weighted normalized fuzzy decision matrix $\tilde{\mathbf{V}}$ can be computed by multiplying the normalized fuzzy decision element and the aggregative fuzzy weight of each attribute, which is defined as

$$\tilde{\mathbf{V}} = [\tilde{v}_{ij}]_{m \times n}, i = 1, 2, \ldots, m, j = 1, 2, \ldots,$$

Where $\tilde{v}_{ij} = \tilde{w}_j \otimes \tilde{r}_{ij}$ and $\tilde{v}_{ij}, \forall i, j$ are positive triangular fuzzy numbers.

Step. The fuzzy positive ideal solution (FPIS, A^+) and fuzzy negative ideal solution (FNIS, A^-) can be determined as

$$A^+ = \{(\max_i \tilde{v}_{ij} | j \in J^+), (\min_i \tilde{v}_{ij} | j \in J^-)\}$$
$$= \{\tilde{v}_1^+, \tilde{v}_2^+, \ldots, \tilde{v}_j^+, \ldots, \tilde{v}_n^+\}$$

$$A^- = \{(\min_i \tilde{v}_{ij} | j \in J^+), (\max_i \tilde{v}_{ij} | j \in J^-)\}$$
$$= \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_j^-, \ldots, \tilde{v}_n^-\}$$

Considering that the ranges of decision elements $\tilde{v}_{ij}, \forall i, j$ belong to the closed interval [0, 1], it satisfies that $\tilde{v}_{J+}^+ = \tilde{v}_{J-}^- = (1,1,1)$ and $\tilde{v}_{J+}^- = \tilde{v}_{J-}^+ = \tilde{v}_{J-}^+ =$ (0; 0; 0) where J^+ is associated with benefit attributes and J^- is associated with cost attributes.

Step8.: The Euclidean distance method is applied to derive the distance of each alternative from A^+ and A^- respectively as

$$S_{i+} = \sqrt{\sum_{j=1}^{n} d^2(\tilde{v}_{ij}, \tilde{v}_j^+)}, i = 1, 2, \ldots, m$$

$$S_{i-} = \sqrt{\sum_{j=1}^{n} d^2(\tilde{v}_{ij}, \tilde{v}_j^-)}, i = 1, 2, \ldots, m \quad (18)$$

Where $d(\tilde{v}_A, \tilde{v}_B)$ denotes the distance measurement between two triangular fuzzy numbers $\tilde{A}$ and $\tilde{B}$.

Step9: Once the S_{i+} and S_{i-} of each alternative have been calculated successfully, a closeness coefficient is defined to determine the final ranking order of all alternatives which is calculated as

$$C_{i^*} = S_{i-}/(S_{i+} + S_{i-}), 0 < C_{i^*} < 1$$

It is obvious that the alternative A_i is closer to A^+ and farther from A^- as C_{i^*} approaches to 1. Therefore, the ranking order of all alternatives can be obtained according to their closeness coefficients [18].

4. LITERATURE REVIEW

Technique for Order Performance by similarity to Ideal solution (TOPSIS), one of the most classical methods for solving MCDM problem, was first developed by Hwang and Yoon [5]. It is based on the principle that the chosen alternative should have the longest distance from the negative-ideal solution i.e. the solution that maximizes the cost criteria and minimizes the benefits criteria; and the shortest distance from the positive-ideal solution i.e. the solution that maximizes the benefit criteria and minimizes the cost criteria. In classical TOPSIS the rating and weight of the criteria are known precisely. However, under many real situations crisp data are inadequate to model real life situation since human judgments are vague and cannot be estimated with exact numeric values [5]. To resolve the ambiguity frequently arising in information from human judgments fuzzy set theory has been incorporated in many MCDM methods including TOPSIS.

In fuzzy TOPSIS all the ratings and weights are defined by means of linguistic variables. A number of fuzzy TOPSIS methods and applications have been developed in recent years. Chen and Hwang [6] first applied fuzzy numbers to establish fuzzy TOPSIS. Triantaphyllou and Lin [15] developed a fuzzy TOPSIS method in which relative closeness for each alternative is evaluated based on fuzzy arithmetic operations. Liang [13] proposed Fuzzy MCDM based on ideal and anti-ideal concepts. Chen [11] considered triangular fuzzy numbers and defined crisp Euclidean distance between two fuzzy numbers to extend the TOPSIS method to fuzzy GDM situations. Chen and Tsao [8] are to extend the TOPSIS method based on Interval-valued fuzzy sets in decision analysis. Jahanshahloo et al. [12] and Chu and Lin [9] extended the fuzzy TOPSIS method based on alpha level sets with interval arithmetic. Chen and Lee [7] extended fuzzy TOPSIS based on type-2 fuzzy TOPSIS method in order to provide additional degree of freedom to represent the uncertainties and fuzziness of the real world.

Fuzzy TOPSIS has been introduced for various multi-attribute decision-making problems. Yong [14] used fuzzy TOPSIS for plant location selection and Chen et al. [10] used fuzzy TOPSIS for supplier selection. Kahraman et al. [17] utilized fuzzy TOPSIS for industrial robotic system selection. Wang and Chang [16] applied fuzzy TOPSIS to help the Air Force Academy in Taiwan choose optimal initial training.

5. CONCLUSION

The expanding competitiveness due to the globalization has dramatically increased the need for manufacturers to produce high-quality products efficiently and respond to changes quickly. Flexible manufacturing systems provide the means to arrive at a solution consistent with industrial goals and objectives. To help address the issue of evaluation and selection of alternative FMSs where the information available is subjective and imprecise, an effective fuzzy- TOPSIS method applied in the group decision-making model is developed. This model is intended to enhance group decision-making, promote consensus and provide invaluable analysis aids. The paper presents study explored the use of TOPSIS and fuzzy TOPSIS method.

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