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Personnel Evaluation and Selection using a Generalized Fuzzy Multi-Criteria Decision Making

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Abstract: This study proposes an extension of fuzzy Multi-Criteria Decision Making (MCDM) method for supporting the personnel selection and evaluation process. In the proposed MCDM method, the ratings of various alternatives versus various subjective criteria and the weights of all criteria are assessed in linguistic terms represented by generalized fuzzy numbers. Then, the weighted fuzzy decision matrix is derived by arithmetic of generalized fuzzy numbers. To make the procedure easier and more practical, the weighted ratings are defuzzified into crisp values by using the most popular ranking approach based on centroid index. Finally, this study applies the proposed fuzzy MCDM method to solve a lecturer selection and evaluation problem, demonstrating its applicability and computational process.

Key words: Fuzzy MCDM, personnel selection and evaluation, centroid index, computational process, defuzzified

INTRODUCTION

Personnel recruitment and selection play a decisive role for finding the sufficient input quality for an organization. In the organization, the personnel defined as capability, knowledge, skill and other abilities (Aksakal *et al*., 2013). Personnel selection is the process of choosing individuals who match the qualifications required to perform a defined job in the best possible way (Dursun and Karsak, 2010). To select the most suitable personnel, many individual attributes, i.e., organizing ability, creativity, personality and leadership, must be considered in selection process (Chien and Chen, 2008). Therefore, personnel selection can be viewed as a Multi-Criteria Decision Making Problem (MCDM). The MCDM approaches for personnel selection is able to incorporate qualitative as well as quantitative data.

Personnel selection is a highly complex and messy problem in real life. It is complex problem because there is uncertainty regarding the outcomes of any choice. It is messy problem because it requires systematic integration of multiple evaluation criteria of the various decision makers involved in the personnel selection process. In addition, several issues need to identify in the personnel selection process including: identify the importance weights of criteria; evaluate the applicants under multiple criteria using linguistic values aggregate the evaluation results and then rank the applicants (Lin, 2010).

In many situations, individuals mostly prefer to express their feelings with verbal expression and they may make accurate guesses in qualitative forecasting (Gungor *et al*., 2009). The fuzzy set theory appears as an essential tool to provide a decision framework that incorporates imprecise judgments inherent in the personnel selection process. Because of the imprecise expressions, a fuzzy multi-criteria approach is commonly used in decision problems.

Numerous studies in the literature have applied MCDM techniques for personal selection. Kundakci (2016) proposed grey relational analysis for employee selection to overcome the drawbacks of the traditional methods. In order to show the applicability of this method, it was applied to the personnel selection process of a technology firm. Candidates that apply for software engineer position were evaluated based on twelve decision criteria. These evaluation criteria were determined based on the personality inventory that the firm applies to the candidates. Saad *et al*. (2014) proposed Hamming distance method to solve personnel selection process. The linguistic terms correspondence to triangular fuzzy numbers were used to evaluate the performance rating values as well as the weight of the criteria in which later will be expressed into interval valued fuzzy numbers. Khorami and Ehsani (2015) reviewed recent advances on the application of MCDM methods for personnel selection problem. The authors have indicated that the literature on the application of MCDM techniques for personnel selection problems has been growing increasingly and it also seems that usage of fuzzy decision making and hybrid approaches would increase within next future years. Bali *et al.* (2013) developed a group multi attribute decision making method using Delphi technique based on intuitionistic fuzzy sets in sensitivity of experts to exploit the uncertainty and to take account of decision maker's importance for each attribute in the PS problem. The proposed method was applied in the case of company that manufactures batteries for vehicles was established in central Turkey. The results showed that taking into account weights of decision makers for each attribute affect the result of the process of personnel selection.

Rouyendegh and Erkart (2012) examined a Fuzzy Analytic Hierarchy Process (FAHP) for selecting the most suitable academic staff where five candidates under ten different sub-criteria are evaluated and prioritised. Kabak *et al.* (2012) adapted a fuzzy hybrid MCDM including Fuzzy Analytic Network Process (FANP) a Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) and ELECTRE, to personnel selection, i.e., sniper selection problem. Dursun and Karsak (2010) developed a fuzzy MCDM algorithm for personnel selection using the principles of fusion of fuzzy information, 2-tuple linguistic representation model and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is developed. An intuitionistic fuzzy multi-criteria group decision making method with Grey Relational Analysis (GRA) is proposed for personnel selection (Zhang and Liu, 2011). Kelemenis and Askounis (2010) proposed a new TOPSIS-based multi-criteria approach to personnel selection. Dursun and Karsak (2010) developed a fuzzy MCDM algorithm for personnel selection using the principles of fusion of fuzzy information, 2-tuple linguistic representation model and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is developed. Gungor *et al.* (2009) applied fuzzy Analytic Hierarchy Process (AHP) to evaluate the best adequate personnel dealing with the rating of both qualitative and quantitative criteria.

In this study, a generalized fuzzy MCDM approach is developed to support for personnel selection and evaluation process. In the proposed approach, the ratings of alternatives and importance weights of criteria for personnel selection are represented by generalized triangular fuzzy numbers. Then, the membership functions of the final fuzzy evaluation value in the proposed approach are developed based on the linguistic expressions. Next, the efficient ranking approach proposed by Dat *et al.* (2012) is applied to determine the ranking order of alternatives. Finally, this study applies the proposed generalized fuzzy MCDM to a university academic staff evaluation and selection problem demonstrating its advantages and applicability.

MATERIALS AND METHODS

Preliminaries: This study briefly reviews some basic concepts of fuzzy numbers and generalized fuzzy numbers as follows.

Basic concepts of generalized fuzzy numbers: Based on Chen (1985), Hsieh and Chen (1999), a generalized trapezoidal fuzzy number A can be represented by A = (a, b, c, d; w where $0<w\leq 1$ and and d are real numbers. Figure 1 is shown the generalized trapezoidal fuzzy number. The membership function f_A of the generalized trapezoidal fuzzy numbers satisfies the following conditions:

- f_A is a continuous mapping from R to the closed interval [0, w], $0\leq w\leq 1$
- $f_A(x) = 0$ for all $x\in[-\infty, a]$
- f_A is strictly increasing on $0<w\leq 1[a, b]$
- $f_A(x) = w$, for all $x\in[b, c]$
- f_A is strictly decreasing on (a, b)
- $f_A(x) = 0$, for all $x\in[d, \infty]$

In Fig. 1, if w = 1 then the generalized trapezoidal fuzzy number A is called a normal trapezoidal fuzzy number and denoted as A = (a, b, c; 1). If a = b and c = d then A is called a crisp interval. If $a<b = c<d$ then A becomes a generalized triangular fuzzy number and can be denoted by A = (a, b, d; w) or A = (a, b, d; 1) if w = 1. If a = b = c = d and w = 1 then A is called a crisp value.

Arithmetic operations on generalized fuzzy numbers: Chen (1985) presented arithmetical operations between generalized trapezoidal fuzzy numbers based on the extension principle. Let A and B are two generalized trapezoidal fuzzy numbers, i.e., $A = (a_1, a_2, a_3, a_4; w_A)$ and $B = (b_1, b_2, b_3, b_4; w_B)$, where a_1-a_4, b_1-b_4 are real values, $0\leq w_A\leq 1$ and $0\leq w_B\leq 1$. Some arithmetic operators between the generalized fuzzy numbers A and B are defined as follows; generalized trapezoidal fuzzy numbers addition (+):

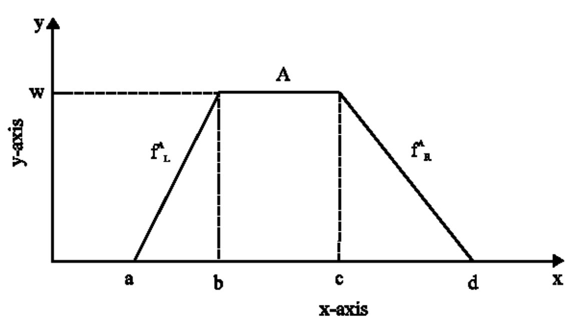

Fig. 1: A generalized trapezoidal fuzzy number

$$\begin{aligned} A(+)B &= (a_1, a_2, a_3, a_4; w_A)\ (+)\ (b_1, b_2, b_3, b_4; w_B) \\ &= (a_1+b_1, a_2+b_2, a_3+b_3, a_4+b_4; \min(w_A, w_B)) \end{aligned} \quad (1)$$

where, a_1-a_4, b_1-b_4 are real values. Generalized trapezoidal fuzzy numbers subtraction (-):

$$\begin{aligned} A(-)B &= (a_1, a_2, a_3, a_4; w_A)\ (-)\ (b_1, b_2, b_3, b_4; w_B) \\ &= (a_1-b_4, a_2-b_3, a_3-b_2, a_4-b_1; \min(w_A, w_B)) \end{aligned} \quad (2)$$

where, a_1, a_2, a_3, a_4, b_1, b_2, b_3 and b_4 are real values. Generalized trapezoidal fuzzy numbers multiplication (×):

$$A(\times)B = (a, b, c, d; \min(w_A, w_B))$$

Where:

$a = \text{Min}(a_1{\times}b_1, a_1{\times}b_4, a_4{\times}b_1, a_4{\times}b_4)$
$b = \text{Min}(a_2{\times}b_2, a_2{\times}b_3, a_3{\times}b_2, a_3{\times}b_3)$
$c = \text{Min}(a_2{\times}b_2, a_2{\times}b_3, a_3{\times}b_2, a_3{\times}b_3)$
$d = \text{Min}(a_1{\times}b_1, a_1{\times}b_4, a_4{\times}b_1, a_4{\times}b_4)$

It is obvious that if a_1, a_2, a_3, a_4, b_1, b_2, b_3 and b_4 are all positive real numbers, then:

$$A(\times)B = (a_1{\times}b_1, a_2{\times}b_2, a_3{\times}b_3, a_4{\times}b_4; \min(w_A, w_B) \quad (3)$$

Generalized trapezoidal fuzzy numbers division (/): the inverse of the fuzzy number B is $1/B = (1/b_4, 1/b_3, 1/b_2, 1/b_1; w_B)$ where b_1-b_4 are non-zero positive numbers or all non-zero negative real numbers. Let a_1-a_4, b_1-b_4 be non-zero positive real numbers. Then, the division of A and B is as follows:

$$\begin{aligned} A(/)B &= (a_1, a_2, a_3, a_4; w_A)(/)(b_1, b_2, b_3, b_4; w_B) \\ &= (a_1/b_4, a_2/b_3, a_3/b_2, a_4/b_1; \min(w_A, w_B)) \end{aligned} \quad (4)$$

α-cuts of fuzzy numbers: The α-cuts of fuzzy number A can be defined as: $A^\alpha = \{x | f_A(x) \geq \alpha\}$, $\alpha \in [0, 1]$ where, A^α is a non-empty bounded closed interval contained in R and can be denoted by $A^\alpha = [A^\alpha_l, A^\alpha_u]$ where A^α_l and A^α_u are its lower and upper bounds, respectively (Zimmermann, 1991). For example, if a triangular fuzzy number A = (a, b, d) then the α-cuts of A can be expressed as:

$$A^\alpha = \left[A^\alpha_l, A^\alpha_u\right] = \left[(b\text{-}a)a\text{+}a, (b\text{-}d)\alpha\text{+}d\right] \quad (5)$$

Arithmetic operations on fuzzy numbers: Given fuzzy numbers A and B, where $A^\alpha = [A^\alpha_l, A^\alpha_u] = [(b\text{-}a)\alpha\text{+}a, (b\text{-}d)\alpha\text{+}d]$ the α-cuts of A and B are $A^\alpha = [A^\alpha_l, A^\alpha_u]$ and $B^\alpha = [B^\alpha_l, B^\alpha_u]$, respectively. By the interval arithmetic, some main operations of A and B can be expressed as follows:

$$(A \oplus B)^\alpha = \left[A^\alpha_l + B^\alpha_l, A^\alpha_u + B^\alpha_u\right] \quad (6)$$

$$(A \Theta B)^\alpha = \left[A^\alpha_l - B^\alpha_u, A^\alpha_u - B^\alpha_l\right] \quad (7)$$

$$(A \otimes B)^\alpha = \left[A^\alpha_l \cdot B^\alpha_l, A^\alpha_u \cdot B^\alpha_u\right] \quad (8)$$

$$(A \varnothing B)^\alpha = \left[A^\alpha_l / B^\alpha_u, A^\alpha_u / B^\alpha_l\right] \quad (9)$$

$$(A \otimes r)^\alpha = \left[A^\alpha_l \cdot r, A^\alpha_u \cdot r\right], r \in R^+ \quad (10)$$

Proposed a generalized fuzzy MCDM approach: This study develops a generalized fuzzy MCDM approach for supporting the personnel selection and evaluation selection process by the following procedure.

Aggregate ratings of alternative versus criteria: Assume that a committee of l decision makers (M_t, t = 1, ..., l) is responsible for evaluating m alternatives (A_i, i = 1, ..., m) under n selection criteria (C_j, j = 1, ..., n). A fuzzy MCDM problem can be concisely expressed in matrix format as:

$$M_t = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \end{array} \begin{array}{c} C_1\ C_2\ \cdots\ C_j \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} \\ x_{21} & x_{22} & \cdots & x_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} \end{bmatrix} \end{array}$$

Let $x_{ijt} = (a_{ijt}, b_{ijt}, c_{ijt}; \varpi_{ijt})$, i = 1, ..., m, j = 1,..., h, t = 1, ..., 11 be the suitability rating assigned to alternative A_i by decision maker M_t for subjective C. $_j$The averaged suitability rating, $x_{ij} = (a_{ij}, b_{ij}, c_{ij}; \varpi_{ij})$ can be evaluated as:

$$x_{ij} = \frac{1}{1} \otimes (x_{ij1} \oplus x_{ij2} \oplus \ldots \oplus x_{ijt} \oplus \ldots \oplus x_{ijl}) \quad (11)$$

Where:

$$a_{ij} = \frac{1}{1}\sum_{t=1}^{l} a_{ijt}, b_{ij} = \frac{1}{1}\sum_{t=1}^{l} b_{ijt}, c_{ij} = \frac{1}{1}\sum_{t=1}^{l} c_{ijt}$$

And:

$$\varpi_{ij} = \min \varpi_{ijt}$$

Aggregate the importance weights: Let $w_{jt} = (o_{jt}, p_{jt}, q_{jt}; \varpi_{jt} \in R^*$, j = 1, ..., n, t = 1, ..., l be the weight assigned by decision maker M_t to criterion M_t. The average weight, .., of criterion C_j assessed by the committee of l decision makers can be evaluated as:

$$w_j = (1/l) \otimes (w_{j1} \oplus w_{j2} \oplus ... \oplus w_{jl}) \quad (12)$$

Where:

$$o_j = (1/l)\sum_{t=1}^{k} o_{jt}, p_j = (1/l)\sum_{t=1}^{k} p_{jt}, q_j = (1/l)\sum_{t=1}^{k} q_{jt}$$

And:

$$\varpi_j = \min \varpi_{jt}$$

Construct the weighted normalized fuzzy decision matrix: Considering the different weight of each criterion, the weighted decision matrix can be computed by multiplying the importance weights of evaluation criteria and the values in the fuzzy decision matrix. The weighted decision matrixes G_i are defined as:

$$G_i = \left(\frac{1}{n}\right)\sum_{j=1}^{n} r_{ij} \otimes w_j, i = 1, ..., m; j = 1, ..., n \quad (13)$$

Defuzzification: This study applies an efficient ranking approach proposed by Dat *et al*. (2012) to defuzzify the weighted decision values of each alternative. The ranking procedure by Dat *et al*. (2012) method is described as follows: Consider a fuzzy number A, the centroid point $(\bar{x}_A, \bar{y}_A)$ is as defined:

$$\bar{x}_A = \frac{\int_{-\infty}^{\infty} xA(x)dx}{\int_{-\infty}^{\infty} A(x)dx} \quad (14)$$

$$\bar{y}_A = \frac{\int_0^w \alpha|A^\alpha|d\alpha}{\int_0^w |A^\alpha|d\alpha} \quad (15)$$

Where:

$$\sup_{x \in R} A(x) = \varpi$$

and $|A^\alpha|$ is the length of the α-cut A^α, $0>\alpha\leq 1$ and $|A| = A^\alpha_u - A^\alpha_l$. If A is a crisp set with $A(x_0) = \varpi$ and $A(x) = 0$ if $x\neq x$, then its centroid point is defined by (x_0, ϖ). For a trapezoidal fuzzy number A (a, b, c;ϖ) the centroid point $(\bar{x}_A, \bar{y}_A)$ is defined as:

$$\bar{x}_0(A) = \frac{1}{3}\left[a+b+c+d-\frac{dc-ab}{(d+c)-(a+b)}\right] \quad (16)$$

$$\bar{y}_0(A) = \frac{\varpi}{3}\left[1+\frac{c-b}{(d+c)-(a+b)}\right] \quad (17)$$

Then, the centroid-index is determined as follows. Suppose A_1, A_2, ..., A_n are fuzzy numbers. First, the centroid points of all fuzzy numbers are calculated $A_i = (\bar{x}_{A_i}, \bar{y}_{A_i}), i = 1, 2, ..., n$. Then, G = (x_{min}, y_{min}) is defined such that $x_{min} = \inf S$, $S = U^n_{i=1} S_i$, $S_i = \{x|f_{Ai}(x)>0\}$, y_{min} = in f Y, $Y = U^n_{i=1} Y_i$, $Y_i = \{y|0<Y_{Ai}(x)\leq\varpi\}$. The distance between the centroid poin $A_i = (x_{A_i}, \bar{y}_{A_i}), i = 1, 2, ..., n$ and the minimum point G = x_{min}, y_{min} is presented as follows:

$$D(A_i, G) = \sqrt{(\bar{x}_{A_i} - x_{min})^2 + (\bar{y}_{A_i} - \frac{\varpi}{3} y_{min})^2} \quad (18)$$

Obtain the ranking values: In this study, Dat *et al*. (2012) ranking method is applied to defuzzify all the final fuzzy evaluation values G_i. From Eq. 13-18 the centroid point, minimum point and the distance between the centroid point and the minimum point of each alternative are determined. The ranking index D(A_i, G) determines the ranking order of alternatives. The greater the D (A_i, G) the bigger the fuzzy number A_i and the higher its ranking order.

RESULTS AND DISCUSSION

Application for teaching staff's performance evaluation problem: In this study, the proposed generalized fuzzy MCDM approach is applied to evaluate and select the academic staffs at Hanoi University of Natural Resources and Environment (HUNRE). HUNRE which has a training tradition over 60 years is a multidiscipline university with the task of training qualified human resources for state administration in natural resources and environment sector at different levels from central, localities, businesses to communities. Recently, HUNRE has 12 faculties, 03 departments, 09 functional departments, 08 centers and 01 clinic with over 11,000 students at different levels.

Suppose that HUNRE needs to evaluate and sort their teaching staff's performance. After preliminary screening, five candidates, namely A_1, ..., A_4 and A_5 are chosen for further evaluation. A committee of three decision makers from HUNRE's Board of management and office of Human resources, i.e., D_1-D_3 conducts the evaluation and selection of the five candidates. Based on literature (Centra, 1977; Wood, 1990; Dursun and Karsak, 2010) and discussions with managers, nine selection criteria are considered including number of publications (C_1) quality of publications (C_2) personal qualification (C_3) personality factors (C_4) activity in professional society (C_5) classroom teaching (C_6) student advising (C_7) research and/or creative activity (independent of publication) (C_8) and fluency in a foreign language (C_9). The computational procedure is summarized as follows:

Table 1: The linguistic ratings evaluated by decision makers

		Decision makers			
Criteria	Candidates	D_1	D_2	D_3	R_{ij}
C_1	A_1	G	G	F	(0.500, 0.700, 0.767; 0.8)
	A_2	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_3	G	VG	G	(0.667, 0.833, 0.900; 0.9)
	A_4	G	F	G	(0.500, 0.700, 0.800; 0.8)
	A_5	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_6	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_7	G	VG	G	(0.667, 0.833, 0.900; 0.9)
	A_8	F	F	F	(0.300, 0.500, 0.633; 0.8)
	A_9	G	VG	G	(0.667, 0.833, 0.900; 0.9)
	A_{10}	G	F	G	(0.500, 0.700, 0.800; 0.8)
C_2	A_1	G	F	G	(0.500, 0.700, 0.800; 0.8)
	A_2	G	F	G	(0.500, 0.700, 0.800; 0.8)
	A_3	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_4	F	F	F	(0.300, 0.500, 0.633; 0.8)
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	A_8	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_9	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_{10}	F	F	G	(0.400, 0.600, 0.733; 0.8)
C_4	A_1	VG	VG	G	(0.733, 0.867, 0.933; 0.9)
	A_2	G	F	F	(0.400, 0.600, 0.700; 0.8)
	A_3	G	G	VG	(0.667, 0.833, 0.900; 0.9)
	A_4	G	F	G	(0.500, 0.700, 0.800; 0.8)
	A_5	G	G	G	(0.600, 0.800, 0.867; 0.9)
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	A_7	G	F	G	(0.500, 0.700, 0.800; 0.8)
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	A_3	F	F	G	(0.400, 0.600, 0.733; 0.8)
	A_4	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_5	G	F	G	(0.500, 0.700, 0.800; 0.8)
	A_6	F	G	F	(0.400, 0.600, 0.700; 0.8)
	A_7	G	VG	G	(0.667, 0.833, 0.900; 0.9)
	A_8	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_9	G	G	G	(0.600, 0.800, 0.867; 0.9)
	A_{10}	F	G	G	(0.500, 0.700, 0.800; 0.8)

Step 1: Aggregate ratings of alternatives versus criteria. Three decision makers use the linguistic rating set S = { VP, P, F, G, VG} where VP = Very Poor = (0.0, 0.0, 0.2; 0.6), P = Poor = (0.1, 0.3, 0.5; 0.7), F = Fair = (0.3, 0.5, 0.7; 0.8), G = Good = (0.6, 0.8, 0.9; 0.9) and VG = Very Good = (0.8, 0.9, 1.0; 1.0) to evaluate the suitability of the candidates under each criteria.

Using Chen's arithmetic operations, the aggregated suitability ratings of ten candidates, i.e., A_1, ..., A_{10} versus nine criteria, i.e., C_1, ..., C_9 from three decision makers can be obtained as shown in Table 1-3.

Step 2: Aggregate the importance weights. After the determination of the teaching staff's performance criteria, each of the three participants established the level of each criteria by means of a linguistic varibale. An important weight set of Q was used to express opinions on the criteria: Q = {UI, OI, I, VI, AI} where UI = Unimportant = (0.0, 0.0, 0.3; 0.7), OI = Ordinary Important = (0.2, 0.3, 0.4; 0.8), I = Important = (0.3, 0.5, 0.7; 0.8), VI = Very Important = (0.6, 0.8, 0.9; 0.9) and AI = Absolutely Important = (0.8, 0.9, 1.0; 1.0). Table 4 displays the importance weights of nine criteria from the three decision-makers. Using Chen's and proposed arithmetic operations, the aggregated weights of criteria from the decision making committee can be obtained as presented in Table 4.

Step 3: Determine the weighted fuzzy decision matrix. This matrix can be obtained by multiplying each aggregated rating by its associated fuzzy weight using Chen's Arithmetic Operation of generalized fuzzy numbers. Table 5 shows the weighted ratings of each candidate.

Table 2: The importance weights of the criteria evaluated by decision makers

	Decision makers			
Criteria	D_1	D_2	D_3	w_{ij}
C_1	VI	AI	VI	(0.667, 0.833, 0.933; 0.9)
C_2	VI	VI	VI	(0.600, 0.800, 0.900; 0.9)
C_3	I	VI	I	(0.400, 0.600, 0.767; 0.8)
C_4	VI	VI	I	(0.500, 0.700, 0.833; 0.8)
C_5	VI	AI	VI	(0.667, 0.833, 0.933; 0.9)
C_6	AI	AI	VI	(0.733, 0.867, 0.967; 0.9)
C_7	I	VI	VI	(0.500, 0.700, 0.833; 0.8)
C_8	I	VI	VI	(0.500, 0.700, 0.833; 0.8)
C_9	I	I	I	(0.300, 0.500, 0.700; 0.8)

Table 3: Weighted ratings of each candidate

Candidates	G_i
A_1	(0.309, 0.550, 0.717; 0.8)
A_2	(0.311, 0.552, 0.721; 0.8)
A_3	(0.316, 0,556, 0,721; 0,8)
A_4	(0,302, 0.539, 0.711; 0.8)
A_5	(0.285, 0.526, 0.690; 0.8)
A_6	(0.269, 0.500, 0.670; 0.8)
A_7	(0.283, 0.516, 0.681; 0.8)
A_8	(0.275, 0.510, 0.679; 0.8)
A_9	(0.332, 0.578, 0.745; 0.8)
A_{10}	(0.289, 0.526, 0.694; 0.8)

Table 4: Distance between the centroid point and the minimum point of each candidate

Candidates	Distances	Ranking order
A_1	0.045	4
A_2	0.048	3
A_3	0.051	2
A_4	0.037	5
A_5	0.021	6
A_6	0.000	10
A_7	0.014	8
A_8	0.008	9
A_9	0.072	1
A_{10}	0.023	7

Step 4: Defuzzification; using Dat *et al.* (2012)'s ranking method, the distance between the centroid point and the minimum point can be obtained as shown in Table 6. Using proposed method the ranking order of the ten candidates by is:

$$A_9 \succ A_3 \succ A_2 \succ A_1 \succ A_4 \succ A_5 \succ A_{10} \succ A_7 \succ A_8 \succ A_6$$

The best selection is candidate A_9 having the largest distance.

CONCLUSION

Personnel selection and evaluation problem is the MCDM problem that is affected by several criteria. This study proposed the generalized fuzzy MCDM model to solve the personnel selection and evaluation problem. In the proposed approach, the ratings of alternatives and relative importance weights of criteria for are expressed in linguistic values which are represented by the generalized triangular fuzzy numbers. To avoid complicated calculations of generalized fuzzy numbers, the weighted ratings were defuzzified into crisp values by using the most recent centroid-index ranking approach to determine the ranking order of alternatives. An application was given to illustrate the applicability of the proposed approach. The results indicate that the proposed generalized fuzzy MCDM approach is practical and useful. The proposed approach can also be applied to other management problems under similar settings.

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