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Multi Criteria Decision-Making Method Using Expected Values in Triangular Hesitant Fuzzy Set

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ABSTRACT

This paper extends hesitant fuzzy sets to Triangular Hesitant Fuzzy sets based on the combination of the concepts of triangular fuzzy numbers and hesitant fuzzy sets and defines some operations on triangular hesitant fuzzy sets. Then, a decision-making method with linguistic assessments is proposed based on expected values of triangular hesitant fuzzy sets to solve the multi criteria decision-making problem in which the criteria weights are completely unknown and the criteria values for an alternative can be given by the linguistic values of triangular fuzzy numbers provided by a group of decision makers to transform them into triangular hesitant fuzzy sets. The criteria weights can be obtained by establishing a weight model based on the standard deviation of expected values from the triangular hesitant fuzzy decision matrix. Then by an approach of weighted expected values for alternatives, the ranking order of all the alternatives can be determined and the best one can be easily identified as well. Finally, a practical example the health hazard of traffic police is analysed to demonstrate the application of the proposed decision-making method.

Keywords:- Triangular Hesitant Fuzzy Set, Triangular Fuzzy Number, Expected Value, Multi criteria Decision Making

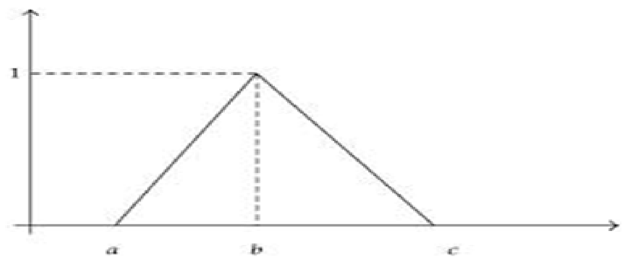
1.INTRODUCTION

Multi criteria decision making is an important part of modern decision science. It has been extensively applied to various areas, like in engineering, social sciences, medical sciences, and economics etc. In many real-world situations, the decision maker cannot provide deterministic alternative values but fuzzy numbers instead. This kind of uncertainty in multi criteria decision making can be modelled using fuzzy set theory and is ideally suited for solving these problems. Since Bellman and Zadeh [1] initially proposed the basic model of fuzzy decision making based on the theory of fuzzy mathematics, fuzzy multi criteria decision making has been receiving more and more attention from researchers. As a generalization of a fuzzy set, Torra [8] proposed the concept of a hesitant fuzzy set. Hesitant fuzzy sets can reflect the original information given by the decision makers as much as possible and the more values obtained from the decision makers or experts, which belong to [0, 1]. Therefore, the hesitant fuzzy set can be regarded as a more comprehensive set, which supports a more flexible approach when the decision makers provide their judgments. It is useful to deal with all the possible values provided by assessments of each alternative with respect to each criterion, which can arise in multi criteria decision-making problems. Therefore, hesitant fuzzy theory has been extensively applied to various areas

Triangular fuzzy number:

A triangular fuzzy number A can be defined as a triplet (a,b,c)and the membership function $\mu_A(x)$ is defined as

$$\mu_A(x)=\begin{cases} 0 & x < a \\ \frac{x-a}{b-a} & a \le x \le b \\ \frac{c-x}{c-b} & b \le x \le c \\ 0 & x > c \end{cases}$$



Linguistic Variable

Fuzzy set theory was introduced by Lofit Zadeh(1965) is an efficient way to model uncertainty and imprecision in terms of linguistic variable. Linguistic variable is a variable whose values are not numbers but words or sentences in a natural or artificial language. Using linguistic values (words or sentences) expresses less specific than numerical ones but it is closely related to the way that humans express and use their knowledge. In order to deal with the uncertainty and vagueness in the linguistic evaluation, many researchers have applied Fuzzy set theory to convert linguistic variable to fuzzy number.

2. BASIC CONCEPTS OF HESITANT FUZZY SETS

Naukara and torra have developed the concept of hesitant fuzzy set which is defined as follows

Definition: Let X be a fixed set, a hesitant fuzzy set on X is in terms of a function that when applied to X returns a subset of [0,1],which can be represented as

$$A = \{(x, h_A(x))/x \in X\}$$

Where $h_A(x)$ is the set of some values in [0,1],denoting the possible membership degrees of the element $x \in X$ to the set A .For convenience we call h a hesitant fuzzy element(HFE)

Basic operations on HFE:

For HFE h, Xia and Xu [11] developed some operations as follows:

Suppose h, h_1, h_2 are hesitant fuzzy elements and $\lambda > 0$ be a scalar then

1. $h^\lambda = \cup_{\gamma \in h}\{\gamma^\lambda\}, \lambda > 0$
2. $\lambda h = \cup_{\gamma \in h}\{1-(1-\gamma)^\lambda\}, \lambda > 0$
3. $h_1 \oplus h_2 = \cup_{\gamma_1 \in h_1, \gamma_2 \in h_2} Max\{\gamma_1 + \gamma_2 - \gamma_1, \gamma_2\}$
4. $h_1 \otimes h_2 = \cup_{\gamma_1 \in h_1, \gamma_2 \in h_2}\{\gamma_1 \gamma_2\}$

Torra[8] defined the complement, union and intersection as follows

1. $h^c = \cup_{\gamma \in h}\{1-\gamma\}$
2. $h_1 \cup h_2 = \cup_{\gamma_1 \in h_1, \gamma_2 \in h_2} Max\{\gamma_1, \gamma_2\}$
3. $h_1 \cap h_2 = \cup_{\gamma_1 \in h_1, \gamma_2 \in h_2} Min\{\gamma_1, \gamma_2\}$

Definition: For a hesitant fuzzy element h , S(h)= $\frac{1}{\#h}\sum_{\gamma \in h}\gamma$ is called the score function of h, where #h is the number of elements in h .For two hesitant elements

$$h_1 and\ h_2 \text{ ,if } (S(h_1) > S(h_2) \text{ then } h_1 > h_2 \text{ and if } (S(h_1) = S(h_2)$$

then $h_1 = h_2$

Triangular Hesitant Fuzzy Set

In decision making problems the decision makers may provide imprecise and incomplete data. To deal with fuzzy decision making problems it is better to choose triangular fuzzy number. Triangular fuzzy numbers also reflect the original information given by the decision makers.

Definition: Let x be a finite set ,a triangular hesitant fuzzy set on X is define as

$$T = \{(x, \mathcal{H}_T(x))/x \in X\}$$

Where $\mathcal{H}_T(x)$ is a set of some triangular fuzzy numbers in the set of real number R, representing the possible membership function of the element $x \in X$. $\mathcal{H}_T(x)$ is called as triangular hesitant fuzzy element. The triangular fuzzy number in $\mathcal{H}_T(x)$ is denoted by $\hbar$ and is represented by

$$t = (a^i, b^j, c^k) \text{ where } t \in \hbar.$$

Definition: For a triangular fuzzy hesitant element $\hbar$, the expected value is defined as $E(\hbar) = \frac{1}{3\#\hbar}\sum_{t \in \hbar}(a^i + b^j + c^k)$,where $\#\hbar$ is the number of triangular fuzzy number in $\hbar$ Some basic operations on Triangular hesitant fuzzy number:

Suppose $\hbar, \hbar_1, \hbar_2$ be three triangular fuzzy hesitant element and $\lambda > 0$ be a scalar then

1. $\lambda\hbar = \cup_{t \in \hbar}\{(\lambda a^i, \lambda b^j, \lambda c^k)\}$
2. $\hbar_1 \oplus \hbar_2 = \cup_{t_1 \in \hbar_1, t_2 \in \hbar_2}\{a_1^i + a_2^i, b_1^j + b_2^j, c_1^k + c_2^k\}$
3. $\hbar_1 \otimes \hbar_2 = \cup_{t_1 \in \hbar_1, t_2 \in \hbar_2}\{a_1^i a_2^i, b_1^j b_2^j, c_1^k c_2^k\}$
4. $\hbar^c = \cup_{t \in \hbar}\{(1-a^i, 1-b^j, 1-c^k)\}$
5. $\hbar_1 \cup \hbar_2 = \cup_{t_1 \in \hbar_1, t_2 \in \hbar_2}\{\max\{a_1^i, a_2^i\}, \max\{b_1^j, b_2^j\}, \max\{c_1^k, c_2^k\}\}$
6. $\hbar_1 \cap \hbar_2 = \cup_{t_1 \in \hbar_1, t_2 \in \hbar_2}\{\min\{a_1^i, a_2^i\}, \min\{b_1^j, b_2^j\}, \min\{c_1^k, c_2^k\}\}$

3. ALGORITHM FOR MULTI-CRITERIA DECISION MAKING IN TRIANGULAR HESITANT FUZZY SET

Let $A = \{A_1, A_2, \dots, A_m\}$ be a set of alternatives and let $C = \{C_1, C_2, \dots, C_n\}$ be a set of criteria. Obtain the opinion of decision makers.

1. Construction of Triangular Hesitant Fuzzy Decision Matrix Suppose we have m alternatives and n criteria. Then the triangular hesitant fuzzy matrix $H = \{h_{ij}\}$ is an m x n matrix

$$H = \begin{pmatrix} h_{11} & h_{12} & \dots & h_{1n} \\ h_{21} & h_{22} & & h_{2n} \\ \vdots & & \ddots & \vdots \\ h_{m1} & h_{m2} & \cdots & h_{mn} \end{pmatrix}$$

Suppose two or more decision makers give the same opinion. Then the numbers present only once in h_{ij}, where h_{ij} is the triangular fuzzy hesitant element.

2. Calculate the expected value by the formula

$$E_{ij} = \frac{1}{3(\#h_{ij})} \sum_{t_{ij} \in h_{ij}} (a_{ij} + b_{ij} + c_{ij})$$

For each triangular hesitant fuzzy element h_{ij} (I = 1 to m, j = 1 to n) in the triangular hesitant fuzzy decision matrix H.

$$E = \begin{pmatrix} E_{11} & E_{12} & \dots & E_{1n} \\ E_{21} & E_{22} & & E_{2n} \\ \vdots & & \ddots & \vdots \\ E_{m1} & E_{m2} & \cdots & E_{mn} \end{pmatrix}$$

3. Obtain the weight vector $w = (w_1, w_2, \dots, w_n)$ as the criteria weight by using the following model

$$w_j = \frac{f_j(C_j)}{\sum_{j=1}^{n} f_j(C_j)}$$

Where $w_j \geq 0$ and $\sum_{j=1}^{n} w_j = 1$ and $f_j(C_j)$ $(j = 1,2,\dots,n)$ is the standard deviation of the expected values for different alternatives with respect to a criterion.

$$f_j(C_j) = \sqrt{\frac{1}{m}\sum_{j=1}^{m}\left(E_{ij} - \frac{1}{m}\sum_{i=1}^{n} E_{ij}\right)^2}$$

4. Obtain the weighted expected value for each alternative $A_i\,(i = 1,2,\dots,m)$

$$E(A_i) = \sum_{j=1}^{n} w_j E_{ij}$$

5. Rank the alternative.

4. Numerical Example

At the time of creation of the World Health Organization (WHO), in 1948, health was defined as being, “a state of complete physical, mental and social well being and not merely the absence of disease or infirmity” Surveillance of work environment and detection of workers’ knowledge on occupational health and safety measures are important components of occupational health and safety service. Occupational health services constitute comprehensive health sources which are essentially preventive and allow a substantial component of curative and rehabilitative services. The services must adapt to the needs of the working environment.[7] The concept of stress at workplace is not a new one and lot of studies have been conducted on the area. The concept of stress at workplace was first in 1936 by Hans Selye. His main focus was on the biological aspects of stress which he termed as eustress (positive stress) and distress (negative stress). Later studies focused on physiological and psychological aspects of stress on employees and its management. Oxford dictionary terms stress as an emotional state of an individual resulting from external environment putting too much demand on that individual. It is also considered as a response that results from demographic differences among individuals (DeFrank and Ivancevich, 1998). Police officers are commonly considered to be a high-risk group for the development of mental health disturbances because of the various critical incidents and potential traumatic events they

encounter during their career. These so-called operational stressors, such as witnessing the death of children, confrontations with victims of sexual harassment, serious traffic accidents, suicide and experiencing violence, might increase the risk of symptoms of anxiety, hostility and fatigue. A (small) minority may develop mental disorders, such as depression and post-traumatic stress disorder (PTSD). Due to psychological issues most of the police men get the following ten diseases D1:Irritable bowl syndrome / D2:Constipation / D3:High blood pressure / D4:Head aches / D5: Cardio vascular diseases / D6:Insomnia / D7:Nausea / D8:Diabetic / D9:Arthritis / D10 : Mental Fatigue.
The alternatives with respect to the criterion are A_1: Stress / A_2 :Tension / A_3:Depression /A_4:Anxiety / A_5:Anger.
Let us consider the seven scale linguistic variable chen (2000)

Linguistic Variable	Linguistic value
Very Low (VL)	(0,0,0.1)
Low (L)	(0,0.1,0.3)
Medium Low(ML)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
Medium High(MH)	(0.5,0.7,0.9)
High(H)	(0.7,0.9,1.0)
Very High (VH)	(0.9,1.0,1.0)

The rating of each criterion with respect to the alternatives given by the five experts' as a linguistic variable chen(2000) given in the following table.

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
A_1	H M MH ML	H M MH ML	H MH H H	VH H H MH	H H MH H	H VH MH H	H MH ML H	MH M M MH	L VL VL L	VH H H MH
A_2	H MH M H	H MH M MH	H VH H H	VH MH H M	H M MH M	M M ML M	ML L ML L	M ML L ML	L VL VL VL	H H MH H
A_3	H H H H	H VH H MH	VH H VH H	VH H VH VH	H MH H H	VH H VH VH	MH H ML H	ML M L MH	ML L L M	VH VH H VH
A_4	ML H H MH	L VL L ML	H MH ML M	VL M ML M	L VL VL L	H VH H H	MH H ML M	VL L VL L	L VL L VL	H MH VH H
A_5	ML MH M L	L ML VL L	H MH VH H	H VH H MH	H MH ML M	L VL ML M	VL ML M L	L VL M ML	L VL L L	M ML M MH

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
A_1	(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.7,0.9,1.0)	(0.9,1,1) (0.7,0.9,1.0) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.7,0.9,1.0) (0.5,0.7,0.9) (0.7,0.9,1.0)	(0.7,0.9,1.0) (0.9,1,1) (0.5,0.7,0.9) (0.7,0.9,1.0)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5) (0.7,0.9,1.0)	(0.5,0.7,0.9) (0.3,0.5,0.7) (0.3,0.5,0.7) (0.5,0.7,0.9)	(0,0.1,0.3) (0,0,0.1) (0,0,0.1) (0,0.1,0.3)	(0.9,1,1) (0.7,0.9,1.0) (0.7,0.9,1.0) (0.5,0.7,0.9)
A_2	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.3,0.5,0.7) (0.7,0.9,1.0)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.3,0.5,0.7) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.9,1,1) (0.7,0.9,1.0)	(0.9,1,1) (0.5,0.7,0.9) (0.7,0.9,1.0) (0.3,0.5,0.7)	(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9) (0.3,0.5,0.7)	(0.3,0.5,0.7) (0.3,0.5,0.7) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0.1,0.3,0.5) (0,0.1,0.3) (0.1,0.3,0.5) (0,0.1,0.3)	(0.3,0.5,0.7) (0.1,0.3,0.5) (0,0.1,0.3) (0.1,0.3,0.5)	(0,0.1,0.3) (0,0,0.1) (0,0,0.1) (0,0,0.1)	(0.7,0.9,1.0) (0.7,0.9,1.0) (0.5,0.7,0.9) (0.7,0.9,1.0)
A_3	(0.7,0.9,1.0) (0.7,0.9,1.0) (0.7,0.9,1.0) (0.7,0.9,1.0)	(0.7,0.9,1.0) (0.9,1,1) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0.9,1,1) (0.7,0.9,1.0) (0.9,1,1)	(0.9,1,1) (0.7,0.9,1.0) (0.9,1,1) (0.9,1,1)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.7,0.9,1.0) (0.7,0.9,1.0)	(0.9,1,1) (0.7,0.9,1.0) (0.9,1,1) (0.9,1,1)	(0.5,0.7,0.9) (0.7,0.9,1.0) (0.1,0.3,0.5) (0.7,0.9,1.0)	(0.1,0.3,0.5) (0.3,0.5,0.7) (0,0.1,0.3) (0.5,0.7,0.9)	(0.1,0.3,0.5) (0,0.1,0.3) (0,0.1,0.3) (0.3,0.5,0.7)	(0.9,1,1) (0.9,1,1) (0.7,0.9,1.0) (0.9,1,1)
A_4	(0.1,0.3,0.5) (0.7,0.9,1.0) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0,0.1,0.3) (0,0,0.1) (0,0.1,0.3) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0,0,0.1) (0.3,0.5,0.7) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0.1,0.3) (0,0,0.1) (0,0,0.1) (0,0.1,0.3)	(0.7,0.9,1.0) (0.9,1,1) (0.7,0.9,1.0) (0.7,0.9,1.0)	(0.5,0.7,0.9) (0.7,0.9,1.0) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0,0.1) (0,0.1,0.3) (0,0,0.1) (0,0.1,0.3)	(0,0.1,0.3) (0,0,0.1) (0,0.1,0.3) (0,0,0.1)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.9,1,1) (0.7,0.9,1.0)
A_5	(0.1,0.3,0.5) (0.5,0.7,0.9) (0.3,0.5,0.7) (0,0.1,0.3)	(0,0.1,0.3) (0.1,0.3,0.5) (0,0,0.1) (0,0.1,0.3)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.9,1,1)	(0.7,0.9,1.0) (0.9,1,1) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0.1,0.3) (0,0,0.1) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0,0.1) (0.1,0.3,0.5) (0.3,0.5,0.7) (0,0.1,0.3)	(0,0.1,0.3) (0,0,0.1) (0.3,0.5,0.7) (0.1,0.3,0.5)	(0,0.1,0.3) (0,0,0.1) (0,0.1,0.3) (0,0.1,0.3)	(0.3,0.5,0.7) (0.1,0.3,0.5) (0.3,0.5,0.7) (0.5,0.7,0.9)

H=

(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.5,0.7,0.9)	(0.9,1,1) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.9,1,1) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5)	(0.5,0.7,0.9) (0.3,0.5,0.7)	(0,0.1,0.3) (0,0,0.1)	(0.9,1,1) (0.7,0.9,1.0) (0.5,0.7,0.9)
(0.7,0.9,1.0) (0.5,0.7,0.9) (0.3,0.5,0.7)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.3,0.5,0.7)	(0.7,0.9,1.0) (0.9,1,1)	(0.9,1,1) (0.5,0.7,0.9) (0.7,0.9,1.0) (0.3,0.5,0.7)	(0.7,0.9,1.0) (0.3,0.5,0.7) (0.5,0.7,0.9)	(0.3,0.5,0.7) (0.1,0.3,0.5)	(0.1,0.3,0.5) (0,0.1,0.3)	(0.3,0.5,0.7) (0.1,0.3,0.5) (0,0.1,0.3)	(0,0.1,0.3) (0,0,0.1)	(0.7,0.9,1.0) (0.5,0.7,0.9)
(0.7,0.9,1.0)	(0.7,0.9,1.0) (0.9,1,1) (0.5,0.7,0.9)	(0.9,1,1) (0.7,0.9,1.0)	(0.9,1,1) (0.7,0.9,1.0)	(0.7,0.9,1.0) (0.5,0.7,0.9)	(0.9,1,1) (0.7,0.9,1.0)	(0.5,0.7,0.9) (0.7,0.9,1.0) (0.1,0.3,0.5)	(0.1,0.3,0.5) (0.3,0.5,0.7) (0,0.1,0.3) (0.5,0.7,0.9)	(0.1,0.3,0.5) (0,0.1,0.3) (0.3,0.5,0.7)	(0.9,1,1) (0.7,0.9,1.0)
(0.1,0.3,0.5) (0.7,0.9,1.0) (0.5,0.7,0.9)	(0,0.1,0.3) (0,0,0.1) (0.1,0.3,0.5)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0,0.1) (0.3,0.5,0.7) (0.1,0.3,0.5)	(0,0.1,0.3) (0,0,0.1)	(0.7,0.9,1.0) (0.9,1,1)	(0.5,0.7,0.9) (0.7,0.9,1.0) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0,0.1) (0,0.1,0.3)	(0,0.1,0.3) (0,0,0.1)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.9,1,1)
(0.1,0.3,0.5) (0.5,0.7,0.9) (0.3,0.5,0.7) (0,0.1,0.3)	(0,0.1,0.3) (0.1,0.3,0.5) (0,0,0.1)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.9,1,1)	(0.7,0.9,1.0) (0.9,1,1) (0.5,0.7,0.9)	(0.7,0.9,1.0) (0.5,0.7,0.9) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0.1,0.3) (0,0,0.1) (0.1,0.3,0.5) (0.3,0.5,0.7)	(0,0,0.1) (0.1,0.3,0.5) (0.3,0.5,0.7) (0,0.1,0.3)	(0,0.1,0.3) (0,0,0.1) (0.3,0.5,0.7) (0.1,0.3,0.5)	(0,0.1,0.3) (0,0,0.1)	(0.3,0.5,0.7) (0.1,0.3,0.5) (0.5,0.7,0.9)

Triangular hesitant fuzzy decision matrix

Determine the expected value of each triangular fuzzy hesitant element in the decision matrix H

$$E=\begin{pmatrix} 0.592 & 0.592 & 0.783 & 0.844 & 0.783 & 0.844 & 0.567 & 0.6 & 0.083 & 0.844 \\ 0.689 & 0.689 & 0.917 & 0.758 & 0.689 & 0.4 & 0.217 & 0.311 & 0.083 & 0.783 \\ 0.867 & 0.844 & 0.917 & 0.917 & 0.783 & 0.917 & 0.622 & 0.358 & 0.311 & 0.917 \\ 0.622 & 0.156 & 0.592 & 0.278 & 0.083 & 0.917 & 0.592 & 0.083 & 0.083 & 0.844 \\ 0.408 & 0.156 & 0.867 & 0.644 & 0.592 & 0.242 & 0.242 & 0.242 & 0.083 & 0.5 \end{pmatrix}$$

Obtain the weights of each criterion from E

W_1=0.077822,W_2=0.147911,W_3=0.063861,W_4=0.117569,W_5=0.136896,W_6=0.149719,W_7=0.094019
W_8=0.088358,W_9=0.047788,W_{10}=0.076057.

Obtain the weighted expected value for each alternative A_i

$E_W(A_1) = 0.6909$
$E_W(A_2)=0.5688$
$E_W(A_3)=0.7779$
$E_W(A_4)=0.4218$
$E_W(A_5)=0.3893$

Rank the alternatives according to expected value

$A_3 > A_1 > A_2 > A_4 > A_5$

According to the rank we can conclude that stress is the main cause for the group of diseases.

5.CONCLUSION

Hesitant fuzzy set theory is a newly emerging mathematical tool to deal with uncertain problems. This paper proposed a triangular hesitant fuzzy set based on the combination of triangular fuzzy numbers and hesitant fuzzy sets and defined some operations on triangular hesitant fuzzy sets. Then, we presented a decision-making method based on expected values for triangular hesitant fuzzy sets, which can deal with the decision-making problem with linguistic assessments and completely unknown criteria weights under the triangular hesitant fuzzy environment. Practical example was given to verify the developed approaches and to demonstrate their practicality and effectiveness. According to the numerical example, we can conclude that through transforming the linguistic terms into corresponding linguistic values of triangular fuzzy numbers in the linguistic assessments, the linguistic values can consist of triangular hesitant fuzzy sets to deal with imprecise or vague information effectively and can automatically take into account much more information than existing (hesitant) fuzzy decision-making methods and the differences of the evaluation data given by different experts or decision makers.

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