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Model for software quality evaluation with hesitant triangular fuzzy information

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ABSTRACT

The quality of software projects always plays an important role in the whole complex program. In order to solve certain problems in software development, this paper try to give new resolution for the corporations in this field by using different types of methods, such as: Quantitative Analysis of Software Quality, Software Quality Management Standard, Quality Assurance System and Software Engineering Methods. In this paper, we investigate the multiple attribute decision making problems for evaluating the software quality with hesitant triangular fuzzy information. We utilize the hesitant triangular fuzzy weighted averaging (HTFWA) operator to aggregate the hesitant triangular fuzzy information corresponding to each alternative and get the overall value of the software systems, then rank the software systems and select the most desirable one (s) by using the formula of the degree of possibility for the comparison between two triangular fuzzy variables. Finally, an illustrative example for evaluating the software quality is given to verify the developed approach.

KEYWORDS

Multiple attribute decision-making; Hesitant triangular fuzzy information; Hesitant triangular fuzzy weighted averaging (HTFWA) operator; Software quality.

INTRODUCTION

As the market increases the demand for management software, Management software in the areas of process from the standard (Such as financial management) to many personalization process and Individual modules[1-2]. In order to reduce costs and improve software reuse rate and stability, Software products usually contain only general management needs of most users. More and more customers, especially large customers, Standard software products can't meet their management requirements[3-4]. This generated a lot of need for the actual management of customer development projects. The quality of development projects is a software company in the market competition and an important indicator of survival. On the one hand, Development projects can attract a large number of large customers, Can establish a good reputation[5]. Good or bad the quality of development projects direct impact on the future of software companies in the industry's image. On the other hand, Project software can make the company go deep into the forefront to demand. Behind closed doors that can't make a good product. Software does not meet the demand is no value[6]. This is a prerequisite for the development of software products, is also the basis for development of software enterprises. As the demand is not easy to grasp, a relatively short development cycles, document management is difficult, the quality of software development projects can't be guaranteed. Development progresses of the repeated delays seriously affect customer satisfaction. There is no good documentation functional products of the future can't make contributions[7-8].

The quality of software projects always plays an important role in the whole complex program. In order to solve certain problems in software development, this paper try to give new resolution for the corporations in this field by using different types of methods, such as: Quantitative Analysis of Software Quality, Software Quality Management Standard, Quality Assurance System and Software Engineering Methods. In this paper, we investigate the multiple attribute decision making problems for evaluating the software quality with hesitant triangular fuzzy information. We utilize the hesitant triangular fuzzy weighted averaging (HTFWA) operator to aggregate the hesitant triangular fuzzy information corresponding to each alternative and get the overall value of the software systems, then rank the software systems and select the most desirable one (s) by using the formula of the degree of possibility for the comparison between two triangular fuzzy variables. Finally, an illustrative example for evaluating the software quality is given to verify the developed approach.

PRELIMINARIES

In this section, we briefly describe some basic concepts and basic operational laws related to triangular fuzzy numbers.

Definition 1[9]. A triangular fuzzy numbers $\tilde{a}$ can be defined by a triplet $\left(a^L, a^M, a^U\right)$. The membership function $\mu_{\tilde{a}}\left(x\right)$ is defined as:

$$\mu_{\tilde{a}}\left(x\right)=\begin{cases}0, & x<a^L,\\ \dfrac{x-a^L}{a^M-a^L}, & a^L\le x\le a^M,\\ \dfrac{x-a^U}{a^M-a^U}, & a^M\le x\le a^U,\\ 0, & x\ge a^U.\end{cases} \quad \textbf{(1)}$$

where $0<a^L\le a^M\le a^U$, a^L and a^U stand for the lower and upper values of the support of $\tilde{a}$, respectively, and a^M for the modal value.

Definition 2[10]. Let $\tilde{b}=\left[b^L,b^M,b^U\right]$ and $\tilde{a}=\left[a^L,a^M,a^U\right]$ be two triangular fuzzy numbers, then the degree of possibility of $a\geq b$ is defined as

$$p\left(a\geq b\right)=\lambda\max\left\{1-\max\left[\frac{b^M-a^L}{a^M-a^L+b^M-b^L},0\right],0\right\}+ \left(1-\lambda\right)\max\left\{1-\max\left[\frac{b^U-a^M}{a^U-a^M+b^U-b^M},0\right],0\right\} \quad (2)$$

where the value λ is an index of rating attitude. It reflects the decision maker's risk-bearing attitude. If $\lambda>0.5$, the decision maker is risk lover. If $\lambda=0.5$, the decision maker is neutral to risk. If $\lambda<0.5$, the decision maker is risk avertor.

Wei et al.[11-12] presented hesitant triangular fuzzy set based on hesitant fuzzy set.

Definition 3[11-12]. Let X be a fixed set, a hesitant triangular fuzzy set (HTFS) on X is in terms of a function that when applied to each x in X and returns a subset of values in [0, 1]. To be easily understood, we express the HTFS by a mathematical symbol:

$$E=\left\{<x,\tilde{h}_{E(x)}>\middle|x\in X\right\} \quad (3)$$

where $\tilde{h}_{E(x)}$ is a set of some possible triangular fuzzy values in [0,1], denoting the possible membership degrees of the element $x\in X$ to the set E. For convenience, we call $\tilde{h}_{E(x)}=\tilde{h}=\left(\gamma^L,\gamma^M,\gamma^R\right)$ a hesitant triangular fuzzy element (HTFE) and $\tilde{H}$ the set of all HTFEs.

Given three HTFEs $\tilde{h}=\left(\gamma^L,\gamma^M,\gamma^R\right)$, $\tilde{h}_1=\left(\gamma_1^L,\gamma_1^M,\gamma_1^R\right)$ and $\tilde{h}_2=\left(\gamma_2^L,\gamma_2^M,\gamma_2^R\right)$ and $\lambda>0$, we define their operations as follows:

(1) $\tilde{h}^\lambda=\bigcup_{\tilde{\gamma}\in\tilde{h}}\left\{\left(\left(\gamma^L\right)^\lambda,\left(\gamma^M\right)^\lambda,\left(\gamma^R\right)^\lambda\right)\right\}$;

(2) $\lambda\tilde{h}=\bigcup_{\gamma\in\tilde{h}}\left\{1-\left(1-\gamma^L\right)^\lambda,\ \left(1-\left(1-\gamma^M\right)^\lambda,1-\left(1-\gamma^R\right)^\lambda\right)\right\}$;

(3) $\tilde{h}_1\oplus\tilde{h}_2=\bigcup_{\tilde{\gamma}_1\in\tilde{h}_1,\tilde{\gamma}_2\in\tilde{h}_2}\left\{\left(\gamma_1^L+\gamma_2^L-\gamma_1^L\gamma_2^L,\ \gamma_1^M+\gamma_2^M-\gamma_1^M\gamma_2^M,\gamma_1^R+\gamma_2^R-\gamma_1^R\gamma_2^R\right)\right\}$;

(4) $\tilde{h}_1\otimes\tilde{h}_2=\bigcup_{\tilde{\gamma}_1\in\tilde{h}_1,\tilde{\gamma}_2\in\tilde{h}_2}\left\{\left(\gamma_1^L\gamma_2^L,\gamma_1^M\gamma_2^M,\gamma_1^R\gamma_2^R\right)\right\}$.

Definition 4[11-12]. For an HTFE $\tilde{h}$, $s\left(\tilde{h}\right)=\frac{1}{\#\tilde{h}}\sum_{\tilde{\gamma}\in\tilde{h}}\tilde{\gamma}$ is called the score function of $\tilde{h}$, where $\#\tilde{h}$ is the number of the triangular fuzzy values in $\tilde{h}$, and $s\left(\tilde{h}\right)$ is an triangular fuzzy values belonging to $\left[0,1\right]$. For two HTFEs $\tilde{h}_1$ and $\tilde{h}_2$, if $s\left(\tilde{h}_1\right)\geq s\left(\tilde{h}_2\right)$, then $\tilde{h}_1\geq\tilde{h}_2$.

Based on the operational principle for HTFEs, Wei et al.[11] developed the hesitant triangular fuzzy weighted averaging (HTFWA) operator.

Definition 5. Let $\tilde{h}_j\left(j=1,2,\cdots,n\right)$ be a collection of HTFEs. The hesitant triangular fuzzy weighted averaging (HTFWA) operator is a mapping $\tilde{H}^n\to\tilde{H}$ such that

$$
\begin{aligned}
& HTFWA\left(\tilde{h}_1, \tilde{h}_2, \cdots, \tilde{h}_n\right) \\
& = \oplus_{j=1}^{n}\left(\omega_j \tilde{h}_j\right) \\
& = \bigcup_{\tilde{\gamma}_1 \in \tilde{h}_1, \tilde{\gamma}_2 \in \tilde{h}_2, \cdots, \tilde{\gamma}_n \in \tilde{h}_n} \left\{1-\prod_{j=1}^{n}\left(1-\gamma_j^L\right)^{\omega_j}, 1-\prod_{j=1}^{n}\left(1-\gamma_j^M\right)^{\omega_j}, 1-\prod_{j=1}^{n}\left(1-\gamma_j^R\right)^{\omega_j}\right\}
\end{aligned} \tag{4}
$$

where $\omega = \left(\omega_1, \omega_2, \cdots, \omega_n\right)^T$ be the weight vector of $\tilde{h}_j \left(j = 1, 2, \cdots, n\right)$, and $\omega_j > 0$, $\sum_{j=1}^{n} \omega_j = 1$.

NUMERICAL EXAMPLE

Because of the increasing size and the complexity of software, the software quality has become difficult to control and manage. Improving the quality of software has become the focus of software industry. Software quality assurance becomes an important approach for improving software quality, which provides developers and managers with the information reflecting the product quality through monitoring the execution of software producing task by independent review. In this section, we present an empirical case study of evaluating the software quality. The software quality of five possible software systems $A_i \left(i = 1, 2, 3, 4, 5\right)$ is evaluated. After preliminary screening, five alternatives $A_i \left(i = 1, 2, \cdots, 5\right)$ have remained in the candidate list. Three decision makers (experts) form a committee to act as decision makers. The computer center in the university must take a decision according to the following four attributes: □G_1 is the costs of hardware/software investment; □G_2 is the contribution to organization performance; □ G_3 is the effort to transform from current system; □G_4 is the outsourcing software developer reliability. In order to avoid influence each other, the decision makers are required to evaluate the five possible software systems $A_i \left(i = 1, 2, 3, 4, 5\right)$ under the above four attributes in anonymity and the decision matrix $H = \left(\tilde{h}_{ij}\right)_{5 \times 4}$ is presented in TABLE 1, where $\tilde{h}_{ij} \left(i = 1, 2, 3, 4, 5,\ j = 1, 2, 3, 4\right)$ are in the form of HTFEs.

TABLE 1: Hesitant triangular fuzzy decision matrix

	G₁	**G₂**	**G₃**	**G₄**
A_1	{(0.5,0.6,0.7)}	{(0.5,0.6,0.7),(0.6,0.7,0.8)}	{(0.2,0.3,0.4),(0.4,0.5,0.6)}	{(0.2,0.3,0.4)}
A_2	{(0.3,0.4,0.5)}	{(0.2,0.3,0.4),(0.5,0.6,0.7)}	{(0.2,0.3,0.4)}	{(0.3,0.4,0.5)}
A_3	{(0.4,0.5,0.6)}	{(0.2,0.3,0.4),(0.5,0.6,0.7)}	{(0.2,0.3,0.4),(0.4,0.5,0.6)}	{(0.3,0.4,0.5)}
A_4	{(0.2,0.3,0.4)}	{(0.3,0.4,0.5)}	{(0.1,0.2,0.3),(0.3,0.4,0.5)}	{(0.5,0.6,0.7)}
A_5	{(0.4,0.5,0.6)}	{(0.7,0.8,0.9)}	{(0.3,0.4,0.5)}	{(0.2,0.3,0.4),(0.3,0.4,0.5)}

In the following, we utilize the approach developed to show potential evaluation of emerging technology commercialization projects of five possible emerging technology enterprises.

We utilize the decision information given in matrix H, and the HTFWA operator to obtain the overall preference values $\tilde{h}_i$ of the software systems $A_i \left(i = 1, 2, 3, 4, 5\right)$. We calculate the scores $s\left(\tilde{h}_i\right)\left(i = 1, 2, 3, 4, 5\right)$ of the overall hesitant triangular fuzzy preference values $h_i \left(i = 1, 2, 3, 4, 5\right)$, the score values for the software systems.

$$h_1 = \left(0.4313, 0.5535, 0.6665\right), h_2 = \left(0.3654, 0.4837, 0.6065\right)$$
$$h_3 = \left(0.5776, 0.6990, 0.8567\right), h_4 = \left(0.5214, 0.6327, 0.7078\right)$$
$$h_5 = \left(0.3242, 0.4627, 0.5907\right)$$

According to the aggregating results and the formula of degree of possibility (2), the ordering of the software systems are shown in TABLE 2. Note that ▪ means “preferred to”. Thus, the desirable software system is A_3.

TABLE 2: Ordering of the alternative

	Ordering
HTFWA	A_3 ▪ A_4 ▪ A_1 ▪ A_2 ▪ A_5

CONCLUSION

With the rapid development and the increasingly widespread application of information technology, the software becomes more and more important. Also, because of the increasing size and the complexity of software, the software quality has become difficult to control and manage. Improving the quality of software has become the focus of software industry. Software quality assurance becomes an important approach for improving software quality, which provides developers and managers with the information reflecting the product quality through monitoring the execution of software producing task by independent review. In this paper, we investigate the multiple attribute decision making problems for evaluating the software quality with hesitant triangular fuzzy information. We utilize the hesitant triangular fuzzy weighted averaging (HTFWA) operator to aggregate the hesitant triangular fuzzy information corresponding to each alternative and get the overall value of the software systems, then rank the software systems and select the most desirable one (s) by using the formula of the degree of possibility for the comparison between two triangular fuzzy variables. Finally, an illustrative example for evaluating the software quality is given to verify the developed approach.

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