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An approach to evaluating the mechanical automation with intuitionistic fuzzy information

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ABSTRACT

The evaluating models of mechanical automation with intuitionistic fuzzy information are investigated. Some operational laws of intuitionistic fuzzy numbers, score functions and accuracy function of intuitionistic fuzzy numbers are introduced. Based on these operational laws, we used the intuitionistic fuzzy Bonferroni mean (IFBM) operator to evaluate the mechanical automation. Finally, an illustrative example for evaluating the mechanical automation with intuitionistic fuzzy information is given to verify the developed approach.

KEYWORDS

Intuitionistic fuzzy numbers; Intuitionistic fuzzy Bonferroni mean (IFBM) operator; Mechanical automation; Evaluating models.

INTRODUCTION

Atanassov[1-2] introduced the concept of intuitionistic fuzzy set (IFS), which is a generalization of the concept of fuzzy set[3]. Later, Atanassov and Gargov[4-5] further introduced the interval-valued intuitionistic fuzzy set (IVIFS), which is a generalization of the IFS. The fundamental characteristic of the IVIFS is that the values of its membership function and nonmembership function are intervals rather than exact numbers. The intuitionistic fuzzy set and interval-valued intuitionistic fuzzy set (IVIFS) have received more and more attention since its appearance[6-14]. Liu and Yuan[6] introduced the concept of fuzzy number intuitionistic fuzzy set (FNIFS) which fundamental characteristic of the FNIFS is that the values of its membership function and nonmembership function are triangular fuzzy numbers. Wang[7] proposed some geometric aggregation operators, including fuzzy number intuitionistic fuzzy weighted geometric (FIFWG) operator, fuzzy number intuitionistic fuzzy ordered weighted geometric (FIFOWG) operator and fuzzy number intuitionistic fuzzy hybrid geometric (FIFHG) operator and develop an approach to multiple attribute group decision making (MAGDM) based on the FIFWAG and the FIFHG operators with fuzzy number intuitionistic fuzzy information. Wang[8] developed some arithmetic aggregation operators, including fuzzy number intuitionistic fuzzy weighted averaging (FIFWA) operatorfuzzy number intuitionistic fuzzy ordered weighted averaging (FIFOWA) operator and fuzzy number intuitionistic fuzzy hybrid aggregation (FIFHA) operator and develop an approach to multiple attribute group decision making (MAGDM) based on the FIFWAA and the FIFHA operators with fuzzy number intuitionistic fuzzy information.

In this paper, we have investigated the evaluating models of mechanical automation with intuitionistic fuzzy information. Some operational laws of intuitionistic fuzzy numbers, score functions and accuracy function of intuitionistic fuzzy numbers are introduced. Based on these operational laws, we used the intuitionistic fuzzy Bonferroni mean (IFBM) operator to aggregate the intuitionistic fuzzy information in order to evaluate the mechanical automation. Finally, an illustrative example is given to verify the developed approach.

PRELIMINARIES

In the following, we introduce some basic concepts related to IFS.

Definition 1[12]. An IFS A in X is given by

$$A=\left\{\left\langle x,\mu_A\left(x\right),\nu_A\left(x\right)\right\rangle \middle| x\in X\right\} \quad \textbf{(1)}$$

where $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$, with the condition $0 \le \mu_A(x)+\nu_A(x) \le 1$, $\forall\, x \in X$. The numbers $\mu_A(x)$ and $\nu_A(x)$ represents, respectively, the membership degree and non- membership degree of the element x to the set A.

Definition 2[13]. Let $\tilde{a}=(\mu,\nu)$ be an intuitionistic fuzzy number, a score function S of an intuitionistic fuzzy value can be represented as follows:

$$S(\tilde{a})=\mu-\nu\,, \quad S(\tilde{a})\in[-1,1] \quad \textbf{(2)}$$

Definition 3[14]**.** Let $\tilde{a}=(\mu,\nu)$ be an intuitionistic fuzzy number, an accuracy function H of an intuitionistic fuzzy value can be represented as follows:

$$H(\tilde{a})=\mu+\nu\,, \quad H(\tilde{a})\in[0,1] \quad \textbf{(3)}$$

to evaluate the degree of accuracy of the intuitionistic fuzzy value $\tilde{a}=(\mu,\nu)$, where $H(\tilde{a})\in[0,1]$. The larger the value of $H(\tilde{a})$, the more the degree of accuracy of the intuitionistic fuzzy value $\tilde{a}$.

Bonferroni[15] originally introduced a mean type aggregation operator, called Bonferroni mean, which can provide for aggregation lying between the max, min operators and the logical "or" and "and" operators, which was defined as follows:

Definition 4[15]. Let $p,q\geq 0$ and $a_i\,(i=1,2,\cdots,n)$ be a collection of non-negative real numbers. Then the aggregaton functions:

$$BM^{p,q}(a_1,a_2,\cdots,a_n)=\left(\frac{1}{n(n-1)}\sum_{\substack{i,j=1\\ i\neq j}}^{n}a_i^p a_j^q\right)^{\frac{1}{p+q}} \quad (4)$$

is called the Bonferroni mean (BM) operator.

Definition 5[16]. Let $\tilde{a}_j=(\mu_j,\nu_j)\,(j=1,2,\cdots,n)$ be a collection of intuitionistic fuzzy values, and let $p,q>0$. If

$$IFBM^{p,q}(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n)=\left(\frac{1}{n(n-1)}\sum_{\substack{i,j=1\\ i\neq j}}^{n}\tilde{a}_i^{\,p}\tilde{a}_j^{\,q}\right)^{\frac{1}{p+q}} \quad (5)$$

then $IFBM^{p,q}$ is called the intuitionistic fuzzy Bonferroni mean (IFBM) operator.
Based on the operations of the intuitionistic fuzzy values described, we can drive the Theorem 1.

Theorem 1. Let $\tilde{a}_j=(\mu_j,\nu_j)\,(j=1,2,\cdots,n)$ be a collection of intuitionistic fuzzy values, then their aggregated value by using the IFBM operator is also a IFFE, and

$$\begin{aligned}&IFBM^{p,q}(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n)\\&=\left(\frac{1}{n(n-1)}\sum_{\substack{i,j=1\\ i\neq j}}^{n}\tilde{a}_i^{\,p}\tilde{a}_j^{\,q}\right)^{\frac{1}{p+q}}\\&=\left(\left(1-\prod_{\substack{i,j=1\\ i\neq j}}^{n}\left(1-(\mu_i)^p(\mu_j)^q\right)^{\frac{1}{n(n-1)}}\right)^{\frac{1}{p+q}},1-\left(1-\prod_{\substack{i,j=1\\ i\neq j}}^{n}\left(1-(1-\nu_i)^p(1-\nu_j)^q\right)^{\frac{1}{n(n-1)}}\right)^{\frac{1}{p+q}}\right)\end{aligned} \quad (6)$$

then $IFBM^{p,q}$ is called the intuitionistic fuzzy Bonferroni mean (IFBM) operator.

EVALUATING MODEL OF MECHANICAL AUTOMATION WITH INTUITIONISTIC FUZZY INFORMATION

In this section, we shall develop an approach based on the intuitionistic fuzzy Bonferroni mean (IFBM) operator to evaluate the mechanical automation with intuitionistic fuzzy information as follows.

Let $A=\{A_1,A_2,\cdots,A_m\}$ be a discrete set of alternatives, and $G=\{G_1,G_2,\cdots,G_n\}$ be the set of attributes. Suppose that $\tilde{R}=(\tilde{r}_{ij})_{m\times n}=(\mu_{ij},\nu_{ij})_{m\times n}$ is the intuitionistic fuzzy decision matrix, where μ_{ij} indicates the degree that the alternative A_i satisfies the attribute G_j given by the decision maker, ν_{ij} indicates the degree that the alternative A_i doesn't satisfy the attribute G_j given by the decision maker, $\mu_{ij}\subset[0,1]$, $\nu_{ij}\subset[0,1]$, $\mu_{ij}+\nu_{ij}\le 1$, $i=1,2,\cdots,m$, $j=1,2,\cdots,n$.

In the following, we apply the IFBM operator to MADM for evaluating the mechanical automation with intuitionistic fuzzy information.

Step 1. Utilize the decision information given in matrix $\tilde{R}$, and the IFBM operator (in general, we can take $p=q=1$)

$$\begin{aligned}\tilde{r}_i&=(\mu_i,\nu_i)\\&=IFBM^{p,q}(\tilde{r}_{i1},\tilde{r}_{i2},\cdots,\tilde{r}_{in})\\&=\left(\frac{1}{n(n-1)}\sum_{\substack{i,j=1\\i\ne j}}^{n}\tilde{r}_{ki}^{\,p}\tilde{r}_{kj}^{\,q}\right)^{\frac{1}{p+q}}\\&=\left(\left(1-\prod_{\substack{i,j=1\\i\ne j}}^{n}\left(1-(\mu_{ki})^p(\mu_{kj})^q\right)^{\frac{1}{n(n-1)}}\right)^{\frac{1}{p+q}},1-\left(1-\prod_{\substack{i,j=1\\i\ne j}}^{n}\left(1-(1-\nu_{ki})^p(1-\nu_{kj})^q\right)^{\frac{1}{n(n-1)}}\right)^{\frac{1}{p+q}}\right)\end{aligned},\quad k=1,2,\cdots,m \qquad \textbf{(7)}$$

to derive the overall values $\tilde{r}_i\,(i=1,2,\cdots,m)$ of the alternative A_i.

Step 2. Calculate the scores $S(\tilde{r}_i)(i=1,2,\cdots,m)$ of the collective overall intuitionistic fuzzy preference values $\tilde{r}_i\,(i=1,2,\cdots,m)$ to rank all the alternatives $A_i\,(i=1,2,\cdots,m)$ and then to select the best one (s).

Step 3. Rank all the alternatives $A_i\,(i=1,2,\cdots,m)$ and select the best one (s) in accordance with $S(\tilde{r}_i)$ and $H(\tilde{r}_i)\,(i=1,2,\cdots,m)$.

ILLUSTRATIVE EXAMPLE

Enterprises, whose businesses based on mechanical producing, will continue to purchase new mechanical equipments or assembly lines in the progressive development of their businesses. Application systems are likely to be based on different platforms, developing tools, operating systems, data formats or logic controlling modes. Therefore, each independent system is gradually formed an isolated "information island", which makes daily use and maintenance of application systems increasingly difficult. Under the pressure of market environment and competitive environment presently, enterprises need a unified controlling system across these "information islands" in order to enhance the competitiveness of their businesses. Let us suppose there is an investment company, which wants to invest a sum of money in the best city for mechanical products. There is a panel with five possible cities $A_i\,(i=1,2,\cdots,5)$ to invest the money. The investment company must take a decision according to the following four attributes: ①G_1 is the existed mechanical products analysis; ②G_2 is the cities growth analysis; ③G_3 is the social-political impact analysis; ④G_4 is the environmental analysis. The five possible cities $A_i\left(i=1,2,\cdots,5\right)$ are to be evaluated using the intuitionistic fuzzy set by the decision makers under the above four attributes, and construct the decision matrix as follows $\tilde{R}=\left(\tilde{r}_{ij}\right)_{5\times 4}$:

$$\tilde{R}=\begin{bmatrix}(0.4,0.6) & (0.6,0.2) & (0.3,0.2) & (0.5,0.4)\\(0.7,0.3) & (0.6,0.2) & (0.6,0.3) & (0.4,0.3)\\(0.5,0.2) & (0.6,0.3) & (0.5,0.2) & (0.7,0.3)\\(0.6,0.3) & (0.4,0.2) & (0.7,0.2) & (0.6,0.4)\\(0.5,0.5) & (0.4,0.4) & (0.5,0.4) & (0.7,0.3)\end{bmatrix}$$

Then, we utilize the approach developed to get the most desirable city.

Step 1. Utilize the decision information given in matrix $\tilde{R}$, and the IFBM operator (in general, we can take $p=q=1$) to derive the overall values $\tilde{r}_i\left(i=1,2,\cdots,m\right)$ of the city A_i.

$$\tilde{r}_1=\left(0.62,0.41\right),\tilde{r}_2=\left(0.58,0.29\right),\tilde{r}_3=\left(0.76,0.17\right)$$
$$\tilde{r}_4=\left(0.43,0.25\right),\tilde{r}_5=\left(0.73,0.48\right)$$

Step 2. Calculate the scores $S\left(\tilde{r}_i\right)\left(i=1,2,3,4,5\right)$ of the overall intuitionistic fuzzy values $\tilde{r}_i\left(i=1,2,3,4,5\right)$

$$S\left(\tilde{r}_1\right)=0.21,S\left(\tilde{r}_2\right)=0.29,S\left(\tilde{r}_3\right)=0.59$$
$$S\left(\tilde{r}_4\right)=0.18,S\left(\tilde{r}_5\right)=0.25$$

Step 3. Rank all the cities $A_i\left(i=1,2,3,4,5\right)$ in accordance with the scores $S\left(\tilde{r}_i\right)\left(i=1,2,3,4,5\right)$ of the intuitionistic fuzzy values $\tilde{r}_i\left(i=1,2,3,4,5\right)$: $A_3\succ A_2\succ A_5\succ A_1\succ A_4$, and thus the most desirable city is A_3.

CONCLUSION

In this paper, we have investigated the evaluating models of mechanical automation with intuitionistic fuzzy information. Some operational laws of intuitionistic fuzzy numbers, score functions and accuracy function of intuitionistic fuzzy numbers are introduced. Based on these operational laws, we used the intuitionistic fuzzy Bonferroni mean (IFBM) operator to aggregate the intuitionistic fuzzy information in order to evaluate the mechanical automation. Finally, an illustrative example is given to verify the developed approach.

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