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Selecting a school on the basis of parent's expectation using intuitionistic fuzzy soft set

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Abstract

In this paper a comparative study have been given for the methods used to solve Intuitionistic Fuzzy Soft Matrix, by taking the problem of selecting a school for their kids according to the parents wish.

Keywords

Intuitionistic fuzzy soft set, Max-Min average composition, Max-Min composition, Distance method.

AMS Subject Classification

03E72.

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Contents

1. Introduction

Due to various uncertainties associated with our real life problems most of them involve data which are not necessarily crisp, precise and deterministic. In 1976 Sanchez developed an algorithm for medical diagnosis, later De et al (2001) have studied sanchez's method for medical diagnosis and applied it in intuitionisitc fuzzy set, also many researchers used sanchez's approach of medical diagnosis in various fuzzy numbers.

Atanassov (1986), introduced intuitionistic fuzzy set, Molodtsov (1999) initiated sot set theory and then Maji et al (2003) applied this theory to several fields. Initially, Rajarajeswari et.al, (2013) introduced max-min composition method to solve the problems of intuitionistic fuzzy sets. Later many researchers applied intuitionistic fuzzy sets for their research and invented many methods. Shanmugasundaram et al. (2014) introduced a new technique called intuitionistic fuzzy soft max-min average composition, he also used it for medical diagnosis process and also given the results. By keeping fuzzy soft max-min average composition as base a new technique revised max-min average composition was introduced by Shanmugasundaram et al in 2014. In 2018, Gandhimathi, used distance between two intuitionistic fuzzy soft matrices.

The result obtained in max-min composition and max-min average composition method is based on the maximum value in the score matrix. And the result obtained in distance method is based on the minimum value in the score matrix. An attempt has been made to provide a formal model to study the selection of Schools by using IFSM theory and implement it in the form of field recommendation system.

2. Preliminaries

Definition 2.1 (Intuitionistic fuzzy soft set)**.** *Let $U=\{C_1,C_2,\ldots,C_m\}$ be the universal set and let $E=\{e_1,e_2,\ldots e_n\}$ be the set of parameters. Let $A\subseteq E$ and let (F,A) be a fuzzy soft set in the fuzzy soft class (U,E). Then fuzzy soft set (F,A) is a matrix form as $A_{m\times n}=[a_{ij}]_{m\times n}$ or $A=[a_{ij}]$, $i=1,2,\ldots,m$ and $j=1,2,\ldots,n$, where*

$$a_{ij}=\begin{cases}(\mu_j(c_i),v_j(c_i)) & \text{if } e_j\in A\\ (0,1) & \text{if } e_j\notin A\end{cases}$$

$\mu_j(c_i)$ represents the membership of c_i in the intuitionistic fuzzy set $F(e_j)$ and $v_j(c_i)$ represents the non membership of c_i in the intuitionistic fuzzy set $F(e_j)$.

2.1 Operations on Intuitionistic fuzzy soft matrices

Definition 2.2 (Addition and Subtraction). *If $A = [a_{ij}] \in IFMS_{m\times n}$ and $B = [b_{ij}] \in IFSM_{m\times n}$ then we define the addition and subtraction of intuitionistic fuzzy soft matrices of A and B as,*

1. $A+B = \left\{\max\left[\mu_A(a_{ij}), \mu_B(b_{ij})\right], \min\left[v_A(a_{ij}), v_B(b_{ij})\right]\right\}, \quad \forall i,j \qquad (2.1)$
2. $A-B = \left\{\min\left[\mu_A(a_{ij}), \mu_B(b_{ij})\right], \max\left[v_A(a_{ij}), v_B(b_{ij})\right]\right\}, \quad \forall i,j \qquad (2.2)$

Definition 2.3 (Max-Min composition). *Let $A = [a_{ij}] \in IFSM_{m\times n}, B = \left[b_{jk}\right] \in IFSM_{n\times p}$, then $\max - \min$ composition fuzzy soft matrix relation of A and B id defined as $A * B = [c_{ik}]_{m\times p}$ Where,*

$$c_{ik} = \left\{ \text{Max} \left\{ \underset{j}{\text{Min}} \left[\mu_A(a_{ij}), \mu_B\left(b_{jk}\right)\right] \right\}, \text{Min} \left\{ \underset{j}{\text{Max}} \left[v_A(a_{ij}), v_B\left(b_{jk}\right)\right] \right\} \right\}. \tag{2.3}$$

Definition 2.4 (Complement function). *Let $A=[a_{ij}] \in IFSM_{m\times n}$, where $a_{ij} = (\mu_j(c_i), v_j(c_i))$ for all i, j. Then A^C is called an intuitionistic fuzzy soft complement matrix if $A^C = [d_{ij}]_{m\times n}$, where,*

$$d_{ij} = (v_j(c_i), \mu_j(c_i)), \quad \forall i,j. \tag{2.4}$$

Definition 2.5 (Max-Min Composition). *If $A = [a_{ij}] \in IFSM_{m\times n}$ and $B = \left[b_{jk}\right] \in IFSM_{n\times p}$, then a operation called fuzzy max-min composition for fuzzy soft matrix relation is defined as,*

$$A\phi B = \left\{\text{Max}\,\text{Min}\left\{\mu_{A_j,\mu_{B_j}}\right\}, \text{Min}\,\text{Max}\left\{v_{A_j}, v_{B_j}\right\}\right\}, \forall i,j \tag{2.5}$$

Definition 2.6 (Max-Min average composition). *If $A = [a_{ij}] \in IFSM_{m\times n}$ and $B = \left[b_{jk}\right] \in IFSM_{n\times p}$, then a new operation called revised intuitionistic fuzzy max-min average composition for fuzzy soft matrix relation is defined as,*

$$A\phi B = \left\{ \text{Max}\left\{ \frac{\mu_A(a_{ij}) + \mu_B\left(b_{jk}\right)}{2} \right\}, \text{Min}\left\{ \frac{v_A(a_{ij}) + v_B\left(b_{jk}\right)}{2} \right\} \right\}, \forall i,j \tag{2.6}$$

Definition 2.7 (Score matrix). *If $A = [a_{ij}] \in IFSM_{m\times n}, B = [b_{ij}] \in IFSM_{m\times n}$, and A^c, B^c are the complement of A and B then the score matrix of A and B is defined as,*

$$S(A,B) = \frac{[V+W]}{2}, \tag{2.7}$$

where V is the matrix defined as $V = \left[\left(\mu_{A\phi B} - v_{A^c\phi B^c}\right)\right]$ and W is the matrix defined as $W = \left[\left(\mu_{A^c\phi B^c} - v_{A\phi B}\right)\right]$

3. Algorithms

Algorithm-1: (Max-Min Average Composition)

Step 1. Input the intuitionistic fuzzy soft set $(F,C),(G,B)$ and obtain the intuitionistic fuzzy soft matrices K,L corresponding to (F,C) and (G,B), respectively.
Step 2. Obtain the intuitionistic fuzzy soft complement matrices K^c, L^c using the formula mentioned in equation (2.4).
Step 3. Compute the intuitionistic fuzzy max-min average compositions $K\phi L$ and $K^c\phi L^c$ using the formula mentioned in equation (2.6).
Step 4. Compute the matrices X,Y and obtain the score matrix Z using the equation (2.7).
Step 5. Identify the maximum score in $Z(A,B)$ for each A_i to select the suitable option.

Algorithm-2: (Max-Min Composition Method)

Step 1. Input the intuitionistic fuzzy soft set $(F,C),(G,B)$ and obtain the intuitionistic fuzzy soft matrices K,L corresponding to (F,C) and (G,B), respectively.
Step 2. Obtain the intuitionistic fuzzy soft complement matrices K^c, L^c using the formula mentioned in equation (2.4).
Step 3. Compute the intuitionistic fuzzy max-min compositions $K\phi L$ and $K^c\phi L^c$ using the formula mentioned in equation (2.5).
Step 4. Compute the matrices X,Y and obtain the score matrix Z using the equation (2.7).
Step 5. Identify the maximum score in $Z(A,B)$ for each A_i to select the suitable option.

Algorithm -3 (Distance method)

Step 1. Input the intuitionistic fuzzy soft set $(F,C),(G,B)$ and obtain the intuitionistic fuzzy soft matrices K,L corresponding to (F,C) and (G,B), respectively.
Step 2. Calculate the distances of intuitionistic fuzzy soft matrices by using distance maeasure.
Step 3. Identify the smallest distance for each Alternative B_i. Then Conclude that the Alternative B_i Suits the satisfies the criteria B_i.

4. Case Study

In this section we used that revised max-min average composition, Max-min composition and distance method to find the suitable school for the children according to the criteria of parents.

Criteria under Consideration: Here is the list of some important points to consider when it comes to finding the best school: Vision and mission of the school, Curriculum, Faculty, Infrastructure, Extra-curricular activities.

4.1 Illustration

We have presented an application of intuitionistic fuzzy soft set theory using maxmin average composition method for decision making in this section.

In a given set of systems, let $A = \{A_1, A_2, \dots A_m\}$ be the set of m alternatives- 1 and let $C = \{C_1, C_2, \dots C_n\}$ be the set of n criterias and let $B = \{B_1, B_2, \dots, B_k\}$ be the set of k alternatives-2 . Now construct a intuitionistic fuzzy soft set (F,C) over A, where F is a mapping $F : C \to IF^A$ and IF^A is the collection of all intuitionistic fuzzy subsets of A. This intuitionistic fuzzy soft set gives a matrix K. Then Construct another intuitionistic fuzzy soft set (G,B) over C, where G is a mapping $G : D \to IF^C$ and IF^C is the collection of all intuitionistic fuzzy subsets of C. This intuitionistic fuzzy soft set gives a matrix L. Obtain the intuitionistic fuzzy soft complement matrices, using the equation (2.4) let it be denoted by K^c, L^c. And then compute $K\phi L, K^c\phi L^c$ and $S(K,L)$ using the equation (2.6) and (2.7). Finally find the maximum value for each Alternative-1 (A_i) in the score matrix and then conclude that the alternative A_i is suitable for the alternative-2's B_j.

Consider $A = \{A_1, A_2, A_3\}$ as the universal set, where A_1, A_2, A_3 represent the set of parents. Then consider $C = \{C_1, C_2, C_3, C_4, C_5\}$ as the set of criterias, where C_1, C_2, C_3, C_4, C_5 represent vision and mission of the school, curriculum, faculty, infrastructure, extra-curricular activities respectively for the case study. Let $B = \{B_1, B_2, B_3\}$ be the set of schools taken for our case study, where B_1, B_2, B_3 denotes R.C. Fathima, New Bharath, Sai Ram school.

Suppose that intuitionistic fuzzy soft set (F,C) over A, where F is a mapping $F : S \to IF^A$, gives the description of parents expectation on each criteria using intuitionistic fuzzy matrix relation in the form of IFS:

$$
\begin{aligned}
&(F,A)\\
&\quad= \{F(A_1)\} = \{(A_1, 0.8, 0.1), (A_2, 0.6, 0.2), (A_3, 0.4, 0.1)\}\\
&\quad= \{F(A_2)\} = \{(A_1, 0.5, 0.3), (A_2, 0.8, 0.1), (A_3, 0.8, 0.1)\}\\
&\quad= \{F(A_3)\} = \{(A_1, 0.4, 0.2), (A_2, 0.6, 0.2), (A_3, 0.9, 0.1)\}\\
&\quad= \{F(A_4)\} = \{(A_1, 0.4, 0.2), (A_2, 0.5, 0.5), (A_3, 0.6, 0.1)\}\\
&\quad= \{F(A_5)\} = \{(A_1, 0.6, 0.3), (A_2, 0.4, 0.4), (A_3, 0.5, 0.4)\}
\end{aligned}
$$

Representing the above intuitionistic fuzzy soft set as intuitionistic fuzzy soft matrix.

$$
K = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}
\begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & C_4 & C_5 \end{array} \\
\begin{bmatrix}
(0.8,0.1) & (0.5,0.3) & (0.4,0.2) & (0.4,0.2) & (0.6,0.3)\\
(0.6,0.2) & (0.8,0.1) & (0.6,0.2) & (0.5,0.5) & (0.4,0.4)\\
(0.4,0.1) & (0.8,0.1) & (0.9,0.1) & (0.6,0.1) & (0.5,0.4)
\end{bmatrix}\end{array}
$$

Suppose that intuitionistic fuzzy soft set (G,B) over C, where G is a mapping $G : D \to IF^C$, gives the weight of the schools according to each criteria, using the intuitionistic fuzzy matrix relation in the form of IFS:

$$
\begin{aligned}
&(G,B)\\
&\quad= \{G(D_1)\} = \{(C_1, 0.7, 0.1), (C_2, 0.4, 0.2), (C_3, 0.1, 0.1),\\
&\qquad (C_4, 0.5, 0.5), (C_5, 0.8, 0.1)\}\\
&\quad= \{G(D_2)\} = \{(C_1, 0.3, 0.3), (C_2, 0.8, 0.1), (C_3, 0.1, 0.2),\\
&\qquad (C_4, 0.8, 0.1), (C_5, 0.5, 0.4)\}\\
&\quad= \{G(D_3)\} = \{(C_1, 0.4, 0.1), (C_2, 0.3, 0.1), (C_3, 0.9, 0.1)\\
&\qquad (C_4, 0.6, 0.3), (C_5, 0.6, 0.3)\}
\end{aligned}
$$

Represent the above mentioned intutionistic fuzzy soft set as a fuzzy soft matrix,

$$
L = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{array}
\begin{array}{c} \begin{array}{ccc} B_1 & B_2 & B_3 \end{array} \\
\begin{bmatrix}
(0.7,0.1) & (0.3,0.3) & (0.4,0.1)\\
(0.4,0.2) & (0.8,0.1) & (0.3,0.1)\\
(0.1,0.1) & (0.1,0.2) & (0.9,0.1)\\
(0.5,0.5) & (0.8,0.1) & (0.6,0.3)\\
(0.8,0.1) & (0.5,0.4) & (0.6,0.3)
\end{bmatrix}\end{array}
$$

Now calculate the intuitionistic fuzzy soft complement matrices as mentioned in step 2.

$$
K^c = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array}
\begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & C_4 & C_5 \end{array} \\
\begin{bmatrix}
(0.1,0.8) & (0.3,0.5) & (0.2,0.4) & (0.2,0.4) & (0.3,0.6)\\
(0.2,0.6) & (0.1,0.8) & (0.2,0.6) & (0.5,0.5) & (0.4,0.4)\\
(0.1,0.4) & (0.1,0.8) & (0.1,0.9) & (0.1,0.6) & (0.4,0.5)
\end{bmatrix}\end{array}
$$

$$
L^c = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{array}
\begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\
\begin{bmatrix}
(0.1,0.7) & (0.3,0.3) & (0.1,0.4)\\
(0.2,0.4) & (0.1,0.8) & (0.1,0.3)\\
(0.1,0.1) & (0.2,0.1) & (0.1,0.9)\\
(0.5,0.5) & (0.1,0.8) & (0.3,0.6)\\
(0.1,0.8) & (0.4,0.5) & (0.3,0.6)
\end{bmatrix}\end{array}
$$

Then to obtain intuitionistic fuzzy max-min average composition relation matrices use equation (2.6). The calculation is as follow, using the equation (2.6), value of $K\pi L$ is as follows,

$$
K^c\phi L^c = \begin{array}{c} \\ P_1 \\ P_2 \\ P_2 \end{array}
\begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\
\begin{bmatrix}
(0.35,0.25) & (0.35,0.25) & (0.30,0.40)\\
(0.50,0.35) & (0.40,0.35) & (0.40,0.50)\\
(0.30,0.50) & (0.40,0.35) & (0.35,0.40)
\end{bmatrix}\end{array}
$$

Then find the matrix X, using the formula,

$$X = \left[\left(\mu_{K\phi L} - v_{K} c_{\phi L} c \right) \right],$$

as follow,

$$
X = \left[\mu_{K\phi L} - v_{K^c\phi L^c} \right] = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array}
\begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\
\begin{bmatrix}
0.50 & 0.40 & 0.25\\
0.30 & 0.45 & 0.25\\
0.15 & 0.45 & 0.50
\end{bmatrix}\end{array}
$$

Then find the matrix Y, using the formula

$$Y = \left[\left(\mu_{K^c\phi L^c} - \nu_{K\phi L}\right)\right],$$

as follow,

$$Y = \left[\mu_{K^c\phi L^c} - \nu_{K\phi L}\right] = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \end{array} & \begin{bmatrix} 0.25 & 0.20 & 0.20 \\ 0.35 & 0.20 & 0.30 \\ 0.20 & 0.30 & 0.25 \end{bmatrix} \end{array}$$

Using the equation (2.7) the score matrix for intuitionistic fuzzy max-min composition method is,

$$Z = \frac{1}{2}[X+Y] = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \end{array} & \begin{bmatrix} 0.375 & 0.300 & 0.325 \\ 0.325 & 0.375 & 0.275 \\ 0.175 & 0.375 & 0.375 \end{bmatrix} \end{array}$$

It is clear from the above result that the school S_1 satisfies the criteria of parent P_1 and school S_2 satisfies the expectation of parents P_2 and both the schools S_2, S_3 satisfies the expectation of P_3.
Then to obtain intuitionistic fuzzy max-min composition relation matrices use equation (2.5). Using the values calculated using the equation (2.5), value of $K\phi L$ is as follows,

$$K\phi L = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \end{array} & \begin{bmatrix} (0.70,0.10) & (0.50,0.20) & (0.60,0.10) \\ (0.60,0.20) & (0.80,0.10) & (0.60,0.10) \\ [0.50,0.10) & (0.80,0.10) & (0.90,0.10) \end{bmatrix} \end{array}$$

Now applying intuitionistic fuzzy max-min average formula for calculating $K^c\phi L^c$ using equation (2.5) in K^c and L^c, Using the values calculated using the equation (2.5) value of $K^c\phi L^c$ is as follows,

$$K^c\phi L^c = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \end{array} & \begin{bmatrix} (0.20,0.40) & (0.30,0.40) & (0.30,0.50) \\ (0.50,0.50) & (0.40,0.50) & (0.30,0.60) \\ (0.10,0.60) & (0.40,0.40) & (0.30,0.40) \end{bmatrix} \end{array}$$

Then find the matrices X, Y using the formula,

$$X = \left[\left(\mu_{K\phi L} - \nu_{K^c\phi L^c}\right)\right]$$

as follow,

$$X = \left[\mu_{K\phi L} - \nu_{K^c\phi L^c}\right] = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_2 \end{array} & \begin{bmatrix} 0.30 & 0.10 & 0.10 \\ 0.10 & 0.30 & 0.00 \\ -0.40 & -0.10 & 0.00 \end{bmatrix} \end{array}$$

Then find the matrices X, Y using the formula,

$$Y = \left[\left(\mu_{K^c\phi L^c} - \nu_{K\phi L}\right)\right]$$

as follow,

$$Y = \left[\mu_{K^c\phi L^c} - \nu_{K\phi L}\right] = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_2 \end{array} & \begin{bmatrix} 0.10 & 0.10 & 0.20 \\ 0.30 & 0.30 & 0.20 \\ 0.00 & 0.30 & 0.30 \end{bmatrix} \end{array}$$

Using the equation (2.7) the score matrix for intuitionistic fuzzy max-min composition method is,

$$Z = \frac{1}{2}[X+Y] = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_2 \end{array} & \begin{bmatrix} 0.200 & 0.100 & 0.150 \\ 0.200 & 0.300 & 0.100 \\ 0.200 & 0.300 & 0.100 \end{bmatrix} \end{array}$$

For the problem illustrated above, we are using the algorithm-3 mentioned in and the results are as follow, the lowest distance points obtained out a proper diagnosis and the only proper way of calculating the widely used distances for IFSM is take into account all the paramereres; the membership function and non-membership function. To be more precise, the normalized Hamming distance for all the symptoms of the ith patient from the kth diagnosis is equal to

$$l[(F,E),(G,E)] = \frac{1}{10}\sum_{j=1}^{5}\left|\mu_j(P_i) - \mu_j(d_k)\right| + \frac{1}{10}\sum_{j=1}^{5}\left|\nu_j(P_i) - \nu_j(d_k)\right| \tag{4.1}$$

From the calculations above, we have the matrix,

$$Z = \begin{array}{c c} & \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_2 \end{array} & \begin{bmatrix} 0.150 & 0.220 & 0.170 \\ 0.200 & 0.170 & 0.180 \\ 0.270 & 0.140 & 0.009 \end{bmatrix} \end{array}$$

We have given a table by comparing all the values obtained by three methods and also we have given a diagram representing our result below,

5. Conclusion

From the above table, we can conclude that School-1 satisfies the criteria of the parent-1 and it suits for their child, and School-2 Satisfies the criteria of the parent-2 and it suits for their child, and School-3 satisfies the criteria of the parent-3 and it suits for their child. Though their arise a tie for parent-3 by using Min-Max average composition, by comparing all the three methods the conclusion have been taken.

Table 1. Comparison table for three methods

	Methods	School-1	School-2	School-3
Parent-1	Min-Max Average Composition	0.375	0.300	0.325
	Min-Max Composition	0.200	0.100	0.150
	Distance method	0.150	0.220	0.170
Parent-2	Min-Max Average Composition	0.325	0.375	0.275
	Min-Max Composition	0.200	0.300	0.100
	Distance method	0.200	0.170	0.180
Parent-3	Min-Max Average Composition	0.175	0.375	0.375
	Min-Max Composition	-0.05	0.350	0.350
	Distance method	0.27	0.140	0.090

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