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An Application Of Fuzzy Binary Soft Set In Decision Making Problems

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Abstract:

In 2020 [4] we introduced fuzzy binary soft set and developed its characteristics in the form of theorems. In our day to day life we are facing very critical when we solve a decision making problem. Fuzzy binary soft set takes a vital role in solving decision making problems. In this paper we find out and study the application of fuzzy binary soft set in our daily life. For that, we introduce a decision making problem and solve by using fuzzy binary soft set.

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1. Introduction

In some situations we cannot deal with certain data, to describe uncertainty. Zadah [11] introduced fuzzy set in 1965. Molodtsov [9] introduced Soft set in 1999 , fuzzy soft set which is the combination of fuzzy set and soft set defined by Maji et al. [8] are dealing with the uncertainties. Many researchers developed applications in the fields like Medical Science, Engineering, Sociology and other fields of real life by using these theories. P.K.Maji , A.R.Roy and R.Biswas [7] introduced the choice value algorithm for the application of soft set theory in decision making problems in 2002. Similarly N. Cagman , S. Enginoglu and F.Citak [2] also gave the application of fuzzy soft set. Roy and Maji [10] initiated the comparison score algorithm for the application of fuzzy soft set in decision making problems. P. K. Das and R. Borgohain [3] introduced an application of Fuzzy Soft Set in Multi criteria Decision Making Problems. Likewise Krishna Gogoi et al. [5] and Z. Kong et al. [6] developed the application of fuzzy soft set.

In 2016, Ahu Acikgoz and Nihal Das [1] initiated "binary soft set" with two universal sets and studied its fundamental properties. In 2020, we introduced [4] "fuzzy binary soft set" and developed many results based on this definition. In this paper we introduced an algorithm based on comparison score algorithm for the application of fuzzy binary soft set which is dealing with uncertainty.

In preliminaries we have reviewed the needed definitions. In the next section we have introduced an application of fuzzy binary soft set in the form of real life problem and we explained that how to take a right decision or choice for the best option using the fuzzy binary soft set.

2. Preliminaries

Definition 1.[4]

Let $\mathbb{U}^{\mathbf{1}}_{\varsigma}$, $\mathbb{U}^{\mathbf{2}}_{\varsigma}$ be the two universal sets, E_P be a set of parameters and $F_{fbs}(\mathbb{U}^{\mathbf{1}}_{\varsigma})$, $F_{fbs}(\mathbb{U}^{\mathbf{2}}_{\varsigma})$ denotes the set of all fuzzy sets respectively. Let $A_P \subseteq E_P$. Then (F_{fbs}, A_P) is said to be "**fuzzy binary soft set**" over $\mathbb{U}^{\mathbf{1}}_{\varsigma}$, $\mathbb{U}^{\mathbf{2}}_{\varsigma}$, where F_{fbs} is a mapping given by $F_{fbs} : A_P \to F_{fbs}(\mathbb{U}^{\mathbf{1}}_{\varsigma}) \times F_{fbs}(\mathbb{U}^{\mathbf{2}}_{\varsigma})$, $F_{fbs}(p) = (S, T)$ for each $p \in A_P$ such that $S \subseteq \mathbb{U}^{\mathbf{1}}_{\varsigma}$, $T \subseteq \mathbb{U}^{\mathbf{2}}_{\varsigma}$.

Definition 2. [4]

The set (F_{fbs}, A_P) is called a **"fuzzy binary soft subset"** of (G_{fbs}, B_P) if

- $A_P \subseteq B_P$,
- $F_{fbs}(p)$ is the fuzzy subset of $G_{fbs}(p)$ for each $p \in A_P$ and is denoted by $(F_{fbs}, A_P) \tilde{\subseteq} (G_{fbs}, B_P)$.

Likewise, (F_{fbs}, A_P) is said to be a **"fuzzy binary soft superset**" of (G_{fbs}, B_P) if $(F_{fbs}, A_P) \tilde{\supseteq} (G_{fbs}, B_P)$.

Definition 3. [4]

The "**complement of a fuzzy binary soft set**" (F_{fbs}, A_P) is $(F_{fbs}, A_P)^c \cong (F_{fbs}{}^c, \rceil A_P)$, where $F_{fbs}{}^c : \rceil A_P \to F_{\mathbf{fbs}}(\mathbb{U}^1_{\varsigma}) \times F_{\mathbf{fbs}}(\mathbb{U}^2_{\varsigma})$, is a mapping defined by $F_{fbs}{}^c(p) \cong (F_{fbs}(\rceil p))^c$ for all $\rceil p \in A_P$.

Definition 4. [4]

A set (F_{fbs}, A_P) is said to be a "**fuzzy binary null soft set**" if for all $p \in A_P$, $F_{fbs}(p)$ is the null fuzzy set over $\mathbb{U}^1_{\varsigma}$, $\mathbb{U}^2_{\varsigma}$ and is denoted by $\tilde{0}$.

Definition 5. [4]

For all $p \in A_P$, the "**fuzzy binary absolute soft set**", (F_{fbs}, A_P) is defined as $F_{fbs}(p)$ is the absolute fuzzy set over $\mathbb{U}^1_{\varsigma}$, $\mathbb{U}^2_{\varsigma}$ and is denoted by $\widetilde{A}$.

Definition 6. [4]

"Union of two fuzzy binary soft sets" (F_{fbs}, A_P) and (G_{fbs}, B_P) is (H_{fbs}, C_P), where $C_P = A_P \cup B_P$ and for each $p \in C_P$,

$$H_{fbs}(p) = \begin{cases} F_{fbs}(p), & p \in A_p \setminus B_p \\ G_{fbs}(p), & p \in B_p \setminus A_p \\ F_{fbs}(p) \cup G_{fbs}(p), & p \in A_p \cap B_p \end{cases}$$

We write $(H_{fbs}, C_P) \cong (F_{fbs}, A_P) \tilde{\cup} (G_{fbs}, B_P)$.

Definition 7. [4]

"Intersection of two fuzzy binary soft sets" (F_{fbs}, A_P), (G_{fbs}, B_P) is (H_{fbs}, C_P), where $C_P = A_P \cap B_P$ and $H_{fbs}(p) = F_{fbs}(p) \cap G_{fbs}(p)$ for each $p \in C_P$, such that $F_{fbs}(p) = (S_1, T_1)$ for each $p \in A_P$ and $G_{fbs}(p) = (S_2, T_2)$ for each $p \in B_P$. we denote it by $(H_{fbs}, P_C) \cong (F_{fbs}, A_P) \tilde{\cap} (G_{fbs}, B_P)$.

3. An application of Fuzzy Binary Soft Set

We redefined the algorithm procedure defined by Roy and Maji [10] for fuzzy binary soft set from step : 6 onwards. Also we used the redefined algorithm to a decision making problem.

3.1 Algorithm

Step1. Convert the given data into fuzzy binary soft sets.
Step 2. Write the fuzzy binary soft sets in the form of matrix.
Step 3. Find the average of the corresponding entries of all the matrices to get the average matrix.
Step 4. Assign the weightage for the decision parameters such that $\sum_{i=1}^{n} w_i \leq 1$.
Step 5. Construct the comprehensive decision matrix by multiplying the average matrix with w_i.
Step 6. Formulate the comparison table of a fuzzy binary soft set. Comparison table is a square table in which the number of rows and number of columns are equal, rows and columns both are labeled by the elements a_i and b_i, $(i = 1, 2, \ldots, n)$ of the universal sets $\mathbb{U}_{\S}^{1}$ and $\mathbb{U}_{\S}^{2}$ respectively, and the entries are e_{ij}, $i,j = 1, 2, \ldots, n$, given by e_{ij} = the number of parameters for which the membership value of either a_i or b_i exceeds or equal to the membership value of either a_i or b_i .
Clearly, $0 \leq e_{ij} \leq k$, and $e_{ii} = k$, $\forall i, j$ where, k is the number of parameters present in a fuzzy binary soft set.
Step 7. Find the row sums r_i and column sums t_i of the comparison table and obtain the score value table by $s_i = r_i - t_i$
Step 8. The best choice is the maximum score in both the universal sets. will be recommended as the best choice.

3.1.1 Problem:

Let us consider a situation, Suppose Mr. X wants to choose a best Engineering college among the set of colleges $\mathbb{U}_{\S}^{\mathbf{1}} = \{c^1, c^2, c^3, c^4\}$ for his studies. As well as the best course among the set of courses $\mathbb{U}_{\xi}^{\mathbf{2}}$ = {d^1 = computer science, d^2 = information technology, d^3 = mechanical, d^4 = electrical and electronics} for him on the basis of his choice parameters E_p = {p^1 = Society ranking about the institution, p^2 = Enrichment activities for student's group, p^3 = Infrastructure facilities, p^4 = Campus placement opportunities}. Also Mr. X consider the choice of counseling agencies of three members.

Now, we use Algorithm 3.1 to solve the above decision making problem.

Step: 1

The counseling agencies consists of three members forms the fuzzy binary soft sets (F_{fbs} , E_P), (G_{fbs} , E_P), (H_{fbs} , E_P) over the $\mathbb{U}_{\xi}^{\mathbf{1}}$ and $\mathbb{U}_{\xi}^{\mathbf{2}}$.

$$\begin{aligned}(F_{fbs}, E_P) = \{&(p^1, (\{\tfrac{c^1}{0.2},\tfrac{c^2}{0.4},\tfrac{c^3}{0.1},\tfrac{c^4}{0.7}\},\ \{\tfrac{d^1}{0.3},\tfrac{d^2}{0.4},\tfrac{d^3}{0.6},\tfrac{d^4}{0.2}\})),\\ &(p^2, (\{\tfrac{c^1}{0.7},\tfrac{c^2}{0.6},\tfrac{c^3}{0.3},\tfrac{c^4}{0.5}\},\ \{\tfrac{d^1}{0.5},\tfrac{d^2}{0.4},\tfrac{d^3}{0.7},\tfrac{d^4}{0.9}\})),\\ &(p^3, (\{\tfrac{c^1}{0.1},\tfrac{c^2}{0.3},\tfrac{c^3}{0.2},\tfrac{c^4}{0.4}\},\ \{\tfrac{d^1}{0.2},\tfrac{d^2}{0.5},\tfrac{d^3}{0.6},\tfrac{d^4}{0.3}\})),\\ &(p^4, (\{\tfrac{c^1}{0.4},\tfrac{c^2}{0.2},\tfrac{c^3}{0.7},\tfrac{c^4}{0.3}\},\ \{\tfrac{d^1}{0.4},\tfrac{d^2}{0.3},\tfrac{d^3}{0.1},\tfrac{d^4}{0.5}\}))\}\end{aligned}$$

$$\begin{aligned}(G_{fbs}, E_P) = \{&(p^1, (\{\tfrac{c^1}{0.4},\tfrac{c^2}{0.3},\tfrac{c^3}{0.6},\tfrac{c^4}{0.7}\},\ \{\tfrac{d^1}{0.5},\tfrac{d^2}{0.1},\tfrac{d^3}{0.7},\tfrac{d^4}{0.3}\})),\\ &(p^2, (\{\tfrac{c^1}{0.3},\tfrac{c^2}{0.2},\tfrac{c^3}{0.5},\tfrac{c^4}{0.8}\},\ \{\tfrac{d^1}{0.4},\tfrac{d^2}{0.9},\tfrac{d^3}{0.6},\tfrac{d^4}{0.2}\})),\\ &(p^3, (\{\tfrac{c^1}{0.5},\tfrac{c^2}{0.2},\tfrac{c^3}{0.6},\tfrac{c^4}{0.7}\},\ \{\tfrac{d^1}{0.8},\tfrac{d^2}{0.3},\tfrac{d^3}{0.4},\tfrac{d^4}{0.5}\})),\\ &(p^4, (\{\tfrac{c^1}{0.4},\tfrac{c^2}{0.7},\tfrac{c^3}{0.8},\tfrac{c^4}{0.3}\},\ \{\tfrac{d^1}{0.6},\tfrac{d^2}{0.4},\tfrac{d^3}{0.8},\tfrac{d^4}{0.2}\}))\}\end{aligned}$$

$$\begin{aligned}(H_{fbs}, E_P) = \{&(p^1, (\{\tfrac{c^1}{0.2},\tfrac{c^2}{0.9},\tfrac{c^3}{0.1},\tfrac{c^4}{0.4}\},\ \{\tfrac{d^1}{0.5},\tfrac{d^2}{0.7},\tfrac{d^3}{0.4},\tfrac{d^4}{0.2}\})),\\ &(p^2, (\{\tfrac{c^1}{0.9},\tfrac{c^2}{0.5},\tfrac{c^3}{0.3},\tfrac{c^4}{0.6}\},\ \{\tfrac{d^1}{0.8},\tfrac{d^2}{0.4},\tfrac{d^3}{0.2},\tfrac{d^4}{0.5}\})),\\ &(p^3, (\{\tfrac{c^1}{0.3},\tfrac{c^2}{0.4},\tfrac{c^3}{0.8},\tfrac{c^4}{0.7}\},\ \{\tfrac{d^1}{0.7},\tfrac{d^2}{0.5},\tfrac{d^3}{0.3},\tfrac{d^4}{0.1}\})),\\ &(p^4, (\{\tfrac{c^1}{0.6},\tfrac{c^2}{0.4},\tfrac{c^3}{0.2},\tfrac{c^4}{0.7}\},\ \{\tfrac{d^1}{0.3},\tfrac{d^2}{0.2},\tfrac{d^3}{0.4},\tfrac{d^4}{0.5}\}))\}\end{aligned}$$

Step: 2

Now we convert the fuzzy binary soft sets into matrix as below

$$F_{fbs} = \begin{bmatrix} 0.2 & 0.7 & 0.1 & 0.4 \\ 0.4 & 0.6 & 0.3 & 0.2 \\ 0.1 & 0.3 & 0.2 & 0.7 \\ 0.7 & 0.5 & 0.4 & 0.3 \\ 0.3 & 0.5 & 0.2 & 0.4 \\ 0.4 & 0.4 & 0.5 & 0.3 \\ 0.6 & 0.7 & 0.6 & 0.1 \\ 0.2 & 0.9 & 0.3 & 0.5 \end{bmatrix}$$

$$G_{fbs} = \begin{bmatrix} 0.4 & 0.3 & 0.5 & 0.4 \\ 0.3 & 0.2 & 0.2 & 0.7 \\ 0.6 & 0.5 & 0.6 & 0.8 \\ 0.7 & 0.8 & 0.7 & 0.3 \\ 0.5 & 0.4 & 0.8 & 0.6 \\ 0.1 & 0.9 & 0.3 & 0.4 \\ 0.7 & 0.6 & 0.4 & 0.8 \\ 0.3 & 0.2 & 0.5 & 0.2 \end{bmatrix}$$

$$H_{fbs} = \begin{bmatrix} 0.2 & 0.9 & 0.3 & 0.6 \\ 0.9 & 0.5 & 0.4 & 0.4 \\ 0.1 & 0.3 & 0.8 & 0.2 \\ 0.4 & 0.6 & 0.7 & 0.7 \\ 0.5 & 0.8 & 0.7 & 0.3 \\ 0.7 & 0.4 & 0.5 & 0.2 \\ 0.4 & 0.2 & 0.3 & 0.4 \\ 0.2 & 0.5 & 0.1 & 0.5 \end{bmatrix}$$

Step: 3

Take the average for the above fuzzy binary soft sets, we get a average matrix as

$$A_{fbs} = \begin{bmatrix} 0.27 & 0.63 & 0.3 & 0.47 \\ 0.53 & 0.43 & 0.3 & 0.43 \\ 0.27 & 0.37 & 0.53 & 0.57 \\ 0.6 & 0.63 & 0.6 & 0.43 \\ 0.43 & 0.57 & 0.57 & 0.43 \\ 0.4 & 0.57 & 0.43 & 0.3 \\ 0.57 & 0.5 & 0.43 & 0.43 \\ 0.23 & 0.53 & 0.3 & 0.4 \end{bmatrix}$$

Step: 4

Suppose that Mr. X assigns the weightage for the decision parameters as follows:

Choice Parameter	p^1	p^2	p^3	p^4
Weightage	0.4	0.1	0.2	0.3

Step: 5

Hence to get the comprehensive decision matrix D_{fbs} , multiply A_{fbs} by the weightage which is assign by Mr. X and get the desired matrix D_{fbs} as follows:

$$\text{Therefore, } D_{fbs} = \begin{bmatrix} 0.11 & 0.06 & 0.06 & 0.14 \\ 0.21 & 0.043 & 0.06 & 0.13 \\ 0.11 & 0.037 & 0.11 & 0.17 \\ 0.24 & 0.06 & 0.12 & 0.13 \\ 0.17 & 0.057 & 0.11 & 0.13 \\ 0.16 & 0.057 & 0.09 & 0.09 \\ 0.23 & 0.05 & 0.09 & 0.13 \\ 0.10 & 0.053 & 0.06 & 0.12 \end{bmatrix}$$

Step: 6

Now the comparison table is formulated by using the comprehensive decision matrix.

$\mathbb{U}_{\S}^{\mathbf{1}}, \mathbb{U}_{\S}^{\mathbf{2}}$	c^1	c^2	c^3	c^4	d^1	d^2	d^3	d^4
c^1	4	3	2	2	2	1	2	4
c^2	2	4	2	1	2	2	1	3
c^3	3	2	4	1	2	2	2	3
c^4	3	4	3	4	4	4	4	4
d^1	2	3	3	1	4	4	2	4
d^2	2	2	2	0	1	4	2	3
d^3	2	4	2	1	2	3	4	3
d^4	1	2	1	0	0	1	1	4

Step: 7

Now compute the row- sum and column-sum for each row and column.

Also find the score value for it. we get,

$\mathbb{U}_{\S}^{\mathbf{1}}, \mathbb{U}_{\S}^{\mathbf{2}}$	Row sum	Column sum	Score value
c^1	20	19	1
c^2	17	24	-7
c^3	19	19	0

c^4	30	10	20
d^1	24	17	7
d^2	16	21	-5
d^3	21	19	2
d^4	10	28	-18

Step: 8

From step: 7, the maximum score for the universal set $\mathbb{U}_{\S}^{\mathbf{1}}$ is 20 and for the universal set $\mathbb{U}_{\S}^{\mathbf{2}}$ is 7, which lies in c^4 and d^1. Therefore the college c^4 will be the best choice for him.

4. Conclusion

The best decision for Mr. X based on his choice parameter together with the choice of counseling agencies is the college c^4 and the course d^1 that is computer science.

In this paper we redefined the algorithm procedure defined by Roy and Maji [10] for fuzzy binary soft set and solved a decision making problem using the algorithm. It helps to solve the decision making problem in a right manner. This algorithm assists to take the best decision in a critical situation with two universal sets.

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