An Application Of Fuzzy Binary Soft Set In Decision Making Problems

1 P.Gino Metilda, 2 Dr. J. Subhashini

1 Research scholar (Reg no: 19221272092006), 2 Assistant Professor,

12Department of Mathematics, St.John’s College, Palayamkottai, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627012, Tamil Nadu, India.

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 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 $\mathcal{U}_1, \mathcal{U}_2$ be the two universal sets, $\mathcal{E}_P$ be a set of parameters and $F_{\text{fbs}}(\mathcal{U}_1), F_{\text{fbs}}(\mathcal{U}_2)$ denotes the set of all fuzzy sets respectively. Let $A_P \subseteq \mathcal{E}_P$. Then $(F_{\text{fbs}}, A_P)$ is said to be \textit{“fuzzy binary soft set”} over $\mathcal{U}_1, \mathcal{U}_2$, where $F_{\text{fbs}}$ is a mapping given by $F_{\text{fbs}}: A_P \rightarrow F_{\text{fbs}}(\mathcal{U}_1) \times F_{\text{fbs}}(\mathcal{U}_2)$, $F_{\text{fbs}}(p) = (S, T)$ for each $p \in A_P$ such that $S \subseteq \mathcal{U}_1, T \subseteq \mathcal{U}_2$.

Definition 2.[4]
The set $(F_{\text{fbs}}, A_P)$ is called a \textit{“fuzzy binary soft subset”} of $(G_{\text{fbs}}, B_P)$ if

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

Likewise, $(F_{\text{fbs}}, A_P)$ is said to be a \textit{“fuzzy binary soft superset”} of $(G_{\text{fbs}}, B_P)$ if $(F_{\text{fbs}}, A_P) \supseteq (G_{\text{fbs}}, B_P)$.

Definition 3. [4]
The \textquoteleft\textquoteleft complement of a fuzzy binary soft set\textquoteright\textquoteright\ $(F_{\text{fbs}}, A_P)$ is $(F_{\text{fbs}}, A_P)^c \equiv (F_{\text{fbs}}^c, 1 A_P)$, where $F_{\text{fbs}}^c: 1 A_P \rightarrow F_{\text{fbs}}(\mathcal{U}_1) \times F_{\text{fbs}}(\mathcal{U}_2)$, is a mapping defined by $F_{\text{fbs}}^c(p) \equiv (F_{\text{fbs}}(1p))^c$ for all $1p \in A_P$.

Definition 4.[4]
A set $(F_{\text{fbs}}, A_P)$ is said to be a \textit{“fuzzy binary null soft set”} if for all $p \in A_P$, $F_{\text{fbs}}(p)$ is the null fuzzy set over $\mathcal{U}_1, \mathcal{U}_2$ and is denoted by $\mathcal{0}$.

Definition 5.[4]
For all $p \in A_P$, the \textit{“fuzzy binary absolute soft set”}, $(F_{\text{fbs}}, A_P)$ is defined as $F_{\text{fbs}}(p)$ is the absolute fuzzy set over $\mathcal{U}_1, \mathcal{U}_2$ and is denoted by $\mathcal{A}$.

Definition 6.[4]
“Union of two fuzzy binary soft sets” \((F_{\text{fbs}}, A_P)\) and \((G_{\text{fbs}}, B_P)\) is \((H_{\text{fbs}}, C_P)\), where \(C_P = A_P \cup B_P\) and for each \(p \in C_P\),
\[
H_{\text{fbs}}(p) = \begin{cases} 
F_{\text{fbs}}(p), & p \in A_P \setminus B_P \\
G_{\text{fbs}}(p), & p \in B_P \setminus A_P \\
F_{\text{fbs}}(p) \cup G_{\text{fbs}}(p), & p \in A_P \cap B_P
\end{cases}
\]

We write \((H_{\text{fbs}}, C_P) \equiv (F_{\text{fbs}}, A_P) \cup (G_{\text{fbs}}, B_P)\).

**Definition 7.** [4]

“Intersection of two fuzzy binary soft sets” \((F_{\text{fbs}}, A_P), (G_{\text{fbs}}, B_P)\) is \((H_{\text{fbs}}, C_P)\), where \(C_P = A_P \cap B_P\) and \(H_{\text{fbs}}(p) = F_{\text{fbs}}(p) \cap G_{\text{fbs}}(p)\) for each \(p \in C_P\), such that \(F_{\text{fbs}}(p) = (S_1, T_1)\) for each \(p \in A_P\) and \(G_{\text{fbs}}(p) = (S_2, T_2)\) for each \(p \in B_P\). We denote it by \((H_{\text{fbs}}, C_P) \equiv (F_{\text{fbs}}, A_P) \cap (G_{\text{fbs}}, B_P)\).

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**

Step 1. 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 \(\cup^1_x\) and \(\cup^2_x\) 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 \(\cup^1_x = \{c^1, c^2, c^3, c^4\}\) for his studies. As well as the best course among the set of
Now we convert the fuzzy binary soft sets for him on the basis of his choice parameters $E_p = \{p^1 = \text{Society ranking about the institution}, p^2 = \text{Enrichment activities for student’s group}, p^3 = \text{Infrastructure facilities}, p^4 = \text{Campus placement opportunities}\}$. 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 $\mathbb{U}_1^2$ and $\mathbb{U}_2^2$.

$$(F_{fbs}, E_p) = \{(p^1, (\{(c_1^{0.2}, c_2^{0.4}, c_3^{0.1}, c_4^{0.7}), (d_1^{0.3}, d_2^{0.4}, d_3^{0.6}, d_4^{0.2})\}), \ldots).$$

$$(G_{fbs}, E_p) = \{(p^1, (\{(c_1^{0.4}, c_2^{0.3}, c_3^{0.6}, c_4^{0.7}), (d_1^{0.5}, d_2^{0.1}, d_3^{0.7}, d_4^{0.3})\}), \ldots).$$

$$(H_{fbs}, E_p) = \{(p^1, (\{(c_1^{0.2}, c_2^{0.9}, c_3^{0.1}, c_4^{0.4}), (d_1^{0.5}, d_2^{0.7}, d_3^{0.4}, d_4^{0.2})\}), \ldots).$$

**Step: 2**

Now we convert the fuzzy binary soft sets into matrix as below
Step: 3
Take the average for the above fuzzy binary soft sets, we get a average matrix as

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

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

\[
H_{\text{fbs}} = \begin{bmatrix}
0.2 & 0.9 & 0.3 & 0.6 \\
0.9 & 0.5 & 0.4 & 0.4 \\
0.1 & 0.3 & 0.8 & 0.2 \\
0.4 & 0.6 & 0.7 & 0.7 \\
0.5 & 0.8 & 0.7 & 0.3 \\
0.7 & 0.4 & 0.5 & 0.2 \\
0.4 & 0.2 & 0.3 & 0.4 \\
0.2 & 0.5 & 0.1 & 0.5
\end{bmatrix}
\]
Step: 4
Suppose that Mr. X assigns the weightage for the decision parameters as follows:

<table>
<thead>
<tr>
<th>Choice Parameter</th>
<th>$p_1$</th>
<th>$p_2$</th>
<th>$p_3$</th>
<th>$p_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weightage</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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:

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

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

Step: 6
Now the comparison table is formulated by using the comprehensive decision matrix.
Now compute the row-sum and column-sum for each row and column.

Also find the score value for it. We get,

<table>
<thead>
<tr>
<th>( U^1_\xi, U^2_\xi )</th>
<th>Row sum</th>
<th>Column sum</th>
<th>Score value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c^1 )</td>
<td>20</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>( c^2 )</td>
<td>17</td>
<td>24</td>
<td>-7</td>
</tr>
<tr>
<td>( c^3 )</td>
<td>19</td>
<td>19</td>
<td>0</td>
</tr>
</tbody>
</table>

Step: 7
Step: 8
From step: 7, the maximum score for the universal set $\mathbb{U}_1$ is 20 and for the universal set $\mathbb{U}_2$ 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.

References


