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An Approach For Solving Decision Making Problem In Intuitionistic Fuzzy Soft Matrix

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Abstract: Soft set theory is a newly mathematical tool to deal with uncertain problems. It has a rich potential for application in solving practical problems in economics, social science, medical science etc. The concept of fuzzy soft sets extended fuzzy soft set to Intuitionistic fuzzy soft sets .In this paper we proposed intuitionistic fuzzy soft matrices and defined different types of intuitionistic fuzzy soft matrices and some operators. Finally a practical example that explains the best operating system on the laptop is analysed and demonstrate the application of the proposed decision making method.

Key words: Soft sets · Fuzzy soft sets · Fuzzy soft matrices · Intuitionistic fuzzy soft matrices

INTRODUCTION

Soft set theory was initiated by Russian researcher Molodtov [1]; he proposed soft set as a completely generic mathematical tool for modeling uncertainties Maji *et al*. [2, 3] applied this theory to several directions for dealing with the problems in uncertainty and imprecision. Pei and Miao [4] and Chen *et al*. [5] improved the work of Maji *et al.* [2, 3] and Yong *et al*. [6] initiated a matrix representation of a fuzzy soft set and applied it in decision making problems. Borah *et al.* [7] and in Neog *et al.* [8] extended fuzzy soft matrix theory and its application. Chetia *et al.* [9] proposed Intuitionistic fuzzy soft matrix theory Rajarajeswari *et al.* [10] proposed new definitions for Intuitionistic fuzzy soft matrices and its types.

Babitha and John [11] described generalized intuitionistic fuzzy soft sets and solved multi criteria decision making problem in generalized intuitionistic fuzzy soft matrices. In this paper, a new approach is proposed to construct the decision method for the operating system on the laptops by using Intuitionistic Fuzzy Soft Matrices. The result is obtained based on the maximum value in the score matrix.

Defenitions and Preliminaries: The basic definitions of Intuitionistic fuzzy soft set theory that are useful for subsequent discussions are given.

Soft Set: Suppose that U is an initial Universe of discourse and E is a set of parameters, let P (U) denotes the power set of U. A pair (F, E) is called a soft set over U where F is a mapping given by F: E → P (U). Clearly, a soft set is a mapping from parameters to P (U) and it is not a set, but a parameterized family of subsets of the Universe.

Fuzzy Soft Set: Let U be an initial Universe of discourse and E be the set of parameters. Let A ⊆ E. A pair (F, A) is called fuzzy soft set over U where F is a mapping given by F: A → I U, where I U denotes the collection of all fuzzy subsets of U.

Fuzzy Soft Matrix: Let U = {c_1, c_2, c_3, . . . , cm} be the Universal set and E be the set of parameters given by E = {e_1, e_2, e_3. . . . , e_n}. Let}. Let A ⊆ E and (F, A) be a fuzzy soft set in the fuzzy soft class (U, E).Then fuzzy soft set (F, A) in a matrix form as Am×n = [aij] m×n or A = [aij], i = 1, 2, . . . , m, j = 1, 2, 3, . . . , n, where,

$$a_{ij} = \begin{cases} (\mu_j(C_j), V_j(C_i)) & if\ e_j \in A \\ (0,1) & if\ e_j \notin A \end{cases}$$

μ_j (c_i) represents the membership of c_i in the Intuitionistic fuzzy set F(e_j). v_j (c_i) represents the non-membership of c_i in the Intuitionistic fuzzy set F(ej).

Intuitionistic Fuzzy Soft Matrix Theory

Intuitionistic Fuzzy Soft Set: Let U be an initial universe set and E be the set of parameters. Let IF U denote the collection of all Intuitionistic fuzzy subsets of U. Let A ⊆ E. A pair (F; A) is called an Intuitionistic fuzzy soft set over U where F is a mapping given by F: A → IF U.

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Intuitionistic Fuzzy Soft Set Complement Matrix: Let A = [aij] ∈ IFSM $_{mxn}$, where $a_{ij} = (\mu_j (c_i), \nu_j (c_i))$ ∀ i, j. Then A^C is called a Intuitionistic Fuzzy Soft Complement Matrix if $A^C = [d_{ij}]$ mxn, where $d_{ij} = (\nu_j (c_i), \mu_j (c_i))$ ∀ i, j.

Intuitionistic Fuzzy Soft Sub Matrix: Let A = $[a_{ij}]$ IFSM $_{mxn}$, B = $[b_{ij}]$ IFSM$_{mxn}$, Then A is a intuitionistic fuzzy soft submatrix of B, denoted by $A \subseteq B$. if $\mu_A \leq \mu_B$ and $\nu_A \geq \nu_B$ ∀ *i*, *j*.

Intuitionistic Fuzzy Soft Null (Zero) Matrix: An intuitionistic fuzzy soft matrix of order mxn is called intuitionistic fuzzy soft null (zero) matrix . If all its elements are (0, 1). It is denoted by Φ.

Intuitionistic Fuzzy Soft Universal Matrix: An intuitionistic fuzzy soft matrix of order mxn is called intuitionistic fuzzy soft universal matrix if all its elements are (1, 0). It is denoted by U.

Intuitionistic Fuzzy Soft Equal Matrix: A = $[a_{ij}]$ IFSM $_{mxn}$, B = $[b_{ij}]$ IFSM$_{mxn}$, Then A is equal to B, denoted by $A = B$. if $\mu_A = \mu_B$ and $\nu_A = \nu_B$ ∀ *i*, *j*.

Intuitionistic Fuzzy Soft Transpose Matrix: Let A = $[a_{ij}]$ IFSM$_{mxn}$ Then A^T is a intuitionistic fuzzy soft transpose matrix of A if $A^T = [a_{ji}]$

Intuitionistic Fuzzy Soft Rectangular Matrix: Let A = $[a_{ij}]$ IFSM$_{mxn}$, where $a_{ij} = (\mu_j (c_i), \nu_j (c_i))$. Then A is called a Intuitionistic Fuzzy Soft rectangular Matrix if m ≠ n.

Intuitionistic Fuzzy Soft Upper Triangular Matrix: Let A = $[a_{ij}]$ IFSM$_{mxn}$, where $a_{ij} = (\mu_j (c_i), \nu_j (c_i))$. Then A is called a Intuitionistic Fuzzy Soft upper rectangular Matrix if m=n and a_{ij} =(0, 1) ∀ i>j.

Intuitionistic Fuzzy Soft Lower Triangular Matrix: Let A = $[a_{ij}]$ IFSM$_{mxn}$, where $a_{ij} = (\mu_j (c_i), \nu_j (c_i))$. Then A is called a Intuitionistic Fuzzy Soft lower rectangular Matrix if m=n and a_{ij} =(0, 1) ∀ i<j.

Operations on Intuitionistic Fuzzy Soft Matrix Theory Addition and Subtraction of Intuitionistic Fuzzy Soft Matrix: If A = $[a_{ij}]$ ∈ IFSM$_{mxn}$, B = $[b_{ij}]$ ∈ IFSM mxn, then we define the addition and subtraction of Intuitionistic Fuzzy Soft Matrices of A and B as;

A + B = { $\max[(\mu_A(a_{ij}), \mu_B(b_{ij})], \min[\nu_A(a_{ij}), \nu_B(b_{ij})]$} ∀ i, j
A – B = { $\min[\mu_A(a_{ij}), \mu_B(b_{ij})], \max[\nu_A(a_{ij}), \nu_B(b_{ij})]$} ∀ i, j.

Product of Intuitionistic Fuzzy Soft Matrix: If A = $[a_{ij}]$ ∈ IFSM$_{mxn}$, B = $[b_{ij}]$ ∈ IFSM$_{nxp}$, then we define A*B, multiplication of A and B as A*B = $[c_{ij}]$ mxp S = {max min$[(\mu_A(a_{ij}), \mu_B(b_{ij})]$, min max$[\nu_A(a_{ij}), \nu_B(b_{ij})$} ∀ i, j.

Score Matrix: If A = $[a_{ij}]$ IFSM$_{mxn}$, B = $[b_{ij}]$ IFSM $_{mxn}$, then we define Score matrix of A and B as $S_{(A, B)}=[d_{ij}]_{mxn}$ where $[d_{ij}]$ =V(A)-V(B)

Value Matrix: Let A = $[a_{ij}]$ IFSM$_{mxn}$, where $a_{ij} = (\mu_j (c_i), \nu_j (c_i))$. Then we define the Value Matrix of intuitionistic Fuzzy Soft Matrix is V(A)= $[a_{ij}]=[(\mu_j (c_i) - \nu_j (c_i)]$.

Total Score: Let A = $[a_{ij}]$ IFSM$_{mxn}$, B = $[b_{ij}]$ IFSM$_{mxn}$. Let the corresponding Value matrices be V(A), V(B) and their score matrix is $S_{(A, B)}=[d_{ij}]_{mxn}$ then we define Total Score for each c_i in U is S_i = $S_i = \sum_{j=1}^{n} d_{ij}$.

Intuitionistic Fuzzy Soft Matrices in Decision Making Algorithm

Step 1: Input the intuitionistic fuzzy soft set (U, E), (V, E) and obtain the intuitionistic fuzzy soft matrices G, H corresponding to (U, E) and (V, E) respectively.

Step 2: Write the intuitionistic fuzzy soft complement set $(U, E)^c$, $(V, E)^c$ and obtain the intuitionistic fuzzy soft matrices G^c, H^c corresponding to $(U, E)^c$ and $(V, E)^c$ respectively.

Step 3: Compute (G+H), (G^c+H^c), V(G+H), $V(G^c+H^c)$ and $S_{((G+H), (G^c+H^c))}$.

Step 4: Compute the total score S_i for each L_i.

Step 5: Find L in S_i, in which L_i have maximum value in S_i, then we can conclude that the laptop Li is selected based on the laptop which has the best operating system. In case max (S_i) occurs for more than one value, then the process will be repeating by reassessing the parameters.

Example: Suppose a company produces a five different types of laptops such as l_1, l_2, l_3, l_4, l_5.Let (U, E) and (V, E) be the Intuitionistic Fuzzy Soft Sets representing the selection of laptops from the Universal set U={ l_1, l_2, l_3, l_4, l_5} and let E={e_1, e_2, e_3, e_4} be the set of parameters which indicates an operating system of the given laptops, such as windows 7, windows 8, windows 10 and linux.

The customer X is going to buy a laptop which has a good rating depending upon its operating system.

Suppose that Intuitionistic Fuzzy Soft Set (F, S) over L, where F is the mapping $F{:}L \to IF^L$, gives a collection of an approximate description of an operating system of the laptops.

(U, E)={U(e_1)={(L_1, 0.6, 0.2) , (L_2, 0.3, 0.5), (L_3, 0.1, 0.8), (L_4, 0.5, 0.5), (L_5, 0.1, 0.7)}

U(e_2)={(L_1, 0.2, 0.6) , (L_2, 0.7, 0.1), (L_3, 0.8, 0.1), (L_4, 0.7, 0.2), (L_5, 0.3, 0.4)}

U(e_3)={(L_1, 0.6, 0.3) , (L_2, 0.5, 0.2), (L_3, 0.6, 0.4), (L_4, 0.5, 0.4), (L_5, 0.7, 0.6)}

U(e_4)={(L_1, 0.8, 0.2) , (L_2, 0.3, 0.4), (L_3, 0.2, 0.7), (L_4, 0.5, 0.3), (L_5, 0.6, 0.3)}

And,

(V, E)={V(e_1)={(L_1, 0.5, 0.4) , (L_2, 0.5, 0.1), (L_3, 0.6, 0.2), (L_4, 0.4, 0.4), (L_5, 0.6, 0.1)}

V(e_2)={(L_1, 0.1, 0.2) , (L_2, 0.3, 0.2), (L_3, 0.3, 0.3), (L_4, 0.3, 0.7), (L_5, 0.4, 0.3)}

V(e_3)={(L_1, 0.4, 0.7) , (L_2, 0.8, 0.3), (L_3, 0.5, 0.5), (L_4, 0.9, 0.2), (L_5, 0.8, 0.5)}

V(e_4)={(L_1, 0.7, 0.5) , (L_2, 0.2, 0.7), (L_3, 0.7, 0.2), (L_4, 0.1, 0.5), (L_5, 0.2, 0.2)}}

The above two Intuitionistic Fuzzy Soft Sets are represented by the following Intuitionistic Fuzzy Soft Matrices respectively.

$$G = \begin{array}{c|cccc} & e_1 & e_2 & e_4 & e_4 \\ \hline L_1 & (0.6,0.2) & (0.2,0.6) & (0.6,0.3) & (0.8,0.2) \\ L_2 & (0.3,0.5) & (0.7,0.1) & (0.5,0.2) & (0.3,0.4) \\ L_3 & (0.1,0.8) & (0.8,0.1) & (0.6,0.4) & (0.2,0.7) \\ L_4 & (0.5,0.5) & (0.7,0.2) & (0.5,0.4) & (0.5,0.3) \\ L_5 & (0.1,0.7) & (0.3,0.4) & (0.7,0.6) & (0.6,0.3) \end{array}$$

$$H = \begin{array}{c|cccc} & e_1 & e_2 & e_4 & e_4 \\ \hline L_1 & (0.5,0.4) & (0.1,0.2) & (0.4,0.7) & (0.7,0.5) \\ L_2 & (0.5,0.1) & (0.3,0.2) & (0.8,0.3) & (0.2,0.7) \\ L_3 & (0.6,0.2) & (0.3,0.3) & (0.5,0.5) & (0.7,0.2) \\ L_4 & (0.4,0.4) & (0.3,0.7) & (0.9,0.2) & (0.1,0.5) \\ L_5 & (0.6,0.1) & (0.4,0.3) & (0.8,0.5) & (0.2,0.2) \end{array}$$

The complement matrix

$$G^C = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & (0.2,0.6) & (0.6,0.2) & (0.3,0.6) & (0.2,0.8) \\ L_2 & (0.5,0.3) & (0.1,0.7) & (0.2,0.5) & (0.4,0.3) \\ L_3 & (0.8,0.1) & (0.1,0.8) & (0.4,0.6) & (0.7,0.2) \\ L_4 & (0.5,0.5) & (0.2,0.7) & (0.5,0.4) & (0.3,0.5) \\ L_5 & (0.7,0.1) & (0.4,0.3) & (0.6,0.7) & (0.3,0.6) \end{array}$$

$$H^C = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & (0.4,0.5) & (0.2,0.1) & (0.7,0.4) & (0.5,0.7) \\ L_2 & (0.1,0.5) & (0.2,0.3) & (0.3,0.8) & (0.7,0.2) \\ L_3 & (0.2,0.6) & (0.3,0.3) & (0.5,0.5) & (0.2,0.7) \\ L_4 & (0.4,0.4) & (0.7,0.3) & (0.2,0.9) & (0.5,0.1) \\ L_5 & (0.1,0.6) & (0.3,0.4) & (0.5,0.8) & (0.2,0.2) \end{array}$$

The addition matrix

$$G{+}H = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & (0.6,0.2) & (0.2,0.1) & (0.6,0.3) & (0.8,0.2) \\ L_2 & (0.5,0.1) & (0.7,0.1) & (0.8,0.2) & (0.3,0.4) \\ L_3 & (0.6,0.2) & (0.8,0.1) & (0.6,0.4) & (0.7,0.2) \\ L_4 & (0.5,0.4) & (0.7,0.2) & (0.9,0.2) & (0.5,0.3) \\ L_5 & (0.6,0.1) & (0.4,0.3) & (0.8,0.5) & (0.6,0.2) \end{array}$$

$$G^C + H^C = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & (0.4,0.5) & (0.6,0.1) & (0.7,0.4) & (0.5,0.7) \\ L_2 & (0.5,0.3) & (0.2,0.3) & (0.3,0.5) & (0.7,0.2) \\ L_3 & (0.8,0.1) & (0.3,0.3) & (0.5,0.5) & (0.7,0.2) \\ L_4 & (0.5,0.4) & (0.7,0.3) & (0.5,0.4) & (0.5,0.1) \\ L_5 & (0.7,0.1) & (0.4,0.3) & (0.6,0.7) & (0.3,0.2) \end{array}$$

The Value Matrix

$$V(G{+}H) = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & (0.4) & (0.1) & (0.3) & (0.6) \\ L_2 & (0.4) & (0.6) & (0.6) & -(0.1) \\ L_3 & (0.4) & (0.7) & (0.2) & (0.5) \\ L_4 & (0.1) & (0.5) & (0.7) & (0.2) \\ L_5 & (0.5) & (0.1) & (0.3) & (0.4) \end{array}$$

$$V(G^c{+}H^c) = \begin{array}{c|cccc} & e_1 & e_2 & e_3 & e_4 \\ \hline L_1 & -(0.1) & (0.5) & (0.3) & (0.2) \\ L_2 & (0.2) & -(0.1) & -(0.2) & (0.5) \\ L_3 & (0.7) & (0.0) & (0.0) & (0.5) \\ L_4 & (0.1) & (0.4) & (0.1) & (0.4) \\ L_5 & (0.6) & (0.1) & -(0.1) & (0.1) \end{array}$$

The Score Matrix

$$S_{((G+H),(G^c+H^c))} = \begin{matrix} L_1 \\ L_2 \\ L_3 \\ L_4 \\ L_5 \end{matrix} \overset{\begin{matrix} e_1 & \quad e_2 & \quad e_3 & \quad e_4 \end{matrix}}{\begin{bmatrix} (0.5) & -(0.4) & (0.0) & (0.8) \\ (0.2) & (0.7) & (0.8) & -(0.6) \\ -(0.3) & (0.7) & (0.2) & (0.0) \\ (0.0) & (0.1) & (0.6) & -(0.2) \\ -(0.1) & (0.0) & (0.4) & (0.3) \end{bmatrix}}$$

$$\text{Total Score} = \begin{matrix} L_1 \\ L_2 \\ L_3 \\ L_4 \\ L_5 \end{matrix} \begin{bmatrix} 0.9 \\ 1.1 \\ 0.6 \\ 0.5 \\ 0.6 \end{bmatrix}$$

From the above result L_2 has maximum value.

CONCLUSION

Hence from the above result we can say that the Laptop L_2 has the maximum value. So finally we can conclude that Mr. X will prefer to select the Laptop L_2 since it has a good rating which indicates that L_2's operating system is good compared to other four laptops. Molodtsov introduced the concept of soft sets, which is one of the recent topics developed for dealing with the uncertainties present in most of our real life situations. The parametrization tool of soft set theory enhance the flexibility of its applications. In this paper, we define intuitionistic fuzzy soft matrices some results are established in continuation to soft matrices introduced by Chagman.

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