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Fuzzy Neutrosophic soft matrix model in decision making

I.R.Sumathi and I.Arockiaranii

Department of Mathematics, Nirmala College for Women, Coimbatore, Tamilnadu, India.

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ABSTRACT

The focus of this paper is to explore different types of matrix operations of fuzzy neutrosophic soft sets and composition method to construct the decision making for medical diagnosis.

1. Introduction

In 1999[13], Molodtsov initiated the novel concept of soft set theory which is a completely new approach for modeling vagueness and uncertainty. Soft set theory finds wide range of applications in complex medical sciences, engineering, management economics and social sciences primarily due to flexibility without restrictions on approximate description of the situation. In [6] Maji et al. initiated the concept of fuzzy soft sets with some properties regarding fuzzy soft union , intersection, complement of fuzzy soft set. Moreover in [8,9] Maji et al extended soft sets to intuitionistic fuzzy soft sets and Neutrosophic soft sets.

The concept of Neutrosophic soft set was initiated by Smarandache [15] which a mathematical tool for handling problems involving imprecise, indeterminant and inconsistent data. Neutrosophic logic was developed to represent mathematical model of uncertainty, vagueness, ambiguity, imprecision undefined, incompleteness, redundancy and contradiction. The Neutrosophic logic is a formal frame to measure truth, indeterminacy and falsehood. In Neutrosophic set, indeterminacy is quantified explicitly whereas the truth membership, indeterminacy membership and falsity membership are independent. This assumption is very important in information fusion when we try to combine the data from different sensors.

In this paper, a new approach is proposed to construct the decision method for medical diagnosis by using fuzzy Neutrosophic soft matrices. The result is obtained on the maximum score value.

2. Preliminaries

Definition 2.1: [13]

Suppose U is an universal set and E is a set of parameters, Let P(U) denote 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.

Definition 2.2:[1]

A Fuzzy Neutrosophic set A on the universe of discourse X is defined as

A= $\langle x, T_A(x), I_A(x), F_A(x)\rangle, x \in X$ where

$T, I, F : X \rightarrow$ [0, 1] and

$0 \le T_A(x) + I_A(x) + F_A(x) \le 3$.

The set of all fuzzy Neutrosophic set over the universe U will be denoted by FNS(U)

Definition 2.3:[1]

Let U be the initial universe set and E be a set of parameters. Consider a non-empty set A, A ⊂ E. Let P (U) denote the set of all Fuzzy Neutrosophic sets of U. The collection (F, A) is termed to be the Fuzzy Neutrosophic soft set over U, where F is a mapping given by

F: A → P(U).

Throughout this paper Fuzzy Neutrosophic soft set is denoted by FNS set / FNSS. The set of all fuzzy Neutrosophic soft set over U will be denoted by (F,A)(U)

Definition 2.4:[2]

Let U = { c_1, c_2, ……….. c_m} be the universal set and E be the set of parameters given by E = {e_1, e_2, ……. e_n}. Let A ⊆ E. A pair (F, A) be a Fuzzy Neutrosophic soft set over U. Then the subset of U x E is defined by R_A = { (u, e) ; e∈A, u ∈ f_A(e)} which is called a relation form of (f_A ,E). The membership function , indeterminacy membership function and non – membership function are

Tele:

E-mail addresses: sumathi_raman2005@yahoo.co.in

written by $T_{R_A}: U \times E \to [0,1]$, $I_{R_A}: U \times E \to [0,1]$ and $F_{R_A}: U \times E \to [0,1]$ where $T_{R_A}(u,e) \in [0,1]$, $I_{R_A}(u,e) \in [0,1]$ and $F_{R_A}(u,e) \in [0,1]$ are the membership value, indeterminacy value and non membership value respectively of u $\in$ U for each e$\in$E.

If $[(T_{ij}, I_{ij}, F_{ij})] = (T_{ij}(u_i, e_j), I_{ij}(u_i, e_j), F_{ij}(u_i, e_j))$ we can define a matrix

$$[(T_{ij}, I_{ij}, F_{ij})]_{mxn} = \begin{bmatrix} (T_{11}, I_{11}, F_{11}) & (T_{12}, I_{12}, F_{12}) & \cdots\cdots & (T_{1n}, I_{1n}, F_{1n}) \\ (T_{21}, I_{21}, F_{21}) & (T_{22}, I_{22}, F_{22}) & \cdots\cdots & (T_{2n}, I_{2n}, F_{2n}) \\ \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ (T_{m1}, I_{m1}, F_{m1}) & (T_{m2}, I_{m2}, F_{m2}) & \cdots\cdots & (T_{mn}, I_{mn}, F_{mn}) \end{bmatrix}$$

which is called an m x n Fuzzy Neutrosophic Soft Matrix of the FNSS (f_A, E) over U.
We denote m x n Fuzzy Neutrosophic Soft Matrix as $FNSM_{mxn}$.

Definition 2.5:[2]

Let U = { c_1, c_2, ………… c_m} be the universal set and E be the set of parameters given by E = {e_1, e_2, ……. e_n}. Let A $\subseteq$ E. A pair (F, A) be a fuzzy neutrosophic soft set. Then fuzzy neutrosophic soft set (F, A) in a matrix form as $A_{m \times n} = [a_{ij}]_{m \times n}$ or $A = [a_{ij}]$, i=1,2,….m, j = 1,2, ….. n where

$$a_{ij} = \begin{cases} (T_j(c_i), I_j(c_i), F_j(c_i)) & if \quad e_j \in A \\ (0,0,1) & if \quad e_j \notin A \end{cases},$$

where $T_j(c_i)$ represent the membership of (c_i), $I_j(c_i)$ represent the indeterminacy of (c_i) and $F_j(c_i)$ represent the non-membership of (c_i) in the Fuzzy Neutrosophic set $F(e_j)$.

Definition 2.6:[2]

Let $\tilde{A} = [T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}] \in$ $FNSM_{m \times n}$ then $\tilde{A}$ is called

a) A zero or null FNSM denoted by $\tilde{0}$ = [0, 0, 1] if $T_{ij}^{\tilde{A}}$ = 0 , $I_{ij}^{\tilde{A}}$ = 0 and $F_{ij}^{\tilde{A}}$ = 1, $\forall$ i and j. It is denoted by φ.

b) A universal FNSM denoted by $\tilde{1}$ = [1,1,0] if $T_{ij}^{\tilde{A}}$ = 1 , $I_{ij}^{\tilde{A}}$ = 1 and $F_{ij}^{\tilde{A}}$ = 0, $\forall$ i and j. It is denoted by U.

Definition 2.7:[2]

Let $\tilde{A} = [T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}]$, $\tilde{B} = [T_{ij}^{\tilde{B}}, I_{ij}^{\tilde{B}}, F_{ij}^{\tilde{B}}] \in$ $FNSM_{m \times n}$. Then

a) $\tilde{A}$ is Fuzzy neutrosophic soft sub matrix of $\tilde{B}$ denoted by $\tilde{A} \subseteq \tilde{B}$ if $T_{ij}^{\tilde{A}} \leq T_{ij}^{\tilde{B}}$, $I_{ij}^{\tilde{A}} \leq I_{ij}^{\tilde{B}}$ and $F_{ij}^{\tilde{A}} \geq F_{ij}^{\tilde{B}}$, $\forall$ i and j.

b) $\tilde{A}$ is Fuzzy neutrosophic soft super matrix of $\tilde{B}$ denoted by $\tilde{A} \supseteq \tilde{B}$ if $T_{ij}^{\tilde{A}} \geq T_{ij}^{\tilde{B}}$, $I_{ij}^{\tilde{A}} \geq I_{ij}^{\tilde{B}}$ and $F_{ij}^{\tilde{A}} \leq F_{ij}^{\tilde{B}}$, $\forall$ i and j.

c) $\tilde{A}$ and $\tilde{B}$ are said to be Fuzzy neutrosophic soft equal matrices denoted by $\tilde{A} = \tilde{B}$ if $T_{ij}^{\tilde{A}} = T_{ij}^{\tilde{B}}$, $I_{ij}^{\tilde{A}} = I_{ij}^{\tilde{B}}$ and $F_{ij}^{\tilde{A}} = F_{ij}^{\tilde{B}}$, $\forall$ i and j.

3. Operations on fuzzy neutrosophic soft matrix theory

Definition 3.1:

If $\tilde{A}$ = $[a_{ij}]$ $\in FNSM_{m \times n}$, $\tilde{B}$ = $[b_{ij}]$ $\in FNSM_{m \times n}$, then we define $\tilde{A} \,\tilde{\cup}\, \tilde{B}$, union $\tilde{A}$ and $\tilde{B}$ as

$\tilde{A} \,\tilde{\cup}\, \tilde{B}$ = $[c_{ij}]_{m \times n}$

= (max ($T_{\tilde{A}}, T_{\tilde{B}}$), max($I_{\tilde{A}}, I_{\tilde{B}}$) , min ($F_{\tilde{A}}, F_{\tilde{B}}$)) $\forall$ i and j .

Definition 3.2:

If $\tilde{A}$ = $[a_{ij}]$ $\in FNSM_{m \times n}$, $\tilde{B}$ = $[b_{ij}]$ $\in FNSM_{m \times n}$, then we define $\tilde{A} \,\tilde{\cap}\, \tilde{B}$, intersection of $\tilde{A}$ and $\tilde{B}$ as

$\tilde{A} \,\tilde{\cap}\, \tilde{B}$ = $[c_{ij}]_{m \times n}$

= (min ($T_{\tilde{A}}, T_{\tilde{B}}$), min($I_{\tilde{A}}, I_{\tilde{B}}$) , max ($F_{\tilde{A}}, F_{\tilde{B}}$)) $\forall$ i and j .

Proposition 3.3:

Let $\tilde{A}$ = $[a_{ij}]$ $\in FNSM_{m \times n}$, $\tilde{B}$ = $[b_{ij}]$ $\in FNSM_{m \times n}$ then

(i) $(\tilde{A} \tilde{\cup} \tilde{B})^c = \tilde{A}^c \tilde{\cap} \tilde{B}^c$

(ii) $(\tilde{A} \tilde{\cap} \tilde{B})^c = \tilde{A}^c \tilde{\cup} \tilde{B}^c$

Proposition 3.4:

Let $\tilde{A}$ = $[a_{ij}] \in FNSM_{m \times n}$, $\tilde{B}$ = $[b_{ij}] \in FNSM_{m \times n}$ and $\tilde{C}$ = $[c_{ij}] \in FNSM_{m \times}$ then

(i) $\tilde{A} \tilde{\cup} \tilde{1} = \tilde{1}$; $\tilde{A} \tilde{\cap} \tilde{1} = \tilde{A}$

(ii) $\tilde{A} \tilde{\cup} \tilde{0} = \tilde{A}$; $\tilde{A} \tilde{\cap} \tilde{0} = \tilde{0}$

(iii) $\tilde{A} \tilde{\cup} \tilde{B} = \tilde{B} \tilde{\cup} \tilde{A}$; $\tilde{A} \tilde{\cap} \tilde{B} = \tilde{B} \tilde{\cap} \tilde{A}$

(iv) $\left(\tilde{A} \tilde{\cup} \tilde{B}\right) \tilde{\cup} \tilde{C} = \tilde{A} \tilde{\cup} \left(\tilde{B} \tilde{\cup} \tilde{C}\right)$; $\left(\tilde{A} \tilde{\cap} \tilde{B}\right) \tilde{\cap} \tilde{C} = \tilde{A} \tilde{\cap} \left(\tilde{B} \tilde{\cap} \tilde{C}\right)$

(v) $\left(\tilde{A} \tilde{\cup} \tilde{B}\right) \tilde{\cap} \tilde{C} = \left(\tilde{A} \tilde{\cap} \tilde{C}\right) \tilde{\cup} \left(\tilde{B} \tilde{\cap} \tilde{C}\right)$;

$\left(\tilde{A} \tilde{\cap} \tilde{B}\right) \tilde{\cup} \tilde{C} = \left(\tilde{A} \tilde{\cup} \tilde{C}\right) \tilde{\cap} \left(\tilde{B} \tilde{\cup} \tilde{C}\right)$

4. Product of fuzzy neutrosophic soft matrices

In this section we define seven types of products of fuzzy neutrosophic soft matrices.

Definition 4.1:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m \times n}$,

then *And*-product $\tilde{A}$ and $\tilde{B}$ is defined by

$\wedge_{\times} : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A} \wedge_{\times} \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}}$ = min ($T_{ij}^{\tilde{A}}$, $T_{ik}^{\tilde{B}}$),

$I_{ip}^{\tilde{C}}$ = min ($I_{ij}^{\tilde{A}}$, $I_{ik}^{\tilde{B}}$) and $F_{ip}^{\tilde{C}}$ = max ($F_{ij}^{\tilde{A}}$, $F_{ik}^{\tilde{B}}$) such that $p = n(j-1) + k$.

Definition 4.2:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m \times n}$,

then *Or*-product $\tilde{A}$ and $\tilde{B}$ is defined by

$\vee_{\times} : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A} \vee_{\times} \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}}$ = max ($T_{ij}^{\tilde{A}}$, $T_{ik}^{\tilde{B}}$),

$I_{ip}^{\tilde{C}}$ = max ($I_{ij}^{\tilde{A}}$, $I_{ik}^{\tilde{B}}$) and $F_{ip}^{\tilde{C}}$ = min ($F_{ij}^{\tilde{A}}$, $F_{ik}^{\tilde{B}}$) such that $p = n(j-1) + k$.

Definition 4.3:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m \times n}$,

then *And-Not* product $\tilde{A}$ and $\tilde{B}$ is defined by

$\overline{\wedge}_{\times} : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A} \overline{\wedge}_{\times} \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}}$ = min ($T_{ij}^{\tilde{A}}$, $F_{ik}^{\tilde{B}}$),

$I_{ip}^{\tilde{C}}$ = min ($I_{ij}^{\tilde{A}}$, $1 - I_{ik}^{\tilde{B}}$) and $F_{ip}^{\tilde{C}}$ = max ($F_{ij}^{\tilde{A}}$, $T_{ik}^{\tilde{B}}$) such that $p = n(j-1) + k$.

Definition 4.4:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m \times n}$, then *Or-Not* product $\tilde{A}$ and $\tilde{B}$ is defined by

$\overline{\vee}_{\times} : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A}\ \overline{\vee}_{\times}\ \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}} = \max(T_{ij}^{\tilde{A}}, F_{ik}^{\tilde{B}})$,

$I_{ip}^{\tilde{C}} = \max(I_{ij}^{\tilde{A}}, 1 - I_{ik}^{\tilde{B}})$ and $F_{ip}^{\tilde{C}} = \min(F_{ij}^{\tilde{A}}, T_{ik}^{\tilde{B}})$ such that $p = n(j-1) + k$.

Definition 4.5:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m\times n}$,

then $\tilde{\times}_1$ - product $\tilde{A}$ and $\tilde{B}$ is defined by

$\tilde{\times}_1 : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A}\ \tilde{\times}_1\ \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}} = T_{ij}^{\tilde{A}} + T_{ik}^{\tilde{B}} - T_{ij}^{\tilde{A}} . T_{ik}^{\tilde{B}}$

$I_{ip}^{\tilde{C}} = I_{ij}^{\tilde{A}} + I_{ik}^{\tilde{B}} - I_{ij}^{\tilde{A}} . I_{ik}^{\tilde{B}}$ and $F_{ip}^{\tilde{C}} = F_{ij}^{\tilde{A}} . F_{ik}^{\tilde{B}}$ such that $p = n(j-1) + k$.

Definition 4.6:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m\times n}$,

then $\tilde{\times}_2$ - product $\tilde{A}$ and $\tilde{B}$ is defined by

$\tilde{\times}_2 : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A}\ \tilde{\times}_2\ \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}} = T_{ij}^{\tilde{A}} . T_{ik}^{\tilde{B}}$

$I_{ip}^{\tilde{C}} = I_{ij}^{\tilde{A}} . I_{ik}^{\tilde{B}}$ and $F_{ip}^{\tilde{C}} = F_{ij}^{\tilde{A}} + F_{ik}^{\tilde{B}} - F_{ij}^{\tilde{A}} . F_{ik}^{\tilde{B}}$ such that $p = n(j-1) + k$.

Definition 4.7:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right], \tilde{B} = \left[T_{ik}^{\tilde{B}}, I_{ik}^{\tilde{B}}, F_{ik}^{\tilde{B}}\right] \in FNSM_{m\times n}$,

then $\tilde{\times}_3$ - product $\tilde{A}$ and $\tilde{B}$ is defined by

$\tilde{\times}_3 : FNSM_{m\times n} \times FNSM_{m\times n} \to FNSM_{m\times n^2}$ such that

$\tilde{A}\ \tilde{\times}_3\ \tilde{B} = \left[T_{ip}^{\tilde{C}}, I_{ip}^{\tilde{C}}, F_{ip}^{\tilde{C}}\right]$ where $T_{ip}^{\tilde{C}} = T_{ij}^{\tilde{A}} . T_{ik}^{\tilde{B}}$

$I_{ip}^{\tilde{C}} = I_{ij}^{\tilde{A}} . I_{ik}^{\tilde{B}}$ and $F_{ip}^{\tilde{C}} = F_{ij}^{\tilde{A}} . F_{ik}^{\tilde{B}}$ such that $p = n(j-1) + k$.

Example 4.8 :

Assume that $\tilde{A} = [a_{ij}] \in FNSM_{4\times 3}$, $\tilde{B} = [b_{ij}] \in FNSM_{4\times 3}$ are given as follows.

$$\tilde{A} = \begin{bmatrix} (0.1,0.4,0.2) & (0.5,0.4,0.4) & (0.3,0.5,0.6) \\ (0.4,0.5,0.4) & (0.2,0.4,0.3) & (0.5,0.6,0.1) \\ (0.5,0.5,0.2) & (0.3,0.1,0.4) & (0.6,0.6,0.2) \\ (0.7,0.5,0.2) & (0.6,0.5,0.1) & (0.5,0.4,0.3) \end{bmatrix}_{4\times 3}$$

$$\tilde{B} = \begin{bmatrix} (0.5,0.3,0.7) & (0.1,0.5,0.6) & (0.7,0.8,0.1) \\ (0.8,0.7,0.1) & (0.4,0.5,0.3) & (0.5,0.4,0.2) \\ (0.2,0.5,0.5) & (0.3,0.4,0.6) & (0.4,0.5,0.6) \\ (0.1,0.5,0.7) & (0.2,0.5,0.6) & (0.5,0.4,0.1) \end{bmatrix}_{4\times 3}$$

Then the *And*-product of $\tilde{A}$ and $\tilde{B}$ is given below

$$\tilde{A} \wedge_{\times} \tilde{B} = \begin{bmatrix} (0.1,0.3,0.7) & (0.1,0.4,0.6) & (0.1,0.4,0.2) & (0.5,0.3,0.4) & (0.1,0.4,0.6) & (0.5,0.4,0.4) & (0.3,0.3,0.7) & (0.1,0.5,0.6) & (0.3,0.5,0.6) \\ (0.4,0.5,0.4) & (0.4,0.5,0.4) & (0.4,0.4,0.4) & (0.2,0.4,0.3) & (0.2,0.4,0.3) & (0.2,0.4,0.3) & (0.5,0.6,0.1) & (0.4,0.5,0.3) & (0.5,0.4,0.2) \\ (0.2,0.5,0.5) & (0.3,0.4,0.6) & (0.4,0.5,0.6) & (0.2,0.1,0.5) & (0.3,0.1,0.6) & (0.3,0.1,0.6) & (0.2,0.5,0.5) & (0.3,0.4,0.6) & (0.4,0.5,0.6) \\ (0.1,0.5,0.7) & (0.2,0.5,0.6) & (0.5,0.4,0.2) & (0.1,0.5,0.7) & (0.2,0.5,0.6) & (0.5,0.4,0.1) & (0.1,0.4,0.7) & (0.2,0.4,0.6) & (0.5,0.4,0.3) \end{bmatrix}_{4\times 9}$$

Similarly we can find the other products also.

5. Fuzzy Neutrosophic soft matrix composite operators

Definition 5.1:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right] \in \text{FNSM}_{m \times n}$ and $\tilde{B} = \left[T_{jk}^{\tilde{B}}, I_{jk}^{\tilde{B}}, F_{jk}^{\tilde{B}}\right] \in \text{FNSM}_{n \times p}$, then the max-min composition for fuzzy Neutrosophic soft matrix relation of A and B is defined as $\tilde{A} * \tilde{B} = \left[\tilde{C}_{ik}\right]_{m \times p}$ where

$$\tilde{C}_{ik} = \left\{ \max\left\{ \min_{j}\left[T_{ij}^{\tilde{A}}, T_{jk}^{\tilde{B}}\right]\right\}, \max\left\{ \min_{j}\left[I_{ij}^{\tilde{A}}, I_{jk}^{\tilde{B}}\right]\right\}, \min\left\{ \max_{j}\left[F_{jk}^{\tilde{A}}, F_{jk}^{\tilde{B}}\right]\right\}\right\}$$

Definition 5.2:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right] \in \text{FNSM}_{m \times n}$ and $\tilde{B} = \left[T_{jk}^{\tilde{B}}, I_{jk}^{\tilde{B}}, F_{jk}^{\tilde{B}}\right] \in \text{FNSM}_{n \times p}$, then the max-min average composition for fuzzy Neutrosophic soft matrix relation of A and B is defined as

$$\tilde{A}\ \psi\ \tilde{B} = \left\{ \max\left\{\frac{T_{ij}^{\tilde{A}}, T_{jk}^{\tilde{B}}}{2}\right\}, \max\left\{\frac{I_{ij}^{\tilde{A}}, I_{jk}^{\tilde{B}}}{2}\right\}, min\left\{\frac{F_{ij}^{\tilde{A}}, F_{jk}^{\tilde{B}}}{2}\right\}\right\}$$

Example 5.3:

Consider

$$\tilde{A} = \begin{bmatrix} (0.8,0.4,0.1) & (0.4,0.5,0.5) \\ (0.7,0.6,0.3) & (0.4,0.5,0.6) \end{bmatrix}$$ and

$$\tilde{B} = \begin{bmatrix} (0.6,0.4,0.3) & (0.8,0.4,0.2) \\ (0.7,0.5,0.3) & (0.5,0.5,0.5) \end{bmatrix}$$ be the two fuzzy Neutrosophic soft matrices, then the max min composition and max – min average composition of fuzzy Neutrosophic soft matrix relation are

$$\tilde{A} * \tilde{B} = \begin{bmatrix} (0.7,0.4,0.3) & (0.4,0.4,0.5) \\ (0.7,0.5,0.3) & (0.4,0.5,0.5) \end{bmatrix}$$

$$\tilde{A}\psi\ \tilde{B} = \begin{bmatrix} (0.7,0.55,0.2) & (0.8,0.55,0.15) \\ (0.65,0.5,0.3) & (0.75,0.5,0.25) \end{bmatrix}$$

Definition 5.4:

Let $\tilde{A} = \left[T_{ij}^{\tilde{A}}, I_{ij}^{\tilde{A}}, F_{ij}^{\tilde{A}}\right] \in \text{FNSM}_{m \times n}$ then the scores of the fuzzy Neutrosophic soft matrix $\tilde{A}$ is given by

(i) $S_1 = T_j - I_j \cdot F_j$

(ii) $S_2 = T_j + [1 - I_j] - F_j$

Application of composite operators:

Let P = {$P_1, P_2,...P_m$} be the set of m patients and S = {$S_1, S_2.....S_n$} be the set of n symptoms and D = {$D_1,D_2,.....D_k$} be the set of k diseases.

Construct an FNSS relation matrix A is called patient symptom matrix(F,S) over P where F is a mapping F:S→FNS(P) where FNS(P) is the collection of all fuzzy Neutrosophic subsets of P and another FNSS relation matrix B called symptom disease- matrix, which is a collection of an approximate description of patient symptoms (G,D) over S, where G is a mapping G:D→FNS(S), FNS(S) is the collection of all fuzzy Neutrosophic subsets of S.

Algorithm:

Step 1: The fuzzy Neutrosophic soft sets (F,S) and (G,D) are given and their corresponding matrices A and B respectively are obtained.

Step 2: Using the definition 3.1 and compute

$\tilde{A} * \tilde{B}$ and $\tilde{A}\ \psi\ \tilde{B}$

Step 3: Obtain the score matrix S for $\tilde{A} * \tilde{B}$ and $\tilde{A}\ \psi\ \tilde{B}$ using the definition 3.4.

Step 4: Identify the maximum score S_{ij}, for each patient P_i. Then we conclude that the patient P_i is suffering from disease D_j.

Suppose the four patients P = {P_1,P_2,P_3,P_4} as the universal sets with symptoms S={ S_1,S_2,S_3} where as the set of symptoms where S_1,S_2,S_3 represents vomiting , pain in abdomen and temperature respectively .Let the possible disease let into the above symptoms D={D_1,D_2,D_3,D_4} be Intestinal Obstruction, Inguinal Hernia , Appendicitis and Ureteric Colic respectively.

Suppose that FNSS (F,S) over P, where F is a mapping F:S→FNS(P) gives a collection of an approximate description of patient symptoms.

(F,S) = {F(S_1)={(P_1,0.7,0.4,0.1), (P_2,0.6,0.5,0.3),
(P_3,0.8,0.4,0.2),(P_4,0.4,0.6,0.3)}
{F(S_2)={(P_1,0.8,0.6,0.7), (P_2,0.6,0.5,0.2),
(P_3,0.5,0.1,0.5),(P_4,0.5,0.4,0.8)}
{F(S_3)={(P_1,0.4,0.8,0.5), (P_2,0.7,0.9,0.0),
(P_3,1.0,0.5,1.0),(P_4,0.5,0.6,0.9)}

This Fuzzy Neutrosophic Soft sets is represented by the following Fuzzy Neutrosophic Soft matrix.

$$A = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array}\!\!\begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{bmatrix} (0.7,0.4,0.1) & (0.8,0.6,0.3) & (0.4,0.8,0.5) \\ (0.6,0.5,0.3) & (0.6,0.5,0.2) & (0.7,0.9,0.0) \\ (0.8,0.4,0.2) & (0.5,0.1,0.5) & (1.0,0.5,1.0) \\ (0.4,0.6,0.3) & (0.5,0.4,0.8) & (0.5,0.6,0.9) \end{bmatrix} \end{array}$$

Suppose that FNSS (G,D) over S, where G is a mapping G:D→FNS(S) gives a collection of an approximate description of the disease and their symptoms.

(G,D) = {G(D_1)={(S_1,0.9,0.6,0.7), (S_2,0.5,0.3,0.3),
(S_3,0.8,0.8,0.9)}
{G(D_2)={(S_1,0.9,1.0,0.5), (S_2,0.4,0.6,0.6),
(S_3,0.7,0.8,0.3)}
{G(D_3)={(S_1,0.9,0.2,0.8), (S_2,0.4,0.5,0.3),
(S_3,0.8,0.1,0.8)}
{G(D_4)={(S_1,0.6,0.2,0.3), (S_2,0.9,0.5,0.8),
(S_3,0.3,0.4,0.5)}

This Fuzzy Neutrosophic Soft sets is represented by the following Fuzzy Neutrosophic Soft matrix.

$$B = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array}\!\!\begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} (0.9,0.6,0.7) & (0.9,1.0,0.5) & (0.9,0.2,0.8) & (0.6,0.2,0.3) \\ (0.5,0.3,0.3) & (0.4,0.6,0.6) & (0.4,0.5,0.3) & (0.9,0.5,0.8) \\ (0.8,0.8,0.9) & (0.7,0.8,0.3) & (0.8,0.1,0.8) & (0.3,0.4,0.5) \end{bmatrix} \end{array}$$

Then the max-min composition method matrix is given by

$$\tilde{A} * \tilde{B} = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} (0.7,0.8,0.7) & (0.7,0.8,0.5) & (0.7,0.5,0.7) & (0.8,0.5,0.3) \\ (0.7,0.8,0.3) & (0.7,0.8,0.3) & (0.7,0.5,0.3) & (0.6,0.5,0.3) \\ (0.8,0.5,0.5) & (0.8,0.5,0.5) & (0.8,0.1,0.5) & (0.5,0.4,0.3) \\ (0.5,0.6,0.7) & (0.5,0.6,0.5) & (0.5,0.4,0.8) & (0.5,0.4,0.3) \end{bmatrix} \end{array}$$

Then the max-min average composition method matrix is given by

$$\tilde{A} \ \psi \ \tilde{B} = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} (0.8,0.8,0.4) & (0.8,0.8,0.3) & (0.8,0.55,0.45) & (0.85,0.55,0.2) \\ (0.75,0.85,0.25) & (0.75,0.85,0.15) & (0.75,0.5,0.25) & (0.75,0.65,0.25) \\ (0.9,0.65,0.4) & (0.85,0.7,0.35) & (0.9,0.3,0.4) & (0.7,0.45,0.25) \\ (0.65,0.7,0.5) & (0.65,0.8,0.4) & (0.65,0.45,0.55) & (0.7,0.5,0.3) \end{bmatrix} \end{array}$$

$$S_1(\tilde{A} * \tilde{B}) = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} 0.2 & 0.4 & 0.5 & \mathbf{1} \\ 0.6 & 0.6 & \mathbf{0.9} & 0.8 \\ 0.8 & 0.8 & \mathbf{1.2} & 0.8 \\ 0.2 & 0.4 & 0.3 & \mathbf{0.8} \end{bmatrix} \end{array}$$

$$S_2(\tilde{A} * \tilde{B}) = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} 0.14 & 0.3 & 0.35 & \mathbf{0.65} \\ 0.46 & 0.46 & \mathbf{0.55} & 0.45 \\ 0.55 & 0.55 & \mathbf{0.75} & 0.38 \\ 0.08 & 0.2 & 0.18 & \mathbf{0.38} \end{bmatrix} \end{array}$$

$$S_1(\tilde{A} \psi \tilde{B}) = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} 0.6 & 0.7 & 0.8 & \mathbf{1.1} \\ 0.65 & 0.75 & \mathbf{1} & 0.85 \\ 0.85 & 0.8 & \mathbf{1.2} & 1 \\ 0.45 & 0.45 & 0.65 & \mathbf{0.9} \end{bmatrix} \end{array}$$

$$S_2(\tilde{A} \ \psi \tilde{B}) = \begin{array}{c c} & \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} & \begin{bmatrix} 0.48 & 0.56 & 0.5525 & \mathbf{0.74} \\ 0.5375 & 0.6225 & \mathbf{0.625} & 0.5875 \\ 0.64 & 0.605 & \mathbf{0.78} & 0.5875 \\ 0.3 & 0.33 & 0.4025 & \mathbf{0.55} \end{bmatrix} \end{array}$$

It is clear from the above matrices $S_1(\tilde{A} * \tilde{B})$, $S_2(\tilde{A} * \tilde{B})$, $S_1(\tilde{A} \psi \tilde{B})$, $S_2(\tilde{A} \psi \tilde{B})$, that patients P_1, P_2, P_3 and P_4 are suffering from the disease D_4, D_3, D_3 and D_4 respectively.

7. Conclusion

It is seen that the max min composition method and max min average composition method gives the same maximum score in the score matrix of the patients and the diseases. Thus the proposed method of diagnosis allows the decision maker to assign the degree of association, non-association and indeterminacy of the symptoms of the alternative with the respective criteria to a vague concept and the above method gives the solution to the decision maker.

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