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# A Significant Factor Of Fuzzy Neutrosophic Soft Matrices In Decision Making

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**Abstract**
First some fundamental tasks of fuzzy neutrosophic soft matrix is characterized and presented a new fuzzy neutrosophic soft complement matrix dependent on reference work and the trace of fuzzy neutrosophic soft matrix. A few properties and models are examined. In conclusion, a fuzzy neutrosophic soft matrix for a choice strategy is characterized.

**Keywords:** Soft set, Fuzzy soft set, Neutrosophic set, Fuzzy neutrosophic soft set, Fuzzy neutrosophic soft matrices, Reference function.

## 1 Introduction

The Soft set idea is started by Molodtsov [6] for demonstrating vaguness and vulnerability. Maji et al. [7] proposed the idea of fuzzy soft set for certain properties. Neutrosophic soft sets and the idea of neutrosophic set was presented by Florentine[8].

Arockiarani and Sumathi [2] initiated new methods on fuzzy neutrosophic soft matrices. The idea of fuzzy soft set dependent on reference function is proposed by Baruah[5]. The proposed technique is an endeavor to further develop the outcomes utilizingfuzzy neutrosophic soft matrix based on reference work and to detail an application of choice strategy.

## 2 Preliminaries

Some essential definitions are given, which are utilized in this paper.

### 2.1 Definition

Let X be a universe of discourse, with a generic element in X denoted by x, the neutrosophic set (NS), A is an object having the structure$A=\{<x,(T_A(x)\ ,\ I_A(x),\ F_A(x)>,\ x \in X\}$ where the function defines $T, I, F: X\rightarrow ]^{-}0, 1^{+}[$ respectively the degree of membership (or truth ), the degree of indeterminacy and the degree of non-membership (or Falsehood) of the component$x \in X$ to

the set A with the property $^{-}0 \leq T_A(x)+I_A(x)+F_A(x) \leq 3^{+}$……….(1)
We assume the value from the subset of [0,1]. ∴ we read equation (1) as
$0 \leq T_A(x)+I_A(x)+F_A(x) \leq 3$. In brief an component ã in the neutrosophic set A , can be read as ã = $\langle a^T, a^I, a^F \rangle$, where $a^T$ symbolise the level of Truth, $a^I$ symbolise the level of Indeterminacy, $a^F$ symbolise the level of Falsity, such that $0 \leq a^T + a^I + a^F \leq 3$.

**2.2 Example**

Assume that the universe of discourse be $U=\{x_1,x_2,x_3\}$, where $x_1$ indicates the capability, $x_2$ indicates the reliability, $x_3$ indicates the cost of price. Suppose A is a Neutrosophic set (NS) of U such that , $A=\{\langle x_1,(0.4,0.6,0.3)\rangle, \langle x_2,(0.2,0.4,0.5)\rangle, \langle x_3,(0.3,0.5,0.5)\rangle\}$ where for $x_1$ the level of truthfulness of capability is 0.4, the level of indeterminacy of capability is 0.6 and the level of falsity of capability is 0.3 etc.

**2.3 Definition**

Let U be an initial universe set and E be a set of parameters. Let $A \subset E$. A pair (F, A) is called a Fuzzy soft set over U, where F is a mapping given by $F: A \rightarrow F^U$, where $F^U$ denotes the collection of all fuzzy subsets of U.

**2.4 Definition**

Let U be the initial universal set and E be a set of parameter. Consider a non-empty set A, $A \subset E$. The family (F, A) is named as the Fuzzy Neutrosophic Soft sets (FNSS) over U, where F is a mapping given by $F: A \rightarrow P(U)$. Let P(U) signifies the set of all fuzzy neutrosophic sets of . We assume A as FNSS over U rather than (F, A).

**2.5 Definition**

Let $U=\{c_1,c_2,c_3 \ldots\ldots c_m\}$ be the universal set and E be the set of parameter given by
$E=\{e_1,e_2,e_3 \ldots\ldots e_n\}$. Let $A \subset E$. A pair (F, A) be a FNSS over U. Then the subset $U \times E$ is defined by $R_A=\{(u,e);\ e \in A, u \in F_A(e)\}$ which is called a relation form of $(F_A, E)$. The function are written by $T_R(A): U \times E \rightarrow [0,1]$, $I_R(A): U \times E \rightarrow [0,1]$ and $F_R(A): U \times E \rightarrow [0,1]$ 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 level of membership, indeterminacy and non membership value.
If $\{\langle T_{ij}, I_{ij}, F_{ij}\rangle\}=[\langle T_{ij}(u_i,e_j), I_{ij}(u_i,e_j), F_{ij}(u_i,e_j)\rangle]$

We define a matrix

$$[\langle T_{ij}, I_{ij}, F_{ij}\rangle]_{m \times n} = \begin{pmatrix} \langle T_{11}, I_{11}, F_{11}\rangle \ldots\ldots\ldots\ldots \langle T_{1n}, I_{1n}, F_{1n}\rangle \\ \langle T_{21}, I_{21}, F_{21}\rangle \ldots\ldots\ldots\ldots \langle T_{2n}, I_{2n}, F_{2n}\rangle \\ \vdots \quad \ldots\ldots\ldots\ldots \quad \vdots \\ \vdots \quad \ldots\ldots\ldots\ldots \quad \vdots \\ \langle T_{m1}, I_{m1}, F_{m1}\rangle \ldots\ldots\ldots\ldots \langle T_{mn}, I_{mn}, F_{mn}\rangle \end{pmatrix}$$

which is called an m ×n Fuzzy Neutrosophic Soft Matrix (FNSM) of the FNSS $(F_A, E)$ over U.

**2.6Definition**

Let U = $\{c_1, c_2, c_3 \ldots\ldots c_m\}$ be the universal set and E be the set of parameter given by E = $\{e_1, e_2, e_3 \ldots\ldots e_n\}$. Let A ⊂ E. A pair$(F, A)$ be a fuzzy neutrosophicsoft setover U. Then the fuzzy neutrosophicsoft set (F, A ) in a matrix form as $A_{m \times n} = (a_{ij})_{m \times n}$

orA = $(a_{ij})$ , $i = 1,2, \ldots \ldots m$, $j = 1,2, \ldots \ldots n$ where

$$(a_{ij}) = \begin{cases} < T(c_i, e_j), I(c_i, e_j), F(c_i, e_j) > & \text{if } e_j \in A \\ < 0, 0, 1 > & \text{if } e_j \notin A \end{cases}$$

Where $T_j(c_i)$ represents the membership of $(c_i)$, $I_j(c_i)$ represents the indeterminacy of $(c_i)$, and $F_j(c_i)$ represents the non-membership of $(c_i)$ in the FNSS $(F, A)$.

**Notation:[10]**

Let $F_{m\times n}$ denotes FNSM of order m ×n and $F_n$ denotes FNSM of order n × n.

**2.7 Definition**

Let $A = < a_{ij}^T, a_{ij}^I, a_{ij}^F > \in F_{m\times n}$ thenA is called

a) Azero (or) null FNSM denoted by$\tilde{0}$= [0,0,1] if $a_{ij}^T$ =0, $a_{ij}^I$ =0, $a_{ij}^F$ =1 ∀ i & j.

It is denoted by ϕ.

b) A universal FNSM denoted by $\tilde{I}$= [1,1,0] if$a_{ij}^T$ =1, $a_{ij}^I$ =1, $a_{ij}^F$ =0 ∀ i & j.

It is denoted by J.

**3. Operations on fuzzy neutrosophic soft matrix theory:**

**3.1 Definition**

If A =$(a_{ij}) \in F_{m\times n}$, B =$(b_{ij}) \in F_{m\times n}$then we define A ∪ B,

A ∪ B= $(c_{ij})_{m\times n}$ = { <max($a_{ij}^T, b_{ij}^T$), max($a_{ij}^I, b_{ij}^I$), min($a_{ij}^F, b_{ij}^F$)>} ∀ i & j.

**3.2 Definition**

If A =$(a_{ij}) \in F_{m\times n}$, B =$(b_{ij}) \in F_{m\times n}$then we define A ∩ B,

A ∩ B= $(c_{ij})_{m\times n}$ = {< min ($a_{ij}^T, b_{ij}^T$), min ($a_{ij}^I, b_{ij}^I$), max ($a_{ij}^F, b_{ij}^F$)>} ∀ i & j.

**3.3 Definition**

If A =$(a_{ij}) \in F_{m\times n}$, where $(a_{ij}) =< a_{ij}^T, a_{ij}^I, a_{ij}^F >$ then $A^c$ is calledcomplement of Aif $A^c = (b_{ij})_{m\times n}$ where $(b_{ij}) = < a_{ij}^F, 1 - a_{ij}^I, a_{ij}^T >$.

**3.4 Definition**

Let $A = < a_{ij}^T, a_{ij}^I, a_{ij}^F > \in F_{m\times n}$ and k ∈ F = [0,1] define scalar multiplication as

kA = {< min (k, $a_{ij}^T$), min(k, $a_{ij}^I$), max (k, $a_{ij}^F$)>} $\in F_{m\times n}$.

**3.5 Definition**

If A $=(a_{ij})\in F_{m\times n}$ ,B $=(b_{ij})\in F_{m\times n}$ then component wise sum and component wise product is determined as

A ⊕ B={ <max($a_{ij}^T, b_{ij}^T$), max($a_{ij}^I, b_{ij}^I$), min($a_{ij}^F, b_{ij}^F$)>}∀ i & j.

A ⊙ B= { <min($a_{ij}^T, b_{ij}^T$), min($a_{ij}^I, b_{ij}^I$), max($a_{ij}^F, b_{ij}^F$)>}∀ i & j.

**3.6 Properties**

1. $[\widetilde{A}^c]^c = \widetilde{A}$
2. $\widetilde{A}\cup\widetilde{A} = \widetilde{A}$
3. $\widetilde{A}\cap\widetilde{A} = \phi$
4. $\widetilde{A}\cap [0] = [0]$
5. $[\widetilde{A}\cup\widetilde{B}]^c = \widetilde{A}^c\cap\widetilde{B}^c$
6. $[\widetilde{A}\cap\widetilde{B}]^c = \widetilde{A}^c\cup\widetilde{B}^c$

All the above properties holds for FNSM.

**4. Fuzzy neutrosophic complement soft matrix based on reference function:**

The above fuzzy neutrosophic complement soft matrix cannot hold for $\widetilde{A}\cap\widetilde{A}^c\neq\phi$ and$\widetilde{A}\cup\widetilde{A}^c\neq J$. So we track a new fuzzy neutrosophic complement soft matrix based on reference work.

**4.1 Definition**

Let A $= [<$ ($a_{ij}^T$,0), ($a_{ij}^I$, 0), ($a_{ij}^F$, 0 )> $]_{m\times n}\in F_{m\times n}$. Then $A^{C(N)}$ is known as new fuzzy neutrosophic complement soft matrix if $A^{C(N)}$ =(<1,$a_{ij}^T$), (1, $a_{ij}^I$),(1, $a_{ij}^F$ )>$]_{m\times n}$for all $a_{ij}\in[0,1]$.Here $a_{ij}^T$ (x), $a_{ij}^I$(x), $a_{ij}^F$(x) are the enrolment value and (0,0,0) is the reference function and their difference value is known as enrolment value for truth, indeterminate and lie.

**4.2 Example**

Let A = $\begin{bmatrix} <(0.3,0),(0.4,0),(0.2,0)> & <(0.4,0),(0.5,0),(0.6,0)> \\ <(0.4,0),(0.5,0),(0.3,0)> & <(0.2,0),(0.4,0),(0.6,0)> \end{bmatrix}$

Then new Fuzzy Neutrosophic Complement Soft Matrix based on Reference work is

$A^{C(N)} = \begin{bmatrix} <(1,0.3),(1,0.4),(1,0.2)> & <(1,0.4),(1,0.5),(1,0.6)> \\ <(1,0.4),(1,0.5),(1,0.3)> & <(1,0.2),(1,0.4),(1,0.6)> \end{bmatrix}$

**4.3.Operations on fuzzy neutrosophic complement soft matrix on the basis of reference function:**

Let A and B be $F_{m\times n}$ where A $=(a_{ij})_{m\times n}$ ,$a_{ij}$ =( < $\mu_{j1}^{T,I,F}$ ($c_i$), $\mu_{j2}^{T,I,F}$ ($c_i$)>) and

B $=(b_{ij})_{m\times n}$ ,$b_{ij}$ = (<$\chi_{j1}^{T,I,F}$ ($c_i$), $\chi_{j2}^{T,I,F}$ ($c_i$)>).To keep away from degenerate cases we consider min(<$\mu_{j1}^{T,I,F}$ ($c_i$), $\chi_{j1}^{T,I,F}$ ($c_i$)>) ≥ max ( < $\mu_{j2}^{T,I,F}$ ($c_i$), $\chi_{j2}^{T,I,F}$ ($c_i$)>)∀ i and j.

The function of sum (+ ) betweenA and B be declared as A +B = C where C = $(c_{ij})_{m\times n}$,

$c_{ij}$=max(< $\mu_{j1}^{T,I,F}(c_i)$, $\chi_{j1}^{T,I,F}(c_i)$),min( $\mu_{j2}^{T,I,F}$ ($c_i$), $\chi_{j2}^{T,I,F}$ ($c_i$)>)where $\mu_{j1}^{T,I,F}$ is the enrolment value and $\chi_{j1}^{T,I,F}$are the reference function.

**4.4Example**

ConsiderA and $A^{C(N)}$ discussed in example 4.2

Now,$A_{11}$=$(<(0.3,0),(1,0.3)>,<(0.4,0),(1,0.4)>,<(0.2,0),(1,0.2)>)$ and

$A_{11}^{C(N)}$= $(<(1,0.3),(0.3,0)>,<(1,0.4),(0.4,0)>,<(1,0.2),(0.2,0)>)$

then$A_{11}\cap A_{11}^{C(N)}$ =([$<(0.3,0),(1,0.3)\cup(1,0.3),(0.3,0)>$],

[$<(0.4,0),(1,0.4)\cup(1,0.4),(0.4,0)>$],[$<(0.2,0),(1,0.2)\cup(1,0.2),(0.2,0)>$])

={< (1,0), (0.3,0.3)>, < (1,0),(0.4,0.4)>}, < (1,0),(0.2,0.2)>}

= J.

Similarly, we can prove for $A \cap A^{C(N)} = \phi$ by taking min instead of max and max instead of min in the above operation.

**4.5 Proposition**

Let A and B be two FNSCM based on reference function. Then

i) $(A^{C(N)})^T = (A^T)^{C(N)}$

ii) $(A^{C(N)} + B^{C(N)})^T = (A^T)^{C(N)} + (B^T)^{C(N)}$

Proof:

We have, let A∈ FNSM $_{m \times n}$, then

A=[< ($a_{ij}^T$, ($c_i$ ),$[0]_{ij}$),(($a_{ij}^I$($c_i$ ), $[0]_{ij}$),(($a_{ij}^F$($c_i$ ), $[0]_{ij}$)>]

$A^{C(N))}$ =[<($[1]_{ij}a_{ij}^T$ ($c_i$)),( $[1]_{ij}$,$a_{ij}^I$($c_i$ )),( $[1]_{ij}$,$a_{ij}^F$($c_i$ ))>]

Then

$[A^{C(N)}]^T$=[<( $[1]_{ji}$ ,,$a_{ji}^T$ ($c_i$)),( $[1]_{ji}$,$a_{ji}^I$, ($c_i$ )),( $[1]_{ji}$, $a_{ji}^F$ ($c_i$))>]

For

$A^T$=[< ($a_{ji}^T$, ($c_i$ ),$[0]_{ji}$),($a_{ji}^I$, ($c_i$ ), $[0]_{ji}$),( $a_{ji}^F$ ($c_i$), $[0]_{ji}$)>]

$(A^T)^{C(N)}$ = [<( $[1]_{ji}$ ,,$a_{ji}^T$ ($c_i$)),( $[1]_{ji}$,$a_{ji}^I$, ($c_i$ )),( $[1]_{ji}$, $a_{ji}^F$ ($c_i$))>]

Hence $(A^{C(N)})^T = (A^T)^{C(N)}$.

The verification of (ii) is just like the above part (i).

**4.6 Trace of a square Fuzzy Neutrosophic Soft Matrix:**

Let A be a $F_n$ matrix then the trace of the matrix A is symbolised by tr(A) is the addition of the leading diagonal elements. Then,

tr(A) = $\sum_{i=i}^{n} a_{ii}$ = { <max { $a_{ii}^T$}, max{ $a_{ii}^I$}, min { $a_{ii}^F$}>}

**4.7 Proposition**

Let A andB be two FNSMF $_n$ each of order n. Then tr(A +B)= tr(A)+ tr(B)

Proof:

tr(A) = {< max($a_{ii}^T$) , max ($a_{ii}^I$) , min($a_{ii}^F$) >}

and tr(B) = {< max($b_{ii}^T$) , max ($b_{ii}^I$) , min ($b_{ii}^F$ )>}

then (A+B) = Cwhere C = ($c_{ii}$).

tr ($c_{ii}$)={$< \max(a_{ii}^T,\ b_{ii}^T), \max(a_{ii}^I,\ b_{ii}^I), \min(a_{ii}^F,\ b_{ii}^F) >$}

tr(C) = tr (A +B)

Conversely,

tr(A) + tr(B)) ={$< \max(a_{ii}^T), \max(a_{ii}^I), \min(a_{ii}^F) >$}+ {$< \max(b_{ii}^T), \max(b_{ii}^I), \min(b_{ii}^F) >$}

= {$< \max(a_{ii}^T,\ b_{ii}^T), \max(a_{ii}^I,\ b_{ii}^I), \min(a_{ii}^F,\ b_{ii}^F) >$}

= tr(A+B)

Hence the result.

**4.8 Proposition**

Let $A = [<a_{ii}^T, a_{ii}^I, a_{ii}^F>] \in F_n$be a Fuzzy neutrosophicsoft square matrix of order n, ifk is a scalar such that 0 ≤k≤ 1. Then tr(kA) = ktr (A).

Proof:

We have

tr(kA)={$< \max(\min(k, a_{ii}^T)), \max(\min(k, a_{ii}^I)), \min(\max(k,\ a_{ii}^F)) >$}

ktr (A) = k{$< \max(a_{ii}^T), \max(a_{ii}^I), \min(a_{ii}^F) >$}

tr(kA) = ktr (A)

Hence the result.

**4.9 Example**

Let A = $\begin{bmatrix} <0.3,0.4,0.2> & <0.4,0.6,0.5> \\ <0.5,0.7.0.3> & <0.7,0.4,0.2> \end{bmatrix}$

Here k =0.6

$(kA)_{11}$ ={< min (0.6,0.3),min(0.6,0.4), max(0.6,0.2)>}

$(kA)_{11}$ = (<0.3,0.4,0.6>)

$(kA)_{22}$ = {<min (0.6,0.7),min(0.6,0.4), max(0.6,0.2)>}

$(kA)_{22}$ = (<0.6,0.4,0.6>)

Then tr(kA) = {<max(0.3,0.6),max(0.4,0.4), min(0.6,0.6)>}

= {<0.6,0.4,0.6>}

tr(A) = {<0.7,0.4,0.2>}

ktr (A) ={<min( 0.6,0.7),min(0.6,0.4),max(0.6,0.2)>}= {<0.6,0.4,0.6>}

Hence shown.

**4.10 Proposition**

Let $A = [<a_{ij}^T, a_{ij}^I, a_{ij}^F>] \in F_n$be a fuzzy neutrosophic soft square matrix of order n. Then tr(A)= tr( $A^T$) where $A^T$ is a transpose ofA.

It can be easily verified.

**5.Application of Harmonic mean ($A_{HM}$) of fuzzy neutrosophic soft matrix in choice**

**strategy:**

An usage of FNSM in choice strategy is presented in this section.

**5.1 Definition**

Let A =[< $a_{ij}^{T}$ , $a_{ij}^{I}$ , $a_{ij}^{F}$ >] ∈FNSM $_{m\,x\,n}$ , then the harmonic mean of FNSM A denoted by $A_{HM}$ is determined as $A_{HM}$ = $\left( 2\frac{\prod_{i=1}^{n} a_{ij}^{T}}{\sum_{i=1}^{n} a_{ij}^{T}}, 2\frac{\prod_{i=1}^{n} a_{ij}^{I}}{\sum_{i=1}^{n} a_{ij}^{I}}, 2\frac{\prod_{i=1}^{n} a_{ij}^{F}}{\sum_{i=1}^{n} a_{ij}^{F}} \right)$

**5.2 Definition**

The score value of $S_i$ for $U_i \in U$ is defined as $S_i = T_i - I_i F_i$ .

**5.3 Algorithm**

1. Build a FNSS (F,A)over U.
2. Build the fuzzy neutrosophic soft matrix of (F,A).
3. Calculate harmonic mean $A_{HM.}$
4. Evaluate the score value $S_i$.
5. Finally, find optimum= max ($S_i$),Then we conclude with the suitable value $U_i$.

**5.4 Example**

Assume there are five distributorsU= $\{u_1, u_2, u_3, u_4, u_5\}$ whose centre capabilities are assessed by means of component E= $\widetilde{X}$ =$\{e_1, e_2, e_3\}$ where $e_1$ = degree of development innovation, $e_2$ = the degree of capacity of the administration and $e_3$ = degree of administration. Suppose a company wants to select the good distributor according to the centre capabilities. A fuzzy neutrosophic soft set is given by

(F,A) =

{{F($e_1$ )={($u_1$ ,0.6,0.7,0.3),($u_2$ ,0.8,0.3,0.2),($u_3$ ,0.7,0.5,0.3),($u_4$ ,0.7,0.4,0.3), $u_5$ ,0.5,0.6,0.4)}

{{F($e_2$ )={($u_1$ ,0.7,0.7,0.3),($u_2$ ,0.6,0.7,0.2),($u_3$ ,0.6,0.5,0.5),($u_4$ ,0.9,0.6,0.3), $u_5$ ,0.7,0.3,0.2)}

{{F($e_3$ )={($u_1$ ,0.6,0.7,0.2),($u_2$ ,0.5,0.8,0.2),($u_3$ ,0.7,0.8,0.3),($u_4$ ,0.7,0.5,0.5), $u_5$ ,0.6,0.6,0.2)}

The matrix representation for the above is given as

$$A = \begin{pmatrix} \langle 0.6,0.7,0.3\rangle & \langle 0.7,0.7,0.3\rangle & \langle 0.6,0.7,0.2\rangle \\ \langle 0.8,0.3,0.2\rangle & \langle 0.6,0.7,0.2\rangle & \langle 0.5,0.8,0.2\rangle \\ \langle 0.7,0.5,0.3\rangle & \langle 0.6,0.5,0.5\rangle & \langle 0.7,0.8,0.3\rangle \\ \langle 0.7,0.4,0.3\rangle & \langle 0.9,0.6,0.3\rangle & \langle 0.7,0.5,0.5\rangle \\ \langle 0.5,0.6,0.4\rangle & \langle 0.7,0.3,0.2\rangle & \langle 0.6,0.6,0.2\rangle \end{pmatrix}$$

0.265 0.3267 0.045

0.252 0.1867 0.0267

$A_{HM}$ =0.21 0.222 0.081

0.383 0.16 0.081

0.233 0.144 0.04

0.25029

$A_{HM}$ = 0.24701

Score 0.192018

**0.37004**

0.22724

Here $u_4$ is the highest value so it is awesome to choose by the dynamic.

## 6 Conclusions

In this work, new idea of complement of FNSM dependent on reference work and trace of FNSMset up for certain connected properties and models is introduced. Atlast a utilizationof fuzzy neutrosophic soft matrix in choice strategy problem using harmonic mean is discussed.

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