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Abstract: The decision making theory is playing a vital role in various engineering problems recently. A contemporary strategy of object identification from a vague collection of multi observer data has been processed here. The strategy we used here involves neutrosophic fuzzy soft set in a parametric sense for managing to identify the best signal transceiver for the distribution. This may use to pick the better signal transceiver for effective communication and to avoid the loss in signal transmission. Reaching Height Transceiver proposed here for better result in communications techniques.

Keywords: Soft set, Neutrosophic fuzzy Soft set, Signal Transceiver, Reaching Height Transceiver

1. Introduction

Many intricate problems in engineering, medical sciences and many other fields involve uncertain data. All the issues cannot be worked out by using general mathematics. Here we need some applied mathematical techniques based on uncertainty to identify the optimum solution for these problems. Recently many theories have risen for dealing with such a problems based on uncertainty and vagueness. Molotov [1999] started off the new concept of soft set theory. This is used to discuss about uncertainty in different view. Smarandache [2005] initiated the concept of neutrosophic set (NS). Florentin Smarandache [2018] defined the extension of soft set to hypersoft set and discussed some of its properties. Maji PK and Biswas R [2001] introduced the concepts of fuzzy soft sets. Roy AR and Maji PK [2007] applied fuzzy soft sets in decision making problems.

M. Zulqarnain et al [2017, 2018, 2020 and 2021] discussed many decision making problems in various fields like medical, engineering etc., to find better solutions. In their continuous research work, They introduced TOPSIS method for decision making problems in numerous fields. From their discussion technique for order preference by similarity to ideal solution is used for Multi – criteria decision making problems and it provides expected results for the problem respectively.

Here we took a structure of Neutrosophic soft fuzzy set and its related properties. Also we tried to apply Neutrosophic Fuzzy soft set in identifying suitable transceiver for an effective communication among the multiple transceivers which involved multi parameters. To identify the best object using the property of Neutrosophic Fuzzy Soft Set (NFSS) is our proposed technique in this paper.

2. A Problem in Effective Communication – Solution by Neutrosophic soft fuzzy sets

Most of our real problems are vague, and we cannot identify the solution by using classical approach of mathematics. Especially some engineering problems with uncertainty conditions can be solved using fuzzy applied techniques. Here we tried to find out the solution for a communication problem using NFSS.

2.1 Preliminaries - Soft set theory

In this section, we present the basic definitions and results of soft set theory in this section. Also we applied important properties of soft set theory which would be very useful for further development of this paper.

1. Definition

Let U be an initial universe set and E be a set of parameters. Let $P(U)$ denote the power set of U and $G \subset E$.

A pair (F,G) is called a soft set over U, where F is a function given by $F : G \rightarrow P(U)$.

On the other hand, a soft set over U is a parameterized family of subsets of the universe U. For $\varepsilon \in G$, $F(\varepsilon)$ may be considered as the set of ε -approximate elements of the soft set (F,G).

2. Definition

Let (F_1,G_1) and (F_2,G_2) be any two soft sets over a common universe U, if

(i) $G_1 \subset G_2$, and

(ii) $\forall\ \varepsilon \in G_1$, $F_1(\varepsilon)$ and $F_2(\varepsilon)$ are identical approximations.

then we say that (F_1,G_1) is a soft subset of (F_2,G_2). We write $(F_1,G_1) \subseteq (F_2,G_2)$. (F_2,G_2) is said to be a soft super set of (F_1,G_1).

3. Definition

If (F_1,G_1) and (F_2,G_2) be two soft sets then "(F_1,G_1) AND (F_2,G_2)" is defined and denoted by $(F_1,G_1) \wedge (F_2,G_2) = (H, G_1 \times G_2)$, where $H(\alpha, \beta) = F_1(\alpha) \cap F_2(\beta)$, $\forall(\alpha, \beta) \in G_1 \times G_2$.

4. Definition

If (F_1,G_1) and (F_2,G_2) be two soft sets then "(F_1,G_1) OR (F_2,G_2)" is defined and denoted by $(F_1,G_1) \vee (F_2,G_2) = (H, G_1 \times G_2)$, where $H(\alpha, \beta) = F_1(\alpha) \cup F_2(\beta)$, $\forall(\alpha, \beta) \in G_1 \times G_2$.

2.2 Preliminaries – Neutrosophic fuzzy sets

5. Definition

A Neutrosophic set A on the universe set X is defined and denoted as $A=\{<x,T(x),I(x),F(x)>:x\in X\}$ $where\ T, I, F: X\rightarrow[0,1]$ and $0\leq T(x)+I(x)+F(x)\leq 3$

3. Neutrosophic fuzzy soft sets in Communication Engineering Problem

Basic definitions of Neutrosophic fuzzy sets and some of its related properties are discussed in this segment.

Let $U=\{x_1, x_2, \ldots, x_n\}$ be a set of n objects, which may be signalized by a set of factors $\{A_1,A_2, \ldots, A_i\}$. The parameter space C may be written as $C \supseteq \{A_1 \cup A_2 \cup \cdots \cup A_i\}$. Let each parameter set A_i represent the i^{th} class of factors and the elements of Ai represents a specific property set called as fuzzy sets. Hence, we now define a fuzzy soft set (Fi,Ai) which specifies a set of items having the parameter set Ai.

6. Definition

Let $\mathbf{P}(U)$ denotes the set of all fuzzy sets of U. Let $Ai \subset E$. A pair (F_i,A_i) is called a fuzzy-soft-set over U, where Fi is a mapping given by $F_i : A_i \rightarrow \mathbf{P}(U)$.

7. Definition

Let ₦(U) denotes the set of all neutrosophic fuzzy sets of U. Let $Ai \subset E$. A pair (₦$_i$, G_i) is called a fuzzy-soft-set over U, where ₦$_i$ is a mapping given by ₦$_i$: $Gi \rightarrow$ ₦ (U).

In view of the above we may now define a NFSS (₦$_i$,G_i) which identifies a group of items having the parameter set Gi .

8. Definition

For two NFSSs (₦$_1$,G_1) and (₦$_2$,G_2) over a common universe U, if

(i) $G_1 \subset G_2$, and

(ii) $\forall\varepsilon \in G_1$, ₦$_1(\varepsilon)$ is a fuzzy subset of ₦$_2(\varepsilon)$.

Then (₦$_1$, G_1) is a fuzzy-soft-subset of (₦$_2$, G_2). We write (₦$_1$, G_1) $\subseteq$ (₦$_2$, G_2).

(₦$_2$, G_2) is said to be a fuzzy soft super set of (₦$_1$, G_1).

Problem:

The common problems that occur in communication system could find its solution in pure Mathematics using the very powerful concept based on the power sets. The problem generated in signal communicating system is rectified with the help of many modern techniques. In communication system, the failure of any of the transceiver in sending (or receiving) the signal to (or from) any one of the secondary receivers can be rectified by the powerful concept of Neutrosophic Fuzzy Soft Set applications. There are many parameters involved in finding good transceivers. For example

1. Output power.
2. Receiving sensitivity
3. Bias current

4. Extinction ratio
5. Saturated optical power
6. Working temperature and so on.

From these we have chosen some parameters, like SNR value of the transceiver, Transmitting capacity etc. So, for each parameter we have considered T, I, F values. T represents truth performance value of a particular parameter of the transceiver. T equal to output value divided by input value. Similarly, we have chosen F, the false value of the parameter (may be considered as performance of failure value of the same parameter), and I is considered as indeterminacy value.

In this research paper, we have discussed the method to identify the best signal transceiver among a group of transceivers with the help of Neutrosophic Fuzzy Soft Sets for better communication. Through this method we are able to locate the Reaching Height Transceiver to receive the signals in a better quality comparing to the other transceivers in the encircled area. RHT (Reaching Height Transceiver) is a better transceiver among the group of transceivers, which will be good in receiving signals from Main Transceiver and transmitting quality signals to the other nearing transceivers. For discussion we can consider many parameters, especially SNR (Signal to Noise Ratio) for communication process.

In general, SNR is the proportion between signal and noise powers. This proportion provides a significant and convenient indication of the grade to which the signal has been contaminated with additive noise.

The $(SNR)_C$ gives " *the ratio of the average power of the modulated signal s(t) to the average power of noise in the message bandwidth, both measured as received input filtered noise n(t)*" and could be calculated using,

$$(SNR)_c = \frac{C^2 A_C^2 P}{2WN_o} = \frac{Avearage\ power\ of\ the\ channel}{Average\ power\ of\ the\ noise\ n(t)},$$ where

C^2 - System dependent scaling factor (a constant);

A_C^2 - Carrier wave constant;

P - Average power of the original message signal m(t); &

WN_0 - The average noise power in the message bandwidth W in the receiver.

The $(SNR)_O$ gives "*the ratio of the average power of the demodulated message signal to the average power of noise, both measured at the receiver output*" and could be calculated using

$$(\mathrm{SNR})_o = \frac{C^2 A_C^2 P/4}{WN_0/2} = \frac{C^2 A_C^2 P'}{2WN_0} = \frac{Average\ power\ of\ the\ component}{Average\ power\ of\ the\ noise\ n(t)},$$ where

C^2 - System dependent scaling factor (a constant);

A_C^2 - Carrier wave constant;

P' - Average power of the output message signal $m_o(t)$; &

WN_0 - The average noise power in the message bandwidth W in the transmitter.

Then we can obtain the figure of merit value through

$$\beta = \frac{SNR_O}{SNR_C} = \frac{\text{The output signal} - \text{to} - \text{noise ratio for a receiver using coherent detection}}{\text{The channel signal} - \text{to} - \text{noise ratio of a coherent receiver}}$$

Example:

Let X be the set of transceivers for communicating the signals and C is the set of factors. Each factor is a neutrosophic term or a sentence. Consider C={c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9, c_{10}} (Example, Receiving capacity, distance from Main transceiver, cost, Delivering Capacity, SNR…..etc). This problem, we define a NFSS means to point out c_1, c_2, c_3…… and so on. Suppose there are twelve transceivers in the universe set X given as, U_1 = {TR_1, TR_2, TR_3, TR_4, TR_5, TR_6} and U_2 = {TR_7, TR_8, TR_9, TR_{10}, TR_{11}, TR_{12}}. Let A = {c_1, c_2, c_3, c_4} where c_1 refers the factor 'Receiving Capacity', c_2 refers for the factor 'Delivering Capacity', c_3 stands for the factor 'Signal to Noise Ratio (β)' and the factor c_4 stands for 'Cost'.

Suppose that NFSS defined on U_1 and the parameter e_1 is given in Table.1 as f(U_1,c_1) follows.

	T	*I*	*F*
TR_1	.7	.5	.4
TR_2	.6	.4	.5
TR_3	.85	.6	.2
TR_4	.7	.6	.4
TR_5	.75	.9	.5
TR_6	.5	.7	.7

Table:1- NFSS (f(U_1,c_1))

NFSS defined on U_1 and the parameter e_2 is given in Table.2 as f(U_1,c_2)

	T	*I*	*F*
TR_1	.8	.4	.3
TR_2	.7	.5	.2
TR_3	.7	.6	.3
TR_4	.9	.2	.5
TR_5	1.0	.6	.5
TR_6	.8	.3	.4

Table:2- NFSS (f(U_1,c_2))

NFSS defined on U_1 and the parameter e_3 is given in Table.3 as f(U_1,c_3)

	T	*I*	*F*
TR_1	.4	.2	.3
TR_2	.6	.6	.1
TR_3	.8	.3	.4
TR_4	.8	.5	.5
TR_5	.3	.4	.7

TR_6	*.5*	*.3*	*.5*

Table:3- NFSS ($f(U_1,c_3)$)

NFSS defined on U_1 and the parameter e_4 is given in Table.3 as $f(U_1,c_4)$

	T	*I*	*F*
TR_1	*.8*	*.3*	*.3*
TR_2	*.5*	*.5*	*.4*
TR_3	*.4*	*.5*	*.6*
TR_4	*.7*	*.2*	*.5*
TR_5	*.1*	*.4*	*.7*
TR_6	*.8*	*.4*	*.2*

Table:4- NFSS ($f(U_1,c_4)$)

Note: The fuzzy values (T) used here are randomly collected from lab and the remaining values are selected according to the condition. We used moderate to high values, which may provide the better solution for the system. The study also based upon these values. In this proposed topic we used random values, but the original output of neutrosophic fuzzy values will be used in our future research work.

Figure 1 is the graphical representation of Table 1 and so on.

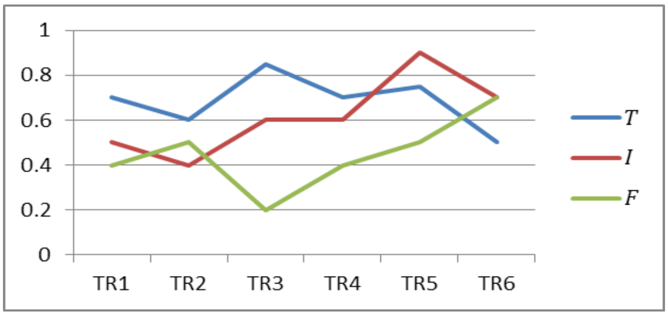

Figure.1 – Graphical representation of $f(U_1,c_1)$

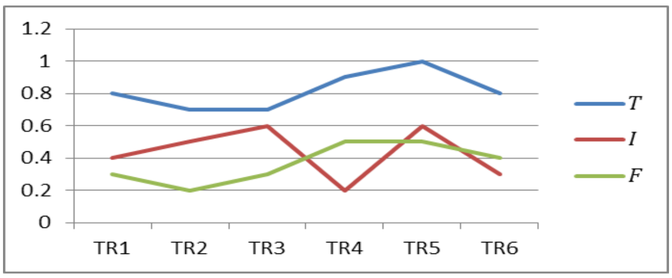

Figure.2 – Graphical representation of $f(U_1,c_2)$

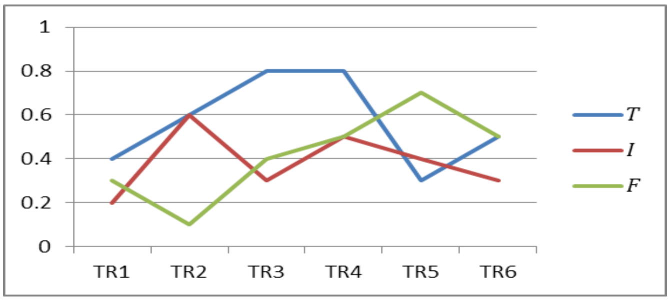

Figure.3 – Graphical representation of f(U_1,c_3)

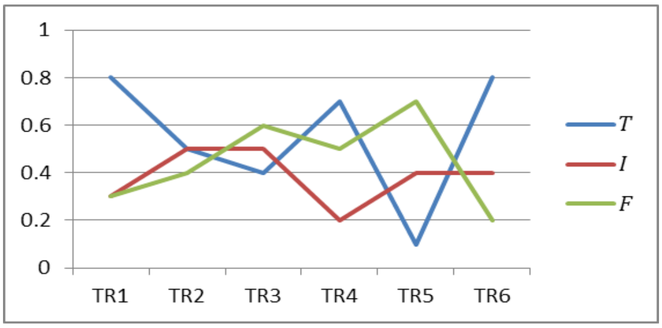

Figure.4 – Graphical representation of f(U_1,c_4)

Similarly we can define the NFSS for other group of transceivers U_2, U_3… and so on.

Also, the attributes TR $(j = 1,2,3,4,5,6)$ have the weight vector is w = $\left(\frac{1}{2},\frac{1}{4},\frac{3}{16},\frac{1}{16}\right)^T$

Then the Neutrosophic Fuzzy Weighted Average values of the Transceivers under the considered criteria are

$A_w(TR_{i1},TR_{i2},TR_{i3},TR_{i4},TR_{i5},TR_{i6})\ where\ i$ =1, 2, 3, 4 are

$$\tilde{a_i} = \left[1 - \prod_{j=1}^{n}(1-T_j)^{w_j}, \prod_{j=1}^{n}(I_j)^{w_j}, \prod_{j=1}^{n}(F_j)^{w_j}\right]$$

And the Score Function $S(\tilde{a_i})$ is defined as

$$S(\tilde{a_i}) = \frac{(T_i + 1 - I_i + 1 - F_i + 1)}{6}$$

For example, we can calculate $\tilde{a_i}$ values are obtained using Table 1 to Table 4 as follows.

$$\tilde{a_1} = \left[1 - \left[(1-0.7)^{\frac{1}{2}}(1-0.8)^{\frac{1}{4}}(1-0.4)^{\frac{3}{16}}(1-0.8)^{\frac{1}{16}}\right]; \left[(0.5)^{\frac{1}{2}}(0.4)^{\frac{1}{4}}(0.2)^{\frac{3}{16}}(0.3)^{\frac{1}{16}}\right]; \left[(0.4)^{\frac{1}{2}}(0.3)^{\frac{1}{4}}(0.3)^{\frac{3}{16}}(0.3)^{\frac{1}{16}}\right]\right.$$

$$\tilde{a_2} = \left[1 - \left[(1-0.6)^{\frac{1}{2}}(1-0.7)^{\frac{1}{4}}(1-0.6)^{\frac{3}{16}}(1-0.2)^{\frac{1}{16}}\right]; \left[(0.4)^{\frac{1}{2}}(0.5)^{\frac{1}{4}}(0.6)^{\frac{3}{16}}(0.5)^{\frac{1}{16}}\right]; \left[(0.5)^{\frac{1}{2}}(0.2)^{\frac{1}{4}}(0.1)^{\frac{3}{16}}(0.4)^{\frac{1}{16}}\right]\right.$$

$$\tilde{a_3} = \left[1 - \left[(1-0.85)^{\frac{1}{2}}(1-0.7)^{\frac{1}{4}}(1-0.8)^{\frac{3}{16}}(1-0.4)^{\frac{1}{16}}\right]; \left[(0.6)^{\frac{1}{2}}(0.6)^{\frac{1}{4}}(0.3)^{\frac{3}{16}}(0.5)^{\frac{1}{16}}\right]; \left[(0.2)^{\frac{1}{2}}(0.3)^{\frac{1}{4}}(0.4)^{\frac{3}{16}}(0.6)^{\frac{1}{16}}\right]\right.$$

$$\widetilde{a_4} = \left[1 - \left[(1-0.7)^{\frac{1}{2}}(1-0.9)^{\frac{1}{4}}(1-0.8)^{\frac{3}{16}}(1-0.7)^{\frac{1}{16}}\right]; \left[(0.6)^{\frac{1}{2}}(0.2)^{\frac{1}{4}}(0.5)^{\frac{3}{16}}(0.2)^{\frac{1}{16}}\right]; \left[(0.4)^{\frac{1}{2}}(0.5)^{\frac{1}{4}}(0.5)^{\frac{3}{16}}(0.5)^{\frac{1}{16}}\right]\right.$$

$$\widetilde{a_5} = \left[1 \;\; - 0 \qquad ; \left[(0.9)^{\frac{1}{2}}(0.6)^{\frac{1}{4}}(0.4)^{\frac{3}{16}}(0.4)^{\frac{1}{16}}\right]; \left[(0.5)^{\frac{1}{2}}(0.5)^{\frac{1}{4}}(0.7)^{\frac{3}{16}}(0.7)^{\frac{1}{16}}\right]\right.$$

$$\widetilde{a_6} = \left[1 - \left[(1-0.5)^{\frac{1}{2}}(1-0.8)^{\frac{1}{4}}(1-0.5)^{\frac{3}{16}}(1-0.8)^{\frac{1}{16}}\right]; \left[(0.7)^{\frac{1}{2}}(0.3)^{\frac{1}{4}}(0.3)^{\frac{3}{16}}(0.4)^{\frac{1}{16}}\right]; \left[(0.7)^{\frac{1}{2}}(0.4)^{\frac{1}{4}}(0.5)^{\frac{3}{16}}(0.2)^{\frac{1}{16}}\right]\right.$$

If we proceed, then we can receive the following $\widetilde{a_i}$ values which are tabulated below

	T	*I*	*F*
$\widetilde{a_1}$	*.6990*	*.3857*	*.3464*
$\widetilde{a_2}$	*.6112*	*.4627*	*.2899*
$\widetilde{a_3}$	*.7946*	*.5209*	*.2699*
$\widetilde{a_4}$	*.7887*	*.4113*	*.4472*
$\widetilde{a_5}$	*1.0000*	*.6640*	*.5438*
$\widetilde{a_6}$	*.5905*	*.4666*	*.5283*

Table: 5-NFSS Weighted average values $\widetilde{a_i}$

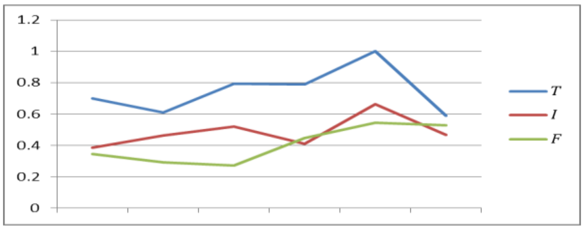

Figure.5 – Graphical representation of Table.5.

$$S(\widetilde{a_1}) = \frac{(0.6990 + 1 - 0.3857 + 1 - 0.3464 + 1)}{6} = 0.4945$$

$$S(\widetilde{a_2}) = \frac{(0.6112 + 1 - 0.4627 + 1 - 0.2899 + 1)}{6} = 0.4764$$

$$S(\widetilde{a_3}) = \frac{(0.7946 + 1 - 0.5209 + 1 - 0.2699 + 1)}{6} = 0.5006$$

$$S(\widetilde{a_4}) = \frac{(0.7887 + 1 - 0.4113 + 1 - 0.4472 + 1)}{6} = 0.4884$$

$$S(\widetilde{a_5}) = \frac{(1.0000 + 1 - 0.6640 + 1 - 0.5438 + 1)}{6} = 0.4653$$

$$S(\widetilde{a_6}) = \frac{(0.5905 + 1 - 0.4666 + 1 - 0.5283 + 1)}{6} = 0.4326$$

Hence Score function values are tabulated here

$S(\widetilde{a_1})$	.4945
$S(\widetilde{a_2})$	.4764
$S(\widetilde{a_3})$	.5006
$S(\widetilde{a_4})$	.4884
$S(\widetilde{a_5})$	.4653
$S(\widetilde{a_6})$	.4326

Table: 6-Score function values $S(\widetilde{a_i})$

Comparing $S(\widetilde{a_i})$ values, we get the following result

$S(\widetilde{a_3}) > S(\widetilde{a_1}) > S(\widetilde{a_4}) > S(\widetilde{a_2}) > S(\widetilde{a_5}) > S(\widetilde{a_6})$

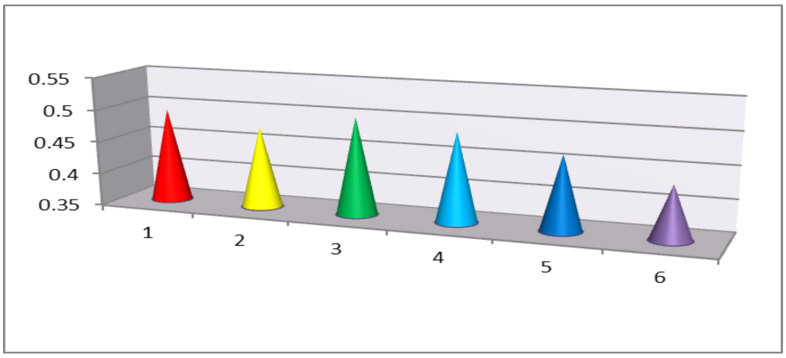

Figure.6 – Graphical representation of Table.6

So, the system can automatically choose TR_3 in the group U_1, and the main transceiver can start to deliver the data to TR_3 to distribute the signals to other transceivers in that group. It will be useful for better communication without interruption and to minimize the interference.

Conclusion:

Usually SNR values are considered to choose the best transceiver for uninterrupted communication. But in the discussed method SNR value is also considered as a parameter of the element. Hence, through the discussed method the better transceiver can be identified using Neutrosophic fuzzy soft sets. This RHT transceiver can be used for fine-tuned communication process and it may reduce loss of signals. It is very useful to increase the efficiency of the particular communication system.

Merits:

1. Proposed method used to identify the better transceiver for effective communication without loss of efficiency.
2. Neutrosophic fuzzy sets used here to identify the better transceiver using multiple parameters including SNR.
3. Score function values are used here to analyze the efficiency of the transceiver. This is better, compare with the analytic studies based upon fuzzy values on communication engineering.

Algorithm:

1. Input neutrosophic fuzzy soft sets: $\langle\langle U_1, A_1, ₦_1 \rangle, \langle U_2, A_2, ₦_2 \rangle\rangle \ldots..$
2. Input the Weightage set "w" by the observer
3. Calculate the neutrosophic fuzzy weighted average $A_w(U_1), A_w(U_2), \ldots$
4. Calculate the neutrosophic fuzzy score functions $S(\widetilde{a_1})$, $S(\widetilde{a_2})$, $S(\widetilde{a_3})$ ….for a group $\langle U_1, A_1, ₦_1 \rangle$ respectively
5. Compare $S(\widetilde{a_i})$ with $S(\widetilde{a_j})$ ∀ i, j ∈k
6. Consider maximum $\widetilde{a_i}$ for all i, Then TR_i be the suitable Reaching Height transceiver for the group U_i.

Future Study:

1. Sudan Jha etal., (2019) discussed a new method to reduce the loss in signal transmission using neutrosophic philosophy in their paper entitled as "Neutrosophic approach for enhancing quality of signals". We would like to develop the new techniques to reduce the loss in signal transmission using NFSS and proposed calculative method. The output of this research will propose significant approach to minimize the loss of efficiency in signal transmitting methods.
2. M. Zulqarnain et al [2017, 2018, 2020 and 2021] discussed many decision making problems in various fields and they used TOPSIS technique to find the better results for Multi – criteria decision making problems. We would like to use TOPSIS technique for finding the suitable solution in our proposed topic.

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Authorship contributions:

M.S. Muthuraman and K.H.Manikandan proposed the idea to apply Neutrosophic fuzzy soft set in the communication engineering problems with transceiver models. M.Sridharan, G.Sabarinathan and R.Muthuraj helped to structure this paper. K.H.Manikandan worked out all the calculations and prepared the graphical representations which are useful to conclude this research article.

References

1. Irfan Deli , Mumtaz Al*i* and Florentin Smarandache, 2015, Proceedings of the 2015 International Conference on Advanced Mechatronic Systems, 22-24, DOI: 10.5281/zenodo.49119.
2. Florentin Smarandache, 2018, Extension of Soft Set to Hypersoft Set, and then to Plithogenic Hypersoft Set, Neutrosophic Sets and Systems, vol. 22, 2018, pp. 168-170. DOI: 10.5281/zenodo.2159754**.**
3. A R Roy, P K Maji, 2007, A fuzzy soft set theoretic approach to decision making problems, Journal of Computational and Applied Mathematics 203 (2007) 412 – 418.
4. D.A.Molodtsov, Soft set theory – first results, Computers and mathematics with applications, 37, (1999), 19-31.
5. Sudan Jha, Raghvendra Kumar, Le Hoang Son, Francisco Chiclana, Vikram Puri and Ishaani Priyadarshini, 2019, Neutrosophic approach for enhancing quality of signals, Multimedia Tools and Applications, https://doi.org/10.1007/s11042-019-7375-0.
6. Zadeh L A, Fuzzy sets, Information and control,8,338-353.
7. Zulqarnain . M, F. Dayan. Choose Best Criteria for Decision Making Via Fuzzy Topsis Method, Mathematics and Computer Science, 2(6): 113-119, 2017.
8. Zulqarnain . M, F. Dayan., M. Saeed. TOPSIS Analysis For the Prediction of Diabetes Based on General Characteristics of Humans, International Journal of Pharmaceutical Sciences and Research, 9(7): 2932-2939, 2018.
9. Zulqarnain . M, X. L. Xin, M. Saeed, N. Ahmad, F. Dayan, B. Ahmad, Recruitment of Medical Staff in Health Department by Using TOPSIS Method, International Journal of Pharmaceutical Sciences Review and Research, 62(1), 1-7, 2020.
10. Zulqarnain . M, Saeed, B. Ali, S. Abdal, M. Saqlain, M. I. Ahamad, Z. Zafar. Generalized Fuzzy TOPSIS to Solve Multi-Criteria Decision-Making Problems, Journal of New Theory, 32, 40-50, (2020).
11. Zulqarnain . M, X. L. Xin, M. Saeed, F. Smarandache, N. Ahmad, Generalized Neutrosophic TOPSIS to Solve Multi-Criteria Decision-Making Problems, Neutrosophic Sets and Systems, 38, 276-292, (2020).
12. M. Zulqarnain., F. Dayan. Choose Best Criteria for Decision Making Via Fuzzy Topsis Method, Mathematics and Computer Science, 2(6): 113-119, 2017.
13. M. Zulqarnain., F. Dayan., M. Saeed. TOPSIS Analysis For the Prediction of Diabetes Based on General Characteristics of Humans, International Journal of Pharmaceutical Sciences and Research, 9(7): 2932-2939, 2018.
14. R. M. Zulqarnain, X. L. Xin, M. Saeed, N. Ahmad, F. Dayan, B. Ahmad, Recruitment of Medical Staff in Health Department by Using TOPSIS Method, International Journal of Pharmaceutical Sciences Review and Research, 62(1), 1-7, 2020.
15. R. M. Zulqarnain, M. Saeed, B. Ali, S. Abdal, M. Saqlain, M. I. Ahamad, Z. Zafar. Generalized Fuzzy TOPSIS to Solve Multi-Criteria Decision-Making Problems, Journal of New Theory, 32, 40-50, (2020).

16. R. M. Zulqarnain, X. L. Xin, M. Saeed, F. Smarandache, N. Ahmad, Generalized Neutrosophic TOPSIS to Solve Multi-Criteria Decision-Making Problems, Neutrosophic Sets and Systems, 38, 276-292, (2020).
17. Abduallah Gamal, Amal F.Abd El-Gawad , Mohamed Abouhawwash, Towards a Responsive Resilient Supply Chain based on Industry 5.0: A Case Study in Healthcare Systems, Neutrosophic Systems with Applications, vol.2, (2023): pp. 8–24. (Doi: https://doi.org/10.5281/zenodo.8185201)
18. Abdel-Monem , A., A.Nabeeh , N., & Abouhawwash, M. An Integrated Neutrosophic Regional Management Ranking Method for Agricultural Water Management. Neutrosophic Systems with Applications, vol.1, (2023): pp. 22–28. (Doi: https://doi.org/10.5281/zenodo.8171194)
19. R. M. Zulqarnain, X. L. Xin, H. Garg, W. A. Khan, Aggregation operators of pythagorean fuzzy soft sets with their application for green supplier chain management, Journal of Intelligent and Fuzzy Systems, (2021) 40 (3), 5545-5563. DOI: 10.3233/JIFS-202781.
20. Ahmed Abdelhafeez , Hoda K.Mohamed, Nariman A.Khalil, Rank and Analysis Several Solutions of Healthcare Waste to Achieve Cost Effectiveness and Sustainability Using Neutrosophic MCDM Model, Neutrosophic Systems with Applications, vol.2, (2023): pp. 25–37. (Doi: https://doi.org/10.5281/zenodo.8185213)
21. Mona Mohamed, Abduallah Gamal, Toward Sustainable Emerging Economics based on Industry 5.0: Leveraging Neutrosophic Theory in Appraisal Decision Framework, Neutrosophic Systems with Applications, Vol. 1, (2023):pp. 14-21, (Doi: https://doi.org/10.5281/zenodo.8171178).
22. Zulqarnain, R.M., Xin, X.L., Garg, H. and Ali, R., Interaction aggregation operators to solve multi criteria decision making problem under pythagorean fuzzy soft environment. Journal of Intelligent & Fuzzy Systems, 41 (1), 1151-1171, 2021.

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