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Research Article

NEUTROSOPHIC SOFT SETS WITH MEDICAL DECISIN-MAKING APPLICATIONS

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ABSTRACT

In this study, we apply neutrosophic soft set theory through Maji's approach for medical decision making. The problem is to choose patient people with the variables used for T2DM diagnosis. A comparison matrix will be obtained for this selection and the maximum score will be reached with this matrix.
Keywords: Neutrosophic soft sets, soft sets, decision making, comparison matrix.

1. INTRODUCTION

Fuzziness has revolutionized many areas such as mathematics, science, engineering, medicine. This concept was initiated by Zadeh [13]. Not only Zadeh discovered this concept, but he also developed the infrastructure of today's popular forms of use such as relations of similarity, decision making, and fuzzy programming in a short time.

Just like in the theory of sets, fuzzy sets(FS) also have led to the emergence of new mathematical concepts, research topics, and the design of engineering applications. Therefore, the nature of the classical set theory must be well known and understood. In particular, consider the two fundamental laws of Boolean algebra the law of excluded middle and law of contradiction. In logic, the proposition every proposition is either true or false excludes any third, or middle, possibility, which gave this principle the name of the law of excluded middle. When look at the principles of Boolean algebra, there are two items as prediction: "True" or "False". Whether classical, Boolean or crisp, set theory can be defined as a characteristic function of the membership of an element x in a set A. For each elements of universal set X, the function that generates the values 0 and 1 is called the characteristic function.

In some real life problems in expert system, belief system, information fusion and so on, we must consider the truth-membership as well as the falsity-membership for proper description of an object in uncertain, ambiguous environment. Neither the fuzzy sets nor the interval valued fuzzy sets is appropriate for such a situation. Intuitionistic fuzzy sets introduced by Atanassov [1] is appropriate for such a situation. The intuitionistic fuzzy sets can only handle the incomplete information considering both the truth-membership (or simply membership) and falsity-

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membership (or non-membership) values. It does not handle the indeterminate and inconsistent information which exists in belief system.

Smarandache [7, 8, 9, 10] introduced the concept of neutrosophic set which is a mathematical tool for handling problems involving imprecise, indeterminacy and inconsistent data. Neutrosophy is a branch of philosophy which studies the origin, nature, and scope of neutralities, as well as their interactions with di_erent ideational spectra [8]. Neutrosophic set is a powerful general formal framework which generalizes the concept of the classic set, fuzzy set [13] interval-valued fuzzy set [11], intuitionistic fuzzy set [1], interval-valued intuitionistic fuzzy set [2], paraconsistent set, dialetheist set, paradoxist set, and tautological set [8]. In [3], a relation on neutrosophic soft sets which allows composing two neutrosophic soft sets is defined.

We firstt define a relation on neutrosophic soft sets which allows composing two neutrosophic soft sets.

In this paper, we will use a real datasaet [4] and make medical decision making using this data set in neutrosophic soft sets. We will use Maji's method for this.

2. PRELIMINARIES

Let's consider that X is a space of points (objects), with $x \in X$. For A is a set in X, truth-membership, indeterminacy-membership, falsity-membership functions are denoted by $G_A(x), B_A(x),\ H_A(x)$, respectively. Then,

$$G_A(x): X \to]0^-, 1^+[, \quad B_A(x): X \to]0^-, 1^+[, \quad H_A(x): X \to]0^-, 1^+[.$$

There is no restriction on the sum of $G_A(x), B_A(x),\ H_A(x)$. Therefore, $0^- \leq \sup G_A(x) + \sup B_A(x) + \sup H_A(x) \leq 3^+$. The set A which consist of with $G_A(x), B_A(x)$, $H_A(x)$ in X is called a neutrosophic sets (NS) and can be written as

$$A = \{\langle x, G_A(x), B_A(x), H_A(x) \rangle : x \in X, G_A(x), B_A(x), H_A(x) \in]0^-, 1^+[\}.$$

In the NS definition, $0^- = 0 - \varepsilon$ and $1^+ = 1 + \varepsilon$, where 0 and 1 are standard parts and ε is non-standard part.

From philosophical point of view, the neutrosophic set takes the value from real standard or non-standard subsets of $]0^-, 1^+[$. So instead of $]0^-, 1^+[$ we need to take the interval $[0,1]$ for technical applications, because $]0^-, 1^+[$ will be difficult to apply in the real applications such as in the scientific and engineering problems. Because of the NSs are difficult to apply in the real-situations, single-valued neutrosophic sets were proposed. Additionally, Ye [12] also introduced the concept of simplified neutrosophic sets (SNSs), which can be described by three real numbers in the real unit interval $[0,1]$.

The definition of SNSs given by Ye [12] is as follows:

Let's consider that X is a space of points (objects), with $x \in X$. A NS A in X is characterized by $G_A(x), B_A(x),\ H_A(x)$, which are subintervals/subsets in the standard interval $[0,1]$, that is $G_A(x): X \to [0,1]$, $B_A(x): X \to [0,1]$,, $H_A(x): X \to [0,1]$. Then, a simplification of A is denoted by

$$A = \{\langle x, G_A(x), B_A(x), H_A(x) \rangle : x \in X\}$$

which is called an SNS. Clearly, SNSs are a subclass of NSs.

Take an initial universe set N. The power set of N and the set of parameters are denoted by $P(N)$ and M, respectively. For a non-empty set $A \subset M$, if $F: A \to P(N)$ is a mapping then, the pair (F, A) is called a soft set (SS) over N [6].

Following definitions are given by Maji [5]:

Take an initial universe set N. The all neutrosophic sets on N and the set of parameters are denoted by $P(N)$ and M, respectively. For a non-empty set $A \subset M$, if $F: A \to P(N)$ is a mapping then the collection (F, A) is termed to be the neutrosophic soft set (NSS) over N.

The value-class of the NSS is define d as the class of all value sets of a NSS (F,M). It is denoted by $C_{(F,M)}$. Clearly, $C_{(F,M)} \subset P(N)$.

Choose two neutrosophic soft sets (F,A) and (J,B) over N. If $A \subset B$, then (F,A) is said to be neutrosophic soft subset of (J,B). $\forall e \in A, x \in N$,

$$G_{F(e)}(x) \leq G_{J(e)}(x), \qquad B_{F(e)}(x) \leq B_{J(e)}(x), \qquad H_{F(e)}(x) \leq H_{J(e)}(x).$$

It denote by $(F,A) \subseteq (J,B)$.

3. METHODS

In this work, the dataset which are given by Kirisci et.al.[4] used for independent variables and T2DM dependent variable are considered.

As the method, the Maji's neutrosophic soft set theory approach [5] and also the algorithm given by Maji will be used.

Let the n number of participants are $p_1, p_2, \cdots, p_n$ and the m numbers of choice parameters are $e_1, e_2, \cdots, e_m$. We also assume that corresponding to the parameter e_j $(j = 1,2,\cdots,m)$ the rating or performance value of the participants p_i $(i = 1,2,\cdots,n)$ is a tuple

$$t_{ij} = \left\{G_{p(e_j)}(p_i), \;\; B_{p(e_j)}(p_i), \;\; H_{p(e_j)}(p_i)\right\},$$

such that for a fixed i that values t_{ij} $(j = 1,2,\cdots,m)$ represents a NSS of all the n objects. Thus the performance values could be arranged in the form of a matrix called the 'criteria matrix'. If the criteria values are more, preferability of the corresponding object is also more. Our problem is to select the most suitable object i.e. the object which dominates each of the objects of the spectrum of the parameters e_j.

Select the participants p_1, p_2, p_3, p_4, p_5. The problem is that according to the variables studied, it is one of these participants to find out which one has T2Dm. The p_1 participant will suffer from T2DM while the other two p_2 and p_3 participants will not suffer, as the selection is dependent on the choice parameters of each participants. We use the technique to calculate the score for the objects.

Comparison Matrix: It is a matrix whose rows are labelled by the object names $p_1, p_2, \cdots, p_n$ and columns are labelled by the parameters $e_1, e_2, \cdots, e_m$. The entries e_{ij} are calculated by $c_{ij} = a + b - c$, where

- $'a'$ is the integer calculated as 'how many times $G_{p_i}(e_j)$ exceeds or equal to $G_{p_k}(e_j)$' for $p_i \neq p_k$, $\forall p_k \in U$,
- $'b'$ is the integer calculated as 'how many times $B_{p_i}(e_j)$ exceeds or equal to $B_{p_k}(e_j)$' for $p_i \neq p_k$, $\forall p_k \in U$,
- $'c'$ is the integer 'how many times $H_{p_i}(e_j)$ exceeds or equal to $H_{p_k}(e_j)$' for $p_i \neq p_k$, $\forall p_k \in U$.

Score of an Object: The score of an object p_i is σ_i and is calculated as $\sigma_i = \sum_j c_{ij}$.

Algorithm:

- Input the NSS (K,A)
- Input V, the choice parameters of p_i which is a subset of A
- Consider the NSS (K,V) and write it in tabular form
- Compute the comparison matrix of the NSS (K,V)
- Compute the score σ_i of p_i, $\forall i$
- Find $\sigma_k = \max_i \sigma_i$
- If k has more than one value then any one of p_i could be the preferable choice.

4. MEDICINE APPLICATON

In this section, we will use the algorithm in previous section.

The set V is contained independent variables which used in dataset of [4], where

$$V = \left\{ \begin{array}{c} age(A), \quad waist\ circumference(WCIR), \quad nurtitional\ habits(NH), \quad activities(Act), \\ genetics(G), \quad BMI \end{array} \right\}.$$

For example, for BMI and age, while Table 2 is obtained, it was used the table "The International Classi_cation of adult underweight, overweight and obesity according to BMI" in web site of World Health Organization in Table 1. The value-classes of other variables in the set V have been obtained in a similar way.

Table 1. Value-class of BMI & Age

BMI & Age	19-24	25-34	35-44	44-54	55-64	65+
Underweight	BMI<19	BMI<20	BMI<21	BMI<22	BMI<23	BMI<24
	0.1-0.3	0.1-0.3	0.1-0.3	0.1-0.3	0.1-0.3	0.1-0.3
Normal	BMI<19-24	BMI<20-25	BMI<21-26	BMI<22-27	BMI<23-28	BMI<24-29
	0.4-0.6	0.4-0.6	0.4-0.6	0.4-0.6	0.4-0.6	0.4-0.6
Overweight	BMI>24	BMI>25	BMI>26	BMI>27	BMI>28	BMI>29
	0.7-0.8	0.7-0.8	0.7-0.8	0.7-0.8	0.7-0.8	0.7-0.8
Obese	0.9	0.9	0.9	0.9	0.9	0.9

Follow the steps below according to the algorithm.

- Generate the NSS (K, V) (Table 2)
- Write the comparison matrix table form (Table 3)
- Compute the score for each p_i (Table 4)
- Decide according to the maximum score in Table 4.

Table 2. The NSS (K,V)

	A	WCR	NH	Act	G	BMI
p_1	(0.7,0.2,0.7)	(0.6,0.2,0.5)	(0.7,0.4,0.3)	(0.8,0.3,0.6)	(0.4,0.6,0.7)	(0.6,0.3,0.8)
p_2	(0.5,0.1,0.5)	(0.5,0.3,0.6)	(0.6,0.5,0.5)	(0.5,0.8,0.3)	(0.8,0.2,0.7)	(0.6,0.3,0.7)
p_3	(0.7,0.2,0.4)	(0.8,0.6,0.2)	(0.4,0.6,0.7)	(0.7,0.3,0.2)	(0.6,0.1,0.5)	(0.3,0.5,0.6)
p_4	(0.6,0.4,0.6)	(0.7,0.7,0.6)	(0.8,0.5,0.8)	(0.7,0.2,0.5)	(0.8,0.2,0.5)	(0.8,0.3,0.6)
p_5	(0.7,0.6,0.6)	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.7,0.6,04)	(0.7,0.2,07)	(0.5,0.6,0.8)

Table 3. Comparison matrix of the NSS (K,V)

	A	WCR	NH	Act	G	BMI
p_1	2	1	3	2	0	1
p_2	-4	-1	3	3	3	3
p_3	6	7	1	5	0	2
p_4	1	4	2	0	6	5
p_5	5	0	2	4	3	1

Table 4. Score

	σ_i
p_1	9
p_2	7
p_3	21
p_4	18
p_5	15

Decision: It seen that in Table 4, the maximum score is 21. This score is measured in the third patient. When the available data are calculated with the neutrosophic soft set, the p_3 appears to be the patient most suffering from T2DM. After p_3, p_4, p_5, p_1, p_2 are suffering from the disease, respectively.

5. CONCLUSION

In this paper, we applied the notion of NSS in Maji's approach for medical diagnosis. Maji's aprroach is based on NSS. Maji use this concept in soft sets considering the fact that the parameters (which are words and sentences) are mostly neutrosophic set. A case study based on real data has been taken to demonstrate the simplicity of the Maji's approach. Future work in this regard would be required to study whether the notions put forward in this paper yield a fruitful result.

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