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Enhancing Medical Diagnosis with Single Valued Neutrosophic Sets and Tan-log Distance

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Abstract

Most diseases share a mix of common and unique traits, with distinct symptoms appearing at the onset. This paper proposes a method to establish relationships between illness classes and individuals with specific pathologies, aiding physicians in plausible diagnoses. We introduce the tan-log distance among single valued neutrosophic sets and discuss its characteristics. This approach addresses uncertainties and shortcomings in current methods. The application of this method to medical diagnosis demonstrates its effectiveness in identifying illnesses. The previously mentioned approach's concept serves as a vital safeguard against uncertainties and shortcomings in the existing methods. To determine the sickness that a person is suffering, the application of medical diagnosis is discussed. The result of the diagnosis showed how effective the recommended course of action was.

Keywords: Neutrosophic set, Single valued neutrosophic set, Tan-log distance, Medical diagnosis.

1 | Introduction

In 1965, Fuzzy set theory was firstly given by Zadeh [1] which is applied in many real applications to handle uncertainty. Sometimes membership function itself is uncertain and hard to be defined by a crisp value. So the concept of interval valued fuzzy sets was proposed to capture the uncertainty of grade of membership. In 1986, Atanassov [2] introduced the intuitionistic fuzzy sets which consider both truth-membership and falsity-membership. Samuel and Narmadhagnanam [3] proposed the tangent inverse distance and sine similarity measure of intuitionistic fuzzy sets and apply them in medical diagnosis. Kozae et al. [4] applied intuitionistic fuzzy sets in corona covid-19 determination. Rajkalpana et al. [5] applied intuitionistic fuzzy set and its operators in medical diagnosis. Shinoj and John [6] extended the concept of fuzzy multi sets by introducing Intuitionistic Fuzzy Multi Sets (IFMS). Rajarajeswari and Uma [7], [8] proposed few methods

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among intuitionistic fuzzy multi sets. Samuel and Narmadhagnanam [9] proposed sine inverse distance of IFMS and apply them in medical diagnosis later on, intuitionistic fuzzy sets were extended to the interval valued intuitionistic fuzzy sets. Intuitionistic fuzzy sets and interval valued intuitionistic fuzzy sets can only handle incomplete information not the indeterminate information and inconsistent information which exists commonly in belief systems. So, Neutrosophic Set (NS) (generalization of fuzzy sets, intuitionistic fuzzy sets and so on) defined by Smarandache [10] has capability to deal with uncertainty, imprecise, incomplete and inconsistent information which exists in real world from philosophical point of view. In 1982, Pawlak [11] introduced the concept of Rough Set (RS), as a formal tool for modeling and processing incomplete information in information systems. There are two basic elements in RS theory, crisp set and equivalence relation, which constitute the mathematical basis of RSs. The basic idea of RS is based upon the approximation of sets by a pair of sets known as the lower approximation and the upper approximation of a set. Here, the lower and upper approximation operators are based on equivalence relation. Nanda and Majumdar [12] examined fuzzy RSs.

Broumi et al. [13] introduced rough NSs. Pramanik and Mondal [14], [15] introduced cosine and cotangent similarity measures of rough NSs. Pramanik et al. [16] introduced correlation coefficient of rough NSs. Samuel and Narmadhagnanam [17–20] proposed few methods among rough NSs and applied it in medical diagnosis. NS is applied to different areas including decision making by many researchers [21–27]. Mohana and Mohanasundari [28] proposed similarity measures of single valued neutrosophic RSs. Bera and Mahapatra [29] applied generalised single valued neutrosophic number in neutrosophic linear programming. Ulucay et al. [30] proposed a new approach for multi-attribute decision-making problems in bipolar NSs.

Wang et al. [31] proposed the single valued NS. Majumdar and Samanta [32] proposed the similarity and entropy of NSs. Ye [33] proposed the cotangent similarity measure of single valued NSs. Broumi et al. [34] proposed single valued (2N+1) sided polygonal neutrosophic numbers and single valued (2N) sided polygonal neutrosophic numbers. Li et al. [35] slope stability assessment method using the arctangent and tangent similarity measure of neutrosophic numbers. Samuel and Narmadhagnanam [36], [37] introduced cosine logarithmic distance and tangent inverse similarity measure among single valued NSs and applied it in medical diagnosis. Garg and Nancy [38] proposed new distance measure of single valued NSs. Chai et al. [39] proposed new similarity measures of single valued NSs. Narmadhagnanam and Samuel [40] introduced sine exponential measure among single valued NSs. Ye and Ye [41]introduced the concept of single valued neutrosophic multi sets. Samuel and Narmadhagnanam [42] introduced cosine exponential distance among single valued neutrosophic multi sets and applied it in medical diagnosis. In 2013, Smarandache [43] extended the classical neutrosophic logic to n-valued refined neutrosophic logic, by refining each neutrosophic component T,I,F into respectively, T1,T2,..,Tm,I1,I2,...,Ip and F1,F2,..,Fr. The concept of Neutrosophic Refined Sets (NRS) is a generalization of fuzzy multisets and IFMS. In 2014, Broumi and Smarandache [44] extended the improved cosine similarity of single valued NS proposed by Ye [45] to the case of NRS. Samuel and Narmadhagnanam [46–48] introduced few methods in NRS and applied it in medical diagnosis.

Zhao and Ye [49] proposed MCGDM approach using the weighted hyperbolic sine similarity measure of neutrosophic multivalued sets for the teaching quality assessment of teachers. Hemabala et al. [50] examined medical diagnosis via refined neutrosophic fuzzy logic. Wang et al. [51] introduced interval NSs. Uluçay [52] proposed some concepts on interval valued refined NSs Pourersmaeil et al. [53] generated a parametric scoring function and the associated method, which they implemented for multicriteria decision making. For interval NSs, Liu et al. [54] devised a similarity measure and used it in resource offloading for edge computing. Ye et al. [55] proposed correlation coefficients under interval and single valued neutrosophic environment. In decision making, Hema et al. [56] stated new approach on plithogenic interval vaued neutrosophic environment. Saqlain et al. [57] used neutrosophic linguistic valued hypersoft set for medical diagnosis and treatment. Broumi et al. [58] generalise the concept of n-valued NSs to the case of n-valued interval NSs. Samuel and Narmadhagnanam [59–62] introduced many methods in n-valued interval NSs and applied it in medical diagnosis. To address the problem of more reliable medical diagnosis, we propose a novel approach using single valued NSs strategy. Without a doubt, this approach is clear-cut and error-free.

The main part of the article is set up as follows. Section 2 deals with preliminaries.Section 3 discusses the Stated notion and some of its features. Sections 4-6 discuss the methodology, procedure and hypothetical example pertaining to medical diagnosis respectively. Significance statements are given in Section 7. A conclusion is given in Section 8.

2 | Preliminaries

Definition 1 ([63]). Let X be a universe of discourse, with a generic element in X denoted by x, the NS A is an object having the form

$$A = \{\langle x : T_A(x), I_A(x), F_A(x)\rangle, x \in X\},$$

where the functions define $T, I, F : X \to]^-0,1^+[$ respectively the degree of membership(or truth), the degree of indeterminacy and the degree of non-membership(or falsehood) ofthe element $x \in X$ to the set A with the condition

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

Definition 2 ([31]). Let X be a space of points (objects) with a generic element in X denoted by x. A single valued NS A in X is characterized by truth membership function T_A, indeterminacy function I_A and falsity membership function F_A. For each point x in X,

$$T_A(x), I_A(x), F_A(x) \in [0,1].$$

When X is continuous, a SVNS A can be written as

$$A = \int_x \langle T(x), I(x), F(x)\rangle / x, x \in X.$$

When X is discrete, a SVNS A can be written as

$$A = \sum_{i=1}^{n} \langle T(x_i), I(x_i), F(x_i)\rangle / x_i, x_i \in X.$$

2 | Stated Concept

2.1 | Tan-Log Distance

Let $G = \sum_{i=1}^{n} \frac{z_i}{\langle T_G(z_i), I_G(z_i), F_G(z_i)\rangle}$ and $H = \sum_{i=1}^{n} \frac{z_i}{\langle T_H(z_i), I_H(z_i), F_H(z_i)\rangle}$ be two single valued NSs in $Z = \{z_1, z_2, ..., z_n\}$ then the tan –log distance is defined as

$$TANLOG_{SVNS}(G,H) = 25n\sum_{i=1}^{n}\Big[\tan\big[\log[1 + |T_G(z_i) - T_H(z_i)| + |I_G(z_i) - I_H(z_i)| + |F_G(z_i) - F_H(z_i)|]\big]\Big]. \quad (1)$$

Example 1. Let G = [0.2,0.3,0.5] & H = [0.3,0.4,0.2] then

$$TANLOG_{SVNS}(G,H) = 0.0768.$$

Proposition 1.

I. $TANLOG_{SVNS}(G,H) > 0.$

II. $TANLOG_{SVNS}(G,H) = TANLOG_{SVNS}(H,G).$

III. If $G \subseteq H \subseteq J$ then $TANLOG_{SVNS}(G,J) \ge TANLOG_{SVNS}(G,H)$ & $TANLOG_{SVNS}(G,J) \ge TANLOG_{SVNS}(H,J).$

Proof:

I. For single-valued NSs, it is evident that the truth-membership function, indeterminacy-membership function and falsity-membership function are within [0,1]. Hence , $TANLOG_{SVNS}(G,H) > 0$.

II. We are aware of that,

$$\left|T_G(z_i) - T_H(z_i)\right| = \left|T_H(z_i) - T_G(z_i)\right|.$$
$$\left|I_G(z_i) - I_H(z_i)\right| = \left|I_H(z_i) - I_G(z_i)\right|.$$
$$\left|F_G(z_i) - F_H(z_i)\right| = \left|F_H(z_i) - F_G(z_i)\right|.$$

Hence, $TANLOG_{SVNS}(G,H) = TANLOG_{SVNS}(H,G)$.

III. We are aware of that,

$$T_G(z_i) \le T_H(z_i) \le T_J(z_i).$$
$$I_G(z_i) \ge I_H(z_i) \ge I_J(z_i).$$
$$F_G(z_i) \ge F_H(z_i) \ge F_J(z_i).$$
$$[\because G \subseteq H \subseteq J].$$

Hence,

$$\left|T_G(z_i) - T_H(z_i)\right| \le \left|T_G(z_i) - T_J(z_i)\right|.$$
$$\left|I_G(z_i) - I_H(z_i)\right| \le \left|I_G(z_i) - I_J(z_i)\right|.$$
$$\left|F_G(z_i) - F_H(z_i)\right| \le \left|F_G(z_i) - F_J(z_i)\right|.$$
$$\left|T_H(z_i) - T_J(z_i)\right| \le \left|T_G(z_i) - T_J(z_i)\right|.$$
$$\left|I_H(z_i) - I_J(z_i)\right| \le \left|I_G(z_i) - I_J(z_i)\right|.$$
$$\left|F_H(z_i) - F_J(z_i)\right| \le \left|F_G(z_i) - F_J(z_i)\right|.$$

Here, the tan –log distance is a rising function

$$\therefore\ TANLOG_{SVNS}(G,J) \ge TANLOG_{SVNS}(G,H)\ \ \&\ \ TANLOG_{SVNS}(G,J) \ge TANLOG_{SVNS}(H,J).$$

3 | Methodology

This section provided a clinical assessment. Make sure that S represents a class of sickness [Viral fever, malaria, stomach problem, chest problem], P represents a band that comprises individuals [Guhan, Karthi, Vel] with a certain pathology and F generates the collection of indicators [Temperature, Headache, Stomach pain, Chest pain]. Let M1 be a single valued neutrosophic relation from the class of sickness to the indications collection, and let M2 be a single valued neutrosophic relation from the indications collection to a band including individuals with a particular disease. The following are the main objectives of the calculation method:

I. Determining the indications.

II. Building scientific knowledge with single-valued NSs (iii). An assessment utilizing the recently created processing technique.

4 | Procedure

Step 1. *Table 1* lists a band that includes people with a specific pathology to the collection of indications M1.

Step 2. *Table 2* lists the collection of indications to the class of sickness M2.

Step 3. *Tables 1* and *2* yield the calculation M3 which is reported in *Table 3*. In every row, the number with the lowest value was chosen in order to determine the likelihood that a band that includes people with a specific pathology impacts by the class of sickness.

5 | Hypothetical Example

Table 1. Relation between a band that includes people with a specific pathology and the collection of indications.

M_1	Temperature	Headache	Stomach Pain	Chest Pain
Guhan	(0.7,0.0,0.0)	(0.1,0.1,0.5)	(0.3,0.1,0.3)	(0.7,0.0,0.0)
Karthi	(0.1,0.1,0.1)	(0.4,0.1,0.0)	(0.0,0.0,0.7)	(0.1,0.0,0.6)
Vel	(0.3,0.1,0.3)	(0.1,0.0,0.6)	(0.0,0.1,0.6)	(0.2,0.0,0.5)

Applying *Step 1*

Table 2. Relation between collection of indications and the class of sickness.

M_2	Viral Fever	Malaria	Stomach Problem	Chest Problem
Temperature	(0.1,0.0,0.7)	(0.8,0.0,0.2)	(0.5,0.1,0.1)	(0.1,0.2,0.3)
Head ache	(0.8,0.1,0.0)	(0.0,0.1,0.7)	(0.1,0.0,0.8)	(0.4,0.3,0.0)
Stomach pain	(0.0,0.0,0.7)	(0.7,0.0,0.0)	(0.3,0.1,0.3)	(0.0,0.2,0.3)
Chest pain	(0.0,0.0,0.7)	(0.8,0.0,0.2)	(0.0,0.1,0.7)	(0.1,0.2,0.5)

Applying *Step 2*

Table 3. Tan-log distance.

M_3	Viral Fever	Malaria	Stomach Problem	Chest Problem
Guhan	1.3100	0.7500	0.9000	1.1800
Karthi	0.8000	1.2900	0.9900	0.6600
Vel	0.9900	1.1000	0.7500	0.8800

Table 3 indicates that Guhan is suffering from malaria, Karthi is experiencing chest problem and Vel is experiencing stomach problem.

Applying *Step 3* (select the minimum value)

6 | Significance Statements

The study's findings will help us pinpoint the exact illness that affected the individuals who participated. The method employed is free of the limitations that are often found in other studies. Without these limitations, this study has led to the development of novel theories about pattern recognition, image processing, etc.

7 | Conclusion

This study has investigated the relationship between a band including individuals with a particular pathology and the signs and class of illness. One technique (tan-log distance) has been employed to ascertain which illness may have affected the individuals. The methods used in this study are reliable and trustworthy, which makes them appropriate for managing problems related to medical diagnostics with ease. Owing to its improved diagnostic precision, the approach could be able to circumvent the limitations and drawbacks of previous research.

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Conflict of Interest

The writers say they have no competing interests.

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