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Cosine Exponential Distance of Single valued neutrosophic multi sets in medical diagnosis

A.Edward Samuel *, R.Narmadhagnanam **
**(Ramanujan Research Centre, P.G. & Research Department of Mathematics, GAC(A),Kumbakonam,TN,India.*
*** (Ramanujan Research Centre, P.G. & Research Department of Mathematics, GAC(A), Kumbakonam, TN, India.*
Corresponding Auther : A.Edward Samuel

ABSTRACT
In this paper, cosine exponential distance among single valued neutrosophic multi sets is proposed and some of its properties are discussed herein. The concept of the above method is an essential tool for dealing with uncertainties and shortcomings that affect the existing methods. Implementation of medical diagnosis is presented to find out the disease impacting the patient.
Keywords - Single valued neutrosophic set, Single valued neutrosophic multi sets, cosine exponential distance, medical diagnosis.

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I. INTRODUCTION

A number of real life problems in engineering, medical sciences, social sciences, economics etc., involve imprecise data and their solution involves the use of mathematical principles based on uncertainty and imprecision. Such uncertainties are being dealt with the help of topics like probability theory, fuzzy set theory [15], rough set theory [8] etc., Healthcare industry has been trying to complement the services offered by conventional clinical decision making systems with the integration of fuzzy logic techniques in them. As it is not an easy task for a clinician to derive a fool proof diagnosis it is advantageous to automate few initial steps of diagnosis which would not require intervention from an expert doctor. Neutrosophic set which is a generalized set possesses all attributes necessary to encode medical knowledge base and capture medical inputs.

As medical diagnosis demands large amount of information processing, large portion of which is quantifiable, also intuitive thought process involve rapid unconscious data processing and combines available information by law of average, the whole process offers low intra and inter person consistency. So contradictions, inconsistency, indeterminacy and fuzziness should be accepted as unavoidable as it is integrated in the behavior of biological systems as well as in their characterization. To model an expert doctor it is imperative that it should not disallow uncertainty as it would be then inapt to capture fuzzy or incomplete knowledge that might lead to the danger of fallacies due to misplaced precision.

As medical diagnosis contains lots of uncertainties and increased volume of information available to physicians from new medical technologies, the process of classifying different set of symptoms under a single name of disease becomes difficult. In some practical situations, there is the possibility of each element having different truth membership, indeterminate and false membership functions. The unique feature of single valued neutrosophic multi set is that it contains multi truth membership, indeterminate and false membership. By taking one time inspection, there may be error in diagnosis. Hence, multi time inspection, by taking the samples of the same patient at different times gives the best diagnosis. So, single valued neutrosophic multi sets and their applications play a vital role in medical diagnosis.

In 1965, Fuzzy set theory was initially 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 membership grade. In 1982, Pawlak [2] introduced the concept of rough set, as a formal tool for modeling and processing incomplete information in information systems. In 1986, Atanassov [3] introduced the intuitionistic fuzzy sets which consider both truth-membership and falsity-membership. 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. Neutrosophic set (generalization of fuzzy sets, intuitionistic fuzzy sets and so on) defined by Florentin Smarandache [4] has capability to deal with uncertainty, imprecise, incomplete and inconsistent information which exists in real world from philosophical point of view. Wang et al[5] proposed the single valued neutrosophic set. Pinaki Majumdar and S.K. Samanta [6] proposed the similarity and entropy of neutrosophic sets. Jun Ye and Jing Fu [7] proposed the tangent similarity measure of single valued neutrosophic sets. Jun Ye [8] proposed the cotangent similarity measure of single valued neutrosophic sets. Shan Ye and Jun Ye [9] introduced the concept of single valued neutrosophic multi sets.

In this paper, by using the notion of single valued neutrosophic multi set, it was provided an exemplary for medical diagnosis. In order to make this a new method was executed.

Rest of the article was structured as follows. In Section 2, the basic definitions were briefly presented. Section 3 deals with proposed definitions and some of its properties. Sections 4, 5 & 6 contain methodology, algorithm and case study related to medical diagnosis respectively. Conclusion was given in Section 7.

II. PRELIMINARIES

2.1 Definition [5]

Let X be a space of points (objects) with a generic element in X denoted by x. A single valued neutrosophic set 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

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

2.2 Definition [9]

Let X be a nonempty set with generic elements in X denoted by x. A single valued neutrosophic multi sets(SVNM) A drawn from X is characterized by the three functions: count truth-membership of CT_A, count indeterminacy-membership of CI_A and count falsity-membership of CF_A such that

$CT_A(x): X \to R$, $CI_A(x): X \to R$,

$CF_A(x): X \to R$ for $x \in X$, where R is the set of all real number multi sets in the real unit interval [0,1]. Then a SVNM A is denoted by

$$A = \left\{ \left\langle x, (T_A^1(x), (T_A^2(x), \ldots T_A^q(x)), (I_A^1(x), (I_A^2(x), \ldots I_A^q(x)), \right. \right.$$
$$\left. \left. F_A^1(x), (F_A^2(x), \ldots F_A^q(x)) \right\rangle \right\}$$
$$/ x \in X$$

where the truth-membership sequence $((T_A^1(x), (T_A^2(x), \ldots T_A^q(x))$, the indeterminacy-membership sequence $((I_A^1(x), (I_A^2(x), \ldots I_A^q(x))$ and the falsity-membership sequence $((F_A^1(x), (F_A^2(x), \ldots F_A^q(x))$ may be in decreasing or increasing order, and the sum of $T_A^i(x),\ I_A^i(x),\ F_A^i(x) \in [0,1]$ satisfies the condition $0 \le \sup T_A^i(x) + \sup I_A^i(x) + \sup F_A^i(x) \le 3$ for $x \in X$ and $i = 1,2,\ldots,q$.

For convenience, a SVNM can be denoted by the simplified form:

$$A = \left\{ \left\langle x, T_A^i(x), I_A^i(x), F_A^i(x) \right\rangle \middle| x \in X, i = 1,2,\ldots,q \right\}$$

III. PROPOSED DEFINITION

3.1 Definition

Let $A = \left\{ \left\langle x_j, T_A^i(x_j), I_A^i(x_j), F_A^i(x_j) \right| x_j \in X, i = 1,2,\ldots,q \right\}$

and $B = \left\{ \left\langle x_j, T_B^i(x_j), I_B^i(x_j), F_B^i(x_j) \right| x_j \in X, i = 1,2,\ldots,q \right\}$

be any two SVNMs in $X = \{x_1, x_2, \ldots x_n\}$.

Then the cosine exponential distance is defined as

$$CED_{SVNMS}(A,B) = \frac{1}{3n-1} \sum_{i=1}^{q} \left[\sum_{j=1}^{n} \cos e^{-\left[\left| T_A^i(x_j) - T_B^i(x_j) \right| + \left| I_A^i(x_j) - I_B^i(x_j) \right| + \left| F_A^i(x_j) - F_B^i(x_j) \right| \right]} \right] \quad (1)$$

Proposition 1

(i) $CED_{SVNMS}(A,B) > 0$

(ii) $CED_{SVNMS}(A,B) = CED_{SVNMS}(B,A)$

If $A \subseteq B \subseteq C$ then

$CED_{SVNMS}(A,C) \ge CED_{SVNMS}(A,B)$ &

$CED_{SVNMS}(A,C) \ge CED_{SVNMS}(B,C)$

Proof

(i) The proof is straightforward

(ii) We know that,

$$\left| T_A^i(x_j) - T_B^i(x_j) \right| = \left| T_B^i(x_j) - T_A^i(x_j) \right|$$
$$\left| I_A^i(x_j) - I_B^i(x_j) \right| = \left| I_B^i(x_j) - I_A^i(x_j) \right|$$
$$\left| F_A^i(x_j) - F_B^i(x_j) \right| = \left| F_B^i(x_j) - F_A^i(x_j) \right|$$

$\therefore CED_{SVNMS}(A,B) = CED_{SVNMS}(B,A)$

(iii)We know that,

$$T_A^i(x_j) \le T_B^i(x_j) \le T_C^i(x_j)$$
$$I_A^i(x_j) \ge I_B^i(x_j) \ge I_C^i(x_j)$$
$$F_A^i(x_j) \ge F_B^i(x_j) \ge F_C^i(x_j)$$
$$(\because A \subseteq B \subseteq C)$$

Hence,

$$\left|T_A^i(x_j) - T_B^i(x_j)\right| \le \left|T_A^i(x_j) - T_C^i(x_j)\right|$$
$$\left|T_B^i(x_j) - T_C^i(x_j)\right| \le \left|T_A^i(x_j) - T_C^i(x_j)\right|$$
$$\left|I_A^i(x_j) - I_B^i(x_j)\right| \le \left|I_A^i(x_j) - I_C^i(x_j)\right|$$
$$\left|I_B^i(x_j) - I_C^i(x_j)\right| \le \left|I_A^i(x_j) - I_C^i(x_j)\right|$$
$$\left|F_A^i(x_j) - F_B^i(x_j)\right| \le \left|F_A^i(x_j) - F_C^i(x_j)\right|$$
$$\left|F_B^i(x_j) - F_C^i(x_j)\right| \le \left|F_A^i(x_j) - F_C^i(x_j)\right|$$

Here, our cosine exponential distance is an increasing function

$\therefore$ $CED_{SVNMS}(A,C) \ge CED_{SVNMS}(A,B)$ & $CED_{SVNMS}(A,C) \ge CED_{SVNMS}(B,C)$

IV. METHODOLOGY

In this section, we present an application of single valued neutrosophic multi set in medical diagnosis. In a given pathology, suppose S is a set of symptoms, D is a set of diseases and P is a set of patients and let Q be a single valued neutrosophic multi relation from the set of patients to the symptoms. i.e., $Q(P \to S)$ and R be a single valued neutrosophic relation from the set of symptoms to the diseases i.e., $R(S \to D)$ and then the methodology involves three main jobs:

1. Determination of symptoms
2. Formulation of medical knowledge based on single valued neutrosophic multi sets & single valued neutrosophic sets
3. Determination of diagnosis on the basis of new computation technique of single valued neutrosophic multi sets

V. ALGORITHM

Step 1: The Symptoms of the patients are given to obtain the patient-symptom relation Q and are noted in Table 1

Step 2: The medical knowledge relating the symptoms with the set of diseases under consideration are given to obtain the symptom-disease relation R and are noted in Table 2.

Step3: The computation T of the relation of patients and diseases is found using (1) and are noted in Table 3.

Step 4: Finally, minimum value from Table 3 of each row were selected to find the possibility of the patient affected with the respective disease and then it was concluded that the patient $P_k\,(k = 1,2,3\ \&\ 4)$ was suffering from the disease $D_r\,(r = 1,2,3\ \&\ 4)$.

VI. CASE STUDY [9]

Let there be four patients $P = \{P_1, P_2, P_3, P_4\}$ and the set of symptoms S ={Temperature, Cough, Throat pain, Headache, Body pain }.The Single valued neutrosophic multi relation $Q(P \to S)$ is given as in Table 1.Let the set of diseases D = {Viral fever, Tuberculosis, Typhoid, Throat disease}.The Single valued neutrosophic relation $R(S \to D)$ is given as in Table 2.

Table 1: Patient-Symptom relation

Q	Temperature	Cough	Throat pain	Headache	Body pain
P_1	(0.8,0.6,0.5) (0.3,0.2,0.1) (0.4,0.2,0.1)	(0.5,0.4,0.3) (0.4,0.4,0.3) (0.6,0.3,0.4)	(0.2,0.1,0.0) (0.3,0.2,0.2) (0.8,0.7,0.7)	(0.7,0.6,0.5) (0.3,0.2,0.1) (0.4,0.3,0.2)	(0.4,0.3,0.2) (0.6,0.5,0.5) (0.6,0.4,0.4)
P_2	(0.5,0.4,0.3) (0.3,0.3,0.2) (0.5,0.4,0.4)	(0.9,0.8,0.7) (0.2,0.1,0.1) (0.2,0.1,0.0)	(0.6,0.5,0.4) (0.3,0.2,0.2) (0.4,0.3,0.3)	(0.6,0.4,0.3) (0.4,0.1,0.1) (0.7,0.7,0.3)	(0.8,0.7,0.5) (0.4,0.3,0.1) (0.7,0.2,0.1)
P_3	(0.2,0.1,0.1) (0.3,0.2,0.2) (0.8,0.7,0.6)	(0.3,0.2,0.2) (0.4,0.2,0.2) (0.7,0.6,0.5)	(0.8,0.8,0.7) (0.2,0.2,0.2) (0.1,0.1,0.0)	(0.3,0.2,0.2) (0.3,0.3,0.3) (0.7,0.6,0.6)	(0.4,0.4,0.3) (0.4,0.3,0.2) (0.7,0.7,0.5)
P_4	(0.5,0.5,0.4) (0.3,0.2,0.2) (0.4,0.4,0.3)	(0.4,0.3,0.1) (0.8,0.3,0.1) (0.7,0.5,0.3)	(0.7,0.1,0.0) (0.7,0.2,0.3) (0.7,0.7,0.6)	(0.6,0.5,0.3) (0.6,0.2,0.1) (0.6,0.4,0.3)	(0.5,0.1,0.1) (0.3,0.3,0.2) (0.6,0.5,0.4)

Table 2: Symptom-Disease relation

R	Viral fever	Tuberculosis	Typhoid	Throat disease
Temperature	(0.8,0.1,0.1)	(0.2,0.7,0.1)	(0.5,0.3,0.2)	(0.1,0.7,0.2)
Headache	(0.2,0.7,0.1)	(0.9,0.0,0.1)	(0.3,0.5,0.2)	(0.3,0.6,0.1)
Stomach pain	(0.3,0.5,0.2)	(0.7,0.2,0.1)	(0.2,0.7,0.1)	(0.8,0.1,0.1)
Cough	(0.5,0.3,0.2)	(0.6,0.3,0.1)	(0.2,0.6,0.2)	(0.1,0.8,0.1)
Chest pain	(0.5,0.4,0.1)	(0.7,0.2,0.1)	(0.4,0.4,0.2)	(0.1,0.8,0.1)

Table 3: Cosine exponential distance

T	Viral fever	Tuberculosis	Typhoid	Throat disease
P_1	0.9059	0.9376	**0.8845**	0.9766
P_2	**0.8975**	0.9225	0.9016	0.9750
P_3	0.9161	0.9507	**0.8850**	0.9770
P_4	0.9145	**0.8693**	0.8873	0.9470

From Table 3, it is obvious that, if the doctor agrees, then both P_1 & P_3 is suffering from Typhoid, P_2 is suffering from Viral fever and P_4 is suffering from Tuberculosis.

VII. CONCLUSION

Our propounded technique is most reliable to handle medical diagnosis problems quiet comfortably. The recommended method can invade in other areas such as clustering, image processing etc., In future, we will enhance this method to other types of neutrosophic sets

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