International Journal of Engineering, Science and Mathematics
Vol. 7,Issue6,June 2018,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

COSINE LOGARITHMIC DISTANCE OF SINGLEVALUED NEUTROSOPHIC SETS IN MEDICAL DIAGNOSIS

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Abstract (10pt)

In this paper, Cosine logarithmic distance among single valued neutrosophic sets is proposed and some of its properties are discussed herein. Finally, an application of medical diagnosis is presented to find out the disease impacting the patient.

Keywords:

Neutrosophic set,
Single valued neutrosophic set,
Cosine logarithmic distance,
Medical diagnosis.

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1 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.Suchuncertainties are being dealt with the help of topics like probability theory,fuzzy set theory[9],rough set theory [6] 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. Neutrosophicset 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

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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.So, single valued neutrosophic sets and their applications play a vital role in medical diagnosis.

In 1965, Fuzzy set theory was initially given by Zadeh[9] 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 uncertaintyof membershipgrade. In 1982, Pawlak[6]introduced the concept of rough set, as a formal tool for modeling and processing incomplete information in information systems. In 1986, Atanassov[5] 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 FlorentinSmarandache[1] has capability to deal with uncertainty, imprecise, incomplete and inconsistent information which exists in real world from philosophical point of view.Wang *et al*[2] proposed the single valued neutrosophic set.PinakiMajumdar and S.K.Samanta [7]proposed the similarity and entropy of neutrosophic sets. Jun Ye[4] proposed the cotangent similarity measure of single valued neutrosophic sets.

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

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

2 Preliminaries

2.2 Definition[8]

Let X be a Universe of discourse,with a generic element in X denoted by x, the neutrosophicset(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

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

2.2 Definition[2]

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

3 Proposed definition

3.1 Definition

Let $A = \sum_{i=1}^{n} \frac{x_i}{\langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle}$ and $B = \sum_{i=1}^{n} \frac{x_i}{\langle T_B(x_i), I_B(x_i), F_B(x_i) \rangle}$ be two single valued neutrosophic sets in $X = \{x_1, x_2, \ldots, x_n\}$, then the cosine logarithmic distance is defined as

$$CLD_{SVNS}(A,B) = \sum_{i=1}^{n} \left[1 - \cos\left[\log 1 + |T_A(x_i) - T_B(x_i)| + |I_A(x_i) - I_B(x_i)| + |F_A(x_i) - F_B(x_i)|\right]\right] \quad (1)$$

Proposition 1

(i) $CLD_{SVNS}(A,B) \geq 0$

(ii) $CLD_{SVNS}(A,B) = 0$ if and only if $A = B$

(iii) $CLD_{SVNS}(A,B) = CLD_{SVNS}(B,A)$

(iv) If $A \subseteq B \subseteq C$ then $CLD_{SVNS}(A,C) \geq CLD_{SVNS}(A,B)$ & $CLD_{SVNS}(A,C) \geq CLD_{SVNS}(B,C)$

Proof

(i) The proof is straightforward

(ii) The proof is straightforward

(iii) We know that,

$$|T_A(x_i) - T_B(x_i)| = |T_B(x_i) - T_A(x_i)|$$
$$|I_A(x_i) - I_B(x_i)| = |I_B(x_i) - I_A(x_i)|$$
$$|F_A(x_i) - F_B(x_i)| = |F_B(x_i) - F_A(x_i)|$$
$$\therefore CLD_{SVNS}(A,B) = CLD_{SVNS}(B,A)$$

(iv) We know that,

$$T_A(x_i) \leq T_B(x_i) \leq T_C(x_i)$$
$$I_A(x_i) \geq I_B(x_i) \geq I_C(x_i)$$
$$F_A(x_i) \geq F_B(x_i) \geq F_C(x_i)$$
$$(\because A \subseteq B \subseteq C).$$

Hence,

$$|T_A(x_i)-T_B(x_i)| \le |T_A(x_i)-T_C(x_i)|$$
$$|I_A(x_i)-I_B(x_i)| \le |I_A(x_i)-I_C(x_i)|$$
$$|F_A(x_i)-F_B(x_i)| \le |F_A(x_i)-F_C(x_i)|$$
$$|T_B(x_i)-T_C(x_i)| \le |T_A(x_i)-T_C(x_i)|$$
$$|I_B(x_i)-I_C(x_i)| \le |I_A(x_i)-I_C(x_i)|$$
$$|F_B(x_i)-F_C(x_i)| \le |F_A(x_i)-F_C(x_i)|$$

Here, the cosine logarithmic distance is an increasing function

$\therefore\ CLD_{SVNS}(A,C) \ge CLD_{SVNS}(A,B)$ & $CLD_{SVNS}(A,C) \ge CLD_{SVNS}(B,C)$

4 Methodology

In this section, we present an application of single valuedneutrosophic 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 valuedneutrosophic relation from the set of patients to the symptoms.i.e., $Q(P \rightarrow S)$ and R be a single valuedneutrosophic relation from the set of symptoms to the diseases i.e.,$R(S \rightarrow D)$and then the methodology involves three main jobs:

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

5. 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.

Step 3 : The Computation *T* of the relation of patients and diseases is found using (1) between Table 1 & Table 2 and are noted in Table 3

Step 4: Finally, we select the minimum value from Table 3 of each row for possibility of the patient affected with the respective disease and then we conclude that the patient P_k is suffering from the disease D_r.

6 Case study[3]

Let there be three patients P=(Ali,Hamza,Imran) and the set of symptoms S={Temperature,Insulin, Blood Pressure, Blood Platelets, Cough}.The Single valued neutrosophic relation $Q(P \rightarrow S)$ is given as in Table 1.Let the set of diseases D = {Diabetes, Dengue, Tuberculosis}.The Single valued neutrosophic relation$R(S \rightarrow D)$ is given as in Table 2.

Table 1:Patient-Symptom relation

Q	Temperature	Insulin	Blood Pressure	Blood Platelets	Cough
Ali	(0.8,0.1,0.1)	(0.2,0.2,0.6)	(0.4,0.2,0.4)	(0.8,0.1,0.1)	(0.3,0.3,0.4)
Hamza	(0.6,0.2,0.2)	(0.9,0.0,0.1)	(0.1,0.1,0.8)	(0.2,0.1,0.7)	(0.5,0.1,0.4)
Imran	(0.4,0.2,0.4)	(0.2,0.1,0.7)	(0.1,0.2,0.7)	(0.3,0.1,0.6)	(0.8,0.0,0.2)

Table 2:Symptom-Disease relation

R	Diabetes	Dengue	Tuberculosis
Temperature	(0.2,0.0,0.8)	(0.9,0.0,0.1)	(0.6,0.2,0.2)
Insulin	(0.9,0.0,0.1)	(0.0,0.2,0.8)	(0.0,0.1,0.9)
Blood Pressure	(0.1,0.1,0.8)	(0.8,0.1,0.1)	(0.4,0.2,0.4)
Blood Platelets	(0.1,0.1,0.8)	(0.9,0.0,0.1)	(0.0,0.2,0.8)
Cough	(0.1,0.1,0.8)	(0.1,0.1,0.8)	(0.9,0.0,0.1)

Table 3:Cosine logarithmic distance

T	Diabetes	Dengue	Tuberculosis
Ali	0.2790	**0.0816**	0.1741
Hamza	**0.0935**	0.2942	0.1737
Imran	0.1889	0.2563	**0.0657**

From Table 3, it is obvious that, if the doctor agrees, then Ali is suffering from Dengue, Hamzais suffering from Diabetes and Imran is suffering from Tuberculosis.

7 Conclusion

In this paper, it was analyzed the relationship between the set of symptoms found with the patients and the set of diseases and employed new method (cosine logarithmic distance) to find out the disease possibly affected the patient. The technique considered in this study was more reliable to handle medical diagnosis problems quiet comfortably.

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