Correlation Measure for Neutrosophic Refined Sets and its application in Medical Diagnosis

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Abstract

In this paper, the correlation measure of neutrosophic refined(multi-) sets is proposed. The concept of this correlation measure of neutrosophic refined sets is the extension of correlation measure of neutrosophic sets and intuitionistic fuzzy multi sets. Finally, using the correlation of neutrosophic refined set measure, the application of medical diagnosis and pattern recognition are presented.

Keyword 0.1 *Neutrosophic sets, neutrosophic refined sets, correlation measure, decision making.*

1 Introduction

Recently, several theories have been proposed to deal with uncertainty, imprecision and vagueness. Probability set theory, fuzzy set theory[56], intuitionistic fuzzy set theory[8], interval intuitionistic fuzzy set theory[7] etc. are consistently being utilized as efficient tools for dealing with diverse types of uncertainties and imprecision embedded in a system. But, all these above theories failed to deal with indeterminate and inconsistent information which exist in beliefs system. In 1995, inspired from the sport games (wining/tie/defeating), from votes (yes/ NA/ no), from decision making (making a decision/ hesitating/not making) etc. and guided by the fact that the law of excluded middle did not work any longer in the modern logics, F. Smarandache[43] developed a new concept called neutrosophic set (NS) which generalizes fuzzy sets and intuitionistic fuzzy sets. NS can be described by membership degree, indeterminate degree and non-membership degree. After that, Wang et al. [50] introduced an instance of neutrosophic sets known as single valued neutrosophic sets (SVNS), which were motivated from the practical point of view and that can be used in real scientific and engineering application, and provide the set theoretic operators and various properties of SVNSs. This theory and their hybrid structures have proven useful in many different fields such as control theory[1], databases[4, 5], medical diagnosis problem[2], decision making problem [20, 31, 33, 55], physics[37], topology [32], etc. The works on neutrosophic set, in theories and applications, have been progressing rapidly (e.g. [3, 6, 12, 16, 17, 22, 52, 53]).

Combining neutrosophic set models with other mathematical models has attracted the attention of many researchers. Maji et al. [34] presented the concept of neutrosophic soft sets which is based on a combination of the neutrosophic set and soft set [35] models. Broumi and Smarandache [9, 13] introduced the concept of the intuitionistic neutrosophic soft set by combining the intuitionistic neutrosophic sets and soft sets. Broumi et al. presented the concept of rough neutrosophic set[18] which is based on a combination of neutrosophic sets and rough set models. The works on neutrosophic sets combining with soft sets, in theories and applications, have been progressing rapidly (e.g. [10, 14, 15, 24, 25, 26, 27]).

The multiset theory was formulated first in [51] by Yager as generalization of the concept of set theory and then the multiset was developed in [19] by Calude et al. Several authors from time to time made a number of generalizations of the multiset theory. For example, Sebastian and Ramakrishnan [46, 47] introduced a new notion called multi fuzzy sets which is a generalization of the multiset. Since then, several researchers [36, 45, 49] discussed more properties on multi fuzzy set. And they [28, 48] made an extension of the concept of fuzzy multisets to an intuitionstic fuzzy set which was called intuitionstic fuzzy multisets (IFMS). Since then in the study on IFMS, a lot of excellent results have been achieved by researchers [21, 38, 39, 40, 41, 42]. An element of a multi fuzzy set can occur more than once with possibly the same or different membership values whereas an element of intuitionistic fuzzy multiset allows the repeated occurrences of membership and non membership values. The concepts of FMS and IFMS fail to deal with indeterminacy. In 2013 Smarandache [44] extended the classical neutrosophic logic to n-valued refined neutrosophic logic, by refining each neutrosophic component T, I, F into respectively T_1, T_2, ..., T_m and I_1, I_2, ..., I_p, and F_1, F_2, ..., F_r. Recently, Deli et al.[23] used the concept of neutrosophic refined sets and studied some of their basic properties. The concept of neutrosophic refined set (NRS) is a generalization of fuzzy multisets and intuitionistic fuzzy multisets.

Rajarajeswari and Uma [42] put forward the correlation measure for IFMS. Recently, Broumi and Smarandache defined the Hausdorff distance between neutrosophic sets and some similarity measures based on the distance such as; set theoretic approach and matching function to calculate the similarity degree between neutrosophic sets. In the same year, Broumi and Smarandache [11] also proposed the correlation coefficient between interval neutrosphic sets. In other research, Ye [54] proposed three vector similarity measure for SNSs, an instance of SVNS and INS, including the Jaccard, Dice, and cosine similarity measures for SVNS and INSs, and applied them to multicriteria decision-making problems with simplified neutrosophic information. Hanafy et al. [29] proposed the correlation coefficients of neutrosophic sets and studied some of their basic propperties. Based on centroid method, Hanafy et al. [30], introduced and studied the concepts of correlation and correlation coefficient of neutrosophic sets and studied some of their properties.

The purpose of this paper is an attempt to extend the correlation measure of neutrosophic sets to neutrosophic refined sets (NRS). This paper is arranged in the following manner. In section 2, we present some definitions and notion about neutrosophic set and neutrosophic refined (multi-) set theory which help us in later section. In section 3, we study the concept of correlation measure of neutrosophic refined set. In section 4, we present an application of correlation measure of neutrosophic refined set to medical diagnosis problem. Finally, we conclude the paper.

2 PRELIMINARIES

In this section, we present the basic definitions and results of neutrosophic set theory [43, 50], neutrosophic refined (multi-) set theory [23] and correlation measure of intuitionistic fuzzy multisets [41] that are useful for subsequent discussions. See especially [2, 3, 4, 5, 6, 12, 20, 23, 24, 31, 32, 37] for further details and background.

Definition 2.1 *[8] Let E be a universe. An intuitionistic fuzzy set I on E can be defined as follows:*

$$I = \{< x, \mu_I(x), \gamma_I(x) >: \; x \in E\}$$

where, $\mu_I : E \to [0,1]$ and $\gamma_I : E \to [0,1]$ such that $0 \le \mu_I(x) + \gamma_I(x) \le 1$ for any $x \in E$.

Here, $\mu_I(x)$ and $\gamma_I(x)$ is the degree of membership and degree of non-membership of the element x, respectively.

Definition 2.2 *[38] Let E be a universe. An intuitionistic fuzzy multiset K on E can be defined as follows:*

$$K = \{< x, (\mu_K^1(x), \mu_K^2(x), ..., \mu_K^P(x)), (\gamma_K^1(x), \gamma_K^2(x), ..., \gamma_K^P(x)) >: \; x \in E\}$$

where, $\mu_K^1(x), \mu_K^2(x), ..., \mu_K^P(x) : E \to [0,1]$ and $\gamma_K^1(x), \gamma_K^2(x), ..., \gamma_K^P(x) : E \to [0,1]$ such that $0 \le \mu_K^i(x) + \gamma_K^i(x) \le 1 (i = 1, 2, ..., P)$ and $\mu_K^1(x) \le \mu_K^2(x) \le ... \le \mu_K^P(x)$ for any $x \in E$.

Here, $(\mu_K^1(x), \mu_K^2(x), ..., \mu_K^P(x))$ and $(\gamma_K^1(x), \gamma_K^2(x), ..., \gamma_K^P(x))$ is the membership sequence and non-membership sequence of the element x, respectively.

We arrange the membership sequence in decreasing order but the corresponding non membership sequence may not be in decreasing or increasing order.

Definition 2.3 *[42] Let E be a universe and $K = \{< x, (\mu_K^1(x), \mu_K^2(x), ..., \mu_K^P(x)), (\gamma_K^1(x), \gamma_K^2(x), ..., \gamma_K^P(x)) >: x \in E\}$, $L = \{< x, (\mu_L^1(x), \mu_L^2(x), ..., \mu_L^P(x)), (\gamma_L^1(x), \gamma_L^2(x), ..., \gamma_L^P(x)) >: \; x \in E\}$ be two intuitionistic fuzzy* *multisets consisting of the membership and non membership functions, then the correlation co efficient of K and L defined as follows:*

$$\rho_{IFMS}(K,L)=\frac{C_{IFMS}(K,L)}{\sqrt{C_{IFMS}(K,K)*C_{IFMS}(L,L)}}$$

where

$$C_{IFMS}(K,L)=\sum_{j=1}^{P}(\sum_{i=1}^{n}(\mu_K^j(x_i)\mu_L^j(x_i)+\gamma_K^j(x_i)\gamma_L^j(x_i)))$$

,

$$C_{IFMS}(K,K)=\sum_{j=1}^{P}(\sum_{i=1}^{n}(\mu_K^j(x_i)\mu_K^j(x_i)+\gamma_K^j(x_i)\gamma_K^j(x_i)))$$

and

$$C_{IFMS}(L,L)=\sum_{j=1}^{P}(\sum_{i=1}^{n}(\mu_L^j(x_i)\mu_L^j(x_i)+\gamma_L^j(x_i)\gamma_L^j(x_i)))$$

Expresses the so-called informational energy of neutrosophic sets A and B.

Definition 2.4 *[43] Let U be a space of points (objects), with a generic element in U denoted by u. A neutrosophic set(N-set) A in U is characterized by a truth-membership function T_A, a indeterminacy-membership function I_A and a falsity-membership function F_A. $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of* $]^{-}0,1^{+}[$.

It can be written as

$$A=\{<x,(T_A(x),I_A(x),F_A(x))>:x\in U,\,T_A(u),I_A(x),F_A(x)\subseteq[0,1]\}.$$

There is no restriction on the sum of $T_A(u)$; $I_A(u)$ and $F_A(u)$, so $^{-}0\leq supT_A(u)+supI_A(u)+supF_A(u)\leq 3^{+}$.

Here, 1^{+}= $1+\varepsilon$, where 1 is its standard part and ε its non-standard part. Similarly, $^{-}0$= *$1+\varepsilon$, where 0 is its standard part and ε its non-standard part.*

For application in real scientific and engineering areas,Wang et al.[50] proposed the concept of an SVNS, which is an instance of neutrosophic set. In the following, we introduce the definition of SVNS.

Definition 2.5 *[50] Let U be a space of points (objects), with a generic element in U denoted by u. An SVNS A inX is characterized by a truth-membership function $T_A(x)$, a indeterminacy-membership function $I_A(x)$ and a falsity-membership function $F_A(x)$, where $T_A(x)$, $I_A(x)$, and $F_A(x)$ belongs to [0,1] for each point u in U. Then, an SVNS A can be expressed as*

$$A=\{<u,(T_A(x),I_A(x),F_A(x))>:x\in E,\,T_A(x),I_A(x),F_A(x)\in[0,1]\}.$$

There is no restriction on the sum of $T_A(x)$; $I_A(x)$ and $F_A(x)$, so $0\leq supT_A(x)+supI_A(x)+supF_A(x)\leq 3$.

Definition 2.6 *[23] Let E be a universe. A neutrosophic refined (multi-) set(NRs) A on E can be defined as follows:*

$$A\ =\{<x,(T_A^1(x),T_A^2(x),...,T_A^P(x)),(I_A^1(x),I_A^2(x),...,I_A^P(x)),(F_A^1(x),F_A^2(x),...,F_A^P(x))>:\ x\in E\}$$

where,

$$T_A^1(x),T_A^2(x),...,T_A^P(x):E\to[0,1],$$
$$I_A^1(x),I_A^2(x),...,I_A^P(x):E\to[0,1],$$

and

$$F_A^1(x),F_A^2(x),...,F_A^P(x):E\to[0,1]$$

such that

$$0 \le supT_A^i(x) + supI_A^i(x) + supF_A^i(x) \le 3$$

$(i = 1, 2, ..., P)$ and

$$T_A^1(x) \le T_A^2(x) \le ... \le T_A^P(x)$$

for any $x \in E$.

$(T_A^1(x), T_A^2(x), ..., T_A^P(x))$, $(I_A^1(x), I_A^2(x), ..., I_A^P(x))$ and $(F_A^1(x), F_A^2(x), ..., F_A^P(x))$ is the truth-membership sequence, indeterminacy-membership sequence and falsity-membership sequence of the element x, respectively. Also, P is called the dimension(cardinality) of Nms A, denoted $d(A)$. We arrange the truth-membership sequence in decreasing order but the corresponding indeterminacy-membership and falsity-membership sequence may not be in decreasing or increasing order.

The set of all Neutrosophic neutrosophic (multi-)sets on E is denoted by NRS(E).

Definition 2.7 *[23] Let $A, B \in NRS(E)$. Then,*

1. *A is said to be Nm-subset of B is denoted by $A\tilde{\subseteq}B$ if $T_A^i(x) \le T_B^i(x)$, $I_A^i(x) \ge I_B^i(x)$,$F_A^i(x) \ge F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.*
2. *A is said to be neutrosophic equal of B is denoted by $A = B$ if $T_A^i(x) = T_B^i(x)$, $I_A^i(x) = I_B^i(x)$,$F_A^i(x) = F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.*
3. *The complement of A denoted by $A^{\tilde{c}}$ and is defined by*

   $$A^{\tilde{c}} = \{< x, (F_A^1(x), F_A^2(x), ..., F_A^P(x)), (I_A^1(x), I_A^2(x), ..., I_A^P(x)), (T_A^1(x), T_A^2(x), ..., T_A^P(x)) >: x \in E\}$$

4. *If $T_A^i(x) = 0$ and $I_A^i(x) = F_A^i(x) = 1$ for all $x \in E$ and $i = 1, 2, ..., P$ then A is called null* ns-set *and denoted by $\tilde{\Phi}$.*
5. *If $T_A^i(x) = 1$ and $I_A^i(x) = F_A^i(x) = 0$ for all $x \in E$ and $i = 1, 2, ..., P$, then A is called universal* ns-set *and denoted by $\tilde{E}$.*

Definition 2.8 *[23] Let $A, B \in NRS(E)$. Then,*

1. *The union of A and B is denoted by $A\tilde{\cup}B = C$ and is defined by*

   $$C = \{< x, (T_C^1(x), T_C^2(x), ..., T_C^P(x)), (I_C^1(x), I_C^2(x), ..., I_C^P(x)), (F_C^1(x), F_C^2(x), ..., F_C^P(x)) >: x \in E\}$$

   where $T_C^i = T_A^i(x) \vee T_B^i(x)$, $I_C^i = I_A^i(x) \wedge I_B^i(x)$,$F_C^i = F_A^i(x) \wedge F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.
2. *The intersection of A and B is denoted by $A\tilde{\cap}B = D$ and is defined by*

   $$D = \{< x, (T_D^1(x), T_D^2(x), ..., T_D^P(x)), (I_D^1(x), I_D^2(x), ..., I_D^P(x)), (F_D^1(x), F_D^2(x), ..., F_D^P(x)) >: x \in E\}$$

   where $T_D^i = T_A^i(x) \wedge T_B^i(x)$, $I_D^i = I_A^i(x) \vee I_B^i(x)$,$F_D^i = F_A^i(x) \vee F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.
3. *The addition of A and B is denoted by $A\tilde{+}B = E_1$ and is defined by*

   $$E_1 = \{< x, (T_{E_1}^1(x), T_{E_1}^2(x), ..., T_{E_1}^P(x)), (I_{E_1}^1(x), I_{E_1}^2(x), ..., I_{E_1}^P(x)), (F_{E_1}^1(x), F_{E_1}^2(x), ..., F_{E_1}^P(x)) >: x \in E\}$$

   where $T_{E_1}^i = T_A^i(x) + T_B^i(x) - T_A^i(x).T_B^i(x)$, $I_{E_1}^i = I_A^i(x).I_B^i(x)$,$F_{E_1}^i = F_A^i(x).F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.
4. *The multiplication of A and B is denoted by $A\tilde{\times}B = E_2$ and is defined by*

   $$E_2 = \{< x, (T_{E_2}^1(x), T_{E_2}^2(x), ..., T_{E_2}^P(x)), (I_{E_2}^1(x), I_{E_2}^2(x), ..., I_{E_2}^P(x)), (F_{E_2}^1(x), F_{E_2}^2(x), ..., F_{E_2}^P(x)) >: x \in E\}$$

   where $T_{E_2}^i = T_A^i(x).T_B^i(x)$, $I_{E_2}^i = I_A^i(x) + I_B^i(x) - I_A^i(x).I_B^i(x)$,$F_{E_2}^i = F_A^i(x) + F_B^i(x) - F_A^i(x).F_B^i(x)$, $\forall x \in E$ and $i = 1, 2, ..., P$.

Here $\vee$, $\wedge$, $+$, $.$, $-$ denotes maximum, minimum, addition, multiplication, subtraction of real numbers respectively.

3 Correlation Measure of two Neutrosophic refined sets

In this section, we give correlation measure of two neutrosophic refined sets. Some of it is quoted from [29, 30, 41, 42, 55].

Following the correlation measure of two intuitionistic fuzzy multisets defined by Rajarajeswari and Uma in [42]. In this section, we extend these measures to neutrosophic refined sets.

Definition 3.1 *Let $X = \{x_1, x_2, x_3, ...x_n\}$ be the finite universe of discourse and $A = \{< T_A^j(x_i), I_A^j(x_i), F_A^j(x_i) > |x_i \in X\}$, $B = \left\{< T_B^j(x_i), I_B^j(x_i), F_B^j(x_i) > |x_i \in X\right\}$ be two neutrosophic refined sets consisting of the membership, indeterminate and non-membership functions. Then the correlation coefficient of A and B*

$$\rho_{NRS}(A,B) = \frac{C_{NRS}(A,B)}{\sqrt{C_{NRS}(A,A) * C_{NRS}(B,B)}}$$

where

$$C_{NRS}(A,B) = \frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_B^j(x_i) + I_A^j(x_i)I_B^j(x_i) + F_A^j(x_i)F_B^j(x_i)\right\},$$

$$C_{NRS}(A,A) = \frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_A^j(x_i) + I_A^j(x_i)I_A^j(x_i) + F_A^j(x_i)F_A^j(x_i)\right\}$$

and

$$C_{NRS}(B,B) = \frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_B^j(x_i)T_B^j(x_i) + I_B^j(x_i)I_B^j(x_i) + F_B^j(x_i)F_B^j(x_i)\right\}$$

Proposition 3.2 *The defined correlation measure between NRS A and NRS B satisfies the following properties*

1. *$0 \leq \rho_{NRS}(A,B) \leq 1$*
2. *ρ_{NRS}(A,B) =1 if and only if A =B*
3. *ρ_{NRS}(A,B) =ρ_{NRS}(B,A).*

Proof

1. $0 \leq \rho_{NRS(A,B)}(A,B) \leq 1$

   As the membership, indeterminate and non-membership functions of the NRS lies between 0 and 1, $\rho_{NRS}(A,B)$ also leis between 0 and

2. ρ_{NRS}(A,B) =1 if and only if A =B

   (a) Let the two NRS A and B be equal (i.e A= B). Hence for any

   $$T_A^j(x_i) = T_B^j(x_i), I_B^j(x_i) = I_B^j(x_i)\, and\, F_A^j(x_i) = F_B^j(x_i),$$

   then

   $$C_{NRS}(A,A) = C_{NRS}(B,B) = \frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_A^j(x_i) + I_A^j(x_i)I_A^j(x_i) + F_A^j(x_i)F_A^j(x_i)\right\}$$

   and

   $$C_{NRS}(A,B) = \frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_B^j(x_i) + I_A^j(x_i)I_B^j(x_i) + F_A^j(x_i)F_B^j(x_i)\right\}$$

$$=\frac{1}{p}\sum_{i=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_A^j(x_i)+I_A^j(x_i)I_A^j(x_i)+F_A^j(x_i)F_A^j(x_i)\right\}$$
$$=C_{NRS}(A,A)$$

Hence

$$\rho_{NRS}(A,B)=\frac{C_{NRS}(A,B)}{\sqrt{C_{NRS}(A,A)*C_{NRS}(B,B)}}=\frac{C_{NRS}(A,A)}{\sqrt{C_{NRS}(A,A)*C_{NRS}(A,A)}}=1$$

(b) Let the ρ_{NRS}(A,B) =1. Then, the unite measure is possible only if

$$\frac{C_{NRS}(A,B)}{\sqrt{C_{NRS}(A,A)*C_{NRS}(B,B)}}=1$$

this refers that

$$T_A^j(x_i)=T_B^j(x_i), I_A^j(x_i)=I_B^j(x_i)\, and\, F_A^j(x_i)=F_B^j(x_i)$$

for all i, j values. Hence A = B

3. If ρ_{NRS} (A,B) $=\rho_{NRS}$ (B,A), it obvious that

$$\frac{C_{NRS}(A,B)}{\sqrt{C_{NRS}(A,A)*C_{NRS}(B,B)}}=\frac{C_{NRS}(B,A)}{\sqrt{C_{NRS}(A,A)*C_{NRS}(B,B)}}=\rho_{NRS}(B,A)$$

as

$$C_{NRS}(A,B)=\frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_A^j(x_i)T_B^j(x_i)+I_A^j(x_i)I_B^j(x_i)+F_A^j(x_i)F_B^j(x_i)\right\}$$
$$=\frac{1}{p}\sum_{j=1}^{p}\sum_{i=1}^{n}\left\{T_B^j(x_i)T_A^j(x_i)+I_B^j(x_i)I_A^j(x_i)+F_B^j(x_i)F_A^j(x_i)\right\}$$
$$=C_{NRS}(B,A)$$

4 Application

In this section, we give some applications of NRS in medical diagnosis and pattern recognition problems using the correlation measure. Some of it is quoted from [41, 42, 48].

From now on, we use

$$A\ =\{<x,(T_A^1(x),I_A^1(x),F_A^1(x)),(T_A^2(x),I_A^2(x),F_A^2(x)),...,(T_A^P(x),I_A^P(x),F_A^P(x))>:\ x\in E\}$$

instead of

$$A\ =\{<x,(T_A^1(x),T_A^2(x),...,T_A^P(x)),(I_A^1(x),I_A^2(x),...,I_A^P(x)),(F_A^1(x),F_A^2(x),...,F_A^P(x))>:\ x\in E\}$$

4.1 Medical Diagnosis via NRS Theory

In what follows, let us consider an illustrative example adopted from Rajarajeswari and Uma [41] and typically considered in [42, 48]. Obviously, the application is an extension of intuitionistic fuzzy multi sets [41].

"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 proposed correlation measure among the patients Vs symptoms and symptoms Vs diseases gives the proper medical diagnosis. The unique feature of this proposed method is that it considers multi truth membership, indeterminate and false membership. By taking one time inspection, there may be error in diagnosis. Hence, this multi time inspection, by taking the samples of the same patient at different times gives best diagnosis" [41].

Now, an example of a medical diagnosis will be presented.

Example 4.1 *Let $P = \{P_1, P_2, P_3\}$ be a set of patients, $D = \{Viral\,Fever,\ Tuberculosis,\ Typhoid, Throat\ disease\}$ be a set of diseases and $S = \{Temperature,\ cough,\ throat\ pain,\ headache,\ bodypain\}$ be a set of symptoms. Our solution is to examine the patient at different time intervals (three times a day), which in turn give arise to different truth membership, indeterminate and false membership function for each patient.*

Table I: Q (the relation Beween Patient and Symptoms)

Q	*Temparature*	*Cough*	*Throat pain*	*Headache*	*Body Pain*
P_1	$(0.4, 0.3, 0.4)$ $(0.3, 0.4, 0.6)$ $(0.2, 0.5, 0.5)$	$(0.5, 0.4, 0.4)$ $(0.4, 0.1, 0.3)$ $(0.3, 0.4, 0.5)$	$(0.3, 0.5, 0.5)$ $(0.2, 0.6, 0.4)$ $(0.1, 0.6, 0.3)$	$(0.5, 0.3, 0.4)$ $(0.5, 0.4, 0.7)$ $(0.3, 0.3, 0.6)$	$(0.5, 0.2, 0.4)$ $(0.2, 0.3, 0.5)$ $(0.1, 0.4, 0.3)$
P_2	$(0.6, 0.3, 0.5)$ $(0.5, 0.5, 0.2)$ $(0.4, 0.4, 0.5)$	$(0.6, 0.3, 0.7)$ $(0.4, 0.4, 0.2)$ $(0.2, 0.4, 0.5)$	$(0.6, 0.3, 0.3)$ $(0.3, 0.5, 0.4)$ $(0.1, 0.4, 0.5)$	$(0.6, 0.3, 0.1)$ $(0.4, 0.5, 0.8)$ $(0.2, 0.4, 0.3)$	$(0.4, 0.4, 0.5)$ $(0.3, 0.2, 0.7)$ $(0.1, 0.5, 0.5)$
P_3	$(0.8, 0.3, 0.5)$ $(0.7, 0.5, 0.4)$ $(0.6, 0.4, 0.4)$	$(0.5, 0.5, 0.3)$ $(0.3, 0.4, 0.3)$ $(0.1, 0.6, 0.4)$	$(0.3, 0.3, 0.6)$ $(0.2, 0.5, 0.7)$ $(0.1, 0.4, 0.5)$	$(0.6, 0.2, 0.5)$ $(0.5, 0.3, 0.6)$ $(0.2, 0.2, 0.6)$	$(0.6, 0.4, 0.5)$ $(0.3, 0.3, 0.4)$ $(0.2, 0.2, 0.6)$

Let the samples be taken at three different timings in a day (in 08:00,16:00,24:00)

Table II: R (the relation among Symptoms and Diseases)

R	*Viral Fever*	*Tuberculosis*	*Typhoid*	*Throat diseas*
Temerature	*(0.2,0.5,0.6)*	*(0.4,0.6,0.5)*	*(0.6,0.4,0.5)*	*(0.3,0.7,0.8)*
Cough	*(0.6,0.4,0.6)*	*(0.8,0.2,0.3)*	*(0.3,0.2,0.6)*	*(0.2,0.4,0.1)*
Throat Pain	*(0.5,0.2,0.3)*	*(0.4,0.5,0.3)*	*(0.4,0.5,0.5)*	*(0.2,0.6,0.2)*
Headache	*(0.6,0.8,0.2)*	*(0.2,0.3,0.6)*	*(0.1,0.6,0.3)*	*(0.2,0.5,0.5)*
Body Pain	*(0.7,0.4,0.4)*	*(0.2,0.3,0.4)*	*(0.2,0.3,0.4)*	*(0.2,0.2,0.3)*

Table III: The Correlation Measure between NRS Q and R

Correlation measure	*Viral Fever*	*Tuberculosis*	*Typhoid*	*Throat diseas*
P_1	*0.846*	***0.910***	*0.884*	*0.880*
P_2	*0.849*	*0.868*	***0.892***	*0.809*
P_3	*0.792*	*0.853*	***0.872***	*0.822*

The highest correlation measure from the Table III gives the proper medical diagnosis. Therefore, patient P_1 suffers from Tuberculosis, patient P_2 and P_3 suffers from Typhoid.

4.2 Pattern Recognition of NRS using proposed correlation mesure

In what follows, let us consider an illustrative example adopted from Rajarajeswari and Uma [41] and typically considered in [42, 48]. Obviously, the application is an extension of intuitionistic fuzzy multi sets [41].

Example 4.2 *Let $X = \{A_1, A_2, A_3, ...A_n\}$ with $A = \{A_1, A_2, A_3, A_4, A_5\}$ and $B = \{A_2, A_5, A_7, A_8, A_9\}$ are the NRS defined as*

$$\begin{aligned} Pattern\,I = \ & \{< A_1, (0.4, 0.5, 0.6), (0.2, 0.3, 0.5) >, < A_2, (0.5, 0.5, 0.2), (0.3, 0.2, 0.7) >, \\ & < A_3, (0.6, 0.3, 0.4), (0.6, 0.5, 0.3) >, < A_4, (0.7, 0.4, 0.5), (0.5, 0.4, 0.6) >, \\ & < A_5 : (0.3, 0.7, 0.2), (0.3, 0.2, 0.5) >\} \end{aligned}$$

and

$$Pattern\,II = \begin{array}{l}\{< A_2, (0.5, 0.2, 0.4), (0.3, 0.4, 0.6) >, < A_5, (0.7, 0.3, 0.1), (0.6, 0.1, 0.4) >, \\ < A_7 : (0.7, 0.2, 0.4), (0.4, 0.5, 0.3) >, < A_8, (0.8, 0.1, 0.4), (0.3, 0.5, 0.7) >, \\ A_9, (0.6, 0.3, 0.1), (0.2, 0.6, 0.1) >\}\end{array}$$

Then the testing NRS patern II be $\{A_6, A_7, A_8, A_9, A_{10}\}$ *such that*

$$Pattern\,III = \begin{array}{l}\{< A_6, (0.6, 0.4, 0.2), (0.4, 0.3, 0.7) >, < A_7, (0.9, 0.1, 0.1), (0.8, 0.3, 0.3) >, \\ < A_8, (0.6, 0.7, 0.1), (0.3, 0.8, 0.2) >, < A_9, (0.3, 0.8, 0.5, (0.2, 0.7, 0.2) >, \\ A_{10}, (0.4, 0.5, 0.6), (0.3, 0.7, 0.2) >\}\end{array}$$

Then, the correlation measure between pattern I and III is 0.8404, pattern II and III is 0.8286. Therefore; the testing pattern III belogns to pattern I type.

5 Conclusion

In this paper, we have firstly defined the correlation measure of neutrosophic refined sets and proved some of their basic properties. We have present an application of correlation measure of neutrosophic refined sets in medical diagnosis and pattern recognition. In The future work, we will extend this correlation measure to the case of interval neutrosophic refined sets.

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