International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 1, Issue 2 (October 2012), PP.39-43
www.irjes.com

Correlation of Neutrosophic Data

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ABSTRACT: *Neutrosophy has been introduced by Smarandache [3, 4] as a new branch of philosophy. Salama et al. [5] in 2012 introduced and studied the operations on neutrosophic sets. The purpose of this paper is to introduce a new type of data called the neutrosophic data. After given the fundamental definitions of neutrosophic set operations due to Salama [5], we obtain several properties, and discussed the relationship between neutrosophic sets and others. Finally, we discuss and derived a fomula for correlation coefficient, defined on the domain of neutrosophic sets.*
Keywords*: Neutrosophic Data; Correlation Coefficient.*

I. INTRODUCTION

The fuzzy set was introduced by Zadeh [9] in 1965, where each element had a degree of membership. The intuitionstic fuzzy set (Ifs for short) on a universe X was introduced by K. Atanassov [1] in 1983 as a generalizaion of fuzzy set, where besides the degree of membership and the degree of non- membership of each element.

After the introduction of the neutrosophic set concept [3,4]. In recent years neutrosophic algebraic structures have been investigated. Neutrosophy has laid the foundation for a whole family of new mathematical theories generalizing both their classical and fuzzy counterparts, such as a neutrosophic set theory.It is very common in statitical analysis of data to find the correlation between variables or attributes, the correlation coefficient defined on ordinary crisp sets, fuzzy sets [2] and intuitionistic fuzzy sets [6,7,8] respectively. In this paper we discuss and derived a fomula for correlation coefficient, defined on the domain of neutrosophic sets.

II. TERMINOLOGIES

We recollect some relevant basic preliminaries, and in partcular, the work of Smarandache in [3, 4], and Atanassov in [1]. Smarandache introduced the neutrosophic components T, I, F which represent the membership, indeterminacy, and non-membership values respectively, where $\left]0^-,1^+\right[$ is non-standard unit interval.

2.1 Defination. [3]

Let T, I,F be real standard or non_standeard subsets of $\left]0^-,1^+\right[$, with
Sup_T=t_sup, inf_T=t_inf
Sup_I=i_sup, inf_I=i_inf
Sup_F=f_sup, inf_F=f_inf
n-sup=t_sup+i_sup+f_sup
n-inf=t_inf+i_inf+f_inf,
T,I,F are called neutrosophic components

III. On NEUTROSOPHIC SETS

Salama et al [5] considered some possible definitions for basic concepts of the neutrosophic set and its operations by the following :

3.1 Definition

Let X be a non-empty fixed set. A neutrosophic set (NS for short) A is an object having the form $A=\left\{\left\langle x,\mu_A(x),\sigma_A(x),\gamma_A(x)\right\rangle : x\in X\right\}$. Where $\mu_A(x),\sigma_A(x)$ and $\gamma_A(x)$ which represent the degree of member ship function (namely $\mu_A(x)$), the degree of indeterminacy (namely $\sigma_A(x)$), and the degree of non-member ship (namely $\gamma_A(x)$) respectively of each element $x\in X$ to the set A .

3.1 Example

Every intuitionistic fuzzy set A a non empty set is obviously a nuetrosophic set having the form $A=\left\{\left\langle x,\mu_A(x),\sigma_A(x),1-\mu_A(x)\right\rangle : x\in X\right\}$

3.1 Remark

A neutrosophic set $A=\left\{<x,\mu_A(x),\sigma_A(x),\gamma_A(x)>: x\in X\right\}$ can be defined an ordered triple $<\mu_A,\sigma_A,\gamma_A>$ in $\left]^-0,1^+\right[^3$ on. X.

3.2 Remark

For the sake of simplicity, we shall use the symbol $A=<x,\mu_A,\sigma_A,\gamma_A>$ for the NS

.3.2 Example

Every Ifs A an non-empty set X is obviously on NS having the form $A=\left\{<x,\mu_A(x),1-\left(\mu_A(x)+\gamma_A(x)\right),\gamma_A(x)>: x\in X\right\}$

Since our main purpose is to construct the tools for developing neutrosophic set and neutrosophic data, we must introduce the two neutrosopohic sets 0_N and 1_N in X as follows:

0_N may be defined as:

(0_1) $0_N=\left\{\left\langle x,0,0,1\right\rangle : x\in X\right\}$

(0_2) $0_N=\left\{\left\langle x,0,1,1\right\rangle : x\in X\right\}$

(0_3) $0_N=\left\{\left\langle x,0,1,0\right\rangle : x\in X\right\}$

(0_4) $0_N=\left\{\left\langle x,0,0,0\right\rangle : x\in X\right\}$

1_N may be defined as:

(1_1) $1_N=\left\{\left\langle x,1,0,0\right\rangle : x\in X\right\}$

(1_2) $1_N=\left\{\left\langle x,1,0,1\right\rangle : x\in X\right\}$

(1_3) $1_N=\left\{\left\langle x,1,1,0\right\rangle : x\in X\right\}$

(1_4) $1_N=\left\{\left\langle x,1,1,1\right\rangle : x\in X\right\}$

3.2 Definition

Let $A=<x,\mu_A(x),\gamma_A(x),\sigma_A(x)>$ a NS on X, then the complement of the set A $(C(A)$, for short $)$ may be defined as three kinds of complements

(C_1) $C(A)=\left\{\left\langle x,1-\mu_A(x),1-\sigma_A(x),1-\nu_A(x)\right\rangle : x\in X\right\}$,

(C_2) $C(A)=\left\{\left\langle x,\nu_A(x),\sigma_A(x),\mu_A(x)\right\rangle : x\in X\right\}$

(C_3) $C(A)=\left\{\left\langle x,\nu_A(x),1-\sigma_A(x),\mu_A(x)\right\rangle : x\in X\right\}$

One can define several relations and operations between two neutrosophic sets follows:

3.3 Definition

Let X be a non-empty set, and two neutrosophics A and B in the form $A=\left\langle x,\mu_A(x),\sigma_A(x),\gamma_A(x)\right\rangle$, $B=\left\langle x,\mu_B(x),\sigma_B(x),\gamma_B(x)\right\rangle$, then we may consider two possible definitions for subsets $(A\subseteq B)$

$(A\subseteq B)$ may be defined as

(1) $A\subseteq B\Leftrightarrow\mu_A(x)\le\mu_B(x),\gamma_A(x)\ge\gamma_B(x)$ and $\sigma_A(x)\le\sigma_B(x)$ $\forall x\in X$

(2) $A\subseteq B\Leftrightarrow\mu_A(x)\le\mu_B(x),\gamma_A(x)\ge\gamma_B(x)$ and $\sigma_A(x)\ge\sigma_B(x)$

3.1 Proposition

For any neutrosophic set A the following are holds

(1) $0_N\subseteq A$, $0_N\subseteq 0_N$

(2) $A \subseteq 1_N$, $1_N \subseteq 1_N$

3.4 Definition

Let X be a non-empty set, and $A = < x, \mu_A(x), \gamma_A(x), \sigma_A(x) >$, $B = < x, \mu_B(x), \sigma_B(x), \gamma_B(x) >$ are NSS . Then

(1) $A \cap B$ may be defined as:

(I_1) $A \cap B = < x, \mu_A(x).\mu_B(x), \sigma_A(x).\sigma_B(x),$
$\gamma_A(x).\gamma_B(x) >$

(I_2) $A \cap B = < x, \mu_A(x) \wedge \mu_B(x), \sigma_A(x) \wedge \sigma_B(x),$
$\gamma_A(x) \vee \gamma_B(x) >$

(I_3) $A \cap B = < x, \mu_A(x) \wedge \mu_B(x), \sigma_A(x) \vee \sigma_B(x),$
$\gamma_A(x) \vee \gamma_B(x) >$

(2) $A \cup B$ may be defined as:

(U_1) $A \cup B = < x, \mu_A(x) \vee \mu_B(x), \sigma_A(x) \vee \sigma_B(x),$
$\gamma_A(x) \wedge \gamma_B(x) >$

(U_2) $A \cup B = < x, \mu_A(x) \vee \mu_B(x), \sigma_A(x) \wedge \sigma_B(x),$
$\gamma_A(x) \wedge \gamma_B(x) >$

(3) $[\ ]A = < x, \mu_A(x), \sigma_A(x), 1 - \mu_A(x) >$

(4) $< > A = < x, 1 - \gamma_A(x), \sigma_A(x), \gamma_A(x) >$

We can easily generalize the operations of intersection and union in Definition 3.4 to arbitrary family of neutrosophic sets as follows:

3.5 Definition

Let $\{Aj : j \in J\}$ be a arbitrary family of neutrosophic sets in X , then

(1) $\cap Aj$ may be defined as:

(i) $\cap Aj = \left\langle x, \underset{j \in J}{\wedge} \mu_{Aj}(x), \underset{j \in J}{\wedge} \sigma_{Aj}(x), \vee \gamma_{Aj}(x) \right\rangle$

(ii) $\cap Aj = \left\langle x, \wedge \mu_{Aj}(x), \vee \sigma_{Aj}(x), \vee \gamma_{Aj}(x) \right\rangle$

(2) $\cup Aj$ may be defined as:

(i) $\cup A_j = < x, \underset{j \in J}{\vee} \mu(x), \underset{j \in J}{\wedge} \sigma(x), \underset{j \in J}{\wedge} \gamma(x) >$

(ii) $\cup A_j = < x, \underset{j \in J}{\vee} \mu(x), \underset{j \in J}{\vee} \sigma(x), \underset{j \in J}{\wedge} \gamma(x) >$

3.6 Definition

Let A and B are two neutrosophic sets then
$A|B$ may be defined as

$A|B = \left\langle x, \mu_A \wedge \gamma_B, \sigma_A(x)\sigma_B(x), \gamma_A \vee \mu_B(x) \right\rangle$

3.2 Proposition

For all A, B two neutrosophic sets then the following are true

(1) $A \subseteq B \Rightarrow C(B) \subseteq C(A), C(C(A)) = A$

(2) $C(1_X) = O_X, C(O_X) = 1_X$

(3) $C(A \cap B) = C(A) \cup C(B)$

(4) $C(A \cup B) = C(A) \cap C(B)$

3.1 Corollary

Let A, B, C be are neutrosophic in X . Then

i) $A \subseteq B$ and $C \subseteq D \Rightarrow A \cup C \subseteq B \cup D$ and $A \cap C \subseteq B \cap D$

ii) $A \subseteq B$ and $A \subseteq C \Rightarrow A \subseteq B \cap C$

iii) $A \subseteq C$ and $B \subseteq C \Rightarrow A \cup B \subseteq C$

iv) $A \subseteq B$ and $B \subseteq C \Rightarrow A \subseteq C$

Proof. It is clear from the definition.

IV. Correlation of two neutrosophic sets.

If we have a random from a crisp set with corresponding of triple membersihp grads of two nuetrosophic sets we have interest in very likely we will compare the grads of membersihip functions of neutrosophic sets to see if there is any linear relationship between the two nuetrosophic sets, we need a formula for the sample correlation cofficient of two nuetrosophic sets to show the relationship between them.

4.1 Definition

For A and B are two neutrosophic sets in a finite space $X = \{x_1, x_2, ..., x_n\}$, we define the correlation of neutrosophic sets A and B as follows:

$$CN(A,B) = \sum_{i=1}^{n} [(\mu_A(x_i).\mu_B(x_i) + \sigma_A(x_i)\sigma_B(x_i) + \nu_A(x_i).\nu_B(x_i).)]$$

and the correlation cofficient of A and B given by

$$R(A,B) = \frac{CN(A,B)}{(T(A).T(B))^{\frac{1}{2}}}$$

Where

$$T(A) = \sum_{i=1}^{n} \left(\mu^2{}_A(x_i) + \sigma^2{}_A(x_i) + \nu^2{}_A(x_i)\right)$$

$$T(B) = \sum_{i=1}^{n} \left(\mu^2{}_B(x_i) + \sigma^2{}_B(x_i) + \nu^2{}_B(x_i)\right)$$

The follwoing Proposition is immediate from the definition

4.1 Proposition

For all A, B are two neutrosophic sets in a finite space X we have

$i) CN(A,B) = CN(B,A), R(A,B) = R(B,A)$

$ii)$ If $A = B$, then $R(A,B) = 1$

The following Therem generalizes both Therem 1.2. [2] and Proposion 2.3. [5].

4.1 Theorem

For neutrosophic sets A and B in X, we have

$$R(A,B) = \frac{CN(A,B)}{(T(A).T(B))^{\frac{1}{2}}} \in [0,1^+[$$

Proof.

Since $CN(A,B) \geq 0$, we need only to show that $CN(A,B) \leq (CN(A,A))^{1/2}(CN(B,B))^{1/2}$ If we denoted by the usual dot product in $\Re^2$, then

$$CN(A,B) = \sum_{i=1}^{n} [(\mu_A(x_i).\mu_B(x_i) + \sigma_A(x_i)\sigma_B(x_i) + \nu_A(x_i).\nu_B(x_i).)] \leq$$

$$\sum_{i=1}^{n} \left(\left(\mu^2{}_A(x_i) + \sigma^2{}_A(x_i) + \nu^2{}_A(x_i)\right)^{\frac{1}{2}} \left(\left(\mu^2{}_B(x_i) + \sigma^2{}_B(x_i) + \nu^2{}_B(x_i)\right)^{1/2} \right) \right) \leq$$

$$\left(\sum_{i=1}^{n} \left(\mu^2{}_A(x_i) + \sigma^2{}_A(x_i) + \nu^2{}_A(x_i)\right) \right)^{1/2} . \left(\sum_{i=1}^{n} \left(\mu^2{}_B(x_i) + \sigma^2{}_B(x_i) + \nu^2{}_B(x_i)\right) \right)^{1/2} =$$

$$((C(A,A))^{1/2}(C(B,B))^{1/2}$$

where the first inequality coms from Schwarz's inequality for $\Re^2$ and the second for $L^2(X)$. This completes the proof.

4.1 Remark

From the following counterexample, we can easily check that

$R(A,B) = 1$, but $A \neq B$.

4.1 Example

Let $X=\{x_1,x_2\}$ and the neutrosophic sets $\boldsymbol{A, B}$ given by $\mu_A(x_i)=\nu_A(x_i)=\sigma_A(x_i)=\frac{1}{2}$ and $\mu_B(x_i)=\nu_B(x_i)=\sigma_B(x_i)=\frac{1}{4}$, $i=1,2$,

$R(A,B)=1$ but $A\neq B$.

4.2 Example

In this example we will estimate the correlation coefficient between the neutrosophic data .

Let A, B are two neutrosophic sets in a finite space $X=\{a,b\}$

defined by $A=\{\langle a,(0.3,0.2,0.5)\rangle,\langle b,(0.5,0.4,0.2)\rangle\}$, $B=\{\langle a,(0.2,0.4,0.6)\rangle,\langle b,(0.4,0.3,0.6)\rangle\}$

Then we have $CN(A,B)=0.88$, $T(A)=0.83$, $T(B)=1$, then $R(A,B)=0.896$.

This value gives us the information that the nutrosophic sets A and B are positively and closely related with Strength 0.896.

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