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DECISION MAKING IN MEDICAL DIAGNOSIS USING IMPROVED CORRELATION COEFFICIENTS OF TETRA NEUTROSOPHIC SETS

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Abstract: In this paper, we introduce the concept of Tetra Neutrosophic Set [TNS] and studied its basic properties. The idea of Tetra neutrosophic topological spaces were also discussed with an example. Finally, we implemented the above technique to the problem of multiple attribute group decision making in medical diagnosis with improved correlation coefficients.

Keywords: Tetra Neutrosophic Set, Neutrosophic Sets, Improved Correlation Coefficient.

1. Introduction

Fuzzy set was introduced by Zadeh [23] in 1965 that permits the membership perform valued within the interval [0,1] and set theory it's an extension of classical pure mathematics. Fuzzy set helps to deal the thought of uncertainty, unclearness and impreciseness that isn't attainable within the cantorian set. As Associate in Nursing extension of Zadeh's fuzzy set theory intuitionistic fuzzy set(IFS) was introduced by Atanassov [1] in 1986, that consists of degree of membership and degree of non membership and lies within the interval of [0,1]. IFS theory wide utilized in the areas of logic programming, decision making issues, medical diagnosis etc.

Florentin Smarandache [15] introduced the idea of Neutrosophic set in 1995 that provides the information of neutral thought by introducing the new issue referred to as uncertainty within the set. thus neutrosophic set was framed and it includes the parts of truth membership function(T), indeterminacy membership function(I), and falsity membership function(F) severally. Neutrosophic sets deals with non normal interval of]−0 1+[. Since neutrosophic set deals minateness effectively it plays an very important role in several applications areas embrace info technology, decision web, multicriteria decision making, electronic database systems, diagnosis, multicriteria higher cognitive process issues etc., To method the unfinished data or imperfect data to unclearness a brand new mathematical approach i.e., To deal the important world issues, Wang [16](2010) introduced the idea of single valued neutrosophic sets(SVNS) that is additionally referred to as an extension of intuitionistic fuzzy sets and it became a really new hot analysis topic currently. Rama Malik.,et al [14] projected the idea of Penta partitioned single valued neutrosophic sets that relies on Belnap's five valued logic and Smarandache's five numerical valued logic. In (PSVNS) indeterminacy is divided into 3 functions referred to as 'Contradiction' (both true and false) and 'Ignorance' (neither true nor false) and an 'unknown' membership in order that PSVNS has five parts, T,C,U,F,G that additionally lies within the non normal unit interval]−0 1+[. Further, R. Radha and A. Stanis Arul Mary[7] outlined a brand new hybrid model of Penta partitioned Neutrosophic Pythagorean sets (PNPS) in 2021.Correlation coefficient may be a effective mathematical tool to live the strength of the link between 2 variables. such a lot of researchers pay the attention to the idea of varied correlation coefficients of the various sets like fuzzy set, IFS, SVNS, QSVNS. In 1999 D.A Chiang and N. P. Lin [3] projected the correlation of fuzzy sets underneath fuzzy setting.

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Later D.H. Hong [4] (2006) outlined fuzzy measures for a coefficient of correlation of fuzzy numbers below Tw (the weakest t-norm) based mostly fuzzy arithmetic operations. The concept of tetra neutrosophic sets and its topological spaces was introduced by Radha[11].
Correlation coefficients plays a very important role in several universe issues like multiple attribute cluster higher cognitive process, cluster analysis, decision making problems, pattern recognition, diagnosis etc., therefore several authors targeted the idea of shaping correlation coefficients to resolve the important world issues in significantly multicriteria decision making strategies. Jun Ye [19] outlined the improved correlation coefficients of single valued neutrosophic sets and interval neutrosophic sets for multiple attribute higher cognitive process to beat the drawbacks of the correlation coefficients of single valued neutrosophic sets (SVNSs) that is outlined in [22].In this paper, we have applying improved correlation coefficient on tetra neutrosophic sets and studied with an example.

2. Preliminaries

2.1 Definition [2]

Let X be a universe. A Neutrosophic set A on X can be defined as follows:

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

Where T_A , I_A, F_A: $U \rightarrow [0,1]$ and $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$

Here, $T_A(x)$ is the degree of membership, $I_A(x)$ is the degree of inderminancy and $F_A(x)$ is the degree of non-membership.
He re, $T_A(x)$ and $F_A(x)$ are dependent neutrosophic components and $I_A(x)$ is an independent component.

2.2 Definition [10]

Let R be a universe. A Neutrosophic Pythagorean set A with T and F as dependent Neutrosophic Pythagorean components and U as independent component for A on R is an object of the form

$A = \{< x, T_A, U_A, F_A >: r \in R\}$

Where $T_A + F_A \leq 1$, $(T_A)^2 + (F_A)^2 \leq 1$ and

$(T_A)^2 + (U_A)^2 + (F_A)^2 \leq 2$

Here, $T_A(x)$ is the truth membership, $U_A(x)$ is indeterminacy membership and $F_A(x)$ is the false membership .

2.3 Definition [10]

The complement of a Neutrosophic Pythagorean set $A = \{< x, T_A, U_A, F_A >: r \in R\}$ with dependent Neutrosophic Pythagorean components is

$A^C = \{< x, F_A, 1 - U_A, T_A >: r \in R\}$.

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2.4 Definition [10]

Let $A = \{< x, T_A, U_A, F_A >: r \in R\}$ *and* $B = \{< x, T_B, U_B, F_B >: r \in R\}$ are two Neutrosophic Pythagorean sets with dependent Neutrosophic Pythagorean components on the universe R. Then the union and intersection of two sets can be defined by

$A \cup B = \{\max (T_A, T_B), \min (U_A, U_B), \min (F_A, F_B)\}$,

$A \cap B = \{\min (T_A, T_B), \max (U_A, U_B), \max (F_A, F_B)\}$.

2.5 Example [10]

Let R = {a, b} and A ={ (a, 0.4,0.5,0.3),(b,0.5,0.2,0.2)}.

Then τ = {0,1, A} is a topology on R. Then A is a Neutrosophic Pythagorean set.

2.6 Example [10]

Let R = {a, b} and A ={ (a, 0.5,0.6,0.6),(b,0.7,0.6,0.7)}.

Then τ = {0,1, A} is a topology on R. Since $T_A + F_A > 1$, then A is not a Neutrosophic Pythagorean set.

3. Improved Correlation Coefficients

Based on the concept of correlation coefficient of PNPSs, we have defined the improved correlation coefficients of PNPSs in the following section.

3.1 Definition

Let X be a universe. A tetra neutrosophic set (TNS) A on X is an object of the form

$A = \{< x, T_A, I_A, F_A >: x \in X\}$

$(T_A)^4 + (I_A)^4 + (F_A)^4 \leq 1$

Here, $T_A(x)$ is the truth membership,

$I_A(x)$ is an indeterminancy membership and

$F_A(x)$ is the false membership

3.2 Definition

Let P and Q be any two TNSs in the universe of discourse R = { $r_1, r_2, r_3, \ldots, r_n$ }, then the improved correlation coefficient between P and Q is defined as follows

$$K(P, Q) = \frac{1}{3n} \sum_{k=1}^{n} [\, \mu_k(1 - \Delta TM_k) + \varphi_k(1 - \Delta IM_k) + \delta_k(1 - \Delta FM_k) \quad (3.1)$$

Where

$$\mu_k = \frac{3 - \Delta TM_k - \Delta TM_{max}}{3 - \Delta TM_{min} - \Delta TM_{max}},$$

$$\varphi_k = \frac{3 - \Delta IM_k - \Delta IM_{max}}{3 - \Delta IM_{min} - \Delta IM_{max}},$$

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$\delta_k = \frac{3- \Delta FM_k - \Delta FM_{max}}{3- \Delta F_{min} - \Delta F_{max}}$,

$\Delta TM_K = |TM_P^4(r_k) - TM_Q^4(r_k)|$,

$\Delta IM_K = |IM_P^4(r_k) - IM_Q^4(r_k)|$,

$\Delta FM_K = |FM_P^4(r_k) - FM_Q^4(r_k)|$

$\Delta TM_{min} = min_k|TM_P^4(r_k) - TM_Q^4(r_k)|$,

$\Delta IM_{min} = min_k|IM_P^4(r_k) - IM_Q^4(r_k)|$,

$\Delta FM_{mi} \;= min_k|FM_P^4(r_k) - FM_Q^4(r_k)|$

$\Delta TM_{max} = max_k|TM_P^4(r_k) - TM_Q^4(r_k)|$,

$\Delta IM_{max} = max_k|IM_P^4(r_k) - IM_Q^4(r_k)|$,

$\Delta FM_{max} = max_k|FM_P^4(r_k) - FM_Q^4(r_k)|$

For any $r_k \in$ R and k = 1, 2, 3….. n.

3.3 Theorem

For any two TNSs P and Q in the universe of discourse R = { r_1, r_2 , r_3 ,…, r_n }, the improved correlation coefficient K(P, Q) satisfies the following properties.

1) K (P, Q) = K (Q, P);
2) $0 \leq K(P, Q) \leq 1$;
3) K(P, Q) = 1 iff P =Q.

Proof

(1) Proof is obvious and straightforward.

(2) Here, $0 \leq \mu_k \leq 1$, $0 \leq \varphi_k \leq 1$, $0 \leq \delta_k \leq 1$, $0 \leq 1 - \Delta TM_k \leq 1$,$0 \leq 1 - \Delta IM_k \leq 1$, $0 \leq 1 - \Delta FM_k \leq 1$. Therefore the following inequation satisfies

$0 \leq \mu_k (1 - \Delta TM_k) + \varphi_k(1 - \Delta IM_k) + \delta_k(1 - \Delta FM_k) \leq 3$.

Hence we have $0 \leq K(P, Q) \leq 1$

(3) If K (P, Q) = 1, then we get $\mu_k (1 - \Delta TM_k) + \varphi_k(1 - \Delta IM_k) + \delta_k(1 - \Delta FM_k) = 3$. Since $0 \leq \mu_k (1 - \Delta TM_k) \leq 1$, $0 \leq \varphi_k(1 - \Delta IM_k) \leq 1$, $0 \leq \delta_k(1 - \Delta FM_k) \leq 1$, there are $\mu_k (1 - \Delta TM_k) = 1$, $\varphi_k(1 - \Delta IM_k) = 1$ and $\delta_k(1 - \Delta FM_k) = 1$. And also since $0 \leq \mu_k \leq 1$, $0 \leq \varphi_k \leq 1$, $0 \leq \delta_k \leq 1$,$0 \leq 1 - \Delta TM_k \leq 1$, $0 \leq 1 - \Delta IM_k \leq 1$, $0 \leq 1 - \Delta FM_k \leq 1$. We get $\mu_k = \varphi_k = \delta_k = 1$ and $1 - \Delta TM_k = 1 - \Delta IM_k = 1 - \Delta FM_k = 1$. This implies, $\Delta TM_k = \Delta TM_{min} = \Delta TM_{max} = 0$, $\Delta IM_k = \Delta IM_{min} = \Delta IM_{max} = 0$, $\Delta F_k = \Delta FM_{min} = \Delta FM_{max} =$

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. Hence $TM_P(r_k) = TM_Q(r_k), IM_P(r_k) = IM_Q(r_k), FM_P(r_k) = FM_Q(r_k)$, for any $r_k \in R$ and k = 1,2,3….n.Hence P = Q.

Conversely, assume that P = Q, this implies $TM_P(r_k) = TM_Q(r_k), IM_P(r_k) = IM_Q(r_k)$, $FM_P(r_k) = FM_Q(r_k)$ for any $r_k \in R$ and k = 1,2,3….n. Thus $\Delta TM_k = \Delta TM_{min} = \Delta TM_{max} = 0$, $\Delta IM_k = \Delta IM_{min} = \Delta IM_{max} = 0$, $\Delta F_k = \Delta FM_{min} = \Delta FM_{max} = 0$Hence we get K (P, Q) = 1.

The improved correlation coefficient formula which is defined is correct and also satisfies these properties in the above theorem . When we use any constant $\varepsilon > 3$ in the following expressions

$$\mu_k = \frac{\varepsilon - \Delta TM_k - \Delta TM_{max}}{\varepsilon - \Delta TM_{min} - \Delta TM_{max}},$$

$$\varphi_k = \frac{\varepsilon - \Delta IM_k - \Delta IM_{max}}{\varepsilon - \Delta IM_{min} - \Delta IM_{max}},$$

$$\delta_k = \frac{\varepsilon - \Delta FM_k - \Delta FM_{max}}{\varepsilon - \Delta FM_{min} - \Delta FM_{max}}$$

In the following, we define a weighted correlation coefficient between TNS s since the differences in the elements are considered into an account.

Let w_k be the weight of each element $r_k(k = 1,2…n)$, $w_k \in [0,1]$ and $\sum_{k=1}^{n} w_k = 1$, then the weighted correlation coefficient between the TNS s A and B

$$K_w(A, B) = \frac{1}{3}\sum_{k=1}^{n} w_k[\, \mu_k(1 - \Delta TM_k) + \varphi_k(1 - \Delta IM_k) + \delta_k(1 - \Delta FM_k) \qquad (3.2)$$

If w = (1/n,1/n,1/n,….1/n) ^{T} , then eqation (3.1) reduces to equation (3.2). $K_w(A, B)$ also satisfies the three properties in the above theorem.

3.4 Decision Making using the improved correlation coefficient of TNSs

Multiple attribute decision making (MADM) problems refers to make decisions when several attributes are involved in real -life problem. For example one may buy a vehicle by analysing the attributes which is given in tems of price, style,safety, comfort etc.,

Here we consider a multiple attribute decision making problem with pentapartitioned neutrosophic pythagorean information and the characteristic 0f an alternative $A_i(i = 1,2,…m)$ on an attribute $C_j(j = 1,2…n)$ is represented by the following PNPS s:

$A_i = \{(C_j, TM_{A_i}(C_j), IM_{A_i}(C_j), FM_{A_i}(C_j) \backslash\, C_j \in C, j = 1,2, \ldots n\}$

Where $TM_{A_i}(C_j), IM_{A_i}(C_j), FM_{A_i}(C_j) \in [0,1]$ and

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$0 \leq TM^4_{A_j}(C_j) + IM^4_{A_j}(C_j) + FM^4_{A_j}(C_j) \leq 1$ for $C_j \in C, j = 1,2,\dots n$ and I = 1,2,…m.

To make it convenient, we are considering the following five functions $TM_{A_i}(C_j), IM_{A_i}(C_j), FM_{A_i}(C_j)$ in terms of tetra neutrosophic value (TNV)

$$d_{ij} = (tm_{ij}, im_{ij}, fm_{ij})(i = 1,2,\dots m; j = 1,2\dots n).$$

Here the values of d_{ij} are usually derived from the evaluation of an alternative A_i with respect to a criteria C_j by the expert or decision maker. Therefore we got a tetra neutrosophic decision matrix $D = (d_{ij})_{m\times n}$.

In the caseof ideal alternative A^* an ideal TNV can be defined by

$d^*_j = (tm^*_j, im^*_j, fm^*_j) = (1,1,0)(j = 1,2\dots n)$ in the decision making method,

Hence the wighted correlation coefficient between an alternative A_i(i=1,2….m) and the ideal alternative A^* is given by,

$$K_w(A_i, A^*) = \frac{1}{3}\sum_{j=1}^{n} w_j[\mu_{ij}(1 - \Delta tm_{ij}) + \varphi_{ij}(1 - \Delta im_{ij}) + \delta_{ij}(1 - \Delta fm_{ij})] \quad (3.3)$$

Where,

$\mu_{ij} = \frac{3 - \Delta tm_{ij} - \Delta tm_{imax}}{3 - \Delta tm_{imin} - \Delta tm_{imax}}$,

$\varphi_{ij} = \frac{3 - \Delta im_{ij} - \Delta im_{imax}}{3 - \Delta im_{imin} - \Delta im_{imax}}$,

$\delta_{ij} = \frac{3 - \Delta fm_{ij} - \Delta fm_{imax}}{3 - \Delta fm_{imin} - \Delta fm_{imax}}$,

$\Delta t_{ij} = |tm^4_{ij} - tm^*_j|$,

$\Delta i_{ij} = |im^4_{ij} - im^*_j|$,

$\Delta fm_{ij} = |fm^4_{ij} - fm^*_j|$,

$\Delta tm_{imin} = \min_j |tm^4_{ij} - tm^*_j|$,

$\Delta i_{imin} = \min_j |im^4_{ij} - im^*_j|$,

$\Delta fm_{imin} = \min_j |fm^4_{ij} - fm^*_j|$,

$\Delta tm_{imax} = \max_j |tm^2_{ij} - tm^*_j|$,

$\Delta im_{imax} = \max_j |im^4_{ij} - im^*_j|$,

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$\Delta fm_{imax} = \max_j |fm_{ij}^4 - fm_j^*|$,

For i = 1,2….m and j = 1,2….n.

By using the above weighted correlation coefficient We can derive the ranking order of all alternatives and we can choose the best one among those.

4.1 Example

This section deals the example for the multiple attribute decision making problem with the given alternatives corresponds to the criteria alloted under tetra neutrosophic environment.

Due to more complexity in medical diagnosis problem, a large information is needed to the physicians of modern medical personalities and those are very often incomplete and inconsistent information in nature. For this example, the three potential alternatives are to be evaluated under the four diffident attributes. The types of intellectual property rights are the alternatives and the various cybercrimes are the attributes for this example. The three potential alternatives are $A_1 -$ Viral fever, $A_2 -$Typhoid and $A_3 -$ Dengue and the four diffident attributes are $C_1 -$ tiredness $C_2 -$ Temperature, $C_3 -$ cough and $C_4 -$ headache . For the evaluation of an alternative A_1 with respect to an attribute C_1 , it is obtained from the questionnaire of a domain expert. According to the attributes we will derive the ranking order of all alternatives and based on this ranking order customer will select the best one.
By assigning the weight vector of the above attributes is given by w = (0.2,0.35,0.25,0.2), Here the alternatives are to be evaluated under the above four attributes by the form of TNS s, In general the evaluation of an alternative A_i with respect to the attributes C_j (i=1,2,3, j=1,2,3,4) will be done by the questionnaire of a domain expert.

$A_i \setminus C_j$	C_1	C_2	C_3	C_4
A_1	[0.6,0.7,0.1]	[0.5. 0.5,0.2]	[0.4, 0.4,0.1]	[0.6,0.6,0.2]
A_2	[0.4,0.6,0.2]	[0.3,0.5,0.1]	[0.1,0.2,0.2]	[0.5,0.6,0.1]
A_3	[0.3,0.4,0.4]	[0.5,0.6,0.1]	[0.4,0.4,0.2]	[0.3,0.5,0.2]

Then by using the proposed method we will obtain the most desirable alternative. We can get the values of the correlation coefficient $M_w(A_i, A^*)$ (i = 1,2,3) by using Equation (3.3).
Hence $M_w(A_1, A^*) = 0.6827$, $M_w(A_2, A^*) = 0.6640$, $M_w(A_3, A^*) = 0.67921$. Therefore
Thus ranking order of the three potential alternatives is A1>A3>A2. Therefore we can say that A1 viral fever have more medical problems in fever, tiredness, headache and body pain as well than the other alternatives of medical diagnosis. The decision making method provided in this paper is more judicious and more vigorous.

5. Conclusion

In this paper, we have defined the new form of set called tetra neutrosophic set and we've outlined the improved correlation coefficient of TNSs and this is often applicable for a few cases once the correlation coefficient of TNSs is undefined (or) unmeaningful and additionally we have studied its properties.

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