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Bipolar Pentapartitioned Neutrosophic Set and its Topological Space

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Abstract: In this paper, we have introduced the new concept of Bipolar Pentapartitioned Neutrosophic set and discussed some of its properties. Also, we have investigated the properties of bipolar pentapartitioned neutrosophic topological spaces.

Keywords: Bipolar quadripartitioned neutrosophic set, bipolar pentapartitioned neutrosophic set.

I. INTRODUCTION

To cope with uncertainty primarily based real and scientific issues, Prof. Zadeh [20] introduced the fuzzy set as a constructive tool. Later on Prof. Atanassov [1] extended the idea of fuzzy set theory to the intuitionistic fuzzy set(IFS), during which every element has both a membership degree and a non-membership degree. It's quite clear that IFS are more useful than fuzzy set theory to deal the varied sorts s of uncertainty model. In 2005, Smarandache [19]introduced the thought of a neutrosophic set (NS) as a further generalization of IFS from philosophical purpose of read. Gradually neutrosophic sets become more powerful technique to represent incomplete, inconsistent and indeterminate data that exists in our real universe. In neutrosophic set, truth membership functions (TA), indeterminacy membership functions (IA), and falsity membership functions (FA) are represented independently. However just in case of NS, all components lie in]0−, 1+[.Thus it is terribly powerful to use NS sets in real world issues. To resolve this problem Wang et al. [7] introduced single valued NS sets in 2010. Recently bipolar fuzzy set and set theoretical operations supported on fuzzy bipolar sets are introduced by Deli et al. in their paper [5]. They have shown that a bipolar fuzzy set consists two independent components, positive membership degree $T+ \longrightarrow [0, 1]$ and a negative membership degree $T - \longrightarrow [-1, 0]$. In a while, many researchers have studied bipolar fuzzy sets and applied it to completely different socio-economic model ..

Asa continuation of neutrosophic set, Deli et al. [6] introduced the thought of bipolar neutrosophic sets, where each element has both + ve and − ve neutrosophic degrees. Here, the positive membership degree T_A^+, I_A^+, F_A^+ denotes the truth membership, indeterminate membership and false membership of an element x ∈ X corresponding to a bipolar neutrosophic set A and the negative membership degree T_A^-, I_A^-, F_A^- denotes the truth membership, indeterminate membership and false membership of a component x ∈ X to some anti-property similar to a bipolar neutrosophic set A.. Rama Malik and Surpati Pranamik[18] has developed Pentapartitioned neutrosophic set and its properties. It is five valued logic set consisting truth membership, a contradiction membership , an ignorance-membership, an unknown membership and a falsity membership for each x ∈ X. Now pentapartitioned single valued neutrosophic set becomes an im portant tool in solving various types of decision making problems, medical diagnosis problems, clustering issues etc. The concept of Bipolar Quadripartitioned single valued neutrosophic sets was developed by Kalyan Sinha.et.al[8]. In this paper, we develop Bipolar pentapartitioned neutrosophic set and studied some of its properties.

II. PRELIMINARIES

2.1 Definition

Suppose X be a non-empty set. A bipolar quadripartitioned neutrosophic set (BQNS) A, over X characterizes each element x in X by a positive truth-membership function T_A^+, a positive contradiction membership function C_A^+, a positive ignorance-membership function U_A^+, a positive falsity membership function F_A^+, a negative truth membership function T_A^-, a negative contradiction membership function C_A^-, a negative ignorance-membership function U_A^-, a negative falsity membership function F_A^-, such that for each $x \in X$, $T_A^+, C_A^+, G_A^+, U_A^+, F_A^+ \in [0,1]$, $T_A^-, C_A^-, G_A^-, U_A^-, F_A^- \in [0,1]$,

and $T_A^+ + C_A^+ + U_A^+ + F_A^+ \leq 4, -4 \leq T_A^- + C_A^- + U_A^- + F_A^- \leq 0$

2.2 Definition .

A BQNS B over X is said to be an absolute BQNS, denoted by 1_X, if and only if its membership values are respectively defined as $T_A^+(x) = 1$, $C_A^+(x) = 1$, $U_A^+(x) = 0$, $F_A^+(x) = 0$, $T_A^-(x) = 0$, $C_A^-(x) = 0$, $U_A^-(x) = -1$, $F_A^-(x) = -1$, for all x ∈ [0,1].

2.3 Definition

A BQNS B over X is said to be an empty BQNS, denoted by 0_X, if and only if its membership values are respectively defined as $T_A^+(x) = 0$, $C_A^+(x) = 0$, $U_A^+(x) = 1$, $F_A^+(x) = 1$, $T_A^-(x) = -1$, $C_A^-(x) = -1$, $U_A^-(x) = 0$, $F_A^-(x) = 0$, for all x ∈ [0,1].

2.4 Definition

A BQN set A = $\{T_A^+, C_A^+, U_A^+, F_A^+, T_A^-, C_A^-, U_A^-, F_A^-\}$ is contained in a BQN set B = $\{T_B^+, C_B^+, U_B^+, F_B^+, T_B^-, C_B^-, U_B^-, F_B^-\}$ if and only if $T_A^+(x) \le T_B^+(x)$, $C_A^+(x) \le C_B^+(x)$, $U_A^+(x) \ge U_B^+(x)$, $F_A^+(x) \ge F_B^+(x)$, $T_A^-(x) \ge T_B^-(x)$, $C_A^-(x) \ge C_B^-(x)$, $U_A^-(x) \le U_B^-(x)$ and $F_A^-(x) \le F_B^-(x)$.

2.5 Definition

The complement of BQNS A = $\{T_A^+, C_A^+, U_A^+, F_A^+, T_A^-, C_A^-, U_A^-, F_A^-\}$ is denoted by A^C and is defined as

$A^C = \{F_A^+, U_A^+, C_A^+, T_A^+, F_A^-, U_A^-, C_A^-, T_A^-\}$

2.6 Definition

The union of any two BQNS A = $\{T_A^+, C_A^+, U_A^+, F_A^+, T_A^-, C_A^-, U_A^-, F_A^-\}$ and

B = $\{T_B^+, C_B^+, U_B^+, F_B^+, T_B^-, C_B^-, U_B^-, F_B^-\}$ is denoted by A∪B and is defined as follows

A∪B = {max $\{T_A^+, T_B^+\}$, max $\{C_A^+, C_B^+\}$, min $\{U_A^+, U_B^+\}$, min $\{F_A^+, F_B^+\}$,

min $(T_A^-, T_B^-\}$, min $(C_A^-, C_B^-\}$, max $(U_A^-, U_B^-\}$, max $(F_A^-, F_B^-\}$}

2.7 Definition

The intersection of any two BQNS A = $\{T_A^+, C_A^+, U_A^+, F_A^+, T_A^-, C_A^-, U_A^-, F_A^-\}$ and

B = $\{T_B^+, C_B^+, U_B^+, F_B^+, T_B^-, C_B^-, U_B^-, F_B^-\}$ is denoted by A∩B and is defined as follows

A∩B = {min $\{T_A^+, T_B^+\}$, min $\{C_A^+, C_B^+\}$, max $\{U_A^+, U_B^+\}$, max $\{F_A^+, F_B^+\}$, max $(\{, T_B^-\}$, max $\{C_A^-, C_B^-\}$, min $\{U_A^-, U_B^-\}$, min $\{F_A^-, F_B^-\}$}

III BIPOLAR PENTAPARTITIONED NEUTROSOPHIC SETS

3.1 Definition

Suppose X be a non-empty set. A bipolar pentapartitioned neutrosophic set (BPNS) A, over X characterizes each element x in X by a positive truth-membership function T_A^+, a positive contradiction membership function C_A^+, a positive ignorance-membership function U_A^+, a positive falsity membership function F_A^+, a positive unknown membership G_A^+, a negative truth membership function T_A^-, a negative contradiction membership function C_A^-, a negative ignorance-membership function U_A^-, a negative falsity membership function F_A^-, a negative unknown membership function G_A^- such that for each $x \in X$, $T_A^+, C_A^+, G_A^+, U_A^+, F_A^+ \in [0,1]$, T_A^-, $C_A^-, G_A^-, U_A^-, F_A^- \in [0,1]$,

and $T_A^+ + C_A^+ + G_A^+ + U_A^+ + F_A^+ \le 5$, $-5 \le T_A^- + C_A^- + G_A^- + U_A^- + F_A^- \le 0$
When X is discrete, A is represented as

A = $\sum_{i=1}^{n} < T_A^+, C_A^+, G_A^+,, U_A^+, F_A^+, T_A^-, C_A^-, G_A^-, U_A^-, F_A^- > / x_i$, $x_i \in X$

3.2 Example

Consider the case where five different persons x_1, x_2, x_3, x_4, x_5 were asked to give their opinion on the statement "is there any climate change in India" in the year 2020. Each of the five persons will give their opinion in terms of degree of agreement, agreement or disagreement both, neither agreement nor disagreement, disagreement in terms of degree of positive and negative arguments and unknown agreement respectively. The aggregate of their opinion is very well expressed by a BPNS A as follows:

A = < 0.8, 0.7,0.6,0.4,0.2,-0.5,-0.8,-0.7,-0.3,-0.1>/x_1 +

< 0.5,0.7,0.9,0.2,0.7,-0.2,-0.5.-0.6,-0.7,-0.3>/x_2 +

< 0.7, 0.7,0.4,0.5,0.2,-0.5,-0.8,-0.5,-0.2,-0.4>/x_3 +

< 0.9,0.3,0.6,0.2,0.7,-0.2,-0.5.-0.6,-0.7,-0.3>/x_4 +

< 0.2, 0.6,0.6,0.4,0.7,-0.5,-0.4,-0.7,-0.9,-0.1>/x_5 +

Here according to x_1, the degree of agreement with the statement is 0.8 and the degree of negative agreement with the statement is 0.5, the degree of both agreement and disagreement is 0.7 and the degree of negative argument of "both agreement and disagreement" is 0.8. The degree of neither agreement nor disagreement is 0.4, while the degree of negative argument of it is 0.3. Similarly the degree of disagreement with the statement is 0.2 and degree of negative disagreement is 0.1 and the degree of unknown agreement is 0.6 and the degree of negative unknown agreement is 0.7. This is how BPNS set has been made.

3.3 Definition .

A BPNS *B* over *X* is said to be an absolute BPNS, denoted by 1_X, if and only if its membership values are respectively defined as $T_A^+(x) = 1$, $C_A^+(x) = 1$, $G_A^+(x) = 0$, $U_A^+(x) = 0$, $F_A^+(x) = 0$, $T_A^-(x) = 0$, $C_A^-(x) = 0$, $G_A^-(x) = -1$, $U_A^-(x) = -1$,

$F_A^-(x) = -1$, for all x ∈ [0,1].

3.4 Definition

A BPNS *B* over *X* is said to be an empty BPNS, denoted by 0_X, if and only if its membership values are respectively defined as $T_A^+(x) = 0$, $C_A^+(x) = 0$, $G_A^+(x) = 1$, $U_A^+(x) = 1$, $F_A^+(x) = 1$, $T_A^-(x) = -1$, $C_A^-(x) = -1$, $G_A^-(x) = 0$, $U_A^-(x) = 0$, $F_A^-(x) = 0$, for all x ∈ [0,1].

Remark

A BPNS is a generalization of a bipolar neutrosophic set. If we take average the components C^+,U^+ ,G^+ and C^-,U^-, G^- together respectively, we can easily get a bipolar SVN set.

3.5 Definition

A BPN set A = $\{T_A^+ , C_A^+, G_A^+, U_A^+, F_A^+, T_A^- , C_A^-, G_A^-, U_A^-, F_A^-\}$ is contained in a BPN set B = $\{T_B^+ , C_B^+, G_B^+, U_B^+, F_B^+, T_B^- , C_B^-, G_B^-, U_B^-, F_B^-\}$ if and only if $T_A^+(x) \leq T_B^+(x)$, $C_A^+(x) \leq C_B^+(x)$, $U_A^+(x) \geq U_B^+(x)$, $G_A^+(x) \geq G_B^+(x)$, $F_A^+(x) \geq F_B^+(x)$,

$T_A^-(x) \geq T_B^-(x)$, $C_A^-(x) \geq C_B^-(x)$, $G_A^-(x) \leq G_B^-(x)$, $U_A^-(x) \leq U_B^-(x)$ and $F_A^-(x) \leq F_B^-(x)$.

3.6 Definition

The complement of BPNS A = $\{T_A^+ , C_A^+, G_A^+, U_A^+, F_A^+, T_A^- , C_A^-, G_A^-, U_A^-, F_A^-\}$ is denoted by A^C and is defined as

$A^C = \{F_A^+ , U_A^+, (1 - G_A^+), C_A^+, T_A^+, F_A^- , U_A^-, (-1 - G_A^-), C_A^-, T_A^-\}$

3.7 Example

Let X ={a,b}. Then the BPNS R of X is given by

$$R = \begin{cases} < a, (0.5,0.7,0.6,0.2,0.4, -0.1, -0.8, -0.5, -0.7, -0.7) > \\ < b, (0.4,0.6,0.7,0.8,0.3, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

$$R^C = \begin{cases} < a, (0.4,0.2,0.4,0.7,0.5, -0.7, -0.7, -0.5, -0.8, -0.1) > \\ < b, (0.3,0.8,0.3,0.6,0.4, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

3.8 Definition

The union of any two BPNS A = $\{T_A^+ , C_A^+, G_A^+, U_A^+, F_A^+, T_A^- , C_A^-, G_A^-, U_A^-, F_A^-\}$ and

B = $\{T_B^+ , C_B^+, G_B^+, U_B^+, F_B^+, T_B^- , C_B^-, G_B^-, U_B^-, F_B^-\}$ is denoted by A∪B and is defined as follows

A∪B = {max $\{T_A^+, T_B^+\}$, max $\{C_A^+, C_B^+\}$, min$\{G_A^+, G_B^+\}$, min $\{U_A^+, U_B^+\}$, min $\{F_A^+, F_B^+\}$,

min $(T_A^-, T_B^-\}$, min $(C_A^-, C_B^-\}$, max $(G_A^-, G_B^-\}$, max $(U_A^-, U_B^-\}$, max $(F_A^-, F_B^-\}$}

3.9 Example

Let X = {p, q}. Then the bipolar pentapartitioned neutrosophic subsets A and B of X can be given as follows.

$$A = \begin{cases} < p, (0.5, 0.7, 0.6, 0.2, 0.4, -0.1, -0.8, -0.5, -0.7, -0.7) > \\ < q, (0.4, 0.6, 0.7, 0.8, 0.3, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

$$B = \begin{cases} < p, (0.9, 0.2, 0.4, 0.7, 0.5, -0.7, -0.7, -0.5, -0.8, -0.1) > \\ < q, (0.5, 0.8, 0.3, 0.6, 0.4, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

Then the union of two BPNS A and B is

$$A \cup B = \begin{cases} < p, (0.9, 0.7, 0.4, 0.2, 0.4, -0.7, -0.8, -0.5, -0.7, -0.1) > \\ < q, (0.5, 0.8, 0.3, 0.6, 0.3, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

3.10 Definition

The intersection of any two BPNS $A = \{T_A^+, C_A^+, G_A^+, U_A^+, F_A^+, T_A^-, C_A^-, G_A^-, U_A^-, F_A^-\}$ and

$B = \{T_B^+, C_B^+, G_B^+, U_B^+, F_B^+, T_B^-, C_B^-, G_B^-, U_B^-, F_B^-\}$ is denoted by A∩B and is defined as follows

$A \cap B = \{\min\{T_A^+, T_B^+\}, \min\{C_A^+, C_B^+\}, \max\{G_A^+, G_B^+\}, \max\{U_A^+, U_B^+\}, \max\{F_A^+, F_B^+\},$

$\max\{T_A^-, T_B^-\}, \max(\{, C_B^-\}, \min\{G_A^-, G_B^-\}, \min\{U_A^-, U_B^-\}, \min\{F_A^-, F_B^-\}\}$

3.11 Example:

Let X = {p, q}. Then the bipolar pentapartitioned neutrosophic subsets A and B of X can be given as follows.

$$A = \begin{cases} < p, (0.5, 0.7, 0.6, 0.2, 0.4, -0.1, -0.8, -0.5, -0.7, -0.7) > \\ < q, (0.4, 0.6, 0.7, 0.8, 0.3, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

$$B = \begin{cases} < p, (0.9, 0.2, 0.4, 0.7, 0.5, -0.7, -0.7, -0.5, -0.8, -0.1) > \\ < q, (0.5, 0.8, 0.3, 0.6, 0.4, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

Then the intersection of two BPNS A and B is

$$A \cap B = \begin{cases} < p, (0.5, 0.2, 0.6, 0.7, 0.5, -0.1, -0.7, -0.5, -0.8, -0.7) > \\ < q, (0.4, 0.6, 0.7, 0.8, 0.4, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

3.12 Proposition

The set-theoretic axioms are satisfied by any BPNS as it can be easily verified. Consider BPNS sets *A*, *B*, *C* over the same universe *X*. Then the following properties holds all for BPNS over *X*.

(i) $A \cup B = B \cup A$
(ii) $A \cap B = B \cap A$.
(iii) $A \cup (B \cup C) = (A \cup B) \cup C$
(iv) $A \cap (B \cap C) = (A \cap B) \cap C$
(v) $A \cap (A \cup B) = A$
(vi) $A \cup (A \cap B) = A$.
(vii) $(A^c)^c = A$.
(viii) $(A \cup B)^c = A^c \cap B^c$
(ix) $(A \cap B)^c = A^c \cup B^c$
(x) $A \cup A = A \cup A$;
(xi) $A \cap A = A \cap A$.
(xii) $A \cup \emptyset = A$;
(xiii) $A \cap \emptyset = \emptyset$.
(xiv) $A \cup \emptyset = A$
(xv) $A \cap \emptyset = \emptyset$.

3.13 Definition

A bipolar pentapartitioned neutrosophic topology (BPNT) on a non empty X is a of BPN sets satisfying the following axioms.

[1] $0_x, 1_x \in \tau$
[2] $A \cap B \in \tau$ for any a,b $\in \tau$
[3] $\cup A_i \in \tau$ for any arbitrary family$\{A_i \in J\} \in \tau$

The pair (X, τ) is called Bipolar Pentapartitioned neutrosophic topological spaces (BPNTS).

Any BPN set in τ is called as BPN open set in X. The complement of BPN open set is BPN closed set.

3.14 Example

Let X = {p, q}. Then the bipolar pentapartitioned neutrosophic subsets A and B of X can be given as follows.

$$A = \begin{cases} < p, (0.5,0.7,0.6,0.2,0.4, -0.1, -0.8, -0.5, -0.7, -0.7) > \\ < q, (0.4,0.6,0.7,0.8,0.3, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

$$B = \begin{cases} < p, (0.9,0.2,0.4,0.7,0.5, -0.7, -0.7, -0.5, -0.8, -0.1) > \\ < q, (0.5,0.8,0.3,0.6,0.4, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

$$C = \begin{cases} < p, (0.9,0.7,0.4,0.2,0.4, -0.7, -0.8, -0.5, -0.7, -0.1) > \\ < q, (0.5,0.8,0.3,0.6,0.3, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

Then τ = { 0_X, 1_X, A, B, C} is a bipolar pentapartitioned neutrosophic topology on X

3.15 Definition

Let (X, τ) be a BPN topological space and A = $\{T_A^+, C_A^+, G_A^+, U_A^+, F_A^+, T_A^-, C_A^-, G_A^-, U_A^-, F_A^-\}$ be a BPN set in X. Then the closure and interior of A is defined as

Int(A) = ∪ {F: F is a BPN open set in X and F ⊆A}

Cl (A) = ∩{F: F is a BPN closed in X and F ⊆ A}

Here Cl(A) is BPN closed set and Int(A) is a BPN open set in X.

(a) A is BPN open set in X iff Int(A) = A

(b) A is BPN closed set in X iff Cl(A) = A

3.16 Example

Let X = {p, q} and τ = { 0_X, 1_X, A, B, C} where

$$A = \begin{cases} < p, (0.5,0.7,0.6,0.2,0.4, -0.1, -0.8, -0.5, -0.7, -0.7) > \\ < q, (0.4,0.6,0.7,0.8,0.3, -0.2, -0.5, -0.7, -0.8, -0.3) > \end{cases}$$

$$B = \begin{cases} < p, (0.9,0.2,0.4,0.7,0.5, -0.7, -0.7, -0.5, -0.8, -0.1) > \\ < q, (0.5,0.8,0.3,0.6,0.4, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

$$C = \begin{cases} < p, (0.9,0.7,0.4,0.2,0.4, -0.7, -0.8, -0.5, -0.7, -0.1) > \\ < q, (0.5,0.8,0.3,0.6,0.3, -0.3, -0.8, -0.3, -0.5, -0.2) > \end{cases}$$

Consider the BPN set D of X as

$$D = \begin{cases} < p, (0.7,0.8,0.3,0.1,0.2, -0.3, -0.9, -0.2, -0.7, -0.7) > \\ < q, (0.5,0.9,0.4,0.7,0.1, -0.4, -0.6, -0.4, -0.8, -0.3) > \end{cases}$$

Then Int(D) = A and Cl(D) = $!_X$.

3.17 Theorem

Let (X, τ) be a BPN topological space and S,T be BPN set in X. Then

1) Int (S) ⊆ S and S ⊆ Cl(S)
2) S ⊆ T Int(S) ⊆ $Int(T)$
3) S ⊆ T Cl(S) ⊆ Cl(T)
4) Int(Int(S)) = Int(S)
5) Cl(Cl(S)) = Cl(S)
6) Int (S T) = Int(S) Int(T)
7) Cl(S T) = Cl(S) Cl(T)
8) Int(1_X) = 1_X
9) Cl(0_X) = 0_X.

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