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Bipolar Quadripartitioned Neutrosophic Soft Set

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Abstract: The aim of this paper is to introduce the concept of bipolar quadripartitioned neutrosophic soft set and its properties are studied.

Keywords – neutrosophic set, neutrosophic soft set, quadripartitioned neutrosophic set, quadripartitioned neutrosophic soft set, bipolar neutrosophic set, bipolar quadripartitioned neutrosophic soft set.

I. Introduction

The fuzzy set was introduced by Zadeh [23] in 1965. F. Smarandache introduced the idea of the Neutrosophic set. It is a mathematical method for handling issues involving unreliable, indeterminate and inconsistent details.

A neutrosophic set[20] is proposed by F. Smarandache. The indeterminacy membership function walks along independently of the membership of the truth or the membership of falsity in neutrosophic sets. Neutrosophic theory has been extensively discussed in the treatment of real life conditions involving uncertainty by researchers for application purposes.

While the hesitation margin of neutrosophical theory is independent of membership in truth or falsehood, it still seems more general than intuitionist fuzzy sets. Recently, the relationships between inconsistent intuitionistic fuzzy sets, image fuzzy sets, neutrosophic sets, and intuitionistic fuzzy sets have been examined in Atanassov et al.[3]; however, it remains doubtful whether the indeterminacy associated with a particular element exists due to the element's ownership or non-belongingness. Chatterjee et al.[4] have pointed out this while implementing a more general structure of neutrosophic set viz. quadri partitioned single valued neutrosophic set (QSVNS). Molodtsov [8] first proposed the idea of Soft Sets as an entirely new mathematical method to solve problems dealing with uncertainties. A soft set is defined by Molodtsov [8] as a parameterized family of universe set subsets where each member is regarded as a set of approximate elements of the soft set. In the past few years, different researchers have researched the foundations of soft set theory.

Ramesh Kumar [16] initiated the idea of quadripartitioned neutrosophic soft sets and its topological spaces. Also he introduced the concept of pentapartitioned neutrosophic soft sets. Mumtaz Ali [9] introduced the concepts of bipolar neutrosophic soft sets and its application in decision making. The bipolar neutrosophic set was proposed by Ali et al.

This paper is dedicated to propose bipolar quadripartitioned neutrosophic soft set which is a hybrid structure of soft set and bipolar quadripartitioned neutrosophic set. Firstly, we introduce the bipolar quadripartitioned neutrosophic soft set and discuss some basic properties with illustrative examples

II. PRELIMINARIES

2.1 Definition [20]

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 $T_A, I_A, F_A: U \to [0,1]$ $and\ 0 \le T_A(x) + I_A(x) + F_A(x) \le 3$

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.

2.2 Definition [7]

Let X be a universe. A Quadripartitioned neutrosophic set A with independent neutrosophic components on X is an object of the form

$$A = \{< x, T_A(x), C_A(x), U_A(x), F_A(x) >: x \in X\}$$
$$and\ 0 \le T_A(x) + C_A(x) + U_A(x) + F_A(x) \le 4$$

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

2.3 Definition [6]

Let U be an initial universe set and E be a set of parameters or attributes with respect to U. Let P(U) denote the power set of U and A ⊆ U. A pair (F, A) is called a soft set over U, where F is a mapping given by F : A → P(U).
In other words, a soft set (F, A) over U is a parameterized family of subsets of U. For e ∈ A, F(e) may be considered as the set of e-elements or e-approximate elements of the sets (F, A). Thus (F, A) is defined as (F, A) = $\{F(e) \in P(X): \ e \in E, F(e) = \emptyset \ if e \notin A\}$.

2.3 Definition [15]

Let P be a non-empty set. A Pentapartitioned neutrosophic set A over P characterizes each element p in P a truth -membership function T_A , a contradiction membership function C_A, an ignorance membership function G_A, unknown membership function U_A and a false membership function F_A , such that for each p in P

$$T_A + C_A + G_A + U_A + F_A \leq 5$$

2.4 Definition [16]

Let X be the initial universe set and E be a set of parameters. Consider a non-empty set A and A ⊆ E. Let P(X) denote the set of all quadri partitioned neutrosophic sets of X. The collection (F, A) is termed to be the quadri partitioned neutrosophic soft set (QNSS) over X, where F is a mapping given by F : A⟶ P(X). Where

$$A = \{< x, T_A(x), C_A(x), U_A(x), F_A(x) >: x \in U\}$$

Where $T_A, F_A, C_A, U_A : X \longrightarrow [0,1]$ *and* $0 \leq T_A(x) + C_A(x) + U_A(x) + F_A(x) \leq 4$
Here $T_A(x)$ is the truth membership, $C_A(x)$ is contradiction membership, $U_A(x)$ is ignorance membership and $F_A(x)$ is the false membership.

2.5 Definition [16]

A Quadripartitioned neutrosophic soft set A is contained in another Quadripartitioned Neutrosophic Soft set B (i.e) A$\subseteq B$ if $T_A(x) \leq T_B(x)$,$C_A(x) \leq C_B(x)$, $U_A(x) \geq U_B(x)$ and $F_A(x) \geq F_B(x)$

2.6 Definition [16]

The complement of a Quadripartitioned neutrosophic Soft set (F, A) on X Denoted by$(F, A)^c$ and is defined as
F^c(x)= $\{< x, F_A(x), U_A(x), C_A(x), T_A(x) > : x \in X\}$

2.7 Definition [16]

Let X be a non-empty set, A = $< x, T_A(x), C_A(x), U_A(x), F_A(x) >$ and B = $< x, T_B(x), I_B(x), F_B(x) >$ are Quadripartitioned neutrosophic soft sets. Then

$$A \cup B = < x, max(T_A(x), T_B(x)), max(C_A(x), C_B(x)), min(U_A(x), U_B(x)), min(F_A(x), F_B(x)) >$$

$$A \cap B = < x, min(T_A(x), T_B(x)), min(C_A(x), C_B(x)), max(U_A(x), U_B(x)), max(F_A(x), F_B(x)) >$$

2.8 Definition [16]

A Quadripartitioned neutrosophic Soft set (F, A) over the universe X is said to be empty neutrosophic soft set with respect to the parameter A if
$T_{F(e)} = 0, C_{F(e)} = 0, U_{F(e)} = 1, F_{F(e)}$=1, $\forall x \in X, \forall e \in A$. It is denoted by 0_N

2.9 Definition [16]

A Quadripartitioned neutrosophic soft set (F, A) over the universe X is said to be universe neutrosophic soft set with respect to the parameter A if $T_{F(e)} = 1, C_{F(e)} = 1, U_{F(e)} = 0, F_{F(e)}$=0, $\forall x \in X, \forall e \in A$. It is denoted by 1_N

2.10 Definition [5]

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

$$A = \{< x, T^+{}_A(x), I^+{}_A(x), F^+{}_A(x), T^-{}_A(x), I^-{}_A(x), F^-{}_A(x) >: x \in X\}$$

Where $T^+{}_A, I^+{}_A, F^+{}_A : U \rightarrow [0,1]$ *, and* $T^-{}_A, I^-{}_A, F^-{}_A : U \rightarrow [-1,0]$
Here $T^+{}_A$ is the positive degree of membership, $I^+{}_A$ is the positive degree of indeterminancy and $F^+{}_A$ is the positive degree of non-membership, $T^-{}_A$ is the negative degree of membership, $I^-{}_A$ is the negative degree of indeterminancy and $F^-{}_A$ is the negative degree of non-membership.

2.11 Definition [7]

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

$$A = \{< x, T^+_A(x), C^+_A(x), U^+_A(x), F^+_A(x), T^-_A(x), C^-_A(x), U^-_A(x), F^-_A(x) >: x \in X\}$$

Where $T^+_A, C^+_A, U^+_A, F^+_A : U \to [0,1]$, *and* $T^-_A, C^-_A, U^-_A, F^-_A : U \to [-1,0]$
Here T^+_A is the positive degree of truth membership, C^+_A is the positive degree of contradiction , U^+_A is the positive degree of ignorance membership and F^+_A is the positive degree of non-membership, T^-_A is the negative degree of membership, C^-_A is the negative degree of contradiction membership, U^-_A is the negative degree of ignorance membership and F^-_A is the negative degree of falsity membership.

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III. BIPOLAR QUADRIPARTITIONED NEUTROSOPHIC SOFT SET

3.1 Definition

Let X be the initial universe set and E be a set of parameters. Consider a non-empty set A and A ⊆ E. Let P(X) denote the set of all quadripartitioned neutrosophic sets of X. The collection (F, A) is termed to be the bipolar quadripartitioned neutrosophic soft set (BQNSS) over X, where F is a mapping given by F : A⟶ P(X). Where

$$A = \{< e, \{< x, T^+_A(x), C^+_A(x), U^+_A(x), F^+_A(x), T^-_A(x), C^-_A(x), U^-_A(x), F^-_A(x) >: x \in X\} >: e \in E\}$$

Where $T^+_A, C^+_A, U^+_A, F^+_A : U \to [0,1]$, *and* $T^-_A, C^-_A, U^-_A, F^-_A : U \to [-1,0]$
Here T^+_A is the positive degree of truth membership, C^+_A is the positive degree of contradiction , U^+_A is the positive degree of ignorance membership and F^+_A is the positive degree of non-membership, T^-_A is the negative degree of membership, C^-_A is the negative degree of contradiction membership, U^-_A is the negative degree of ignorance membership and F^-_A is the negative degree of falsity membership.

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3.2 Example

Let X={ x1,x2,x3}, E=(e1,e2}. Then bipolar quadripartitioned neutrosophic soft sets A over U is given by
A = {(e1,{(u1,0.6,0.8,0.3,0.2,- 0.6,- 0.7,- 0.4,- 0.3),(u2,0.7,0.8,0.3,0.2,- 0.6,- 0.7, -0.4,- 0.3),
(u3,0.7,0.8,0.3,0.2,- 0.6, - 0.8, -0.8, -0.9)}),(e2,{(u1,0.9,0.8,0.9,0.7,- 0.6,- 0.7,- 0.4, - 0.3),
(u2,0.5,0.8,0.9,0.8,- 0.6,- 0.7,- 0.4, - 0.3),(u3,0.8,0.8,0.3,0.2,- 0.5,- 0.7, - 1.6, - 0.5)})}

3.3 Definition

A bipolar quadripartitioned neutrosophic soft set A is contained in another bipolar quadripartitioned Neutrosophic Soft set B (i.e) A⊆ B if $T^+_A(x) \le T^+_B(x)$, $C^+_A(x) \le C^+_B(x)$, $U^+_A(x) \ge U^+_B(x)$, $F^+_A(x) \ge F^+_B(x)$, $T^-_A(x) \le T^-_B(x)$, $C^-_A(x) \le C^-_B(x)$, $U^-_A(x) \ge U^-_B(x)$ and $F^-_A(x) \ge F^-_B(x)$

3.4 Definition

The complement of a bipolar quadripartitioned neutrosophic Soft set (F, A) on X Denoted by$(F,A)^c$ and is defined as
$F^c(x) = \{< e, \{< x, F^+_A(x), U^+_A(x), C^+_A(x), T^+_A(x), F^-_A(x), U^-_A(x), C^-_A(x), T^-_A(x) >: x \in X\} >: e \in E\}$

3.5 Definition

Let X be a non-empty set,
$A = \{< e, \{< x, T^+_A(x), C^+_A(x), U^+_A(x), F^+_A(x), T^-_A(x), C^-_A(x), U^-_A(x), F^-_A(x) >: x \in X\} >: e \in E\}$ and

$$B = \{< e, \{< x, T^+_B(x), C^+_B(x), U^+_B(x), F^+_B(x), T^-_B(x), C^-_B(x), U^-_B(x), F^-_B(x) >: x \in X\} >: e \in E\}$$

are two bipolar quadripartitioned neutrosophic soft sets. Then

$$A\cup B = \{(e,(x, max\left(T^+_A(x), T^+_B(x)\right), max\left(C^+_A(x), C^+_B(x)\right), min\left(U^+_A(x), U^+_B(x)\right), \min(F^+_A(x), F^+_B(x))\}$$

$$A\cap B = \{(e,(x, min\left(T^+_A(x), T^+_B(x)\right), min\left(C^+_A(x), C^+_B(x)\right), max\left(U^+_A(x), U^+_B(x)\right), \max(F^+_A(x), F^+_B(x))\}$$

3.6 Definition

A bipolar quadripartitioned neutrosophic Soft set (F, A) over the universe X is said to be empty bipolar quadripartitioned neutrosophic soft set with respect to the parameter A if
$T^+_{F(e)} = 0, C^+_{F(e)} = 0, U^+_{F(e)} = 1, F^+_{F(e)}=1, T^-_{F(e)} = -1, C^-_{F(e)} = -1, U^-_{F(e)} = 0, F^-_{F(e)}=0$, $\forall x \in X, \forall e \in A$. It is denoted by 0_N

3.7 Definition

A bipolar quadripartitioned neutrosophic Soft set (F, A) over the universe X is said to be universe bipolar quadripartitioned neutrosophic soft set with respect to the parameter A if
$T^{+}{}_{F(e)} = 1, C^{+}{}_{F(e)} = 1, U^{+}{}_{F(e)} = 0, F^{+}{}_{F(e)}=0,\ T^{-}{}_{F(e)} = 0, C^{-}{}_{F(e)} = 0, U^{-}{}_{F(e)} = -1, F^{-}{}_{F(e)} = -1,\quad \forall x \in X, \forall e \in A.$ It is denoted by 0_N

3.8 Definition

Let A and B be two bipolar quadripartitioned neutrosophic soft sets on X then A\B may be defined as

$$A\backslash B = \{e, < x, min(T^{+}{}_{A}, F^{+}{}_{B}), min(C^{+}{}_{A}, U^{+}{}_{B}), max(I^{+}{}_{A}, 1 - I^{+}{}_{B}), \max(U^{+}{}_{A}, C^{+}{}_{B}), \max(F^{+}{}_{A}, T^{+}{}_{B}),$$
$$min(T^{-}{}_{A}, F^{-}{}_{B}), min(C^{-}{}_{A}, U^{-}{}_{B}), max(I^{-}{}_{A}, 1 - I^{-}{}_{B}), max(U^{-}{}_{A}, C^{-}{}_{B}), max(F^{-}{}_{A}, T^{-}{}_{B} >$$

3.9 Definition

The Set F_E is called absolute bipolar quadripartitioned neutrosophic soft set over X if F(e) =Δ for any $e \in E$. We denote it by X_E

3.10 Definition

The set F_E is called relative null bipolar quadripartitioned neutrosophic soft set over X if F(e) = $\emptyset$ for any $e \in E$. We denote it by $\emptyset_E$

Obviously $\emptyset_E = X_E^c$ and $X_E = \emptyset_E^c$

3.11 Definition

The complement of a bipolar quadripartitioned neutrosophic soft set (F, A) over X can also be defined as $(F, A)^c = U_E \backslash F(e)$ for all $e \in A$.

Note: We denote X_E by X in the proofs of proposition.

3.12 Definition

If (F, A) and (G, B) be two bipolar quadripartitioned neutrosophic soft set then "(F, A) AND (G, B)" is a denoted by (F, A) ∧(G, B) and is defined by (F, A)∧ (G, B) = (H, A ×B)
where H (a, b) = F(a) ∩ G(b) $\forall a \in A$ and $\forall b \in B$, where ∩ is the operation intersection of bipolar quadripartitioned neutrosophic soft set.

3.13 Definition

If (F, A) and (G, B) be two bipolar quadripartitioned neutrosophic soft set then "(F, A) OR (G, B)" is a denoted by (F, A) ∨(G, B) and is defined by (F, A)∨ (G, B) = (K, A ×B)
where K (a, b) = F(a) ∪ G(b) $\forall a \in A$ and $\forall b \in B$, where ∪ is the operation union of bipolar quadripartitioned neutrosophic soft set.

3.14 Theorem

Let (F, A) and (G, A) be two bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) (F, A)⊆ (G, A) iff (F, A) ∩ (G, A) = (F, A)
(ii) (F, A)⊆ (G, A) iff (F, A) ∪ (G, A) = (F, A)

Proof:

(i)Suppose that (F, A)⊆ (G, A),
then F(e) ⊆G(e) for all e∈ A.
Let (F, A) ∩ (G, A) = (H, A).
Since H(e) = F(e) ∩ G(e) =F(e) for all e∈ A,
by definition (H, A) = (F, A).
Suppose that (F, A) ∩ (G, A) = (F, A).
Let (F, A) ∩ (G, A) = (H, A).
Since H(e) = F(e) ∩ G(e) =F(e) for all e∈ A,
we know that F(e)⊆ G(e) for all e∈ A.
Hence (F, A)⊆ (G, A).

(ii)The proof is similar to (i).

3.15 Theorem

Let (F, A), (G, A), (H, A), and (S, A) are bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) If (F, A) ∩ (G, A) =$\emptyset_A$, then (F, A)⊆ (G, A)^c
(ii) If (F, A)⊆ (G, A) and (G, A)⊆ (H, A) then
(F, A)⊆ (H, A)
(iii) If (F, A)⊆ (G, A) and (H, A)⊆ (S, A) then
(F, A) ∩ (H, A) ⊆ (G, A) ∩ (S, A)
(iv) (F, A)⊆ (G, A) iff (G, A)^c ⊆ (F, A)^c

Proof:

(i)Suppose that (F, A) ∩ (G, A) =$\emptyset_A$.
Then F(e)∩ G(e) = ∅.
So, F(e)⊆ U\G(e)=$G^c(e)$ for all e∈ A.
Therefore, we have(F, A)⊆ (G, A)^c
Proof of (ii) and (iii) are obvious.
(iv) suppose that(F, A)⊆ (G, A)
⟺ F(e)⊆ G(e) for all e∈ A.
⟺ (G(e))^c ⊆ (F(e))^c for all e ∈ A.
$\Leftrightarrow\ G^c(e)\ \subseteq\ F^c(e)\ for\ all\ e\ \in\ A.$
⟺(G, A)^c ⊆ (F, A)^c

3.16 Definition

Let I be an arbitrary index $\{(F_i, A)\}_{i\in I}$be a subfamily of bipolar quadripartitioned neutrosophic soft set over the universe X.
(i)The union of these bipolar quadripartitioned neutrosophic soft set is the bipolar quadripartitioned neutrosophic soft set (H, A) where H(e) = $\bigcup_{i\in I} F_i\,(e)$ for each e∈ A.
$We\ write\ \bigcup_{i\in I}(F_i\,, A)$= (H, A)

(ii)The intersection of these bipolar quadripartitioned neutrosophic soft set is the bipolar quadripartitioned neutrosophic soft set (M, A) where M(e) = $\bigcap_{i\in I}\ F_i(e)$ for each e∈ A.
$We\ write\ \bigcap_{i\in I}(F_i, A)$= (M, A)

3.17 Theorem

Let I be an arbitrary index set and $\{(F_i, A)\}_{i\in I}$be a subfamily of bipolar quadripartitioned neutrosophic soft set over the universe X. Then

(i) $(\bigcup_{i\in I}(F_i\,, A))^C = \bigcap_{i\in I}(F_i, A)^C$
(ii) $(\bigcap_{i\in I}(F_i, A))^C = \bigcup_{i\in I}(F_i\,, A)^C$

Proof:

(i) $(\bigcup_{i\in I}(F_i\,, A))^C$ = (H, A) ^{C},
By definition H^C(e) =X_E\H(e) =$X_E\backslash\bigcup_{i\in I} F_i\,(e)$
=$\bigcap_{i\in I}(X_E\backslash F_i(e))$ for all e ∈ A.
On the other hand, $(\bigcap_{i\in I}(F_i, A))^C$ = (K, A).
By definition, K(e)=$\bigcap_{i\in I} F_i^C(e)$=$\bigcap_{i\in I}(X - F_i(e))$ for all e ∈ A.
(ii) It is obvious.

Note: We denote $\emptyset_E$ by ∅ and X_E $by\ X$.

3.18 Theorem

Let (F, A) be bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.

(i) (∅,A)^c = (X, A)
(ii) (X, A)^c = $(\emptyset, A)$

3.19 Theorem

Let (F, A) be bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) (F, A)∪ (∅, A) = (F, A)
(ii) (F, A)∪ (X ,A) = (X, A)

3.20 Theorem

Let (F, A) be bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) (F, A)∩ (∅, A) = (∅, A)
(ii) (F, A)∩ (X, A) = (F, A)

3.21 Theorem

Let (F, A) and (G, B) are bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) (F, A)∪ (∅, B) = (F, A) iff B⊆A
(ii) (F, A)∪ (X, B) = (X, A) iff A⊆ B

3.22 Theorem

Let (F, A) and (G, B) are two bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) (F, A)∩ (∅, B) = (∅, A∩B)
(ii) (F, A)∩ (X, B) = (F, A∩B)

3.23 Theorem

Let (F, A) and (G, B) be bipolar quadripartitioned neutrosophic soft set over the universe X. Then the following are true.
(i) ((F, A)∪ (G, B))^C⊆ (F, A)^C∪(G, B)^C
(ii) (F, A)^C ∩(G, B)^C⊆((F, A)∩ (G, B))^C

3.24 Theorem

Let (F, A) and (G, A) are two bipolar quadripartitioned neutrosophic soft sets over the same universe X. We have the following
(i) ((F, A)∪ (G, A))^C = (F, A)^C ∩(G, A)^C
(ii) ((F, A)∩(G, A))^C = (F, A)^C∪(G, A)^C

IV. CONCLUSION

In this paper, we introduced the bipolar quadripartitioned neutrosophic soft set that combines soft sets and bipolar quadripartitioned neutrosophic sets. Some new operations on bipolar quadripartitioned neutrosophic soft sets were designed. In future, we will study with decision making problems such as medical diagnosis, image clustering etc.

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