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Abstract: In this article we have investigated some properties of netrosophic multiset topology. The behavior of compactness and connectedness in netrosophic multiset topology, continuous function on netrosophic multiset topology etc have been examined. Neutrosophic multiset is a generalization of multisets and neutrosophic sets. Several properties of neutrosophic topological space in view of neutrosophic multiset topological space have been studied.

Keywords: Neutrosophic Multiset; Neutrosophic Minimal set; Neutrosophic Maximal set; Neutrosophic Multiset topology; Compactness, Connectedness; Continuous Neutrosophic Multiset; Separation axioms; Distance function.

1. Introduction

In recent years, multisets and neutrosophic sets have become a subject of great interest for researchers. Mathematicians always like to solve a complicated problem in a simple way and to find out the most feasible solution. Neutrosophy has been introduced and studied by Smarandache [13, 15] as a new branch of philosophy. Recently various papers published on neutrosophic topology and many researchers doing very well, neutrosophic decision making had been studied in [15, 17]. Algebraic properties of neutrosophic set studied in [9, 13], Neutrosophic Bipolar Vague Soft Set, and its property studied in [9]. Smarandache generalizes intuitionistic fuzzy sets (IFSs) and other kinds of sets to neutrosophic sets (NSs). In Smarandache [12, 13], some distinctions between NSs and IFSs are underlined. decision-making problem, algebraic property one can analysis by topological property connectedness and compactness property that property can help to take the decision into a more reliable way. Smarandache [13, 14, 15] also defined various notions of neutrosophic topologies on the non-standard interval. The logic of the neutrosophic set is very clear and its utilization on topology is very beneficial for many standard problems like diagnosis of bipolar disorder diseases group decision making and analytical property and evaluation Hospital medical care systems etc. [1, 9, 13]. The relation between the intuitionistic fuzzy topology (IFT) on an IFS and the neutrosophic topology are also analyzed by Smarandache.

Multiset theory was introduced by Bilzard [3]. Later on multiset topological space was studied by many researcher Shravan and Tripathy [17, 18, 19]. The purpose of this paper is to construct a new generalization of topological space called the neutrosophic multiset topological space. The possible application of neutrosophic multiset topological space has been studied. For the different types of behavior of objects in nature sometimes set theory and multiset theory fails to describe some particular situation. Sometimes it is observed that Neutrosophic Multiset can be described in an easier way to handle such cases. Neutrosophic set and topological space have been studied by Salama and Alblowi [10, 11]. The concept of multiset topological space has been applied for studying different properties of spatial objects. In this article we have used multiset neutrosophic topological space for studying various spatial topological properties, like closeness connectedness and the completeness property and its application further in various fields.

2. Materials and Methods

We procure some existing definitions in this paper, one may refer to Smarandache ([13], [15]) and S. Alias, et.al [2].

We define functions T, F and I from X to [0, 1]. Where T is membership value, F fails membership value and I is the indeterminacy value.

The definition of neutrosophic multiset was first define by Smarandache [12] as follows.

Definition 2.1. [12] A Neutrosophic Multiset is a neutrosophic set where one or more elements are repeated with the same neutrosophic components, or with different neutrosophic components.

Definition 2.2. The Empty neutrosophic multiset is denoted by N_Θ and define by

$N_\Theta = \{<x_{(0,1,1)}> : \forall x \in X\}$ where x can be repeated.

Definition 2.3. The Whole neutrosophic multiset is denoted by W_X and define by

$W_X = \{<x_{(1,0,0)}> : \forall x \in X\}$ where x can be repeated.

The power set of neutrosophic multiset is denoted by $P(X)$.

The collection of all possible subsets of X is called the power set of the netrosophic multiset.

Definition 2.4. Let $A = \{(x_{<T_{A(x)}, I_{A(x)}, F_{A(x)}>}): x \in X\}$ be a neutrosophic multiset on X then the compliment of A is denoted by A^c and define by

$A^c = \{(x_{<F_{A(x)}, 1-I_{A(x)}, T_{A(x)}>}): x \in X\}$.

Where x can be repeated based on its multiplicity and the corresponding T, F, I values may or may not be equal.

Definition 2.5. The intersection of *NM* sets are defined by $A \cap B = \{x: x \in A \text{ and } x \in B\}$.

Definition 2.6. The union of *NM* sets are defined by $A \cup B = \{x: x \in A \text{ or } x \in B\}$.

Definition 2.7. In the *NM* sets $A \subset B$ if $x \in A$ implies that $x \in B$.

Definition 2.8. Cardinality of a *NM* set *A* is denote the number of elements in a set *A* which is define by card(*A*).

Definition 2.9. The Cartesian product of two neutrosophic multiset is defined by $A \times B = \{(x, y) : x \in A$ and $y \in B\}$.

Definition 2.10 The difference of two *NM* sets *A* and *B* is the collection of members such that all members belong to *A* but not in *B*.

Now we introduce two new types of operation maximal union *NM* set and minimal intersection *NM* set.

Definition 2.11. Let *X* be a non-empty set, and neutrosophic multiset *A* and *B* in the form $A = \{(x_{<T_{A(x)}, I_{A(x)}, F_{A(x)}>}): x \in X\}$ and $B = \{(x_{<T_{B(x)}, I_{B(x)}, F_{B(x)}>}): x \in X\}$, then the operations of maximal union and minimal intersection *NM* set relation are defined as follows:

1. $(A \cup B)_{\max} = \{(x_{<T_{(A\cup B)_{max}}(x), I_{(A\cup B)_{max}}(x)}\ {}_{F_{(A\cup B)_{max}}(x)}): x \in X\}$, where $T_{(A\cup B)_{max}}(x) = \max\{T_{A(x)}, T_{B(x)}\}$, $F_{(A\cup B)_{max}}(x) = \min\{T_{A(x)}, T_{B(x)}\}$ and $I_{(A\cup B)_{max}}(x) = \min\{I_{A(x)}, I_{B(x)}\}$.

2. $(A \cap B)_{\min} = \{(x_{<T_{(A\cap B)_{min}}(x), I_{(A\cap B)_{min}}(x)}\ {}_{F_{(A\cap B)_{min}}(x)>}) : x \in X\}$, where $T_{(A\cap B)_{min}}(x) = \min\{T_{A(x)}, T_{B(x)}\}$ and $F_{(A\cap B)_{min}}(x) = \max\{F_{A(x)}, F_{B(x)}\}$ and $I_{(A\cap B)_{min}}(x) = \max\{I_{A(x)}, I_{B(x)}\}$.

Example 2.1. Let $X = \{x, y, z, t\}$ and $A = \{x_{<0.7, 0.2, 0.3>}, x_{<0.7, 0.2, 0.3>}, y_{<0.3, 0.2, 0.7>}, y_{<0.9, 0.3, 0.1>}, z_{<0.0, 1, 1>}, t_{<0.5, 0.7, 0.5>}\}$, $B = \{x_{<0.7, 0.2, 0.3>}, x_{<0.8, 0.5, 0.2>}, y_{<0.3, 0.2, 0.7>}, y_{<0.3, 0.2, 0.7>}, z_{<0.7, 0.8, 0.3>}, t_{<0.0, 1, 1>}\}$ be neutrosophic multisets, then the maximal union and minimal intersection are

$(A \cup B)_{\text{Max}} = \{x_{<0.8, 0.2, 0.2>}, y_{<0.9, 0.2, 0.1>}, z_{<0.7, 0.7, 0.3>}, t_{<0.5, 0.7, 0.5>}\}$ and

$(A \cap B)_{\text{Min}} = \{x_{<0.7, 0.5, 0.3>}, y_{<0.3, 0.3, 0.7>}, z_{<0.0, 1, 1>}, t_{<0.0, 1, 1>}\}$

We formulate the following results without proof.

Result 2.1. Union of any family of neutrosophic multisets is always a neutrosophic multiset.

Result 2.2. Intersection of any family of neutrosophic multisets is always a neutrosophic multiset.

Result 2.3. The compliment of a neutrosophic multiset is always a neutrosophic multiset.

Result 2.4. Every neutrosophic set is a neutrosophic multiset but not necessarily conversely.

Example 2.2. Let $A = \{8_{\langle 0.6, 0.3, 0.2\rangle}, 8_{\langle 0.6, 0.3, 0.2\rangle}, 8_{\langle 0.4, 0.1, 0.3\rangle}, 7_{\langle 0.2, 0.7, 0.0\rangle}\}$.
Here A is a neutrosophic multiset but not a neutrosophic set.

Result 2.5. Let $\{A_j : j \in \Lambda\}$ be an arbitrary family of NM set in X , then the arbitrary maximal union and arbitrary minimal intersection is also a NM set.

Remark 2.1. A neutrosophic multiset is a natural generalization of multiset as well as Cantor set.

We introduced neutrosophic multiset topological space and study some of its properties.

Definition 2.12. Let X be neutrosophic multiset and a non-empty family τ subsets of W_X is said to be neutrosophic multiset topological space if the following axioms hold:

1. $N_\Theta, W_X \in \tau$.
2. $A \cap B \in \tau$, for $A, B \in \tau$.
3. $\bigcup_{i \in \Lambda} A_i \in \tau$, for $\forall \{A_i : i \in \Lambda\} \in \tau$

In this case the pair (W_X, τ) is called a neutrosophic multiset topological space (*NMTS* in short) and any neutrosophic multiset in τ is known as open neuterosophic multiset (*ONMS* in short) in W_X . The elements of τ^c are called closed neutrosophic multisets, otherwise a neutrosophic set F is closed if and only if its complement F^c is an open neutrosophic multiset.

Definition 2.13. Let (W_X, τ_1) and (W_X, τ_2) be two neutrosophic multiset topological spaces on W_X. Then τ_1 is said be contained in τ_2 that is if $\tau_1 \subseteq \tau_2$ i.e, $A \in \tau_2$ for each $A \in \tau_1$. In this case, we also say that τ_1 is coarser than τ_2.

Definition 2.14. Let (W_X, τ) be a neutrosophic multiset topological space on W_X. A non-empty family of subsets β of X is called neutrosophic multiset basis of the neutrosophic multiset topological space W_X if any element of τ can be express as the union of the element of β.

Remark 2.2. As usual, basis of a neutrosophic multiset topological space is not unique.

Definition 2.15. Let (W_X, τ) be a neutrosophic multiset topological space with base β. The interior of the neutrosophic multiset A is the union of basis element of τ which is contained in A and it is denoted by $NM_{int}A$, i.e, $NM_{int}(A) = \{ \cup\beta_i : \beta_i \subseteq A$ and $\beta_i \in \beta\}$.

Definition 2.16. Let (W_X, τ) be a neutrosophic multiset topological space. The closure of the neutrosophic multiset A is the intersection of all closed neutrosophic multiset containing the set A it is denoted by $NM_{Cl}(A)$, i.e, $NM_{Cl}(A) = \{\cap F_i : A \subseteq F_i$ and $F_i^c \in \tau$ }.

In view of the definitions, we formulate the following result.

Proposition 2.1. Let (W_X, τ) be a neutrosophic multiset topological space and A, B be two neutrosophic multiset on W_X, then the following property hold:

1. $NM_{int}A \subseteq A$.
2. $A \subseteq B \Rightarrow NM_{int}(A) \subseteq NM_{int}(B)$.
3. $A \subseteq NM_{Cl}(A)$.
4. $A \subseteq B \Rightarrow NM_{Cl}(A) \subseteq NM_{Cl}(B)$
5. $NM_{int}(NM_{int}(A)) = NM_{int}(A)$.
6. $NM_{Cl}(NM_{Cl}(A)) = NM_{Cl}(A)$.
7. $NM_{Cl}(A \cup B) = NM_{Cl}(A) \cup NM_{Cl}(B)$.
8. $NM_{int}(W_X) = W_X$.
9. $NM_{Cl}(N_\Theta) = N_\Theta$.

Definition 2.17. Let (W_X, τ) be a neutrosophic multiset topological space a non-empty set S is called a subbasis if the finite intersection of the elements of S can form a basis for τ.

Definition 2.18. Let (W_X, τ) be a neutrosophic multiset topological space a point $P \in A \subseteq W_X$ is said to be a limit point of A if for every basis element β containing p contains one element of A other than p, i.e, $\beta \cap A \neq N_\Theta$.

3. Results

3.1. Compactness, Connectedness and Continuous map.

Definition 3.1.1. Let (W_X, τ) be a neutrosophic multiset topological space. A neutrosophic multiset A is said to be disjoint if $\exists$ two neutrosophic multisubsets B, C such that $B \cap C = N_\Theta$ and A = $B \cup C$.

Definition 3.1.2. Let (W_X, τ) be a neutrosophic multiset topological space. The space W_X is said to be connected if W_X cannot be express as the union of two disjoint neutrosophic multisets.

Definition 3.1.3. Let (W_X, τ) be a neutrosophic multiset topological space. The space W_X is said to be compact if every open cover of W_X has a finite subcover.

Proposition 3.1.1. Every finite neutrosophic multiset topological space is compact.

Definition 3.1.4. Let (W_X, τ_1) and (W_X, τ_2) be two neutrosophic multiset topological space. The *NMS* function $f : (W_X, \tau_1) \rightarrow (W_X, \tau_2)$ is said to be continuous if for each open neutrosophic multiset V of τ_2 the neutrosophic multiset $f^{-1}(V)$ is an open submset of τ_1.

Proposition 3.1.2. Let f be a continuous function from a *NMS* topological space (W_X, τ_1) to another *NMS* topological space (W_X, τ_2), the function f is said to be a homomorphism if $f(A \cup B) = f(A) \cup f(B)$ where $A, B \in \tau_1$ and $f(A)$, $f(B) \in \tau_2$.

3.2. Separation axioms on neutrosophic multiset.

We have defined disjoint neutrosophic multiset, connectedness, compactness and the continuous image of neutrosophic multiset topological space. In this section we define separation axioms on *NMS* topological space.

In the *NMS* a singleton set $\{p\}$ is define by $\{p\} = \{x_{<T_{(x)}, I_{(x)}, F_{(x)}>}: T_{(x)} \neq 0$, when $x = p$ otherwise $T_{(x)} = 0$, $I_{(x)} = 1 - T_{(x)}$ and $F_{(x)} = 1 - T_{(x)}$ for all $x \in W_X\}$.

Where x can be occurs more than one times it's depends on its multiplicity and then T, F, I value may or may not be equal.

Definition 3.2.1. Let (W_X, τ) be a neutrosophic multiset topological space. If there exist only two open neutrosophic multiset in (W_X, τ) is called indiscrete *NMS* topological space.

Definition 3.2.2. Let (W_X, τ) be a neutrosophic multiset topological space. If every singleton neutrosophic multiset is an open *NMS* set then (W_X, τ) is called discrete *NMS* topological space.

Definition 3.2.3. Let (W_X, τ) be a neutrosophic multiset topological space. If for every two distinct *NMS* singleton sets, $\{x_1\}$; $\{x_2\}$ then there exist $V, U \in \tau$ such that$\{x_1\} \subseteq V$ and $\{x_2\} \not\subset V$ or $\{x_2\} \subseteq U$ and $\{x_1\} \not\subset U$. Hence, (W_X, τ) is $NMST_o$-space. i.e., there exists τ-open *NMS* which contains one of them but not the other.

Definition 3.2.4. Let (W_X, τ) be a neutrosophic multiset topological space. If for every two distinct *NMS* singleton sets, $\{x_1\}$; $\{x_2\}$ then there exist $V,U \in \tau$ such that$\{x_1\} \subseteq V$ and $\{x_2\} \not\subset V$ and $\{x_2\} \subseteq U$ and $\{x_1\} \not\subset U$. Hence, (W_X, τ) is $NMST_1$-space.

Definition 3.2.5. Let (W_X, τ) be a neutrosophic multiset topological space. If for every two distinct *NMS* singleton sets, $\{x_1\}$; $\{x_2\}$ then there exist $V,U \in \tau$ such that$\{x_1\} \subseteq V$ and $\{x_2\} \not\subset V$ and $\{x_2\} \subseteq U$ and $\{x_1\} \not\subset U$ and $U \cap V = N_\Theta$. Hence, (W_X, τ) is $NMST_2$-space.

Proposition 3.2.1. Every $NMST_2$-space is $NMST_1$-space but it is not necessarily conversely.

Example 3.2.1. In co-finite neutrosophic multiset topological space is not a $NMST_2$-space but when the space has the finite neutrosophic multiset topology then it is $NMST_1$-space.

So when we consider the infinite neutrosophic multiset topology we can get our desire result.

Proposition 3.2.2. Every $NMST_1$-space is $NMST_0$-space but it is not necessarily conversely.

Example 3.2.2. Let $W_X = \{x_{<0.5, 0.7, 0.5>}, x_{<0.5, 0.7, 0.5>}, y_{<0.3, 0.4, 0.7>}\}$ and $\tau = \{W_X, N_\Theta, \{y\}\}$.

Here (W_X, τ) is a $NMST_0$-space but it is not a $NMST_1$.

Proposition 3.2.3. Every $NMST_2$-space is $NMST_0$-space but it is not necessarily conversely.

Example 3.2.3. Since every $NMST_0$-space is not a $NMST_1$-space and every $NMST_1$-space is not a $NMST_2$-space so every $NMST_0$-space is not a $NMST_2$-space.
Proposition 3.2.4. Every discrete *NMS* topological space is $NMST_2$-space.

3.3. Distance function on NMS.

In this section we are going to define a distance function on Neutrosophic set. Since in Neutrosophic set we have defined Neutrosophic elements, Neutrosophic subset so it is natural to ask, can we measure the distance between two Neutrosophic points or two Neutrosophic sets or is there any distance between a Neutrosophic point to a Neutrosophic set?

The distance function between multiset points is defined by Shravan and Tripathy [12], based on the multiplicity and the elements.

The Neutrosophic point p of a Neutrosophic multiset W_X is define by $p = \{(T_{(x)}, \mathrm{I}_{(x)}, \mathrm{F}_{(x)}): T_{(x)} \neq 0$, when $x=p$, otherwise $T_{(x)}= 0$, $\mathrm{I}_{(x)} = 1\text{-}T_{(x)}$ and $\mathrm{F}_{(x)} = 1\text{-}T_{(x)}$ for all $x \in W_X\}$.

Note: The Neutrosophic point p can have multiple time it's depends on its multiplicity.

Definition 3.3.1. Let x, y be two Neutrosophic points on a Neutrosophic set W_X. The distance between the points is denoted by $\bar{d}(x, y)$ and is define by $\bar{d}(x, y) = \sup\{|x\text{-}y|, |T_{(x)} - T_{(y)}|, |\mathrm{I}_{(x)} - \mathrm{I}_{(y)}|, |\mathrm{F}_{(x)} - \mathrm{F}_{(y)}|\}$, where the distance function $\bar{d}$ is define by, $\bar{d}: W_X \rightarrow R^+ \cup \{0\}$.

Definition 3.3.2. Let x be a Neutrosophic point and A be a subset on a Neutrosophic set W_X. The distance between the point x and set the A is denoted by $\bar{d}(x, A)$ and is define by $\bar{d}(x, B)$ =inf-sup{$|x-y_i|$, $|T_{(x)} - T_{(y)_i}|$, $|I_{(x)} - I_{(y)_i}|$, $|F_{(x)} - F_{(y)_i}|$: for all $y_i \in A$}.

Definition 3.3.3. Let A, B be two Neutrosophic subset of a Neutrosophic set W_X the distance between the sets A and set B is denoted by $\bar{d}(A, B)$ and is define by $\bar{d}(A, B)$ =inf sup{$|x_i - y_i|$, $|T_{(x)_i} - T_{(y)_i}|$, $|I_{(x)_i} - I_{(y)_i}|$, $|F_{(x)_i} - F_{(y)_i}|$: $\forall x_i \in A$, and $y_i \in B$}.

From the definition 5.1, 5.2 and 5.3 we can define another definition of matric space on a Neutrosophic multiset.

Definition 3.3.4. A non-empty Neutrosophic set W_X is said to be a Neutrosophic metric space with the distance function $\bar{d}$: $W_X X W_X \rightarrow R_+ \cup \{0\}$, if W_X satisfy following:

1. $\bar{d}(x,y) \geq 0$, $\forall x, y \in W_X$.
2. $\bar{d}(x,y)=0$, *iff* $x=y$ and $T_{(x)_i} = T_{(y)_i}$, $F_{(x)_i} = F_{(y)_i}$, $I_{(x)_i} = I_{(y)_i}$.
3. $\bar{d}(x,y) = \bar{d}(y,x)$, $\forall x,y \in W_X$
4. $\bar{d}(x,z) \leq \bar{d}(x,y) + \bar{d}(y,z)$, $\forall x,y,z \in W_X$

Theorem 3.3.1. If $\bar{d}^1$ and $\bar{d}^2$ be two Neutrosophic metric spaces then $\bar{d}$ = max{$\bar{d}^1$, $\bar{d}^2$} is also a Neutrosophic metric space.

Theorem 3.3.2. If $\bar{d}^1$ and $\bar{d}^2$ be two Neutrosophic metric space then $\bar{d}$ = min{$\bar{d}^1$, $\bar{d}^2$} is not a Neutrosophic metric space.

The proof of the above two theorem is obvious using the concept of general matric space.

4. Applications

The work done in this paper is based on the application of neutrosophic sets in multiset topological space. These can be further applicable for the development of neutrosophic topology separation axioms on neutrosophic multiset topology and neutrosophic multisets.

5. Conclusions

In this paper we have established some properties of the neutrosophic multiset topological space such as compactness and connectedness, continuous function on netrosophic multiset topology, separation axioms on neutrosophic multiset topology. Also we have introduced the notion of the distance function in neutrosophic multiset and examined some properties. This paper can be useful for further development of neutrosophic multiset theory and neutrosophic topology.

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