FUZZY NEUTROSOPHIC DENSE SETS AND BAIRE SPACES

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Abstract:

This paper introduces the concept of fuz. neu. den. sets in fuz. neu. top. sp.s. Also, we obtain several charact. of fuz. neu. den. sets in fuz. neu. Baire sp.s are established. Connection. between fuz. neu. den. sets and fuz. neu. Baire sp., fuz. neu. den. Baire sp.s are studied. Several properties are also discussed with illustration and suitable examples.

Keywords:

Fuz. neu. den. set, Fuz. neu. Baire sp., Fuz. neu. den. Baire sp..

1. Introduction:

The concept of fuz. sets were first initiate by Zadeh. L. A [11] in 1965, in which he proposed that the traditional notion of set, in which an element is either a member or not a member, should be generalized to allow for degree of membership. This gives rise to the expansion of fuz. set theory, which has since been applied to a large assortment of fields, involve control theory, image processing, and artificial intelligence.

Neu. sets were first initiate by Florentin Smarandache [7] in 1955, which is a overview of the concepts of fuz. sets and intuitionistic fuz. sets. Neu. sets allow for consideration of indeterminacy, neutrality, and inconsistency in a given sp.. In 2017, Veereswari [10] initiate fuz. neu. top. sp.s, which combines the ideas of fuz. sets and neu. sets to introduce a more general framework for studying top. sp.s.

Since then, researches have been working on developing the theory of fuz. neu. top. sp.s and its application to diverse fields such as soft computing, artificial intelligence, decision making, pattern recognition, and image processing.

2. Preliminaries:

Throughout this present paper, X denotes the fuzzy neutrosophic topological spaces. Let A_N be a fuzzy neutrosophic set on X. The fuzzy neutrosophic interior and closure of A_N is denoted as $fn(A_N)^+$, $fn(A_N)^-$ respectively. A fuzzy neutrosophic set A_N is defined to be fuzzy neutrosophic open set ($fnOS$) if $A_N \leq fn\,(((A_N)^-)^+)^-$. The complement of a fuzzy neutrosophic open set is called fuzzy neutrosophic closed set ($fnCS$).

Definition 2.1 [2]:

A fuzzy neutrosophic set A on the universe of discourse X is defined as $A = \langle x, T_A(x), I_A(x), F_A(x) \rangle$, $x \in X$ where $T, I, F: X \to [0,1]$ and $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

With the condition $0 \leq T_{A^*}(x) + \mathrm{I}_{A^*}(x) + F_{A^*}(x) \leq 2$.

Definition 2.2 [2]:

A fuzzy neutrosophic set A is a subset of a fuzzy neutrosophic set B (i.e.,) $A \subseteq B$ for all x if $T_A(x) \leq T_B(x)$, $I_A(x) \leq I_B(x), F_A(x) \geq F_B(x)$.

Definition 2.3 [2]:

Let X be a non-empty set, and $A = \langle x, T_A(x), I_A(x), F_A(x)\rangle$, $B = \langle x, T_B(x), I_B(x), F_B(x)\rangle$ be two fuzzy neutrosophic sets. Then

$$A \cup B = \langle x, \max(T_A(x), T_B(x)), \max(I_A(x), I_B(x)), \min(F_A(x), F_B(x))\rangle$$

$$A \cap B = \langle x, \min(T_A(x), T_B(x)), \min(I_A(x), I_B(x)), \max(F_A(x), F_B(x))\rangle$$

Definition 2.4 [2]:

The difference between two fuzzy neutrosophic sets A and B is defined as $A \backslash B(x) = \langle x, \min(T_A(x), F_B(x)), \min(I_A(x), 1 - I_B(x)), \max(F_A(x), T_B(x))\rangle$

Definition 2.5 [2]:

A fuzzy neutrosophic set A over the universe X is said to be null or empty fuzzy neutrosophic set if $T_A(x) = 0$, $I_A(x) = 0$, $F_A(x) = 1\ for\ all\ x \in X$. It is denoted by 0_N.

Definition 2.6 [2]:

A fuzzy neutrosophic set A over the universe X is said to be absolute (universe) fuzzy neutrosophic set if $T_A(x) = 1$, $I_A(x) = 1$, $F_A(x) = 0\ for\ all\ x \in X$. It is denoted by 1_N.

Definition 2.7 [2]:

The complement of a fuzzy neutrosophic set A is denoted by A^C and is defined as

$A^C = \langle x, T_{A^C}(x), I_{A^C}(x), F_{A^C}(x)\rangle$ where $T_{A^C}(x) = F_A(x), I_{A^C}(x) = 1 - I_A(x), F_{A^C}(x) = T_A(x)$

The complement of fuzzy neutrosophic set A can also be defined as $A^C = 1_N - A$.

Definition 2.8 [1]:

A fuzzy neutrosophic topology on a non-empty set X is a r of fuzzy neutrosophic sets in X

(i) $0_N, 1_N \in r$

(ii) $A_1 \cap A_2 \in r$ $for\ any\ A_1, A_2 \in r$

(iii) $\cup A_i \in r$ $for\ any\ arbitrary\ family$ $\{A_i : i \in J\} \in r$

Satisfying the following axioms.

In this case the pair (X, r) is called fuzzy neutrosophic topological space and any Fuzzy neutrosophic set in r is known as fuzzy neutrosophic open set in X.

Definition 2.9 [1]:

The complement A^C of a fuzzy neutrosophic set A in a fuzzy neutrosophic topological space (X, r) is called fuzzy neutrosophic closed set in X.

Definition 2.10 [1]:

Let (X, r_N) be a fuzzy neutrosophic topological space and $A = \langle x, T_A(x), I_A(x), F_A(x)\rangle$ be a fuzzy neutrosophic set in X. Then the closure and interior of A are defined by

$$int(A) = \cup \{G: G \text{ is a fuzzy neutrosophic open set in } X \text{ and } G \subseteq A\}$$

$$cl(A) = \cap \{G: G \text{ is a fuzzy neutrosophic closed set in } X \text{ and } A \subseteq G\}$$

Definition 2.11 [4]:

A fuzzy neutrosophic set A_N in a fuzzy neutrosophic topological space (X, r_N) is called a fuzzy neutrosophic $F_\sigma -$ set if $A_N = \vee_{i=1}^{\infty} A_{N_i}$, where $\overline{A_{N_i}} \in r_N$ for $i \in I$.

Definition 2.12 [4]:

A fuzzy neutrosophic set A_N in a fuzzy neutrosophic topological space (X, r_N) is called a fuzzy neutrosophic $G_\delta -$ set in (X, r_N) if $A_N = \wedge_{i=1}^{\infty} A_{N_i}$, where $A_{N_i} \in r_N$ for $i \in I$.

Definition 2.13 [4]:

A fuzzy neutrosophic set A_N in a fuzzy neutrosophic topological space (X, r_N) is called a fuzzy neutrosophic semi-open if $A_N \leq fn(\,((A_N)^+)^-)$. The complement of A_N in (X, r_N) is called a fuzzy neutrosophic semi-closed set in (X, r_N).

Definition 2.14 [4]:

A fuzzy neutrosophic set A_N in a fuzzy neutrosophic topological space $(X,\ r_N)$ is called a fuzzy neutrosophic dense if there exist no fuzzy neutrosophic closed set B_N in (X, r_N) such that $A_N \subset B_N \subset 1_X$. That is, $fn\ (A_N)^- = 1_N$.

Definition 2.15 [4]:

A fuzzy neutrosophic set A_N in a fuzzy neutrosophic topological space $(X,\ r_N)$ is called a fuzzy neutrosophic nowhere dense set if there exist no non-zero fuzzy neutrosophic open set B_N in (X, r_N) such that $B_N \subset fn(A_N)^-$. That is, $fn(((A_N)^-)^+) = 0_N$.

Definition 2.16 [4]:

Let $(X,\ r_N)$ be a fuzzy neutrosophic topological space. A fuzzy neutrosophic set A_N in (X, r_N) is called fuzzy neutrosophic one category set if $A_N = \vee_{i=1}^{\infty} A_{N_i}$, where A_{N_i}'s are fuzzy neutrosophic nowhere dense sets in (X, r_N). Any other fuzzy neutrosophic set in (X, r_N) is said to be of fuzzy neutrosophic two category.

Definition 2.17 [4]:

A fuzzy neutrosophic topological space (X, r_N) is called fuzzy neutrosophic one category space if the fuzzy neutrosophic set 1_X is a fuzzy neutrosophic one category set in (X, r_N). That is $1_X = \vee_{i=1}^{\infty} A_{N_i}$, where

${A_{N_i}}'$s are fuzzy neutrosophic nowhere dense sets in (X, r_N). Otherwise (X, r_N) will be called a fuzzy neutrosophic two category space.

Definition 2.18 [4]:

Let A_N be a fuzzy neutrosophic first category set in $(X,\ r_N)$. Then $\overline{A_N}$ is called fuzzy neutrosophic residual set in (X, r_N).

3. On Fuzzy Neutrosophic Dense Sets and Baire Spaces

Definition 3.1:

Let $(M,\ r_N)$ be a fuz. neu. top. sp.. A fuz. neu. set A_N in $(M,\ r_N)$ is called fuz. neu. Baire den. set if B_N is a fuz. $G_\delta -$ set in $(M,\ r_N)$, A_N A B_N is a fuz. neu. two caty. set in (M, r_N).

Eg; 3.1:

Let $M = \{a, b, c\}$ and consider the family $r_N = \{0_{N,}1_N, A_N, B_N, C_N, E_N, G_N\}$ where

$A_N = \{\langle a, 0.3,0.3,0.5\rangle, \langle b, 0.6,0.6,0.5\rangle, \langle c, 0.6,0.6,0.5\rangle\}$

$B_N = \{\langle a, 0.6,0.6,0.6\rangle, \langle b, 0.3,0.3,0.3\rangle, \langle c, 0.6,0.6,0.6\rangle\}$

$C_N = \{\langle a, 0.3,0.3,0.4\rangle, \langle b, 0.7,0.7,0.4\rangle, \langle c, 0.3,0.3,0.4\rangle\}$

$E_N = \{\langle a, 0.3,0.3,0.3\rangle, \langle b, 0.3,0.3,0.3\rangle, \langle c, 0.7,0.6,0.6\rangle\}$

$G_N = \{\langle a, 0.4,0.3,0.3\rangle, \langle b, 0.3,0.2,0.4\rangle, \langle c, 0.6,0.6,0.5\rangle\}$

Thus $(M,\ r_N)$ is a fuz. neu. top. sp.s. Now, $\bar{A}_N \bar{B}_N$ and $C_N,$ are fuz. neu. nowh. den. sets in $(M,\ r_N)$. Now, $\bar{A}_N \bar{B}_N and$ $C_N,$ are fuz. neu. one caty. sets in $(M,\ r_N)$. Now, the fuz. neu. sets E_N & A_N, G_N & B_N are not fuz. neu. one caty. sets in $(M,\ r_N)$ and hence fuz. neu. two caty. sets in $(M,\ r_N)$. Thus E_N & G_N are fuz. neu. Baire den. set in (M, r_N).

Pro. 3.1:

If A_N is a fuz. neu. Baire den. set in a fuz. neu. top. sp. (M, r_N), then for a fuz. $G_\delta -$ set B_N in (X, r_N), $A_N \wedge B_N = \vee_{i=1}^{\infty} (C_{N_i})$, where $(C_{N_i})'s$ are fuz. neu. nowhere den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. Baire den. set in a fuz. neu. top. sp. $(M,\ r_N)$, then for a fuz. $G_\delta -$ set in B_N in $(M,\ r_N)$, $A_N \wedge\ B_N$ is a fuz. neu. two caty. set in (M, r_N) and hence $A_N \wedge B_N$ is not a fuz. neu. one caty. set in (M, r_N). Thus $A_N \wedge B_N = \vee_{i=1}^{\infty} (C_{N_i})$, where $(C_{N_i})'s$ are fuz. neu. nowhere den. set in (M, r_N).

Pro. 3.2:

If A_N is a fuz. neu. Baire den. set in a fuz. neu. top. sp. (M, r_N), then for a fuz. neu. $G_\delta -$ set B_N in (M, r_N), $1 - (A_N \wedge B_N) = \wedge_{i=1}^{\infty} E_{N_i}$, where $fn\ (E_{N_i})^- = 1_N$.

Proof:

Let A_N be a fuz. neu. Baire den. set in a fuz. neu. top. sp. (M, r_N). Then by Pro. (3.1), $A_N \wedge B_N = \vee_{i=1}^{\infty}(C_{N_i})$, where $(C_{N_i})'s$ are fuz. neu. nowhere den. set in (M, r_N). Then $1 - (A_N \wedge B_N) = 1 - \vee_{i=1}^{\infty}(C_{N_i}) = \wedge_{i=1}^{\infty}(1 - C_{N_i})$ in (M, r_N). Since, C_{N_i} is a fuz. neu. nowhere den. set in (M, r_N), $fn((C_{N_i}{}^{-})^{+}) = 0$. Since $fn(C_{N_i}{}^{+}) \leq fn((C_{N_i}{}^{-}))^{+}$ in (M, r_N), $fn(C_{N_i}{}^{+}) = 0$ and hence $1 - fn(C_{N_i}{}^{+}) = 1$ in (M, r_N). This $\Rightarrow fn(1 - C_{N_i})^{-} = 1$. Thus $1 - (A_N \wedge B_N) = \wedge_{i=1}^{\infty}(1 - C_{N_i})$, where $(1 - C_{N_i})'s$ are fuz. neu. nowhere den. set in (M, r_N). Let $E_{N_i} = 1 - C_{N_i}$. Then let $1 - (A_N \wedge B_N) = \wedge_{i=1}^{\infty}(E_{N_i})$, where $(E_{N_i})'s$ are fuz. neu. nowhere den. set in (M, r_N).

Pro. 3.3:

If A_N is a fuz. neu. Baire den. set in a fuz. neu. top. sp. (M, r_N), then there exist a fuz. $G_\delta -$ set B_N in (X, r_N), fuz. neu. two caty. set C_N s.t $C_N \leq A_N$ in (M, r_N).

Proof:

Let A_N be a fuz. neu. Baire den. set in (M, r_N), then for a fuz. $G_\delta -$ set in B_N in (M, r_N), $A_N \wedge B_N$ is a fuz. two caty. set in (M, r_N). Clearly $A_N \wedge$

$B_N \leq A_N$. Let $A_N \wedge B_N = C_N$. Thus C_N is a fuz. neu. two caty. set in (M, r_N) s.t $C_N \leq A_N$ in (M, r_N).

Pro. 3.4:

If A_N is a fuz. neu. Baire den. set in (M, r_N), then each fuz. neu. two caty. set is a fuz. neu. den. set in a fuz. neu. topological (M, r_N), then A_N is a fuz. neu. den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. Baire den. set in (M, r_N), then by Pro. (3.3), ∃ a fuz. neu. two caty. set $C_N \leq A_N$ in (M, r_N) and hence $fn(C_N)^- = fn(A_N)^+$, in (M, r_N). By hypothesis, $fn(C_N)^- = 1$ in (M, r_N). Then, $1 \leq fn(A_N)^-$. That is, $fn(A_N)^- = 1$ in (M, r_N). Hence A_N is a fuz. neu. den. set in (M, r_N).

Definition 3.2:

A fuz. neu. top. sp. (M, r_N) is called a fuz. neu. submaximal sp. if for each fuz. neu. set A_N in (M, r_N) s.t $fn(A_N)^- = 1$, $A_N \in r_N$ in (M, r_N).

Definition 3.3:

A fuz. neu. top. sp. (M, r_N) is called a fuz. neu. $P -$ sp. if countable intersection of fuz. neu. op. sets in (M, r_N) is fuz. neu. open. That is, every non zero fuz. neu. $G_\delta -$ set in (M, r_N) is a fuz. neu. op. set in (M, r_N).

Definition 3.4:

If the fuz. neu. top. sp. $(M,\ r_N)$ is a fuz. neu. Baire sp. then no non-zero fuz. neu. op. set is a fuz. neu. one caty. set in (M, r_N) .

Definition 3.5:

If A_N is a fuz. neu. nowhere den. set in a fuz. neu. submaximal sp. (M, r_N), then A_N is a fuz. neu. cld. set in (M, r_N).

Definition 3.6:

If A_N is a fuz. neu. $G_\delta -$ set in a fuz. neu. Baire and fuz. neu. $P -$ sp. (M, r_N), then A_N is a fuz. neu. two caty. set in (M, r_N).

Pro. 3.5:

If each fuz. neu. $G_\delta -$ set is a fuz. neu. Baire den. set in a fuz. neu. submaximal sp. (M, r_N), then (M, r_N) is a fuz. neu. $P -$ sp..

Proof:

Let A_N be a fuz. neu. $G_\delta -$ set in a fuz. neu. submaximal sp. $(M,\ r_N)$. Then by the hypothesis, A_N A B_N is a fuz. neu. Baire den. set in $(M,\ r_N)$. Since (M, r_N) is a fuz. neu. submaximal sp., the fuz. neu. Baire den. set A_N A B_N in $(M,\ r_N)$, is a fuz. neu. op. set in $(M,\ r_N)$. That is, every fuz. neu. $G_\delta -$ set in $(M,\ r_N)$ is a fuz. neu. op. set in $(M,\ r_N)$. Therefore $(M,\ r_N)$ is a fuz. neu. $P -$ sp..

Pro. 3.6:

If A_N is a fuz. neu. Baire den. set in a fuz. neu. submaximal sp. (M, r_N), then for fuz. neu. op. set B_N in (M, r_N), $A_N \wedge B_N$ is not a fuz. neu. $F_\sigma -$ set in (M, r_N).

Proof:

Let A_N be a fuz. neu. Baire den. set in (M, r_N). Then by Pro. (3.1), for a fuz. neu. op. set B_N in (M, r_N), $A_N \wedge B_N = \bigvee_{i=1}^{\infty} (C_{N_i})$, where $(C_{N_i})'s$ are fuz. neu. nowh. den. sets in (M, r_N). Since (M, r_N) is a fuz. neu. submaximal sp., by definition (3.5), the fuz. neu. nowh. den. sets $(C_{N_i})'s$ are fuz. neu. closed sets in (M, r_N). Then $\bigvee_{i=1}^{\infty}(C_{N_i})$ is a fuz. neu. $F_\sigma -$ set in (M, r_N). Thus $A_N \wedge B_N = \bigvee_{i=1}^{\infty}(C_{N_i})$, $\Rightarrow$ $A_N \wedge B_N$ is not a fuz. neu. $F_\sigma -$ set in (M, r_N).

Pro. 3.7:

If A_N is a fuz. neu. set in a fuz. neu. Baire and fuz. neu. $P -$ sp. (M, r_N) s.t $A_N \wedge B_N$ is a fuz. neu. $G_\delta -$ set, for a fuz. neu. op. set B_N in (M, r_N), then A_N is a fuz. neu. Baire den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. set in (M, r_N) s.t $A_N \wedge B_N$ is a fuz. neu. $G_\delta -$ set, for a fuz. neu. op. set B_N in (M, r_N). Since (M, r_N) is a fuz. neu. $P -$ sp., the fuz. neu. $G_\delta -$ set $A_N \wedge B_N$ is a fuz. neu. op. set B_N in (M, r_N). Also since (M, r_N) is a fuz. neu. Baire sp. by definition (3.4), the non-zero fuz. neu. op. set $A_N \wedge B_N$ is not a fuz. neu. one caty. set in (M, r_N) and hence $A_N \wedge B_N$ is a fuz. neu. two caty. set in (M, r_N). This $\Rightarrow$ A_N is a fuz. neu. Baire den. set in (M, r_N).

Pro. 3.8:

If A_N is a fuz. neu. $G_\delta -$ set in a fuz. neu. Baire and fuz. neu. $P -$ sp. (M, r_N) s.t $A_N \leq B_N$, for fuz. neu. op. set B_N in (M, r_N), then A_N is a fuz. neu. Baire den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. $G_\delta -$ set s.t $A_N \leq B_N$, for a fuz. neu. op. set B_N in (M, r_N). Since (M, r_N) is a fuz. neu. Baire and fuz. neu. $P -$ sp. by definition (3.6), the fuz. neu. $G_\delta -$ set is a fuz. neu. two caty. set in (M, r_N). Now $A_N \wedge B_N = A_N \Rightarrow A_N \wedge B_N$ is a fuz. neu. two caty. set in (M, r_N) and hence A_N is a fuz. neu. Baire den. set in (M, r_N).

Pro. 3.9:

If A_N is a fuz. neu. $F_\sigma -$ set in a fuz. neu. Baire and fuz. neu. $P -$ sp. (M, r_N) s.t $A_N \geq B_N$, for fuz. neu. cld. set B_N in (M, r_N), then $1 - A_N$ is a fuz. neu. Baire den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. $F_\sigma -$ set s.t $A_N \geq B_N,$ for a fuz. neu. cld. set B_N in (M, r_N). Now $1 - A_N$ is a fuz. neu. $G_\delta -$ set s.t $1 - A_N \leq 1 - B_N$, where $1 - B_N$ is a fuz. neu. op. set in (M, r_N). Then by Pro. (3.8), $1 - A_N$ is a fuz. neu. Baire den. set in (M, r_N).

Pro. 3.10:

If A_N is a fuz. neu. op. set in a fuz. neu. Baire sp. (M, r_N), then A_N is a fuz. neu. Baire den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. op. set in (M, r_N). Then for a fuz. neu. op. set B_N in (M, r_N), $A_N \wedge B_N$ is a fuz. neu. op. set in (M, r_N). Since (M, r_N) is a fuz. neu. Baire sp. by definition (3.4), $A_N \wedge B_N$ is not a fuz. neu. one caty. set in (M, r_N) and hence $A_N \wedge B_N$ is a fuz. neu. two caty. set in (M, r_N). Thus A_N is a fuz. neu. Baire den. set in (M, r_N).

Pro. 3.11:

If A_N is a fuz. neu. $G_\delta -$ set in a fuz. neu. Baire and fuz. neu. $P -$ sp. (M, r_N), then A_N is a fuz. neu. Baire den. set in (M, r_N).

Proof:

Let A_N be a fuz. neu. $G_\delta -$ set in (M, r_N). Since (M, r_N) is a fuz. neu. $P -$ sp., the fuz. neu. $G_\delta -$ set A_N is a fuz. neu. op. set in (M, r_N). Since

(M, r_N) is a fuz. neu. Baire sp., by Pro. (3.10), A_N is a fuz. neu. Baire den. set in (M, r_N).

Shortcut keywords:

S.No	KEYWORDS	SHORTCUTS
1	fuzzy	fuz.
2	neutrosophic	neu.
3	category	caty.
4	such that	s.t
5	closed set	cld. set
6	open set	op. set
7	Nowhere dense sets	Nowh.den.sets
8	implies that	$\Rightarrow$
9	Proposition	Pro.
10	Submaximal space	Submax. sp.
11	(X, r_n)	(M, r_n)
12	topological space	top.sp.
13	implies that	$\Rightarrow$
14	dense sets	den. sets
15	Example	Eg;
16	residual	resd.
17	universex	U of X
18	characterizations	charact.
19	relations	connection.
20	introduced	initate
21	Lofti A Zadeh	Zadeh. L. A

Conclusion:

In this paper, the concept of fuz. neu. den. sets in fuz. neu. top. sp.s and its properties are discussed. Also, we obtained several charact. of fuz. neu. den. sets in fuz. neu. Baire sp.s. Connection. between fuz. neu. den. sets and fuz. neu. Baire sp., fuz. neu. den. Baire sp.s are studied. Some of its charact. and examples of fuz. neu. Baire sp.s are established. This shall be extended in the future research studies.

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