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New Generalized Closed Set in ℵeutrosophic Topological Spaces.

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Abstract: The main intention of this paper is to develop the idea of ℵeutrosophic Semi-generalized pre-closed set in neutrosophic topological space. We also study relations and some properties between the existing ℵeutrosophic closed set. The examples are provided wherever necessary. Besides, we discuss some applications of ℵeutrosophic Semi-generalized pre closed set.

Keywords: ℵsgp-closed set,ℵsgp-open set, ℵ-sgp-$T_{1/2}$, ℵ-pc-$T_{1/2}$,ℵ-open set , ℵ-closed set.

1. Introduction

Fuzzy set theory is introduced and studied as a mathematical tool for dealing with uncertainties where each element had a degree of membership, truth(t), by Zadeh[14]. The falsehood (f), the degree of non-membership, was introduced by Atanassov [2] in an intuitionistic fuzzy set. Coker [3] developed intuitionistic fuzzy topology. Neutrality (i), the degree of indeterminacy, as an independent concept, was introduced by Smarandache[8,9,10]. He also defined the neutrosophic set on three components (t, f, i) = (truth, falsehood, indeterminacy). Salama et.al. [6,7] converted Neutrosophic crisp set in to neutrosophic topological spaces. This opened a wide range of investigation in terms of neutrosophic topology and its application in decision making problems. A.A. Salama et al in [7] introduced neutrosophic closed sets and continuous functions. R. Dhavaseelan et al [4] introduced generalized neutrosophic closed sets. Neutrosophic semi-open, pre-open, α-open and semipro-open are presented in [11]. In [13]authors discussed properties of Generalized pre-closed sets in neutrosophic topological space(NTS in short).

This paper is devoted to the study new generalized closed set in Neutrosophic topology called Neutrosophic semi-generalized pre closed set. The basic properties are discussed and compared the new set with existing neutrosophic closed sets. As its applications, we have defined as ℵeutrosophic-sgp-$T_{1/2}$ and as ℵeutrosophic-pc-$T_{1/2}$.

2. Preliminaries

Definition: 2.1[8,9]: Let S_1 be a non-empty fixed set. A neutrosophic set (in short NS) Λ is an object such that $\Lambda = \{\langle x, \mu_\Lambda(x), \sigma_\Lambda(x), \gamma_\Lambda(x)\rangle : x \in S_1\}$ wherein $\mu_\Lambda(x), \sigma_\Lambda(x)$ and $\gamma_\Lambda(x)$ which represents the degree of membership function (viz $\mu_\Lambda(x)$), the degree of indeterminacy (viz $\sigma_\Lambda(x)$) as well as the degree of non-membership (viz $\gamma_\Lambda(x)$) respectively of each element $x \in S_1$ to the set Λ.

Remark: 2.2[8,9]: (i) An N-set $\Lambda = \{\langle x, \mu_\Lambda(x), \sigma_\Lambda(x), \Gamma_\Lambda(x)\rangle : x \in S_1\}$ can be identified to an ordered triple $\langle \mu_\Lambda, \sigma_\Lambda, \Gamma_\Lambda\rangle$ in $]0^-, 1^+[$ on S_1.

(ii) In this paper, we use the symbol $\Lambda = \langle \mu_\Lambda, \sigma_\Lambda, \Gamma_\Lambda\rangle$ for the N-set $\Lambda = \{\langle x, \mu_\Lambda(x), \sigma_\Lambda(x), \Gamma_\Lambda(x)\rangle : x \in S_1\}$.

Definition: 2.3*[8,9]:* Let $S_1 \neq \emptyset$ and the N-sets Λ and Γ be defined as

$\Lambda = \{\langle x, \mu_\Lambda(x), \sigma_\Lambda(x), \Gamma_\Lambda(x)\rangle : x \in S_1\}$, $\Gamma = \{\langle x, \mu_\Gamma(x), \sigma_\Gamma(x), \Gamma_\Gamma(x)\rangle : x \in S_1\}$. Then

I. $\Lambda \subseteq \Gamma$ *iff* $\mu_\Lambda(x) \leq \mu_\Gamma(x)$, $\sigma_\Lambda(x) \leq \sigma_\Gamma(x)$ *and* $\Gamma_\Lambda(x) \geq \Gamma_\Gamma(x)$ *for all* $x \in S_1$;

II. $\Lambda = \Gamma$ *iff* $\Lambda \subseteq \Gamma$ *and* $\Gamma \subseteq \Lambda$;

III. $\bar{\Lambda} = \{\langle x, \Gamma_\Lambda(x), \sigma_\Lambda(x), \mu_\Lambda(x)\rangle : x \in S_1\}$; *[Complement of* Λ*]*

IV. $\Lambda \cap \Gamma = \{\langle x, \mu_\Lambda(x) \wedge \mu_\Gamma(x), \sigma_\Lambda(x) \wedge \sigma_\Gamma(x), \Gamma_\Lambda(x) \vee \Gamma_\Gamma(x)\rangle : x \in S_1\}$;

V. $\Lambda \cup \Gamma = \{\langle x, \mu_\Lambda(x) \vee \mu_\Gamma(x), \sigma_\Lambda(x) \vee \sigma_\Gamma(x), \Gamma_\Lambda(x) \wedge \gamma_\Gamma(x)\rangle : x \in S_1\}$;

VI. $[\ ]\Lambda = \{\langle x, \mu_\Lambda(x), \sigma_\Lambda(x), 1 - \mu_\Lambda(x)\rangle : x \in S_1\}$;

VII. $\langle\rangle\, \Lambda = \{\langle x, 1 - \Gamma_\Lambda(x), \sigma_\Lambda(x), \Gamma_\Lambda(x)\rangle : x \in S_1\}$.

Definition: 2.4[9,10]: Let $\{\Lambda_i : i \in J\}$ be an arbitrary family of N-sets in S_1. Thereupon

I. $\cap \Lambda_i = \{\langle p \wedge \mu_{\Lambda_i}(p), \wedge \sigma_{\Lambda_i}(p), \vee \Gamma_{\Lambda_i}(p)\rangle : p \in S_1\}$;

II. $\cup \Lambda_i = \{\langle p \vee \mu_{\Lambda_i}(p), \vee \sigma_{\Lambda_i}(p), \wedge \Gamma_{\Lambda_i}(p)\rangle : p \in S_1\}$.

The main theme is to construct the tools for developing NTS, so we establish the neutrosophic sets $0_\aleph$ along with $1_\aleph$ in X as follows:

Definition: 2.5[9,10]:$0_\aleph = \{\langle q, 0, 0, 1\rangle : q \in X\}$ and $1_\aleph = \{\langle q, 1, 1, 0\rangle : q \in X\}$.

Definition: 2.6[7]: A neutrosophic topology (in short, $\aleph T$)$S_1 \neq \emptyset$ is a family ξ_1 of N-sets in S_1 satisfying the laws given below:

I. $0_\aleph, 1_\aleph \in \xi_1$,

II. $W_1 \cap W_2 \in T$ *being* $W_1, W_2 \in \xi_1$,

III. $\cup W_i \in \xi_1$ *for arbitrary family* $\{W_i | i \in \Lambda\} \subseteq \xi_1$.

In this case the ordered pair (S_1, ξ_1) or simply S_1 is termed as NTS and each NS in ξ_1 is named as neutrosophic open set (in short, ℵOS) . The complement $\overline{\Lambda}$ of an ℵ-open set Λ in S_1 is known as neutrosophic closed set (briefly,ℵCS) in S_1.

Definition: 2.7[7,8]: Let Λ be an NS in an NTS S_1. Thereupon

$\aleph int(\Lambda) = \cup \{G | G$ is an ℵOS in S_1 and $G \subseteq \Lambda\}$ is termed as neutrosophic interior (in brief $\aleph int$) of Λ;

$\aleph cl(\Lambda) = \cap \{G|G$ is an ℵCS in S_1 and $G \supseteq \Lambda\}$ is termed as neutrosophic closure (shortly $\aleph cl$) of Λ.

Definition: 2.8[4]: Let X be a nonempty set. Whenever r, t, s be real standard or non standard subsets of $]0^-, 1^+[$ then the neutrosophic set $x_{r,t,s}$ is termed as neutrosophic point(in short NP)in X given by $x_{r,t,s}(x_p) = \begin{cases} (r,t,s), & if \quad x = x_p \\ (0,0,1), & if \quad x \neq x_p \end{cases}$ for $x_p \in X$ is termed as the support of $x_{r,t,s}$, wherein r indicates the degree of membership value, t indicates the degree of indeterminacy along with s as the degree of non-membership value of $x_{r,t,s}$.

Definition 2.9[11]: For an ℵS D in an NTS (X, T). We have,

(i) ℵeutrosophic semiopen set (ℵSOS) if $D \subseteq \aleph cl(\aleph int(D))$.
(ii) ℵeutrosophic preopen set (ℵPOS) if $D \subseteq \aleph int(\aleph cl(D))$.
(iii) ℵeutrosophic α-open set (ℵαOS) if $D \subseteq \aleph int(\aleph cl(\aleph int(D)))$.
(iv) ℵeutrosophic semi-preopen (ℵSPOS) if $D \subseteq \aleph cl(\aleph int(\aleph cl(D)))$.

The complement of D is an ℵSOS, ℵPOS,ℵαOS, ℵSPOS is called respectively as ℵSCS, ℵPCS, ℵαCS, ℵSPCS

Definition 2.10[13]: Let (X,T) be an NTS then neutrosophic pre-closure of D (in short, pℵCl(D)) is defined as

(i) $p\aleph Cl(D) = \cap\{K: K\ is\ an\ NPC\ in\ T, D \subseteq K\}$.
(ii) $p\aleph Int(D) = \cup\{Q: K\ is\ an\ NPO\ in\ T, D \subseteq Q\}$.

Definition 2.11 [13]: An NS is said to be a neutrosophic generalized pre-closed set (GNPCS in short) in (X, T) if $p\aleph Cl(R) \subseteq Q$ whenever $R \subseteq Q$ and Q is a NOS in (X,T).

Definition 2.12 [13]: AnℵTS (X, S) is named as ℵeutrosophic-gp-$T_{1/2}$ (ℵgp-$T_{1/2}$ in short) space if every GNPCS in X is a ℵPCS.

3. Neutrosophic Semi-Generalized-Pre-Closed Sets.

Definition 3.1: An NS μ of NTS(X, S) is termed as Neutrosophic Semigeneralized pre-closed set (ℵsgp-CS in short) if pℵCl(μ) ⊆ η whenever μ ⊆ η and η is ℵSOS in X.

Definition 3.2: Let (X, S) be a NTS and η be an NS in X. Then the neutrosophic semigeneralized pre-closure and neutrosophic semigeneralized pre-interior of η are deonoted and defined by,

$\aleph sgpCl(\eta) = \cap\{\ \lambda$: λ is a ℵsgp-CS in X and $\eta \subseteq \lambda\}$

$\aleph sgpInt(\eta) = \cup\{\ \lambda$: λ is a ℵsgp-OS in X and $\eta \supseteq \lambda\}$

Proposition 3.3: Consider(X, S) be any NTS and A and B be neutrosophic sets in (X, S). Then the ℵsg-closure and ℵsgp-interior operator satisfy the following properties

i. $\eta \subseteq \aleph sgpCl(\eta)$

ii. $\aleph sgpInt(\eta) \subseteq \eta$

iii. $\eta \subseteq \lambda \Rightarrow \aleph sgpCl(\eta) \subseteq \aleph sgpCl(\lambda)$

iv. $\eta \subseteq \lambda \Rightarrow \aleph sgpInt(\eta) \subseteq \aleph sgpInt(\lambda)$

v. $\aleph sgpCl(\eta \cup \lambda) = \aleph sgpCl(\eta) \cup \aleph sgpCl(\lambda)$

vi. $\aleph sgpInt(\eta \cap \lambda) = \aleph sgpInt(\eta) \cap \aleph sgpInt(\lambda)$

vii. $\aleph s\bar{g}p\bar{Cl}(\eta)\bar{} = \aleph sgpInt(\bar{\eta})$

viii. $\aleph s\bar{h}p\bar{Int}(\eta)\bar{} = \aleph sgpCl(\bar{\eta})$

Proposition 3.4: Each ℵCS set is ℵsgp-CS.

Proof: Let μ is ℵCS such that μ ⊆ η and η is ℵSOS in X. As μ is ℵCS, μ = ℵcl(μ). Hence ℵcl(μ) ⊆ μ. But pℵCl(μ) ⊆ ℵcl(μ), therefore pℵCl(μ) ⊆ μ whenever μ ⊆ η and η is ℵSOS in X. Therefore μ is ℵsgp-CS.

Remark 3.5: The example makes clear that converse of the above proposition is not true.

Example 3.6: Let $X = \{a, b, c\}$. Define the neutrosophic sets A,B and C in X as follows A = $\langle x, \left(\frac{a}{0.6}, \frac{b}{0.6}, \frac{c}{0.6}\right), \left(\frac{a}{0.7}, \frac{b}{0.7}, \frac{c}{0.7}\right), \left(\frac{a}{0.3}, \frac{b}{0.3}, \frac{c}{0.3}\right)\rangle$, B = $\langle x, \left(\frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.5}\right), \left(\frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.5}\right), \left(\frac{a}{0.5}, \frac{b}{0.5}, \frac{c}{0.5}\right)\rangle$ and C = $\langle x, \left(\frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.6}\right), \left(\frac{a}{0.4}, \frac{b}{0.4}, \frac{c}{0.6}\right), \left(\frac{a}{0.5}, \frac{b}{0.5}, \frac{c}{0.5}\right)\rangle$. Then the families $\tau = \{0_N, 1_N, A, B\}$ is topology on X and the space (X, τ) is NTS. Then C is a ℵsgp-CS but not a ℵCS.

Proposition 3.7: Every ℵαCS is ℵsgp-CS.

Proof: Let W is ℵCS such that W ⊆ Q and Q is ℵSOS in X. Since W is ℵαCS, W = ℵαcl(μ). Hence ℵαcl(W) ⊆ Q. But pℵCl(W) ⊆ ℵαcl(W), therefore pℵCl(W) ⊆ W whenever W⊆ Q and Q is ℵSOS in X. Therefore μ is ℵsgp-CS.

Remark 3.8: Converse of the above proposition is not true as seen below.

Example 3.9: Consider $X = \{\eta, \beta, \delta\}$. Define the neutrosophic sets P, Q and R in X as follows P = $\langle x, \left(\frac{\eta}{0.6}, \frac{\beta}{0.6}, \frac{\delta}{0.6}\right), \left(\frac{\eta}{0.7}, \frac{\beta}{0.7}, \frac{\delta}{0.7}\right), \left(\frac{\eta}{0.3}, \frac{\beta}{0.3}, \frac{\delta}{0.3}\right)\rangle$, Q = $\langle x, \left(\frac{\eta}{0.4}, \frac{\beta}{0.4}, \frac{\delta}{0.5}\right), \left(\frac{\eta}{0.4}, \frac{\beta}{0.4}, \frac{\delta}{0.5}\right), \left(\frac{\eta}{0.5}, \frac{\beta}{0.5}, \frac{\delta}{0.5}\right)\rangle$ and R = $\langle x, \left(\frac{\eta}{0.4}, \frac{\beta}{0.4}, \frac{\delta}{0.5}\right), \left(\frac{\eta}{0.4}, \frac{\beta}{0.4}, \frac{\delta}{0.5}\right), \left(\frac{\eta}{0.5}, \frac{\beta}{0.5}, \frac{\delta}{0.5}\right)\rangle$. Then the families $\tau = \{0_N, 1_N, P, Q\}$ is topology on X and the space (X, τ) is NTS. Then C is a ℵsgp-CS but not a ℵαCS.

Proposition 3.10: Each ℵPCS is ℵsgp-CS.

Proof: Consider Jas ℵCS with J ⊆ K and K is ℵSOS in X. Since W is ℵPCS, J = pℵCl(J). Hence $p\aleph C$l(J) ⊆ J whenever J ⊆ K and K is ℵSOS in X. Therefore J is ℵsgp-CS.

Remark 3.11: The example shows that the reverse implication of above proposition is not possible.

Example 3.12: For $X = \{p, q, r\}$ the neutrosophic sets K, M and L in X are defined as $A = \langle x, \left(\frac{p}{0.6}, \frac{q}{0.6}, \frac{r}{0.6}\right), \left(\frac{p}{0.7}, \frac{q}{0.7}, \frac{r}{0.7}\right), \left(\frac{p}{0.3}, \frac{q}{0.3}, \frac{r}{0.3}\right)\rangle$, $M = \langle x, \left(\frac{p}{0.4}, \frac{q}{0.4}, \frac{r}{0.5}\right), \left(\frac{p}{0.4}, \frac{q}{0.4}, \frac{r}{0.5}\right), \left(\frac{p}{0.5}, \frac{q}{0.5}, \frac{r}{0.5}\right)\rangle$ and $L = \langle x, \left(\frac{p}{0.4}, \frac{q}{0.4}, \frac{r}{0.6}\right), \left(\frac{p}{0.4}, \frac{q}{0.4}, \frac{r}{0.6}\right), \left(\frac{p}{0.5}, \frac{q}{0.5}, \frac{r}{0.5}\right)\rangle$. Then the families $\tau = \{0_N, 1_N, K, M\}$ is topology on X and the space (X, τ) is NTS. Thereupon C is a ℵsgp-Closed set but not a ℵPCS

Proposition 3.13: Every is ℵsgp-CS is GNPCS.

Proof: Let J is ℵsgp-CS with $J \subseteq$ K and K is ℵOS in X. Since eachℵOS is ℵSOS , K is ℵSOS such that J ⊆ K. By definition 3.1, $p\aleph Cl(J) \subseteq K$ whenever J ⊆ K and K is ℵOS in X. Therefore J is GNPCS.

Proposition 3.14: Let D be a ℵsgp-CS in an ℵTS (X, S) and $D \subseteq E \subseteq p\aleph Cl(D)$. Thereupon E is ℵsgp-CS in X.

Proof: Consider G be a ℵSOS in X thereby $E \subseteq G$. Then $D \subseteq G$ and since D is ℵsgp-CS, $p\aleph Cl(D) \subseteq G$. Now $E \subseteq p\aleph Cl(D)$implies $\aleph cl(E) \subseteq p\aleph Cl(D) \subseteq G$. Consequently E is ℵsgp-CS in X.

Definition 3.15: An NS B of a ℵTS (X,S) is named as neutrosophic semi-generalized open set (ℵsgp-OS in short) if and only if $\bar{B}$ is ℵsgp-CS.

Remark 3.16: For any two Neutrosophic Sets A and B of NTS(X, S). Then
i). A is a $\aleph\, closed$ set iff $\aleph cl(A) = A$.
ii). A is a $\aleph\, open$ set iff $\aleph int(A) = A$.
iii). $\aleph cl(\bar{A}) = \overline{\aleph int(\bar{A})}$
iv). $\aleph int(\bar{A}) = \overline{\aleph cl(A)}$

Proposition 3.17: An NS F of a ℵTS (X, S) is ℵsgp-OS if $G \subseteq p\aleph Cl(F)$ whenever G is ℵSCS and $G \subseteq F$.

Proof: Follows from definition 3.1 and remark 3.16.

Proposotion 3.18: Let A be a ℵsgp-OS in a ℵTS (X, S) and $p\aleph Int(A) \subseteq B \subseteq A$. Then B is ℵsgp-OS.
Proof: Suppose A is ℵsgp-OS in X and $p\aleph Int(A) \subseteq B \subseteq A$ implies $\bar{A} \subseteq \overline{B} \subseteq \overline{(p\aleph Int(A))}$ implies $\bar{A} \subseteq \overline{B} \subseteq p\aleph Cl(\bar{A})$. Then B is ℵsgp-OS.

4. Applications of Neutrosophic Semi Generalized Pre Closed Set.

Definition 4.1: An ℵTS (X, S) is named as ℵeutrosophic-sgp-$T_{1/2}$ (in short ℵ-sgp-$T_{1/2}$) space if every ℵsgp-CS in X is a ℵCS.

Definition 4.2: An ℵTS (X, S) is named as ℵeutrosophic-pc-$T_{1/2}$ (in short ℵ-pc-$T_{1/2}$) space if every ℵsgp-CS in X is a ℵPCS.

Proposition 4.3: Each ℵ-pc-$T_{1/2}$ space is ℵ-sgp-$T_{1/2}$.

Proof: Consider X to be a ℵ-pc-$T_{1/2}$ space and G be ℵsgp-CS in X. By assumption, G is ℵPCS in X. Since every ℵPCS is ℵsgp-CS , G is ℵsgp-CS in X. Hence, X is ℵ-pc-$T_{1/2}$.

Proposition 4.5: Each ℵ-sgp-$T_{1/2}$ is Ngp$T_{1/2}$.

Proof: Consider X to be a ℵ-sgp-$T_{1/2}$ space and Q be GNPCS in X. By assumption, Q is ℵsgp-CS in X. Since every ℵsgp-CS is GNPCS, Q is GNPCS in X. Hence, X is Ngp-$T_{1/2}$.

Proposition 4.6: Let (X, S) be a ℵTS and ℵ-sgp-$T_{1/2}$. Then the following statements hold.

(i) Any union of ℵsgp-CS is a ℵsgp-CS.

(ii) Any intersection of ℵsgp-CS is a ℵsgp-CS.

Proof:(i) Let $\{B_i\}_{i\epsilon j}$ be a collection of ℵsgp-CS in a ℵ-sgp-$T_{1/2}$ space (X, S). Therefore every ℵsgp-CS is ℵCS. However, the union of ℵCS is a ℵCS. Hence the union of ℵsgp-CS is ℵsgp-CS in X.

(ii) It can be proved by taking complement in (i).

Proposition 4.7: An NTS X is an ℵ-sgp-$T_{1/2}$ iff ℵsgp-OS= ℵPOS.

Proof:(i)Consider K be a ℵsgp-OS in X, thereupon K^c is ℵsgp-CS in X. By presumption, K^c is an ℵPCS in X. Thus, K is ℵsgp-OS in X. Therefore, ℵsgp-OS = ℵPOS.

(ii) Consider ℵsgp-CS in X. Then, K^c is ℵsgp-OS in X. By assumption, K^c is an ℵPOS in X. Then, K is an ℵPCS in X. Thereupon, X is an ℵ-sgp-$T_{1/2}$.

5. Conclusions

The class of neutrosophic semi-generalized pre closed sets in neutrosophic topological space is useful not only increase our understanding of some special features of the already known notions of neutrosophic topology but also useful in developing the neutrosophic multifunction theory in neutrosophic control theory as well as in neutrosophic economy. Some results have been proved to show that how far topological structures are preserved by the new neutrosophic set defined. We have given examples where such properties fail to be preserved. Here we have presented the idea; still some more theoretical research is to be carried out to establish a general frame work for decision making and to define patterns for complex network conceiving and practical application.

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