Initial Material of Neutrosophic Preliminaries to Study Some Neutrosophic Notions Based on Neutrosophic SuperHyperEdge (NSHE) in Neutrosophic SuperHyperGraph (NSHG)

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Initial Material of Neutrosophic Preliminaries to Study Some Neutrosophic Notions Based on Neutrosophic SuperHyperEdge (NSHE) in Neutrosophic SuperHyperGraph (NSHG)

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Abstract

Based on neutrosophic SuperHyperEdge (NSHE) in neutrosophic SuperHyperGraph (NSHG), I introduce some neutrosophic notions. I define different types of neutrosophic SuperHyperEdge (NSHE), neutrosophic SuperHyperPath (NSHP), stable (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) number, connected (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) number, (-/stable/connected) (-/dual/total) perfect (SuperHyperResolving/SuperHyperDominating) set, general forms of neutrosophic SuperHyperGraph (NSHG), p neutrosophic SuperHyperGraph (pNSHG), x neutrosophic SuperHyperGraph (xNSHG), and t-norm neutrosophic SuperHyperGraph (tNSHG) with related characterizations. Also, I formalize restricted status of neutrosophic classes of neutrosophic SuperHyperGraph (NSHG).

Keywords: Neutrosophic SuperHyperEdge (NSHE), Neutrosophic SuperHyperGraph (NSHG).

AMS Subject Classification: 05C17, 05C22

1 Background

Dimension and coloring alongside domination in neutrosophic hypergraphs in **Ref.** [4] by Henry Garrett (2022), three types of neutrosophic alliances based on connectedness and (strong) edges in **Ref.** [6] by Henry Garrett (2022), properties of SuperHyperGraph and neutrosophic SuperHyperGraph in **Ref.** [5] by Henry Garrett (2022), are studied. Also, some studies and researches about neutrosophic graphs, are proposed as a book in **Ref.** [3] by Henry Garrett (2022).

2 Preliminaries

Definition 2.1 (Neutrosophic Set)**.** (**Ref.** [2],Definition 2.1,p.87).

Let X be a space of points (objects) with generic elements in X denoted by x; then the **neutrosophic set** A (NS A) is an object having the form

$$A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$$

where the functions $T, I, F : X \to]^-0, 1^+[$ define respectively the a **truth-membership function**, an **indeterminacy-membership function**, and a **falsity-membership function** of the element $x \in X$ to the set A with the condition

$$^-0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3^+.$$

The functions $T_A(x), I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of $]^-0, 1^+[$.

Definition 2.2 (Single Valued Neutrosophic Set)**.** (**Ref.** [9],Definition 6,p.2).

Let X be a space of points (objects) with generic elements in X denoted by x. A **single valued neutrosophic set** A (SVNS A) is characterized by truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. For each point x in X, $T_A(x), I_A(x), F_A(x) \in [0, 1]$. A SVNS A can be written as

$$A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}.$$

Definition 2.3. The **degree of truth-membership**, **indeterminacy-membership** and **falsity-membership of the subset** $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$T_A(X) = \min[T_A(v_i), T_A(v_j)]_{v_i, v_j \in X},$$

$$I_A(X) = \min[I_A(v_i), I_A(v_j)]_{v_i, v_j \in X},$$

$$\text{and } F_A(X) = \min[F_A(v_i), F_A(v_j)]_{v_i, v_j \in X}.$$

Definition 2.4. The **support** of $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$supp(X) = \{x \in X : \ T_A(x), I_A(x), F_A(x) > 0\}.$$

Definition 2.5 (Neutrosophic SuperHyperGraph (NSHG))**.** (**Ref.** [8],Definition 3,p.291).

Assume V' is a given set. A **neutrosophic SuperHyperGraph** (NSHG) S is an ordered pair $S = (V, E)$, where

(i) $V = \{V_1, V_2, \ldots, V_n\}$ a finite set of finite single valued neutrosophic subsets of V';

(ii) $V = \{(V_i, T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i)) : \ T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i) \geq 0\}, \ (i = 1, 2, \ldots, n)$;

(iii) $E = \{E_1, E_2, \ldots, E_{n'}\}$ a finite set of finite single valued neutrosophic subsets of V;

(iv) $E = \{(E_{i'}, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'})) : \ T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}) \geq 0\}, \ (i' = 1, 2, \ldots, n')$;

(v) $V_i \neq \emptyset, \ (i = 1, 2, \ldots, n)$;

(vi) $E_{i'} \neq \emptyset, \ (i' = 1, 2, \ldots, n')$;

(vii) $\sum_i supp(V_i) = V, \ (i = 1, 2, \ldots, n)$;

$(viii)$ $\sum_{i'} supp(E_{i'}) = V, \ (i' = 1, 2, \ldots, n')$;

(ix) and the following conditions hold:

$$T'_V(E_{i'}) \leq \min[T_{V'}(V_i), T_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$I'_V(E_{i'}) \leq \min[I_{V'}(V_i), I_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$\text{and } F'_V(E_{i'}) \leq \min[F_{V'}(V_i), F_{V'}(V_j)]_{V_i, V_j \in E_{i'}}$$

where $i' = 1, 2, \ldots, n'$.

Here the neutrosophic SuperHyperEdges (NSHE) $E_{j'}$ and the neutrosophic SuperHyperVertices (NSHV) V_j are single valued neutrosophic sets. $T_{V'}(V_i), I_{V'}(V_i)$, and $F_{V'}(V_i)$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership the neutrosophic SuperHyperVertex (NSHV) V_i to the neutrosophic SuperHyperVertex (NSHV) V. $T'_V(E_{i'}), T'_V(E_{i'})$, and $T'_V(E_{i'})$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the neutrosophic SuperHyperEdge (NSHE) $E_{i'}$ to the neutrosophic SuperHyperEdge (NSHE) E. Thus, the ii'th element of the **incidence matrix** of neutrosophic SuperHyperGraph (NSHG) are of the form $(V_i, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}))$, the sets V and E are crisp sets.

Example 2.6. (Application in Game Theory).
??????Description, Model(...Table and Figure), Problem, Analysis, Algorithm ??????

Definition 2.7 (Characterization of the Neutrosophic SuperHyperGraph (NSHG))**.** (**Ref.** [8],Section 4,pp.291-292).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. The neutrosophic SuperHyperEdges (NSHE) $E_{i'}$ and the neutrosophic SuperHyperVertices (NSHV) V_i of neutrosophic SuperHyperGraph (NSHG) $S = (V, E)$ could be characterized as follow-up items.

(i) If $|V_i| = 1$, then V_i is called **vertex**;

(ii) if $|V_i| \geq 1$, then V_i is called **SuperVertex**;

(iii) if for all V_is are incident in $E_{i'}$, $|V_i| = 1$, and $|E_{i'}| = 2$, then $E_{i'}$ is called **edge**;

(iv) if for all V_is are incident in $E_{i'}$, $|V_i| = 1$, and $|E_{i'}| \geq 2$, then $E_{i'}$ is called **HyperEdge**;

(v) if there's a V_i is incident in $E_{i'}$ such that $|V_i| \geq 1$, and $|E_{i'}| = 2$, then $E_{i'}$ is called **SuperEdge**;

(vi) if there's a V_i is incident in $E_{i'}$ such that $|V_i| \geq 1$, and $|E_{i'}| \geq 2$, then $E_{i'}$ is called **SuperHyperEdge**.

3 General Forms of Neutrosophic SuperHyperGraph (NSHG)

If we choose different types of binary operations, then we could get hugely diverse types of general forms of neutrosophic SuperHyperGraph (NSHG).

Definition 3.1 (t-norm)**.** (**Ref.** [7], Definition 5.1.1, pp.82-83).

A binary operation $\otimes : [0, 1] \times [0, 1] \to [0, 1]$ is a ***t*-norm** if it satisfies the following for $x, y, z, w \in [0, 1]$:

(i) $1 \otimes x = x$;

(ii) $x \otimes y = y \otimes x$;

(iii) $x \otimes (y \otimes z) = (x \otimes y) \otimes z$;

(iv) If $w \leq x$ and $y \leq z$ then $w \otimes y \leq x \otimes z$.

Definition 3.2. The **degree of truth-membership**, **indeterminacy-membership** and **falsity-membership of the subset** $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$ (with respect to t-norm T_{norm}):

$$T_A(X) = T_{norm}[T_A(v_i), T_A(v_j)]_{v_i, v_j \in X},$$

$$I_A(X) = T_{norm}[I_A(v_i), I_A(v_j)]_{v_i, v_j \in X},$$

$$\text{and } F_A(X) = T_{norm}[F_A(v_i), F_A(v_j)]_{v_i, v_j \in X}.$$

Definition 3.3. The **support** of $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$supp(X) = \{x \in X : \ T_A(x), I_A(x), F_A(x) > 0\}.$$

Definition 3.4. (General Forms of Neutrosophic SuperHyperGraph (NSHG)).

Assume V' is a given set. A **neutrosophic SuperHyperGraph** (NSHG) S is an ordered pair $S = (V, E)$, where

(i) $V = \{V_1, V_2, \ldots, V_n\}$ a finite set of finite single valued neutrosophic subsets of V';

(ii) $V = \{(V_i, T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i)) : \ T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i) \geq 0\}, \ (i = 1, 2, \ldots, n)$;

(iii) $E = \{E_1, E_2, \ldots, E_{n'}\}$ a finite set of finite single valued neutrosophic subsets of V;

(iv) $E = \{(E_{i'}, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'})) : \ T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}) \geq 0\}, \ (i' = 1, 2, \ldots, n')$;

(v) $V_i \neq \emptyset, \ (i = 1, 2, \ldots, n)$;

(vi) $E_{i'} \neq \emptyset, \ (i' = 1, 2, \ldots, n')$;

(vii) $\sum_i supp(V_i) = V, \ (i = 1, 2, \ldots, n)$;

$(viii)$ $\sum_{i'} supp(E_{i'}) = V, \ (i' = 1, 2, \ldots, n')$.

Here the neutrosophic SuperHyperEdges (NSHE) $E_{j'}$ and the neutrosophic SuperHyperVertices (NSHV) V_j are single valued neutrosophic sets. $T_{V'}(V_i), I_{V'}(V_i)$, and $F_{V'}(V_i)$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership the neutrosophic SuperHyperVertex (NSHV) V_i to the neutrosophic SuperHyperVertex (NSHV) V. $T'_V(E_{i'}), T'_V(E_{i'})$, and $T'_V(E_{i'})$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the neutrosophic SuperHyperEdge (NSHE) $E_{i'}$ to the neutrosophic SuperHyperEdge (NSHE) E. Thus, the ii'th element of the **incidence matrix** of neutrosophic SuperHyperGraph (NSHG) are of the form $(V_i, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}))$, the sets V and E are crisp sets.

Definition 3.5 (Characterization of the Neutrosophic SuperHyperGraph (NSHG))**.** (**Ref.** [8],Section 4,pp.291-292).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. The neutrosophic SuperHyperEdges (NSHE) $E_{i'}$ and the neutrosophic SuperHyperVertices (NSHV) V_i of neutrosophic SuperHyperGraph (NSHG) $S = (V, E)$ could be characterized as follow-up items.

(i) If $|V_i| = 1$, then V_i is called **vertex**;

(ii) if $|V_i| \geq 1$, then V_i is called **SuperVertex**;

(iii) if for all V_is are incident in $E_{i'}$, $|V_i| = 1$, and $|E_{i'}| = 2$, then $E_{i'}$ is called **edge**;

(iv) if for all V_is are incident in $E_{i'}$, $|V_i| = 1$, and $|E_{i'}| \geq 2$, then $E_{i'}$ is called **HyperEdge**;

(v) if there's a V_i is incident in $E_{i'}$ such that $|V_i| \geq 1$, and $|E_{i'}| = 2$, then $E_{i'}$ is called **SuperEdge**;

(vi) if there's a V_i is incident in $E_{i'}$ such that $|V_i| \geq 1$, and $|E_{i'}| \geq 2$, then $E_{i'}$ is called **SuperHyperEdge**.

4 Relations of Single Valued Neutrosophic Graph and Single Valued Neutrosophic HyperGraph With Neutrosophic SuperHyperGraph (NSHG)

Definition 4.1 (Single Valued Neutrosophic Graph)**.** (**Ref.** [2],Definition 3.1,p.89).
A **single valued neutrosophic graph** (SVN-graph) with underlying set V is defined to be a pair $G = (A, B)$ where

(i) The functions $T_A : V \to [0, 1], I_A : V \to [0, 1]$, and $F_A : V \to [0, 1]$ denote the degree of truth-membership, degree of indeterminacy-membership and falsity-membership of the element $v_i \in V$, respectively, and

$$0 \leq T_A(v_i) + I_A(v_i) + F_A(v_i) \leq 3 \text{ for all } v_i \in V \ (i = 1, 2, \ldots, n).$$

(ii) The functions $T_B : V \times V \to [0, 1], I_B : V \times V \to [0, 1]$, and $F_B : V \times V \to [0, 1]$ are defined by

$$T_B(\{v_i, v_j\}) \leq \min[T_A(v_i), T_A(v_j)],$$

$$I_B(\{v_i, v_j\}) \leq \min[I_A(v_i), I_A(v_j)],$$

$$\text{and } F_B(\{v_i, v_j\}) \leq \min[F_A(v_i), F_A(v_j)]$$

denote the degree of truth-membership, indeterminacy-membership and falsity-membership of the edge $(v_i, v_j) \in E$ respectively, where

$$0 \leq T_B(\{v_i, v_j\}) + I_B(\{v_i, v_j\}) + F_B(\{v_i, v_j\}) \leq 3 \text{ for all } \{v_i, v_i\} \in E \ (i = 1, 2, \ldots, n).$$

We call A the **single valued neutrosophic vertex set** of V, B the **single valued neutrosophic edge set** of E, respectively. Note that B is a symmetric single valued neutrosophic relation on A. We use the notation (v_i, v_j) for an element of E. Thus, $G = (A, B)$ is a single valued neutrosophic graph of $G^* = (A, B)$ if

$$T_B(\{v_i, v_j\}) \leq \min[T_A(v_i), T_A(v_j)],$$

$$I_B(\{v_i, v_j\}) \leq \min[I_A(v_i), I_A(v_j)],$$

$$\text{and } F_B(\{v_i, v_j\}) \leq \min[F_A(v_i), F_A(v_j)] \text{ for all } (v_i, v_j) \in E.$$

Proposition 4.2. *Let an ordered pair $S = (V, E)$ be a single valued neutrosophic graph. Then $S = (V, E)$ is a neutrosophic SuperHyperGraph (NSHG) S.*

The converse doesn't hold.

Definition 4.3 (Single Valued Neutrosophic HyperGraph). (**Ref.** [1],Definition 2.5,p.123).

Let $V = \{v_1, v_2, \ldots, v_n\}$ be a finite set and $E = \{E_1, E_2, \ldots, E_m\}$ be a finite family of non-trivial single valued neutrosophic subsets of V such that $V = \sum_i supp(E_{i'}),\ i = 1, 2, 3, \ldots, m$, where the edges $E_{i'}$ are single valued neutrosophic subsets of $V,\ E_{i'} = \{(v_j, T_{E_{i'}}(v_j), I_{E_{i'}}(v_j), F_{E_{i'}}(v_j))\},\ E_{i'} \neq \emptyset$, for $i = 1, 2, 3, \ldots, m$. Then the pair $H = (V, E)$ is a **single valued neutrosophic HyperGraph** on V, E is the family of single-valued neutrosophic HyperEdges of H and V is the crisp vertex set of H.

Proposition 4.4. *Let an ordered pair $S = (V, E)$ be single valued neutrosophic HyperGraph. Then $S = (V, E)$ is a type of general forms of neutrosophic SuperHyperGraph (NSHG) S.*

The converse doesn't hold.

5 Types of Neutrosophic SuperHyperEdges (NSHE)

Definition 5.1. Let an ordered pair $S = (V, E)$ be a neutrosophic SuperHyperGraph (NSHG) S. Then a sequence of neutrosophic SuperHyperVertices (NSHV) and neutrosophic SuperHyperEdges (NSHE)

$$V_1, E_1, V_2, E_2, V_3, \ldots, V_{s-1}, E_{s-1}, V_s$$

is called a **neutrosophic SuperHyperPath** (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_1 to neutrosophic SuperHyperVertex (NSHV) V_s if either of following conditions hold:

(i) $V_i, V_{i+1} \in E_{i'}$;

(ii) there's a vertex $v_i \in V_i$ such that $v_i, V_{i+1} \in E_{i'}$;

(iii) there's a SuperVertex $V'_i \in V_i$ such that $V'_i, V_{i+1} \in E_{i'}$;

(iv) there's a vertex $v_{i+1} \in V_{i+1}$ such that $V_i, v_{i+1} \in E_{i'}$;

(v) there's a SuperVertex $V'_{i+1} \in V_{i+1}$ such that $V_i, V'_{i+1} \in E_{i'}$;

(vi) there are a vertex $v_i \in V_i$ and a vertex $v_{i+1} \in V_{i+1}$ such that $v_i, v_{i+1} \in E_{i'}$;

(vii) there are a vertex $v_i \in V_i$ and a SuperVertex $V'_{i+1} \in V_{i+1}$ such that $v_i, V'_{i+1} \in E_{i'}$;

$(viii)$ there are a SuperVertex $V'_i \in V_i$ and a vertex $v_{i+1} \in V_{i+1}$ such that $V'_i, v_{i+1} \in E_{i'}$;

(ix) there are a SuperVertex $V'_i \in V_i$ and a SuperVertex $V'_{i+1} \in V_{i+1}$ such that $V'_i, V'_{i+1} \in E_{i'}$.

Definition 5.2. (Characterization of the Neutrosophic SuperHyperPaths).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. A neutrosophic SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_1 to neutrosophic SuperHyperVertex (NSHV) V_s is sequence of neutrosophic SuperHyperVertices (NSHV) and neutrosophic SuperHyperEdges (NSHE)

$$V_1, E_1, V_2, E_2, V_3, \ldots, V_{s-1}, E_{s-1}, V_s,$$

could be characterized as follow-up items.

(i) If for all $V_i, E_{j'}$, $|V_i| = 1,\ |E_{j'}| = 2$, then NSHP is called **path**;

(ii) if for all $E_{j'}$, $|E_{j'}| = 2$, and there's V_i, $|V_i| \geq 1$, then NSHP is called **SuperPath**;

(iii) if for all $V_i, E_{j'}$, $|V_i| = 1$, $|E_{j'}| \geq 2$, then NSHP is called **HyperPath**;

(iv) if there are $V_i, E_{j'}$, $|V_i| \geq 1, |E_{j'}| \geq 2$, then NSHP is called **SuperHyperPath**.

Definition 5.3. (Neutrosophic Strength of the Neutrosophic SuperHyperPaths).
Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. A neutrosophic SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_1 to neutrosophic SuperHyperVertex (NSHV) V_s is sequence of neutrosophic SuperHyperVertices (NSHV) and neutrosophic SuperHyperEdges (NSHE)

$$V_1, E_1, V_2, E_2, V_3, \ldots, V_{s-1}, E_{s-1}, V_s,$$

have

(i) **neutrosophic t-strength** $(\min\{T(V_i)\}, m, n)_{i=1}^{s}$;

(ii) **neutrosophic i-strength** $(m, \min\{I(V_i)\}, n)_{i=1}^{s}$;

(iii) **neutrosophic f-strength** $(m, n, \min\{F(V_i)\})_{i=1}^{s}$;

(iv) **neutrosophic strength** $(\min\{T(V_i)\}, \min\{I(V_i)\}, \min\{F(V_i)\})_{i=1}^{s}$.

Definition 5.4. (Different Neutrosophic Types of neutrosophic SuperHyperEdges (NSHE)).
Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Consider a neutrosophic SuperHyperEdge (NSHE) $E = \{V_1, V_2, \ldots, V_s\}$. Then E is called

(i) **neutrosophic $\mathbf{a_T}$** if $T(E) = \min\{T(V_i)\}_{i=1}^{s}$;

(ii) **neutrosophic $\mathbf{a_I}$** if $I(E) = \min\{I(V_i)\}_{i=1}^{s}$;

(iii) **neutrosophic $\mathbf{a_F}$** if $F(E) = \min\{F(V_i)\}_{i=1}^{s}$;

(iv) **neutrosophic $\mathbf{a_{TIF}}$** if
$(T(E), I(E), F(E)) = (\min\{T(V_i)\}, \min\{I(V_i)\}, \min\{F(V_i)\})_{i=1}^{s}$;

(v) **neutrosophic $\mathbf{b_T}$** if $T(E) = \prod\{T(V_i)\}_{i=1}^{s}$;

(vi) **neutrosophic $\mathbf{b_I}$** if $I(E) = \prod\{I(V_i)\}_{i=1}^{s}$;

(vii) **neutrosophic $\mathbf{b_F}$** if $F(E) = \prod\{F(V_i)\}_{i=1}^{s}$;

(viii) **neutrosophic $\mathbf{b_{TIF}}$** if
$(T(E), I(E), F(E)) = (\prod\{T(V_i)\}, \prod\{I(V_i)\}, \prod\{F(V_i)\})_{i=1}^{s}$;

(ix) **neutrosophic $\mathbf{c_T}(/-\mathbf{d_T}/-\mathbf{e_T}/-\mathbf{f_T}/-\mathbf{g_T})$** if
$T(E) > (/- \geq /- = /- < /- \leq)$ maximum number of neutrosophic t-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j where $1 \leq i, j \leq s$;

(x) **neutrosophic $\mathbf{c_I}(/-\mathbf{d_I}/-\mathbf{E_{i'}}/-\mathbf{f_I}/-\mathbf{g_I})$** if $I(E) > (/- \geq /- = /- < /- \leq)$ maximum number of neutrosophic i-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j where $1 \leq i, j \leq s$;

(xi) **neutrosophic $\mathbf{c_F}(/-\mathbf{d_F}/-\mathbf{e_F}/-\mathbf{f_F}/-\mathbf{g_F})$** if $F(E) > (/-\geq/-=/-</-\leq)$ maximum number of neutrosophic f-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j where $1 \leq i, j \leq s$;

(xii) **neutrosophic $\mathbf{c_{TIF}}(/-\mathbf{d_{TIF}}/-\mathbf{e_{TIF}}/-\mathbf{f_{TIF}}/-\mathbf{g_{TIF}})$** if $(T(E), I(E), F(E)) > (/-\geq/-=/-</-\leq)$ maximum number of neutrosophic strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j where $1 \leq i, j \leq s$.

6 Types of Neutrosophic Notions Based on Different neutrosophic SuperHyperEdges (NSHE)

6.1 Symmetric Neutrosophic Notions

For instance, having neutrosophic SuperHyperEdge (NSHE) and both neutrosophic SuperHyperVertices (NSHV) SuperHyperDominate, instantly.

Definition 6.1. (Neutrosophic SuperHyperDominating).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let D be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertex (NSHV) N in $V \setminus D$, there's at least a neutrosophic SuperHyperVertex (NSHV) D_i in D such that N, D_i is in a neutrosophic SuperHyperEdge (NSHE) is neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic $\mathbf{a_T}(-\mathbf{a_I}/-\mathbf{a_F}/-\mathbf{a_{TIF}}/-\mathbf{b_T}/-\mathbf{b_I}/-\mathbf{b_F}/-\mathbf{b_{TIF}}/-\ldots/-\mathbf{g_T}/-\mathbf{g_I}/-\mathbf{g_F}/-\mathbf{g_{TIF}})$ SuperHyperDominating set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ SuperHyperDominating sets is called **(I-/F-/- -)T-neutrosophic $\mathbf{a_T}(-\mathbf{a_I}/-\mathbf{a_F}/-\mathbf{a_{TIF}}/-\mathbf{b_T}/-\mathbf{b_I}/-\mathbf{b_F}/-\mathbf{b_{TIF}}/-\ldots/-\mathbf{g_T}/-\mathbf{g_I}/-\mathbf{g_F}/-\mathbf{g_{TIF}})$ SuperHyperDominating number** and it's denoted by $\mathcal{D}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.2. (Neutrosophic k-number SuperHyperDominating).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let D be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertex (NSHV) N in $V \setminus D$, there are at least neutrosophic SuperHyperVertices (NSHV) $D_1, D_2, \ldots, D_k$ in D such that $N, D_i (i = 1, 2, \ldots, k)$ is in a neutrosophic SuperHyperEdge (NSHE) is neutrosophic

$a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **k-number SuperHyperDominating set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ SuperHyperDominating sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **k-number SuperHyperDominating number** and it's denoted by $\mathcal{D}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.3. (Neutrosophic Dual SuperHyperDominating).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let D be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertex (NSHV) D_i in D, there's at least a neutrosophic SuperHyperVertex (NSHV) N in $V \setminus D$, such that N, D_i is in a neutrosophic SuperHyperEdge (NSHE) is neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **dual SuperHyperDominating set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ SuperHyperDominating sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **dual SuperHyperDominating number** and it's denoted by $\mathcal{D}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.4. (Neutrosophic Perfect SuperHyperDominating).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let D be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertex (NSHV) N in $V \setminus D$, there's only one neutrosophic SuperHyperVertex (NSHV) D_i in D such that N, D_i is in a neutrosophic SuperHyperEdge (NSHE) is neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **perfect SuperHyperDominating set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ SuperHyperDominating sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **perfect SuperHyperDominating number** and it's denoted by

$\mathcal{D}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.5. (Neutrosophic Total SuperHyperDominating).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let D be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertex (NSHV) N in V, there's at least a neutrosophic SuperHyperVertex (NSHV) D_i in D such that N, D_i is in a neutrosophic SuperHyperEdge (NSHE) is neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **total SuperHyperDominating set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})$ SuperHyperDominating sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}$ **total SuperHyperDominating number** and it's denoted by

$\mathcal{D}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-g_T/-g_I/-g_F/-g_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.6. (Different Types of SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. If $d(R_i, N) \neq d(R_i, N')$, then two neutrosophic SuperHyperVertices (NSHV) N and N' are

(i) **neutrosophic $\mathbf{a_T}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \min\{T(V_i), T(V_j)\}$;

(ii) **neutrosophic $\mathbf{a_I}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \min\{I(V_i), I(V_j)\}$;

(iii) **neutrosophic $\mathbf{a_F}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \min\{F(V_i), F(V_j)\}$;

(iv) **neutrosophic $\mathbf{a_{TIF}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = (\min\{T(V_i), T(V_j)\}, \min\{I(V_i), I(V_j)\}, \min\{F(V_i), F(V_j)\})$;

(v) **neutrosophic $\mathbf{b_T}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \prod\{T(V_i), T(V_j)\}$;

(vi) **neutrosophic $\mathbf{b_I}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \prod\{I(V_i), I(V_j)\}$;

(vii) **neutrosophic $\mathbf{b_F}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = \prod\{F(V_i), F(V_j)\}$;

(viii) **neutrosophic $\mathbf{a_{TIF}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j) = (\prod\{T(V_i), T(V_j)\}, \prod\{I(V_i), I(V_j)\}, \prod\{F(V_i), F(V_j)\})$;

(ix) **neutrosophic $\mathbf{c_T}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic t-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(x) **neutrosophic $\mathbf{c_I}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic i-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xi) **neutrosophic $\mathbf{c_F}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic f-strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xii) **neutrosophic $\mathbf{c_{TIF}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic strength of SuperHyperPath (NSHP) from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xiii) **neutrosophic $\mathbf{d_T}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of degree of truth-membership of all neutrosophic SuperHyperVertices (NSHV) in SuperHyperPath (NSHP) with maximum number of neutrosophic t-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xiv) **neutrosophic $\mathbf{d_I}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of degree of indeterminacy-membership of all neutrosophic SuperHyperVertices (NSHV) in SuperHyperPath (NSHP) with maximum number of neutrosophic i-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xv) **neutrosophic $\mathbf{d_F}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of degree of falsity-membership of all neutrosophic SuperHyperVertices (NSHV) in SuperHyperPath (NSHP) with maximum number of neutrosophic f-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xvi) **neutrosophic $\mathbf{d_{TIF}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of the triple (degree of truth-membership, degree of indeterminacy-membership, degree of falsity-membership) of all neutrosophic SuperHyperVertices (NSHV) in SuperHyperPath (NSHP) with maximum number of neutrosophic f-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

$(xvii)$ **neutrosophic $\mathbf{e_T}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic SuperHyperEdges (NSHE) in SuperHyperPath (NSHP) with maximum number of neutrosophic t-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

$(xviii)$ **neutrosophic $\mathbf{E_{i'}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic SuperHyperEdges (NSHE) in SuperHyperPath (NSHP) with maximum number of neutrosophic i-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xix) **neutrosophic $\mathbf{e_F}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic SuperHyperEdges (NSHE) in SuperHyperPath (NSHP) with maximum number of neutrosophic f-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j;

(xx) **neutrosophic $\mathbf{e_{TIF}}$ resolved** by neutrosophic SuperHyperVertex (NSHV) R_i where $d(V_i, V_j)$ is the maximum number of neutrosophic SuperHyperEdges (NSHE) in SuperHyperPath (NSHP) with maximum number of neutrosophic t-strength, neutrosophic i-strength and neutrosophic f-strength from neutrosophic SuperHyperVertex (NSHV) V_i to neutrosophic SuperHyperVertex (NSHV) V_j.

Definition 6.7. (Neutrosophic SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let R be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertices (NSHV) N and N' in $V \setminus R$, there's at least a neutrosophic SuperHyperVertex (NSHV) R_i in R such that N and N' are neutrosophic
$a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$
resolved by R_i, then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic**
$\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$
SuperHyperResolving set. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic
$a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$
SuperHyperResolving sets is called **(I-/F-/- -)T-neutrosophic**

$\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **SuperHyperResolving number** and it's denoted by $\mathcal{R}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.8. (Neutrosophic k-number SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let R be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertices (NSHV) N and N' in $V \setminus R$, there are at least neutrosophic SuperHyperVertices (NSHV) $R_1, R_2, \ldots, R_k$ in R such that N and N' are neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ resolved by $R_i (i = 1, 2, \ldots, k)$, then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **k-number SuperHyperResolving set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ SuperHyperResolving sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **k-number SuperHyperResolving number** and it's denoted by $\mathcal{R}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.9. (Neutrosophic Dual SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let R be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertices (NSHV) R_i and R_j in R, there's at least a neutrosophic SuperHyperVertex (NSHV) N in $V \setminus R$ such that R_i and R_j are neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ resolved by R_i, then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic**

$\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **dual SuperHyperResolving set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ SuperHyperResolving sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **dual SuperHyperResolving number** and it's denoted by $\mathcal{R}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.10. (Neutrosophic Perfect SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let R be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertices (NSHV) N and N' in $V \setminus R$, there's only one neutrosophic SuperHyperVertex (NSHV) R_i in R such that N and N' are neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ resolved by R_i, then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **perfect SuperHyperResolving set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ SuperHyperResolving sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **perfect SuperHyperResolving number** and it's denoted by $\mathcal{R}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i, v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i, v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.11. (Neutrosophic Total SuperHyperResolving).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let R be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. If for every neutrosophic SuperHyperVertices (NSHV) N and N' in V, there's at least a neutrosophic SuperHyperVertex (NSHV) R_i in R such that N and N' are neutrosophic

$a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ resolved by R_i, then the set of neutrosophic SuperHyperVertices (NSHV) S is called **neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **total SuperHyperResolving set**. The minimum (I-/F-/- -)T-neutrosophic cardinality between all neutrosophic $a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})$ SuperHyperResolving sets is called **(I-/F-/- -)T-neutrosophic** $\mathbf{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}$ **total SuperHyperResolving number** and it's denoted by $\mathcal{R}_{a_T(-a_I/-a_F/-a_{TIF}/-b_T/-b_I/-b_F/-b_{TIF}/-\ldots/-e_T/-E_{i'}/-e_F/-e_{TIF})}(NSHG)$ where **(I-/F-/- -)T-neutrosophic cardinality** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$|A|_T = \sum [T_A(v_i), T_A(v_j)]_{v_i,v_j \in A},$$

$$|A|_I = \sum [I_A(v_i), I_A(v_j)]_{v_i,v_j \in A},$$

$$|A|_F = \sum [F_A(v_i), F_A(v_j)]_{v_i,v_j \in A},$$

$$\text{and } |A| = \sum [|A|_T, |A|_I, |A|_F].$$

Definition 6.12. (Neutrosophic Stable and Neutrosophic Connected).

Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$. Let Z be a set of neutrosophic SuperHyperVertices (NSHV) [a SuperHyperVertex alongside triple pair of its values is called neutrosophic SuperHyperVertex (NSHV).]. Then Z is called

(i) **stable** if for every two neutrosophic SuperHyperVertices (NSHV) in Z, there's no SuperHyperPaths amid them;

(ii) **connected** if for every two neutrosophic SuperHyperVertices (NSHV) in Z, there's at least one SuperHyperPath amid them.

Thus Z is called

(i) **stable (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set** if Z is (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set and stable;

(ii) **connected (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set** if Z is (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set and connected.

A number N is called

(i) **stable (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) number** if its corresponded set Z is (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set and stable;

(ii) **connected (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) number** if its corresponded set Z is (k-number/dual/perfect/total) (SuperHyperResolving/SuperHyperDominating) set and connected.

Thus Z is called

(i) **(-/stable/connected) (-/dual/total) perfect (SuperHyperResolving/SuperHyperDominating) set** if Z is (-/stable/connected) (-/dual/total) perfect (SuperHyperResolving/SuperHyperDominating) set.

A number N is called

(i) **(-/stable/connected) (-/dual/total) perfect (SuperHyperResolving/SuperHyperDominating) number** if its corresponded set Z is -/stable/connected) (-/dual/total) perfect (SuperHyperResolving/SuperHyperDominating) set.

6.2 Antisymmetric Neutrosophic Notions

For instance, having neutrosophic SuperHyperEdge (NSHE) but neutrosophic SuperHyperVertex (NSHV) with bigger values SuperHyperDominates, instantly.

7 Classes of Neutrosophic SuperHyperGraphs (NSHG)

7.1 Restricted Status of Classes of Neutrosophic SuperHyperGraphs (NSHG)

Assume neutrosophic SuperHyperEdges (NSHE) $E_{i'}$ such that there's a V_i is incident in $E_{i'}$ such that $|V_i| \geq 1$, and $|E_{i'}| = 2$. Consider $\mu = (T_{V'}, I_{V'}, F_{V'}), \mu' = (T'_V, T'_I, F'_V)$.

Definition 7.1. Assume a neutrosophic SuperHyperGraph (NSHG) S is an ordered pair $S = (V, E)$ and $\mathcal{O}(NSHG) = |V|$. Then

(i) : a sequence of consecutive neutrosophic SuperHyperVertices (NSHV) $(NSHP) : \{x_0\}, \{x_1\}, \cdots, \{x_{\mathcal{O}(NSHG)}\}$ is called **neutrosophic SuperHyperPath** (NSHP) where

$$\{\{x_i\}, \{x_{i+1}\}\} \in E,\ i = 0, 1, \cdots, \mathcal{O}(NSHG) - 1;$$

(ii) : **neutrosophic SuperHyperStrength** (NSHH) of neutrosophic SuperHyperPath (NSHP) $NSHP : \{x_0\}, \{x_1\}, \cdots, \{x_{\mathcal{O}(NSHG)}\}$ is $\bigwedge_{i=0,\cdots,\mathcal{O}(NSHG)-1} \mu'(\{\{x_i\}, \{x_{i+1}\}\})$;

(iii) : **neutrosophic SuperHyperConnectedness** (NSHN) amid neutrosophic SuperHyperVertices (NSHV) $\{x_0\}$ and $\{x_t\}$ is

$$NSHN = \mu^{\infty}(\{x_0\}, \{x_t\}) = \bigvee_{P:\{x_0\},\{x_1\},\cdots,\{x_{\mathcal{O}(NSHG)}\}} \bigwedge_{i=0,\cdots,t-1} \mu'(\{\{x_i\}, \{x_{i+1}\}\});$$

(iv) : a sequence of consecutive neutrosophic SuperHyperVertices (NSHV) $NSHP : \{x_0\}, \{x_1\}, \cdots, \{x_{\mathcal{O}(NSHG)}\}, \{x_0\}$ is called **neutrosophic SuperHyperCycle** (NSHC) where

$$\{\{x_i\}, \{x_{i+1}\}\} \in E,\ i = 0, 1, \cdots, \mathcal{O}(NTG) - 1,\ \{\{x_{\mathcal{O}(NTG)}\}, \{x_0\}\} \in E$$

and there are two neutrosophic SuperHyperEdges (NSHE) $\{\{x\}, \{y\}\}$ and $\{\{u\}, \{v\}\}$ such that

$$\mu'(\{\{x\}, \{y\}\}) = \mu'(\{\{u\}, \{v\}\}) = \bigwedge_{i=0,1,\cdots,n-1} \mu'(\{\{v_i\}, \{v_{i+1}\}\});$$

(v) : it's **neutrosophic SuperHyper-t-partite** (NSHT) where V is partitioned to t parts, $V_1^{s_1}, V_2^{s_2}, \cdots, V_t^{s_t}$ and the neutrosophic SuperHyperEdge (NSHE) $\{\{x\},\{y\}\}$ implies $\{x\} \in V_i^{s_i}$ and $\{y\} \in V_j^{s_j}$ where $i \neq j$. If it's neutrosophic SuperHyperComplete (NSHM), then it's denoted by $K_{\sigma_1,\sigma_2,\cdots,\sigma_t}$ where σ_i is σ on $V_i^{s_i}$ instead V which mean $\{x\} \notin V_i$ induces $\mu_i(\{x\}) = 0$. Also, $|V_j^{s_i}| = s_i$;

(vi) : neutrosophic SuperHyper-t-partite is **neutrosophic SuperHyperBipartite** (NSHB) if $t = 2$, and it's denoted by K_{σ_1,σ_2} if it's neutrosophic SuperHyperComplete (NSHM);

(vii) : neutrosophic SuperHyperBipartite is **neutrosophic SuperHyperStar** (NSHS) if $|V_1| = 1$, and it's denoted by S_{1,σ_2};

$(viii)$: a neutrosophic SuperHyperVertex (NSHV) in V is **neutrosophic SuperHyperCenter** (NSHR) if the neutrosophic SuperHyperVertex (NSHV) joins to all neutrosophic SuperHyperVertices (NSHV) of a neutrosophic SuperHyperCycle (NSHC). Then it's **neutrosophic SuperHyperWheel** (NSHW) and it's denoted by W_{1,σ_2};

(ix) : it's **neutrosophic SuperHyperComplete** (NSHM) where

$$\forall \{u\},\{v\} \in V,\ \mu'(\{\{u\},\{v\}\}) = \mu(\{u\}) \wedge \mu(\{v\});$$

(x) : it's **neutrosophic SuperHyperStrong** (NSHO) where

$$\forall \{\{u\},\{v\}\} \in E,\ \mu'(\{\{u\},\{v\}\}) = \mu(\{u\}) \wedge \mu(\{v\}).$$

There's an open way to extend.

8 Further Directions

8.1 First Direction

Definition 8.1 (t-norm)**.** (**Ref.** [7], Definition 5.1.1, pp.82-83).
A binary operation $\otimes : [0,1] \times [0,1] \to [0,1]$ is a ***t*-norm** if it satisfies the following for $x, y, z, w \in [0,1]$:

(i) $1 \otimes x = x$;

(ii) $x \otimes y = y \otimes x$;

(iii) $x \otimes (y \otimes z) = (x \otimes y) \otimes z$;

(iv) If $w \leq x$ and $y \leq z$ then $w \otimes y \leq x \otimes z$.

Definition 8.2. (t-norm Single Valued Neutrosophic Graph).
A **t-norm single valued neutrosophic graph** (tSVN-graph) with underlying set V is defined to be a pair $G = (A, B)$ where

(i) The functions $T_A : V \to [0,1], I_A : V \to [0,1]$, and $F_A : V \to [0,1]$ denote the degree of truth-membership, degree of indeterminacy-membership and falsity-membership of the element $v_i \in V$, respectively, and

$$0 \leq T_A(v_i) + I_A(v_i) + F_A(v_i) \leq 3 \text{ for all } v_i \in V \ (i = 1, 2, \ldots, n).$$

(ii) The functions $T_B : V \times V \to [0,1], I_B : V \times V \to [0,1]$, and $F_B : V \times V \to [0,1]$ are defined by

$$T_B(\{v_i, v_j\}) \leq T_{norm}[T_A(v_i), T_A(v_j)],$$
$$I_B(\{v_i, v_j\}) \leq T_{norm}[I_A(v_i), I_A(v_j)],$$
$$\text{and } F_B(\{v_i, v_j\}) \leq T_{norm}[F_A(v_i), F_A(v_j)]$$

denote the degree of truth-membership, indeterminacy-membership and falsity-membership of the edge $(v_i, v_j) \in E$ respectively, where

$$0 \leq T_B(\{v_i, v_j\}) + I_B(\{v_i, v_j\}) + F_B(\{v_i, v_j\}) \leq 3 \text{ for all } \{v_i, v_i\} \in E \ (i = 1, 2, \ldots, n).$$

We call A the **single valued neutrosophic vertex set** of V, B the **single valued neutrosophic edge set** of E, respectively. Note that B is a symmetric single valued neutrosophic relation on A. We use the notation (v_i, v_j) for an element of E. Thus, $G = (A, B)$ is a t-norm single valued neutrosophic graph of $G^* = (A, B)$ if

$$T_B(\{v_i, v_j\}) \leq T_{norm}[T_A(v_i), T_A(v_j)],$$
$$I_B(\{v_i, v_j\}) \leq T_{norm}[I_A(v_i), I_A(v_j)],$$
$$\text{and } F_B(\{v_i, v_j\}) \leq T_{norm}[F_A(v_i), F_A(v_j)] \text{ for all } (v_i, v_j) \in E.$$

Definition 8.3. The **degree of truth-membership**, **indeterminacy-membership** and **falsity-membership of the subset** $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$ (with respect to t-norm T_{norm}):

$$T_A(X) = T_{norm}[T_A(v_i), T_A(v_j)]_{v_i, v_j \in X},$$
$$I_A(X) = T_{norm}[I_A(v_i), I_A(v_j)]_{v_i, v_j \in X},$$
$$\text{and } F_A(X) = T_{norm}[F_A(v_i), F_A(v_j)]_{v_i, v_j \in X}.$$

Definition 8.4. The **support** of $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$supp(X) = \{x \in X : \ T_A(x), I_A(x), F_A(x) > 0\}.$$

Definition 8.5. (t-norm Neutrosophic SuperHyperGraph (tNSHG)).

Assume V' is a given set. A **t-norm neutrosophic SuperHyperGraph** (tNSHG) S is an ordered pair $S = (V, E)$, where

(i) $V = \{V_1, V_2, \ldots, V_n\}$ a finite set of finite single valued neutrosophic subsets of V';

(ii) $V = \{(V_i, T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i)) : \ T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i) \geq 0\}, \ (i = 1, 2, \ldots, n)$;

(iii) $E = \{E_1, E_2, \ldots, E_{n'}\}$ a finite set of finite single valued neutrosophic subsets of V;

(iv) $E = \{(E_{i'}, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'})) : \ T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}) \geq 0\}, \ (i' = 1, 2, \ldots, n')$;

(v) $V_i \neq \emptyset, \ (i = 1, 2, \ldots, n)$;

(vi) $E_{i'} \neq \emptyset, \ (i' = 1, 2, \ldots, n')$;

(vii) $\sum_i supp(V_i) = V, \ (i = 1, 2, \ldots, n)$;

(viii) $\sum_{i'} supp(E_{i'}) = V, \ (i' = 1, 2, \ldots, n')$;

(*ix*) and the following conditions hold:

$$T'_V(E_{i'}) \leq T_{norm}[T_{V'}(V_i), T_{V'}(V_j)]_{V_i,V_j \in E_{i'}},$$

$$I'_V(E_{i'}) \leq T_{norm}[I_{V'}(V_i), I_{V'}(V_j)]_{V_i,V_j \in E_{i'}},$$

$$\text{and } F'_V(E_{i'}) \leq T_{norm}[F_{V'}(V_i), F_{V'}(V_j)]_{V_i,V_j \in E_{i'}}$$

where $i' = 1, 2, \ldots, n'$.

Here the neutrosophic SuperHyperEdges (NSHE) E_j and the neutrosophic SuperHyperVertices (NSHV) V_j are single valued neutrosophic sets. $T_{V'}(V_i), I_{V'}(V_i)$, and $F_{V'}(V_i)$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership the neutrosophic SuperHyperVertex (NSHV) V_i to the neutrosophic SuperHyperVertex (NSHV) V. $T'_V(E_{i'}), T'_V(E_{i'})$, and $T'_V(E_{i'})$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the neutrosophic SuperHyperEdge (NSHE) E_i to the neutrosophic SuperHyperEdge (NSHE) E. Thus, the ii'th element of the **incidence matrix** of t-norm Neutrosophic SuperHyperGraph (tNSHG) are of the form $(V_i, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}))$, the sets V and E are crisp sets.

8.2 Second Direction

Definition 8.6. (x Single Valued Neutrosophic Graph (xSVN-graph)).
A **x single valued neutrosophic graph** (xSVN-graph) with underlying set V is defined to be a pair $G = (A, B)$ where

(*i*) The functions $T_A : V \to [0,1], I_A : V \to [0,1]$, and $F_A : V \to [0,1]$ denote the degree of truth-membership, degree of indeterminacy-membership and falsity-membership of the element $v_i \in V$, respectively, and

$$0 \leq T_A(v_i) + I_A(v_i) + F_A(v_i) \leq 3 \text{ for all } v_i \in V \ (i = 1, 2, \ldots, n).$$

(*ii*) The functions $T_B : V \times V \to [0,1], I_B : V \times V \to [0,1]$, and $F_B : V \times V \to [0,1]$ are defined by

$$T_B(\{v_i, v_j\}) \leq \max[T_A(v_i), T_A(v_j)],$$

$$I_B(\{v_i, v_j\}) \leq \max[I_A(v_i), I_A(v_j)],$$

$$\text{and } F_B(\{v_i, v_j\}) \leq \max[F_A(v_i), F_A(v_j)]$$

denote the degree of truth-membership, indeterminacy-membership and falsity-membership of the edge $(v_i, v_j) \in E$ respectively, where

$$0 \leq T_B(\{v_i, v_j\}) + I_B(\{v_i, v_j\}) + F_B(\{v_i, v_j\}) \leq 3 \text{ for all } \{v_i, v_i\} \in E \ (i = 1, 2, \ldots, n).$$

We call A the **single valued neutrosophic vertex set** of V, B the **single valued neutrosophic edge set** of E, respectively. Note that B is a symmetric single valued neutrosophic relation on A. We use the notation (v_i, v_j) for an element of E. Thus, $G = (A, B)$ is a x single valued neutrosophic graph of $G^* = (A, B)$ if

$$T_B(\{v_i, v_j\}) \leq \max[T_A(v_i), T_A(v_j)],$$

$$I_B(\{v_i, v_j\}) \leq \max[I_A(v_i), I_A(v_j)],$$

$$\text{and } F_B(\{v_i, v_j\}) \leq \max[F_A(v_i), F_A(v_j)] \text{ for all } (v_i, v_j) \in E.$$

Definition 8.7. The **degree of truth-membership**, **indeterminacy-membership** and **falsity-membership of the subset** $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$ (with respect to t-norm T_{norm}):

$$T_A(X) = \max[T_A(v_i), T_A(v_j)]_{v_i, v_j \in X},$$

$$I_A(X) = \max[I_A(v_i), I_A(v_j)]_{v_i, v_j \in X},$$

$$\text{and } F_A(X) = \max[F_A(v_i), F_A(v_j)]_{v_i, v_j \in X}.$$

Definition 8.8. The **support** of $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$supp(X) = \{x \in X : \ T_A(x), I_A(x), F_A(x) > 0\}.$$

Definition 8.9. (x Neutrosophic SuperHyperGraph (xNSHG)).

Assume V' is a given set. A **x neutrosophic SuperHyperGraph** (xNSHG) S is an ordered pair $S = (V, E)$, where

(i) $V = \{V_1, V_2, \ldots, V_n\}$ a finite set of finite single valued neutrosophic subsets of V';

(ii) $V = \{(V_i, T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i)) : \ T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i) \geq 0\}, \ (i = 1, 2, \ldots, n)$;

(iii) $E = \{E_1, E_2, \ldots, E_{n'}\}$ a finite set of finite single valued neutrosophic subsets of V;

(iv) $E = \{(E_{i'}, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'})) : \ T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}) \geq 0\}, \ (i' = 1, 2, \ldots, n')$;

(v) $V_i \neq \emptyset, \ (i = 1, 2, \ldots, n)$;

(vi) $E_{i'} \neq \emptyset, \ (i' = 1, 2, \ldots, n')$;

(vii) $\sum_i supp(V_i) = V, \ (i = 1, 2, \ldots, n)$;

$(viii)$ $\sum_{i'} supp(E_{i'}) = V, \ (i' = 1, 2, \ldots, n')$;

(ix) and the following conditions hold:

$$T'_V(E_{i'}) \leq \max[T_{V'}(V_i), T_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$I'_V(E_{i'}) \leq \max[I_{V'}(V_i), I_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$\text{and } F'_V(E_{i'}) \leq \max[F_{V'}(V_i), F_{V'}(V_j)]_{V_i, V_j \in E_{i'}}$$

where $i' = 1, 2, \ldots, n'$.

Here the neutrosophic SuperHyperEdges (NSHE) E_j and the neutrosophic SuperHyperVertices (NSHV) V_j are single valued neutrosophic sets. $T_{V'}(V_i), I_{V'}(V_i)$, and $F_{V'}(V_i)$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership the neutrosophic SuperHyperVertex (NSHV) V_i to the neutrosophic SuperHyperVertex (NSHV) V. $T'_V(E_{i'}), T'_V(E_{i'})$, and $T'_V(E_{i'})$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the neutrosophic SuperHyperEdge (NSHE) E_i to the neutrosophic SuperHyperEdge (NSHE) E. Thus, the ii'th element of the **incidence matrix** of x Neutrosophic SuperHyperGraph (xNSHG) are of the form $(V_i, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}))$, the sets V and E are crisp sets.

8.3 Third Direction

Definition 8.10. (p Single Valued Neutrosophic Graph (pSVN-graph)).
A **p single valued neutrosophic graph** (pSVN-graph) with underlying set V is defined to be a pair $G = (A, B)$ where

(i) The functions $T_A : V \to [0,1], I_A : V \to [0,1]$, and $F_A : V \to [0,1]$ denote the degree of truth-membership, degree of indeterminacy-membership and falsity-membership of the element $v_i \in V$, respectively, and

$$0 \leq T_A(v_i) + I_A(v_i) + F_A(v_i) \leq 3 \text{ for all } v_i \in V \ (i = 1, 2, \ldots, n).$$

(ii) The functions $T_B : V \times V \to [0,1], I_B : V \times V \to [0,1]$, and $F_B : V \times V \to [0,1]$ are defined by

$$T_B(\{v_i, v_j\}) \leq T_A(v_i) \times T_A(v_j),$$
$$I_B(\{v_i, v_j\}) \leq I_A(v_i) \times I_A(v_j),$$
$$\text{and } F_B(\{v_i, v_j\}) \leq F_A(v_i) \times F_A(v_j)$$

denote the degree of truth-membership, indeterminacy-membership and falsity-membership of the edge $(v_i, v_j) \in E$ respectively, where

$$0 \leq T_B(\{v_i, v_j\}) + I_B(\{v_i, v_j\}) + F_B(\{v_i, v_j\}) \leq 3 \text{ for all } \{v_i, v_i\} \in E \ (i = 1, 2, \ldots, n).$$

We call A the **single valued neutrosophic vertex set** of V, B the **single valued neutrosophic edge set** of E, respectively. Note that B is a symmetric single valued neutrosophic relation on A. We use the notation (v_i, v_j) for an element of E. Thus, $G = (A, B)$ is a p single valued neutrosophic graph of $G^* = (A, B)$ if

$$T_B(\{v_i, v_j\}) \leq T_A(v_i) \times T_A(v_j),$$
$$I_B(\{v_i, v_j\}) \leq I_A(v_i) \times I_A(v_j),$$
$$\text{and } F_B(\{v_i, v_j\}) \leq F_A(v_i) \times F_A(v_j) \text{ for all } (v_i, v_j) \in E.$$

Definition 8.11. The **degree of truth-membership**, **indeterminacy-membership** and **falsity-membership of the subset** $X \subset A$ of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$T_A(X) = [T_A(v_i) \times T_A(v_j)]_{v_i, v_j \in X},$$
$$I_A(X) = [I_A(v_i) \times I_A(v_j)]_{v_i, v_j \in X},$$
$$\text{and } F_A(X) = [F_A(v_i) \times F_A(v_j)]_{v_i, v_j \in X}.$$

Definition 8.12. The crisp subset of X in which all its elements have nonzero membership degree is defined as the **support** of the single valued neutrosophic set $A = \{< x : T_A(x), I_A(x), F_A(x) >, x \in X\}$:

$$supp(A) = \{x : \ T_A(x), I_A(x), F_A(x) > 0\}.$$

Definition 8.13. (p Neutrosophic SuperHyperGraph (pNSHG)).
Assume V' is a given set. A **p neutrosophic SuperHyperGraph** (pNSHG) S is an ordered pair $S = (V, E)$, where

(i) $V = \{V_1, V_2, \ldots, V_n\}$ a finite set of finite single valued neutrosophic subsets of V';

(ii) $V = \{(V_i, T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i)) : \ T_{V'}(V_i), I_{V'}(V_i), F_{V'}(V_i) \geq 0\}, \ (i = 1, 2, \ldots, n)$;

(iii) $E = \{E_1, E_2, \dots, E_{n'}\}$ a finite set of finite single valued neutrosophic subsets of V;

(iv) $E = \{(E_{i'}, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'})) : T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}) \geq 0\}$, $(i' = 1, 2, \dots, n')$;

(v) $V_i \neq \emptyset$, $(i = 1, 2, \dots, n)$;

(vi) $E_{i'} \neq \emptyset$, $(i' = 1, 2, \dots, n')$;

(vii) $\sum_i supp(V_i) = V$, $(i = 1, 2, \dots, n)$;

$(viii)$ $\sum_{i'} supp(E_{i'}) = V$, $(i' = 1, 2, \dots, n')$;

(ix) and the following conditions hold:

$$T'_V(E_{i'}) \leq [T_{V'}(V_i) \times T_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$I'_V(E_{i'}) \leq [I_{V'}(V_i) \times I_{V'}(V_j)]_{V_i, V_j \in E_{i'}},$$

$$\text{and } F'_V(E_{i'}) \leq [F_{V'}(V_i) \times F_{V'}(V_j)]_{V_i, V_j \in E_{i'}}$$

where $i' = 1, 2, \dots, n'$.

Here the neutrosophic SuperHyperEdges (NSHE) E_j and the neutrosophic SuperHyperVertices (NSHV) V_j are single valued neutrosophic sets. $T_{V'}(V_i), I_{V'}(V_i)$, and $F_{V'}(V_i)$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership the neutrosophic SuperHyperVertex (NSHV) V_i to the neutrosophic SuperHyperVertex (NSHV) V. $T'_V(E_{i'}), T'_V(E_{i'})$, and $T'_V(E_{i'})$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the neutrosophic SuperHyperEdge (NSHE) E_i to the neutrosophic SuperHyperEdge (NSHE) E. Thus, the ii'th element of the **incidence matrix** of p Neutrosophic SuperHyperGraph (pNSHG) are of the form $(V_i, T'_V(E_{i'}), I'_V(E_{i'}), F'_V(E_{i'}))$, the sets V and E are crisp sets.

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