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SELF-CENTERED INTERVAL VALUED SIGNED NEUTROSOPHIC GRAPH

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ABSTRACT

In this paper, we discuss the concepts of interval valued neutrosophic gragh, single valued neutrosophic signed graph, self centered single valued neutrosophic graph. We present the concept of self-centered interval valued signed netrosophic graph. We investigate some properties of self-centered interval valued signed neutrosophic graphs and investigate some of their properties with proof and example.

Keywords: *Neutosophic graph, interval valued graph, signed graph, self-centered graph, self centered signed graph.*

1. INTRODUCTION

Karunambigai M.G and Kalaivani O introduced the concept of self-centered IFG. Smarandache F, Broumi S, Talea M, Bakali A,- Dhavaseelan R, Vikram-prasad R, Krishnaraj V introduced the idea of neutrosophic sets by combining the non-standard analysis. Neutrosophic set is a mathematical tool for dealing real life problems having imprecise, indeterminacy and inconsistent data. Neutrosophic set theory, as a generalization of classical set theory, fuzzy set theory and intuitionistic fuzzy set theory, is applied in a variety of fields, including control theory, decision making problems, topology, medicines and inmany more real life problems. Wang *et al.* Wang H, Samarandache F, ZhangY.Q presented the notion of single-valued neutrosophic sets to apply neutrosophic sets in real life problems more conveniently. A single-valued neutrosophic set has three components: truth membership degree, indeterminacymembership degree and falsity membership degree. These three components of a single-valued neutrosophic set are not dependent and their values arecontained in the standard unit interval [0, 1]. Single-valued neutrosophic sets are the generalization of intuitionistic fuzzy sets. Single-valued neutrosophic sets have been a new hot research topic and many researchers haveaddressed this issue. Akram *et al.* Akram M and Shahzadi S has discussed several concepts related to single-valued neutrosophic graphs. Majumdarand Samanta Majumdar P and Samanta S.K studied similarity and entropy of single-valued neutrosophic sets. In this paper, we introduce the concepts of length, distance, radius and eccentricity of self-centered of a interval valued neutrosophic graph. We also discuss some interesting properties besides giving some examples.

2. PRELIMINARIES

Definition 2.1: Let $\boldsymbol{X}$ be a space of points (objects) with generic elements in $\boldsymbol{X}$ denoted by $\boldsymbol{x}$; then the neutrosophic set $\boldsymbol{A}$ is an object of 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, indeterminacy -membership function and 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 non standard subsets of $]^{-}0, 1^{+}[$.

Definition 2.2: Let X be a space of points (options) with generic elements in X denoted by x. A single valued neutrosophic set $\boldsymbol{A}$ (SVNS) is characterized by truth-membership function $\boldsymbol{T_A(x)}$, an indeterminacy-membership function $\boldsymbol{I_A(x)}$ and a falsity-membership $\boldsymbol{F_A(x)}$. For each point $\boldsymbol{x \in X}$, $\boldsymbol{T_A(x), I_A(x), F_A(x) \in \{0, 1\}}$.

A (SVNS) can be written as $A = \{< x: T_A(x), I_A(x), F_A(x) >, x \in X\}$

Definition 2.3: A fuzzy graph $\boldsymbol{G(\sigma, \mu)}$ is said to be a fuzzy signed graph if there is a mapping $\boldsymbol{\eta}: \boldsymbol{E} \to \{+, -\}$ such that each edge signed to $\{+, -\}$ or all nodes and edges assigned to $\{+, -\}$ when we assign $\{+, -\}$ to each of the following nodes called vertex signed fuzzy graph.

For assignment of sign to any edge we follow some rule, according to the problems or relations between the objects we define some α after it we take an α-cut for the set of edges, then we assign positive or negative to the edges appear in α-cut set alternate sign for those which are not in α-cut set.

In the following fuzzy graph shown in figure, wee assume $\alpha = 0.4$, thus α-cut sets for edge set contain only two edges v_1v_2 and v_1v_4. So we assign positive sign to these edges and for remaining we assigned it by negative sign.

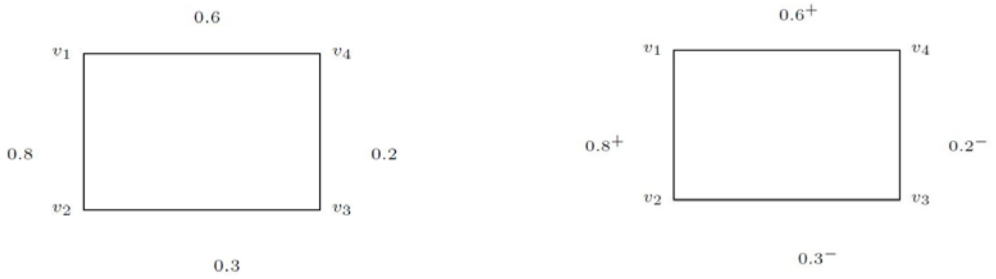

Figure-2.1: Fuzzy graph and its signed graph

Definition 2.4: Let $\boldsymbol{A} = (\boldsymbol{T_A}, \boldsymbol{I_A}, \boldsymbol{F_A})$ and $\boldsymbol{B} = (\boldsymbol{T_B}, \boldsymbol{I_B}, \boldsymbol{F_B})$ be single valued neutrosophic sets on a set on a set $\boldsymbol{X}$. If $\boldsymbol{A} = (\boldsymbol{T_A}, \boldsymbol{I_A}, \boldsymbol{F_A})$ is a single valued neutrosophic relation on a set $\boldsymbol{X}$, then

$T_B(x,y) \le min(T_A(x), T_A(y))$, $I_B(x,y) \ge max(I_A(x), I_A(x))$ and
$F_B(x,y) \ge max(F_A(x), F_A(x))$

A single valued neutrosophic relation A on X is called symmetric if

$T_A(x,y) = T_A(y,x) T_B(x,y) = T_B(y,x)$, $I_A(x,y) = I_A(y,x) I_B(x,y) = I_B(y,x)$ and
$F_A(x,y) = F_A(y,x) F_B(x,y) = F_B(y,x)$

$x, y \in X$. Throughout this paper, we denote $G^* = (V, E)$ a crisp graph, and $G = (A, B)$ a single valued neutrosophic graph.

Definition 2.5: A single valued neutrosophic graph (SVN-graph) with underlying set $\boldsymbol{V}$ is defined to be a pair $\boldsymbol{G} = (\boldsymbol{A}, \boldsymbol{B})$ where

1. The functions $T_A: V \to [0,1]$, $I_A: V \to [0,1]$, $F_A: V \to [0,1]$ denote degree of truth-membership, degree of indeterminacy-membership and degree of falsity-membership of the element $v_i \in V$ respectively and $0 \le T_A(v_i) + I_A(v_i) + F_A(v_i) \le 3$ for all $v_i \in V (i = 1,2, \dots n)$
2. The functions $T_B: E \le V \times V \to [0,1]$, $I_B: E \le V \times V \to [0,1]$ and $F_B: E \le V \times V \to [0,1]$ are defined by $T_B(v_i, v_j) \le min[T_A(v_i), T_A(v_j)]$, $I_B(v_i, v_j) \ge max[I_A(v_i), I_A(v_j)]$ and $F_B(v_i, v_j) \ge max[F_A(v_i), F_A(v_j)]$

Denotes the degree of truth-membership, indeterminacy-membership and falsity-membership of the edge $(v_i, v_j) \in E$ respectively, where $0 \le T_B(v_i, v_j) + I_B(v_i, v_j) + F_B(v_i, v_j) \le 3$ for all $(v_i, v_j) \in E (i, j = 1,2, \dots n)$ 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 for an element of E. Thus, $G = (A, B)$ is a single valued neutrosophic graph of $G^* = (V, E)$ if $T_B: E \le V \times V \to [0,1]$, $I_B: E \le V \times V \to [0,1]$ and $F_B: E \le V \times V \to [0,1]$ are defined by

$$T_B(v_i, v_j) \le min[T_A(v_i), T_A(v_j)],\ I_B(v_i, v_j) \ge max[I_A(v_i), I_A(v_j)] \text{and}$$
$$F_B(v_i, v_j) \ge max[F_A(v_i), F_A(v_j)] \text{ forall } (v_i, v_j \in E)$$

Example 2: Consider the graph G^* such that $V = \{v_1, v_2, v_3, v_4\}, E = \{v_1v_2, v_2v_3, v_3v_4, v_4v_1\}$. Let A be a single valued neutrosophic subset of V and let B a single valued neutrosophic subset of E denoted by

	v_1	v_2	v_3	v_4
T_A	0.4	0.5	0.3	0.2
I_A	0.2	0.2	0.5	0.4
F_A	0.5	0.3	0.6	0.3

	v_1v_2	v_2v_3	v_3v_4	v_4v_5
T_B	0.4	0.3	0.2	0.1
I_B	0.2	0.5	0.5	0.4
F_B	0.5	0.6	0.6	0.5

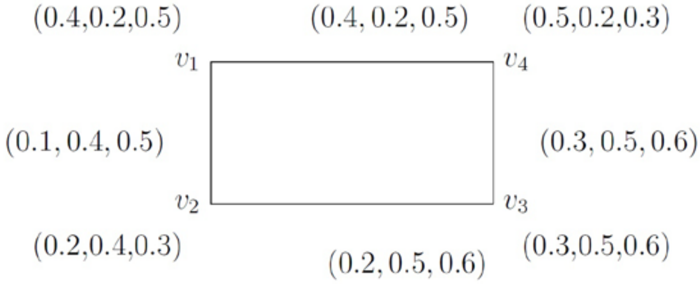

Figure 2.2: Single valued neutrosophic graph

in figure 2.2,

1. (v_1,0.4,0.2,0.5) is single valued neutrosophic vertex or SVN-vertex.
2. ($v_1 v_2$,0.4,0.2,0.5) is single valued neutrosophic edge or SVN-edge.
3. (v_1,0.4,0.2,0.5) and (v_2,0.5,0.2,0.3) are single valued neutrosophic adjacent vertices.
4. ($v_1 v_2$,0.4,0.2,0.5) and ($v_1 v_4$,0.1,0.4,0.5) are single valued neutrosophic adjacent edge.

Definition 2.6: A single valued neutrosophic graph $\breve{\boldsymbol{G}}$ is said to be single valued signed neutrosophic graph if $\boldsymbol{\sigma}: \boldsymbol{E}(\breve{\boldsymbol{G}}) \rightarrow \{+\mathbf{1}, -\mathbf{1}\}$ is a function associated from $\boldsymbol{E}(\breve{\boldsymbol{G}})$ of $\breve{\boldsymbol{G}}$ such that each edges signed to $\{+\mathbf{1}, -\mathbf{1}\}$.

We assign $E(\breve{G}) \rightarrow \{+1, -1\}$ on the comparison basis of its truth-membership, indeterminacy-membership and falsity-membership values. If the truth-membership value is greater than both indeterminacy-membership and falsity-membership values, we assign it positive and in reverse case we assign it negative and in case of equality we keep it unsigned.

Definition 2.7: Let $\boldsymbol{X}$ be a space of points (objects) with generic elements in $\boldsymbol{X}$ denoted by $\boldsymbol{x}$. An interval valued neutrosophic set (for short IVNS) $\boldsymbol{A}$ in $\boldsymbol{X}$ is characterized by truth-membership function $\boldsymbol{T_A(x)}$, indeterminacy-membership function $\boldsymbol{I_A(x)}$ and falsity-membership function $\boldsymbol{F_A(x)}$. For each point $\boldsymbol{x}$ in $\boldsymbol{X}$, we have that $\boldsymbol{T_A(x) = [T_{AL}(x), T_{AU}(x)]}$, $\boldsymbol{I_A(x) = [I_{AL}(x), I_{AU}(x)]}$, $\boldsymbol{F_A(x) = [F_{AL}(x), F_{AU}(x)]}$, $\boldsymbol{0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3}$.

Definition 2.8: Let $\boldsymbol{X}$ be a space of points (objects) with generic elements in $\boldsymbol{X}$ denoted by $\boldsymbol{x}$. An interval valued neutrosophic set (for short IVNS A) $\boldsymbol{A}$ in $\boldsymbol{X}$ is characterized by truth-membership function $\boldsymbol{T_A(x)}$, indeterminacy-membership function $\boldsymbol{I_A(x)}$ and falsity-membership function $\boldsymbol{F_A(x)}$. For each point $\boldsymbol{x}$ in $\boldsymbol{X}$,

we have that $T_A(x) = [T_{AL}(x), T_{AU}(x)]$, $I_A(x) = [I_{AL}(x), I_{AU}(x)]$,
$F_A(x) = [F_{AL}(x), F_{AU}(x)] \subseteq [0,1]$ and $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Definition 2.9: An interval valued neutrosophic graph of a graph $\boldsymbol{G^* = (V, E)}$ we mean a pair $\boldsymbol{G = (A, B)}$ where $\boldsymbol{A =< [T_{AL}, T_{AU}], [I_{AL}, I_{AU}], [F_{AL}, F_{AU}] >}$ is an interval valued neutrosophic set on $\boldsymbol{V}$ and $\boldsymbol{B =< [T_{BL}, T_{BU}], [I_{BL}, I_{BU}], [F_{BL}, F_{BU}] >}$ is an interval valued neutrosophic set on $\boldsymbol{E}$ satisfies the following condition:

1. $V = \{v_1, v_2 \ldots v_n\}$ such that $T_{AL}: V \rightarrow [0,1]$, $T_{AU}: V \rightarrow [0,1]$, $I_{AL}: V \rightarrow [0,1]$, $I_{AU}: V \rightarrow [0,1]$, and $F_{AL}: V \rightarrow [0,1]$, $F_{AU}: V \rightarrow [0,1]$ denote the degree of the truth-membership,the degree of indeterminacy-membership and degree of falsity-membership of the element $y \in V$, respectively, and

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

2. The functions $T_{BL}: V \times V \rightarrow [0,1]$,$T_{BU}: V \times V \rightarrow [0,1]$, $I_{BL}: V \times V \rightarrow [0,1]$,$I_{BU}: V \times V \rightarrow [0,1]$ and $F_{BL}: V \times V \rightarrow [0,1]$, $F_{BU}: V \times V \rightarrow [0,1]$ are such that

$T_{BL}(\{v_i, v_j\}) \leq min[T_{AL}(v_i), T_{AL}(v_j)]$, $T_{BU}(\{v_i, v_j\}) \leq min[T_{AU}(v_i), T_{AU}(v_j)]$,
$I_{BL}(\{v_i, v_j\}) \geq min[I_{AL}(v_i), I_{AL}(v_j)]$, $I_{BU}(\{v_i, v_j\}) \geq min[I_{AU}(v_i), I_{AU}(v_j)]$,
$F_{BL}(\{v_i, v_j\}) \geq min[F_{AL}(v_i), F_{AL}(v_j)]$ and
$F_{BU}(\{v_i, v_j\}) \geq min[F_{AU}(v_i), F_{AU}(v_j)]$

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

$$0 \leq T_B(v_i, v_j) + I_B(v_i, v_j) + F_B(v_i, v_j) \leq 3$$

for all $\{v_i, v_j\} \in E (i, j = 1,2, \ldots n)$ We call A the IVN vertex set of V, B the IVN edge set of E, respectively. Note that B is a symmetric IVN relation on A. We use the notation (v_i, v_j) for an element of E Thus, $G = (A, B)$ is an IVNG of $G^* = (V, E)$ if

$T_{BL}(v_i, v_j) \leq min[T_{AL}(v_i), T_{AL}(v_j)]$, $T_{BU}(v_i, v_j) \leq min\ [T_{AU}(v_i), T_{AU}(v_j)]$,
$I_{BL}(v_i, v_j) \geq min[I_{AL}(v_i), I_{AL}(v_j)]$, $I_{BU}(v_i, v_j) \geq min[I_{AU}(v_i), I_{AU}(v_j)]$ and
$F_{BL}(v_i, v_j) \geq min[F_{AL}(v_i), F_{AL}(v_j)]$, $F_{BU}(v_i, v_j) \geq min[F_{AU}(v_i), F_{AU}(v_j)]$ for all $(v_i, v_j) \in E$

Example 3: Let consider $\boldsymbol{G = (A, B)}$ of $\boldsymbol{G^* = (V, E)}$ where $\boldsymbol{V = \{v_1, v_2, v_3, v_4\}}$ and $\boldsymbol{E = \{v_1v_2, v_2v_3, v_3v_4, v_4v_1\}}$

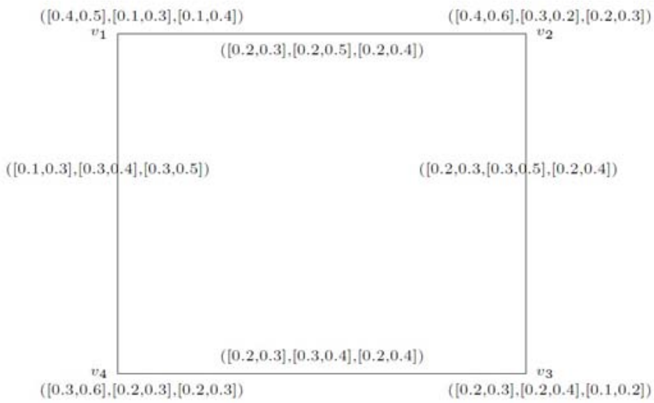

Figure 2.3: Interval Valued Neutrosophic Graph

Definition 2.10: Let $\boldsymbol{T_A(x) = [T_{A_L}(x), T_{A_U}(x)]}$, $\boldsymbol{I_A(x) = [I_{A_L}(x), I_{A_U}(x)]}$ and $\boldsymbol{F_A(x) = [F_{A_L}(x), F_{A_U}(x)]}$ be the interval valued truth membership, interval valued indeterminacy membership and interval valued falsity membership and the relation is

$$T_{B_L}(x,y) \leq min(T_{A_L}(x), T_{A_L}(y)), T_{B_U}(x,y) \leq min(T_{A_U}(x), T_{A_U}(y)),$$
$$I_{B_L}(x,y) \geq max(I_{A_L}(x), I_{A_L}(y)), I_{B_U}(x,y) \geq max(I_{A_U}(x), I_{A_U}(y)),$$
$$F_{B_L}(x,y) \geq max(F_{A_L}(x), F_{A_L}(y)), F_{B_U}(x,y) \geq max(F_{A_U}(x), F_{A_U}(y)).$$

Then interval valued signed neutrosophic graph (IVSNG) A is

$S_N(G) = (S(G_{B_L}), S(G_{B_U}))$, where $S(G_{B_L}) =$ sign of G_{B_L} and $S(G_{B_U}) =$ sign of G_{B_U}.

The condition for sign is as follows:

If T_{B_L} is greater than the both I_{B_L}, F_{B_L} then it assigns positive sign otherwise negative sign. Similarly T_{B_U} is greater than the both I_{B_U}, F_{B_U} then it assigns positive sign otherwise negative sign.

Example 4: Let consider $\boldsymbol{G = (A, B)}$ of $\boldsymbol{G^* = (V, E)}$ where $\boldsymbol{V = \{v_1, v_2, v_3, v_4\}}$ and $\boldsymbol{E = \{v_1v_2, v_2v_3, v_3v_4, v_4v_1\}}$ has the values are given in fig.3.1 then the interval valued signed neutrosophic graph is as follows.

We rewrite here as L-values and U-values separately for convenience.

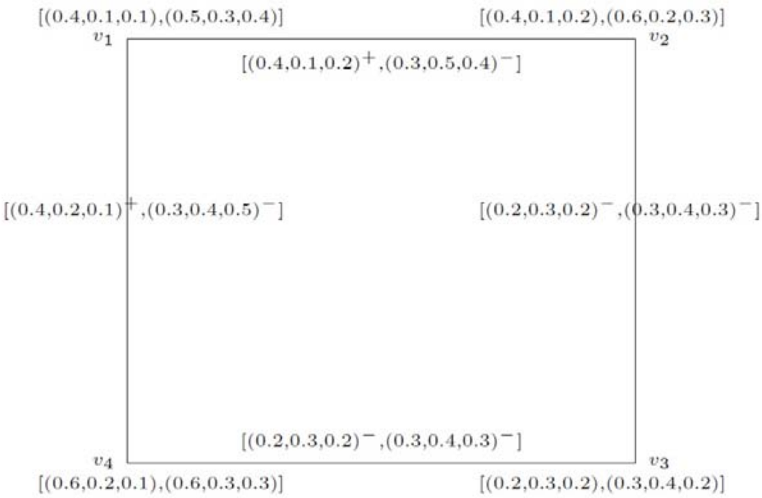

Figure-2.4: Interval valued signed neutrosophic graph

$$S_N(G)(v_1, v_2) = (+, -)$$

i.e.L-values has positive sign and U-values negative sign. In this way

$$S_N(G)(v_2, v_3) = (-, -),\ S_N(G)(v_3, v_4) = (-, -),\quad S_N(G)(v_4, v_1) = (+, -)$$

Definition 2.11: An IVSNG is said to be $\boldsymbol{L}$-balanced IVSNG if every cycle of $\boldsymbol{L}$-values have even number of negative signed edges or all positive signed edges. An IVSNG is said to be $\boldsymbol{U}$-balanced IVSNG if every cycle of $\boldsymbol{U}$-values have even number of negative signed edges or all positive signed edges.

Example 5:

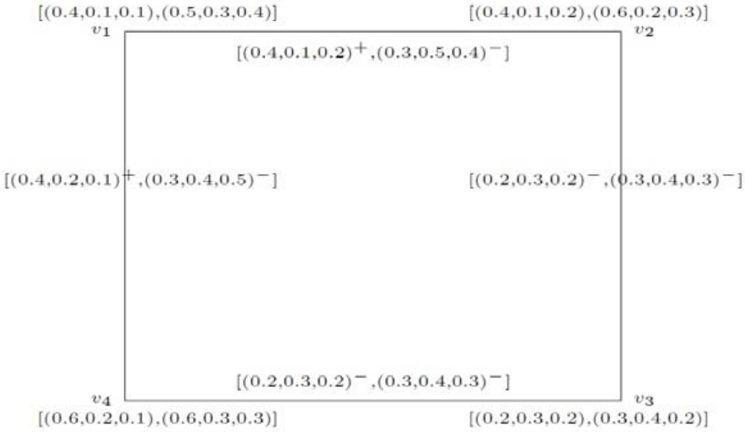

Figure-2.5: L-balanced IVSNG and U-balanced IVSNG

Definition 2.12: If an IVSNG's edge has alternative signs of $\boldsymbol{L}$-values and $\boldsymbol{U}$-values then it is called as self-balanced.

Example 6: In the figure 3.2, $\boldsymbol{S_N(G)(v_1, v_2)}$ and $\boldsymbol{S_N(G)(v_1, v_4)}$ are self-balanced and $\boldsymbol{S_N(G)(v_2, v_3)}$ and $\boldsymbol{S_N(G)(v_3, v_4)}$ are not self-balanced.

Definition 2.13: An IVSNG is said to be fully-balanced IVSNG if it has $\boldsymbol{L}$-balanced IVSNG and $\boldsymbol{U}$-balanced IVSNG.
The fig 3.2, is also an example of fully-balanced IVSNG.

3. SELF-CENTERED INTERVAL VALUED SIGNED NEUTROSOPHIC GRAPH

Throught this paper, we approach some sign for self-centered interval valued neutrosophic graph. i.e. It assigns some positive or negative sign.

Definition 3.1: Let $\boldsymbol{T_A(x) = [T_{A_L}(x), T_{A_U}(x)]}$, $\boldsymbol{I_A(x) = [I_{A_L}(x), I_{A_U}(x)]}$ and $\boldsymbol{F_A(x) = [F_{A_L}(x), F_{A_U}(x)]}$ be the self-centered interval valued truth membership, self-centered interval valued indeterminacy membership and self-centered interval valued falsity membership and the relation is

$$T_{B_L}(x,y) \le min(T_{A_L}(x), T_{A_L}(y)), T_{B_U}(x,y) \le min(T_{A_U}(x), T_{A_U}(y)),$$
$$I_{B_L}(x,y) \ge max(I_{A_L}(x), I_{A_L}(y)), I_{B_U}(x,y) \ge max(I_{A_U}(x), I_{A_U}(y)),$$
$$F_{B_L}(x,y) \ge max(F_{A_L}(x), F_{A_L}(y)), F_{B_U}(x,y) \ge max(F_{A_U}(x), F_{A_U}(y)).$$

Then self-centered interval valued signed neutrosophic graph (SCIVSNG) A is

$$S_N(G) = (S(G_{B_L}), S(G_{B_U})) \quad \text{where } S(G_{B_L}) = \text{signof}G_{B_L} \text{ and } S(G_{B_U}) = \text{signof}G_{B_U}$$

The condition for sign is as follows:

If T_{B_L} is greater than the both I_{B_L}, F_{B_L} then it assigns positive sign otherwise negative sign. Similarly T_{B_U} is greater than the both I_{B_U}, F_{B_U} then it assigns positive sign otherwise negative sign.

Example 3.1:

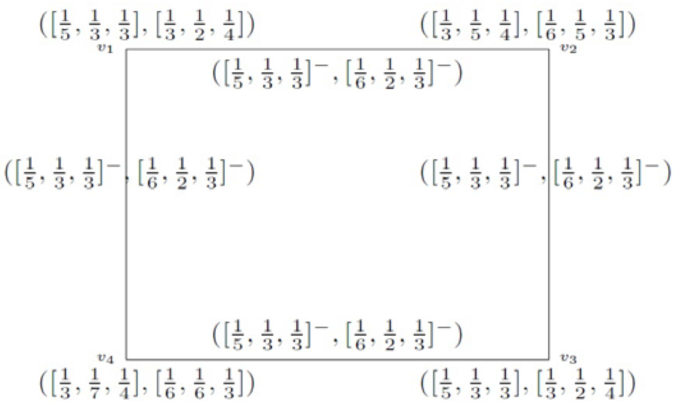

Figure-3.1: Self-Centered Interval Valued Signed Neutrosophic Graph $S_N(G)(v_1, v_2) = (-,-)$

i.e.L-values has negative sign and U-values negative sign. In this way

$$S_N(G)(v_2, v_3) = (-,-),\ S_N(G)(v_3, v_4) = (-,-),\ S_N(G)(v_4, v_1) = (-,-)$$

Definition 3.2: An SCIVSNG is said to be $\boldsymbol{L}$-balanced SCIVSNG if every cycle of $\boldsymbol{L}$-values has even number of negative signed edges or all positive signed edges.

An SCIVSNG is said to be U-balanced SCIVSNG if every cycle of U-values has even number of negative signed edges or all positive signed edges.

Example 3.2:

In figure 3.1, the L-values has even number of negative signs. Therefore it is a L-balanced SCIVSNG.
In figure 3.1, the U-values has even number of negative signs. Therefore it is a U-balanced SCIVSNG.

Definition 3.3: An SCIVSNG is said to be fully-balanced SCIVSNG if it has $\boldsymbol{L}$-balanced SCIVSNG and $\boldsymbol{U}$-balanced SCIVSNG.

The fig 3.1, is also an example of fully-balanced SCIVSNG.

Theorem 3.1: An SCIVSNG's $\boldsymbol{L}$-values is positive if every even length cycles of $\boldsymbol{L}$-values having all negative signed edges.

Proof: If all edges contains negative sign in even length cycle then the product of edges sign is always positive. Hence it is always a positive signed graph.

Note: It is also true for also $\boldsymbol{U}$-values.

Theorem 3.2: Odd length cycle having all negative signed edges is always a negative signed graphs.

Proof: If all edges contains negative sign in odd length cycle then the product of edges sign is always negative. Hence it is always a negative signed graph.

Theorem 3.3: If an IVNG is a complete INVG then the SCIVSNG's sign will be always negative. But the converse is need not be true.

Proof: Consider a complete IVNG. By the definition of complete IVNG is all the $\boldsymbol{L}$-values and $\boldsymbol{U}$-values are equal to 1.

i.e, $T_L = I_L = F_L = 1$ and $T_U = I_U = F_U = 1$.

Since the condition of signs L-values have positive sign when
$T_L > I_L + F_L$ and otherwise negative.

Similarly U-values have positive sign when $T_U > I_U + F_U$ and otherwise negative.

In complete IVNG, $T_L \leq I_L + F_L$ and $T_U \leq I_U + F_U$.

All its L-values and U-values have negative signs.

Hence, if there is a complete IVNG then their SCIVSNG is always negative.

But the converse is need not be true because it is not possible every negative signed IVNG be complete IVNG.

Hence the proof.

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