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Novel Properties of Edge Irregular Single Valued Neutrosophic Graphs

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Abstract. In this paper, some types of edge irregular single valued neutrosophic graphs such as neighbourly edge totally irregular single valued neutrosophic graphs, strongly edge irregular single valued neutrosophic graphs and strongly edge totally irregular single valued neutrosophic graphs are introduced. A comparative study between neighbourly edge irregular single valued neutrosophic graphs and neighbourly edge totally irregular single valued neutrosophic graphs is done. Likewise some properties of them are studied. Finally, we have given some interesting results about edge irregular single valued neutrosophic graphs that are very useful in computer science and networks.

Keywords: Edge irregular SVNG; Neighbourly edge irregular SVNG; Neighbourly edge totally irregular SVNG; Strongly edge irregular SVNG; Strongly edge totally irregular SVNG.

1. **Introduction**

In 1736, Euler first introduced the concept of graph theory. In the history of mathematics, the solution given by Euler of the well known Konigsberg bridge problem is considered to be the first theorem of graph theory. This has now become a subject generally regarded as a branch of combinatorics. The theory of graph is an extremely useful tool for solving combinatorial problems in different areas such as logic, geometry, algebra, topology, analysis, number theory, information theory, artificial intelligence, operations research, optimization, neural networks, planning, computer science and etc [10–12, 14].

Fuzzy set theory, introduced by Zadeh in 1965, is a mathematical tool for handling uncertainties like vagueness, ambiguity and imprecision in linguistic variables [41]. Research on theory of fuzzy sets has been witnessing an exponential growth; both within mathematics and in its application. Fuzzy set theory has emerged as a potential area of interdisciplinary research and fuzzy graph theory is of recent interest.

In 1983, Atanassov [3,4] introduced the concept of intuitionistic fuzzy sets as a generalization of fuzzy sets [41]. Atanassov added a new component(which determines the degree of non-membership) in the definition of fuzzy set. The concept of neutrosophic set was introduced by F. Smarandache [31, 32] which is a mathematical tool for handling problems involving imprecise, indeterminacy and inconsistent data. The theory is generalization of classical sets and fuzzy sets and is applied in decision making problems, control theory, medicines, topology and in many more real life problems.

In 1975, Rosenfeld [25] introduced the concept of fuzzy graphs. The fuzzy relations between fuzzy sets were also considered by Rosenfeld and he developed the structure of fuzzy graphs, obtaining analogs of several graph theoretical concepts. Later on, Bhattacharya gave some remarks on fuzzy graphs, and some operations on fuzzy graphs were introduced by Mordeson and Peng [13].

Later, Broumi et al. [7] presented the concept of single valued neutrosophic graphs by combining the single valued neutrosophic set theory and the graph theory, and defined different types of single valued neutrosophic graphs (SVNG).

In the literature, many extensions of fuzzy graphs and their properties have been deeply studied by several researchers, such as intuitionistic fuzzy graphs, interval valued fuzzy graphs, interval valued intuitionistic fuzzy graphs, bipolar fuzzy graphs and etc [1, 2, 5, 6, 8, 9, 15, 21–24, 26, 30, 33–40].

Nagoorgani and Radha [17, 18] introduced the concept of regular fuzzy graphs and defined degree of a vertex in fuzzy graphs. Nagoorgani and Latha [16] introduced the concept of irregular fuzzy graphs, neighbourly irregular fuzzy graphs and highly irregular fuzzy graphs in 2008. Nandhini and Nandhini introduced the concept of strongly irregular fuzzy graphs and discussed about its properties [19].

Radha and Kumaravel [20] introduced the concept of edge degree, total edge degree in fuzzy graph and edge regular fuzzy graphs and discussed about the degree of an edge in some fuzzy graphs. Santhi Maheswari and Sekar introduced the concept of edge irregular fuzzy graphs and edge totally irregular fuzzy graphs and discussed about its properties [27]. Also, Santhi Maheswari and Sekar introduced the concept of neighbourly edge irregular fuzzy graphs, neighbourly edge totally irregular fuzzy graphs, strongly edge irregular fuzzy graphs and strongly edge totally irregular fuzzy graphs and discussed about its properties [28, 29].

This is the background to introduce neighbourly edge irregular single valued neutrosophic graphs, neighbourly edge totally irregular single valued neutrosophic graphs, strongly edge irregular single valued neutrosophic graphs, strongly edge totally irregular single valued neutrosophic graphs and discussed some of their properties. Also neighbourly edge irregularity and strongly edge irregularity on some single valued neutrosophic graphs whose underlying crisp graphs are a path, a cycle and a star are studied.

2. Preliminaries

We present some known definitions and results for ready reference to go through the work presented in this paper.

Definition 2.1. *A graph is an ordered pair $G^* = (V, E)$, where V is the set of vertices of G^* and E is the set of edges of G^*. A graph G^* is finite if its vertex set and edge set are finite.*

Definition 2.2. *The degree $d_{G^*}(v)$ of a vertex v in G^* or simply $d(v)$ is the number of edges of G^* incident with vertex v.*

Definition 2.3. *A Fuzzy graph denoted by $G : (\sigma, \mu)$ on the graph $G^* : (V, E)$ is a pair of functions (σ, μ) where $\sigma : V \longrightarrow [0, 1]$ is a fuzzy subset of a non empty set V and $\mu : E \longrightarrow [0, 1]$ is a symmetric fuzzy relation on σ such that for all u and v in V the relation $\mu(u, v) = \mu(uv) \leq \min[\sigma(u), \sigma(v)]$ is satisfied.*

Definition 2.4. *An intuitionistic fuzzy graph (IFG) is of the form $G : (\sigma, \mu)$ where $\sigma = (\sigma_1, \sigma_2)$ and $\mu = (\mu_1, \mu_2)$ such that*
(1) The functions $\sigma_1 : V \longrightarrow [0, 1]$ and $\sigma_2 : V \longrightarrow [0, 1]$ denote the degree of membership and nonmembership of the element $u \in V$, respectively, and $0 \leq \sigma_1(u)+\sigma_2(u) \leq 1$ for every $u \in V$;
(2) The functions $\mu_1 : V \times V \longrightarrow [0, 1]$ and $\mu_2 : V \times V \longrightarrow [0, 1]$ are the degree of membership and nonmembership of the edge $uv \in E$, respectively, such that $\mu_1(uv) \leq \min[\sigma_1(u), \sigma_1(v)]$ and $\mu_2(uv) \geq \max[\sigma_2(u), \sigma_2(v)]$ and $0 \leq \mu_1(uv) + \mu_2(uv) \leq 1$ for every uv in E.

Definition 2.5. *A single valued neutrosophic graph (SVNG) is of the form $G : (A, B)$ where $A = (T_A, I_A, F_A)$ and $B = (T_B, I_B, F_B)$ such that*
(1) The functions $T_A : V \longrightarrow [0, 1]$, $I_A : V \longrightarrow [0, 1]$ and $F_A : V \longrightarrow [0, 1]$ denote the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the element $u \in V$, respectively, and $0 \leq T_A(u) + I_A(u) + F_A(u) \leq 3$ for every $u \in V$;
(2) The functions $T_B : V \times V \longrightarrow [0, 1], I_B : V \times V \longrightarrow [0, 1]$ and $F_B : V \times V \longrightarrow [0, 1]$ are the degree of truth-membership, the degree of indeterminacy-membership and the degree of falsity-membership of the edge $uv \in E$, respectively, such that $T_B(uv) \leq \min[T_A(u), T_A(v)]$, $I_B(uv) \geq$

$\max[I_A(u), I_A(v)]$ *and* $F_B(uv) \geq \max[F_A(u), F_A(v)]$ *and* $0 \leq T_B(uv) + I_B(uv) + F_B(uv) \leq 3$ *for every* uv *in* E.

Definition 2.6. *Let* $G : (A, B)$ *be a SVNG on* $G^* : (V, E)$. *Then the degree of a vertex* u *is defined as* $d_G(u) = (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u))$ *where* $d_{T_A}(u) = \Sigma_{v \neq u} T_B(uv)$, $d_{I_A}(u) = \Sigma_{v \neq u} I_B(uv)$ *and* $d_{F_A}(u) = \Sigma_{v \neq u} F_B(uv)$.

Definition 2.7. *Let* $G : (A, B)$ *be a SVNG on* $G^* : (V, E)$. *Then the total degree of a vertex* u *is defined by* $td_G(u) = (t(d_{T_A}(u), td_{I_A}(u), td_{F_A}(u))$ *where* $td_{T_A}(u) = \Sigma_{v \neq u} T_B(uv) + T_A(u)$, $td_{I_A}(u) = \Sigma_{v \neq u} I_B(uv) + I_A(u)$ *and* $td_{F_A}(u) = \Sigma_{v \neq u} F_B(uv) + F_A(u)$.

Definition 2.8. *Let* $G : (A, B)$ *be a SVNG on* $G^* : (V, E)$. *Then:*

(1) G is irregular, if there is a vertex which is adjacent to vertices with distinct degrees.

(2) G is totally irregular, if there is a vertex which is adjacent to vertices with distinct total degrees.

Definition 2.9. *Let* $G : (A, B)$ *be a connected single valued neutrosophic graph on* $G^* : (V, E)$. *Then:*

(1) G is said to be a neighbourly irregular single valued neutrosophic graph if every pair of adjacent vertices have distinct degrees.

(2) G is said to be a neighbourly totally single valued neutrosophic fuzzy graph if every pair of adjacent vertices have distinct total degrees.

(3) G is said to be a strongly irregular single valued neutrosophic graph if every pair of vertices have distinct degrees.

(4) G is said to be a strongly totally irregular single valued neutrosophic graph if every pair of vertices have distinct total degrees.

(5) G is said to be a highly irregular single valued neutrosophic graph if every vertex in G is adjacent to the vertices having distinct degrees.

(6) G is said to be a highly totally irregular single valued neutrosophic graph if every vertex in G is adjacent to the vertices having distinct total degrees.

Definition 2.10. *Let* $G : (A, B)$ *be a SVNG on* $G^* : (V, E)$. *The degree of an edge* uv *is defined as* $d_G(uv) = (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv))$ *where* $d_{T_B}(uv) = d_{T_A}(u) + d_{T_A}(v) - 2T_B(uv)$, $d_{I_B}(uv) = d_{I_A}(u) + d_{I_A}(v) - 2I_B(uv)$ *and* $d_{F_B}(uv) = d_{F_A}(u) + d_{F_A}(v) - 2F_B(uv)$.

Definition 2.11. *Let* $G : (A, B)$ *be a SVNG on* $G^* : (V, E)$. *The total degree of an edge* uv *is defined as* $td_G(uv) = (td_{T_B}(uv), td_{I_B}(uv), td_{F_B}(uv))$ *where* $td_{T_B}(uv) = d_{T_A}(u) + d_{T_A}(v) - T_B(uv) = d_{T_B}(uv) + T_B(uv)$, $td_{I_B}(uv) = d_{I_A}(u) + d_{I_A}(v) - I_B(uv) = d_{I_B}(uv) + I_B(uv)$ *and* $td_{F_B}(uv) = d_{F_A}(u) + d_{F_A}(v) - F_B(uv) = d_{F_B}(uv) + F_B(uv)$.

3. Neighbourly edge irregular single valued neutrosophic graphs and neighbourly edge totally irregular single valued neutrosophic graphs

In this section, neighbourly edge irregular single valued neutrosophic graphs and neighbourly edge totally irregular single valued neutrosophic graphs are introduced.

Definition 3.1. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Then G is said to be:*
(1) A neighbourly edge irregular single valued neutrosophic graph if every pair of adjacent edges have distinct degrees.
(2) A neighbourly edge totally irregular single valued neutrosophic graph if every pair of adjacent edges have distinct total degrees.

Example 3.2. *Graph which is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph.*
Consider $G^* : (V, E)$ where $V = \{u, v, w, x\}$ and $E = \{uv, vw, wx, xu\}$.

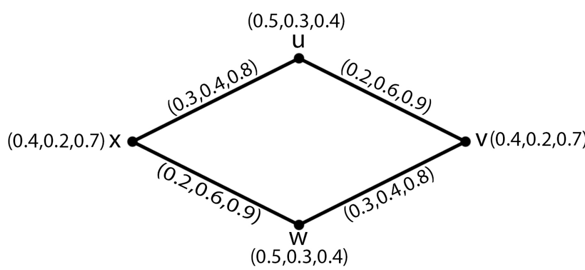

Figure 1. Both neighbourly edge irregular SVNG and neighbourly edge totally irregular SVNG.

From Figure 1,
$d_G(u) = d_G(v) = d_G(w) = d_G(x) = (0.5, 1.0, 1.7)$.
Degrees of the edges are calculated as follows
$d_G(uv) = d_G(wx) = (0.6, 0.8, 1.6), d_G(vw) = d_G(xu) = (0.4, 1.2, 1.8)$.
It is noted that every pair of adjacent edges have distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph.
Total degrees of the edges are calculated as follows
$td_G(uv) = td_G(wx) = (0.8, 1.4, 2.5), td_G(vw) = td_G(xu) = (0.7, 1.6, 2.6)$.
It is observed that every pair of adjacent edges having distinct total degrees. So, G is a neighbourly edge totally irregular single valued neutrosophic graph.
Hence G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph.

Example 3.3. *Neighbourly edge irregular single valued neutrosophic graph do not need to be neighbourly edge totally irregular single valued neutrosophic graph.*
Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a star on four vertices.

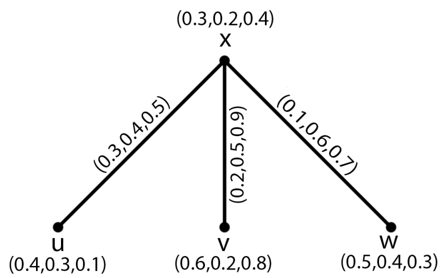

Figure 2. Neighbourly edge irregular SVNG, not neighbourly edge totally irregular SVNG.

From Figure 2,
$d_G(u) = (0.3, 0.4, 0.5), d_G(v) = (0.2, 0.5, 0.9), d_G(w) = (0.1, 0.6, 0.7), d_G(x) = (0.6, 1.5, 2.1)$;
$d_G(ux) = (0.3, 1.1, 1.6), d_G(vx) = (0.4, 1.0, 1.2), d_G(wx) = (0.5, 0.9, 1.4)$;
$td_G(ux) = td_G(vx) = td_G(wx) = (0.6, 1.5, 2.1)$.
Here, $d_G(ux) \neq d_G(vx) \neq d_G(wx)$. Hence G is a neighbourly edge irregular single valued neutrosophic graph. But G is not a neighbourly edge totally irregular single valued neutrosophic graph, since all edges have same total degrees.

Example 3.4. *Neighbourly edge totally irregular single valued neutrosophic graphs don't need to be neighbourly edge irregular single valued neutrosophic graphs. Following shows this subject:*
Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a path on four vertices.

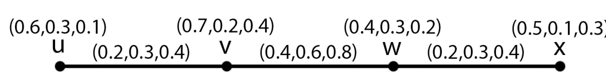

Figure 3. Neighbourly edge totally irregular single valued neutrosophic graph, not neighbourly edge irregular single valued neutrosophic graph

From Figure 3,
$d_G(u) = d_G(x) = (0.2, 0.3, 0.4), d_G(v) = d_G(w) = (0.6, 0.9, 1.2)$;
$d_G(uv) = d_G(vw) = d_G(wx) = (0.4, 0.6, 0.8)$;
$td_G(uv) = td_G(wx) = (0.6, 0.9, 1.2), td_G(vw) = (0.8, 1.2, 1.6)$.
Here, $d_G(uv) = d_G(vw) = d_G(wx)$. Hence G is not a neighbourly edge irregular single valued

neutrosophic graph. But G is a neighbourly edge totally irregular single valued neutrosophic graph, since $td_G(uv) \neq td_G(vw)$ and $td_G(vw) \neq td_G(wx)$.

Theorem 3.5. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. Then G is a neighbourly edge irregular single valued neutrosophic graph, if and only if G is a neighbourly edge totally irregular single valued neutrosophic graph.*

Proof: Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$, for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.
Let uv and vw be pair of adjacent edges in E, then we have
$d_G(uv) \neq d_G(vw)$
$\iff d_G(uv) + C \neq d_G(vw) + C$
$\iff (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) + (C_T, C_I, C_F) \neq (d_{T_B}(vw), d_{I_B}(vw), d_{F_B}(vw)) + (C_T, C_I, C_F)$
$\iff (d_{T_B}(uv) + C_T, d_{I_B}(uv) + C_I, d_{F_B}(uv) + C_F) \neq (d_{T_B}(vw) + C_T, d_{I_B}(vw) + C_I, d_{F_B}(vw) + C_F)$
$\iff (d_{T_B}(uv) + T_B(uv), d_{I_B}(uv) + I_B(uv), d_{F_B}(uv) + F_B(uv)) \neq (d_{T_B}(vw) + T_B(vw), d_{I_B}(vw) + I_B(vw), d_{F_B}(vw) + F_B(vw))$
$\iff (td_{T_B}(uv), td_{I_B}(uv), td_{F_B}(uv)) \neq (td_{T_B}(vw), td_{I_B}(vw), td_{F_B}(vw))$
$\iff td_G(uv) \neq td_G(vw)$.
Therefore every pair of adjacent edges have distinct degrees if and only if have distinct total degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph if and only if G is a neighbourly edge totally irregular single valued neutrosophic graph.

□

Remark 3.6. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. If G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph, Then B don't need to be a constant function.*

Example 3.7. *Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a path on four vertices.*

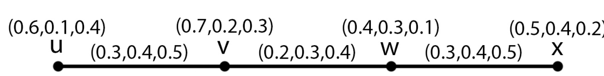

Figure 4. B is not a constant function.

From Figure 4,
$d_G(u) = d_G(x) = (0.3, 0.4, 0.5), d_G(v) = d_G(w) = (0.5, 0.7, 0.9)$;
$d_G(uv) = d_G(wx) = (0.2, 0.3, 0.4), d_G(vw) = (0.6, 0.8, 1.0)$;

$td_G(uv) = td_G(wx) = (0.5, 0.7, 0.9), td_G(vw) = (0.8, 1.1, 1.4)$.

Here, $d_G(uv) \neq d_G(vw)$ and $d_G(vw) \neq d_G(wx)$. Hence G is a neighbourly edge irregular single valued neutrosophic graph. Also, $td_G(uv) \neq td_G(vw)$ and $td_G(vw) \neq td_G(wx)$. Hence G is a neighbourly edge totally irregular single valued neutrosophic graph. But B is not constant function.

Theorem 3.8. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly irregular single valued neutrosophic graph, then G is a neighbourly edge irregular single valued neutrosophic graph.*

Proof: Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$, for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.

Let uv and vw be any two adjacent edges in G. Let us suppose that G is a strongly irregular single valued neutrosophic graph. Then every pair of vertices in G having distinct degrees, and hence

$d_G(u) \neq d_G(v) \neq d_G(w)$

$\Rightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) \neq (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w))$

$\Rightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) + (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) - 2(C_T, C_I, C_F) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) + (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w)) - 2(C_T, C_I, C_F)$

$\Rightarrow (d_{T_A}(u)+d_{T_A}(v)-2C_T, d_{I_A}(u)+d_{I_A}(v)-2C_I, d_{F_A}(u)+d_{F_A}(v))-2C_F) \neq (d_{T_A}(v)+d_{T_A}(w)-2C_T, d_{I_A}(v) + d_{I_A}(w) - 2C_I, d_{F_A}(v)) + d_{F_A}(w) - 2C_F)$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v) - 2T_B(uv), d_{I_A}(u) + d_{I_A}(v) - 2I_B(uv), d_{F_A}(u) + d_{F_A}(v)) - 2F_B(uv)) \neq (d_{T_A}(v) + d_{T_A}(w) - 2T_B(vw), d_{I_A}(v) + d_{I_A}(w) - 2I_B(vw), d_{F_A}(v)) + d_{F_A}(w) - 2F_B(vw))$

$\Rightarrow (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) \neq (d_{T_B}(vw), d_{I_B}(vw), d_{F_B}(vw))$

$\Rightarrow d_G(uv) \neq d_G(vw)$.

Therefore every pair of adjacent edges have distinct degrees, hence G is a neighbourly edge irregular single valued neutrosophic graph.

□

Similar to the above theorem can be considered the following theorem:

Theorem 3.9. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly irregular single valued neutrosophic graph, then G is a neighbourly edge totally irregular single valued neutrosophic graph.*

Remark 3.10. *Converse of the above theorems don't need to be true.*

Example 3.11. *Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a path on four vertices.*

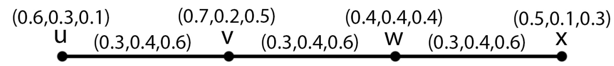

Figure 5. Both neighbourly edge irregular SVNG and neighbourly edge totally irregular SVNG, not strongly irregular SVNG

From Figure 5,
$d_G(u) = d_G(x) = (0.3, 0.4, 0.6), d_G(v) = d_G(w) = (0.6, 0.8, 1.2)$. *Here, G is not a strongly irregular single valued neutrosophic graph.*
$d_G(uv) = d_G(wx) = (0.3, 0.4, 0.6), d_G(vw) = (0.6, 0.8, 1.2)$;
$td_G(uv) = td_G(vw) = td_G(wx) = (0.6, 0.8, 1.2)$.
It is noted that $d_G(uv) \neq d_G(vw)$ and $d_G(vw) \neq d_G(wx)$. And also, $td_G(uv) \neq td_G(vw)$ and $td_G(vw) \neq td_G(wx)$. Hence G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph. But G is not a strongly irregular single valued neutrosophic graph.

Theorem 3.12. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. Then G is a highly irregular single valued neutrosophic graph if and only if G is a neighbourly edge irregular single valued neutrosophic graph.*

Proof: Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$, for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.
Let uv and vw be any two adjacent edges in G. Then we have
$d_G(u) \neq d_G(w)$
$\Longleftrightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) \neq (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w))$
$\Longleftrightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) + (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) - 2(C_T, C_I, C_F) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) + (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w)) - 2(C_T, C_I, C_F)$
$\Longleftrightarrow (d_{T_A}(u) + d_{T_A}(v) - 2C_T, d_{I_A}(u) + d_{I_A}(v) - 2C_I, d_{F_A}(u) + d_{F_A}(v)) - 2C_F) \neq (d_{T_A}(v) + d_{T_A}(w) - 2C_T, d_{I_A}(v) + d_{I_A}(w) - 2C_I, d_{F_A}(v)) + d_{F_A}(w) - 2C_F)$
$\Longleftrightarrow (d_{T_A}(u) + d_{T_A}(v) - 2T_B(uv), d_{I_A}(u) + d_{I_A}(v) - 2I_B(uv), d_{F_A}(u) + d_{F_A}(v)) - 2F_B(uv)) \neq (d_{T_A}(v) + d_{T_A}(w) - 2T_B(vw), d_{I_A}(v) + d_{I_A}(w) - 2I_B(vw), d_{F_A}(v)) + d_{F_A}(w) - 2F_B(vw))$
$\Longleftrightarrow (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) \neq (d_{T_B}(vw), d_{I_B}(vw), d_{F_B}(vw))$
$\Longleftrightarrow d_G(uv) \neq d_G(vw)$.
Therefore every pair of adjacent edges have distinct degrees, if and only if every vertex adjacent

to the vertices having distinct degrees. Hence G is a highly irregular single valued neutrosophic graph, if and only if G is a neighbourly edge irregular single valued neutrosophic graph.

□

Theorem 3.13. *Let $G:(A,B)$ be a connected single valued neutrosophic graph on $G^*:(V,E)$ and $B:(T_B,I_B,F_B)$ is a constant function. Then G is highly irregular single valued neutrosophic graph if and only if G is neighbourly edge totally irregular single valued neutrosophic graph.*

proof: Proof is similar to Theorem 3.12.

□

Theorem 3.14. *Let $G:(A,B)$ be a single valued neutrosophic graph on $G^*:(V,E)$, a star $K_{1,n}$. Then G is a totally edge regular single valued neutrosophic graph. Also, if the degrees of truth-membership, indeterminacy-membership and falsity-membership of no two edges are same, then G is a neighbourly edge irregular single valued neutrosophic graph.*

proof: Let $v_1,v_2,v_3,...,v_n$ be the vertices adjacent to the vertex x. Let $e_1,e_2,e_3,...,e_n$ be the edges of a star G^* in that order having the degrees of truth-membership $p_1,p_2,p_3,...,p_n$, the degrees of indeterminacy-membership $q_1,q_2,q_3,...,q_n$ and the degrees of falsity-membership $r_1,r_2,r_3,...,r_n$

that $0\leq p_i+q_i+r_i\leq 3$ for every $1\leq i\leq n$. Then,
$td_G(e_i)=(td_{T_B}(e_i),td_{I_B}(e_i),td_{F_B}(e_i))=(d_{T_B}(e_i)+T_B(e_i),d_{I_B}(e_i)+I_B(e_i),d_{F_B}(e_i)+F_B(e_i))=((p_1+p_2+p_3+...+p_n)-p_i+p_i,(q_1+q_2+q_3+...+q_n)-q_i+q_i,(r_1+r_2+r_3+...+r_n)-r_i+r_i)=(p_1+p_2+p_3+...+p_n,q_1+q_2+q_3+...+q_n,r_1+r_2+r_3+...+r_n)$.
All edges e_i , $(1\leq i\leq n)$, having same total degrees. Hence G is a totally edge regular single valued neutrosophic graph. Now, if $p_i\neq p_j$, $q_i\neq q_j$ and $r_i\neq r_j$ for every $1\leq i,j\leq n$, then we have
$d_G(e_i)=(d_{T_B}(e_i),d_{I_B}(e_i),d_{F_B}(e_i))=(d_{T_A}(x)+d_{T_A}(v_i)-2T_B(xv_i),d_{I_A}(x)+d_{I_A}(v_i)-2I_B(xv_i),d_{F_A}(x)+d_{F_A}(v_i)-2F_B(xv_i))=((p_1+p_2+p_3+...+p_n)+p_i-2p_i,(q_1+q_2+q_3+...+q_n)+q_i-2q_i,(r_1+r_2+r_3+...+r_n)+r_i-2r_i)=((p_1+p_2+p_3+...+p_n)-p_i,(q_1+q_2+q_3+...+q_n)-q_i,(r_1+r_2+r_3+...+r_n)-r_i)$ for every $1\leq i\leq n$.

Therefore, all edges e_i ,$(1\leq i\leq n)$, having distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph.

□

Theorem 3.15. *Let $G:(A,B)$ be a single valued neutrosophic graph such that $G^*:(V,E)$ is a path on $2m(m>1)$ vertices. If the degrees of truth-membership, indeterminacy-membership* *and falsity-membership of the edges e_i, $i = 1, 3, 5, ..., 2m-1$, are p_1 , q_1 and r_1,respectively, and the degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges e_i, $i = 2, 4, 6, ..., 2m-2$, are p_2 , q_2 and r_2, respectively, such that $p_1 \neq p_2$, $p_2 \neq 2p_1$, $q_1 \neq q_2$, $q_2 \neq 2q_1$, $r_1 \neq r_2$ and $r_2 \neq 2r_1$, then G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a single valued neutrosophic graph on $G^* : (V, E)$, a path on $2m(m > 1)$ vertices. Let $e_1, e_2, e_3, ..., e_{2m-1}$ be the edges of path G^*. If the alternate edges have the same degrees of truth-membership, indeterminacy-membership and falsity-membership, such that

$$B(e_i) = (T_B(e_i), I_B(e_i), F_B(e_i)) = \begin{cases} (p_1, q_1, r_1) \ if \ i \ is \ odd \\ (p_2, q_2, r_2) \ if \ i \ is \ even. \end{cases}$$

where $0 \leq p_i + q_i + r_i \leq 3$ and $p_1 \neq p_2$, $p_2 \neq 2p_1$, $q_1 \neq q_2$, $q_2 \neq 2q_1$, $r_1 \neq r_2$ and $r_2 \neq 2r_1$, then

$d_G(e_1) = ((p_1) + (p_1 + p_2) - 2p_1, (q_1) + (q_1 + q_2) - 2q_1, (r_1) + (r_1 + r_2) - 2r_1) = (p_2, q_2, r_2)$

for $i = 3, 5, 7, ..., 2m-3$;

$d_G(e_i) = ((p_1 + p_2) + (p_1 + p_2) - 2p_1, (q_1 + q_2) + (q_1 + q_2) - 2q_1, (r_1 + r_2) + (r_1 + r_2) - 2r_1) = (2p_2, 2q_2, 2r_2)$

for $i = 2, 4, 6, ..., 2m-2$;

$d_G(e_i) = ((p_1 + p_2) + (p_1 + p_2) - 2p_2, (q_1 + q_2) + (q_1 + q_2) - 2q_2, (r_1 + r_2) + (r_1 + r_2) - 2r_2) = (2p_1, 2q_1, 2r_1)$

$d_G(e_{2m-1}) = ((p_1 + p_2) + (p_1) - 2p_1, (q_1 + q_2) + (q_1) - 2q_1, (r_1 + r_2) + (r_1) - 2r_1) = (p_2, q_2, r_2)$.

We observe that the adjacent edges have distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph. Also we have

$td_G(e_1) = (p_1 + p_2, q_1 + q_2, r_1 + r_2)$

$td_G(e_i) = (2p_1 + p_2, 2q_1 + q_2, 2r_1 + r_2)$ for $i = 2, 4, 6, ..., 2m-2$

$td_G(e_i) = (p_1 + 2p_2, q_1 + 2q_2, r_1 + 2r_2)$ for $i = 3, 5, 7, ..., 2m-3$

$td_G(e_{2m-1}) = (p_1 + p_2, q_1 + q_2, r_1 + r_2)$.

Therefore the adjacent edges have distinct total degrees, hence G is a neighbourly edge totally irregular single valued neutrosophic graph.

□

Theorem 3.16. *Let $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is an even cycle of length $2m$. If the alternate edges have the same degrees of truth-membership,* *the same degrees of indeterminacy-membership and the same degrees of falsity-membership , then G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph.*

proof: Let $G:(A,B)$ be a single valued neutrosophic fuzzy graph on $G^*:(V,E)$, an even cycle of length $2m$. Let $e_1, e_2, e_3, ..., e_{2m}$ be the edges of cycle G^*. If the alternate edges have the same degrees of truth-membership, the same degrees of indeterminacy-membership and the same degrees of falsity-membership, such that

$$B(e_i) = (T_B(e_i), I_B(e_i), I_B(e_i)) = \begin{cases} (p_1, q_1, r_1)\ if\ i\ is\ odd \\ (p_2, q_2, r_2)\ if\ i\ is\ even. \end{cases}$$

where $0 \le p_i + q_i + q_i \le 3$ and $p_1 \neq p_2$, $q_1 \neq q_2$ and $r_1 \neq r_2$,then
for $i = 1, 3, 5, 7, ..., 2m-1$;
$d_G(e_i) = ((p_1+p_2)+(p_1+p_2)-2p_1, (q_1+q_2)+(q_1+q_2)-2q_1, (r_1+r_2)+(r_1+r_2)-2r_1) = (2p_2, 2q_2, 2r_2)$
for $i = 2, 4, 6, ..., 2m$;
$d_G(e_i) = ((p_1+p_2)+(p_1+p_2)-2p_2, (q_1+q_2)+(q_1+q_2)-2q_2, (r_1+r_2)+(r_1+r_2)-2r_2) = (2p_1, 2q_1, 2r_1)$

We observe that the adjacent edges have distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graphs. Also we have
$td_G(e_i) = (p_1+2p_2, q_1+2q_2, r_1+2r_2)$ for $i = 1, 3, 5, 7, ..., 2m-1$
$td_G(e_i) = (2p_1+p_2, 2q_1+q_2, 2r_1+r_2)$ for $i = 2, 4, 6, ..., 2m$.

Therefore the adjacent edges have distinct total degrees, hence G is a neighbourly edge totally irregular single valued neutrosophic graph.

□

Theorem 3.17. *Let $G:(A,B)$ be a single valued neutrosophic graph on $G^*:(V,E)$, a cycle on $m(m \ge 4)$ vertices. If the degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges $e_1, e_2, e_3, ..., e_m$ are $p_1, p_2, p_3, ..., p_m$ such that $p_1 < p_2 < p_3 < ... < p_m$, $q_1, q_2, q_3, ..., q_m$ such that $q_1 > q_2 > q_3 > ... > q_m$ and $r_1, r_2, r_3, ..., r_m$ such that $r_1 > r_2 > r_3 > ... > r_m$, respectively, then G is both neighbourly edge irregular single valued neutrosophic graph and neighbourly edge totally irregular single valued neutrosophic graph.*

proof: Let $G:(A,B)$ be a single valued neutrosophic graph on $G^*:(V,E)$, a cycle on $m(m \ge 4)$ vertices. Let $e_1, e_2, e_3, ..., e_m$ be the edges of cycle G^* in that order. Let degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges

$e_1, e_2, e_3, ..., e_m$ are $p_1, p_2, p_3, ..., p_m$ such that $p_1 < p_2 < p_3 < ... < p_m$, $q_1, q_2, q_3, ..., q_m$ such that $q_1 > q_2 > q_3 > ... > q_m$ and $r_1, r_2, r_3, ..., r_m$ such that $r_1 > r_2 > r_3 > ... > r_m$, respectively, then

$d_G(v_1) = (p_1 + p_m, q_1 + q_m, r_1 + r_m)$

$d_G(v_i) = (p_{i-1} + p_i, q_{i-1} + q_i, r_{i-1} + r_i)$ for $i = 2, 3, 4, 5, ..., m$

$d_G(e_1) = (p_2 + p_m, q_2 + q_m, r_2 + r_m)$

$d_G(e_i) = (p_{i-1} + p_{i+1}, q_{i-1} + q_{i+1}, r_{i-1} + r_{i+1})$ for $i = 2, 3, 4, 5, ..., m - 1$

$d_G(e_m) = (p_1 + p_{m-1}, q_1 + q_{m-1}, r_1 + r_{m-1})$.

We observe that the adjacent edges have distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph.

$td_G(e_1) = (p_1 + p_2 + p_m, q_1 + q_2 + q_m, r_1 + r_2 + r_m)$

$td_G(e_i) = (p_{i-1} + p_i + p_{i+1}, q_{i-1} + q_i + q_{i+1}, r_{i-1} + r_i + r_{i+1})$ for $i = 2, 3, 4, 5, ..., m - 1$

$td_G(e_m) = (p_1 + p_{m-1} + p_m, q_1 + q_{m-1} + q_m, r_1 + r_{m-1} + r_m)$.

We note that the adjacent edges have distinct total degrees. Hence G is a neighbourly edge totally irregular single valued neutrosophic graph.

□

4. Strongly edge irregular single valued neutrosophic graphs and strongly edge totally irregular single valued neutrosophic graphs

Now, In this section, we study strongly edge irregular single valued neutrosophic graphs and strongly edge totally irregular single valued neutrosophic graphs.

Definition 4.1. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Then G is said to be:*
(1)A strongly edge irregular single valued neutrosophic graph if every pair of edges having distinct degrees (or no two edges have same degree). (2) A strongly edge totally irregular single valued neutrosophic graph if every pair of edges having distinct total degrees (or no two edges have same total degree).

Example 4.2. *Graph which is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph.*
Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ which is a cycle of length five.

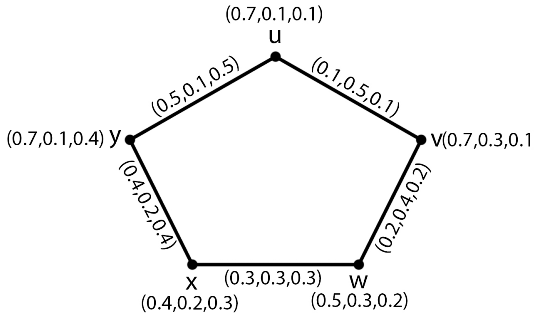

Figure 6. Both strongly edge irregular SVNG and strongly edge totally irregular SVNG.

From Figure 6,
$d_G(u) = (0.6, 0.6, 0.6), d_G(v) = (0.3, 0.9, 0.3), d_G(w) = (0.5, 0.7, 0.5), d_G(x) = (0.7, 0.5, 0.7),$
$d_G(y) = (0.9, 0.3, 0.9).$
Degrees of the edges are calculated as follows
$d_G(uv) = (0.7, 0.5, 0.7), d_G(vw) = (0.4, 0.8, 0.4), d_G(wx) = (0.6, 0.6, 0.6),$
$d_G(xy) = (0.8, 0.4, 0.8), d_G(yu) = (0.5, 0.7, 0.5).$
It is noted that every pair of edges having distinct degrees. Hence G is a strongly edge irregular single valued neutrosophic graph.
Total degrees of the edges are calculated as follows
$td_G(uv) = (0.8, 1.0, 0.8), td_G(vw) = (0.6, 1.2, 0.6), td_G(wx) = (0.9, 0.9, 0.9),$
$td_G(xy) = (1.2, 0.6, 1.2), td_G(yu) = (1.0, 0.8, 1.0).$
It is observed that every pair of edges having distinct total degrees. So, G is a strongly edge totally irregular single valued neutrosophic graph.
Hence G is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph.

Example 4.3. *Strongly edge irregular single valued neutrosophic graph need not be strongly edge totally irregular single valued neutrosophic graph.*

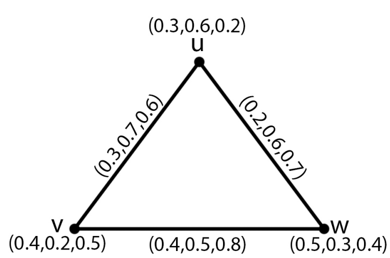

Figure 7. Strongly edge irregular SVNG, not strongly edge totally irregular SVNG

Consider $G:(A,B)$ be a single valued neutrosophic graph such that $G^*:(V,E)$, a cycle of length three.
From Figure 7,
$d_G(u)=(0.5,1.3,1.3), d_G(v)=(0.7,1.2,1.4), d_G(w)=(0.6,1.1,1.5)$;
$d_G(uv)=(0.6,1.1,1.5), d_G(vw)=(0.5,1.3,1.3), d_G(wu)=(0.7,1.2,1.4)$;
$td_G(uv)=td_G(wx)=td_G(wu)=(0.9,1.8,2.1)$.
noted that G is strongly edge irregular single valued neutrosophic graph, since every pair of edges having distinct degrees. Also, G is not strongly edge totally irregular single valued neutrosophic graph, since all the edges having same total degree. Hence strongly edge irregular single valued neutrosophic graph need not be strongly edge totally irregular single valued neutrosophic graph.

Example 4.4. *Strongly edge totally irregular single valued neutrosophic graphs need not be strongly edge irregular single valued neutrosophic graphs.*
Consider $G:(A,B)$ be a single valued neutrosophic graph such that $G^*:(V,E)$, a cycle of length four.

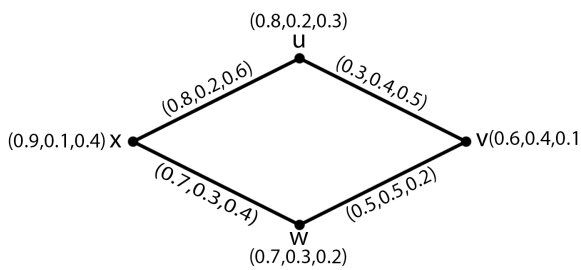

Figure 8. Strongly edge totally irregular SVNG, not strongly edge irregular SVNG.

From Figure 8,
$d_G(u)=(1.1,0.6,1.1), d_G(v)=(0.8,0.9,0.7), d_G(w)=(1.2,0.8,0.6), d_G(x)=(1.5,0.5,1.0)$;
$d_G(uv)=d_G(wx)=(1.3,0.7,0.8), d_G(vw)=d_G(xu)=(1.0,0.7,0.9)$;
$td_G(uv)=(1.6,1.1,1.3), td_G(vw)=(1.5,1.2,1.1), td_G(wx)=(2.0,1.0,1.2)$,
$d_G(xu)=(1.9,0.8,1.5)$.
It is noted that $d_G(uv)=d_G(wx)$. Hence G is not strongly edge irregular single valued neutrosophic graph.
But G is strongly edge totally irregular single valued neutrosophic graph, since $td_G(uv)\neq td_G(vw)\neq td_G(wx)\neq td_G(xu)$.
Hence strongly edge totally irregular single valued neutrosophic graph need not be strongly edge irregular single valued neutrosophic graph.

Theorem 4.5. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. Then G is a strongly edge irregular single valued neutrosophic graph, if and only if G is a strongly edge totally irregular single valued neutrosophic graph.*

proof: Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$, for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.
Let uv and xy be any pair of edges in E. Then we have
$d_G(uv) \neq d_G(xy)$
$\Longleftrightarrow d_G(uv) + C \neq d_G(xy) + C$
$\Longleftrightarrow (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) + (C_T, C_I, C_F) \neq (d_{T_B}(xy), d_{I_B}(xy), d_{F_B}(xy)) + (C_T, C_I, C_F)$
$\Longleftrightarrow (d_{T_B}(uv)+C_T, d_{I_B}(uv)+C_I, d_{F_B}(uv)+C_F) \neq (d_{T_B}(xy)+C_T, d_{I_B}(xy)+C_I, d_{F_B}(xy)+C_F)$
$\Longleftrightarrow (d_{T_B}(uv) + T_B(uv), d_{I_B}(uv) + I_B(uv), d_{F_B}(uv) + F_B(uv)) \neq (d_{T_B}(xy) + T_B(xy), d_{I_B}(xy) + I_B(xy), d_{F_B}(xy) + F_B(xy))$
$\Longleftrightarrow (td_{T_B}(uv), td_{I_B}(uv), td_{F_B}(uv)) \neq (td_{T_B}(xy), td_{I_B}(xy), td_{F_B}(xy))$
$\Longleftrightarrow td_G(uv) \neq td_G(xy)$
Therefore every pair of edges have distinct degrees if and only if have distinct total degrees. Hence G is strongly edge irregular single valued neutrosophic graph if and only if G is a strongly edge totally irregular single valued neutrosophic graph.

□

Remark 4.6. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. If G is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph, Then B need not be a constant function.*

Example 4.7. *Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a cycle of length five.*

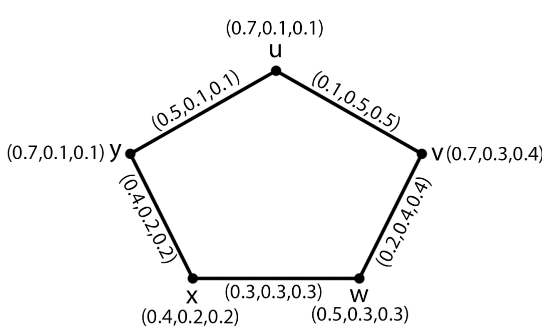

Figure 9. B is not a constant function.

From Figure 9,
$d_G(u) = (0.6, 0.6, 0.6), d_G(v) = (0.3, 0.9, 0.9), d_G(w) = (0.5, 0.7, 0.7), d_G(x) = (0.7, 0.5, 0.5),$
$d_G(y) = (0.9, 0.3, 0.3).$
Also, $d_G(uv) = (0.7, 0.5, 0.5), d_G(vw) = (0.4, 0.8, 0.8), d_G(wx) = (0.6, 0.6, 0.6),$
$d_G(xy) = (0.8, 0.4, 0.4), d_G(yu) = (0.5, 0.7, 0.7).$
It is noted that every pair of edges in G *having distinct degrees. Hence* G *is a strongly edge irregular single valued neutrosophic graph.*
Also, $td_G(uv) = (0.8, 1.0, 1.0), td_G(vw) = (0.6, 1.2, 1.2), td_G(wx) = (0.9, 0.9, 0.9),$
$td_G(xy) = (1.2, 0.6, 0.6), td_G(yu) = (1.0, 0.8, 0.8).$
Note that every pair of edges in G *having distinct total degrees. Hence* G *is a strongly edge totally irregular single valued neutrosophic graph. Therefore* G *is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph. But* μ *is not a constant function.*

Theorem 4.8. *Let* $G : (A, B)$ *be a single valued neutrosophic graph on* $G^* : (V, E)$*. If* G *is a strongly edge irregular single valued neutrosophic graph, then* G *is a neighbourly edge irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a single valued neutrosophic graph on $G^* : (V, E)$. Let us assume that G is a strongly edge irregular single valued neutrosophic graph, then every pair of edges in G have distinct degrees. So every pair of adjacent edges have distinct degrees. Hence G is a neighbourly edge irregular single valued neutrosophic graph.

□

Theorem 4.9. *Let* $G : (A, B)$ *be a single valued neutrosophic graph on* $G^* : (V, E)$*. If* G *is a strongly edge totally irregular single valued neutrosophic graph, then* G *is a neighbourly edge totally irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a single valued neutrosophic graph on $G^* : (V, E)$. Let us assume that G is a strongly edge totally irregular single valued neutrosophic graph, then every pair of edges in G have distinct total degrees. So every pair of adjacent edges have distinct total degrees. Hence G is a neighbourly edge totally irregular single valued neutrosophic graph.

□

Remark 4.10. *Converse of the above Theorems 4.8 and 4.9 need not be true.*

Example 4.11. *Consider* $G : (A, B)$ *be a fuzzy graph such that* $G^* : (V, E)$ *is a path on four vertices.*

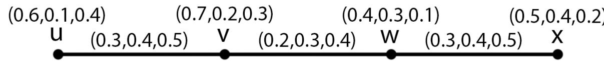

Figure 10. Neighbourly edge irregular SVNG, not strongly edge irregular SVNG; Neighbourly edge totally irregular SVNG, not strongly edge totally irregular SVNG.

From Figure 10,

$d_G(u) = (0.3, 0.4, 0.5), d_G(v) = (0.5, 0.7, 0.9), d_G(w) = (0.5, 0.7, 0.9),$

$d_G(x) = (0.3, 0.4, 0.5);$

$d_G(uv) = d_G(wx) = (0.2, 0.3, 0.4), d_G(vw) = (0.6, 0.8, 1.0);$

$td_G(uv) = td_G(wx) = (0.5, 0.7, 0.9), td_G(vw) = (0.8, 1.1, 1.4).$

Here, $d_G(uv) \neq d_G(vw)$ and $d_G(vw) \neq d_G(wx)$. Hence G is a neighbourly edge irregular single valued neutrosophic graph. But G is not a strongly edge irregular single valued neutrosophic graph, since $d_G(uv) \neq d_G(wx)$. Also, note that $td_G(uv) \neq td_G(vw)$ and $td_G(vw) \neq td_G(wx)$. Hence G is a neighbourly edge totally irregular single valued neutrosophic graph. But G is not a strongly edge totally irregular single valued neutrosophic graph, since $td_G(uv) \neq td_G(wx)$.

Theorem 4.12. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly edge irregular single valued neutrosophic graph, then G is an irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$, for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.

Let us Suppose that G is a strongly edge irregular single valued neutrosophic graph. Then every pair of edges having distinct degrees. Let uv and vw be adjacent edges in G having distinct degrees, and hence

$d_G(uv) \neq d_G(vw)$

$\Rightarrow (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) \neq (d_{T_B}(vw), d_{I_B}(vw), d_{F_B}(vw))$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v) - 2T_B(uv), d_{I_A}(u) + d_{I_A}(v) - 2I_B(uv), d_{F_A}(u) + d_{F_A}(v)) - 2F_B(uv)) \neq (d_{T_A}(v) + d_{T_A}(w) - 2T_B(vw), d_{I_A}(v) + d_{I_A}(w) - 2I_B(vw), d_{F_A}(v)) + d_{F_A}(w) - 2F_B(vw))$

$\Rightarrow (d_{T_A}(u)+d_{T_A}(v)-2C_T, d_{I_A}(u)+d_{I_A}(v)-2C_I, d_{F_A}(u)+d_{F_A}(v))-2C_F) \neq (d_{T_A}(v)+d_{T_A}(w)-2C_T, d_{I_A}(v) + d_{I_A}(w) - 2C_I, d_{F_A}(v)) + d_{F_A}(w) - 2C_F)$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v), d_{I_A}(u) + d_{I_A}(v), d_{F_A}(u) + d_{F_A}(v)) - 2(C_T, C_I, C_F) \neq (d_{T_A}(v) + d_{T_A}(w), d_{I_A}(v) + d_{I_A}(w), d_{F_A}(v)) + d_{F_A}(w)) - 2(C_T, C_I, C_F)$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v), d_{I_A}(u) + d_{I_A}(v), d_{F_A}(u) + d_{F_A}(v)) \neq (d_{T_A}(v) + d_{T_A}(w), d_{I_A}(v) + d_{I_A}(w), d_{F_A}(v)) + d_{F_A}(w))$

$\Rightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) + (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) + (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w))$

$\Rightarrow d_G(u) + d_G(v) \neq d_G(v) + d_G(w)$
$\Rightarrow d_G(u) \neq d_G(w)$
So there exists a vertex v which is adjacent to vertices u and w having distinct degrees. Hence G is an irregular single valued neutrosophic graph.

□

Theorem 4.13. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly edge totally irregular single valued neutrosophic graph, then G is an irregular single valued neutrosophic graph.*

proof: Proof is similar to the above Theorem 4.12.

□

Remark 4.14. *Converse of the above Theorems 4.12 and 4.13 need not be true.*

Example 4.15. *Consider $G : (A, B)$ be a single valued neutrosophic graph such that G^* : (V, E) is a path on four vertices.*

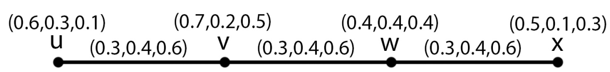

Figure 11. Irregular SVNG, not strongly edge irregular SVNG and not strongly edge totally irregular SVNG.

From Figure 11,
$d_G(u) = d_G(x) = (0.3, 0.4, 0.6), d_G(v) = d_G(w) = (0.6, 0.8, 1.2)$. *Here, G is an irregular single valued neutrosophic graph.*
Also, $d_G(uv) = d_G(wx) = (0.3, 0.4, 0.6), d_G(vw) = (0.6, 0.8, 1.2)$;
$td_G(uv) = td_G(wx) = (0.6, 0.8, 1.2), td_G(vw) = (0.9, 1.2, 1.8)$.
It is noted that $d_G(uv) = d_G(wx)$. Hence G is not a strongly edge irregular single valued neutrosophic graph. Also, $td_G(uv) = td_G(wx)$. Hence G is not a strongly edge totally irregular single valued neutrosophic graph.

Theorem 4.16. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly edge irregular single valued neutrosophic graph, Then G is a highly irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$. Assume that $B : (T_B, I_B, F_B)$ is a constant function, let $B(uv) = C$ for all uv in E, where $C = (C_T, C_I, C_F)$ is constant.
Let v be any vertex adjacent with u, w and x. Then uv, vw and vx are adjacent edges in G.

Let us suppose that G is strongly edge irregular single valued neutrosophic graph. Then every pair of edges in G have distinct degrees. So every pair of adjacent edges in G have distinct degrees. Hence $d_G(uv) \neq d_G(vw) \neq d_G(vx)$

$\Rightarrow (d_{T_B}(uv), d_{I_B}(uv), d_{F_B}(uv)) \neq (d_{T_B}(vw), d_{I_B}(vw), d_{F_B}(vw)) \neq (d_{T_B}(vx), d_{I_B}(vx), d_{F_B}(vx))$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v) - 2T_B(uv), d_{I_A}(u) + d_{I_A}(v) - 2I_B(uv), d_{F_A}(u) + d_{F_A}(v)) - 2F_B(uv)) \neq (d_{T_A}(v) + d_{T_A}(w) - 2T_B(vw), d_{I_A}(v) + d_{I_A}(w) - 2I_B(vw), d_{F_A}(v)) + d_{F_A}(w) - 2F_B(vw)) \neq (d_{T_A}(v) + d_{T_A}(x) - 2T_B(vx), d_{I_A}(v) + d_{I_A}(x) - 2I_B(vx), d_{F_A}(v)) + d_{F_A}(x) - 2F_B(vx))$

$\Rightarrow (d_{T_A}(u)+d_{T_A}(v)-2C_T, d_{I_A}(u)+d_{I_A}(v)-2C_I, d_{F_A}(u)+d_{F_A}(v))-2C_F) \neq (d_{T_A}(v)+d_{T_A}(w)-2C_T, d_{I_A}(v)+d_{I_A}(w)-2C_I, d_{F_A}(v))+d_{F_A}(w)-2C_F) \neq (d_{T_A}(v)+d_{T_A}(x)-2C_T, d_{I_A}(v)+d_{I_A}(x)-2C_I, d_{F_A}(v)) + d_{F_A}(x) - 2C_F)$

$\Rightarrow (d_{T_A}(u) + d_{T_A}(v), d_{I_A}(u) + d_{I_A}(v), d_{F_A}(u) + d_{F_A}(v)) \neq (d_{T_A}(v) + d_{T_A}(w), d_{I_A}(v) + d_{I_A}(w), d_{F_A}(v)) + d_{F_A}(w)) \neq (d_{T_A}(v) + d_{T_A}(x), d_{I_A}(v) + d_{I_A}(x), d_{F_A}(v)) + d_{F_A}(x))$

$\Rightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) + (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) + (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w)) \neq (d_{T_A}(v), d_{I_A}(v), d_{F_A}(v)) + (d_{T_A}(x), d_{I_A}(x), d_{F_A}(x))$

$\Rightarrow (d_{T_A}(u), d_{I_A}(u), d_{F_A}(u)) \neq (d_{T_A}(w), d_{I_A}(w), d_{F_A}(w)) \neq (d_{T_A}(x), d_{I_A}(x), d_{F_A}(x))$

$\Rightarrow d_G(u) \neq d_G(w) \neq d_G(x)$

Therefore the vertex v is adjacent to the vertices with distinct degrees. Hence G is a highly irregular single valued neutrosophic graph.

□

Theorem 4.17. *Let $G : (A, B)$ be a connected single valued neutrosophic graph on $G^* : (V, E)$ and $B : (T_B, I_B, F_B)$ is a constant function. If G is a strongly edge totally irregular single valued neutrosophic graph, Then G is a highly irregular single valued neutrosophic graph.*

proof: Proof is similar to the above Theorem 4.16.

□

Remark 4.18. *Converse of the above Theorems 4.16 and 4.17 need not be true.*

Example 4.19. *Consider $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a path on four vertices.*

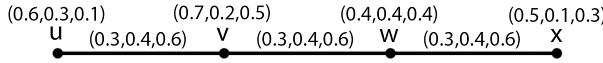

Figure 12. highly irregular SVNG, not strongly edge irregular SVNG and not strongly edge totally irregular SVNG

From Figure 12,

$d_G(u) = d_G(x) = (0.3, 0.4, 0.6), d_G(v) = d_G(w) = (0.6, 0.8, 1.2)$. *Here, G is a highly irregular*

single valued neutrosophic graph.
Note that $d_G(uv) = d_G(wx) = (0.3, 0.4, 0.6), d_G(vw) = (0.6, 0.8, 1.2)$. *So, G is not a strongly edge irregular single valued neutrosophic graph.*
Also, $td_G(uv) = td_G(wx) = (0.6, 0.8, 1.2), td_G(vw) = (0.9, 1.2, 1.8)$. *So, G is not a strongly edge totally irregular single valued neutrosophic graph.*

Theorem 4.20. *Let* $G : (A, B)$ *be a single valued neutrosophic graph on* $G^* : (V, E)$*, a star* $K_{1,n}$. *Then G is a totally edge regular single valued neutrosophic graph. Also, if the degrees of truth-membership, indeterminacy-membership and falsity-membership of no two edges are same, then G is a strongly edge irregular single valued neutrosophic graph.*

proof: Proof is similar to Theorem 3.14.

□

Theorem 4.21. *Let* $G : (A, B)$ *be a single valued neutrosophic graph such that* $G^* : (V, E)$ *is a path on* $2m(m > 1)$ *vertices.If the degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges* $e_1, e_2, e_3, ..., e_{2m-1}$ *are* $p_1, p_2, p_3, ..., p_{2m-1}$ *such that* $p_1 < p_2 < p_3 < ... < p_{2m-1}$, $q_1, q_2, q_3, ..., q_{2m-1}$ *such that* $q_1 > q_2 > q_3 > ... > q_{2m-1}$ *and* $r_1, r_2, r_3, ..., r_{2m-1}$ *such that* $r_1 > r_2 > r_3 > ... > r_{2m-1}$*, respectively, then G is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a single valued neutrosophic graph on $G^* : (V, E)$, a path on $2m(m > 1)$ vertices. Let $e_1, e_2, e_3, ..., e_{2m-1}$ be the edges of path G^* in that order. Let degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges $e_1, e_2, e_3, ..., e_{2m-1}$ are $p_1, p_2, p_3, ..., p_{2m-1}$ such that $p_1 < p_2 < p_3 < ... < p_{2m-1}$, $q_1, q_2, q_3, ..., q_{2m-1}$ such that $q_1 > q_2 > q_3 > ... > q_{2m-1}$ and $r_1, r_2, r_3, ..., r_{2m-1}$ such that $r_1 > r_2 > r_3 > ... > r_{2m-1}$, respectively, then
$d_G(v_1) = (p_1, q_1, r_1)$
$d_G(v_i) = (p_{i-1} + p_i, q_{i-1} + q_i, r_{i-1} + r_i)$ for $i = 2, 3, 4, 5, ..., 2m - 1$
$d_G(v_m) = (p_{2m-1}, q_{2m-1}, r_{2m-1})$
$d_G(e_1) = (p_2, q_2, r_2)$
$d_G(e_i) = (p_{i-1} + p_{i+1}, q_{i-1} + q_{i+1}, r_{i-1} + r_{i+1})$ for $i = 2, 3, 4, 5, ..., 2m - 2$
$d_G(e_{2m-1}) = (p_{2m-2}, q_{2m-2}, r_{2m-2})$
We observe that any pair of edges have distinct degrees. Hence G is a strongly edge irregular single valued neutrosophic graph. Also we have
$td_G(e_1) = (p_1 + p_2, q_1 + q_2, r_1 + r_2)$
$td_G(e_i) = (p_{i-1} + p_i + p_{i+1}, q_{i-1} + q_i + q_{i+1}, r_{i-1} + r_i + r_{i+1})$ for $i = 2, 3, 4, 5, ..., 2m - 2$

$td_G(e_{2m-1}) = (p_{2m-2} + p_{2m-1}, q_{2m-2} + q_{2m-1}, r_{2m-2} + r_{2m-1})$

Therefore any pair of edges have distinct total degrees, hence G is a strongly edge totally irregular single valued neutrosophic graph.

□

Theorem 4.22. *Let $G : (A, B)$ be a single valued neutrosophic graph such that $G^* : (V, E)$ is a cycle on $m(m \geq 4)$ vertices. If the degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges $e_1, e_2, e_3, ..., e_m$ are $p_1, p_2, p_3, ..., p_m$ such that $p_1 < p_2 < p_3 < ... < p_m$, $q_1, q_2, q_3, ..., q_m$ such that $q_1 > q_2 > q_3 > ... > q_m$ and $r_1, r_2, r_3, ..., r_m$ such that $r_1 > r_2 > r_3 > ... > r_m$, respectively, then G is both strongly edge irregular single valued neutrosophic graph and strongly edge totally irregular single valued neutrosophic graph.*

proof: Let $G : (A, B)$ be a single valued neutrosophic graph on $G^* : (V, E)$, a cycle on $m(m \geq 4)$ vertices. Let $e_1, e_2, e_3, ..., e_m$ be the edges of cycle G^* in that order. Let degrees of truth-membership, indeterminacy-membership and falsity-membership of the edges $e_1, e_2, e_3, ..., e_m$ are $p_1, p_2, p_3, ..., p_m$ such that $p_1 < p_2 < p_3 < ... < p_m$, $q_1, q_2, q_3, ..., q_m$ such that $q_1 > q_2 > q_3 > ... > q_m$ and $r_1, r_2, r_3, ..., r_m$ such that $r_1 > r_2 > r_3 > ... > r_m$, respectively,then

$d_G(v_1) = (p_1 + p_m, q_1 + q_m, r_1 + r_m)$

$d_G(v_i) = (p_{i-1} + p_i, q_{i-1} + q_i, r_{i-1} + r_i)$ for $i = 2, 3, 4, 5, ..., m$

$d_G(e_1) = (p_2 + p_m, q_2 + q_m, r_2 + r_m)$

$d_G(e_i) = (p_{i-1} + p_{i+1}, q_{i-1} + q_{i+1}, r_{i-1} + r_{i+1})$ for $i = 2, 3, 4, 5, ..., m - 1$

$d_G(e_m) = (p_1 + p_{m-1}, q_1 + q_{m-1}, r_1 + r_{m-1})$

We observe that any pair of edges have distinct degrees. Hence G is a strongly edge irregular single valued neutrosophic graph.

$td_G(e_1) = (p_1 + p_2 + p_m, q_1 + q_2 + q_m, r_1 + r_2 + r_m)$

$td_G(e_i) = (p_{i-1} + p_i + p_{i+1}, q_{i-1} + q_i + q_{i+1}, r_{i-1} + r_i + r_{i+1})$ for $i = 2, 3, 4, 5, ..., m - 1$

$td_G(e_m) = (p_1 + p_{m-1} + p_m, q_1 + q_{m-1} + q_m, r_1 + r_{m-1} + r_m)$

We note that any pair of edges have distinct total degrees. Hence G is a strongly edge totally irregular single valued neutrosophic graph.

□

5. Conclusion

It is well known that graphs are among the most ubiquitous models of both natural and human-made structures. They can be used to model many types of relations and process dynamics in computer science, physical, biological and social systems. In general graphs theory has a wide range of applications in diverse fields. In this paper, we introduced some types of edge irregular single valued neutrosophic graphs and properties of them. A comparative study between neighbourly edge irregular single valued neutrosophic graphs and neighbourly edge totally irregular single valued neutrosophic graphs and also between strongly edge irregular single valued neutrosophic graphs and strongly edge totally irregular single valued neutrosophic graphs did. Also some properties of neighbourly edge irregular single valued neutrosophic graphs and strongly edge irregular single valued neutrosophic graphs studied, and they examined for neighbourly edge totally irregular single valued neutrosophic graphs and strongly edge totally irregular single valued neutrosophic graphs.

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