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L. Jagadeeswari and V. J. Sudhakar

Self-Centered Bipolar Interval Valued Neutrosophic Graph

L. Jagadeeswari[a)] and V.J. Sudhakar[b)]

PG & Research Department of Mathematics, Islamiah College (Autonomous), Vaniyambadi 635752, Tirupattur District, TamilNadu, India .

[a)]*Corresponding author: jaga25maths@gmail.com*
[b)]*Electronic mail: vjsvec1@gmail.com*

Abstract. Hereby the paper, we explain the path, length, eccentricity, radius and self-centered BIVNG with characteristics and illustrations.

INTRODUCTION

Attanasov found IFG. Smarandache F, Broumi et al [4] initiated Neutrosophic. It has three modules. SVNS notations are given by Wang [2]. Sudhakar et al [6-10] introduced IVSNG. We defined self-centered BIVNG.

PRELIMINARIES

Definition .1 In a BIVNG $G=(A,B)$, the path P_n is defined as different vertices $v_1,v_2,\ldots,v_n$. So, any one statement is proved.

(i): $[T_{BL}(v_i,v_j),T_{BU}(v_i,v_j)]>0,[I_{BL}(v_i,v_j),I_{BU}(v_i,v_j)]>0$ and $[F_{BL}(v_i,v_j),F_{BU}(v_i,v_j)]=0$ for some i and j

(ii): $[T_{BL}(v_i,v_j),T_{BU}(v_i,v_j)]=0,[I_{BL}(v_i,v_j),I_{BU}(v_i,v_j)]=0$ and $[F_{BL}(v_i,v_j),F_{BU}(v_i,v_j)]>0$ for some i and j

SELF-CENTERED BIPOLAR INTERVAL VALUED NEUTROSOPHIC GRAPH

Definition .2 A path P_n in a bipolar interval valued neutrosophic graph $G=(A,B)$ is a sequence of different vertices $v_1,v_2,\ldots,v_n$ so any one of the following statement is proved.

(a): $\left[T^P_{BL}(v_i,v_j),T^P_{BU}(v_i,v_j)\right]>0,\left[I^P_{BL}(v_i,v_j),I^P_{BU}(v_i,v_j)\right]>0$ and $\left[F^P_{BL}(v_i,v_j),F^P_{BU}(v_i,v_j)\right]=0\ \forall\, i$ and j
$\left[T^N_{BL}(v_i,v_j),T^N_{BU}(v_i,v_j)\right]<0,\left[I^N_{BL}(v_i,v_j),I^N_{BU}(v_i,v_j)\right]<0$ and $\left[F^N_{BL}(v_i,v_j),F^N_{BU}(v_i,v_j)\right]=0\ \forall\, i$ and j

(b): $\left[T^P_{BL}(v_i,v_j),T^P_{BU}(v_i,v_j)\right]=0,\left[I^P_{BL}(v_i,v_j),I^P_{BU}(v_i,v_j)\right]=0$ and $\left[F^P_{BL}(v_i,v_j),F^P_{BU}(v_i,v_j)\right]>0$ for some i and j
$\left[T^N_{BL}(v_i,v_j),T^N_{BU}(v_i,v_j)\right]=0,\left[I^N_{BL}(v_i,v_j),I^N_{BU}(v_i,v_j)\right]=0$ and $\left[F^N_{BL}(v_i,v_j),F^N_{BU}(v_i,v_j)\right]<0$ for some i and j

Definition .3 Let $G=(A,B)$ is a connected BIVNG.

1. T length: In G, the path $P_n: v_1,v_2,\ldots,v_n$ $l_{T^P}(P_n)$ and $l_{T^N}(P_n)$ is defined as

$$l_{T^P}(P_n)=\left[l_{T^P_L}(P_n),l_{T^P_U}(P_n)\right] \qquad l_{T^N}(P_n)=\left[l_{T^N_L}(P_n),l_{T^N_U}(P_n)\right]$$

$$\text{where } l_{T^P_L}(P_n)=\sum_{i=1}^{n-1}\left(\frac{1}{T^P_{B_L}(v_i,v_{i+1})}\right) \qquad \text{where } l_{T^N_L}(P_n)=\sum_{i=1}^{n-1}\left(\frac{1}{T^N_{B_L}(v_i,v_{i+1})}\right)$$

$$l_{T^P_U}(P_n)=\sum_{i=1}^{n-1}\left(\frac{1}{T^P_{B_U}(v_i,v_{i+1})}\right) \qquad l_{T^N_U}(P_n)=\sum_{i=1}^{n-1}\left(\frac{1}{T^N_{B_U}(v_i,v_{i+1})}\right)$$

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2. I length: In G, the path $P_n : v_1, v_2, \ldots, v_n$ $l_{I^P}(P_n)$ and $l_{I^N}(P_n)$ is defined as

$$l_{I^P}(P_n) = \left[l_{I_L^P}(P_n), l_{I_U^P}(P_n)\right] \qquad l_{I^N}(P_n) = \left[l_{I_L^N}(P_n), l_{I_U^N}(P_n)\right]$$

$$\text{where } l_{I_L^P}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{I_{B_L}^P(v_i, v_{i+1})}\right) \qquad \text{where } l_{I_L^N}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{I_{B_L}^N(v_i, v_{i+1})}\right)$$

$$l_{I_U^P}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{I_{B_U}^P(v_i, v_{i+1})}\right) \qquad l_{I_U^N}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{I_{B_U}^N(v_i, v_{i+1})}\right)$$

3. F length: In G, the path $P_n : v_1, v_2, \ldots, v_n$ $l_{F^P}(P_n)$ and $l_{F^N}(P_n)$ is defined as

$$l_{F^P}(P_n) = \left[l_{F_L^P}(P_n), l_{F_U^P}(P_n)\right] \qquad l_{F^N}(P_n) = \left[l_{F_L^N}(P_n), l_{F_U^N}(P_n)\right]$$

$$\text{where } l_{F_L^P}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{F_{B_L}^P(v_i, v_{i+1})}\right) \qquad \text{where } l_{F_L^N}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{F_{B_L}^N(v_i, v_{i+1})}\right)$$

$$l_{F_U^P}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{F_{B_U}^P(v_i, v_{i+1})}\right) \qquad l_{F_U^N}(P_n) = \sum_{i=1}^{n-1}\left(\frac{1}{F_{B_U}^N(v_i, v_{i+1})}\right)$$

Then $(T, I, F) \Rightarrow$ $P_n : v_1, v_2, \ldots, v_n$

$$l^P_{(\mathrm{TIF})}(P_n) = \left(\left[l^P_{T_L}(P_n), l^P_{T_U}(P_n)\right], \left[l^P_{I_L}(P_n), l^P_{I_U}(P_n)\right], \left[l^P_{F_L}(P_n), l^P_{F_U}(P_n)\right]\right)$$

$$l^N_{(\mathrm{TIF})}(P_n) = \left(\left[l^N_{T_L}(P_n), l^N_{T_U}(P_n)\right], \left[l^N_{I_L}(P_n), l^N_{I_U}(P_n)\right], \left[l^N_{F_L}(P_n), l^N_{F_U}(P_n)\right]\right)$$

Definition .4 Let $G = (A, B)$ be a connected BIVNG.

1. T^P-distance $\delta_{T^P}(v_i, v_j)$ is min(T^P)-length $\forall$ $v_i, v_j \in V$

$$\delta_{T^P}(v_i, v_j) = \left[\delta_{T_L^P}(v_i, v_j), \delta_{T_U^P}(v_i, v_j)\right]$$

$\Rightarrow$ $\delta_{T_L^P}(v_i, v_j) =$ minimum $\left\{l_{T_L^P}(P_n)\right\}$, $\delta_{T_U^P}(v_i, v_j) =$ minimum $\left\{l_{T_U^P}(P_n)\right\}$

T^N-distance $\delta_{T^N}(v_i, v_j)$ is max(T^N)-length $\forall$ $v_i, v_j \in V$.

$$\delta_{T^N}(v_i, v_j) = \left[\delta_{T_L^N}(v_i, v_j), \delta_{T_U^N}(v_i, v_j)\right]$$

$\Rightarrow$ $\delta_{T_L^N}(v_i, v_j) =$ maximum $\left\{l_{T_L^N}(P_n)\right\}$, $\delta_{T_U^N}(v_i, v_j) =$ maximum $\left\{l_{T_U^N}(P_n) :\right\}$

2. I^P-distance $\delta_{I^P}(v_i, v_j)$ is min(I^P)-length $\forall$ $v_i, v_j \in V$

$$\delta_{I^P}(v_i, v_j) = \left[\delta_{I_L^P}(v_i, v_j), \delta_{I_U^P}(v_i, v_j)\right]$$

$\Rightarrow$ $\delta_{I_L^P}(v_i, v_j) =$ maximum $\left\{l_{I_L^P}(P_n)\right\}$, $\delta_{I_U^P}(v_i, v_j) =$ maximum $\left\{l_{I_U^P}(P_n)\right\}$

The I^N-distance $\delta_{I^N}(v_i, v_j)$ is max(I^N)-length $\forall$ $v_i, v_j \in V$.

$$\delta_{I^N}(v_i, v_j) = \left[\delta_{I_L^N}(v_i, v_j), \delta_{I_U^N}(v_i, v_j)\right]$$

$\Rightarrow$ $\delta_{I_L^N}(v_i, v_j) =$ maximum $\left\{l_{I_L^N}(P_n) :\right\}$, $\delta_{I_U^N}(v_i, v_j) =$ maximum $\left\{l_{I_U^N}(P_n) :\right\}$

3. The F^P-distance $\delta_{F^P}(v_i,v_j)$ is min(F^P)-length $\forall\ v_i,v_j\in V$

$$\delta_{F^P}(v_i,v_j)=\left[\delta_{F_L^P}(v_i,v_j),\delta_{F_U^P}(v_i,v_j)\right]$$

$\Rightarrow\ \ \delta_{F_L^P}(v_i,v_j)=$ minimum $\left\{l_{F_L^P}(P_n):\right\}$ $\delta_{F_U^P}(v_i,v_j)=$ minimum $\left\{l_{F_U^P}(P_n):\right\}$

The F^N-distance $\delta_{F^N}(v_i,v_j)$ is max(F^N)-length $\forall\ v_i,v_j\in V$.

$$\delta_{F^N}(v_i,v_j)=\left[\delta_{F_L^N}(v_i,v_j),\delta_{F_U^N}(v_i,v_j)\right]$$

$\Rightarrow\ \ \delta_{F_L^N}(v_i,v_j)=$ maximum $\left\{l_{F_L^N}(P_n)\right\}$, $\delta_{F_U^N}(v_i,v_j)=$ maximum $\left\{l_{F_U^N}(P_n)\right\}$

Then $\delta_{(T^P,\ I^P,\ F^P)}(v_i,v_j)\Rightarrow\ \ \delta_{(T^P,\ I^P,\ F^P)}(v_i,v_j)=(\delta_{T^P},\delta_{I^P},\delta_{F^P})$

$$\delta_{(T^P,\ I^P,\ F^P)}=\left(\left[\delta_{T_L^P},\ \delta_{T_U^P}\right]\ \left[\delta_{I_L^P},\ \delta_{I_U^P}\right]\ \left[\delta_{F_L^P},\ \delta_{F_U^P}\right]\right)$$

The distance $\delta_{(T^N,\ I^N,\ F^N)}(v_i,v_j)=(\delta_{T^N},\delta_{I^N},\delta_{F^N})$

$$\delta_{(T^N,\ I^N,\ F^N)}=\left(\left[\delta_{T_L^N},\ \delta_{T_U^N}\right]\ \left[\delta_{I_L^N},\ \delta_{I_U^N}\right]\ \left[\delta_{F_L^N},\ \delta_{F_U^N}\right]\right)$$

Definition .5 If $G=(A,B)$ is a connected BIVNG.

1. $\forall\ v_i\in V$, the T^P-eccentricity of v_i

$$\Rightarrow\quad e_{T^P}(v_i)=\left[e_{T_L^P}(v_i),e_{T_U^P}(v_i)\right]$$

Now $e_{T_L^P}(v_i)=\max\left\{\delta_{T_L^P}(v_i,v_j)/\,v_i\in V,\,i\neq j\right\}$, $e_{T_U^P}(v_i)=\max\left\{\delta_{T_U^P}(v_i,v_j)/\,v_i\in V,\,i\neq j\right\}$

$\forall\ v_i\in V$, the T^N-eccentricity of v_i

$$\Rightarrow\quad e_{T^N}(v_i)=\left[e_{T_L^N}(v_i),e_{T_U^N}(v_i)\right]$$

Now $e_{T_L^N}(v_i)=\min\left\{\delta_{T_L^N}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$, $e_{T_U^N}(v_i)=\min\left\{\delta_{T_U^N}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$

2. $\forall\ v_i\in V$, the I^P-eccentricity of v_i

$$\Rightarrow\quad e_{I^P}(v_i)=\left[e_{I_L^P}(v_i),e_{I_U^P}(v_i)\right]$$

Now $e_{I_L^P}(v_i)=\max\left\{\delta_{I_L^P}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$, $e_{I_U^P}(v_i)=\max\left\{\delta_{I_U^P}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$

$\forall\ v_i\in V$, the I^N-eccentricity of v_i

$$\Rightarrow\quad e_{I^N}(v_i)=\left[e_{I_L^N}(v_i),e_{I_U^N}(v_i)\right]$$

Now $e_{I_L^N}(v_i)=\min\left\{\delta_{I_L^N}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$, $e_{I_U^N}(v_i)=\min\left\{\delta_{I_U^N}(v_i,v_j)/\,v_i\in V,\,v_i\neq v_j\right\}$

3. $\forall\ v_i\in V$, the F^P-eccentricity of v_i

$$\Rightarrow\quad e_{F^P}(v_i)=\left[e_{F_L^P}(v_i),e_{F_U^P}(v_i)\right]$$

Now $e_{F_L^P}(v_i) = \max\left\{\delta_{F_L^P}(v_i,v_j)/\, v_i \in V,\, v_i \neq v_j\right\},\ e_{F_U^P}(v_i) = \max\left\{\delta_{F_U^P}(v_i,v_j)/\, v_i \in V,\, v_i \neq v_j\right\}$
$\forall\ v_i \in V$, the F^N-eccentricity of v_i

$$\Rightarrow\ \ e_{F^N}(v_i) = \left[e_{F_L^N}(v_i), e_{F_U^N}(v_i)\right]$$

Now $e_{F_L^N}(v_i) = \min\left\{\delta_{F_L^N}(v_i,v_j)/\, v_i \in V,\, v_i \neq v_j\right\},\ e_{F_U^N}(v_i) = \min\left\{\delta_{F_U^N}(v_i,v_j)/\, v_i \in V,\, v_i \neq v_j\right\}$
$\forall\ v_i \in V$, the eccentricity of v_i

$$e(v_i) = \left(e_T^P(v_i), e_I^P(v_i), e_F^P(v_i)\right) \quad \text{and} \quad e(v_i) = \left(e_T^N(v_i), e_I^N(v_i), e_F^N(v_i)\right)$$

That is,

$$e(v_i)^P = \left(\left[e_{T_L^P}(v_i), e_{T_U^P}(v_i)\right], \left[e_{I_L^P}(v_i), e_{I_U^P}(v_i)\right], \left[e_{F_L^P}(v_i), e_{F_U^P}(v_i)\right]\right)$$
$$e(v_i)^N = \left(\left[e_{T_L^N}(v_i), e_{T_U^N}(v_i)\right], \left[e_{I_L^N}(v_i), e_{I_U^N}(v_i)\right], \left[e_{F_L^N}(v_i), e_{F_U^N}(v_i)\right]\right)$$

Definition .6 If $G = (A,B)$ is a connected BIVNG. The radius G is

1. The T^P-radius $r_{T^P}(G) = \left[r_{T_L^P}(G), r_{T_U^P}(G)\right]$
   where $r_{T_L^P}(G) = \min\left\{e_{T_L^P}(v_i) : v_i \in V\right\},\ r_{T_U^P}(G) = \min\left\{e_{T_U^P}(v_i) : v_i \in V\right\}$
   The T^N-radius $r_{T^N}(G) = \left[r_{T_L^N}(G), r_{T_U^N}(G)\right]$
   where $r_{T_L^N}(G) = \max\left\{e_{T_L^N}(v_i) : v_i \in V\right\},\ r_{T_U^N}(G) = \max\left\{e_{T_U^N}(v_i) : v_i \in V\right\}$
2. The I^P-radius $r_{I^P}(G) = \left[r_{I_L^P}(G), r_{I_U^P}(G)\right]$
   where $r_{I_L^P}(G) = \min\left\{e_{I_L^P}(v_i) : v_i \in V\right\},\ r_{I_U^P}(G) = \min\left\{e_{I_U^P}(v_i) : v_i \in V\right\}$
   The I^N-radius $r_{I^N}(G) = \left[r_{I_L^N}(G), r_{I_U^N}(G)\right]$
   where $r_{I_L^N}(G) = \max\left\{e_{I_L^N}(v_i) : v_i \in V\right\},\ r_{I_U^N}(G) = \max\left\{e_{I_U^N}(v_i) : v_i \in V\right\}$
3. The F^P-radius $r_{F^P}(G) = \left[r_{F_L^P}(G), r_{F_U^P}(G)\right]$
   where $r_{F_L^P}(G) = \min\left\{e_{F_L^P}(v_i) : v_i \in V\right\},\ r_{F_U^P}(G) = \min\left\{e_{F_U^P}(v_i) : v_i \in V\right\}$
   The F^N-radius $r_{F^N}(G) = \left[r_{F_L^N}(G), r_{F_U^N}(G)\right]$
   where $r_{F_L^N}(G) = \max\left\{e_{F_L^N}(v_i) : v_i \in V\right\},\ r_{F_U^N}(G) = \max\left\{e_{F_U^N}(v_i) : v_i \in V\right\}$

The radius of G

$$\Rightarrow\ \ r(G)^P = \left(r_{T^P}(G), r_{I^P}(G), r_{F^P}(G)\right),\ r(G)^N = \left(r_{T^N}(G), r_{I^N}(G), r_{F^N}(G)\right)$$

That is,

$$r(G)^P = \left\{\left[r_{T_L^P}(G), r_{T_U^P}(G)\right], \left[r_{I_L^P}(G), r_{I_U^P}(G)\right], \left[r_{F_L^P}(G), r_{F_U^P}(G)\right]\right\}$$
$$r(G)^N = \left\{\left[r_{T_L^N}(G), r_{T_U^N}(G)\right], \left[r_{I_L^N}(G), r_{I_U^N}(G)\right], \left[r_{F_L^N}(G), r_{F_U^N}(G)\right]\right\}$$

Definition .7 A connected BIVNG G be a

1. T^P, T^N-self centered BIVNG, if $\forall\ v_i \in V$ of G is T^P, T^N-middle vertex, respectively.
   $r_{T^P}(G) = e_{T^P}(v_i), \quad \Rightarrow \quad r_{T_L^P}(G) = e_{T_L^P}(v_i), r_{T_U^P}(G) = e_{T_U^P}(v_i)$ for all $v_i \in V$
   $r_{T^N}(G) = e_{T^N}(v_i), \quad \Rightarrow \quad r_{T_L^N}(G) = e_{T_L^N}(v_i), r_{T_U^N}(G) = e_{T_U^N}(v_i)$ for all $v_i \in V$

2. I^P, I^N-self centered BIVNG, if $\forall\ v_i \in V$ of G is I^P, I^N-middel vertex, respectively.
   $r_{I^P}(G) = e_{I^P}(v_i), \quad \Rightarrow \quad r_{I_L^P}(G) = e_{I_L^P}(v_i), r_{I_U^P}(G) = e_{I_U^P}(v_i)$ for all $v_i \in V$
   $r_{I^N}(G) = e_{I^N}(v_i), \quad \Rightarrow \quad r_{I_L^N}(G) = e_{I_L^N}(v_i), r_{I_U^N}(G) = e_{I_U^N}(v_i)$ for all $v_i \in V$

3. F^P, F^N-self centered BIVNG, if $\forall\ v_i \in V$ of G is F^P, F^N-middle vertex, respectively.
   $r_{F^P}(G) = e_{F^P}(v_i), \quad \Rightarrow \quad r_{F_L^P}(G) = e_{F_L^P}(v_i), r_{F_U^P}(G) = e_{F_U^P}(v_i)$ for all $v_i \in V$
   $r_{F^N}(G) = e_{F^N}(v_i), \quad \Rightarrow \quad r_{F_L^N}(G) = e_{F_L^N}(v_i), r_{F_U^N}(G) = e_{F_U^N}(v_i)$ for all $v_i \in V$

Self centered BIVNG if, $\forall\ v_i \in V$ of G is middle vertex.

$$r_{T^P}(G) = e_{T^P}(v_i), r_{T^N}(G) = e_{T^N}(v_i),$$
$$r_{I^P}(G) = e_{I^P}(v_i), r_{I^N}(G) = e_{I^N}(v_i),$$
$$r_{F^P}(G) = e_{F^P}(v_i), r_{F^N}(G) = e_{F^N}(v_i) \quad \forall\ v_i \in V$$

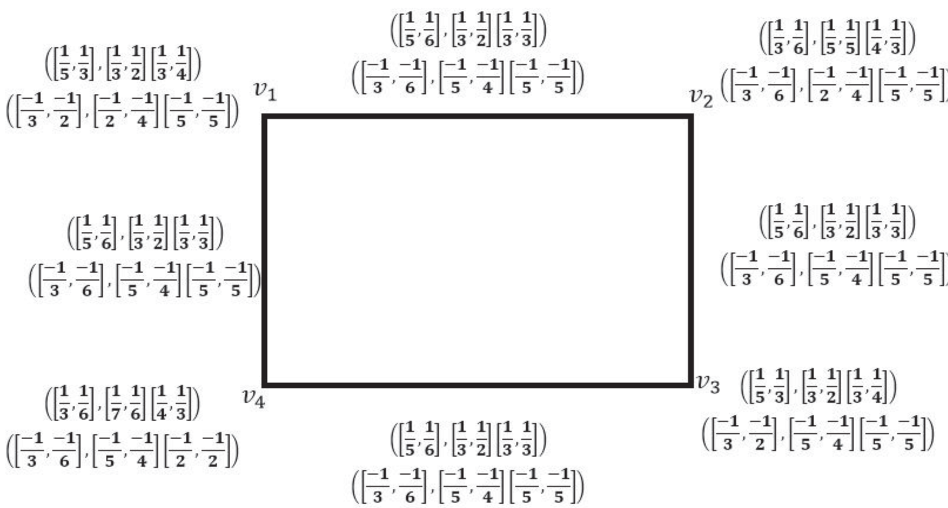

FIGURE 1: SCBIVNG

Example 1

path	$v_1\ v_2$	$v_2\ v_3$	$v_3\ v_4$
Distance $\delta^P_{TIF}(v_i, v_j)$	[5,6][3,2][3,3]	[5,6][3,2][3,3]	[5,6][3,2][3,3]
Distance $\delta^N_{TIF}(v_i, v_j)$	[-3,-6][-5,-4][-5,-5]	[-3,-6][-5,-4][-5,-5]	[-3,-6][-5,-4][-5,-5]
path	$v_1\ v_4$	$v_1\ v_3$	$v_2\ v_4$
Distance $\delta^P_{TIF}(v_i, v_j)$	[5,6][3,2][3,3]	[10,12][6,4][6,6]	[10,12][6,4][6,6]
Distance $\delta^N_{TIF}(v_i, v_j)$	[-3,-6][-5,-4][-5,-5]	[-6,-12][-10,-8][-10,-10]	[-6,-12][-10,-8][-10,-10]

Then the eccentricity of V_i are
$e^P_{(v_1)} = ([10,12][6,4][3,3])$ $e^P_{(v_2)} = ([10,12][6,4][3,3])$ $e^P_{(v_3)} = ([10,12][6,4][3,3])$
$e^P_{(v_4)} = ([10,12][6,4][3,3])$
Radius of G is $r(G) = ([10,12][6,4][3,3])$. Here $r(G) = e^P_{(v_i)}\ \forall v_i \in V$, and
$e^N_{(v_1)} = ([-6,-12][-10,-8][-5,-5])$ $e^N_{(v_2)} = ([-6,-12][-10,-8][-5,-5])$
$e^N_{(v_3)} = ([-6,-12][-10,-8][-5,-5])$ $e^N_{(v_4)} = ([-6,-12][-10,-8][-5,-5])$
Radius of G is $r(G) = ([-6,-12][-10,-8][-5,-5])$. Here $r(G) = e^N_{(v_i)}\ \forall v_i \in V$.

Theorem .1 *A BIVNG $G=(A,B)$ is a self centered BIVNG iff $\delta_{T^P}(v_i,v_j)\leq r_{T^P}(G)$, $\delta_{I^P}(v_i,v_j)\leq r_{I^P}(G)$, $\delta_{F^P}(v_i,v_j)\geq r_{F^P}(G)$. That is*

$$\delta_{T_L^P}(v_i,v_j)\leq r_{T_L^P}(G),\, \delta_{T_U^P}(v_i,v_j)\leq r_{T_U^P}(G), \delta_{I_L^P}(v_i,v_j)\leq r_{I_L^P}(G),\, \delta_{I_U^P}(v_i,v_j)\leq r_{I_U^P}(G),$$
$$\delta_{F_L^P}(v_i,v_j)\geq r_{F_L^P}(G),\, \delta_{F_U^P}(v_i,v_j)\geq r_{F_U^P}(G),$$

$\delta_{T^N}(v_i,v_j)\geq r_{T^N}(G)$, $\delta_{I^N}(v_i,v_j)\geq r_{I^N}(G)$, $\delta_{F^N}(v_i,v_j)\leq r_{F^N}(G)$. That is

$$\delta_{T_L^N}(v_i,v_j)\geq r_{T_L^N}(G),\, \delta_{T_U^N}(v_i,v_j)\geq r_{T_U^N}(G), \delta_{I_L^N}(v_i,v_j)\geq r_{I_L^N}(G),\, \delta_{I_U^N}(v_i,v_j)\geq r_{I_U^N}(G),$$
$$\delta_{F_L^N}(v_i,v_j)\leq r_{F_L^N}(G),\, \delta_{F_U^N}(v_i,v_j)\leq r_{F_U^N}(G),$$

Proof: Let us consider G is self-centered BIVNG.

$$e_{T_L^P}(v_i)=e_{T_L^P}(v_j),\, e_{T_U^P}(v_i)=e_{T_U^P}(v_j), e_{I_L^P}(v_i)=e_{I_L^P}(v_j),\, e_{I_U^P}(v_i)=e_{I_U^P}(v_j)$$
$$e_{F_L^P}(v_i)=e_{F_L^P}(v_j),\, e_{F_U^P}(v_i)=e_{F_U^P}(v_j)$$

and

$$e_{T_L^N}(v_i)=e_{T_L^N}(v_j),\, e_{T_U^N}(v_i)=e_{T_U^N}(v_j), e_{I_L^N}(v_i)=e_{I_L^N}(v_j),\, e_{I_U^N}(v_i)=e_{I_U^N}(v_j),$$
$$e_{F_L^N}(v_i)=e_{F_L^N}(v_j),\, e_{F_U^N}(v_i)=e_{F_U^N}(v_j)$$

Now we want to prove

$$\delta_{T^P}(v_i,v_j)\leq r_{T^P}(G) \text{ (ie) } \delta_{T_L^P}(v_i,v_j)\leq r_{T_L^P}(G),\, \delta_{T_U^P}(v_i,v_j)\leq r_{T_U^P}(G),$$
$$\delta_{I^P}(v_i,v_j)\leq r_{I^P}(G) \Rightarrow \delta_{I_L^P}(v_i,v_j)\leq r_{I_L^P}(G),\, \delta_{I_U^P}(v_i,v_j)\leq r_{I_U^P}(G),$$
$$\delta_{F^P}(v_i,v_j)\geq r_{F^P}(G) \Rightarrow \delta_{F_L^P}(v_i,v_j)\geq r_{F_L^P}(G),\, \delta_{F_U^P}(v_i,v_j)\geq r_{F_U^P}(G),$$
$$\delta_{T^N}(v_i,v_j)\geq r_{T^N}(G) \text{ (ie) } \delta_{T_L^N}(v_i,v_j)\geq r_{T_L^N}(G),\, \delta_{T_U^N}(v_i,v_j)\geq r_{T_U^N}(G),$$
$$\delta_{I^N}(v_i,v_j)\geq r_{I^N}(G) \Rightarrow \delta_{I_L^N}(v_i,v_j)\geq r_{I_L^N}(G),\, \delta_{I_U^N}(v_i,v_j)\geq r_{I_U^N}(G),$$
$$\delta_{F^N}(v_i,v_j)\leq r_{F^N}(G) \Rightarrow \delta_{F_L^N}(v_i,v_j)\leq r_{F_L^N}(G),\, \delta_{F_U^N}(v_i,v_j)\leq r_{F_U^N}(G),$$

By the definition of eccentricity, we get

$$\delta_{T^P}(v_i,v_j)\leq e_{T^P}(v_i),\; \delta_{I^P}(v_i,v_j)\leq e_{I^P}(v_i),\; \delta_{F^P}(v_i,v_j)\geq e_{F^P}(v_i)$$
$$\delta_{T^N}(v_i,v_j)\geq e_{T^N}(v_i),\; \delta_{I^N}(v_i,v_j)\geq e_{I^N}(v_i),\; \delta_{F^N}(v_i,v_j)\leq e_{F^N}(v_i)$$

That is

$$\delta_{T_L^P}(v_i,v_j)\leq e_{T_L^P}(v_i),\; \delta_{T_U^P}(v_i,v_j)\leq e_{T_U^P}(v_i),$$
$$\delta_{I_L^P}(v_i,v_j)\leq e_{I_L^P}(v_i),\, \delta_{I_U^P}(v_i,v_j)\leq e_{I_U^P}(v_i),$$
$$\delta_{F_L^P}(v_i,v_j)\geq e_{F_L^P}(v_i),\, \delta_{F_U^P}(v_i,v_j)\geq e_{F_U^P}(v_i)$$

Likewise prove negative.
Since G is self-centered BIVNG, then we write

$$\delta_{T_L^P}(v_i,v_j)\leq r_{T_L^P}(G),\, \delta_{T_U^P}(v_i,v_j)\leq r_{T_U^P}(G),$$
$$\delta_{I_L^P}(v_i,v_j)\leq r_{I_L^P}(G),\, \delta_{I_U^P}(v_i,v_j)\leq r_{I_U^P}(G),$$
$$\delta_{F_L^P}(v_i,v_j)\geq r_{F_L^P}(G),\, \delta_{F_U^P}(v_i,v_j)\geq r_{F_U^P}(G)$$
$$\delta_{T_L^N}(v_i,v_j)\geq r_{T_L^N}(G),\, \delta_{T_U^N}(v_i,v_j)\geq r_{T_U^N}(G),$$
$$\delta_{I_L^N}(v_i,v_j)\geq r_{I_L^N}(G),\, \delta_{I_U^N}(v_i,v_j)\geq r_{I_U^N}(G),$$
$$\delta_{F_L^N}(v_i,v_j)\leq r_{F_L^N}(G),\, \delta_{F_U^N}(v_i,v_j)\leq r_{F_U^N}(G),\, \forall\,(v_i,v_j)\in V.$$

That is,

$$\delta_{T^P}(v_i,v_j) \le r_{T^P}(G),\, \delta_{I^P}(v_i,v_j) \le r_{I^P}(G),\, \delta_{F^P}(v_i,v_j) \ge r_{F^P}(G).$$

$$\delta_{T^N}(v_i,v_j) \ge r_{T^N}(G),\, \delta_{I^N}(v_i,v_j) \ge r_{I^N}(G),\, \delta_{F^N}(v_i,v_j) \le r_{F^N}(G).$$

Consider that,

$$\delta_{T^P}(v_i,v_j) \le r_{T^P}(G),\, \delta_{I^P}(v_i,v_j) \le r_{I^P}(G),\, \delta_{F^P}(v_i,v_j) \ge r_{F^P}(G).$$

That is,

$$\begin{aligned}
&\delta_{T_L^P}(v_i,v_j) \le r_{T_L^P}(G),\, \delta_{T_U^P}(v_i,v_j) \le r_{T_U^P}(G),\\
&\delta_{I_L^P}(v_i,v_j) \le r_{I_L^P}(G),\, \delta_{I_U^P}(v_i,v_j) \le r_{I_U^P}(G),\\
&\delta_{F_L^P}(v_i,v_j) \ge r_{F_L^P}(G),\, \delta_{F_U^P}(v_i,v_j) \ge r_{F_U^P}(G),\, \forall\,(v_i,v_j) \in V.
\end{aligned}$$

Similarly,

$$\delta_{T^N}(v_i,v_j) \ge r_{T^N}(G),\, \delta_{I^N}(v_i,v_j) \ge r_{I^N}(G),\, \delta_{F^N}(v_i,v_j) \le r_{F^N}(G).$$

That is,

$$\begin{aligned}
&\delta_{T_L^N}(v_i,v_j) \ge r_{T_L^N}(G),\, \delta_{T_U^N}(v_i,v_j) \ge r_{T_U^N}(G),\\
&\delta_{I_L^N}(v_i,v_j) \ge r_{I_L^N}(G),\, \delta_{I_U^N}(v_i,v_j) \ge r_{I_U^N}(G),\\
&\delta_{F_L^N}(v_i,v_j) \le r_{F_L^N}(G),\, \delta_{F_U^N}(v_i,v_j) \le r_{F_U^N}(G),\, \forall\,(v_i,v_j) \in V.
\end{aligned}$$

In case G is not self centered BIVNG, then

$$\begin{aligned}
&r_{T^P}(G) = e_{T^P}(v_i),\;\; r_{I^P}(G) = e_{I^P}(v_i),\;\; r_{F^P}(G) = e_{F^P}(v_i),\\
&r_{T^N}(G) = e_{T^N}(v_i),\;\; r_{I^N}(G) = e_{I^N}(v_i),\;\; r_{F^N}(G) = e_{F^N}(v_i),\\
&r_{T_L^P}(G) = e_{T_L^P}(v_i),\;\; r_{T_U^P}(G) = e_{T_U^P}(v_i),\;\; r_{I_L^P}(G) = e_{I_L^P}(v_i),\\
&r_{T_L^N}(G) = e_{T_L^N}(v_i),\;\; r_{T_U^N}(G) = e_{T_U^N}(v_i),\;\; r_{I_L^N}(G) = e_{I_L^N}(v_i),\\
&r_{I_U^P}(G) = e_{I_U^P}(v_i),\;\; r_{F_L^P}(G) = e_{F_L^P}(v_i),\;\; r_{F_U^P}(G) = e_{F_U^P}(v_i)\\
&r_{I_U^N}(G) = e_{I_U^N}(v_i),\;\; r_{F_L^N}(G) = e_{F_L^N}(v_i),\;\; r_{F_U^N}(G) = e_{F_U^N}(v_i)
\end{aligned}$$

for some $v_i \in V$. Let us assume that

$$\begin{aligned}
&e_{T_L^P}(v_i),\, e_{T_U^P}(v_i),\, e_{I_L^P}(v_i),\, e_{I_U^P}(v_i),\, e_{F_L^P}(v_i),\;\text{ and }\; e_{F_U^P}(v_i)\\
&e_{T_L^N}(v_i),\, e_{T_U^N}(v_i),\, e_{I_L^N}(v_i),\, e_{I_U^N}(v_i),\, e_{F_L^N}(v_i),\;\text{ and }\; e_{F_U^N}(v_i)
\end{aligned}$$

It is the smallest eccentricity value,

$$\begin{aligned}
r_{T_L^P}(G) = e_{T_L^P}(v_i),\;\; r_{T_U^P}(G) = e_{T_U^P}(v_i),\;\; r_{I_L^P}(G) = e_{I_L^P}(v_i),\;\; r_{I_U^P}(G) = e_{I_U^P}(v_i),\\
r_{F_L^P}(G) = e_{F_L^P}(v_i),\;\text{ and }\; r_{F_U^P}(G) = e_{F_U^P}(v_i),\\
r_{T_L^N}(G) = e_{T_L^N}(v_i),\;\; r_{T_U^N}(G) = e_{T_U^N}(v_i),\;\; r_{I_L^N}(G) = e_{I_L^N}(v_i),\;\; r_{I_U^N}(G) = e_{I_U^N}(v_i),\\
r_{F_L^N}(G) = e_{F_L^N}(v_i),\;\text{ and }\; r_{F_U^N}(G) = e_{F_U^N}(v_i),
\end{aligned} \tag{1}$$

Where

$$\begin{aligned}
e_{T_L^P}(v_i) < e_{T_L^P}(v_j),\;\; e_{T_U^P}(v_i) < e_{T_U^P}(v_j),\;\; e_{I_L^P}(v_i) < e_{I_L^P}(v_j),\;\; e_{I_U^P}(v_i) < e_{I_U^P}(v_j),\\
e_{F_L^P}(v_i) < e_{F_L^P}(v_j),\;\text{ and }\; e_{F_U^P}(v_i) < e_{F_U^P}(v_j),\\
e_{T_L^N}(v_i) < e_{T_L^N}(v_j),\;\; e_{T_U^N}(v_i) < e_{T_U^N}(v_j),\;\; e_{I_L^N}(v_i) < e_{I_L^N}(v_j),\;\; e_{I_U^N}(v_i) < e_{I_U^N}(v_j),\\
e_{F_L^N}(v_i) < e_{F_L^N}(v_j),\;\text{ and }\; e_{F_U^N}(v_i) < e_{F_U^N}(v_j),
\end{aligned}$$

$$
\begin{aligned}
&\delta_{T_L^P}(v_i,v_j)=e_{T_L^P}(v_j)>e_{T_L^P}(v_i),\;\; \delta_{T_U^P}(v_i,v_j)=e_{T_U^P}(v_j)>e_{T_U^P}(v_i),\\
&\delta_{I_L^P}(v_i,v_j)=e_{I_L^P}(v_j)>e_{I_L^P}(v_i),\;\; \delta_{I_U^P}(v_i,v_j)=e_{I_U^P}(v_j)>e_{I_U^P}(v_i),\\
&\delta_{F_L^P}(v_i,v_j)=e_{F_L^P}(v_j)>e_{F_L^P}(v_i),\;\; \delta_{F_U^P}(v_i,v_j)=e_{F_U^P}(v_j)>e_{F_U^P}(v_i),\text{ for some }(v_i,v_j)\in V.
\end{aligned}\tag{2}
$$

Same way prove negative.
Hence form equations (1) and (2), we get

$$
\begin{aligned}
&\delta_{T_L^P}(v_i,v_j)>r_{T_L^P}(G),\;\; \delta_{T_U^P}(v_i,v_j)>r_{T_U^P}(G),\\
&\delta_{I_L^P}(v_i,v_j)>r_{I_L^P}(G),\;\; \delta_{I_U^P}(v_i,v_j)>r_{I_U^P}(G),\\
&\delta_{F_L^P}(v_i,v_j)>r_{F_L^P}(G),\;\; \delta_{F_U^P}(v_i,v_j)>r_{F_U^P}(G),\\
&\delta_{T_L^N}(v_i,v_j)<r_{T_L^N}(G),\;\; \delta_{T_U^N}(v_i,v_j)<r_{T_U^N}(G),\\
&\delta_{I_L^N}(v_i,v_j)<r_{I_L^N}(G),\;\; \delta_{I_U^N}(v_i,v_j)<r_{I_U^N}(G),\\
&\delta_{F_L^N}(v_i,v_j)<r_{F_L^N}(G),\;\; \delta_{F_U^N}(v_i,v_j)<r_{F_U^N}(G),\;\; \text{for some }(v_i,v_j)\in V.
\end{aligned}
$$

Which is the contradiction to the fact that

$$
\begin{aligned}
&\delta_{T_L^P}(v_i,v_j)\le r_{T_L^P}(G),\;\; \delta_{T_U^P}(v_i,v_j)\le r_{T_U^P}(G),\\
&\delta_{I_L^P}(v_i,v_j)\le r_{I_L^P}(G),\;\; \delta_{I_U^P}(v_i,v_j)\le r_{I_U^P}(G),\\
&\delta_{F_L^P}(v_i,v_j)\ge r_{F_L^P}(G),\;\; \delta_{F_U^P}(v_i,v_j)\ge r_{F_U^P}(G),\;\forall\,(v_i,v_j)\in V.\\
&\delta_{T_L^N}(v_i,v_j)\ge r_{T_L^N}(G),\;\; \delta_{T_U^N}(v_i,v_j)\ge r_{T_U^N}(G),\\
&\delta_{I_L^N}(v_i,v_j)\ge r_{I_L^N}(G),\;\; \delta_{I_U^N}(v_i,v_j)\ge r_{I_U^N}(G),\\
&\delta_{F_L^N}(v_i,v_j)\le r_{F_L^N}(G),\;\; \delta_{F_U^N}(v_i,v_j)\le r_{F_U^N}(G),\;\; \text{for some }(v_i,v_j)\in V.
\end{aligned}
$$

That is,

$$
\begin{aligned}
&\delta_{T^P}(v_i,v_j)\le r_{T^P}(G),\;\; \delta_{I^P}(v_i,v_j)\le r_{I^P}(G),\;\; \delta_{F^P}(v_i,v_j)\ge r_{F^P}(G),\\
&\delta_{T^N}(v_i,v_j)\le r_{T^N}(G),\;\; \delta_{I^N}(v_i,v_j)\le r_{I^N}(G),\;\; \delta_{F^N}(v_i,v_j)\ge r_{F^N}(G),
\end{aligned}
$$

$\therefore\ G-$ Self Centered BIVNG.

CONCLUSION

Here we define the path, length, eccentricity and self-centered BIVNG. Next we develop it as a self median BIVNG.

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