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ON DIRECT SUM OF SIX FUZZY GRAPHS

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ABSTRACT:

The graph G_1,G_2,G_3,G_4,G_5 and G_6 Which is defined by the direct sum of six fully graphs $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ .This is also proved the effective values .The degree of the vertices is $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ is calculated with the establishment of the regular property and the connectedness of the direct sum of six fuzzy graphs.

Key words:

Fuzzy graph, Degree of vertices in the direct sum, Regular fuzzy graphs, connected fuzzy graphs and Effective fuzzy graphs.

1.INTRODUCTION

The concept of fuzzy graphs was established by A.Rosenfeld in 1975[6]. Mordeson .J.N and Peng . S[2] were developed some operations on fuzzy graphs. Further Bhattacharya [1] discussed about the remarks of fuzzy graphs . Also , Dr.k. Radha and Mrs. Arumukam [7] asserted the connectedness and regular properties of direct sum of two fuzzy graphs. Similarly, the direct sum of two fuzzy graphs was extended to three fuzzy graphs in T. Henson and N.Devi [3].

By using numerical example, can be calculated the direct sum of six fuzzy graphs with the degree of nodes. In this whole article V is a fuzzy subset of σ and μ is a symmetric fuzzy relation on σ was represented. In addition, also, with the help of numerical example direct sum six fuzzy graphs of Regularness, Connectedness, and Effectiveness of six fuzzy graphs were checked in this paper below.

2. PRELIMINARIES

2.1. Definition

The valency of is x defined as $dG(x) = \sum_{x\neq y} \mu(x,y)$, *and if each vertex with same degree K, and if* $dG(x) = K$ *for every x and y then the graph is said to be a regular fuzzy graph of degree K* [6].

2.2. Definition

If every pair of vertices is connected by an edge then the graph is a connected fuzzy graph [6].

3. Direct sum

Let $G_1 : (\sigma_1, \mu_1)$, $G_2 : (\sigma_2, \mu_2)$, $G_3 : (\sigma_3, \mu_3)$, $G_4 : (\sigma_4, \mu_4)$, $G_5 : (\sigma_5, \mu_5)$ and $G_6 : (\sigma_6, \mu_6)$ denote six fuzzy graphs with underlying crisp $G_1^*:(V_1,E_1)$, $G_2^*:(V_2, E_2)$, $G_3^*:(V_3, E_3)$, $G_4^*: (V_4, E_4)$, $G_5^*:(V_5,E_5)$ and $G_6^*:(V_6,E_6)$ respectively

Let $V= V_1 \cup V_2 \cup V_3 \cup V_4 \cup V_5 \cup V_6$

$E= E_1 \cup E_2 \cup E_3 \cup E_4 \cup E_5 \cup E_6$

Define: $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 = G : (\sigma, \mu)$ by

$$\sigma(X) = \begin{cases} \sigma_1(x_1) & \text{if } x \in V_1 \\ \sigma_2(x_2) & \text{if } x \in V_2 \\ \sigma_3(x_3) & \text{if } x \in V_3 \\ \sigma_4(x_4) & \text{if } x \in V_4 \\ \sigma_5(x_5) & \text{if } x \in V_5 \\ \sigma_6(x_6) & \text{if } x \in V_6 \end{cases}$$

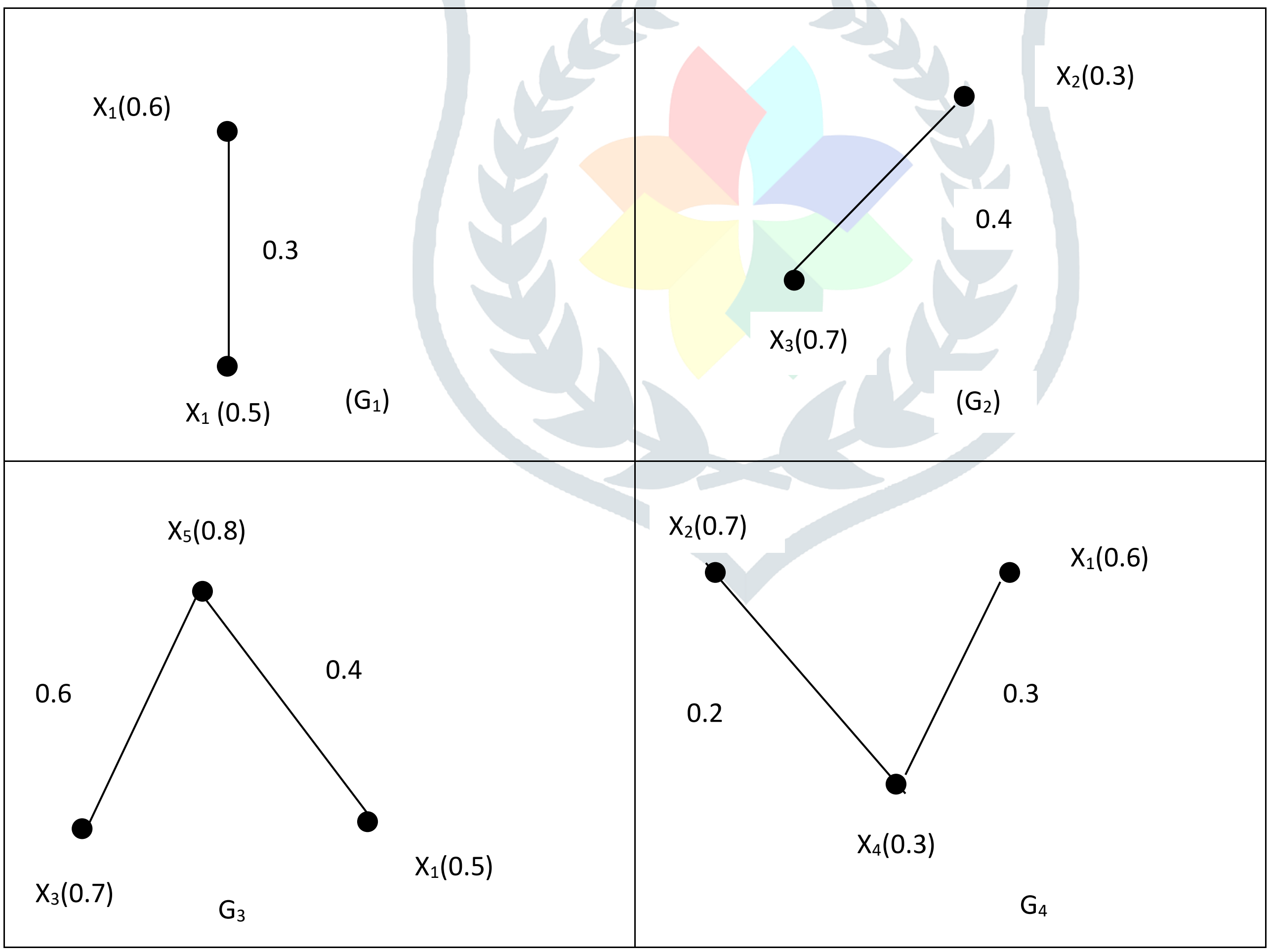
$\sigma_1(x_1) \cup \sigma_2(x_2) \cup \sigma_3(x_3) \cup \sigma_4(x_4) \cup \sigma_5(x_5) \cup \sigma_6(x_6)$

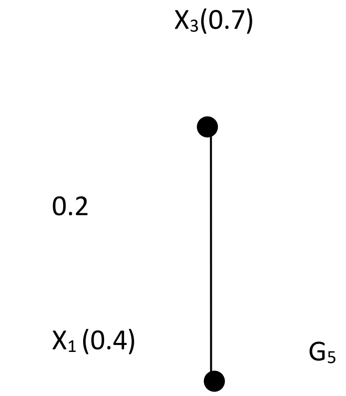
If $x \in V_1 \cup V_2 \cup V_3 \cup V_4 \cup V_5 \cup V_6$

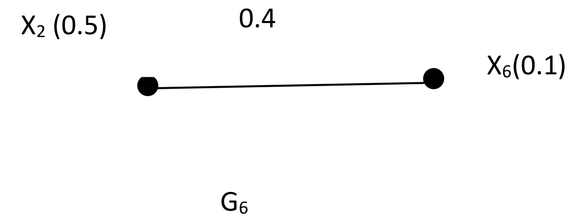
$$\mu\,(E) = \begin{cases} \mu_1(E_1) \leq \min\,(\sigma_1) \text{ where } \sigma_1 \in V_1 \\ \mu_2\,(E_2) \leq \min\,(\sigma_2) \text{ where } \sigma_2 \in V_2 \\ \mu_3\,(E_3) \leq \min\,(\sigma_3) \text{ where } \sigma_3 \in V_3 \\ \mu_4\,(E_4) \leq \min\,(\sigma_4) \text{ where } \sigma_4 \in V_4 \\ \mu_5\,(E_5) \leq \min\,(\sigma_5) \text{ where } \sigma_5 \in V_5 \\ \mu_6\,(E_6) \leq \min\,(\sigma_6) \text{ where } \sigma_6 \in V_6 \end{cases}$$

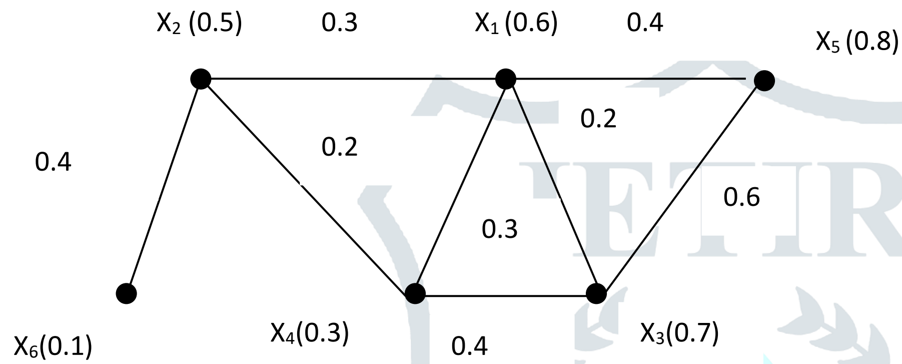
Therefore, $G_1 \oplus G2 \oplus G3 \oplus G4 \oplus G5 \oplus G6 = G\,(\sigma,\mu)$ is the direct sum of six fuzzy graphs.

Example: 1



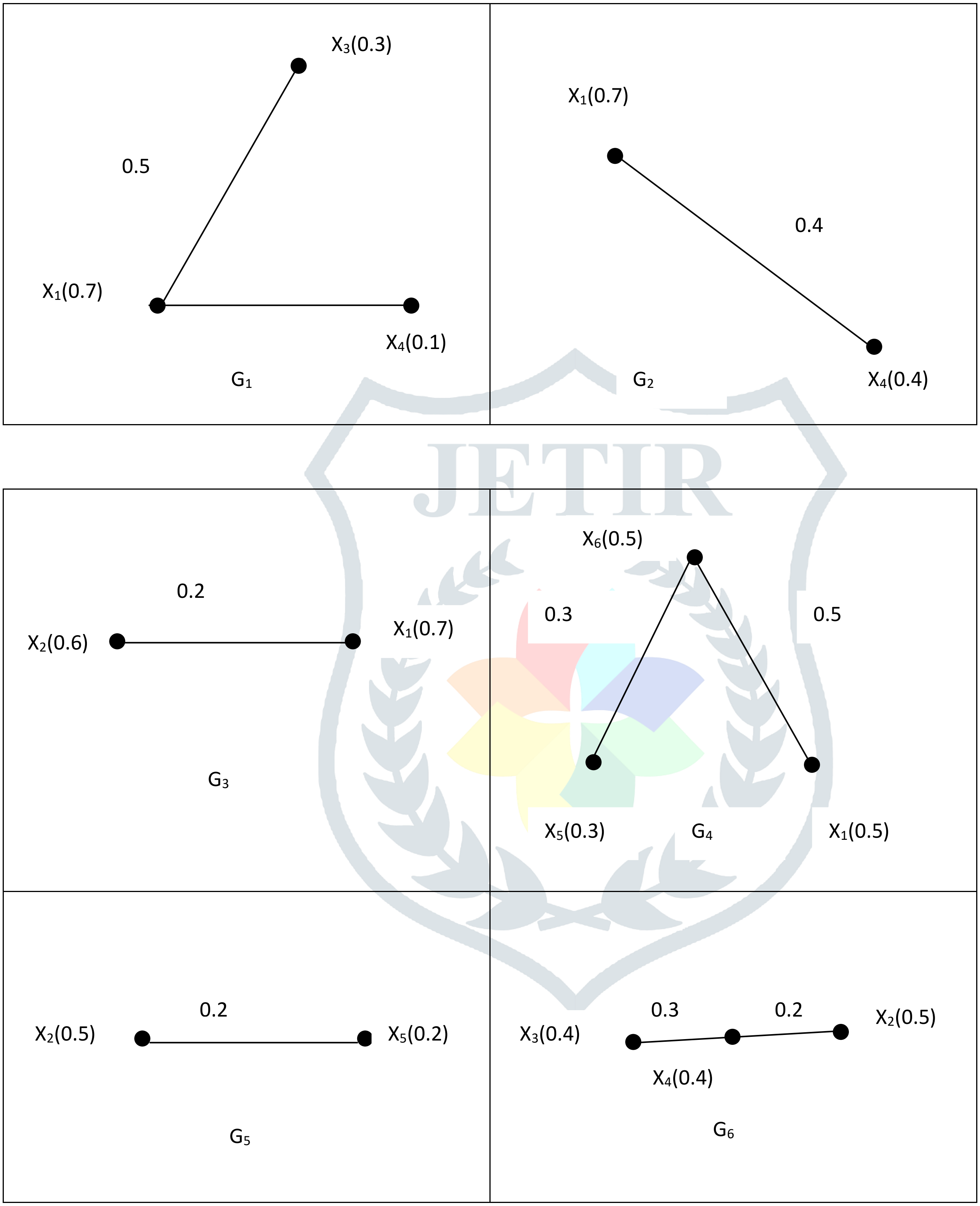


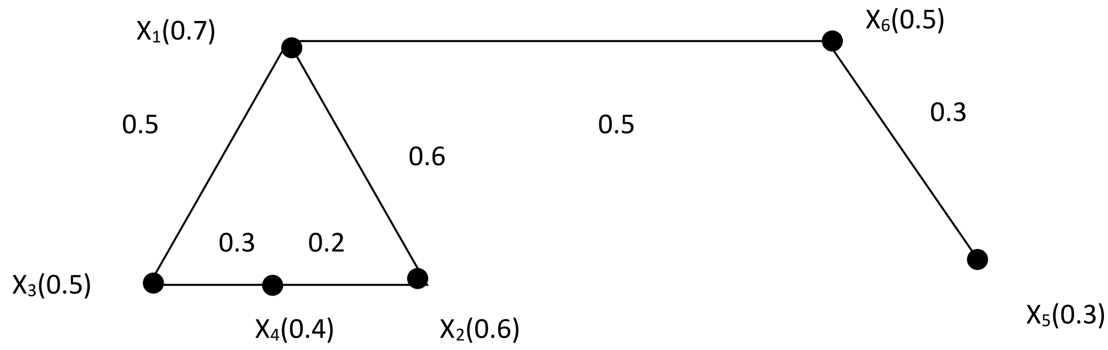




($G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$) Direct sum of six connected fuzzy graphs valency of node

Example: 2


X3(0.3)
0.5
X1(0.7)
X4(0.1)
G1
X1(0.7)
0.4
X4(0.4)
G2
0.2
X2(0.6)
X1(0.7)
G3
X6(0.5)
0.3
0.5
X5(0.3)
G4
X1(0.5)
0.2
X2(0.5)
X5(0.2)
G5
0.3
0.2
X3(0.4)
X2(0.5)
X4(0.4)
G6



$(G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6)$

4. The Direct sum of six fuzzy Graphs in the valency of nodes :

Theorem:

Find the valency of nodes in the direct sum of six fuzzy graphs in term of the valency of the node in $G_1,$ G_2 G_3 $G_4,$ G_5 and G_6 is given by

$$D_{G1 \oplus G2 \oplus G3 \oplus G4 \oplus G5 \oplus G6}(X) = \begin{cases} D_{G1}(x), \text{ if } x \epsilon\ v_1 \\ D_{G2}(x), \text{ if } x \epsilon\ v_2 \\ D_{G3}(x), \text{ if } x \epsilon\ v_3 \\ D_{G4}(x), \text{ if } x \epsilon\ v_4 \\ D_{G5}(x), \text{ if } x \epsilon\ v_5 \\ D_{G6}(x), \text{ if } x \epsilon\ v_6 \end{cases}$$

$$D_{G1}(x)+D_{G2}(x)+D_{G3}(x)+D_{G4}(x)+D_{G5}(x)+D_{G6}(x).$$

If $x \epsilon\ V_1 \cap V_2 \cap V_3 \cap V_4 \cap V_5 \cap V_6$ and $E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6 = \Phi$.

Proof:

In $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$, for any vertex we have two cases,

Case (i) :

If $x \epsilon V_1$ or $x \epsilon V_2$ or $x \epsilon V_3$ or $x \epsilon V_4$ or $x \epsilon V_5$ or $x \epsilon V_6$ then the edge incident at 'x' lies in $E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6$.

$$(\mu_1 \oplus \mu_2 \oplus \mu_3 \oplus \mu_4 \oplus \mu_5 \oplus \mu_6)(E) = \begin{cases} \mu_1 \ (x\ y) \text{ if } x \epsilon V_1, xy \epsilon E_1 \\ \mu_2 \ (x\ y) \text{ if } x \epsilon V_2, xy \epsilon E_2 \\ \mu_3 \ (x\ y) \text{ if } x \epsilon V_3, xy \epsilon E_3 \\ \mu_4 \ (x\ y) \text{ if } x \epsilon V_4, xy \epsilon E_4 \\ \mu_5 \ (x\ y) \text{ if } x \epsilon V_5, xy \epsilon E_5 \\ \mu_6 \ (x\ y) \text{ if } x \epsilon V_6, xy \epsilon E_6 \end{cases}$$

Hence,

If $x \epsilon V_1$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E1} \mu (E_1) = DG_1 (X)$

If $x \epsilon V_2$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E2} \mu (E_2) = DG_2 (X)$

If $x \epsilon V_3$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E3} \mu (E_3) = DG_3 (X)$

If $x \epsilon V_4$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E4} \mu (E_4) = DG_4 (X)$

If $x \epsilon V_5$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E5} \mu (E_5) = DG_5 (X)$

If $x \epsilon V_6$ then $DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X) = \sum_{E6} \mu (E_6) = DG_6 (X)$

Case (ii) :

If $x \epsilon V_1 \cap V_2 \cap V_3 \cap V_4 \cap V_5 \cap V_6$ then there is no incident to x on $E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6$ but it lies in E_1 or E_2 or E_3 or E_4 or E_5 or E_6.

Hence,

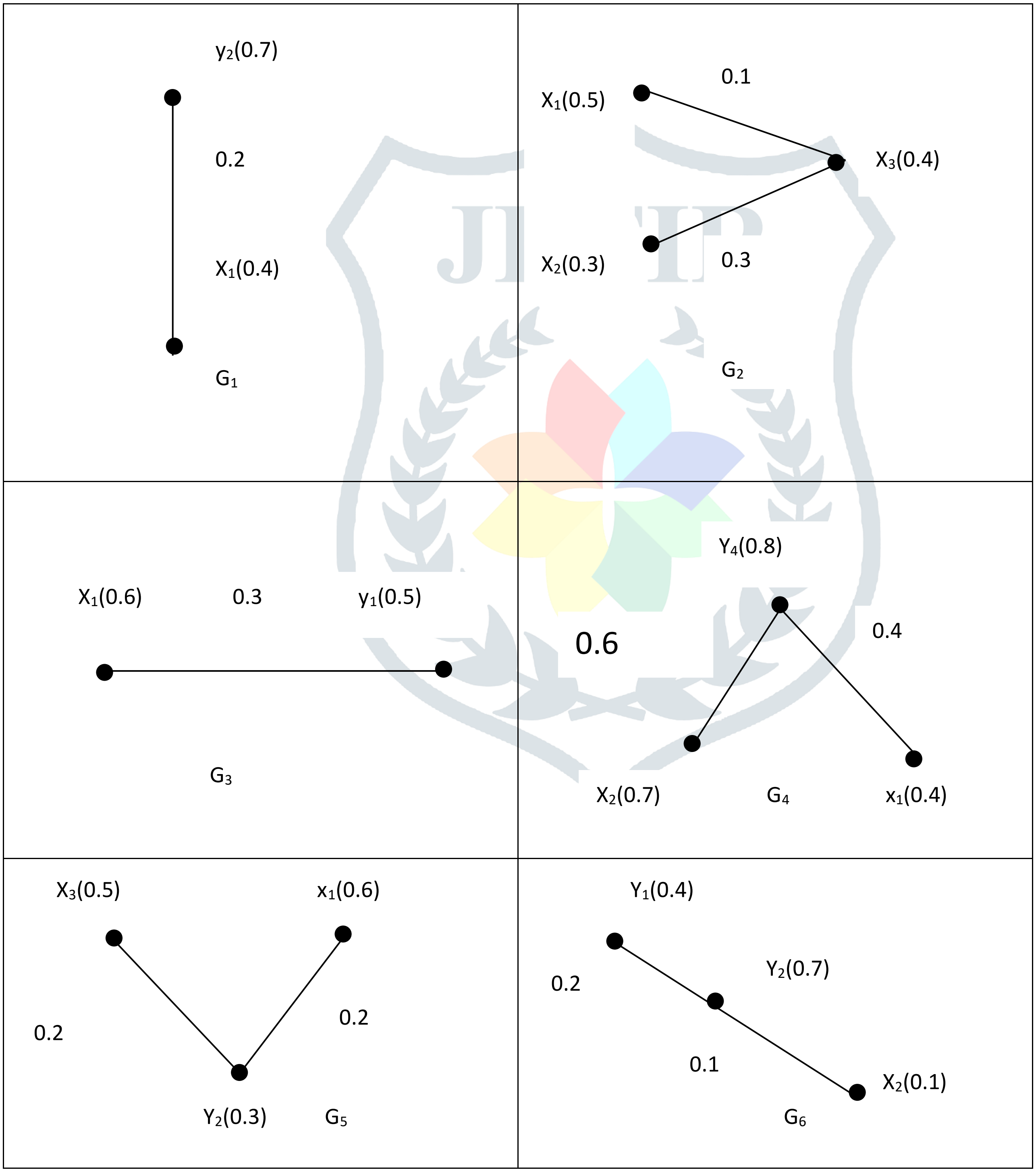
The valency of x in $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ is given by

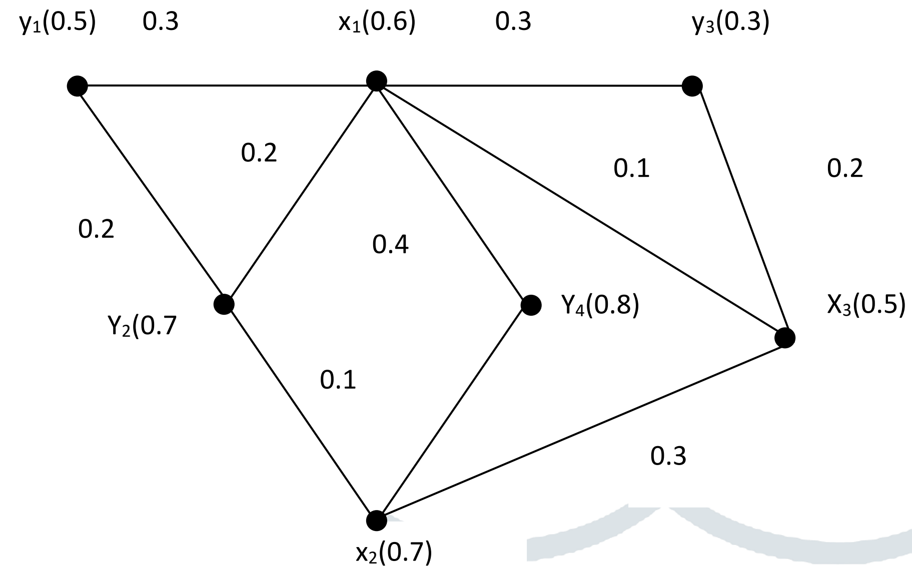
$$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (x) = \sum_{E} (\mu_1 \oplus \mu_2 \oplus \mu_3 \oplus \mu_4 \oplus \mu_5 \oplus \mu_6)(E)$$

$=\Sigma_{E1}\ \mu(E_1) + \Sigma_{E2}\ \mu(E_2) + \Sigma_{E3}\ \mu(E_3) + \Sigma_{E4}\ \mu(E_4) + \Sigma_{E5}\ \mu(E_5) + \Sigma_{E6}\ \mu(E_6)$

$= D_{G1}(X) + D_{G2}(X) + D_{G3}(X) + D_{G4}(X) + D_{G5}(X) + D_{G6}(X).$

Example:





$(G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6)$ Direct sum of six fuzzy graphs in the valency of nodes

The valency of the node in $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ is as follows.

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_1) = 0,2 + 0.1 + 0.3 + 0.4 + 0.3 = 1.3$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_2) = 0.3 + 0.6 + 0.1 = 1$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_3) = 0.1 + 0.2 = 0.3$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (y_1) = 0.3 + 0.2 = 0.5$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (y_2) = 0.2 + 0.2 + 0.1 = 0.5$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (y_3) = 0.2 + 0.3 = 0.5$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (y_3) = 0.6 + 0.4 = 1$

Now,

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_1)$

$= DG_1 (X_1) + DG_2 (X_1) + DG_3 (X_1) + DG_4 (X_1) + DG_5 (X_1) + DG_6 (X_1)$

$= 0.2+0.1+0.3+0.4+03$

$=1.3$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_2) = DG_4 (X_2) = 0.6$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (X_3) = DG_2 (X_3) = 0.4$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_1) = DG_3 (Y_1) = 0.3$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_2) = DG_1 (Y_2) = 0.2$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_3) = DG_5 (Y_3) = 0.5$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_4) = DG_4 (Y_4) = 1$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_1) = DG_6 (Y_1) = 0.2$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_2) = DG_6 (Y_2) = 0.3$

$DG_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 (Y_3) = DG_5 (Y_3) = 0.5$

Hence the degree of nodes is verified by the direct sum of six fuzzy graphs.

5.Direct sum of six connected fuzzy graphs:

Theorem:

If G_1: (σ_1, μ_1), G_2 :(σ_2, μ_2), G_3: (σ_3, μ_3), G_4: (σ_4, μ_4), G_5: (σ_5, μ_5) G_6: (σ_6, μ_6) are six connected fuzzy graphs with underlying crisp graphs G_1^* (σ_1, μ_1), G_2^*:(σ_2, μ_2), G_3^*:(σ_3, μ_3), G_4^*:(σ_4, μ_4), G_5^*:(σ_5, μ_5) G_6^*:(σ_6, μ_6) respectively such that

$E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6 = \Phi$, $V_1 \cap V_3 \neq \Phi$, $V_2 \cap V_4 \neq \Phi$, $V_3 \cap V_5 \neq \Phi$, $V_4 \cap V_6 \neq \Phi$ then their direct sum $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$:(σ,μ) is connected fuzzy graphs.

Proof:

Let,

G_1: (σ_1, μ_1) is a connected fuzzy graph, $\mu_1^{\infty}(E_1) > O$

G_2: (σ_2, μ_2) is a connected fuzzy graph, $\mu_2^{\infty}(E_2) > O$

G_3: (σ_3, μ_3) is a connected fuzzy graph, $\mu_3^{\infty}(E_3) > O$

G_4: (σ_4, μ_4) is a connected fuzzy graph, $\mu_4^{\infty}(E_4) > O$

G_5: (σ_5, μ_5) is a connected fuzzy graph, $\mu_4^{\infty}(E_5) > O$

G_6: (σ_6, μ_6) is a connected fuzzy graph, $\mu_6^{\infty}(E_6) > O$

Then, $V_1 \cap V_3 \neq \Phi$, $V_2 \cap V_4 \neq \Phi$, $V_3 \cap V_5 \neq \Phi$, $V_4 \cap V_6 \neq \Phi$

At least one vertex in $V_1 \cap V_3$, one vertex in $V_2 \cap V_4$, one vertex in $V_3 \cap V_5$ one vertex in $V_4 \cap V_6$ and no edges in $E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6$.

Two vertices exist a path

$G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (\sigma,\mu)$, that is

$\mu\ G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (E) > 0$.

Which implies that $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (\sigma,\mu)$ is connected .

Example:

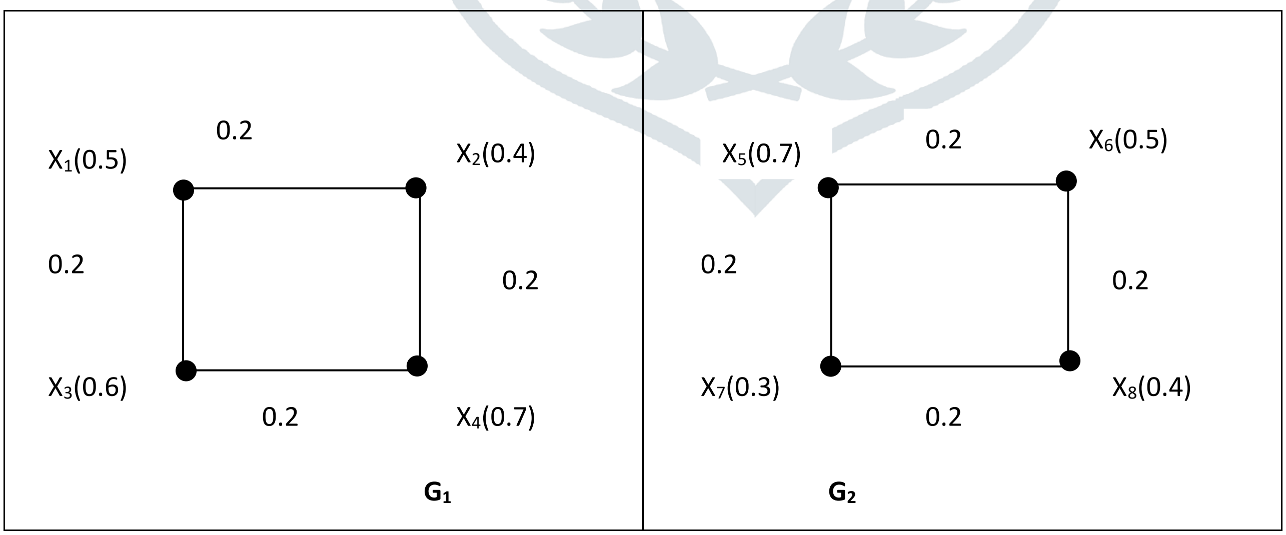
If $G_1:(\sigma_1,\mu_1)$, $G_2:(\sigma_2,\mu_2)$, $G_3:(\sigma_3,\mu_3)$, $G_4:(\sigma_4,\mu_4)$, $G_5:(\sigma_5,\mu_5)$, and $G_6:(\sigma_6,\mu_6)$ are six connected fuzzy graphs ,with

$\cap(V_1 \cap V_3) = 1$ and $\cap(V_2 \cap V_4) = 1$

Then $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (\sigma,\mu)$ is the connected fuzzy graphs.

Solution:

Consider the direct sum of six connected fuzzy graphs



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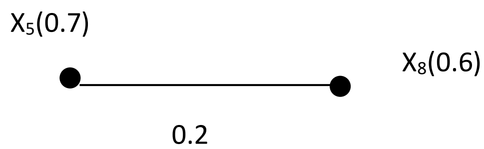
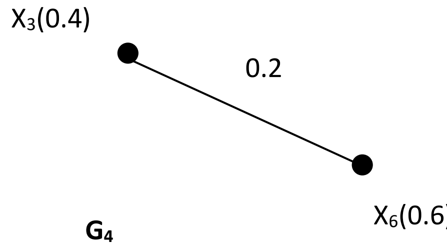
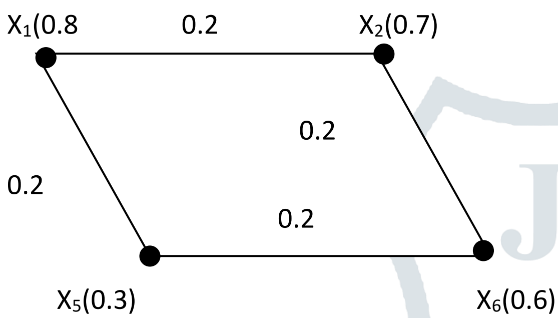


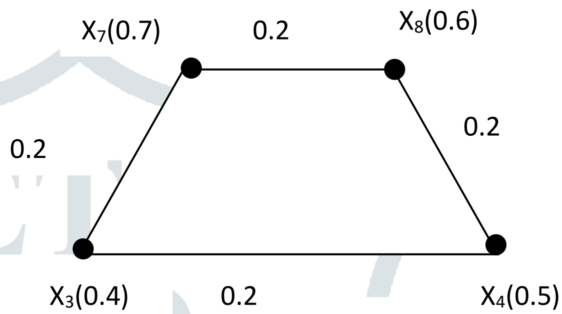
G₃



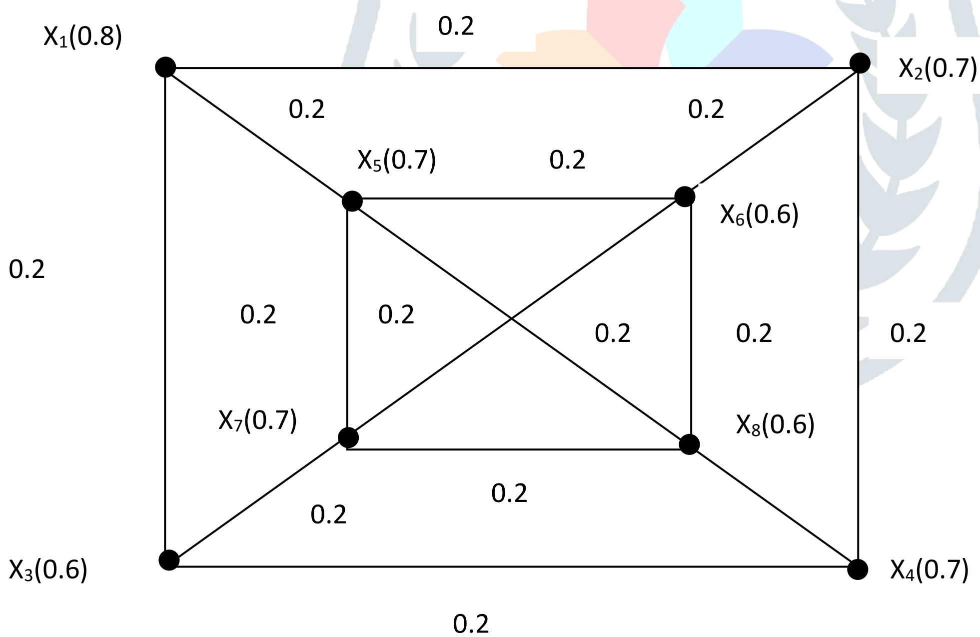
G₄



G₅



G₆



$G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ Direct sum of six connected fuzzy graphs

6.Regular fuzzy graphs on six direct sums:

Theorem:

If G_1: (σ_1,μ_1),G_2:(σ_2,μ_2),G_3:(σ_3,μ_3),G_4:(σ_4,μ_4),G_5:(σ_5,μ_5) and G_6:(σ_6,μ_6) are regular fuzzy graphs with degrees k_1,k_2,k_3,k_4,k_5 and k_6 respectively and $v_1 \cap v_2 \cap v_3 \cap v_4 \cap v_5 \cap v_6 \neq \Phi$ then $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$: (σ,μ) is regular if and only if $K_1 = K_2 = K_3 = K_4 = K_5 = K_6$.

Proof :

Let G_1: (σ_1, μ_1) be a k_1-regular fuzzy graph

G_2: (σ_2, μ_2) be a k_2-regular fuzzy graph

G_3: (σ_3, μ_3) be a k_3-regular fuzzy graph

G_4: (σ_4, μ_4) be a k_4-regular fuzzy graph

G_5: (σ_5, μ_5) be a k_5-regular fuzzy graph

G_6: (σ_6, μ_6) be a k_6-regular fuzzy graph

Let us consider $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$: (σ,μ) is regular.

We know that,

$$D_{G1 \oplus G2 \oplus G3 \oplus G \oplus 4G5 \oplus G6}(x) = \begin{cases} D_{G1}(x), & \text{if } x \epsilon V_1 \\ D_{G2}(x), & \text{if } x \epsilon V_2 \\ D_{G3}(x), & \text{if } x \epsilon V_3 \\ D_{G4}(x), & \text{if } x \epsilon V_4 \\ D_{G5}(x), & \text{if } x \epsilon V_5 \\ D_{G6}(x), & \text{if } x \epsilon V_6 \end{cases}$$

$D_{G1}(x) + D_{G2}(x) + D_{G3}(x) + D_{G4}(x) + D_{G5}(x) + D_{G6}(x)$,

If $x \epsilon V_1 \cap V_2 \cap V_3 \cap V_4 \cap V_5 \cap V_6$ and

$E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6 = \Phi$

Since $V_1 \cap V_2 \cap V_3 \cap V_4 \cap V_5 \cap V_6 \neq \Phi$

$$D_{G1 \oplus G2 \oplus G3 \oplus G4 \oplus G5 \oplus G6}(x) = \begin{cases} D_{G1}(x) = k_1, \text{ if } x \epsilon V_1 \\ D_{G2}(x) = k_2, \text{if } x \epsilon V_2 \\ D_{G3}(x) = k_3, \text{if } x \epsilon V_3 \\ D_{G4}(x) = k_4, \text{if } x \epsilon V_4 \\ D_{G5}(x) = k_5, \text{if } x \epsilon V_5 \\ D_{G6}(x) = k_6, \text{if } x \epsilon V_6 \end{cases}$$

Since $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (\sigma,\mu)$ is regular

So, we conclude that $k_1 = k_2 = k_3 = k_4 = k_5 = k_6$

converse part

Consider $k_1 = k_2 = k_3 = k_4 = k_5 = k_6 = k$ (say)

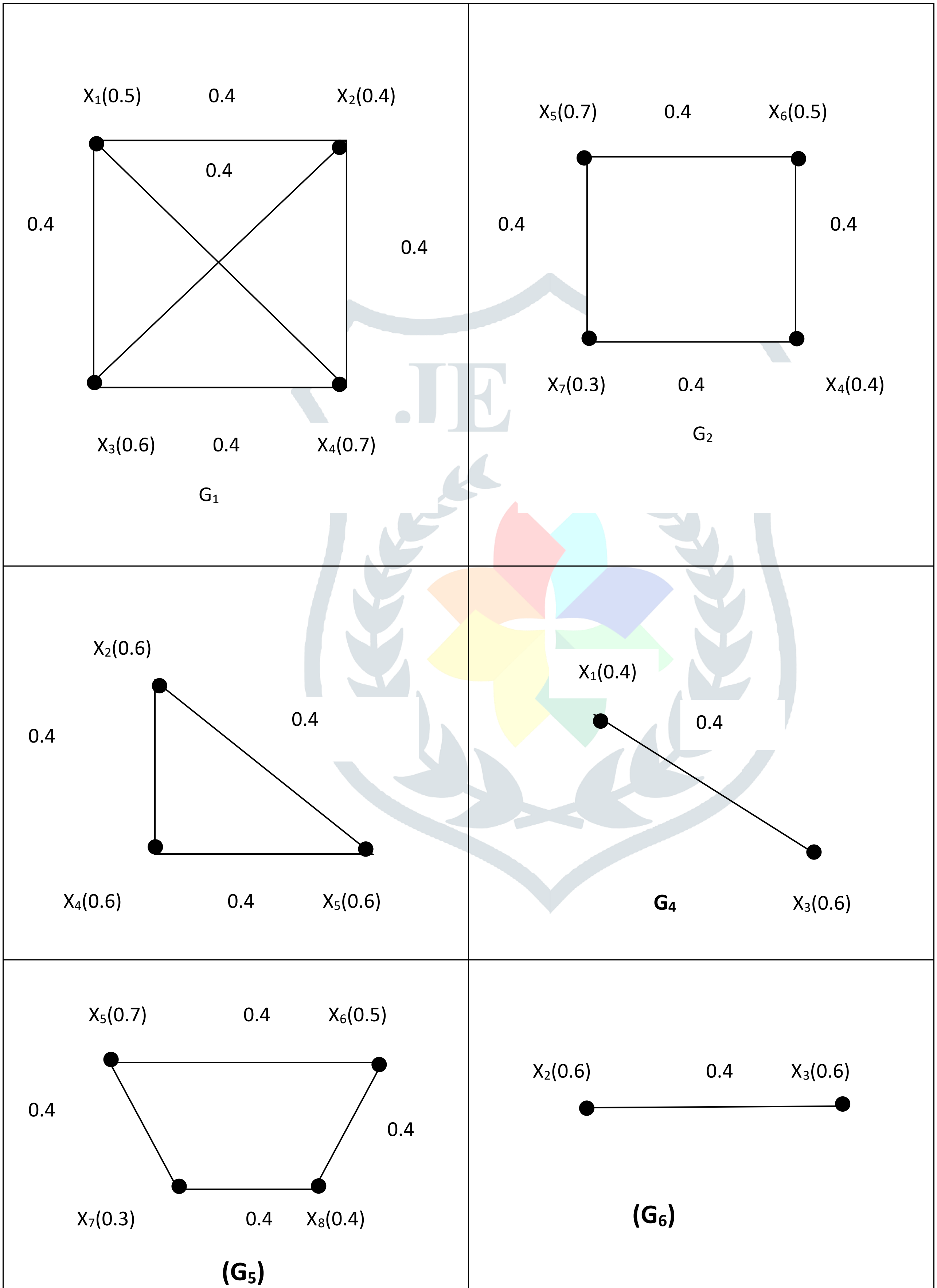
Then k- regular fuzzy graphs be G_1, G_2 G_3 G_4, G_5 , G_6 such that $V_1 \cap V_2 \cap V_3 \cap V_4 \cap V_5 \cap V_6 \neq \Phi$.

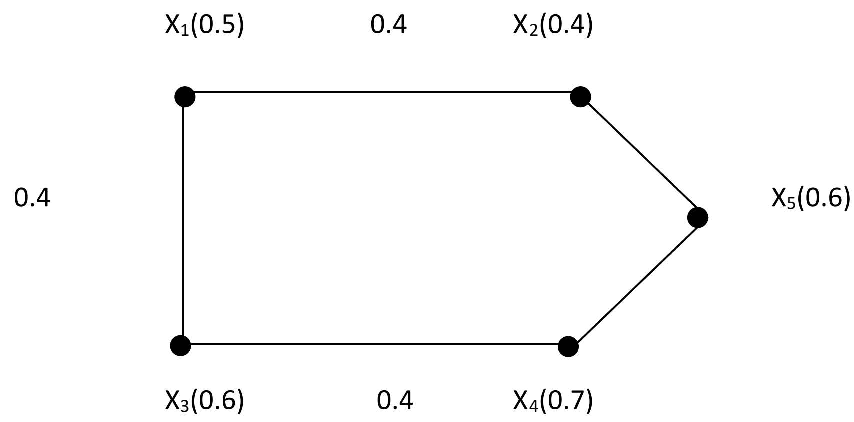
Then the valency node in the direct sum is given by

$$D_{G1 \oplus G2 \oplus G3 \oplus G4 \oplus G5 \oplus G6}(x) = \begin{cases} D_{G1}(x) = k, \text{ if } x \epsilon V_1 \\ D_{G2}(x) = k, \text{ if } x \epsilon V_2 \\ D_{G3}(x) = k, \text{ if } x \epsilon V_3 \\ D_{G4}(x) = k, \text{ if } x \epsilon V_4 \\ D_{G5}(x) = k, \text{ if } x \epsilon V_5 \\ D_{G6}(x) = k, \text{ if } x \epsilon V_6 \end{cases}$$

There fore, the degree of direct sum of six fuzzy graphs is K.

Hence $G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6 : (\sigma,\mu)$ is regular.





$G_1 \oplus G_2 \oplus G_3 \oplus G_4 \oplus G_5 \oplus G_6$ Direct sum of six regular fuzzy graphs

Conclusion:

We conclude that , the valency of nodes for the direct sum of six fuzzy graphs is proposed by the formulas and the regular, connected and effective fuzzy graphs are verified with the characteristic of the direct sum with an example. In future this work can be taken as next stage like the direct sum of six, seven etc., and this direct sum was applicable to the traffic light signals and the roadways.

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