Dominating Energy in Products of intuitionistic Fuzzy Graphs

R.Vijayaragavan¹, A.Kalimulla², S. Sharief Basha³*

¹Associate professor, Department of mathematics, Thiruvalluvar University, Serkadu, Vellore, TN, India.
²Research Scholar, Thiruvalluvar University, Serkadu, Vellore, TN, India.
³Assistant Professor(Sr) Department of mathematics, S A S, VIT University, Vellore, TN, India.

*Corresponding Author: S. Sharief Basha

Abstract

The concept of energy of an Intuitionistic Fuzzy Graph is extended to dominating Energy in various products in Intuitionistic Fuzzy Graph. In this paper, We have obtained the value of dominating Energy in different products such as ring Sum, Cartesian Product, Lexicographic Product, Tensor product and Strong Product between two intuitionistic Fuzzy graphs. Also we study the relation between the dominating Energy in the various products in two Intuitionistic Fuzzy Graphs.

Keywords: Intuitionistic fuzzy Graph, Ring Sum, Cartesian product, Lexicographic Product, Tensor product and Strong Product of two intuitionistic fuzzy Graphs.

Introduction

It is quite well known that graphs are simply models of relations. A graph is a convenient way of representing information involving relationship between objects. The objects are represented by vertices and relations by edges. When there is vagueness in the description of the objects or in its relationships or in both, it is natural that we need to design a 'Fuzzy Graph Model'. Fuzzy graph is a symmetric binary fuzzy relation on a fuzzy subset. The concept of fuzzy sets and fuzzy relations was introduced by L.A. Zadeh in 1965 [14] and further studied in [2]. It was Rosenfeld [11] who considered fuzzy relations on fuzzy sets and developed the theory of fuzzy graphs in 1975.

Atanassov [2] introduced the concept of intuitionistic fuzzy relation and intuitionistic fuzzy graphs(IFG). Recent on the theory of intuitionistic fuzzy sets (IFS) has been witnessing an exponential growth of mathematics and its applications. This ranges from normal mathematics to computer sciences, information sciences and communication systems.

Graph spectrum appears in problems in Statistical physics and in combinatorial optimization problems in mathematics. Spectrum of a graph also plays an important role in pattern recognition, modelling virus propagation in computer networks and in securing personal data in databases. A concept related to the spectrum of a graph is that of energy.

Let dᵢ be the degree of iᵗʰ vertex of G, i =1,2,...,n. The spectrum of the graph G, consisting of the numbers λ₁,λ₂,.....λₙ is the spectrum of its adjacency matrix [5]. In 1960, the study of domination in graphs was begun. In 1862, C.F. De Jaenisch [4] attempted to determine the minimum number of queens required to cover a n×n chessboard.

Cockayne [3] introduced the independent domination number in graphs. Domination in graphs has applications to several fields. A. Somasundaram and S. Somasundaram [12] introduced domination in fuzzy graphs in terms of effective edges. A. Nagoorgani

Study on domination concepts in intuitionistic fuzzy graphs are more convenient that fuzzy graphs, which is useful in the traffic density and telecommunication systems.

This paper is organized as follows. In section 2, we give some basic definitions related to energy of an intuitionistic fuzzy graph and domination in an intuitionistic fuzzy graph.

In section 3, we defined the dominating energy of different products of an intuitionistic fuzzy graphs and in section 4, we give the conclusion.

Preliminaries
Intuitionist Fuzzy Graph

Definition [5] An intuitionistic fuzzy graph is defined as $G=(V,E,\mu,\gamma)$ where $V$ is the set of vertices and $E$ is the set of edges, $\mu$ is a fuzzy membership function defined on $V \times V$ and $\gamma$ is a fuzzy non membership function we define $\mu(v_i, v_j)$ by $\mu_{ij}$ and $\gamma(v_i, v_j)$ by $\gamma_{ij}$ such that (i) $0 \leq \mu_{ij} + \gamma_{ij} \leq 1$ (ii) $0 \leq \mu_{ij}, \gamma_{ij}, \pi_{ij} \leq 1$ where $\pi_{ij} = 1 - \mu_{ij} - \gamma_{ij}$.

Hence $(V \times V, \mu, \gamma)$ is an Intuitionistic fuzzy graph.

Energy of an Intuitionistic Fuzzy Graph

Definition [5, 10] The energy of an intuitionistic fuzzy graph $G=(V,E,\mu,\gamma)$ is defined as

$$E(\mu_{ij}(G))$$

where $\sum_{i \in V} |\mu_{ij}|$ is defined as an energy of the membership matrix denoted by $E(\mu_{ij}(G))$ and $\sum_{\delta \in E} |\delta|$ is defined as an energy of the non-membership matrix denoted by $E(\gamma_{ij}(G))$.

Theorem [10] Let $G$ be an intuitionistic fuzzy directed graph (without loops) with $|V|=n$ and $|E|=m$ and $A(IG) = (\mu_{ij}, \gamma_{ij})$ be an intuitionistic fuzzy adjacency matrix of $G$ then (i)

$$\sqrt{2 \sum_{i<j \in E} \mu_{ij} \mu_{ji} + n(n-1)|A|^2} \leq E(\mu_{ij}(G)) \leq \sqrt{2n \sum_{i<j \in E} \mu_{ij} \mu_{ji}}$$

where $|A|$ is the determinant of $A(\mu_{ij})$ and (ii)

$$\sqrt{2 \sum_{i<j \in E} \gamma_{ij} \gamma_{ji} + n(n-1)|B|^2} \leq E(\gamma_{ij}(G)) \leq \sqrt{2n \sum_{i<j \in E} \gamma_{ij} \gamma_{ji}}$$

where $|B|$ is the determinant of $A(\gamma_{ij})$.

Dominating Energy in Products of Intuitionistic Fuzzy Graphs

Dominating Energy in Ring Sum of an Intuitionistic Fuzzy Graph

Definitions: Ring sum

The ringsum of two Intuitionistic fuzzy graphs $G_1=(V_1,E_1)$ and $G_2=(V_2,E_2)$ denoted by $G_1 \oplus G_2$ is an intuitionistic fuzzy graph $G=(V \cup V, E, \langle \mu, \nu \rangle, \langle \mu_n, \nu_n \rangle)$

Where 1. $E= [(E_1 \cup E_2) \cdot (E_1 \cap E_2)]$

2. $\langle \mu, \nu \rangle$ denote the degrees of membership and non-membership of vertices of $G$, and is given by

$$\langle \mu, \nu \rangle = \begin{cases} \langle \mu_i, \nu_i \rangle & \text{if } v_i \in v_1 \\ \langle \mu_p, \nu_p \rangle & \text{if } v_i \in v_2 \\ \langle \max(\mu, \mu_p), \min(\nu, \nu_p) \rangle & \text{if } v_i \in v_1 \cap v_2 \end{cases}$$

3. $\langle \mu, \nu \rangle$ denote the degrees of membership and non-membership of edges of $G$, and is given by

$$\langle \mu, \nu \rangle = \begin{cases} \langle \mu_{ij}, \nu_{ij} \rangle & \text{if } (v_i, v_j) \in E_1 \\ \langle \mu_{pq}, \nu_{pq} \rangle & \text{if } (v_i, v_j) \in E_2 \\ \langle 0, 0 \rangle & \text{if } (v_i, v_j) \in E_1 \cap E_2 \end{cases}$$
First we find the Dominating Energy of Intuitionist Fuzzy Graph $G_1(V,E)$

$\mu(v_1) = \max[\mu(v_1v_2)] = \max[0.3] = 0.3$  $\mu_1(v_2) = \max[\mu(v_2v_1)] = \max[0.3] = 0.3$

$\gamma_1(v_1) = \min[\gamma(v_1v_2)] = \min[0.1] = 0.1$  $\gamma_1(v_2) = \min[\gamma(v_2v_1)] = \min[0.1] = 0.1$

Here $v_1$ dominates $v_2$ because

$\mu(v_1v_2) \leq \mu_1(v_1) \land \mu_1(v_2) \land \gamma_1(v_1) \land \gamma_1(v_2)$

$0.3 \leq 0.3 \land 0.3 \land 0.1 \land 0.1$

Here $V=\{V_1,V_2\}$ and $D=\{V_1\}$  $V-D=\{V_2\}$

$|D|=1$=Sum of dominating elements

$D(G_1)=\begin{bmatrix}
(0,0) & (0.3,0.1) \\
(0.3,0.1) & (1,1)
\end{bmatrix}$

$\mu_D(G_1)=\begin{bmatrix}
0 & 0.3 \\
0.3 & 1
\end{bmatrix}$  $\gamma_D(G_1)=\begin{bmatrix}
0 & 0.1 \\
0.1 & 1
\end{bmatrix}$

Eigen values of $\mu_D(G_1)=[-0.0831,1.0831]=1.1662$.

Eigen values of $\gamma_D(G_1)=[-0.0099,1.0099]=1.0198$.

Next We Find the Dominating Energy of Intuitionistic Fuzzy Graph $G_2(V,E)$

$\mu_1(u_1) = \max[\mu(u_1u_2)] = \max[0.1] = 0.1$

$\mu(u_2) = \max[\mu(u_1u_2) \mu(u_2u_3)] = \max[0.1,0.1] = 0.1$

$\mu(u_3) = \max[\mu(u_2u_3)] = \max[0.1] = 0.1$

$\gamma_1(u_1) = \min[\gamma(u_1u_2)] = \min[0.5] = 0.5$

$\gamma_1(u_2) = \min[\gamma(u_1u_2),\gamma(u_2u_3)] = \min[0.5,0.6] = 0.5$

$\gamma_1(u_3) = \min[\gamma(u_2u_3)] = \min[0.6] = 0.6$

Here $u_1$ dominates $u_2$ because

$\mu(u_1u_2) \leq \mu_1(u_1) \land \mu_1(u_2) \land \gamma_1(u_1u_2) \leq \gamma_1(u_1) \land \gamma_1(u_2)$

$0.1 \leq 0.1 \land 0.1 \land 0.5 \leq 0.5 \land 0.5$

Here $u_2$ dominates $u_3$ because
Here $V=\{u_1, u_2, u_3\}$ and $D=\{ u_1, u_2\}$ $V-D=\{u_3\}$

$|D|=2=$Sum of dominating elements

$D(G_2)=\begin{bmatrix}
1 & 0.1 & 0 \\
0.1 & 0.1 & 0.1 \\
0 & 0.1 & 0
\end{bmatrix}$

$\mu_\mu(G_2)=\begin{bmatrix}
1 & 0.5 & 0 \\
0.5 & 0.5 & 0.6 \\
0 & 0 & 0.6
\end{bmatrix}$

$\lambda_\mu(G_2)=[-0.0100,0.9054,1.1046]=2.02$

$\lambda_\gamma(G_2)=[-0.3188,0.6957,1.6231]=2.6376$

Now we find the Dominating Energy of Intuitionistic fuzzy Graph $G_1 \oplus G_2 (V,E)$

$\mu_\mu(v_1)=\max[\mu(v_1),\mu(v_2)]=\max[0.3]=0.3$

$\mu_\mu(v_2)=\max[\mu(v_2),\mu(v_3)]=\max[0.3]=0.3$

$\mu_\mu(u_1)=\max[\mu(u_1),\mu(u_2)]=\max[0.1]=0.1$

$\mu_\mu(u_2)=\max[\mu(u_2),\mu(u_3)]=\max[0.6]=0.6$

$\mu_\gamma(v_1)=\min[\gamma(v_1),\gamma(v_2)]=\min[0.1]=0.1$

$\mu_\gamma(v_2)=\min[\gamma(v_2),\gamma(v_3)]=\min[0.1]=0.1$

$\mu_\gamma(u_1)=\min[\gamma(u_1),\gamma(u_2)]=\min[0.1]=0.1$

$\mu_\gamma(u_2)=\min[\gamma(u_2),\gamma(u_3)]=\min[0.6]=0.6$

Here $v_1$ dominates $v_2$ because

$\mu(v_1,v_2)\leq \mu_\mu(v_1) \land \mu_\mu(v_2) \land \mu_\gamma(v_1,v_2) \leq \gamma_\mu(v_1) \land \gamma_\gamma(v_2)$

$0.3 \leq 0.3 \land 0.3 \leq 0.1 \land 0.1$

Here $u_1$ dominates $u_2$ because

$\mu(u_1,u_2)\leq \mu_\mu(u_1) \land \mu_\mu(u_2) \land \mu_\gamma(u_1,u_2) \leq \gamma_\mu(u_1) \land \gamma_\gamma(u_2)$

$0.1 \leq 0.1 \land 0.1 \leq 0.1 \land 0.1$

Here $u_2$ dominates $u_3$ because

$\mu(u_2,u_3)\leq \mu_\mu(u_2) \land \mu_\mu(u_3) \land \mu_\gamma(u_2,u_3) \leq \gamma_\mu(u_2) \land \gamma_\gamma(u_3)$

$0.1 \leq 0.1 \land 0.1 \leq 0.5 \land 0.6$

Here $V=\{v_1,v_2,u_1,u_2,u_3\}$ and $D=\{ v_1,u_1,u_2\}$ $V-D=\{v_2,u_3\}$

$|D|=3=$Sum of dominating elements
Eigen values of $\mu_d(G_1 \oplus G_2) = \{-0.1846, 0.0026, 0.5732, 0.7237, 1.8851\}$

$\text{LE}[\mu_d(G_1 \oplus G_2)] = 3.3692$

Eigen values of $\gamma_d(G_1 \oplus G_2) = \{-0.7528, -0.2058, 0.7864, 0.9, 2.2721\}$

$\text{LE}[\gamma_d(G_1 \oplus G_2)] = 4.9171$

$\text{LE}[G_1 \oplus G_2] = [3.3692, 4.9171]$.

**Dominating Energy in Cartesian Product of an Intuitionistic Fuzzy Graph $G_1 \boxtimes G_2(V,E)$**

**Definitions: Cartesian product**

The Cartesian product of two Intuitionistic fuzzy graphs $G_1=(V_1,E_1)$ and $G_2=(V_2,E_2)$ denoted by $G_1 \boxtimes G_2$ is an intuitionistic fuzzy graph $G=(V,E,\langle \mu_r, v_r \rangle, \langle \mu_n, v_n \rangle)$

Where $V=V_1 \cup V_2$ for all $v_i \in V_1$ and $u_p \in V_2, V_1 \cap V_2 = \emptyset, i=1,2,\ldots,m, p=1,2,\ldots,n.$

1. $E=\langle v_i u_p, v_i u_q \rangle$, such that either one of the following is true:

   - $(u_p, u_q) \in E_2,$ when $i=j$
   - $(v_i, v_j) \in E_1,$ when $p=q$

2. $\langle \mu_r, v_r \rangle$ denote the degrees of membership and non-membership of vertices of $G$, and is given by

   $$\langle \mu_r, v_r \rangle = \langle \min(\mu_r, \mu_p), \max(v_i, v_j) \rangle$$

for all $v_r \in V, r=1,2,3,\ldots,m,n.$
4. \( \langle \mu_n, v_n \rangle \) denote the degrees of membership and non-membership of edges of \( G \), and is given by

\[
\langle \mu_n, v_n \rangle = \begin{cases} 
\langle \min(\mu, \mu_{pq}), \max(v, v_{pq}) \rangle & \text{if } \{j, (u_p, u_q) \in E_2 \\
\langle \min(\mu, \mu_q), \max(v_p, v_q) \rangle & \text{if } \{p, (v, v_j) \in E_1 \\
\langle 0, 0 \rangle & \text{otherwise}
\end{cases}
\]

Now We Find the Dominating Energy of Intuitionistic Fuzzy Graph \( G_1 \Box G_2 \) (V,E)

\[
\mu_i(v_{1i}) = \max[\mu(v_{1i}, v_{1j}), \mu(v_{1j}, v_{1i})] = \max[0.1, 0.3] = 0.3
\]

\[
\mu_i(v_{2i}) = \max[\mu(v_{2i}, v_{2j}), \mu(v_{2j}, v_{2i})] = \max[0.1, 0.1, 0.1] = 0.1
\]

\[
\mu_i(v_{3i}) = \max[\mu(v_{3i}, v_{3j}), \mu(v_{3j}, v_{3i})] = \max[0.3, 0.1] = 0.3
\]

\[
\mu_i(v_{4i}) = \max[\mu(v_{4i}, v_{4j}), \mu(v_{4j}, v_{4i})] = \max[0.3, 0.1] = 0.3
\]

\[
\mu_i(v_{5i}) = \max[\mu(v_{5i}, v_{5j}), \mu(v_{5j}, v_{5i})] = \max[0.3, 0.1] = 0.3
\]

\[
\gamma_i(v_{1i}) = \min[\gamma(v_{1i}, v_{1j}), \gamma(v_{1j}, v_{1i})] = \min[0.5, 0.3] = 0.3
\]

\[
\gamma_i(v_{2i}) = \min[\gamma(v_{2i}, v_{2j}), \gamma(v_{2j}, v_{2i})] = \min[0.6, 0.7, 0.5] = 0.5
\]

\[
\gamma_i(v_{3i}) = \min[\gamma(v_{3i}, v_{3j}), \gamma(v_{3j}, v_{3i})] = \min[0.4, 0.6] = 0.4
\]

\[
\gamma_i(v_{4i}) = \min[\gamma(v_{4i}, v_{4j}), \gamma(v_{4j}, v_{4i})] = \min[0.3, 0.5] = 0.3
\]

\[
\gamma_i(v_{5i}) = \min[\gamma(v_{5i}, v_{5j}), \gamma(v_{5j}, v_{5i})] = \min[0.5, 0.7, 0.6] = 0.5
\]

Here \( v_{1i} \) dominates \( v_{2i} \) because

\[
\mu(v_{1i}, v_{2i}) = 0.1 \leq 0.3 \wedge 0.1 \quad 0.5 \leq 0.3 \wedge 0.5
\]

Here \( v_{1i} \) dominates \( v_{2i} \) because

\[
0.1 \leq 0.3 \wedge 0.1 \quad 0.5 \leq 0.3 \wedge 0.5
\[\mu(v_i u_2, v_i u_3) \leq \mu_i(v_i u_2) \land \mu_i(v_i u_3) \land \gamma(v_i u_2, v_i u_3) \leq \gamma_i(v_i u_2) \land \gamma_i(v_i u_3)\]
\[0.3 \leq 0.3 \land 0.3, 0.4 \leq 0.4 \land 0.4\]

Here \(v_2 u_1\) dominates \(v_1 u_1\) because

\[\mu(v_2 u_1, v_1 u_1) \leq \mu_i(v_2 u_1) \land \mu_i(v_1 u_1) \land \gamma(v_2 u_1, v_1 u_1) \leq \gamma_i(v_2 u_1) \land \gamma_i(v_1 u_1)\]
\[0.3 \leq 0.3 \land 0.3, 0.3 \leq 0.3 \land 0.3\]

Here \(v_2 u_2\) dominates \(v_2 u_1\) because

\[\mu(v_2 u_2, v_2 u_1) \leq \mu_i(v_2 u_2) \land \mu_i(v_2 u_1) \land \gamma(v_2 u_2, v_2 u_1) \leq \gamma_i(v_2 u_2) \land \gamma_i(v_2 u_1)\]
\[0.1 \leq 0.1 \land 0.3, 0.5 \leq 0.5 \land 0.3\]

Here \(V=\{v_1 u_1, v_1 u_3, v_2 u_1, v_2 u_2, v_2 u_3\}\) and \(D=\{v_1 u_1, v_1 u_3, v_2 u_1, v_2 u_2\}\) \(V-D=\{v_2 u_3\}\)

\[|D|=4=\text{Sum of dominating elements}\]

\[D(G_1 \Box G_2) = \begin{bmatrix}
(1,1) & (0.1,0.5) & (0,0) & (0.3,0.3) & (0,0) & (0,0) \\
(0.1,0.5) & (0,0) & (0.1,0.6) & (0,0) & (0.1,0.7) & (0,0) \\
(0,0) & (0.1,0.6) & (1,1) & (0,0) & (0,0) & (0.3,0.4) \\
(0.3,0.3) & (0,0) & (0,0) & (1,1) & (0.1,0.5) & (0,0) \\
(0,0) & (0.1,0.7) & (0,0) & (0.1,0.5) & (1,1) & (0.1,0.6) \\
(0,0) & (0,0) & (0.3,0.4) & (0,0) & (0.1,0.6) & (0,0)
\end{bmatrix}\]

\[\mu_D(G_1 \Box G_2) = \begin{bmatrix}
1 & 0.1 & 0 & 0.3 & 0 & 0 \\
0.1 & 0 & 0.1 & 0 & 0.1 & 0 \\
0 & 0.1 & 1 & 0 & 0.3 & 0 \\
0.3 & 0 & 0 & 1 & 0.1 & 0 \\
0 & 0.1 & 0 & 0.1 & 1 & 0.1 \\
0 & 0 & 0.3 & 0 & 0.1 & 0
\end{bmatrix}\]

\[\gamma_D(G_1 \Box G_2) = \begin{bmatrix}
1 & 0.5 & 0 & 0.3 & 0 & 0 \\
0.5 & 0 & 0.6 & 0 & 0.7 & 0 \\
0 & 0.6 & 1 & 0 & 0 & 0.4 \\
0.3 & 0 & 0 & 1 & 0.5 & 0 \\
0 & 0.7 & 0 & 0.5 & 1 & 0.6 \\
0 & 0 & 0.4 & 0 & 0.6 & 0
\end{bmatrix}\]

Eigen values of \(\mu_D(G_1 \Box G_2)=[-0.1072,-0.0128,0.6945,1.0008,1.1013,1.3235]\)

\[\text{LE}[\mu_D(G_1 \Box G_2)]=4.2401\]

Eigen values of \(\gamma_D(G_1 \Box G_2)=[-0.8740,-0.0827,0.6174,1.0781,1.2512,2.0100]\)

\[\text{LE}[\gamma_D(G_1 \Box G_2)]=5.9134\]

\[\text{LE}[G_1 \Box G_2]= [4.2401, 5.9134]\]

**Dominating Energy in Lexicographic Product of an Intuitionistic fuzzy graph**

**Definitions: Lexicographic Product**

The Lexicographic product of two Intuitionistic fuzzy graphs \(G_1=(V_1,E_1)\) and \(G_2=(V_2,E_2)\) denoted by \(G_1 \circ G_2\) is an intuitionistic fuzzy graph \(G=(V,E,\langle \mu_r, v_r \rangle, \langle \mu_r, v_r \rangle)\)

Where

\[1.V=v_i u_p \text{ for all } v_i \in V_1 \text{ and } u_p \in V_2, V_1 \cap V_2 = \phi, i=1,2, \ldots, m, p=1,2, \ldots, n.\]
2. \( E = \{ v \mu_p, v \mu_q \} \), such that either one of the following is true:

- \((v_i, v_j) \in E_1\), when \(i \neq j\)
- \((u_p, u_q) \in E_2\), when \(i=j\)

3. \( \langle \mu, v \rangle \) denote the degrees of membership and non-membership of vertices of G, and is given by

\[
\langle \mu, v \rangle = \left\{ \min(\mu, \mu_p), \max(v, v_p) \right\}
\]

for all \(v_i \in V, r =1,2,3,\ldots, m,n\).

4. \( \langle \mu_r, v \rangle \) denote the degrees of membership and non-membership of edges of G, and is given by

\[
\langle \mu_r, v \rangle = \begin{cases} 
\left\{ \min(\mu, \mu_p), \max(v, v_p) \right\} & \text{if } i = j, (u_p, u_q) \in E_2 \\
\left\{ \min(\mu, \mu_q), \max(v, v_q) \right\} & \text{if } p = q, (v_i, v_j) \in E_1 \\
\left\{ \min(\mu, \mu_q, \mu_q), \max(v, v_q, v_q) \right\} & \text{if } i \neq j, p \neq q, (v_i, v_j) \in E_1 \\
\langle 0,0 \rangle & \text{otherwise}
\end{cases}
\]

**Figure 4.** \( G_1 \circ G_2 \)

Now We Find the Dominating Energy \( \text{ in Lexicographic Product of Intuitionistic Fuzzy Graph } G_1 \circ G_2 (V,E) \)

\[
\mu_l(v_1 u_1) = \max[\mu(v_1 u_1, v_1 u_2), \mu(v_1 u_1, v_2 u_1), \mu(v_1 u_1, v_2 u_2), \mu(v_1 u_1, v_2 u_3)] = \max[0.1,0.3,0.1,0.3] = 0.3
\]

\[
\mu_l(v_2 u_1) = \max[\mu(v_2 u_1, v_1 u_2), \mu(v_2 u_1, v_2 u_2), \mu(v_2 u_1, v_2 u_3), \mu(v_2 u_1, v_2 u_3)] = \max[0.3,0.1,0.3,0.1] = 0.3
\]

\[
\gamma_l(v_1 u_1) = \min[\gamma(v_1 u_1, v_1 u_2), \gamma(v_1 u_1, v_2 u_1), \gamma(v_1 u_1, v_2 u_2), \gamma(v_1 u_1, v_2 u_3)] = \min[0.5,0.4,0.7,0.3] = 0.3
\]
\[ \gamma_1(v_1 u_2) = \min[\gamma(v_1 u_2, v_1 u_3), \gamma(v_1 u_2, v_2 u_3), \gamma(v_1 u_2, v_3 u_2), \gamma(v_1 u_2, v_1 u_4), \gamma(v_1 u_2, v_2 u_4), \gamma(v_1 u_2, v_3 u_4)] = \min[0.6, 0.7, 0.7, 0.7, 0.5] = 0.5 \]

\[ \gamma_1(v_1 u_3) = \min[\gamma(v_1 u_3, v_3 u_2), \gamma(v_1 u_3, v_2 u_3), \gamma(v_1 u_3, v_3 u_3), \gamma(v_1 u_3, v_2 u_4), \gamma(v_1 u_3, v_3 u_4)] = \min[0.4, 0.7, 0.4, 0.6] = 0.4 \]

\[ \gamma_1(v_2 u_2) = \min[\gamma(v_2 u_2, v_1 u_2), \gamma(v_2 u_2, v_2 u_3), \gamma(v_2 u_2, v_2 u_3), \gamma(v_2 u_2, v_2 u_4), \gamma(v_2 u_2, v_3 u_2), \gamma(v_2 u_2, v_3 u_3)] = \min[0.3, 0.7, 0.4, 0.5] = 0.3 \]

Here \( v_1 u_1 \) is dominates \( v_2 u_3 \) because
\[ \mu_1(v_1 u_1, v_3 u_3) \leq \mu_1(v_1 u_1) \land \mu_1(v_2 u_3) \land \gamma_1(v_1 u_1, v_2 u_3) \leq \gamma_1(v_1 u_1) \land \gamma_1(v_2 u_3) \]
\[ 0.3 \leq 0.3 \land 0.3 \quad 0.4 \leq 0.3 \land 0.4 \]

Here \( v_2 u_2 \) is dominates \( v_1 u_1 \) because
\[ \mu_1(v_2 u_2, v_1 u_4) \leq \mu_1(v_2 u_2) \land \mu_1(v_1 u_4) \land \gamma(v_2 u_2, v_2 u_4) \leq \gamma_1(v_2 u_2) \land \gamma_1(v_1 u_4) \]
\[ 0.1 \leq 0.1 \land 0.3 \quad 0.5 \leq 0.5 \land 0.3 \]

Here \( v_1 u_3 \) is dominates \( v_2 u_1 \) because
\[ \mu_1(v_1 u_3, v_1 u_1) \leq \mu_1(v_1 u_3) \land \mu_1(v_2 u_1) \land \gamma(v_1 u_3, v_2 u_1) \leq \gamma_1(v_1 u_3) \land \gamma_1(v_2 u_1) \]
\[ 0.3 \leq 0.3 \land 0.3 \quad 0.4 \leq 0.4 \land 0.3 \]

Here \( v_2 u_1 \) is dominates \( v_1 u_1 \) because
\[ \mu_1(v_2 u_1, v_1 u_1) \leq \mu_1(v_2 u_1) \land \mu_1(v_1 u_1) \land \gamma(v_2 u_1, v_2 u_4) \leq \gamma_1(v_2 u_1) \land \gamma_1(v_1 u_1) \]
\[ 0.3 \leq 0.3 \land 0.3 \quad 0.3 \leq 0.3 \land 0.3 \]

Here \( v_2 u_1 \) is dominates \( v_1 u_1 \) because
\[ \mu_1(v_2 u_1, v_3 u_4) \leq \mu_1(v_2 u_1) \land \mu_1(v_1 u_4) \land \gamma(v_2 u_1, v_3 u_4) \leq \gamma_1(v_2 u_1) \land \gamma_1(v_1 u_4) \]
\[ 0.1 \leq 0.1 \land 0.3 \quad 0.5 \leq 0.5 \land 0.3 \]

Here \( v_2 u_3 \) is dominates \( v_1 u_3 \) because
\[ \mu_1(v_2 u_3, v_2 u_1) \leq \mu_1(v_2 u_3) \land \mu_1(v_2 u_1) \land \gamma(v_2 u_3, v_3 u_4) \leq \gamma_1(v_2 u_3) \land \gamma_1(v_2 u_1) \]
\[ 0.3 \leq 0.3 \land 0.3 \quad 0.4 \leq 0.4 \land 0.4 \]

Here \( V=\{v_1 u_1, v_1 u_3, v_2 u_2, v_2 u_4\} \) and \( D=\{v_1 u_1, v_1 u_3, v_2 u_2, v_2 u_4\} \quad V \cap D=\{0\} \]

\[ |D|=6=\text{Sum of dominating elements} \]

<table>
<thead>
<tr>
<th>( D(G_1 \circ G_2) ) =</th>
<th>( \mu_D(G_1 \circ G_2) = )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.1)</td>
<td>(0.1, 0.5)</td>
</tr>
<tr>
<td>(0.1, 0.5)</td>
<td>(1.1)</td>
</tr>
<tr>
<td>(0.0)</td>
<td>(0.1, 0.6)</td>
</tr>
<tr>
<td>(0.3, 0.3)</td>
<td>(0.1, 0.7)</td>
</tr>
<tr>
<td>(0.1, 0.7)</td>
<td>(0.1, 0.7)</td>
</tr>
<tr>
<td>(0.3, 0.4)</td>
<td>(0.1, 0.7)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \gamma_D(G_1 \circ G_2) = )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 0.5 0 0.3 0.7 0.4</td>
</tr>
<tr>
<td>0.5 1 0.6 0.7 0.7 0.7</td>
</tr>
<tr>
<td>0 0.6 1 0.4 0.7 0.4</td>
</tr>
<tr>
<td>0.3 0.7 0.4 1 0.5 0</td>
</tr>
<tr>
<td>0.7 0.7 0.5 1 0.6 0.6</td>
</tr>
<tr>
<td>0.4 0.7 0.4 0 0.6 1</td>
</tr>
</tbody>
</table>
Eigen values of $\mu_d(G_1 \circ G_2) = [0.4000, 0.9000, 0.9725, 1.0000, 1.0000, 1.7275] = 6$

Eigen values of $\gamma_d(G_1 \circ G_2) = [-0.0432, 0.0613, 0.4757, 0.9474, 1.0630, 3.4958] = 6.0864$.

**Dominating Energy in Tensor Product of an Intuitionistic Fuzzy Graph $G_1 \boxtimes G_2 (V,E)$

**Definitions: Tensor Product**

The tensor product of two Intuitionistic fuzzy graphs $G_1=(V_1,E_1)$ and $G_2=(V_2,E_2)$ denoted by $G_1 \boxtimes G_2$ is an intuitionistic fuzzy graph $G=(V,E, (\mu_{v}, \mu_{v}), (\mu_{r}, \mu_{r}))$

Where

1. $V=v_{i} \mu_{p}$ for all $v_{i} \in V_{1}$ and $u_{p} \in V_{2}$, $V_{1} \cap V_{2}=\phi, i=1,2,\ldots,m, p=1,2,\ldots,n$.

2. $E=\langle v_{i} \mu_{p}, v_{j} \mu_{q} \rangle$, if $i \neq j, p \neq q, (v_{i}, v_{j}) \in E_{1}$ and $(u_{p}, u_{q}) \in E_{2}$

3. $\langle \mu_{v}, \nu_{r} \rangle$ denote the degrees of membership and non-membership of vertices of $G$, and is given by

$$\langle \mu_{v}, \nu_{r} \rangle = \langle \min(\mu_{v}, \mu_{r}), \max(v_{i}, v_{j}) \rangle$$ for all $v_{i} \in V$, $r =1,2,3,\ldots,m,n$.

4. $\langle \mu_{r}, \nu_{r} \rangle$ denote the degrees of membership and non-membership of edges of $G$, and is given by

$$\langle \mu_{r}, \nu_{r} \rangle = \begin{cases} \langle \min(\mu_{v}, \mu_{r}), \max(v_{i}, v_{j}) \rangle & \text{if } i \neq j, p \neq q, (v_{i}, v_{j}) \in E_{1} \text{ and } (u_{p}, u_{q}) \in E_{2} \\ (0,0) & \text{otherwise} \end{cases}$$

*Figure 5. $G_1 \boxtimes G_2$*

Now We Find the Dominating Energy in Tensor Product of Intuitionistic Fuzzy Graph $G_1 \circ G_2 (V,E)$

$\mu_{l}(v_{1}u_{1}) = \max[\mu(v_{1}u_{1}, v_{2}u_{2})] = \max[0.1] = 0.1$

$\mu_{l}(v_{1}u_{2}) = \max[\mu(v_{1}u_{2}, v_{3}u_{1}), \mu(v_{1}u_{2}, v_{2}u_{3})] = \max[0.1,0.1] = 0.1$

$\mu_{l}(v_{1}u_{3}) = \max[\mu(v_{1}u_{3}, v_{2}u_{1})] = \max[0.1] = 0.1$

$\mu_{l}(v_{2}u_{1}) = \max[\mu(v_{2}u_{1}, v_{2}u_{2})] = \max[0.1] = 0.1$

$\mu_{l}(v_{2}u_{2}) = \max[\mu(v_{2}u_{2}, v_{3}u_{1}), \mu(v_{2}u_{2}, v_{1}u_{3})] = \max[0.1,0.1] = 0.1$

$\mu_{l}(v_{2}u_{3}) = \max[\mu(v_{2}u_{3}, v_{3}u_{1}), \mu(v_{2}u_{2}, v_{1}u_{3})] = \max[0.1,0.1] = 0.1$
\[
\mu_t(v_{2u_3}) = \max[\mu_t(v_{2u_1}, v_{2u_2})] = \max[0.1] = 0.1
\]
\[
\gamma_t(v_{2u_1}) = \min[\gamma_t(v_{2u_1}, v_{2u_2})] = \min[0.5] = 0.5
\]
\[
\gamma_t(v_{2u_2}) = \min[\gamma_t(v_{2u_2}), \gamma_t(v_{2u_1}, v_{2u_2})] = \min[0.5, 0.6] = 0.5
\]
\[
\gamma_t(v_{2u_1}) = \min[\gamma_t(v_{2u_1}, v_{2u_2})] = \min[0.6] = 0.6
\]
\[
\gamma_t(v_{2u_2}) = \min[\gamma_t(v_{2u_2}, v_{2u_1})] = \min[0.5, 0.6] = 0.5
\]
\[
\gamma_t(v_{2u_1}) = \min[\gamma_t(v_{2u_1}, v_{2u_2})] = \min[0.6] = 0.6
\]

Here \(v_{2u_1}\) dominates \(v_{2u_2}\) because
\[
\mu_t(v_{2u_1}, v_{2u_2}) \leq \mu_t(v_{2u_1}) \land \mu_t(v_{2u_2}) \land \gamma_t(v_{2u_1}, v_{2u_2}) \leq \gamma_t(v_{2u_1}) \land \gamma_t(v_{2u_2})
\]
\[
0.1 \leq 0.1 \land 0.1 \quad 0.5 \leq 0.5 \land 0.5
\]

Here \(v_{2u_2}\) dominates \(v_{2u_1}\) because
\[
\mu_t(v_{2u_2}, v_{2u_1}) \leq \mu_t(v_{2u_2}) \land \mu_t(v_{2u_1}) \land \gamma_t(v_{2u_2}, v_{2u_1}) \leq \gamma_t(v_{2u_2}) \land \gamma_t(v_{2u_1})
\]
\[
0.1 \leq 0.1 \land 0.1 \quad 0.5 \leq 0.5 \land 0.5
\]

Here \(v_{2u_3}\) dominates \(v_{2u_2}\) because
\[
\mu_t(v_{2u_3}, v_{2u_2}) \leq \mu_t(v_{2u_3}) \land \mu_t(v_{2u_2}) \land \gamma_t(v_{2u_3}, v_{2u_2}) \leq \gamma_t(v_{2u_3}) \land \gamma_t(v_{2u_2})
\]
\[
0.1 \leq 0.1 \land 0.1 \quad 0.6 \leq 0.6 \land 0.5
\]

Here \(v_{2u_2}\) dominates \(v_{2u_3}\) because
\[
\mu_t(v_{2u_2}, v_{2u_3}) \leq \mu_t(v_{2u_2}) \land \mu_t(v_{2u_3}) \land \gamma_t(v_{2u_2}, v_{2u_3}) \leq \gamma_t(v_{2u_2}) \land \gamma_t(v_{2u_3})
\]
\[
0.1 \leq 0.1 \land 0.1 \quad 0.6 \leq 0.6 \land 0.5
\]

Here \(V=\{v_{1u_1}, v_{1u_2}, v_{1u_3}, v_{2u_1}, v_{2u_2}, v_{2u_3}\}\) and \(D=\{v_{1u_1}, v_{1u_2}, v_{1u_3}, v_{2u_2}\}\) \(|D|=4\) = Sum of dominating elements

\[
D(G_1 \otimes G_2) =
\begin{bmatrix}
(1,1) & (0,0) & (0,0) & (0,0) & (0,1,0.5) & (0,0) \\
(0,0) & (1,1) & (0,0) & (0,1,0.5) & (0,0) & (0,1,0.6) \\
(0,0) & (0,0) & (1,1) & (0,0) & (0,1,0.6) & (0,0) \\
(0,0) & (0,1,0.5) & (0,0) & (0,0) & (0,0) & (0,0) \\
(0,1,0.5) & (0,0) & (0,1,0.6) & (0,0) & (0,0) & (0,0) \\
(0,0) & (0,1,0.6) & (0,0) & (0,0) & (0,0) & (1,1) \\
\end{bmatrix}
\]

\[
\mu_d(G_1 \otimes G_2) =
\begin{bmatrix}
1 & 0 & 0 & 0 & 0.1 & 0 \\
0 & 1 & 0 & 0.1 & 0 & 0.1 \\
0 & 0 & 1 & 0 & 0.1 & 0 \\
0 & 0.1 & 0 & 0 & 0 & 0 \\
0.1 & 0.1 & 0 & 0 & 0 & 0 \\
0 & 0.1 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

\[
\gamma_d(G_1 \otimes G_2) =
\begin{bmatrix}
1 & 0 & 0 & 0.5 & 0 & 0 \\
0 & 1 & 0.5 & 0 & 0.6 & 0 \\
0 & 0 & 0.6 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
0.5 & 0 & 0.6 & 0 & 0 & 0 \\
0 & 0.6 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\]
Eigen values of $\mu_G(G_1 \otimes G_2) = [-0.0196, -0.0100, 0.9054, 1.0000, 1.0196, 1.1046] = 4.0592$

Eigen values of $\gamma_G(G_1 \otimes G_2) = [-0.4274, -0.2574, 0.5784, 1.0000, 1.4274, 1.6790] = 5.3696$

**Dominating Energy in Strong Product of an Intuitionistic Fuzzy Graph $G_1 \boxtimes G_2 (V,E)$**

**Definitions: Strong Product**

The strong product of two Intuitionistic fuzzy graphs $G_1=(V_1,E_1)$ and $G_2=(V_2,E_2)$ denoted by $G_1 \boxtimes G_2$ is an intuitionistic fuzzy graph $G=(V,E,\{\mu_r, v_r\}, \{\mu_s, v_s\})$.

Where

1. $V = \bigcup \{V_1, V_2\}$ for all $v_i \in V_1$ and $u_p \in V_2, V_1 \cap V_2 = \emptyset, i=1,2,...,m, p=1,2,...,n$.

2. $E= \{v_i u_p, v_j u_q\}$, such that either one of the following is true:
   - $(u_p, u_q) \in E_2$, when $i=j, p \neq q$
   - $(v_i, v_j) \in E_1$, when $p=q, i \neq j$
   - $(v_i, v_j) \in E_1$ and $(u_p, u_q) \in E_2$, when $i \neq j, p \neq q$

3. $\{\mu_r, v_r\}$ denote the degrees of membership and non-membership of vertices of $G$, and is given by $\{\mu_r, v_r\} = \{\min(\mu_i, \mu_p), \max(v_i, v_p)\}$ for all $v_i \in V, r=1,2,3,...,m,n$.

4. $\{\mu_s, v_s\}$ denote the degrees of membership and non-membership of edges of $G$, and is given by

$$\{\mu_s, v_s\} = \begin{cases} 
\{\min(\mu_i, \mu_p), \max(v_i, v_p)\} & \text{if } i=j, (u_p, u_q) \in E_2 \\
\{\min(\mu_p, v_q), \max(v_p, v_q)\} & \text{if } p=q, (v_i, v_j) \in E_1 \\
\{\min(\mu_i, v_q), \max(v_i, v_q)\} & \text{if } i \neq j, p \neq q, (v_i, v_j) \in E_1, (u_p, u_q) \in E_2 
\end{cases}$$

Now We Find the Dominating Energy in Tensor Product of Intuitionistic Fuzzy Graph $G_1 \boxtimes G_2 (V,E)$

$\mu_i(v_i u_i) = \max[\mu_i(v_1 u_1, v_1 u_2), \mu_i(v_1 u_1, v_2 u_2), \mu_i(v_1 u_1, v_2 u_3)] = \max[0.1, 0.1, 0.3] = 0.3$
\[ \mu_i(v_1 u_2) = \max[\mu(v_1 u_2, v_1 u_3), \mu(v_1 u_2, v_2 u_2), \mu(v_1 u_2, v_3 u_1), \mu(v_1 u_2, v_1 u_1)] \\
= \max[0.1, 0.1, 0.1, 0.1, 0.1] = 0.1 \]

\[ \mu_i(v_1 u_3) = \max[\mu(v_1 u_3, v_1 u_3), \mu(v_1 u_3, v_2 u_2), \mu(v_1 u_3, v_3 u_1), \mu(v_1 u_3, v_1 u_1)] = \max[0.3, 0.1, 0.1] = 0.3 \]

\[ \mu_i(v_2 u_1) = \max[\mu(v_2 u_1, v_1 u_1), \mu(v_2 u_1, v_2 u_2), \mu(v_2 u_1, v_3 u_1), \mu(v_2 u_1, v_2 u_3)] = \max[0.3, 0.1, 0.1] = 0.3 \]

\[ \mu_i(v_2 u_2) = \max[\mu(v_2 u_2, v_1 u_1), \mu(v_2 u_2, v_2 u_2), \mu(v_2 u_2, v_3 u_1), \mu(v_2 u_2, v_2 u_3)] = \max[0.1, 0.1, 0.1, 0.1, 0.1] = 0.1 \]

\[ \gamma_i(v_1 u_1) = \min[\gamma(v_1 u_1, v_1 u_1), \gamma(v_1 u_1, v_2 u_2), \gamma(v_1 u_1, v_3 u_1), \gamma(v_1 u_1, v_1 u_1)] = \min[0.5, 0.5, 0.3] = 0.3 \]

\[ \gamma_i(v_1 u_2) = \min[\gamma(v_1 u_2, v_1 u_1), \gamma(v_1 u_2, v_2 u_2), \gamma(v_1 u_2, v_3 u_1), \gamma(v_1 u_2, v_2 u_2), \gamma(v_1 u_2, v_3 u_1), \gamma(v_1 u_2, v_3 u_1)] = \min[0.6, 0.6, 0.7, 0.5, 0.5] = 0.5 \]

\[ \gamma_i(v_1 u_3) = \min[\gamma(v_1 u_3, v_1 u_1), \gamma(v_1 u_3, v_2 u_2), \gamma(v_1 u_3, v_3 u_1), \gamma(v_1 u_3, v_2 u_2), \gamma(v_1 u_3, v_3 u_1), \gamma(v_1 u_3, v_3 u_1)] = \min[0.4, 0.6, 0.6] = 0.4 \]

Here \( v_1 u_1 \) is dominates \( v_1 u_2 \) because

\[ \mu(v_1 u_1, v_1 u_2) \leq \mu_i(v_1 u_1) \land \mu_i(v_2 u_2) \land \gamma(v_1 u_1, v_1 u_2) \leq \gamma_i(v_1 u_1) \land \gamma_1(v_1 u_2) \]

\[ 0.1 \leq 0.3 \land 0.1 \leq 0.3 \land 0.5 \leq 0.3 \land 0.5 \]

Here \( v_1 u_2 \) is dominates \( v_2 u_1 \) because

\[ \mu(v_2 u_1, v_1 u_2) \leq \mu_i(v_2 u_1) \land \mu_i(v_1 u_2) \land \gamma(v_2 u_1, v_2 u_2) \leq \gamma_i(v_2 u_1) \land \gamma_1(v_2 u_2) \]

\[ 0.1 \leq 0.1 \land 0.1 \leq 0.5 \land 0.5 \leq 0.3 \land 0.5 \]

Here \( v_1 u_3 \) is dominates \( v_2 u_3 \) because

\[ \mu(v_1 u_3, v_2 u_3) \leq \mu_i(v_1 u_3) \land \mu_i(v_2 u_3) \land \gamma(v_1 u_3, v_2 u_3) \leq \gamma_i(v_1 u_3) \land \gamma_i(v_2 u_3) \]

\[ 0.3 \leq 0.3 \land 0.3 \leq 0.4 \land 0.4 \leq 0.4 \land 0.4 \]

Here \( v_2 u_1 \) is dominates \( v_1 u_1 \) because

\[ \mu(v_2 u_1, v_1 u_1) \leq \mu_i(v_2 u_1) \land \mu_i(v_1 u_1) \land \gamma(v_2 u_1, v_1 u_1) \leq \gamma_i(v_2 u_1) \land \gamma_1(v_1 u_1) \]

\[ 0.3 \leq 0.3 \land 0.3 \leq 0.3 \land 0.3 \leq 0.3 \land 0.3 \]

Here \( v_2 u_2 \) is dominates \( v_1 u_1 \) because

\[ \mu(v_2 u_2, v_1 u_1) \leq \mu_i(v_2 u_2) \land \mu_i(v_1 u_1) \land \gamma(v_2 u_2, v_1 u_1) \leq \gamma_i(v_2 u_2) \land \gamma_1(v_1 u_1) \]

\[ 0.1 \leq 0.1 \land 0.1 \leq 0.3 \land 0.5 \leq 0.3 \land 0.5 \]

Here \( v=v_1 u_1, v_1 u_2, v_1 u_3, v_2 u_1, v_2 u_2, v_2 u_3 \) and \( D=\{ v_1 u_1, v_1 u_2, v_1 u_3, v_2 u_1, v_2 u_2, v_2 u_3 \} \)

\[ |D|=5=\text{Sum of dominating elements} \]
\[ D(G_1 \boxtimes G_2) = \begin{bmatrix} (1,1) & (0.1,0.5) & (0.3,0.3) & (0.1,0.5) & (0.0) \\ (0.1,0.5) & (1,1) & (0.1,0.6) & (0.1,0.5) & (0.1,0.7) \\ (0.0) & (0.1,0.6) & (1,1) & (0.0) & (0.1,0.6) \\ (0.3,0.3) & (0.1,0.5) & (0.0) & (1,1) & (0.1,0.5) \\ (0.1,0.5) & (0.1,0.7) & (0.1,0.6) & (0.1,0.5) & (1,1) \\ (0.0) & (0.1,0.6) & (0.3,0.4) & (0.0) & (0.1,0.6) \end{bmatrix} \]

\[ \mu D(G_1 \boxtimes G_2) = \begin{bmatrix} 1 & 0.1 & 0 & 0.3 & 0.1 & 0 \\ 0.1 & 1 & 0.1 & 0.1 & 0.1 \\ 0 & 0.1 & 1 & 0 & 0.1 & 0.3 \\ 0.3 & 0.1 & 0 & 1 & 0.1 \\ 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 \\ 0 & 0.1 & 0.3 & 0 & 0.1 & 0 \end{bmatrix} \]

\[ \gamma D(G_1 \boxtimes G_2) = \begin{bmatrix} 1 & 0.5 & 0 & 0.3 & 0.5 & 0 \\ 0.5 & 1 & 0.6 & 0.5 & 0.7 & 0.6 \\ 0 & 0.6 & 1 & 0 & 0.6 & 0.4 \\ 0.3 & 0.5 & 0 & 1 & 0.5 & 0 \\ 0.5 & 0.7 & 0.6 & 0.5 & 1 & 0.6 \\ 0 & 0.6 & 0.4 & 0 & 0.6 & 0 \end{bmatrix} \]

Eigen values of \( \mu D(G_1 \boxtimes G_2) \) = \([-0.0916, 0.7000, 0.8726, 0.9000, 1.1671, 1.4519]\) = 5.1832

Eigen values of \( \gamma D(G_1 \boxtimes G_2) \) = \([-0.4565, 0.2262, 0.3000, 0.7000, 1.2283, 3.0019]\) = 5.9129

Conclusion

In this paper we have defined the dominating intuitionist fuzzy graph \( G = (V, E, \mu, \gamma, \mu_1, \gamma_1) \). The Dominating energy in the various products of Intuitionist fuzzy graph is defined and the results with suitable examples are examined in detail.

References