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Total Degree of a Vertex in Cartesian Product and Composition of Some Intuitionistic Fuzzy Graphs

***A.Nagoor Gani*[1] and *H.Sheik Mujibur Rahman*[2]**

[1]PG & Research Department of Mathematics, Jamal Mohamed College (Autonomous)
Tiruchirappalli-620020, India. e-mail: ganijmc@yahoo.co.in
[1]Corresponding Author
[2]PG & Research Department of Mathematics, Jamal Mohamed College (Autonomous)
Tiruchirappalli-620020, India. e-mail: mujeebmaths@gmail.com

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Abstract. An intuitionistic fuzzy graph can be obtained from two given intuitionistic fuzzy graphs using Cartesian product and composition. In this paper, we discuss the total degree of a vertex in intuitionistic fuzzy graphs formed by these operations in terms of the degree of vertices in the given intuitionistic fuzzy graphs in some particular cases.

Keywords: Totaldegree of a vertex, Cartesian product and composition of two IFGs

AMS Mathematics Subject Classification (2010): 03E72, 03F55

1. Introduction

Intuitionistic Fuzzy Graph theory was introduced by Atanassov in [1]. In [5], Karunambigai and Parvathi introduced intuitionistic fuzzy graph as a special case of Atanassov's IFG. In [2], NagoorGani and Begum introduced degree, order and size in intuitionistic fuzzy graph. In [6] Radha and Vijaya introduced the total degree of a vertex in some fuzzy graphs. In[3] NagoorGani and Rahman introduced the total and middle intuitionistic fuzzy graph and they also introduced Total degree of a vertex in union and join of some intuitionistic fuzzy graphs in [4]. In this paper we discuss about Cartesian product and Composition operations of intuitionistic fuzzy graph and some properties of intuitionistic fuzzy graph are introduced.

2. Preliminaries

Definition 2.1. An intuitionistic fuzzy graph (IFG) is of the form $G = \langle V, E \rangle$ where
(i) $V = \{v_1, v_2, \ldots, v_n\}$ such that $\mu_1 : V \to [0,1]$ and $\nu_1 : V \to [0,1]$ denotes the degree of membership and non-membership of the element $v_i \in V$ respectively and $0 \le \mu_1(v_i) + \nu_1(v_i) \le 1$, for every $v_i \in V$.
(ii)$E \subseteq V \times V$ where $\mu_2 : V \times V \to [0,1]$ and $\nu_2 : V \times V \to [0,1]$ such that

$$\mu_2(v_i, v_j) \le \min\left(\mu_1(v_i), \mu_1(v_j)\right)$$

$$\nu_2(v_i, v_j) \le \max\left(\nu_1(v_i), \nu_1(v_j)\right)$$

and $0 \le \mu_2(v_i, v_j) + \nu_2(v_i, v_j) \le 1$, for every$(v_i, v_j) \in E$.

Here the triple $(v_i, \mu_{1i}, \nu_{1i})$ denotes the degree of membership and non-membership of the vertex v_i. The triple $(e_{ij}, \mu_{2ij}, \nu_{2ij})$ denotes the degree of membership and non-membership of the edge relation $e_{ij} = (v_i, v_j)$ on $V \times V$.

Definition 2.2. Let $G = \langle V, E \rangle$ be an IFG .Then the degree of a vertex v is defined by d(v)=(d_μ(v), d_ν(v)) where d_μ(v)=$\sum_{u\neq v} \mu_2$(v,u) and d_ν(v)=$\sum_{u\neq v} \nu_2$(v,u).

Definition 2.3. Let $G = \langle V, E \rangle$ be an IFG. If (d_μ(v), d_ν(v)) = (k_1, k_2) for all v∈ V that is if each vertex has same membership degree k_1 and same nonmembership degree k_2 then G is said to be a regular intuitionistic fuzzy graph.

Definition 2.4. Let $G = \langle V, E \rangle$ be an IFG. Then the total degree of a vertex u∈ v is defined by

$$td(u) = (td_\mu(u), td_\nu(u)) = \left(\sum_{u\neq v} \mu_2(u,v) + \mu_1(u), \sum_{u\neq v} \nu_2(u,v) + \nu_1(u) \right)$$
$$= \left(d_\mu(u) + \mu_1(u), d_\nu(u) + \nu_1(u) \right)$$

If each vertex of G has same membership total degree k_1 and same nonmembership total degree k_2 , then said to be a total regular IFG.

3. Total degree of a vertex in Cartesian product

Definition 3.1. The Cartesian product of two intuitionistic fuzzy graphs G_1 and G_2 is defined as an intuitionistic fuzzy graph $G = G_1 \times G_2 : (\mu \times \mu', \nu \times \nu')$ on $G^* = (V, E)$ where $V = V_1 \times V_2$ and

$$E = \{ ((u_1, u_2)(v_1, v_2)) \ / u_1 = v_1, u_2v_2 \in E_2 \ or \ u_2 = v_2, u_1v_1 \in E_1 \}$$

$$(\mu_1 \times \mu_1')(u_1, u_2) = \mu_1(u_1) \wedge \mu_1'(u_2), for\ all\ (u_1, u_2) \in V_1 \times V_2 \text{ and}$$

$$(\nu_1 \times \nu_1')(u_1, u_2) = \nu_1(u_1) \vee \nu_1'(u_2), for\ all\ (u_1, u_2) \in V_1 \times V_2$$

$$(\mu_2 \times \mu_2')((u_1, u_2)(v_1, v_2)) = \begin{cases} \mu_1(u_1) \wedge \mu_2'(u_2v_2), & if\ u_1 = v_1, u_2v_2 \in E_2 \\ \mu_1'(u_2) \wedge \mu_2(u_1v_1), & if\ u_2 = v_2, u_1v_1 \in E_1 \end{cases}$$

$$(\nu_2 \times \nu_2')((u_1, u_2)(v_1, v_2)) = \begin{cases} \nu_1(u_1) \vee \nu_2'(u_2v_2), & if\ u_1 = v_1, u_2v_2 \in E_2 \\ \nu_1'(u_2) \vee \nu_2(u_1v_1), & if\ u_2 = v_2, u_1v_1 \in E_1 \end{cases}$$

Definition 3.2. By definition $For\ any\ (u_1, u_2) \in V_1 \times V_2$

$$td_{\mu(G_1 \times G_2)}(u_1, u_2) = \sum_{(u_1,u_2)(v_1,v_2) \in E} \left((\mu_2 \times \mu_2')(u_1, u_2)(v_1, v_2) \right) + (\mu_1 \times \mu_1')(u_1, u_2)$$
$$= \sum_{u_1 = v_1, u_2v_2 \in E_2} \mu_1(u_1) \wedge \mu_2'(u_2v_2) + \sum_{u_2 = v_2,\ u_1v_1 \in E_1} \mu_1'(u_2) \wedge \mu_2(u_1v_1) + (\mu_1 \times \mu_1')(u_1, u_2) \quad ---(3.2.1)$$

$td_{\nu(G_1 \times G_2)}(u_1, u_2)$
$$= \sum_{(u_1,u_2)(v_1,v_2)\in E} \big((\nu_2 \times \nu_2')(u_1, u_2)(v_1, v_2)\big)$$
$$+ (\nu_1 \times \nu_1')(u_1, u_2)$$
$$= \sum_{u_1 = v_1, u_2v_2 \in E_2} \nu_1(u_1) \vee \nu_2'(u_2v_2)$$
$$+ \sum_{u_2 = v_2,\ u_1v_1 \in E_1} \nu_1'(u_2) \vee \nu_2(u_1v_1) + (\nu_1 \times \nu_1')(u_1, u_2) - -$$
$$- -(3.2.2)$$

Hence, the Total degree of a vertex in $G_1 \times G_2$ is defined as
$$td_{(G_1 \times G_2)}(u_1, u_2) = (\, td_{\mu(G_1 \times G_2)}(u_1, u_2), td_{\nu(G_1 \times G_2)}(u_1, u_2))$$

Theorem 3.3. Let $G_1 : (\mu, \nu)$ $and G_2 : (\mu', \nu')$ be two intuitionistic fuzzy graphs.
(i) If $\mu_1 \geq \mu_2'$ and $\mu_1' \geq \mu_2$ then $td_{\mu G_1 \times G_2}(u_1, u_2) = td_{\mu G_1}(u_1) + td_{\mu G_2}(u_2) - \mu_1(u_1) \vee \mu_1'(u_2)$
(ii) If $\nu_1 \leq \nu_2'$ and $\nu_1' \leq \nu_2$ then $td_{\nu G_1 \times G_2}(u_1, u_2) = td_{\nu G_1}(u_1) + td_{\nu G_2}(u_2) - \nu_1(u_1) \wedge \nu_1'(u_2)$

Proof:
(i) $From (3.2.1)$,
$$td_{\mu(G_1 \times G_2)}(u_1, u_2) = \sum_{u_1 = v_1, u_2v_2 \in E_2} \mu_1(u_1) \wedge \mu_2'(u_2v_2)$$
$$+ \sum_{u_2 = v_2, u_1v_1 \in E_1} \mu_1'(u_2) \wedge \mu_2(u_1v_1) + \mu_1(u_1) \wedge \mu_1'(u_2)$$
$$= \sum_{u_2v_2 \in E_2} \mu_2'(u_2v_2) + \sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) + \mu_1(u_1) + \mu_1'(u_2) - \mu_1(u_1) \vee \mu_1'(u_2)$$
$$= \sum_{u_2v_2 \in E_2} \mu_2'(u_2v_2) + \mu_1'(u_2)$$
$$+ \sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) + \mu_1(u_1) - \mu_1(u_1) \vee \mu_1'(u_2)$$

$$td_{\mu(G_1 \times G_2)}(u_1, u_2) = td_{\mu G_1}(u_1) + td_{\mu G_2}(u_2) - \mu_1(u_1) \vee \mu_1'(u_2).$$

(ii) $From (3.2.2)$,
$$td_{\nu(G_1 \times G_2)}(u_1, u_2) = \sum_{u_1 = v_1, u_2v_2 \in E_2} \nu_1(u_1) \vee \nu_2'(u_2v_2)$$
$$+ \sum_{u_2 = v_2, u_1v_1 \in E_1} \nu_1'(u_2) \vee \nu_2(u_1v_1) + \nu_1(u_1) \vee \nu_1'(u_2)$$

$$= \sum_{u_2v_2\in E_2} \nu_2{}'(u_2v_2) + \sum_{u_1v_1\in E_1} \nu_2\,(u_1v_1) + \nu_1(u_1) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

$$= \sum_{u_2v_2\in E_2} \nu_2{}'(u_2v_2) + \nu_1{}'(u_2) + \sum_{u_1v_1\in E_1} \nu_2(u_1v_1) + \nu_1(u_1) - \nu_1\,(u_1) \wedge \nu_1{}'(u_2)$$

$$td_{\nu(G_1\times G_2)}(u_1\,,u_2) = td_{\nu G_1}(u_1) + td_{\nu G_2}(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2).$$

Example 3.4. Consider the intuitionistic fuzzy graphs $G_1 : (\mu\ \ ,\nu\ \ )$ *and* $G_2 : (\mu'\ \ ,\nu')$ in *Fig.* 3.1.

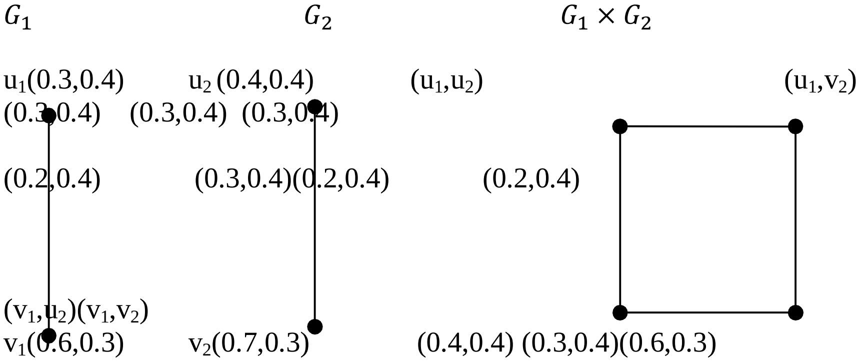

Figure 3.1:

(i) If $\mu_1 \geq \mu_2{}'$ and $\mu_1{}' \geq \mu_2$ then

$$td_{\mu G_1\times G_2}(u_1, u_2) = td_{\mu G_1}(u_1) + td_{\mu G_2}(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$
=0.5+0.7-0.4=0.8

(ii) If $\nu_1 \leq \nu_2{}'$ and $\nu_1{}' \leq \nu_2$

then $td_{\nu G_1\times G_2}(u_1, u_2) = td_{\nu G_1}(u_1) + td_{\nu G_2}(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$
= 0.8+0.8-0.4=1.2

Theorem 3.5. Let $G_1 : (\mu,\nu)$ *and* $G_2 : (\mu',\nu')$ be two intuitionistic fuzzy graphs.

(i) If $\mu_1 \leq \mu_2{}'$ and $\nu_1 \geq \nu_2{}'$

$$td_{\mu(G_1\times G_2)}(u_1\,,u_2) = td_{\mu G_1}(u_1) + \mu_1(u_1)d_{G_2^*}(u_2) + \mu_1{}'(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

(ii) If $\mu_1{}' \leq \mu_2$ and $\nu_1{}' \geq \nu_2$

$$td_{\nu(G_1\times G_2)}(u_1\,,u_2) = td_{\nu G_1}(u_1) + \nu_1(u_1)d_{G_2^*}(u_2) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

Proof:

(i) We have $\mu_1 \leq \mu_2{}'$. Hence $\mu_1{}' \geq \mu_2$

From (3.2.1) $td_{\mu(G_1\times G_2)}(u_1\,,u_2)$

$$= \sum_{u_1=v_1,u_2v_2\in E_2} \mu_1(u_1) \wedge \mu_2{}'(u_2v_2) + \sum_{u_2=v_2,u_1v_1\in E_1} \mu_1{}'(u_2) \wedge \mu_2\,(u_1v_1) + \mu_1(u_1) \wedge \mu_1{}'(u_2)$$

$$= \sum_{u_2v_2 \in E_2} \mu_1(u_1) \quad + \sum_{u_1v_1 \in E_1} \mu_2\,(u_1v_1) + \mu_1(u_1) + \mu_1{}'(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$= \quad td_{\mu G_1}(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2) + \mu_1{}'(u_2) + \mu_1(u_1) \sum_{u_2v_2 \in E_2} 1$$

$$= \quad td_{\mu G_1}(u_1) + \mu_1(u_1) d_{G_2^*}(u_2) + \mu_1{}'(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$\therefore td_{\mu(G_1 \times G_2)}(u_1\,, u_2) \ = td_{\mu G_1}(u_1) \ + \mu_1(u_1) d_{G_2^*}(u_2) + \mu_1{}'(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

(ii) We have $\nu_1 \ \geq \nu_2{}'$. Hence $\nu_1{}' \leq \nu_2$

$From(3.2.2)\ td_{\nu(G_1 \times G_2)}(u_1\,, u_2)$

$$= \sum_{u_1 = v_1, u_2v_2 \in E_2} \nu_1(u_1) \vee \nu_2{}'(u_2v_2)$$

$$+ \sum_{u_2 = v_2, u_1v_1 \in E_1} \nu_1{}'(u_2) \vee \nu_2\,(u_1v_1) + \nu_1(u_1) \vee \nu_1{}'(u_2)$$

$$= \sum_{u_2v_2 \in E_2} \nu_1(u_1) \quad + \sum_{u_1v_1 \in E_1} \nu_2\,(u_1v_1) + \nu_1(u_1) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

$$= \quad td_{\nu G_1}(u_1) - \nu_1(u_1) \wedge \nu_1{}'(u_2) + \nu_1{}'(u_2) + \nu_1(u_1) \sum_{u_2v_2 \in E_2} 1$$

$$= \quad td_{\nu G_1}(u_1) + \nu_1(u_1) d_{G_2^*}(u_2) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

$$\therefore td_{\nu(G_1 \times G_2)}(u_1\,, u_2) = td_{\nu G_1}(u_1) \ + \nu_1(u_1) d_{G_2^*}(u_2) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

Example 3.6. Consider the intuitionistic fuzzy graphs $G_1 : (\mu \ \ , \nu \ \ ) and G_2 : (\mu' \ \ , \nu' \ \ )$ in $Fig.$ 3.2.

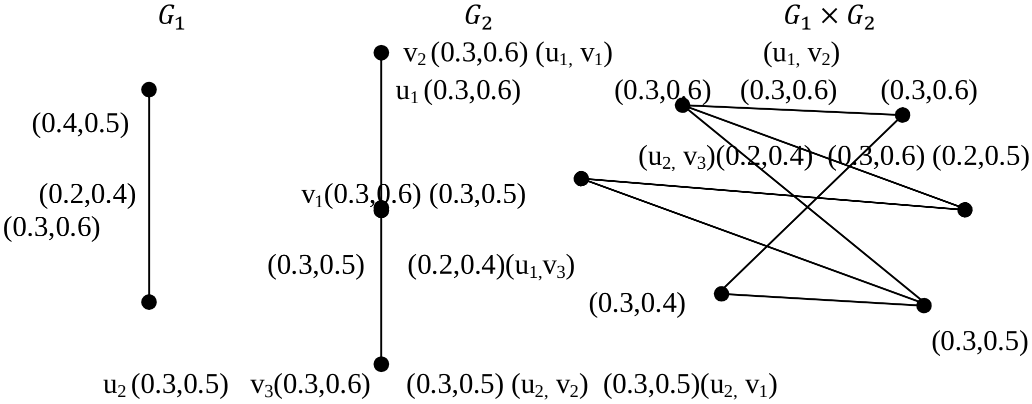

Figure 3.2:

(i) If $\mu_1 \ \leq \mu_2{}'$ and $\nu_1 \ \geq \nu_2{}'$

$td_{\mu(G_1 \times G_2)}(u_1, u_2) = td_{\mu G_1}(u_1) + \mu_1(u_1) d_{G_2^*}(v_1) + \mu_1'(u_2) - \mu_1(v_1) \vee \mu_1'(v_1)$
= 0.5+0.3(2)+0.6-0.6
=1.1.

(ii) If $\mu_1' \leq \mu_2$ and $\nu_1' \geq \nu_2$

$td_{\nu(G_1 \times G_2)}(u_1, u_2) = td_{\nu G_1}(u_1) + \nu_1(u_1) d_{G_2^*}(u_2) + \nu_1'(u_2) - \nu_1(u_1) \wedge \nu_1'(u_2)$
= 1+0.6(2)+(0.5)-0.5
= 2.2.

4. Total degree of a vertex in Composition

Definition 4.1. The Composition of two intuitionistic fuzzy graphs G_1 and G_2 is defined as a intuitionistic fuzzy graph $G = G_1 \circ G_2 : (\mu \circ \mu', \nu \circ \nu')$ on $G^* : (V, E)$ where $V = V_1 \times V_2$ and $E = \{ ((u_1, u_2)(v_1, v_2)) \ / u_1 = v_1, u_2v_2 \in E_2 \ or \ u_2 = v_2, u_1v_1 \in E_1 \ or u_2 = v_2, u_1v_1 \in E_1 \}$

$(\mu_1 \circ \mu_1')(u_1, u_2) = \mu_1(u_1) \wedge \mu_1'(u_2), \ for all \ (u_1, u_2) \in V_1 \times V_2$ and

$(\nu_1 \circ \nu_1')(u_1, u_2) = \nu_1(u_1) \vee \nu_1'(u_2), \ for all \ (u_1, u_2) \in V_1 \times V_2$

$$(\mu_2 \circ \mu_2)((u_1, u_2)(v_1, v_2)) = \begin{cases} \mu_1(u_1) \wedge \mu_2'(u_2v_2), & if u_1 = v_1, u_2v_2 \in E_2 \\ \mu_1'(u_2) \wedge \mu_2(u_1v_1), & if u_2 = v_2, u_1v_1 \in E_1 \\ \mu_1'(u_2) \wedge \mu_1'(v_2) \wedge \mu_2(u_1v_1), & if u_2 \neq v_2, u_1v_1 \in E_1 \end{cases}$$

$$(\nu_2 \circ \nu_2')((u_1, u_2)(v_1, v_2)) = \begin{cases} \nu_1(u_1) \vee \nu_2'(u_2v_2), & if u_1 = v_1, u_2v_2 \in E_2 \\ \nu_1(u_2) \vee \nu_2(u_1v_1), & if u_2 = v_2, u_1v_1 \in E_1 \\ \nu_1'(u_2) \vee \nu_1'(v_2) \vee \nu_2(u_1v_1), & if u_2 \neq v_2, u_1v_1 \in E_1 \end{cases}$$

Definition 4.1. By definition for any $(u_1, u_2) \in V_1 \times V_2$

$$td_{\mu(G_1[G_2])}(u_1, u_2) = \sum_{(u_1, u_2)(v_1, v_2) \in E} ((\mu_2 \circ \mu_2')(u_1, u_2)(v_1, v_2)) + \mu_1(u_1) \wedge \mu_1'(u_2)$$

$$= \sum_{u_1 = v_1, u_2v_2 \in E_2} \mu_1(u_1) \wedge \mu_2'(u_2v_2) + \sum_{u_2 = v_2, u_1v_1 \in E_1} \mu_1'(u_2) \wedge \mu_2(u_1v_1) + \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \mu_1'(u_2) \wedge \mu_1'(v_2) \wedge \mu_2(u_1v_1) + \mu_1(u_1) \wedge \mu_1'(u_2)$$

$$td_{\nu(G_1[G_2])}(u_1, u_2) = \sum_{(u_1, u_2)(v_1, v_2) \in E} ((\nu_2 \circ \nu_2')(u_1, u_2)(v_1, v_2)) + \nu_1(u_1) \vee \nu_1'(u_2)$$

$$= \sum_{u_1 = v_1, u_2v_2 \in E_2} \nu_1(u_1) \vee \nu_2'(u_2v_2) + \sum_{u_2 = v_2, u_1v_1 \in E_1} \nu_1'(u_2) \vee \nu_2(u_1v_1) + \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \nu_1'(u_2) \vee \nu_1'(v_2) \vee \nu_2(u_1v_1) + \nu_1(u_1) \vee \nu_1'(u_2)$$

Theorem 4.2. Let $G_1 : (\mu, \quad) \; and G_2 : (\mu', \quad ')$ be two intuitionistic fuzzy graphs.

(i) If $\mu_1 \geq \mu_2{}'$ and $\mu_1{}' \geq \mu_2$, then

$$td_{\mu(G_1[G_2])}(u_1, u_2) = td_{\mu G_2}(u_2) + p_2 td_{\mu G_1}(u_1) - (p_2 - 1)\,\mu_1(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

(i) If $\nu_1 \leq \nu_2{}'$ and $\nu_1{}' \leq \nu_2$, then

$$td_{\nu(G_1[G_2])}(u_1, u_2) = td_{\nu G_2}(u_2) + p_2 td_{\nu G_1}(u_1) - (p_2 - 1)\,\nu_1(u_1) - \nu_1(u_1) \wedge \nu_1{}'(u_2),$$

where $p_2 = |V_2|$, V_2 is the set of all nodes inG_1

Proof :

$$\text{(i)} td_{\mu(G_1[G_2])}(u_1, u_2) = \sum_{u_1 = v_1, u_2v_2 \in E_2} \mu_1(u_1) \wedge \mu_2{}'(u_2v_2) + \sum_{u_2 = v_2, u_1v_1 \in E_1} \mu_1{}'(u_2) \wedge \mu_2(u_1v_1) + \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \mu_1{}'(u_2) \wedge \mu_1{}'(v_2) \wedge \mu_2(u_1v_1) + \mu_1(u_1) \wedge \mu_1{}'(u_2) = \sum_{u_2v_2 \in E_2} \mu_2{}'(u_2v_2) + \sum_{u_2 = v_2, u_1v_1 \in E_1} \mu_2(u_1v_1) + \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \mu_2(u_1v_1)$$

$$+\mu_1(u_1) + \mu_1{}'(u_2) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$= \sum_{u_2v_2 \in E_2} \mu_2{}'(u_2v_2) + \mu_1{}'(u_2) + \sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) + \mu_1(u_1) + \sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$= td_{\mu G_2}(u_2) + |V_2| \sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) + \mu_1(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$= td_{\mu G_2}(u_2) + p_2 \left[\sum_{u_1v_1 \in E_1} \mu_2(u_1v_1) + \mu_1(u_1) \right] - (p_2 - 1)\mu_1(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

$$\Rightarrow td_{\mu(G_1[G_2])}(u_1, u_2) = td_{\mu G_2}(u_2) + p_2 td_{\mu G_1}(u_1) - (p_2 - 1)\,\mu_1(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

(ii)$td_{\nu(G_1[G_2])}(u_1, u_2) = \sum_{u_1=v_1, u_2v_2 \in E_2} \nu_1(u_1) \vee \nu_2{}'(u_2v_2)$

$+ \sum_{u_2 = v_2, u_1v_1 \in E_1} \nu_1{}'(u_2) \vee \nu_2(u_1v_1)$

$+ \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \nu_1{}'(u_2) \vee \nu_1{}'(v_2) \vee \nu_2(u_1v_1) + \nu_1(u_1)$

$\vee \nu_1{}'(u_2) = \sum_{u_2v_2 \in E_2} \nu_2{}'(u_2v_2) + \sum_{u_2 = v_2, u_1v_1 \in E_1} \nu_2(u_1v_1)$

$+ \sum_{u_2 \neq v_2, u_1v_1 \in E_1} \nu_2(u_1v_1)$

$+\nu_1(u_1) + \nu_1{}'(u_2) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$

$= \sum_{u_2v_2 \in E_2} \nu_2{}'(u_2v_2) + \nu_1{}'(u_2) + \sum_{u_1v_1 \in E_1} \nu_2(u_1v_1) + \nu_1(u_1) + \sum_{u_1v_1 \in E_1} \nu_2(u_1v_1)$

$- \nu_1(u_1) \wedge \nu_1{}'(u_2)$

$= td_{\nu G_2}(u_2) + |V_2| \sum_{u_1v_1 \in E_1} \nu_2(u_1v_1) + \nu_1(u_1) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$

$= td_{\nu G_2}(u_2) + p_2 \left[\sum_{u_1v_1 \in E_1} \nu_2(u_1v_1) + \nu_1(u_1) \right] - (p_2 - 1)\nu_1(u_1)$

$-\nu_1(u_1) \wedge \nu_1{}'(u_2)$

$\Rightarrow td_{\nu(G_1[G_2])}(u_1, u_2) = td_{\nu G_2}(u_2) + p_2 td_{\nu G_1}(u_1) - (p_2 - 1)\, \nu_1(u_1)$

$-\nu_1(u_1) \wedge \nu_1{}'(u_2)$

Example 4.3. Consider the fuzzy graphs G_1 and G_2 in $Fig. 4.1$.

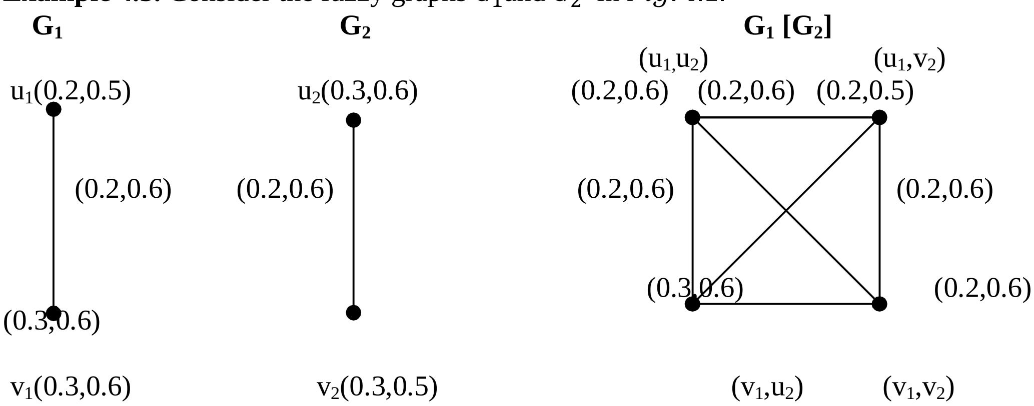

Figure 4.1:

(i) If $\mu_1 \geq \mu_2{}'$ and $\mu_1{}' \geq \mu_2$, then

$$td_{\mu(G_1[G_2])}(u_1, u_2) = td_{\mu G_2}(u_2) + p_2 td_{\mu G_1}(u_1) - (p_2 - 1)\,\mu_1(u_1) - \mu_1(u_1) \vee \mu_1{}'(u_2)$$

= 0.5+2(0.4)-(2-1) (0.2) - (0.2∨ 0.3)

= 0.8

(ii) If $\nu_1 \leq \nu_2{}'$ and $\nu_1{}' \leq \nu_2$, then

$$td_{\nu(G_1[G_2])}(u_1, u_2) = td_{\nu G_2}(u_2) + p_2 td_{\nu G_1}(u_1) - (p_2 - 1)\,\nu_1(u_1) - \nu_1(u_1) \wedge \nu_1{}'(u_2)$$

= 1.2+2(1.1)-(2-1)0.5-0.5

= 2.4.

5. Conclusion

In this paper, we have found the total degree of vertices in $G_1 \times G_2$ and $G_1 \circ G_2$ in terms of the total degree of vertices in G_1 and G_2 under some conditions and illustrated them through examples. They will be useful in studying various properties of Cartesian product and Composition of two intuitionistic fuzzy graphs.

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