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Research Article

Perfect Fuzzy Soft Tripartite Graphs and Their Complements

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Fuzzy soft graphs are efficient numerical tools for simulating the uncertainty of the real world. A fuzzy soft graph is a perfect fusion of the fuzzy soft set and the graph model that is widely used in a variety of fields. This paper discusses a few unique notions of perfect fuzzy soft tripartite graphs (PFSTG), as well as the concepts of complement of perfect fuzzy soft tripartite graphs (CPFSTGs). Because soft sets are most useful in real-world applications, the newly developed concepts of perfect soft tripartite fuzzy graphs will lead to many theoretical applications by adding extra fuzziness in analysing. We look at some of their properties and come up with a few results that are related to these concepts. Furthermore, we investigated some fundamental theorems and illustrated an application of size of perfect fuzzy soft tripartite graphs in employee selection for an institution using the perfect fuzzy soft tripartite graph.

1. Introduction

Zadeh's [1] fuzzy set theory, established in 1965, is the best explanation for interacting with sources of uncertainty. In 1986, Honda and Ohsato [2] have discussed some fuzzy set concepts and applications. A graph is a simple way to communicate data and the relationship between various types of substances. Vertices represent the elements, while edges express the relationships. Rosenfield [3] created the notion of fuzzy graphs in 1975, providing an overview of fuzzy sets to graph theory. Kotzig and Rosa [4] defined the properties of magic graphs in 1970. In 1987, Bhattacharya [5] examined fuzzy graphs and made some remarkable observations. So many researchers introduced numerous maintainable and remarkable concepts in fuzzy graphs. In 1994, Mordeson and Chang-Shyh [6] introduced the concepts of the complement of fuzzy graphs.

In 1999, Molodtsov [7] created a fuzzy soft theory to rectify inexact technological difficulties in social science, entrepreneurship, medicine, and the surroundings. He also applied this theory to a variation of many other areas, including crispness of function and game theory. In recent years, soft set research has been very active, with researchers from all over the world participating. In 2001, Maji et al. [8, 9] proposed the concept of fuzzy soft sets, which are a perfect combination of a fuzzy set and a soft set. In 2009, Aygünglu et al. [10] have given some ideas in mathematics with applications. In 2013, Ghosh et al. [11] proposed some ideas on the operations of intuitionistic fuzzy soft sets. In 2014, Rajesh [12] proposed the notion of soft graphs and also they investigated some of their characteristics. In the year 2015, Akram and Nawaz [13] proposed fuzzy soft graphs. Mohinta et al. developed FSG independently. They present the concept of FSG as well as a few properties related to them in their paper. All the concepts of FSG (strong, complete, and regular) have been introduced by Akram and Nawaz [14]. In 2016, Akram and Nawaz [15] presented the concepts of FSG and its applications in social networks and road networks. They also explained into different types of arcs in FSG. Al-Masarwah et al. [16] introduced some new notions in CFSG. Varkey and Shyla [17] discussed some notes on bipartite and balanced fuzzy graph structures in 2017. In 2018, Sarala and Manju [18] proposed some applications of fuzzy soft bipartite graphs. In 2019, Khan et al. [19] have described picture fuzzy soft sets and their implementation in software applications. Sarala and Tharani [20, 21] gave some ideas in bipolar and intuitionistic fuzzy soft digraph in 2019. Sarala and Tharani [22] have described fuzzy soft digraph implementation in genetic eye and hair color in 2020.

Bibin et al. [23] examined vertex rough graphs and made some remarkable observations. In 2021, Paik and Mondal [24] represent and gave application of fuzzy soft set in type-2 environment. In the same year Karbasioun and Ameri [25] discussed the product of two fuzzy soft graphs. In 2016, Masarwah [26] computed genus value of fuzzy soft graphs. The next year the properties are investigated by Poubassani and Doostie [27]. Al-Masarwah and Abuqamar [28] developed the types of fuzzy soft graphs in 2017. In 2019, Sashikala and Anil [29] gave some ideas in fuzzy soft cycles. In the same year, Akilandeswari [30] investigate regular fuzzy soft graphs. Finally in 2021, Nawaz and Akram [31] presented the important application of wireless Internet services with the use of fuzzy soft graphs.

Fuzzy soft bipartite graphs and fuzzy soft tripartite graphs were already discussed by several researchers along with their applications. Following that, the concepts were applied to the complement of fuzzy soft tripartite graphs. Fuzzy soft-tripartite graphs produce better results than fuzzy soft bipartite graphs. The value of the fuzzy soft tripartite graph is larger than that of the fuzzy soft bipartite graph, which gives exact maximum values. This motivates us to define and analyse the fuzzy soft tripartite graphs and their complement to form a unique mathematical model.

A few main ideas of FSTG and its complement are also discussed briefly. The following is how the paper is positioned out: Section 2 discusses the fundamental concepts of the fuzzy graph theory. Section 3 introduces the notion of FSTGs. Section 4 describes the concept of CFSTGs. Finally, Section 5 illustrates a model for implementing these FSTGs. Section 6 contains the conclusion.

2. Preliminaries

Definition 1. [2] A fuzzy graph is an ordered triple $G_F(V_F, \sigma_F, \mu_F)$ where V_F is a set of vertices $\{u_{F_1}, u_{F_2}, \ldots, u_{F_n}\}$ and σ_F is a fuzzy subset of V_F that is $\sigma_F\colon V_F \longrightarrow [0,1]$ and is denoted by $\sigma_F = \{(u_{F_1}, \sigma_F(u_{F_1})), (u_{F_2}, \sigma(u_{F_2})) \ldots\ldots, (u_{F_n}, \sigma(u_{Fn}))\}$, and μ_F is a fuzzy relation on σ_F.That is,

Definition 2. [14] Let $V = \{x_1, x_2, \ldots, x_n\}$ nonempty set, E (parameters set), and $A \subseteq E$. Also, let

(1) $\rho\colon A \longrightarrow F(V)$ (collection of all fuzzy subsets in V) $e \longrightarrow \rho(e) = \rho_e$ (say) and $\rho_e\colon V \longrightarrow [0,1], X\colon \longrightarrow \rho_e(X_i)(A, \rho)$: Fuzzy soft vertex.

(2) $\mu\colon A \longrightarrow F(V \times V)$ (collection of all fuzzy subsets in $(V \times V) e \longrightarrow \mu(e) = \mu_e$ (say) and $\mu_e\colon v \times v \longrightarrow [0,1]$.

$$\left(x_i, x_j\right) \longrightarrow \mu_e\left(x_i, x_j\right), \tag{1}$$

(A, μ): Fuzzy soft edge. Then, $((A, \rho), (A, \mu))$ is called a fuzzy soft graph iff $\mu_e(x_i, x_j) \le \rho_e(x_i) \wedge \rho_e(x_j)$ for all $e \in A$ and for all $i, j = 1, 2, \ldots, n$ and this fuzzy soft graph is denoted by $G_{A,V}$.

Definition 3. [19] A fuzzy soft graph $G_{A,V} = ((A, \rho), (A, \mu))$ is said be a fuzzy soft bipartite graph. If the vertex set V is partition into two disjoint vertex pair and $\mu_e(x_i, x_j) = \rho_e(x_i) \wedge \rho_e(x_j)$ for all $x_i \in v_i$ and $y_j \in v_j$.

Definition 4. [19] If a fuzzy soft graph $G_{A,V} = ((A, \rho), (A, \mu))$ is said be a fuzzy soft bipartite graph, then, the size of the fuzzy soft bipartite graph is

$$S\left(G_{A,V \bigcup v_{ji}}\right) = \sum_{e \in A} \left(\sum_{x_i y_j \in V_i \bigcup v_j} \mu_e\left(x_i, x_j\right) \right). \tag{2}$$

3. Perfect Fuzzy Soft Tripartite Graphs

Definition 5. A FSG $G_{A,V} = ((A, \wp), (A, \mathfrak{I}))$ is said to be a FSTG, if the vertices can be partitioned into 3 disjoint vertex pairs and

$$\begin{aligned} \mathfrak{I}_e\left(x_{ii}, y_{jj}\right) &\le \min\left\{\wp_e\left(x_{ii}\right), \wp_e\left(y_{jj}\right)\right\}, \\ \mathfrak{I}_e\left(y_{jj}, z_{kk}\right) &\le \min\left\{\wp_e\left(y_{jj}\right), \wp_e\left(Z_{kk}\right)\right\}, \\ \mathfrak{I}_e\left(z_{kk}, x_{ii}\right) &\le \min\left\{\wp_e\left(z_{kk}\right), \wp_e\left(x_{ii}\right)\right\}. \end{aligned} \tag{3}$$

It is denoted by $(G_{A,V_i \bigcup V_j \bigcup V_K})$.

Definition 6. A FSTG is said to be a perfect fuzzy soft tripartite graph if any one of the vertex value has one, i.e., $\wp(V_i) = 1$.

Definition 7. If a FSG $G_{A,V} = ((A, \wp), (A, \mathfrak{I}))$ is said to be a FSTG, then, the size of the PFSTG is

$$S\left(G_{A,V_i \bigcup V_j \bigcup V_K}\right) = \sum_{e \in A} \sum_{a_i b_j c_K \in V_i U V_j U V_k} \mathfrak{I}_e\left(a_i, b_j, c_k\right), \tag{4}$$

$$\begin{aligned} \text{where } S[F(e_1)] &= \textstyle\sum_{a_i b_j c_K \in V_i U V_j U V_k} \mathfrak{I}_{e_1}\left(a_i, b_j, c_k\right), \\ S[F(e_2)] &= \sum_{a_i b_j c_K \in V_i U V_j U V_k} \mathfrak{I}_{e_2}\left(a_i, b_j, c_k\right), \\ S[F(e_3)] &= \sum_{a_i b_j c_K \in V_i U V_j U V_k} \mathfrak{I}_{e_3}\left(a_i, b_j, c_k\right). \end{aligned} \tag{5}$$

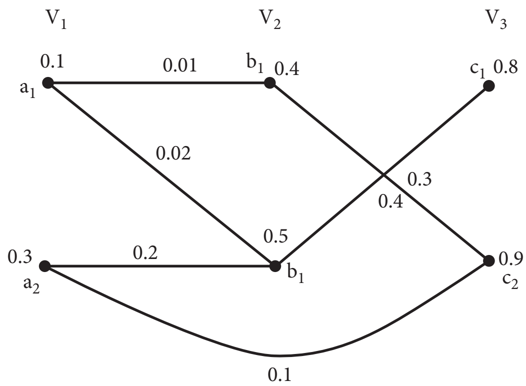


Figure 1: $F(e_1)$.

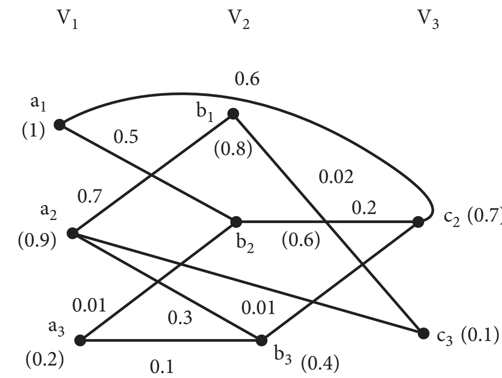


Figure 2: $F(e_2)$.

Definition 8. If a FSG $G_{A,V} = ((A, \wp), (A, \mathfrak{I}))$ is said to be a PFSTG, then the degree of the PFSTG is $d(a_i) = \sum_{e \in A} \sum_{b_j c_k \in v_j \bigcup v_k} \mathfrak{I}_e(b_j, c_k) d(b_j) = \sum_{e \in A} \sum_{a_j c_k \in v_j \bigcup v_k} \mathfrak{I}_e \ (a_i, c_k)$ $d(c_k) = \sum_{e \in A} \sum_{a_i b_j \in v_i \bigcup v_j} \mathfrak{I}_e(a_i, b_j)$

Definition 9. If a FSG $G_{A,V} = ((A, \wp), (A, \mathfrak{I}))$ is said to be a PFSTG, then the order of the PFSTG is $O(G_{A,V_i \bigcup V_j \bigcup V_k}) = \sum_{e \in A} \sum_{a_i b_j c_k \in V_i U V_j U V_k} \wp_e(a_i, b_j, c_k)$,where

$$\begin{aligned} O[F(e_1)] &= \sum_{a_i b_j c_K \in V_i U V_j U V_k} \wp_{e_1}(a_i, b_j, c_k), \\ O[F(e_2)] &= \sum_{a_i b_j c_K \in V_i U V_j U V_k} \wp_{e_2}(a_i, b_j, c_k), \\ O[F(e_3)] &= \sum_{a_i b_j c_K \in V_i U V_j U V_k} \wp_{e_3}(a_i, b_j, c_k). \end{aligned} \tag{6}$$

Example 1. Consider $F(e_1)$, $F(e_2)$, and $F(e_3)$ defined in Figure 1–3 (Tables 1 and 2).

The size of the PFSTG is

$$\begin{aligned} S[F(e_1)] &= 1.33, \\ S[F(e_2)] &= 2.47, \\ S[F(e_3)] &= 3.21, \\ \therefore S\left(G_{A,V_i \bigcup V_j \bigcup V_k}\right) &= 7.01. \end{aligned} \tag{7}$$

The order of the PFSTG is

$$\begin{aligned} O[F(e_1)] &= 3.5, \\ O[F(e_2)] &= 4.7, \\ O[F(e_3)] &= 4.5, \\ \therefore O\left(G_{A,V_i \bigcup V_j \bigcup V_k}\right) &= 12.7. \end{aligned} \tag{8}$$

The degree of the PFSTG is

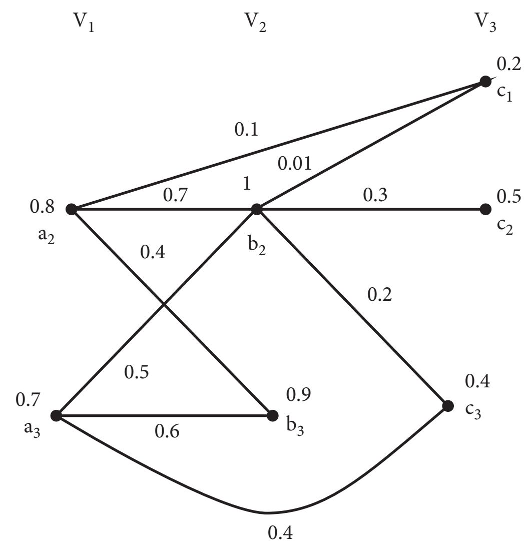


Figure 3: $F(e_3)$.

$$\begin{aligned} d(a_1) &= 1.13, \\ d(a_2) &= 2.51, \\ d(a_3) &= 1.53, \\ d(b_1) &= 0.32, \\ d(b_2) &= 1.62, \\ d(b_3) &= 0.03, \\ d(c_1) &= 0.51, \\ d(c_2) &= 1.35, \\ d(c_3) &= 0.63. \end{aligned} \tag{9}$$

4. Complement of Perfect Fuzzy Soft Tripartite Graph

Definition 10. A FSTG $G_{A,V_i \bigcup V_j \bigcup V_k}$ is known as a strong fuzzy soft tripartite graph (SFSTG) if

Table 1: Relation between vertices and parameters of perfect fuzzy soft tripartite graphs.

ρ	a_1	a_2	a_3	b_1	b_2	b_3	c_1	c_2	c_3
e_1	0.1	0.3	0	0.4	1	0	0.8	0.9	0
e_2	1	0.9	0.2	0.8	0.6	0.4	0	0.7	0.1
e_3	0	0.8	0.7	0	1	0.9	0.2	0.5	0.4

Table 2: Relation between vertices and edges of perfect fuzzy soft tripartite graphs.

μ	e_1	e_2	e_3
a_1b_1	0.01	0	0
a_1b_2	0.02	0.5	0
a_1c_2	0	0.6	0
a_2b_1	0	0.7	0
a_2b_2	0.2	0	0.7
a_2b_3	0	0.3	0.4
a_2c_1	0	0	0.1
a_2c_2	0.1	0	0
a_2c_3	0	0.01	0
a_3b_2	0	0.3	0.5
a_3b_3	0	0.1	0.6
a_3c_3	0	0	0.4
b_1c_2	0.3	0	0
b_1c_3	0	0.02	0
b_2c_1	0.7	0	0.01
b_2c_2	0	0.02	0.3
b_2c_3	0	0	0.2
b_3c_2	0	0.03	0

$$\begin{aligned}\mathfrak{I}_e(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\},\\ \mathfrak{I}_e(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(Z_{kk})\},\\ \mathfrak{I}_e(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e\in A.\end{aligned} \tag{10}$$

and is complete FSTG if

$$\begin{aligned}\mathfrak{I}_e(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\},\\ \mathfrak{I}_e(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(Z_{kk})\},\\ \mathfrak{I}_e(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e\in A.\end{aligned} \tag{11}$$

Definition 11. Let $G_{A,V_i\bigcup V_j\bigcup V_k}$ be a FSTG. Then, $G_{A,V_i\bigcup V_j\bigcup V_k}$ is called isolated fuzzy soft tripartite graph (IFSTG) if $\mathfrak{I}_e(x_{ii}, y_{jj}) = 0$, $\mathfrak{I}_e(y_{jj}, z_{kk}) = 0$ and $\mathfrak{I}_e(z_{kk}, x_{ii}) = 0\,\forall x_{ii}, y_{jj}, z_{kk}\in V\times V$ and $e\in A$.

Definition 12. Let $G_{A,V_i\bigcup V_j\bigcup V_K}$ be a FSTG. The CFSTG is defined as $\overline{G}_{A,V_i\bigcup V_j\bigcup V_K}$ where

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}),\\ \overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\} - \mathfrak{I}_e(y_{jj}, z_{kk}),\\ \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\} - \mathfrak{I}_e(z_{kk}, x_{ii}).\end{aligned} \tag{12}$$

Definition 13. A CFSTG is called a complement of perfect fuzzy soft tripartite graph if any one of the vertex value has one, i.e., $\overline{\wp}(V_i) = 1$.

Definition 14. A CFSTG $\overline{G}_{A,V_i\bigcup V_j\bigcup V_K}$ is called SFSTG if

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\},\\ \overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\},\\ \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e\in A,\end{aligned} \tag{13}$$

and is complete FSTG if

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\},\\ \overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\},\\ \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e\in A.\end{aligned} \tag{14}$$

Proposition 1.

$$\begin{aligned}S\left(\overline{G}_{A,V_i\bigcup V_j}\right) + S\left(G_{A,V_i\bigcup V_j}\right) &\le 2\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\wp_e(x_{ii})\wedge\wp_e(y_{jj}),\\ S\left(\overline{G}_{A,V_j\bigcup V_k}\right) + S\left(G_{A,V_j\bigcup V_k}\right) &\le 2\sum_{e\in A}\sum_{y_{jj}\neq z_{kk}}\wp_e(y_{jj})\wedge\wp_e(z_{kk}),\\ S\left(\overline{G}_{A,V_k\bigcup V_i}\right) + S\left(G_{A,V_k\bigcup V_i}\right) &\le 2\sum_{e\in A}\sum_{x_{ii}\neq z_{kk}}\wp_e(z_{kk})\wedge\wp_e(x_{ii}).\end{aligned} \tag{15}$$

Proof. Since

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \wp_e(x_{ii})\wedge\wp_e(y_{jj}) - \mathfrak{I}_e(x_{ii}, y_{jj}),\\ \mathfrak{I}_e(x_{ii}, y_{jj}) &\le \wp_e(x_{ii})\wedge\wp_e(y_{jj}).\end{aligned} \tag{16}$$

Also,

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) \le \wp_e(x_{ii})\wedge\wp_e(y_{jj}). \tag{17}$$

From (16) and (17), we have

$$\mathfrak{I}_e(x_{ii}, y_{jj}) + \overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) \le 2\left[\wp_e(x_{ii})\wedge\wp_e(y_{jj})\right]. \tag{18}$$

Now, $\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}(\mathfrak{I}_e(x_{ii}, y_{jj}) + \overline{\mathfrak{I}_e}(x_{ii}, y_{jj})) \le \sum_{e\in A}\sum_{x_{ii}\neq y_{jj}} 2[\wp_e(x_{ii})\wedge\wp_e(y_{jj})]$

$$\begin{aligned}&\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\mathfrak{I}_e(x_{ii}, y_{jj}) + \sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj})\\ &\le 2\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\wp_e(x_{ii})\wedge\wp_e(y_{jj}).\end{aligned} \tag{19}$$

Hence,

$$S\left(G_{A,V_i\bigcup V_j}\right) + S\left(\overline{G}_{A,V_i\bigcup V_j}\right) \le 2\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\left[\wp_e(x_{ii})\wedge\wp_e(y_{jj})\right]. \tag{20}$$

Similarly,

$$\begin{aligned}S\left(G_{A,V_j\bigcup V_K}\right) + S\left(\overline{G}_{A,V_j\bigcup V_K}\right) &\le 2\sum_{e\in A}\sum_{y_{jj}\neq z_{kk}}\left[\wp_e(y_{jj})\wedge\wp_e(z_{kk})\right],\\ S\left(G_{A,V_K\bigcup V_i}\right) + S\left(\overline{G}_{A,V_K\bigcup V_i}\right) &\le 2\sum_{e\in A}\sum_{x_{ii}\neq z_{kk}}\left[\wp_e(x_{ii})\wedge\wp_e(z_{kk})\right].\end{aligned} \tag{21}$$

□

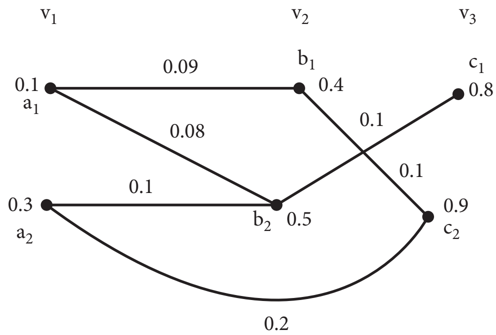


Figure 4: $F(e_1)$.

Example 2. Consider $F(e_1)$, $F(e_2)$, and $F(e_3)$ defined in Figures 4–6.

$$\begin{aligned}
S\left(\overline{G}_{A,V_i\cup V_j}\right) &= 1.66,\\
S\left(\overline{G}_{A,V_j\cup V_K}\right) &= 1.64,\\
S\left(\overline{G}_{A,V_K\cup V_i}\right) &= 0.49,\\
S\left(G_{A,V_i\cup V_j}\right) &= 4.04,\\
S\left(G_{A,V_j\cup V_K}\right) &= 1.46,\\
S\left(G_{A,V_K\cup V_i}\right) &= 1.21,\\
S\left(\overline{G}_{A,V_i\cup V_j}\right) &= 5.7,\\
S\left(\overline{G}_{A,V_j\cup V_K}\right) &= 3.1,\\
S\left(\overline{G}_{A,V_K\cup V_i}\right) &= 1.7,\\
\sum \wp_e(x_{ii})\wedge\wp_e(y_{jj}) &= 5.7,\\
\sum \wp_e(y_{jj})\wedge\wp_e(z_{kk}) &= 3.1,\\
\sum \wp_e(z_{kk})\wedge\wp_e(x_{ii}) &= 1.7,\\
\therefore S\left(\overline{G}_{A,V_i\cup V_j}\right) + S\left(G_{A,V_i\cup V_j}\right) &\leq 2\sum_{e\in A}\sum_{x_{ii}\neq y_{jj}}\left[\wp_e(x_{ii})\wedge\wp_e(y_{jj})\right].
\end{aligned} \tag{22}$$

Properties of complement of perfect fuzzy soft tripartite graph.

(1) The order of $\overline{G}_{A,V_i\cup V_j\cup V_K}$ is equal to the order of $G_{A,V_i\cup V_j\cup V_K}$.

$$O\left(\overline{G}_{A,V_i\cup V_j\cup V_K}\right) = O\left(G_{A,V_i\cup V_j\cup V_K}\right) = 12.2. \tag{23}$$

(2) The proportion of edge set elements of $\overline{G}_{A,V_i\cup V_j\cup V_K}$ is not exactly or equivalent to the proportion of edge set elements of $G_{A,V_i\cup V_j\cup V_K}$.

(3) Node set of $\overline{G}_{A,V_i\cup V_j\cup V_K}$ is same as the node set of $G_{A,V_i\cup V_j\cup V_K}$. The number of vertices in the complement of fuzzy soft tripartite graph is equal to the number of vertices in the perfect fuzzy soft tripartite graph.

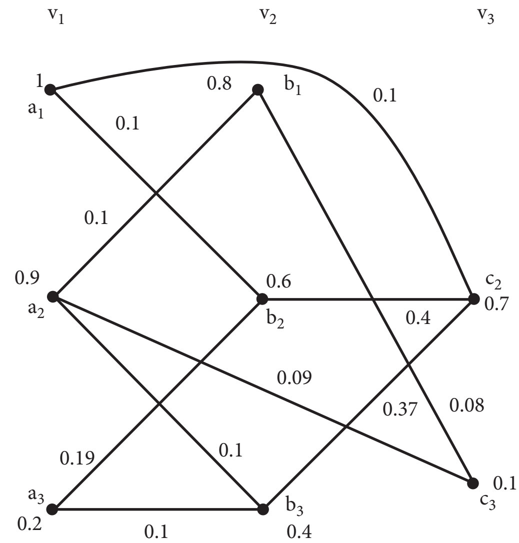


Figure 5: $F(e_2)$.

(4) $S(\overline{G}_{A,V_i\cup V_j}) + S(G_{A,V_i\cup V_j}) = \sum_{e\in A}\sum_{x_{ii},y_{jj}\in\mathfrak{I}}\wp_e(x_{ii})\wedge\wp_e(y_{jj})$,

$$\begin{aligned}
S\left(\overline{G}_{A,V_j\cup V_K}\right) + S\left(G_{A,V_j\cup V_K}\right) &= \sum_{e\in A}\sum_{y_{jj},z_{kk}\in\mathfrak{I}}\wp_e(y_{jj})\wedge\wp_e(z_{kk}),\\
S\left(\overline{G}_{A,V_k\cup V_i}\right) + S\left(G_{A,V_k\cup V_i}\right) &= \sum_{e\in A}\sum_{x_{ii},z_{kk}\in\mathfrak{I}}\wp_e(z_{kk})\wedge\wp_e(x_{ii}),\\
S\left(\overline{G}_{A,V_i\cup V_j}\right) &= 1.66,\\
S\left(\overline{G}_{A,V_j\cup V_K}\right) &= 1.64,\\
S\left(\overline{G}_{A,V_K\cup V_i}\right) &= 0.49,\\
S\left(G_{A,V_i\cup V_j}\right) &= 4.04,\\
S\left(G_{A,V_j\cup V_K}\right) &= 1.46,\\
S\left(G_{A,V_K\cup V_i}\right) &= 1.21,\\
S\left(\overline{G}_{A,V_i\cup V_j}\right) &= 5.7,\\
S\left(\overline{G}_{A,V_j\cup V_K}\right) &= 3.1,\\
S\left(\overline{G}_{A,V_K\cup V_i}\right) &= 1.7,\\
\sum \wp_e(x_{ii})\wedge\wp_e(y_{jj}) &= 5.7,\\
\sum \wp_e(y_{jj})\wedge\wp_e(z_{kk}) &= 3.1,\\
\sum \wp_e(z_{kk})\wedge\wp_e(x_{ii}) &= 1.7.
\end{aligned} \tag{24}$$

$$\begin{aligned}
\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\left\{\wp_e(x_{ii}), \wp_e(y_{jj})\right\},\\
\overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\left\{\wp_e(y_{jj}), \wp_e(z_{kk})\right\},\\
\overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) &= \min\left\{\wp_e(z_{kk}), \wp_e(x_{ii})\right\}.
\end{aligned} \tag{25}$$

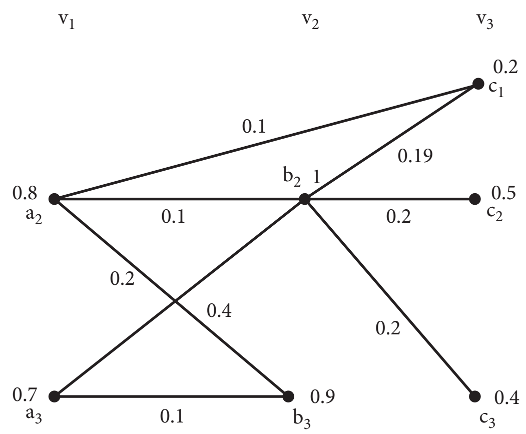


Figure 6: $F(e_3)$.

Theorem 1. *The complement of a PSFSTG is also SFSTG.*

Proof. Let $G_{A,V_i\bigcup V_j\bigcup V_K}$ be a SFSTG. $\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}$

$$\begin{aligned}\overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\},\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e \in A.\end{aligned} \tag{26}$$

By the definition of complement of perfect soft tripartite is defined as

$$\begin{aligned}\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{J}_e(x_{ii}, y_{jj}),\\ \overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\} - \mathfrak{J}_e(y_{jj}, z_{kk}),\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\} - \mathfrak{J}_e(z_{kk}, x_{ii})\end{aligned} \tag{27}$$

and any one of the vertex values has one.Now consider,

$$\begin{aligned}\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{J}_e(x_{ii}, y_{jj}),\\ &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\\ &\quad - \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\forall x_{ii}, y_{jj} \in V, e \in A,\\ &= \begin{cases} 0, \mathfrak{J}_e(x_{ii}, y_{jj}) > 0,\\ \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\mathfrak{J}_e(x_{ii}, y_{jj}) = 0.\end{cases}\\ \therefore \overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= 0,\\ \overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\forall x_{ii}, y_{jj} \in V.\end{aligned} \tag{28}$$

Similarly,

$$\begin{aligned}\overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \begin{cases} 0,\\ \min(\wp_e(y_{jj}), \wp_e(z_{kk})),\end{cases}\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \begin{cases} 0,\\ \min(\wp_e(z_{kk}), \wp_e(x_{ii})).\end{cases}\end{aligned} \tag{29}$$

∴The complement of a PSFSTG is also a SFSTG. □

Theorem 2. *The complement of a perfect complete FSTG is also complete FSTG.*

Proof. Let $G_{A,V_i\bigcup V_j\bigcup V_K}$ be a compete FSTG.

$$\begin{aligned}\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\},\\ \overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\},\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}\forall e \in A.\end{aligned} \tag{30}$$

By the definition of complement of perfect soft tripartite graph is defined as

$$\begin{aligned}\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{J}_e(x_{ii}, y_{jj}),\\ \overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\} - \mathfrak{J}_e(y_{jj}, z_{kk}),\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\} - \mathfrak{J}_e(z_{kk}, x_{ii}),\end{aligned} \tag{31}$$

and any one of the vertex value has must be one.Now consider,

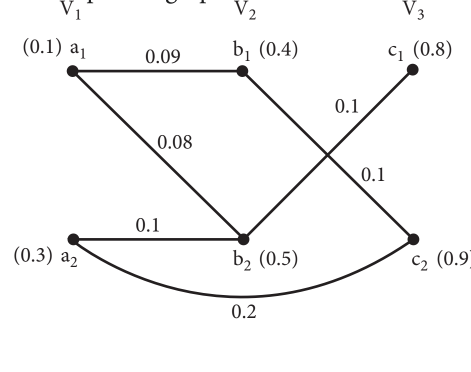
$$\begin{aligned}\overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{J}_e(x_{ii}, y_{jj}),\\ &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\\ &\quad - \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\forall x_{ii}, y_{jj} \in V, e \in A,\\ &= \begin{cases} 0, \quad \mathfrak{J}_e(x_{ii}, y_{jj}) > 0,\\ \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\mathfrak{J}_e(x_{ii}, y_{jj}) = 0,\end{cases}\\ \therefore \overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= 0,\\ \overline{\mathfrak{J}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}\forall x_{ii}, y_{jj} \in V.\end{aligned} \tag{32}$$

Similarly,

$$\begin{aligned}\overline{\mathfrak{J}_e}(y_{jj}, z_{kk}) &= \begin{cases} 0\\ \min(\wp_e(y_{jj}), \wp_e(z_{kk}))\end{cases},\\ \overline{\mathfrak{J}_e}(z_{kk}, x_{ii}) &= \begin{cases} 0\\ \min(\wp_e(z_{kk}), \wp_e(x_{ii}))\end{cases}.\end{aligned} \tag{33}$$

∴ The complement of a complete PFSTG is also a complete FSTG. □

Example 3. In the graph (see Figure 7) the number of vertices in the complement of perfect fuzzy soft tripartite graph is equal to number of vertices in the complete fuzzy soft tripartite graph.



Moreover, the above fuzzy graph is a complement fuzzy soft tripartite graph. It is also satisfy the condition for the complete fuzzy soft tripartite graph.

Theorem 3. *If $G_{A,V_i\bigcup V_j\bigcup V_K} = ((A,\wp), (A,\mathfrak{I}))$ is a PFSTG. Then, $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG if CPFSTG is a complete FSTG.*

Proof. Given $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG. Now, consider $G_{A,V_i\bigcup V_j}$ is an IFSTG. Then,

$$\mathfrak{I}_e(x_{ii}, y_{jj}) = 0. \tag{34}$$

We know that

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}). \tag{35}$$

Substitute (33) in (34),

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}. \tag{36}$$

Similarly,

$$\begin{aligned}\overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\} \& \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) \\ &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}.\end{aligned} \tag{37}$$

Hence, the CPFSTG is a complete FSTG.Conversely, given the CPFSTG is a complete FSTG, i.e.,

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}. \tag{38}$$

To prove, $G_{A,V_i\bigcup V_j\bigcup V_k}$ is an IFSTG.We know that

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}) \\ \Rightarrow \overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}), \\ &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} \\ &\quad - \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}.\end{aligned} \tag{39}$$

By (3),

$$\mathfrak{I}_e(x_{ii}, y_{jj}) = 0.$$

Similarly,

$$\overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) = 0 \& \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) = 0. \tag{40}$$

Hence, $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG. □

Theorem 4. *If $G_{A,V_i\bigcup V_j\bigcup V_K} = ((A,\wp), (A,\mathfrak{I}))$ is a FSTG. Then, $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG if CPFSTG is a SFSTG.*

Proof. Given $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG. Now, consider $G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG.
Then,

$$\mathfrak{I}_e(x_{ii}, y_{jj}) = 0. \tag{41}$$

We know that

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}). \tag{42}$$

Substitute (40) in (41),

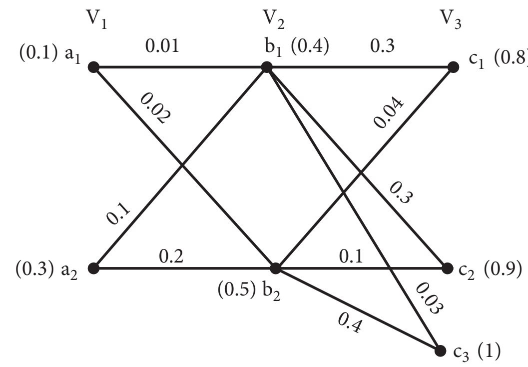


Figure 7: $F(e_1)$.

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}. \tag{43}$$

Similarly,

$$\begin{aligned}\overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) &= \min\{\wp_e(y_{jj}), \wp_e(z_{kk})\} \& \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) \\ &= \min\{\wp_e(z_{kk}), \wp_e(x_{ii})\}.\end{aligned} \tag{44}$$

Hence, the CPFSTG is a SFSTG.Conversely, Given the CPFSTG is a SFSTG, i.e.,

$$\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) = \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\}. \tag{45}$$

To prove,
$G_{A,V_i\bigcup V_j\bigcup V_K}$ is an IFSTG.We know that

$$\begin{aligned}\overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}), \\ \Rightarrow \overline{\mathfrak{I}_e}(x_{ii}, y_{jj}) &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} - \mathfrak{I}_e(x_{ii}, y_{jj}), \\ &= \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} \\ &\quad - \min\{\wp_e(x_{ii}), \wp_e(y_{jj})\} \quad \text{By}\,(3), \\ \mathfrak{I}_e(x_{ii}, y_{jj}) &= 0.\end{aligned} \tag{46}$$

Similarly,

$$\overline{\mathfrak{I}_e}(y_{jj}, z_{kk}) = 0 \& \overline{\mathfrak{I}_e}(z_{kk}, x_{ii}) = 0. \tag{47}$$

Hence, $G_{A,V_i\bigcup V_j\bigcup V_k}$ is an IFSTG. □

5. Application

To accomplish objectives in their day-to-day existence, they need the best school and the understudies assume a significant part in professional openings in any organization. Recruiting the best school and the best understudy, they pick the best programming organization is a challenging process. A study is carried out here using PFSTG. The study's goal is to find the best match between colleges, students, and software companies.

Consider colleges, students, and software companies to be three sets of disjoint vertex sets, with matching qualities as parameters and preferences for colleges, students, and software companies as edges. Let $V = v_i \bigcup v_j \bigcup v_k = \{v_i\colon (a_1, a_2, a_3)\}, \{v_j\colon (b_1, b_2, b_3)\}, \{v_k\colon (c_1, c_2, c_3)\}$ are set of

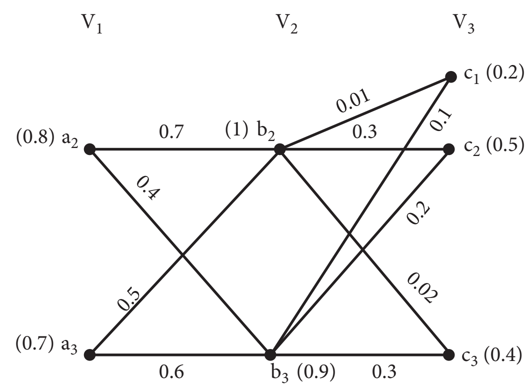


Figure 8: $F(e_2)$.

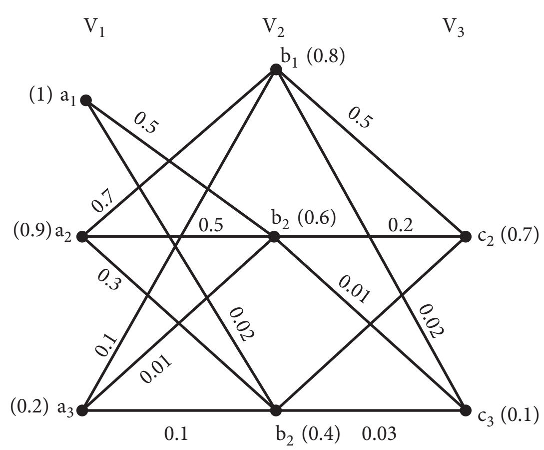


Figure 9: $F(e_3)$.

all three disjoint vertices and $A = \{e_1, e_2, e_3, e_4\}$ are parameter set.

Identified qualities of colleges are given below.

a_1 = Good communication and a comfortable environment.

a_2 = Professional advancement and on-site opportunity.

a_3 = On-site opportunity and a comfortable environment.

Identified qualities of students are given below.

b_1 = Self-discipline and responsible.

b_2 = Professional skills and responsible.

b_3 = Confident and professional skills.

Identified qualities of software companies are given below.

c_1 = Good salary and friendly work environment.

c_2 = Transparency and good salary.

c_3 = Professional advancement and friendly work environment.

Also, the parameters are

e_1 ={college-a comfortable environment, student-confident, company-good salary}

e_2 ={college-professional advancement, student-responsible, company-Friendly work environment}

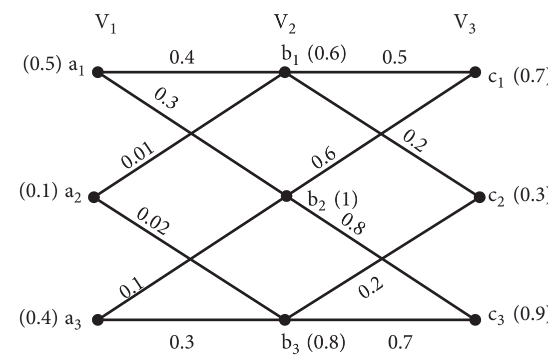


Figure 10: $F(e_4)$.

Table 3: Relation between vertices and parameters of perfect fuzzy soft tripartite graphs.

ρ	a_1	a_2	a_3	b_1	b_2	b_3	c_1	c_2	c_3
e_1	0.1	0.3	0	0.4	0.5	0	0.8	0.9	1
e_2	1	0.9	0.2	0.8	0.6	0.4	0	0.7	0.1
e_3	0	0.8	0.7	0	1	0.9	0.2	0.5	0.4
e_4	0.5	0.1	0.4	0.6	1	0.8	0.7	0.3	0.9

μ	e_1	e_2	e_3	e_4
a_1b_1	0.01	0	0	0.4
a_1b_2	0.02	0.5	0	0.3
a_1b_3	0	0.02	0	0
a_2b_1	0.1	0.7	0	0.01
a_2b_2	0.2	0.5	0.7	0
a_2b_3	0	0.3	0.4	0.02
a_3b_1	0	0.1	0	0
a_3b_2	0	0.01	0.5	0.1
a_3b_3	0	0.1	0.6	0.3
b_1c_1	0.3	0	0	0.5
b_1c_2	0.3	0.5	0	0.2
b_1c_3	0.03	0.02	0	0
b_2c_1	0.04	0	0.01	0.6
b_2c_2	0.1	0.2	0.3	0
b_2c_3	0.4	0.01	0.02	0.8
b_3c_1	0	0	0.1	0
b_3c_2	0	0.3	0.2	0.2
b_3c_3	0	0.3	0.3	0.7

e_3 ={college-on-site opportunity, student-professional skills, company-Transparency}

e_4 ={college-good communication, student-self-discipline, company-professional advancement}

Example 4. Consider $F(e_1)$, $F(e_2)$, $F(e_3)$, and $F(e_4)$ defined in Figures 7–10 (Table 3).

$$\begin{aligned} S[F(e_1)] &= 1.5S[F(e_2)] \\ &= 3.29S[F(e_3)] \\ &= 3.13S[F(e_4)] \\ &= 4.13. \end{aligned} \tag{48}$$

Most of the best colleges taught good communication skills, software companies hired self-disciplined students, and students preferred software companies with good professional advancement. According to the above discussion, "the most favourable matching occurs between good communication in college, self-discipline student, and professional advancement in company."

6. Comparison Analysis

Only the principles and applications of fuzzy soft bipartite graphs were discussed previously. Later, we discovered a novel size concept that was only used for perfect fuzzy soft tripartite graphs. Following that, the concepts were applied to the complement of perfect fuzzy soft tripartite graphs. Perfect fuzzy soft tripartite graphs produce better results than fuzzy soft bipartite graphs. The value of the perfect fuzzy soft tripartite graph is larger than that of the fuzzy soft bipartite graph, which gives exact maximum values.

7. Conclusion

PFSTG and its complements are a modern phenomenon based on the combination of fuzzy graphs. The introduction of these PFSTG is a novel idea that can be expanded into a variety of graph hypothetical concepts. We introduced this PFSTG and its complement, explored their properties, and established related theorems to contribute to the theoretical aspect of the fuzzy graph theory. The PFSTG and its complement, as well as several of its fundamental properties, have been defined. The order, size, and degree of PFSTG have been defined with appropriate examples. We have used this PFSTG in a practical application. Since 1965, several generalizations of fuzzy sets are introduced including picture fuzzy, interval-valued fuzzy, Pythagorean fuzzy, and spherical fuzzy sets. The theory established in this article can be extended to these generalizations. Graph theory and fuzzy sets are two important areas with wide range applications in real life combining the two will broaden the application by integrating the uncertain and imprecise information.

Data Availability

No data are used to support this study.

Disclosure

The statements made and views expressed are solely the responsibility of the authors.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Authors' Contributions

All authors contributed equally to the preparation of this manuscript.

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