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PRODUCT OF TOTAL AND RANGE FUZZY EDGE LABELING FOR FLOWER RELATED GRAPHS

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Abstract

In flower-related graph structures, it is feasible to define a hybrid labeling scheme combining the product of total and range fuzzy edge labeling. Vertices and edges are assigned labels such that the edge label equals the modulo product of the total and range of incident vertices labels. Edge membership values remain distinct based on a fuzzy function derived from the vertex labels. This interactive framework gives an adaptable technique to the analysis of extensive interconnected networks with uncertain or discontinuous connections by ensuring balance, injectivity, and inconsistency.

Key Words Lotus flower, shell flower, zinnia flower, cherry blossom flower.

1 Introduction

The labels in graph labeling theory are mathematical entities that may be prime numbers, either group members, modular integers, or integers. Labeling graphs have been the subject of numerous studies[1,2,9]. Finding graph classes that support a particular type of labeling has been the main focus of an analysis of graph labeling. Many practical issues in the actual world have spurred study toward labeling a graph under particular circumstances [5,6, 10].Fuzzy set theory is the opposite of fuzzy graphs. L. A. Zadeh first defined a fuzzy set in 1965[7,8].Each component of the universal set has a membership grade, which is a value between 0 and 1.A fuzzy set is created by combining the elements of the universal set with their membership grades. In 1965, Zadeh was the first to define fuzzy relations on a set. On G1 and G2, there are numerous operations[12,13]. Union, intersection, and symmetric difference all operations on (crisp) graphs were extended to fuzzy graphs via matching. A collection of non-adjacent edges is called a matching. Our findings are examined here for a basic connected fuzzy labeling graph [14,15].

Definition 1.1. The term "vertex-labeled graph" refers to a graph that has a vertex labeling defined, which is a function of V to a set of labels given a graph G = (V, E). Similarly, an edge labeling affects a set of labels as a function of E. The graph in this instance is referred to as an edge-labeled graph.

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Definition 1.2. Every vertex and edge in a fuzzy graph with a membership value between 0 and 1 is called a fuzzy labeling graph. To guarantee that the membership values of vertices and edges are different, this assignment is carried out via a bijective function. The minimum membership value of the vertices that are connected to an edge is always greater than or equal to the edge's membership value.

Definition 1.3. A graph $G = (V, E)$ is said to be a product of total and range fuzzy labeling if $\rho : v \to [0, 1]$ and $\delta : V \times V \to [0, 1]$ are bijective $\delta(u, v) < \rho(u) \wedge \rho(v)$ and $\delta(u, v) = |\rho(u + v)\, \rho(u - v) \forall u, v \in V$.

Definition 1.4 ([3]). A vertex is added between each pair of neighboring vertices on a shell graph's cycle to create a stem-lotus graph.

Definition 1.5 ([11]). Every shell in the shell flower graph is referred to as a petal, therefore it has k petals and k pendant edges. The shell $C(n; n-3)$ and K_2 are both represented by k copies, with one vertex of K_2 attached to the shell's apex.

Definition 1.6 ([4]). Zinnia flower graph $Z(n)$ with $n \geq 1$ is a graph with

$$V(Z(n)) = \{\, a_i \mid 1 \leq i \leq 2n+2 \,\} \cup \{\, b_j \mid j = 1, 2 \,\} \cup \{\, c_{ij} \mid 1 \leq i \leq n,\ j = 1, 2 \,\}$$

and

$$\begin{aligned} E(Z(n)) = \{\, a_i b_j \mid 1 \leq i \leq 2n+2,\ j = 1, 2 \,\} \\ \cup \{\, a_1 c_{ij} \mid 1 \leq i \leq n,\ j = 1, 2 \,\} \\ \cup \{\, a_2 c_{ij} \mid 1 \leq i \leq n,\ j = 1, 2 \,\}. \end{aligned}$$

Definition 1.7 ([16]). The cherry blossom flower graph in CB_n and $CB_{n,m}$ with $(n - 1 \leq m \leq 32(n-1))$. The cherry blossom graph obtained from S_n by attaching $mn + 1$ edges to different pairs of pendant vertices, such that the pendant vertices of S_n is of degree no more than 2.

2 Computation of the product of total and range fuzzy edge labelling for flower related graphs

Theorem 2.1. *The lotus flower graph $[L_3 \odot C_4 \odot S_1]2P_n$, if $n \geq 1$ is product of total and range fuzzy edge graph.*

Proof. The lotus flower graph $[L_3 \odot C_4 \odot S_1]2P_n$ The apex $a = 4n + 5$ and length $l = 5n + 8$.
The set $\rho(G) = \{u, v, u_1, u_2, u_3, \ldots, u_{gn}, v_1, v_2, v_3, \ldots, v_{gn+1}, w_1, w_2, w_3, \ldots, w_n\}$ Let, u be the centre of vertex in flower graph, v be the stem vertex attached by centre of the vertex, $(u_1, u_2, u_3, \ldots u_{2n})$ be the vertices joined by centre of the vertex u. $(v_1, v_2, v_3, \ldots v_{2n+1})$ be the vertices attached by the vertices of $(u_1, u_2, u_3, \ldots u_{2n})(w_1, w_2, \ldots .w_6)$ be the vertices joined by the centre of the vertex in flower graph. Edge set

$$\begin{aligned} \delta(G) = \{e_1, e_2, e_3, \ldots, e_{2n}, f_1, f_2, f_3, \ldots, f_{2n}, e, g_1, g_2, \ldots, g_6\}, \\ e_i = |uu_i|, \quad f_i = |u_i v_i|, \\ e = |uw|, \quad g_i = |uw_i|, \end{aligned}$$

$(e(n_1, n_2))_1$ (as defined)

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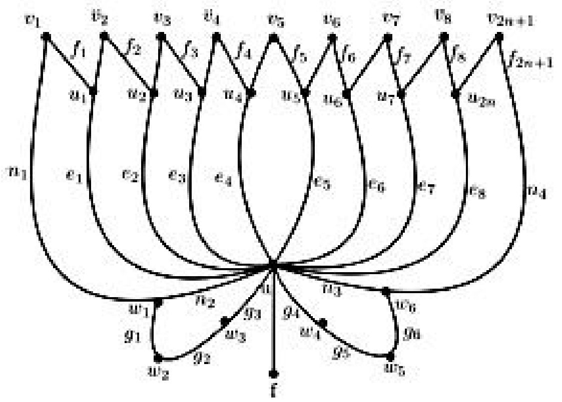

Figure 1: Lotus graph of PTRFE Graph

as shown in figure 1. The membership function for the vertices

$$
\begin{aligned}
&\rho : V \to [0,1] \\
&\rho(v_i) = \bigcup_{i=1}^{2n+1} (2n + 44 + i) \cdot 0.001, \\
&\rho(u_i) = \bigcup_{i=1}^{2n} (10n + 3 + 3i) \cdot 0.001, \\
&\rho(u) = (2n+1) \cdot 0.005, \\
&\rho(v) = (5n+2) \cdot 0.003 + 0.001, \\
&\rho(w_i) = \bigcup_{i=1}^{2p} (4n + 3 + 3i) \cdot 0.001, \quad \text{if } p = 3.
\end{aligned}
$$

The membership function for the Edges:

$$
\begin{aligned}
\delta(e_i) &= |(u + u_i)(u - u_i)|, && 1 \le i \le 2n+1, \\
\delta(f_i) &= |(u_i + v_i)(u_i - v_i)|, && 1 \le i \le 2n, \\
\delta(e) &= |(u + w)(u - w)|, \\
\delta(g_i) &= |(u + w_i)(u - w_i)|, && 1 \le i \le 2p, \\
\delta(n_1, n_2) &= |(v + w)(v - w)|.
\end{aligned}
$$

Hence, Product of total and range fuzzy edge graph, membership value for the condition

$$\delta(e_i) < \rho(v_i) \wedge \rho(v_{i+1})$$

Then the general graph for the Lotus Graph,

Example: The Lotus graph in Figure 2 is $[L_3 \odot C_4 \odot S_1]2P_3$ with: Apex = 17, Length = 23

Vertex Labels:

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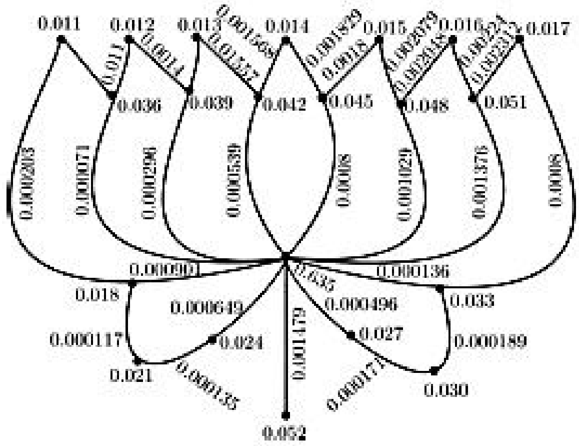

Figure 2:

$\rho(u) = 0.035$	$\rho(v) = 0.052$
$\rho(u_1) = 0.036$	$\rho(v_1) = 0.011$
$\rho(u_2) = 0.039$	$\rho(v_2) = 0.012$
$\rho(u_3) = 0.042$	$\rho(v_3) = 0.013$
$\rho(u_4) = 0.045$	$\rho(v_4) = 0.014$
$\rho(u_5) = 0.048$	$\rho(v_5) = 0.015$
$\rho(u_6) = 0.051$	$\rho(v_6) = 0.016$
	$\rho(v_7) = 0.017$
$\rho(w_1) = 0.018$	$\rho(w_4) = 0.027$
$\rho(w_2) = 0.021$	$\rho(w_5) = 0.030$
$\rho(w_3) = 0.024$	$\rho(w_6) = 0.033$

Edge Labels

$\delta(e) = 0.001479$	$\delta(f_1) = 0.001$	$\delta(f_1^1) = 0.0014$
$\delta(e_1) = 0.000071$	$\delta(f_2) = 0.0013$	$\delta(f_2^1) = 0.01557$
$\delta(e_2) = 0.000296$	$\delta(f_3) = 0.0015$	$\delta(f_3^1) = 0.001829$
$\delta(e_3) = 0.00539$	$\delta(f_4) = 0.0018$	$\delta(f_4^1) = 0.002079$
$\delta(e_4) = 0.0008$	$\delta(f_5) = 0.002048$	$\delta(f_5^1) = 0.00224$
$\delta(e_5) = 0.001079$	$\delta(f_6) = 0.002312$	
$\delta(e_6) = 0.001376$		

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$$\begin{aligned} \delta(h_1) &= 0.000203 & \delta(g_1) &= 0.000117 \\ \delta(h_2) &= 0.000901 & \delta(g_2) &= 0.000135 \\ \delta(h_3) &= 0.000136 & \delta(g_3) &= 0.0006 \\ \delta(h_4) &= 0.0008 & \delta(g_4) &= 0.000496 \\ & & \delta(g_5) &= 0.000171 \\ & & \delta(g_6) &= 0.000189 \end{aligned}$$

Theorem 2.2. *The Shell-flower graph mp_1Ak, Ams_n is product of total and range fuzzy edge graph.*

Proof. Let mp_1Ak, Ams_n be a Shell-flower graph, with apex a and length l as:

$$a = 5n + 1, \quad l = 5n + 6$$

The set

$$\rho(G) = \{v, v_1, v_2, v_3, \ldots, v_{4m}, u_1, u_2, \ldots, u_m\}$$

Let v be the centre of the vertex, joined by $\{v, v_1, v_2, v_3, \ldots, v_{4m}\}$ vertices. The vertex v is attached by m copies of pendent vertices.

Let Edge set be

$$\delta(G) = \{e_1, e_2, \ldots, e_{4m}, f_1, f_2, \ldots, f_{4m-1}, h_1, h_2, \ldots, h_m\}$$

$$\begin{aligned} \delta(e_i) &= |v, v_i|, & \delta(f_i) &= |v, v_{i+1}| \\ \delta(n_i) &= |v, u_i|, & 1 &\le i \le m \end{aligned}$$

The membership function for the vertex label:

$$\begin{aligned} \rho(v_i) &= \bigcup_{i=1}^{4m} (2mn - 1 + 5i)0.01, && \text{if } n = 4 \text{ petals}, m = \text{no. of copies} \\ \rho(u_i) &= \bigcup_{i=1}^{m} (7mn + 5i - 1)0.01, && \text{if } n = 4 \text{ petals}, m = \text{no. of copies} \\ \rho(v) &= 8mn + 3 \end{aligned}$$

The membership function for the edge label:

$$\begin{aligned} \delta(e_i) &= |(v + v_i)(v - v_i)|, && 1 \le i \le mn \\ \delta(f_i) &= |(v_i + v_{i+1})(v_i - v_{i+1})|, && 1 \le i \le mn \\ \delta(h_i) &= |(v + u_i)(v - u_i)|, && 1 \le i \le m \end{aligned}$$

Main condition for the product of total and range fuzzy edge graph:

$$\delta(e_i) = \rho(v_i) \wedge \rho(v_{i+1})$$

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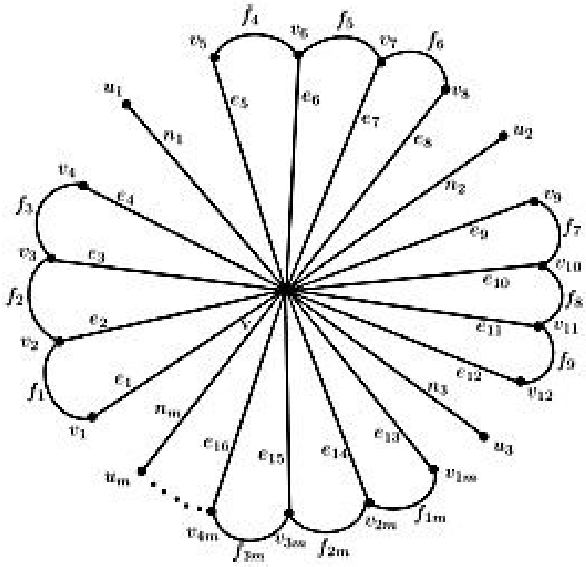

Figure 3: Shell-flower graph of PTRFE Graph

Example: The graph $3p_1Ak_1A3s_4$ is shown in Figure 4. The Shell-flower graph with Apex and length are:

$$a = 16, \quad l = 21$$

Vertex Labels:

$\rho(v_1) = 0.02$	$\rho(v_7) = 0.050$
$\rho(v_2) = 0.025$	$\rho(v_8) = 0.055$
$\rho(v_3) = 0.030$	$\rho(v_9) = 0.06$
$\rho(v_4) = 0.035$	$\rho(v_{10}) = 0.065$
$\rho(v_5) = 0.040$	$\rho(v_{11}) = 0.070$
$\rho(v_6) = 0.045$	$\rho(v_{12}) = 0.075$
$\rho(u_1) = 0.080$	
$\rho(u_2) = 0.085$	
$\rho(u_3) = 0.090$	
$\rho(v) = 0.095$	

Edge Labels

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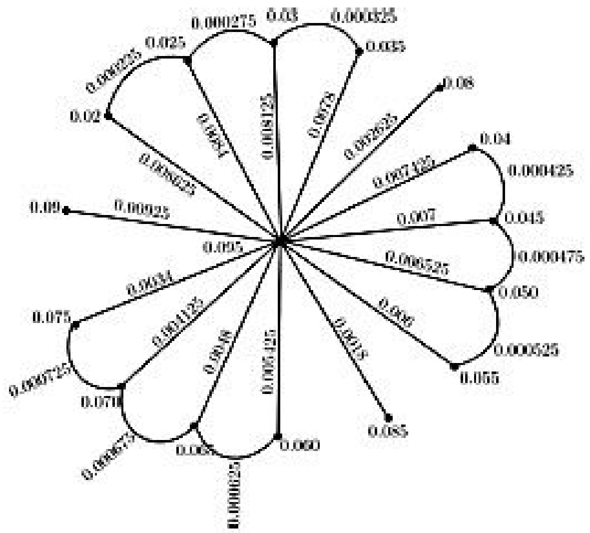

Figure 4: Shell-flower graph of $3p_1Ak_1A3s_4$ in PTRFE Graph

$\delta(e_1) = 0.008625$	$\delta(h_1) = 0.002625$
$\delta(e_2) = 0.0084$	$\delta(h_2) = 0.0018$
$\delta(e_3) = 0.008125$	$\delta(h_3) = 0.000925$
$\delta(e_4) = 0.0078$	$\delta(f_1) = 0.000225$
$\delta(e_5) = 0.007425$	$\delta(f_2) = 0.000275$
$\delta(e_6) = 0.007$	$\delta(f_3) = 0.000325$
$\delta(e_7) = 0.006525$	$\delta(f_4) = 0.000425$
$\delta(e_8) = 0.006$	$\delta(f_5) = 0.000475$
$\delta(e_9) = 0.005425$	$\delta(f_6) = 0.000525$
$\delta(e_{10}) = 0.0048$	$\delta(f_7) = 0.000625$
$\delta(e_{11}) = 0.004125$	$\delta(f_8) = 0.000675$
$\delta(e_{12}) = 0.0034$	$\delta(f_9) = 0.000725$

Theorem 2.3. *Zinnia flower*$(Z_4 \odot 4P_n)$, *if* $n \geq 1$ *is product of Total and Range fuzzy edge graph.*

Proof. $(Z_4 \odot 4P_n)$ be a Zinnia flower graph. The graph Z_4 is cycle graph with attached n number of pedals. Then the graph apex $a = mn + 4$, length $l = mn + 8$.

The vertex set is

$$\rho(G) = \{z_1, z_2, z_3, z_4, v_1, v_2, \ldots, v_{4n}\}$$

where the vertices $\{z_1, z_2, z_3, z_4\}$ are attached by the vertices $\{v_1, v_2, \ldots, v_{4n}\}$.

The edge set is

$$\delta(G) = \{e_1, e_2, e_3, e_4, f_1, f_2, \ldots, f_{4n}, g_1, g_2, \ldots, g_{4n}\}$$

where

$$\delta(e_i) = |z_i z_{i+1}|, \quad \delta(f_i) = |z_i v_i|, \quad \delta(g_i) = |z_{i+2} v_i|$$

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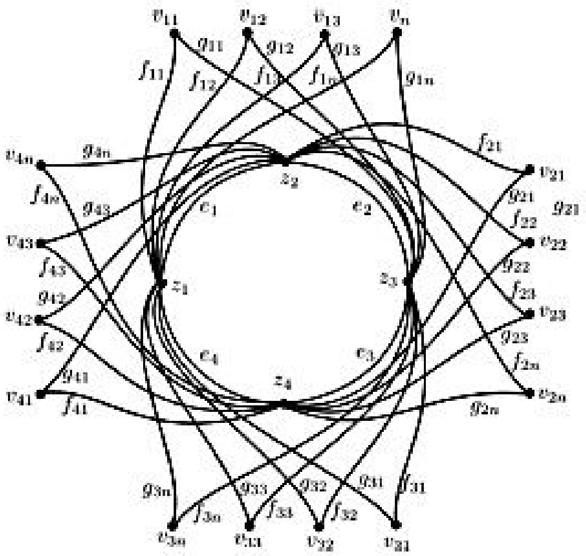

Figure 5: Zinnia flower graph $Z_4 4P_n$

The main condition for the product of Total and Range fuzzy edge graph:

$$\delta(e_i) < \rho(v_i) \wedge \rho(v_{i+1})$$

Vertex Labels:

$$\rho(z_i) = \bigcup_{i=1}^{m} (m+1+5i)0.001, \qquad \text{if } m=4, i=1,2,\ldots,m$$

$$\rho(v_i) = \bigcup_{i=1}^{4m} (4m+3n+3+2i)0.001, \qquad \text{if } m=4, i=1,2,\ldots,4m$$

Edge Labels:

$$\begin{aligned} \delta(e_i) &= |(z_i+z_{i+1})(z_i-z_{i+1})|, && 1 \le i \le 4 \\ \delta(f_i) &= |(z_i+v_i)(z_i-v_i)|, && 1 \le i \le n \\ \delta(g_i) &= |(z_{i+2}+v_i)(z_{i+2}-v_i)|, && 1 \le i \le n \end{aligned}$$

□

Example

The graph $(Z_4 \odot 4P_n)$, 4P$_n$ as shown in Figure 4. The apex is given by $a = 20$ and the length is $l = 24$.

$$(Z_4 \odot 4P_n)$$

Vertex and Edge Labels for $(Z_4 \odot 4P_n)$, 4P$_n$ Vertex Labels

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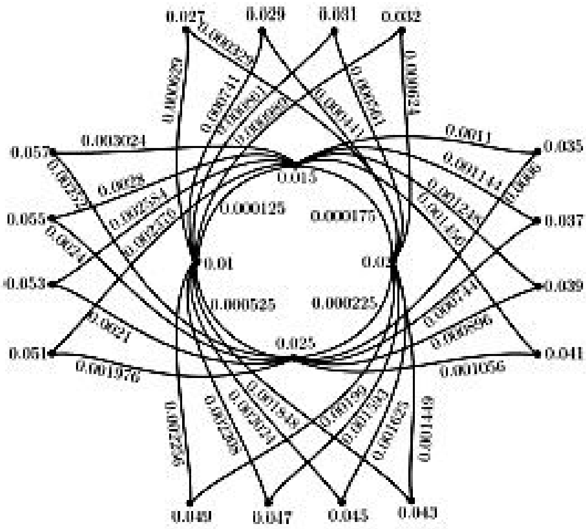

Figure 6: Zinnia flower graph of PTRFG ($Z_4 4P_4$)

$\rho(z_1) = 0.01$	$\rho(z_2) = 0.015$	$\rho(z_3) = 0.02$	$\rho(z_4) = 0.025$
$\rho(v_1) = 0.027$	$\rho(v_9) = 0.043$	$\rho(v_2) = 0.029$	$\rho(v_{10}) = 0.045$
$\rho(v_3) = 0.031$	$\rho(v_{11}) = 0.047$	$\rho(v_4) = 0.033$	$\rho(v_{12}) = 0.049$
$\rho(v_5) = 0.035$	$\rho(v_{13}) = 0.051$	$\rho(v_6) = 0.037$	$\rho(v_{14}) = 0.053$
$\rho(v_7) = 0.039$	$\rho(v_{15}) = 0.055$	$\rho(v_8) = 0.041$	$\rho(v_{16}) = 0.057$
00123			

Edge Labels

Edges e_i:

$\delta(e_1) = 0.000125, \quad \delta(e_2) = 0.000175, \quad \delta(e_3) = 0.000225, \quad \delta(e_4) = 0.000525$

Edges f_i:

$\delta(f_1) = 0.000629,\ \delta(f_2) = 0.000741,\ \delta(f_3) = 0.000861,\ \delta(f_4) = 0.000989,\ \delta(f_5) = 0.0011,\ \delta(f_6) = 0.$
$\delta(f_7) = 0.001248,\ \delta(f_8) = 0.001456,\ \delta(f_9) = 0.001449,\ \delta(f_{10}) = 0.001625,\ \delta(f_{11}) = 0.001593,\ \delta(f_{12})$
$\delta(f_{13}) = 0.001972,\ \delta(f_{14}) = 0.0021,\ \delta(f_{15}) = 0.0024,\ \delta(f_{16}) = 0.0025$

Edges h_i:

$\delta(h_1) = 0.000329,\ \delta(h_2) = 0.000441,\ \delta(h_3) = 0.000561,\ \delta(h_4) = 0.000624,\ \delta(h_5) = 0.0006,\ \delta(h_6) =$
$\delta(h_7) = 0.000896,\ \delta(h_8) = 0.001056,\ \delta(h_9) = 0.001848,\ \delta(h_{10}) = 0.002024,\ \delta(h_{11}) = 0.002208,\ \delta(h_{1}$
$\delta(h_{13}) = 0.002376,\ \delta(h_{14}) = 0.002584,\ \delta(h_{15}) = 0.0028,\ \delta(h_{16}) = 0.003024$

□

Theorem 2.4. *Let $nCB_2\,Ak_1AP_n$ be a Cherry Blossom flower graph. Then it is the product of Total and Range fuzzy edge graph.*

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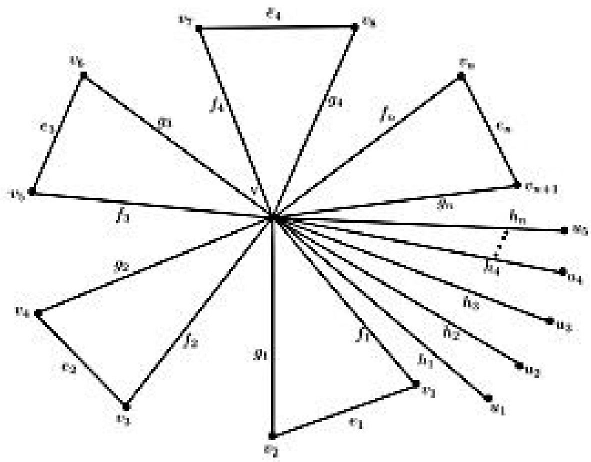

Figure 7: Cherry blossom graph in PTEFL

Proof. Consider $nCB_2\,Ak_1AP_n$ be a Cherry Blossom flower graph with apex

$$a = 3n + 1, \quad \text{and length } l = 4n + 1.$$

The vertex set is defined as

$$\rho(G) = \{v, v_1, v_2, \ldots, v_{2n}, u_1, u_2, \ldots, u_n\}.$$

The central vertex v is attached to the vertices $\{v_1, v_2, \ldots, v_{2n}\}$, and each vertex v_i is further connected to the pendent vertices $\{u_1, u_2, \ldots, u_n\}$.

The edge set is given by

$$\delta(G) = \{e_1, e_2, \ldots, e_n, f_1, f_2, \ldots, f_n, g_1, g_2, \ldots, g_n, h_1, h_2, \ldots, h_n\},$$

where

$$\begin{aligned} e_i &= |v_i v_{i+1}|, \\ f_i &= |v v_i|, \\ g_i &= |v v_{i+1}|, \\ h_i &= |v u_i|, \quad \text{for } 1 \leq i \leq n, \end{aligned}$$

as shown in Figure 7.

Vertex Labels:

$$\begin{aligned} \rho(v_{2i-1}) &= \bigcup_{i=1}^{n} (4n + 3 + i)\,0.01, \quad n \geq 1, \\ \rho(v_{2i}) &= \bigcup_{i=1}^{n} (7n - i)\,0.01, \quad n \geq 1, \\ \rho(v) &= (7n)\,0.01, \\ \rho(u_i) &= \bigcup_{i=1}^{n} (7n + 2 + i)\,0.01. \end{aligned}$$

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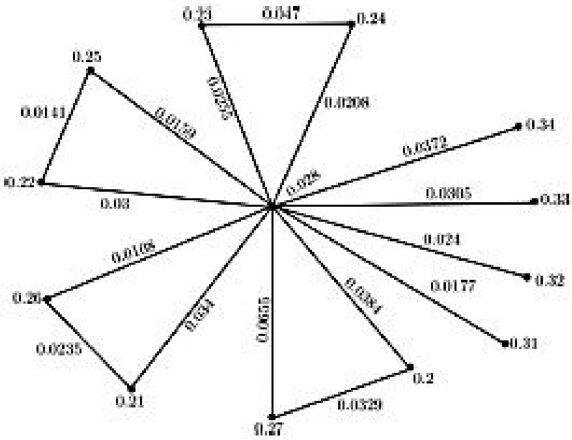

Figure 8: Cherry blossom graph $4CB_2AK_1AP_4$

Edge Labels:

$$\delta(e_i) = |(v_i + v_{i+1})(v_i - v_{i+1})|,$$
$$\delta(f_i) = |(v_i + v)(v_i - v)|,$$
$$\delta(g_i) = |(v_{i+1} + v)(v_{i+1} - v)|,$$
$$\delta(h_i) = |(v_i + u_i)(v - u_i)|.$$

Example:

The graph $4CB_2AK_1P_4$ is a PTEFL labeling.
The apex is $a = 13$ and the length is $l = 17$.

Vertex Values:

$$\rho(v_1) = 0.20, \quad \rho(v_2) = 0.27, \quad \rho(v_3) = 0.21, \quad \rho(v_4) = 0.26,$$
$$\rho(v_5) = 0.22, \quad \rho(v_6) = 0.25, \quad \rho(v_7) = 0.23, \quad \rho(v_8) = 0.24,$$
$$\rho(u_1) = 0.31, \quad \rho(u_2) = 0.32, \quad \rho(u_3) = 0.33, \quad \rho(u_4) = 0.34.$$

Edge Values:

$$\delta(e_1) = 0.0329, \quad \delta(e_2) = 0.0235, \quad \delta(e_3) = 0.0141, \quad \delta(e_4) = 0.047,$$
$$\delta(f_1) = 0.0384, \quad \delta(f_2) = 0.0340, \quad \delta(f_3) = 0.0300, \quad \delta(f_4) = 0.0255,$$
$$\delta(g_1) = 0.0056, \quad \delta(h_1) = 0.0179, \quad \delta(h_2) = 0.0240, \quad \delta(h_3) = 0.0305,$$
$$\delta(h_4) = 0.0372.$$

Hence, the Cherry Blossom fuzzy graph $nCB_2\, Ak_1AP_n$ represents the product of Total and Range fuzzy edge graph. □

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