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AN APPLICATION OF DOMINATION IN VAGUE FUZZY INCIDENCE GRAPHS

K.KALAIARASI *, P.GEETHANJALI

Abstract. Fuzzy Graphs (FGs), also known as Fuzzy Incidence Graphs (FIGs), are a well-organized and useful tool for capturing and resolving a range of real-world scenarios involving ambiguous data and information. In this paper, the Composition of Two Vague Fuzzy Incidence Graphs (CT-VFIGs) and use incidence pairs to extend the idea of FG dominance to CT-VFIGs defined . Examples are used to clarify the concepts of Edge Incidentally Dominating Set (EIDS), Strong Edge Incidentally Dominating Set (SEIDS), and Weak Edge Incidentally Dominating Set (WEIDS).CT-VFIGs have an Edge Incidentally Domination Number (EIDN), a Strong Edge Incidentally Domination Number (SEIDN), and a Weak Edge Incidentally Domination Number (WEIDN). In the research field, CT-VIFGs are used to find the best combinations of journal publications that express the most progress and the least amount of non-progress. The results of our investigation are compared to those of other studies. Our research will help us fully appreciate and comprehend the additional properties of CT-VFIGs.Another benefit of our research is that it will aid in determining the maximum percentage of progress and the minimum percentage of non-progress in various journal publications.

KEYWORDS: Vague Fuzzy Incidence Graph, Composition of two VFIGs, Strong Edge Incidentally Dominating Set, Weak Edge Incidentally Dominating Set.

1. Introduction

Zadeh [40] [42] [43] introduced fuzzy set theory and related fuzzy logic as a technique of dealing with and addressing a wide range of situations in which variables, parameters, and relationships are only approximated, necessitating the employment of approximate reasoning systems. This is true of practically all nontrivial occurrences, processes, and systems that exist in reality, and standard binary logic mathematics cannot sufficiently characterize them.We summariseGorzalczany's work on interval-valued fuzzy sets(IVFSs) [8] and Roy *et al.* [29] works on fuzzy relations because interval-valued fuzzy graphs (IVFGs) are commonly employed. Vague sets (VSs) were first proposed by W.L Gau and D.J Buehrer [7]. FG operations were investigated by R. Parvathi *et al.* [22]. In vague graphs (VGs), N. Ramakrishna [6] developed the concepts. In IFGs, A. N. Gani [9] developed the concepts of degree, order, and size. S. Samanta and M. Pal [30] have also expressed many FGs. H. Rashmanlou and M. Pal [26] advised irregular IVFGs.Akram. M [2] proposed vague hyper graphs. Degree of vertices in VGs were proposed by Borzooei [3]. Dinesh [5] looked at the topic of FIGs.Borzooei *et al.* [4] suggested and implemented regularity of VGs. Kalaiarasi & Mahalakshmi have also articulated and Kalaiarasi & Gopinath discussed fuzzy strong graphs. Akram *et al.* [1] proposed the concept Cayley VGs. S. Mathew and J.N.

Mordeson [17] proposed concepts in FIGs.Mordeson *et al. [*19] talked about VFIGs. Properties of VGs extended by Rao *et al. [*27].

Ore and Berge were the first to introduce dominance. IrfanNazeer *et al. [*11], developed the new graph'sproduct. Haynes and Hedetniemi[10] looked into dominance in graphs further. Somasundaram and Somasundaram[33] have gained supremacy in FGs by utilising effective edges. In FGs, Xavior *et al. [*38] suggested dominance. PradipDebnath [23] has also shown dominance in IVFGs. For FGs, Revathi and Harinarayaman [28] developed an equitable domination number. Sunitha & Manjusha [34] have also declared that they have a stronghold..Nagoorgani & Chandrasekaran [21] have also demonstrated dominance in a FG. Sarala & Kavitha [35] have also expressed (1,2)-domination for FGs. Dharmalingam & Nithya[6] have also provided dominance values for FGs. Manjusha *et al.* [18] have studied paired domination. In FIGs, IrfanNazeer *et al*. [12] have achieved dominance. AN Shain and MMQ Shubatah [36] advocated the inverted dominating set of IVFGs . Kalaiarasi *&* Sabina have also expressedfuzzy inventory EOQ optimization mathematical model [15]. Kalaiarasi *&* Gopinath suggested fuzzy inventory order EOQ model with machine learning [16]. A new path graph definition was proposed by Tushar *et al.* [32]. A .Nagoor Gani *et al.*[10] addressed domination in FGs. AM Ismayil and HS Begum[4] have both accurately depicted split dominance. In ambiguous graphs, Yongsheng Rao *et al*.[39] established dominance. Shanmugavadivu and Gopinath suggested non homogeneous ternary five degrees equation [31]. Shanmugavadivu and Gopinath have also expressedon the homogeneous five degree equation [32]. Priyadharshini *et al.* have also expresseda fuzzy MCDM approach for measuring the business impact of employee selection [24]. and Mapreduce Methodology for Elliptical Curve Discrete Logarithmic Problems [41].

Section 2 gives some preliminary findings that are required in order to understand the rest of the paper. A definition of CT-VIFGs is given in section 3. In section 4, we look at the relationship between CT-VFIG order and size. Domination in CT-VFIGs is discussed in Section 5. Strong and weak domination in CT-VFIGs is discussed in section 6. The application of CT-VFIGs is discussed in section 7. A comparative analysis is offered in section 8.

2. Preliminaries

Definition 2.1[12]

Assume $G_I = (V_I, E_I)$ is a graph. Then, $G_I = (V_I, E_I, I_I)$ is named as an incidence graph, where $I_I \subseteq V_I \times E_I$.

Definition 2.2[12]

Assume $G_{FS} = (V_{FS}, E_{FS})$ is a graph, μ_{FS} is a fuzzy subset of V_{FS}, and γ_{FS} is a fuzzy subset of $V_{FS} \times V_{FS}$. Let ψ_{FS} be a fuzzy subset of $V_{FS} \times E_{FS}$. If $\psi_{FS}(w_{11}, w_{11}w_{22}) \leq min\{\mu_{FS}(w_{11}), \gamma_{FS}(w_{11}w_{22})\}$ for every $w_{11} \in V_{FS}, w_{11}w_{22} \in E_{FS}$, then ψ_{FS} is a fuzzy incidence of G_{FS}.

Definition 2.3[12]

Assume G_I is a graph and (μ_I, γ_I) is a fuzzy sub graph of G_I. If ψ_I is a fuzzy incidence of G_I, then $G_I = (\mu_I, \gamma_I, \psi_I)$ is named as FIG of G_I.

Definition 2.4 [4]

A VS A is a pair (t_{VA}, f_{VA}) on set V where t_{VA} and f_{VA} are taken as real valued functions which can be defined on $V \to [0,1]$, so that $t_{VA}(w_{11}) + f_{VA}(w_{11}) \leq 1$, for all w_{11}belongs$V$. The interval $[t_{VA}(w_{11}), 1 - f_{VA}(w_{11})]$ is known as the vague value of $w_{11}$is A.

Definition 2.5[6]

A pair $G_V = (A, B)$ is said to be a VG on a crisp graph $G = (V, E)$, where $A = (t_{VA}, f_{VA})$ is a VS on V and $B = (t_{VB}, f_{VB})$ is a VS on $E \subseteq V \times V$ such that $t_{VB}(w_{11}w_{22}) \leq min(t_{VA}(w_{11}), t_{VA}(w_{22}))$ and $f_{VB}(w_{11}w_{22}) \geq max(f_{VA}(w_{11}), f_{VA}(w_{22}))$, for each edge $w_{11}w_{22} \in E$

Definition 2.6

An VFIG is of the form $G_{VI} = (V_{VI}, E_{VI}, I_{VI}, A_{VI}, B_{VI}, C_{VI})$ where $A_{VI} = (t_{A_{VI}}, f_{A_{VI}})$, $B_{VI} = (t_{B_{VI}}, f_{B_{VI}})$, $C_{VI} = (t_{C_{VI}}, f_{C_{VI}})$ and $V_{VI} = \{w_0, w_1, \ldots\ldots. w_n\}$ such that $t_{A_{VI}}: V_{VI} \to [0,1]$ and $f_{A_{VI}}: V_{VI} \to [0,1]$ represent the degree (DG) of membership(MS) and non membership (NMS) of the vertex $w_{ii} \in V_{VI}$ respectively, and $0 \leq t_{A_{VI}} + f_{A_{VI}} \leq 1$ for each $w_{ii} \in V_{VI}(i = 1,2,\ldots., n)$,$t_{B_{VI}}: V_{VI} \times V_{VI} \to [0,1]$ and $f_{B_{VI}} : V_{VI} \times V_{VI} \to [0,1]$ $t_{B_{VI}}(w_{11}, w_{22})$ and$f_{B_{VI}}(w_{11}, w_{22})$ show the DG of MS and NMS of the edge (w_{11}, w_{22}) respectively, such that$t_{B_{VI}}(w_{11}, w_{22}) \leq min\{t_{A_{VI}}(w_{11}), t_{A_{VI}}(w_{22})\}andf_{B_{VI}}(w_{11}, w_{22}) \geq max\{f_{A_{VI}}(w_{11}), f_{A_{VI}}(w_{22})\}$,$0 \leq t_{B_{VI}}(w_{11}, w_{22}) + f_{B_{VI}}(w_{11}, w_{22}) \leq 1$ for every (w_{11}, w_{22}), $t_{C_{VI}}: V_{VI} \times E_{VI} \to [0,1]$ and $f_{C_{VI}}: V_{VI} \times E_{VI} \to [0,1]$,$t_{C_{VI}}(w_{11}, w_{11}w_{22})$ and $f_{C_{VI}}(w_{11}, w_{11}w_{22})$ show the DG of MS and NMS of the incidence pair respectively, such that $t_{C_{VI}}(w_{11}, w_{11}w_{22}) \leq min\{t_{A_{VI}}(w_{11}), t_{B_{VI}}(w_{11}, w_{22})\}$ and

$f_{C_{VI}}(w_{11}, w_{11}w_{22}) \geq max\{f_{A_{VI}}(w_{11}), f_{B_{VI}}(w_{11}, w_{22})\}$, $0 \leq t_{C_{VI}}(w_{11}, w_{11}w_{22}) + f_{C_{VI}}(w_{11}, w_{11}w_{22}) \leq 1$ for every $(w_{11}, w_{11}w_{22})$.

3. Composition of two VFIGs

Definition 3.1

The Composition of two VFIGs (CT-VFIGs)$G^1_{VI} = (V^1_{VI}, E^1_{VI}, I^1_{VI}, A^1_{VIP}, B^1_{VIL}, C^1_{VII})$ and $G^2_{VI} = (V^2_{VI}, E^2_{VI}, I^2_{VI}, A^2_{VIP}, B^2_{VIL}, C^2_{VII})$ is defined as an VFIG

$G_{CVI} = G^1_{VI} \Theta G^2_{VI} = (V_{VI}, E_{VI}, I_{VI}, A^1_{VIP} \Theta A^2_{VIP}, B^1_{VIL} \Theta B^2_{VIL}, C^1_{VII} \Theta C^2_{VII})$where$V_{CVI} = V^1_{VI} \Theta V^2_{VI}$

and$E_{CVI} = \{((m_{11}, n_{11}), (m_{22}, n_{22}))/m_{11} = m_{22}, (n_{11}, n_{22}) \in E^2_{VI}\, or n_{11} = n_{22}, (m_{11}, m_{22}) \in E^1_{VI}\}$

$I_{CVI} = \{(m_{11}, n_{11}), (m_{11}, n_{11})(m_{11}, n_{22})/m_{11} = m_{22}, (n_{11}, n_{11}n_{22}) \in I^2_{VI}, (n_{22}, n_{11}n_{22}) \in I^2_{VI} or n_{11} = n_{22}(m_{11}, m_{11}m_{22}) \in I^1_{VI}, (m_{22}, m_{11}m_{22}) \in I^1_{VI}\}$with

$(A^1_{1VIP} \Theta A^2_{1VIP})(m_{11}, n_{11}) = min\{A^1_{1VIP}(m_{11}), A^2_{1VIP}(n_{11})\} \forall (m_{11}, n_{11}) \in V^1_{VI} \Theta V^2_{VI}$,

$(A^1_{2VIP} ? A^2_{2VIP})(m_{11}, n_{11}) = max\{A^1_{2VIP}(m_{11}), A^2_{2VIP}(n_{11})\} \forall (m_{11}, n_{11}) \in V^1_{VI} ? V^2_{VI}$

$$(B^1_{1VIL} ⍰ B^2_{1VIL})\big((m_{11},n_{11})(m_{22},n_{22})\big) = \begin{cases} min\{A^1_{1VIP}(m_{11}), B^2_{1VIL}(n_{11},n_{22})\}, if m_{11} = m_{22}, (n_{11},n_{22}) \in E^2_{VI} \\ min\{B^1_{1VIL}(m_{11},m_{22}), A^2_{1VIP}(n_{11})\}, if n_{11} = n_{22}, (m_{11},m_{22}) \in E^1_{VI} \\ min\{B^1_{1VIL}(m_{11},m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if n_{11} \neq n_{22}, (m_{11},m_{22}) \in E^1_{VI} \end{cases}$$

$$(B^1_{2VIL} ⍰ B^2_{2VIL})\big((m_{11},n_{11})(m_{22},n_{22})\big) = \begin{cases} max\{A^1_{2VIP}(m_{11}), B^2_{2VIL}(n_{11},n_{22})\}, if m_{11} = m_{22}, (n_{11},n_{22}) \in E^2_{VI} \\ max\{B^1_{2VIL}(m_{11},m_{22}), A^2_{2VIP}(n_{11})\}, if n_{11} = n_{22}, (m_{11},m_{22}) \in E^1_{VI} \\ max\{B^1_{1VIL}(m_{11},m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if n_{11} \neq n_{22}, (m_{11},m_{22}) \in E^1_{VI} \end{cases}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{11},n_{11}),(m_{11},n_{11})(m_{11},n_{22})] = min\{A^1_{1VIP}(m_{11}), C^2_{1VII}(n_{11},n_{11}n_{22})\} if m_{11} = m_{22}, (n_{11},n_{11}n_{22}) \in I^2_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{11},n_{22}),(m_{11},n_{11})(m_{11},n_{22})] = min\{A^1_{IVIP}(m_{11}), C^2_{IVII}(n_{22},n_{11}n_{22})\} if m_{11} = m_{22}, (n_{22},n_{11}n_{22}) \in I^2_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{11},n_{11}),(m_{11},n_{11})(m_{22},n_{11})] = min\{C^1_{1VII}(m_{11},m_{11}m_{22}), A^2_{1VIP}(n_{11})\} if n_{11} = n_{22}, (m_{11},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{22},n_{11}),(m_{11},n_{11})(m_{22},n_{11})] = min\{C^1_{1VII}(m_{22},m_{11}m_{22}), A^2_{1VIP}(n_{11})\} if n_{11} = n_{22}, (m_{22},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{11},n_{11}),(m_{11},n_{11})(m_{22},n_{22})] = min\{C^1_{1VII}(m_{11},m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{11},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{22},n_{22}),(m_{11},n_{11})(m_{22},n_{22})] = min\{C^1_{1VII}(m_{22},m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{22},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{11},n_{22}),(m_{11},n_{22})(m_{22},n_{11})] = min\{C^1_{1VII}(m_{11},m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{11},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{1VII} ⍰ C^2_{1VII})[(m_{22},n_{11}),(m_{11},n_{22})(m_{22},n_{11})] = min\{C^1_{1VII}(m_{22},m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{22},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{2VII} ⍰ C^2_{2VII})[(m_{11},n_{11}),(m_{11},n_{11})(m_{11},n_{22})] = max\{A^1_{2VIP}(m_{11}), C^2_{2VII}(n_{11},n_{11}n_{22})\} if m_{11} = m_{22}, (n_{11},n_{11}n_{22}) \in I^2_{VI}$$

$$(C^1_{2VII} ⍰ C^2_{2VII})[(m_{11},n_{22}),(m_{11},n_{11})(m_{11},n_{22})] = max\{A^1_{2VIP}(m_{11}), C^2_{2VII}(n_{22},n_{11}n_{22})\} if m_{11} = m_{22}, (n_{22},n_{11}n_{22}) \in I^2_{VI}$$

$$(C^1_{2VII} ⍰ C^2_{2VII})[(m_{11},n_{11}),(m_{11},n_{11})(m_{22},n_{11})] = max\{C^1_{2VII}(m_{11},m_{11}m_{22}), A^2_{2VIP}(n_{11})\} if n_{11} = n_{22}, (m_{11},m_{11}m_{22}) \in I^1_{VI}$$

$$(C^1_{2VII} ⍰ C^2_{2VII})[(m_{22},n_{11}),(m_{11},n_{11})(m_{22},n_{11})] = max\{C^1_{2VII}(m_{22},m_{11}m_{22}), A^2_{2VIP}(n_{11})\} if n_{11} = n_{22}, (m_{22},m_{11}m_{22}) \in I^1_{VI}$$

$(C^1_{2VII} \square C^2_{2VII})[(m_{11}, n_{11}), (m_{11}, n_{11})(m_{22}, n_{22})]$
$= max\{C^1_{2VII}(m_{11}, m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{11}, m_{11}m_{22}) \in I^1_{VI}$

$(C^1_{2VII} \square C^2_{2VII})[(m_{22}, n_{22}), (m_{11}, n_{11})(m_{22}, n_{22})]$
$= max\{C^1_{2VII}(m_{22}, m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{22}, m_{11}m_{22}) \in I^1_{VI}$

$(C^1_{2VII} \square C^2_{2VII})[(m_{11}, n_{22}), (m_{11}, n_{22})(m_{22}, n_{11})]$
$= max\{C^1_{2VII}(m_{11}, m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{11}, m_{11}m_{22}) \in I^1_{VI}$

$(C^1_{2VII} \square C^2_{2VII})[(m_{22}, n_{11}), (m_{11}, n_{22})(m_{22}, n_{11})]$
$= max\{C^1_{2VII}(m_{22}, m_{11}m_{22}), A^2_{1VIP}(n_{11}), A^2_{1VIP}(n_{22})\}, if m_{11} \neq m_{22}, n_{11} \neq n_{22}, (m_{22}, m_{11}m_{22}) \in I^1_{VI}$

Example 3.2

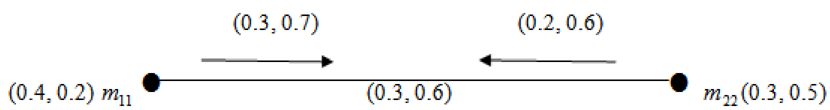

Figure1. VFIG G^1_{VI}

Figure 1 indicates a VFIG$G^1_{VI} = (V^1_{VI}, E^1_{VI}, I^1_{VI}, A^1_{VIP}, B^1_{VIL}, C^1_{VII})$ with
$A^1_{VIP}(m_{11}) = (0.4,0.2)$,$A^1_{VIP}(m_{22}) = (0.3,0.5)$,$B^1_{VIL}(m_{11}m_{22}) = (0.3,0.6)$,
$C^1_{VII}(m_{11}, m_{11}m_{22}) = (0.3,0.7)$,$C^1_{VII}(m_{22}, m_{11}m_{22}) = (0.2,0.6)$

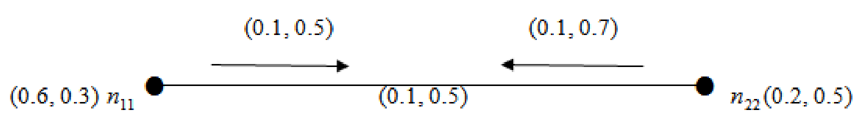

Figure2. VFIG G^2_{VI}

Figure 2 indicates a VFIG$G^2_{VI} = (V^2_{VI}, E^2_{VI}, I^2_{VI}, A^2_{VIP}, B^2_{VIL}, C^2_{VII})$ with
$A^2_{VIP}(n_{11}) = (0.6,0.3)$,$A^2_{VIP}(n_{22}) = (0.2,0.5)$,$B^2_{VIL}(n_{11}n_{22}) = (0.1,0.5)$,$C^2_{VII}(n_{11}, n_{11}n_{22}) = (0.1,0.5)$,$C^2_{VII}(n_{22}, n_{11}n_{22}) = (0.1,0.7)$.

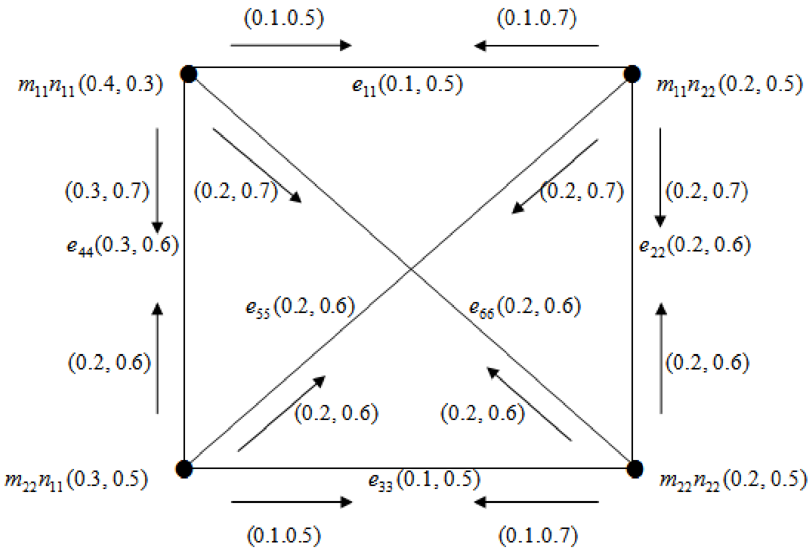

Figure3. Composition of figure 1 and figure 2

Figure 3 indicates a CT-VFIGs

$$G_{VI}^1 \square G_{VI}^2 = (V_{VI}, E_{VI}, I_{VI}, A_{VIP}^1 \square A_{VIP}^2, B_{VIL}^1 \square B_{VIL}^2, C_{VII}^1 \square C_{VII}^2)$$

$(A_{VIP}^1 \square A_{VIP}^2)(m_{11}, n_{11}) = (0.4,0.3)$, $(A_{VIP}^1 \Theta A_{VIP}^2)(m_{11}, n_{22}) = (0.2,0.5)$

$\left(A_{VIP}^1 \Theta A_{VIP}^2\right)(m_{22}, n_{11}) = (0.3,0.5)$ $(A_{VIP}^1 \square A_{VIP}^2)(m_{22}, n_{22}) = (0.2,0.5)$

$(B_{VIL}^1 \square B_{VIL}^2)\big((m_{11}, n_{11})(m_{11}, n_{22})\big) =$ 0.1,0.5, $(B_{VIL}^1 \Theta B_{VIL}^2)\big((m_{11}, n_{22})(m_{22}, n_{22})\big) = 0.2,0.6$,

$(B_{VIL}^1 \Theta B_{VIL}^2)\big((m_{22}, n_{11})(m_{22}, n_{22})\big) = 0.1,0.5$,

$(B_{VIL}^1 \Theta B_{VIL}^2)\big((m_{11}, n_{11})(m_{22}, n_{11})\big) = 0.3,0.6$,

$(B_{VIL}^1 \Theta B_{VIL}^2)\big((m_{11}, n_{11})(m_{22}, n_{22})\big) = 0.2,0.6$,

$(B_{VIL}^1 \Theta B_{VIL}^2)\big((m_{11}, n_{22})(m_{22}, n_{11})\big) = 0.2,0.6$

$(C_{VII}^1 \square C_{VII}^2)[(m_{11}, n_{11}), (m_{11}, n_{11})(m_{11}, n_{22})] = (0.1,0.5)$,$(C_{VII}^1 \Theta C_{VII}^2)[(m_{11}, n_{22}), (m_{11}, n_{11})(m_{11}, n_{22})] =$ (0.1,0.7), $(C_{VII}^1 \Theta C_{VII}^2)[(m_{11}, n_{22}), (m_{11}, n_{22})(m_{22}, n_{22})] = (0.2,0.7)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{22}), (m_{11}, n_{22})(m_{22}, n_{22})] = (0.2,0.6)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{11}), (m_{22}, n_{11})(m_{22}, n_{22})] = (0.1,0.5)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{22}), (m_{22}, n_{11})(m_{22}, n_{22})] = (0.1,0.7)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{11}, n_{11}), (m_{11}, n_{11})(m_{22}, n_{11})] = (0.3,0.7)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{11}), (m_{11}, n_{11})(m_{22}, n_{11})] = (0.2,0.6)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{11}, n_{11}), (m_{11}, n_{11})(m_{22}, n_{22})] = (0.2,0.7)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{22}), (m_{11}, n_{11})(m_{22}, n_{22})] = (0.2,0.6)$,

$(C_{VII}^1 \square C_{VII}^2)[(m_{22}, n_{11}), (m_{22}, n_{11})(m_{11}, n_{22})] = (0.2,0.6)$,

$$(C_{VII}^1 \square C_{VII}^2)[(m_{11}, n_{22}), (m_{22}, n_{11})(m_{11}, n_{22})] = (0.2,0.7)$$

Definition 3.3

Let G_{CVI} be a CT-VFIGs

(i) G_{CVI}cardinality is determined by

$$|G_{CVI}| = \sum_{w_{11} \in V_{VI}} \frac{1 + t_{A_{VIP}}(w_{11}) - f_{A_{VIP}}(w_{11})}{2} + \sum_{w_{11}w_{22} \in E_{VI}} \frac{1 + t_{B_{VIL}}(w_{11}w_{22}) - f_{B_{VIL}}(w_{11}w_{22})}{2} + \sum_{w_{11}, w_{11}w_{22} \in I_{VI}} \frac{1 + t_{C_{VII}}(w_{11}, w_{11}w_{22}) - f_{C_{VII}}(w_{11}, w_{11}w_{22})}{2}$$

(ii) G_{CVI} vertex cardinality is determined by $|V_{CVI}| = \sum_{w_{11} \in V_{CVI}} \frac{1+t_{A_{VIP}}(w_{11}) - f_{A_{VIP}}(w_{11})}{2} \forall w_{11} \in V_{CVI}$

(iii) G_{CVI} edge cardinality is specified by $|E_{CVI}| = \sum_{w_{11}w_{22} \in E_{CVI}} \frac{1+t_{B_{VIL}}(w_{11}w_{22}) - f_{B_{VIL}}(w_{11}w_{22})}{2} \forall w_{11}w_{22} \in E_{CVI}$

(iv) G_{CVI} incidence pair cardinality is specified by

$$|I_{CVI}| = \sum_{w_{11}, w_{11}w_{22} \in I_{CVI}} \frac{1 + t_{C_{VII}}(w_{11}, w_{11}w_{22}) - f_{C_{VII}}(w_{11}, w_{11}w_{22})}{2} \forall w_{11}, w_{11}w_{22} \in I_{CVI}$$

4. Relationship between order and size of CT-VFIGs

Definition 4.1

Assume G_{CVI} is a CT-VFIGs. Then $O_{CVI}(G_{CVI}) = \sum_{w_{11} \neq w_{22}, w_{11}, w_{22} \in V_{CVI}} \left(\frac{1+t_{C_{CVI}}(w_{11}, w_{11}w_{22}) - f_{C_{CVI}}(w_{11}, w_{11}w_{22})}{2} \right)$ is called order of G_{CVI} and $S_{CVI}(G_{CVI}) = \sum_{w_{11}, w_{22} \in E_{CVI}} \left(\frac{1+t_{B_{CVI}}(w_{11}, w_{22}) - f_{B_{CVI}}(w_{11}w_{22})}{2} \right)$ is called size of G_{CVI}.

Definition 4.2

The edge degree of a e_{1VI} in a CT-VFIGs is defined as the sum of the weights of edges incident to e_{1VI}. It is defined by $|d_{G_{CVI}}(e_{1VI})| = \{deg^t(e_{1VI}), deg^f(e_{1VI})\}$. The minimum cardinality of edge degree of G_{CVI} is $\delta_{CVI}(G_{CVI}) = min\{d_{G_{CVI}}(e_{1VI}) / e_{1VI} \in E_{CVI}\}$. The maximum cardinality of edge degree of G_{CVI} is $\Delta_{CVI}(G_{CVI}) = max\{d_{G_{CVI}}(e_{1VI}) / e_{1VI} \in E_{CVI}\}$

Proposition 4.3

In a CT-VFIGs $O_{CVI}(G_{CVI}) \geq S_{CVI}(G_{CVI})$

Proof. Let G_{CVI} be a CT-VFIGs with one node. Then $O_{CVI}(G_{CVI}) = S_{CVI}(G_{CVI}) = 0$. That is $O_{CVI}(G_{CVI}) = S_{CVI}(G_{CVI})$ (1)

It is a trivial case. Assume G_{CVI} with more than one nodes. $O_{CVI}(G_{CVI})$ is the sum of all incidence pairs cardinality of G_{CVI}. Since incidence pairs are two times of edges. Therefore, the total sum of all the incidence pairs cardinality will always greater than the total sum of all the edge cardinality.

$O_{CVI}(G_{CVI}) > S_{CVI}(G_{CVI})$ (2)

From equations (1) and (2), we get $O_{CVI}(G_{CVI}) \geq S_{CVI}(G_{CVI})$.

Proposition 4.4

For any CT-VFIGs the following inequality holds

$\delta_{CVI}(G_{CVI}) \leq$ ⍰$_{CVI}(G_{CVI}) \leq S_{CVI}(G_{CVI}) \leq O_{CVI}(G_{CVI})$.

Proof. Assume G_{CVI} is a CT-VFIGs with non empty node set.

Since $\delta_{CVI}(G_{CVI})$ represents lowest edge degree and $\Delta_{CVI}(G_{CVI})$ denotes highest edge degree of G_{CVI}.

$\delta_{CVI}(G_{CVI}) \leq$?$_{CVI}(G_{CVI})$ (3)

We know $O_{CVI}(G_{CVI}) = \sum_{w_{11} \neq w_{22}, w_{11}, w_{22} \in V_{CVI}} \left(\frac{1+t_{C_{CVI}}(w_{11}, w_{11}w_{22}) - f_{C_{CVI}}(w_{11}, w_{11}w_{22})}{2}\right)$

and $S_{CVI}(G_{CVI}) = \sum_{w_{11}, w_{22} \in E_{CVI}} \left(\frac{1+t_{B_{CVI}}(w_{11}, w_{22}) - f_{B_{CVI}}(w_{11}w_{22})}{2}\right)$

By definition of size of G_{CVI}, $S_{CVI}(G_{CVI}) = \sum_{w_{11}, w_{22} \in E_{CVI}} \left(\frac{1+t_{B_{CVI}}(w_{11}, w_{22}) - f_{B_{CVI}}(w_{11}w_{22})}{2}\right) \geq max\{d_{G_{CVI}}(e_{1VI})/e_{1VI} \in E_{CVI}\}$

That is $S_{CVI}(G_{CVI}) \geq$?$_{CVI}(G_{CVI})$ (4)

Also, in a CT-VFIGs, G_{CVI} by 4.3 proposition

$O_{CVI}(G_{CVI}) \geq S_{CVI}(G_{CVI})$ (5)

From inequalities (3), (4) and (5),we obtained$\delta_{CVI}(G_{CVI}) \leq$?$_{CVI}(G_{CVI}) \leq S_{CVI}(G_{CVI}) \leq O_{CVI}(G_{CVI})$

5. Domination in CT-VFIGs

Definition 5.1

A edge e_{VI}in an CT-VFIGs G_{CVI} is called incidentally dominate edge if $t_{C_{CVI}}(w_{11}, w_{11}w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{B_{CVI}}(w_{11}, w_{22})\}$and $f_{C_{CVI}}(w_{11}, w_{11}w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{B_{CVI}}(w_{11}, w_{22})\}$

Definition 5.2

A edge e_{1VI} in an CT-VFIGsG_{CVI} dominates to edge e_{2VI} if they are incidentally dominate edges.

Definition 5.3

A subset R_{CVI} of $E_{CVI}$is said to be edge incidentally dominating set (EIDS) if for each edge e_{1VI} not in R_{CVI}, e_{1VI} is dominate at least one edge in R_{CVI}.

Definition 5.4

A edge incidentally dominating set R_{CVI} of the CT-VFIGsG_{CVI} is said to be a minimal EIDS of CT-VFIGsG_{CVI} if each edge in R_{CVI}, the set$R_{CVI} - \{e_{1VI}\}$ is not a EIDS.

Definition 5.5

AEIDS with the lowest edge cardinality is called a minimum EIDS. The edge cardinality of a minimum EIDS is called edge incidentally dominating number of the CT-VFIGsG_{CVI}It is denoted by $\gamma_{VI}(G_{CVI})$

Example 5.6

In figure 3, the incidentally dominating edges are $\{e_{11}\}$, $\{e_{22}\}$, $\{e_{33}\}$, $\{e_{44}\}$,$\{e_{55}\}$, $\{e_{66}\}$and the EIDSs are $S_{11} = \{e_{11}e_{22}\}$,$S_{22} = \{e_{11}e_{33}\}$,$S_{33} = \{e_{11}e_{44}\}$,$S_{44} = \{e_{11}e_{55}\}$,$S_{55} = \{e_{11}e_{66}\}$,........ After calculating the edge cardinality of $S_{11}, S_{22}, . S_{33}, S_{44}, \ldots\ldots$, we obtain $|S_{11}| = 0.6$,$|S_{22}| = 0.6$,$|S_{33}| = 0.65$,$|S_{44}| = 0.6$,$|S_{55}| = 0.6$,....... Theedge cardinality of a minimum EIDS is $|S_{11}| = 0.6$and $\gamma_{VI}(G_{CVI}) = 0.6$.

Theorem 5.7

Let $G_{VI}^1 = (A_{VIP}^1, B_{VIL}^1, C_{VII}^1)$ and $G_{VI}^2 = (A_{VIP}^2, B_{VIL}^2, C_{VII}^2)$ be two VFIGs. Then $\gamma_{VI}(G_{CVI}) = min\{A_{VIP}^1(m_{11}), A_{VIP}^2(n_{11})\}$ where $m_{11} \in G_{VI}^1$and $n_{11} \in G_{VI}^2$

Proof. Assume $G_{VI}^1 = (A_{VIP}^1, B_{VIL}^1, C_{VII}^1)$ and $G_{VI}^2 = (A_{VIP}^2, B_{VIL}^2, C_{VII}^2)$ are two VFIGs. Since G_{VI}^1 and G_{VI}^2 are two VFIGs, then $G_{VI}^1 \Theta G_{VI}^2$ will be a VFIGs. So, each two edges in $G_{VI}^1 \Theta G_{VI}^2$ will dominates remaining edges. Then by definition of EIDN, $\gamma_{VI}(G_{CVI}) = min\{cardinalityof(A_{VIP}^1(m_{11}), A_{VIP}^2(n_{11}))\}$.

Theorem 5.8

Let $G_{VI}^1 = (A_{VIP}^1, B_{VIL}^1, C_{VII}^1)$ and $G_{VI}^2 = (A_{VIP}^2, B_{VIL}^2, C_{VII}^2)$ be two VFIGs with $k \geq 2$and $l \geq 2$, where k and $l$are representing the number of vertices in G_{VI}^1 and G_{VI}^2, respectively. Then $\frac{\gamma_{VI}(G_{CVI})}{2} = min\{cardinalityof(B_{VIL}^1(m_{11}m_{22}), B_{VIL}^2(n_{11}n_{22}))\}$.

Proof. Consider$G_{VI}^1 = (A_{VIP}^1, B_{VIL}^1, C_{VII}^1)$ and $G_{VI}^2 = (A_{VIP}^2, B_{VIL}^2, C_{VII}^2)$ are two VFIGs. Since G_{VI}^1 and G_{VI}^2 are VFIGs. Then $G_{VI}^1 \Theta G_{VI}^2$ will also a VFIG with $\frac{\gamma_{VI}(G_{CVI})}{2} = min\{cardinalityof(B_{VIL}^1(m_{11}m_{22}), B_{VIL}^2(n_{11}n_{22}))\}$ because each two edges in $G_{VI}^1 \Theta G_{VI}^2$ dominates to all remaining edges.

6. Strong and Weak Domination inCT-VFIGs

Definition 6.1

Let G_{CVI} be a CT-VFIGs. For any two edges $e_{1VI}, e_{2VI} \in E_{CVI}$,$e_{1VI}$ strongly dominates e_{2VI} in CT-VFIGsG_{CVI} if

(i) they are incidentally dominate edges

(ii) $deg^t(e_{1VI}) \geq deg^t(e_{2VI}), deg^f(e_{1VI}) \leq deg^f(e_{2VI})$

Similarly e_{1VI} weakly dominates e_{2VI}if

(i) they are incidentally dominate edges

(ii) $deg^t(e_{2VI}) \geq deg^t(e_{1VI}), deg^f(e_{2VI}) \leq deg^f(e_{1VI})$

Definition 6.2

An edge incidentally dominating set $R_{CVI} \subseteq E_{CVI}$ is called a strong (weak) edge incidentally dominating set (SEIDS,WEIDS) of G_{CVI} if, for each $e_{1VI} \in E_{CVI} - R_{CVI}$, there exist at least one edge $e_{2VI} \in R_{CVI}$, so that e_{1VI} strongly (weakly) dominates e_{2VI}. The strong (weak) edge incidentally domination number of G_{CVI} denoted by $\gamma_{SVI}(G_{CVI})\gamma_{WVI}(G_{CVI})$, is called as the minimum cardinality of a strong (weak) edge incidentally dominating set of G_{CVI}.

Example 6.3

In figure 3, the incidentally dominating edges are $\{e_{11}\}$, $\{e_{22}\}$, $\{e_{33}\}$, $\{e_{44}\}$,$\{e_{55}\}$, $\{e_{66}\}$and the SEIDSs are $S_{11} = \{e_{11}e_{22}\}$,$S_{22} = \{e_{11}e_{44}\}$,$S_{33} = \{e_{22}e_{33}\}$,$S_{44} = \{e_{33}e_{44}\}$. After calculating the edge cardinality of $S_{11}, S_{22}, . S_{33}, S_{44}$we obtain$|S_{11}| = 0.6$,$|S_{22}| = 0.65$,$|S_{33}| = 0.6$,$|S_{44}| = 0.6$. Theedge cardinality of a minimum SEIDS is $|S_{11}| = 0.6$and $\gamma_{SVI}(G_{CVI}) = 0.6$.The WEIDSs are $S_{55} = \{e_{11}e_{55}\}$,$S_{66} = \{e_{11}e_{66}\}$,$S_{77} = \{e_{33}e_{66}\}$. After calculating the edge cardinality of $S_{55}, S_{66}, . S_{77}$we obtain$|S_{55}| = 0.6$,$|S_{66}| = 0.6$,$|S_{77}| = 0.6$Theedge cardinality of a minimum WEIDS is $|S_{55}| = 0.6$and $\gamma_{WVI}(G_{CVI}) = 0.6$.

Theorem 6.4

Let G_{CVI} be a CT-VFIGs without single node and R_{CVI} be a minimum SEIDS of G_{CVI}, then $E_{CVI} - R_{CVI}$is an SEIDS of CT-VFIGs.

Proof. Let G_{CVI} be a CT-VFIGswith minimum SEIDS, then for each edge $e_{2VI} \in R_{CVI}$, there is at least one edge $e_{1VI} \in E_{CVI} - N_{CVI}$ so that $deg^t(e_{1VI}) \geq deg^t(e_{2VI})$, $deg^f(e_{1VI}) \leq deg^f(e_{2VI})$ and $t_{C_{CVI}}(w_{11}, w_{11}w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{B_{CVI}}(w_{11}, w_{22})\}$, $f_{C_{CVI}}(w_{11}, w_{11}w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{B_{CVI}}(w_{11}, w_{22})\}$. Hence $E_{CVI} - R_{CVI}$ strongly dominates each edge of R_{CVI}. So, $E_{CVI} - R_{CVI}$ is an SEIDS of CT-VFIGs.

Theorem 6.5

Let G_{CVI} be a CT-VFIGs without single node and R_{CVI} be a minimum WEIDS of G_{CVI}, then $E_{CVI} - R_{CVI}$is an WEIDS of CT-VFIGs.

Theorem 6.6

For any CT-VFIGs with $t_{C_{CVI}}(w_{11}, w_{11}w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{B_{CVI}}(w_{11}, w_{22})\}$and $f_{C_{CVI}}(w_{11}, w_{11}w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{B_{CVI}}(w_{11}, w_{22})\}$ for all $w_{11} \in V_{CVI}, w_{11}w_{22} \in E_{CVI}$, then $\gamma_{SVI} = \gamma_{WVI}$.

Proof. Let G_{CVI} be a CT-VFIGs with $t_{C_{CVI}}(w_{11}, w_{11}w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{B_{CVI}}(w_{11}, w_{22})\}$and $f_{C_{CVI}}(w_{11}, w_{11}w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{B_{CVI}}(w_{11}, w_{22})\}$. Assume for every node have same or different value. Since G_{CVI} is CT-VFIGs with $t_{B_{CVI}}(w_{11}, w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{A_{CVI}}(w_{22})\}andf_{B_{CVI}}(w_{11}, w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{A_{CVI}}(w_{22})\}$ for all $w_{11}, w_{22} \in V_{CVI}$ and$t_{C_{CVI}}(w_{11}, w_{11}w_{22}) = min\{t_{A_{CVI}}(w_{11}), t_{B_{CVI}}(w_{11}, w_{22})\}andf_{C_{CVI}}(w_{11}, w_{11}w_{22}) = max\{f_{A_{CVI}}(w_{11}), f_{B_{CVI}}(w_{11}, w_{22})\}$for all $w_{11} \in V_{CVI}, w_{11}w_{22} \in E_{CVI}$. Thus every $e_{1VI}e_{2VI} \in E_{CVI}$ is SEIDS as well as WEIDS. Therefore $\gamma_{SVI} = \gamma_{WVI}$.

Theorem 6.7

For a CT-VFIGs, the below inequalities are true.

(i) $\gamma_{VI} \leq \gamma_{SVI} \leq O_{CVI}(G_{CVI}) - max\,i\,mumd_{G_{CVI}} of G_{CVI}$.

(ii) $\gamma_{VI} \leq \gamma_{WVI} \leq O_{CVI}(G_{CVI}) - min\,i\,mumd_{G_{CVI}} of G_{CVI}$.

Proof. (i) From definition 6.1 and 6.2 we have $\gamma_{VI} \leq \gamma_{SVI}$ (6)

We know $O_{CVI}(G_{CVI})$ = the sum of the incidence pair of CT-VFIGs.

Also $O_{CVI}(G_{CVI})$ - not including the maximum $d_{G_{CVI}}$ of CT-VFIGs

$$= O_{CVI}(G_{CVI}) - \text{?}_{CVI}(G_{CVI}) \quad (7)$$

From equation (6) and (7)

$$\gamma_{VI} \leq \gamma_{SVI} \leq O_{CVI}(G_{CVI}) - max\,i\,mumd_{G_{CVI}} of G_{CVI}$$

(ii) From definition 6.1 and 6.2 domination number γ_{VI} ofCT-VFIGs is less than or equal to the γ_{WVI} of CT-VFIGs, because the edges of WEIDSM_{CVI}, it weakly dominates any one of the edges of $E_{CVI} - M_{CVI}$.

Therefore $\gamma_{CVI}(G_{CVI}) \geq \gamma_{VI}(G_{CVI})$ (8)

Also $O_{CVI}(G_{CVI})$ -not including the minimum $d_{G_{CVI}}$ of CT-VFIGs

$=O_{CVI}(G_{CVI}) - \delta_{CVI}(G_{CVI})$

(9)

From equation (8) and (9), we get

$$\gamma_{VI} \leq \gamma_{WVI} \leq O_{CVI}(G_{CVI}) - min\,i\,mumd_{G_{CVI}} of\, G_{CVI}$$

7. Real-Life Application of CT-VFIGs

An application of CT-VFIGs is included here. Consider two networks (CT-VFIGs) G_{VI}^{1}andG_{VI}^{2}, which have two and two vertices, respectively, and show distinct journal publications from different journals of a research filed. The vertices MS value indicates the percentage of accepted research papers in journal publishing, while the NMS value represents the rejected research papers. The MS value of the edges indicates that the journal publications are mutually collaborative, whereas the NMS value indicates that the journal publications are not mutually collaborative. The MS value of the incidence pairs represents the percentage of progress, whereas the NMS value represents the percentage of journal publications that have not progressed. As in figure 3 composition of $G_{VI}^{1}$and G_{VI}^{2} show the percentage of progress of journal publication $m_{11}$with journal publications n_{11} and n_{22} has the maximum MS value and the percentage of non progress of journal publication m_{11} with journal publications n_{11} and n_{22} has the lesser NMS value. As a result, the best suited combinations of journal publications demonstrating the largest percentage of progress and the lowest percentage of non-progress in the research field exist.

8. Comparative Analysis

In figure 3, calculate the edge cardinality of each edge, we get all the edges have same value. In our study the edge degree cardinality of the CT-VIFGs $|d_{G_{CVI}}(e_{1VI})| = 0.2$ and $|d_{G_{CVI}}(e_{2VI})| = 0.3$ are not all the same. It can be observed that the edge degree of the edges $|d_{G_{CVI}}(e_{1VI})| = \{0.9,2.4\}$ shows the percentage of progress of journal publication m_{11} with journal publicationsn_{11} and n_{22} has the maximum MS value and the percentage of non progress of journal publication $m_{11}$with journal publications n_{11} and n_{22} has the lesser NMS value. As a result, the current method is ineffective in determining which journal publications have the highest percentage of progress and the lowest percentage of non-progress. The current method is useful for single networks, but it is insufficient to explain the overall impact of different networks' products. However, we may use composition to discuss the overall impact of combining multiple networks in our strategy. Our technique works with several networks as well as a single network. This allows us to discuss the overall influence of various networks products. As a result, our proposed strategy outperforms the existing one.

9. Conclusion

CT-VFIGs are extremely useful tools for researching a variety of computational intelligence and computer science topics. CT-VFIGs are used in a variety of fields, including natural networks and operations research.Three new CT-VIFG concepts in this article EIDS, SEIDS, and WEIDS. In the CT-VFIGs, some advantageous and instrumental theorems of domination are also explained. A study of the makeup of VFIGs in the field of research is also included. Our research into CT-VFIG coloring, Hamiltonian CT-VFIGs, and CT-VFIG chromaticity in the future. The results of future research on these concepts will be revealed in upcoming papers.

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K.KALAIARASI: D.SC., (MATHEMATICS)-RESEARCHER, SRINIVAS UNIVERSITY, SURATHKAL, MANGALURU, KARNATAKA. ASSISTANT PROFESSOR, PG & RESEARCH, DEPARTMENT OF MATHEMATICS, CAUVERY COLLEGE FOR WOMEN (AUTONOMOUS), AFFILIATED TO BHARATHIDASAN UNIVERSITY, TRICHY-18, TAMILNADU, INDIA

E-MAIL: KALAISHRUTHI1201@GMAIL.COM

P.GEETHANJALI: ASSISTANT PROFESSOR, PG & RESEARCH, DEPARTMENT OF MATHEMATICS, CAUVERY COLLEGE FOR WOMEN (AUTONOMOUS), AFFILIATED TO BHARATHIDASAN UNIVERSITY, TRICHY-18, TAMILNADU, INDIA.