A SURVEY ON DOMINATION IN DIFFERENT TYPES OF FUZZY GRAPHS

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Abstract

The idea of a fuzzy graph is a generalisation of graph theory. The fuzzy graph is now finding a lot of application in modern science. In this paper, we present some basic concepts and systematic review on the recent theoretical results and developments in domination of different types of fuzzy graphs.

Keywords: Fuzzy Graph and Domination.

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1. Introduction

Fuzzy graph theory was introduced by Euler in 1736. Graph theoretical concepts are extremely used in topology, geometry number, theory algebra, operations research, optimizations, biology, computer science and social system. The first definition of fuzzy graph introduced by Kauffman [1] it was based on Zadeh's concept of fuzzy sets in the year 1965 [2]. Rosenfeld proposed the fuzzy graph notations, as well as numerous fuzzy analogue ideas of cycles, trees, routes, and connectedness, as well as some of their features, in 1975 [3]. Bhutani and Rosenfeld proposed the concept of strong arcs and fuzzy end nodes, as well as a geodesic fuzzy graph [4] the works on fuzzy are also done by Akram Mordeson, Samanta, T.Pathinadhan, Dudak, Devaz, Borzooei, Hossein Rashmanlou, M.Pal, Sunita, R.A.Pradip, Telebi, Yeh, and Pramanik [[5]–[10]. A Fuzzy graph has another important branch that is domination number in graphs. The first notation for a dominance set came from the game of chess, where the challenge was to cover the entire 8-by-8 checkerboard with the fewest amount of chess pieces possible. Ore and Berge first proposed the concept of graph dominance in 1962. The dominance number and independent domination number were introduced by Cockayne and Hedetni emi. [11].

A.Somasundaram and S.Somasundaram developed the fascinating concept of domination in fuzzy graphs. [[12], [13]]. Domination in fuzzy graphs and employing domination in strong arcs were studied by Nagoor Gani and V.T. Chandrashekaran [14]. We the summarise dominance on several types of fuzzy graphs in this study.

Preliminaries

Graph

Intuitively, a graph $G(V, E)$ is a pair consisting of a set of vertices (nodes) and a set of edges. In V, an edge is an unordered pair of vertices (X, Y).

Fuzzy Graph

A graph $G(V, E)$ intuitively is defined as a pair consisting of a set of points and a set of edges. An edge is an element of the fuzzy set $E: X \times Y \longrightarrow [0,1]$.

Domination

A dominating set of each node $V(G) - D$ is close to at least one neighbour D in a vertex subset D of graph $G(V, E)$. The maximum cardinality of D is called the domination number and it is denoted by $\gamma(G)$.

Intuitionistic Fuzzy Graph (IFG)

An Intuitionistic Fuzzy Graph (IFG) is the form of $G = (V, E)$ where (i) $V=\{V_1, V_2, V_3, \dots, V_n\}$ such that $\alpha_1: V \to [0,1]$ and $\beta_1: V \to [0,1]$ denotes the degree of membership and non-membership of the element $x_i \epsilon V$ respectively and $0 \le \alpha_1(x_i) + \beta_1(x_i) \le 1$ for every $x_i \epsilon V$. (ii) $E \subseteq V \times V$ where $\alpha_2: V \times V \to [0,1]$ and $\beta_2: V \times V \to [0,1]$ are such that $\alpha_2(x_i, x_j) \le \min\{\alpha_1(x_i), \alpha_1(x_j)\}$ and $\beta_2(x_i, x_j) \le \max\{\beta_1(x_i), \beta_1(x_j)\}$ and $0 \le \alpha_2(x_i, x_j) \le \beta_2(x_i, x_j) \le 1$ for each $(x_i, x_j) \epsilon E$.

2.5. Interval Valued Fuzzy Graph (IVFG)

$B = \{x, [\mu_B^-(x), \mu_B^+(x)]: x \epsilon V\}$ Defines the set of interval-valued fuzzy B on a set V, where μ_B^- and μ_B^+ are fuzzy subsets of V, so that $\mu_B^-(x) \le \mu_B^+(x)$ for all $x \epsilon V$.

If $G^* = (V, E)$ be a crisp graph, then by an IVFR A on V, we mean an IVFS on E such that $\mu_A^-(xy) \le \min\{\mu_B^-(x)\mu_B^-(y)\}$ and $\mu_A^+(xy) = \max\{\mu_B^{\pm}(x)\mu_B^{\pm}(y)\}$ for all $xy \epsilon E$ and we compose $A = \{x, [\mu_A^-(xy), \mu_A^+(xy)]: xy: E\}$.

Bipolar Fuzzy Graph (BFG)

A bipolar fuzzy graph (BFG) is of the form $G = (V, E)$ where (i) $V = \{V_1, V_2, V_3, \dots, V_n\}$ such that $\mu_1^+: X \to [0,1]$ and $\mu_1^-: X \to [-1,0]$ (ii) $E \sqsubset V \times V$ where $\mu_2^+: V \times V \to [0,1]$ and $\mu_2^-: V \times V \to [-1,0]$ such that $\mu_{2ij}^+ = \mu_2^+(v_i, v_j) \le \min(\mu_1^+(v_i), \mu_1^+(v_j))$ and $\mu_{2ij}^- = \mu_2^-(v_i, v_j) \le \min(\mu_1^-(v_i), \mu_1^-(v_j))$ for all $(v_i, v_j) \epsilon E$.

Fuzzy Soft Graph (FSG)

Let $V = \{x_1, x_2, x_3, \dots, x_n\}$ (non empty set) E (parameters set) and $A \subseteq E$. Also let

(i) $\rho: A \to F(V)$ The set of all collection fuzzy subsets in V and every element e of A mapped to $\rho(e) = \rho_e$ (say) and $\rho_e: V \to [0,1]$, every element x_i corresponds to $\rho_e(x_i)$ and we call (A, ρ), a fuzzy soft vertex.

(ii) $\mu: A \to F(V \times V)$ The set of all collection fuzzy subsets in $V \times V$ and which corresponds to every element e to A mapped to $\mu(e) = \mu_e$ (say) and $\mu_e: V \times V \to [0,1]$, each element (x_i, x_j) corresponds to $\mu_e(x_i, x_j)$ and we call (A, μ), a fuzzy soft edge.

Then ((A, ρ), (A, μ)) is called FSG if and only if $\mu_e(x_i, x_j) \le \rho_e(x_i) \wedge \rho_e(x_j)$ for all $e \in A$ and for all $i, j = 1,2,3, \dots n$, this fuzzy graph is denoted by $G_{A,V}$.

Hesitancy Fuzzy Graph (HFG)

A Hesitancy Fuzzy Graph $G(V, E)$, where the set of node V is a triplet fuzzy function. It is defined by $\alpha_1 : V \to [0,1]$, $\beta_1 : V \to [0,1]$ and $\mu_1 : V \to [0,1]$ is called as membership, non-membership and hesitancy of the node $v_i \in V$ respectively and $\alpha_1(v_i) + \beta_1(v_i) + \mu_1(v_i) = 1$,

$\mu_1(v_i) = 1 - [\alpha_1(v_i) + \beta_1(v_i)]$. The edge set of $G(V,E)$ is a triplet fuzzy function, it is defined by $\alpha_2 : V \times V \to [0,1]$, $\beta_2 : V \times V \to [0,1]$ and $\mu_2 : V \times V \to [0,1]$ so that $\alpha_2(u,v) \le \alpha_1(u) \wedge \alpha_1(v)$, $\beta_2(u,v) \le \beta_1(u) \vee \beta_1(v)$, $\mu_2(u,v) \le \mu_1(u) \wedge \mu_1(v)$ and $0 \le \alpha_2(uv) \le \beta_2(uv) \le \mu_2(uv) \le 1$ for each $uv \in E$.

Anti Fuzzy Graph (AFG)

An anti-fuzzy graph $G(\sigma,\mu)$ is an ordered pair of functions $\sigma: V \to [0,1]$ and $\mu: V \times V \to [0,1]$ where for all $u, v \in V$, we have $\mu(u,v) \ge \sigma(u) \vee \sigma(v)$ and it is denoted by $G_A(\sigma,\mu)$.

Picture Fuzzy Graph (PFG)

A Picture Fuzzy Graph (PFG) is of the form $G = (V, E)$ where

(i) V={ $v_1, v_2, v_3, \dots, v_n$ } such that by $\alpha_1 : V \to [0,1]$, $\beta_1 : V \to [0,1]$ and $\mu_1 : V \to [0,1]$ degree of Positive membership, neutral membership and negative membership of the element $v_i \in V$ respectively and $0 \le \alpha_1(v_i) \le \beta_1(v_i) \le \mu_1(v_i) \le 1$ for every $v_i \in V$, $i = 1,2,3, \dots n$.

(ii) $E \subseteq V \times V$ where $\alpha_2 : V \times V \to [0,1]$, $\beta_2 : V \times V \to [0,1]$ and $\mu_2 : V \times V \to [0,1]$ such that $\alpha_2(v_i, v_j)\{\alpha_1(v_i) \wedge \alpha_1(v_j)\}$, $\beta_2(v_i, v_j) \le \{\beta_1(v_i) \wedge \beta_1(v_j)\}$, $\mu_2(v_i, v_j) \le \mu_1(v_i) \vee \mu_1(v_j)$ and $0 \le \alpha_2(v_i v_j) + \beta_2(v_i v_j) + \mu_2(v_i v_j) \le 1$ for every $v_i, v_j \in E$, $i, j = 1,2,3, \dots n$.

Here, the 4-tuple (v_i , α_{ii} , β_{ii} , μ_{ii}) denotes the degree of positive membership, neutral membership and negative membership of the vertex v_i and the 4-tuple (e_{ij} , α_{ij} , β_{ij} , μ_{ij}) denotes the degree of positive membership, neutral membership and negative membership of the edge relation $e_{ij} = (v_i, v_j)$.

Domination in different types of fuzzy graph

Intuitionistic Fuzzy Graph (IFG)

In 2010, R.Parvathi and Thamizhendhi [16] addressed the concept of cardinality in IFG and discussed the definition of set of dominating, dominance number, set of independent domination, independent domination number, set of total domination, and total domination number, bipartite, complete bipartite, strong arc, and the strength of connectivity in IFG. The collection of an independent set is the set of maximal independent set of IFG, $G = (V,E)$, if and only if it is a collection of an independent and dominant set, according to the author $G = (V,E)$ is the least dominant set for each maximal independent set in an IFG, and $t(G) = O(G)$ if and only if each node of G has unique neighbours. Furthermore investigated some of these properties concepts for them. In 2011, Vinoth Kumar.N, Geetha Ramani.G [15] developed the concept such as set of independent dominating, set of effective dominating, set of strong (weak) domination, set of connected dominating for an IFG and proved some results on these parameters such as, if G be an IFG then (i)$\gamma_{if}(G) \le \gamma_{cif}(G)$, (ii)$\gamma_{sif}(G) \le \gamma_{wif}(G)$, (iii)$\gamma_{cif}(G) \le \gamma_{eif}(G)$ and if G is an IFG of order $O(G)$ then $O(G)\backslash[1 + \Delta_N(G)] \le \gamma_{if}(G) \le O(G) - \Delta_N(G)$. Furthermore, introduced the domination of these sets and investigated some of the properties for these parameters in IFG. These concepts were applied on various types of IFG. S.Velammal [17] in IFG concept of set of edge domination, set of total edge domination, edge domination number, and total edge domination number were defined. Author proved G be a fuzzy graph with q edges $\gamma'_t = q$ if and only if each edge of G has a unique neighbour and also proved for any G is an Intuitionistic Fuzzy Graph without isolated edges $\gamma'_t + \bar{\gamma}_t \le 2q$ and equality holds provided that the number of edges in G is even that is $2n$. For the parameters, Nordhaus - Gaddum type results were also obtained. J.John Stephen et al.[18] established the set of connected domination, set of efficient domination, set of total strong (weak) and set of independent domination in Intuitionistic fuzzy graphs, a new dominating parameter of these sets was introduced, and the property of these parameters was examined also proved $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$ be two IFG $V_1 \& V_2$ respectively with $V_1 \cap V_2 = \phi$ then (i) $\gamma(G_1 + G_2) \min\{\gamma(G_1), \gamma(G_2)\{\mu_1(u) + \mu_1(v), \gamma_1(u) + \gamma_1(v)\}\}(ii)\gamma_1(G_1 + G_2) \min\{\gamma_1(G_1), \gamma_1(G_2)\}$ where $u_1 \epsilon V_1, v \epsilon V_2(iii)D_1 X D_2$ is a set of dominating $G_1 o G_2$ (iv) D_1 and D_2 is a set of minimum dominating in IFG then $\gamma_1(G_1 \otimes G_2) \le \{|D_1 X V_2|, |V_1 X D_2|\}$. R.Jahir Hussain and S.Yahya Mohammed [19] defined global domination set and global domination number in IFG. Also obtained some of the theorems and bounds of these parameters in IFG and proved if G= (V,E) be the purely semi-complete IFG then γg- set contains at least three vertices**.** Also introduced the complementary nil domination, complementary nil domination number in IFG, and obtained some of their bounds in standard types of IFG. Also some theorems, such as the dominant set S is cnd-set if and only if it contains at least one enclave were proved and any IFG $G = (V,E)$, every cnd-set of G intersects with each set of dominating in G also cnd-set G= (V,E) in IFG is not a singleton [20]. V.K.Santhi and S.Jayalakshmi [21] introduced the concept of edge double domination and domination number. The author also defined the total edge double domination and its number in several classes of IFG. Further obtained some of the bounds for these parameters and then given some important results such as for any IFG $\gamma'' + \overline{\gamma''}$ and equality holds if and only if $0 < \mu_1(uv) < \sigma_1(u) \wedge$

$\sigma_1(v)$ and $0 < \mu_1(uv) < \sigma_1(u) \vee \sigma_1(v)\ \forall\ u, v \epsilon V$ and any IFG with q edges $\gamma''_i = q$ if and only if every edge has two neighbours**.** P.Gladyis et al. [22] defined the concept set of split independent domination, set of independent strong (weak) domination, set of inverse domination in IFG, and inverse independent dominating set in intuitionistic fuzzy graph and proved some of the interesting results if so $\gamma_{isif}(G) \leq \gamma_{iwif}(G)$ and $\gamma^{-1}(G) \leq \beta_0(G)$. Further proposed to introduce new dominating parameters in IFG and applied these concepts to intuitionistic fuzzy graph models. J. John Stephan et al. [23] defined the concepts of a set of strong (weak) domination and the strong (weak) domination number in IFG and proved some of the dominating properties. Further given some of the results if $G = (V, E)$ IFG and order of p then $\gamma_{if}(G) \leq \gamma_{sd}(G) \leq p - \Delta_N(G) \leq p - \Delta_E(G)$ and $\gamma_{if}(G) \leq \gamma_{wd}(G) \leq p - \delta_N(G) \leq p - \delta_E(G)$. Also G be complete intuitionistic fuzzy graph, $u, v \in V$ be the nodes having the minimum and maximum node cardinality in G respectively $\gamma_{sd}(G) \leq \frac{1+\mu_1(v)-\gamma_1(v)}{2}$ and $\gamma_{wd}(G) \leq \frac{1+\mu_1(u)-\gamma_1(u)}{2}$**.** Parvathi. R and Thamizhendhi.G [25] defined the operations such as ring sum, join, lexicographic product, Cartesian product, strong product, and tensor product, α-product, β-product, and γ-product of two IFGs. Also proved for $G_1 = (V_1, E_1)$ & $G_2 = (V_2, E_2)$ any two IFGs and D_1 & D_2 are the two dominating sets (i) Then $D_1 \times D_2$ is a dominating set of $G_1 \circ G_2$, (ii) If D_1 and D_2 be a set of two minimum domination then $d(G_1 \square G_2) \leq \min\{|D_1 \times V_2|, |V_1 \times D_2|\}$ refers to the cartesian product, in crisp sense (iii) $G_1 \boxtimes G_2$ is connected (iv) If D_1 is connected then $D_1 \times V_2$ set of connected domination of a $G_1 \boxtimes G_2$. (v) if D_1 is connected then $V_1 \times D_2$ connected dominating set of $G_1 \boxtimes G_2$. Further investigated some domination parameters like independent domination, connected domination, total domination on join, cartesian, lexicographic, tensor, and strong product of two IFGs. Nagoor Gani et al. [24] have given some results of a set of point set domination and domination number in IFG. Also established intuitionistic fuzzy point set domination sets of purely semi-complete in IFG and obtained some the bounds for them. Furthermore, derived some of their results such as for any IFG $\mathrm{Min}\{|v_i| \leq \gamma_{ip}(G) \leq p\}$, if G be an IFG and S is intuitionistic fuzzy point set dominating set and $u, v \in V - S$ then there are at most two strong arcs between u and v. If G is a purely semi-complete IFG with n vertices and S is an intuitionistic fuzzy dominating set with more than or equal to $n - 2$ vertices, then S is an intuitionistic fuzzy psd-set in G [26]**.** Nagoor Gani and S.Anupriya [24] examined non-split dominance and global non-split dominance were examined, as well as other varieties of non-split dominating sets such as path non-split dominance, cycle non-split dominance, and strong non-split dominance, and proved some theorems for this known parameter such as for any IFG $G = (V, E), \gamma_{ns}(G) \leq \frac{O(G)}{\Delta_\mu(G)}$ and if the degree of each vertex in the IFG is the same, then a cycle non split dominant set occurs. If D is a cycle non-split dominating set, then D must have at least one strong arc, and any complete IFG with vertices $P > 3$ must contain a strong non-split dominating set.

Nagoor Gani et al. [27] discussed the concepts of double dominating set of Intuitionistic Fuzzy Graphs and some of their properties, also proved D set of double domination it is a minimal if and only if one of the following conditions holds for any two vertices $\{v, w\} \in D$ (i) there exists a node $u \in V - D$ so that $N(u) \cap D = \{v, w\}$ (ii) $V - D$ is disclosed. (iii) if D is a set of minimal double domination then $W(D) \leq \delta(G) + 2$ and $W(D) \geq \Delta(G) - 1$ (iv) $\gamma_{dd}(G) \geq \frac{O(G)}{\Delta_\gamma(G)+1}$ where $\Delta_\gamma(G)$ is the maximum γ −degree of G (v) $\gamma^{-1}(G) \leq \gamma_{dd}(G) \leq |V|$ where $\gamma^{-1}(G)$ inverse domination number (vi) if double dominating set D in G , then G is independent in contrast to not in G. Also finally discussed how this parameter related to set of minimal domination, independent sets, end nodes and cut vertices in IFG. P.J.Jayalakshmi et al [28] derived the concept of IFG in total strong (weak) domination, degree of a node in intuitionistic fuzzy graph, order of intuitionistic fuzzy graph, size of IFG, Semi-μ Strong IFG, semi-μ strong domination IFG. The Author proved some of the examples and theorems such as (i) $\gamma_{sif}(G) \leq t_{tsif} \leq O(G) - \Delta_N(G) \leq O(G) - \Delta_E(G)$ (ii) $\gamma_{sif}(G) \leq t_{twif} \leq O(G) - \delta_N(G) \leq O(G) - \delta_E(G)$ (iii) $\gamma_{tsif}(G) \leq \gamma_{twif}(G)$ and (iv) $O(G) - S(G) \leq \gamma_{tsif}(G) \leq O(G) - \delta_E(G)$ (v) $O(G) - S(G) \leq \gamma_{twif}(G) \leq O(G) - \Delta_E(G)$. S.John Stephen et al. [29] developed the concept of multiple domination and explained in detail finding algorithm to set of K domination of an IFG and proved if D is a set of minimal node domination of an IFG in G then there exist a node in $(V - D)$ is not dominated by multiple nodes and if G_1 or G_2 be an IFG, D_1 be the K_1 dominating set of G_1 then $D_1 \times V_1$ is the set of minimum K_1 domination of $G_1 \times G_2$. Also discussed some of their results in operations in IFG. P.J. Jayalakshmi et al. [30] established the concept of total semi-μ strong (weak) domination in IFG and demonstrated theoretically semi-μ strong (weak) IFG and took minimum value between the two edges. Discussed some of the theorems like for any semi-μ IFG (i) $\gamma_{tsif}(G) \leq t_{ts\mu sif} \leq O(G) - \Delta_N(G) \leq O(G) - \Delta_E(G)$ (ii) $\gamma_{tsif}(G) \leq t_{tswsif} \leq O(G) - \delta_N(G) \leq O(G) - \delta_E(G)$ (iii) $\gamma_{ts\mu-sif}(G) \leq$

$\gamma_{ts\mu-wif}(G)$ and (iv) $O(G) - S(G) \leq \gamma_{ts\mu-sif}(G) O(G) - \delta_E(G)$ (v) $O(G) - S(G) \leq \gamma_{ts\mu-sif}(G) \leq O(G) - \Delta_E(G)$ and has given some of examples related to total semi-μ strong (weak) domination in IFG. Ponnappan et al. [31] introduced the concept of a set of connected domination, set of connected strong domination, set of disconnected strong domination, set of left semi-connected domination, set of right semi-connected domination, set of total connected strong domination and set of total disconnected strong domination number for several classes of intuitionistic fuzzy graph. Also proved for any IFG $\gamma_{cs}(G) \leq \gamma_{tcs}(G) \leq 2\gamma_{cs}(G), \gamma(G) \leq \gamma_{lcs}(G)$ and all connected strong dominating sets are minimal dominating sets on the intuitionistic fuzzy path, and it has exactly two connected strong dominating sets. For the above parameters, author obtained bounds and a Nordhaus – Gaddum type result. M.G Karunambigai et al. [32] developed a set of edge domination using strong edge and set of edge independent in IFG. Also determined edge domination number for various classes of IFG and proved some of results such as for IFG is a collection of edge independent set with only strong edges is a set of maximal edge independent if and only if it is set of edge independent and set of edge domination also proved if IFG is set of maximal edge independent then it has only strong edges is a set of minimal edge domination of G. Finally discussed the relation between them and introduced a regular dominating set and regular independent set in IFG and given suitable examples, also proved set of independent in IFG if and only if it is the set of regular independent and the regular dominating set and every maximal independent set in an IFG is a regular minimal dominating set of G. A. Nagoor Gani et al. [33] investigated the concept of edge domination number and some parameters as well as edge dominating sets, cut vertices, end vertices, and set of independent edge domination also proved some remarkable results in edge dominating set in IFG such as $G = (V, E)$ for an IFG if D is an edge dominating set with end vertices, then at least one end vertex occurs in D. If G is edge dominating set then (i) $\delta(G) \leq \gamma_e(G)$ (ii) the edges of an edge dominating set D incident with the vertices containing maximum degree. (iii) at least one set of edge domination D itself is an set of edge independent and also proved D_1 and D_2 be an IFG, D_1 be the set of edge domination in IFG G_1 and G_2 then $D_1 \times D_2$ is not an edge dominating set of $G_1 \times G_2$. M.G Karunambigai [34] investigated the concept set of a secure domination, set of secure domination number, set of secure total domination, set of secure total domination number in IFG and determined several classes of IFG and proved some important theorems found here. If S is a minimal dominating set in complete intuitionistic fuzzy graph G, then (i) S is a set of secure domination, (ii) S is not a set of secure total domination (iii) S is not a set of 2-domination (iv) S is not a set of 2-total domination. Finally derived if G is an IFG, then $\gamma^*_{2s}(G) \geq \gamma^*_2(G)$ and if G be an IFG with only strong and without isolated nodes and S is a set of minimal secure domination. Then $V - S$ is a set of secure domination in G. C.Y Ponnappan et al. [35] discussed the concept of neighbourhood connected total domination in an IFG, neighbourhood disconnected total domination in an IFG, neighbourhood connected perfect domination in an IFG, and neighbourhood disconnected perfect domination in IFG. Finally discussed this domination parameter compared with other known parameters and given some of the results on if G be an IFG then $\gamma_{cs}(G) \leq \gamma_{tcs}(G) \leq 2\gamma_{cs}(G)$ and if G be an intuitionistic fuzzy path, all set of connected strong domination are set of minimal domination. Sankar Sahoo et al. [36] defined covering and matching using strong arcs in an IFG and discussed the concept of strong matching, strong arc cover, strong cover node, and strong independent number in IFG. Finally, the author introduced and investigated paired domination numbers using strong arcs, strong paired domination numbers of complete IFG, complete bipartite IFG, and discussed some of their properties and theorems such as for complete bipartite IFG $K_{\sigma',\sigma''}$ with partite set V' and V'' then $\alpha_{s10}(K_{\sigma',\sigma''}) = \wedge\{W_1(V'), W_1(V'')\}$ and $\alpha_{s20}(K_{\sigma',\sigma''}) = \vee\{W_2(V'), W_2(V'')\}$. If every IFG $G = (V, \sigma, \mu)$ of order (m, n) containing no isolated vertices $\alpha_{s0} + \beta_{s0} = W(V) \leq m$ and $\alpha_{s1} + \beta_{s1} \geq n$. S.Revathi [37] developed some of the parametric criteria and presented the concept of a set of perfect domination and its domination number for constant IFG. In addition, several features of the set of perfect domination in constant IFG were studied. and total constant IFG with suitable examples and given some results if constant IFG of degree (k_i, k_J), then (i) $\gamma_{pcif}(G) \leq p \leq q$ (ii) $W(G) \leq O(G) \leq S(G)$ (iii) $|O_\gamma - S_\gamma| \leq \gamma_{pcif}(G) \leq |O_\mu - S_\mu|$ (iv) $\gamma_{pcif}(G) \leq \frac{p}{2}$ (v) $\left(\frac{p-\Delta_\mu}{2}\right) \leq \gamma_{pcif}(G) \leq 3(q - \Delta_\mu)(vi)|O_\mu - \Delta_\mu| \leq \gamma_{pcif}(G) \leq |O_\gamma - \Delta_\mu|$. Praba B et al. [38] defined the energy of such graph and analyzed the spreading of a virus on the Energy of dominating IFG and illustrated with suitable examples. R.Vijayaragavan et al. [39] extended the Energy of an IFG to dominating energy in various products in IFG and obtained the value of dominating Energy in different products like α-product, β-product and γ- product between two IFGs. Also explained comparison between the dominating energy in the various products in two IFGs. V Senthil Kumar [40] discussed the concept of strong arc and non-strong arc in an IFG like intuitionistic fuzzy cycle and intuitionistic fuzzy path, introduced the definition of μ-strong arc, effective arc, semi-effective arc. Furthermore, proved if G be IFG with any two vertices are connected by exactly one path, then each arc of G is a strong arc also investigated every connected non-trivial Intuitionistic Fuzzy Graph G has at least strong arcs when $n \geq 2$. In the intuitionistic fuzzy cycle, there can be at most two non-strong arcs. Also, let G be an IFG if the arc (u, v) is an effective arc in G, then it does not have to be a strong arc in G (it must be a semi-strong arc). Jehruth Emelda Mary. L and K.Ameebal Bibi [41] introduced the concept of domination intuitionistic triple-layered FG and total domination in the intuitionistic triple-layered fuzzy graph (ITLFG). Then illustrated with some suitable example parameters for them and proved G be ITL fuzzy graph then $\gamma(G) + \gamma(G) \leq 2p$, where $p -$ number vertices $p \geq 3$ and G be ITL simple fuzzy graph the total domination number $\gamma_t(G) = p$ if and only if each vertex of ITL has unique neighbour. Also extended to a simple Intuitionistic Triple Layered Fuzzy graph. A.Kalimulla et al. [42]. The concept of dominating energy in operations on an Intuitionistic Fuzzy Graph was extended, and the value of dominating Energy in different operations was determined. Basic definitions for Laplacian energy of an IFG were given, and the dominating Laplacian energy of different operations of IFG was defined. Furthermore the author examined the complement dominating energy of an IFG and investigated the join and union of the two IFGs on in this parameter. R.Buvaneswari and K.Jayadurga [43] defined the concept of nil complementary dominating set in an IFG, nil complementary dominating number in IFG, and some of their properties and derived some of the theorems. J.John Stephen et al. [44] developed the concept of a vertex cover in an IFG and obtained some of their results if G be an IFG and $K \subseteq V$ is a minimum node cover of IFG in G then $V(G) - K$ is a set of independent in G. If G be a complete IFG then $\beta_{if}(G) = \delta_N(G)$ and G be a complete bipartite IFG then $\beta(G) = \min(|v_1|, |v_2|)$. Also finally proved for G be an IFG and $u \in V$ such that $\Delta_N(G) = d_N(u)$ then $u \in K$. S.Ravi Narayanan and S.Murugesan [45] defined $((c_1, c_2), 2)$ - regular domination in IFG. Then introduced $((c_1, c_2), 2)$ - regular intuitionistic strong (weak) fuzzy dominating set. Also obtained some of the properties $((c_1, c_2), 2)$ - regular domination and $((c_1, c_2), 2)$- regular intuitionistic strong (weak) fuzzy dominating in IFG. Finally proved some results like if G be an IFG then $\gamma_{rif}(G) \leq \gamma_{risf}(G) \leq P - \Delta_N(G) \leq P - \Delta_E(G)$ and $\gamma_{rif}(G) \leq \delta_N(G) \leq P - \delta_E(G)$. Dr.K. Kalaiarasi and P.Geethanjali [46] introduced the mixed IFG and defined the direct product of two mixed IFGs, semi-strong and semi-product of two square mixed IFGs. Also defined dual strong domination and investigated some of their results such as if G_1 and G_2 are MIFG then $G_1 \prod G_2$ is also an MIFG, if G_1 and G_2 are SMIFGs then $G_1 \bullet G_2$ is also a strong SMIFG and if it is complete SMIFG then $G_1 \otimes G_2$. For G be an MIFG and if G contains only one strong arc then $\gamma_{DSM}(G) = 0$, G_1 and G_2 be a strong SMIFG then the set of semi strong product of two SMIFGs contain dual strong domination number. A.Bozhenyuk et al. [47] introduced the notion of a set of domination an invariant of the IFG. Also finding an algorithm for all set of minimal intuitionistic dominating the node subset and proposed dominating set of this parameter in this method is the generalization of Maghout's method of fuzzy graph. J.John Stephen et al. [48] defined regular dominating sets and domination numbers in IFG and proved if $d_N(v) = \Delta_N(G)$ in an IFG of G then the degree of each node in $\gamma_R(G)$ set is equal to $\Delta_N(G)$. If D_1 and D_2 be the set of minimal regular domination of G_1 and G_2 respectively then the set of regular domination $G_1 \cup G_2$ is $\gamma_R(G_1 \cup G_2) = |D_1| + |D_2|$ and $\gamma_R(G_1 + G_2) = \min\{|D_1|, |D_2|\}$. The author defined the set of total domination and set of total domination number in IFG and obtained some of the results for G be complete IFG, then $\gamma_{ifT} = |u|$, here $d_N(v) = \Delta_N(G)$, if G be a complete bipartite IFG then $\gamma_{ifT} = |u| + |v|$ here u and v having the lowest cardinality among the node sets in the set V_1 and V_2 respectively and G be an IFG and u is the node having maximum or greatest degree of the graph of G then $\gamma_{ifT} \leq O(G) - \Delta_N(G)$ [49]. A.Bozhenyuk et al. [50] considered the vertex subset of minimal intuitionistic dominating and a domination set of the first kind IFG and developed a method for finding all minimal dominating node subsets then proved that this method gives an exact outcome. Also discussed the point of view of invariants the dominating set estimated in any IFG. In this method the generalization of Maghout's method of FG.

Interval Valued Fuzzy Graph (IVFG)

Pradip Debnath [51] introduced the concept of a set of domination, set of domination number, collection of independent set, etc in IVFG and has given some characterizations for set of minimal domination and finding relations between set of domination and collection of independent set. Furthermore, obtained some of the parameters for them and proved some of the results such as G is a set of all maximal independent in IVFG if and only if it is both set of independent and dominating set, and it has been demonstrated that any maximal independent set is also a minimal dominating set. Also if $\gamma_t = p$ then number of vertices in G is even. Seema Mehra and Manjeet Singh [52] developed the concept of complementary nil domination in

IVIFG and also obtained some of the theorems and results like for if G is an IVIFG, dominating set X is cnd-set if it contains at least one enclave, and cnd-set of an IVIFG $G = (A, B)$ of the graph $G^* = (A, B)$ is not a singleton. Also proved for any IVIFG $G = (A, B)$ of the graph $G^* = (V, E)$, and X is a cnd-set of graph G, if two enclaves is x and y then following condition holds (i) $N[x] \cap N[y] \neq \emptyset$ and (ii) x and y are adjacent. S.Yohya Mohammad and M.Saral Mary [53] defined the concept of domination parameters on IVIFG and defined some of the properties. Then discussed and defined complementary of IVIFG and proved some of the theorems such as any IVIFG $G = (V, E)$ with IVIF end vertex then $\gamma_s(G) \geq \gamma(G)$ and G be a strongly connected IVIFG then $\gamma_c(G) \leq \gamma_g(G)$. Finally introduced immoderate semi-complete, purely semi-complete in IVIFG and defined some of their properties. Saral.N and Kavita.T [54] in IVFG, author introduced the concept of strong (weak) dominance. Also derived some of the theorems such as if D be a set of minimal strong domination in IVFG of G then for each $u \in D$ of the following condition holds (i) No vertex in D has a strong dominante on v (ii) There exists $v \in V - D$ such that v is the only node in D that has a strong dominance over u also proved if G be an IVFG of order p then $\gamma(G) \leq \gamma_s(G) \leq p - \Delta_N(G) \leq p - \Delta_E(G)$ and $\gamma(G) \leq \gamma_w(G) \leq p - \delta_N(G) \leq p - \delta_E(G)$ and established relations between domination number in IVFG and strong (weak) domination in IVFG. S.Revathi et al. [55] in IVFG author establishs the concept of a set of an equitable dominance. Also, several theorems were obtained, such as if S is a set of minimal equitable domination in IVFG, then the following holds for each $u \in S$ (i) $N(u) \cap S = \varphi$ (ii) there is a node $v \in V - S$ such that $N(v) \cap S = \{u\}$ and G be an IVFG without isolated nodes, S be a set of minimal equitable domination of G then $V - S$ is a set of equitable domination of G. N.Saral et al. [56] combined the concept of IVFG and fuzzy graph with domination number and also introduced (weak) strong complete and complementary domination in IVFSG. Furthermore, obtained some results for this new parameter in interval-valued fuzzy soft graphs and proved some of the theorems related to this concept such as if M is a set of minimal strong domination IVFSG of G then for every $u \in M$ if one of the following conditions is true, (i) No node in M strongly dominates V (ii) There exists $v \in V - D$ such that v is the only node in D which strongly dominates u also proved if G be an IVFSG with an order of p then $\gamma(G) \leq \gamma_s(G) \leq p - \Delta_N(G) \leq p - \Delta_E(G)$ and $\gamma(G) \leq \gamma_w(G) \leq p - \delta_N(G) \leq p - \delta_E(G)$. G be a complete IVFSG without isolated nodes, S be a set of complete minimal domination in G then $V - S$ is a complete dominating set of G and G be a complete IVFSG, every maximal independent set is a minimal dominating set. Nooralden. O. et al. [57] introduced the concept of a set 2-domination, 2-domination number and using effective edges in IVFG and obtained some of their results the relationship between 2-domination number known parameter in IVFG and given some important result that is for $G = (A, B)$ be any IVFG and D be minimal 2-dominating set of G if $G \neq K_P$ and $\neq K_{m,n}$ then $V - D$ need not be a 2-dominating set of G , if . $G = K_{\mu_1,\mu_2}$ is a complete bipartite fuzzy graph then $\gamma_2(G) = \min\{|V_1|, |V_2|\}$ and G be any IVFG (i) every vertex of G has a unique neighbour then $\gamma_2(G) = p$, (ii) if $G^* = nK_2$ then $\gamma_2(G) = np$ (iii) if $G \neq K_P$ then $\gamma_2(G) \leq p - \delta_N$. Also proved every double dominating set D of an IVFG of G is a 2-dominating set of G . Ahmed N.Shain and Mahiuob. M.Q Shubatah [58] introduced inverse domination numbers and provided several interval-valued fuzzy graphs, such as complete, complete bipartite, star, etc. Also obtained upper and lower bounds of inverse domination in IVFG and some of their results such as if G be an IVFG then (i) $\gamma'(G) + \gamma(G) \leq p$ (ii) $\gamma'(G) + \gamma'(G) \leq 2p$ (iii) $\gamma'(G) \leq p - \Delta_N(G)$ (iv) G has without isolated vertex the$\gamma(G) \leq \gamma'(G)$and $\gamma(G) \leq \beta_0(G)$.

Bipolar Fuzzy Graph (BFG)

M.G Karunambigai et al. [59] in BFG proposed the idea of dominance, which is both independent and irredundant, and proved certain theorems, such as $G = (V, E)$ is a set of minimal domination in G if and only if one of the following criteria holds, for each $d \in D$, there is a node $v \in V - D$ such that $N(v) \cap D = d$ and d is not a strong neighbor of any node in D. If G be without isolated of BFG and D is a set of minimal domination then $V - D$ is a set of domination in G. If independent s if G be a set of maximal independent in BFG then G is a set of minimal domination. On BFG, we also looked into various irredundance features. and given some important results such as if any BFG $G = (V, E)$ with order $O(G)$ and minimum degree $\delta(G)$ then $ir_B(G) \leq O(G) - \delta(G)$ and for any fuzzy graph of order $O(G)$ and minimum neighbourhood degree $\delta(G)$, $ir_B(G) + IR_B(G) \leq 2(O(G) - \delta(G))$. The equality holds if and only if $(G) - \delta(G)$ divides $O(G)$. V.Mohanaselvi and S. Sivamani [60] introduced the paramount domination number and proved some of their theorems and results that is G be a BFG, dominant set D is pad-set if and only if it has at least one enclave and pad-set of B_G is not a singleton and not independent. Also proved pad set of B_G is minimal if and if $u \in D$ then at least one of the following conditions holds (i) $N[u] \cap ND = \emptyset$ and (ii) there is a node $v \in V - D$ such that $N(v) \cap D = \{u\}$ (iii) $V - (D - \{u\})$ is a dominating set of B_G. Also studied this parameter for connected non-complete fuzzy graph. Again, author introduces the concepts of global domination in BFG and gives necessary and sufficient conditions for a global dominating set. Also defined semi-complete, purely semi-complete, semi complementary, and semi-global domination and obtained some of their results and theorems such as if G be a BFG with effective edges, then $\min\{|v_i| + |v_j|\} \leq \gamma_g(G) \leq p, i \neq j$. If G be a purely semi BFG, then the global dominating set contains at least 3 vertices. Let G be a connected BFG with effective edges if $G^c = G^{sc}$ then there must be at least two effective edges between each pair of non-dominating vertices. The global and semi-global bipolar fuzzy dominating sets D in G are not singletons [61]. R. Muthuraj and Kanimozhi [62] defined set of strong (weak) domination in BFG and established the parametric conditions of these related concepts. Also defined and established a total strong (weak) bipolar domination number and its parametric conditions. Finally discussed some of the properties of strong (weak) bipolar domination numbers and total strong (weak) bipolar domination numbers and proved important theorems that is if T_b is a set of minimal total strong (weak) domination BFG of G, then $B \in T_b$, satisfying one of the following conditions (i) No nodes in T_b strongly dominates B (ii) there exists $B \in V - T_b$ such that v is the only node in T_b which strongly dominates A (iii) T_b is the set of total domination in BFG also proved each complete BFG is total strong (weak) domination in BFG. RJahir Hussain and S.Satham Hussain [63] triple connected domination and its properties discussed in BFG also investigated triple connected domination number for some with a suitable example was discussed and proved some of the important results if G has a cut vertex v such that ω (G − v) ≥ 3 then G is not BFG triple connected and T is triple connected tree if and only if $T \cong P_n, n \geq 2$. G be any connected BFG with p vertices, $\gamma_{BFtc}(G) = p - 1$ if and only if $G \cong P_4, C_4, K_4, K_{1,3}, K_4 - \{e\}, C_3(P_2)$. Umamageshwari et al. [64] the concept of multiple dominations and multiple domination numbers in BFG introduced and determined several classes of BFG then defined the k-dominating set and-dominating number in BFG and analyzed the some of the properties and bounds. Also obtained multiple domination numbers in the operations on BFG such as join, cartesian product, and composition also proved some of the important theorems if G be a strong BFG with K nodes and D be a set of minimum domination of G then $V - D$ be a set of K-multiple domination of G, where $K = \min_{v_i \in D}\{[\frac{d(v_i)}{\wedge_{u \in N(v_i)}|u|_f}]\}$ and if D_1 and D_2 be the set of K_1 and K_2 minimum domination of a BFG G_1 and G_2 respectively, then $D_1 X V_2$ and $V_1 X D_2$ is the K_1 and K_2 dominating set of $G_1 \times G_2$ respectively. S.Ramya and S. Lavanya [65] investigated the concept of critical edge domination variant in BFG and analyzed how to remove the effect of node or an edge affect the edge domination number of BFG. Then discussed and explored edge domination number of various types of BFG. Finally discussed the critical concept in BFG and given some of the important results such as for G be a BFG on V if vertex v is in V_e^+ then v is an end node of some edge in every edge dominating set of G. Also proved $e = uv \in E$ the greatest edge neighbourhood degree in G, then $e = uv \in E^+$. A. Prasanna et al. [66] introduced the concepts, set of split domination and non – split domination in BFG and investigated some of the properties for these parameters. Also discussed the relationship between set of split domination, set of connected domination, set of strong split domination, and set of non – split domination number in BFG. R.Muthuraj et al. [67] defined the concept of a set of perfect domination in BFG and perfect domination number for various classes of BFG. Also determined the sum of their properties for perfect domination in BFG and proved some of the results like if G be a BFG without isolated vertices and P_b be a set of minimal perfect domination of G then $V - P_b$ is not a set of a perfect domination of G and if G be complete BFG then perfect domination number $\gamma_{P_b} = \min\{|x_i|\}$. Also proved G be BFG $\gamma_{P_b}(G) \leq O^P(G) - \Delta_N^P(G) \leq O^P(G) - \Delta_E^P(G)\, \delta_E(G)$ and $\gamma_{P_b}(G) \leq O^P(G) - \delta_N^P(G) \leq O^P(G) - \delta_E^P(G)$, if G be perfect domination number then it does not exists for any complement of complete BFG of G. The same author defined non-split total strong (weak) domination BFG and examined the effecting degree of a vertex in BFG. He provides the classification of size, order and degree and non-split total strong (weak) domination in BFG with suitable examples. Also introduced some basic parametric conditions then the features of total strong (weak) domination number and non-split total strong (weak) domination number were finally studied in BFG. and given some important results such as if G be any Non-Split total strong (weak) domination of BFG, then (i) $\gamma_{NS_{T_b}}(G) \geq \delta_N^P(G) \geq \delta_E^P(G)$ (ii) $\delta_N^N(G\ ) \leq \delta_E^N(G) \leq \gamma_{NS_{T_b}}(G)$ (iii) $\gamma_{T_b}(G) \leq \gamma_{NS_{T_b}}(G) \leq p - \Delta_N(G)$ (iv) $\gamma_{T_b}(G) \leq \gamma_{NS_{T_b}}(G) \leq p - \Delta_N(G) \leq q - \Delta_E(G)$ [68]. R.Muthuraj et al. [69] defined regular total strong (weak) domination and several classifications in BFG. He provides the classifications of size, order and degree and total strong (weak) domination in BFG with suitable examples and proved if G be a regular total strong(weak) dominating BFG then $\gamma_{R_{T_b}}(G) \geq O^P(G) \geq S^P(G)$ and $O^N(G) \leq S^N(G) \leq \gamma_{R_{T_b}}(G)$. Also introduced some basic parametric conditions with some examples then finally discussed the properties of regular total strong (weak) domination number in BFG. Mohammed Akram et al [70] defined the domination and double domination of BFG and notations of energy of dominating and energy double dominating BFG. Author discussed some of the bounds and properties for the energy dominating and Energy of double dominating in BFG and given important results that is for $\widetilde{G} = (v^P, v^N, v_1^P, v_1^N)$ be a double dominating bipolar fuzzy graph with n vertices and m edges and $\widetilde{D}$ be a double dominating set $\theta_1, \theta_2, \theta_3, \dots, \theta_n$ are the eigenvalues of adjacency matrix $v_{\widetilde{D}}^P(\widetilde{G})$, then (i) $\sum_{l=1}^{n} \theta_l = \delta$ (ii) $\sum_{l=1}^{n} \theta_l^2 = \sum_{l=1}^{n} (v_{ll}^P)^2 + 2\sum_{1\le l\le m\le n} v_{lm}^P v_{lm}^P$ and $\varphi_1, \varphi_2, \varphi_3, \dots, \varphi_n$ are the eigenvalues of adjacency matrix $v_{\widetilde{D}}^P(\widetilde{G})$, then (i) $\sum_{l=1}^{n} \varphi_l = -\delta$ (ii) $\sum_{l=1}^{n} \varphi_l^2 = \sum_{l=1}^{n} (v_{ll}^N)^2 + 2\sum_{1\le l\le m\le n} v_{lm}^N v_{lm}^N$. Mansour Hezam Al-Sherby and Mahioub M.Q. Shubatah [71] presented the concept of independent domination number and determined independent domination number in the operations on BFG such as join, Cartesian products, strong product and composition. The author has given some important results that is if G_1 and G_2 be two BFG and D_1 be $\gamma_i -$ set of G_1, D_2 be $\gamma_i -$ set of G_2 then the independent dominating set of $\gamma_i(G_1 + G_2) = \min\{\gamma_i(G_1), \gamma_i(G_2)\}$, $\gamma_i(G_1 \circ G_2) = |D_1 \times D_2|$ and $\gamma_i(G_1 \otimes G_2) = |D_1 \times D_2|$. The author in the same year studied and introduced the concept of independent domination of BFG and chromatic number of BFG, investigated the relationship of independent domination and chromatic number with the other known parameters. Finally explained some standard type set of independent domination in BFG and proved some of theorems such as G is a set of minimal domination and D be a set of independent domination in BFG if and only if for every $d \in D$ one of the following conditions satisfied d is not a strong neighbour of any node in D and there is a node $v \in V - D$ such that $N(v) \cap D = d$. If G be without isolated vertices a subset $D \subseteq V$ is an independent dominating set then $V - D$ is a vertex covering set of G. For independent set of BFG, if G be a maximal independent set of BFG then G is an independent dominating set [72]. R. Muthuraj and Kanimozhi [73] introduced equitable domination in BFG, defined various classifications and has given some important results that is if G be any BFG then $\gamma_E(G) < p$ and G be n-regular BFG for $n \ge 1$ then $\gamma_{TE}(G) = \gamma_T(G)$ .Also discussed some basic parametric conditions, and properties of total domination number, and equitable total domination number in BFG. In the same year author provides the size, order, degree, etc of BFG with suitable examples. The double domination number of a BFG has been clarified and addresses some of the properties of double domination on the BFG. Finally proved some simple theorems such as if G be a BFG then (i) $\gamma(G) \le \gamma_{D_d}(G)$ (ii) $\gamma_{D_d}(G) < p$ and (iii) G be a set of double domination in BFG then $\gamma(G) + \gamma_{D_d}(G) \le p$. Also proved G be completely bipartite BFG with $n > 2$ then D_d of G exists [74]. Saqr. H et al. [75] introduced inverse domination number on BFG and investigated the relationship of inverse domination with some other known parameters in BFG and proved some of the theorems and results for that if G be any BFG then (i) $\gamma'(G) + \gamma'(G) \le p$ (ii) $\gamma'(G) \le p - \Delta_N(G)$ (iii) $\gamma'(G) \le \gamma'_s(G) \le \gamma'_{ns}(G)$ (iv) $\gamma'(G) \le \frac{P.\Delta_N(G)}{\Delta_N(G)+1}$ (v) G has without isolated vertex then $\gamma(G) \le \beta_0(G)$ also proved each set of inverse domination bipolar fuzzy graph is inverse dominating set of a crisp graph G^*, but the converse is not true. Ambika. P and Ramya. R [76] explained the concept of dominating critical in BFG and analysed dominating critical properties in various types of BFG and investigated some of the theorems related to these concepts such as in a complete BFG of G and D be a set of domination then $D = V^+$ and $V - D = V^0$. In a BFG (i) if $d_N(G) = \Delta_N(G)$ then $v \in V^+$ (ii) D is a $\gamma_{bf}(G)$ set of G then $D \subseteq V^+$. Also proved if $(G_1 + G_2)$ be two join BFG and D_1 and D_2 be a set of domination in G_1 and G_2 then $|D_1| < |D_2|, D_1 \in V^+, D_2 \in V^0$ and $|D_2| < |D_1|, D_2 \in V^+, D_1 \in V^0$. Roseline Mary et al [77] presented the liar domination number in BFG and discussed some of their properties and characteristics. Furthermore, proved some of the theorems and results for these concepts like G is a liar dominating set and B be set of minimal domination in BFG if and only if for every $t_m \in B$ one of the following conditions satisfied t_i is a strong neighbour of only one node in B and there is a node $v \in V_B$ such that $N(v) \cap B = \{t_i, t_j\}$ and for liar dominating set of BFG contains at least three vertices. Also proved if liar dominating number of complete BFG then $\lambda(k_n) = \sum_{i=1}^{3}[\{\frac{1+\mu^+(v_i)+\mu^-(v_i)}{2}\}]$ a $\lambda(k_{v_1,v_2}) = \sum_{i=1}^{3}[\min_{u_i \in v_1}\{\frac{1+\mu^+(u_i)+\mu^-(u_i)}{2}\}] + \sum_{i=1}^{3}[\min_{u_j \in v_2}\{\frac{1+\mu^+(u_j)+\mu^-(u_j)}{2}\}]$. As'ad, Mahmoud and As'ad Alnasar [78] investigated the concepts of total strong (weak) domination of BIFG and defined strong domination BIFG. Also author proved strong domination theorems that is G be BIFG τ_B is a set of minimal total strong (weak) domination, if and only if for every $J \in \tau_B$ one of the following axioms satisfied (i) there is no node of τ_B strongly dominates J (ii) $\ni J \in V - \tau_B$ is a strongly dominates only one node and τ_B BIFG with total dominating set. Finally proved if G be BIFG order of G then $\mathcal{T}_{sbif}(G) \le \mathcal{T}_{tsbif}(G) \le O(G) - \Delta_n(G) \le O(G) - \Delta_e(G)$ and $\mathcal{T}_{sbif}(G) \le t_{twbif}(G) \le O(G) - \delta_n(G) \le O(G) - \delta_e(G)$.

Fuzzy Soft Graph (FSG)

R.Jahir Hussain and Saddam Hussain [79] investigated the topic of dominance in Fuzzy Soft

Graphs. Dominance was produced by utilising the concepts of strength of connectivity, strength of a path, and strong arc. Then the fuzzy soft graph was then given a set of domination, set of a domination number, set of a total domination and set of a total domination number, an independent domination set, and an independent domination number. In addition, the required and sufficient requirements for FSG's minimum domination set were examined. Finally obtained some of the results such as $G_{A,v} = ((A,\rho),(A,\mu))$ is a set of minimal domination and D be a set of domination FSG if and only if for every $d \in D$ one of the following axioms holds d is not a strong neighbour of any node in D and there is a vertex $v \in V - D$ such that $N(v) \cap D$ =d. If $G_{A,v} = ((A,\rho),(A,\mu))$ be without isolated nodes and D is a set of minimal domination then $V - D$ is a set of domination in $G_{A,v}$. For independent set of FSG, if G be a set of maximal independent in FSG then G is an independent and dominating set. Also proved G is a minimum dominant set in every maximal independent set in an FSG. Matthew Varkey and T.K Rani Rajjeevan [80] defined the concepts of a set of fuzzy soft edge domination, set of fuzzy soft edge domination number, set of fuzzy soft t-edge domination, and set of fuzzy soft t-edge domination numbers and proved some of the theorems related to these concepts that is if $G_{A,v}$ complete FSG with n vertices must have perfect fuzzy soft t-dominating sets, where $1 < t \leq n-1$ also proved if $G_{A,v}$ is any FSG then $\gamma_{pfs-t}(G_{A,v}) \geq \frac{tn}{G_{A,v}+1}$. Also the same author introduced the concepts of perfect fuzzy soft domination, perfect fuzzy soft domination number, perfect t-vertex domination , perfect t-vertex domination number and proved some of the theorems for that $G_{A,v}$ is any FSG then $\gamma^1(G_{A,v}) + \bar{\gamma}^1(G_{A,v}) \leq 2S(G_{A,v})$ if and only if $0 < \mu_e(x_i,x_j) < \rho_e(x_i) \wedge \rho_e(x_j)$ and if (x_m,x_n) is an FSG without isolated edges then $\frac{S(G_{A,v})}{\Delta^1(G_{A,v}+1)} \geq \gamma^1{}_{fs}(G_{A,v})$. Also proved if $G_{A,v}$ is a complete fuzzy soft graph with even nodes then there exists a set of fuzzy soft t-edge domination and the minimum value of t is $\frac{n}{2}$ where $n \geq 4$ [81]. Also they have extends the concepts set of soft fuzzy equitable domination, set of soft fuzzy equitable independent, set of minimal fuzzy soft equitable dominating, and set of strong (weak) fuzzy soft equitable domination are all notions developed by the author. Also derived some of the theorems like D be a minimal fuzzy soft equitable dominating set of FSG if and only if for each $x_i \in D$ one of the following axioms holds $N^{efs}(x_i) \cap D = \phi$ and there is a node $x_i \in V - D$ such that $N^{efs}(x_i) \cap D = x_i$. If G be FSG without isolated nodes and D is a minimal fuzzy soft equitable dominating set then $V - D$ is a fuzzy soft equitable dominating set of G. If G be FSG with order p then $\gamma^{efs}(G) \leq \gamma^{sefs}(G) \leq p - \Delta^{efs}(G)$ and $\gamma^{efs}(G) \leq \gamma^{wefs}(G) \leq p - \delta^{efs}(G)$. Finally proved G be FSG then $\gamma^{efs}(G) \leq \beta^{efs}(G)$ and if G be a set of soft fuzzy equitable independent and S is a set of maximal soft fuzzy equitable independent if and only if it is a set of soft fuzzy equitable domination [82], T.K Rani Rajjeevan and Matthew Varkey [83]. introduced the concepts of domination parameters like set of fuzzy soft accurate domination, set of fuzzy soft accurate domination number, set of fuzzy soft connected accurate domination, set of fuzzy soft connected accurate domination number and derived some of the results such as if $G_{A,V}$ be a fuzzy soft connected graph with more than 2 nodes for every parameter, then $\gamma_{fs}(G_{A,V}) \leq \gamma_{fsa}(G_{A,V}) \leq \gamma_{fsca}(G_{A,V})$ and $\gamma_{fsc}(G_{A,V}) \leq \gamma_{fsca}(G_{A,V})$. If $G_{A,V}$ be a fuzzy soft complete graph with more than 2 nodes for each parameter all nodes having unequal fuzzy soft cardinality then $\gamma_{fsca}(G_{A,V}) = \wedge[\sum_{e \in A} \rho_e(x_i)]$. Also proved fuzzy soft connected equitable domination set and obtained some of the results that is for $G_{A,V}$ is a fuzzy soft regular graph then $\gamma_{fsce}(G_{A,V}) = \gamma_{fsc}(G_{A,V})$and $G_{A,V}$ is any fuzzy soft connected graph then $\gamma_{fs}(G_{A,V}) \leq \gamma_{fse}(G_{A,V}) \leq \gamma_{fsce}(G_{A,V})$ also $\gamma_{fsc}(G_{A,V}) \leq \gamma_{fsce}(G_{A,V})$.

Hesitancy Fuzzy graph (HFG)

R.Jahir Hussain et al [84] address domination in HFG and established the topic in strength of path, the connectivity strength, and strong arc dominance set in HFG. Finally investigated some of the properties of independent domination of HFG. R.Sakthivel et al. [85] introduced the domination in HFG and some of the properties. Also investigated domination in products of HFG like Union, join, cartesian product, and composition. R.Sakthivel et al. [86] introduced the concept of various domination numbers in HFG and investigated some of the properties also examined total domination number in operations of HFG like union, join, and direct product and proved some of the theorems such as if G be a complete HFG and D is a set of minimum domination then $D = \{u\}$ such that $u \in V$ is a node having the maximum neighbourhood degree in G and if G be HFG then $\gamma_{hf}(G) \leq p - \Delta_N(G) \leq p - \delta_N(G)$ and $\gamma_{T_b}(G) \leq \gamma_{NS_{T_b}}(G) \leq p - \Delta_N(G) \leq q - \Delta_E(G)$. If $G_1 = (V_1,E_1)$ and $G_2 = (V_2,E_2)$ any two HFG and D_1 and D_2 set of minimum domination then (i) $\gamma_h(G_1 + G_2) \leq \gamma_h(G_1) \wedge \gamma_h(G_2)$ and (ii) $\gamma_h(G_1 \cdot G_2) \leq |V_1 X D_2| \wedge |D_1 X V_2|$ (iii) $\gamma_h(G_1 \odot G_2) \leq |V_1 X D_2| \wedge |D_1 X V_2|$ and (iv) $\gamma_h(G_1 \otimes G_2) \leq |V_1 X D_2| \wedge |D_1 X V_2|$. Also, the author proposed the set of inverse domination and set of domination number of HFG, also discussed the set of inverse domination number of complete and complete bipartite in HFG and proved some of the results and bounds. Further investigated the inverse domination number of join of two HFG and cartesian product of two HFG [87]. The author extends his research in the concept of node degree and strong neighbour of the node are introduced by using membership and non-membership and hesitance degree of a node in HFG. Finally discussed some of their results that is G be HFG then D is a set of minimal strong (weak) domination, then $V - D$ is a set of weak (strong) dominating in G and if G is HFG of order p then $\varsigma(G) \le \varsigma_s(G) \le p - \Delta_N(G) \le p - \Delta_E(G)$ and $\varsigma(G) \le \varsigma_w(G) \le p - \delta_N(G) \le p - \delta_E(G)$. Also derived if G be a complete HFG, u and v are the nodes having minimum cardinality and maximum cardinality respectively, then $\varsigma_s(G) = |u|$, $\varsigma_w(G) = |v|$ and G be regular HFG then $\varsigma_s(G) = \frac{O(G)}{2}$[88]. S.K.Sriram Kalyan [89] defined the concept of regular domination and regular domination number in HFG. Furthermore, discussed some of the properties and proved $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$ any two HFG and D_1 and D_2 the minimal K-regular dominating sets then the regular dominating number of $\gamma_{HR}(G_1 \cup G_2) = |D_1| + |D_2|$. And G_1 and G_2 has unique order $\gamma_{HR}(G_1 + G_2) = \min\{|D_1|, |D_2|\}$.

Anti Fuzzy graph (AFG)

R.Muthuraj and A.Sasirekha [90] introduced the concept of a set of domination and set of domination number in AFG and obtained the sum of the bounds on various types of AFG. Also examined the column and row maximal algorithms and characterized to find minimal dominating set and discussed the domination number applied in an anti-Cartesian product, anti fuzzy path, anti fuzzy cycle, and complete anti fuzzy graph then proved some of their results that is G_A be an unimodal AFG then $q - p \leqq \gamma_A \leqq p - \delta$ and $\gamma(G_A) \leqq \frac{p}{2}$. and proved G_A be an unimodal AFG (i) with $m \ge 2$ then $\gamma_A \leqq p - \Delta(G_A)$ (ii) with $q = 2p$ then $(G_A) = \frac{p}{2}$ and (iii) connected AFG with $m \ge 2$ then $\frac{p}{1+\Delta(G_A)}$. Finally proved $G_{A_1} \times G_{A_2}$ be an anti cartesian product of AFG paths then the following conditions satisfied removal of all weak points in $G_{A_1} \times G_{A_2}$ remains connected say $(G_{A_1} \times G_{A_2})'$ and $\gamma(G_{A_1} \times G_{A_2}) = \gamma\,(G_{A_1} \times G_{A_2})'$. In the same year, the author introduced the concept of total domination set and total domination number in AFG and obtained some of results such as G_A is an unimodal AFG then (i) $\gamma_t(G_A) = \{\leqq p/2, \text{for } p \leqq q \text{ and } \geqq \frac{p}{2}, \text{for } p > q\}$ (ii) G_A with no isolated vertices then $\gamma_t(G_A) = p - \Delta(G_A)$ (iii) G_A is a complete unimodal AFG $\gamma_t(G_A) = 2\sigma(u_{1.})$ (iv) G_A is an anti fuzzy cycle then $\gamma_{At}(G_A) \le \frac{p+q-\Delta(G_A)}{2}$ and G_A is an anti fuzzy path then $\gamma_{At}(G_A) \le p - \delta$. Further explained how to find an algorithm for minimal total dominating set AFG. Further discussed the total domination number applied in the anti cartesian product, anti fuzzy cycle, anti fuzzy path, and complete anti fuzzy graph and obtained some of the bounds for these parameters [91]. The author extends the concepts of connected domination set domination number in AFG and discussed the connected domination number related results such as G_A is a set of minimal connected domination of a simple connected and D be a set of connected domination if and only if for each $u \in D$ at least one of the following conditions satisfied u is a cut vertex in D, there is a vertex $v \in V - D$ such that $N_E(v) \cap D = \{u\}$ and u is in leaf in D. G_A is any connected AFG then $\gamma_A \le \gamma_{Ac}$, G_A is an uninodal AFG then $|p - q| \le \gamma_{Ac} \le p - \delta$ and G_A is a complete bipartite graph with r and s nodes then $\gamma_c(G_A) \le \min\{r, s\}$. Finally applied the connected domination number on anti Cartesian product of AFG such as cycle, path and complete anti fuzzy graph and derived some of the theorems that is $G_A = G_{A_1} \times G_{A_2}$ is an anti Cartesian product of AFG cycles G_{A_1} and G_{A_2} then the connected dominating set is isomorphic to cycle or a tree [92]. R.Muthuraj and A.Sasirekha [93] introduced the concept of perfect domination set and domination number in AFG, applied in various types of AFG and derived some of the results such as if P be the perfect domination number and G be any complete uninodal AFG then $\gamma_{paf} = \sigma(u)$ here $\sigma(u)$ membership value of a vertex u and G be a star AFG then $\gamma_{paf} = \sigma(v)$ here v is the centre vertex. In the same year author discussed the application of AFG and application of domination in AFG. Then explained in detail the method to find a suitable employee in a merging bank by using an anti-cartesian product of AFG and domination in AFG. Also discussed fixing stations in railways using Domination on AFG [94]. R.Muthuraj and A.Sasirekha [95] introduced the concept of edge domination number in AFG. Also discussed how the edge domination number applied various types of AFG and proved some of the various bounds on them. Finally explained this concept applied and anti cartesian product of anti fuzzy graph and obtained some of the results on these parameters. H.J.Yousif and A.A.Omran [96] discussed the concept of a split anti fuzzy dominating set in AFG and investigated the relationship of domination number with some of the known parameters also found the exact value of anti fuzzy domination in AFG and derived some of theorems related this concepts that such as if D is a split anti fuzzy domination set of a BFG of G_{AF}, if and only if then $u_2 \in D$, satisfying one of the following condition (i) u_2 is an isolated in D (ii) there is exists $u_1 \in$

$V - D$ such that $N(u_1) \cap D = \{u_2\}$ and (iii) $< (V - D) \cup \{u_2\} >$is connected also proved if G_{AF} is a AFG then $P \leq \alpha_{0+}\beta_0$ and each split anti fuzzy domination (SAFD) set of G_{AF} is a split dominating set in crisp graph $G_A{}^*$. Also in the same year author defined the set of 2 - anti fuzzy domination and the 2 - anti fuzzy domination number on AFG by effective edges and then discussed the 2 - anti fuzzy domination number applied a various AFG. Also proved some of the relationships between 2-anti fuzzy domination numbers with the parameters and derived the important results that is if $G_{AF} =(\eta, \rho)$, $\sum_{v_i \varepsilon S} \eta(v_i) \leq \gamma_{2AF} \leq P$ here if D is a 2-anti fuzzy domination set of G_{AF} , then S is a set containing all the nodes that have at most one neighbour. Then, in general, $V - D$ is not a 2-anti fuzzy dominance set of G_{AF}. Finally derived if $G_{AF} = (\eta, \rho)$ be an uninodal anti fuzzy graph without isolated and D be a γ_{2AF} set of G_{AF} that is not independent set then $\gamma_{AF} + t \leq \gamma_{2AF}$ and if $G_{AF} = (\eta, \rho)$ connected an unimodal AFG and $\gamma_{AF} = \gamma_{2AF}$ [97]. R.Muthuraj et al. [98] defined the notion of a set of split domination, set of strong split domination, set of split domination number, set of strong split dominating numbers also examined strength of anti-path in IAFG and the strength of anti-connectedness between two vertices of IAFG. Furthermore discussed the anti-fuzzy structure of Intuitionistic Fuzzy Graphs in split domination and split domination number also proved some of the theorems. H.J.Yousif and A.A.Omran [99] have defined the Inverse 2-anti fuzzy dominance set and inverse 2-anti fuzzy domination number, and inverse 2-anti fuzzy domination was addressed in relation to various types of AFG. Finally obtained some of their results that is G_{af} any AFG has an inverse 2_{afd} then $x \in V - D$ belongs to each inverse 2_{afd} of G_{af} and if x has either two or three neighbours and if D' is an inverse 2_{afd} set and G_{af} be any AFG such that $|D'| = \gamma_{2af}^{-1}$is minimal if and only if then $x \in D'$, either $N(x) \cap D' < 2$ or there exists $y \in V - D'$ such that $N(y) \cap D' = 2$. R.Muthuraj et al. [100] discussed regular intuitionistic anti fuzzy graph and derived some of their results like G_A of any IAFG an isolated node does not dominate any other node of G_A . Investigated two different types of domination as connected strong domination and multiple connected domination in IAFG and obtained some of the theorems on these concepts.

Picture Fuzzy Graph (PFG)

S.Mohammed Ismayil and N.Asha Basley [101] introduced the topic of a set of domination in PFG and defined the order and size of a PFG. Also obtained some of their results and proved some of the theorems such as G is a set of minimal domination and D be a set of domination in PFG if and only if for each $u \in D$ one of the following conditions satisfied u is not an effective neighbour of any vertex in D and there is a node $v \in V - D$ such that $N_E(v) \cap D = \{u\}$. If G be a set of independent domination in PFG and a subset is $D \subseteq V$ then $V–D$ is a vertex covering set of G. For independent set of PFG, if G be a maximal independent set of PFG then G is an independent and dominating set. Also proved D is each set of maximal independent in PFG is a set of all minimal dominating in G and any PFG $\gamma(G) + \gamma(\overline{G}) \leq 2p$ and equality holds if and only if $0 < \mu_2(x, y) < \mu_1(x) \wedge \mu_1(y)$, $0 < \sigma_2(x, y) < \sigma_1(x) \wedge \sigma_1(y)$ and $0 < \rho_2(x, y) < \rho_1(x) \vee \rho_1(y)\ \forall\, x, y \in V$ and G be any PFG without isolated nodes $\alpha(G) + \beta(G) = p$. Finally investigated some of the bounds domination in PFG. S.Mohammed Ismayil et al. [102] introduced the concepts of edge domination set, edge domination number, edge independent set, maximal edge independent number, and edge covering the number with suitable examples in PFG also obtained some of their theorems proved G is a minimal edge dominating set and S be an edge dominating set of PFG if and only if for each $e_i \in S$ one of the following conditions satisfied $N_E(e_i) \cap S = \{\phi\}$ and there is an edge $e_j \in E - S$ such that $N_E(e_j) \cap S = \{e_i\}$. If G be any PFG and if and only if be a maximal edge independent dominating set of a subset is $I \subseteq E$ then $E - I$ is an edge covering set of G. For set of edge independent I of a PFG, if G be a maximal edge independent set of PFG then G is an independent and edge dominating set. Also proved I is every maximal edge independent set of PFG is a minimal edge dominating set of G and any PFG $\gamma_e(G) + \gamma_e(\overline{G}) \leq 2q$ and equality holds if and only if $0 < \mu_2(x, y) < \mu_1(x) \wedge \mu_1(y)$, $0 < \sigma_2(x, y) < \sigma_1(x) \wedge \sigma_1(y)$ and $0 < \rho_2(x, y) > \rho_1(x) \vee \rho_1(y)\ \forall\, x, y \in V$ and any PFG without isolated edges $\alpha_e(G) + \beta_e(G) \leq q$. Finally proved if G be a complete PFG and S is a minimal edge dominating set, then the edge that intersects the vertex dominates the set S one of the edges has the greatest degree also G be PFG and S be an edge dominating set then $\delta(G) \leq \gamma_e(G)$. A.Nagoor Gani et al. [103] introduced the concept of strong and weak domination set, strong and weak domination number in PFG, independent domination strong and weak in PFG and discussed strong and weak domination using strong arcs in PFG. Finally proved some of the properties for this parameter and theorems like D is a minimal strong picture fuzzy dominating set and if G be a constant PFG of degree (c_i, c_j, c_k) without isolated vertices then $V – D$ is a picture fuzzy dominating set of G. Also given result such as G be PFG with order of p then $\gamma_{pf}(G) \leq \gamma_{spf}(G) \leq q - \Delta_s(G)$ and $\gamma_{pf}(G) \leq \gamma_{wpf}(G) \leq p - \delta_s(G)$ also proved if G constant

PFG of degree $(c_i, c_{j,}c_k)$then then $\gamma_{spf}(G) \leq\leq p \leq q$ and $\gamma_{wpf}(G) \leq p \leq q$.

2. Conclusion

Based on the literature survey, this work conducts a detailed examination of different types of domination in various types of fuzzy graphs. Based on the literature survey, this work conducts a detailed examination of different types of domination in various types of graphs. This survey study provides an outline on the growth and developments in fuzzy graphs and hope it inspires the future researchers looking to dominate in the field of fuzzy graphs.

3. References

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