Edge Domination in Neutrosophic Graphs

EDGE DOMINATION IN NEUTROSOPHICGRAPHS

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ABSTRACT

This paper investigates an edge domination in neutrosophic graphs. Some basic definitions on edge dominating set with suitable examples are introduced. Further some results on edge domination number are investigated and theorems on edge dominating set with a known parameter of a neutrosophic graph are established.

Keywords:

Neutrosophic set, neutrosophic graph, neutrosophic number, edge dominating set.
AMS Subject Classification: 05C69

1 INTRODUCTION

The study of dominating sets in graphs was started by Ore [29]. The domination number and the independent domination number were introduced by Cockayne and Hedetniemi [10]. Fuzzy relation was introduced by Zadeh [41] in his classical paper in 1965. Rosenfeld [34] introduced the notation of fuzzy graph and several fuzzy analogs of graph theoretic concepts such as paths, cycles and connectedness. Somasundaram and Somasundaram [39] discussed domination in fuzzy graphs. They defined domination using effective edges in fuzzy graphs. Nagoor Gani and Chandrasekaran [23] discussed domination in fuzzy graph using strong arcs. Nagoor Gani and Vadivel [28] discussed domination, independent domination and irredundance in fuzzy graphs using strong arcs. Several advanced topics and different types of domination are listed in Haynes et al. [14,15]. In 1976, the idea of a connected domination graphs was introduced and studied by Sampathkumar and Walikar [36]. In 1977, the concept of edge domination was introduced by Mitchell and Hedetniemi [19] as an analogue of vertex domination. A subset X of D is called an edge dominating set of G if every edge not in X is adjacent to some edge in X. Arumugam and Velammal [3] introduced the concept of connected edge domination of a connected graph. They have shown that a characterization of graphs reaching the upper bounds. The edge domination number of connected graphs has been introduced by Chaemchan [8] which is based on [3]. In 2015, Puttaswamy and Alatif [33] was introduced the concept of the boundary of edge domination in graphs, and also they have obtained exact values of some standard graphs. The intuitionistic fuzzy set is introduced by Atanassov [4] as a generalization of fuzzy set [40], which have both membership grades and non-membership grades. As an application, he applied his idea into expert systems, pattern recognition and especially in decision making. As a new emerging study of an intuitionistic fuzzy graph (IFG) has been addressed in [37]. Chountas and Alzebdi [9] presented an intuitionistic fuzzy version of a tree in graph theory. Furthermore, the operations [31] and some particular case of intuitionistic fuzzy graphs [30] were done by Parvathy and Karunambigai. The domination of graph in an intuitionistic environment defined in [32]. Later, Nangoorgani and Prasanna Devi [27] proposed the idea of edge domination and independence in the fuzzy graph. In this research, inspired from [32] and [27] investigated the concept of edge dominating set in IFGs and proved some remarkable results on edge dominating set. Neutrosophic set proposed by Smarandache [12] is a powerful tool for dealing incomplete and indeterminate problems in the real world. It is the generalization of fuzzy sets [13] and intuitionistic fuzzy set [16,17]. Fuzzy graph and intuitionistic approaches are failed in some applications when indeterminacy occurs. So Smarandache defined four main categories of neutrosophic graphs in [38]. M. Mullai (2019), introduced the concept of domination and various types of domination in neutrosophic graphs . In this proposed work, edge domination in neutrosophic graph are developed with suitable examples and some results and theorems are explored.

2 Preliminaries:

Definition 2.1 An arc (v_i, v_j) is said to be a strong arc if $\mu_{2ij} \geq CONN_{\mu(G)}(v_i, v_j)$

and $\nu_{2ij} \leq CONN_{\nu(G)}(v_i, v_j)$ for every $v_i, v_j \in V$.

Definition 2.2 [32]

The strong neighbourhood of an edge e_i in a intuitionistic fuzzy graph G is
$N_s(e_i) = \{e_j \in E(G)/e_j$ is a strong arc in G and adjacent to $e_i\}$ *($S \subseteq E(G)$)*

Definition 2.3 [32]

Let G = (V,E) be an IFG. Let e_i and e_j be two edges of G. We say that e_i dominates e_j, if e_i is a strong arc in G and adjacent to e_j.

Definition 2.4 [32]

Let D be a minimum dominating set of intuitionistic fuzzy graph G. If for every $e_j \in E(G) - D$, there exists $e_i \in D$ such that e_i dominates e_j, then D is called an edge dominating set of D. The minimum intuitionistic fuzzy cardinality of all edge dominating set of IFG G is known as edge dominating number and it is denoted by $\gamma_e(G)$.

Definition 2.5 [32]

Let G be an IFG and D be a subset of an edge set E. Then the node cover of D in G is defined as the set of all nodes incident to each edge in D.

Definition 2.6 [32]

Let IFG G=(V,E) and D is an edge dominating set in G.

(i) If the induced subgraph $< E - D >$ is disconnected. Then D is called split edge dominating set of G.

(ii) If the induced subgraph $< E - D >$ is connected. Then D is called a non-split edge dominating set of G.

(iii) If the induced subgraph $< E - D >$ is a path. Then D is called a path non-split edge dominating set of G.

(iv) If the induced subgraph $< E - D >$ is a cycle. Then D is called a cycle non-split edge dominating set of G.

Definition 2.7 [32]

Let e_i and e_j be any two edges of an intuitionistic fuzzy graph G. If $e_i \in$ $\notin N_s(e_j)$

and $e_j \notin N_s(e_i)$, then e_i and e_j are called intuitionistic fuzzy independent. A set S E(G) is said to be an intuitionistic fuzzy edge independent set of an intuitionistic fuzzy graph G, if any two edges in S are intuitionistic fuzzy independent. The intuitionistic fuzzy edge independence number $\beta_e(G)$ is the maximum cardinality of all Intuitionistic fuzzy edge independent sets of G.

Definition 2.8 Let G = (A,B) be a single valued neutrosophic graph on the edge set E and Let $e_1, e_2 \in E$. e_1 dominates e_2 in G if

$T_A(e_1, e_2) = \min\{T_B(e_1), T_B(e_2)\}$, $I_A(e_1, e_2) = \min\{I_B(e_1), I_B(e_2)\}$ and

$F_A(e_1, e_2) = \min\{F_B(e_1), F_B(e_2)\}$.

Definition 2.9 A subset D^N of E is called an edge dominating set in G if for every edge $e_i \notin D^N$ there exists $e_j \in D^N$ such that e_j dominates e_i.

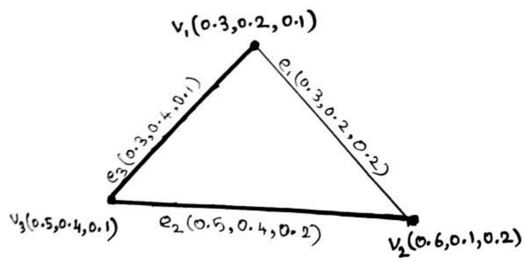
3 Edge Domination in Neutrosophic Graphs

Definition 3.1 The minimum cardinality of an edge dominating set in a neutrosophic graph G is called the edge dominating number of G and is denoted by $\gamma^N(G)$ or γ^N.

Example

Consider a figure 1,

Let $D^N = \{e_3\}$ is an edge dominating set and $E - D^N = \{e_1, e_2\}$. Edge domination



Figur
e 1:

number is $\gamma^N_e(G) = 0.4$.

Note:

(i) For any $e_i, e_j \in E$, if e_i dominates e_j in G then e_j dominates e_i and hencedomination is a symmetric relation on E.

(ii) For any e_i in E, $N(e_i)$ is the set of all edges which are dominated by e_i.

(iii) If $T_B(e_1, e_2) < \min\{T_B(e_1), T_B(e_2)\}$,

$I_B(e_1, e_2) < \max\{I_B(e_1), I_B(e_2)\}$ and

$F_B(e_1, e_2) < \max\{F_B(e_1), F_B(e_2)\}$, $\forall e_1, e_2 \in E$

then the only dominating set in G is E.

Definition 3.2 Let G be a neutrosophic graph and D^N is an edge dominating set of

G. Then D^N is said to be a minimal edge dominating set if no proper subset of D^N is a edge dominating set of G.

Definition 3.3 An edge e_1 of a neutrosophic graph G is said to be an isolated edgeif

$T_B(e_1, e_2) < \min\{T_B(e_1), T_B(e_2)\}$,

$I_B(e_1, e_2) < \max\{I_B(e_1), I_B(e_2)\}$ and

$F_B(e_1, e_2) < \max\{F_B(e_1), F_B(e_2)\}, \ \forall e_2 \in E - \{e_1\}$

i.e, $N(e_1) = \Phi$

Definition 3.4 Let G be a neutrosophic graph. A set of edges D^N in a neutrosophic graph G is said to be independent if

$T_A(e_1, e_2) < \min\{T_A(e_1), T_A(e_2)\}$,

$I_A(e_1, e_2) < \max\{I_A(e_1), I_A(e_2)\}$ and

$F_A(e_1, e^2) < \max\{F^A(e^1), F^A(e^2)\}, \ \forall e_1, e_2 \in D^N$

Definition 3.5 Let G be a neutrosophic graph without isolated edges and E be an edge set of G. A subset D^N of E is said to be a total edge dominating set if every edge in E is dominated by an edge in D^N.

Definition 3.6 The minimum neutrosophic cardinality of a total edge dominating set is called total edge domination number of a neutrosophic graph G.

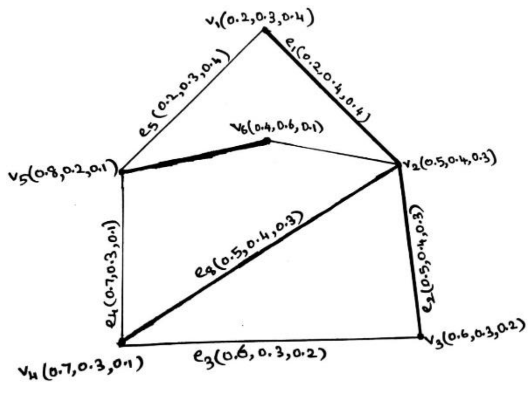
Definition 3.7 Let G be an neutrosophic Graph (NG) and D^N be a subset of an edge set E. Then, the node cover of D^N in G is defined as the set of all nodes incident to each edge in D^N.

Example

Consider a figure 2,

Let $D^N = \{e_6, e_8\}$ is an edge dominating set in NG and $E - D^N = \{e_1, e_2, e_3, e_4, e_5, e_7\}$.

Therefore, node cover of D^N is $\{v_5, v_2, v_6, v_4\}$.



Figur
e 2:

Definition 3.8 Let neutrosophic graph G and D^N is an edge dominating set in G.

(i) If the induced subgraph $< E - D^N >$ is a path. Then D^N is called a path non-split edge dominating set of G.

(ii) If the induced subgraph $< E - D^N >$ is a cycle. Then D^N is called a cyclenon-split edge dominating set of G.

Definition 3.9 Let e_i and e_j be any two edges of neutrosophic graph G. If $e_i \notin N_S(e_j)$ and $e_j \notin N_S(e_i)$, then e_i and e_j are called neutrosophic independent.

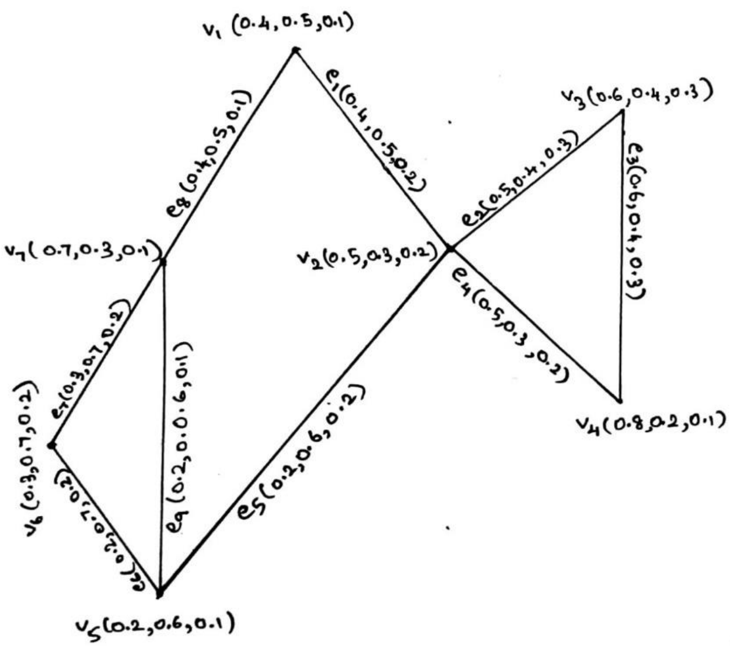
Definition 3.10 Let G be a neutrosophic graph. If any two edges of S^N are neutrosophic independent, then a set $S^N \subseteq E(G)$ is said to be a neutrosophic edge independent set

of G.

Definition 3.11 The neutrosophic edge independence number $\beta^N(G)$ is the maximum cardinality of all neutrosophic edge independent set of G.

Example:

Consider the following figure ,



Here, {e_1}, {e_2}, {e_3}, {e_4}, {e_5}, {e_6}, {e_1, e_3, e_7}, {e_1, e_9, e_8}, {e_3, e_5, e_8}, {e_2, e_8, e_6}, {e_3, e_5, e_7}, {e_1, e_8}, {e_2, e_7}... etc

Theorem 3.12 Every edge dominating set D^N of an neutrosophic graph G containsat least one dominating set D'^N in G.

Proof:

Let D^N be an edge dominating set of neuutrosophic graph G.

Let us assume that the edge dominating set D^N of neutrosophic graph G contains no dominating set D'^N in D^N.

This implies any two nodes of D^N are independent and non-adjacent. Hence,

all $e's$ are not strong in D^N.

Therefore, for every $e_i \in E - D^N$, there exists no e_i in D^N, such that e_i will not dominate e_j that contradicts to D^N.

Therefore, D^N must contain at least one dominating set D'^N in G.

Theorem 3.13 Let D^N be a cycle non-split edge dominating set, if $< E - D^N >$ node cover includes all the nodes of G.

Proof:

We know that D^N is a cycle non-split edge dominating set of G

Assume that node cover of $< E–D^N >$ does not include all the nodes of G. Then $< E–D^N >$ may be connected (or) disconnected.

Case:1

If $< E–D^N >$ is connected, then any two edges of edge dominating set D^N of Gcontains no vertex in common and is disconnected.

Thisshows D^N is a non-split edge dominating set that contradicts our assumption that D^N is a cycle non-split edge dominating set of G.

Case:2

If $< E –D^N >$ is disconnected, then any two edges of edge dominating set D^N are non-adjacent and there exists independent vertices in D^N.

This implies edge dominating set D^N is a split dominating set that is a contradictionto our assumption.

Therefore, the node cover of

$< E– D^N >$ must contain all the nodes of G from the above two cases. This completesthe proof.

Theorem 3.14 If D^N is an edge dominating set in neutrosophic graph G with end nodes, then at least one end node occur in D^N.

Proof:

Let D^N be an edge dominating set in neutrosophic graph G with end nodes.

Suppose there is no end node in D^N then some of the edges in edge dominating set D^N are independent and others are strong.

This implies for each $\forall e_j \in E - D^N$ $\exists e_i \in D^N$ such that e_i dominates e_j but D^N will not be minimum.

Then it is contradicts to the definition.

Therefore, D^N contains at least one end node in G. This completes the proof.

Theorem 3.15 If D^N is an edge dominating set, then $\delta(G) \leq \gamma_e^N$.

Proof:

Let D^N be an edge dominating set of neutrosophic graph G.

By definition of edge dominating set, D^N must be minimum and most of the arcs should be strong. Minimum degree of G is nothing but minimum of degrees of all the vertices in G.

Since, degree of a vertex v is the sum of the weights of all strong arcs incident in v, implies cardinality of an edge dominating set D^N should be maximum.

Hence, the minimum degree of G is less than the cardinality of an edge dominating set D^N . Therefore, $\delta(G) \leq \gamma_e^N(G)$.

Theorem 3.16 Let G be a neutrosophic graph and G' the complement of G with the nodes and arcs as in G. If D^N is an edge dominating set of G, then D^N is anedge dominating set of G'.

Proof:

Let G and G' be a neutrosophic graph.

Let us assume that G' contains the nodes and arcs less than G.

Suppose any two edges e_i and e_j are adjacent in G may be adjacent (or) non-adjacentin G'.

Then, there exists distinct edge dominating sets in G' which does not equals D^N

which is a contradiction to the assumption that G’ contains the edges and nodes less than G. Therefore, G and G’ should contain equal number of nodes and arcs.

hence D^Noccurs both in G and G’.

Theorem 3.17 If D^N be an edge dominating set of complete neutrosophic graph G, then the edges of an edge dominating set D^N incident with the nodes containing maximum degree.

Proof: Let D^N be an edge dominating set in G.

Assume that edges of edge dominating set D^N is not incident with the nodes having maximum degree. Then arcs of edge dominating set D^N are strong, which are incident with the node containing minimum degree.

By definition of edge dominating set, for each $e_j \in E - D^N$ there exists $e_i \in D^N$ such that e_i dominates e_j.

Hence, edge dominating set D^n must contain more number of strong arcs.

This implies D^N is not minimum, then it leads to contradiction.

Hence, edges of edge dominating set D^N should incident with the nodes containing maximum degree.

Theorem 3.18 Let D_1^N and be an edge dominating set of neutrosophic graph G_1

and G_2 respectively. Then $D_1^N \times D_2^N$ is not an edge dominating set of $G_1 \times G_2$.

Proof:

Let D_1^N and D_2^N be an edge dominating set of neutrosophic graph G_1 and G_2 respectively.
Then $D_1^N \times D_2^N$ the connected neutrosophic graph. Most of the edges in $D_1^N \times D_2^N$ are strong edges.

Since, the connected graph, $D_1^N \times D_2^N$ is the part of the graph $G_1 \times G_2$, many of the edges of $G_1 \times G_2$ are non-adjacent to this connected graph $D_1^N \times D_2^N$.

Also some edges of $D_1^N \times D_2^N$ has common vertex with the edges of $G_1 \times G_2$.

This implies for each $e_j \in E - \{D_1^N \times D_2^N\}$ there exist $e_i \in \{D_1^N \times D_2^N\}$ such that e_i dominates e_j.

This is not true for all $e_j \in E - \{D_1^N \times D_2^N\}$, then it leads to contradiction.
Therefore, $D_1^N \times D_2^N$ cannot become as an edge dominating set of $G_1 \times G_2$.

Theorem 3.19 Let G be a complete neutrosophic graph with $n \geq 2$ vertices.If $S^N(G)$ is the size of edge dominating set D^N then

$$S_e^N(G)=\begin{cases}\frac{n-1}{2}, & n \text{ is odd} \\ \frac{n}{2}, & n \text{ is even}\end{cases}$$

Proof:

Let G be a complete neutrosophic graph with $n \geq 2$ vertices in G. Here no vertex is independent in G. This implies maximum arcs are strong arcs.
Otherwise, maximum number of end nodes will occur in G. Now we take some e_i's which are strong and non-adjacent in edge dominating set D^N. That is, they have no vertex in common. By definition of edge dominating set, D^N must be minimum.
Therefore, we select e_i's in such a way that for each $e_j \in E - D^N$ there exists $e_i \in D^N$ such that e_i dominates e_j which implies that, if n is even, then size of an edge dominating set $S_e^N(G)$ is $n / 2$ such pairs and if n is odd, then there exist n-1/ 2 such pairs. This completes the proof..

Theorem 3.20 If D^N is an edge dominating set of G, then at least one edge dominating set D^N is itself an edge independent set.

Proof:

Let G be neutrosophic graph and D^N be an edge dominating set in G.

Case:1

Let us assume that D^N contains an isolated edge e_i in G. By definition of a Neutrosophic edge independent set, every e_i is an edge independent set in G. Obviously D^N is an edge independent set.

Case:2

Suppose D^N is not a neutrosophic independent set in G. Then each edge e_i in G will be strong. Hence, we have G must be a neutrosophic graph with only strong arcs, which is a contradiction to our assumption.

Therefore, at least one edge dominating set must be an edge dominating set. This completes the proof .

Conclusion

This paper demonstrates an edge domination in neutrosophic graphs by introducing some definitions on edge dominating set with suitable examples. Further some results on edge domination number γ_e^N (G) are investigated and theorems on edge dominating set D^N with a known parameter of G are established. Using these concepts, this research could be expanded in the future to find the lower and upper bounds of edge domination number of a neutrosophic graph. Also, edge domination in neutrosophic graphs will be applied in traffic problems and look for possible relationships between edge domination number and other parameters.

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