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SENTIMENT ANALYSIS USING ROUGH CO-ZERO DIVISOR GRAPH

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Abstract: The article is focused on determining the Domination and Double Domination number of a Rough Co-zero divisor graph $G(Z^*(J))$ and the Rough ideal based rough edge Cayley graph $G(T^*(J))$ of a rough Semiring (T, Δ, ∇) for a specific approximation space $I = (U, R)$ where $U$is nonempty finite set of objects and $R$is an arbitrary equivalence relation on U. Results are established with suitable example. A detailed Sentiment Analysis is made in a Twitter data using domination and double domination number of $G(Z^*(J))$ and $G(T^*(J))$.

Keywords: degree; domination number; double domination number; rough Co-zero divisor graph.

2010 AMS Subject Classification: 11B85, 20M35, 37B15, 68Q45, 68Q80.

1. INTRODUCTION

Rough set theory is a formal theory derived from fundamental research on logical properties of information systems. In Rough set theory, two precise boundary lines are established namely lower and upper approximation to describe the imprecise concepts. Therefore, in a sense the rough set theory is a certain tool to solve the uncertain problems.

In2013, Praba et al. [2-7] considered an approximation space$I = (U, R)$,where U is nonempty finite set and R is an arbitrary equivalence relation on U. With respect to the two operations

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$Praba\Delta$and$Praba\nabla$ the set of all rough sets T on U is proved to be a Semiring. The ideals of this Semiring are also studied widely and in G(T(J)) all graph theoretic properties are studied deeply. In the domain of mathematics and computer science, graph theory is the study of graphs that concerns with the relationship among edges and vertices. It is a popular subject having its applications in Computer Science, Information technology, Bio sciences and Mathematics Analysis aims to determine the attitude of the people of a specific part of content with respect to the topic of interest. Comments and content can be referred to as Positive, Negative and Neutral and also it is a subjective tool to understand people attitudes, opinions and emotions from the comment. Opinion investigation of Twitter data is a field that has been given much attention over the last decade and involves dissecting "tweets" (comments) and the content of these expressions. As such, this paper explores the sentiment analysis applied to twitter data and their outcomes.

Section 2 deals with the understanding of necessary dentitions that are required and in section 3 we discover the Domination and Double Domination Number of $G(T^*(J))$ and $G\left(Z^*(J)\right)$. In section 4 we covered the defined concepts with suitable examples followed by an application in sentiment analysis using Twitter data.

2. PRELIMINARIES

In this section we concentrate on the basic notions that are required.

2.1. Rough set theory

Let U be a non empty finite set and R be an subjective equivalence relation on U then $I = (U, R)$ is called an approximation space and for $x \in U, [x]_R = \{\, y \in U/\ (x, y) \in R\ \}$ is said to be an equivalence class. Then, for $X \subseteq U$, let $RS(X) = \left(\underline{R}(X), \overline{R}(X)\right)$ be the rough set, where $\underline{R}(X) = \{x \in U \mid [x]_R \subseteq X\ \}$ is said to be a lower approximation and the upper approximation is defined as $\overline{R}(X) = \{x \in U \mid [x]_R \cap X \neq \phi\}$. Also we defined the set of rough sets as $T = \{RS(X) | X \subseteq U\}$.

Theorem 2.1 $(T, \Delta, \nabla)$is a Semiring.

Definition 2.1

The Rough Ideal based Rough Edge Cayley graph denoted by $G = (V, E)$where $V = T$and

$E = \{(RS(X), RS(Y)) | RS(X) \nabla RS(Y) = RS(Z), RS(Y) \in J\}$.

Definition 2.2

The Rough Co-zero divisorgraph $G(Z^*(J)) = (V, E)$ where V is the set of vertices consisting of the elements of $T^* = T - \{RS(\emptyset), RS(U)\}$ and two elements $RS(X), RS(Y) \in T^*$ are adjacent iff $RS(X) \notin RS(Y)\nabla J$ and $RS(Y) \notin RS(X)\nabla J$.

Definition 2.3

Minimum degree of a graph , $\boldsymbol{\delta(G)}$ is the degree of a vertex with minimum number of lines incident with in the vertex set.

Definition 2.4

Dominating set S of G is defined as $S \subseteq V$ such that each elements in $V - S$ is connected to at least one element in S and the cardinality of the minimal dominating set is called the domination number.

Definition 2.7

Double dominating set $\boldsymbol{S'}$ of a graph G is defined as a subset of V such that each vertex in $\boldsymbol{V - S'}$ is adjacent to at least two vertices in $\boldsymbol{S'}$ and the cardinality of the minimal double dominating set is called the double domination number.

3. DOMINATION AND DOUBLE DOMINATION NUMBER OF $\boldsymbol{G(T^*(J))}$ & $\boldsymbol{G(Z^*(J))}$

This section deals with acalculation of Domination and Double Domination number of $G(T^*(J))$ and $G(Z^*(J))$ During the whole of section we assume that $I = (U, R)$ is an approximation space where U is non empty finite set of objects and R is an arbitrary equivalence relation on U. Let $\{X_{1,}X_2, \dots X_n\}$ are the equivalence classes induced by Ron U. Without loss of generality, we also assume that there are m equivalence $\{X_{1,}X_2, \dots X_m\}$ with cardinality greater than one and the remaining $n - m$ equivalence classes $\{X_{m+1,}X_{m+2}, \dots X_n\}$ have cardinality equal to one where $1 < m \leq n$. Let $\{x_{1,}x_2, \dots x_m\}$ are the representative elements of the equivalences whose cardinality larger than one and $J = \{RS(Y) | Y \in P(B) - \emptyset\}$. This means that $G(T^*(J)) = \{G(T^*(J)) – RS(\emptyset), RS(U)\}$.

Theorem 3.1

The Domination number $G\left(T^*(J)\right)$ is m, (i.e)., $|D(T^*(J))| = m$ for $1 \leq m < n$.

Proof:

Let us consider $D\left(T^*(J)\right) = \{RS(x_1), RS(x_2), \ldots RS(x_m)\}$

To prove $D\left(T^*(J)\right)$ is a dominating set of $G\left(T^*(J)\right)$if its satisfies the property that every element in $D'(T^*(J)) = T^*(J) - D(T^*(J)$)is connecetd to at least one element in $D\left(T^*(J)\right)$.

Let $RS(Z) \in T^*(J)$if $RS(Z)$contains $RS(x_i)$ or $RS(X_i)$ for $i = 1,2,..m$ then $RS(Z)\nabla J^* = RS(x_i)$. Hence $RS(Z)$ is adjacent to $RS(x_i)$ in $D\left(T^*(J)\right)$ if not $RS(Z)$ contains elements of M' which are all isolated in $G\left(T^*(J)\right)$ and thses vertices are not taken into account for the calculation of domination number.

To prove $D\left(T^*(J)\right)$ is minimal. We have to show that if removal of any elements in $D\left(T^*(J)\right)$ will affect the domination property. If $RS(x_1)$ from $D\left(T^{*(J)}\right)$ then, let $D_1\left(T^*(J)\right) = \{RS(x_2), RS(x_3) \ldots RS(x_m)\}$ such that $RS(X_1) \in T^*(J\ )$ is not connected to any element in $D_1\left(T^*(J\ )\right)$. Similar argument is true if we remove any of $RS(x_2), RS(x_3) \ldots RS(x_m)$. Hence forth $|D(T^*(J\ ))| = m$ for $1 \leq m < n$.

Theorem 3.2

The Domination number of a Rough Co-zero divisor graph $G\left(Z^*(J\ )\right)$ is

$\left|D\left(Z^*(J\ )\right)\right| = 2\ if\ m = n$ and $\left|D\left(Z^*(J\ )\right)\right| = 1\ if\ m < n$

Proof

When $m = n$

Let $D(\ Z^*(J\ ) = \{RS(X_1),\ RS(X_2)\}$ and now let us prove that $D(\ Z^*(J\ )$ is the minimal dominating set. Consider $RS(Y) \in D(\ Z^*(J\ )$now it is suffient to prove that $RS(Y)$ is adjacent to either $RS(X_1)$ or $RS(X_2)$.

Note that $RS(X_1)\nabla J = RS(x_1)$ if $Y \neq RS(x_1)$ then $RS(Y) \notin RS(X_1)\nabla J$ and $RS(X_1) \notin RS(Y)\nabla J$and if $Y = RS(x_1)$ then $RS(Y)$ is not adjacent to $RS(X_1)$. But in this case $RS(X_1)$ does not belong to $RS(X_2)\nabla J = RS(x_2)$ and $RS(Y) \notin RS(X_2)\nabla J$ and $RS(X_2) \notin RS(Y)\nabla J$. Therefore $RS(Y)$ is adjacent to $RS(X_2)$.

When $m < n$

Consider the set $D(Z^*(J) = \{RS(X_{m+1})\}$ we have to prove that $RS(X_{m+1})$ is connected to all the elements of $G\big(Z^*(J)\big)$. Since $RS(X_{m+1})\nabla J = RS(\emptyset)$ and therefore for $RS(Y) \in G\big(Z^*(J)\big)$, $RS(Y) \notin RS(X_{m+1})\nabla J$ and $RS(X_{m+1}) \notin RS(Y)\nabla J$. Hence $RS(Y)$ is adjacent to $RS(X_{m+1})$.

To prove $D(Z^*(J)$ is minimal we have to prove that if there exists a dominating set $D'(Z^*(J) = RS(Y)$ where as Y should contain at least one pivot element say $\{x_k\}$ But $RS(Y)$ is not connected to $RS(x_k)$ if $x_k \in Y$ but should contain at least one pivot element as Y is nonempty. Hence $D'(Z^*(J)$ cannot be a dominating set. Therefore $D(Z^*(J)$ is the minimal dominating set.

Theorem 3.3

Let $G\big(T^*(J)\big)$ be a rough ideal based rough edge cayley graph with $\delta(T^*(J)) = 1$ and no isolated vertices then the domination number of a rough co-zero divisor graph $G\big(Z^*(J)\big)$ is 2.

Proof

Let $G\big(T^*(J)\big)$ be a reduced rough ideal based rough edge cayley graph with $\delta(T^*(J)) = 1$.

Let $RS(Y)$ be a vertex of $G\big(T^*(J)\big)$ with degree 1.

(i.e)., $RS(Y)$ is adjacent is adjacent with only one vertex in $G\big(T^*(J)\big)$, say $RS(Z)$. Clearly $RS(Y)$ is connected to all the vertices in $G\big(Z^*(J)\big)$ other than $RS(Z)$. Now $\{ RS(Y), RS(Z) \}$ is a dominating set of $G\big(Z^*(J)\big)$ with two elements. Hence $\big|D\big(Z^*(J)\big)\big| = 2$.

Theorem 3.4

Let $G\big(T^*(J)\big)$ by theorem 3.1 and $\delta(T^*(J)) = 1$ and isolated vertices then the domination number of a rough co-zero divisor graph $G\big(Z^*(J)\big)$ is 1.

Proof

Let $RS(Z)$ be an isolated vertex in $G\big(T^*(J)\big)$ then it has no adjacent vertices $G\big(T^*(J)\big)$. Without any doubt $RS(Z)$is adjacent to all other vertices$G\left(Z^*(J\ )\right)$.

(i.e)., $RS(Z)$is a dominating set of $G\left(Z^*(J\ )\right)$with one element then$\left|DD\left(Z^*(J\ )\right)\right| = 1$.

Lemma 3.1

The double domination number of$G\left(T^*(J\ )\right)$ is zero.

Proof

The degree of $RS(X_i)$ is one for $i = 1,2, \dots m$. If $D_2\left(T^*(J\ )\right)$is a double dominating set of$G\left(T^*(J\ )\right)$ then $RS(X_i)$ for $i = 1,2, \dots m$ cannot be adjacent to two element in $D_2(G\left(T^*(J\ )\right)$.

Therefore$\left|D_2(G\left(T^*(J\ )\right)\right| = 0$.

Lemma 3.2

The double domination number of a Rough Co-zero divisor graph$G\left(Z^*(J\ )\right)$ is 3. (i.e)., $\left|D_2(G\left(Z^*(J\ )\right)\right| = 3$ for $1 < m \leq n$.

Proof

The proof is obvious from theorem 3.1.

Let us consider $D_2(G\left(Z^*(J\ )\right) = \{RS(x_1), RS(X_1), RS(X_2)\}$ such that each vertex not in $D_2(G\left(Z^*(J\ )\right)$is connected to not less than two vertices in $D_2(G\left(Z^*(J\ )\right)$for $1 < m \leq n$. Hence evidently, $\left|D_2(G\left(Z^*(J\ )\right)\right| = 3$.

4. ILLUSTRATION

Example 4.1

Let $U = \{x_1, x_2, x_3, x_4, x_5, x_6\}$ and let $\{X_1, X_2, X_3\}$are the equivalence classes induced by an equivalence relation R on U such that $X_1 = \{x_1, x_3\}$, $X_2 = \{x_2, x_4, x_6\}$and $X_3 = \{x_5\}$

(i.e)., $T^*(J\ ) = \{RS(X_1),\ RS(X_2), RS(X_3), RS(x_1), RS(x_2), RS(x_1 \cup x_2), RS(X_1 \cup x_2), RS(x_1 \cup X_2), RS(X_1 \cup X_2), RS(X_1 \cup X_3), RS(x_1 \cup X_3)\ , RS(X_2 \cup X_3), RS(x_2 \cup X_3),\ RS(x_1 \cup X_2 \cup X_3), RS(X_1 \cup x_2 \cup X_3), RS(x_1 \cup x_2 \cup X_3)\}$.

Let $B = \{x_1, x_2\}$ implies $J = \{RS(x_1), RS(x_2), RS(x_1 \cup x_2)\}$.

Now let us consider

$D(T^*(J)) = \{RS(x_1), RS(x_2)\}$ and $|D(T^*(J))|$which is shown in the following figure 1 and hence$D_2(G(T^*(J))$is zero.

Correspondingly

$D(Z^*(J)) = \{RS(X_3)\}$. Hence $D(Z^*(J))$ minimal dominating set of $D(Z^*(J))$ and the Domination number is 1.

$D_2(G(Z^*(J)) = \{RS(x_1),\ RS(X_1), RS(X_2)\}$ and $|D_2(G(Z^*(J))| = 3$. Since everyvertex not in $D_2(G(Z^*(J))$ is adjacent to at least two vertices in $D_2(G(Z^*(J))$. Figure 1 indicates the $G(T^*(J))$and $G(Z^*(J))$ for $n = 3$ and $m = 2$.

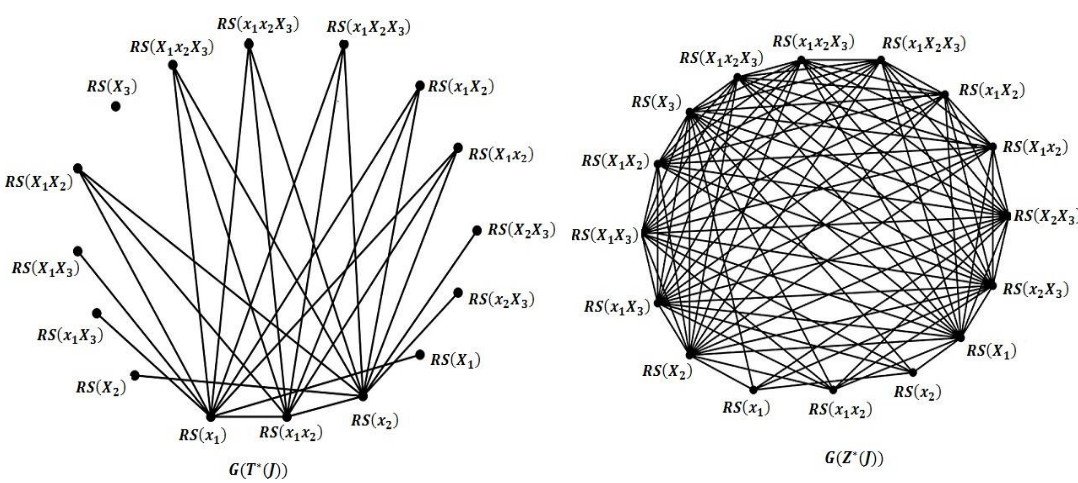


Figure 1. $G(T^*(J))$ *and* $G(Z^*(J)$

Example 4.2

Let $U = \{x_1, x_2, x_3, x_4, x_5, x_6\}$ and let $\{X_1, X_2, X_3\}$are the equivalence classes induced by an equivalence relation R on Usuch that $X_1 = \{x_1, x_4\}$, $X_2 = \{x_2, x_5\}$and$X_3 = \{x_3,\ x_6\}$

$T^*(J) = \{RS(X_1),\ RS(X_2), RS(X_3), RS(X_1 \cup X_2), RS(X_1 \cup X_3), RS(X_2 \cup X_3),\ RS(x_1), RS(x_2),$ $RS(x_3), RS(x_1 \cup x_2), RS(x_1 \cup x_3), RS(x_2 \cup x_3), , RS(X_1 \cup x_2), RS(x_1 \cup X_2), RS(x_1 \cup$ $X_3)$, $RS(X_1 \cup x_3), RS(X_2 \cup x_3)$, $RS(x_2 \cup X_3),\ RS(x_1 \cup X_2 \cup X_3), RS(X_1 \cup x_2 \cup X_3), RS(X_1 \cup$

$X_2 \cup x_3)$, $RS(x_1 \cup x_2 \cup X_3), RS(x_1 \cup X_2 \cup x_3), RS(X_1 \cup x_2 \cup x_3), RS(x_1 \cup x_2 \cup x_3)\}$

Let $B = \{x_1, x_2, x_3\}$ implies $J = \{RS(x_1), RS(x_2), RS(x_3), RS(x_1 \cup x_2), RS(x_1 \cup x_3), RS(x_2 \cup x_3), \} RS(x_1 \cup x_2 \cup x_3)\}$

$D(T^*(J)) = \{RS(x_1), RS(x_2), RS(x_3)\}$ which implies that each element not in $D(T^*(J))$is connected to at least one element in$D(T^*(J))$. Hence$D(T^*(J))$is a minimal dominating set of$G(T^*(J))$ and $|D(T^*(J))| = 3$. $|D_2(T^*(J))|$is zero. Since$RS(X_1)$is connected with only one element in $D(T^*(J))$ namely $RS(x_1)$. Hence double domination number of a reduced $G(T^*(J))$ is zero. Figure 2 gives the $G(T^*(J))$for $n = m = 3$

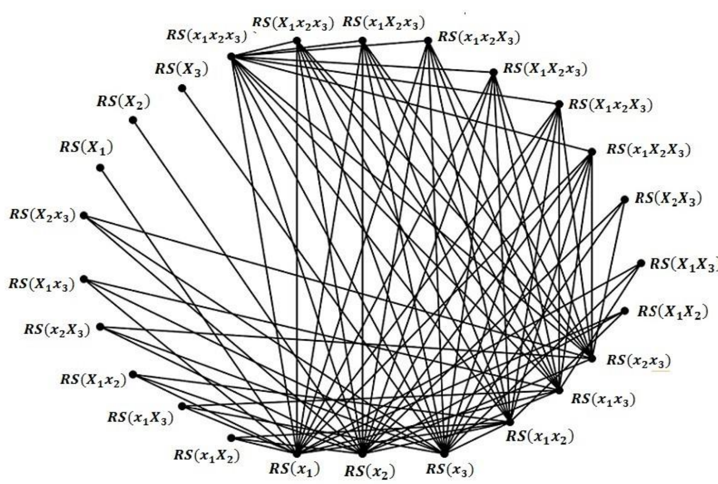


Figure 2. $G(T^*(J))$

Similarly $D(Z^*(J)) = \{RS(X_1), RS(X_2)\}$which indicates that every element not in$D(Z^*(J))$ is adjacent to at least one element in $G(Z^*(J))$. Hence $D(Z^*(J))$ minimal dominating set of $G(Z^*(J))$ and the Domination number is 2.

$D_2(Z^*(J)) = \{RS(x_1), RS(X_1), RS(X_2)\}$ and $|D_2(Z^*(J))| = 3$. Since all element not in $D_2(Z^*(J))$ is connecetd to at least two vertex in $D_2(Z^*(J))$. Figure 3 gives the $G(Z^*(J))$ for $n = m = 3$

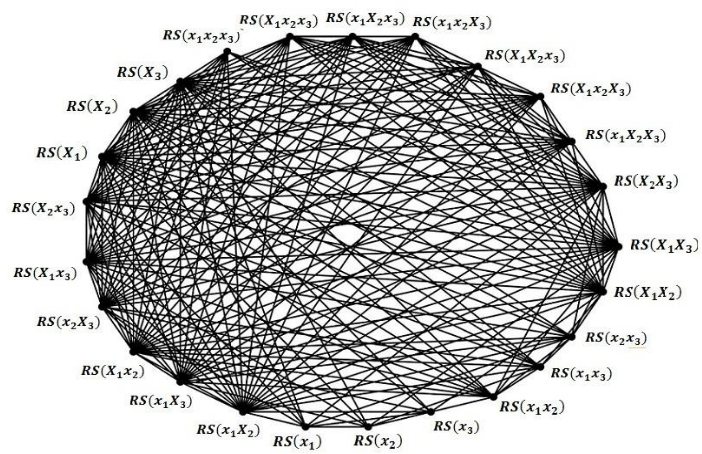


Figure 3. $G(Z^*(J\,))$

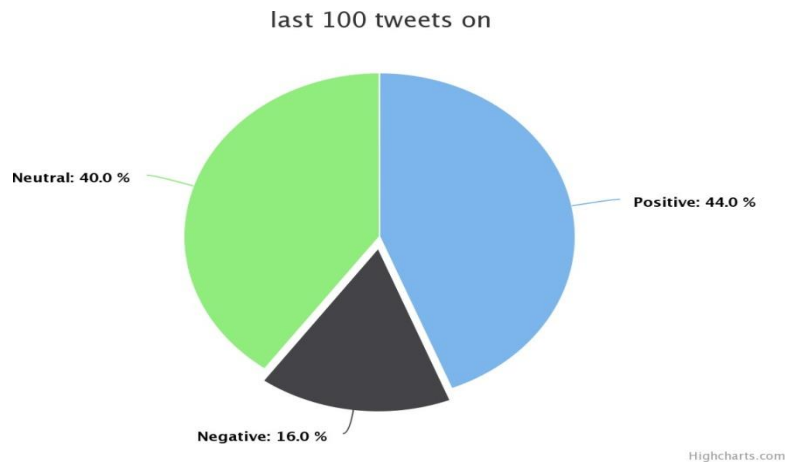
5. APPLICATION

The main growing technique of computers is semantic linguistics that analyzes human opinions known as opinion mining or called as Sentiment analysis. It is primarily for analyzing conversation, opinion and sharing of views for deciding strategy, current situation analysis and also for assessing publicactions. Practically sentiment anaysis measures the behavior of customer approach over the use of situation, tone, mental state, review, atttitude etc. Sentiment analysis is also utilize public opinion of aparticular company and specific products, or to evaluate the customer fullfillment. This study is helpful for organizations s to resolve with the problems.

Now let us consider a current situation for which n opinions are collected from a large group of people. Then, the people can be divided into n disjoint groups$\{X_1, X_2, \dots X_n\}$ where X_i is the group of people giving opinion i for $i = 1,2, .. n$. Let us assuming that the number of people in each group is greater than one. Also are presentative x_i chosen from $X_i, i = 1,2, .. n$ clearly J and $T\ *(J\,)$are defined in section3.

Note that for all$X, Y \subset X_i$, $RS(X) = RS(Y)$and if$X = x_i$then$RS(x_i) = RS(Y)$for all$Y \subset X_i$ then $D(T^*(J))$= $\{RS(x_1)RS(x_2), \dots . RS(x_m)\}$ as in theorem 3.2 . This means that for every group X of the given set of people $RS(X)$ will be adjacent to any one of the element in$D(T^*(J))$ which means that every group of people$RS(X)$ that we choose will contains at least one people giving opinion i for some i and hence$RS(X)$ is connected $RS(x_i)$. In other words, $RS(x_i)$is connected to those $RS(X)$such that X will contain at least one having opinion i.

In particular when Sentiment analysis is done for a twitter data analyzing the opinion about learning of data science in which three opinions are allowed namely positive comments (Good, Excellent, Easy and Secure), negative comments (Connection problem , Less response and poor



connection with subject) and neutral comments (Average, Somewhat ok and Not good not bad).

Figure 4. *Pie diagram*

Table l: *Sentiment analysis for the Twitter data.*

Opinion	Sentiment	No. of Sentiments
1	Positive (X_1)	44
2	Negative (X_2)	16
3	Neutral (X_3)	40

This is the case when$n = m = 3$ irrespective of whether we consider 100 people or 1000 people or 10000 people the corresponding $G(T^*(J))$ is shown in figure. In this case $D(T^*(J)) = \{RS(x_1), RS(x_2), RS(x_3)\}$ this is established in figure 4. The main advantage of this $G(T^*(J)$) is that it depend on only n, m but not on the number of elements (number of opinions) in U.

Hence instead of taking all possible groups from U it is enough to consider the three group X_1, X_2, $X_3$and their representative elements $\{x_1, x_2, x_3\}$. Note that$RS(X_1)$ is connected to

$RS(Y)$ in $G\big(T^*(J)\big)$ if $RS(Y)$contains at least one whose having opinion$i$ for $i = 1,2,3$this is clearly established in figure 2.

Similarly when we consider $G\big(Z^*(J)\big)$ it also depends on$n$ and $m$and not on thenumber of elements (number of opinions) in U. For the same twitter data $D\big(Z^*(J)\big)$={$RS(X_1), RS(X_2)$}. Note that$RS(X_i)$ is connected to $RS(Y)$ in $G\big(T^*(J)\big)$ if $RS(Y)$ contains at least one whose not having opinion i for $i = 1,2$ this is clearly established in figure 3.

5. CONCLUSION

In this article the domination number and the double domination number of $G(T^*(J))$ and $G\big(Z^*(J)\big)$ are obtained. Allthese concepts are illustrated through examples and Twitter sentiment analysis methods were discussed. Our future work is to find the Energy and Wiener index of $G(T^*(J))$ and $G(Z^*(J))$.

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CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

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