Pythagorean Neutrosophic Fuzzy Graphs

D. Ajay [1,*], P. Chellamani [2]

[1] Department of Mathematics, Sacred Heart College (Autonomous), Tirupattur – 635 601, Tirupattur District, Tamil Nadu, INDIA;

[2] Department of Mathematics, Sacred Heart College (Autonomous), Tirupattur – 635 601, Tirupattur District, Tamil Nadu, INDIA;

Emails: dajaypravin@gmail.com, joshmani238@gmail.com

* Correspondence: dajaypravin@gmail.com

Abstract

In this paper, we present the new idea of pythagorean neutrosophic fuzzy graphs (PNFG). Pythagorean neutrosophic set [PNS] is a generalization of neutrosophic set with dependent neutrosophic components and Pythagorean fuzzy set with condition $0 \leq \mu_A(x)^2 + \beta_A(x)^2 + \sigma_A(x)^2 \leq 2$. The main aim of this article is to apply pythagorean neutrosophic set to fuzzy graphs. Thus we extend some of the basic properties for this PNFG along with few examples.

Keywords: Pythagorean neutrosophic set, Pythagorean neutrosophic graphs, Neutrosophic set.

1.Introduction

L.A. Zadeh originated the idea of fuzzy set theory in 1965 [1]. Atanassov [2] presented a new set intuitionistic set as an extension of fuzzy set which defines element with the membership and non-membership grade with restriction that totality of both must not exceed 1. The new perception of pythagorean fuzzy sets was published by Yager [3] in which the sets has constraint that their square sum is ≤ 1. From the definition of pythagorean sets, pythagorean fuzzy graphs have been developed and is applied in many fields [12].

Neutrosophic set, a combination of fuzzy and intuitionistic sets was introduced by Smarandache [4] in 1995. Many researchers have developed this results and applied in many relevant fields as decision making and so on [13-16]. A neutrosophic set has truth, falsity and indeterminacy membership for each element. In particular, the neutrosophic set has been applied to fuzzy graph theory and many new concepts of neutrosophic fuzzy graph has been developed [8-11, 17-18]. Smarandache introduced the degree of dependence among components of fuzzy set and in neutrosophic set. Then the researchers studied about neutrosophic and developed many new concepts in neutrosophic sets and in neutrosophic graphs magic labellling was applied [6-7]. In neutrosophic set, out of three dependency cases we choose one special case in which indeterminacy is independent, truth and falsity are completely dependent with $0 \leq \mu_A(x)^2 + \beta_A(x)^2 + \sigma_A(x)^2 \leq 2$ is termed as pythagorean neutrosophic set. In this

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

research, we put on the pythagorean neutrosophic sets to fuzzy graphs and also we study some types of different notions of pythagorean neutrosophic graph.

2. Preliminaries

An intuitionistic fuzzy set I on universe Y is given by $I = \{ < s,\ \mu_I(s),\ \sigma_I(s) >: s \in Y \}$ where μ_I, σ_I from Y to [0,1] such that $0 \leq \mu_I(s) + \sigma_I(s) \leq 1$ for any $s \in Y$. $\mu_I(s)$ and $\sigma_I(s)$ are the membership and non-membership grade of s correspondingly.

A neutrosophic set N in Y is given by $N = \{(\mathfrak{k},\ \mu_N(\mathfrak{k}),\ \eta_N(\mathfrak{k}),\ \gamma_N(\mathfrak{k})) \mid \mathfrak{k} \in Y)\}$, where $\mu_N(\mathfrak{k}),\ \eta_N(\mathfrak{k}),\ \gamma_N(\mathfrak{k}) \in [0,1]$ denote truth, indeterminacy and false membership of $\mathfrak{k}$ of N and $\mu_N(\mathfrak{k}),\ \eta_N(\mathfrak{k}),\ \gamma_N(\mathfrak{k})$ follow the condition that $0 \leq \mu_N(\mathfrak{k}) + \eta_N(\mathfrak{k}) + \gamma_N(\mathfrak{k}) \leq 3$.

A neutrosophic fuzzy graph is $G = (V, E)$ where $V = \{v_1, v_2, \dots v_n\}$ such that μ_1, β_1 and σ_1 from V to [0,1] represent degree of truth-membership, indeterminacy-membership and falsity-membership of c_i in V correspondingly, and $0 \leq \mu_1(c_i) + \beta_1(c_i) + \sigma_1(c_i) \leq 3 \quad \forall\, c_i \in V\ (i = 1, \dots n)$, $E \subseteq V \times V$ with μ_2, β_2 and σ_2 from V x V to [0,1] such that

$$\mu_2(c_i c_j) \leq \mu_1(c_i) \wedge \mu_1(c_j)$$

$$\beta_2(c_i c_j) \leq \beta_1(c_i) \wedge \beta_1(c_j)$$

$$\sigma_2(c_i c_j) \leq \sigma_1(c_i) \vee \sigma_1(c_j)$$

$$0 \leq \mu_2(c_i c_j) + \beta_2(c_i c_j) + \sigma_2(c_i c_j) \leq 3 \text{ for every } (c_i c_j) \in E\ (i, j = 1,2, \dots n).$$

Pythagorean fuzzy set (PFS) set P of Y is $P = \{ < \mathfrak{r},\ \mu_P(\mathfrak{r}),\ \sigma_P(\mathfrak{r}) >: \mathfrak{r} \in Y\}$ where $\mu_P(\mathfrak{r})$ and $\sigma_P(\mathfrak{r})$from Y to [0,1] represents degree of membership and non-membership of $\mathfrak{r}$ in P correspondingly. $\forall\, \mathfrak{r} \in Y$, the following condition should be satisfied $0 \leq \mu_P^2(\mathfrak{r}) + \sigma_P^2(\mathfrak{r}) \leq 1$.

A Pythagorean fuzzy graph (PFG) is a duo $G = (V, E)$ with μ_1 and σ_1 from V to [0,1] signifying membership, non-membership functions of V and $0 \leq \mu_1^2(v) + \sigma_1^2(v) \leq 1$ for $v \in V$ such that

$$\mu_2(uv) \leq \mu_1(u) \wedge \mu_1(v),$$

$$\sigma_2(uv) \leq \sigma_1(u) \vee \sigma_1(v).$$

where μ_2, σ_2 from V x V to [0,1] represent the membership, non-membership functions of E, with $0 \leq \mu_2^2(uv) + \sigma_2^2(uv) \leq 1$ for all $uv \in E$.

A Pythagorean Neutrosophic set with truth, falsity as dependent neutrosophic components [PNS] on non-empty universe Y is $D = \{(d,\ \mu_D(d), \beta_D(d), \sigma_D(d)) : d \in Y\}$, where $\mu_D(d),\ \beta_D(d),\ \sigma_D(d) \in [0, 1]$, $0 \leq (\mu_D(d))^2 + (\beta_D(d))^2 + (\sigma_D(d))^2 \leq 2, \quad \forall\, d \in Y$. $\mu_D(d),\ \beta_D(d),\ \sigma_D(d)$ are the degrees of membership, indeterminacy and non-membership respectively. Here $\mu_D(d)$ and $\sigma_D(d)$ are dependent and $\beta_D(d)$ is independent [5].

3. Pythagorean Neutrosophic Fuzzy Graphs

Definition 3.1: Pythagorean Neutrosophic Fuzzy Graph (PNFG) is $G = (V, E)$, where $V = \{v_1, v_2, \dots v_n\}$ such that μ_1, β_1 and $\sigma_1$from V to [0,1] with $0 \leq \mu_1(v_i)^2 + \beta_1(v_i)^2 + \sigma_1(v_i)^2 \leq 2\ \forall\, v_i$ in V

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

signifies membership, indeterminacy and non-membership functions correspondingly and $E \subseteq V \times V$ where μ_2, β_2 σ_2 from $V \times V$ to [0,1] such that

$$\mu_2(v_i v_j) \leq \mu_1(v_i) \wedge \mu_1(v_j)$$

$$\beta_2(v_i v_j) \leq \beta_1(v_i) \wedge \beta_1(v_j)$$

$$\sigma_2(v_i v_j) \leq \sigma_1(v_i) \vee \sigma_1(v_j)$$

With $0 \leq \left((\mu_2(v_i v_j))\right)^2 + \left(\beta_2(v_i\, v_j)\right)^2 + \left(\sigma_2(v_i v_j)\right)^2 \leq 2\ \forall\, (v_i v_j) \in E.$

The example given in figure 1 is a PNFG

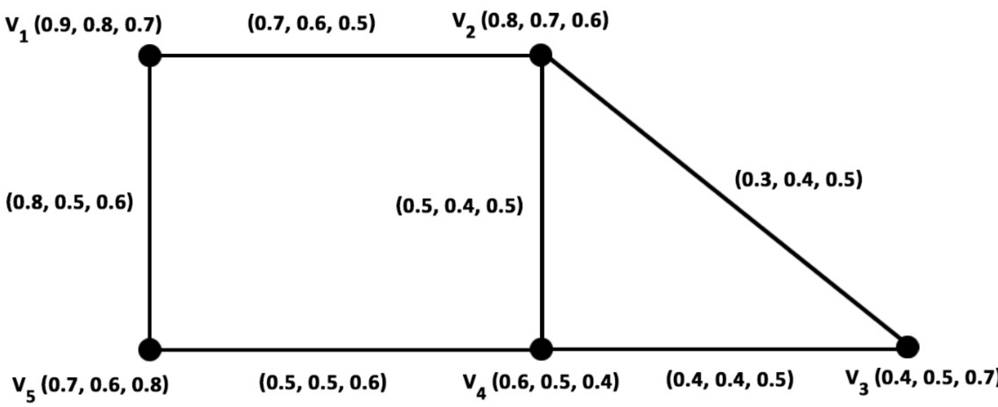

Figure 1. Pythagorean Neutrosophic Fuzzy Graph

Definition 3.2: A PNFG $G = (V, E)$ is termed as complete PNFG (CPNFG) if $\mu_2(v_i v_j) = \mu_1(v_i) \wedge \mu_1(v_j)$, $\beta_2(v_i v_j) = \beta_1(v_i) \wedge \beta_1(v_j)$, $\sigma_2(v_i v_j) = \sigma_1(v_i) \vee \sigma_1(v_j)$ for every $v_i, v_j \in V$.

Definition 3.3: A PNFG $G = (V, E)$ is named as strong PNFG if

$$\mu_2(v_i v_j) = \min\,(\mu_1(v_i), \mu_1(v_j))$$

$$\beta_2(v_i v_j) = \min\,(\beta_1(v_i), \beta_1(v_j))$$

$$\sigma_2(v_i v_j) = \max\,(\sigma_1(v_i), \sigma_1(v_j))\ \forall\, (v_i v_j) \in E.$$

Definition 3.4: Let $G = (V, E)$ with μ, β, σ as the membership (MD), indeterminacy (ID) and non-membership (NMD) degree be a PNFG. Then a PNFG $H = (V', E')$ with $V' \subseteq V$ and $E' \subseteq E$, μ', β' and σ' as the MD, NMD, and ID is called Pythagorean Neutrosophic fuzzy subgraph (PNFSG) if $\mu'(\mathfrak{d}) \leq \mu(\mathfrak{d})$, $\beta'(\mathfrak{d}) \leq \beta(\mathfrak{d})$, $\sigma'(\mathfrak{d}) \geq \sigma(\mathfrak{d})$ for $\mathfrak{d} \in V$.

Definition 3.5: Let $G' = (V', E')$, $G'' = (V'', E'')$ be PNFG with (μ', β', σ') and $(\mu'', \beta'', \sigma'')$ as their MD, ID and NMD correspondingly. Then the intersection of G' and G'', $G = (V, E)$ is a PNFG where $V = V' \cap V''$, $E = E' \cap E''$ and the MD, ID and NMD of V and E of for all $a, b, r \in V$ such that

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

(i) $\mu_1(r) = \begin{cases} \mu_1'(r) & if\ r \text{ is in } V' \text{ and not in } V'' \\ \mu_1''(r) & if\ r \text{ is in } V'' \text{and not in } V' \\ \mu_1'(r) \wedge \mu_1''(r) & if\ r \text{ is in both } V' \text{ and } V'' \end{cases}$

$$\beta_1(r) = \begin{cases} \beta_1'(r) & if\ r \text{ is in } V' \text{ and not in } V'' \\ \beta_1''(r) & if\ r \text{ is in } V'' \text{and not in } V' \\ \beta_1'(r) \wedge \beta_1''(r) & if\ r \text{ is in both } V' \text{ and } V'' \end{cases}$$

$$\sigma_1(r) = \begin{cases} \sigma_1'(r) & if\ r \text{ is in } V' \text{ and not in } V'' \\ \sigma_1''(r) & if\ r \text{ is in } V'' \text{and not in } V' \\ \sigma_1'(r) \vee \sigma_1''(r) & if\ r \text{ is in both } V' \text{ and } V'' \end{cases}$$

(i) $\mu_2(ab) = \begin{cases} \mu_2'(ab) & if\ ab \text{ is in } E' \text{ and not in } E'' \\ \mu_2''(ab) & if\ ab \text{ is in } E'' \text{ and not in } E' \\ \mu_2'(ab) \wedge \mu_2''(ab) & if\ ab \text{ is in both } E' \text{ and } E'' \end{cases}$

$$\beta_2(ab) = \begin{cases} \beta_2'(ab) & if\ ab \text{ is in } E' \text{ and not in } E'' \\ \beta_2''(ab) & if\ ab \text{ is in } E'' \text{ and not in } E' \\ \beta_2'(ab) \wedge \beta_2''(ab) & if\ ab \text{ is in both } E' \text{ and } E'' \end{cases}$$

$$\sigma_2(ab) = \begin{cases} \sigma_2'(ab) & if\ ab \text{ is in } E' \text{ and not in } E'' \\ \sigma_2''(ab) & if\ ab \text{ is in } E'' \text{ and not in } E' \\ \sigma_2'(ab) \vee \sigma_2''(ab) & if\ ab \text{ is in both } E' \text{ and } E'' \end{cases}$$

Definition 3.6: Let $G' = (V', E')$, $G'' = (V'', E'')$ be PNFG with $(\mu_1', \beta_1', \sigma_1')$, $(\mu_1'', \beta_1'', \sigma_1'')$ and $(\mu_2', \beta_2', \sigma_2')$, $(\mu_2'', \beta_2'', \sigma_2'')$ as the MD, ID and NMD of the vertices and edges correspondingly. Then the union of G' & G'', $G = (V, E)$ is a PNFG where $V = V' \cup V''$, $E = E' \cup E''$ and the MD, ID and NMD of vertices (V), edges (E) of G for all $g, h \in V$ such that

(i) $\mu_1(g) = \begin{cases} \mu_1'(g) & if\ g \text{ is in } V' \text{ and not in } V'' \\ \mu_1''(g) & if\ g \text{ is in } V'' \text{and not in } V' \\ \mu_1'(g) \vee \mu_1''(g) & if\ g \text{ is in } V' \text{ or } V'' \end{cases}$

$$\beta_1(g) = \begin{cases} \beta_1'(g) & if\ g \text{ is in } V' \text{ and not in } V'' \\ \beta_1''(g) & if\ g \text{ is in } V'' \text{and not in } V' \\ \beta_1'(g) \vee \beta_1''(g) & if\ g \text{ is in } V' \text{ or } V'' \end{cases}$$

$$\sigma_1(g) = \begin{cases} \sigma_1'(g) & if\ g \text{ is in } V' \text{ and not in } V'' \\ \sigma_1''(g) & if\ g \text{ is in } V'' \text{and not in } V' \\ \sigma_1'(g) \wedge \sigma_1''(g) & if\ g \text{ is in } V' \text{ or } V'' \end{cases}$$

(ii) $\mu_2(gh) = \begin{cases} \mu_2'(gh) & if\ gh \text{ is in } E' \text{ and not in } E'' \\ \mu_2''(gh) & if\ gh \text{ is in } E'' \text{ and not in } E' \\ \mu_2'(gh) \vee \mu_2''(gh) & if\ gh \text{ is in } E' \text{ or } E'' \end{cases}$

$$\beta_2(gh) = \begin{cases} \beta_2'(gh) & if\ gh \text{ is in } E' \text{ and not in } E'' \\ \beta_2''(gh) & if\ gh \text{ is in } E'' \text{ and not in } E' \\ \beta_2'(gh) \vee \beta_2''(gh) & if\ gh \text{ is in } E' \text{ or } E'' \end{cases}$$

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

$$\sigma_2(gh) = \begin{cases} \sigma_2'(gh) & if\ gh \text{ is in } E' \text{ and not in } E'' \\ \sigma_2''(gh) & if\ gh \text{ is in } E'' \text{ and not in } E' \\ \sigma_2'(gh) \wedge \sigma_2''(gh) & if\ gh \text{ is in } E' \text{ or } E'' \end{cases}$$

Note: The following notion is followed in this paper, If $G = (V, E, \rho, \gamma)$ where $\rho = (\mu_1, \beta_1, \sigma_1)$ and $\gamma = (\mu_2, \beta_2, \sigma_2)$ represents the MD, ID and NMD of the vertices and edges of PNFG respectively.

Definition 3.7: A Pythagorean Neutrosophic path $P(PNP)$ in PNG $G = (V, E, \rho, \gamma)$ is a arrangement of different vertices $v_0, v_1, \ldots v_n$ (leaving v_0, v_1) such that $\gamma(v_{i-1}, v_i) > 0$, $i = 1\ to\ n$ (where n is the length of the PNP).

The consecutive pair of the PNP are called the edges.

Definition 3.8: The diameter of a, b in V is the length of the longest PNP joining a and b and denoted as $diam\ (a, b)$.

The strength of PNP P is is represented by $d(P)$ or $S(P)$ and defined as

$$\bigwedge_{k=1}^{n} \gamma(v_{k-1}, v_k) = \left(\bigwedge_{k=1}^{n} \mu_2(v_{k-1}, v_k), \bigwedge_{k=1}^{n} \beta_2(v_{k-1}, v_k), \bigvee_{k=1}^{n} \sigma_2(v_{k-1}, v_k)\right) \quad \text{where } v_k \in V\ \ (k = 1,2, \ldots, n)$$

Definition 3.9: The pythagorean neutrosophic strength of connectedness of vertices a and b of PNFG is defined as the maximum of the strength of all PNP's among a and b and represented by $PNCONN_G(x, y)$.

$PNCONN_G(x, y) = \max\ (S(P))$ where P is a $x - y$ PNP in G.

If $n \geq 3$ and $V_0 = V_n$ then PNP P is called a Pythagorean Neutrosophic Cycle (PNC).

Example 3.10: Consider the following PNFG

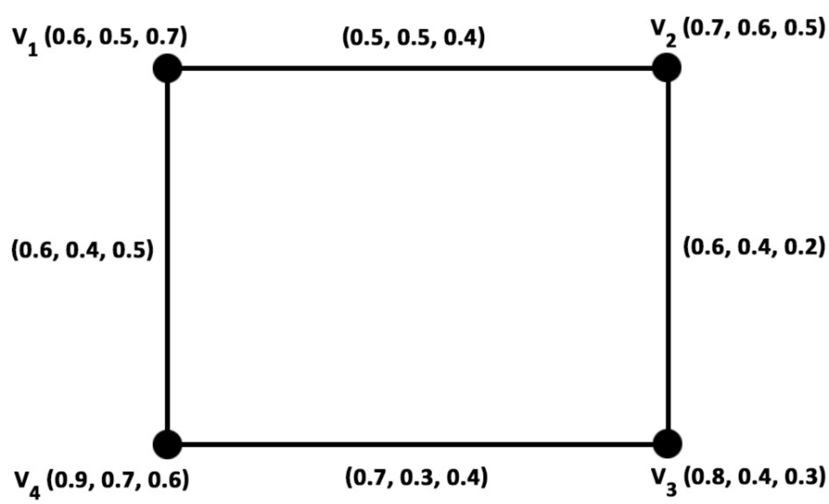

Figure 2. Pythagorean Neutrosophic strength of connectedness of PNFG

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

$$PNCONN_G(v_1, v_2) = \left(max(0.5,0.6), max(0.5,0.3), min(0.4,0.5)\right)$$

$$= (0.6, 0.5, 0.4)$$

$$PNCONN_G(v_1, v_3) = \left(max(0.5,0.6), max(0.4,0.3), min(0.4,0.5)\right)$$

$$= (0.6, 0.4, 0.4)$$

$$PNCONN_G(v_1, v_4) = \left(max(0.6,0.5), max(0.4,0.3), min(0.5,0.4)\right)$$

$$= (0.6, 0.4, 0.4)$$

Definition 3.11: Let $G = (V, E, \rho, \gamma)$ be a PNFG and *x, y* be two different vertices, let G' be a PNFSG of G attained by removing the edge *xy*. *xy* is a Pythagorean neutrosophic fuzzy bridge (PNFB) in G if $PNCONN_{\,G'}(a, b) < PNCONN_G(a, b)$ for some *a,b*. The removal of the edge *xy* decreases the strength of connectedness among some duo of vertices in G. Thus, *xy* is a PNFB if and only if there exists vertices a, b such that *xy* is an edge of each strongest path from a to b.

Theorem 3.12: Let $G = (V, E, \rho, \gamma)$ be a PNFG. Then the subsequent statements are equivalent.

1. *xy* is a PNFB
2. $PNCONN_{\,G'}(x, y) < \gamma(xy)$
3. *xy* is not the weakest edge of any Pythagorean neutrosophic cycle (PNC)

Proof:

2 ⇒1 If *xy* is not a PNFB, then $PCONN_{\,G'}(x, y) = PCONN_G(x, y) \geq \gamma(xy)$.

1 ⇒ 3 If *xy* is the weakest edge of a PNC, then any PNP *P* including the edge *xy* can be converted into a PNP P' not involving *xy* but at least as strong as *P*, by using the rest of the PNC as a PNP from *x* to *y*. Thus, *xy* cannot be a PNFB.

3 ⇒ 2 If $PCONN_{\,G'}(x, y) < \gamma(xy)$, there is a PNP from *x* to *y* not including *xy* with strength $\geq \gamma(xy)$, and this PNP together with *xy* forms a PNC of *G* in which *xy* is a weakest edge.

Definition 3.13: Let *w* be any vertex and let $G' = (V', E', \rho', \gamma')$be a PNFSG of $G = (V, E, \rho, \gamma)$ attained by removing the vertex *w*. That is, $G' = (V', E', \rho', \gamma')$ is the PNFSG of G such that $\rho'(w) = 0, \rho' = \rho$ for all other vertices, $\gamma'(wz) = 0$ for all vertices *z*, and $\gamma' = \gamma$ for all other edges. Thus we call *w* a Pythagorean neutrosphic fuzzy cutvertex in G if $PNCONN_{\,G'}(u, v) < PNCONN_{\,G}(u, v)$ for some *u, v* in V such that $u \neq w \neq v$.

5. Conclusions

Herein, we have defined a new concept pythagorean neutrosophic graphs by applying pythagorean neutrosophic set to fuzzy graph. Also have defined some of its basic definitions and properties of the pythagorean neutrosophic graphs. In future, we would extend this by introducing more definitions and apply labelling, coloring to PNFG.

Funding: “This research received no external funding”

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020

Conflicts of Interest: "The authors declare no conflict of interest."

References

[1] Zadeh, L.A., "Fuzzy Sets", Inform. and Control, Vol 8, pp.338- 353, 1965.

[2] Atanassov, K., "Intuitionistic Fuzzy Sets", Fuzzy Sets and Systems, Vol 20, pp.87-96, 1986.

[3] Yager, R.R., "Pythagorean Fuzzy Subsets", In:Proc Joint IFSA World Congress and NAFIPS Annual Meeting, Edmonton, Canada, pp.57-61, 2013.

[4] Smarandache, F., "A Unifying Field in Logics: Neutrosophic Logic, Neutrosophy, Neutrosophic Set, Neutrosophic Probability", American Research Press: Rehoboth, DE, USA, pp.1-141, 1999.

[5] Jansi, R., Mohana, R.K., & Smarandache, F., "Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components", Neutrosophic Sets and Systems, Vol 30(1), pp.202-212, 2019.

[6] Ajay, D., Charisma, J. J., & Chellamani, P., "Fuzzy Magic and Bi-magic Labelling of Intuitionistic Path Graph", International Journal of Recent Technology and Engineering, Vol 8(4), pp.11508-11512, 2019.

[7] Ajay, D., & Chellamani, P., "Fuzzy Magic Labelling of Neutrosophic Path and Star graph", Advances in Mathematics: Scientific Journal Vol 9(8), pp.6059-6070, 2020.

[8] Hussain, S.S., Hussain, R.J., Jun, Y.B., & Smarandache, F., "Neutrosophic bipolar vague set and its application to neutrosophic bipolar vague graphs", Neutrosophic Sets and Systems, Vol 28, pp.69-86, 2019.

[9] Hussain, S.S., Hussain, R.J., & Muhiuddin, G., "Neutrosophic Vague Line Graphs", Neutrosophic Sets and Systems, Vol 36, pp.121-130. 2020.

[10] Hussain, S.S., Hussain, R.J., & Smarandache, F., "On neutrosophic vague graphs", Neutrosophic Sets and Systems, Vol 28, pp.245-258, 2019.

[11] Dhavaseelan, R., Jafari, S., Farahani, M.R., & Broumi, S., "On single-valued co-neutrosophic graphs", Neutrosophic Sets and Systems: An International Book Series in Information Science and Engineering, vol. 22/2018, 22. 2018.

[12] Akram, M., Khan, A., & Borumand Saeid, A., "Complex Pythagorean Dombi fuzzy operators using aggregation operators and their decision-making", Expert Systems, pp.1-28, 2020.

[13] Ajay, D., Broumi, S., & Aldring, J., "An MCDM Method under Neutrosophic Cubic Fuzzy Sets with Geometric Bonferroni Mean Operator", Neutrosophic Sets and Systems, Vol 32(1), pp.187-202, 2020.

[14] Ajay, D., Manivel, M., & Aldring, J., "Neutrosophic Fuzzy SAW Method and It's Application", Vol 11, pp.881-887, 2019.

[15] Ajay, D., Aldring, J., Abirami, S., & Jeni Seles Martina, D., "A SVTrN-number approach of muliti-objective optimization on the basis of simple ration analysis based on MCMD method", International Journal of Neutrosophic Science, Vol 5(1), 16-28, 2020.

[16] Ajay, D., & Aldring, J., "A Decision Making Technique Based on Similarity Measure and Entropy of Bipolar Neutrosophic Sets", The International journal of analytical and experimental modal analysis, Vol 11(9), pp.520-529, 2019.

[17] Mullai, M., Broumi, S., & Jeyabalan, R., "Homomorphism and Isomorphism in strong neutrosophic graphs", International Journal of Neutrosophic Science, Vol 0, pp.08-20, 2020.

[18] Mullai, M., & Broumi, S., "Dominating energy in neutrosophic graphs", International Journal of Neutrosophic Science, Vol 5(1), pp.38-58, 2020.

DOI: https://doi.org/10.54216/IJNS.0110205
Received: July 18, 2020 Accepted: Octobre 20, 2020