A New Score Function of Pentagonal Neutrosophic Number and its Application in Networking Problem

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Abstract

Pentagonal neutrosophic number is an extended version of a single typed neutrosophic number. Real-humankind problems have different sorts of ambiguity in nature and among them; one of the important problems is solving the networking problem. In this contribution, the conception of pentagonal neutrosophic number has been focused on a distinct framework of reference. Here, we develop a new score function and its estimation has been formulated from different perspectives. Further, a time computing-based networking problem is considered herein the pentagonal neutrosophic arena and solved it using an influx of dissimilar logical & innovative thinking. Lastly, the computation of the total completion time of the problem reflects the impotency of this noble work.

Keywords: Pentagonal neutrosophic number; Networking problem; Score function.

1. Introduction:

Researchers though have various fields to work on but the hesitant theory is one of the vital topics in today's world to deal with. Professor Zadeh [1] was the first to familiarize himself with the fuzzy set theory (in 1965) to handle hesitant ideas. The theory of fuzziness has a leading feature to solve clear sound engineering and statistical problem. Applying the uncertainty theory, plentiful varieties of realistic problems can be solved, including networking problems, decision-making problems, influence on social science, etc. Pertaining the concept of Zadeh's research paper, Atanassov [2] created phenomenally the intuitionistic fuzzy set where he meticulously elucidates the concept of membership and non-membership function. With the going research triangular [3], trapezoidal [4], pentagonal [5], and hexagonal [6] fuzzy numbers are constructed in an indefinite environment. The notion of a triangular intuitionistic fuzzy set was put forth by Liu & Yuan [7]. The elementary idea of a trapezoidal intuitionistic fuzzy set in the research arena was constructed by Ye [8]. Unsurprisingly a basic question ascends onto our mind how can a mathematical model deal with the idea of vagueness? Different sorts of methodologies have been devised by the researchers to describe intricately the conceptions of some new uncertain parameters and to handle these complicated problems, the decision-makers put forth their various ideas in disjunctive areas. F. Smarandache [9] 1998 germinated the notion of having a neutrosophic set holding three different fundamental elements (i) truth, (ii) indeterminate, and (iii) falsity. Each and every attribute of the neutrosophic sets are very relevant factor to our real-life models. Afterward, Wang et al. [10] progressed with a single typed neutrosophic set which serves the solution to any sort of complicated problem in a

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very efficient way. Later on, Chakraborty et al. [11, 12] abstracted the concept of triangular and trapezoidal neutrosophic numbers and functionalized it in diversified real-life problems fruitfully. Also, Maity et al. [13] constructed ranking and defuzzification using totally dissimilar sort of attributes. Bosc and Pivert [14] fostered the concept of bipolarity to deal with human decision-making problems on the base of positive and negative sides. Lee [15] continued the expound on the theory of bipolar fuzzy set in their research article. Broadening the hypothesis into groups and semi-group structure fields were done by Kang and Kang [16]. With ongoing research, Deli et al. [17] build up the concept of bipolar neutrosophic number and applied it in the field of decision-making associated problems. Broumi et al. [18] put forward the concept of bipolar neutrosophic graph theory and successively Ali and Smarandache [19] proposed the perception of the indeterminate complex neutrosophic set. Chakraborty [20] acquainted us with bipolar numbers in distinctive aspects. Sequentially, the notion of the use of operators in the bipolar neutrosophic set was put forward by Wang et al. [21]. He applied to the decision-related problems. For researchers dealing with the evaluation of any scientific decision, the multi-criteria decision-making (MCDM) problem is of the utmost concern. Nowadays utilization of a group of criteria is more likely agreeable. The application of MCDM has a wider aspect in disjunctive fields under numerous skepticism frameworks. Researchers show their enthusiasm against problems relating to multi-criteria group decision-making (MCGDM) problems. Several applications and progressions in neutrosophic theory could be found under multi-criteria decision-making problems, moving with literature surveys shown in [22-25], graph theory [26-30], and optimization systems [31-33], etc. In recent times, Abdel [34] structured the viewpoint of the pathogenic set which had a vast significance in the uncertain fields in the research area. Correspondingly, Chakraborty [35, 36] established the outset of cylindrical neutrosophic number and applied it to networking planning problems, MCDM problems, and minimal spanning tree problems. Recently, the concept of pentagonal fuzzy number was first incubated by R. Helen [37]. Later on, utilizing this concept, Christi [38] established pentagonal intuitionistic numbers and solved transportation problems very proficiently. Chakraborty [39, 40] set forth the idea of pentagonal neutrosophic numbers and their application in transportation problems and graphical research areas. Also, Ye [41] manifested the idea of a Single valued neutrosophic minimal spanning tree and clustering method & Mandal & Basu [42] focused on similarity measure-based spanning tree problems in the neutrosophic arena. Mullai et.al [43] ignited the minimum spanning tree problem & Broumi et.al [44] introduced the shortest path problem in neutrosophic graphs. Also, Broumi et.al [45] manifested the neutrosophic shortest path to solve the Dijkstra algorithm & some published articles [46-47] are addressed here related to the neutrosophic domain which plays an essential role in the research arena.

This paper deals with the conception of pentagonal neutrosophic numbers in a different aspect. Nowadays researchers are very much interested in doing networking problems in the neutrosophic domain. In this article, we consider a networking-based PERT problem in pentagonal neutrosophic where we utilize the idea of our developed score function for solving the problem.

1.1 Motivation

The idea of vagueness plays an essential role in the construction of mathematical modeling, economic problem and social real-life problem, etc. Now there will be a vital point if someone considers the pentagonal neutrosophic number in the networking domain then what will be the final solution and the critical path? How should we convert a pentagonal neutrosophic number into a crisp number? From this aspect, we actually try to develop this research article.

1.2 Novelties

To date lots of research works are already published in a neutrosophic environment. In numerous fields, researchers have established formulas to work on. Although many fields are unknown and works are still going on. Our job is to give a try on developing new ideas on unfamiliar points.

(i) To develop score and accuracy function.

(ii) Usage of our function in networking problem.

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2. Preliminaries

Definition 2.1: Fuzzy Set: **[1]** Set $\widetilde{M}$ called as a fuzzy set when represented by the pair $\left(x, \mu_{\widetilde{M}}(x)\right)$ and thus stated as $\widetilde{M} = \left\{\left(x, \mu_{\widetilde{M}}(x)\right): x \in X, \mu_{\widetilde{M}}(X) \in [0, 1]\right\}$ where x $\in the\ crisp\ set\ X$ and $\mu_{\widetilde{M}}(X)$ $\in the\ interval [0, 1]$.

Definition 2.2: Intuitionistic Fuzzy Set (IFS): [2] An fuzzy set [2] $\widetilde{S}_F$ in the universal discourse X, symbolized widely by x is referred as Intuitionistic set if $\widetilde{S}_F = \{\langle x; [\gamma(x), \delta(x)]\rangle : x \in X\}$, where $\gamma(x): X \to [0, 1]$ is termed as the certainty membership function which specify the degree of confidence, $\delta(x): X \to [0, 1]$ is termed as the uncertainty membership function which specify the degree of indistinctness.

$\gamma(x)$, $\delta(x)$ exhibits the following the relation

$$0 \le \gamma(x) + \delta(x) \le 1.$$

2.3Defination: Neutrosophic Set: [9] A set $\widetilde{Ne}_M$ in the universal discourse X, figuratively represented by x named as a neutrosophic set if $\widetilde{Ne}_M = \left\{\langle x; \left[\lambda_{\widetilde{Ne}_M}(x), \pi_{\widetilde{Ne}_M}(x), \sigma_{\widetilde{Ne}_M}(x)\right]\rangle : x \in X\right\}$, where $\lambda_{\widetilde{Ne}_M}(x): X \to [0, 1]$ is stated as the certainty membership function, which designates the degree of confidence, $\pi_{\widetilde{Ne}_M}(x): X \to [0, 1]$ is stated as the uncertainty membership, which designates the degree of indistinctness, and $\sigma_{\widetilde{Ne}_M}(x): X \to [0, 1]$ is stated as the untruthful membership, which designates the degree of deceptiveness on the decision taken by the decision maker.

$\lambda_{\widetilde{Ne}_M}(x)$, $\pi_{\widetilde{Ne}_M}(x) \& \sigma_{\widetilde{Ne}_M}(x)$ displays the following relation:

$$-\ 0 \le \lambda_{\widetilde{Ne}_M}(x) + \pi_{\widetilde{Ne}_M}(x) + \sigma_{\widetilde{Ne}_M}(x) \le 3\ +.$$

2.4 Definition: Single-Valued Neutrosophic Set: [10] A Neutrosophic set $\widetilde{Ne}_M$ in the definition 2.3 is assumed as a Single-Valued Neutrosophic Set $\left(\widetilde{SNe}_M\right)$ if x is a single-valued independent variable. $\widetilde{SNe}A = \left\{\langle x; \left[\lambda_{\widetilde{SNe}_M}(x), \pi_{\widetilde{SNe}_M}(x), \sigma_{\widetilde{SNe}_M}(x)\right]\rangle : x \in X\right\}$, where $\lambda_{\widetilde{SNe}_M}(x), \pi_{\widetilde{SNe}_M}(x)\ \&\ \sigma_{\widetilde{SNe}_M}(x)$ signified the notion of correct, indefinite and incorrect memberships function respectively.

If three points d_0, $e_0 \& f_0$ exists for which $\lambda_{\widetilde{SNe}_M}\left(d_0\right) = 1, \pi_{\widetilde{SNe}_M}\left(e_0\right) = 1\ \&\ \sigma_{\widetilde{SNe}_M}\left(f_0\right) = 1$, then the $\widetilde{SNe}_M$ is termed neut-normal.

$\widetilde{SCS}_M$ is called neut-convex indicating that $\widetilde{SCS}_M$ is a subset of a real line by meeting the resulting conditions:

i. $\lambda_{\widetilde{SNe}_M}\langle \delta d_1 + (1 - \delta)d_2\rangle \ge min\langle \lambda_{\widetilde{SNe}_M}\left(d_1\right), \lambda_{\widetilde{SNe}_M}\left(d_2\right)\rangle$

ii. $\pi_{\widetilde{SNe}_M}\langle \delta d_1 + (1 - \delta)d_2\rangle \le max\langle \pi_{\widetilde{SNe}_M}\left(d_1\right), \pi_{\widetilde{SNe}_M}\left(d_2\right)\rangle$

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iii. $\sigma_{\widetilde{SNe}_M}\langle \delta d_1 + (1-\delta)d_2\rangle \le max\langle \sigma_{\widetilde{SNe}_M}(d_1), \sigma_{\widetilde{SNe}_M}(d_2)\rangle$

where d_1 & $d_2 \in R$ *and* $\delta \in [0, 1]$

2.5 Definition: Single-Valued Pentagonal Neutrosophic Number: A Single-Valued Pentagonal Neutrosophic Number $(\widetilde{M})$ is demarcated as $\widetilde{Ss} = \langle [(s^1, t^1, u^1, v^1, w^1); \mu], [(s^2, t^2, u^2, v^2, w^2); \theta], [(s^3, t^3, u^3, v^3, w^3); \eta]\rangle$, where $\mu, \theta, \eta \in [0, 1]$. The correct membership function $(\mu_{\widetilde{Ss}}): R \to [0, \mu]$, the indefinite membership function $(\theta_{\widetilde{Ss}}): R \to [\theta, 1]$ and the incorrect membership function $(\eta_{\widetilde{Ss}}): R \to [\eta, 1]$ are given as:

$$\mu_{\widetilde{Ss}}(x) = \{\mu_{\widetilde{Ssl1}}(x)\ \mu_{\widetilde{Ssl2}}(x)\ \mu\ \mu_{\widetilde{Ssr2}}(x)\ \ s^1 \le x < t^1\ t^1 \le x < u^1\ x = u^1\ u^1 \le x < v^1\ \ \mu_{\widetilde{Ssr1}}(x) v^1 \le x < w^1\ 0\quad otherwise\ , \quad \theta_{\widetilde{Ss}}(x) = \{$$

$$\eta_{\widetilde{Ss}}(x) = \{\eta_{\widetilde{Ssl1}}(x)\ \eta_{\widetilde{Ssl2}}(x)\ \vartheta\ \eta_{\widetilde{Ssr2}}(x)\ \ s^3 \le x < t^3\ t^3 \le x < u^3\ x = u^3\ u^3 \le x < v^3\ \ \eta_{\widetilde{Ssr1}}(x) v^3 \le x < w^3\ 1\quad otherwise$$

3. Proposed Score Function:

Score function utterly relies upon the value of exact membership indicator degree, inexact membership indicator degree and hesitancy membership indicator degree for a pentagonal neutrosophic number. The fundamental use of score function is to drag the judgment of conversion of pentagonal neutrosophic number to real number. A score function is developed for any Pentagonal Single typed Neutrosophic Number (PSNN).

$$\widetilde{P}_{Pen} = (P_1, P_2, P_3, P_4, P_5; \alpha, \beta, \gamma)$$

Score function is described as $\widetilde{S}_{Pen} = \frac{1}{15}\{(P_1 + P_2 + P_3 + P_4 + P_5) \times (2 + \alpha - \beta - \gamma)\}$

Here, $\widetilde{S}_{Pen} \in [0, 1]$

3.1 Relationship between any two pentagonal neutrosophic fuzzy numbers:

Let us consider any two pentagonal neutrosophic fuzzy number defined as follows

$P_{Pen1} = (\alpha_{Pen1}, \beta_{Pen1}, \gamma_{Pen1})$,$P_{Pen2} = (\alpha_{Pen2}, \beta_{Pen2}, \gamma_{Pen2})$

1) $S_{Pen1} > S_{Pen2}$, $P_{Pen1} > P_{Pen2}$
2) $S_{Pen1} < S_{Pen2}$, $P_{Pen1} < P_{Pen2}$
3) $S_{Pen1} = S_{Pen2}$, $P_{Pen1} = P_{Pen2}$

Table 1: Numerical Examples

Pentagonal Neutrosophic Number (P_{Pen})	Score Value (S_{Pen})	Ordering
$P_{Pen1} =< (0.3, 0.4, 0.5, 0.6, 0.7; 0.4, 0.7, 0.6) >$	0.1833	$P_{Pen2} > P_{Pen3} > P_{Pen4} > P_{Pen1}$
$P_{Pen2} =< (0.3, 0.35, 0.45, 0.55, 0.7; 0.6, 0.5$	0.2663	

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$P_{Pen3} =< (0.25, 0.3, 0.4, 0.5, 0.7; 0.6, 0.5, 0.5) >$	0.2293	
$P_{Pen4} =< (0.4, 0.45, 0.5, 0.6, 0.7; 0.3, 0.5, 0.6) >$	0.2120	

4. PERT in Pentagonal Neutrosophic Environment and the Proposed Model

PERT system or Project Evaluation and Review Technique are a project managing scheme which is used to plan, arrange, systemize and equalize tasks amongst a project. These techniques basically examine the minimum time required in finishing the total task and also calculate the time required in completion of each task for the given project.

PERT arrangement entails the specified steps:

1. Identification of specified activities and milestones.

2. In determination of accurate sequence of the activities.

3. In construction of a network map.

4. Evaluation of time needed for ac task.

5. Determination of the critical path.

6. Updating the PERT chart on progression with the project.

The chief purpose of PERT chart is to simplify and to decrease both time and cost of completion of any decision forming project. This method is proposed for wide-ranging, one-time, non-routine difficult projects having high degree of dependence. In projects, where series of tasks are present, some are always executed successively while rest are accomplished matching with other activities. In case of new projects having huge uncertainty in technology and networking system PERT is essentially used. For handling the uncertainties, triangular neutrosophic setting For PERT activity duration has been introduced.

The three time estimations for activity duration are:

Optimistic Time$\left(\check{o}_t\right)$: In general, the optimistic time requires minimum time for completing the activities and it is considered with three standards deviations from mean and approximately there is 1% chance for the activity to complete within time.

Pessimistic time$\left(\check{p}_t\right)$: . It is known for tasks taking the longest time. Here also the three standards deviations are used.

Most Likely time$\left(\check{m}_t\right)$: – The completion time in general status for most likely have the highest probability and is absolutely different from the projected time

We choose all the different three activities duration for the model put forward as in triangular neutrosophic number. Score value $R(\widetilde{S}_{Pen}, 0) = \frac{1}{15}\left(P_1 + P_2 + P_3 + P_4 + P_5\right) \times (2 + \alpha - \beta - \gamma)$ is presented to attain the pentagonal neutrosophic number$\left(P_1, P_2, P_3, P_4, P_5; \alpha, \beta, \gamma\right)$. By the use of formulas the expected time $E_t = \frac{(o_t + 4m_t + p_t)}{6}$ and the standard deviation $\sigma_t = \frac{(p_t - o_t)}{6}$ is calculated where o_t, p_t, m_t denotes the optimistic time, pessimistic time and most likely time respectively for all crisp value. For the add-on calculations of latest time, critical path and float CPM method is used. Considering the forward pass with zero starting time, the first event progresses from left to right and reaches to the final event. Let

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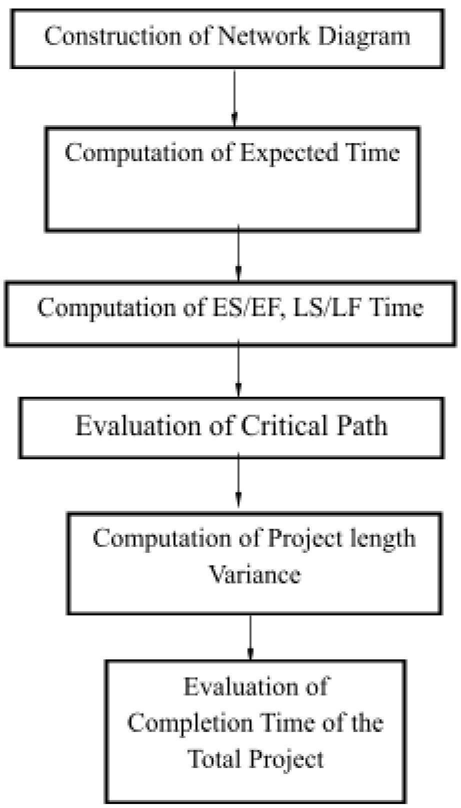
us assume j, k for any activity, the earliest time event of j is ES_j therefore $S_k = ES_j + t_{jk}$. There might be a case where in an event more than one activity enters then the earliest time is calculated as $ES_k = max\{ES_j + t_{kj}\}$ for all activities radiating from node j to k. Backward pass starts with the final node and calculation progresses from right to left till the initial event. Let us assume j, k for any activity, the latest finished time event of j is LF_j therefore, $F_j = LF_k - t_{jk}$. There might be a case where in an event more than one activity enters then the latest finish time is calculated as $LF_j = min\{LF_k - t_{kj}\}$ for all activities radiating from node k to i. Once the critical path is calculated, computation of project length variance is done which is sum of the variances of all critical activities. After that standard normal variable $Z = \frac{T_{sd} - T_{ex}}{\sigma}$ is computed where T_{sd} is the schedules time given for a project to complete and , T_{ex} is the expected project length duration. By the use of normal curve, the probability of project completion within the definite time can be approximated.

Figure 1: Flowchart of the proposed model



4.1 Illustrative Example:

Table 2: Illustrative Example

Acti	**Description**	**Pred**	**Optimistic Time**	**Pessimistic Time**	**Most Likely Time**

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vity		ecessors			
A	Selection of Manager and Other Marketing members	—	< 0.5, 1.8, 2.5, 3, 4.4; 0.5,	< 1.4, 2, 2.6, 3, 4.5; 0.4, 0.	< 2.2, 2.8, 3.8, 4.6, 5.5; 0.7
B	Choice of Market Areas	—	< 0.7, 1.6, 2.8, 3.5, 4.8; 0.	< 2, 3, 4, 5, 6; 0.6, 0.7, 0.6	< 1.5, 2, 2.5, 3, 4; 0.6, 0.5, 0
C	Selection of Marketing Products	A	< 1, 2, 3, 4, 5; 0.7, 0.6, 0.4	< 2, 2.5, 3, 3.5, 4.5; 0.8, 0.	< 1.8, 2.6, 3.6, 4.2, 5.5; 0.6
D	Ultimate Planning and Master-plan	B	< 2.5, 3, 4, 4.5, 6; 0.6, 0.5,	< 0.8, 1.8, 2.5, 3.6, 5; 0.4,	< 1, 1.8, 2.6, 3.6, 5; 0.6, 0.7
E	Training Schedule	B	< 1.5, 2.5, 3, 4, 5.5; 0.7, 0.	< 2, 3, 4, 5, 6; 0.8, 0.6, 0.7	< 1.4, 2.2, 2.8, 3.5, 4.5; 0.6
F	Delay Times	C, D	< 2, 2.5, 3.5, 4, 5.5; 0.7, 0.	< 1.6, 2.4. 3.2. 4.5. 5.6; 0.	< 2.2, 2.8, 3.6, 4.5, 5.5; 0.7
G	Estimation of the total time	E	< 1.6, 2, 2.5, 3, 4.5; 0.6, 0.	< 2, 2.5, 3.5, 4, 5.5; 0.8, 0.	< 2.6, 3.5, 4, 5, 6; 0.7, 0.5, 0

Draw the project network and find the probability that the project is completed in 5.6 days?

Table 3: Illustrative Example: Step-1

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Optimistic Time(o_t)	Pessimistic Time(p_t)	Most Likely Time(m_t)	$E_{jk} = \frac{o_t+4m_t+p_t}{6}$	$\sigma_{jk}^{2} = \left(\frac{p_t-o_t}{6}\right)^{2}$
0.9760	1.0800	2.0160	1.6867	0.0003
1.5187	1.7333	1.2133	1.3509	0.0013
1.7000	1.4467	2.0060	1.8618	0.0018
1.8667	1.0047	1.3067	1.3497	0.0206
1.8700	2.0000	1.3440	1.5410	0.0005
1.9833	1.8453	2.1080	2.0434	0.0005
1.2693	2.1000	2.3913	2.1558	0.0192

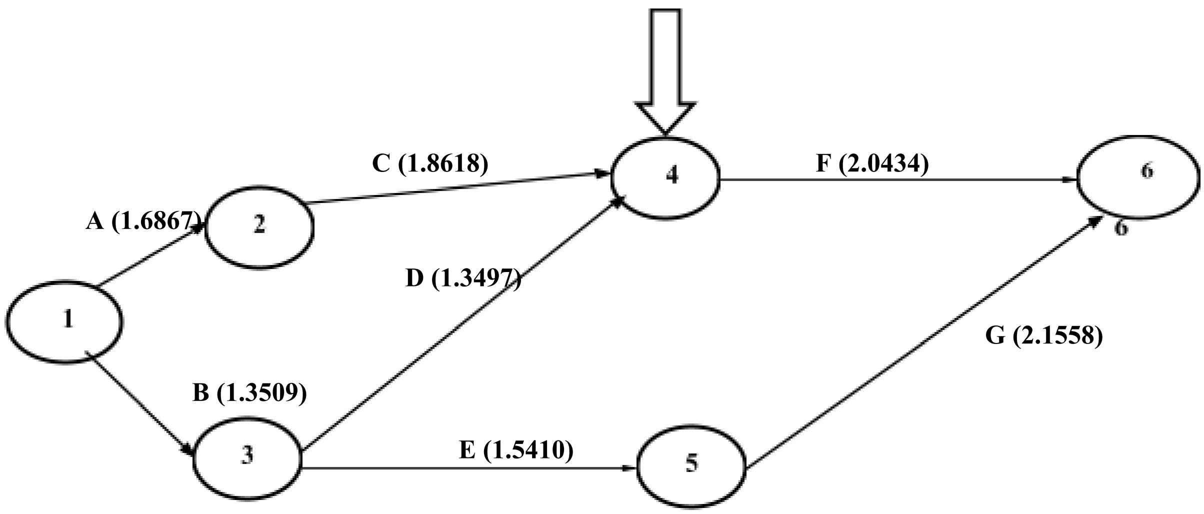

Figure 2: Network Diagram (step 2)

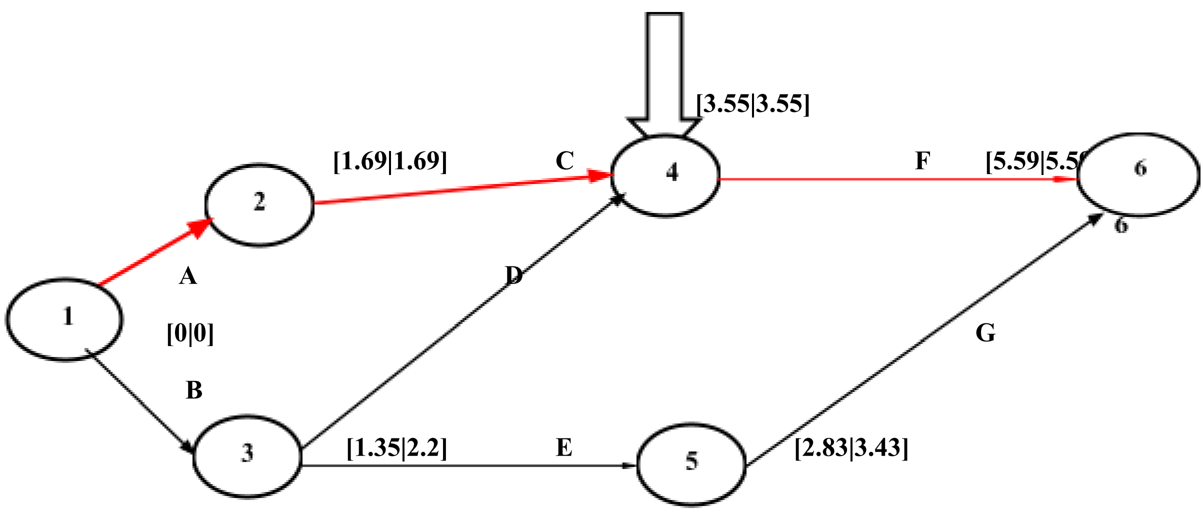

Figure 3: Network Diagram (step 3)

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Line denote the Critical Path

So, expected project duration-5.59 days

Critical path- 1→2→4→6

Project length variance $\sigma^2 = 0.0026$, Standard deviation-0.051

Probability that the project will be finished within 5.6 days is $P\left(z \le \frac{5.6-5.59}{0.051}\right) = P(z \le 0.2)$

$Area\ under\ the\ normal\ curve\ P(z \le 0.2) = 0.5 + \emptyset(0.2) = 0.5793$

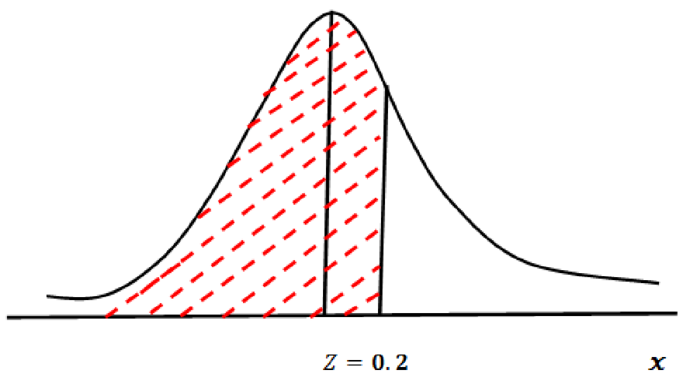

Figure 4: Normal Distribution Curve

5. Conclusion and future research scope

The idea of pentagonal neutrosophic number is intriguing, competent and has an ample scope of utilization in various research domains. In this research article, we vigorously erect the perception of pentagonal neutrosophic number from different aspects. We introduced a score function here in pentagonal neutrosophic domain. Additionally, we consider a networking problem in neutrosophic environment and solve the problem utilizing the idea of score function. Since, there is no such articles is till now established in pentagonal networking neutrosophic arena, thus we cannot compare our work with other methods.

Further, researchers can immensely apply this idea of neutrosophic number in numerous flourishing research fields like engineering problem, mobile computing problems, diagnoses problem, realistic mathematical modeling, social media problem etc.

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