ISSN 2278-3091

Volume 8, No.1.1, 2019

International Journal of Advanced Trends in Computer Science and Engineering

Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse4081.12019.pdf

https://doi.org/10.30534/ijatcse/2019/4081.12019

Shortest Path Problem under Interval Valued Neutrosophic Setting

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ABSTRACT

This paper provides a research of the shortest neutrosophic path with interval valued neutrosophic numbers on a network. The suggested algorithm also provides the shortest path length utilizing ranking function from the source node to the destination node. Each of the arc lengths is attributed to an interval valued neutrosophic number. Lastly, we provide a numerical example to illustrate the suggested approach.

Key words : Interval Valued Neutrosophic Graph, Score Function, Shortest Path Problem.

1. INTRODUCTION

Smarandache pioneered neutrosophy in 1998. It is a philosophical branch studying the nature, origins, and scope of neutralities, in addition to interaction with various ideational spectra. Smarandache generalized the fuzzy set concept [28] and the intuitionistic fuzzy set [25] through the addition of an independent indeterminacy-membership. The neutrosophic set is a useful tool for dealing with inconsistent, indeterminate, and incomplete information in the real world, which has become a concern for researchers. The neutrosophic set concept is characterized by three independent degrees, which are falsity-membership degree (F), indeterminacy-membership degree (I), and truth-membership degree (T).

Later, Smarandache extended the neutrosophic set to neutrosophic offset, underset, and overset [46]. From an engineering or scientific viewpoint, the set- theoretic operator and neutrosophic set are hard to apply in real applications. Consequently, there are different extended neutrosophic sets, such as bipolar neutrosophic sets, simplified neutrosophic sets, interval valued neutrosophic sets, single valued neutrosophic sets, etc. The neutrosophic subclass sets, called single-valued neutrosophic sets [14] (SVNS for short), has been researched by numerous researchers. The single valued neutrosophic theoretical concept is useful in various fields, such as the decision making problem, medical diagnosis, etc. Later, the concept of interval valued neutrosophic sets [15] (IVNS for short) generalized fuzzy sets, interval valued fuzzy sets [20], interval valued intuitionistic fuzzy sets [26], single valued neutrosophic sets, and intuitionistic fuzzy sets. The interval valued neutrosophic set is a model of a neutrosophic set, which handles uncertainty in the engineering, environmental, and scientific fields. This concept is characterized by the truth-membership, the indeterminacy-membership and the falsity-membership independently, which are useful tools for dealing with inconsistent, indeterminate, and incomplete information. The interval valued neutrosophic set concept has greater flexibility and precision than a single valued neutrosophic set. The interval valued neutrosophic sets have recently become a topic of research interest. More literature on interval valued neutrosophic sets and single valued neutrosophic sets can be found in [1, 5, 6, 7, 8, 11, 13, 17, 18, 19, 20, 21, 22, 23, 28, 29, 30, 32, 35, 38, 42, 44]. Generalizations of a single valued neutrosophic set, and the concept of interval valued neutrosophic have been proposed and studied. Research has dealt with inconsistent and indeterminate problems through the application of interval neutrosophic sets. The concept of the single valued neutrosophic set was combined with graph theory and a new graph model was presented. This is a single valued neutrosophic graph [34, 37, 39]. The single valued neutrosophic graph model permits the attachment of truth-membership (t), indeterminacy–membership (i) and falsity-membership degrees (f) both to edges and vertices. The single valued neutrosophic graph is the generalization of fuzzy graphs and intuitionistic fuzzy graphs. Additionally, the interval valued neutrosophic set concept was combined with graph theory and a new graph model was introduced This concept is an interval valued neutrosophic graph. An interval valued neutrosophic graph [36, 43] generalizes the concepts of a fuzzy graph, an intuitionistic fuzzy graph, an interval valued fuzzy graph and a single valued neutrosophic graph. Recently, research on single valued neutrosophic graphs and interval valued neutrosophic graphs have been researched.

The shortest path problem is a fundamental algorithmic problem, where the minimum weight path is calculated between two nodes directed, weighted graph. The issue is much researched and has attracted researchers from different areas such as computer science, operation research, communication networks, etc. There are numerous shortest path problems [2, 3, 4, 12, 31, 45] which have been studied with various input data types, including fuzzy set, intuitionistic fuzzy sets, trapezoidal intuitionistic fuzzy sets vague set. Up until now, few research papers have dealt with the shortest path in a neutrosophic environment. Broumi et. al. [40] suggested an algorithm to solve the neutrosophic shortest path problem based on score function.

The same authors also [41] proposed research into a neutrosophic shortest path with a single valued trapezoidal neutrosophic number on a network. There are two problems which must be addressed to handle the neutrosophic path problem. One is determining the sum of two edges. The other is how make a comparison between the lengths of two different paths as the length of each edge is represented by neutrosophic numbers. Thus, here we extend the proposed method to solve the neutrosophic shortest path problem as proposed by Broumi et al. [40]. This is to solve the interval valued neutrosophic shortest path problems where the network arc lengths are represented by interval valued neutrosophic numbers.

This paper is organized as follows. In Section 2, we review some of the basic concepts about neutrosophic sets and interval valued neutrosophic graphs. In Section 3, an algorithm is suggested to find the shortest path and distance in an interval valued neutrosophic graph. In Section 4 an illustrative example is used to discover the shortest path and distance between the destination node and source node. Lastly, in Section 5 we provide a conclusion and proposals for future research.

2. PRELIMINARIES

Here we offer some basic definitions and concepts on neutrosophic sets; interval valued neutrosophic graphs are reviewed from the literature.

Definition 2.1 [9-10]. Let X be a space of points (objects) with generic elements in X denoted by x; thus the neutrosophic set A (NS A) is an object which has the form A = {< x: $T_A(x)$, $I_A(x)$, $F_A(x)$ >, x ϵ X}, where the functions T, I, F: X→]$^-0,1^+$[respectively define the truth-membership function, an indeterminacy-membership function, and a falsity-membership function of the element x ϵ X to the set A with the condition:

$$^-0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3^+. \quad (1)$$

The functions $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of]$^-0,1^+$[.

In 1998 Smarandache, and later Wang et al., [15] suggested the INS concept, which is an example of a neutrosophic set, and introduces an INS definition.

Definition 2.2 [15]. Let X is a space of points (objects) with generic elements in X denoted by x. An interval valued neutrosophic set A (INS A) in X is shown by the truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$.

For each point x in X , there are $T_A(x) = [T_A^L, T_A^U] \subseteq [0, 1]$, $I_A(x) = [I_A^L, I_A^U] \subseteq [0, 1]$ and $F_A(x) = [F_A^L, F_A^U] \subseteq [0, 1]$, and the sum $T_A(x)$, $I_A(x)$ and $F_A(x)$ satisfies the condition $0 \leq \sup T_A(x) + \sup I_A(x) \sup F_A(x) \leq 3$, then , an INS A can be expressed as

$$A = \{< x: T_A(x), I_A(x), F_A(x) >, x \in X\}$$

$$= \{< x: [T_A^L(x), T_A^U(x)], [I_A^L(x), I_A^U(x)], [F_A^L(x), F_A^U(x)] >, x \in X\} \quad (2)$$

Definition 2.3 [15]. An interval valued neutrosophic number $\tilde{A}_1 = (T_1, I_1, F_1)$ can be stated as a zero interval valued neutrosophic number if and only if

$$T_1^L = 0, T_1^U = 0, I_1^L = 1, I_1^U = 1, \text{ and } F_1^L = 1, F_1^U = 1 \quad (3)$$

Definition 2.4 [33]. Let

$\tilde{A}_1 = < [T_1^L, T_1^U], [I_1^L, I_1^U], [F_1^L, F_1^U] >$ and

$\tilde{A}_2 = < [T_2^L, T_2^U], [I_2^L, I_2^U], [F_2^L, F_2^U] >$

be two interval valued neutrosophic numbers and l > 0 . Thus, the operational rules are defined as:

(i)

$$\tilde{A}_1 \oplus \tilde{A}_2 = \left[T_1^L + T_2^L - T_1^L T_2^L, T_1^U + T_2^U - T_1^U T_2^U\right], \left[I_1^L I_2^L, I_1^U I_2^U\right], \left[F_1^L F_2^L, F_1^U F_2^U\right] \quad (4)$$

(ii)

$$\tilde{A}_1 \otimes \tilde{A}_2 = < \left[T_1^L T_2^L, T_1^U T_2^U\right], \left[I_1^L + I_2^L - I_1^L I_2^L, I_1^U + I_2^U - I_1^U I_2^U\right], \left[F_1^L + F_2^L - F_1^L F_2^L, F_1^U + F_2^U - F_1^U F_2^U\right] > \quad (5)$$

(iii)

$$\lambda \tilde{A} = < \left[1-(1-T_1^L)^{\lambda}, 1-(1-T_1^U)^{\lambda}\right], \left[(I_1^L)^{\lambda}, (I_1^U)^{\lambda}\right], \left[(F_1^L)^{\lambda}, (F_1^U)^{\lambda}\right] > \quad (6)$$

(iv)

$$\tilde{A}_1^{\lambda} = < \left[(T_1^L)^{\lambda}, (T_1^U)^{\lambda}\right], \left[1-(1-I_1^L)^{\lambda}, 1-(1-I_1^U)^{\lambda}\right], \left[1-(1-F_1^L)^{\lambda}, 1-(1-F_1^U)^{\lambda}\right] >$$

where $\lambda > 0$ (7)

Definition 2.5 [33]. To compare between two IVNN, Ridvan [33] used a score function concept in 2014. The score function is used for comparing the IVNS grades. This function demonstrates that the greater the value, the greater the interval-valued neutrosophic sets, and through the use of this concept paths can be ranked. Let $\tilde{A}_1 = (T_1, I_1, F_1)$ be an interval valued neutrosophic number, then, the score function $s(\tilde{A}_1)$, accuracy function $a(\tilde{A}_1)$ and certainty function $c(\tilde{A}_1)$ if an IVNN can be defined as follows:

$$\text{(i) } s(\tilde{A}_1) = \left(\frac{1}{4}\right) \times \left[2 + T_1^L + T_1^U - 2I_1^L - 2I_1^U - F_1^L - F_1^U\right] \quad (8)$$

(ii) Comparison of interval valued neutrosophic numbers

Let $\tilde{A}_1 = (T_1, I_1, F_1)$ and $\tilde{A}_2 = (T_2, I_2, F_2)$ be two interval valued neutrosophic numbers then

(i) $\tilde{A}_1 \prec \tilde{A}_2$ if $s(\tilde{A}_1) \prec s(\tilde{A}_2)$

(ii) $\tilde{A}_1 \succ \tilde{A}_2$ if $s(\tilde{A}_1) \succ s(\tilde{A}_2)$

(iii) $\tilde{A}_1 = \tilde{A}_2$ if $s(\tilde{A}_1) = s(\tilde{A}_2)$

2. The functions $T_B^L : V \times V \to [0, 1]$, $T_B^U : V \times V \to [0, 1]$, $I_B^L : V \times V \to [0, 1]$, $I_B^U : V \times V \to [0, 1]$ and $F_B^L : V \times V \to [0,1]$, $F_B^U : V \times V \to [0, 1]$ are such that:

$T_B^L(v_i, v_j) \leq \min[T_A^L(v_i), T_A^L(v_j)]$, $T_B^U(v_i, v_j) \leq \min[T_A^U(v_i), T_A^U(v_i)]$,

$I_B^U(v_i, v_j) \geq \max[I_A^L(v_i), I_A^L(v_i)]$, $I_B^U(v_i, v_j) \geq \max[I_A^U(v_i), I_A^U(v_i)]$ and

$F_B^L(v_i, v_j) \geq \max[F_A^L(v_i), F_A^L(v_i)]$, $F_B^U(v_i, v_j) \geq \max[F_A^U(v_i), F_A^U(v_i)]$ (10)

Definition 2.6[36]. By an interval-valued neutrosophic graph of a graph = (V, E) we mean a pair G = (A, B), where A=<

denoting the degrees of truth-membership, indeterminacy- membership and falsity-membership of the edge

$$0 \leq T_B(v_i, v_j) + I_B(v_i, v_j) + F_B(v_i, v_j) \leq 3, \text{ for all } (v_i, v_j) \in E \ (i, j = 1, 2, \ldots, n). \quad (11)$$

They named A the interval valued neutrosophic vertex set of V, and B the interval valued neutrosophic edge set of E, respectively; note that B is a symmetric interval valued neutrosophic relation on A.

3. ALGORITHM OF INTERVAL VALUED NEUTROSOPHIC PATH PROBLEM

This algorithm shows the stages involved to find the network arc length. This network considers each arc length as a neutrosophic number in intervals.

The algorithm for the shortest path is:

Step 1: Identify the first arc node length $\tilde{d}_1$ = <[0, 0], [1, 1], [1, 1]> and label the source node (say node1) as [$\tilde{d}_1$ = <[0, 0], [1, 1], [1, 1]>,-].

Step 2: Find node 1 minimum length with its neighbor node as $\tilde{d}_j = \min\{\tilde{d}_i \oplus \tilde{d}_{ij}\}$; j = 2,3,…,n.

Step 3: If the minimum occurs in the node which corresponds to unique value of i (i.e.,i = r), then label node j as [$\tilde{d}_j$, r].

Step 4: If the minimum occurs in the node which corresponds to over one value of I then it demonstrates that there is more than one interval valued neutrosophic path between source node *i* and node *j* but interval valued neutrosophic distance along path is $\tilde{d}_i$ hoose any value of *i*.

Step 5: If the destination node (say node n) is labeled as [$\tilde{d}_n$, l]. Then the interval valued neutrosophic shortest distance between source node is $\tilde{d}_n$.

Step 6: Regarding [d_n, l] find the interval valued neutrosophic shortest path between source node and destination node and check the node l label. Let it be [d_j,p]. Check the label of node p and etc. Repeat the same procedure until node 1 is obtained.

Step 7: The interval valued neutrosophic shortest path is obtained by combining every node gained by repeating the process in step 4.

Remark 5.1 Let $\tilde{A}_i$; i =1, 2,…, n be a set of interval valued neutrosophic numbers, if $S(\tilde{A}_i) < S(\tilde{A}_k)$, for all i, the interval valued neutrosophic number is the minimum of $\tilde{A}_k$

4. ILLUSTERATIVE EXAMPLE

This example illustrates the procedure of finding the shortest distance and shortest path between source node and destination node on the network of a interval valued neutrosophic graph (figure 1).

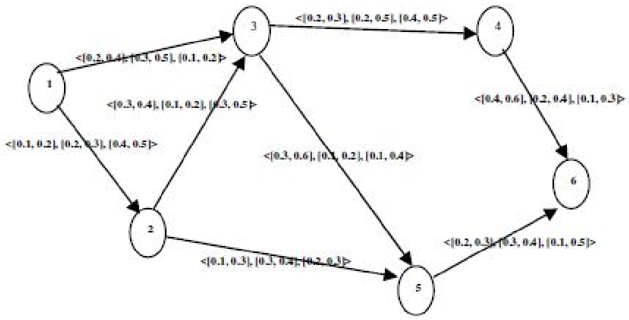

Figure 1: In this network each edge is assigned an interval valued neutrosophic number as follows:

:

Table 1: weights of the interval valued neutrosophic graphs

Edges	Interval valued Neutrosophic distance
1-2	<[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]>
1-3	<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]>
2-3	<[0.3, 0.4], [0.1, 0.2], [0.3, 0.5]>
2-5	<[0.1, 0.3], [0.3, 0.4], [0.2, 0.3]>
3-4	<[0.2, 0.3], [0.2, 0.5], [0.4, 0.5]>
3-5	<[0.3, 0.6], [0.1, 0.2], [0.1, 0.4]>
4-6	<[0.4, 0.6], [0.2, 0.4], [0.1, 0.3]>
5-6	<[0.2, 0.3], [0.3, 0.4], [0.1, 0.5]>

The shortest path computation based on the algorithm of interval valued neutrosophic path problem is displayed below and in table 1. As node 6 is the destination node, so n= 6.

assume $\tilde{d}_1$ = <[0, 0], [1, 1], [1, 1]> and label the source node (say node 1) as [<[0, 0], [1, 1], [1, 1]>,-], the value of $\tilde{d}_j$; j= 2, 3, 4, 5 ,6 can be obtained as follows:

Iteration 1 As only node 1 is the predecessor node of node 2, thus putting i = 1 and j = 2 in step 2 of the proposed algorithm, the value of $\tilde{d}_2$ is

$\tilde{d}_2$ = minimum{ $\tilde{d}_1 \oplus \tilde{d}_{12}$ } = minimum{<<[0, 0], [1, 1], [1, 1]> ⊕ <[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]> = <[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]>

Since minimum occurs corresponding to i = 1, so label node 2 as [<[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]>, 1]

Iteration 2 The predecessor node of node 3 are node 1 and node 2, so putting i = 1, 2 and j = 3 in step 2 of the proposed algorithm, the value of $\tilde{d}_3$ is $\tilde{d}_3$ = minimum{ $\tilde{d}_1 \oplus \tilde{d}_{13}$, $\tilde{d}_2 \oplus \tilde{d}_{23}$ }= minimum{<[0, 0], [1, 1], [1,1]> ⊕ <[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]>, <[0.1, 0.2], [0.2,0.3], [0.4, 0.5]> ⊕ <[0.3, 0.4], [0.1, 0.2], [0.3, 0.5]>} = minimum{<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]> , <[0.37, 0.52], [0.02, 0.06], [0.12, 0.25]>}

S (<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]>)

$$= s(\tilde{A}_1) = \left(\frac{1}{4}\right)\times\left[2+T_1^L+T_1^U-2I_1^L-2I_1^U-F_1^L-F_1^U\right]=0.175$$

= S (<[0.37, 0.52], [0.02, 0.06], [0.12, 0.25]>) = 0.59

Since S (<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]>) < S (<[0.37, 0.52], [0.02, 0.06], [0.12, 0.25]>) So, minimum{<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]> , <[0.37,0.52], [0.02, 0.06], [0.12, 0.25]>} = <[0.2, 0.4], [0.3, 0.5],[0.1, 0.2]>

Since minimum occurs corresponding to i = 1, so label node 3 as [<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]>, 1]

Iteration 3. The predecessor node of node 4 is node 3, so putting i = 3 and j = 4 in step 2 of the proposed algorithm, the value of $\tilde{d}_4$ is $\tilde{d}_4$ = minimum{ $\tilde{d}_3 \oplus \tilde{d}_{34}$ }= minimum{<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]> ⊕ <[0.2, 0.3], [0.2, 0.5], [0.4,0.5]>} = <[0.36, 0.58], [0.06, 0.25], [0.04, 0.1]>

So minimum{<[0.2, 0.4], [0.3, 0.5], [0.1, 0.2]> ⊕ <[0.2, 0.3],[0.2, 0.5], [0.4, 0.5]>}= <[0.36, 0.58], [0.06, 0.25], [0.04,0.1]>

Since minimum occurs corresponding to i = 3, so label node 4 as [<[0.36, 0.58], [0.06, 0.25], [0.04, 0.1]>,3]

Iteration 4 The predecessor node of node 5 are node 2 and node 3, so putting i= 2, 3and j= 5 in step 2 of the proposed algorithm, the value of $\tilde{d}_5$ is $\tilde{d}_5$ = minimum{ $\tilde{d}_2 \oplus \tilde{d}_{25}$, $\tilde{d}_3 \oplus \tilde{d}_{35}$ } = minimum{<[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]> ⊕ <[0.1, 0.3], [0.3, 0.4], [0.2, 0.3]>, <[0.2,0.4], [0.3, 0.5], [0.1, 0.2]> ⊕ <[0.3, 0.6], [0.1, 0.2], [0.1,0.4]>} =

Minimum{<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>, , <[0.44,

0.76], [0.03, 0.1], [0.01, 0.08]>}

S (<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>) = 0.51

S (<[0.44, 0.76], [0.03, 0.1], [0.01, 0.08]>) = 0.71

Since S (<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15 < S (<[0.44,

0.76], [0.03, 0.1], [0.01, 0.08]>)

Minimum{<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>, <[0.44,

0.76], [0.03, 0.1], [0.01, 0.08]>}

= <[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>,

$\tilde{d}_5$ = <[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>

Since minimum occurs corresponding to i=2, so label node 5 as [<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>, 2]

Iteration 5. The predecessor node of node 6 are node 4 and node 5, so putting i = 4, 5and j = 6 in step 2 of the proposed algorithm, the value of $\tilde{d}_6$ is $\tilde{d}_6$ =

minimum{ $\tilde{d} \oplus \tilde{d}$, $\tilde{d} \oplus \tilde{d}$ }=minimum{<[0.36, 0.58], [0.06, 0.25], [0.04, 0.1]> ⊕ <[0.4, 0.6], [0.2, 0.4], [0.1, 0.3]>,

<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]> ⊕ <[0.2, 0.3], [0.3, 0.4], [0.1, 0.5]> } = minimum{<[061, 0.83], [0.01, 0.1], [0.004, 0.03]>, <[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]> }

S (<[061, 0.83], [0.01, 0.1], [0.004, 0.03]>) = 0.79

S (<[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]>) = 0.68

Since S (<[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]>) < S (<[061, 0.83], [0.01, 0.1], [0.004, 0.03]>)

So minimum{<[061, 0.83], [0.01, 0.1], [0.004, 0.03]>, <[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]> }= <[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]

$\tilde{d}_6$ = <[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]

Since minimum occurs corresponding to i = 5, so label node 6 as [<[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]>, 5]

As node 6 is the destination node of the network, therefore the interval valued neutrosophic shortest distance between node 1 and node 6 is <[0.35, 0.60], [0.01, 0.04], [0.008,0.075]>

The interval valued neutrosophic shortest path between node 1 and node 6 is obtained as follows:

Since node 6 is labeled by [<[0.35, 0.60], [0.01, 0.04], [0.008, 0.075]> , 5], which represents that we are coming from node 5. Node 5 is labeled by [<[0.19, 0.44], [0.06, 0.12], [0.08, 0.15]>, 2] , which represents that we are coming from node 2.

Node 2 is labeled by [<[0.1, 0.2], [0.2, 0.3], [0.4, 0.5]>, 1]
which represents an emergence from node 1. Hence, the interval valued neutrosophic shortest path between node 1 and node 6 is obtaining by joining all the obtained nodes. Hence the interval valued neutrosophic shortest path is 1→ 2→5→6
The interval valued neutrosophic shortest distance and the neutrosophic shortest path of every node from node 1 is shown in table 2 and each labelled node is shown in figure 2

Table 2: Tabular representation of different interval valued neutrosophic shortest path

Node No.(j)	$\tilde{d}_i$	Interval valued Neutrosophic shortest path between jth and 1st node
2	**<[0.1, 0.2], [0.2, 0.3],**	1 → 2
3	**<[0.2, 0.4], [0.3,**	1 → 3
4	**<[0.36, 0.58], [0.06, 0.25], [0.04,**	1 → 3 → 4
5	**<[0.19, 0.44], [0.06, 0.12], [0.08,**	1 → 2 → 5
6	**<[0.35, 0.60], [0.01, 0.04], [0.,**	1 → 2 → 5 → 6

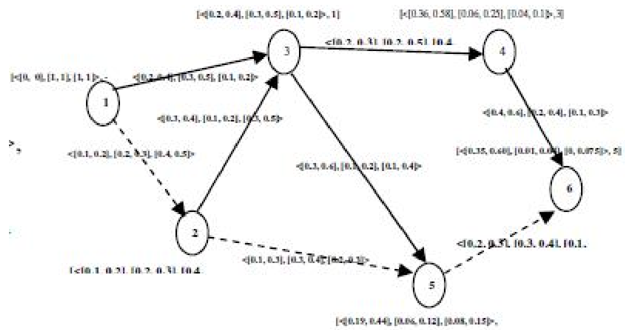

Figure 2: Network with interval valued neutrosophic shortest distance of each node from node 1

5. CONCLUSION

We have developed an algorithm to solve the shortest path problem on a network with an interval valued neutrosophic arc lengths. The path ranking process is useful in making decisions to choose the best potential path alternative. We explain the method by example with the assistance of hypothetical data. Furthermore, we extend the following algorithm of the interval neutrosophic shortest path problem in an interval valued bipolar neutrosophic environment.

ACKNOWLEDGMENT

The authors are very grateful to the chief editor and reviewers for their comments and suggestions, which is helpful in improving the paper.

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