CHAPTER – V

Bipolar spherical Neutrosophic Cubic Graph and Minimum Spanning Tree Algorithm

5.1 Introduction

Neutrosophic sets are a suitable mathematical tool to handle the uncertainty along with the bipolarity ie., the positivity and negativity of the information. The concept of bipolar fuzzy sets is a generalization of fuzzy set to deal with vagueness and uncertainty. Graph theory concepts are widely used to study various applications in different areas. Minimum spanning tree have direct applications in the design of networks, other practical applications include taxonomy, cluster analysis and circuit design. Here in this chapter, application of bipolar spherical neutrosophic cubic graph in decision making problem and minimum spanning tree problem are presented.

5.2 Bipolar spherical Neutrosophic Cubic Minimum Spanning Tree Algorithm

In this section, we have defined score function of bipolar single-valued spherical fuzzy neutrosophic cubic set and presented a minimum spanning tree algorithm.

Definition 5.2.1: Let A be a bipolar single-valued spherical fuzzy neutrosophic cubic set, we define a new score function as follows:

$$S(A)=\frac{1}{18}\left\{\begin{array}{l}(T_{A_L}^{P+}+T_{A_U}^{P+})+(1-(I_{A_L}^{P+}+I_{A_U}^{P+}))+(1-(F_{A_L}^{P+}+F_{A_U}^{P+}))+T_{\lambda}^{P+}+I_{\lambda}^{P+}-F_{\lambda}^{P+}\\+(1+(T_{A_L}^{P-}+T_{A_U}^{P-}))-(I_{A_L}^{P-}+I_{A_U}^{P-})-(F_{A_L}^{P-}+F_{A_U}^{P-})-T_{\lambda}^{P-}+I_{\lambda}^{P-}+F_{\lambda}^{P-}\end{array}\right\}$$

In the following, we propose Bipolar spherical Neutrosophic Cubic Minimum Spanning Tree algorithm [BSFNCMST]

Step (1): Input bipolar spherical neutrosophic cubic adjacency matrix A.

Step (2): Interpret the bipolar spherical neutrosophic cubic matrix into score matrix S_{ij} by using score.

Step (3): Find the score matrix *S(A)* either row-wise or column-wise to find the cost of the corresponding edge e_{ij} in *S(A)* that is the minimum entries in S_{ij}.

Step (4): Set $S_{ij}=0$ if the edge e_{ij} of selected S_{ij} construct a cycle with the previous marked elements of the score matrix *S(A)* else mark S_{ij}.

Step (5): Repeat Step (3) & Step (4) until all (n-1) entries of the matrix of *S(A)* are either marked to zero or all the non-zero entries are marked.

Step (6): Compute minimum cost spanning tree of the graph G by construct the tree T including only the marked elements from the score matrix *S(A)*.

Step (7): End

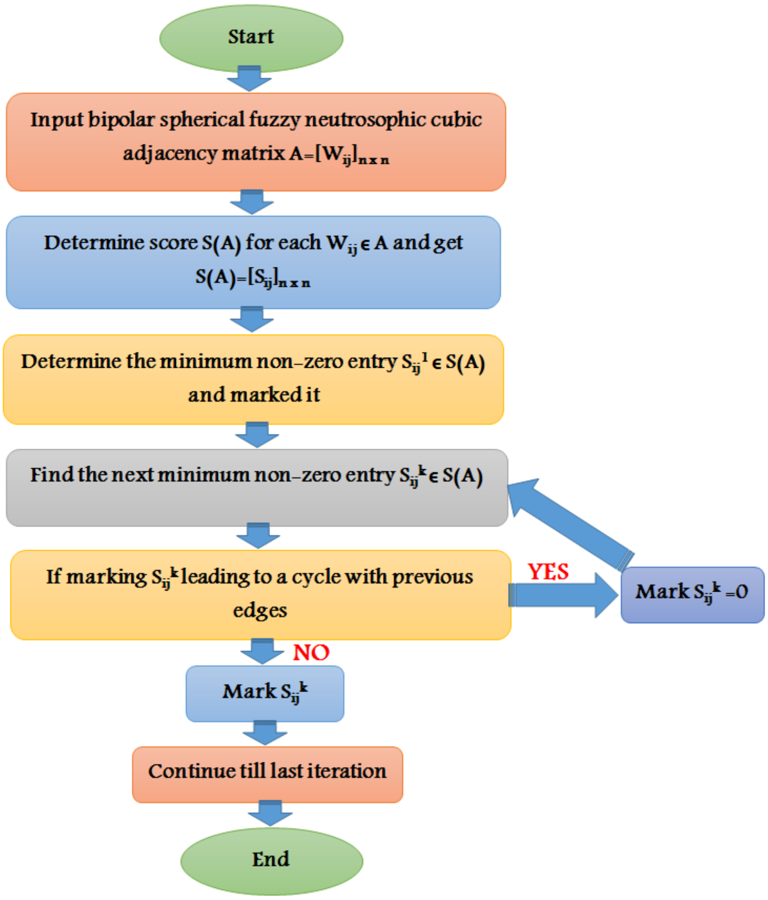

Fig. 5.1 Flow chart for proposed algorithm

5.3 Numerical Example

In this section, bipolar spherical neutrosophic cubic minimum spanning tree problem is presented and discussed it on a graph.

Example 5.3.1:

Assume the graph *G=(V,E)* where *V* be the vertices and *E* be the edge of the graph. Here we have 5 vertices and 7 edges. Erection of the minimum cost spanning tree are discussed as follows

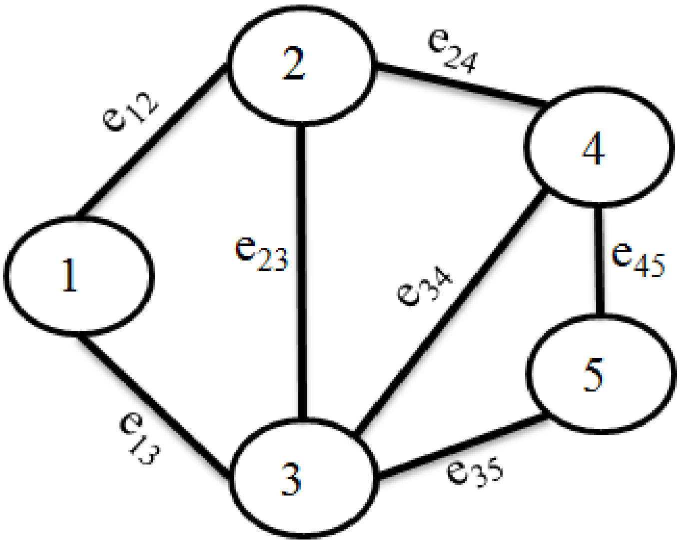

Fig. 5.2: Undirected Graph *G=(V,E)* with 5 vertices and 7 edges

E	Edge length
e_{12}	$\left\{\begin{matrix}([0.3,0.5],0.6),([0.4,0.5],0.8),([0.1,0.6],0.5),\\ ([-0.2,-0.4],-0.3),([-0.6,-0.5],-0.1),([-0.8,-0.1],-0.2)\end{matrix}\right\}$
e_{13}	$\left\{\begin{matrix}([0.7,0.8],0.2),([0.5,0.4],0.8),([0.6,0.3],0.4),\\ ([-0.7,-0.3],-0.8),([-0.2,-0.6],-0.5),([-0.4,-0.5],-0.3)\end{matrix}\right\}$
e_{23}	$\left\{\begin{matrix}([0.9,0.5],0.3),([0.7,0.2],0.9),([0.4,0.2],0.5),\\ ([-0.6,-0.2],-0.7),([-0.8,-0.9],-0.5),([-0.9,-0.6],-0.6)\end{matrix}\right\}$
e_{24}	$\left\{\begin{matrix}([0.9,0.8],0.1),([0.6,0.1],0.7),([0.4,0.2],0.5),\\ ([-0.5,-0.8],-0.6),([-0.7,-0.4],-0.8),([-0.8,-0.4],-0.7)\end{matrix}\right\}$
e_{34}	$\left\{\begin{matrix}([0.6,0.9],0.7),([0.6,0.1],0.9),([0.5,0.4],0.5),\\ ([-0.7,-0.9],-0.4),([-0.9,-0.7],-0.1),([-0.5,-0.7],-0.5)\end{matrix}\right\}$

e35	$\left\{\begin{matrix}([0.7,0.4],0.9),([0.7,0.8],0.9),([0.9,0.8],0.5),\\([-0.5,-0.6],-0.9),([-0.8,-0.6],-0.9),([-0.9,-0.5],-0.7)\end{matrix}\right\}$
e45	$\left\{\begin{matrix}([0.1,0.9],0.8),([0.3,0.7],0.9),([0.6,0.8],0.7),\\([-0.7,-0.5],-0.9),([-0.9,-0.9],-0.3),([-0.9,-0.8],-0.4)\end{matrix}\right\}$

The bipolar spherical neutrosophic cubic adjacency matrix A is given below

$$=\begin{bmatrix} 0 & e_{12} & e_{13} & 0 & 0 \\ e_{12} & 0 & e_{23} & e_{24} & 0 \\ e_{13} & e_{23} & 0 & e_{34} & e_{35} \\ 0 & e_{24} & e_{34} & 0 & e_{45} \\ 0 & 0 & e_{35} & e_{45} & 0 \end{bmatrix}$$

Thus, the score matrix using the score function

$$S(A) = \begin{pmatrix} 0 & 0.25 & 0.222 & 0 & 0 \\ 0.25 & 0 & 0.311 & 0.211 & 0 \\ 0.222 & 0.311 & 0 & 0.272 & 0.178 \\ 0 & 0.211 & 0.272 & 0 & 0.283 \\ 0 & 0 & 0.178 & 0.283 & 0 \end{pmatrix}$$

Fig. 5.3: Score Matrix

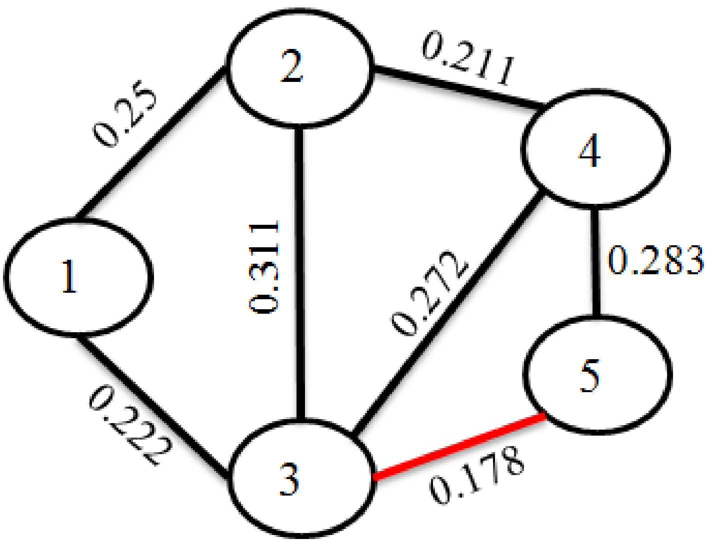

Fig. 5.4: The selected edge (3,5) in G

In the score matrix, the minimum entry 0.178 is selected and the corresponding edge (3,5) is highlighted in Fig. 5.3.

Fig. 5.4 represents the bipolar spherical neutrosophic cubic graph where the edge (3,5) is highlighted.

S(A) =

0	0.25	0.222	0	0
0.25	0	0.311	0.211	0
0.222	0.311	0	0.272	0.178
0	0.211	0.272	0	0.283
0	0	0.178	0.283	0

Fig. 5.5: The next minimum entry 0.211 in score matrix

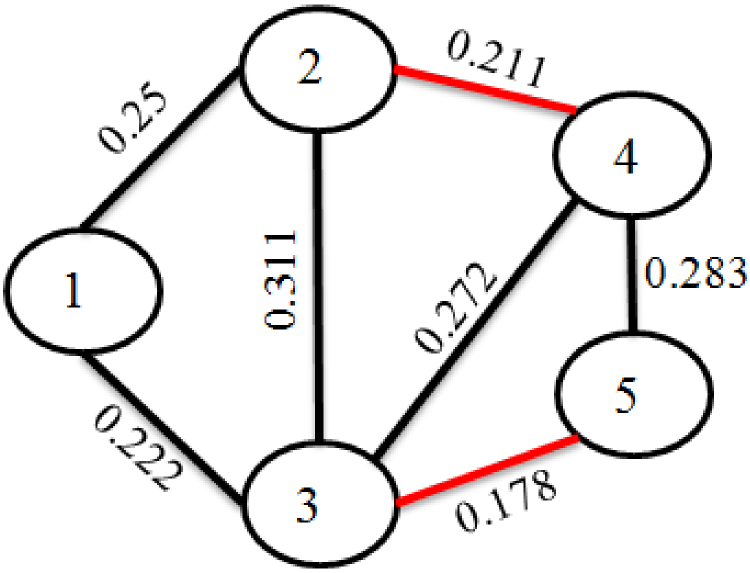

Fig. 5.6: The selected edge (2,4) in G

The next non-zero minimum entry from Fig. 5.5 & Fig. 5.6 is 0.211 is marked and the corresponding edge (2,4) is highlighted.

S(A) =

0	0.25	0.222	0	0
0.25	0	0.311	0.211	0
0.222	0.311	0	0.272	0.178
0	0.211	0.272	0	0.283
0	0	0.178	0.283	0

Fig. 5.7: The next minimum entry 0.222 in score matrix

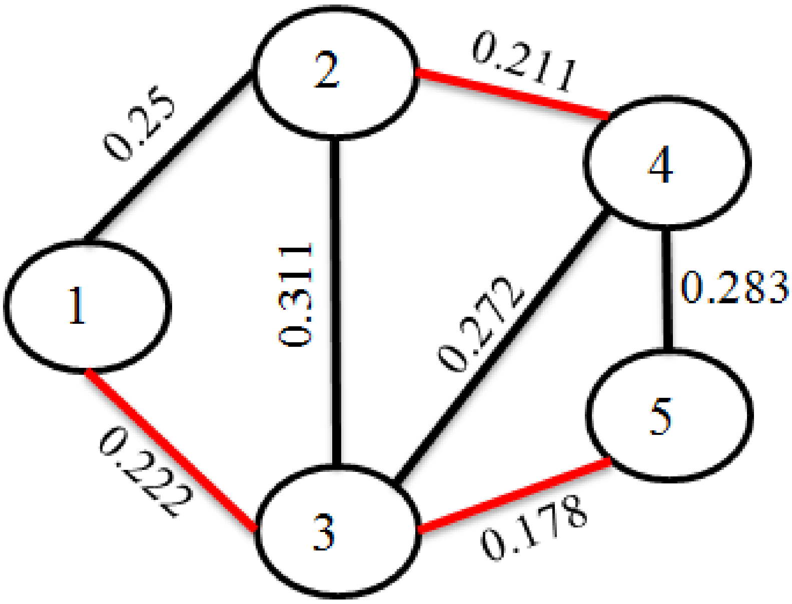

Fig. 5.8: The selected edge (1,3) in G

The next non-zero minimum entry from Fig. 5.7 & Fig. 5.8 is 0.222 is selected and the corresponding edge (1,3) is highlighted.

$$S(A) = \begin{pmatrix} 0 & 0.25 & 0.222 & 0 & 0 \\ 0.25 & 0 & 0.311 & 0.211 & 0 \\ 0.222 & 0.311 & 0 & 0.272 & 0.178 \\ 0 & 0.211 & 0.272 & 0 & 0.283 \\ 0 & 0 & 0.178 & 0.283 & 0 \end{pmatrix}$$

Fig. 5.9: The next minimum entry 0.25 in score matrix

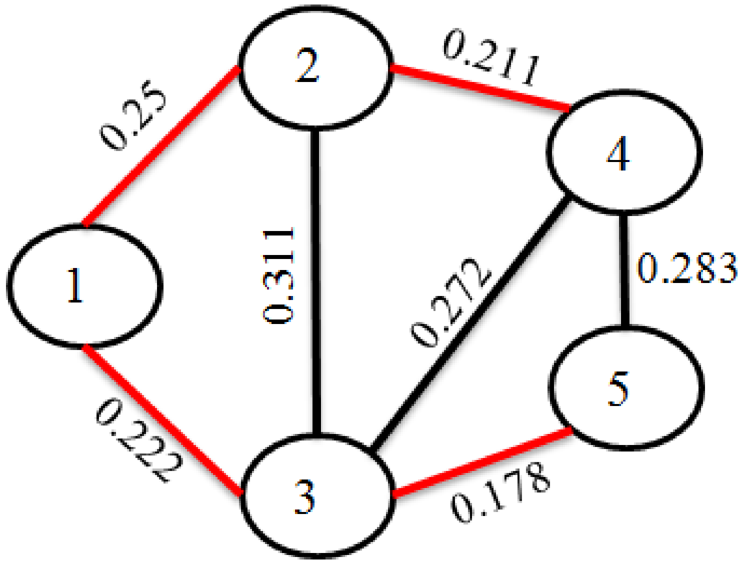

Fig. 5.10: The selected edge (1,2) in G

The final minimum non-zero entry 0.25 is selected and the corresponding edge (1,2) is highlighted in the Fig. 5.9 & Fig. 5.10.

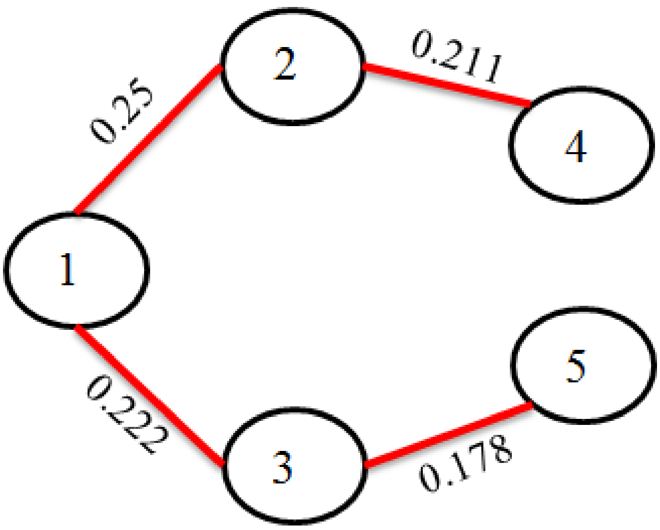

Fig. 5.11: The final path of minimum spanning tree

Using the above steps, the crisp minimum cost spanning tree is 0.861 and the final path of minimum spanning tree is $\{4,2\},\{2,1\},\{1,3\},\{3,5\}$.