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New Heuristic Fuzzy Triangular Approach for Minimum Spanning Tree Using Triangular Fuzzy Krushkal's Algorithm underNipah Virus Model

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Abstract:
Background*: The origin of Nipah virus infection established a drastic change in the environmental status which commonly affected in human activities. We studied and characterized Nipah virus-encephalitis and respiratory illness that have recently emerged to cause severe infection in humans. Also we developed graphical representation for those affecting deadly people with their corresponding symptoms those who are affected with Nipah virus. The investigation under medical diagnostic model and graph theoretic structures smoothen the facts on triangular fuzzy number. But the notion of triangular fuzzy krushkal's algorithm we introduced here connected with Nipah virus diseased patients.*
Materials and Methods*: Next we analyze triangular fuzzy krushkal's algorithm under Nipah virus model where we have considered 5 patients those who are affected with the virus symptoms like Headache, Common cold, Cough, Mental confusion, Fever, Shortness of breath, Vomiting, Rabies, Drowsiness, and Coma. Also our assumptions are a fuzzy connected graph in connection with triangular number and patient's symptoms Nipah virus disease diagnostic model.*
Let us consider K_5 connected fuzzy graph where A,B,C,D,E,F,G,H,I,J denotes the symptoms with patients affected with Nipah virus model with respect to the crisp value assumed the patients under medical diagnostic model as $P_1 = (0.1,0.2,0.3) P_2 = (0.2,0.4,0.6)$ $P_3 = (0.3,0.6,0.9) P_4 = (0.3,0.4,0.7) P_5 = (0.4,0.5,0.6)$ respectively which is 5 vertices for the K_5 graph.
Results*: Thus we conclude that the edges of minimum spanning trees are 1-2,1-4,1-5,4-3 & 1-2,1-3,1-5,5-4 whose total length of two trees are same (0.2,0.5,1.0)*
Conclusion: *In this fast paced world under the field of medicine, research study on Nipah virus enlightened the field of graph theory. But the approach on triangular fuzzy number put-forth and developed a new algorithm named triangular fuzzy krushkal's algorithm.*
Key Word*: Minimum spanning tree, Triangular fuzzy number, Triangular Fuzzy Krushkal's algorithm, Fuzzy graph Structure, Nipah virus, encephalitis and respiratory illness.*

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I. Introduction

L.A.Zadeh [1] established fuzzy set theory. Fuzzy set theory is extended to large domains in both mathematical way and field of medicine from which the information is not known and indefinite. During the period of study Nipah virus emerges a deadly disease in this world. Some authors like Brenda S.P. Ang et.al [4] characterized and studied Nipah virus. It emerged as a new virus among the most affected Nipah virus, among them we have chosen encephalitis and respiratory illness as a new study and we relate our concepts with respect to the medical field of knowledge. Our research developed a new algorithm named triangular fuzzy krushkal's algorithm using triangular fuzzy number. The development of Nipah virus is a fast growing virus in today's world. The common symptoms which observed in this type of virus will be easily affected among humans and other living organisms. The graph theoretical concepts play an important role in fuzzy set theory. This emerges a new result based on Nipah virus model with the approach of triangular fuzzy number under medical diagnostic model.

II. Material And Methods

Study Design: Triangular fuzzy number using krushkal's algorithm
Study Location: SRM IST, Department of mathematics, kattankulathur, Chengalpattu, Tamil Nadu.
Study Duration: November 2018 to April 2020.
Sample size: 5 patients.

Sample size calculation: 5 patients those who are affected with the virus symptoms like Headache, Common cold, Cough, Mental confusion, Fever, Shortness of breath, Vomiting, Rabies, Drowsiness, Coma. Also our assumptions are a fuzzy connected graph in connection with triangular number and patient's symptoms Nipah virus disease diagnostic model.
Subjects & selection method: Fuzzy sets, information and control, discrete mathematics. The study of method is krushkal's algorithm.

Firstly, we discuss few definitions and some basic concepts of fuzzy graph structure

2.1(FUZZY SET):
If J is set in which a fuzzy set Z is mapping from J to [0,1]. Also the membership function of Z is denoted byμ_Z.

2.2(FUZZY NUMBER):
From definition 2.1 a fuzzy number Z whose membership functionsμ_Z follows: piecewise continuous, convex, and normal.

2.3(TRIANGULAR FUZZY NUMBER):
Suppose that we consider three elements$d_1, d_2, d_3 \in R$ there exist $d_1 < d_2 < d_3$ in a set J= (d_1, d_2, d_3) and is said to be a triangular fuzzy number if

$$Z = \begin{cases} \dfrac{x - d_1}{d_2 - d_1} & d_1 \le x \le d_2 \\ \dfrac{d_3 - x}{d_3 - d_2} & d_2 \le x \le d_3 \\ 1 & x = d_2 \\ 0 & otherwise \end{cases}$$

Also we define some basic definitions of addition and multiplication of triangular fuzzy number:

a)(x_1, x_2, x_3)**+(**$y_1,\ y_2,\ y_3$)= $(x_1 + y_1,\ \ x_2 + y_2,\ \ x_3 + y_3)$
b) (x_1, x_2, x_3)**(**$y_1,\ y_2,\ y_3$) = [min$(x_1y_1, x_1y_3, x_3y_1, x_3y_3)$,$x_2y_2, max(x_1y_1, x_1y_3, x_3y_1, x_3y_3)$]

2.4(MINIMUM SPANNING TREE):
a)Aconnected undirect graph is a tree and acyclic
b)A graph S(V,E) is minimum spanning tree such as it subdivide the weights assigned to each and every connected edges which undirects all the vertices.
c)$|E| = |V| - 1$.

2.5(KRUSHKAL'S ALGORITHM):
A connected graph which is found to be minimum weight of edges and connects all the vertices that form a spanning tree to be minimum.

2.6(FUZZY GRAPH STRUCTURE):[5]
A graph structure $G^{'}$=(V,$R_1, R_2, R_3, \ldots, R_n$) consists of a nonempty set V with relations $R_1, R_2, R_3, \ldots, R_n$ on set V which are mutually disjoint such that each relation $R_i, 1 \le i \le n$ is symmetric and reflexive.
Graph structure $G^{''} = (V, R_1, R_2, R_3, \ldots, R_n)$can be represented just like a graph where each edge is labelled as$R_i, 1 \le i \le n$.

TRIANGULAR FUZZY KRUSHKAL'S ALGORITHM
Next we will developed a new algorithm under triangular fuzzy number as triangular fuzzy krushkal's algorithm with approach of Nipah virus model

STEP 1:
Let $G^{'}$ be a complete fuzzy graph structure. At first we will calculate how we can find vertices from the edges of complete fuzzy graph.

STEP 2:
Next let us arrange the edges based on the order of the increasing weights assigned to given complete fuzzy graph.

STEP 3: From step 2 we obtained minimum weight viewed under triangular fuzzy number which do not form a circuit for the complete fuzzy graph.

STEP 3.1:

Further we investigated that there is a possible of finding edges that do not form a circuit, if so their total length will be same.

STEP 4:

Using step 3 the process is continued and we successively add all the selected edges with minimum weight.

STEP 5:

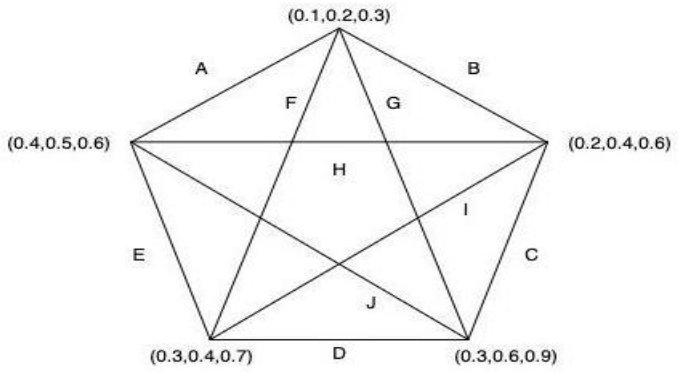
This step is concluded unless (n-1) edges have been selected.

III. Results

Next we analyze triangular fuzzy krushkal's algorithm under Nipah virus model where we have considered 5 patients those who are affected with the virus symptoms like Headache, Common cold, Cough, Mental confusion, Fever, Shortness of breath, Vomiting, Rabies, Drowsiness, and Coma. Also our assumptions are a fuzzy connected graph in connection with triangular number and patient's symptoms Nipah virus disease diagnostic model.

Let us consider K_5 connected fuzzy graph where A,B,C,D,E,F,G,H,I,J denotes the symptoms with patients affected with Nipah virus model with respect to the crisp value assumed the patients under medical diagnostic modelas$P_1 = (0.1,0.2,0.3) P_2 = (0.2,0.4,0.6)\ P_3 = (0.3,0.6,0.9) P_4 = (0.3,0.4,0.7) P_5 = (0.4,0.5,0.6)$ respectively which is 5 vertices for the K_5 graph.

Figure no 1:K_5 connected fuzzy graph patients affected with Nipah virus.

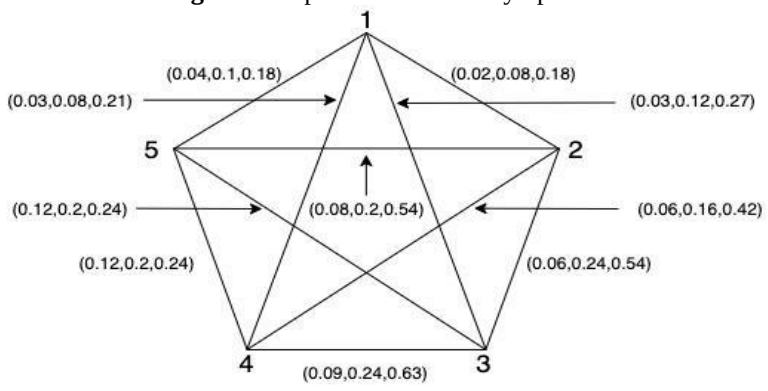


STEP 1:

Suppose we consider two patients having same symptoms under Nipah virus model. Using the notion of triangular fuzzy number and by definition 2.3(b) we observe that patients symptoms description between the vertices of edges is calculated A=(0.04,0.1,0.18), B=(0.02,0.08,0.18),C=(0.06,0.24,0.54), D=(0.09,0.24,0.63), E=(0.12,0.2,0.42), F=(0.03,0.08,0.21), G=(0.03,0.12,0.27), H=(0.08,0.2,0.36), I=(0.06,0.16,0.42), J=(0.12,0.36,0.54)

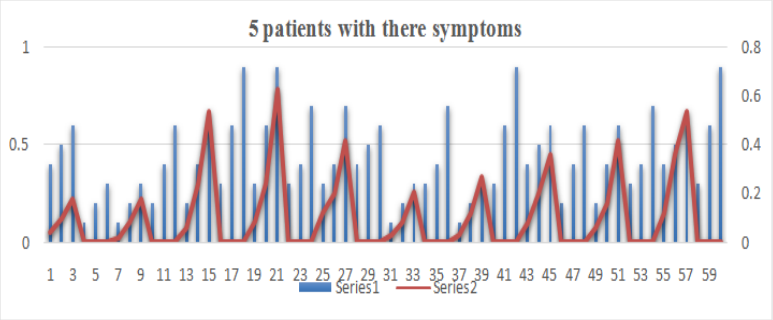
From graph 1 we found the edges showing the K_5 connected graph as

Figure no 2.patient with their symptoms



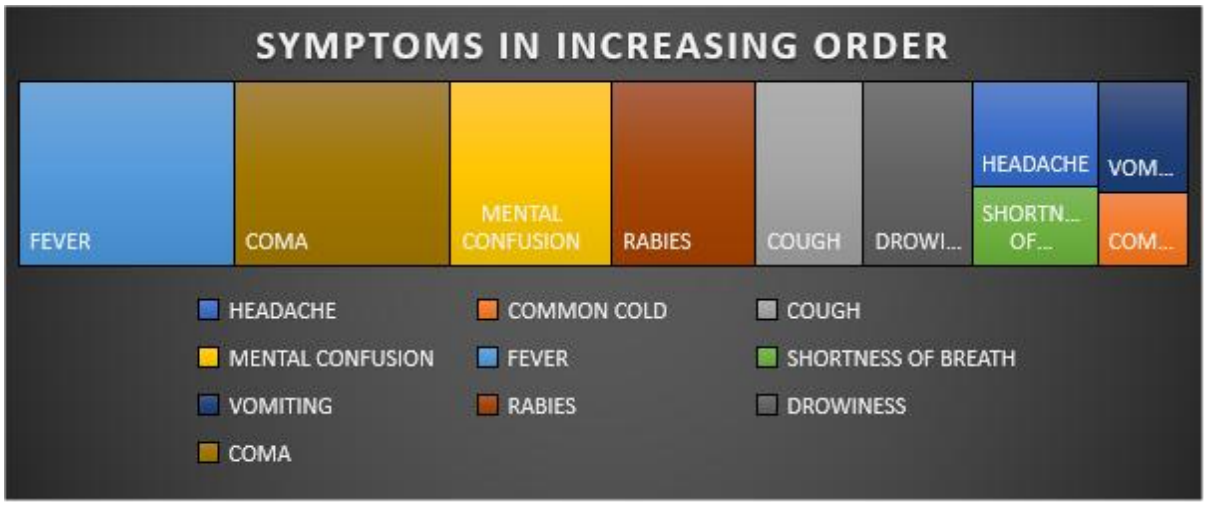
Furthermore for the graph 2 we represent the network model for the patients-symptoms for the Nipah virus diseases. It is clearly mentioned in the network graph that symptoms vary discrepancy from one to another symptoms which are highly affected according to the patients surrounding.

Figure no 3. Represent as symptoms vary from one to other patient's symptoms



STEP 2&3:
From graph 2 firstly we arrange the symptoms in increasing order and using definition 2.4 to make the array minimum weight to maximum.
B-(0.02,0.08,0.18),F-(0.03,0.08,0.21), G-(0.03,0.12,0.27), A-(0.04,0.1,0.18), I-(0.06,0.16,0.42),C-(0.06,0.24,0.54), H-(0.08,0.2,0.36), D-(0.09,0.24,0.63), E-(0.12,0.2,0.42), J-(0.12,0.36,0.54)
The chart shows the Nipah virus affected patient's symptoms from minimum to maximum.

Figure no 4. Represent highly affected symptoms as shown below

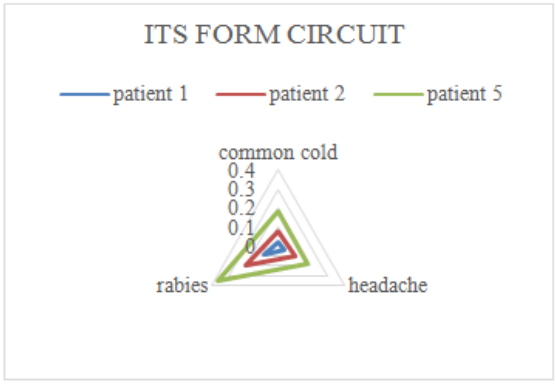


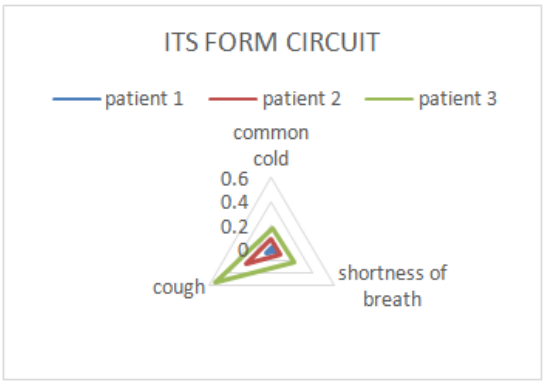
In the figure 4 the highly affected symptoms are fever and coma.

Table no 1: Shows the triangular fuzzy number with respect to the fuzzy graph and minimum spanning tree

PATIENTS OF NIPAH VIRUS	SYMPTOMS	INCLUDED IN THE SPANNING TREE OR NOT	IF NOT INCLUDED, CIRCUIT FORMED
1-2	B(0.02,0.08,0.18)	YES	-
1-3,1-4	F(0.03,0.08,0.21) G(0.03,0.12,0.27)	YES	-
1-5	A(0.04,0.1,0.18)	YES	-
2-4,2-3	I(0.06,0.16,0.42) C(0.06,0.24,0.54)	NO	**1-2-3-1**
2-5	H(0.08,0.2,0.36)	NO	**1-2-5-1**
3-4	D(0.09,0.24,0.63)	YES	-
4-5,3-5	E(0.12,0.2,0.42) J(0.12,0.36,0.54)	YES	-

Figure no 5&6.represent as commonly affected symptoms, its form circuit





STEP 4:
In K_5 connected graph there are 5 vertices we should stop the procedure for finding the edges of the minimum spanning tree, when 4 edges have been found out.
The edges of the minimum spanning tree are 1-2,1-3,1-4,1-5,4-3,5-4 whose total length are same.
Similarly we get two other alternative minimum spanning tree of total length same and using definition 2.3(a) where edges are listed below as
1)1-2,1-4,1-5,3-4(encephalitis)
2)1-2,1-3,1-5,5-4(respiratory illness)
1) **ENCEPHALITIS**

Figure no 7.its satisfies minimum spanning tree conditions that do not form circuit with (n-1) vertices

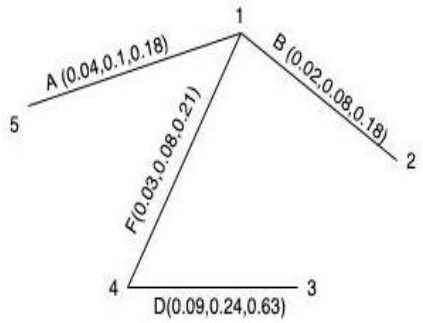
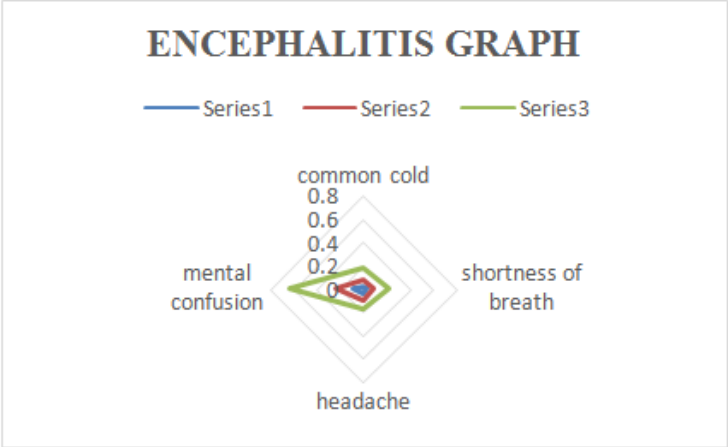


Figure no 8.the below structure with connected symptoms from disease of encephalitis



A+B=(0.04,0.1,0.18)+(0.02,0.08,0.18)=(0.06,0.18,0.36)
D+F=(0.09,0.24,0.63)+(0.03,0.08,0.21)=(0.12,0.32,0.84)
(A+B)+(D+F)=(0.18,0.50,1.2) ≈(0.2,0.5,1.0)
Thus we have constructed two graphs with successively added

2) **RESPIRATORY ILLNESS**

Figure no 9. Its satisfies minimum spanning tree conditions do not form circuit with (n-1) vertices

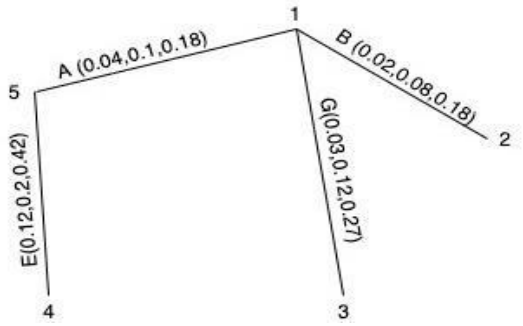
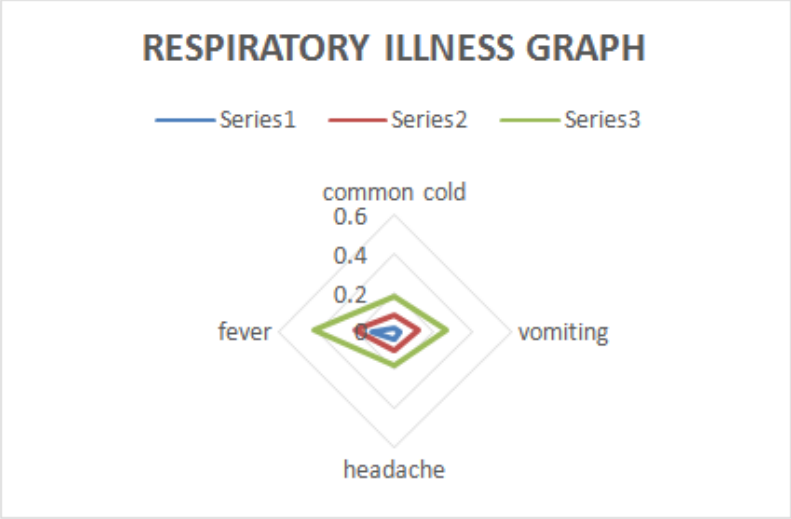


Figure no 10. The below structure with connected symptoms from disease of respiratory illness



A+B=(0.04,0.1,0.18)+(0.02,0.08,0.18)=(0.06,0.18,0.36)
E+G=(0.12,0.2,0.42)+(0.03,0.12,0.27)=(0.15,0.32,0.67)
A+B+E+G=(0.21,0.50,1.13) ≈(0.2,0.5,1.0)
Thus we have constructed two graph with successively added

STEP 5:

Thus we conclude that the edges of minimum spanning trees are 1-2,1-4,1-5,4-3 & 1-2,1-3,1-5,5-4 whose total length of two trees are same (0.2,0.5,1.0)

IV. Discussion

APPLICATIONS FOR DETERMINATION OF NIPAH VIRUS

A system that was designed for determination Nipah virus is the two-input and single-output neuro-fuzzy network, based on Takagi-Sugeno (TS) type fuzzy model with triangular membership functions.

The set data we have consider in 10 symptoms correspondingly we have taken two diseases as encephalitis and respiratory illness respectively.

When the membership functions of parameters are taken as triangle, their mathematical formulas in suitable way

For example fuzzy membership functions for Nipah virus model is given below

Let x be the Nipah virus patients symptoms form which affected two disease as encephalitis and respiratory illness respectively

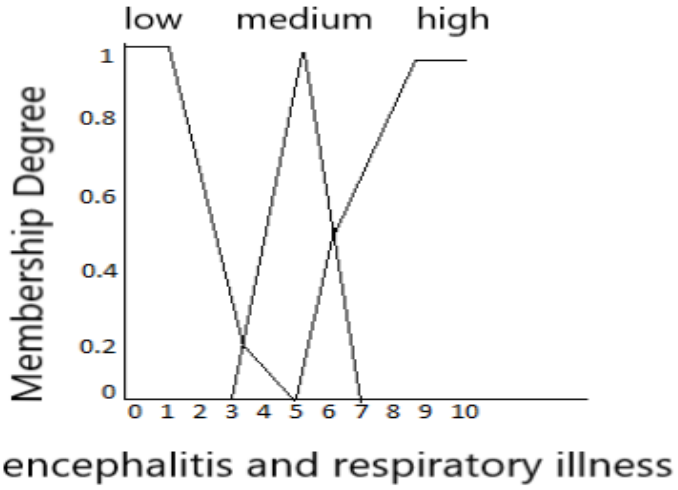
For encephalitis, the fuzzy membership functions are

$$\mu_{enc}(d) = \begin{cases} \frac{0.5 - d_1}{0.3} & 0.2 \le x \le 0.5 \\ \frac{1 - x}{0.5} & 0.5 \le x \le 1 \\ 1 & x = 1 \\ 0.2 & x \ge 1 \end{cases}$$

For respiratory illness, the fuzzy membership functions are

$$\mu_{res}(d) = \begin{cases} \frac{0.5 - d_1}{0.3} & 0.2 \le x \le 0.5 \\ \frac{1 - x}{0.5} & 0.5 \le x \le 1 \\ 1 & x = 1 \\ 0.2 & x \ge 1 \end{cases}$$

Figure 11. Membership function of encephalitis and respiratory illness

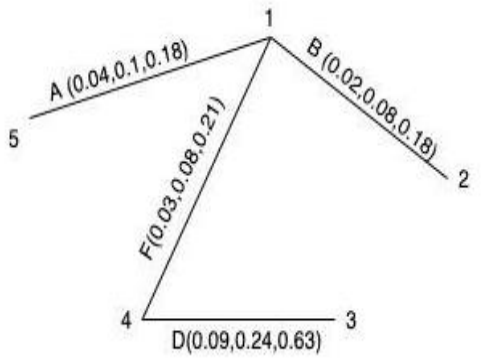


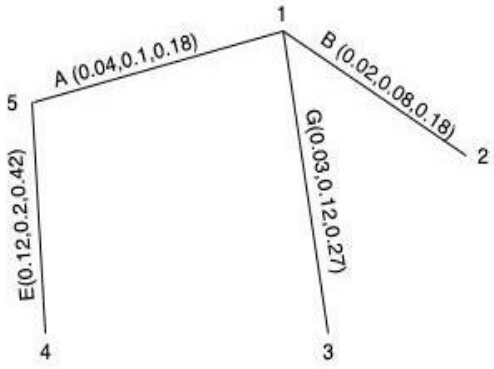
This is our new triangular fuzzy membership function, the affect of common cold and headache is **low,** then cough is **medium** and finally fever and coma are **high.**

REMARK 1:
Using definition 1.4 and step 4 of triangular fuzzy krushkal's algorithm its satisfies the minimum spanning tree conditions.

EXAMPLE FOR FUZZY GRAPH STRUCTURE
Consider the graph S= (V,S_1, S_2) we defined a fuzzy set $\delta: V \rightarrow$[0, 1] by
$\delta(V_1)$=(0.1,0.2,0.3), $\delta(V_2)$=(0.2,0.4,0.6), $\delta(V_3)$=(0.3,0.6,0.9),
$\delta(V_4)$= (0.3, 0.4, 0.7), $\delta(V_5)$= (0.4, 0.5, 0.6)

PROOF:
We defined the fuzzy set μ_1, μ_2 on relations S_1, S_2 respectively
$\mu_1(V_1V_2)$=(0.02,0.08,0.18), $\mu_1(V_1V_4)$=(0.03,0.08,0.21),
$\mu_1(V_1V_5)$=(0.04,0.1,0.18), $\mu_1(V_3V_4)$=(0.09,0.24,0.63).
$\mu_2(V_1V_2)$=(0.02,0.08,0.18), $\mu_2(V_1V_3)$=(0.03,0.12,0.27),
$\mu_2(V_1V_5)$=(0.04,0.1,0.18), $\mu_2(V_4V_5)$=(0.12,0.2,0.42).





V. Conclusion

In this fast paced world under the field of medicine, research study on Nipah virus enlightened the field of graph theory. But the approach on triangular fuzzy number put-forth and developed a new algorithm named triangular fuzzy krushkal's algorithm. Also we have described the algorithm under patient-symptoms diseases and their network graphical representation id concluded in a more elaborate way. Also the fuzzy membership function for the Nipah virus model established smoothly.

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AUTHORS PROFILE

Dr.G.Sheejais professor at SRM IST, and a gold medalist during her PhD. currently working on extensive research towards advanced algorithm and algebra and how classification model can be used to solve problems in day to day life

K.Dinakarancurrently studying in final year MSc Mathematics in SRM Institute of Science and Technology deeply interested in the field of fuzzy network and Fuzzy graph theory under various medical diagnostic model.

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