ORIENTAL JOURNAL OF
COMPUTER SCIENCE & TECHNOLOGY
An International Open Free Access, Peer Reviewed Research Journal
Published By: **Oriental Scientific Publishing Co., India.**
www.computerscijournal.org

ISSN: 0974-6471
June 2013,
Vol. 6, No. (2):
Pgs.67-74

User-Based Intelligent Decision Support System in Route Selection on Road Network

M.GEETHA[1] and G.M.KADHAR NAWAZ[2]

[1]Sona College of Technology (Autonomous),Department of MCA,Salem - 636 005,Tamilnadu,(India).
[2]Director, Sona College of Technology (Autonomous),Department of MCA ,
Salem - 636 005, Tamilnadu,(India).
Corresponding author E-mail :geethasaravananjaswa@gmail.com, nawazse@yahoo.co.in

(Received: May 25, 2013; Accepted: June 05, 2013)

ABSTRACT

Improving the efficiency of dynamic routing problem on road network is a difficult .There is numerous works proposed for this problem and they try to solve this in different aspects. Most of the existing routing problem based on static approach. In this paper, we propose a fuzzy Dijkstra's shortest path algorithm based on dynamic approach. The linguistic variables that qualify user parameters are quantified using fuzzy set theory that provides fuzzy numbers outputs to predict the shortest route on network. By handling the fuzzy parameter, it gives issue to compare the distance between two different paths with their edge lengths represented by fuzzy numbers. The addition of fuzzy numbers using graded mean integration representation is used to improve Dijkstra's algorithm. A numerical example of a road network is used to illustrate the efficiency of the proposed method.

Key words: User-based intelligent Decision Support System, Dijkstra's Algorithm, User Parameter, Fuzzy Set Theory, Fuzzy Numbers.

INTRODUCTION

User-based decision support system in route selection on a road network is great interest. It is necessary to provide the shortest path from origin to destination nodes[1, 2]. In a road network, the edge weight based on one of the distance, cost and travelling time. We propose a new type of path searching technique using fuzzy numbers. The main objective of this work is to deal with the imprecise data involved in different kinds of existing searching techniques in a more efficient way and thus to suggest a new improved version of searching technique under uncertainty which will be helpful in solving real life problems of transportation, routing, communications etc. in the road network of edge in the path of a network have the parameters that are not precise (i.e. distance, cost , travelling time , traffic, road quality, number of tollgate etc.). In these cases the use of fuzzy numbers for modeling the problem is quite appropriate. The algorithm is based on the idea from all the shortest paths from source to destination.

Many efficient algorithms have been developed by Bellman, Dijkstra's, Dreyfus and these algorithms are referring to as the standard shortest path algorithms. One of the most used methods to solve the shortest path problem is Dijkstra's algorithm; it handles only the crisp number. But many optimization methods the linguistic variables quantity cannot be applied directly to fuzzy numbers, some modification are needed before using Dijkstra's algorithm. Many typical works[3] transform the fuzzy number into crisp number[4] by defuzzification method. When applying the fuzzy Dijkstra's, we need three key issues. Quantify the linguistic variables into fuzzy numbers, the graded mean integration representation method leads to the result that addition of two numbers can be represented in crisp number then the Dijkstra algorithm can be easily implemented.

In this paper , we are motivated to develop a Dijkstra's algorithm for fuzzy shortest path problem. The most classical shortest path algorithm is the Dijkstra's algorithm. Whose complexity is O(|E|+|V| log|V|, where |V| is the number of vertices and |E| is the number of edges, it is not applicable under fuzzy environments. Therefore, in this paper we modify the algorithm with the help of fuzzy set theory. At first, fuzzy numbers are used to represent the user parameter, then the fuzzy arithmetic between fuzzy numbers are adopted to find the shortest path, resulting in the fuzzy Dijkstra's algorithm(FDA) .So FDA handle the fuzzy shortest problem flexibility and effectively. In addition, one feature of FDA is that no order relation between fuzzy numbers is used.

The rest of the paper is organized as follows. In section 2, some basic concept of fuzzy set theory. Section 3 deals with User-based intelligent decision support system to find the set of user parameter for road network. Section 4 proposed FDA to solve fuzzy shortest path algorithm. Section 5 gives the assessment model and process. The results obtained are also given in this section. Section 6 concludes the paper.

Preliminaries

In this section some basic definition, fuzzy numbers and fuzzy arithmetic operations are reviewed[5].

Definition 2.1:

A fuzzy number $\bar{A}$. Let X be the Universe of discourse, then a fuzzy set is defined as:

$$\bar{A} = \left\{ \left[x, \mu\bar{A}(x)\, X \varepsilon X \right] \right\} \quad ..(1)$$

This is characterized by a membership function $\mu\bar{A} : X \rightarrow [01]$, where, $\mu\bar{A}(x)$ denotes the degree of membership of the element x to the set $\bar{A}$.

Definition 2.2:

A triangular fuzzy number represented with three points as follows $\bar{A}$=(a_1,a_2,a_3) shown in Fig 1. This representation is interpreted as membership functions and holds the following conditions

a_1 to a_2 is increasing function
a_2 to a_3 is decreasing function
$a_1 \leq a_2 \leq a_3$

$$\mu_{\bar{A}}(x) = \begin{cases} 0, & x < a_1 \\ \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \leq x \leq a_3 \\ 0, & x > a_3 \end{cases} \quad ...(2)$$

Definition 2.3:

A trapezoidal fuzzy number represented with three points as follows $\bar{A}$=(a_1,a_2,a_3,a_4) shown in Fig 2. This representation is interpreted as membership functions and holds the following conditions

a_1 to a_2 is increasing function
a_2 to a_3 is stable function
a_3 to a_4 is decreasing function
$a_1 \leq a_2 \leq a_3 \leq a_4$

$$\mu_{\bar{A}}(x) = \begin{cases} 0, & x \leq a_1 \\ \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ 1, & a_2 \leq x \leq a_3 \\ \frac{a_4-x}{a_4-a_3}, & a_3 \leq x \leq a_4 \\ 0, & a_4 > x \end{cases} \quad ...(3)$$

Definition 2.4:

Arithmetic Operation of Triangular Fuzzy Number Consider two triangular fuzzy numbers $A = (a_1, a_2, a_0)$ and $B = (b_1, b_2, b_3)$.

1. Addition of A and B :
   A + B = (a1, a2, a3) + (b1, b2, b3) = (a1+b1, a2+b2, a3+ b3) where a1, a2, a3, b1, b2, and b3 are real numbers.
2. Product of A and B :
   A x B=(c1, c2, c3) where T= {a1b1, a1b3, a3b1, a3b3} c1 = min T, c2 = a2b2, c3 = max T If a1, a2, a3, b1, b2, b3 are all non zero positive real numbers, then A x B = (a1b1, a2b2, a3b3)
3. Subtraction of A and B :
   $\tilde{A} - B = (a_1, a_2, a_3) - (b_1, b_2, b_3) = (a_1 - b_3, a_2 - b_2, a_3 - b_1)$ where a_1, a_2, a_3, b_1, b_2, and b3 are real numbers.
4. Division of A and B :
   $A / B = (a_1, a_2, a_3) / (b_1, b_2, b_3) = (a_1/b_3, a_2/b_2, a_3/b_1)$ Where Ã and are non-zero positive real numbers

Definition 2.5:

Defuzzification by Graded Mean Integration Method

The conversion of a fuzzy set (or) a fuzzy number to single crisp value is called defuzzification and is the reverse process of fuzzification.

Let B be a triangular fuzzy number and be denoted as $\tilde{B} = (b_1, b_1, b_3)$.Then we can set the graded mean integration representation[6] of B by above formula as

$$p(\tilde{A}) = \frac{1}{6}(a_1 + 4 \text{ x } a_2 + a_3) \qquad \text{...(4)}$$

Let C be a trapezoidal fuzzy number, and be denoted as $\bar{C} = (c_1, c_2, c_3, c_4)$. Then we can get the graded mean integration representation of C by formula as

$$p(\tilde{C}) = \frac{1}{6}(c_1 + 2 \text{ x } a_2 + 2 \text{ x } a_3 + a_4) \qquad \text{... (5)}$$

The graded mean integration representation of the addition of triangular fuzzy number $\bar{A}$ and $\tilde{B}$ can be defined as:

$$p(\tilde{A} \oplus \tilde{B}) = p(\tilde{A}) + P(\tilde{B}) = \frac{1}{6}(a_1 + 4 \text{ x } a_2 + a_3) + \frac{1}{6}(b_1 + 4 \text{ x } b_2 + b_3) \qquad \text{...(6)}$$

The graded mean integration representation of the addition of triangular fuzzy number $\bar{A}$ and $\tilde{B}$ can be defined as:

$$p(\tilde{A} \otimes \tilde{B}) = p(\tilde{A}) \text{ x } P(\tilde{B}) = \frac{1}{6}(a_1 + 4 \text{ x } a_2 + a_3) \text{ x } \frac{1}{6}(b_1 + 4 \text{ x } b_2 + b_3) \qquad \text{...(7)}$$

The graded mean integration representation of the addition of trapezoidal fuzzy number $\bar{A}$ and $\tilde{B}$ can be defined as:

$$p(\tilde{A} \oplus \tilde{B}) = p(\tilde{A}) + P(\tilde{B}) = \frac{1}{6}(a_1 + 2 \text{ x } a_2 + 2 \text{x} a_3 + a_4) + \frac{1}{6}(b_1 + 2 \text{x} b_2 + 2 \text{x} b_3 + b_4) \qquad \text{...(8)}$$

The graded mean integration representation of the addition of trapezoidal fuzzy number $\bar{A}$ and $\tilde{B}$ can be defined as:

$$p(\tilde{A} \otimes \tilde{B}) = p(\tilde{A}) \text{ x } P(\tilde{B}) = \frac{1}{6}(a_1 + 2 \text{ x } a_2 + 2 \text{x} a_3 + a_4) \text{ x } \frac{1}{6}(b_1 + 2 \text{x} b_2 + 2 \text{x} b_3 + b_4) \qquad \text{...(9)}$$

Dijkstra algorithm

It conceived by Dutch computer scientist Edger Dijkstra's in 1956 and published in 1959[7], is a graph search algorithm that solves the single-source shortest path problem for a graph with non-negative edge path costs, producing a shortest path tree. For a given source vertex (node) in the graph, the algorithm finds the path with lowest cost (i.e. the shortest path) between that vertex and every other vertex. The signle-source shortest-paths problem for a given city called source in a trapezoidal fuzzy number connected cities, find shortest routes to all its other cities. They are several well-known algorithms for solving it,including Floyd's algorithm for the more general all-pairs-shortest-paths problem . But we consider the best-known algorithm for the single-source shortest-paths problem, called Dijkstra's algorithm. It finds the shortest paths to a graph's vertices in order of their risk factor from a given source. First,it finds the shortest path from the source to a vertex nearest to it, then to a second nearest, and so on.In general,before its ith iteration commences,the algorithm has already identified the shortest paths to i-1 other vertices nearest to the source.

Let the node at which we are starting be called the initial node. Let the distance of node Y be the distance from the initial node to Y. Dijkstra's algorithm will assign some initial distance values and will try to improve them step by step.

1. Assign to every node a tentative distance value: set it to zero for our initial node and to infinity for all other nodes.
2 Mark all nodes unvisited. Set the initial node as current. Create a set of the unvisited nodes called the unvisited set consisting of all the nodes except the initial node.
3. For the current node, consider all of its unvisited neighbors and calculate their tentative distances. Even though a neighbor has been examined, it is not marked as "visited" at this time, and it remains in the unvisited set.
4. When we are done considering all of the neighbors of the current node, mark the current node as visited and remove it from the unvisited set. A visited node will never be checked again.
5. If the destination node has been marked visited (when planning a route between two specific nodes) or if the smallest tentative distance among the nodes in the unvisited set is infinity (when planning a complete traversal), then stop. The algorithm has finished.
6. Select the unvisited node that is marked with the smallest tentative distance, and set it as the new "current node" then go back to step 3.

Proposed method

Fuzzy logic is very effective in dealing with table that involve uncertain such as qualitative term, linguistic vagueness and human intervention[8]. There are assessment criteria in driver-preference route selection[9] such as Travel time, Travel distance, Number of traffic signal, Entertainment of route, Difficulty of driving, etc. The membership function Travel time, Travel distance used to find the shortest path. The best route based on Number of traffic signal, Entertainment of route, Difficulty of driving etc.

Fuzzy Dijkstra's algorithm

Step 1

Construct a Network G = (V, E) where V is the set of vertices and E is the set of edges.

Step 2

Get the Trapezoidal fuzzy number of Traffic signal, Entertainment of route and Difficulty of driving member functions for each edge.

Step 3

Add Tollgate, Traffic and Quality of road fuzzy number using fuzzy arithmetic operation.

Step 4

Calculate risk factor of each edge using Definition 2.5.1

Step 5

Calculate all possible paths Pi, from source vertex s to all other vertices using Dijkstra's shortest path algorithm.

Fuzzy Dijikstra's algorithm Algorithm finds the shortest paths to a graph's vertices in order to their fuzzy values from a given source. First, it finds the shortest path from the source to a vertex nearest fuzzy values to it, then to a second nearest, and so on, In general , before its ith iteration commences, the algorithm has already identified the shortest paths to i-1 other vertices nearest to the source.These vertices, the source, and the edges of the shortest paths leading to them from the source form a subtree Ti can be referred to as "fringe vertices". They are the candidates from which Dijkstra's algorithm selects the next vertex nearest to the source.

fuzzydijkstra(G,S)
// Fuzzy Dijikstra's algorithm for single-source shortest paths
//Input:A weighted connected graph G=<V,E>with fuzzy parameter values is a (triangular or trapezoidal) fuzzy numbers and its strating city node
//Output:the length dv of a shortest path from s to v and its penultimate vertex pv for every vertex v in V
for every route e in E do
R ⟵ Add(Tc,Qy,Et) // add it all fuzzy parameter values

GradeMeanIntMethod(R)// using for geeting crisp number

Initialize(Q) //initialize vertext priority in the priority queue to empty

for every vertex v in V do

$d_\upsilon \leftarrow \infty$;$p_\upsilon \leftarrow$ null

Insert(Q,υ,d_υ)$d_s \leftarrow 0$;

Decrease(Q,s,d_s) V_τ θ

for $\iota \leftarrow 0$ to|V|-1 do

u* $\leftarrow$ DeleteMin(Q)

$V_\tau \leftarrow V_\tau \cup \{u^*\}$

for every vertex u in V-V_τ that is adjacent to u* do

if du*+w(u*,u)<d_u;

$d_\upsilon \leftarrow$ du*+w(u*,u); $p_\upsilon \leftarrow$ u*

Decrease(Q,u,d_υ)

Example

Consider the simple network from[10] shown in Fig 3,with five nodes and six routes.For example. See Fig 3 and Table 1. From node a to d ,there are two routes. One is $a \rightarrow b \rightarrow c \rightarrow d$ and the other $a \rightarrow b \rightarrow d$. The use of canonoiucal representation of the additional operation on fuzzy numbers in shortest path finding problem can be illustrated as follows. The first route $a \rightarrow b \rightarrow c \rightarrow d$, can be follows

Route1(a,d)

$$= Route(a,b) = (0,0,1,2) + (1,2,3,4) + (2,3,4,5) = (3,5,8,11)$$

$$= \text{Route}(b,c) = (1,2,3,4) + (2,3,4,5) + (3,4,5,5) = (6,9,12,14)$$

$$= \text{Route}(c,d) = (1,2,3,4) + (1,2,3,4) + (2,3,4,5) = (4,7,10,13)$$

$$= \text{Route}(a,b) \oplus \text{Route}(b,c) \oplus \text{Route}(c,d)$$

$$= (3,5,8,11) \oplus (6,9,12,14) \oplus (4,7,10,13)$$

$$= \frac{1}{6}(3+2\times5+2\times8+11) + \frac{1}{6}(6+2\times9+2\times12+14) + \frac{1}{6}(4+2\times7+2\times10+13)$$

$$= \frac{40}{6} + \frac{62}{6} + \frac{51}{6} = \frac{153}{6}$$

Route1(a,d)

$$= Route(a,b) = (0,0,1,2) + (1,2,3,4) + (2,3,4,5) = (3,5,8,11)$$

$$= \text{Route}(b,d) = (0,0,1,2) + (3,4,5,5) + (0,0,1,2) = (3,4,7,9)$$

$$= \text{Route}(a,b) \oplus \text{Route}(b,d)$$

$$= (3,5,8,11) \oplus (3,4,7,9)$$

$$= \frac{1}{6}(3+2\times5+2\times8+11) + \frac{1}{6}(3+2\times4+2\times7+9)$$

$$= \frac{40}{6} + \frac{34}{6} = \frac{74}{6}$$

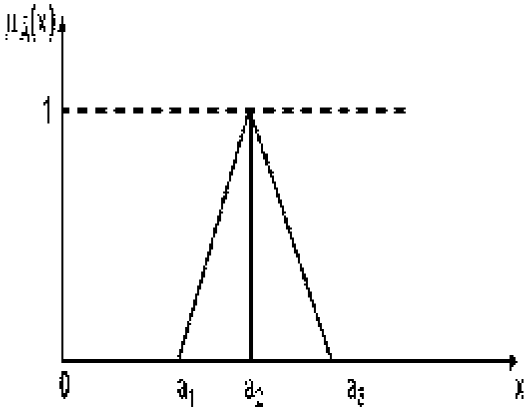


Fig. 1 : A triangular fuzzy number

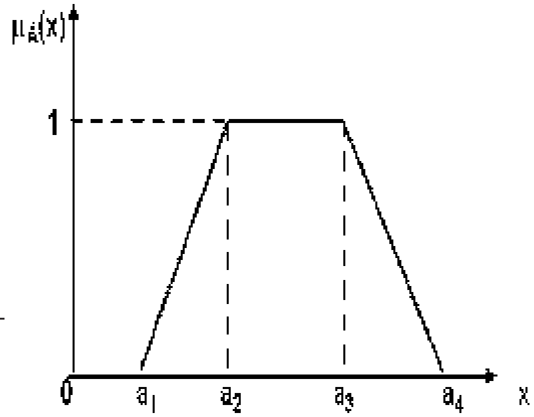


Fig. 2 :A trapezoidal fuzzy number

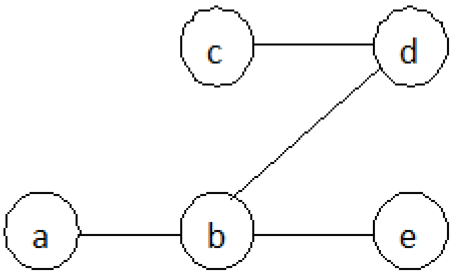


Fig . 3 :A simple transportation network.

The result shows that the $\frac{74}{6}$ is better than $\frac{153}{6}$. Here dynamic routing under Dijikstras algorithm using fuzzy parameter, decision making can be easily obtained by using the canonical representation of the addition operation is that its result is a crisp number without the process of

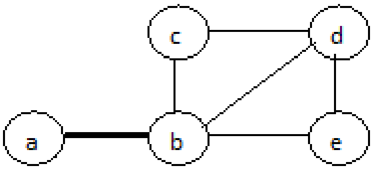
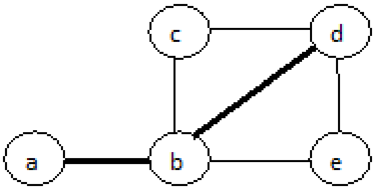
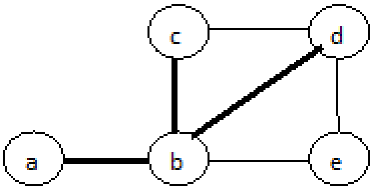
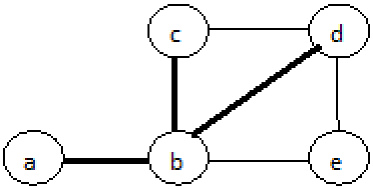
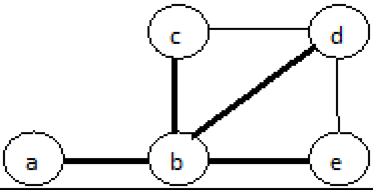
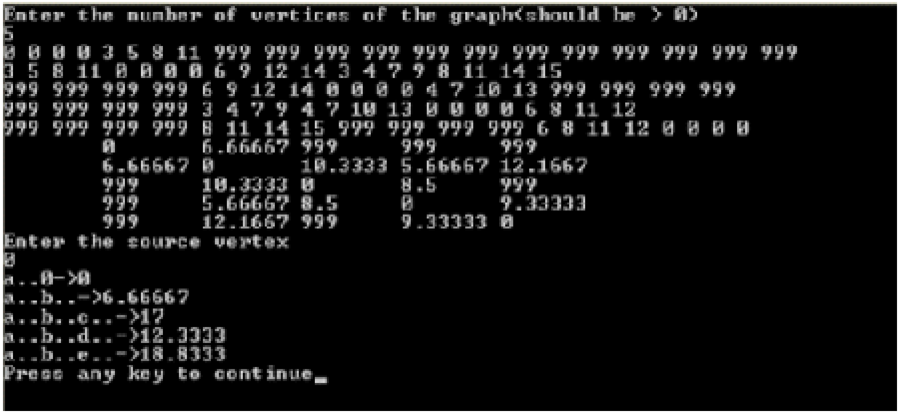
Tree cities	Remaining cities	illustration
$a(-,0)$	$b(a,6.66)c(-,\infty)d(-,\infty)e(-,\infty)$	
$b(a,6.66)$	$c(b,16.99)d(b,14.76)e(b,18.82)$	
$d(b,14.76)$	$c(b,16.99)\ e(b,18.82)$	
$c(b,16.99)$	$e(b,18.82)$	
$e(b,18.82)$		

Fig . 4 :Application of Dijkstra's algorithm. The next closest vertex is shown in bold.



```
Enter the number of vertices of the graph(should be > 0)
5
0 0 0 0 3 5 8 11 999 999 999 999 999 999 999 999 999 999 999 999
3 5 8 11 0 0 0 0 6 9 12 14 3 4 7 9 8 11 14 15
999 999 999 999 6 9 12 14 0 0 0 0 4 7 10 13 999 999 999 999
999 999 999 999 3 4 7 9 4 7 10 13 0 0 0 0 6 8 11 12
999 999 999 999 8 11 14 15 999 999 999 999 6 8 11 12 0 0 0 0
        0       6.66667 999     999     999
        6.66667 0       10.3333 5.66667 12.1667
        999     10.3333 0       8.5     999
        999     5.66667 8.5     0       9.33333
        999     12.1667 999     9.33333 0
Enter the source vertex
0
a..0->0
a..b..->6.66667
a..b..c..->17
a..b..d..->12.3333
a..b..e..->18.8333
Press any key to continue_
```

Fig . 5 :The result of fuzzy Dijkstra algorithm in simple transportation network.

Table 1. Parameters to compute membership functions.

Arc	Member function		
	Traffic signal of Road	Entertainment of Road	Quality of Road
(a,b)	(0,0,1,2)	(1,2,3,4)	(2,3,4,5)
(b,c)	(1,2,3,4)	(2,3,4,5)	(3,4,5,5)
(b,d)	(0,0,1,2)	(3,4,5,5)	(0,0,1,2)
(b,e)	(2,3,4,5)	(3,4,5,5)	(3,4,5,5)
(c,d)	(1,2,3,4)	(1,2,3,4)	(2,3,4,5)
(d,e)	(3,4,5,5)	(0,0,1,2)	(3,4,5,5)

ranking fuzzy numbers.

A numerical example of the fuzzy shortest path problem.It (Fig 4.) is used to show the efficiency of the proposed method.Tthe transportation network routes are trapezoidal fuzzy numbers with membership functions as shown in Table 1.

In step 1,city (a), which is source node,is moved to tree cities, while the distance from source city to all other remaining cities are calculated.Among them, the shortest one a?b ,whose route value 6.66 is moved to tree vertices.

In step 2, the next shortest path b?d, whose route value 14.76 is moved to tree vertices from the remaining cities.In step 3, city c ,value 16.99 from city b selected.In step 4, city e ,value 18.82 from city b selected. The remaining cities become an empty set and the search is complete. The shortest path , in Fig 5. Shows the result

CONCLUSION

This paper using Dijkstras algorithm to solve the shortest path with fuzzy parameters.Three key issused are addressed. First how to add the fuzzy parameters.Second how to determine the addition of route fuzzy numbers.Third how to compare the distance between two different path when their routes are represented by fuzzy numbers. The proposed method using fuzzy arithmetic addition,graded mean integration method for fuzzy numbers.The example of simple network problem illustrate the efficieny of fuzzy Dijkstras algorithm.The proposed method can be applied to many network optimization problem.

REFERENCES

1. M.xu, Y.Liu, Q.Huang, Y.Zhang, G.Luan; An improved Dijkstra shortest path algorithm for sparse network, *Applied Mathematics and Computation* **185**, 247-254 (2007).
2. X.Lu, M. Camitz; Finding the shortest paths by node combination, *Applied Mathematics and Computation* **217**, 6401-6408 (2011).
3. S.T.Liu, C.Kao; Network flow problems with fuzzy arc lengths,IEEE Transaction on Systems, Man, and Cybernetics, Part B: *Cybernetics* **34**, 765-769 (2004).
4. C.C.Chou; The canonical representation of multiplication operation on triangular fuzzy numbers *, Computers and Mathematics with Applications* **45** , 1601-1610 (2003).
5. R.E.Belman and L.A.Zadeh;,Decision making in a fuzzy environment, *Management science*,**17**, B141-B164 (1970).
6. C.C.Chou.;The canonical representation of multiplication operation on triangular fuzzy numbers, *Computers and Mathematics with Applications* **45**, 1601-1610 (2003).
7. E.W. Dijkstra; A note on two problems in connexion with graphs, *Numerische Mathmatik* **1**, 269-271 (1959).

8. T.Padma,P.Balasubramanie; Analytic hierarchy process to assess occupational risk for shoulder and neck pain,*Applied Mathmatics and cmputation* **193**, 321-324 (2007).
9. Gyoo-Seok Choi(1), Jong-Jin Park(2) and Ki-Sung Seo(3);, Driver-preference Optimal Route Search based on Genetic-Fuzzy Approaches
10. S.Okada; Fuzzy shortest path problems incorporating interactivity among oaths,*Fuzzy Sets and Systems* **142(3)**, 35-357 (2004).