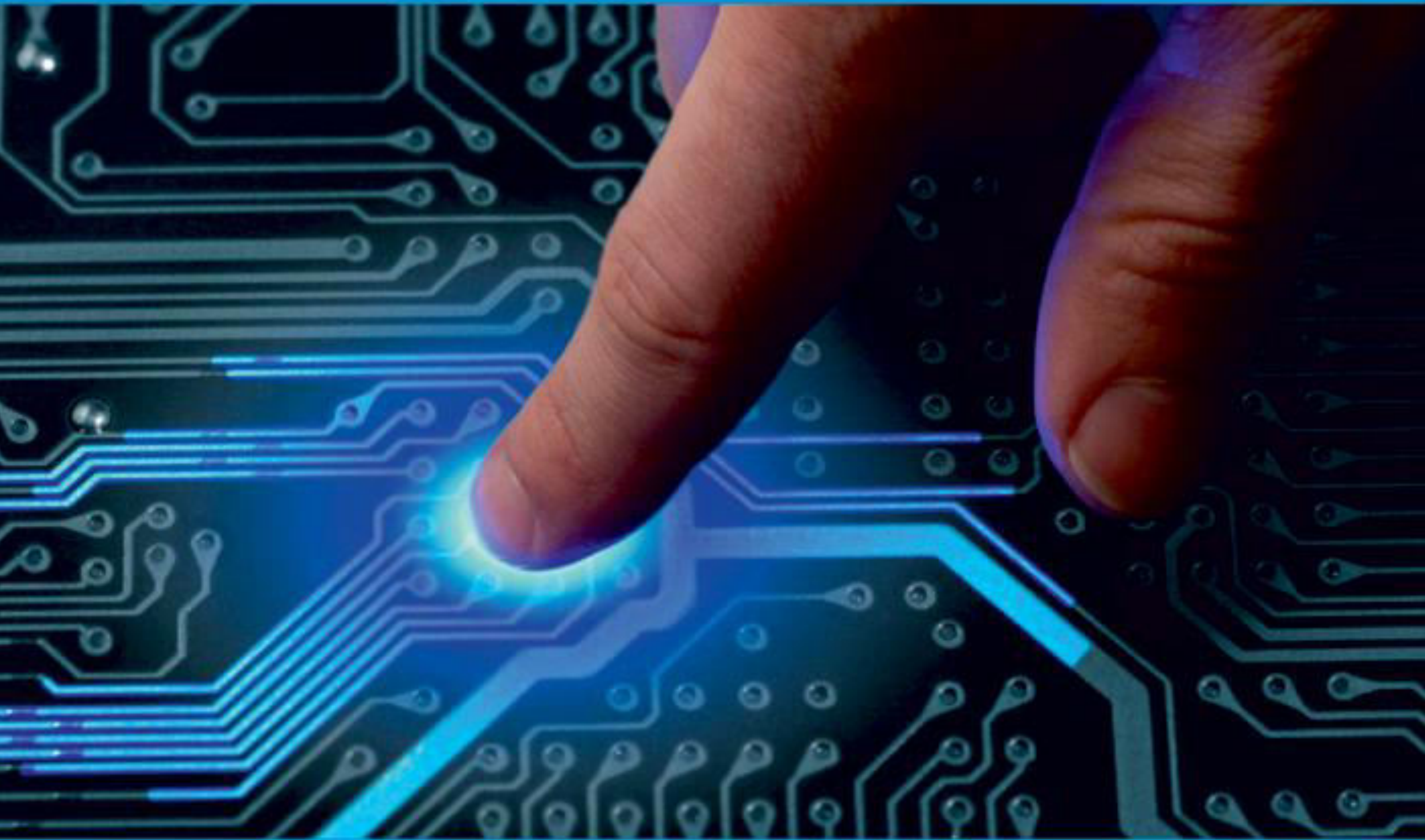
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 9, Septmber 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 || A Monthly Peer Reviewed & Referred Journal |

|| Volume 11, Issue 9, September 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1109023 |

Solving A Fuzzy Assignment Problem Using New Ranking Method

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ABSTRACT: In this paper, we consider the Fuzzy Transportation Problem (FTP) where cost, supply and demand are octagonal fuzzy numbers. It can be solved using Best Candidates Method and FTP can be converted into a crisp valued TP using the centroid ranking techniques

I. INTRODUCTION

The Assignment Problem is a special type of linear programming problem. Assignment problem is used to solving real world problems. Assignment problems is an impressive subject and is employed all the time in solving problems of engineering and management science and has been widely applied in both manufacturing and service systems. In an assignment problem, n jobs are to be performed by n persons depending on their efficiency to do the job. In assignment problem Cij denotes the cost of assigning the jth job to the ith person. We assume that one person can be assigned exactly one job also each person can do at most one job. The problem is to find a minimum assignment so that the total cost of performing all jobs is minimum or the total profit is maximum. The idea of fuzzy sets was first introduced by L.A. Zadeh (1965) provide us a new mathematical model of representing impreciseness of vagueness. There onwards many authors presented various approaches for solving the FLP problems. Few of these ranking approaches have been reviewed and compared by Bortolan and Degani(1985). Chen and H Wang (1992) reviewed the existing method for ranking fuzzy numbers and each approach has drawbacks in some aspects such as indiscrimination and finding not so easy to interpret. Chan (1985) stated that in many situations it is not possible to restrict the membership function to the normal form and proposed the concept of generalized fuzzy numbers. Jain R (1976) presents the fuzzy variables in decision making. Lee and Chen (2008) analyzed the different shapes of fuzzy numbers and different deviations of fuzzy numbers. Wang YJ(2008) revises the ranking methods of fuzzy numbers. Since then remarkable efforts are made on the development of numerous methodologies for the comparison of trapezoidal fuzzy numbers and trapezoidal fuzzy numbers are used in different areas of fuzzy optimization. In this paper, we proposed a new method for the ranking of trapezoidal fuzzy numbers. To illustrate this proposed method, examples are discussed. As the proposed ranking procedure is very direct and simple it is very easy to understand and using which it is easy to find the fuzzy optimal solution of fuzzy assignment problems occurring in the real life situations.

II.PRELIMINARIES

2.1. Fuzzy Set

Let X be non – empty set. A fuzzy set $\widetilde{A}$ in X, mapping a membership function in the range $\mu_{\hat{A}}(x): X \to [0,1]$, for each $x \in X$. Then the fuzzy set is defined as $\widetilde{A} = \{x, \mu_{\hat{A}}(x) \setminus x \in X\}$.

2.2. Fuzzy Number:

A fuzzy number $\widetilde{A}$ on $\widetilde{R}$ in the real line set $\widetilde{A}: \widetilde{R} \to I$ where $\widetilde{A}(x)$ the membership function of set is $\widetilde{A}$ .Then the fuzzy number $\hat{A}$ is defined by

(i) $\widetilde{A}$ is normal.

(ii) $\widetilde{A}$ is convex.

(iii) $\widetilde{A}$ is upper semi continuous $X \in \widetilde{R}$

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2.3. $\alpha-$cut

An α cut of a fuzzy set- P is a Crisp set P_α comprising all the elements of the universal set X with a membership grade P greater than or equal to a given value thus $P=\{x\in X/\mu_{\tilde{A}}(x)\geq\alpha\},0\leq\alpha\leq 1.$

2.4. Triangular Fuzzy Number:

A triangular fuzzy number $\tilde{A}=(a,b,c)$ specified as membershipfunction

$$\mu_{\tilde{A}}(x)=\begin{cases}0 & if\ x\leq a\\ \dfrac{(x-a)}{(b-a)} & if\ a\leq x\leq b\\ \dfrac{(x-c)}{(b-c)} & if\ b\leq x\leq c\\ 0 & if\ x\geq c\end{cases}$$

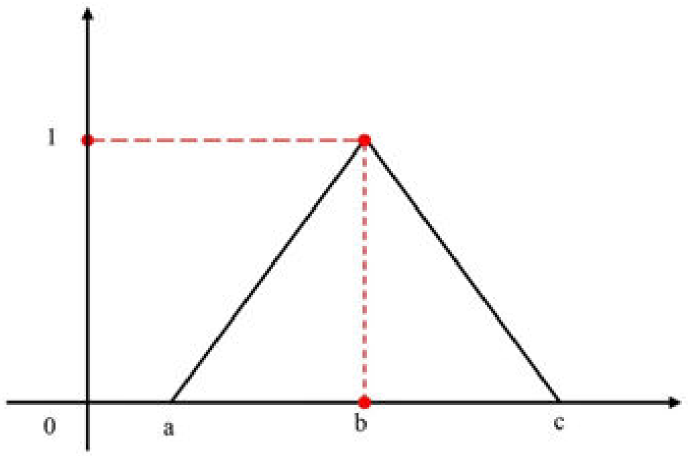

Fig. 1 – Fuzzy Triangular Number

III.ASSIGNMENT PROBLEM

The problem of assignment can be represented as a $n\times n$ cost matrix $[C_{ij}]$ of real numbers as shown in the :table below

	1	2	3	…j…	M
1	$B_1 1$	$B_1 2$	$B_1 3$	$..B_1 j..$	$B_1 n$
2	$B_2 1$	$B_2 2$	$B_2 3$	$..B_2 j...$	$B_2 n$
-					
-					
i	$B_i 1$	$B_i 2$	$B_i 3$	$..B_i j..$	$B_i n$
-					
N	$B_n 1$	$B_n 2$	$B_n 3$	$..B_n j..$	$B_n n$

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Mathematically assignment problem can be expressed as

Minimize z= $\sum_{i=1}^{n}\sum_{j=1}^{n} B_{ij}x_{ij}$

Subject to $\sum_{i=1}^{n} x_{ij} = 1$ i=1,2,3…..n

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad j=1, 2, 3,\ldots.n \tag{1}$$

$$x_{ij} \in \{0,1\}$$

$$x_{ij} = \begin{cases} 1 & \text{if the } i^{th} \text{ person is assigned the } j^{th} \text{ job} \\ 0 & \text{otherwise} \end{cases}$$

IV.FUZZY ASSIGNMENT PROBLEM

The generalized fuzzy assignment problem can be represented with in the form of $n \times n$ fuzzy cost matrix A_{ij} as given below:

	1	2	3	…j…	M
1	$B_1 1$	$B_1 2$	$B_1 3$	$..B_1 j..$	$B_1 n$
2	$B_2 1$	$B_2 2$	$B_2 3$	$..B_2 j...$	$B_2 n$
-					
-					
i	$B_i 1$	$B_i 2$	$B_i 3$	$..B_i j..$	$B_i n$
-					
N	$B_n 1$	$B_n 2$	$B_n 3$	$..B_n j..$	$B_n n$

The generalized trapezoidal fuzzy numbers cost or time $[A_{ij}]$ $A_{ij} = \left(A^{(1)}{}_{ij}, A^{(2)}{}_{ij}, A^{(3)}{}_{ij}, A^{(4)}{}_{ij}; w_{ij}\right)$.

V.PROPOSED RANKING PROCEDURE

We determine square root of a fuzzy number by α-cut cut method.Let X= [a, b, c] > 0 be a fuzzy number. Then $X^{\alpha} = [(b-a)\alpha + a, c-(c-b)\alpha]$ is $\alpha-$cut of the fuzzy numbers X.

To calculate square root of the fuzzy number X we first take the square root of the $\alpha-$cut of X using interval arithmetic

$$\sqrt{X^{\alpha}} = \sqrt{[(b-a)\alpha + a, c-(c-b)\alpha]}, \forall\, \alpha \in 1$$

VI.NUMERICAL EXAMPLES

Example- 1

Let us consider fuzzy assignment problem with rows representing four person A,B,C,D and columns representing the four jobs job1, job2,job3,job4 . The cost matrix [Ĉij] is given whose elements are linguistic variables which are replaced by fuzzy numbers. The problem is then solved by Hungarian method to find the optimal assignment.

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$$\begin{pmatrix} \textit{Extremely}\,\text{Low} & \textit{Low} & \text{Fairly Low} & \text{Extremely High} \\ \text{Low} & \textit{Very}\,\text{Low} & \text{High} & \textit{Very High} \\ \textit{Medium} & \text{Extremely High} & \text{Very Low} & \textit{Extremely}\,\text{Low} \\ \textit{Very High} & \text{Low} & \textit{Fairly}\,\text{Low} & \text{Fairly Low} \end{pmatrix}$$

The linguistic variables showing qualitative data is converted into quantitative data using the following tables. As the assignment cost varies between 0 $ to 50 $the minimum possible value is taken as 0 and the maximum possible value is taken as 50.

Extremely low	(0,2,4)
Very low	(2,4,6)
Low	(4,8,12)
Fairly low	(15,18,21)
Medium	(23,25,27)
Fairly High	(28,30,32)
High	(34,36,38)
Very High	(37,40,43)
Extremely High	(46,48,50)

The linguistic variables are represented by triangular fuzzy numbers

$$\begin{pmatrix} (0,2,4) & (4,8,12) & (15,18,21) & (46,48,50) \\ (4,8,12) & (2,4,6) & (34,36,38) & (37,40,43) \\ (23,25,27) & (46,48,50) & (2,4,6) & (0,2,4) \\ (37,40,43) & (4,8,12) & (15,18,21) & (15,18,21) \end{pmatrix}$$

SOLUTION:

To calculate (0,2,5) by applying Square root of fuzzy number by α-cut method

$$\sqrt{X^{\alpha}} = \sqrt{[(b-a)\alpha + a, c-(c-b)\alpha]}$$

$$\sqrt{(0,2,4)} = \sqrt{(2-0)\alpha + 0,4-(4-2)\alpha}$$

$$= \sqrt{2\alpha + 4 - 2\alpha}$$

$$= \sqrt{4}$$

$$= 2$$

Proceeding similarly, the square root alpha cut indices for the costs Ĉij are calculated as:

$$C_{12} = \sqrt{(4,8,12)} = \sqrt{16} = 4$$

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$$C_{13} = \sqrt{(15,18,21)} = \sqrt{36} = 6$$

$$C_{14} = \sqrt{(46,48,50)} = \sqrt{96} = 9.798$$

$$C_{21} = \sqrt{(4,8,12)} = \sqrt{16} = 4$$

$$C_{22} = \sqrt{(2,4,6)} = \sqrt{8} = 2.828$$

$$C_{23} = \sqrt{(34,36,38)} = \sqrt{72} = 8.485$$

$$C_{24} = \sqrt{(37,40,43)} = \sqrt{80} = 8.944$$

$$C_{31} = \sqrt{(23,25,27)} = \sqrt{50} = 7.071$$

$$C_{32} = \sqrt{(46,48,50)} = \sqrt{96} = 9.798$$

$$C_{33} = \sqrt{(2,4,6)} = \sqrt{8} = 2.828.$$

$$C_{34} = \sqrt{(0,2,4)} = \sqrt{4} = 2$$

$$C_{41} = \sqrt{(37,40,43)} = \sqrt{80} = 8.944$$

$$C_{42} = \sqrt{(4,8,12)} = \sqrt{16} = 4$$

$$C_{43} = \sqrt{(15,18,21)} = \sqrt{36} = 6$$

$$C_{44} = \sqrt{(15,18,21)} = \sqrt{36} = 6$$

We replace these values for their corresponding Ĉij and solve the resulting assignment problem by Hungarian Method

$$\begin{pmatrix} 2 & 4 & 6 & 9.798 \\ 4 & 2.828 & 8.485 & 8.944 \\ 7.071 & 9.798 & 2.828 & 2 \\ 8.944 & 4 & 6 & 6 \end{pmatrix}$$

Applying Hungarian Method,

$$\begin{pmatrix} (0) & 2 & 2 & 6.626 \\ 1.172 & (0) & 3.657 & 4.944 \\ 6.243 & 8.970 & 0 & (0) \\ 4.944 & 0 & (0) & 0.828 \end{pmatrix}$$

Optimal Cost is 2+2.828+2+6=12.828

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VII.COMPARISON RESULT

Ranking Method	Optimal Solution
Robust Ranking Method	26
Our method	12.828

This is the optimal value, the solution obtained using Robust ranking technique hence the optimal value obtained from new method is best.

Example 2

Consider a fuzzy assignment problem with four persons A, B, C,D and four jobs P, Q, R and S whose costs varying between 0 to50 dollars. The cost matrix is given with linguistic variables which are replaced by fuzzy numbers. The problem is to find the optimal assignment in an efficient way.

Persons\ Jobs	P	Q	R	S
A	Reasonably Low	Distinctly Low	Reasonably High	Very High
B	Drastically low	Moderate	Drastically High	Reasonably High
C	Moderate	Very low	Distinctly High	Distinctly Low
D	Distinctly Low	Reasonably High	Reasonably Low	Very low

Solution: The cost involving in executing a given job is considered as fuzzy quantifiers which characterize the linguistic variables are replaced by generalized triangular fuzzy numbers using the following table. As the cost varies between 0 to 50 dollars, the minimum possible value is taken as 0 and the maximum possible value is taken as 50.

Drastically Low	(0, 1, 2)
Very Low	(1, 3, 5)
Distinctly Low	(4, 8, 12)
Reasonably Low	(10, 14 ,18)
Moderate	(13, 17, 21)
Reasonably high	(18,22,26)
Distinctly High	(25,29,33)
Very High	(34,38,42)
Drastically High	(42,46,50)

The linguistic variables are represented by generalized triangular fuzzy numbers

Persons\Jobs	P	Q	R	S
A	(10,14,18)	(4,8,12)	(18,22,26)	(34,38,42)
B	(0,1,2)	(13,17,21)	(42,46,50)	(18,22,26)
C	(13,17,21)	(1,3,5)	(25,29,33)	(4,8,12)
D	(4,8,12)	(18,22,26)	(10,14,18)	(1,3,5)

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By applying Square root of fuzzy number by α-cut method

$$\sqrt{X^{\alpha}} = \sqrt{[(b-a)\alpha + a, c-(c-b)\alpha]}$$

The rank of generalized triangular fuzzy cost matrix is given below

Persons\Jobs	P	Q	R	S
A	5.292	4	6.633	8.718
B	1.414	5.831	9.592	6.633
C	5.831	2.236	7.616	4
D	4	6.633	5.099	2.449

Proceeding by Hungarian method, the optimal allocations are:

Persons\Jobs	P	Q	R	S
A	1.292	0	(0)	4.685
B	(0)	4.417	5.545	5186
C	3.595	(0)	2.747	1.731
D	1.551	4.184	0	(0)

Therefore, the assignment is A→R, B→P, C→Q and D→S.

Optimal Cost is 6.633+1.414+2.236+2.449=12.732

Comparison Result:

Ranking Method	Optimal Solution
Robust Ranking Method	29
Our method	12.732

This is the optimal value, the solution obtained using Robust ranking technique hence the optimal value obtained from new method is best.

VIII.CONCLUSION

In this paper, Fuzzy Assignment problem with cost values as Fuzzy Triangular Numbers is considered. The Fuzzy Triangular Numbers are converted into crisp values using square root of fuzzy numbers by alpha cut method. The optimum assignment schedule of the Fuzzy Assignment Problem is then obtained by Hungarian Method. We hope that this approach will be effective in assignment problems involving imprecise data.

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