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An Optimal Solution for Fuzzy Balanced Transportation Environment

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Abstract: *In this paper, we are computed balanced transportation problem when Transportation problem contains fuzzy numbers, Intuitionistic fuzzy numbers and real numbers. The purpose of this paper is to find the optimal transportation cost in which cost, supply and demand are fuzzy numbers. This procedure is illustrated with numerical example.*

Keywords: Real numbers, hexagonal fuzzy numbers, trapezoidal fuzzy numbers, Intuitionistic fuzzy numbers, Pentagonal fuzzy numbers, ranking functions, optimal solution

I. INTRODUCTION

In today's most competitive market, we need to find better way in transportation problem to minimize the transportation cost. Optimization methods and algorithms have lately become very important tools to optimize the problem. Due to incertitude in real life we have introduced fuzzy numbers in transportation problem. There may be such a situation in which we have to apply several of fuzzy numbers in transportation problem. The idea of fuzzy sets was introduced by Zadeh [8]. Klir [3] apply his logic in fuzzy sets and fuzzy logic. Ahmed et al. [5] develop a new algorithm for finding an initial basic feasible solution of transportation problem when transportation matrix contains fuzzy numbers and real numbers. Prabha et al. [7] worked on mixed Intuitionistic fuzzy transportation problem and solved by best candidate method. The transportation problem was first initiated by Hitcock [5] and it was developed with the systematic solution proceduresfrom simplex algorithm, primarily by G.B. Dantzig [4] and thenby Charnes and Cooper [3]. IBFS of Transportation problem isthe first stage for an optimal solution. The well-known classicalmethods for finding an IBFS for the transportation problemsare North West Corner Method (NWCM), Least Cost Method (LCM) and Vogel's Approximation Method (VAM). The researcherkeeps going towards the development of the new algorithm of transportation problem to find excellent IBFS for transportationproblem. In this work we have added a new algorithm [1] that provides a better IBFS, for both the balanced and unbalancedtransportation problem.Fuzzy set theory used to many areas such as managementsciences, mathematical modelling, control theory and industrialapplications. In real world situations such as industry or corporate of distribution problems are indefinite in nature due to variations in the parameters. Zadeh [7] introduced the fuzzy set theory to deal with uncertaint due to imprecision and indefiniteness. Fuzzy linear programming was explained by Zimmermann [8]. Charnes et al [2] expressed as crisp values or defuzzified values into fuzzy linear programming problems.

In section 2 basic definitions are briefly explained. In section 3 we derived the algorithm. In section 4 we have computed some numerical example using different ranking techniques. In section 5 conclusions is discussed.

II. PRELIMINARIES

2.1 Fuzzy set

A fuzzy set is characterized by a membership function mapping element of a domain, space or universe of discourse X to the unit interval [0,1] i.e., $\mathring{A}= \{ X, \mu_{\mathring{A}}(X) : x \in X \}$. Here $\mu_{\mathring{A}}(X) : X \rightarrow [0, 1]$ is a mapping called the degree of membership function of the fuzzy set Å and $\mu_{Å}$ (X) is called the membership value of x Є X in the fuzzy set Å. These membership grades are often represented by real numbers ranging from [0, 1].

2.2 Fuzzy number

A fuzzy number is a generalized of a regular real number and which does not refer to a single value but rather to a connected set of possible values, where each possible value has its weight between 0 and 1. This weight is called the membership function.

A fuzzy number Å is a convex normalized fuzzy set on the real line R such that:

There exist at least one xЄR with $\mu_{Å}$ (X) = 1

$\mu_{Å}$ (X) is piecewise continuous.

2.3 Triangular Fuzzy number

A triangular fuzzy number Å is denoted by 3- tuples (a_1, a_2, a_3), where a_1, a_2 and a_3 are real numbers and $a_1 \le a_2 \le a_3$ with membership function defined as

$$\mu_{Å}(X) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \le x \le a_3 \\ 0, & \text{otherwise} \end{cases}$$

2.4 Trapezoidal Fuzzy number

A trapezoidal fuzzy number is denoted by 4- tuples = (a_1,a_2,a_3,a_4) , where a_1,a_2,a_3 and a_4 are real numbers and $a_1 \le a_2 \le a_3 \le a_4$ with membership function defined as

$$\mu_{Å}(X) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ 1, & a_2 \le x \le a_3 \\ \frac{a_4-x}{a_4-a_3}, & a_3 \le x \le a_4 \\ 0, & \text{otherwise} \end{cases}$$

2.5: (Pentagonal Fuzzy Numbers):

A fuzzy number Å = (a_1,a_2,a_3,a_4,a_5) is called a pentagonal fuzzy number when the membership function has the form where the middle point a_3 has the grade of membership 1 and w_1,w_2 are the respective grades of points a_2, a_4. Note that every PFN is associated with two weights w_1 and w_2.

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$$\mu_{\tilde{A}}(X) = \begin{cases} w_1\left(\frac{x-a_1}{a_2-a_1}\right) & , \ a_1 \le x \le a_2 \\ 1-(1-w_1)\left(\frac{x-a_2}{a_3-a_2}\right) & , \ a_2 \le x \le a_3 \\ 1 & , \ x = a_3 \\ 1-(1-w_2)\left(\frac{x-a_3}{a_4-a_3}\right) & , \ a_3 \le x \le a_4 \\ w_2\left(\frac{x-a_4}{a_5-a_4}\right) & , \ a_4 \le x \le a_5 \\ 0 & , \ x > a_5 \end{cases}$$

2.6: (Hexagonal Fuzzy number):

A fuzzy number is denoted by 6- tuples = $(a_1,a_2,a_3,a_4,a_5,a_6)$, where a_1,a_2,a_3,a_4,a_5 and a_6 are real numbers and $a_1 \le a_2 \le a_3 \le a_4 \le a_5 \le a_6$ with membership function defined as

$$\mu_{\tilde{A}}(X) = \begin{cases} \frac{1}{2}\left(\frac{x-a_1}{a_2-a_1}\right) & , \ a_1 \le x \le a_2 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_2}{a_3-a_2}\right) & , \ a_2 \le x \le a_3 \\ 1 & , \ a_3 \le x \le a_4 \\ 1-\frac{1}{2}\left(\frac{x-a_4}{a_5-a_4}\right) & , \ a_4 \le x \le a_5 \\ \frac{1}{2}\left(\frac{x-a_5}{a_6-a_5}\right) & , \ a_5 \le x \le a_6 \\ 0 & , \ \text{otherwise} \end{cases}$$

2.7 Intuitionistic Fuzzy Set

Let X be the universal set. In the following, I will describe those aspects of intuitionistic fuzzy sets which will be needed in our next discussion. An intuitionistic fuzzy set (IFS) $\mathcal{A}$ in X is given by $\mathcal{A} = \{(x, \mu_{\mathcal{A}}(x), \vartheta_{\mathcal{A}}(x)) / x \in X\}$, where the functions , $\mu_{\mathcal{A}}(x)$, $\vartheta_{\mathcal{A}}(x)$ define the degree of membership and degree of non-membership of the element $x \varepsilon X$ to the set $\mathcal{A}$ respectively , which is a subset of X , and for every $x \in X$, $0 \le \mu_{\mathcal{A}}(x) + \vartheta_{\mathcal{A}}(x) \le 1$.

2.8 Intuitionistic fuzzy numbers

An IFS A in X is given by A = {(x, μA(x), νA(x)) | x ϵ X}, where the functions μA, νA : X → [0, 1] define respectively, the degree of membership and degree of non-membership of the element x ϵ X to the set A, which is a subset of X, and for every x ϵ X, 0 ≤ μ(x) + ν(x) ≤ 1. Obviously, every fuzzy set has the form {(x, μA(x), νA(x)) | x ϵ X}. 1 For each IFS A in X, we will call ΠA(x) = 1 − μ(x) − ν(x) the intuitionistic fuzzy index of x in A. It is obvious that 0 ≤ ΠA(x) ≤ 1, ∀x ∈ X.

2.9 Intuitionistic Triangular Fuzzy Number

An Intuitionistic triangular Fuzzy Number of a Intuitionistic Fuzzy set is $\mathcal{A}$ is defined as $\mathcal{A} = \{ (a_1,a_2,a_3), (b_1,b_2,b_3) \}$, where $\mathcal{A}$ ϵ R and its membership and non-membership is given by

$$\mu \mathring{A}(X) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \le x \le a_3 \\ 0, & \text{otherwise} \end{cases}$$

and

$$\vartheta \mathcal{A}(X) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \le x \le a_3 \\ 0, & \text{otherwise} \end{cases}$$

2.10 Intuitionistic Trapezoidal Fuzzy Number

$\mathcal{A}$ is a trapezoidal intuitionistic fuzzy number with parameter $b_1 \le a_1 \le b_2 \le a_2 \le a_3 \le b_3 \le a_4 \le b_4$ and denoted by $\mathcal{A} = \{ b_1,a_1,b_2,a_2,a_3,b_3,a_4,b_4 \}$

$$\mu \mathcal{A}(X) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ 1, & a_2 \le x \le a_3 \\ \frac{a_4-x}{a_4-a_3}, & a_3 \le x \le a_4 \\ 0, & \text{otherwise} \end{cases}$$

$$\vartheta \mathcal{A}(X) = \begin{cases} \frac{x-b_1}{b_2-b_1}, & b_1 \le x \le b_2 \\ 1, & b_2 \le x \le b_3 \\ \frac{b_4-x}{b_4-b_3}, & b_3 \le x \le b_4 \\ 0, & \text{otherwise} \end{cases}$$

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2.11 Ranking of hexagonal fuzzy numbers

A number of approaches have been proposed for the ranking of fuzzy numbers. In this paper for a hexagonal fuzzy number , A(H) = (a_1,a_2,a_3,a_4,a_5,a_6) then the ranking will be the magnitude of a HFN, A(H) = (a_1 , a_2 , a_3 , a_4 , a_5 , a_6) is defined as

$$\text{Mag}(A(H)) = \frac{2a_1 + 3a_2 + 4a_3 + 4a_4 + 3a_5 + 2a_6}{18}$$

Algorithm:

Step 1: Construct the mixed type fuzzy transportation table for a given fuzzy transportation problem.
Step 2: Using ranking function convert all fuzzy numbers into the crisp numbers.
Step 3: Check whether the transportation table is balanced or not, if not, make it balanced.
Step 4: After defuzzify the quantities of the problem, if any of values are not integers, round off into integers.
Step 5: Select the minimum odd cost from all cost in the matrix. Suppose all costs are even, multiply each column by 1/2.
Step 6: Subtract selected least odd cost only from odd cost in the matrix. Now there will be at least one zero and remaining all cost become even.
Step 7: Allocate minimum of supply/ demand at the place of zero.
Step 8: After the allotment, multiply each column by 1/2.
Step 9: Again select minimum odd cost in the remaining column except zeros in that column.
Step 10: Go to step 6 and repeat step 7and 8 till optimal solution are obtained.
Step 11: Finally total minimum cost is calculated as sum of the product of the cost and corresponding allocated value of supply /demand.

Numerical Example:

Consider a fuzzy transportation problem

	D_1	**D_2**	**D_3**	**Supply**
S_1	(4 ,4 , 4.5)	(3, 4, 5, 5, 6, 7)	50	(3,5,7,9,11)
S_2	(5,4,8,13,15)	(2, 3, 4.5, 6; 1.5, 3, 4.5, 7)	(9,11,12,14)	35
S_3	(180,190,200, 200,210,220)	[4,8,12,16]	(13,14,15; 12,14,16)	(2, 4, 7, 10, 11)
Demand	(20,40,60)	23	(10,12,13,14,15,17)	

It is a balanced mixed fuzzy transportation problem since total demand equal to total supply.
i.e) $\sum a_i = \sum b_j = 76.5$.

	D_1	**D_2**	**D_3**	**Supply**
S_1	4	20	50	21
S_2	**27**	2	12	35
S_3	200	10	14	21
Demand	40	23	14	

Since the minimum odd cost in the odd matrix is 27, subtract 27 from all the odd costs and allocate minimum of supply or demand to the cell where there is zero cost then delete the row or column.

	D_1	D_2	D_3	**Supply**
S_1	4	20	50	21
S_2	**35** 0	2	12	35
S_3	200	10	14	21
Demand	40	23	14	

Now all the cost is even, hence multiply all the cost by ½ and subtract the minimum of odd cost from all the odd cost.

	D_1	**D_2**	**D_3**	**Supply**
S_1	2	10	20	21
S_3	100	**21** 0	2	21
Demand	5	25	14	

The optimum cost is given by,

Cost Z = (5 × 4) + (2 × 20) + (14 × 50) + (35 × 27) + (21 × 10) = Rs. 1915.

III. CONCLUSION

In this paper, cost, supply and demand of fuzzy transportation problem are considered as mixed fuzzy numbers, i.e hexagonal fuzzy numbers, trapezoidal fuzzy numbers,triangular number, real numbers and intuitionistic pentagonal fuzzy numbers. By using different ranking functions the quantities have modified to crisp values and optimal solution has got by the given methodology. This method is very easy to solve the mixed fuzzy transportation problem.

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