A Dynamic Method for Solving Intuitionistic Fuzzy Transportation Problem

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Abstract:
This paper deals with intuitionistic fuzzy transportation problem whose parameters are intuitionistic trapezoidal fuzzynumbers. Transportation problem is a particular method of linear programming problem.Intuitionistic fuzzy set is an extension of fuzzy set. In the present work an efficient method is proposed to solve intuitionistic fuzzy transportation problem in which all the parameters are taken as trapezoidal Intuitionistic fuzzy numbers. A numerical example is given to illustrate this method.

Keywords:
Intuitionistic fuzzy set, intuitionistic trapezoidal fuzzy number.

1. INTRODUCTION

The extension of Zadeh's notion of fuzzy set has been developed further by Atanassov(1993) based on intuitionistic fuzzy set extending the classical notion of a set by its self. The convolution of an ambiguity data has fascinated the minds of current researcher semantic portrayal of intuitionistic fuzzy set has turned to be more expressive, enterprising and suitable because it arguments the degree of belongingness and degree of non-belongingness. Intuitionistic fuzzy set plays a vital role in certain life challenges life sales examining, advanced product marketing, financial affairs, arrangements, psychological inquires etc,. Intuitionistic fuzzy set has huge impact in solving transportation problem in order to derive the optimal solution in which the cost, supply and demand of fuzzy number. According to such situations, fuzzy set theory is applied to solve the transportation problems. When the decision maker is ambiguity about the precise value of the transportation cost, supply, quantity, availability and demand. The transportation problem may be developed into fuzzy transportation problem. Paul et al. [8] introduced a new method for solving transportation problem using triangular and trapezoidal intuitionistic fuzzy number. Chanas and kuchta [10] proposed the concept of the optimal solution for the transportation problem with fuzzy coefficients expressed as fuzzy numbers and introduced an algorithm for obtaining the optimal solution. Gani et al. [2] developed the distribution for solving intuitionistic fuzzy transportation problem.Pramila and Uthra [5] introduced the optimal solution of an intuitionistic fuzzy transportation problem.Geetharamani et al. [4] established to solve fuzzy transportation problem is habituated to find the optimal minimum cost.

The aim of this paper is to find the minimum transportation cost , when the parameters are intuitionistic trapezoidal fuzzy numbers. The methodology proposed by Geetharamani et al., [4] to solve fuzzy transportation problem is used to find the optimal cost. A numerical example is given to illustrate the proposed method

2. PRELIMINARIES

2.1 Fuzzy set

Let A be a classical set, $\mu_{\bar{A}}$(x) be a function from A to[0,1]. A **fuzzy set** Ā with the membership function $\mu_{\bar{A}}$(x) is defined by

$$\bar{A} = \{x, \mu_{\bar{A}}(x)); x \epsilon A, \mu_{\bar{A}}(x) \epsilon [0,1] \}.$$

2.2 Intuitionistic Fuzzy Set

Let X denote universe of discourse, then an **intuitionistic fuzzy set** Ā' in X is given by Ā\` = $\{x, \mu_{\bar{A}'}(x), \nu_{\bar{A}'}(x))/x \epsilon X\}$ where$\mu_{\bar{A}'}(x), \nu_{\bar{A}'}(x)$: X → [0, 1] are functions such that 0≤ $\mu_{\bar{A}'}(x) + \nu_{\bar{A}'}(x) \leq 1$ for all xϵX. For each x the membership functions $\mu_{\bar{A}'}(x)$ and $\nu_{\bar{A}'}(x)$ represents the degree of membership and non-membership of the element x ϵX to A⊂X respectively.

2.3 Intuitionistic Fuzzy Number

An intuitionistic fuzzy subset Ā'= $\{x, \mu_{\bar{A}'}(x), \nu_{\bar{A}'}(x))/x \epsilon X\}$ of the real line R is called an **intuitionistic fuzzy number** if the following holds:

i. There exists m ϵR, $\mu_{\bar{A}'}(m)$ = 1 and $\nu_{\bar{A}'}(m)$ = 0, m is called the mean value of Ā'.
ii. $\mu_{\bar{A}'}$ is a continuous mapping from R to the closed interval [0, 1] and for all xϵR, the relation 0≤ $\mu_{\bar{A}'} + \nu_{\bar{A}'} \leq 1$ holds.

The membership and non-membership function of Ā' is of the following form

$$\mu_{\bar{A}'}(x) = \begin{cases} 0 & -\infty < x \leq m - \alpha \\ f_1(x) & x \in [m-\alpha, m] \\ 1 & x = m \\ h_1(x) & x \in [m, m+\beta] \\ 0 & m + \beta \leq x \leq \infty \end{cases}$$

$$\vartheta_{\bar{A}'}(x)= \begin{cases} 0 & -\infty < x \le m-\alpha' \\ f_2(x) & x\epsilon\,[m-\alpha', m],\ 0\le f_1(x)+f_2(x) \le 1 \\ 0 & x = m \\ h_2(x) & x\epsilon\,[m, m+\beta],\ 0\le h_1(x)+h_2(x) \le 1 \\ 1 & m+\beta' \le x \le \infty \end{cases}$$

Here m is the mean value of Ā', α and β are called left and right spreads of membership functioning $\mu_{\bar{A}'}(x)$ respectively. α', β' represent left and right spreads of non-membership function $\vartheta_{\bar{A}'}(x)$ respectively.

2.4 Trapezoidal intuitionistic fuzzy number

A **trapezoidal intuitionistic fuzzy number** ã is an intuitionistic fuzzy subset in R with the following membership function $\mu_{\tilde{a}}$(x) and non-membership function $\vartheta_{\tilde{a}}$(x).

$$\mu_{\tilde{a}}(x) = \begin{cases} 0 & \text{for } x\le a_1 \\ \frac{x-a_1}{a_2-a_1} & \text{for } a_1 \le x \le a_2 \\ 1 & \text{for } a_2 \le x \le a_3 \\ \frac{a_4-x}{a_4-a_3} & \text{for } a_3 \le x \le a_4 \\ 0 & \text{for } x\ge a_4 \end{cases}$$

$$\vartheta_{\tilde{a}}(x) = \begin{cases} 0 & \text{for } x\le a_1 \\ \frac{x-a'_1}{a_2-a'_1} & \text{for } a'_1 \le x \le a_2 \\ 1 & \text{for } a_2 \le x \le a_3 \\ \frac{a'_4-x}{a'_4-a_3} & \text{for } a_3 \le x \le a'_4 \\ 0 & \text{for } x > a`_4 \end{cases}$$

Where $a'_1 \leq a_1 \leq a_2 \leq a_3 \leq a_4 \leq a'_4$ for all x϶X. Trapezoidal intuitionistic fuzzy number ã is denoted by $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$.

2.5 Operation on trapezoidal intuitionistic fuzzy number:

Let ã = $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$ and $\tilde{b}$ =$(b_1, b_2, b_3, b_4; b`_1, b_2, b_3, b'_{4)}$ be two trapezoidal fuzzy numbers. Then

Addition: $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$+$(b_1, b_2, b_3, b_4; b'_1, b_2, b_3, b'_{4)}$ =$(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4; a'_1 + b'_1, a_2 + b_2, a_3 + b_3, a'_4 + b'_4)$

Subtraction: $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$-$(b_1, b_2, b_3, b_4; b'_1, b_2, b_3, b'_4$ = $(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1; a'_1 - b'_4, a_2 - b_3, a_3 - b_2, a'_4 - b'_1)$

Multiplication: $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$× $(b_1, b_2, b_3, b_4; b'_1, b_2, b_3, b'_4)$=$(t_1, t_2, t_3, t_4)$.

Where t_1 = minimum $\{a_1b_1, a_1b_4, a_4b_1, a_4b_4; a'_1b'_1, a'_1b'_4, a'_4b'_1, a'_4b'_4\}$

t_2 = minimum $\{a_2b_2, a_2b_3, a_3b_2, a_3b_3; a'_2b'_2, a'_2b'_3, a'_3b'_2, a'_3b'_3\}$

t_3 = maximum $\{a_2b_2, a_2b_3, a_3b_2, a_3b_3; a'_2b'_2, a'_2b'_3, a'_3b'_2, a'_3b'_3\}$

t_4 = maximum $\{a_1b_1, a_1b_4, a_4b_1, a_4b_4; a'_1b'_1, a'_1b'_4, a'_4b'_1, a'_4b'_4\}$

Scalar multiplication:k$(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$
=(k$a_1, ka_2, ka_3, ka_4; ka'_1, ka_2, ka_3, ka'_4$) for k≥0.

k $(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$ = (k$a_4, ka_3, ka_2, ka_1; ka'_4, ka_3, ka_2, ka'_1$) for k<0.

2.6Defuzzification:

If ã =$(a_1, a_2, a_3, a_4; a'_1, a_2, a_3, a'_4)$ is a trapezoidal fuzzy number, then the defuzified value or the ordinary (crisp) number of ã, a is given below.

$$a = \frac{a_1 + 2a_2 + 2a_3 + a_4 + a'_1 + 2a_2 + 2a_3 + a'_4}{12}$$

3. INTUITIONISTIC FUZZY TRANSPORTATION PROBLEM (IFTP):

Consider a transportation problem with m intuitionistic fuzzy (IF) origins and n intuitionistic fuzzy destination. Let C_{ij} = (i = 1,2,3,……..,m, j = 1,2,3,……n) be the cost of transportation one unit of the product from ith origin to jth destination. Let $\tilde{a}_i$ = (i = 1,2,…….,m) be the quantity of commodity available at intuitionistic origin i. Let $\tilde{b_j}$ = (j = 1,2,…..,n) be the quantity of commodity needed of intuitionistic fuzzy destination j. Let X_{ij} (i = 1,2,3,……,m, j = 1,2,3,……,n) is quantity transported from ith intuitionistic fuzzy origin to jth intuitionistic fuzzy destination.

Mathematical Model of Intuitionistic Fuzzy Transportation Problem:

Minimum $\tilde{Z} = \sum_{j=1}^{m} \sum_{j=1}^{n} \tilde{c_{ij}} \times \tilde{x_{ij}}$

Subject to $\sum_{j=1}^{n} \tilde{x_{ij}} \approx \tilde{a_j}$, for i = 1, 2,……., m (1)

$\sum_{i=1}^{m} \tilde{x_{ij}} \approx \tilde{b_j}$, for j = 1, 2,….…., n (2)

$\tilde{x_{ij}} \geq 0$, for i = 1, 2,…..,m and j = 1,2,…..,n (3)

Where

m = the number of supply points;

n = the number of demand points; $\tilde{x_{ij}} = ({x_{ij}}^1, {x_{ij}}^2, {x_{ij}}^3, {x_{ij}}^4)$ is the uncertain number of units shipped from supply point i to demand point j;

$\tilde{c_{ij}} = ({c_{ij}}^1, {c_{ij}}^2, {c_{ij}}^3, {c_{ij}}^4)$ is the uncertain cost of shipping one unit from supply point i to demand point j;

$\tilde{a_i} = (a^1, {a_i}^2, {a_i}^3, {a_i}^4)$ is the uncertain supply at supply point i and

$\tilde{b_i} = ({b_j}^1, {b_j}^2, {b_j}^3, {b_j}^4)$ is the uncertain demand at demand point j.

The above problem can put in a table namely, fuzzy transportation table given below. Supply

$\tilde{c_{11}}$	…….	$\tilde{c_{1n}}$	$\tilde{b_1}$
….	…	…	…
$\tilde{c_{m1}}$	…….	$\tilde{c_{mn}}$	$\tilde{b_n}$
$\tilde{a_1}$	……..	$\tilde{a_n}$	Demand

4.ALGORITHM FOR INTUITIONISTIC FUZZY TRANSPORTATION PROBLEM

Step 1: Defuzzification of the parameters for the given problem. It is mainly concentrated on integers, and in case of no integers rounding off the integers is appreciable.
Step 2: In the given cost matrix,select the minimum odd cost. In case all the cost of even number multiply every column by ½.
Step 3: Subtract the smallest odd cost throughout the odd cost of the matrix. As a result, it holds atleast one zeroand remaining allcost become even.
Step 4: If the place of zero,allocate minimum of supply/demand instead.
Step 5: Further, multiply every column by 1/2.
Step 6: Thereafter, a minimum odd cost will be selected exempting the zeros in the column.
Step 7: To obtain an optimal solution, proceed from step 3 following with the repetition of step 4 and 5 until an optimal solution is reached.
Step 8: The total minimum cost is calculated by summing up the product of the cost and value placed in supply/ demand culminating the algorithm of IFTP.

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5. NUMERICAL EXAMPLE

Consider trapezoidal intuitionistic fuzzy transportation problem whose quantities are trapezoidal intuitionistic fuzzy number.

Table 1:Transportation cost per unit when an item transported

	D_1	D_2	D_3	D_4	**Supply**
O_1	(0,1,2,3; -8,1,2,5)	(12,16,17,18; 11,16,17,19)	(12,13,14,18; 11,13,14,19)	(7,8,9,13; 6,8,9,14)	(2,3,4,8; 1,3,4,9)
O_2	(3,4,5,9; 2,4,5,10)	(7,11,12,13; 6,11,12,14)	(6,10,11,12; 4,10,11,14)	(3,7,8,9; 2,7,8,10)	(5,6,7,11; 4,6,7,12)
O_3	(12,15,16,17; 9,15,16,18)	(4,8,9,10; 3,8,9,11)	(1,2,3,6; 0,2,3,9)	(5,9,10,11; 4,9,10,12)	(7,8,9,13; 5,8,9,15)
O_4	(10,12,13,18; 8,12,13,20)	(5,6,7,9; 4,6,7,14)	(3,13,14,15; 2,13,14,16)	(2,6,7,8; 1,6,7,9)	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

By defuzzifying with the quantities we get,

$$\mathbf{a_{11} = 1}\ ;\ \mathbf{a_{12} = 16};\ \mathbf{a_{13} = 14};\ \mathbf{a_{14} = 9};$$

$$\mathbf{a_{21} = 5}\ ;\ \mathbf{a_{22} = 11};\ \mathbf{a_{23} = 10};\ \mathbf{a_{24} = 7};$$

$$\mathbf{a_{31} = 15};\ \mathbf{a_{32} = 8}\ ;\ \mathbf{a_{33} = 3};\ \mathbf{a_{34} = 9};$$

$$\mathbf{a_{41} = 13};\ \mathbf{a_{42} = 7}\ ;\mathbf{a_{43} = 12};\ \mathbf{a_{44} = 6}.$$

Table 2:

	D_1	D_2	D_3	D_4	Supply
O_1	1	16	14	9	(2,3,4,8; 1,3,4,9)
O_2	5	11	10	7	(5,6,7,11; 4,6,7,12)
O_3	15	8	3	9	(7,8,9,13; 5,8,9,15)

O_4	13	7	12	6	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Table 3: Minimal odd cost in the odd matrix is 1,and then subtract 1 from all odd cost and arrange the minimum supply or minimum demand. If there exists a zero cost then delete the row or column.

	D_1	D_2	D_3	D_4	**Supply**
O_1	**0(2,3,4,8; 1,3,4,9)**	16	14	8	(2,3,4,8; 1,3,4,9)
O_2	4	10	10	6	(5,6,7,11; 4,6,7,12)
O_3	14	8	2	8	(7,8,9,13; 5,8,9,15)
O_4	12	6	12	6	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Table 4:By step 2, all the cost are even, and then multiply all the cost by ½ and subtract all the minimal odd cost from the given cost.

	D_1	D_2	D_3	D_4	**Supply**
O_2	2	5	5	3	(5,6,7,11; 4,6,7,12)
O_3	7	4	1	4	(7,8,9,13; 5,8,9,15)

O_4	6	3	6	3	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Table 5:

	D_1	D_2	D_3	D_4	**Supply**
O_2	2	4	4	2	(5,6,7,11; 4,6,7,12)
O_3	6	4	**0(6,7,8,12; 5,7,8,13)**	4	(7,8,9,13; 5,8,9,15)
O_4	6	2	6	2	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Table 6:By continuing in this way

	D_1	D_2	D_4	**Supply**
O_2	1	2	1	(5,6,7,11; 4,6,7,12)
O_3	3	2	2	(7,8,9,13; 5,8,9,15)
O_4	3	1	1	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(9,12,13,14; 5,12,13,16)	

Table 7:Again repeating the procedure.

	D_1	D_2	D_4	**Supply**
O_2	0	2	**0(5,6,7,11; 4,6,7,12)**	(5,6,7,11; 4,6,7,12)
O_3	2	2	2	(7,8,9,13; 5,8,9,15)
O_4	2	0	0	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(9,12,13,14; 5,12,13,16)	

Table 8:

	D_1	D_2	D_4	**Supply**
O_3	2	2	2	(7,8,9,13; 5,8,9,15)
O_4	2	**0(1,4,5,6; -2,4,5,7)**	0	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(9,12,13,14; 5,12,13,16)	

Table 9:

	D_1	D_4	**Supply**
O_3	2	2	(7,8,9,13; 5,8,9,15)
O_4	2	**0(-5,3,5,7; -7,3,5,9)**	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(9,12,13,14; 5,12,13,16)	

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Table 10: By using **subtraction** formula

(6,10,11,12 ; 5,10,11,13) – (5, 6,7,11; 4,6,7,12) = (-5,3,5,7 ; -7,3,5,9).

	D_1	D_2	**Supply**
O_3	**0(-5,1,3,6; -7,1,3,12)**	0	(7,8,9,13; 5,8,9,15)
Demand	(3,5,6,10; 2,5,6,13)	(9,12,13,14; 5,12,13,16)	

Table 11: By using **subtraction of** intuitionistic trapezoidal formula

(3, 5, 6, 10; 2, 5, 6, 13) – (2, 3, 4, 8; 1, 3, 4, 9) = (-5,1,3,6; -7,1,3,12)

	D_1	D_2	D_3	D_4	**Supply**
O_1	**1(2,3,4,8; 1,3,4,9)**	16	14	9	(2,3,4,8; 1,3,4,9)
O_2	5	11	10	**7(5,6,7,11; 4,6,7,12)**	(5,6,7,11; 4,6,7,12)
O_3	**15(-5,1,3,6; -7,1,3,12)**	8	**3(6,7,8,12; 5,7,8,13)**	9	(7,8,9,13; 5,8,9,15)
O_4	13	**7(1,4,5,6; -2,4,5,7)**	12	**6(-5,3,5,7; -7,3,5,9)**	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; - 2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Table 12:

	D_1	D_2	D_3	D_4	**Supply**
O_1	**(0,1,2,3; -8,1,2,5) (2,3,4,8; 1,3,4,9)**	(15,16,17,20; 13,16,17,22)	(12,13,14,18; 11,13,14,19)	(7,8,9,13; 6,8,9,14)	(2,3,4,8; 1,3,4,9)

O_2	(3,4,5,9; 2,4,5,10)	(7,11,12,13; 6,11,12,14)	(6,10,11,12; 4,10,11,14)	**(3,7,8,9; 2,7,8,10) (5,6,7,11; 4,6,7,12)**	(5,6,7,11; 4,6,7,12)
O_3	**(12,15,16,17; 9,15,16,18) (-5,1,3,6; -7,1,3,12)**	(4,8,9,10; 3,8,9,11)	**(1,2,3,6; 0,2,3,9) (6,7,8,12; 5,7,8,13)**	(5,9,10,11; 4,9,10,12)	(7,8,9,13; 5,8,9,15)
O_4	(10,12,13,18; 8,12,13,20)	**(5,6,7,9; 4,6,7,14) (1,4,5,6; -2,4,5,7)**	(3,13,14,15; 2,13,14,16)	**(2,6,7,8; 1,6,7,9) (-5,3,5,7; -7,3,5,9)**	(6,10,11,12; 5,10,11,13)
Demand	(3,5,6,10; 2,5,6,13)	(1,4,5,6; -2,4,5,7)	(6,7,8,12; 5,7,8,13)	(9,12,13,14; 5,12,13,16)	

Intuitionistic fuzzy optimum cost:

Min Z = (-74,117,200,389; -142,117,200,469).

6.CONCLUSION

In thispaper an efficient algorithm is proposed to find the optimal solution of intuitionistic fuzzy transportation problem where cost, supply and demand of an IFTP are considered as trapezoidal intuitionistic fuzzy numbers. This algorithm is very compact for the decision makers, since the methodology is simple and takes minimum number of iterations. This method is approachable for anyintuitionistic fuzzy transportation problem with differenttype of intuitionistic fuzzy numbers.

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