Middle-East Journal of Scientific Research 25 (2): 374-379, 2017
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2017.374.379

A Strategy to Solve Mixed Intuitionistic Fuzzy Transportation Problems by BCM

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Abstract: Transportation Problem (TP) mainly deals with the supply and demand of commodities transported from several sources to the different destinations. In this work a Mixed Intuitionistic Fuzzy Transportation Problem (MIFTP) is considered for which the transportation costs are imprecise numbers described by fuzzy numbers and Intuitionistic fuzzy numbers which are more realistic and general in nature. An alternative method called Best Candidate Method (BCM) is used to solve the MIFTP. The result is demonstrated by considering a numerical example.

AMS Subject Classification: 90C08, 90C90, 90C29, 90C70, 90B06, 03E72, 03F55.
Key words: Mixed Intuitionistic Fuzzy Transportation Problem ・ Triangular intuitionistic fuzzy numbers and mixed constraints

INTRODUCTION

The challenge of how to supply the commodities to the customers in an more efficient way is tackled by an efficient framework called Transportation model. The problems on distribution and transportation of resources from one place to another can be solved by Transportation methods. They ensure the efficient movement and timely availability of raw materials and finished goods. The basic transportation problem was originally developed by Hitchcock [1] in 1941. In 1963, Dantzig [2] used the simplex method to the transportation problems as the primal simplex transportation method. Several researchers studied extensively to solve cost minimizing transportation problem in various ways. All the parameters of the transportation problems may not be known precisely due to uncontrollable factors in real world applications. This type of imprecise data is not always well represented by random variable selected from a probability distribution. In day to day problems various calculations should be solved with uncertainty and inexactness. Variations in measurement, deviation in accuracy, errors in computation leads to uncertainty and in exactness. In order to deal with this uncertainty we use fuzzy transportation problems instead of classical assignment problems. If it is not possible to explain an imprecise concept by using the conventional fuzzy set the intustinistic fuzzy set can be used. The membership of an element to a fuzzy set is a single value with the degree of acceptance between zero and one. But in the case of Intuitionistic fuzzy Set it is characterized by a membership function and a non-membership function so that the sum of both values is less than one. Optimization in intuitionistic fuzzy environment was given by Angelov [3]. The idea of intuitionistic fuzzy set (IFS) introduced by Atanassov [4, 5] is the generalization of Zadeh's [6] fuzzy set.

In 1996, Chanas *et al*. [7] presented a fuzzy approach to the transportation problem. Nagoor Gani *et al*. [8] built up a two stage cost minimizing fuzzy. Stephen Dinager *et al*. [9] inferred a fuzzy transportation problem with the aid of trapezoidal fuzzy numbers. Pandian *et al*. [10] developed a new algorithm for finding a fuzzy optimal solution for fuzzy transportation problem. An Algorithmic approach for solving a mixed Intustinistic Fuzzy Assignment problem was presented by Senthil Kumar *et al*. [11]. A systematic approach for solving mixed intustionistic fuzzy transportation problem by zero point method was proposed by Senthil Kumar *et al*. [12]. Abdullah A. Hlayel, Mohammad A. Alia [13, 14] has proposed the BCM for solving optimization problems.

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Annie Christi and Malini [15, 16] have solved the transportation problems with hexagonal and octagonal fuzzy numbers using best candidate method and centriod ranking techniques. S. Krishna Prabha and S. Vimala [17] have implemented BCM for Solving the Fuzzy Assignment Problem With Various Ranking Techniques.

In this paper Best Candidate Method (BCM) is introduced for solving a balanced mixed intustionistic fuzzy transportation problem. The mixed fuzzy quantities as the cost, coefficients, supply and demands are transformed into crisp quantities by the given ranking methods and the BCM is applied to obtain the solution.

In section 2 elementary concepts have been reviewed. Mathematical Model of MIFTP and ranking methods of the various fuzzy numbers are introduced in section 3. In section 4, corresponding algorithm called BCM have been proposed for solving MIFTP. A numerical example is taken and the above there methods are applied and tested numericallyin section 5. Section 6concludes the paper.

Preliminaries

Definition 2.1: A Triangular Intuitionistic Fuzzy Number ($\tilde{A}^I$) is an intuitionistic fuzzy set in R with the following membership function $\mu_A(x)$ and non membership function.

v_A (x))

$$\mu_A(x) = \begin{cases} 0 & if\ x \le a \\ \frac{x-a_1}{a_2-a_1} & a_1 \le x \le a_2 \\ 1 & x = a_2 \\ \frac{a_3-x}{a_3-a_2} & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \quad \text{and} \quad v_A(x)$$

$$= \begin{cases} 1 & x < a' \\ \frac{a_2-x}{a_2-a_1} & a_1' \le x \le a_2 \\ 0 & x = a_2 \\ \frac{x-a_2}{a_3-a_2} & a_2 \le x \le a_3' \\ 1 & x \ge a_3' \end{cases}$$

where $\alpha_1' \le \alpha_1 \le \alpha_2 \le \alpha_3 \le \alpha_3'$ and $\mu_A(x)$, $v_A(x) \le 0.5$ for $\mu_A(x) = v_A(x)$, $\forall x \in R$.

This TrIFN is denoted by $\tilde{A}^I = (a_1, a_2, a_3)\ (a_1', a_2, a_3')$

Particular Cases

Let $\tilde{A}^I = (a_1, a_2, a_3)\ (a_1', a_2, a_3')$ be a TrIFN.

Then the following cases arise

Case 1: If $a_1' = a_1$, $a_3' = a_3$, then $\tilde{A}^I$ represent Tringular Fuzzy Number (TrFN). It is denoted by $A = (a_1, a_2, a_3)$.

Case 2: If $a_1' = a_1 = a_2 = a_3 = a_3' = $ m, then $\tilde{A}^I$ represent a real number m.

Definition 2.4.6: Let $A\ I$ and $B\ I$ be two TrIFNs. The ranking of $\tilde{A}^I$ and $\breve{B}^I$ by the R(.) on E, the set of TrIFNs is defined as follows:

i. $\mathcal{R}(\tilde{A}^I) > \mathcal{R}(\breve{B}^I)$ iff $\tilde{A}^I \succ \breve{B}^I$

ii. $\mathcal{R}(\tilde{A}^I) < \mathcal{R}(\breve{B}^I)$ iff $\tilde{A}^I \prec \breve{B}^I$

iii. $\mathcal{R}(\tilde{A}^I) = \mathcal{R}(\breve{B}^I)$ iff $\tilde{A}^I \approx \breve{B}^I$

iv. $\mathcal{R}(\tilde{A}^I + \breve{B}^I) = \mathcal{R}(\tilde{A}^I) + \mathcal{R}(\breve{B}^I)$

v. $\mathcal{R}(\tilde{A}^I - \breve{B}^I) = \mathcal{R}(\tilde{A}^I) - \mathcal{R}(\breve{B}^I)$

Ranking Techniques:

Yager's Ranking Technique: Yager's ranking technique which satisfies compensation, linearity, additivity properties and provides results which consists of human intuition. For a convex fuzzy number ã, the Robust's Ranking Index is defined by,

$$\text{R}(\tilde{a}) \int_0^1 (0.5)(a^L \propto, a^U \propto) d \propto \quad (1)$$

where $(a^L{}_\propto, a^U{}_\propto) = \{(b-a)\propto + a, c-(c-b)\propto\}$ which is the α – level cut of the fuzzy number ã.

Ranking of Triangular Intuitionistic Fuzzy Numbers: The Ranking of a triangular intuitionistic fuzzy number $\tilde{A}^I = (a_1, a_2, a_3)\ (a_1', a_2, a_3')$ is defined by

$$R(\tilde{A}^I) = \frac{1}{3}\left[\frac{(a_3'-a_1')(a_3-2a_1'-2a_3')+(a_3-a_1)(a_1+a_2+a_3)+3(a_3'-a_1')}{a_3-a_1+a_3-a_1}\right] \quad (2)$$

The ranking technique is: If $R(\tilde{A}^I) \le R(\breve{B}^I)$, then

$\tilde{A}^I = \breve{B}^I$ i.e, min { $\tilde{A}^I$, $\breve{B}^I$ }= $\tilde{A}^I$

Fuzzy Balanced and Unbalanced Transportation Problem [10, 18, 19]: The balanced fuzzy transportation problem, in which a decision maker is uncertain about the precise values of transportation cost, availability and demand, may be formulated as follows:

$$minimize \sum_{i=1}^{p} \sum_{j=1}^{q} c_{ij} - x_{ij}$$

Subject to $\sum_{j=1}^{q} x_{ij}$ = ã$_i$, i = 1, 2, 3, ………, p

$\sum_{i=1}^{p} x_{ij}$ = b_j, j = 1, 2, 3, ………, q

$\sum_{i=1}^{p} a_i = \sum_{j=1}^{q} b_j$

X_{ij} is a non- negative trapezoidal fuzzy number ,

where p = total number of sources
Q = total number of destinations
a_i = the fuzzy availability of the product at ith source
b_j = the fuzzy demand of the product at jth destination
c_{ij} = the fuzzy transportation cost for unit quantity of the product from ith source to jth destination
x_{ij} = the fuzzy quantity of the product that should be transported from ith source to jth destination to minimize the total fuzzy transportation cost.

$\sum_{i=1}^{p} a_i$ = 1total fuzzy availability of the product,

$\sum_{j=1}^{q} b_j$ = 1total fuzzy demand of the product

$\sum_{i=1}^{p}\sum_{j=1}^{q} c_{ij} * x_{ij}$ = total fuzzy transportation cost.

If $\sum_{i=1}^{p} a_i = \sum_{j=1}^{q} b_j$ then the fuzzy transportation problem is said to be balanced fuzzy transportation problem, otherwise it is called unbalanced fuzzy transportation problem. Consider transportation with m fuzzy origins (rows) and n fuzzy destinations (Columns) Let C_{ij} =[$C_{ij}^{(1)}$, $C_{ij}^{(2)}$, $C_{ij}^{(3)}$] be the cost of transporting one unit of the product from ith fuzzy origin to jth fuzzy destination a_i=[$a_i^{(1)}$, $a_i^{(2)}$, $a_i^{(3)}$] be the quantity of commodity available at fuzzy origin i b_j = [$b_j^{(1)}$, $b_j^{(2)}$, $b_j^{(3)}$] be the quantity of commodity requirement at fuzzy destination j. X_{ij} =[X_{ij}^{1}, X_{ij}^{2}, X_{ij}^{3}] is quantity transported from ith fuzzy origin to jth fuzzy destination. An unbalanced transportation problem is converted into a balanced transportation problem by introducing a dummy origin or dummy destinations which will provide for the excess availability or the requirement the cost of transporting a unit from this dummy origin (or dummy destination) to any place is taken to be zero. After converting the unbalanced problem into a balanced problem, we adopt the usual procedure for solving a balanced transportation problem.

Algorithm for Best Candidates Method (BCM) has the Following Solution Steps:

Step1: From the matrix with the Fuzzy Assignment Costs. Balance the unbalanced matrix and don't use the added row or column candidates in our solution procedure.

Step2: The best candidates are selected by choosing minimum cost for minimization problems and maximum cost for maximization problems. Select the best two candidates in each row, if the candidate is repeated more than two times select it also. Check the columns that not have candidates and select one candidate for them, if the candidate is repeated more than one time select it also.

Step3: The combinations are found by determining only one candidate for each row and column starting from the row that have least candidates and delete that row and column if there is situation that has no candidate for some rows or columns, select directly the best available candidate. Repeat step 3 (1, 2) by determining the next candidate in the row that started from. The total sum of candidates for each combination is computed and compared to determine the best combinations that give the optimal solution.

Algorithm to Solve MIFTP with BCM:

Step1: If the matrix is balanced go to step2, If not balance by adding dummy row/column as needed to make the supply equal to demand.

Step2: Find the best combination by BCM to produce the lowest total weight of the cost, where is one candidate for each row or column.

Step 3: Selected a row with the smallest cost candidate from the choosen combination. Allocate the demand and supply as much as possible to the variable with least unit cost in the selected row/column. Adjust the supply and demand by crossing out the row /column. If the row/column is not assigned to zero then we check the selected row if it has an element with lowest cost comparing to the determined element in the choosen combination then we elect it.

Step 4: Find the next least cost from the choosen combination and repeat step3 until all columns and rows are exhausted.

Numerical Example: Consider the Mixed Intustionstic fuzzy transportation problem

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	(6, 7, 8:4, 7, 10)	3	(2, 4, 6)	(1, 2, 3)
*F*02	(1, 2, 3)	(0, 1, 2)	(1, 3, 5:2, 3, 4)	3
*FO*3	(1, 3, 5)	(2, 4, 6:1, 4, 7)	6	(3, 5, 7:1, 5, 9)
Fuzzy Requirement	(2, 4, 6:1, 4, 7)	1	(3, 5, 7)	

By using the above ranking techniques for defuzzification, we get the following MIFTP table

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	7	3	4	2
*F*02	2	1	3	3
*FO*3	3	4	6	5
Fuzzy Requirement	4	1	5	

Determine the cost table from the given problem. Here total demand equals total demand.

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	7	3	4	2
*F*02	2	1	3	3
*FO*3	3	4	6	5
Fuzzy Requirement	4	1	5	10

Applying the above new algorithm for solving the transportation problem, we get the following allocations
Select the best candidates from step 2.

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	7	③	④	2
*F*02	②	①	3	3
*FOO*3	③	④	6	5
Fuzzy Requirement	4	1	5	10

Using BCM we select the best combination that will produce the lowest total weight of the costs, where there is one candidate for each row and column.

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	7	3	④ 3	2
*F*02	2	①	3	3
*FO*3	③	4	6	5
Fuzzy Requirement	4	1	5	

Optimal Solution

	*FD*1	*FD*2	*FD*3	Fuzzy Available
*F*01	7	3	④②	2\ 0
*F*02	2	1	3	3\2\0
*FO*3	③④	4	6①	5\1
Fuzzy Requirement	4\0	1\0	5\3\1	

The optimal solution is given by (6x1)+(3x2)+(3x4)+(1x1)+(4x2) = 6+6+12+1+8 =33
Total minimum cost will be Rs.33

CONCLUSION

In this paper, the transportation costs are considered as mixed intustionistic fuzzy numbers. Thus the MIFTP has been transformed into crisp balanced transportation problem using various ranking techniques. The best combinations are selected without any complication. Optimal solution or closest to optimal solution can be obtained using BCM with less computation time. This method is very easy to solve and it minimize the iterations and reduce the complexity.

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