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A New Method Of Intuitionistic Fuzzy Soft Transportation System

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***Abstract:** In this paper, a general fuzzy soft set transportation problem model is discussed. There are several approaches by different authors to solve such a problem. We introduce fuzzy numbers using which we develop a new model to solve the transportation problem. By defining a soft set to the fuzzy numbers, it is possible to compare them and using this we convert the fuzzy valued transportation problem (cost, supply and demand appearing as fuzzy numbers) to a crisp valued transportation problem, which then can be solved using the Modified Distribution Method. We have proved that the optimal value for a fuzzy transportation problem, when solved using fuzzy number gives a optimal value than when it is solved using trapezoidal fuzzy number as done by Basirzadeh [3] which is illustrated through a numerical example.*

***Keywords:** Fuzzy numbers, Fuzzy Transportation Problem.*

I. INTRODUCTION

In a fuzzy transportation problem, all parameters are fuzzy numbers. Fuzzy numbers may be normal or abnormal, triangular or trapezoidal or it can also be octagonal. Thus, they cannot be compared directly. Several methods were introduced for ranking of fuzzy numbers, so that it will be helpful in comparing them. Basirzadeh et al [2] have also proposed a method for fuzzy numbers using α – cuts in which he has given a triangular and trapezoidal fuzzy numbers.

A using α-cut is introduced on fuzzy numbers. Using this α – cuts the fuzzy transportation problem is converted to a crisp valued problem, which can be solved using VAM for initial solution and MODI for optimal solution. The optimal solution can be got either as a fuzzy number or as a crisp number. Soft set play an important role in the broad area of science and engineering.

In this paper, a new approach for transportation system is proposed by employing intuitionistic fuzzy soft table. In order to attain this, Value of the TP table and Score are employed. The Solution is obtained based on the minimum score in the table.

II. PRELIMINARIES

DEFINITION: Suppose that C_{ij} =[C_{ij}^{1} C_{ij}^{2}, C_{ij}^{3} , C_{ij}^{4}] is a cost cell for each occupied cell,and D = [Fd_1, Fd_2, Fd_3, Fd_4] is a set of destinations, consider the mapping from parsmer set D to the set of all subsets of power set C_{ij} , let soft transportation set (O,D) describes the cost of the cell with respect to the given parameters, for finding the minimum cost of transportation problem.

DEFINITION: Let C be an initial Universe cost set and (O,D) be the set of parametersof origins and destinations. Let $X \subseteq (O,D)$. A pair (F, X) is called fuzzy soft transportation cost over C where F is a mapping given by $F : X \to I^{C}$,where I^{C} denotes the collection of all fuzzy transportation subsets of C.

EXAMPLE: Consider the example [2.1], in soft transporation subsets cost set (O,D),if if FO_1, is medium in studies, we cannot expressed with only the two numbers 0 and 1,we can characterize it by a membership function instead of the crisp number 0 and 1,which associates with each element a real number in the interval [0, 1].Then fuzzy soft transportation cost set can describe as

$(F, X) = \{$ (Fd_1) = $\{(d_1, 0.9), (d_2, 0.3), (d_3, 0.7), (d_4, 0.8)\}$

(Fd_2) = $\{(d_1, 0.8), (d_2, 0.9), (d_3, 0.4), (d_4, 0.3)\}$

(Fo_1) = $\{((o_1, 0.9), (o_2, 0.3), (o_3, 0.7), o_4, 0.8)\}$

(Fo_2) = $\{((o_1, 0.8), o_2, 0.9), (o_3, 0.4), (o_4, 0.3)\}\}$

Where X = $\{(FO_1, Fd_1)$ $[FO_2, Fd_2]$,$[FO_3, Fd_3]$,$[FO_4, Fd_4]\}$

We can represent a fuzzy transportation soft set in the form of table given below

U	Fd_1	Fd_2	Fd_3	Fd_4
FO_1	0.9	0.8	0.9	0.7
FO_2	0.3	0.4	0.8	0.9
FO_3,	0.7	0.3	0.3	0.9
,FO_4	0.7	0.7	0.4	0.3

Table 1

Demand	supply
0.9	0.8
0.3	0.9
0.8	0.4
0.9	0.3

Table 2

DEFINITION: Let C = $\{c1, c2, c3, \ldots, cm\}$ be the cost Universal set and (O,D) be the set of destination given by (O,D) = $\{[FO_1, Fd_1)$ $[FO_2, Fd_2]$,$[FO_3, Fd_3]$,$[FO_4, Fd_4]$..$[FO_m, FD_m]\}$. Let X $\subseteq$ (O,D) and (F, X) be a fuzzy transportation cost soft set in the fuzzy soft TP class (C,X). Then fuzzy soft set (F, X) in a TP table form as $X_{m\times n} = [C_{ij}]_{m\times n}$ or X = $[C_{ij}]$ $i = 1, 2, \ldots, m$, $j = 1, 2, 3, \ldots, n$, $\mu_{ij}(C_{ij})$ represent the membership of C_{ij} in the fuzzy cost F(o,d)

EXAMPLE: Suppose that C = $\{c1, c2, c3, \ldots, cm\}$ is a set of dealer and (O,D) = $\{(a_1, b_1), (a_2, b_2) \ldots\ldots (a_n, b_n)\}$ is a set of parameters, which consider the mapping from cost set respectively. Consider the mapping from parameters set X $\subseteq$(O,D) to the set of all intuitionistic fuzzy triangular transportation subsets of power set U.Then soft transportation cost set (F, X) describes the bet of job of the dealer with respect to the given cost TP form, for finding the best job of an dealer. Consider, X = $\{(a_1, b_1), (a_2, b_2) \ldots\ldots (a_n, b_n)\}$.then intuitionistic fuzzy soft TP set is

(F,X)= $\{FO_1, Fd_1)$ =$\{(C1, 0.6,0.2,0.1), (C2, 0.3, 0.4,0.2), (C3, 0.5, 0.3, 0.1), (C4, 0.6,0.3,0.0)\}$,

We would represent in Fuzzy TP form

(C1,0.6,0.2,0.1)	(C2 , 0.3, 0.4,0.2),	(C3 , 0.5, 0.3, 0.1)	(C4 , 0.6,0.3,0.0)
(C1, 0.5,0.3, 0.1),	(C2 , 0.3,0.4,0.2),	(C3,0.6,0.3,0.0),	(C4 , 0.9,0.0,0.0)
(C1, 0.5,0.3, 0.1),	(C2 , 0.3,0.4,0.2),	(C3,0.6,0.3,0.0),	(C4 , 0.9,0.0,0.0)
(C1, 0.5,0.3, 0.1),	(C2 , 0.3,0.4,0.2),	(C3,0.6,0.3,0.0),	(C4 , 0.9,0.0,0.0)

Supply	Demand
0.8	(0.7
0.9	(0.3
0.1	(0.5
0.6	0.4
	0.5
Total supply=total demand=2.4	

Table 3

DEFINITION: ([9]). If X = $[C_{ij}] \in IFTPSF_{m\times n}$, Y = $[a_{jk}, b_{jk}] \in IFTPSF_{n\times p}$, then we define $X * Y$, product X and Y as

$X * Y = [c_{ik}]_{m\times p}$

$= (\max \min(\mu_{Aj}, \mu_{Bj}), \min \max(\nu_{Aj}, \nu_{Bj}))\ \forall i, j$

DEFINITION: Let $Z = (a_1, a_2, a_3, a_4)$ is said to be trapezoidal fuzzy number if its membership function is given by where $a_1 \leq a_2 \leq a_3 \leq a_4$,

$\delta(z) = \{$o for $z<a_1$, $\frac{z-a_1}{a_2-a_1}$ for $a_1 \leq Z \leq a_2$, 1 for $a_2 \leq z \leq a_3$, $\frac{a-Z}{a_4-a_3}$ for $a_3 \leq z \leq a_4$, 0 for $z>a_4\}$

DEFINITION: Intuitionistic fuzzy set (IFS) A in x is a set of ordered triples < universe element, degree of membership to μ_A degree of non-membership to ν_A are fuzzy numbers with $\mu_A + \nu_A \leq 1$ and $\mu_A, \nu_A \in [0,1]$

When $\mu_A + \nu_A = 1$ one obtain the fuzzy set, and if $\mu_A + \nu_A < 1$

There is an I=1- $\mu_A - \nu_A$

DEFINITION: Interval valued Intuitionistic fuzzy set (IVIFS)

Is similar to IFS, but μ_A and ν_A are subsets of [0,1] and sup μ_A+sup $\nu_A \leq 1$.

DEFINITION: Intuitionistic fuzzy set of second type (IFS2)

Is similar to IFS, but $\mu_A^2 + \nu_A^2 \leq 1$. μ_A and ν_A are inside of the upper right quarter of unit circle.

III. ALPHA CUT METHOD

DEFINITION: The truely of fuzzy set T{A(x)/xϵX} is the maximum value of its membership function such that truly $\alpha \in (0,1]$: T Aα= $\{x \epsilon X / \mu_A(x) \geq \alpha\}$ and 0 does not belongs to α .

The fuzzy set where max {T{A(x)/xϵX}=1 is called as a natural fuzzy, otherwise, it is referred as natural maximum fuzzy set. The convex set of $\mu_A(\alpha)$ called the alpha cut set is the set of element whose degree of membership function is (a_1, a_2, a_3, a_4) is no less than, α it is defined as, $\mu_A(\alpha) = \{x \epsilon X / \mu_A(x) \geq \alpha\}$

$A(\alpha) = \min \lambda \epsilon x \{\lambda / \mu_A(a) \geq \alpha\} \max \lambda \epsilon x \{\lambda / \nu_A(a) \geq \alpha\}$ using α - cut method

$\alpha_\lambda = [\alpha(a_4 - a_3) + \alpha(a_3 - a_2) + a_1,$
$\lambda_4 - \alpha(a_4 - a_3) - \alpha(a_3 - a_2)]$

If we set crisp interval by α cut operation interval $\mu_A(\alpha)$ shall be obtained as follows for all $\alpha \epsilon [0,1]$

Consider 1[st] interval= αie $\frac{z-a_1}{a_2-a_1} = \alpha$, $z_1 = a\lambda_1 + \alpha(a_2 - a_1)$,$\frac{a_3-z}{a_3-a_2} = \alpha$, $z_2 = a\lambda_3 - \alpha(a_3 - a_2)$

$(z_1, z_2) = (a_1 + \alpha(a_2 - a_1), a_3 - \alpha(a_3 - a_2)$

Consider

$\frac{z-a_1}{a_2-a_1} = \alpha$, $z_1 = a_1 + \alpha(a_2 - \lambda a_1)$, $\frac{a-z}{a_4-a} = \alpha$, $z_2 = a_4 - \alpha(a_4 - a_3)$, $m(z_1, z_2) = (a_1 + \alpha(a_2 - a_1), a_4 - \alpha(a_4 - a_3)$

Hence α - cut method

α_1=[$\alpha(a_4 - a_3) + \alpha(a_3 - a_2) + a_1$,
$a_4 - \alpha(a_4 - a_3) - \alpha(a_3 - a_2)$] for $\alpha\epsilon(0,1)$

IV. ARITHMETIC OPERATIONS OF FUZZY NUMBER

We define fuzzy arithmetic operation on fuzzy numbers in terms of the α-cuts. Let $\tilde{A} = (a_1 b_1 c_1 d_1)$ $\tilde{B}$=$(a_2 b_2 c_2 d_2)$are the two trapezoidal fuzzy numbers then the arithmetic opewrations on A and B are two fuzzy sets and if operation "*" denotes any of the four basic arithmetic operations (+,-,* and ÷) then a fuzzy set z=(A*B) and zεR can be defined as,$^{\alpha}$(A*B)=$^{\alpha}$A*$^{\alpha}$B , such that for every α∈(0,1]. However if "*"is a divisor operator, then Following are the three operations that can be performed an intuitionistic fuzzy numbers.

V. SOLUTION PROCEDURE

Using the concept of alpha cut principle
α_a=[$\alpha(a_3 - a_4) + \alpha(a_2 - a_3) + a_1$,
$a_4 - \alpha(a_4 - a_3) - \alpha(a_3 - a_2)$] for $\alpha\epsilon(0,1)$
Similarlyα_b=[$\alpha(b_3 - b_4) + \alpha(b_2 - b_3) + b_1$,
$b_4 - \alpha(b_4 - b_3) - \alpha(b_3 - b_2)$]

We put α=0 and α= 1 in above and obtain an approximate trapezoidal fuzzy number. Since the Transporation characteristics are described by the membership function, it preserves the fuzziness of input information. However the designer would prefer one crisp value for one of the system charactersistics than set.

EXAMPLE: Let A=(0.7,0.3,0.4,0.6), B=(0.7,0.3,0.5,0.5)

Are the intuitionistic fuzzy transportation soft form
α_a=[$b1(a_3 - a_4) + b2(a_2 - a_3) + a_1$,
$a_4 - b3(a_4 - a_3) - b4(a_3 - a_2)$] *for* $\alpha\epsilon(0,1)$
$A * B$ ={ 0.7(0.4-0.3)+0.3(0.3-0.7)+0.7,0.6 -0.5(0.6-0.4)-0.5(0.4-0.3)}=0.7(0.1)+0.3(-0.4)+0.7,0.6-0.5(0.2)-0.5(0.1) =0.07-0.12+0.7,0.6-0.1-0.05=(0.65,0.45)
α_b=[$a1(b_3 - b_4) + a2(b_2 - b_3) + b_1$,
$b_4 - a3(b_4 - b_3) - a4(b_3 - b_2)$]
$B * A$ ={0.7(0.5-0.5)+0.3(0.3-0.5)+0.7,0.5-0.4(0.5-0.5)-0.6(0.5-0.3)}=0.7(0)+0.3(-0.2)+0.7,0.5-0-0.6(0.2)=0-0.6+0.7,0.5-0-0.12=(0.1,0.38)

VI. PROCEDURE FOR SOLVING FUZZY TRANSPORTATION PROBLEM

We shall present a solution to fuzzy transportation problem involving shipping cost, customer demand and availability of products from the producers using octagonal fuzzy numbers.

STEP 1: Input the intuitionistic fuzzy soft transporation (*F*,*D*), (F O) and obtain the intu-itionistic fuzzy soft initial cost Table. *A*, *B* corresponding to (*F*, *D*) and (F,O) respectively.

First convert the cost, demand and supply values which are all octagonal fuzzy numbers into crisp values by using the measure defined by (Definition 3.3) in Section 3.

STEP 2: we solve the transportation problem with crisp values by using the VAM procedure to get the initial solution and then the MODI Method to get the optimal solution and obtain the allotment table.

REMARK 7.1: A solution to any transportation problem will contain exactly (*m*+*n*-1) basic feasible solutions. The allotted value should be some positive integer or zero, but the solution obtained may be an integer or non-integer, because the original problem involves fuzzy numbers whose values are real numbers. If crisp solution is enough the solution is complete but if fuzzy solution is required go to next step.

STEP 3: Determine the locations of nonzero basic feasible solutions in transportation table. There must be atleast one basic cell in each row and one in each column of the transportation table. Also the *m*+*n*-1 basic cells should not contain a cycle. Therefore, there exist some rows and columns which have only one basic cell. By starting from these cells, we calculate the fuzzy basic solutions, and continue until (*m*+*n*-1) basic solutions are obtained.

STEP 4: Write the intuitionistic fuzzy soft TP complement set $(F, D)^C$, $(F,O)^C$ and obtain the intuitionistic fuzzy soft Tp cost values A^C, B^C corresponding to $(F, D)^C$ and (F,OE)c respectively.

Step5: Compute $(A * B)$, $(A^C * B^C)$, $V(A * B)$, $V(A^C * B^C)$.

Step 6: Compute the score cost..

Step 7: Find *p* for which $max(S_i)$.

CASE STUDY: Suppose there are four cost in TP table denote four dealers. Let the possible work related to the above automobile dealers be very good, good, moderate, bad jobs. Now take $C = \{c_1, c_2, c_3, ..., c_m\}$ as the universal set where A= (a_1, a_2, a_3, a_4), B= (b_1, b_2, b_3, b_4) represents set of supply and demand form dealers. Suppose that *I F TPS*(F,O) over C , where F is a mapping $F : O \rightarrow I^C$, $F : D \rightarrow I^C$ gives a allocation of an cost cell minimum of Supply and demand in the transportation table. approximate description of dealer jobs in the marketing.

This intuitionistic fuzzy TP soft set is represented by the following intuitionistic fuzzy soft transportation table

	D1	D2	D3	D4	D5	supply
O1	0.8, 0.1	0.0, 0.8	0.8, 0.1	0.6, 0.1	0.1, 0.6	0.7, 0.1
O2	0.0, 0.8	0.4, 0.4	0.6, 0.1	0.1, 0.7	0.1, 0.8	0.2, 0.7
O3	0.8, 0.1	0.8, 0.1	0.0, 0.6	0.2, 0.7	0.0, 0.5	0.1, 0.0
O4	0.1, 0.6	0.5, 0.4	0.3, 0.4	0.7, 0.2	0.3, 0.4	0.5, 0.1

demand	0.2, 0.5	0.1, 0.1	0.4, 0.1	0.2, 0.2	0.3, 0.2	2.4

Table 4

Next consider the set Fd $= \{Fd_1, Fd_2, Fd_3, Fd_4, \}$ and FO$= \{Fo_1, Fo_2, Fo_3, Fo_4$ universal set of TP where FO *to* Fd *,from rigin to destination allocatuion and the rime requirement satisfied by any one the TP method.* Suppose that $IFTPSS(F, D)$ and (F,O)over C, where F is a mapping $F : D \rightarrow I^C$,gives an approximate description of intuitionistic fuzzy soft TP table.

This intuitionistic fuzzy TP soft set is represented by the following intuitionistic fuzzy soft TP table

	D1	D2	D3	D4	D5
O1	(0.8, 0.1) (0.2, 0.5)	(0.0, 0.8) (0.5,-0.4)	(0.8, 0.1	0.6, 0.1	0.1, 0.6
O2	(0.0, 0.8)	(0.4, 0.4) (-0.3, 0.5)	(0.6, 0.1) (0.4, 0.1)	(0.1, 0.7) (0.1,0.1)	(0.1, 0.8)
O3	(0.8, 0.1)	(0.8, 0.1)	(0.0, 0.6)	(0.2, 0.7) (0.1,0.0)	(0.0, 0.5)
O4	(0.1, 0.6)	(0.5, 0.4)	(0.3, 0.4)	(0.7, 0.2) (0.1,0.0)	(0.3, 0.4) (0.3, 0.2)

Table 5

The number of allocation= 8, m+n-1=4+5-1=8

Here the number of allocation = m+n-1, the fuzzy intuitionistic transportation problem is non-degerate solution.

The current optimistic intuitionistic fuzzy score TP cost is (0.8,0.1) (0.2,0.5) +(0.0,0.8)(0.5,-0.4) + (0.4,0.4)(-0.3,0.5) + (0.6 ,0.1) (0.4,0.1) + (0.1,0.7) (0.1,0.1) + (0.2,0.7) (0.1,0.0) + (0.7,0.2) (0.1,0.0) + (0.3,0.4) (0.3 , 0.2)

= (0.5-0.1)/(0.2-0.8) + (-0.4-0.8) /(0.5-0) + (0.5-0.4) /(-0.3-0.4) + (0.1-0.1) /0.4-0.6)+ (0.1-0.7) / (0.1-0.1) + (0.0 -0.7) / (0.1-0.2) + (0-0.2) / (0.7 – 0.1) + (0.2- 0.4) / (0.3- 0..4) = -0.66667-2.4-0.1429+7-0.4+2=9-3.60957=5.39043.

Then the intuitionistic fuzzy soft transportation complement table are A^c

It is clear from the above TP table that have four dealers(d_1, d_2, d_3) is

	D1	D2	D3	D4	D5
O1	(0.1 0.8) (0.2, 0.5)	(0.0, (0.5, -0.4) 0.8)	(0.1 0.8,)	(0.1 0.6,)	(0.6 0.1)
O2	(0.8 0.0)	(0.4, 0.4,) (0.5,-0.3)	(0.1 0.6) (0.1, 0.4)	(0.7, 0.1) (0.1, 0.1)	(0.8 0.1)
O3	0.1 0.8,	0.1 0.8,	0.6 0.0,	0.7, 0.2, (0.0, 0.1)	0.5 0.0,
O4	0.6 0.1,	, 0.4 0.5	0.4 0.3,	(0.2 0.7,) (0.0, 0.1)	(0.4 0.3) (0.2, 0.3)

Table 6

jobs better than d4.

V. CONCLUSIONS

In this paper, we have developed an algorithm which is a new approach in transportation model, by implementing intuitionistic fuzzy soft TP table. This algorithm is more flexible and adjustable. Solution is obtained by looking for the maximum score in the score matrix. As far as, future directions are concerned, there would be required to study whether the notion put forward in this paper yield a fruitful result.

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