A NOVEL TRANSPORTATION APPROACH TO SOLVING TYPE - 2 TRIANGULAR INTUITIONISTIC FUZZY TRANSPORTATION PROBLEMS

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Abstract

In this article we propose a new transportation strategy to achieve an ideal answer for triangular intuitionistic fuzzy transportation problem of type – 2 i.e., limits and requests are considered as real numbers and the transportation cost from cause to objective is considered as triangular intuitionistic fuzzy numbers as product cost per unit. The proposed method is solving by using ranking function. The appropriate response system is delineated with a numerical model.

Keywords: IFN, TIFN, IF Optimum solution, TIFTP of type-2.

I. Introduction

In genuine world, there are general complex circumstances in each field, in which specialists and chiefs battle with uncertainty and hesitation. In useful circumstances, assortment of fresh information of different boundaries is troublesome because of absence of precise interchanges, mistake in information, market information and consumer loyalties. The data accessible is some of the time ambiguous and inadequate. The real-life problems, when defined by the decision maker with uncertainty leads to the notion of fuzzy sets. Due to imprecise information, the exact evaluation of participation values is not possible. Moreover, the evaluation of non-participation esteems is consistently impossible. This prompts an in deterministic climate where dithering endures. Managing estimated data while deciding, idea of fuzziness was presented by Bellman and Zadeh [6]. K. T, Atanassov [4] presented idea of Intuitionistic fuzzy set hypothesis, which is more able to manage such issues. B. Chetia and P. K. Das [1] demonstrated a few outcomes on intuitionistic fuzzy delicate network. Intuitionistic fuzzy sets [5], [7], [8] discovered to be exceptionally powerful in managing ambiguity, among a few higher request fuzzy sets. S.K. Singh, S.P. Yadav [9] proposed their strategies to address case 2 sort of intuitionistic fuzzy transportation problem (IFTP) for example IFTP of type-2. G. Gupta and A. Kumara [3] a capable technique was introduced in which limit and request factors are taken as TIFN's utilized in this article to tackle mathematical model. This paper proposes another transportation strategy for tackling TIFTP of type – 2 by applying ranking function found in [2].

The association of this article is as per the following: In Section 2, a review on essentials IFS and IFN's. Segment 3, presents the Ranking function and Comparison of TIFN's. Area 4, briefs the numerical detailing and proposed TP technique. Delineates the mathematical model in Section 5. At long last, Section 6 exposes the conclusion.

II. Preliminaries

In this part a couple of essential definitions and math tasks are examined.

Intuitionistic Fuzzy Set (IFS): An IFS $\tilde{A}^{IFS}$ in X an IFS is described as an object of following design

$$\tilde{A}^{IFS} = \{\langle x, \mu_{\tilde{A}^{IFS}}(x), \nu_{\tilde{A}^{IFS}}(x)\rangle : x \in X\}$$

where, functions$\mu_{\tilde{A}^{IFS}} : X \to [0, 1]$ and $\nu_{\tilde{A}^{IFS}}: X \to [0, 1]$ defines degree of Enrollment work and non-participation element$x \in X$, respectively and $0 \le \mu_{\tilde{A}^{IFS}}(x), \nu_{\tilde{A}^{IFS}}(x) \le 1$, for every$x \in X$.

Intuitionistic Fuzzy Numbers (IFN's): A subset of IFS,$\tilde{A}^{IFS} = \{\langle x, \mu_{\tilde{A}^{IFS}}(x), \nu_{\tilde{A}^{IFS}}(x)\rangle : x \in X\}$, of real line $\Re$ is called an IFN if the following holds:

(i) $\exists m \in \Re, \mu_{\tilde{A}^{IFS}}(m) = 1 \; and \; \nu_{\tilde{A}^{IFS}}(m) = 0$

(ii) $\mu_{\tilde{A}^{IFS}} : \Re \to [0, 1]$ is continuous and for every $x \in \Re, 0 \le \mu_{\tilde{A}^{IFS}}(x), \nu_{\tilde{A}^{IFS}}(x) \le 1$ holds.

Enrollment work and non-participation capacity of$\tilde{A}^{IFS}$ is as follows,

$$\mu_{\tilde{A}^{IFS}}(x) = \begin{cases} f_1(x), & x \in [m-\alpha_1, m) \\ 1, & x = m \\ h_1(x), & x \in (m, m+\beta_1] \\ 0, & otherwise \end{cases} \text{ and } \nu_{\tilde{A}^{IFS}}(x) = \begin{cases} 1, & x \in (-\infty, m-\alpha_2) \\ f_2(x), & x \in [m-\alpha_2, m) \\ 0, & x = m, x \in [m+\beta_2, \infty) \\ h_2(x), & x \in (m, m+\beta_2] \end{cases}$$

Where, $f_i(x)$and $h_i(x)$; $i = 1,2$ are strictly increasing and decreasing functions in $[m-\alpha_i, m)$ and $(m, m-\beta_i]$ respectively. α_i and β_i are left and right spreads of $\mu_{\tilde{A}^{IFS}}(x)$and $\nu_{\tilde{A}^{IFS}}(x)$ respectively.

Triangular Intuitionistic Fuzzy Number (TIFN): A TIFN $\tilde{A}^{IFN}$is an IFS in $\Re$ with the following Enrollment function $\mu_{\tilde{A}^{IFN}}$and non-participation capacity $\nu_{\tilde{A}^{IFN}}$defined by

$$\mu_{\tilde{A}^{IFN}}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ \frac{a_1-x}{a_3-a_2}, & a_2 \le x \le a_3 \\ 0, & otherwise \end{cases} \text{ and } \nu_{\tilde{A}^{IFN}}(x) = \begin{cases} \frac{a'_1-x}{a_2-a'_1}, & a'_1 \le x \le a_2 \\ \frac{x-a_2}{a'_3-a_2}, & a_2 \le x \le a'_3 \\ 0, & otherwise \end{cases}$$

Where$a'_1 \le a_1 \le a_2 \le a_3 \le a'_3$. This TIFN is denoted by $\tilde{A}^{IFN} = (a_1, a_2, a_3; a'_1, a_2, a'_3)$ in Fig 1.

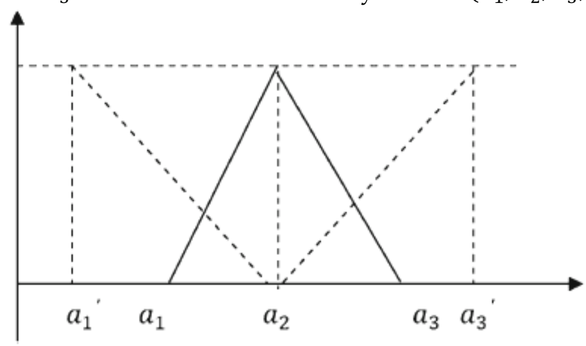

Figure 1: *Participation and non-enrollment elements of TIFN*

Arithmetic operations of TIFN:

Forany two TIFN's$\tilde{A}^{IFN} = (a_1, a_2, a_3; a'_1, a_2, a'_3)and\tilde{B}^{IFN} = (b_1, b_2, b_3; b'_1, b_2, b'_3)$, arithmetic operations are as follows,

(i) Addition:

$$\widetilde{A}^{IFN} \oplus \widetilde{B}^{IFN} = (a_1 + b_1, a_2 + b_{2,}, a_3 + b_3; a'_1 + b'_1, a_2 + b_2, a'_3 + b'_3)$$

(ii) Subtraction:

$$\widetilde{A}^{IFN} - \widetilde{B}^{IFN} = (a_1 - b_3, a_2 - b_{2,}, a_3 - b_1; a'_1 - b'_3, a_2 - b_2, a'_3 - b'_1)$$

(iii) Multiplication:

$$\widetilde{A}^{IFN} \otimes \widetilde{B}^{IFN} = (a_1 b_1, a_2 b_{2,}, a_3 b_3; a'_1 b'_1, a_2 b_2, a'_3 b'_3)$$

(iv) Scalar multiplication:

$$k \times \widetilde{A}^{IFN} = \begin{cases} (ka_1, ka_2, ka_3; ka'_1, ka_2, ka'_3), k \geq 0 \\ (ka_3, ka_2, ka_1; ka'_3, ka_2, ka'_1), k < 0 \end{cases}$$

III. Ranking Function

Ranking function is taken from [2], i.e., the ranking function is defined for Trapezoidal and triangular Intuitionistic fuzzy number as

$$R\left(\tilde{A}^{IFN}\right) = \left(\frac{a_1 + b_1 + 2(a_2 + b_3) + 5(a_3 + b_2) + (a_4 + b_4)}{18}\right)\left(\frac{4w_1 + 5w_2}{18}\right)$$

$$R\left(\tilde{A}^{IFN}\right) = \left(\frac{(a_1 + b_1) + 14a_2 + (a_4 + b_4)}{18}\right)\left(\frac{4w_1 + 5w_2}{18}\right)$$

Consider $w_1 = w_2 = 1$, we get ranking function is

$$R\left(\tilde{A}^{IFN}\right) = \left(\frac{(a_1 + b_1) + 14a_2 + (a_4 + b_4)}{36}\right)$$

Comparison of TIFN's: To contrast TIFN's and one another, we need to rank them. A function such as R: $F(\Re) \rightarrow \Re$, which maps each TIFN's into real line, is called ranking function. Here, $F(\Re)$means the arrangement of all TIFN's.

By using ranking function"R", TIFN's can be compared.

Let $\widetilde{A}^{IFN} = (a_1, a_2, a_3; a'_1, a_2, a'_3)$ and $\widetilde{B}^{IFN} = (b_1, b_2, b_3; b'_1, b_2, b'_3)$are two TIFN's then $\mathrm{R}\left(\widetilde{A}^{IFN}\right) = \frac{a_1+14a_2+a_3+a'_1+a'_3}{36}$ and $\mathrm{R}\left(\widetilde{B}^{IFN}\right) = \frac{b_1+14b_2+b_3+b'_1+b'_3}{36}$ then the orders are defined as follows

(i) $\widetilde{A}^{IFN} > \widetilde{B}^{IFN}$ if $\mathrm{R}\left(\widetilde{A}^{IFN}\right) > R\left(\widetilde{B}^{IFN}\right)$,

(ii) $\widetilde{A}^{IFN} < \widetilde{B}^{IFN}$ if $\mathrm{R}\left(\widetilde{A}^{IFN}\right) < R\left(\widetilde{B}^{IFN}\right)$, and

(iii) $\widetilde{A}^{IFN} = \widetilde{B}^{IFN}$ if $\mathrm{R}\left(\widetilde{A}^{IFN}\right) = \mathrm{R}\left(\widetilde{B}^{IFN}\right)$

Ranking function R also holds the following properties:

(i) $\mathrm{R}\left(\widetilde{A}^{IFN}\right) + \mathrm{R}\left(\widetilde{B}^{IFN}\right) = \mathrm{R}\left(\widetilde{A}^{IFN} + \widetilde{B}^{IFN}\right)$, (ii) $\mathrm{R}\left(\mathrm{k}\widetilde{A}^{IFN}\right) = \mathrm{k}\,\mathrm{R}\left(\widetilde{A}^{IFN}\right) \forall \mathrm{k} \in \boldsymbol{R}$

IV. Mathematical Formulation of Triangular Intuitionistic Fuzzy transportation problem (TIFTP) and proposed method

I. TIFTP of type - 2:

Consider a transportation with 'm' Intuitionistic Fuzzy (IF) origins and 'n' IF destination.

Let $C_{ij} (i = 1,2, \dots, m; j = 1,2, \dots, n)$ be the cost of transporting one unit of the product form i^{th}origin to j^{th}destination.

$\widetilde{a}_i^{IFS} = (a_1^i, a_2^i, a_3^i; a_1^{i'}, a_2^i, a_3^{i'})$ be IF extent at i^{th} vendor.

$\widetilde{b}_j^{IFS} = (b_1^i, b_2^i, b_3^i; b_1^{i'}, b_2^i, b_3^{i'})$ be IF abundant at j^{th} insistent.

$\widetilde{x}_{ij}^{IFS} = (x_1^{ij}, x_2^{ij}, x_3^{ij}; x_1^{ij'}, x_2^{ij}, x_3^{ij'})$ be IF quantity transformed fromi^{th}vendor to j^{th} insistent

Then balanced triangular IFTP of type - 2 is given by

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

$$s.t. \sum\nolimits_{j=1}^{n} \tilde{x}_{ij}^{IFN} = \tilde{a}_i^{IFN} \quad , i = 1, 2, \ldots, m$$

$$\sum\nolimits_{i=1}^{m} \tilde{x}_{ij}^{IFN} = \tilde{b}_j^{IFN} \quad , j = 1, 2, \ldots, n$$

$$\tilde{x}_{ij}^{IFN} \geq \tilde{0}; \ \ i = 1, 2, \ldots., m; \ j = 1, 2, \ldots., n$$

II. Proposed Transportation strategy

Stage 1: Utilizing separation formula, considered in "Comparison of IFTN's" segment, adopt least and greatest IFN from each archive and segmentof intuitionistic fuzzy price matrix of TIFTP of type - 2 and deduct it from each IFN's of their relating line and segment.

Stage 2: Find sum of row difference and column difference and denote row sum by R and column sum by C. Identify Maximum sum of row and column. Select maximum difference in row and column.

Stage 3: Choose the cell having most minimal expense in row and column identified in stage 2.

Stage 4: Make a feasible assignment to the cell picked in stage 5. Delete fulfilled row/column.

Stage 5: Repeat the technique until all the designations has been made.

Stage 6: The Optimum solution and triangular intuitionistic optimum value is attained in step 5, is optimum solution $\{x_{ij}\}$ and triangular intuitionistic fuzzy optimum value is $\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} \otimes x_{ij.}$

V. Numerical Example

In this part, an existing mathematical model ([2]) is solved to illustrate the proposed transportation strategy.

Table 1: *TIFTP of type – 2*

	D_1	D_2	D_3	D_4	Supply (s_i)
S_1	(2,4,5; 1,4,6)	(2,5,7; 1,5,8)	(4,6,8; 3,6,9)	(4,7,8; 3,7,9)	11
S_2	(4,6,8; 3,6,9)	(3,7,12; 2,7,13)	(10,15,20; 8,15,22)	(11,12,13; 10,12,14)	11
S_3	(3,4,6; 1,4,8)	(8,10,13; 5,10,16)	(2,3,5; 1,3,6)	(6,10,14; 5,10,15)	11
S_4	(2,4,6; 1,4,7)	(3,9,10; 2,9,12)	(3,6,10; 2,6,12)	(3,4,5; 2,4,8)	12
Demand (d_j)	16	10	8	11	45

Example 1: An existing TIFTP of type - 2, with four suppliers i.e., S_1, S_2, S_3, S_4 and four destinations i.e.,D_1 , D_2, D_3, D_4, respectively by Table 1, is solved using the proposed method. This problem is solved in the following steps.

Select maximum and minimum TIFN in each row and column take the difference as given in table 2.

Table 2: *Row and Column Difference Table*

	D_1	D_2	D_3	D_4	$Supply$ (s_i)	Row $diff$
S_1	(2,4,5; 1,4,6)	(2,5,7; 1,5,8)	(4,6,8; 3,6,9)	(4,7,8; 3,7,9)	11	1.4444
S_2	(4,6,8; 3,6,9)	(3,7,12; 2,7,13)	(10,15,20; 8,15,22)	(11,12,13; 10,12,14)	11	4.5
S_3	(3,4,6; 1,4,8)	(8,10,13; 5,10,16)	(2,3,5; 1,3,6)	(6,10,14; 5,10,15)	11	3.5
S_4	(2,4,6; 1,4,7)	(3,9,10; 2,9,12)	(3,6,10; 2,6,12)	(3,4,5; 2,4,8)	12	2.125
$Demand$ (d_j)	16	10	8	11	45	*R*=11.56
$Column$ $diff$	1.0555	2.6111	5.9444	3.9444	*C*=13.55	

The problem given in Table 2, transformed in Table 3 by using the Stage 2 and assign first allocation using stage 4 of proposed method.

Table 3: *First allocation Table*

	D_1	D_2	D_3	D_4	$Supply$	Row $difference$
S_1	(2,4,5; 1,4,6)	(2,5,7; 1,5,8)	(4,6,8; 3,6,9)	(4,7,8; 3,7,9)	11	1.4444
S_2	(4,6,8; 3,6,9)	(3,7,12; 2,7,13)	(10,15,20; 8,15,22)	(11,12,13; 10,12,14)	11	4.5
S_3	(3,4,6; 1,4,8)	(8,10,13; 5,10,16)	(2,3,5; 1,3,6) [**8**]	(6,10,14; 5,10,15)	~~11~~ **3**	3.5
S_4	(2,4,6; 1,4,7)	(3,9,10; 2,9,12)	(3,6,10; 2,6,12)	(3,4,5; 2,4,8)	12	2.125
$Demand$	16	10	~~8~~	11	45	R = 11.5416
$Column$ $difference$	1.0555	2.6111	5.9444	3.9444	***C* = 13.5554**	

Using Stage 4 of proposed method remove D_3 from Table 3. New reduced shown in Table 4 again apply the procedure.

Table 4: *New Reduced Table*

	D_1	D_2	D_4	Supply (s_i)	Row difference
S_1	(2,4,5; 1,4,6)	(2,5,7; 1,5,8)	(4,7,8; 3,7,9)	11	1.4444
S_2	(4,6,8; 3,6,9)	(3,7,12; 2,7,13)	(11,12,13; 10,12,14)	11	3
S_3	(3,4,6; 1,4,8)	(8,10,13; 5,10,16)	(6,10,14; 5,10,15)	3	3
S_4	(2,4,6; 1,4,7)	(3,9,10; 2,9,12)	(3,4,5; 2,4,8)	12	2.125
Demand (d_j)	16	10	11	45	$R = 9.5694$
Column differen	1.0555	2.6111	3.9444	$C = 7.6110$	

Table 5: *Second Allocation table*

	D_1	D_2	D_4	Supply (s_i)	Row diff
S_1	(2,4,5; 1,4,6)	(2,5,7; 1,5,8)	(4,7,8; 3,7,9)	11	1.4444
S_2	(4,6,8; 3,6,9)	(3,7,12; 2,7,13)	(11,12,13; 10,12,14)	11	3
S_3	(3,4,6; 1,4,8) [**3**]	(8,10,13; 5,10,16)	(6,10,14; 5,10,15)	3	3
S_4	(2,4,6; 1,4,7)	(3,9,10; 2,9,12)	(3,4,5; 2,4,8)	12	2.125
Demand (d_j)	$\cancel{16}$ **13**	10	11	45	$\boldsymbol{R = 9.5694}$
Column dif	1.0555	2.6111	3.9444	$C = 7.6110$	

Again, applying the Stage 5 of the proposed method, all the allocations are made as shown in Table 6.

Table 6: *Final allocation table*

	D_1	D_2	D_3	D_4
S_1	(2,4,5; 1,4,6) [**1**]	(2,5,7; 1,5,8) [**10**]	(4,6,8; 3,6,9)	(4,7,8; 3,7,9)
S_2	(4,6,8; 3,6,9) [**11**]	(3,7,12; 2,7,13)	(10,15,20; 8,15,22)	(11,12,13; 10,12,14)
S_3	(3,4,6; 1,4,8) [**3**]	(8,10,13; 5,10,16)	(2,3,5; 1,3,6) [**8**]	(6,10,14; 5,10,15)
S_4	(2,4,6; 1,4,7) [**1**]	(3,9,10; 2,9,12)	(3,6,10; 2,6,12)	(3,4,5; 2,4,8) [**11**]

Step 6: Optimum solution and IF optimum value

The optimum solution, obtained in Step 5, is $x_{11}=1, x_{12}=10, x_{21}=11, x_{31}=3, x_{33}=8, x_{41}=1$ and $x_{44}=11$. The IF optimum value of IFTP of type - 2, given in Table 1, is

$$1\otimes(2,4,5;1,4,6)\oplus 10\otimes(2,5,7;1,5,8)\oplus 11\otimes(4,6,8;3,6,9)\oplus 3\otimes(3,4,6;1,4,8)\oplus 8\otimes(2,3,5;1,3,6)\oplus 1\otimes(2,4,6;1,4,7)\oplus 11\otimes(3,4,5;2,4,8)=(126,204,282;78,204,352).$$

VI. Conclusion

Numerical Formulation for IFTP of type – 2 and system for acquiring an IF ideal arrangement is examined with relevant numerical example. The proposed transportation strategy is utilized to get the ideal arrangement of TIFTP of type – 2. The proposed transportation technique gives same outcome, as found by G. Gupta, A. Kumara [3], in single emphasis. Consequently, this might be favored over the current strategies.

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