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Interval Value Intuitionistic Fuzzy Transportation Problem Via Modified ATM

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Abstract

The transportation model provides effective solutions to the problem of how to get things to customers in a more skilled manner. Many unpredictable situations arise in real-world problems, such as traffic restrictions and weather conditions. Researchers and businesspeople are becoming interested in the interval value intuitionistic fuzzy set (IVIFS) to solve the uncertainty and hesitation of real-world problems. IVIFS' capacity to effectively judge real-world problems with uncertainty and hesitation is a standout feature. In this research, we apply a novel proposed ranking approach to solve an interval value intuitive fuzzy transportation problem utilizing the allocation table method (ATM) and proposed a new modified allocation table method. The effectiveness of the allotment table technique to illuminate the maximizing transportation issue is validated in this article. The modified allocation table technique (ATM) may be a well-organized strategy for unraveling the intuitive FTP with interval values.

1. Introduction

In 1941, Hitchcock [7] presented the basics of transportation dilemma. In 1953, Charnes et al [3] proposed venturing stone approach, which was a novel approach to the simplex technique. The fundamental simplex transportation approach was invented by Dantzig [5] in 1963. Many scholars have looked into various methods for reducing the cost of solving the transportation challenge. All parameters of the transportation problem may not be fully known in existing applications due to unpredictable variables. In 1965, Zadeh invented the fuzzy set and systems. H.J. Zimmermann deciphered fuzzy LPP in 1996. Furthermore, it has been noted that fuzzy systems do not manage unclear scenarios and do not hesitate when dealing with real-life challenges. Atanssov [1] has expanded dispersed sets to a powerful blurred set known as intuitionistic fuzzy set (IFS), which includes a non-wet grade extension. To improve IFS's capacity to contend with uncertainty and hesitation, Atanassov and Gargov [1] devised an interval-valued intuitionistic fuzzy set, which is a generalization of IFS in which the degree is an interval rather than a fixed real number for members and non-members. The IVIFS notion is a fascinating and effective technique for modeling and making decisions about real-life problems under uncertainty and hesitation, among the different FS generalizations. In 2006[10], Md Sharif et al debated the efficacy of the allocation table technique for solving the transportation maximization problem. Md Sharif suggested the Incessant Allocation Method for troubleshooting transportation issues in 2006[11]. In the year 2000, Li put forward a fuzzy technique to solving the multi-objective transportation problem[9]. Lee projected that interval-valued intuitionistic fuzzy numbers may be employed in decision-making in 2009[8]. In 2011[12], Nayagam et al implied a modified grading of IVIFS. Chen in 2014[4] introduced the LINMAP methodology for multicriteria decision analytics in IVIFS. In 2017, Darunee et al suggested a Robust ranking technique and ATM-based strategy for tackling a fuzzy transportation problem [6]. Bharati introduced a novel ranking approach for addressing IVIFS in 2018[2]. In 2021, Shailendra Kumar Bharati presented a new ranking technique for transportation problem using IVIFS.

This paper proposes an modified ATM technique for Interval Valued Intuitionistic Fuzzy Transportation Problem (IVIFTPP). IVIFTPP can handle uncertainty and hesitation predicaments by characterizing the outlay of transportation problems as intuitionistic fuzzy numbers with triangular intervals as the value, incorporating triangular membership functions and triangular non-membership functions. A novel ranking technique for defuzzification is applied to get the best IVIFTPP solution. The proposed modified ATM strategy has received much interest among users who are searching for a much more reasonable solution than the conventional fuzzy approaches for its extreme accuracy, reliability, and versatility. We have illustrated a numerical example to validate the proposed method.

2. Preliminaries:

Definition 1: (Atanassov): Let Y be an universal set. An intuitionistic fuzzy set S in Y is of the form $S=\{y, \mu_s(y), \nu_s(y)\}$, where $\mu_s(y): Y \to [0,1]$ and $\nu_S(y): Y \to [0,1]$ define the degree of membership and degree of non-membership of the element $y \in Y$, respectively, and for every $y \in Y$, $0 \le \mu_s(y) + \nu_s(y) \le 1.$

The value of $\pi_s(y) = 1 - \mu_s(y) - \nu_s(y)$ is called the degree of non-determinacy (or uncertainty) of the element $y \in Y$ to the intuitionistic fuzzy set S.In IFS, if $\pi_s(y)$=0, then an IFS becomes a FS and it takes the form $S=\{y, \mu_s(y), 1-\nu_s(y))\}$.

Definition2: An interval-valued intuitionistic fuzzy number is expressed as:

$A=\{(p,q,r):[\mu^-,\mu^+],[\nu^-,\nu^+]\}$, where $\mu^-: Y \to [0,1]$, $\mu^+(y): Y \to [0,1]$ define the lower and upper degrees of memberships, and $\nu^-: Y \to [0,1]$, $\nu^+(y): Y \to [0,1]$ define lower and upper degrees of non-memberships, and these are:

$$\mu_s^-(y) = \begin{cases} \mu^{-\frac{(y-p)}{(q-p)},}, & p < y < q \\ \mu^- & y = q \\ \mu^{-\frac{(r-y)}{(r-q)},} & q < y < r \end{cases}$$

$$\mu_s^-(y) = \begin{cases} \mu^{-\frac{(y-p)}{(q-p)},}, & p < y < q \\ \mu^- & y = q \\ \mu^{-\frac{(r-y)}{(r-q)},} & q < y < r \end{cases}$$

$$\nu_s^-(y)=\begin{cases}1-(1-\nu^-)\dfrac{(y-p)}{(q-p)}, & p<y<q\\ \nu^- & y=q\\ \nu^-+(1-\nu^-)\dfrac{(y-q)}{(r-q)} & q<y<r\end{cases}$$

$$\nu_s^+(y)=\begin{cases}1-(1-\nu^-)\dfrac{(y-p)}{(b-a)}, & p<y<q\\ \nu^+ & y=q\\ \nu^++(1-\nu^+)\dfrac{(y-p)}{(r-p)} & q<y<r\end{cases}$$

Lemma: Let S_1 and S_2 be two interval-valued intuitionistic fuzzy numbers, and $R(S)=\frac{(p+2q+r)(\mu^-+\mu^++2-\gamma^--\gamma^+)}{16}$ ---(1)

Then exactly one of the following is true:

(i) If $R(S_1)<R(S_2)$, $then\, S_1<S_2$

(ii) If $R(S_1)>R(S_2)$, $then\, S_1>S_2$

(iii) If $R(S_1)=R(S_2)$, $then\, S_1=S_2$

III Modified Allocation Table Method:

A modified ATM for handling transportation difficulties in order to save time and maximize profit is illustrated here.

Step 1: From the given IVIFTPP, generate a Transportation Table (TT) by defuzzying the given IVIF numbers by using the lemma (1).

Step 2: Check to see if the TP is balanced, and if it isn't, balance it.

Step 3: From all the cost cells of the TT, select the Least Odd Cost (LOC). If there is no odd cost in the TT's cost cells, divide all of them by 2 (two) until there is at least one odd cost in the cost cells.

Step 4: Create an allocation table (AT) by retaining the LOC in the operational cost cell/cells and subtracting selected LOC from each of the TT's odd cost valued cells. All cell entries in AT are now referred as Allocation Cell Values (ACV).

Step 5: At the designated ACV's location in the AT, classify the minimum ACV and allot the minimum quantity of resource. If two ACVs have the same minimum allocation, choose the one with the highest allotment. Choose the minimum cost cell that corresponds to the cost cells of TT produced in Step-1, if the ACVs have the same allocation .Pick the cell that is nearest to the demand/supply minimum that needs to be allocated if the cost cells and allotments are similar Delete the column if requirements are satisfied, and the row if production is complied.

Step-6: Steps 5 and 6 should be continued until the demand and supply are exhausted.

Step-7: Revisit to the initial TT with this allotment.

Step 8: Finally, calculate the TT's overall profit. This calculation is the result of multiplying the cost by the TT's allotted value.

IV NUMERICAL EXAMPLE

Interval-valued Intuitionistic Fuzzy Transportation Problem

Consider an IVIFTP with three sources, S1, S2, and S3, and three destinations, D1, D2, and D3. Table 1 shows the cost of conveying one unit of products from the i^{th} source to the j^{th} destination, with the elements being IVIFTP. Determine the cheapest total fuzzy transportation alternative.

TABLE 1: Interval Valued Intuitionistic Fuzzy transportation problem

	D1	D2	D3	ai
S1	{(1,4,9); [0.1,0.5], [0.01,0.03]}	{(3,13,14); [0.2,0.4], [0.02,0.04]}	{(4,6,16); [0.3,0.4], [0.03,0.07]}	7
S2	{(4,5,7); [0.3,0.4], [0.01,0.02]}	{(5,10,15); [0.2,0.5], [0.01,0.04]}	{(7,16,24); [0.3,0.5], [0.02,0.03]}	15
S3	{(1,3,6); [0.4,0.5], [0.01,0.02]}	{(5,13,21); [0.3,0.4], [0.03,0.04]}	{(8,18,27)ꞌ[0.4,0.5], [0.05,0.05]}	10
bj	8	6	18	

by the lemma and by equation (1),the formula for ranking the IVIFTP is given bellow.

$$R(A) = \frac{(p+2q+r)(\mu^{-}+\mu^{+}+2-\gamma^{-}-\gamma^{+})}{16}$$

{(1,4,9); [0.1,0.5], [0.01,0.03]}

$$R(A) = \frac{(1+2*4+9)(0.1+0.5+2-0.01-0.03)}{16}$$

$$= \frac{(1+8+9)(2.6-0.01-0.03)}{16}$$

$$= \frac{(1+8+9)(2.6-0.04)}{16}$$

$$= \frac{(18)(2.56)}{16} = \frac{46.06}{16} = 2.8$$

Preceding with the above process convert all IVIFTP into crisp numbers

TABLE 2: Crisp Interval Valued Intuitionistic FTP

	D1	**D2**	**D3**	**a_i**
S1	2.88	6.8	5.2	7
S2	3.5	6.6	10.8	15

S3	2.3	8.5	12.4	10
b_j	8	6	18	

By step 2

Verify if the given problem is balanced or not.

$\sum a_i = \sum b_j = 32$

Using **step 3,** choose the cost cell (3, 1) with the least cost 2.3 out of all the cost cells in Table 2.

Step 4: Create a new table called allocation table by retaining the minimum odd cost 2.3 in the corresponding cost cell/cells as is, and subtracting the specified minimum odd cost 2.3 from each of the FTT's odd cost valued cells. In the allocation table, each cell value is now referred to as an allocation cell value.

TABLE 3: Allocation Table

	D1	D2	D3	ai
S1	2.88	6.8	5.2	7
S2	1.2	6.6	10.8	15
S3	2.3	6.2	12.4	10
bj	8	6	18	

By **step 5** the min allocation cost from the AT is 1.2 in (2,1) and the minimum of supply/demand (8) is allocated at the place of selected ACV in the A

TABLE 4: Allocating the Minimum of Supply/Demand

	D1	D2	D3	ai
S1	2.88	6.8	5.2	7
S2	1.2,8	6.6	10.8	15,7
S3	2.3	6.2	12.4	10
bj	8,0	6	18	

Now column D1 is exhausted.

By proceeding by the above steps until the demand and supply are exhauste

TABLE 5: Allocating the Minimum of Supply/Demand.

	D2	D3	ai
S1	6.8	5.2	7
S2	6.6	10.8	7
S3	6.2	12.4	10
bj	6	18	

TABLE 6: Final Allocation

	D1	D2	D3	ai
S1	2.88	6.8	5.2,**7**	7
S2	3.5,**8**	6.6	10.8,**7**	15
S3	2.3	8.5,**6**	12.4,**4**	10
b_j	8	6	18	

Therefore, $X_{21}=8$, $x_{13}=7$,$x_{23}=7$,$x_{32}=6$,$x_{33}=4$ are optimal solutions and minimum cost is :

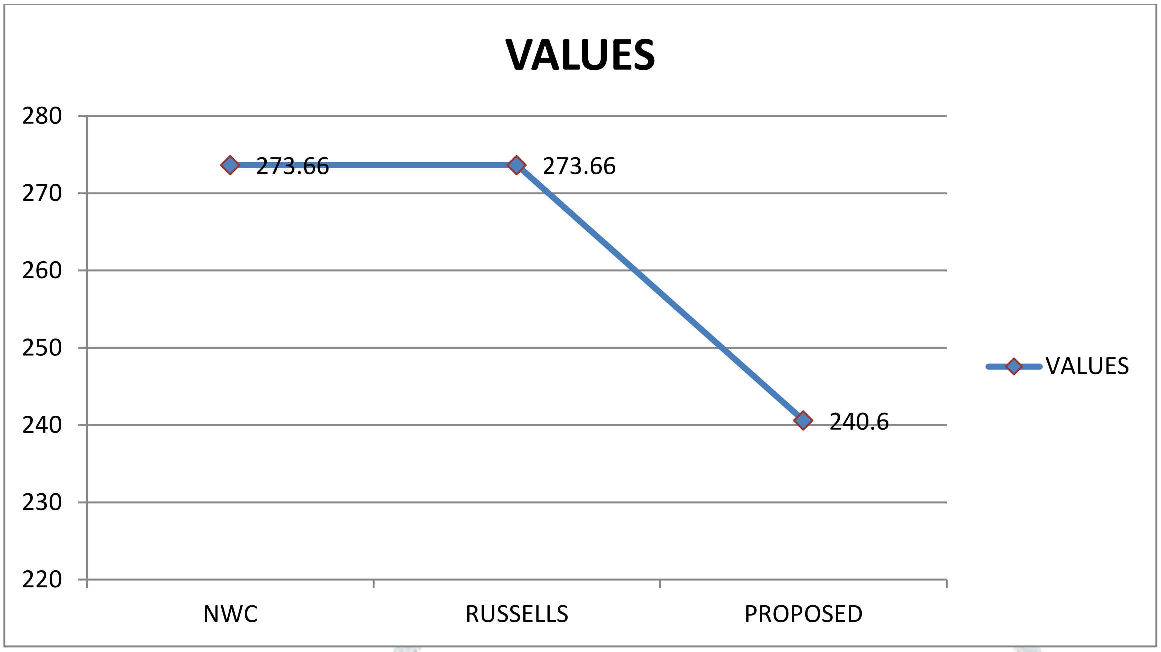
(3.5x8)+ (5.2x7) + (10.8x7) + (8.5x6) +(12.4x4)

= 28+36.4+75.6+51+49.6 =240.6

This procedure of applying Modified ATM with the given ranking technique is applied for the problem discussed by Shailendra Kumar Bharati.

By applying the same procedure with the other existing methods like North West Corner and Russell's method we have the result given in the table below.

NWC	RUSSELLS	PROPOSED
273.66	273.66	240.6



Hence our method gives an better result than the above methods.

V CONCLUSION

Modified ATM is applied to find the IBFS in this paper. By utilizing the proposed ranking the IVIFTP is defuzzified. This method is straightforward and has little iteration. As a result this proposal can be applied to handle the real-life transportation problem. A comparison of our proposed method is applied with the above existing methods and the proposed method gives a better approximation.

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