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HEPTAGONAL INTUITIONISTIC FUZZY NUMBER AND IT'S APPLICATION

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Abstract: The objective of this paper is to introduce the Heptagonal Intuitionistic fuzzy number. In addition to this new ranking technique for Heptagonal Intuitionistic fuzzy number to convert the intuitionistic fuzzy number into a crisp value. Applying this novel technique we also obtain the minimum transportation cost for the intuitionistic fuzzy transportation problem.
Keywords: Fuzzy number, Heptagonal fuzzy number,Intuitionistic fuzzy number, Heptagonal Intuitionistic fuzzy number, Ranking function.

1. INTRODUCTION

Intuitionistic fuzzy set is a tool in modelling real life problems like sale analysis, new product marketing, financial services, negotiation process, psychological investigations etc.,. Also it has greater influence in solving transportation problem to find the optimal solution in which the cost, supply and demand are Intuitionistic fuzzy numbers. The concept of intuitionistic fuzzy sets was presented by Atanassov which was established to be extremely useful to deal with vagueness. The intuitionistic fuzzy set separates the degree of membership with degree of non-membership of an element in the set. This is the main advantage of the intuitionistic fuzzy set.

The transportation problem is one of the sub-classes of Linear Programming Problems in which the objective is to transport various quantities of a single homogeneous commodity, that are initially stored at various origins, to different destinations in such a way that the total transportation cost is minimum.To achieve this objective we must know the amount and location of available supplies and the quantities demanded. And also the costs that result from transporting one unit of commodity from various origins to various destinations should also be known.

The Intuitionistic fuzzy transportation problem (IFTP) is one of the special kinds of Intuitionistic fuzzy linear programming problem. An IFTP is a transportation problem in which the transportation costs, supply and demand quantities are intuitionistic fuzzy quantities. Paul et al.[5] proposed a new method for solving transportation problem using triangular intuitionistic fuzzy number. Ponnivalavan and Pathinathan[6] have introduced a new number called Pentagonal Intuitionistic fuzzy number in 2015. Annie christi and Kasthuri[1] proposed a new method using the Pentagonal Intuitionistic fuzzy number in 2016. Recently in 2017, Sahaya Sudha and Karunambigai[9] have introduced the Heptagonal fuzzy number to solve the transportation problem. Now we have introduced the Heptagonal Intuitionistic fuzzy number to solve the transportation problems. Also we have introduced a ranking technique to defuzzify the HpIFN.

2. PRELIMINARIES

Definition 1. Fuzzy Set Let X be a non-empty set. A fuzzy set $\bar{A}$ of X is defined as $\bar{A} = (x, \mu_{\bar{A}}(x); x \in X)$ where $\mu_{\bar{A}}(x)$ is called the membership function which maps each element of X to a value between 0 and 1.

Definition 2. Fuzzy Number A fuzzy number $\bar{A}$ is a convex normalized fuzzy set on the real line R such that:

(i) There exist at least one $x \in R$ with $\mu_{\bar{A}}(x) = 1$

(ii) $\mu_{\bar{A}}(x)$ is piecewise continuous.

Definition 3. Heptagonal Fuzzy Number A fuzzy number $\bar{A}$ denoted by $\bar{A} = (a_1, a_2, a_3, a_4, a_5, a_6, a_7)$ in R where $a_1, a_2, a_3, a_4, a_5, a_6, a_7$ are real numbers is said to be a Heptagoal fuzzy number if its membership function $\mu_H: R \to [0,1]$ has the following characteristics.

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & \text{for } x \le a_1 \\ \frac{1}{2}\left(\frac{x-a_1}{a_2-a_1}\right), & for\ a_1 \le x \le a_2 \\ \frac{1}{2}, & for\ a_2 \le x \le a_3 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_3}{a_4-a_3}\right) & for\ a_3 \le x \le a_4 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{a_5-x}{a_5-a_4}\right) & for\ a_4 \le x \le a_5 \\ \frac{1}{2}, & for\ a_5 \le x \le a_6 \\ \frac{1}{2}\left(\frac{a_7-x}{a_7-a_6}\right), & for\ a_6 \le x \le a_7 \\ 0 & for\ x \ge a_7 \end{cases}$$

Definition 4. Intuitionistic Fuzzy set Let X be a nonempty set. A intuitionistic fuzzy set $\tilde{A}^I$ of X is defined as $\tilde{A}^I = (x, \mu_{\tilde{A}^I}(x), \vartheta_{\tilde{A}^I}(x)); x \in X$ where $\mu_{\tilde{A}^I}(x)$ and $\vartheta_{\tilde{A}^I}(x)$ are the membership function and non-membership function such that $\mu_{\tilde{A}^I}(x), \vartheta_{\tilde{A}^I}(x): X \to [0,1]$ and $0 \le \mu_{\tilde{A}^I}(x), \vartheta_{\tilde{A}^I}(x) \le 1$ for all $x \in X$.

Definition 5. Intuitionistic Fuzzy number An intuitionistic fuzzy subset
$\tilde{A}^I = (x, \mu_{\tilde{A}^I}(x), \vartheta_{\tilde{A}^I}(x); x \in X)$ of the real line R is called an intuitionistic fuzzy number (IFN) if the following conditions holds:
(i) There exist x $\in R$ such that $\mu_{\tilde{A}^I}(x) = 0$ and $\vartheta_{\tilde{A}^I}(x) = 0$
(ii) $\mu_{\tilde{A}^I}(x)$ is continuous function from $R \to [0,1]$ such that $0 \le \mu_{\tilde{A}^I}(x) + \vartheta_{\tilde{A}^I}(x) \le 1$ for all x $\in X$.

3. HEPTAGONAL INTUITIONISTIC FUZZY NUMBER (HPIFN)

Following are the newly introduced Heptogonal Intuitionistic fuzzy number and the ranking technique for the Heptogonal Intuitionistic fuzzy transportation problem.

1. *Heptagonal Intuitionistic Fuzzy Number*

An Intuitionistic fuzzy number A^I in R is said to be a Heptagoal Intuitionistic fuzzy number if its membership function $\mu_A^I(x): R \to [0,1]$ and non membership function $\vartheta_{\tilde{A}^I}(x): R \to [0,1]$ has the following characteristics. We denote the heptagonal intuitionistic fuzzy number $A^I = (a_1, a_2, a_3, a_4, a_5, a_6, a_7;\ a_1', a_2', a_3', a_4', a_5', a_6', a_7')$ where $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_1', a_2', a_3', a_4', a_5', a_6', a_7'$ are real numbers 2

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & for\ x < a_1 \\ \frac{1}{2}\left(\frac{x-a_1}{a_2-a_1}\right), & for\ a_1 \le x \le a_2 \\ \frac{1}{2}, & for\ a_2 \le x \le a_3 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_3}{a_4-a_3}\right) & for\ a_3 \le x \le a_4 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{a_5-x}{a_5-a_4}\right) & for\ a_4 \le x \le a_5 \\ \frac{1}{2}, & for\ a_5 \le x \le a_6 \\ \frac{1}{2}\left(\frac{a_7-x}{a_7-a_6}\right), & for\ a_6 \le x \le a_7 \\ 0 & for\ x \ge a_7 \end{cases}$$

$$\vartheta_{\tilde{A}}(x) = \begin{cases} 1 & \text{for } x \le a_1' \\ \frac{1}{2}-\frac{1}{2}\left(\frac{a_2'-x}{a_2'-a_1'}\right) & for\ a_1' \le x \le a_2' \\ \frac{1}{2}, & for\ a_2' \le x \le a_3' \\ \frac{1}{2}\left(\frac{a_3'-x}{a_4'-a_3'}\right) & for\ a_3' \le x \le a_4' \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_5'}{a_5'-a_4'}\right) & for\ a_4' \le x \le a_5' \\ \frac{1}{2}, & for\ a_5' \le x \le a_6' \\ \frac{1}{2}\left(\frac{x-a_7'}{a_7'-a_6'}\right), & for\ a_6' \le x \le a_7' \\ 1 & for\ x \ge a_7' \end{cases}$$

The graphical representation of the Heptogonal Intuitionistic fuzzy number is given below

[Picture: *"HIFN.jpg"* , click on me and press F9]

2. *Operations on Heptagonal intuitionistic fuzzy number*

Let $A = (a_1, a_2, a_3, a_4, a_5, a_6, a_7; \quad a_1', a_2', a_3', a_4', a_5', a_6', a_7')$ and $B = (b_1, b_2, b_3, b_4, b_5, b_6, b_7; b_1', b_2', b_3', b_4', b_5', b_6', b_7')$ be two triangular fuzzy numbers then the arithmetic operations on a and b as follows.

(i) Addition : $a + b = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4, a_5 + b_5, a_6 + b_6, a_7 + b_7; a_1' + b_1', a_2 + b_2, a_3' + b_3', a_4' + b_4', a_5 + b_5, a_6' + b_6', a_7' + b_7')$

(ii) Subtraction : $a - b = (a_1 - b_7, a_2 - b_6, a_3 - b_5, a_4 - b_4, a_5 - b_2, a_6 - b_2, a_7 - b_1; a_1' - b_7', a_2' - b_6', a_3' - b_5', a_4' - b_4', a_5' - b_3', a_6' - b_2', a_7' - b_1')$

3. *Ranking HpIFN Based on Accuracy Function*

Accuracy function of a Heptagonal Intuitionistic fuzzy number $\tilde{A}^I = (a_1, a_2, a_3, a_4, a_5, a_6, a_7; a_1', a_2', a_3', a_4', a_5', a_6', a_7')$ is defined as $R(\tilde{A}^I) = Max(R(\mu_{\tilde{A}}(x)), R(\vartheta_{\tilde{A}}(x)))$

where $R(\mu_{\tilde{A}}(x)) = \frac{a_1+a_2+a_3+a_4+a_5+a_6-a_7}{5}$ and $R(\vartheta_{\tilde{A}}(x)) = \frac{a_1'+a_2'+a_3'+a_4'+a_5'+a_6'-a_7'}{5}$

4. *Intuitionistic Fuzzy Transportation problem*

Consider a transportation problem with m intuitionistic fuzzy (IF) origins and n IF destinations. Let $c_{ij}(i = 1,2,\ldots,m, j = 1,2,\ldots,n)$ be the cost of transporting one unit of the product from i^{th} origin to j^{th} destination. Let $\tilde{a}_i^I(i = 1,2,\ldots,m)$ be the quantity of commodity available at IF origin i. Let $\tilde{b}_j^I(j = 1,2,\ldots,n)$ is quantity of commodity needed of IF destination j. Let $x_{ij}(i = 1,2,\ldots,m, j = 1,2,\ldots,n)$ is quantity transported from i^{th} IF origin to j^{th} destination.

Mathematical Model of Intuitionistic Fuzzy transportation is

$Minimize \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} * x_{ij}$

subject to $\sum_{j=1}^{n} x_{ij} = a_i, i = 1,2,\ldots,m$

$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2,\ldots,n$

$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

5. *Proposed Algorithm*

There are many methods to find the basic feasible solution for a transportation problem we have analysed a fuzzy version of Russell' s Method which gives the better optimal solution compared with other methods.

Step 1:

Construct the fuzzy transportation table for the given fuzzy transportation problem and then, convert it into a balanced one, if it is not.

Step 2:

Using the above ranking function, the fuzzy transportation problem is converted into a crisp value problem and solved using Russell' s Method.

Step 3:

(i) In the reduced FTP, identify the row and column difference considering the least two numbers of the respective row and column.

(ii) Select the maximum among the difference (if more than one, then select any one) and allocate the respective demand/supply to the minimum value of the corresponding row or column.

(iii) We take the difference of the corresponding supply and demand of the allocated cell which leads either of one to zero, eliminating corresponding row or column (eliminate both row and column if both demand and supply is zero)

(iv) Repeat the steps ((i),(ii) and(iii)) until all the rows and columns are eliminated.

(v) Finally total minimum cost is calculated as sum of the product of the cost and the allocated value.

6. *Numerical Example*

Consider an Intuitionistic fuzzy transportation problem whose cost, supply and demand values are Heptagonal intuitionistic fuzzy number.

[Picture: *"Table.jpg"* , click on me and press F9]

By using the new ranking function the above HpIFN can be converted into the crisp values and the new crisp transportation problem is given below

[Picture: *"Crisp.jpg"* , click on me and press F9]

center

[Picture: *"Allocation.jpg"* , click on me and press F9]

section

4. CONCLUSION

In this paper we have introduced Heptagonoal intuitionistic fuzzy number and its ranking technique. This innovative concept provides us the minimum transportation cost for the intuitionistic fuzzy transportation problem. The proposed technique is excellently proven in the given numerical illustration.

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