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Solution of Intuitionistic Fuzzy Matrix Games Using Centroid Method

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Abstract**:** ***The purpose of this paper is to give a solution procedure for matrix games in fuzzy enviornment. In this paper the payoffs of matrix is represented by trapezoidal intuitionistic fuzzy numbers. Different types of ranking approaches are used to solve matrix games but there exist rare use of centroid concept. In this paper centroid concept is used to rank trapezoidal intuitionistic fuzzy numbers and to solve fuzzy game problem. In this paper a relation is also given to convert trapezodial numbers into triangular intuitionistic fuzzy numbers. A numerical example is also given to justify the proposed ranking method.***

Index Terms**:** ***Fuzzy matrix game, Trapezodial Intuitionistic fuzzy numbers, Triangular intuitionistic fuzzy numbers, Ranking function, centroid method.***

I. INTRODUCTION

Game theory deals with the study of decision making in competing situations where two or more opponents select their best strategy to maximize their gain. The technique of game theory was originated by John von Neumann, a mathematician and the Economist Oskar Morgenstren [3]. Their approach is based on the principle of minimization of the maximum losses. Nash [2] proved that a finite game problem always has a point of equilibrium at which all the opponents choose their best strategy. However there is lack of certainty in the environment so such situations can be modeled by using fuzzy set theory. Zadeh [30] was the first to introduce fuzzy set theory. Cevikel and Ahlatcioglu [21] considered two models to study two persons zero sum fuzzy matrix games whose payoffs and goals are fuzzy and obtained that there is equivalent relation in max-min. The approach to solve fuzzy problems which consist intersection of given fuzzy constraints and fuzzy goals was given by Bellman and Zadeh [1]. Jain [4] gave a procedure to compare the rating of optimal alternatives to other alternatives in the fuzzy environment. The concept of intuitionistic fuzzy set theory was introduced by Atanassov [5] in which membership and non membership both are included to deal with the vague problems. There are various studies on fuzzy game theory and there are many approaches to rank the generalized fuzzy numbers [22-28]. Varghese and Kuriakose [7] introduced a formula and properties for finding the centroid of intuitionistic fuzzy cooperative bi- matrix games. Li et.al [11] developed a ranking method of TIFN's by using values and ambiguities index to solve decision making problems. Li et.al [12] proposed a method for solving fuzzy matrix game problems in which payoffs are Atanassov's TIFN's and the base of the given methodology is weighted average method used to find optimal strategies. Parkash et.al [18] introduced the concept of centroid to rank trapezodial and triangular intuitionistic fuzzy numbers. Nan et.al [13] defined two intuitionistic fuzzy non linear programming models to solve matrix games whose payoffs are TrIFNs. In their paper a ranking method based on value and ambiguity is used to convert the matrix game problem into bi-objective non linear programming models and find the optimal solution. Bhaumik et al [6] used robust ranking technique to triangular intuitionistic fuzzy numbers to solve matrix game. Seikh et.al [14] introduced a methodology to convert the triangular intuitionistic fuzzy numbers into crisp nonlinear programming problem and then obtain optimal solution of matrix game. Nayak and Pal [8] presented an application of intuitionistic fuzzy linear programming problem to matrix games involving two players. Li [9] developed a new methodology for ranking of triangular intuitionistic fuzzy numbers. He defined values and ambiguities of TIFN for membership and non membership functions. Seikh et.al [10] introduced the concept of inequality relations between two TIFN's and applied these numbers to find nash equilibrium solution for bi matrix games. Verma et.al [15] defined a new Mehar's method to solve matrix game problems in which payoffs are represented by triangular intuitionistic fuzzy numbers. Nayagam and Sivaraman [16] introduced a new method based on upper lower dense sequence to find the total ordering on the entire class of intuitionistic fuzzy numbers. An et.al [17] proposed ranking method based on weighted mean area of IFN's. They introduced the concept of pareto optimal solution. Nan et al. [19]

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proposed a ranking technique for value and ambiguity of TIFNs and used this technique to solve matrix game problems. Selvakumari and Lavanya [20] defined ranking of octagonal intutionistic fuzzy numbers based on the approach alpha cuts and used the ranking method to convert the intuitionistic fuzzy numbers into crisp to solve fuzzy game problems. The most of the existing research is available on the different ranking techniques to convert intuitionistic fuzzy numbers into crisp numbers to solve optimizations problems. But not enough literature is available on ranking of these fuzzy numbers by using centroid method and for solving game problems where payoffs are expressed in trapezodial intuitionistic fuzzy numbers.

The paper is discussed in different sections which consist of basic definitions of intuitionistic fuzzy numbers, the centroid based ranking method, algorithm to solve fuzzy game problems, numerical example and discussion on results.

II. PREMILINARIES

Definition 2.1 [5] Let X = {x} is a collection of objects denoted generally *by x. Then an Intuitionistic fuzzy set* $\widetilde{A}$ *in X is a set* $\widetilde{A}$ = {(x, $\mu_{\tilde{A}}(x)$, $v_{\tilde{A}}(x)$); x ∈ X} *where* $\mu_{\tilde{A}}(x)$ is termed as the grade of membership of x in A and *where* $v_{\tilde{A}}(x)$ is termed as the grade of non membership of x in A. $\mu_{\tilde{A}}, v_{\tilde{A}}(x)$: X → M is a function from X to a space M which are called membership space. When M contains only two points, 0 and 1.Here $0 \le \mu_{\tilde{A}}(x)+v_{\tilde{A}}(x) \le 1, \forall\, x \in X$

Definition 2.2 [5] $\pi_{\tilde{A}}(x) = 1 - \mu_{\tilde{A}}(x) - v_{\tilde{A}}(x)$ is defined as degree of hesitation.

Definition 2.3 [5] An intuitionistic fuzzy numbers (IFN) $\widetilde{A}$ has the following properties:

- $\widetilde{A}$ is convex for membership function $\mu_{\tilde{A}}$ *(x),* $i.e.\ \mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min[\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)]$
- $\widetilde{A}$ is concave for non-membership function $v_{\tilde{A}}$ *(x),* $i.e.\ v_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \le \max[v_{\tilde{A}}(x_1), v_{\tilde{A}}(x_2)]$
- $\widetilde{A}$ is normal.

Definition 2.4 [18] Trapezodial Intuitionistic fuzzy number

A intuitionistic fuzzy number $\widetilde{A_{Tr}} = \langle (a_1, b_1, c_1, d_1); (a_2, b_2, c_2, d_2) \rangle$ is a Trapezodial Intuitionistic fuzzy number (where $a_2 \le a_1 \le b_2 \le b_1 \le c_1 \le c_2 \le d_1 \le d_2$) if its membership function and non-membership function is defined by

$$\mu_{\widetilde{A_{Tr}}}(x) = \begin{cases} 0 & x < a_1 \\ \left(\frac{x-a_1}{b_1-a_1}\right) & a_1 \le x \le b_1 \\ 1 & b_1 \le x \le c_1 \\ \left(\frac{x-d_1}{c_1-d_1}\right) & c_1 \le x \le d_1 \\ 0 & x > d_1 \end{cases}$$

and

$$v_{\widetilde{A_{Tr}}}(x) = \begin{cases} 1 & x < a_2 \\ \left(\frac{x-b_2}{a_2-b_2}\right) & a_2 \le x \le b_2 \\ 1 & b_2 \le x \le c_2 \\ \left(\frac{x-d_2}{c_2-d_2}\right) & c_2 \le x \le d_2 \\ 1 & x > c_2 \end{cases}$$

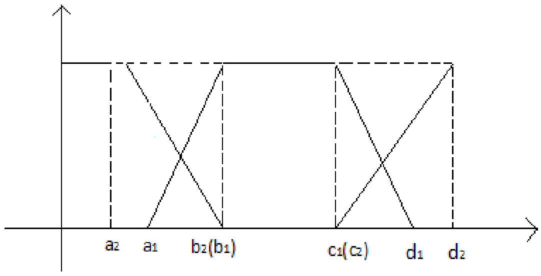

Fig-1

Remark: In the above definition if $b_1 = b_2 = c_1 = c_2$ then the trapezoidal intuitionistic fuzzy numbers are converted into triangular intuitionistic fuzzy numbers. In this membership function $\mu_{\widetilde{A_T}}$(x) increases at the constant rate in the interval $[a_1, b_1]$ and decreases in the interval $[b_1, c_1]$. Similarly non-membership function $v_{\widetilde{A_T}}$(x) decreases at the constant rate in the interval $[a_2, b_1]$ and increases in the interval $[b_1, c_2]$.

Definition 2.5 Arithmetic Operations: The addition, subtraction and scalar multiplication of two Trapezodial Intuitionistic Fuzzy Number

$\widetilde{A_{Tr}} = \langle (a_1, b_1, c_1, d_1); (a_2, b_2, c_2, d_2) \rangle$

And

$\widetilde{B_{Tr}} = \langle (e_1, f_1, g_1, h_1); (e_2, f_2, g_2, h_2) \rangle$ is defined as under:

Addition:

$\widetilde{A_{Tr}} + \widetilde{B_{Tr}} = \langle (a_1 + e_1, b_1 + f_1, c_1 + g_1, d_1 + h_1); (a_2 + e_2, b_2 + f_2, c_2 + g_2, d_2 + h_2) \rangle$

Subtraction:

$\widetilde{A_{Tr}} - \widetilde{B_{Tr}} = \langle (a_1 - e_1, b_1 - f_1, c_1 - g_1, d_1 - h_1); (a_2 - e_2, b_2 - f_2, c_2 - g_2, d_2 - h_2) \rangle$

and

Scalar Multiplication:

$$\lambda \widetilde{A_{Tr}} = \begin{cases} \langle (\lambda a_1, \lambda b_1, \lambda c_1, \lambda d_1); (\lambda a_2, \lambda b_1, \lambda c_2, \lambda d_2) \rangle \; if \; \lambda \geq 0 \\ \langle (\lambda d_1, \lambda c_1, \lambda b_1, \lambda a_1); (\lambda d_2, \lambda c_2, \lambda b_1, \lambda a_2) \rangle \; if \; \lambda < 0 \end{cases}$$

; λ *is any real numb*

III. CENTROID BASED RANKING METHOD [18]

Here we consider centroid ranking technique of trapezodial intuitionistic fuzzy numbers TrIFN. This ranking technique with centroid value uses geometric centre of these fuzzy numbers. The centre corresponds to the values $\tilde{x}(A_{Tr})$ on the horizontal axis and the values $\tilde{y}(A_{Tr})$ *on the* vertical axis. The centroid point of TrIFN is $\left(\tilde{x}(A_{Tr}), \tilde{y}(A_{Tr})\right)$

$$\widetilde{x_\mu}(A_{Tr}) = \frac{1}{3}\left[\frac{c_1^2+d_1^2-a_1^2-b_1^2-a_1b_1+c_1d_1}{d_1+c_1-b_1-a_1}\right] ,$$

$$\widetilde{x_\nu}(A_{Tr}) = \frac{1}{3}\left[\frac{2d_2^2-2a_2^2+2b_2^2+2c_2^2+a_2b_2-c_2d_2}{d_2+c_2-a_2-b_2}\right] \text{ and}$$

$$\widetilde{y_\mu}(A_{Tr}) = \frac{1}{3}\left[\frac{a_1+2b_1-2c_1-d_1}{a_1+b_1-c_1-d_1}\right] ,$$

$$\widetilde{y_\nu}(A_{Tr}) = \frac{1}{3}\left[\frac{2a_2+b_2-c_2-2d_2}{a_2+b_2-c_2-d_2}\right]$$

The ranking function of TrIFN of

$\widetilde{A_{Tr}} = \langle (a_1, b_1, c_1, d_1); (a_2, b_2, c_2, d_2) \rangle$ is defined by

$$R(\widetilde{A_{Tr}}) = \sqrt{\frac{1}{2}\left(\left[\widetilde{x_\mu}(A_{Tr}) - \widetilde{y_\mu}(A_{Tr})\right]^2 + \left[\widetilde{x_\nu}(A_{Tr}) - \widetilde{y_\nu}(A_{Tr})\right]^2\right)}$$

3.1 Special case: In order to get the centroid of triangular intuitionistic fuzzy number (TIFN), use the relation $b_1 = b_2 = c_1 = c_2$ in centroid of TrIFN. The centroid point of TIFN is

$$\widetilde{x_\mu}(A_{Tr}) = \frac{a_1+b_1+d_1}{3} , \qquad \widetilde{x_\nu}(A_{Tr}) = \frac{2a_2-b_2+2d_2}{3}$$

and $\widetilde{y_\mu}(A_{Tr}) =$, $\widetilde{y_\nu}(A_{Tr}) =$

IV. MATHEMATICAL MODEL AND ALGORITHM TO SOLVE MATRIX GAMES [29]

Let a two person zero sum fuzzy game in the form of matrix (b_{ij}) *for* $i = 1,2,3, \ldots .. m$ *and* $j = 1,2,3, \ldots .. n$ in which all payoffs are trapezoidal or triangular intuitionistic fuzzy numbers.

B

$$A = \begin{bmatrix} \tilde{b}_{11} & \tilde{b}_{12} & \tilde{b}_{13} & \ldots & b_{1n} \\ \tilde{b}_{21} & \tilde{b}_{22} & \tilde{b}_{23} & \ldots & \tilde{b}_{2n} \\ \tilde{b}_{31} & \tilde{b}_{32} & \tilde{b}_{33} & \ldots & \tilde{b}_{3n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \tilde{b}_{m1} & \tilde{b}_{m2} & \tilde{b}_{m3} & \ldots & \tilde{b}_{mn} \end{bmatrix}$$

Let player A will play his 'm' moves with the probabilities $p_1, p_2, p_3 \ldots . p_m$; $p_i \geq 0$, $\sum_{i=1}^{m} p_i = 1$ and is assumed to be the profit player and player B will play his 'n' moves with probabilities $q_1, q_2, q_3 \ldots . q_n$;$q_j \geq 0$, $\sum_{j=1}^{n} q_j = 1$ and is assumed to be the loss player. It is supposed that each player has to select his best strategy from amongst the pure strategies. The minimum of column maxima and the maximum of row minima does not always lead to the saddle point. In such situation the optimal mixture of available strategies is considered to get the equilibrium point. Every player chooses his best strategy to get maximum gains or minimum looses. The expected payoff to a player with matrix (b_{ij}) of $m \times n$ order is defined as:

$$\tilde{E} = \sum_{i=1}^{m} \sum_{j=1}^{n} (p_i b_{ij} q_j)$$

A two person zero sum game of any order matrix without any saddle point can be reduced to 2×2 matrix by using dominance principle. In dominance principle the inferior strategies are dominated by superior one. So a player has no incentive to choose those inferior strategies. Under dominance principle the size of the payoff matrix can be reduced by deleting those strategies which are dominated by the others. When the payoff matrix reduces to 2×2 matrix then the probability of optimum strategies and value of the game can be obtained by the following method:

<table>
<tr><td rowspan="4">Player A</td><td colspan="3">Player B</td></tr>
<tr><td></td><td>B_1</td><td>B_2</td></tr>
<tr><td>A_1</td><td>a_{11}</td><td>a_{12}</td></tr>
<tr><td>A_2</td><td>a_{21}</td><td>a_{22}</td></tr>
</table>

The player A has optimum mixed strategies with probability $p_1$and $p_2$and the player B has optimum mixed strategies with probability q_1 and q_2 are defined as

$$p_1 = \frac{a_{22}-a_{21}}{a_{11}+a_{22}-(a_{12}+a_{21})}, \quad p_2 = \frac{a_{11}-a_{12}}{a_{11}+a_{22}-(a_{12}+a_{21})} \; and$$

$$q_1 = \frac{a_{22}-a_{12}}{a_{11}+a_{22}-(a_{12}+a_{21})}, q_2 = \frac{a_{11}-a_{21}}{a_{11}+a_{22}-(a_{12}+a_{21})}$$

Where $p_1 + p_2 =$and $q_1 + q_2 =$. The value of the game to player A is defined as

$$V = \frac{a_{11}a_{22}-a_{12}a_{2}}{a_{11}+a_{22}-(a_{12}+a}$$

V. SOLUTION OF FUZZY GAME PROBLEMS USING CENTROID RANKING METHOD

Example: Tours and Travel Agency companies' marketing problem

Let the two companies namely, Paradise Tours and Travels Pvt. Limited and Global Travel Services Inc. are in fierce competition with each other to gain most

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of the market share in the Indian tours and travel business. Since the Paradise Tours and Travels have a long standing in the Indian tours and travel market it thinks of applying the following three strategies to restrict the growth of foreign major namely, Global Travel Services in India who has recently ventured into the Indian tours and travel market. The three strategies listed by Paradise Tours and Travels Pvt. Limited (called Player A) are:

1. Offering 20 percent discount on all travel and hotel bookings.
2. Offering 35 percent discount on all hotel bookings exceeding three days.
3. Offering 2N3D (two night-three days) complementary holiday package to a family of four on specified Indian locations that can be availed in the next one year.

In competition Global Travel Services Inc. (called Player B) plans to use the following three strategies to counter the strategies of Paradise Tours and Travels:

1. It will provide a gift voucher worth Rs. 3000 on all travel bookings and a gift voucher worth Rs. 5000 on all hotel bookings done through them.
2. It will provide free transport for all local sightseeing.
3. It will provide a flat 15 percent off on every billing done through the travel agency.

When both the companies (players) compete with each other then the resulting pay off matrix is represented in the form of TrIFN as below:

B

$$A\begin{bmatrix} \begin{pmatrix}0.16,0.22,0.34,0.44;\\0.12,0.18,0.38,0.48\end{pmatrix} & \begin{pmatrix}0.38,0.48,0.56,0.66;\\0.34,0.42,0.62,0.74\end{pmatrix} & \begin{pmatrix}0.25,0.35,0.45,0.55;\\0.2,0.4,0.5,0.65\end{pmatrix} \\ \begin{pmatrix}0.55,0.62,0.76,0.84;\\0.48,0.62,0.82,0.88\end{pmatrix} & \begin{pmatrix}0.14,0.18,0.26,0.38;\\0.12,0.16,0.32,0.42\end{pmatrix} & \begin{pmatrix}0.32,0.4,0.46,0.52;\\0.28,0.36,0.5,0.56\end{pmatrix} \\ \begin{pmatrix}0.8,0.14,0.22,0.34;\\0.6,0.18,0.32,0.38\end{pmatrix} & \begin{pmatrix}0.1,0.16,0.26,0.38;\\0.8,0.14,0.32,0.44\end{pmatrix} & \begin{pmatrix}0.44,0.54,0.64,0.74;\\0.38,0.46,0.68,0.76\end{pmatrix} \end{bmatrix}$$

By applying the centroid ranking technique the fuzzy pay off values are converted into crisp values

The rank value for the strategy (A_1,B_1) is

$\widetilde{x_\mu}(A_{Tr}) = 0.29$, $\widetilde{x_\nu}(A_{Tr}) = 0.37$ and $\widetilde{y_\mu}(A_{Tr}) = 0.43$, $\widetilde{y_\nu}(A_{Tr}) = 0.55$

$$R(\widetilde{A_{Tr}}) = \sqrt{\frac{1}{2}\left([\widetilde{x_\mu}(A_{Tr}) - \widetilde{y_\mu}(A_{Tr})]^2 + [\widetilde{x_\nu}(A_{Tr}) - \widetilde{y_\nu}(A_{Tr})]^2\right)} = 0.16$$

The rank value for the strategy (A_1,B_2) is

$\widetilde{x_\mu}(A_{Tr}) = 0.52$, $\widetilde{x_\nu}(A_{Tr}) = 0.41$ and $\widetilde{y_\mu}(A_{Tr}) = 0.93$, $\widetilde{y_\nu}(A_{Tr}) = 0.56$,

$$R(\widetilde{A_{Tr}}) = 0.27$$

The rank value for the strategy (A_1,B_3) is

$\widetilde{x_\mu}(A_{Tr}) = 0.4$, $\widetilde{x_\nu}(A_{Tr}) = 0.42$ and $\widetilde{y_\mu}(A_{Tr}) = 0.81$, $\widetilde{y_\nu}(A_{Tr}) = 0.61$, $R(\widetilde{A_{Tr}}) = 0.15$

The rank value for the strategy (A_2,B_1) is

$\widetilde{x_\mu}(A_{Tr}) = 0.69$, $\widetilde{x_\nu}(A_{Tr}) = 0.44$ and $\widetilde{y_\mu}(A_{Tr}) = 1.54$, $\widetilde{y_\nu}(A_{Tr}) = 0.56$

$$R(\widetilde{A_{Tr}}) = 0.72$$

The rank value for the strategy (A_2,B_2) is

$\widetilde{x_\mu}(A_{Tr}) = 0.24$, $\widetilde{x_\nu}(A_{Tr}) = 0.42$ and $\widetilde{y_\mu}(A_{Tr}) = 0.34$, $\widetilde{y_\nu}(A_{Tr}) = 0.55$,

$$R(\widetilde{A_{Tr}}) = 0.19$$

The rank value for the strategy (A_2,B_3) is

$\widetilde{x_\mu}(A_{Tr}) = 0.42$, $\widetilde{x_\nu}(A_{Tr}) = 0.41$ and $\widetilde{y_\mu}(A_{Tr}) = 0.83$, $\widetilde{y_\nu}(A_{Tr}) = 0.56$

$$R(\widetilde{A_{Tr}}) = 0.2$$

The rank value for the strategy (A_3,B_1) is

$\widetilde{x_\mu}(A_{Tr}) = 0.47$, $\widetilde{x_\nu}(A_{Tr}) = 0.26$ and $\widetilde{y_\mu}(A_{Tr}) = 0.73$, $\widetilde{y_\nu}(A_{Tr}) = 1.25$

$$R(\widetilde{A_{Tr}}) = 0.39$$

The rank value for the strategy (A_3,B_2) is

$\widetilde{x_\mu}(A_{Tr}) = 0.28$, $\widetilde{x_\nu}(A_{Tr}) = 0.42$ and $\widetilde{y_\mu}(A_{Tr}) = 1.25$, $\widetilde{y_\nu}(A_{Tr}) = 1$

$$R(\widetilde{A_{Tr}}) = 0.23$$

The rank value for the strategy (A_3,B_3) is

$\widetilde{x_\mu}(A_{Tr}) = 0.59$, $\widetilde{x_\nu}(A_{Tr}) = 0.42$ and $\widetilde{y_\mu}(A_{Tr}) = 1.04$, $\widetilde{y_\nu}(A_{Tr}) = 0.54$

$$R(\widetilde{A_{Tr}}) = 0.37$$

The reduced crisp game problem is as below:

B

$$A\begin{bmatrix} 0.16 & 0.27 & 0.15 \\ 0.72 & 0.19 & 0.2 \\ 0.39 & 0.23 & 0.37 \end{bmatrix}$$

Let the reduced crisp problem is first verified for existence of saddle point as below:

Row minimum   Column maximum

First	0.15	0.72
Second	0.19	0.27
Third	0.23	0.37

Maximum of row minimum (MAXMIN) = 0.23

Minimum of column maximum (MINIMAX) = 0.27

Since MAXMIN ≠ MINIMAX, therefore the reduced crisp game problem does not have saddle point. Hence the players A and B will be using mix of two or more strategies to obtain optimal solution.

Now dominance principle is applied to the above reduced crisp payoff matrix. Since all the elements of B_1 are greater than B_3, so player B has no incentive to use strategy B_1. Hence by eliminating the first column, the crisp game problem is reduced to

$$A \overset{B}{\begin{bmatrix} 0.27 & 0.15 \\ 0.19 & 0.2 \\ 0.23 & 0.37 \end{bmatrix}}$$

Now, A_2 strategy is dominated by the A_3 as all the elements A_2 are less than A_3. So A_2 strategy is inferior to A_3. Hence by eliminating second row, the crisp game problem is further reduced into 2 X 2 payoff matrix as below:

$$A \overset{B}{\begin{bmatrix} 0.27 & 0.15 \\ 0.23 & 0.37 \end{bmatrix}}$$

The above reduced payoff matrix is further solved by applying method as defined in section 4.

Hence the player A chooses the optimum mixed strategy (A_1, A_3) and player B chooses optimum mixed strategy (B_2, B_3) are determined by the probabilities

$$p_1 = 0.54\,, p_2 = 1 - p_1 = 0.46 \text{ and } q_1 = 0.85\,, q_2 = 1 - q_1 = 0.15$$

The value of the game to player A is

$$V = \frac{a_{11}a_{22} - a_{12}a_{21}}{a_{11} + a_{22} - (a_{12} + a_{21})} = 0.25.$$

Hence the player A and B select their mixed strategies to maximize their profits and minimize their losses respectively. So Player A will use his strategy of offering 20 percent discount on all travel and hotel bookings with probability of 0.54 and also uses the strategy of offering 2N3D complementary holiday package to a family of four on specified Indian locations with probability of 0.4 On the other side, the loss player B will use strategy of offering free transport for all local sightseeing with probability 0.85 and also a flat 15 percent off on every billing done through the travel agency with probability 0.15. So when both the Players uses their optimal strategies, then the value of game for player A will be 0.25 units.

VI. RESULTS AND DISCUSSION

There is always an uncertainty in competitive situations related to real life. When two competitors compete with each other in fuzzy environment then the result of pay offs matrix may be in fuzzy numbers which can be of any order. In this paper a ranking method of centroid of trapezodial fuzzy numbers is used to solve real life competing situation. In the given example, the two companies namely, Paradise Tours and Travels Pvt. Limited and Global Travel Services Inc. are in fierce competition with each other to gain most of the market share. In this example the payoffs are trapezodial intuitionistic fuzzy numbers which are converted into crisp numbers by using centroid approach. The obtained result reveals that the Paradise company will choose its two strategies from the given three strategies, that is, A2 and A3 with probability of 0.54and 0.46. On the other hand Global Travel Services Inc. will also choose its two strategies out of three given strategies, that is B2 and B3 with probabilities 0.85 and 0.15. Finally when the two companies uses the optimum mix of their strategies the value of the game to the maximization player will be 0.25 units.

VII. CONCLUSION

In this paper the concept of centroid of fuzzy numbers is used to solve fuzzy game problems whose payoffs are trapezodial intuitionistic fuzzy numbers. No literature is available to solve fuzzy game problems by using centroid method. By using the centroid ranking approach the intuitionistic fuzzy numbers are converted into crisp problem and then solved by using traditional methods. A relation is also defined to convert these numbers into triangular intuitionistic fuzzy numbers so that all the problems related to trapezodial and triangular fuzzy numbers can be solved.

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