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Fuzzy Decision Making Problem in Hexadecagonal Fuzzy Number

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Abstract: *The aim of this article is to address the fuzzy decision making problem (FDMP) utilizing Hexadecagonal fuzzy numbers. We initiate the evaluation of the Payoff matrix through Hexadecagonal fuzzy numbers. We transform the fuzzy decision making problem into a crisp valued decision making problem by employing a ranking method for the payoffs. The crisp valued decision making problem can be effectively formulated using the savage mini max regret criterion.*

Keywords: Fuzzy decision making problem (FDMP), Hexadecagonal fuzzy number, membership function, Pay off matrix

I. INTRODUCTION

Fuzzy decision making was introduced by Bellman and Zadeh [1]. In the context of decision making, it is essential to identify the alternatives from which a conclusion must be drawn. There are various types of decision making. The approach to decision making on a specific issue can differ from one individual to another. When a single individual is responsible for making decisions, this is referred to as individual decision making. Conversely, when multiple individuals convene and share their expertise to make decisions, this is known as multi-person decision making. It is crucial to gather accurate information to facilitate better decision making. Decision making encompasses the processes involved in selecting an appropriate alternative from those necessary to achieve a specific plan. Jain [2] was the pioneer in proposing a method for ranking fuzzy numbers in decision making scenarios involving fuzziness. V. Raju and Jayagopal [3] were the first to present the concept of the Hexadecagonal fuzzy number. Numerous decisions are made based on data collection. Decision makers often utilize Hexadecagonal fuzzy numbers instead of real numbers to articulate their judgments. The accumulation of facts is vital for reaching a decision. The ability to solve problems and make decisions is essential for both business and personal life. Problem solving underscores the significance of decision making. Effective decision making is critical for management and leadership. In today's environment, there are numerous procedures and techniques available to enhance decision making and its overall value. In this article, we have addressed a decision making problem where imprecise values are represented by Hexadecagonal fuzzy numbers. We have executed this by converting it into a crisp valued decision making problem through the application of a ranking technique. Furthermore, we have elaborated on the fuzzy decision making problem utilizing Hexadecagonal fuzzy numbers, supported by examples.

II. PRELIMINARIES

In this section, we give the preliminaries that are required for this study.

Definition 2.1. *A fuzzy set A is defined by* $A = \{(x, \mu_A(x)): x \in A, \mu_A(x) \in [0,1]\}$. *Here* x *is crisp set* A *and* $\mu_A(x)$ *is membership function in the interval* $[0,1]$.

Definition 2.2. *The fuzzy number A is a fuzzy set whose membership function must satisfy the following conditions.*

(i) A fuzzy set A of the universe of discourse X is convex

(ii) A fuzzy set A of the universe of discourse X is a normal fuzzy set if $x_i \in X$ exists

(iii) $\mu_A(x)$ is piecewise continuous

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Definition 2.3 *An α-cut of fuzzy set A is classical set defined as* $^{\alpha}[A] = \{x \in X | \mu_A(x) \geq \alpha\}$

Definition 2.4 *A fuzzy set A is a convex fuzzy set iff each of its α-cut* $^{\alpha}A$ *is a convex set.*

2.5 Ranking of Hexadecagonl fuzzy number:

Let I be a normal Hexadecagonl l fuzzy number. The value $M(I)$, called as measure of I is calculated as

$$M(I) = \frac{e_1 + e_2 + e_3 + e_4 + e_5 + e_6 + e_7 + e_8 + e_9 + e_{10} + e_{11} + e_{12} + e_{13} + e_{14} + e_{15} + e_{16}}{16}$$

$$where\ \ 0 \leq k_1 \leq k_2 \leq k_3 \leq 1$$

Definition 2.6 [2]

A fuzzy number A = $(a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, ...a_{16})$ is Hexadecagonl fuzzy number and its membership function is given by

$$\mu_E(x) = \begin{cases} 0, \ for \ \ x < e_1 \\ \frac{1}{4}\left(\frac{x - e_1}{e_2 - e_1}\right), \ for \ \ e_2 \leq x \leq e_3 \\ \frac{1}{2}\left(\frac{x - e_3}{e_4 - e_3}\right), \ for \ \ e_3 \leq x \leq e_4 \\ \frac{1}{2} \quad for \ \ e_4 \leq x \leq e_5 \\ \frac{3}{4}\left(\frac{x - e_5}{e_6 - e_5}\right), \ for \ \ e_5 \leq x \leq e_6 \\ \frac{3}{4}, \ for \ \ e_6 \leq x \leq e_7 \\ \left(\frac{x - e_7}{e_8 - e_7}\right), \ for \ \ e_7 \leq x \leq e_8 \\ 1, \ e_8 \leq x \leq e_9 \\ \left(\frac{e_{10} - x}{e_{10} - e_9}\right), \ for \ \ e_9 \leq x \leq e_{10} \\ \frac{3}{4}, \ for \ \ e_{10} \leq x \leq e_{11} \\ \frac{3}{4}\left(\frac{e_{12} - x}{e_{12} - e_{11}}\right), \ for \ \ e_{11} \leq x \leq e_{12} \\ \frac{1}{2}, \ for \ \ e_{12} \leq x \leq e_{13} \\ \frac{1}{2}\left(\frac{e_{14} - x}{e_{14} - e_{13}}\right), \ for \ \ e_{13} \leq x \leq e_{14} \\ \frac{1}{4}, \ for \ \ e_{14} \leq x \leq e_{15} \\ \frac{1}{4}\left(\frac{e_{16} - x}{e_{16} - e_{15}}\right), \ for \ \ e_{15} \leq x \leq e_{16} \\ 0, \ for \ \ e_{16} \leq x \end{cases}$$

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III. MATHEMATICAL FORMULATION OF FUZZY DECISION MAKING PROBLEM

Consider a fuzzy decision making problem in which all the entries of the payoff matrix are Hexadecagonl fuzzy numbers. Let us obtain the problem R has m strategies and problem S has n strategies. Then the payoff matrix m x n is

$$A=\begin{pmatrix} r_{11} & r_{12} & . & r_{1n} \\ r_{21} & r_{22} & . & r_{2n} \\ . & . & . & . \\ r_{m1} & r_{m2} & . & r_{mn} \end{pmatrix}$$

3.1 Procedures for solving Savage Minimax regret criterion:

Step 1: Construct a regret (opportunity loss) table of each alternative for every state of nature from the given pay off matrix

Step 2: Pick out the maximum pay off in each column and subtract all the elements in that column from this maximum value

Step 3: For each decision alternative (row) , pick out the maximum row value and enter this in the last decision column

Step 4: Choose the decision alternative with the smallest value in the decision column

IV. NUMERICAL EXAMPLE

Let us consider the Matrix

a_{11}	- 2,-1,0,1,2 ,3,4,5,6,7 ,8,9,10,11 ,12,13	$\mu_{EDC}(a_{11}) = 5.5$
a_{12}	- 1,0,1,2,3, 4,5,6,7,8, 9,10,11,12 ,13,14	$\mu_{EDC}(a_{12}) = 6.5$
a_{13}	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	$\mu_{EDC}(a_{13}) = 8.5$
a_{21}	- 3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	$\mu_{EDC}(a_{21}) = 7.125$
a_{22}	- 2,-1,0,1,2 ,3,4,5,6,7 ,8,9,10,11 ,12,13	$\mu_{EDC}(a_{22}) = 5.5$
a_{23}	0,1,2,4,5,6,7,8,9,10,11,12,13,14,16,24	$\mu_{EDC}(a_{23}) = 8.3125$
a_{31}	3,4,5,6,7,9,10,11,13,14,15,17,19,21,22,25	$\mu_{EDC}(a_{31}) = 12.5625$
a_{32}	6,8,9,10,12,13,15,16,17,19,20,22,23,25,28,30	$\mu_{EDC}(a_{32}) = 17.0625$
a_{33}	- 3,-2,-1,0, 1,2,3,4,5, 6,7,8,9,10 ,11,12	$\mu_{EDC}(a_{33}) = 4.5$

This problem is solved by taking the values $for \quad k_1 = \frac{1}{4}, k_2 = \frac{2}{4}, k_3 = \frac{3}{4}$. We obtain the values of Measure of matrix A and is denoted by $\mu_{EDC}(a_{ij})$

Step 1: The given fuzzy decision making problem is reduced to the following payoff profit matrix

Alternatives	Expected level of Sale (in Rupees)		
	I	II	III
Rice	5.5	6.5	8.5
Wheat	7.125	5.5	8.3125
Sugar	12.5625	17.0625	4.5

Step 2: The opportunity loss table for each alternative with the states of nature is depicted below

Alternatives	Expected level of Sale (in Rupees)		
	I	II	III
Rice	7.0625	10.5625	0
Wheat	5.4375	11.5625	0.1875
Sugar	0	0	4
Column Maximum	12.5625	17.0625	8.5

Step 4: The opportunity loss table and the maximum loss in each row is entered and shown in the below table

Alternatives	Expected level of Sale (in Rupees)			Decision Column
	I	II	III	(Maximum Loss)
Rice	7.0625	10.5625	0	10.5625
Wheat	5.4375	11.5625	0.1875	11.5625
Sugar	0	0	4	4

Result: Since the minimum of maximum loss is in alternative Sugar = 4 rupees, this alternative must be selected.

V. CONCLUSION

In this article, we have outlined and addressed the fuzzy decision-making problem along with its payoff matrix, which consists of hexadecagonal fuzzy numbers. We have demonstrated the process of selecting alternatives for the fuzzy-valued decision-making problem by converting it into a crisp-valued decision-making problem through the application of ranking techniques. The crisp-valued decision-making problem is resolved using the Savage minimax regret criterion.

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a_{11}	- 2,-1,0,1,2 ,3,4,5,6,7 ,8,9,10,11 ,12,13	$\mu_{EDC}(a_{11}) = 5$
a_{12}	- 1,0,1,2,3, 4,5,6,7,8, 9,10,11,12 ,13,14	$\mu_{EDC}(a_{12}) = 6$
a_{13}	1,2,3,4,5,6,7,8,9,10 ,11 ,12 ,13 ,14 ,15 ,16	$\mu_{EDC}(a_{13}) = 10$
a_{21}	- 3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	$\mu_{EDC}(a_{21}) = 6$
a_{22}	- 2,-1,0,1,2 ,3,4,5,6,7 ,8,9,10,11 ,12,13	$\mu_{EDC}(a_{22}) = 7$
a_{23}	0,1,2 ,4,5,6,7,8,9,10 ,11 ,12 ,13 ,14 ,16 ,24	$\mu_{EDC}(a_{23}) = 10.63$
a_{31}	3,4,5,6,7,9,10 ,11,13,14,15,17 ,19 ,21,22 ,25	$\mu_{EDC}(a_{31}) = 10.68$
a_{32}	6,8,9,10 ,12 ,13 ,15 ,16 ,17 ,19 ,20 ,22 ,23 ,25 ,28 ,30	$\mu_{EDC}(a_{32}) = 14.16$
a_{33}	- 3,-2,-1,0, 1,2,3,4,5, 6,7,8,9,10 ,11,12	$\mu_{EDC}(a_{33}) = 6$