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Sequencing Problem with Processing Time as Decagonal Fuzzy Numbers

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Abstract: In this paper, a new method to solve Job Sequencing problem with Decagonal Fuzzy Numbers is given. Job sequencing technique is used to find optimal sequence in order to minimize the total elapsed time of the sequence. In this paper ranking method of decagonal fuzzy numbers based on area is given. To find out area given region is divided into nine triangles then centroids are calculated for each triangle. From centroids of triangles centroid of centroids and incentre of centroids is calculated from which ranking function is derived for doing ranking of decagonal fuzzy numbers. Numerical example is given to clarify the concept. Finally, the conclusion is given.

I. INTRODUCTION

A fuzzy number is a generalization of a regular, real number in the sense that it does not refer to one single value but rather to a connected set of possible values, where each possible value has its own weight between 0 and 1. This weight is called the membership function. A fuzzy number is thus a special case of a convex, normalized fuzzy set of the real line. The various types of fuzzy numbers are triangular fuzzy numbers, trapezoidal fuzzy numbers, hexagonal fuzzy numbers etc. Here we study decagonal fuzzy numbers. The concept of fuzzy set theory was first given by[1] in 1965. Jain[2] was the first to propose method of ranking fuzzy numbers for decision making in fuzzy situations. Yager [3] used the concept of centroids in ranking of fuzzy numbers. Thorani et al. [4] presented a procedure for ordering fuzzy numbers based on Area, Mode, Spreads and Weights of generalized fuzzy numbers. The area used in this method is obtained from the non normal trapezoidal fuzzy number. Dhanalakshmi and Felbin [6] gave ranking method for octagonal fuzzy numbers based on area between centroid point of an octagonal fuzzy number and the origin, sign distance and deviation. Rajarajeswari and Sudha [7] also introduced a method for ordering fuzzy numbers based on Area, Mode, Divergence, Spreads and Weights of generalized (non-normal) hexagonal fuzzy numbers. In this paper a method for ranking of decagonal fizzy number is given which is based on centroid of centroids and incentre of centroids. In decagonal fuzzy number the given area is divided into nine triangles and the centroids of these triangles are calculated. After this centriods of triangles are calculated whose vertices are previous calculated centroids followed by centroid of centroids and incentre of centroids. In Section 2 some basic fuzzy definitions are given. In Section 3 definition of decagonal fuzzy numbers is given. Section 4 includes method for calculating centroid of centroids and incentre of centroids. In Section 5 proposed method is illustrated with the help of numerical example. Finally we conclude in Section 6.

II. BASIC DEFINITIONS

In this section, some basic definitions are presented.

Definition 2.1 Let X be universal set, the characteristic function of a crisp set A assigns a value either 0 and 1 to each individual in the universal set, so discriminating between members and non members of the crisp set. This function can be generalized such that the values assigned to the elements of the universal set fall within a specified range and indicate the membership grade of these elements in the set. Such a function is called membership function and the set defined by it a fuzzy set. The membership function of a fuzzy set A is denoted by μ_A; i.e. μ_A:X→[0,1] and the set {(x, μ_A(x)):x lies in X } is called fuzzy set.

Definition 2.2 A fuzzy set A is called normal if $\text{Sup}\{\mu_A(x) : x \in X\} = 1$ and it is called subnormal if $\text{Sup}\{\mu_A(x) : x \in X\} < 1$.

Definition 2.3 A fuzzy set A in universal set X is called convex iff
$\mu_A(\gamma x_1 + (1-\gamma)x_2) \geq \min[\mu_A(x_1), \mu_A(x_2)]$ for all $x_1, x_2 \in X$ and $\gamma \in [0,1]$.

Definition 2.4 A fuzzy set A defined on universal set X is said to be a fuzzy number if its membership function has the following characteristics:

i) A is convex.

ii) A is normal.

iii) μ_A is piecewise continuous.

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Definition 2.5 A fuzzy number
A = (m,n,α,β)$_{LR}$ is said to be LR flat fuzzy number if its membership function is given by

$$\begin{cases} L\left(\frac{m-x}{\alpha}\right), x \le m, \alpha > 0 \\ R\left(\frac{x-n}{\beta}\right), x \ge n, \beta > 0 \\ 1, \quad m \le x \le n \end{cases}$$

If m = n then A = (m,n,α,β)$_{LR}$ will convert into (m,α,β)$_{LR}$ and is said to be an LR fuzzy number. L and R are called reference functions which are continuous, non-increasing functions that defining the left and right shapes of $\mu_A(x)$ respectively and L(0) = R(0) = 1. Its special cases are triangular, trapezoidal, hexagonal, octagonal and decagonal fuzzy numbers.

III. DECAGONAL FUZZY NUMBER

Definition 3.1
A fuzzy number
A = (m, n, α, α', α'', α''',β, β', β'', β''')$_{LR}$ is said to be an LR flat decagonal fuzzy number if its membership function $\mu_A(x)$ is given by

$$\begin{cases} L\left(\frac{m-x}{\alpha}\right), & x \le m, \quad \alpha > 0 \\ L\left(\frac{m-x}{\alpha'}\right), & x \le m, \quad \alpha' > 0 \\ L\left(\frac{m-x}{\alpha''}\right), & x \le m, \quad \alpha'' > 0 \\ L\left(\frac{m-x}{\alpha'''}\right), & x \le m, \quad \alpha''' > 0 \\ R\left(\frac{x-n}{\beta}\right), & x \ge n, \quad \beta > 0 \\ R\left(\frac{x-n}{\beta'}\right), & x \ge n, \quad \beta' > 0 \\ R\left(\frac{x-n}{\beta''}\right), & x \ge n, \quad \beta'' > 0 \\ R\left(\frac{x-n}{\beta'''}\right), & x \ge n, \quad \beta''' > 0 \\ 1 & , m \le x \le n \end{cases}$$

IV. RANKING METHOD

Find the centriod of given figure, it is considered as balancing point of the given area. For this divide given area into nine triangles namely ΔPAB, ΔCPQ, ΔDQR, Find centriod of each of these triangles namely $G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_9$. Now find centroid of triangles whose vertices are above calculated centroids i.e. find the centroids of centroids

$$G' = \left(\frac{9m-(\alpha'''+3\alpha''+3\alpha'+2\alpha)}{9}, \frac{2y_1+3y_2}{9}\right)$$

$$G'' = \left(\frac{4m+5n-\alpha+2\beta}{9}, \frac{2y_2+4y_3}{9}\right)$$

$$G''' = \left(\frac{9n+(\beta'''+4\beta\beta''+3\beta'+\beta)}{9}, \frac{2y_1+3y_2}{9}\right)$$

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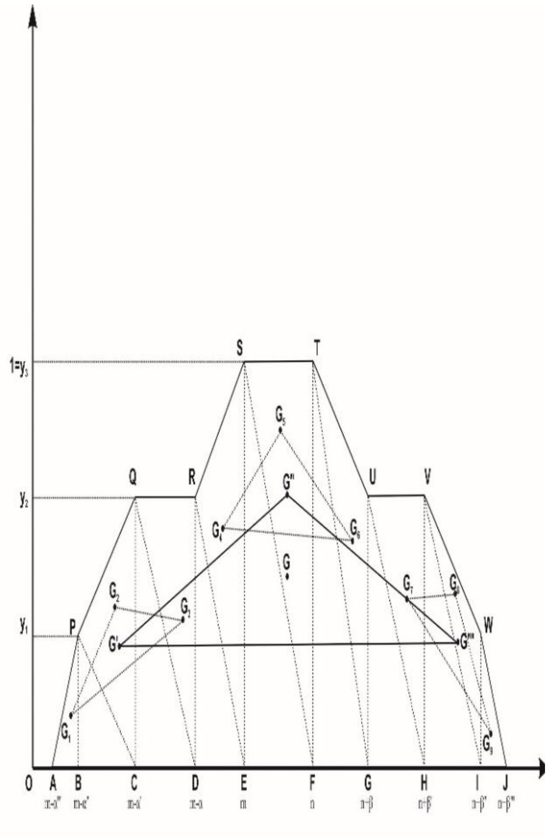

Here equation of the line G'G''' is $y = \frac{2y_1+3y_2}{9}$ and G'' does not lie on this line so the points G', G'' ,G''' are non-collinear and therefore they form a triangle. Now centroid of this triangle $\left(\frac{13m+14n-(3\alpha+3\alpha'+3\alpha''+\alpha''')+(3\beta+3\beta'+4\beta''+\beta''')}{9}, \frac{4y_1+8y_2+4y_3}{9}\right)$

Now define the incentre I_A of the triangle with vertices G', G'' ,G''' of decagonal fuzzy number as

$$\left(\begin{array}{c} a\left(\frac{9m-(\alpha'''+3\alpha''+3\alpha'+2\alpha)}{9}\right)+b\left(\frac{4m+5n-\alpha+2\beta}{9}\right) \\ +c\left(\frac{9n+\beta+3\beta'+4\beta''+\beta'''}{9}\right), \\ a\left(\frac{2y_1+3y_2}{9}\right)+b\left(\frac{2y_2+4y_3}{9}\right)+c\left(\frac{2y_1+3y_2}{9}\right) \end{array}\right)$$

Where

$$a = \sqrt{\frac{(4n-4m+\alpha-\beta+3\beta'+4\beta''+\beta''')^2+(2y_1+y_2-4y_3)^2}{9}}$$

$$b = \frac{9n-9m+(\alpha'''+3\alpha''+3\alpha'+2\alpha)+(\beta+3\beta'+4\beta''+\beta''')}{9}$$

$$c = \frac{\sqrt{(5n-5m+2\beta+\alpha+3\alpha'+3\alpha''+\alpha''')^2+(4y_3-2y_1-y_2)^2}}{9}$$

Here the ranking function of the decagonal fuzzy number is defined as

$$R(A) = \sqrt{x^2+y^2}$$

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Example

There are 5 jobs each of which must go through the two machines M_1 and M_2 in the order $M_1 M_2$ with following processing times. Find optimal sequence of jobs that minimizes the total elapsed time required to complete all jobs.

Jobs→ Machines↓	M_1	M_2
J_1	(0.1,0.15,0.2,0.3,0.35,0.4,0.45,0.5,0.6,0.7;0.3,0.7,1)	(0.1,0.2,0.3,0.4,0.5,0.6,0.65,0.7,0.75,0.8;0.35,0.65,1)
J_2	(0.15,0.15,0.12,0.34,0.5,0.2,0.45,0.5,0.6,0.7;0.25,0.75,1)	(0.1,0.15,0.22,0.3,0.35,0.24,0.45,0.5,0.6,0.7;0.23,0.77,1)
J_3	(0.41,0.15,0.2,0.23,0.35,0.4,0.45,0.5,0.6,0.7;0.6,0.4,1)	(0.1,0.15,0.2,0.23,0.35,0.24,0.7,0.5,0.6,0.7;0.2,0.8,1)
J_4	(0.4,0.15,0.2,0.2,0.15,0.4,0.45,0.5,0.6,0.7;0.1,0.9,1)	(0.21,0.25,0.2,0.34,0.35,0.14,0.45,0.5,0.6,0.7;0.33,0.67,1)
J_5	(0.31,0.15,0.2,0.3,0.5,0.4,0.45,0.5,0.6,0.7;0.27,0.73,1)	(0.1,0.25,0.2,0.3,0.35,0.4,0.45,0.5,0.6,0.7;0.43,0.57,1)

Solution:

Step 1: Find ranking function of all processing times.

Jobs→ Machines↓	J_1	J_2	J_3	J_4	J_5
M_1	0.36	0.635	0.64	0.605	0.4
M_2	0.605	0.305	0.885	0.74	0.335

Step 2: Add processing times of machines M_1 and M_2

Jobs→ Machines↓	J_1	J_2	J_3	J_4	J_5
Sum	0.965	0.94	1.525	1.345	0.735

Job sequence of this table is

-	-	-	-	J_5

Step 3: Reduced table is

Jobs→ Machines↓	J_1	J_2	J_3	J_4
M_1	0.36	0.635	0.64	0.605
M_2	0.605	0.305	0.885	0.74

Add processing times of machines M_1 and M_2

Jobs→ Machines↓	J_1	J_2	J_3	J_4
Sum	0.965	0.94	1.525	1.345

Job sequence of this reduced table is

-	-	-	J_2	J_5

Step 4: Reduced table is

Jobs→ Machines↓	J_1	J_3	J_4
M_1	0.36	0.64	0.605
M_2	0.605	0.885	0.74

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Add processing times of machines M_1 and M_2

Jobs→ Machines↓	J_1	J_3	J_4
Sum	0.965	1.525	1.345

Job sequence of this reduced table is

J_1	-	-	J_2	J_5

Step 5: Reduced table is

Jobs→ Machines↓	J_3	J_4
M_1	0.64	0.605
M_2	0.885	0.74

Add processing times of machines M_1 and M_2

Jobs→ Machines↓	J_3	J_4
Sum	1.525	1.345

Job sequence of this reduced table is

J_1	J_4	-	J_2	J_5

Step 6: Final sequence is

J_1	J_4	J_3	J_2	J_5

Step 7: Find total elapsed time

Job Sequence	M_1		M_2	
	Time in	Time out	Time in	Time out
J_1	0	0.36	0.36	0.965
J_4	0.36	0.965	0.965	1.705
J_3	0.965	1.605	1.705	2.59
J_2	1.605	2.24	2.59	2.895
J_5	2.24	2.64	2.895	3.23

Thus the minimum total elapsed time is 3.23 hours.

V. CONCLUSION

This paper gives method for ranking of decagonal fuzzy numbers. Ranking method is based on incentre of centroids.This ranking procedure is applied on sequencing problem to get minimum elapsed time. This method provides more accuracy than other methods in job sequencing field.

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