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# An Application of Evaluating Fuzzy Sequencing Problems with Pentagonal Fuzzy Numbers Using Harmonic Mean

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**KEYWORDS**

Fuzzy number, Pentagonal fuzzy number, Fuzzy arithmetic operations, Fuzzy Sequencing problems, Johnson's Algorithm.

**ABSTRACT:**

Consider the situation of scheduling jobs from 3 factories to 4 warehouses, the processing time as Pentagonal fuzzy nos. The fuzzy sequencing numbers is modified into crisp value by using the Harmonic mean in 'C' program. Consequently the optimum solution total elapsed time, idle time for each warehouse is obtained.

**Introduction**:

The term fuzzy logic was introduced in 1965 with the proposal of fuzzy set theory by L. A. Zadeh [6]. Fuzzy logic had, however, been studied since the 1920s, as infinite-valued logic notably by Łukasiewicz and Tarski. The main role of the classical sequencing problem is to find the Ideal succession of the jobs on machines so as to minimize the total amount of time required to complete the process of all the jobs. Apurba Panda, Madhumangal Pal [1] proposed the logical definition in developing a pentagonal fuzzy number, along with its arithmetic operations. K.S. Keerthika & S. Parthiban [2], approaches a Test of Hypothesis Using Pentagonal Fuzzy Number.

Someshwar Siddi & Y Raghunatha Reddy [4] Solved Fuzzy Lpp For Pentagonal Fuzzy Number Using Ranking Approach. Monika Bisht, Ismat Beg & Rajesh Dangwal [5] Found An Optimal Solution Of Pentagonal Fuzzy Transportation Problem Using A New Ranking Technique. H.J. Zimmermann [7] introduced Fuzzy Set Theory and Its Applications. In this paper we introduce the basic concepts and definitions of fuzzy numbers which deals with the proposed new algorithm. To solve this procedure a suitable example is illustrated.

**Definitions:**

**Fuzzy Number:**

A fuzzy number is a generalization of a regular real number and which does not refer to a single value but connected to a set of possible value, where each possible value has its weight between 0 and 1.

A fuzzy number is a convex normalized fuzzy set on the real line R such that, there exist at least one i) $x \in X$ with $\mu_{\bar{A}}(x) = 1$ ii) $\mu_{\bar{A}}(x)$ is piece wise continuous.

**Pentagonal Fuzzy Number:**

A fuzzy number with membership function $\bar{A} = (a_1, a_2, a_3, a_4, a_5)$ in the form

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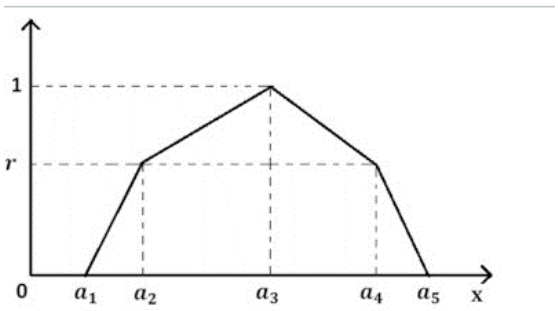
$$\mu_A(x) = \begin{cases} 0, & \text{for } x < a_1, a_5 \le x \\ \dfrac{x - a_1}{a_2 - a_1}; & \text{for } a_1 \le x \le a_2 \\ \dfrac{x - a_2}{a_3 - a_2}; & \text{for } a_2 \le x \le a_3 \\ 1, & \text{for } x = a_3 \\ \dfrac{a_4 - x}{a_4 - a_3}; & \text{for } a_3 \le x \le a_4 \\ \dfrac{a_5 - x}{a_5 - a_4}; & \text{for } a_5 \le x \le a_4 \end{cases}$$




is called a Pentagonal fuzzy number.

**Fuzzy arithmetic operations:**

Addition: $(a_1, b_1, c_1) + (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$

$(a_1, b_1, c_1) - (a_2, b_2, c_2) = (a_1 - a_2, b_1 - b_2, c_1 - c_2)$

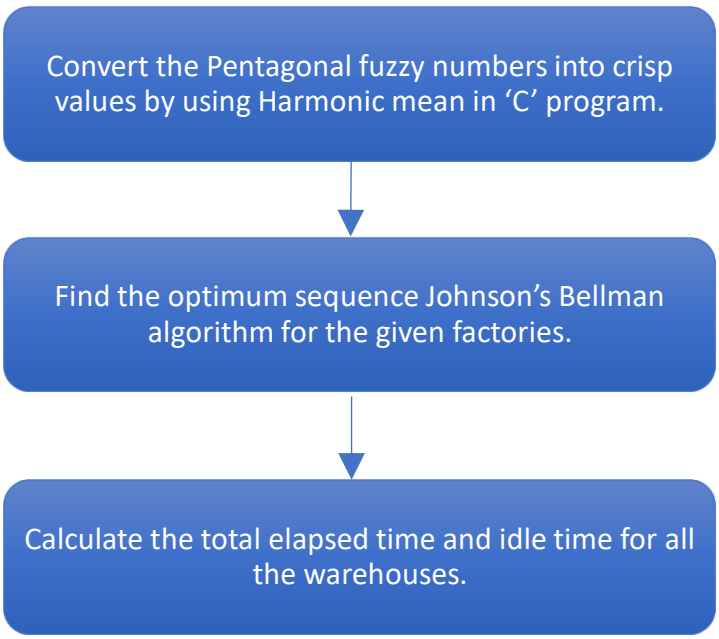
**Fuzzy Sequencing Problem:**

It is a selection of an appropriate order in which the number of jobs can be assigned to a finite number of machines so as to optimize the output in terms of time, cost or profit.

**Description of the model:**

In this model, Pentagonal fuzzy numbers of scheduling jobs from 3 factories to 4 warehouses are defuzzified by using the Harmonic mean in 'C' language then find the optimum sequence evaluated by Johnson's Bellman algorithm and also evaluated the total elapsed time and idle times for the given projects.

**Proposed Algorithm:**




**Numerical example:**

There are four ware houses **$W_1$**, **$W_2$**, **$W_3$** & **$W_4$** which must go through three factories **$F_1$** , **$F_2$** & **$F_3$**. The fuzzy processing times for all the ware houses on various factories are given below:

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| Job | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| $F_1$ | (6,7,9,10,12) | (9, 11, 12, 13, 15) | (12, 13, 15, 16, 18) | (7,8,10,11,13) |
| $F_2$ | (2,4,6,7,8) | (4,5,7,9,10) | (7, 8, 9, 12, 13) | (5,6,8,9,11) |
| $F_3$ | (17,19,20,21,23) | (11,12,13,15,17) | (8,9,11,13,14) | (15,18,19,20,21) |

Determine a sequence for the jobs that will minimize the total elapsed time and find the idle time for each ware houses.

**Solution:**

| Job | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| $F_1$ | (6,7,9,10,12) | (9, 11, 12, 13, 15) | (12, 13, 15, 16, 18) | (7,8,10,11,13) |
| $F_2$ | (2,4,6,7,8) | (4,5,7,9,10) | (7, 8, 9, 12, 13) | (5,6,8,9,11) |
| $F_3$ | (17,19,20,21,23) | (11,12,13,15,17) | (8,9,11,13,14) | (15,18,19,20,21) |

**Converting the Pentagonal fuzzy number into crisp value using Harmonic Mean in 'C' program as follows:**

```
#include <stdio.h>
int main()
{
   int m,n;
   float job[m][n],avg[m][n],a,b,c,d,e;
   printf("Enter the number of rows and columns: ");
   scanf("%d%d",&m,&n);
   for(int i=0;i<m;i++)
   {
      for(int j=0;j<n;j++)
      {
         printf("\nEnter value of Job[%d][%d]\n",i,j);
         printf("Enter any 5 elements of Job: ");
         scanf("%f%f%f%f%f",&a,&b,&c,&d,&e);
         avg[i][j]=(5/((1/a)+(1/b)+(1/c) +(1/d)+(1/e) ));
         printf("Average Job of machine 1 is %.2f",avg[i][j] );
      }
   }
   printf("\n\n");

printf("**********\n");
   printf("The processing time for %d machines and %d jobs is \n",m,n);

printf("**********\n");
   for(int i=0;i<m;i++)
   {
      for(int j=0;j<n;j++)
      {
         printf("%.2f\t",avg[i][j]);
      }
      printf("\n");
   }
   return 0;
}
```

Hence the processing times are as follows:

| Job | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| $F_1$ | 8.28 | 11.66 | 14.49 | 9.33 |
| $F_2$ | 4.22 | 6.22 | 9.27 | 7.21 |
| $F_3$ | 19.8 | 13.27 | 10.52 | 18.35 |

Let us consider the 2 ware houses A & B as follows:

**A** = $W_1 + W_2 + W_3$ **&** **B** = $W_2 + W_3 + W_4$

If any one of the following rule or both can be satisfied in that case the problem is converted into 2 x n. (i) Min($F_3$) > Max($F_2$) (ii) Min($F_1$) > Max($F_2$)

**Optimal sequence:**

| $F_3$ | $F_2$ | $F_1$ |
|---|---|---|

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For the given optimum sequence, the total elapsed time & idle time for the warehouses are calculated in the following table:

| Job | Ware houses | | | | | | | | Idle Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $W_1$ | | $W_2$ | | $W_3$ | | $W_4$ | | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
| | Time | | Time | | Time | | Time | | | | | |
| | In | Out | In | Out | In | Out | In | Out | | | | |
| $F_3$ | 0 | 19.8 | 19.8 | 33.07 | 33.07 | 43.59 | 43.59 | 61.94 | – | 19.8 | 33.07 | 43.59 |
| $F_2$ | 19.8 | 24.02 | 33.07 | 39.29 | 43.59 | 52.86 | 61.94 | 69.15 | – | – | – | – |
| $F_1$ | 24.02 | 32.3 | 39.29 | 50.95 | 52.86 | 67.35 | 69.15 | 78.48 | 46.18 | 27.53 | 11.13 | – |
| | | | | | | | | Total | 46.18 | 47.33 | 44.2 | 43.59 |

The minimum total elapsed time = 43.59 hrs.
Idle time on **Ware houses $W_1$** = 46.18 hrs.
Idle time on **Ware houses $W_2$** = 47.33 hrs.
Idle time on **Ware houses $W_3$** = 44.2 hrs.
Idle time on **Ware houses $W_4$** = 43.59 hrs.

**Conclusion:**

Fuzzy sequencing problem is solved by Operations Research techniques after defuzzification, which is easy for compilation and execution. It helps for decision makers to identify the total time to complete the project in real time situations.

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