Advances in Fuzzy Mathematics.
ISSN 0973-533X Volume 12, Number 5 (2017), pp. 1097-1109

http://www.ripublication.com

A Novel approach to analyze the three Dimensional Interval Fuzzy Optimal Assignment Cost using partition Method

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Abstract

In this paper, we analysed the fuzzy optimal assignment cost with the help of statistical manner. Initially, we construct the fuzzy three dimensional assignment problem, and to the parameters are considered as symmetric triangular fuzzy numbers. The job assignment made with the help of proposed one's termination algorithm. Latterly, the fuzzy variables are separated into lower bound and upper bound of the fuzzy variable using α - cut method. Finally, Interval fuzzy optimal costs are analysed in statistical manner. A Numerical example is illustrated.

Keywords: α-cut, Triangular Fuzzy Number, Fuzzy 3-dimensional Assignment Problem, t-test, One's Termination algorithm, robust ranking method.

1. INTRODUCTION:

The assignment problem is a distinct type of transportation problem and it's logically represents on linear zero – one programming problem. This type of problem plays an important role in decision making concept on management science and it has been widely applied the manufacturing service system. Generally, many authors were analyzed the optimal cost in different algorithm of assignment problem. H.W.Kuhn [10] introduced a specially intended algorithm so called Hungarian method for solving assignment problem in crisp environment. Due to the natural calamities or

depends on the unexpected situation the decision maker did not to take a correct decision (cost as well as assign the job). For this situation, the fuzzy theory can give a wonderful support to the decision maker. Initially, L.A.Zadeh [19] has introduced the fuzzy set theory and derived the fuzzy membership function and α- cut method. Lin and Wen [12] analyzed the interval fuzzy optimal cost on labelling algorithm. Kumar and Gupta [11] have suggested a new method for solving fuzzy assignment problem and travelling salesman problem. Bai et al [1] stated the optimal cost in generalized fuzzy assignment problem. Wang [10] derived the new algorithm on fuzzy assignment problem with the help of graph theory application. B.Sriniwas and G.Ganesan[16] have proposed the branch and bound technique for the fuzzy assignment problem and the author has consider the parameters are trapezoidal fuzzy number. Srinivasan and Geetharamani[15] and R.R.Yager [18] had proposed a new technique to analyse the fuzzy optimal assignment cost using robust ranking method.

The fuzzy three dimensional assignment problem have an extension of the fuzzy assignment problem. The application on this kind of problem exists on many areas as particularly launching on the satellite, capital investments on different areas. Pierskalla [14], Crama and Spieksma[6] was very first introduced the three dimensional fuzzy assignment problem and the cost coefficients are satisfied the triangle inequalities. P.Hansen and L.Kaufman[8] has designed the graph theoretic approach on the prima dual implicit enumeration technique. Magos and Milotis[13] stated the procedure on branch and bound technique in three index assignment problem and to analysed to fuzzy three dimension fuzzy assignment cost. Many authors were done in fuzzy optimal assignment cost on three dimensions but very less number of researchers were done on interval optimal cost on three dimensional problem but no one using the statically analysis. In this paper, we analyse the Interval fuzzy optimal assignment cost on three dimensional problem with the help of proposed method. Finally, check out the confidence level of interval optimal cost in statistical manner. This paper is divided into five sections as follows: 1) Introduction 2) Preliminaries and fuzzy basis 3) Mathematical formulation of three dimensional fuzzy assignment problem 4) Proposed Methods: i)One's Termination algorithm ii) Fuzzy Partition Method.5) Example and Conclusion.

2. PRELIMINARIES

Definition: 2.1 [9]

Mathematical Formulation of Assignment problem:

$$\text{Min} \quad Z = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \text{ S.to} \qquad \sum_{j=1}^{n} x_{ij} = 1 \,, \sum_{i=1}^{m} x_{ij} = 1 \qquad i = 1,2,,,m,\ j = 1,2,..n$$

Where c_{ij} is the cost associated with assigning i^{th} job to j^{th} machine.

Definition: 2.2 [9]

If the number of jobs is equal to the number of machines,(ie) m= n , then the assignment problem is said to be a balanced Assignment problem. Otherwise unbalanced assignment problem

Definition 2.3:[12]

A Fuzzy set $\tilde{A}$ in a universe of discourse X is defined by $\tilde{A} = \{(x, \mu_A(x)); x \in A \text{ and } \mu_A(x) \in [0,1]\}$

Definition 2.4[12]:

If $\tilde{A} = [a_1, a_2, a_3]$ as a triangular fuzzy number then the α –cut of triangular fuzzy number $\tilde{A}(\alpha)$ is defined as $\tilde{A}(\alpha) = \{x / \mu(x) \geq \alpha, \alpha \in [0,1]\}$

Definition 2.5: [12]

If $\tilde{A} = [a_1, a_2, a_3]$ as a triangular fuzzy number then the fuzzy membership function $\mu_{\tilde{A}}(x)$ is given as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x - a_1}{a_2 - a_1}, & \text{if} \quad a_1 \leq x \leq a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, & a_2 \leq x \leq a_3 \\ 0 & \text{otherwise} \end{cases}$$

Definition2.6: [10]

If $\tilde{A} = [a_1, a_2, a_3]$ and $\tilde{B} = [b_1, b_2, b_3]$ be two triangular fuzzy numbers then the addition is defined as follows: $\tilde{A} + \tilde{B} = [a_1 + b_1,\ a_2 + b_2,\ a_3 + b_3]$

Definition 2.7: [10]

If $\tilde{A} = [a_1, a_2, a_3]$ be a triangular fuzzy number the robust rank function denoted as $R(\tilde{A})$ and it is defined as follows $R(\tilde{A}) = \int_0^1 0.5(\tilde{A}_\alpha^l, \tilde{A}_\alpha^u) d\alpha$, where $(\tilde{A}_\alpha^l, \tilde{A}_\alpha^u)$ is the α-level cut of the fuzzy number $\tilde{A}$.

3. MATHEMATICAL FORMULATION OF FUZZY ASSIGNMENT PROBLEM

Fuzzy Assignment problem can be stated as follows

$$Min\ Z=\sum_{i=1}^{m}\sum_{j=1}^{n}\tilde{c}_{ij}\tilde{x}_{ij},\ S.to\ \sum_{j=1}^{n}\tilde{x}_{ij}=1,\ \sum_{i=1}^{m}\tilde{x}_{ij}=1,\ i=1,2..m\ \&\ j=1,2..n$$

$\tilde{c}_{ij}=[c_{ij}^{l},c_{ij},c_{ij}^{u}]\ \&\ \tilde{x}_{ij}=[x_{ij}^{l},x_{ij},x_{ij}^{u}]$ is the fuzzy parameters

3.1 Mathematical Formulation of Fuzzy 3-Dimensional Assignment Problem:

The fuzzy 3-Dimensional Assignment problem can be stated as

$$\text{Min}\quad z=\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{l}\tilde{C}_{ijk}X_{ijk},$$

Subject to

$$\sum_{j=1}^{n}\sum_{k=1}^{l}X_{ijk}=1,\ \ i=1,2,3....m$$

$$\sum_{i=1}^{m}\sum_{k=1}^{l}X_{ijk}=1,\ \ j=1,2,3...n$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n}X_{ijk}=1,\quad k=1,2,...l$$

$$X_{ijk}=0\ \ (or)\ 1,\ for\ all\ \ i,j\ and\ k.$$

Where $\tilde{C}_{ijk}$'s is the cost of assigning ithworker to jth job on the kth machine and all $\tilde{C}_{ijk}$'s form a cubic matrix.

Jobs	J1			J2			J3		
Men/ Factories	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	$\tilde{C}_{111}$	$\tilde{C}_{112}$	$\tilde{C}_{113}$	$\tilde{C}_{121}$	$\tilde{C}_{122}$	$\tilde{C}_{123}$	$\tilde{C}_{131}$	$\tilde{C}_{132}$	$\tilde{C}_{133}$
M2	$\tilde{C}_{211}$	$\tilde{C}_{212}$	$\tilde{C}_{213}$	$\tilde{C}_{221}$	$\tilde{C}_{222}$	$\tilde{C}_{223}$	$\tilde{C}_{231}$	$\tilde{C}_{232}$	$\tilde{C}_{233}$
M3	$\tilde{C}_{311}$	$\tilde{C}_{312}$	$\tilde{C}_{313}$	$\tilde{C}_{321}$	$\tilde{C}_{322}$	$\tilde{C}_{323}$	$\tilde{C}_{331}$	$\tilde{C}_{332}$	$\tilde{C}_{333}$

4. PROPOSED ALGORITHMS:

4.1 One's Termination Algorithm:

Step 1: Construct the three dimensional Fuzzy Assignment Table and consider all the parameters are Triangular Fuzzy Numbers.

(i) If the number of rows is equal to the number of columns, then go to step 3.

(ii). If the number of rows is not equal to number of columns then, go to step 2.

Step 2: Add dummy row or dummy column, because fuzzy cost table become a square matrix and introduced the fuzzy cost dummy entries are always zero.

Step 3: Step (i) parameters are converting to crisp number with the help of Robust Ranking Function.

Step 4: Choose the minimum cost value in each column and divide that element in step (3) matrix. Because, it can be create at least one 1's in each row and column.

Step 5: O_T = Sum the cost of all adjacent 1's and divide by the total number of adjacent cells.

Step 6: The allocation of the assignment value is maximum possibilities of the 1's cell. Suppose more than 1's cell having attained the possibility level choose the minimum value of the assignment cost.

Step 7: Draw the minimum number of horizontal and vertical lines to cover all the ones of the matrix. If the numbers of lines are equal to the number of allocation then the optimal assignment is obtained. Otherwise go to step (8).

Step 8: Draw the new revised cost matrix as follows.

Choose the smallest cost value of the uncovered cell and divide the cost in uncovered cell. Multiply the smallest value lying at the pivot element of the cost matrix.

Step 9: Go to step 3 to step 7 and repeat the procedure until fuzzy optimal assignment is obtained.

4.2 Fuzzy Partition Method:

Our proposed algorithm gives the optimal fuzzy assignment cost. It is described as follows.

Step 1: Formulated the fuzzy assignment cost table.

(i) If the number of row is equal to number of column, then go to step 3.

(ii) If the number of row is not equal to number of column, then go to step 2.

Step 2: Add dummy row or dummy column, because fuzzy cost of the table become a square matrix and introduced the fuzzy cost dummy entries are always zero.

Step 3: Step (1) Using α-cut, we obtained the interval of Fuzzy Assignment Cost Table.

Step 4: Step (3) we split the table into lower bound and upper bound Fuzzy assignment cost Table.

Step 5: Using the algorithm 4.1. We obtained the optimal fuzzy assignment cost (separately in lower bound and upper bound).

4.3 Statistical Implementation

Statistics deals with gathering, classifying and analyzing data. Statistics is concerned with the relationship between abstract probability models and actual physical systems. One of the primary tools of the statistician is knowledge of probability theory. Statistical theory split up into two branches one is descriptive and another one is inductive statistics. Descriptive statistics deals with the collection of data such as summarizing the available data by such variables as the mean, mode, SD., etc., the statistical interference uses the data draw the conclusions about the environment from which the data came. Now, the statistical concept using fuzzy assignment concept, because we analyzed the significance level of each job assign to the each machine. Using T-distribution, the observed data collection then we obtain the mean and variance of the interval $[x_\alpha^l, x_\alpha^u]$

The T-calculated value (T_{cal}) compare with the table value (T_{tab}) of Tin 5% LOS. If $T_{cal} > T_{tab}$,then the null hypothesis is rejected or otherwise it is accepted. The test of statistic value is calculated as follows:

$T = \dfrac{\overline{X} - \mu}{S/\sqrt{n}}$. The interval of Fuzzy optimal Assignment Cost is as follows:

$$\overline{X}_l \pm 1.96(\sigma/\sqrt{n}) \text{ and } \overline{X}_u \pm 1.96(\sigma/\sqrt{n})$$

5 NUMERICAL EXAMPLE:

Suppose that there are three men denoted by M1,M2 and M3, three factories denoted by F1, F2 and F3, and three jobs J1, J2 and J3. Then three men, three factories and three jobs can be associated with only one of the others that is only one men is associated with one job and one factory. Find the optimum assignment cost. The costs are Triangular Fuzzy numbers $\widetilde{C}_{ijk}$ which are given in the following Table.

Table: 2: Fuzzy 3-Dim Assignment Table

Jobs	J1			J2			J3		
Men/ Factories	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	(8,10,12)	(7,8,9)	(10,12,14)	(6,9,12)	(5,10,15)	(25,27,29)	(13,15,17)	(9,10,11)	(10,13,16)
M2	(7,8,9)	(4,6,8)	(6,7.8)	(8,9,10)	(5,6,7)	(8,12,16)	(6,7,8)	(9,11,13)	(10,12,14)
M3	(8,9,10)	(5,7,9)	(4,6,8)	(8,10,12)	(6,7,8)	(9,12,15)	(7,8,9))	(5,6,7)	(4,8,12)

Solution: Using Robust ranking function we obtained the crisp assignment table as follows.

Table3: Fuzzy assignment values converted to crisp assignment value

Jobs	J1			J2			J3		
Men/ Factories	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	10	8	12	9	10	27	15	10	13
M2	8	6	7	9	6	12	7	11	12
M3	9	7	6	10	7	12	8	6	8

Using our proposed algorithm (4.1) we easily obtained the optimal fuzzy assignment is

$$M1 \xrightarrow{F1} J2,\ \ M2 \xrightarrow{F3} J1,\ \ M3 \xrightarrow{F2} J3$$

Z = (7,9,11) + (5,7,9) + (5,6,7)= (17,22,27)

5.1 Determination of α -cut of fuzzy optimal Assignment cost:

α- cut of fuzzy Assignment cost values are computed from their membership functions as follows:

$$\mu_{c_{121}}(x) = \begin{cases} \dfrac{x-7}{9-7}, & 7 \le x \le 9 \\ \dfrac{11-x}{11-9}, & 9 \le x \le 11 \end{cases}$$

$C_{121}(x)= [2\alpha+7,11-2\alpha]$ -----(1),

Similarly

$C_{213}(x) = [2\alpha+5, 9- 2\alpha]$ ------ (2),

$C_{332}(x) = [\alpha+5, 7-\alpha]$ ------- (3)

Adding (1),(2) and (3) , we get α-cut of fuzzy assignment cost value is

$Z^{(\alpha)} = [5\alpha+17,27-5\alpha]$

Table4: The range of uncertainty optimal fuzzy assignment cost

α- degree of uncertainty	Interval of optimal fuzzy assignment cost [5α+17,27-5α]	Average of assignment cost
0	[17,27]	22
0.1	[17.5, 26.5]	22
0.2	[18,26]	22
0.3	[18.5,25.5]	22
0.4	[19,25]	22
0.5	[19.5,24.5]	22
0.6	[20,24]	22
0.7	[20.5,23.5]	22
0.8	[21,23]	22
0.9	[21.5,22.5]	22
1.0	[22,22]	22

Algorithm (4.2) Using $\alpha - cut$ value of the membership functions and we obtained the interval of triangular fuzzy numbers.

(8,10,12) =[2α+8,12-2α]	(7,8,9)= [α+7,9-α]	(10,12,14) =[2α+10,14-2α]
(6,9,12)= [3α +6,12- α]	(5,10,15)= [5 α+ 5,15-5α]	(25,27,29) = [2α+25,29-2α]
(13,15,17)= [2α+13,17-2α]	(9,10,11) = [α+9,11- α]	(10,13,16)= [3α +10,16-3α]
(7,8,9)= [α+7,9- α]	(4,6,8)= [2 α+4,8-2 α]	(6,7,8)=[α+6,8- α]
(8,9,10) =[α +8,10- α]	(5,6,7)= [α +5,7- α]	(8,12,16)= [4 α +8,16-4 α]
(6,7,8) = [α+6,8- α]	(9,11,13)= [2 α+9,13-2 α]	(10,12,14)= [2 α+10,14-2 α]
(8,9,10)=[α +8,10- α]	(5,7,9)= [2α+5,9-2α]	(4,6,8)=[2α+2,8-2α]
(8,10,12)= [2α+8,12-2α]	(6,7,8)= [α+6,8-α]	(9,12,15)= [3α+9,15-3α]
(7,8,9)=[α+7,9-α]	(5,6,7)= [α+5,7-α]	(4,8,12)=[4α+4,12-4α]

Table 5: $\alpha - cut$ interval of fuzzy assignment table

Jobs	J1			J2			J3		
Factories/Men	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	[2α+8, 12-2α]	[α+7, 9-α]	[2α+10, 14-2α]	[3α+6, 12- α]	[5α+5, 15-5α]	[2α +25, 29-2 α]	15α+5, 17-2 α]	[α+9, 11- α]	3α+10, 16-3 α]
M2	[α +7, 9 - α]	[2α+4, 8-2 α]	[α+6, 8- α]	[α+8, 10- α]	[α+5, 7- α]	[4α+8, 16-4 α]	[α+6 ,8- α]	[2α+9, 13-2 α]	[2α+10, 14-2 α]
M3	[α +8, 10- α]	[2α+5, 9-2α]	[2α+2, 8-2α]	[2α+8, 12-2α]	[α+6, 8-α]	[3α+9, 15-3α]	[α+7, 9-α]	[α+5, 7-α]	[4α+4, 12-4α]

Table 6: The lower bound of fuzzy assignment problem

Jobs	J1			J2			J3		
Factories/ Men	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	2α+8	α+7	2α+10	3 α +6	2α+25	5 α+ 5	5 α+ 5	α+9	3α +10
M2	α +7	2α +4	α+6	α +8	α +5	4α+ 8,	α+6	2α+9	2 α+10
M3	α +8	2α+5	2α+2	2α+8,	α+6	3α+9	α+7	α+5	4α+4

Table 7: The upper bound of fuzzy assignment table

Jobs	J1			J2			J3		
Factories/Men	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	12-2α	9-α	14-2α	12- α	15-5α	29-2 α	17-2 α	11- α	16-3 α
M2	9 - α	8-2 α	8- α	10- α	7- α	16-4 α	8- α	13-2 α	14-2 α
M3	10- α	9-2α	8-2α	12-2α	8-α	15-3α	9-α	7-α	12-4α

Table 8: Put α=0 in the lower bound of the fuzzy assignment table

Jobs	J1			J2			J3		
Factories/ Men	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	8	7	10	6	5	25	13	9	10
M2	7	4	6	8	5	8	6	9	10
M3	8	5	2	8	6	9	7	5	4

Table 9: Put α=0 in the upper bound fuzzy assignment table

Jobs	J1			J2			J3		
Factories/ Men	F1	F2	F3	F1	F2	F3	F1	F2	F3
M1	12	9	14	12	15	29	17	11	16
M2	9	8	8	10	7	16	8	13	14
M3	10	7	8	12	8	15	9	7	12

Using our proposed algorithm (4.2) we obtained the Interval optimal fuzzy assignment cost is $X = [x^l, x^u] = [5\alpha + 22, 30 - 4\alpha]$..... (I)

$M1 \xrightarrow{F2} J1,\ , M2 \xrightarrow{F1} J3,\ \ M3 \xrightarrow{F3} J2$

The Lower bound assignment cost is $x^l = [\alpha + 7, \alpha + 6, 3\alpha + 9] = 5\alpha + 22$

$M1 \xrightarrow{F3} J1,\ \ M2 \xrightarrow{F2} J2,\ M3 \xrightarrow{F1} J3$

The Upper bound assignment cost is $x^u = 7 - \alpha + 14 - 2\alpha + 9 - \alpha = 30 - 4\alpha$

Now, Using T-distribution we obtain the SD and mean value of the α-cut lower and upper bound value, the data collection from (I) $\overline{X}_l = 24.5$ and $\overline{X}_u = 28$.

To analyze the range of uncertainty value in lower bound and upper bound optimal fuzzy assignment cost table is as follows:

Table10: Lower bound of optimal Fuzzy Assignment Cost

α-degree of uncertainty	Lower bound cost [5α +22]	α-degree of uncertainty	Lower bound cost
0	22	0.6	25
0.1	22.5	0.7	25.5
0.2	23	0.8	26
0.3	23.5	0.9	26.5
0.4	24	1.0	27
0.5	24.5		

Table11: Upper bound of optimal Fuzzy Assignment Cost

α-degree of uncertainty	Upper bound cost [30-4α]	α-degree of uncertainty	Upper bound cost
0	30	0.6	27.6
0.1	29.6	0.7	27.2
0.2	29.2	0.8	26.8
0.3	28.8	0.9	26.4
0.4	28.4	1.0	26
0.5	28		

The mean and variance of lower bound and upper bound values are $\overline{X}_l = 24.5$, $\overline{X}_u = 28$, $S_l = 1.57$, $S_u = 1.26$ respectively. From (1) we obtained the largest and smallest interval of Fuzzy Optimal Assignment Cost at 5%LOS is [23.57, 28.745] and [25.43, 27.255].

6. CONCLUSION

In this paper, we considered the 3Dimensional fuzzy assignment problem with uncertain data. The solution procedure of the proposed algorithms are explained with the help of the example and we find out the interval of lower bound and upper bound values. This method is very helpful to decision makers to choose appropriate decision while handling various types of 3-Dimensional assignment problems in real life situations.

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