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Non-Dominating Alternate Path of Bi-objective Fuzzy Assignment Problem

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Abstract: - **In this paper, we present a new algorithm to obtain the non-dominating alternative assignment path of multi objective fuzzy assignment. This method did not need any parameters or node to solve the problem and successfully goes to solving multi objective assignment problem into bi-objective assignment problem. Moreover, it gives the best alternative assignment path. But due to the situation the assignment parameters are uncertain. So, we consider the assignment parameters are fuzzy numbers. A numerical example has been illustrated.**

Keywords: **MOFAP, BOFAP, Triangular Fuzzy Number, Robust Ranking Function. One's Termination Algorithm, Proposed Algorithm. AMS Classification (2010): 90C10, 03E72**

I. INTRODUCTION

In a real world, the assignment problem is most help to the decision maker decision for particularly business people. The Hungarian method can easily obtain the optimal value of single objective assignment problem. Multi objective assignment problem are especially significant and this type of problems are involving the various parameters. Consequently, to solving through the regular method is impossible once because solution of the regional space in non-convex. Many researchers [1, 2, 3]have stated many results but all the time they faced complicated calculations to reach the best alternate path.[5] Completed the projects using the FDOT to establish a model constructed the functional relation between the time and cost for the collected highway construction projects. [6]Proposed a Multi objective ant colony optimization technique to analyze the advanced time cost – quality trade off problem.[12]Stated that the mathematical modeling of FAP converted into the crisp AP with the help of grade mean integration and to obtain the optimal solution using Fourier elimination method. Due to the situation the parameters are uncertain. In this case fuzzy set theory is most helpful to rectify the uncertainty problem. [13]studied the MOAP with imprecise cost, time and ineffectiveness instead of the precise information and assigning parameters are considered as trapezoidal fuzzy numbers. He developed the priority based fuzzy goal programming method and forms an appropriate priority structure among the different priorities of the fuzzy goals with Euclidean distance function.[10] has proposed the concept of fuzzy sets. Since, FAP have established the great attention. [11] Proposed the flexible assignment problem which combines the fuzzy theory, multi criteria decision making problem.[14]Investigates the two objectives of k-cardinality assignment problem and using the constrained chance method to construct the modeling of FAP. Generally the probability theory to deal with the uncertain factors investigated the LPP to solving randomly generated occurrences. Later [4] has established an upper bound for the expected cost of optimal AP. Many researchers[7, 8, 9]have stated the stronger result from the quadratic AP. So, in this chapter we extended [11]work to proposed a new algorithm and to obtain the alternate path assignment and the parameters are considered as triangular fuzzy numbers.

II. MATHEMATICAL FORMULATION OF MOAP:

A multi objective assignment problem is formulated generally as follows:

$$Min\ z^{(k)} = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}^{(k)} x_{ij}\ ,\ k = 1,2 \ldots p$$

$$subject\ to \{ \sum_{i=1}^{n} x_{ij} = 1 \quad j = 1,2 \ldots .n$$

$$\sum_{j=1}^{n} x_{ij} = 1 \quad i = 1,2 \ldots .n, \quad x_{ij} \in [0,1]$$

Where c_{ij}^{k} is the objective function coefficients and all are positive integers. The feasible region of the above

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problem to avoid the repeating terms (s) and the cost matrix are dependent to k. The set of objective function $Z(x)=\left(z_1(x),z_2(x).......z_p(x)\right)$ where $X=\left(x_{11},......x_{nn}\right)\in s$

2.1 Mathematical Formulation of BOAP: Consider the following bi–objective assignment problem

(P_1) Subject to ------ (1.1) $Min\, z_1=\sum_{i=1}^{n}\sum_{j=1}^{n}c_{ij}x_{ij}$

------ (1.2) $\sum_{j=1}^{n}x_{ij}=1 \;\; for\, i=1,2,3.....n$

------- (1.3) $\sum_{i=1}^{n}x_{ij}=1 \;\; for\, j=1,2,3.....n$

$x_{ij}\geq 0,\ \forall i,j$

(P_2)

Subject to ------ (1.1) $Min\, z_2=\sum_{i=1}^{n}\sum_{j=1}^{n}d_{ij}x_{ij}$

------ (1.2) $\sum_{j=1}^{n}x_{ij}=1 \;\; for\, i=1,2,3....n$

------ (1.3) $\sum_{i=1}^{n}x_{ij}=1 \;\; for\, j=1,2,3.....n$

$x_{ij}\geq 0,\ \forall i,j$

Remark: 2 Assume $x^{i^*}\in S$ for each $i\in\{1,2....p\}$ is the optimize point of $z_i(x)$ on s, and then the $\left(z_1(x^{1^*}),z_2(x^{2^*})........z_p(x^{p^*})\right)$ point in the target space is called the ideal point and shown by I.

Remark: 3 The efficient of $x^*\in s$ is called the super-efficient when $z(x^*)$ has the at least distance to the ideal point, therefore $z(x^*)$ is called the best alternate path of the AP

III. THEOREMS

3.1 Theorem: If x^* is optimized solution of the problem p_1 iff it is the optimized solution of the problem p_2.

Proof: Let the ideal point is optimized solution of $\min\ z_i(x),\ s.t\ x\in S$ for each $i\in\{1,2.....p\}$ then $z_i(x)-I_i$ is always a positive amount of all the unconditional values can be removed from the problem p_1 and the fixed value of I_i did not affect the optimization.

3.2 Theorem: Every optimized point of p_1 is an efficient point of p_1

Proof: Assume that x^* is an optimized point of the problem p_1. To prove x^* is an efficient point of p_1. But every efficient point is not optimized the any one of the problem, then there is $y\in S$ for each i, $z_i(y)\leq z_i(x^*)$ and at least one j $z_j(y)\leq z_j(x^*)$ and x^* being an optimized of p_2. Therefore, x^* is an optimized point of the problem p_1. Using the theorem (1) and (2) it is shown that efficient alternate path of the AP of p_1 is equal to obtaining the optimized point of p_2.

3.3 Theorem: Let X^0 ={ x_{ij} , i = 1,2,…m; j=1,2,…n} be an optimal solution to $(P_1)$where (P_1) Minimize $Z_1=\sum_{i=1}^{m}\sum_{j=1}^{n}C_{ij}x_{ij}$ subject to 1.1 , 1.2 and 1.3.

Let Y^0 ={ y_{ij} , i = 1,2,…m; j=1,2,…n} be an optimal solution to $(P_2)$where (P_2) Minimize $Z_2=\sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}x_{ij}$ subject to 1.1 , 1.2 and 1.3.

Then, U^0 = { u_{ij} , i = 1, 2…m; j=1,2,…n} which is obtained from X^0 ={ x_{ij} , i = 1,2,…m; j=1,2,…n} or Y^0 ={ y_{ij} , I = 1,2,…m; j=1,2,…n} is an efficient / non-efficient solution to the problem.

Proof:

Now, since X^0 = { x_{ij} , i = 1, 2…m; j=1, 2…n} is an optimal solution of P_1, Clearly, X^0 = { x_{ij}^o , i = 1, 2…m; j=1, 2…n} is a feasible solution of P_2, Clearly, X^0 = { x_{ij} , i = 1, 2…m; j=1, 2…n} is an efficient solution to the problem (P) which is trivial.

Step 1: Let us choose the allocated cell (α,β) with maximum d_{ij} in (P_2). Now, we float a quantity from the allocated cell (α, β) cell to the lowest cost cell through a closed loop so that total deterioration cost is minimum.

Step: 2 Construct a rectangular loop ABCDA where AC are in the r^{th} column and BD are in the s^{th} column such

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that A is the (α,β) allocated cell, D is the (γ,ω) allocated cell, C is the (γ,β) cell, and B is the (α,ω) unallocated cell with minimum deterioration cost.

Let θ = Min $\left\{x^0_{\alpha\beta}, x^0_{\gamma\omega}\right\}$

Step: 3 we flow the quantity λ where through the closed loop ABCDA. First, allocateλ unit to the unallocated cell (α,ω) and subtract λ unit to the allocated cells (α,β) and (γ,ω) and also add λ unit to the cell (γ,β).Then, we obtain a new allotment for A, B, C and D. Thus, we have the following feasible solution: $U^0 = \{ u_{ij}$, i = 1, 2…m; j=1, 2…n} to (P_1) and (P_2)

$$u^0_{ij} = \begin{cases} x^0_{ij} & if\ i \neq \alpha,\gamma\ \ and\ \ j \neq \beta,\omega \\ \upsilon^0_{ij} & if\ i = \alpha,\gamma\ \ and\ \ j = \beta,\omega \end{cases}$$

It is better than $X^0 = \{ x_{ij}$, i = 1, 2…m; j=1, 2…n} for the problem (P_2). Thus $U^0 = \{ u_{ij}$, i = 1, 2…m; j=1, 2…n} is an efficient / a non–efficient solution to the problem (P). Similarly, we can also obtain an efficient solution to the problem (P) from the optimal solution $Y^0 = \{ y_{ij}$, i = 1, 2,…m; j=1,2,…n} of (P_2) repeating the same procedure.

IV. PROPOSED ALGORITHM OF ALTERNATE PATH ASSIGNMENT:

4.1 One Termination Method:

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

(i) If the number of jobs , number of workers and number of machines are equal, then go to step 3.

(ii) If the number of jobs , number of workers and number of machines are not equal, then go to step 2.

Step 2: Add dummy job or dummy worker or dummy machine, because the fuzzy cost table becomes a square matrix and the introduced fuzzy cost dummy entries are always are zero.

Step 3: By Step1, the parameters are converted into crisp numbers 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 of 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 allocations, then the optimal assignment id 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 by the cost in the 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 Optimal BOFAP Algorithm:

We summarize the following new algorithm to execute the proposed method to find the fuzzy optimal solution to BOFAP with the help of Triangular Fuzzy Numbers.

Step 1: Construct two individual problems of the given BOFAP namely, FOFAP and SOFAP.

Step 2: Find out the optimal solution (X_0), (Y_0) of the problems FOFAP and SOFAP respectively, by using One Termination Method.

Step 3: If. $X_0 = Y_0$, then X_0 is an optimal solution to the BOFAP by the theorem (4.1) and go to step . If not go to next step .

Step 4: Fix H_0 where $H_0 = X_0$ or Y_0 as an initial solution to the given BOFAP. Then calculate the value of $f(H_0)$, f_0.

Step 5: Calculate the dual variables (MODI indices) u_i and v_j for all I and j using the relation $u_i + v_j + \alpha_{ij} + f_0\gamma_{ij} = 0$ for all allotted cells by taking u_i=0 ,for all i.

Step 6: Construct MODI index table for the initial solution, H_0 to the BOFAP. Then, calculate $\delta_{ij} = u_i + v_j + \alpha_{ij} + f_0\gamma_{ij}$ for all non-allotted cells. If $\delta_{ij} \geq 0$ for all non-allotted cells , go to step , if not go to step 7,

Step 7: Find a cell having the most negative value of δ_{ij} ,say (m,n) . Then

(a) If the assignments of m and n in the initial solution H_0 are (m. o) and (p, s) and if $(\gamma_{mo}+\gamma_{ps})-(\gamma_{mn}+\gamma_{op}) \leq 0\ \ and\ \ (\alpha_{mo}+\alpha_{ps})-(\alpha_{mn}+\alpha_{op}) \geq 0$ assign (m, p) and (o, s) and obtain an improve solution $H_1 = (H_O - \{((m, o) ,(p ,s)\} \bigcup \{(m, p) ,(o ,s) \}$ by theorem 3.2 then go to the step 2, for next iteration.

If one of the conditions $(\gamma_{mo}+\gamma_{ps})-(\gamma_{mn}+\gamma_{op}) \leq 0\ \ and\ \ (\alpha_{mo}+\alpha_{ps})-(\alpha_{mn}+\alpha_{op}) \geq 0$ are not satisfied , go to step step 7 (b).

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(b) Find out the cell in the (p ,t) which satisfies

$$(\phi_{mn}+\phi_{ps}+\phi zt)-(\phi_{mn}+\phi_{op}+\phi_{zr})\le 0 \text{ and } (\alpha_{mn}+\alpha_{ps}+\alpha_{zt})-(\alpha_{mn}+\alpha_{op}+\alpha_{zr})\ge 0$$

Where (z, t) is the assignment of 't' in the initial solution H_0 assign (m ,n),(o ,p),(z ,r) and obtain an improve solution $H_1= H_0$ –{(m, r),(o ,m),(z, t)}U{ (m ,n)(o, p),(z, r)} by theorem (4.1) then go to step 3 for next iteration. If one of the above conditions

$$(\phi_{mn}+\phi_{ps}+\phi zt)-(\phi_{mn}+\phi_{op}+\phi_{zr})\le 0 \text{ and } (\alpha_{mn}+\alpha_{ps}+\alpha_{zt})-(\alpha_{mn}+\alpha_{op}+\alpha_{zr})\ge 0$$

Is not satisfied, go to step 7 (c).

(c) Continuing the above process, we get an assignment to the r^{th} column in the step 7 (b).

Repeat the steps 3 to step 7(b) and at last an improve solution is obtained. Then goto step 3 for next iteration.

Step 8: The current solution is the optimal solution to the BOFAP. Then STOP. The current path is the optimal assignment path.

V. NUMERICAL EXAMPLE:

A departmental head has four subordinates and four tasks to be performed. The subordinates differ in efficiency and differ in tasks. His estimate of the time each man would take to perform each task is given in the following table. How should the tasks be allocated one to a man so as to minimize the total man hours? The tasks are given in Bi objective Triangular fuzzy Numbers.

Table 1: Bi objective Fuzzy Assignment Table

Machines/ Jobs	1	2	3	4
A	(0,1,2) (2,3,4)	(1,2,3) (3,4,5)	(5,6,7) (8,9,10)	(3,4,5) (6,7,8)
B	(1,2,3) (3,4,5)	(7,8,9) (8,9,10)	(2,3,4) (6,7,8)	(5,6,7) (8,9,10)
C	(7,8,9) (9,10,11)	(0,1,2) (7,8,9)	(0,1,2) (5,6,7)	(2,3,4) (8,9,10)
D	(4,5,6) (8,9,10)	(3,4,5) (6,7,8)	(1,2,3) (5,6,7)	(3,4,5) (7,8,9)

Case(i) The First Objective Fuzzy Assignment Table (SOFAP)

Table 2: The First Objective fuzzy Assignment Table (FOFAT) .

Machines / Jobs	1	2	3	4
A	(0,1,2)	(1,2,3)	(5,6,7)	(3,4,5)
B	(1,2,3)	(7,8,9)	(2,3,4)	(1,2,3)
C	(7,8,9)	(0,1,2)	(0,1,2)	(2,4,6)
D	(4,5,6)	(3,4,5)	(1,2,3)	(3,4,5)

Using One's Termination Method, we get

Table 3:

Machines/ Jobs	1	2	3	4
A	$\mathbf{1}^{(2.3)}$	2	6	4
B	$1^{(3.2)}$	4	2	$\mathbf{1}^{(3.2)}$
C	8	$\mathbf{1}^{(2.75)}$	$1^{(2)}$	4
D	3	2	$\mathbf{1}^{(1.8)}$	2

The assignments are A→1, B→4, C→ 2, D→3

Case (ii) The Second Objective Fuzzy Assignment Table (SOFAP)

Table 4:

Machines/ Jobs	1	2	3	4
A	(2,3,4)	(3,4,5)	(8,9,10)	(6,7,8)
B	(3,4,5)	(8,9,10)	(6,7,8)	(8,9,10)
C	(9,10,11)	(7,8,9)	(5,6,7)	(8,9,10)
D	(8,9,10)	(6,7,8)	(5,6,7)	(7,8,9)

Table 5:Using One Termination Method we get

Machines/ Jobs	1	2	3	4
A	$1^{(1.3)}$	$\mathbf{1}^{(1.8)}$	3	2
B	$\mathbf{1}^{(1.4)}$	2	2	2
C	2	$1^{(1.5)}$	$\mathbf{1}^{(1.5)}$	2
D	2	$1^{(1.4)}$	$1^{(1.2)}$	$\mathbf{1}^{(1.3)}$

The possible fuzzy assignments are : A→2, B→1, C→3, D→4.

In case (i) and case(ii) ,the possible Fuzzy Assignments are

The lower bound Fuzzy Assignment is A→1, B→4, C→ 2, D→3 and

The upper bound Fuzzy Assignment is A→2, B→1, C→3, D→4.

Now, $(\alpha_{ij})=\begin{pmatrix}1&2&6&4\\2&8&3&2\\8&1&1&3\\5&4&2&4\end{pmatrix}$, $(\beta_{ij})=\begin{pmatrix}3&4&9&7\\4&9&7&9\\10&8&6&9\\9&7&6&8\end{pmatrix}$, $(q_{ij})=\begin{pmatrix}0.5&.0.7&0.9&0.8\\0.6&0.9&0.5&0.6\\0.8&0.9&0.6&0.5\\0.9&0.8&0.9&0.7\end{pmatrix}$

Then $\gamma_{ij}=\dfrac{\beta_{ij}-\alpha_{i\,j}}{q_{ij}}$

Table 6: The (α,γ) table is as follows

Mach/Job	1	2	3	4
A	1 4	2 3	6 3	4 6
B	2 3	8 1	3 8	2 12
C	8	1	1 8	3

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	3	8		12
B	5 4	4 4	2 4	4 6

Case (i): Initial solution:
A→2, B→1, C→3, D→4 (Second objective fuzzy Assignment cost)
Now, the value of "f"for the above allotment = 0.55= 0.6.
Hence f= 0.6
Take $u_i = 0$, for all i, Now $v_j = -\alpha_{ij} - f\gamma_{ij}$, for all allocated cells

Table 7:

	v_1=-3.8	v_2=-8.6	v_3 = -9.8	v_4 = -7.6
u_1=0	1 -0.4 0.6 4	2 **X** 0.6 3	6 -2 0.6 3	4 0 0.6 6
u_2=0	2 **X** 0.6 3	8 0 0.6 1	3 -2 0.6 8	2 1.6 0.6 12
u_3=0	8 6 0.6 3	0 -2.8 0.6 8	1 **X** 0.6 8	3 2.6 0.6 12
u_4=0	5 3.6 0.6 4	4 -2.2 0.6 4	2 - 5.4 0.6 4	4 **X** 0.6 6

For the allotted cells, $v_j = -\alpha_{ij} - f\gamma_{ij}$
$v_1 = -\alpha_{21} - f\gamma_2$ =- 3.8, v_2= - 8.6 v_3 = - 9.8 v_4 = -7.6
now to find the non-allotted cells δ_{ij}= ui+ vj+ $\alpha_{ij} + f_0\gamma_{ij}$ here f_0 = 0.6
δ_{11} = -0.4, δ_{13} = -2.0, δ_{14}= 0, δ_{22} = 0, δ_{23} = -2.0, δ_{24} = 1.6, δ_{31} = 6.0,
δ_{32} = -2.8, δ_{34} = 2.6, δ_{41}=3.6, δ_{42} = -2.2, δ_{43} = -5.4
Case (ii) First Objective Fuzzy Assignment Table:

Table 8:The (β, γ) table.

Machines/Jobs	1	2	3	4
A	3 4	4 3	9 3	7 6
B	4 3	9 1	7 8	9 12
C	10 3	8 8	6 8	9 12
D	9 4	7 4	6 4	8 6

The lower bound assignment is A→1, B→4, C→ 2, D→3.
Now the value of "f" for the above allotment = 1 (i.e.) f = 1.
Take $u_i = 0$, for all i, Now $v_j = -\beta_{ij} - f\gamma_{ij}$, for all allocated cells

Table 9:

Machines/Jobs	1	2	3	4
A	3 4	4 3	9 3	7 6
B	4 3	9 1	7 8	9 12
C	10 3	8 8	6 8	9 12
D	9 4	7 4	6 4	8 6

For the allotted cells, $v_j = -\beta_{ij} - f\gamma_{ij}$, v_1 = -7. v_2 = -21, v_3 == 0, v_4 = -10
To find the non-allotted cells: $\delta_{ij}= u_i + v_j + \beta_{ij} + f_0\gamma_{ij}$ here f_0 = 1.0
To find the New path assignment of Lowest bound assignment using upper assignment is:

$$(\gamma_{33}+\gamma_{44})-(\gamma_{43}+\gamma_{34})\geq 0,\ and\,(\alpha_{33}+\alpha_{44})-(\alpha_{43}+\alpha_{34})\geq 0$$

The new assignment is (1,2),(2,1) (3,4),(4,3)
R(z)= (3,4,5) +(3,4,5) + (8,9,10) +(5,6,7) = (19,23,27)

The membership value of the lower bound assignment value is (19, 23, 27) is

$$\mu(x)=\begin{cases}\dfrac{x-19}{23-19}, & 19\leq x\leq 23\\ \dfrac{27-x}{27-23}, & 23\leq x\leq 27\end{cases} = [4\alpha+19,\ 27-4\alpha],$$

Find the new path assignment of Upper bound assignment using lower assignment is (3, 2), (4, 3). New path assignment is

$$(\gamma_{32}+\gamma_{43})-(\gamma_{43}+\gamma_{23})=0,\ (\beta_{32}+\beta_{43})-(\beta_{43}+\beta_{23})=1$$

The new assignment is = (1,1),(2,4) (3,3)(4,2).

VI. CONCLUSION

In this paper, a bi-objective fuzzy assignment problem is split into two cases (i) FOFAP (ii) SOFAP. One termination method is used to obtain optimal path of each objective FAP and using proposed algorithm to used obtain the alternate optimal path of BOFAP. In this method no parameters are used to solve the BOFTP. Moreover it gives the best alternate optimal path due the uncertain situations.

REFERENCES

[1] Abel Garcia-Najera and John A. Bullinaria "Bi-objective Optimization for the Vehicle Routing Problem with Time Windows: Using Route Similarity to Enhance Performance " 1- 15

[2] Afshar, A., Kaveh, A. and Shoghli, O.R. (2007) Multi objective Optimization of Time-Cost-Quality Using Multi-Colony ant Algorithm. Asian Journal of civil Engineering (Building and Housing), 8, 113-124

[3] Anthony Przybylski, Xavier Gandibleuxa, Matthias Ehrgott, A two phase method for multi-objective integer programming and its application to the assignment problem with three objectives, Discrete Optimization 7(2010) 149-165.

[4] Belacela, N. and Boulasselb, M. R. 2001. Multi criteria fuzzy assignment problem: a useful tool to assist medical diagnosis. Artificial intelligence in Medicine 21, 201-207.

[5] Bowen, P.A., Hall, K.A., Edwards, P.J., Pearl, R.G. and Cattell, K.S. (2002) Perceptions of Time, Cost, Quality Management on Building Projects. The Australian Journal of Construction Economics and Building, 2, 48-56

[6] Chen, M.S. 1985. On a fuzzy assignment problem. Tamkang J. 22, 407– 411

[7] Emrouznejad, A., Angiz, M. Z., and L, W. Ho. 2012, An alternative formulation for the fuzzy assignment problem. Journal of the Operational Research Society. 63, 59-63

[8] Kagade, K.L., Bajaj, V. H. 2010 Fuzzy method for solving multi objective assignment problem with interval cost. Journal of Statistics and Mathematics 1(1), 01-09.

[9] Kagade, K.L., Bajaj, V. H. 2009 Fuzzy approach with linear and some non-linear membership functions for solving multi-objective assignment problems. Advances in Computational Research 1(2), 14-17

[10] Kumar, A., and Gupta, A. 2011. Methods for solving fuzzy assignment problems and fuzzy travelling salesman problems with different membership functions, Fuzzy Information and Engineering, 3(1), 3-21

[11] Majumder, J., and Bhunia, A.K. 2007. Elitist genetic algorithm for assignment problem with imprecise goal, European Journal of Operation Research, 177, 684-692

[12] Muruganandam.S and Hema.K., 2017, Solving Fuzzy Assignment Problem Using Fourier Elimination Method, Global Journal of Pure and Applied Mathematics. 13(2), pp. 453-462

[13] SurapatiPramanik,2012, Multi-objective Assignment Problem with Generalized Trapezoidal Fuzzy Numbers" International Journal of Applied Information Systems, 2(6), pp,13-20

[14] Yuan Feng 2006, A two-objective fuzzy k - cardinality assignment problem, Journal of computational and Applied Mathematics"197(1), 233-244