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A New Data Transfer Approach Through Fuzzy Vogel's Approximation Method

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Abstract: In the present scenario, transportation model plays a crucial role in supply chain management that reduce the cost and improve the services as per user requirement. There are several methods to find the optimal solution like Vogel's Approximation Method (VAM), Row minima, Column minima, North-West Corner method etc. In this paper, the proposed method gives the optimal solution and takes less number of iterations for a fuzzy transportation problem as compare to VAM. The Proposed method is illustrated for the secure data transfer from source to the destination node which is considered as Laptop/ Desktop/ Mobile Devices/ Hand-held Devices.

Keywords: Fuzzy Transportation; North-West corner method; Optimal Solution; Supply Chain Management.

I.INTRODUCTION

From the literature, it is revealed that many researchers have solved various securities by the use of optimization technique with special reference to transportation methods however limited research work is available on the fuzzy transportation. Let us describe some of the important research paper available on these aspects. The algorithm for finding an initial basic feasible solution of a transportation problem is developed by Ahmed U.A. et al. They found the solution when the transportation matrix contains fuzzy numbers and real numbers then this new algorithm would be applied [1]. Kaur A. and Kumar A. developed a new method for solving fuzzy transportation problem by assuming that a decision maker is uncertain about the specific values of the transportation cost, availability and demand of the product. They represent these values as generalized trapezoidal fuzzy numbers [2]. Pandian P. and Natarajan G. introduced a new algorithm named as Fuzzy Zero Point Method. In this method, the solution for the fuzzy transportation problem is found by using the FZP method which is a trapezoidal fuzzy number [3]. Narayanamoorthy S. and Kalyni S. introduced a method in which the initial basic feasible solution for a fuzzy transportation problem is obtained by using a new method [4]. Chauhan S. S. and Joshi N. presented a study that revealed the solution of fuzzy transportation problem by finding the least transportation cost of commodities when supply, demand and cost of commodities are represented by fuzzy numbers. They proposed a ranking method to find out the fuzzy optimal solution by balanced fuzzy transportation problem by using trapezoidal fuzzy numbers with improved Vogel's Approximation Method (VAM) [5]. Radhika C. and Parvathi R. tried to introduce various types of intuitionistic fuzzification function such as triangular, trapezoidal, Gaussian bell shaped sigmoidal, S-shaped, Z-shaped functions which would be more useful for this intuitionistic fuzzy environment [6]. Gani N.A. tried to find out the efficient solution for the large scale fuzzy transshipment problem. The author improved the version of VAM through find out the efficient initial solution for the large scale transshipment problem [7]. In transportation problem, there are various applications in logistics and supply chain for minimizing cost. In actual-life circumstances, the parameters of transportation issues may not be known correctly due to some uncontrollable elements. Henceforth Ebrahimnejad A. proposed a new method for solving fuzzy transportation problem in which the cost of transportation, supply and demand are represented by non-negative LR flat fuzzy numbers. In real life applications, triangular and trapezoidal numbers are the most frequently used numbers that represent the fuzzy number. The basic reason behind using the triangular and trapezoidal fuzzy number is that they are easy to use and easy to interpret [8]. Nuran G. investigated a fuzzy transportation problem with fuzzy quantity in which fuzzy triangular numbers and fuzzy transportation cost per unit is bounded with upper fuzzy numbers. They solved this problem in two stages. In first stage maximum satisfactory level that satisfying balance between fuzzy supply and fuzzy demand is calculated. In the second stage, the unit transportation cost and the arranged problem have been investigated for the optimization of unit transportation cost [9]. Gani A. N. and Assarudeen S.N.M. proposed a new operation on triangular fuzzy number in which the method of subtraction and division has been modified. These modified operators results in exact inverse of addition and multiplication operators [10]. Khalaf W.S. studied a new approach which is known as fuzzy russell's approximation method for solving the fuzzy transportation. The initial fuzzy basic feasible solution has been obtained when all the cost coefficients are fuzzy numbers and all the demands and supplies are the crisp numbers. The initial fuzzy basic feasible solution is also used for the fuzzy optimal solution by using the approach known as fuzzy modified distribution method [11]. Solaiappan S.and Jeyaraman K. studied the fuzzy transportation problem and investigated it by using zero termination method. In this method the transportation cost, supply and demand values are assumed to lie in an interval of values. Robust ranking method is applied to arrange the fuzzy numbers in a perticular interval. This method is also helpful to convert the fuzzy transportation problem into crisp transportation problem [12]. Rani D. et al. considered the fully fuzzy unbalanced transportation problem in which the total production cost is more than the total demand and this problem is solved by adding a dummy destination. The advantage of this method over the existing method is that the fuzzy optimal solution did not involve the dummy destination as the dummy destination has no existence in reality. So the excess availability is not transported and is held back at one or more origins [13]. Poonam S. et al. presented some new method for fuzzy transportation problem. A ranking technique was proposed with alpha optimal solution for solving fuzzy transportation problem. In this problem fuzzy demand and supply are in the form of triangular fuzzy numbers. Kumar A. and Kaur A. introduced two new methods to find out the fuzzy optimal solution for unbalanced fuzzy transportation problem. This method is based on fuzzy linear programming formulation and classical transportation method and also proposed a new representation of trapezoidal fuzzy numbers [15]. Shanmugasundari M. and Ganesan K. introduced a new method for fuzzy optimal solution to the transportation problem with fuzzy parameters. Vogel's and MODI algorithms have been modified for finding fuzzy basic feasible solution and fuzzy optimal solution of fuzzy transportation problems. They introduced the fuzzy version in these previously established methods without converting them to classical problems [16]. Fegade et al. find the least transportation cost of some commodities through a capacitated network when the supply cost, demand cost, capacity cost and cost of edges are represented as fuzzy numbers. A ranking technique has been proposed for solving the fuzzy transportation problem. In this technique the fuzzy demand and supply are in the form of triangular fuzzy numbers. Simple algorithms are used for solving the computed fuzzy transportation problem [17]. Mohanaselvi S. and Ganesan K. proposed a new algorithm for the initial fuzzy feasible solution to a fully fuzzy transportation problem and modified the fuzzy version into fully fuzzy transportation problem without converting it into a classical transportation problem [18]. Narayanamoorthy S. et al. proposed a new algorithm known as fuzzy Russell's method for the initial basic feasible solution to a fuzzy transportation problem. This method can be easily applicable to any kind of fuzzy numbers like normal or abnormal, triangular or trapezoidal or any other LR fuzzy number [19]. Nareshkumar S. and Kumaraghuru S. described a closed bounded and non empty feasible region of the transportation problem by using fuzzy trapezoidal numbers which ensures the existence of an optimal solution for the balance of transportation problem to find out the initial solution of the transportation problem, authors used fuzzy VAM and the optimality of the obtained solution was determined by using the fuzzy modified distribution method [20]. Maliniand P. and Ananthanarayanan M. presented a new ranking method which is helpful to convert the fuzzy transportation problem into a crisp valued transportation problem which can be solved by using MODI method for finding the fuzzy optimal solution [21]. Das U. K. et al. discuss the limitation of VAM and developed an improved algorithm for solving the transportation problem. The VAM is not applied when highest penalty cost is lying in two or more row or column. So in this case VAM fails to give a valuable output. In this paper, author proposed an approach for this problem and developed a new algorithm known as logical development of VAM which is more useful in finding the optimal solution [22]. Samuel, A. E. and Venkatachalapathy M. proposed a new method named as modified VAM for solving the fuzzy transportation problem [23].

II. PRELIMINARIES

Fuzzy Set: A fuzzy set is distinguished by a membership function mapping element of a domain, universe of discourse X to the unit interval [0, 1] i.e. $A = \{(x, \mu A(x); x \in X\}$, Here $\mu A: X \rightarrow [0,1]$ is a mapping known as the degree of membership function of the fuzzy set A and $\mu A(x)$ is known as the membership value of $x \varepsilon X$ in the fuzzy set A. These membership category are often represented by real numbers ranging from [0,1].

Triangular Fuzzy number: A fuzzy number $\tilde{A} = (a_1, a_2, a_3)$ represented in figure 1 is said to be triangular fuzzy number and interpreted as membership functions and holds the following conditions

(i) a_1 to a_2 is increasing function
(ii) a_2 to a_3 is decreasing function
(iii) $a_1 \leqslant a_2 \leqslant a_3$.

$$\mu_{(A)}(x) = \begin{cases} 0, & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, & a_2 \le x \le a_3 \\ 0, & x > a_3 \end{cases} \quad (1)$$

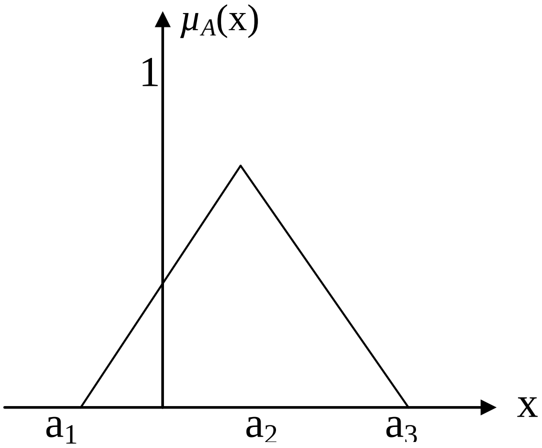

Figure 1- Triangular Fuzzy Number

III. MATERIALS AND METHOD

Consider a transportation problem in which a cell Cij represents the transportation cost from i to j, where i is number of row, j is number of column. Convert the transportation problem into fuzzy transportation problem and then solve with the following steps:

1. Balance the given transportation problem if either (total supply>total demand) or (total supply<total demand) by adding dummy row or column;
2. Compute the fuzzy penalty cost for each row and column of the transportation matrix by calculating the square root of the difference between minimum and next-to-the-minimum transportation cost Cij in that row or column;
3. If minimum transportation cost Cij appear two or more times in a row or column then select this same transportation cost Cij as a minimum and next to minimum transportation cost and penalty will be zero;
4. Identify the row or column with the largest fuzzy penalty cost. If tie occurs, than select that row or column where transportation cost Cij is minimum. If again tie occurs in minimum transportation cost Cij, than select that row or column where total transportation cost of that row or column is minimum;

5. Now allocate as much as possible feasible amount to that smallest transportation cost Cij cell in that row or column;
6. Adjust the supply and demand and cross out the satisfied row or column. If row and column are satisfied simultaneously then crossed out one of them and remaining row or column is assigned a zero supply or demand;
7. Again compute the fuzzy penalty cost for each row and column of the transportation matrix until all requirements have been satisfied;

8. Finally compute total fuzzy transportation cost for the fuzzy feasible cost allocations using the original balanced fuzzy transportation matrix;

A sample of transportation problem is obtained from secure data transfer software shown in the following table I, in which sender sends the data through the data transfer software and receiver receives the data from another device from where data transfer software is installed. This network flow data transfer shows the status of data, size of data, create time, finish time, complete time, average speed of transfer and time consumed.

In this example, the information on supplied and demanded as well as the fuzzy transportation costs per unit can be arranged in the following table II.

Table I. A SAMPLE OF TRANSPORTATION PROBLEM

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	*Supply*
S_1	489	350	142	365	424	272	272	2314
S_2	272	410	350	489	365	489	253	2628
S_3	424	489	365	253	410	410	142	2493
S_4	365	257	472	272	350	410	142	2268
S_5	350	272	365	472	410	257	272	2398
Demand	1900	1778	1694	1851	1959	1838	1081	

Table II. CONVERSION OF TRANSPORTATION PROBLEM INTO FUZZY TRANSPORTATION PROBLEM

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	*Supply*
S_1	(449,489,529)	(320,350,380)	(132,142,152)	(325,365,405)	(389,424,459)	(252,272,292)	(252,272,292)	(2014,2314, 2614)
S_2	(252,272,292)	(385,410,435)	(320,350,380)	(449,489,529)	(325,365,405)	(449,489,529)	(223,253,283)	(2278,2628, 2978)
S_3	(389,424,459)	(449,489,529)	(325,365,405)	(223,253,283)	(385,410,435)	(385,410,435)	(132,142,152)	(2213,2493, 2773)
S_4	(325,365,405)	(222,257,292)	(422,472,522)	(252,272,292)	(320,350,380)	(385,410,435)	(132,142,152)	(2018,2268, 2518)
S_5	(320,350,380)	(252,272,290)	(325,365,405)	(422,472,522)	(385,410,435)	(222,257,292)	(252,272,292)	(2118,2398, 2678)
Demand	(1650,1900, 2150)	(1578,1778, 1978)	(1544,1694, 1844)	(1601,1851, 2101)	(1679,1959, 2239)	(1638,1838, 2038)	(981,1081,1181)	

In the first iteration fuzzy penalty cost for each row and column of the transportation matrix is obtained by calculating the square root of the difference between minimum and next-to-the-minimum transportation cost Cij in that row or column. In Table III, fuzzy penalty cost for row s_1 is obtained by calculating the square root of the difference between 142 and 272 i.e. 11.40, similarly fuzzy penalty cost for each row and column is calculated. Now identify the row or column with the largest fuzzy penalty cost i.e. 14.42 than select that row or column where transportation cost Cij is minimum i.e. 142 ($C_{1,3}$). Now allocate as much as possible feasible amount i.e. **(1544, 1694, 1844)** to that smallest transportation cost $C_{1,3}$ cell in that row or column than adjust the supply and demand and cross out the satisfied row or column. If row and column are satisfied simultaneously then crossed out one of them and remaining row or column is assigned a zero supply or demand. Again compute the fuzzy penalty cost for each row and column of the transportation matrix until all requirements have been satisfied.

Table III. COMPUTATION OF ITERATION 1 FOR FUZZY VAM

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	*Supply*	*Row Panalty*
S_1	(449,489,529)	(320,350,380)	(132,142,152) **(1544,1694,1844)**	(325,365,405)	(389,424,459)	(252,272,292)	(252,272,292)	**(570,620,670)**	11.40
S_2	(252,272,292)	(385,410,435)	(320,350,380)	(449,489,529)	(325,365,405)	(449,489,529)	(223,253,283)	(2278,2628,2978)	4.36
S_3	(389,424,459)	(449,489,529)	(325,365,405)	(223,253,283)	(385,410,435)	(385,410,435)	(132,142,152)	(2213,2493,2773)	10.54
S_4	(325,365,405)	(222,257,292)	(422,472,522)	(252,272,292)	(320,350,380)	(385,410,435)	(132,142,152)	(2018,2268,2518)	10.72
S_5	(320,350,380)	(252,272,290)	(325,365,405)	(422,472,522)	(385,410,435)	(222,257,292)	(252,272,292)	(2118,2398,2678)	3.87
Demand	(1650,1900,2150)	(1578,1778,1978)	**0**	(1601,1851,2101)	(1679,1959,2239)	(1638,1838,2038)	(981,1081,1181)		
Column Penalty	8.83	3.87	**14.42**	4.36	3.87	3.87	10.54		

Table IV. FINAL ALLOCATION MATRIX

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	*Supply*
S_1	(449,489,529)	(320,350,380)	(132,142,152) **(1544,1694,1844)**	(325,365,405)	(389,424,459) **(539,589,639)**	(252,272,292) **(26,31,36)**	(252,272,292)	(2014,2314,2614)
S_2	(252,272,292) **(1650,1900,2150)**	(385,410,435)	(320,350,380)	(449,489,529)	(325,365,405) **(,728,)**	(449,489,529)	(223,253,283)	(2278,2628,2978)
S_3	(389,424,459)	(449,489,529)	(325,365,405)	(223,253,283) **(1601,1851,2101)**	(385,410,435) **(582,642,702)**	(385,410,435)	(132,142,152)	(2213,2493,2773)
S_4	(325,365,405)	(222,257,292) **(1037,1187,1337)**	(422,472,522)	(252,272,292)	(320,350,380)	(385,410,435)	(132,142,152) **(981,1081,1181)**	(2018,2268,2518)
S_5	(320,350,380)	(252,272,290) **(546,591,636)**	(325,365,405)	(422,472,522)	(385,410,435)	(222,257,292) **(1607,1807,2007)**	(252,272,292)	(2118,2398,2678)
Demand	(1650,1900,2150)	(1578,1778,1978)	(1544,1694,1844)	(1601,1851,2101)	(1679,1959,2239)	(1638,1838,2038)	(981,1081,1181)	

IV. RESULT AND DISCUSSION

The total obtained Fuzzy transportation cost for the above transportation problem by using Fuzzy modified VAM is 3096471. The following table shows that by using modified Fuzzy VAM we got the optimal solution in less number of iteration as compared to VAM which is clearly shown in TableV.

Table V. COMPARISION BETWEEN VAM AND FUZZY VAM

Method	No. of iteration	Optimal solution
VAM	11	3097060
Modified VAM (Proposed Method)	9	3096471

V. CONCLUSION

The proposed method provides an optimal solution for a fuzzy transportation problem that gives better results. The proposed method is easy to understand and apply. With the help of numerical example this method gives the optimal solution of fuzzy transportation problem. The proposed technique can also be used to solve real time problems such as network flow problem, assignment problem, linear programming problem, project schedule etc.

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