IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 8, May 2026
Impact Factor: 8.2

An Optimal Algorithm for a Pythagorean Fuzzy Transportation Problem

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Abstract: *Pythagorean Transportation Problem (PTP) is applied on Capacity and Requirement of commodities taken from one source to the different destinations. In this paper Decagonal Pythagorean Fuzzy Numbers using Transportation problem by ranking method and Centroid Ranking Technique and Proposed Ranking Method. The transportation cost can be minimized by using of Proposed Ranking Method under Score function Method. The procedure is illustrated with a numerical example.*

Keywords: Pythagorean Transportation problems, Decagonal fuzzy numbers, Ranking method, CRT, PRM, Initial Basic Feasible Solution, Optimal Solution

I. INTRODUCTION

Transportation problem deals with the hauling of a single/multi artifact feigned at different plants (origins) to number of various storehouses (destinations).Transportation algorithm is one of the influential structures to provide the merchandise to the purchaser in proficient comportment. The core goals of Transportation problems gratify the claim at targets from the supply restraints at the least amount probable transportation cost. Transportation problem guarantee the proficient evolution and prudent accessibility of raw equipments and completed goods. A well-built accord to meet up the confront of how to provide the merchandise to the customers in more adept approaches is accomplished with the aid of transportation models Hitchcock in 1941 developed the essential transportation problem. Stepping stone technique which offered a different way of shaping the simplex method was suggested by Charnes et al in 1953. Decision making field is one of the most significant field which enables to choose the best option among the feasible ones. Prof. Zadeh introduced the concept of fuzzy set theory to cope up with uncertainty and fuzziness of things in real life problems. Fuzzy set has a membership function is defined to assign the degree of membership of an element from the universe to a unit interval [0, 1].

Definition

Ƒuzzy Set: Ƒuzzy set Ά in ℛeal is given to be a set {(x, ($\mu_{Ά}$ (x)) |x∈R }, $\mu_{Ά}$(x): X tends to [0,1] is mapping called the degree of membership function of the fuzzy set Ά and $\mu_{Ά}$(x) is called the membership value of x ∈X in the fuzzy set Ά . These membership values are represented by real numbers lying in [0, 1]. Fuzzy number is formulated as a fuzzy set defining a fuzzy interval in the real number. Generally a fuzzy interval is represented by two end points p and r and q peak point as [p, q, r]. It is a fuzzy set the following conditions:
Convex fuzzy set , normalized fuzzy set , It is defined in the real number
It ís membership function is piecewise continuous.

Pythagorean fuzzy set : Let X is a Classical set, a Pythagorean fuzzy set is an object having the form P = {(x , (τ_P (x), φ_P (x))/x ∈ X },where the function τ_P (x): X→ [0, 1] and φ_P (x): X→[0, 1] are the degree of membership and non-membership of the element x ∈ X to P, respectively.
Also for every x∈X, it holds that $(\tau_P (x))^2 + (\varphi_P (x))^2 \leq 1$.

Definition: RANKING TECHNIQUE

Let P = {(x , (τP (x), φP (x))} a Pythagorean fuzzy number. The ranking R of $\tilde{}$ on the set of Pythagorean fuzzy number is defined as follows:

$$R(P) = \{(\tau_P(x))^2 + (\varphi_P(x))^2\}/2$$

Definition – Ranking Technique: A positioning procedure that fulfills praise, linearity and addictive homes offers consequences that depend upon human instinct. If α_i^p is a fuzzy number after that the place is distinct by

$$R(\alpha_i^p) = \frac{1}{\alpha_i^p}\sum \alpha_i^p \text{ , i = 1 to 10.}$$

Mathematical Formulation of Pythagorean fuzzy transportation Problem

The Pythagorean fuzzy transportation problem can be represented in the form of n x n cost table $[C_{ij}]$after defuzzification as given below.

The costs $[C_{ij}]$ = (τP (x), φP (x)) are Pythagorean fuzzy numbers. The goal is to minimize the Pythagorean fuzzy cost incurred in transportation effectively.

The Pythagorean fuzzy transportation problem can be mathematically expressed as

$$\text{Min } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C^p{}_{ij} x^p{}_{ij}$$

Subject to the constraints

$\sum_{j=1}^{n} x_{ij} = a^p{}_i$, i = 1,2,……,m.

$\sum_{i=1}^{m} x_{ij} = b^p{}_j$, j = 1,2,……,n.

$x_{ij} \geq 0$, for all i and j.

A Pythagorean fuzzy transportation problem is said to be balanced if the total Pythagorean fuzzy supply from all sources equal to the total Pythagorean fuzzy demand in all destination

$\sum_{j=1}^{n} a^p{}_i = \sum_{j=1}^{n} b^p{}_j$, otherwise is called unbalanced.

Definition: Pythagorean Decagonal Fuzzy Number

A Pythagorean Decagonal fuzzy number $(a_p^1, a_p^2, a_p^3, a_p^4, a_p^5, a_p^6, a_p^7, a_p^8, a_p^9, a_p^{10})$can be defined as and the membership function is defined as

$$\mu_{A_p}(x) = \begin{cases} \frac{1}{4}\frac{(x-a_p^1)}{(a_p^2-a_p^1)}, & a_p^1 \leq x \leq a_p^2 \\ \frac{1}{4}+\frac{1}{4}\frac{(x-a_p^2)}{(a_p^3-a_p^2)}, & a_p^2 \leq x \leq a_p^3 \\ \frac{1}{2}+\frac{1}{4}\frac{(x-a_p^3)}{(a_p^4-a_p^3)}, & a_p^3 \leq x \leq a_p^4 \\ \frac{3}{4}+\frac{1}{4}\frac{(x-a_p^4)}{(a_p^5-a_p^4)}, & a_p^4 \leq x \leq a_p^5 \\ 1, & a_p^5 \leq x \leq a_p^6 \\ 1-\frac{1}{4}\frac{(x-a_p^6)}{(a_p^7-a_p^6)}, & a_p^6 \leq x \leq a_p^7 \\ \frac{3}{4}-\frac{1}{4}\frac{(x-a_p^7)}{(a_p^8-a_p^7)}, & a_p^7 \leq x \leq a_p^8 \\ \frac{1}{2}-\frac{1}{4}\frac{(x-a_p^8)}{(a_p^9-a_p^8)}, & a_p^8 \leq x \leq a_p^9 \\ \frac{1}{4}\frac{(x-a_p^9)}{(a_p^{10}-a_p^9)}, & a_p^9 \leq x \leq a_p^{10} \\ 0, & otherwise \end{cases}$$

ISSN: 2581-9429
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Proposed approach of Pythagorean decagonal fuzzy Transportation Problem

Step 1: Test whether the given Pythagorean decagonal fuzzy transportation problem is balanced or not.
If it is a balanced (i.e., the total supply is equal to the total demand) then go to step 3.
If it is an unbalanced (i.e., the total supply is not equal to the total demand) then go to step 2.

Step 2: Introduce dummy rows and /or dummy columns with zero Pythagorean fuzzy costs(decagonal number)to form a balanced one.

Step 3: Find the rank of each cell C_{ij} of the chosen Pythagorean fuzzy cost matrix by using the ranking function as mentioned.

Step 4: Apply Zero Cost Method, (i.e) If demand is greater than supply then the respective cell cost will be zero. After complete this process then apply VAM method.

Step 5: Proceed by the VAM method to find the initial basic feasible solution and if m+n-1 = number of allocations, then proceeds by MODI method to obtain the optimal solution.

Step 6: Add the optimal Pythagorean fuzzy cost using Pythagorean decagonal fuzzy addition mentioned to optimize the cost.

Numerical Example

The input data for Decagonal fuzzy transportation problem is given bellow. The optimal aim of the process is to minimize the transportation cost and maximize the profit. The same problem used in [6] is taken for verification.

Fuzzy transportation problem with decagonal numbers

	D_1	D_2	D_3	D_4	Supply
S_1	(-5,−4,-3,-2,1, 2,3,4,5,6)	(−7,-6,-5,0,2, 3,4,5,6,7)	[-18,-16,-14,-11,0, 8,11,14,16,18)	(-13,-10,-9,-7,1, 2,7,9,10,13]	(-1,0,1,2,3, 8,17,29,40,51)
S_2	(-13,-12,-11,-9,0,5, 9,11,12,13)	(−4,−3,−2,−1,0, 1,2,4,5,6)	(-11,-10-9,-7,2, 5,7,9,10,11)	(-13.-12,-11,-9,0, 6,9,11,12,13)	(-1,1,5,20,25, 30,35,40,45,50)
S_3	(-11,-10,-9,-8,0, 6,8,9,10,11)	(-13,-12,-11,-9,2, 5,9,11,12,13)	(-21,-20,-18,-16,0, 4,16,18,20,21)	(-16,-14,-13,-8,1,7 ,8,13,14,16)	(-10,-7,12,17,18, 19,21,22,33,35)
Demand	(-4,0,4,5,10, 16,17,19,20,23)	(0,1,2,3,4, 5,7,8,9,11)	(−23,-21,13,19,21, 23,30,35,36,37)	(−1,0,10,13,15, 23,30,35,50,55)	

Solution:

Step 1: The Decagonal fuzzy numbers transportation problem is converted into Pythagorean fuzzy transportation problem using the ranking method.

	D_1	D_2	D_3	D_4	Supply
S_1	(0.7,0.3)	(0.9,0.1)	(0.8,0.2)	(0.3,0.7)	15
S_2	(0.5,0.5)	(0.8,0.2)	(0.7,0.3)	(0.6,0.4)	25
S_3	(0.6,0.4)	(0.7,0.3)	(0.4,0.6)	(0.8,0.2)	16
Demand	11	5	17	23	

ISSN: 2581-9429 Volume 6, Issue 8, May 2026 Impact Factor: 8.2

Step 2: Using Score function to convert PFTP into Crisp number

	D_1	D_2	D_3	D_4	Supply
S_1	0.21	0.09	0.16	0.21	15
S_2	0.25	0.16	0.21	0.24	25
S_3	0.24	0.21	0.24	0.16	16
Demand	11	5	17	23	

Step 3: After apply the zero cost method the matrix will be

	D_1	D_2	D_3	D_4	Supply
S_1	0.21	0.09	0	0	15
S_2	0.25	0.16	0.21	0.24	25
S_3	0.24	0.21	0	0	16
Demand	11	5	17	23	

Cost Z = (11×0.25) + (5×0.16) + (9 ×0.21) + (8×0) + (15×0) + (8×0)
= Rs. 5.44

After apply MODI method, All $\Delta_{ij} \geq 0$, so the optimal value is 5.44.

Comparison Table:

S.No.	NWCM	Optimal Solution	LCM	Optimal Solution	VAM	Optimal Solution	**Proposed Method**	**Optimal Solution**
1	10.64	10.64	10.51	10.51	10.51	10.51	**5.44**	**5.44**

II. CONCLUSION

This paper has proposed a new ranking for Pythagorean decagonal fuzzy numbers. The proposed ranking is applied to explicate Pythagorean decagonal fuzzy transportation problem. Further, a numerical example is explained whose costs are taken as Pythagorean decagonal fuzzy numbers .The proficiency of the proposed technique is shown in the comparison table. As a future extension, the proposed algorithm may be used to solve, Pythagorean fuzzy Assignment problem (any number) and Pythagorean fuzzy interval valued fuzzy assignment and Pythagorean fuzzy transportation problems with any number.

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