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An Improved Ant Colony Algorithm to Solve Prohibited Transportation Problems

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Abstract: Physical distribution (transportation) of goods and services from multiple supply centers to multiple demand centers is an important application of linear programming (LP). A transportation problem (TP) can also be solved using the simplex method when expressed as an LP model. However, because a TP has a large number of variables and constraints, solving it using simplex methods takes a long time. Many scientists have devised and continue to devise novel solutions to the classic TP. The prohibited route transportation problem, on the other hand, is a subset of TPs for which most scientists have yet to develop a specific TP. Certain routes may be impassable in some cases due to transportation issues. To name a few: construction projects, poor road conditions, strikes, unexpected disasters, and local traffic laws. Such limits (or prohibitions) in the TP can be managed by assigning a very high cost to the prohibited routes, ensuring that they do not appear in the optimal solution. This paper presents a heuristic algorithm and an improved ant colony optimization algorithm for achieving an initial feasible solution (IFS) to a prohibitive transportation problem (PTP). Using the PTP in the proposed method, on the other hand, produces the best IFS for a prohibited transportation problem and outperforms existing methods with less computation time and complexity. As a result, the proposed methods are an appealing alternative to traditional problem-solving approaches. In some numerical examples, the feasible solution of the proposed method is the same as the optimal solution.

Keywords: Ant Colony Optimization Algorithm, Initial Feasible Solution, Optimal Solution, Prohibited Transportation Problems, Transportation Problem

1. Introduction

The transportation problem (TP) is a problem of optimization. The usual dates are from the 1940s and later. Tolstoy [18] was a pioneer in operations research and thus wrote a book on transportation planning that was published by the Soviet Union's National Commissariat of Transportation. It was an article called "Methods of Ending the Minimal Total Kilometer in Cargo-Transportation Planning in Space," in which he studied the TP and described a number of solution approaches, including the now well-known idea that an optimum solution does not exist. The TP is concerned with determining the best distribution strategy for a single commodity. There is a specified demand for the commodity at each of a number of destinations, and the transportation cost between each source and destination pair is known. In the most basic case, the unit transportation cost is constant.

Here, sources denoted where transportation will begin, destinations denoted where the product must arrive, and denoted the transportation unit cost of transporting from source to destination, and demand denoted the destination. Hitchcock [6] introduced the most basic mode of transportation. Koopmans [7] and Dantzig [2] expanded on it. Ford and Fulkerson [5] generalized the method to transportation problems in general. Several extensions to the transportation model and methods have since been developed by many scientists. TP is based on the supply and demand for commodities transported from various sources to various destinations. Many studies have developed various approaches. For example, Saumis et al. (1991), for example, considered the problem of preparing a low-cost transportation plan by simultaneously solving two sub-problems: first, the assignment of units available at a series of origins to satisfy demand at a series of destinations; and second, the design of vehicle tours to transport these units when the vehicles must be returned to their departure point. Vishwas [20], Identifying more-for-less paradox in the linear fractional transportation problem using objective matrix. Their method makes use of the topological properties of basis trees within a framework of generalized upper bounds. Pandian and Natarajan [11] created a technique for transportation problems that is similar to an optimal solution. Rashid [12] created a heuristic called the improvement of the initial basic feasible solution of a balanced transportation problem. Ekanayake and colleagues [8-19] detailed the practical issues for solving transportation problems and provided comments on various aspects of transportation problem methodologies, as well as discussions on the computational results of the respective researchers Sharma and Sharma [14] proposed a new heuristic approach for obtaining good starting solutions for dual-based approaches to transportation problems. A modified ant colony optimization algorithm for solving a TP was recently developed by Ekanayake et al. [9]. According to a recent paper, because the transportation criteria appear to be unknown to the majority of those working on the TP, one may be tempted to believe that this phenomenon is merely an academic curiosity that will most likely not occur in any practical situation. It has been observed that, on numerous occasions, the decision problem can also be formatted as TP. In today's highly competitive market, the pressure on organizations to find better ways to create and deliver products and services to customers grows stronger.

There are different types of TPs, including cost-minimizing transportation problems, cost-minimizing transportation problems with mixed constraints, bottleneck transportation problems, multi-objective transportation problems, etc. Furthermore, in many practical solutions, some transportation routes are prohibited due to operational problems such as flood situations, road conditions, or government restrictions. These operational problems can be handled to solve transportation problems by converting them into a mathematical problem by assigning a very high transportation cost to these prohibitive routes to ensure that these routes will not be included in the final optimal solution. Also, a few studies have introduced specific routes into the category of prohibited transportation problems (PTP). Many studies have been conducted to develop various types of TPs, but PTPs must have a few studies.

The choice of the construction graph is widely assumed and observed in experiments to have a significant impact on the runtime behavior of an ACO algorithm. The construction graph used in [1, 3, 4, 8, 10] is a generic optimization graph. ACO algorithms have the advantage of incorporating more knowledge about the structure of a given problem into the construction of solutions. This is accomplished by selecting an appropriate construction graph and a procedure that allows for the generation of feasible solutions. Propose an algorithm and investigate ACO algorithms that work on construction graphs and appear to be more suitable for the PTP problem. Consider starting with a random walk on the input graph to come up with solutions to the problem. It is well understood how to use random walk algorithms to choose the best path of a given PTP at random [16, 17].

2. Transportation Model

It has been seen that on many occasion, the decision problem can also be formatting as TP. In general, proposed to minimize total prohibited transportation cost for the commodities transporting from source to destination.

Let there be m sources of supply, S_i having $a_i, (i = 1, 2, \dots, m)$ units of supply (or capacity), respectively to be transported to n destinations, D_j with $b_j, (j = 1, 2, \dots, n)$ units of demand (or requirement), respectively. Let c_{ij} be the cost of shipping one unit of the commodity from source i to destination j. If x_{ij} represents number of units shipped from source i to destination j, the problem is to determine the transportation schedule so as to minimize the total transportation cost while satisfying the supply and demand conditions. the LP formulation of this problem is Minimize.

Minimize $\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} c_{ij}$

Subject constrains;

$$\sum_{j=1}^{n} x_{ij} = a_i, i = 1,2, \dots, m$$

$$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2, \dots, n \text{ and}$$

$$x_{ij} \geq 0 \text{ for all } i = 1,2, \dots, m, \ j = 1,2, \dots, n$$

One of the main requirements here is that the problem be a balanced transportation problem. i.e,

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

When problem unbalance, total demand and total supply are not equal.

The issue is determining the best distribution strategy for transporting products from their origin to their destination while minimizing total transportation costs. Figure 1, shows this.

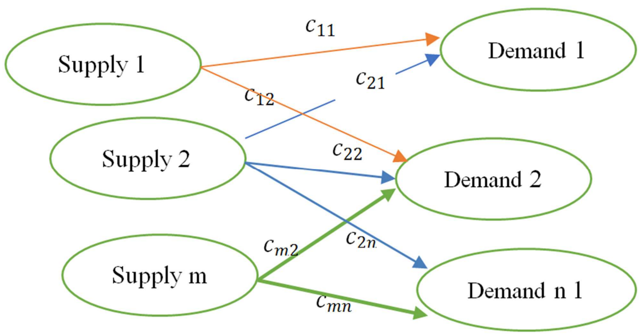

Figure 1. *Network representation of the prohibited transportation problem.*

A transportation table, as shown in Table 1, can also be used to represent the transportation model in tabular form.

Table 1. *Transportation cost table.*

Destination→Source↓	D1	D2	…	Dn	Supply a_i
S_1	c_{11}	-	…	c_{1n}	a_1
S_2	c_{11}	c_{22}	…	c_{2n}	a_2
⋮	⋮	⋮	⋮	⋮	⋮
S_m	-	c_{m2}	…	c_{mn}	a_m
Demand b_j	b_1	b_2	…	b_n	$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

3. Construction Algorithm of PTP

M. Dorigo and colleagues introduced Ant Colony Optimization (ACO) in the early 1990s as a novel nature-inspired metaheuristic for the solution of hard combinatorial optimization (CO) problems. ACO is a type of metaheuristic (4), which are approximate algorithms for solving difficult CO problems in a reasonable time. Furthermore, Wang et al. [21] developed a hybrid optimization algorithm based on ant colony and immune data. ACO is a new metaheuristic approach to solving difficult CO problems. The pheromone trail laying and following behavior of real ants, which use pheromones as a communication medium, is an inspiration for ACO.

The indirect communication of a colony of simple agents known as ants, mediated by (artificial) pheromone trails, is the foundation of ACO. In ACO, the pheromone trails serve as distributed, numerical information, which the ants use to probabilistically construct solutions to the problem at hand, and which the ants adapt during the algorithm's execution to reflect their search experience.

When foraging, some ant species are known to deposit a type of chemical substance called pheromone, which they use to communicate with one another in order to choose the shortest path from their nest to the food source. The ACO, a stochastic, meta-heuristic, and population-based optimization algorithm, is based on this biological phenomenon. Dorigo et al. proposed the ACO for combinatorial optimization problem solving (6), and numerous variations have since been studied. It is a fast way to handle various optimization tasks like routing and scheduling. The ACO can be defined as (3):

1) The probabilistic transition rule is used to determine each ant's moving direction.
2) The pheromone update mechanism indicates the quality of the problem solution.

Clearly, continuous ACO is based on both a global and a local search for the elitist. According to the transition probability $P_i(t)$ of region i, the local ants are capable of moving to the latent region with the best solution:

$$P_i(t) = \frac{\emptyset_i(t)}{\sum_{j=1}^{g} \emptyset_j(t)} \tag{1}$$

where $\emptyset_i(t)$ is the total pheromone at region i at time t, and g is the number of global ants. As a result, the better the region is, the more attracted the successive ants are. If their fitness is improved, the ants can deposit the pheromone increment as in (2). Otherwise, no pheromone is left. Therefore, the better the region is, the more attraction to the successive ants it has. If their fitness is improved, the ants can deposit the pheromone increment $\Delta\emptyset_i$ as in (2). Otherwise, no pheromone is left.

$$\emptyset_i(t+1) = \begin{cases} \emptyset_i(t) + \Delta\emptyset_i; & \text{if fitness is improved} \\ \emptyset_i(t); & \text{Otherwise} \end{cases} \tag{2}$$

After each generation, the pheromone is updated as:

$$\emptyset_i(t+1) = (1-\sigma)\emptyset_i(t) \tag{3}$$

where σ is the pheromone evaporation rate. Using the suggested methodology, it was found that local ants are more likely to choose a location based on its pheromone trail. The rate of pheromone evaporation, ant age, and fitness growth, on the other hand, all have an effect. Thus, this pheromone-based selection mechanism is capable of promoting the solution candidate update, which is certainly suitable for handling the changing environments in optimization.

3.1. ACO Algorithms for Prohibited Transportation Problem

This novel method for addressing PTP is simple, easy to understand, and useful for decision making, and it provides the minimum solution of PTP.

Using the new modified probability function (4) from (1).

$$P_{ij}(t) = \frac{c_{ij}+\omega}{\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}+\omega} \tag{4}$$

where, $\omega =$ maximum c_{ij}

The novel method transforms transportation cost, demand, and supply (Table 1) into a probability table (Table 2) using formula (4).

Table 2. *Probability table for PTP.*

Supply / Demand	D_1	D_2	D_3	…	D_n	Supply
S_1	p_{11}	p_{12}	p_{13}	…	p_{1n}	a_1
S_2	p_{21}	p_{22}	p_{23}	…	p_{2n}	a_2
⋮	⋮	⋮	⋮		⋮	⋮
S_m	p_{m1}	p_{m2}	p_{m3}	…	p_{mn}	a_m
Demand	b_1	b_2	b_3	…	b_n	

3.2. Proposed Method

Step 1: If the transportation problem is unbalanced, start by balancing it by inserting a dummy column or row as needed.

Step 2; Determine the maximum unit cost and adding the particular value each of unit costs without maximum unit cost.

Step 3; Using the above equation, compute the probability table.

Step 4: Ants move to the starting nodes with the second lowest probability cell in the probability table to make the first allocation.

Step 5: Determine the $\min(a_i, b_j)$ and assign the preceding step.

Step 6: If the demand in the column (or supply in the row) is satisfied, remove that column (or row) and proceed to the next maximum.

Step 7: If the termination condition is satisfied $(i.e. a_i = b_j = 0)$ then go to Step 8. Otherwise go to Step 5.

Step 7: Total cost is calculated as the sum of the cost product and the corresponding allocated supply/demand value. That is,

$$\text{Total cost} = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} c_{ij}$$

4. Result

4.1. Numerical Illustrations [Example 1 [15]]

Table 3. *Ex. 1. Step 1.*

	D1	D2	D3	D4	D5	D6	Supply
S1	5	4	4	6	7	7	100
S2	8	6	6	5	7	7	200
S3	7	6	6	8	9	9	150
S4	-	-	0	0	-	0	110
Demand	80	40	50	60	80	250	

Table 4. *Ex. 1. Step 2: Determine the maximum unit cost and adding the particular value each of unit costs without maximum unit cost.*

	D1	D2	D3	D4	D5	D6	Supply
S1	14	13	13	15	16	16	100
S2	17	15	15	14	16	16	200
S3	16	15	15	17	9	9	150
S4	9	9	0	0	9	0	110
Demand	80	40	50	60	80	250	

Table 5. *Ex. 1. Step 3; Using the above equation, compute the probability table.*

	D1	D2	D3	D4	D5	D6	Supply
S1	.048	.045	.045	.052	.055	.055	100
S2	.059	.052	.052	.048	.055	.055	200
S3	.055	.052	.052	.059	.031	.031	150
S4	.031	.031	0	0	.031	.031	110
Demand	80	40	50	60	80	250	

Table 6. *Ex. 1. Step 4: Ants move to the starting nodes with the second lowest probability cell in the probability table to make the first allocation, and step 5.*

	D1	D2	D3	D4	D5	D6	Supply
S1	.048	.045*40	.045*50	.052	.055	.055	100*10
S2	.059	.052	.052	.048	.055	.055	200
S3	.055	.052	.052	.059	.031	.031	150
S4	.031	.031	0	0	.031	.031	110
Demand	80	40*0	50*0	60	80	250	

Table 7. *Ex. 1. Step 4 and Step 5.*

	D1	D2	D3	D4	D5	D6	Supply
S1	.048	.045*40	.045*50	.052	.055	.055	100*10
S2	.059	.052	.052	.048	.055	.055	200
S3	.055	.052	.052	.059	.031	.031	150
S4	.031	.031	0	0	.031	.031	110
Demand	80	40*0	50*0	60	80	250	

Table 8. *Ex. 1. Step 4 and Step 5.*

	D1	D2	D3	D4	D5	D6	Supply
S1	.048*10	.045*40	.045*50	.052	.055	.055	100*10*0
S2	.059	.052	.052	.048*60	.055	.055	200*140
S3	.055	.052	.052	.059	.031	.031	150
S4	.031	.031	0	0	.031	.031	110
Demand	80*70	40*0	50*0	60*0	80	250	

Table 9. *Ex. 1. Step 4 and Step 5.*

	D_1	D_2	D_3	D_4	D_5	D_6	Supply
S_1	.048*10	.045*40	.045*50	.052	.055	.055	100*10*0
S_2	.059	.052	.052	.048*60	.055*80	.055*60	200*140*0
S_3	.055*70	.052	.052	.059	.031	.031	150*80
S_4	.031	.031	0	0	.031	.031	110
Demand	80*70*0	40*0	50*0	60*0	80*0	250*190	

Table 10. *Ex. 1. Step 7: If the termination condition is satisfied $(i.e. a_i = b_j = 0)$ then go to Step 8. Otherwise go to Step 5.*

	D_1	D_2	D_3	D_4	D_5	D_6	Supply
S1	.048*10	.045*40	.045*50	.052	.055	.055	100*10*0
S2	.059	.052	.052	.048*60	.055*80	.055*60	200*140*0
S3	.055*70	.052	.052	.059	.031	.031*80	150*80*0
S4	.031	.031	0	0	.031	.031*110	110*0
Demand	80*70*0	40*0	50*0	60*0	80*0	250*190*0	

Table 11. *Ex. 1. Step 8.*

	D_1	D_2	D_3	D_4	D_5	D_6	Supply
S_1	5*10	4*40	4*50	6	7	7	100
S_2	8	6	6	5*60	7*80	7*60	200
S_3	7*70	6	6	8	9	9*80	150
S_4	-	-	0	0	-	0*110	110
Demand	80	40	50	60	80	250	

Total cost =(5×10)+(4×40)+(4×50)+(5×60)+(7×80)+(7×60)+(9×80)+(0×110)=2900

4.2. Numerical Illustrations [Example 2 [15]]

A manufacturer must produce a certain product in sufficient quantity in order to meet contracted sales for the next four months. The production facilities available for this product are limited and vary in different months. The unit cost of production also changes according to the facilities and personnel available. The product may be produced in one month and then held for sale in a later month, at an estimated storage cost of Rs 1 per unit per month. No storage charge is incurred for goods that are sold in the same month in which they are produced. Presently, there is no inventory of this product and none is desired at the end of four months. Given the following table, show how much to produce in each of the four months in order to minimize total cost.

Table 12. *Ex. 2.*

Month	Contracted Sales (in units)	Maximum Production (in units)	Unit Cost of Production (Rs.)	Unit Storage Cost per Month (Rs.)
1	20	40	14	1
2	30	50	16	1
3	50	30	15	1
4	40	50	17	1

Formulate the problem as a transportation problem and solve it.

Table 13. *Ex. 2. Step 1. Transportation table.*

From/To	1	2	3	4	Dummy	Supply
1	14	15	16	17	0	40
2	-	16	17	18	0	50
3	-	-	15	16	0	30
4	-	-	-	17	0	50
Demand	20	30	50	40	30	

Table 14. *Ex. 2. Step 2; Determine the maximum unit cost and adding the particular value each of unit costs without maximum unit cost.*

From/To	1	2	3	4	Dummy	Supply
1	14	15	16	17	0	40
2	18	16	17	18	0	50
3	18	18	15	16	0	30
4	18	18	18	17	0	50
Demand	20	30	50	40	30	

Table 15. *Ex. 2. Step 3; Using the above equation, compute the probability table.*

From/To	1	2	3	4	Dummy	Supply
1	32	33	34	35	0	40
2	18	34	35	18	0	50
3	18	18	33	34	0	30
4	18	18	18	35	0	50
Demand	20	30	50	40	30	

Table 16. *Ex. 2. Step 4: Ants move to the starting nodes with the second lowest probability cell in the probability table to make the first allocation, and step 5.*

From/To	1	2	3	4	Dummy	Supply
1	.074	.076	.078	.081	0	40
2	.041	.078	.081	.041	0	50
3	.041	.041	.076	.078	0	30
4	.041	.041	.041	.081	0	50
Demand	20	30	50	40	30	

Table 17. *Ex. 2. Step 5 and Step 6.*

From/To	1	2	3	4	Dummy	Supply
1	.074^20	.076^20	.078	.081	0	40
2	.041	.078^10	.081^20	.041	0^20	50
3	.041	.041	.076^30	.078	0	30
4	.041	.041	.041	.081^40	0^10	50
Demand	20	30	50	40	30	

Table 18. *Ex. 2. Total cost* $= \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij}c_{ij}$.

From/To	1	2	3	4	Dummy	Supply
1	14^20	15^20	16	17	0	40
2	-	16^10	17^20	18	0^20	50
3	-	-	15^30	16	0	30
4	-	-	-	17^40	0^20	50
Demand	20	30	50	40	30	

Total cost = 14×20+15×20+16×10+17×20+15×30+17×40=2210

4.3. Numerical Illustrations [Example 3 [15]]

Consider the problem of scheduling the weekly production of certain items for the next four weeks. The production cost of the item is Rs. 10 for the first two weeks and Rs. 15 for the last two weeks. The weekly demands are 300, 700, 900, and 800, which must be met. The plant can produce a maximum of 700 units per week. In addition, the company can use overtime during the second and third weeks. This increases the weekly production by an additional 200 units, but the production cost also increases by Rs. 5. Excess production can be stored at a unit cost of Rs. 3 per week. How should the production be scheduled so as to minimize the total cost?

Solution

The given information is presented as a transportation problem in Table 19. The cost elements in each cell are determined by adding the production cost, the overtime cost of Rs 5, and the storage cost of Rs 3. Thus, in the first row, the cost of Rs 3 is added during the second week onward. Since the output of any period cannot be used in a period preceding it, the cost element is written in the appropriate cells. A dummy column has been added because the supply exceeds demand.

Table 19. *Ex. 3.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	10	13	16	19	0	700
R_2	-	10	13	16	0	700
O_2	-	15	18	21	0	200
R_3	-	-	15	18	0	700
O_3	-	-	20	23	0	200
R_4	-	-	-	15	0	700
Demand	300	700	900	800	500	3,200

Table 20. *Ex. 3. Probability table to make the first allocation, and step 5.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	.042*300	.046	.050	.054	0	700*400
R_2	.029	.042*700	.046	.050	0	700*0
O_2	.029	.049	.053	.057	0	200
R_3	.029	.029	.049	.053	0	700
O_3	.029	.029	.055	.029	0	200
R_4	.029	.029	.029	.049	0	700
Demand	300 *0	700 *0	900	800	500	3,200

Table 21. *Ex. 3. Step 5 and Step 6.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	.042*300	.046	.050	.054	0	700*400
R_2	.029	.042*700	.046	.050	0	700*0
O_2	.029	.049	.053	.057	0	200
R_3	.029	.029	.049*700	.053	0	700*0
O_3	.029	.029	.055	.029	0	200
R_4	.029	.029	.029	.049*700	0	700*0
Demand	300 *0	700 *0	900 *200	800 *100	500	3,200

Table 22. *Ex. 3. Step 5 and Step 6.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	.042*300	.046	.050*200	.054	0	700*400*200
R_2	.029	.042*700	.046	.050	0	700*0
O_2	.029	.049	.053	.057	0	200
R_3	.029	.029	.049*700	.053	0	700*0
O_3	.029	.029	.055	.029	0	200
R_4	.029	.029	.029	.049*700	0	700*0
Demand	300 *0	700 *0	900 *200*0	800 *100	500	3,200

Table 23. *Ex. 3. Step 5 and Step 6.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	.042*300	.046	.050*200	.054*100	0*100	700*400*200*100*0
R_2	.029	.042*700	.046	.050	0	700*0
O_2	.029	.049	.053	.057	0*200	200*0
R_3	.029	.029	.049*700	.053	0	700*0
O_3	.029	.029	.055	.029	0*200	200*0
R_4	.029	.029	.029	.049*700	0	700*0
Demand	300 *0	700 *0	900 *200*0	800 *100*0	500 *0	3,200

Table 24. *Ex. 3. Step 5 and 6.*

Week (Origin)	Production Cost per Week (Destination)					Supply
	I	II	III	IV	Dummy	
R_1	10*300	13	16*200	19*100	0*100	700
R_2	-	10*700	13	16	0	700
O_2	-	15	18	21	0*200	200
R_3	-	-	15*700	18	0	700
O_3	-	-	20	23	0*200	200
R_4	-	-	-	15*700	0	700
Demand	300	700	900	800	500	3,200

The total minimum cost for the optimal production= 10×300+16×200+19×100+10×700+15×700+15×700=36100.

4.4. Numerical Illustrations [Example 4 [15]]

Minimization transportation problem with data shown below table.

Table 25. *Ex. 4.*

4	α	9
30		20
β	7	8
	30	30

Find the values of α and β that the given solution optimal.
If $\alpha = \beta$ then find the optimal solution.

Transportation table

Table 26. *Ex. 4. North west cost method.*

4	α	9	50
β	7	8	60
30	30	50	

Using North west cost method
Transportation cost =120+20α+70+400=590+20α

Table 27. *Ex. 4. Calculate another method.*

4*30	α	9*20	50
β	7*30	8*30	60
30	30	50	

Minimum cost=750 then $\alpha \leq 8$.
Using Least Cost method (assume β is minimum)

Table 28. *Ex. 4. Calculate another method.*

4	8	9*50	50
$\beta * 30$	7*30	8	60
30	30	50	

Minimum cost=750=30 β+210+450
Implies $\beta = 3$ b.

Table 29. *Ex. 4. Optimal solution.*

.178*30	.123	.123*20	50*20*0
.123	.219*30	.232*30	60*30*0
30*0	30*0	50*20*0	

Optimal solution=750

5. Conclusions

Discuss a novel alternative technique in this research work, a modified ant colony optimization algorithm that frequently provides an optimal PTP solution. This research paper presents an overview of the concept of an ant colony algorithm and provides a review of its applications to solve PTPs. Several modifications to the ant colony algorithm are made and ensure a solution that is very close to the optimal solution. An extensive numerical study was carried out to see the potential significance of this modified ant colony algorithm. However, in practice, when researchers and practitioners deal with large-sized transportation problems, they urge them to use the proposed MACOA due to the time-consuming computation of other methods. The proposed method is very simple, easy to understand, and easy to implement. This method requires a minimum number of steps to reach optimality as compared to the existing methods. The existing well-known exact optimal cost solution technique deals fully with the path tracing technique, but it becomes very difficult to solve large-scale transportation problems. As a result, concentrate all efforts in the near future on formulating a new, better plan of action that solves this issue. The proposed method can be used successfully to solve different business problems in the distribution of products, which is commonly referred to as PTPs.

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