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Article

Designing the Distribution Route for 40 Kg Cement Using Ant Colony Optimization Algorithm at PT. SBI Tuban

Rusindiyanto, Yekti Condro Winursito, Isna Nugraha*, Hafid Syaifullah and Mochammad Dicky

Department of Industrial Engineering, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya 60294, Indonesia
*Corresponding author: *isna.nugraha.ti@upnjatim.ac.id | Phone number: +6285293006434

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Abstract

Distribution is a process of distributing goods or services needed from producers or service producers to consumers and to users, wherever and whenever needed. Problems that often occur in the distribution process that are often encountered are constraints on ineffective routes and inadequate fleet carrying capacity, especially in the Tuban and surrounding areas. This study aims to optimize the distribution route using the Ant Colony Optimization algorithm. This method is used to determine the shortest route that can be taken with the help of ants, achieving optimal results in reducing the distance. The conclusion from this research is that the route, namely the total distance traveled for the ant colony algorithm is 163.2 km for one trip. The fleet required for each shipment is 2 trucks with each truck carrying 8 tons and 7.6 tons. And each truck covers a round trip distance of 151.7 km and 61.7 km.

Keywords: Ant Colony Algorithm, Travelling Salesman Problem

1. Introduction

The development of the manufacturing industry in Indonesia has been a focus in recent years. With strong government support, improved infrastructure, and abundant human resources, Indonesia's manufacturing sector is experiencing rapid growth. In addition, the continually increasing domestic demand and growing exports of manufactured products have provided additional impetus. The development of Indonesia's manufacturing industry demonstrates significant potential for continued growth and a pivotal role in the country's economic expansion [1]. Many challenges need to be addressed by companies, one of which is the issue of determining the distribution routes of manufactured products [2].

Company X is a manufacturing company in the cement production sector. One of the products produced by Company X is General Use 40 KG cement. With a wide distribution area in Tuban Regency, Company X is required to have reliable delivery performance. The demand for cement at Company X is currently fluctuating, leading to suboptimal fleet capacity. Based on this issue, the company needs a solution to solve the Traveling Salesman Problem using the Ant Colony Optimization Algorithm [3].

The Ant Colony algorithm is an optimization algorithm, that primarily uses ants to find the shortest routes [4]. Compared to other methods, this algorithm offers a solution that is almost close to optimal [5]. In this algorithm, ants leave pheromone trails that are used by subsequent ants in determining routes to find food; the thicker the pheromone trail, the shorter the distance traveled [6]. Therefore, this method is considered to provide a suitable solution to the

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company's problem. By using the Ant Colony algorithm approach, is expected to reduce the distance traveled by each agent and optimize the routes taken by the transport trucks [7]. Having shorter routes will lead to optimal order fulfillment for customers, improved sales performance, and the ability to meet demand on time while minimizing distribution costs.

2. Material and Method

This research was conducted at Company X, a cement manufacturer. The primary objective of this study is to efficiently manage distribution routes using the Ant Colony Optimization Algorithm method. This method is employed to optimize delivery routes within a single trip, with the aim of reducing distribution costs. In this research, two types of variables are utilized: dependent variables and independent variables. Dependent variables are those influenced or affected by independent variables. The distribution routes for cement are among the dependent variables in this study. On the other hand, independent variables are factors that cause or influence changes in dependent variables. In this research, independent variables include product demand data, vehicle types used, vehicle capacity, origin and destination points for distribution, and the distance to be covered in the distribution route.

3. Results and Discussion

Data processing using the Ant Colony algorithm.

Table 1. Location data

No.	Store	Address
1.	Company X (Plant)	Jalan Merakurak-Kerek
2.	Agent 1	Jalan Basuki Rahmat No. 82
3.	Agent 2	Jalan Raya Semarang KM 8, No. 222
4.	Agent 3	Jalan Raya Kerek No. 5
5.	Agent 4	Jl. Merakurak, Semampir
6.	Agent 5	Jl. Blora No.609
7.	Agent 6	Jl. Raya Rengel No.367
8.	Agent 7	Jalan Raya Penampangan No.3
9.	Agent 8	Jl. Raya Grabagan-Tuban
10.	Agent 9	Jl. Raya Glondong

Source: Company X

Table 2. Agent Location Distance Matrix

	1	2	3	4	5	6	7	8	9	10
1	0	28	19	9	14	38	39	32	33	2.6
2	28	0	9	23	13	56	25	4	22	25
3	19	9	0	18	10	53	28	14	22	17
4	9	23	18	0	9	38	32	26	26	11
5	14	13	10	9	0	48	30	18	24	15
6	38	56	53	38	48	0	56	55	51	37
7	39	25	28	32	30	56	0	19	23	40
8	32	4.2	14	26	18	55	19	0	11	30
9	33	22	22	26	24	51	6	17	0	34
10	2.6	25	17	11	15	37	40	30	19	0

Source: Company X

As for the data of demand for each agent for one shipment can be explained in the following table below

Table 3. Quantity of Demand for Each Agent Per Shipment

No	Agent	Demand (Ton)
1	Agent 1	4
2	Agent 2	1.6
3	Agent 3	1
4	Agent 4	1
5	Agent 5	1
6	Agent 6	2
7	Agent 7	2
8	Agent 8	2
9	Agent 9	1

Source: Company X

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Determine the visibility of each agent. Next is to calculate the probability of which agents will be visited next using the following formula

$$p_k(r,s) = \frac{\tau(r,s)^a \, x \, \eta(r,s)^\beta}{\sum \tau(r,s)^a \, x \, \eta(r,s)^\beta} \quad (1)$$

The above steps are repeated until all points are visited by the ants. After all ants have visited each point, these ants will leave pheromone trails that can be calculated using the following formula

$$\tau_{ij}^{(t)} = \tau_{ij}^{old} + \sum_k \Delta\tau^{(t)} \quad (2)$$

After all the ants have completed their journeys, all pheromones must be added and incorporated into the pheromone matrix. With the help of a MATLAB application, the calculation for the desired route is obtained, which is 163.2 km in length.

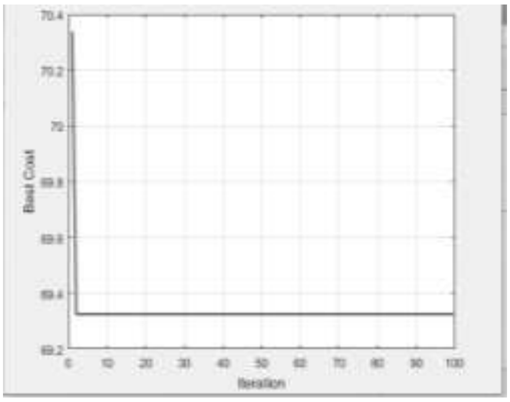

Fig. 1. Graph of Total Distance Traveled vs. Number of Iterations
(Source: Processed Data)

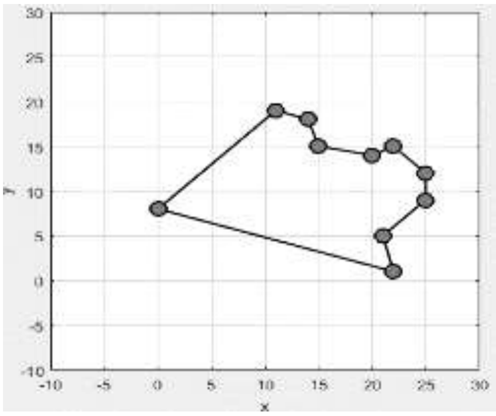

Fig. 2. Optimal Distribution Routes
(Source: Processed Data)

The graph above can be interpreted as follows below

Table 4. The initial route from the Ant Colony Optimization program's output

No	Route	Distance	Total Distance
1	Plant – Agent 2 -Agent 7 – Agent 6 – Agent 8 – Agent 1 – Agent 5- Agent 4 – Agent 9 – Agent 3- Plant	2,6 + 37,5 + 56,3 + 6 + 17,3 + 4,2 + 9,2 + 10 + 9,5 + 14,4	162,3

Source: Processed Data

After adjusting for the transport fleet's capacity, the result for delivering 40 kg of cement is separated into two routes with the following conditions

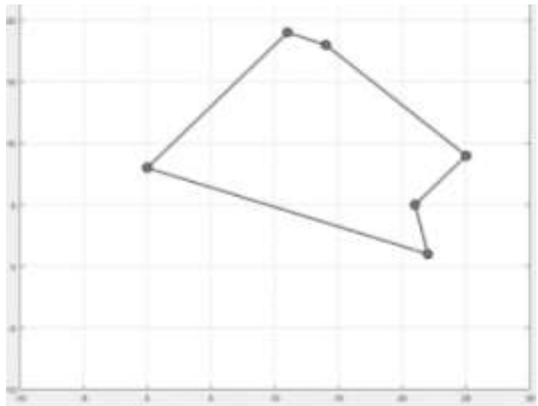

Fig. 3. The distribution route 1
(Source: Processed Data)

Table 5. The first route from the output of the Ant Colony

No	Route	Distance	Total Distance
1	Plant – Agent 9 -Agent 5 – Agent 6– Agent 8 – Agent 7 – Plant	2,6 + 37,5 + 56,38 + 6 + 17,3 + 32	151,7

Source: Processed Data

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Table 6. List of agents and allocation of shipment quantities for each agent

No.	Agent	Shipment (ton)
1	Agent 9	1
2	Agent 5	1
3	Agent 6	2
4	Agent 8	2
5	Agent 7	2
Total		8

Source: Processed Data

Continuing to the second route with the following details

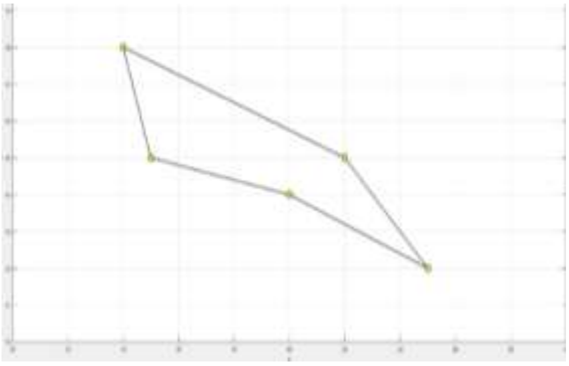

Fig. 3. The distribution route 2
(Source: Processed Data)

Table 7. The second route from the output of the Ant Colony

No	Route	Distance	Total Distance
1	Plant – Agent 2 -Agent 1 – Agent 4– Agent 3 – Plant	19,5 + 9,2 + 13,8 + 9,5 + 9,7	61,7

Source: Processed Data

Table 8. List of agents and allocation of shipment quantities for each agent

No.	Agent	Shipment (ton)
1	Agent 2	1,6
2	Agent 1	4
3	Agent 4	1
4	Agent 3	1
Total		7,6

Source: Processed Data

4. Conclusions

Conclusion: Based on the processing and analysis of data, it can be concluded that by using the Ant Colony algorithm, an optimal distance of 162.3 km is obtained. After adjusting for fleet capacity, each truck carries 8 tons and 7.6 tons, covering distances of 151.7 km and 61.7 km, respectively.

Recommendations: In future research, it is recommended to utilize the Ant Colony Optimization algorithm with a greater number of nodes or tour salesmen and a broader geographical scope.

The company is advised to implement the proposed route search results using the Ant Colony Optimization algorithm based on the minimum distance criteria to achieve optimal outcomes.

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