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Optimization of Pouch Oil Distribution Routes Using Ant Colony Optimization Method

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Abstract

In Indonesia, cooking oil is very important as a food ingredient. Where the production volume of a product can affect distribution system decisions. An efficient distribution process can provide a competitive advantage in terms of cost and service. Distribution at PT. A is currently still done manually, besides that the company has not optimized the transport capacity of vehicles so that it results in swelling distribution costs, as well as distribution bridges. This research is aimed at finding the most optimal distribution route for cooking oil products at PT. A using the Ant Colony Optimization method. After processing the data using the Ant Colony Optimization method, the optimal distribution route was obtained by dividing it into 4 sub-routes with a total mileage of 2371 Km with a total distribution cost of Rp. 1,612,960. and the total mileage of the initial route was 2693 Km with a total distribution cost of Rp. 1,831,240. The total saving obtained from this research is in mileage of 322 Km or 218,960 rupias. Therefore, the results obtained using the Ant Colony Optimization method will be selected as the proposed method.

A. Introduction

Indonesia is the fourth most populous country in the world [1]. For Indonesia, cooking oil is very important as a food ingredient, namely as a source of energy and fat [2]. Cooking oil is one of the downstream palm oil products that has a strategic role in people's lives in Indonesia [3]. With the need for cooking oil is very important, causing high demand in producing cooking oil. Where the production volume of a product can affect distribution system decisions. Distribution is defined as the distribution or distribution of something either goods or services from producers to agents [4]. Distribution activities are activities that are often carried out to distribute production to consumers [5]. Distribution is a problem that must be resolved when companies want to distribute goods to consumers [6]. In the industrial world, good distribution is very important because it affects cost optimization, quality of goods and timeliness of delivery [7]. To achieve the company's goal of delivering the highest quality products to customers in a timely manner, all activity entities within a company must be well coordinated [8]. To achieve the optimal number of customers in a timely manner and at a low cost, but to achieve and maintain a certain level of distribution control, a distribution channel structure strategy is required [9].

In an increasingly globalized business environment, companies need to compete efficiently in providing their products or services [10]. An efficient distribution process can provide a competitive advantage in terms of delivery time, cost, and service [11]. An optimal distribution and logistics system will contribute to the optimum cost which makes the cost of distributing a product will decrease [12]. Of course, every company wants to carry out optimal distribution activities, so that the total costs incurred are also minimal. Likewise at PT A where this company distributes its products to various shipping destinations by endeavoring products to easily reach agents in a timely manner.

PT. A is one of the agribusiness industries engaged in the largest crude oil processing services in Indonesia, which one of its main activities is producing types of cooking oil products. Based on sales data in 2023, One liter pouch of cooking oil products are the highest by reaching a sales figure of 20 million pcs or around 19.05% compared to other products. In the process of distributing its products, of course the company needs a means of transportation to send to the destination area according to the number of requests. To distribute its products PT A uses transportation facilities in the form of wingsbox trucks.

To find the optimal route, good planning is needed to obtain the shortest distribution route to reach all agents and meet demand. Therefore, this research uses the Ant Colony Optimization method, where the ACO concept itself is inspired by observations of ant behavior. The interesting thing about ant behavior is its ability to find the shortest distance between their nest and food sources [13]. By utilizing the adaptive behavior of ant colonies, ACO can provide more accurate price predictions than conventional analysis methods [14]. One of the routing problems that companies often face is the Vehicle Routing Problem (VRP). VRP is a problem that concerns the goods distribution from a corporate depot (warehouse) to its customers [15]. In this problem, one or more vehicles travel through the network, leaving and returning to the depot node.

From this description, this research is aimed at finding the most optimal distribution route for cooking oil products at PT A using the Ant Colony Optimization method.

B. Research Method

Identification and Operational Definition of Variables

The variables related to the problem can be identified and will be analyzed as follows.

1. Dependent Variable

The dependent variable is a variable that can change due to the effect of an independent variable. A dependent variable in this study is a distribution route for One liter pouch of cooking oil at PT. A

2. Independent Variable

The independent variables are variables that affect other variables or that have caused or changed other variables. In this study, the independent variables are:

a) Agent Location
Agent locations to be traveled to.

b) Distance Between Agents
Distance data of origin and destination points of One liter pouch of cooking oil product distribution.

c) Product Demand
Demand data for cooking oil products One liter pouch of PT. A

d) Distance of the company's initial route
Data containing route distances from the point of origin and destination points traversed by transportation using the help of google maps.

e) Vehicle capacity data
Data on the capacity of vehicles shipping One liter pouch of cooking oil products PT. A

f) Fuel Cost
Vehicle fuel cost data.

Data Collection Methods

The data used for this research are primary data and secondary data, namely:

1) Primary Data
Primary data is data obtained from respondents through questionnaires, or also data from interviews. This data is obtained by conducting interviews or direct observations with parties related to and understanding the conditions of the company, such as employees.

2) Secondary Data
Secondary data is a set of information that has existed before and is used as a trap for research data needs. To obtain secondary data can be done by observing books, company documents and other references related to the object under study.

C. Result and Discussion

Data Collection

1. Agent Location Data

Agent location data in the East Java Province area for December 2023 are as follows:

Table 1. Agent Location Data

No/ Node	Agent Name	Address
1	PT. A	Gresik, East Java
2	PT. B	Jember, East Java
3	PT. C	Pacitan, East Java
4	PT. D	Pamekasan, East Java
5	PT. E	Kediri, East Java
6	PT. F	Tulungagung, East Java
7	PT. G	Sidoarjo, East Java
8	PT. H	Banyuwangi, East Java
9	PT. I	Malang, East Java
10	PT. J	Madiun, East Java
11	PT. K	Sidoarjo, East Java
12	PT. L	Mojokerto, East Java
13	PT. M	Pacitan, East Java

2. Distance Data Between Agent

Distance data from companies to agents and agents to other agents in the East Java Province area for distribution in December 2023 is shown in the following distance matrix tables:

Table 2. Distance Matrix Data Between Agents

Matrix (Km)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	216	275	75	126	133	34	307	93	159	38	56	276
2	216	0	448	319	298	326	186	109	196	332	185	200	447
3	275	448	0	391	175	145	267	542	331	133	265	232	1,7
4	75	319	391	0	237	264	129	412	200	270	133	167	389
5	126	298	175	237	0	33	118	393	182	63	116	82	161
6	133	326	145	264	33	0	145	420	119	91	143	110	129
7	34	186	267	129	118	145	0	280	69	151	5	48	267
8	307	109	542	412	393	420	280	0	290	426	280	294	542
9	93	196	331	200	182	119	69	290	0	215	68	83	330
10	159	332	133	270	63	91	151	426	215	0	148	115	134
11	38	185	265	133	116	143	5	280	68	148	0	47	266
12	56	200	232	167	82	110	48	294	83	115	47	0	229
13	276	447	1,7	389	161	129	267	542	330	134	266	229	0

3. Agent Demand Data

The demand for each agent in the East Java Province area in December 2023 is as follows:

Table 3. Demand Data for the Products in December 2023

No	Agent Name	Demand (Carton)
1	PT. B	345
2	PT. C	190
3	PT. D	250
4	PT. E	450
5	PT. F	443

No	Agent Name	Demand (Carton)
6	PT. G	450
7	PT. H	330
8	PT. I	425
9	PT. J	507
10	PT. K	275
11	PT. L	349
12	PT. M	150

4. Initial Distribution Route

The initial route data is the route used by the company in the process of distributing the products to all agent locations spread across East Java Province, to meet consumer demand. We start and end the regular route at the same node, namely at PT A with node 1 located at Jl. Kapten Darmo Sugondo No. 56, Gresik Regency, East Java.

Table 4. Early Distribution Route

Route	Delivery Route	Distance (Km)	Total Distance (Km)	Demand (Carton)	Total Distribution Cost
1	PT. A – PT. K – PT. L – PT. B – PT. H – PT. C – PT. A	38+47 +200+109+542+275	1211	1489	Rp. 823.480
2	PT. A – PT. D – PT. I – PT. J – PT. A	75+200+215+159	649	1182	Rp. 441.320
3	PT. A – PT. F – PT. G – PT. E – PT. M – PT. A	133+145+118+161+276	833	1493	Rp. 566.440
Total			2693	4164	Rp. 1.831.240

Data Processing

1. The Company's Initial Distribution Route

The distance calculation is done by adding up the total initial distances that are traveled the company takes from the start to the end of the trip. The total distance that must be traveled by the company is by summing up the distance from the beginning of the trip.

Table 5. Company Distributin Routes

Route	Delivery Route	Total Distance (Km)
1	PT. A – PT. K – PT. L – PT. B – PT. H – PT. C – PT. A	1211
2	PT. A – PT. D – PT. I – PT. J – PT. A	649
3	PT. A – PT. F – PT. G – PT. E – PT. M – PT. A	833
Total		2693

2. Routing Using The Vehicle Routing Problem

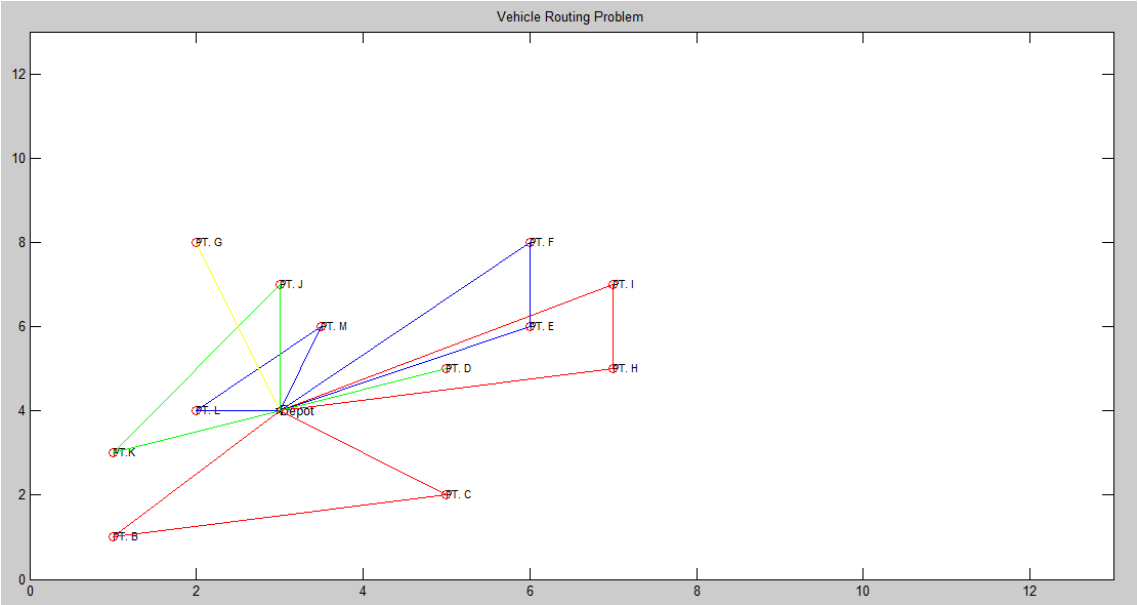

Figure 1. Routes Generated Using ACO

From the picture above, we can see the route generated using the ACO algorithm by providing a fleet of 4 fleets with the capacity of each fleet of 18 tons or 1500 cartons.

3. Comparison of Distance and Distribution Costs of The Company with Distance and Distribution of The Ant Colony Optimization Method

Comparing the distance of distribution and cost of distribution of the company with the distance of distribution and cost of distribution using the Ant Colony Optimization method. The results of the comparison of distance and distribution costs after and before using the Ant Colony Optimization method are as follows:

Table 6. Comparison of Total Distance and Distribution Costs of The Company's Initial Route with The Ant Colony Optimization Method

Route	Company's Distribution Route	Total Distance (Km)	Total Distribution Cost	Distribution Route Ant Colony Optimization Method	Total Distance (Km)	Total Distribution Cost
1	PT. A – PT. K – PT. L – PT. B – PT. H – PT. C – PT. A	1211	Rp. 823.480	PT. A – PT. I – PT. H – PT. B – PT. A	1215	Rp. 826.200
2	PT. A – PT. D – PT. I – PT. J – PT. A	649	Rp. 441.320	PT. A – PT. L – PT. M – PT. F – PT. A	573	Rp. 389.640
3	PT. A – PT. F – PT. G – PT. E – PT. M – PT. A	833	Rp. 566.440	PT. A – PT. D – PT. K – PT. J – PT. A	515	Rp. 350.200
4	-	-	-	PT. A – PT. G – PT. A	68	Rp. 46.240

Route	Company's Distribution Route	Total Distance (Km)	Total Distribution Cost	Distribution Route Ant Colony Optimization Method	Total Distance (Km)	Total Distribution Cost
	Total	2693	Rp. 1.831.240		2371	Rp. 2.612.280

From the results of the data processing above, we conclude this method is a better method than the Ant Colony Optimization method applied by the company. Therefore, the results obtained using the Ant Colony Optimization methods will be chosen as the recommended method, with a total mileage of 2371 KM with a total distribution cost of Rp. 1,612,960 and a total mileage of the initial route of 2693 KM with a total distribution cost of Rp. 1,831,240. then we get a total mileage savings of 322 KM and total distribution cost savings of Rp. 218,960 with a savings percentage of 11.95%.

D. Conclusion

After processing the data using the Ant Colony Optimization method, the optimal distribution route was obtained by dividing it into 4 sub-routes, on the first route (1-9-8-2-3-1) with a distance of 1215 Km, the second route (1-12-13-6-5-1) with a distance of 573 Km, the third route (1-4-11-10-1) with a distance of 515 Km, and the fourth route (1-7-1) with a distance of 68 Km, and obtained a total distribution cost of Rp. 1,612,280. Thus the Ant Colony Optimization method produces a better route compared to the company's initial route. The results obtained savings in distribution distance from 2693 Km to 2371 Km with a difference of 322 Km and savings in distribution costs from Rp. 1,831,240 to Rp. 1,612,280 with a difference of Rp. 218,960.

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