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Distribution Route Making for Mushroom Harvest Using Artificial Bee Colony Method

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Abstract

Mushrooms are food ingredient that is currently favored by the public. Seeing the large demand for mushrooms, many mushroom businesses have developed. The high level of demand for mushrooms by consumers in different locations results in the high time and costs spent in distributing mushrooms. In addition, determining distribution routes in mushroom marketing is still done manually based on the sender's knowledge, therefore reduces the effectiveness and efficiency of mushroom marketing because the distribution routes used are not optimal. To overcome these problems, it is necessary to determine an effective and efficient distribution route to reduce distribution costs and speed up distribution time. Based on these problems, this research uses the Artificial Bee Colony (ABC) method in determining the distribution route of mushroom harvest. The purpose of this study was to apply the ABC method in determining the distribution routes of mushroom harvest. The result of this research is a visualization of mushroom distribution routes using the ABC method, so it can help to distribute mushroom harvest effectively and efficiently. The research method consists of defining the problem, collecting data, analyzing systems and implementing methods, designing systems, building systems, and drawing conclusions.

Keywords: Mushroom Distribution, Artificial Bee Colony Method (ABC)

1. INTRODUCTION

Horticulture is one of the agricultural sub-sectors which occupies an important position in contributing to the Indonesian economy. One of the products of horticultural commodities is mushrooms [1]. Mushrooms are very suitable for Indonesian people who are still difficult to fulfill complete nutritional needs, especially the need of protein because most Indonesian people do not consume much meat due to their low welfare level [2]. Seeing the large demand for mushrooms has resulted in the development of a lot of mushroom business. Mushroom farmers distribute their products to several locations, both traditional markets, stalls, restaurants, supermarkets, and resellers. The growing of industry sector has lead various problem in distribution of logistics and supply chain management. Increment of industry scale has effect in increasing the cost of the transportation aspect. To reduce the cost, CVRP has become the most necessary role in logistic and supply chain management [3]. Distribution is a marketing activity in order to distribute products or services from producers to consumers that are adjusted to the type, quantity, price and place according to needs [4]. Distribution routes are very important in company activities in order to improve

service quality and increase company competitiveness [5]. Based on interviews conducted with several mushroom entrepreneurs in Denpasar, the high level of mushroom demand by consumers has different locations. This results in the high time and costs incurred by entrepreneurs in distributing mushrooms. In addition, determining distribution routes in mushroom marketing is still done manually based on the sender's knowledge, this of course reduces the effectiveness and efficiency of the mushroom product marketing because the distribution routes used are not optimal. To overcome these problems, it is necessary to determine an effective and efficient distribution route so as to reduce distribution costs and speed up distribution time.

There are several methods that can be used in solving problems in determining distribution routes. One of the methods that can be used is Artificial Bee Colony (ABC). The Artificial Bee Colony method was first proposed by Dervis Karaboga in 2015 to optimize numerical problems inspired by the intelligent behavior of honey bees in foraging [6]. In the ABC method, there are three kinds of bees: employee bee, onlooker bee and scout bee [7]. Scouts and employed is used for mutation process to generate randomization then the solution will be selected by the onlooker. Employed bees will forage every food sources available with ratio of one bee per food source. When the food sources area been discard, forager bee will become scout to search for new food sources area by referring to the information given by onlooker bees. When compared to honey bee algorithm, ABC has advantage when the forager bees converted to scout directly [8]. The advantages of the ABC method are very simple, reliable and included in a population-based stochastic optimization algorithm. Other advantages are easy concept and implementation, few parameters and very simple and flexible when compared to other algorithms [9]. The ABC method has been proven to have the ability to handle local problems optimally and has better or equal quality when compared to other methods such as Genetic Algorithms, Particle Swarm Optimization, Differential Evolution, and Strategic Evolution on constrained and unconstrained problems [10]. The ABC method has been applied to several studies in optimizing distribution routes. Research by [11] uses the ABC method in optimizing the distribution route of fruit chips. Case study at Anta Kripik Malang, Research by [12] using the ABC method in optimizing the cement distribution route and Research by [13] using the ABC method in optimizing the distribution route of Carica Nida Food Wonosobo.

Based on the research that has been done previously, the research currently being developed applies the Artificial Bee Colony method in determining the distribution route for mushroom harvest. However, there is a difference from previous research because this research raises a case study of mushroom distribution that has rarely been studied before. In addition, this research also produces visualization of distribution route based on the ABC calculation method by utilizing geographic information systems. GIS is a computer based system that enables to handle geographically referenced data including data inputing, management, manipulation and analysis, and output of data [14]. GIS also combines digital maps with

traditional databases, and provides a visual representation of information [15]. The results of this study are expected to help to distribute mushroom yields effectively and efficiently so as to reduce transportation costs and speed up distribution time.

2. METHODS

2.1. Related Research

Research by [11] with the title "Implementation of Artificial Bee Colony Algorithm to Determine the Shortest Route in the Distribution of Fruit Chips (Anta Kripik Case Study, Malang)", in this study an experiment was conducted to find distribution routes with 20 customers whose addresses are spread across several villages in Malang. The experiment concluded that the artificial bee colony algorithm is the best method for finding the shortest route for distribution. In addition other tests were also carried out which is user testing by distributing questionnaires to 20 respondents as well as function and performance testing carried out on Windows 7, both of which showed 100% results. Research by [12] with the title "Optimization of Cement Distribution Transportation Problems using Artificial Bee Colony Algorithm", in this research an experiment was conducted to determine the route of cement distribution to 7 destination warehouses. Based on the simulation results, in the optimization process through the employed bees, onlooker bees, and scout bees stages, the nectar information is updated so that the distribution cost as the fitness value decreases and the optimum solution approach is obtained. The results of this research can be concluded that through the ABC algorithm, an optimum solution approach is obtained that minimizes distribution costs by meeting the constraints of the quantity of supply and the number of demand for cement units. Reserch by [13] with the title "Implementation of the Bee Colony Algorithm for the Optimization of Carica Nida Food Wonosobo Distribution Routes" From the results of these tests, it shows that in the case of Nida Food for the best route search in 13 stores, of the three parameters the number of bees, the number of trips and the number of iterations shows no difference in results. significant. After several attempts, the search process showed that the best distance results ranged from 54.35 km to 55.09 km. The best line search results on the Google Map view of the 13 cities visited by Nida Food with a distance of 54.35 km.

2.2. Distribution

Distribution system is a marketing activity to distribute products or services from prosudents to consumers according to the type, quantity, price and place required. Distribution is carried out in order to make it easier for consumers to get a product. This can make it easier for consumers to obtain a product if the distribution process is effective. The factors that must be prepared in a distribution system are storage warehouses, factory suppliers of products, customers served, means of transportation, transportation routes, and an inventory control system [16].

2.3. Metode Artificial Bee Colony (ABC)

Karaboga has designed an artificial bee colony (ABC) algorithm to mimic the foraging behavior of honey bee swarm intelligence. Meta-Heuristic is Greek words

and it consists Meta which means high-level and heuristics means to find or to know. Meta-heuristic is set of the intelligent step which enhances the efficiency of heuristic procedure. An artificial bee colony is nature enthused algorithm which is based on the foraging behavior of bee [17]. Artificial bee colony (ABC) algorithm new optimization method which is good at consideration but poor at manipulation. This ABC method / algorithm uses intelligent behavior from a swarm of honey bees in the form of foraging behavior [18]. In general, there are three groups of bees in the ABC algorithm: employees, scouts and observers. The employees exploit the food sources (possible solutions) initially found by a group of scout bees. A single employee bee is located in each food source, so that the number of employee bees is equal to the number of solutions to be found. After handling the first food sources, a search and selection process is carried out by the employee and observer bees, which is different depending on which type of bee performs the action [19]. In any case, the purpose is to find better food sources to take advantage of them [20]. The steps in the Artificial Bee Colony method are as follows [21].

1) Route Formation
   In the Traveling Salesman Problem for route formation the Nearest Neighboor method is used. The routes formed are used as food sources as a reference.
2) Initialization
   The route that has been established in the first stage will be selected by the bees to determine which route is the best and is the solution to the problem. At this stage, the experimental value of each possible solution will be given, namely 0. The initialization process of the possible solutions (food sources) is carried out randomly using the equation (1).

$$X_{ij} = X_{jmin} + rand(0,1).(X_{jmax} - X_{jmin}) \quad (1)$$

Where:

X_{ij} = inilitialize the possible solution of i with the j parameter
X_{jmin} = smallest possible solution value based on j parameter
X_{jmax} = largest possible solution value based on j parameter
$rand(0,1)$ = random value between 0 to 1
$i = 1..SN$ =, SN is the number of possible solustions (food sources)
$j = 1..D$ =, D is the number of parameters used

3) Employed Bee Phase
   Next is the stage where the bees expand the value of each possible solution using the equation (2).

$$V_{ij} = X_{ij} + \emptyset_{ij}.(X_{kj} - X_{ij}) \quad (2)$$

Where:

V_{ij} = expansion of possible value of i solution with j parameter
X_{ij} = possible value of i solution with j parameter
$i = 1..SN$ =, SN is the number of possible solustions (food sources)
$j = 1..D$ =, D is the number of parameters used
$k = 1..SN$ =, SN is the number of parameters used
$\emptyset_{ij}$ = random real number between [-1, 1]

After each possible solution is expanded, a greedy selection will be applied between the possible value of the solution x_i and the new value of the expansion

result v_i. If the value of v_i is less than the value of x_i the the value v_i will be assumed to be the same as the value of x_i and the experimental value will still be 0. Otherwise, the stored x_i value and the i trial value are increased by 1. This process is repeated until the number of extensions is equal to the number food sources.

4) Population Evaluation Phase
   Each possible extended solution is compared with the initial initialization value. Next, we calculate the quality of each possible solution using the fitness function in equation (3).

$$fitness\ (x_i) = \begin{cases} \frac{1}{(1+f(x_i)}, f(x_i) \geq 0 \\ 1 + f(x_i)|, f(x_i) < 0 \end{cases} \quad (3)$$

Where:
$i = 1..SN =$, SN is the number of possible solustions (food sources)

5) Onlooker Bee Phase
   After the employed bee stage has met all the extensions for each possible solution and each probability value has been calculated, the information from the worker bee will be passed on to the onlooker bee. The keeper bee will calculate a probability value based on this information. Each possible solution will be calculated using the equation (4).

$$P_i = \frac{fitness_i}{\sum_{i=1}^{SN} fitness_i} \quad (4)$$

Where:
$fitness_i$ = fitness solution value of i
$\sum_{i=1}^{SN} fitness_i$ = the number of fitness value from i to SN
After the probability value of each possible solution is calculated, the guard bee then selects the next possible solution which will be explored by the scout bee using the roulette-wheel method.

6) Scout Bee Phase
   On applying the roullete-wheel method, initially a real number is randomly selected between [0,1] for each possible solution. If the P_i value is greater than the specified random number, the guard bee will assign the scout bee to re-expand the possible solutions chosen according to the previous worker bee stage. After the possibility of the selected solution is expanded, a greedy selection will be applied between the possible value of the solution x_i and the new value of the expansion result v_i. If the value of v_i is less than the value of x_i then the value v_i will be assumed to be the same as the value of x_i. Otherwise, the stored v_i alue and the i trial value are increased by 1. This process is repeated until the number of extensions matches the possible solutions. After all possible solutions have experimental values, then the possible solution with the maximum experimental value is selected and the best solution is chosen. The process returns to the worker bee stage and repeats until the limiting criteria are met, the limiting criterion is the number of bees in the colony.

2.4. Geographic Information System (GIS)

Geographic information system consists of three terms, namely system, information and geography. Geographic information systems can also be defined as an information system that can analyze, store, update, integrate and display all forms of information related to the earth's surface. The existence of an efficient geographic information system capable of managing data with complex and large-scale structures can assist in the decision-making process [22]. GIS is a management tool in the form of computer-assisted information which is closely related to the mapping and analysis system of everything and events that occur on earth. GIS technology integrates database-based data processing operations that are commonly used today, such as data retrieval based on needs and statistical analysis using unique visualizations as well as the various advantages that geographic analysis can offer through its map images [23]. GIS software creates digital maps and manages their associated numerical, text, and multimedia attributes. More specifically, for 2D mapping, GIS software can be thought of as having multiple layers of map information, each layer associated with its attributes. For instance, one layer could display point locations of a discount retail chain's outlets and another layer could display highway and street patterns [24].

2.5. Research Methodology

This section will explain the stages in the research. The research flow shown in Figure 1.

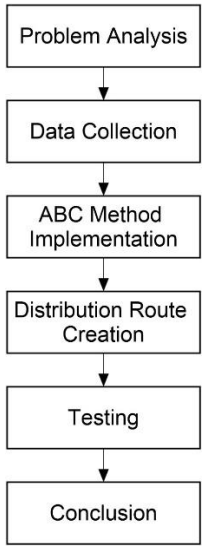

Figure 1. Research methodology

The first stage in this research is problem analysis where at this stage the identification of problems that occur in determining the distribution route of mushroom yields and the parameters used is carried out. The second stage is data collection where at this stage the data collection process is carried out which

supports the determination of the distribution route for mushroom harvest and the ABC method. The third stage is the ABC method implementation where at this stage the ABC method has been tested and implemented in determining an effective and efficient mushroom harvest distribution route. The fourth stage is distribution route creation where at this stage the route formed based on the calculation results of the ABC method is visualized in the form of digital maps to facilitate the distribution process. The last stage is drawing conclusions based on the results of the research conducted.

3. RESULT AND DISCUSSION

There are 4 mushroom distribution transactions that must be done with the mushroom warehouse as the starting point of departure as well as the end point of delivery. Goods delivery transaction data and the distance matrix between one delivery point and another are as follows.

Table 1. Distribution transaction

Distribution ID	Latitude	Longitude
0	-8.670458	115.212629
1	-8.673808	115.217078
2	-8.667530	115.221670
3	-8.666681	115.215147
4	-8.672576	115.209593

The next stage is calculated the distance for each delivery point using. From the results of calculations using longitutude and latitude conversions, the distance matrix between each delivery point is generated as in Table 2.

Table 2. Distance between points matrix

		Starting Point				
		0	**1**	**2**	**3**	**4**
Destination Point	**0**	0	1230	2998	3102	933
	1	1660	0	2850	2983	2243
	2	1706	1185	0	3029	2290
	3	701	1129	2420	0	1285
	4	934	1792	3560	2814	0

Table 2 is a matrix table of distances between points where this table presents data on the distance between depots to delivery points and between delivery points. By using the Artificial Bee Colony algorithm using the following parameters. The calculation results are shown in Table 3 with the parameters used are the number of bees = 10, the number of active bees = 7, the number of inactive bees = 1, the number of search bees = 2, the maximum number of trips = 10 and the number of iterations = 100.

Table 3. Distribution route formation process

Process	Route	Value
Bee 1	0 – 1 – 2 – 3 – 4 – 0	9012 m
Bee 2	0 – 2 – 1 – 3 – 4 – 0	9432 m
Bee 3	0 – 3 – 2 – 1 – 4 – 0	9305 m
Bee 4	0 – 4 – 2 – 3 – 1 – 0	9857 m
Bee 5	0 – 1 – 3 – 2 – 4 – 0	10311 m
Bee 6	0 – 1 – 4 – 3 – 2 – 0	10764 m
Bee 7	0 – 1 – 2 – 4 – 3 – 0	10792 m
Bee 8	0 – 4 – 2 – 1 – 3 – 0	10305 m
Bee 9	0 – 1 – 3 – 4 – 2 – 0	10891 m
Bee 10	0 – 3 – 1 – 4 – 2 – 0	10764 m

From the results of the route search process above, the best solution can be taken, namely a minimum distance of 9012 meters with a route 0 - 1 - 2 - 3 - 4 - 0. The search process whose route has been carried out is then visualized by using google maps api to produce a digital route map. distribution of fungi. The distribution route starts from the mushroom warehouse (ID 0) to the distribution destination location and returns to the mushroom warehouse. The visualization of the distribution route of mushrooms based on the calculation results can be seen in Figure 2.

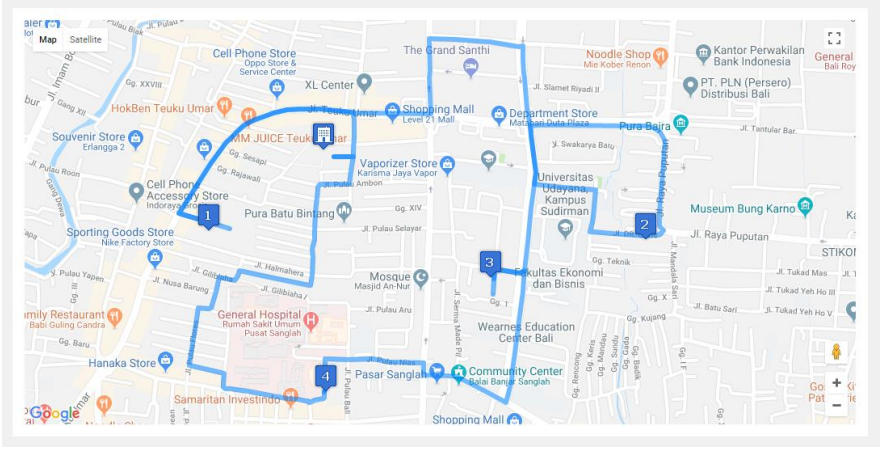

Figure 2. Mushroom distribution route

4. CONCLUSION

The Artificial Bee Colony algorithm can be applied to find a mushroom distribution route with the minimum distance of 9012 meters with a route 0 - 1 - 2 - 3 - 4 - 0. In addition, the system built can provide distribution route visualization. delivery of

mushrooms so that it can facilitate the sender in distribution process. Suggestions that are expected in further research is to pay attention to the level of traffic jams that exist because it will affect the delivery time.

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