The Implementation of Ant Colony Algorithm In Finding The Shortest Travel Route of Palembang Tourism By Android Based

Safira Faizah¹, Leni Novianti, S.Kom., M.Kom.², Nita Novita, S.E., M.M³
1 Informatics Management Department Student, State Polytechnic of Sriwijaya
2,3 Informatics Management Department Lecturer, State Polytechnic of Sriwijaya

email: safirafzh@gmail.com, leninovianti16@gmail.com, nitanovita_polsri@yahoo.com

Abstract. Ant Colony is a methodology produced by observing ants. In this algorithm, ants as agents assigned to find solutions to an optimization problem, like to find the optimal solution on Traveling Salesman Problem (TSP). Therefore, the research will apply ant colony algorithm to search the shortest path of tourism in Palembang City, covering tourist destinations, culinary, hotels and handicrafts. The results of this study, will provide ease of tourists in accessing tourist destination information and information about travel routes easily via mobile applications with android operating system and use of Google Maps API.

1. Introduction

Palembang is the capital of South Sumatera Province which is interpreted as the oldest city since June, 17th, 688 AD. In addiction, Palembang is known as the “Bumi Sriwijaya” because it was as the capital of the Buddiest Maritie Kingdom in Southeast Asia, namely Sriwijaya Kingdom. This city is the second largest city in Sumatera island after Medan with an area of 358.88 km² and inhabited by around 1,7 million people. As we know, Palembang has a historical heritage of Sriwijaya Kingdom, typical culinary, handicrafts and strategic location for domestic and foreign tourist destination.

According to the data by Tourism Office, Palembang has a increase of tourist arrival up to 303,63 percent from 2009 until 2017. It was recorded at 2,011,417 from the previous years. And in upcoming August, Palembang as the host of Asian Games XVIII, actually it will be an added value. However the information of tourism still limited. Usually, the tourist know about the tourism information by the website of Tourism Office and access the travel route separately by using Google Maps. In other words, there is no an application on mobile device that provide the information with the shortest travel route.

Therefore, we need an appllication on mobile device that provide the information with the shortest travel route.

Based on the description above, the authors intends to create an application by applying the ant colony algorithm.
2. Literature Review

2.1 Application
Application are things, ways or results. Meanwhile, application is a process, method, or act of applying. Based on the three meanings, it can be concluded that application is an action that is carried out both individually and in groups with a view to achieving the objectives that have been formulated.

2.2 Ant Colony Algorithm
The Ant Colony was introduced by Moyson and Manderick and broadly developed by Marco Dorigo. This algorithm is bioinspired metaheuristic because it has a special group that tries to match the behavior characteristics of social insects, namely ant colonies. In addition Ant-Colony belongs to the Swarm Intelligence group, which is one type of development paradigm that is used to solve optimization problems, where the inspiration used to solve these problems comes from the behavior of swarms of insects. When looking for food at first the ants will randomly travel around the nest area, knowing that there is food ants will analyze the quality and quantity of the food and bring some parts to the nest. In the course of the ants always leave a trail in the form of a number of chemicals called pheromone[2],[9].
Pheromone comes from the word "fer" which means to carry and "hormones". Thus pheromone can be interpreted as "hormone carrier", which is a hormone produced by the endocrine glands that can provide chemical signals.

2.2.1 Component of Ant Colony Algorithm
The component of Ant Colony Algorithm are [3] :
1. The Colony is the starting place and destination, where the starting place is the origin of the ant or ant nest and the destination is the source of food that the ant will go to.
2. Ant is an ant who will find a path from the place of origin to the destination.
3. Route is a path that ants may travel from their place of origin to their destination.
4. Pheromone is a trace in the form of chemicals left by ants and become chemical signals so that other ants can recognize them in determining the optimal path.

2.2.2 Ant Colony Algorithm Calculation Stages
There are three stages to calculate the shortest path [4] :
1. Status Transition Rules.
The status transition rules that apply to ACS are as follows:
If $q \leq q_0$, then the selection of the point to be addressed applies the rules shown by equation (1):
\[
\text{temporary}(t,u) = [\tau(t,u)] \cdot [\eta(t,u)]^\beta, \quad i = 1,2,3,\ldots,n
\]
with $v = \max\{[\tau(t,u)] \cdot [\eta(t,u)]^\beta\}$
with $v = \text{the point to be addressed}$, while if $q \geq q_0$ is used the equation (2) :
\[
v = p_k(t,v) = \frac{[\tau(t,v)] \cdot [\eta(t,v)]^\beta}{\sum_{i=1}^{n}[\tau(r,u)] \cdot [\eta(r,u)]^\beta}
\]
with $\eta(t,u) = \frac{1}{|\text{arak}(t,u)|}$. Where $\tau(t,u)$ is the value of the pheromone trace at point $(t,u)$. $\eta(t,u)$ is a heuristic function which is chosen as the inverse distance between point $t$ and $u$. Meanwhile, $\beta$ is a parameter that considers the relative importance of heuristic information, namely the amount of weight given to heuristic information parameters, so that the resulting solution tends to be based on the value of mathematical functions. The value for the parameter $\beta$ is $\geq 0$. 
2. Local Pheromone Update
While touring to find solutions from TSP, ants visit sections and change the level of pheromone in these sections by applying the local pheromone update rule shown by the equation as below:

$$\tau(t,u) \leftarrow (1-\rho) \cdot \tau(t,u) + \rho \cdot \Delta \tau(t,u)$$

with

$$\Delta \tau(t,u) = \frac{1}{L_{nn}}$$

where:

- $L_{nn}$ = length of tour that you get
- $C$ = number of locations
- $\rho$ = parameter with a value of 0 to 1
- $\Delta \tau$ = change of pheromone

$\rho$ is a parameter (evaporation coefficient), namely the magnitude of the pheromone evaporation coefficient. The presence of pheromone evaporation causes not all ants to follow the same path as the ant before. This allows more alternative solutions to be produced. The role of this local pheromone update rule is to randomize the direction of the trajectory being built, so that the points that have been passed before by an ant tour may be passed later by another ant tour. In other words, the effect of this local renewal is to make the level of interest in the existing segments dynamically change: each time an ant uses a segment, this segment will immediately decrease its level of interest (because the segment loses a number of its pheromone), indirectly other ants will choose other segments that have not been visited. Consequently, ants will not have the tendency to gather on the same path.

3. Global Pheromone Update
In this system, global pheromone renewal is only carried out by ants that make the shortest tour since the beginning of the experiment. At the end of an iteration, after all the ants had finished their tour, a number of pheromones were placed on the sections passed by an ant who had found the best tour (the other segments were not changed). The pheromone level is updated by applying the global pheromone update rule shown by the equation:

$$\tau(t,u) \leftarrow (1-\alpha) \cdot \tau(t,u) + \alpha \cdot \Delta \tau(t,u)$$

$$\Delta \tau(t,u) = \frac{1}{L_{gb}} \text{ if } (t,u) \in \text{best tour}$$

Where:

- $\tau(t,u)$ = the final pheromone value after experiencing a local update
- $L_{gb}$ = the length of the shortest path at the end of the cycle
- $\alpha$ = parameter with a value between 0 s.d 1
- $\Delta \tau$ = change in pheromone

$\Delta \tau(t,u)$ is 1 / $L_{gb}$ if the segment $(t, v)$ is part of the best route, but if the opposite is $\Delta \tau(t,u) = 0$. $\alpha$ is the relative importance of pheromone or the weight given to pheromone, so the resulting solution tends to follow the past history of the ant from the previous trip, where the parameter $\alpha$ is $\geq 0$, and $L_{gb}$ is the length of the best tour globally since the beginning of the experiment. This equation explains that only the sections that are part of the best tour globally will receive the addition of pheromone.

2.3 Shortest Routes
The route is the distance or direction that must be followed (passed). Meanwhile, short is defined near its distance from end to end; from the bottom; not high. From the two meanings above it can be concluded that the shortest route is the shortest distance that must be passed from a point.

2.4 Tourism
Tourism is a complex activity that can be viewed as a large system, which has various components such as economic, ecological, political, social, cultural and so on. In addition, tourism is a system of various elements arranged like a cobweb: "like a spider's web-touch one part of it and reverberations will be felt throughout"[10].
3. Research Methodology

3.1 Problem Formulation Stages
This stage is the process of formulating the problem and limiting the problems to be examined. This is needed in order to better direct the researcher in making the application so that what is done is not out of the predetermined limits.

3.2 Data Collection Stages
In the data collection stage, the author refers to Suryabrata's opinion[5], it divides into two types, namely:

1. Primary Data
Primary data is the first recorded and collected in research. Primary data (main data) requires direct interaction with employees of the Palembang City Tourism Office. The steps are through interview techniques. In field practice, the author conducted an interview with the Palembang City Tourism Office employees. The interview resulted in a problem faced by some domestic and foreign tourists who still do not know much about the information on tourism places and the shortest path that can be taken which results in the lack of efficient transportation costs incurred.

2. Secondary Data
Secondary data is data collected from existing sources. Here, the author takes data indirectly by searching and studying journal references, books, articles, supporting theories and other references related to the final project.

3.3 Design System Stages
In this final project, we used design system called UML (Unified Modeling Language) which consists of Use Case, Class Diagram, Activity Diagram, and Sequence Diagram.

4. Result and Discussion
4.1 Ant Colony Algorithm Calculation

1. Status Transition Rules
   a. Distance Between Object Location

| Table 1. Location of Tourism Destination | Coordinates |
|----------------------------------------|-------------|
| **Initial Location** | **Latitude** | **Longitude** |
| State Polytechnic Sriwijaya | -2.9833933 | 104.7317932 |

| **Destination** | **Coordinates** |
|----------------|----------------|
| Monumen Perjuangan Rakyat | -2.989188 | 104.7595965 |
| Pempek Saga Sudi Mampir | -2.99059 | 104.7542003 |
| Wyndham OPI Hotel | -3.0369752 | 104.7906593 |
| Songket Tujuh Saudara | -2.994004 | 104.7434782 |

*Source: google.com/maps*
Measurement of distance between start position and tourism object is calculated using the following conditions\cite{7},\cite{8}:

\[ d_{ij} = \sqrt{(\text{lat}1 - \text{lat}2)^2 + (\text{lng}1 - \text{lng}2)^2} \]

To calculate the distance between the starting position of the location of tourism destinations in full, can be seen in the following table:

**Table 2. Distance Between Tourism Object Locations (in meter)**

| Distance | 0     | 1     | 2     | 3     | 4     |
|----------|-------|-------|-------|-------|-------|
| 0        | 0     | 0,003161626 | 0,002619901 | 0,008861285 | 0,001757073 |
| 1        | 0,003161626 | 0     | 0,000620653 | 0,006344878 | 0,001872701 |
| 2        | 0,002619901 | 0,000620653 | 0     | 0,006567851 | 0,001252649 |
| 3        | 0,008861285 | 0,006344878 | 0,006567851 | 0     | 0,00710421 |
| 4        | 0,001757073 | 0,001872701 | 0,001252649 | 0,00710421 | 0     |

b. Calculation of Distance Inversions

\[ [\eta(i,j)] = \frac{1}{\text{distance}(ij)} \]

The overall results of inverse distance \([\eta(i,j)]\) can be seen in table 3 below:

**Table 3. Distance Inversions**

| Distance | 0     | 1     | 2     | 3     | 4     |
|----------|-------|-------|-------|-------|-------|
| 0        | 000,000 | 316,2929455 | 381,6938121 | 112,85045 | 569,1283174 |
| 1        | 316,2929455 | 000,000 | 161,206262 | 157,6074434 | 533,9880739 |
| 2        | 381,6938121 | 161,206262 | 000,000 | 152,2568036 | 798,3082252 |
| 3        | 112,85045 | 157,6074434 | 152,2568036 | 000,000 | 140,7616047 |
| 4        | 569,1283174 | 533,9880739 | 798,3082252 | 140,7616047 | 000,000 |

Next, set the pheromone value (\(\tau\)) with a very small initial number. In the example calculation of this study the initial pheromone value (\(\tau\)) was 0.0001. This value setting is intended so that each segment has a value of interest to be visited by each ant. After inversion of distance and initial pheromone value is obtained, then the next step is to choose the point to be addressed. The parameter of ACS calculation to get the optimal value is \(\beta \geq 0\), so that in this calculation the value \(\beta = 2\) is determined. Then the calculation is done to get the temporary value (i, j) based on equation (1) and probability value using equation (2) from the point start to the next point. Examples of temporary calculations can be seen in the process below\cite{6}:

\[
\text{temporary}(i,j) = [\tau(i,j)] \cdot [\eta(i,j)]^\beta
\]

(1)

Meanwhile, the calculation for probability values is:

\[
\text{probability}(i,j) = \frac{[\tau(i,j)] \cdot [\eta(i,j)]^\beta}{\sum_{i,j} [\tau(i,j)] \cdot [\eta(i,j)]^\beta}
\]

(2)

where :

\(\tau(i,j)\) = pheromone trace value at point (i,j)

\(\eta(i,j)\) = the heuristic function which is chosen as the inverse distance between point i and j

\(\beta\) = parameters that consider the relative importance of heuristic information

\(p_k(i,j)\) = probability (i, j)

\[
\text{Probability} = [(0,0001) x (0)^2] + [(0,0001) x (316,2929455)^2] + [(0,0001) x (381,6938121)^2] + [(0,0001) x (112,85045)^2] + [(0,0001) x (569,1283174)^2]
\]

\[
= 0 + 10,00412274 + 14,56901726 + 1,273522407 + 32,39070417
\]

\[
= 58,23736594
\]
The results of the temporary calculation and the probability of the starting point can be seen in the table below:

**Table 4. Temporary Values and Probabilities**

| τ   | 0   | 1       | 2       | 3       | 4       |
|-----|-----|---------|---------|---------|---------|
| Temporary | 0   | 10,00412274 | 14,56901662 | 1,273522407 | 32,39070417 |
| Probability | 0   | 0,17178 | 0,25016 | 0,01286 | 0,55618 |
| Accumulative Prob | 0   | 0,17178 | 0,42194 | 0,4348 | 0,99098 |

To determine the exact equation in the next calculation stage, it necessary to generate a random number (q) and set a limiting number that is (q0) between 0 and 1. In this calculation analysis is set q0 value of 0.9 and q value of 2 which in the ACS algorithm means that the ants conduct a space exploration process with a 90% probability and an exploration process without a probability of 10%. This means that the ants use the heuristic function in exploration so that the objectives of the ACS algorithm can be achieved. If you see from the number of random numbers q and q0 it can be found that q ≤ q0 therefore at the next stage of determining the location of exploration will be based on equation (1) that is by looking at the largest temporary results. In this case the largest temporary results in the ant 1 path are 0 → 4 → 2 → 1 → 3.

2. **Local Pheromone Update**

The next step is update a local pheromone by using:

\[
\tau_{(i,j)} \leftarrow (1-p) \cdot \tau_{(i,j)} + \rho \cdot \Delta \tau_{(i,j)}
\]

(3)

In the mathematical formula to update pheromone locally it takes a parameter (ρ) which has a value between 0 to 1. In this calculation analysis the value ρ = 0.1. The calculation of the local pheromone renewal stage for the largest temporary is in the second column:

\[
\Delta \tau_{(0,1)} = \frac{1}{L_{nn,c}} = \frac{1}{0.003161626 \times 4} = 79.07
\]

It makes

\[
\tau_{(i,j)} \leftarrow (1-p) \cdot \tau_{(i,j)} + \rho \cdot \Delta \tau_{(i,j)} =
\]

\[
\tau (0,1) \leftarrow (1-0.1) \times 0.00009 + 0.1 \times 79.07 =
\]

\[
\tau (0,1) \leftarrow 7.90709
\]

3. **Global Pheromone Update**

The example of update pheromone global by the first column it can be:

\[
\alpha = 0.1
\]

\[
L_{gb} = 34,49836
\]

\[
\Delta \tau (0,1) = 34,49836^{-1} \cdot 0.028986885
\]

with

\[
\tau(0,1)\leftarrow(1-\alpha)\cdot\tau(i,j) + \alpha\cdot\Delta\tau(i,j) =
\]

\[
\tau(0,1)\leftarrow(1-0.1) \times 7.9709 + (0.1 \times 0.00009 \times 7.9709) + (0.002898688) =
\]
\[
\tau(0,1) = 0.000717381 + 0.002898688 = 0.003616069
\]

4.2 Design System
4.2.1 Usecase Diagram

Even List:
1. There are 2 (two) actors in the application, admin and tourist.
2. Admin can manage the destination data by adding place names, descriptions and coordinates of the destination.
3. Tourist can view the information and choose the destination route.

4.3 Implementation
Here are some interface views of the application:

On the main page there are 5 (five) grid-shaped menus. This is the initial page when the user accesses the application. These five grid-shaped menus have images and descriptions of each of them, tourist menus, culinary, hotels, handicrafts and travel routes.
The second page will display the list of each menu. And the next page after clicked the list will display an image and description of each tourism place.

Users can choose the tourism destination to be visited.

This page will help the user get the location with the shortest distance.
5. Conclusion
According to the discussion result above, can be concluded that:
1. The shortest trip route, provides information on tourism destinations including, culinary, hotel and handicraft destinations in Palembang City on a mobile base.
2. Tourism information in the city of Palembang is presented by including a description of each place and direction of the route to be addressed.
3. This application is created by applying ant colony algorithm as the method used in the application.

6. Recommendation
1. Can be developed by give an update of tourism information and adding features that can further introduce any tourism destinations in Palembang City.
2. The database can be change to online mode, it can easier to add, delete and edit data.

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