# JAIT_Plagiarism

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# The Use of an Application Running on the Ant Colony Algorithm in Determining the Nearest Path between Two Points

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***Abstract*—Being able to carry out tasks like moving from one point to another with great speed is highly needed in this 4.0 revolution era. Therefore, information technology is expected to provide a lasting solution to this problem. The aim of this research is to create an android application and website which runs on the Ant Colony Algorithm and is capable of determining the shortest path to a location, such as the mosque, restaurant, and clinic in specific region. Furthermore, it aims to use the architecture system, which consists of several stages, such as data collection, and management, which is carried out through three phases, including, parsing MySQL data to the JSON, then to Java, and lastly, managing the data using the ant algorithm in order to find the shortest pathway. The result was then examined, and it showed that this application is capable of detecting the shortest distance between two locations. Therefore, it will be beneficial to both the locals and tourists in a specific region.**

***Index Terms*—Android, ant colony algorithm, shortest path, GIS mobile**

## I. Introduction

Currently, the industrial world is in the revolution 4.0 era, which requires the use of the latest technology in carrying out businesses more flexibly, efficiently and sustainably, and in creating quality products at low costs [1]. Furthermore, the main characteristic is the use of automated technology in increasing the efficiency and effectiveness of production [2].

Today, the internet and intelligent devices which unite the virtual and the real world are very common [3]. Therefore, the existence of mobile devices, the internet and fast connection speeds greatly support the existence of businesses [4]. In addition, the use of smart machines is highly demanded, as technology is now a part of everyday life [5] and [6].

Advanced and automatic technologies are very important as they significantly increase production [7]. Furthermore, high-tech machines and the internet can now collaborate with humans to create an intelligent working environment that enables faster production and marketing [8]. It is currently easier for entrepreneurs to understand the target market and desires of consumers because technologies which can analyze their activities are now available [9] and [10].

In this era, the need for speed and flexibility in the production and delivery of goods cannot be ignored [11] because they are part of the determining factors in the success of a business. Furthermore, speed is one of the main factors that influence customer loyalty [12], [13] because it increases their satisfaction [14]. Conversely, sluggishness in delivering services reduces loyalty to products and services [15].

Satisfaction is very important for the continuation of business because it has a direct and significant influence on customer loyalty [16]. Furthermore, it both develops and increases coverage [17].

The need for speed is inseparable from the Z generation customers because they lack patience. Moreover, this generation comprises of people born after 1995, and as at 2019, their population was 1.7 billion or 32% of that of the world [18] and [19]. Lastly, they are very good at using technology, like smart devices, [20] and usually turn to them for solutions when faced with challenges [21] and [22].

Considering the need for speed in the business world and the existence of the Z generation, applications which run on smartphone and can easily locate the fastest path to different locations, like from a hotel to a restaurant in a large city like Banjarmasin, are needed.

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Banjarmasin is one of the major cities in Indonesia, and it covers a land area of 98.46km$^2$. Furthermore, it has population density of about 6860 inhabitants/km$^2$ [23]. This City is also the Capital of the South Kalimantan province, and is known as the "City of a Thousand Rivers" because it has many rivers and canals that flow and divide it into various parts, as well as being a center for trade and services in the province [24]. Along with its increasing economic activity, it is also developing in other public sectors such as restaurants, hospitals, and mosques. However, locating these facilities is quite difficult, therefore there is the need for applications like the Google map which covers most of the city [25]. Lastly, this map and all other location finding applications run using algorithms.

In previous research, several algorithms such as Djikstra, the A * (A Star), and others were used to optimize the shortest path [26]. Moreover, they are a collection of commands to solve a problem [27], and have their advantages and disadvantages. The ant colony algorithm, for instance, has several advantages, including, flexibility, strength, being measurable, decentralized, and self-organized [28]. Furthermore, it has proven to be very effective, powerful, and suitable for processing large amounts of data [29], as well as solving problems like the Non-deterministic Polynomial-time (NP) [30]. It also helps to optimize parameters for industrial growth and quality control [31]. In another research, this algorithm was also successfully implemented for a bike-sharing system, where it helped to reduce pollution, determine the demand for the vehicle at stations and design distribution routes [32].

The first ant colony algorithm was successfully used to help traveling salesmen find the shortest rarity in commuting [28]. Furthermore, utilizing coordinated interactions, it was used to solve problems, related to discrete optimization, like ascertaining the shortest route to a location [33], and colony optimization occurs as a result of coordinated interaction [34].

Considering the advantages and evidences offered by this algorithm, this research is aimed at using it to create an application for determining the shortest routes to public places in Banjarmasin. Furthermore, these routes are believed to be the optimum solution for reducing the time spent moving from one place to another. It is hoped that the results will be of use to entrepreneurs, especially those working in the fields of transportation and expedition.

## II. Literature Review

### A. Graf Theory

Graf is a group of the knots (vertex or nodes) that are connected to one another through edges or arcs. Furthermore, it consists of two sets, V (Vertex) and E (edges), where V is the set of knots that is not empty but limited, and E is the edge that combines them [35].

Knots in Graf are represented using numbers or letters or maybe both, while edges are represented by symbols like e1, e2, …, en, with the number of 1, 2, ...n as their index. In Fig. 1 it is shown that the Graf consists of the V and E set.

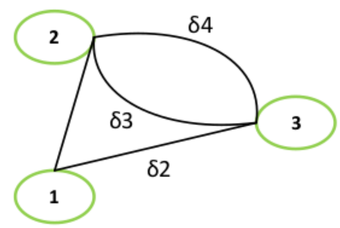


Figure 1. G Graf [35].

Fig. 1 shows that the G Graf which includes the set of $V$ and $E$, where:

$V = \{1, 2, 3\}$
$E = \{a1, a2, a3, a4\}$
$G = \{(1,2), (2,3), (2,3), (1,3)\}$

### B. Ant Colony Algorithm

This algorithm was designed based on the habits of ants in a colony, since they can determine the shortest path from their nest to food sources without needing any signal. Studies show that ants are able to do this with the help of the pheromones, which they secrete. These pheromones serve as footprints which can be traced by another ant in order to locate food sources [36].

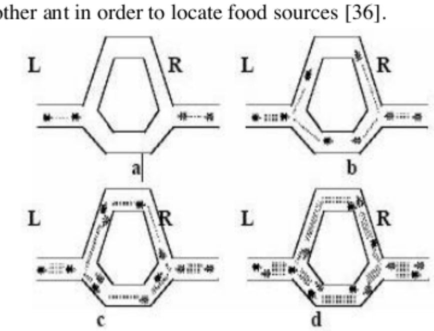


Figure 2. The journey of ants to look for their sources of food [36].

In Fig. 2a, there are 2 groups of ants. The first is group L, which is on the left and is heading to the food source on the right, while the second which is group R is on the right and is heading to the nest on the left. In Fig. 2b and Fig. 2c it is seen that the ants do not know the best routes, therefore, some choose to take the upper road, while the rest, the lower. When walking from the nest to the food source and vice versa, they secrete pheromone substances on their paths, which then guides other ants. Fig. 2d shows that the upper road is less traversed compared to the lower because it is a longer route. Consequently, the pheromone secreted there, begins to evaporate because of lack of use.

The amount of this chemical released is determined by the amount of food discovered. Therefore, the more the food, the more the amount secreted.

Searching for the shortest path using the ant colony algorithm is carried out through the following steps [37].

Step 1:

Initialization of parameters.

Step 2:

Note all cities the ants go through, and the result will serve as the initial element from their *taboo list,* with the initial score being that of the first city.

Step 3:

Organize the paths of all ants from a city to another. This is because colonies usually move from city to city until they get to their final destination, which marks the end of their journey. Furthermore, the formula below helps to determine the best aim based on probability.

$$P_{ij}^{k} = \frac{[t_{ij}]^{\alpha}.[n_{ij}]^{\beta}}{\sum[\tau_{ik^l}]^{\alpha}.[n_{ik^l}]^{\beta}} \text{ for j} \in \{N - \ taboo_k\}$$

$$k^l \in \{N - \ tabu_k\}$$

$$P_{ij}^{k} = 0, \text{for other j}$$

Step 4:

1) Finding the shortest route.

After the probability of every ant was counted, the minimum score of the route length in each cycle, and that of the whole route length was ascertained.

2) Calculation of the Change in the intensity of Inter-city Ants footprint value.

This change is calculated based on the difference in the amount of pheromone secreted by the ants, and that left after evaporation had occurred. This change is represented by the equation below:

$$\Delta\tau_{ij}^{k} = \frac{Q}{L_k}$$

$$\Delta\tau_{ij} = \sum_{k=1} \Delta\tau_{ij}^{k}$$

where $\Delta\tau_{ij}^{k}$ is the change in the value of the ant footprints intensity.

### C. Related Studies

The ant colony algorithm is proven to work very well in solving problems related to discrete optimization that needs to find a short route to a destination [33]. Furthermore, for research related to that by Donny Sanjaya [36] which was titled "Implementation of Mobile Tracking Using the Ant Colony Optimization Method and Google Maps APL", algorithms are used to calculate the distance between one waypoint and another, by converting the longitude and latitude obtained from Google maps.

In addition, in a research entitled, "designing information systems for determining the delivery of goods", using the ant colony optimization method, the case research, pt. xyz designed a system to determine solutions for shipping goods to consumers quickly [38], using the data on their order and distance. All data were then processed using this algorithm and the shortest distance route was determined. The results showed that the use of this algorithm can reduce delays by 10% because the search for the shortest route performed with this method gets optimal results [38]. A similar research was conducted by [37], and it made similar findings. According to them, a simple mechanism for exchanging information between ants heading in different directions leads to a significant increase in inaccuracy. They also discovered that the results of comparisons between algorithms with evolutionary and genetic approaches showed that this algorithm was one of the best-met heuristics for the problem of determining the shortest path.

Research on the use of the modified ant colony algorithm by [40] proved successful in solving the problem of finding the shortest route by an automatic vehicle in all directions (Omnidirectional Mobile Vehicle). Moreover, that conducted in Russia by [41] found that it was able to solve transportation problems. Similarly, [42] in India found that this algorithm is effective in finding the fastest path to locations around the campus. Therefore, the information was used to help students with visual impairments through a voice monitoring system.

The ant colony algorithm can also be used to solve virtual problems, as it has been used by [43] and [44] in their studies to find the fastest path on the Mobile Ad-hock Network (MANET).

When it comes to number of advantages, this algorithm has the most of any other. Furthermore, it can be easily combined with other methods, has good distribution calculation mechanisms, and has proven to have good performance in solving complex optimization problems, especially those involving distances [28]. The superiority of this algorithm is that it is able to provide clues to find the fastest path by avoiding obstacles that may be on the way. [45].

In general, the advantages of ant colony algorithm are: flexible, strong, measurable, and decentralized, self-organized, easily combined with other methods, have good distribution calculation mechanisms, and have proven to have good performance in solving complex optimization problems [28]. It is also proven to be very effective, powerful, and suitable for processing large amounts of data [29]. In fact, according to [30], many Non-deterministic Polynomial-time (NP) problems can be solved using this algorithm. In addition, the ant colony algorithm is also reported to be able to help optimize parameters to aid quality control in industries, according to the results of research conducted by [31]. Lastly, it has proven to be successfully implemented for the creation of a bicycle sharing system, which helped to reduce pollution, determining bicycle demand at each station, and designing distribution routes [32]. The success of ant colony optimization occurs as a result of coordinated interaction [34].

### D. Architecture of System

In order to make the system of find the fastest route to public places in Banjarmasin according to the purpose of this study, the architectural system as shown in Fig. 3 below was implemented:

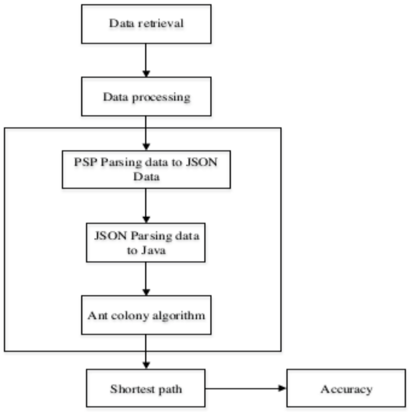


Figure 3. The architecture of the shortest path finding.

The architectural design consists of four stages, which are first, the data retrieval stage, second, data processing, third processing with the algorithm, and fourth, test for accuracy. The data processing stage was conducted by parsing the MySQL data to JSON, and then to Java. Furthermore, after going through the data processing stage, the data was processed again using the ant algorithm to obtain shortest path. Lastly, which is the forth stage, after obtaining the results, they were tested to check the accuracy of the path.

*1) Parsing MySQL data to the JSON data*

In order to parse the MySQL data to the JSON data, the data was first inputted, and then inserted to a website. The following Fig. 4 shows the process:

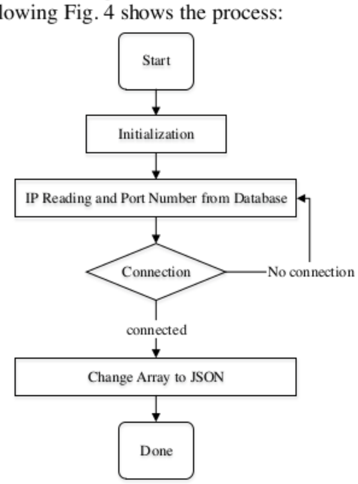


Figure 4. MySQL parsing database to JSON.

*2) Parsing the JSON data to Java*

After the MySQL data was parsed to JSON it was then parsed to Java, so that it can be read by the program. Furthermore, this made it possible for the data to be used by the mobile program. Meanwhile, the JSON parsing data process to Java can be seen in Fig. 5 below:

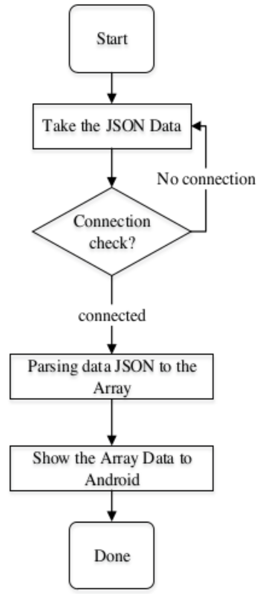


Figure 5. JSON data parsing to Java.

*3) The ant colony algorithm*

This algorithm was implemented by obtaining the location of the An-Nur Clinic as shown in Fig. 6. Furthermore, it was carried out using the graph concept, which was applied to roads in Banjarmasin. Herein, the roads were vertical (vertex) and the edges were arcs. In addition, the user's location will be marked with the symbol P, the destination with T and the node, with a number.

From the Graf in Fig. 6, it is clear that the distance between locations can be inserted into a table. This is further explained in Table I.


Figure 6. The appearance of the An-Nur clinic map.

Table I shows the distance to the An-Nur Clinic. The next step is to input the parameters, which are:

1) Alfa (α) = 0,1
2) Beta (β) = 1,00
3) Rho (ρ) = 0,50
4) Q = 1
5) The numbers of ants (m) = 3
6) The needed cycle (NCMax) = 1
7) Initial Pheromone $\tau ij = 0{,}01$

After this, the visibility between the spots or points was counted using $(\pi ij) = \frac{1}{dij}$, and the result showed the edge quality. Furthermore this result can be seen in Table II.

TABLE I. DISTANCE BETWEEN THE AN-NUR CLINIC POINT IN METERS

| | Initial Point | Point k1 | Point k2 | Point k3 | Point k4 | Point k5 | Point k6 | Point k7 | Point k8 | Point k9 | Destination Point |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Point | 0 | 32.01 | - | - | - | - | 60.13 | - | - | - | - |
| Point 1 | 32.01 | 0 | 33.95 | 51.29 | - | - | - | - | - | - | - |
| Point 2 | - | 33.95 | 0 | - | 36.56 | - | - | - | - | - | - |
| Point 3 | - | 51.29 | - | 0 | 45.4 | - | - | - | - | - | - |
| Point 4 | - | - | 36.56 | 45.4 | 0 | 146.06 | - | - | - | - | - |
| Point 5 | - | - | - | - | 146.06 | 0 | - | - | - | - | 438.36 |
| Point 6 | 60.13 | - | - | - | - | - | 0 | 31.65 | - | - | - |
| Point 7 | - | - | - | - | - | - | - | 0 | 126.82 | - | - |
| Point 8 | - | - | - | - | - | - | 31.65 | 126.82 | 0 | 62.76 | - |
| Point 9 | - | - | - | - | - | - | - | - | 62.76 | 0 | 431.58 |
| Destination point | - | - | - | - | - | 438.36 | - | - | - | 451.58 | 0 |

TABLE II. VISIBILITY BETWEEN CITIES

| | Initial Point | Point k1 | Point k2 | Point k3 | Point k4 | Point k5 | Point k6 | Point k7 | Point k8 | Point k9 | Destination Point |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Point | 0 | 0.031 | - | - | - | - | 0.017 | - | - | - | - |
| Point 1 | 0.031 | 0 | 0.029 | 0.019 | - | - | - | - | - | - | - |
| Point 2 | - | 0.029 | 0 | - | 0.027 | - | - | - | - | - | - |
| Point 3 | - | 0.019 | - | 0 | 0.022 | - | - | - | - | - | - |
| Point 4 | - | - | 0.027 | 45.4 | 0 | 0.007 | - | - | - | - | - |
| Point 5 | - | - | - | - | 0.007 | 0 | - | - | - | - | 0.002 |
| Point 6 | 0.017 | - | - | - | - | - | 0 | 31.65 | - | - | - |
| Point 7 | - | - | - | - | - | - | - | 0 | 0.008 | - | - |
| Point 8 | - | - | - | - | - | - | 0.008 | 126.82 | 0 | 0.016 | - |
| Point 9 | - | - | - | - | - | - | - | - | 0.016 | 0 | 0.002 |
| Destination Point | - | - | - | - | - | 0.002 | - | - | - | 0.002 | 0 |

After inter-city visibility is determined, the next step in finding the shortest path is to calculate the probability from one point to another, using the following formula.

P point to the other points:

$$P_k(r,s) = \begin{cases} \frac{[\tau(r,s)]^{\alpha}.[\eta(r,s)]^{\beta}}{\sum_{u \in J_k(r)}[\tau(r,u)]^{\alpha}.[\eta(r,u)]^{\beta}} \\ 0 \end{cases}$$

$\sum[\tau(r,s)]^{a}.[\eta(r,s)]^{b}$ = (0,01*0) + (0,01*0,031) + (0,01*0,017)
= 0 + 0,00031 + 0,00017
= 0,00048

The probability to go to Point 1
Point 1 = (0,01)1 * (0,031)1 / 0,00048 = 0,646
The probability to go to Point 6
Point 6 = (0,01)1 * (0,017)1 / 0,00048 = 0,354
Point 1 to other points:

$\sum[\tau(r,s)]^{a}.[\eta(r,s)]^{b}$ = (0,01*0) + (0,01*0,029) + (0,01*0,019)
= 0 + 0,00029 + 0,00019
= 0,00048

The probability to go to Point 2
Point 1 = (0,01)1 * (0,029)1 / 0,00048 = 0,604
The probability to go to Point 3
Point 6 = (0,01)1 * (0,019)1 / 0,00048 = 0,396
Point 2 only has direction to point 4
Point 3 only has direction to point 4
Point 4 only has direction to point 5
Point 5 only has direction to destination point
Point 6 only has direction to point 7.
Point 7 only has direction to point 8.
Point 8 only has direction to point 9.
Point 9 only has direction to point T.

TABLE III. PROBABILITY OF EVERY POINT

| | Initial Point | Point k1 | Point k2 | Point k3 | Point k4 | Point k5 | Point k6 | Point k7 | Point k8 | Point k9 | Destination Point |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Point | 0 | 0.646 | - | - | - | - | 0.354 | - | - | - | - |
| Point 1 | 0.646 | 0 | 0.604 | 0.396 | - | - | - | - | - | - | - |
| Point 2 | - | 0.604 | 0 | - | 1 | - | - | - | - | - | - |
| Point 3 | - | 0.396 | - | 0 | 1 | - | - | - | - | - | - |
| Point 4 | - | - | 1 | 1 | 0 | 1 | - | - | - | - | - |
| Point 5 | - | - | - | - | 1 | 0 | - | - | - | - | 1 |
| Point 6 | 0.354 | - | - | - | - | - | 0 | - | - | - | - |
| Point 7 | - | - | - | - | - | - | 1 | 0 | - | - | - |
| Point 8 | - | - | - | - | - | - | - | 1 | 0 | - | - |
| Point 9 | - | - | - | - | - | - | - | - | 1 | 0 | 1 |
| Destination Point | - | - | - | - | - | 1 | - | - | - | 1 | 0 |

Table III shows the point passed by the ants. In cycle 1 there are 3 paths, and the shortest based on probability is P - 1 - 2 - 4 - 5 - T, with a length of 686.94 meters. The results can be seen in the following Table IV:

TABLE IV. THE RESULT OF CYCLE 1 ANT COLONY ALGORITHM

| Ant | Route | Distance (meter) |
|---|---|---|
| 1 | P-1-2-4-5-T | 686.94 |
| 2 | P-1-3-4-5-T | 713.12 |
| 3 | P-6-7-8-9-T | 712.94 |

It can be seen from Table IV that the best route based on the first cycle is the P – 1 – 2 – 4 – 5 – T route, with a length 686,94 meters.

## III. ANALYSIS AND TESTING

This system was tested by comparing the result of the manual count of the algorithm to that obtained using the application system. Furthermore, this comparison was carried out by searching the An-Nur Clinic at the point (-3.310126, 114.602963). The map of the An-Nur clinic can be seen in Fig. 7 below:

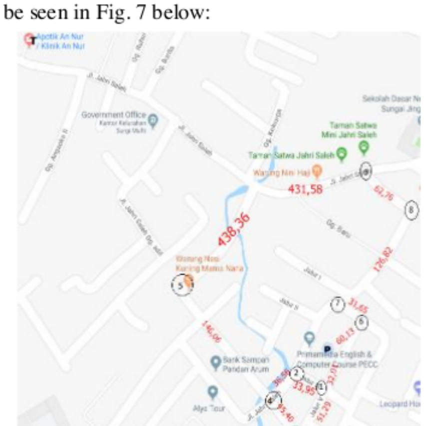


Figure 7. An-Nur clinic map.

After the manual calculations were conducted, the result was tested through the system as shown in Fig. 8.

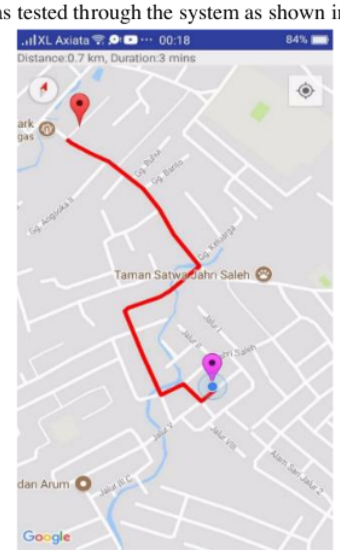


Figure 8. Testing by using the mobile system.

Fig. 7 and Fig. 8 show that the shortest path to the An-Nur Clinic has the same route.

From the results of the above research, this algorithm succeeded in determining the shortest path to the desired public place. Therefore, it confirms previous studies by [39], which found that this algorithm can determine the shortest path to places. Likewise with the results of research conducted by [40], which discovered that this algorithm also proved successful in solving the problem of finding the shortest route by automatic vehicles in all directions (Omnidirectional Mobile Vehicle). The same result was also obtained in the research conducted by [41], which concluded that it also able to solve transportation problems by finding the fastest route. In fact, according to [45], it can provide instructions for finding the fastest route, by avoiding obstacles along the path.

It is hoped that the results can be further developed, and subsequently utilized by entrepreneurs, communities, and tourists visiting Banjarmasin City. For entrepreneurs, it is expected to aid the faster sending of products or services, considering that speed is very important in the business world especially in the 4.0 revolution era, considering the speed of service and it is one of the most crucial factors in building customer loyalty and increasing satisfaction (see [12], [13]) and [14]. Furthermore, it will also be very useful for the z generation, which is now more than 32% of the world's population [18]. This generation consists of individuals born after 1995, and they are often called the internet or digital native generation. They are very good at using technology, always connected to the internet and are impatient [20]. Their characteristics are that they are always carrying smart devices that must always be connected to the internet, and only feel comfortable when within internet coverage [21]. Therefore, when faced with problems they usually turn to the internet for solution [22]. In a condition when they need to find the fastest route, they will also rely on the systems on their smartphones.

## IV. Conclusion and Recommendation

This research reported the development of a mobile application which utilized the ant colony algorithm for the determination of the shortest path to some public places. It is recommended that in future studies, applications which can choose alternative routes in case of road congestion should be developed. Furthermore, these applications should be simple enough to be used by pedestrians, bicycle users, and others.

## Conflict of Interest

The authors declare that there is no conflict of interest.

## Author Contributions

All authors contributed to the designing and implementation of the research, including its analysis, and the writing of the manuscript.

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