**UNIVERSITI TEKNOLOGI MARA**

# ROUTE OPTIMIZATION FOR RICE DELIVERY USING ANT COLONY OPTIMIZATION

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# Route Optimization for Rice Delivery using Ant Colony Optimization Algorithm

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# SUPERVISOR APPROVAL

# ROUTE OPTIMIZATION FOR RICE DELIVERY USING ANT COLONY OPTIMIZATION ALGORITHM

By

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Assoc Prof Dr Marina Yusoff

Project Supervisor

FEBRUARY 20, 2023

# STUDENT DECLARATION

I certify this thesis and the project to which it refers is the product of my own work and that any idea or quotation from the work of other people, published or otherwise are fully acknowledged in accordance with the standard referring practices of the discipline.

………………………………

MUHAMMAD HAKIM BIN MOHAMMAD FADZLI

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# ABSTRACT

The goal of this research is to identify the factors that influence rice product delivery route and to develop an optimal route for customers to reach the nearest rice retailer using Ant Colony Optimization algorithm. The factors that are influencing the rice product delivery route was identified to be. The ideal optimal route was determined using Ant Colony Optimization (ACO) approach. The ACO algorithm is a form of swarm intelligence system that searches for the shortest route between two locations acting like ants. The research was carried out in Seksyen 7, Shah Alam and the results shows that Ant Colony Algorithm was able to determine the optimal route for the residents to show the nearest rice retailer. The result from 3 case studies with 400 instance demonstrated that the best approach. This research offers a complete approach for the optimal path for rice distribution by including the availability of rice product in each store in Seksyen 7, Shah Alam. The results of the study may be utilized by customer segments such as local families and businesses to help them purchase rice in their area and increase their awareness of the rice they consume.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACO | Ant Colony Optimization |
| TSP | Travelling Salesman Problem |
| VRP | Vehicle Routing Problem |
| GA | Genetic Algorithm |
| GPS | Global Positioning System |
| AI | Artificial Intelligence |
| PSO | Particle Swarm Optimization |
| AIS | Artificial Immune System |
| FA | Firefly Algorithm |
| ACS | Ant Colony System |
| AS | Ant System |

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# CHAPTER 1

# INTRODUCTION

This chapter delivers key ideas of this research and justification for the study. It includes the problem statement, research question, research objectives, research scope, research significance and conclusion from this chapter.

## 1.1 Project Background

According to the Food and Agriculture Organization of the United Nations (FAO), rice is a major staple food for a significant portion of the global population, with over 3.5 billion people relying on rice as a primary source of nutrition (Chapter 1 - Rice in the World, n.d.). However, the efficient and effective delivery of rice products to end-users, particularly in urban areas, presents significant logistical challenges. Last mile delivery, or the final leg of the delivery process from the retailer or distributor to the end-user, is often the most complex and costly part of the delivery process.

Based on the "The Status of the Paddy and Rice Industry in Malaysia" report, the rice food distribution infrastructure in Malaysia is generally well-developed and efficient, with a strong network of wholesalers, distributors, and retailers. The report states that the country has many modern rice mills and processing facilities, which are equipped with advanced technology to produce high-quality rice products. The report also mentions that there is a strong distribution network that spans across the country, connecting rice growers with consumers in both urban and rural areas. This network is supported by well-maintained roads, ports, and transportation systems, which facilitate the movement of rice products from production centres to distribution centres and retail outlets.

In addition, the report highlights the growing trend towards e-commerce and online food retail, which is changing the way that rice and other food products are distributed in Malaysia. Online platforms and food delivery services are becoming increasingly popular and are providing new opportunities for rice food distributors to reach consumers. Hence the focus of food delivery of rice produc

Route optimization in the context of food distribution refers to the process of finding the most efficient and convenient route for delivering food products from distribution centres to the end consumer. This can be achieved using software or other tools that take into account various factors such as Consumer location: the location of the end consumer, with the goal of delivering food products to the consumer in the most efficient and convenient manner. Delivery schedules: the delivery schedules of the food products, with the goal of ensuring that they are delivered at a time that is convenient for the consumer. Delivery options: the delivery options available to the consumer, such as same-day delivery, next-day delivery, or delivery at a specific time, with the goal of providing the consumer with the most convenient delivery option. Delivery costs: the cost of delivering food products to the consumer, with the goal of minimizing the cost of delivery while ensuring that the food products are delivered in a timely and cost-effective manner. By optimizing the route for delivery to the end consumer, food distributors can improve the convenience and efficiency of the delivery process, while providing better value to the end consumer. This can help to increase customer satisfaction and loyalty, and ultimately improve the competitiveness and success of the food distribution system.

This study aims to optimize the last mile delivery of rice products using the Ant Colony Optimization (ACO) algorithm. Specifically, the study seeks to develop an optimal route for customers to reach the nearest rice retailer to improve the efficiency and effectiveness of the delivery process. The goal is to improve the accessibility and affordability of rice products for residents, particularly in urban areas where last mile delivery can be a significant challenge. By optimizing the route used to deliver rice products to end-users, this research can help to improve food security and contribute to the health and well-being of communities that rely on rice as a staple food.

## 1.2 Problem statement

Rice is a crucial staple food in Malaysia, but last mile delivery of rice products remains a significant challenge for businesses and customers. Urbanization, traffic congestion, and unpredictable demand are among the factors that contribute to the inefficiency and high cost of last mile delivery in Malaysia (Tiwari et al., 2020). Additionally, many customers, particularly in urban areas, have a lack of awareness of where rice is sold in their area, which can lead to inconvenience and reduced accessibility to this important food product (Zainal & Chin, 2020).

Businesses are forced to rely on packaged rice during peak hours, which may result in increased costs and lower product quality (Arif & Farooq, 2019). Furthermore, the COVID-19 pandemic has further highlighted the importance of efficient last mile delivery for rice products, as it is a critical component of ensuring food security and meeting the increased demand for home deliveries (Wong et al., 2020).

Overall, the last mile delivery of rice products in Malaysia presents significant challenges for businesses and customers, with implications for accessibility, cost, and product quality. Addressing this problem requires the development and implementation of effective optimization techniques and solutions that can improve delivery efficiency and meet the needs of local communities (Chen & Chen, 2019).

## 1.3 Research Questions

The research questions for this project have been identified as follow:

I. What is the factor that influence the delivery of rice products?
II. How to develop an optimal route for customer to reach the nearest rice retailer?

## 1.4 Research Objectives

The objectives for this research are:

I. To identify the factors that influence rice product delivery route.

II. To develop an optimal route for customers to reach the nearest rice retailer using Ant Colony Optimization algorithm.

## 1.5 Project Scope

The scope for this project is develop an optimal route for customers to reach the nearest rice retailer using Ant Colony Optimization algorithm in Section 7 of Shah Alam, The product delivery is aimed at the customer segment, including families and local businesses, who rely on rice. During Peak hour, businesses may need to rely on pre-packaged rice when demand for rice is highest, to ensure that they have sufficient rice to meet their customers' needs. For this project, other factors like traffic congestion, poor transportation infrastructure and unpredictable supply and demand fluctuations are not counted. Figure 1.1 below show the map of Seksyen 7 in Shah Alam.

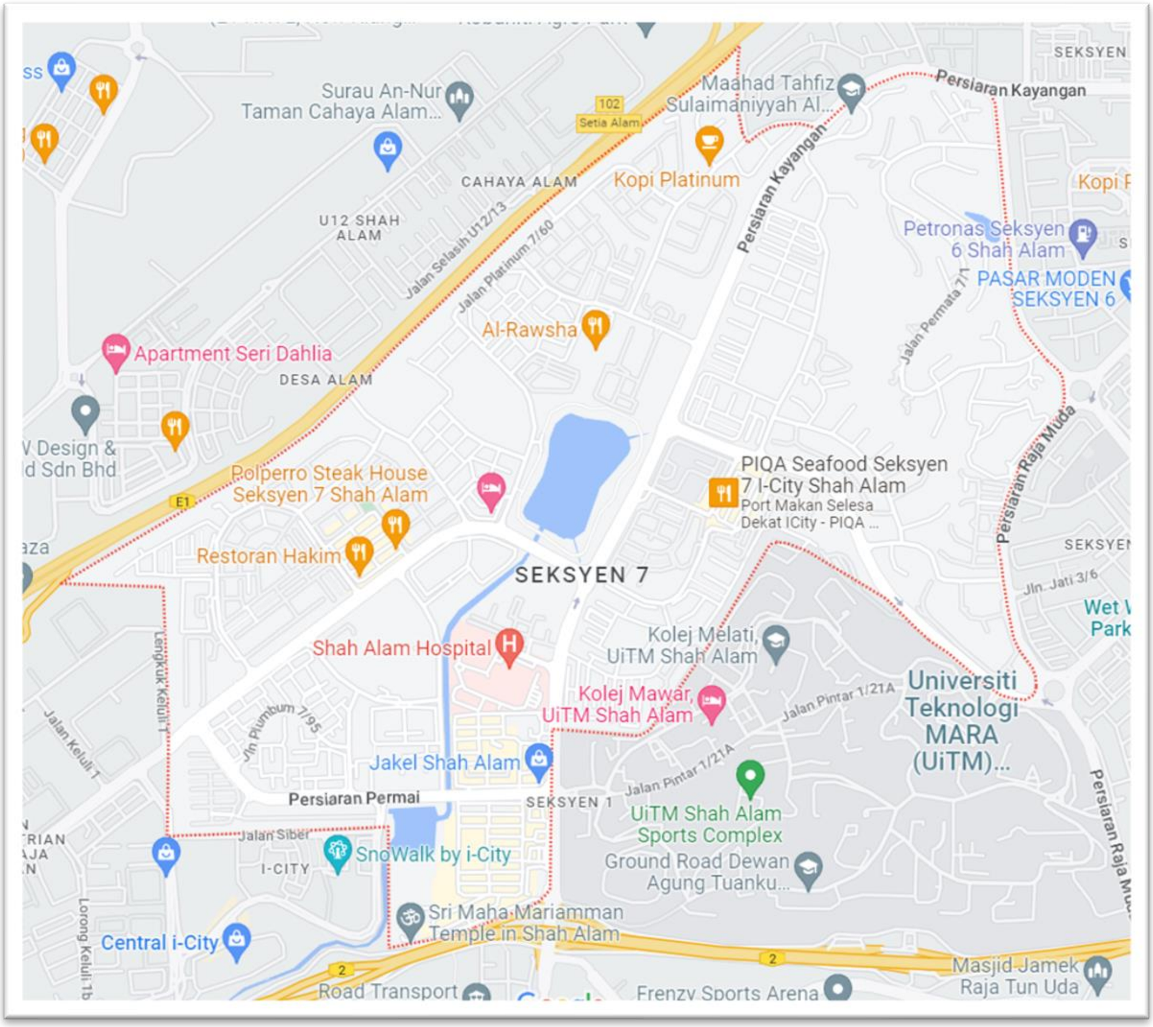


**Figure 1.1** Seksyen 7, Shah Alam

## 1.6 Research Significance

The significance of this research is that through Optimizing the last mile delivery of rice products can improve the accessibility and affordability of rice, a staple food crucial for food security in Malaysia. By developing more efficient routes, delivery costs can be reduced, delivery times can be faster, and resource utilization can be improved, leading to enhanced efficiency. This can benefit local families and businesses, especially in urban areas where last mile delivery can be challenging, resulting in better access to rice products.

## 1.7 Summary

To recapitulate this chapter, project initialization to start this research has been described in this chapter. The project initialization has been described which is the background of study, problem statement, research questions, research objectives, research scopes and research significance.

## 1.8 Outline of the report

This research consists of 5 chapters from chapter 1 until chapter 5 which are the introduction, literature review, methodology, findings and lastly conclusion of this research. Brief description for each chapter were as followed:

i. Chapter 2 consists of previous article or study that related with this research domain and AI techniques.

ii. Chapter 3 gives a detailed of explanation about the methodology to complete the objective of the research.

iii. Chapter 4 describes the result based on the data collected and the AI techniques used in this research.

iv. Chapter 5 recaps the whole research made, form the objective achieved and recommendation to further the research development.

# CHAPTER 2

# LITERATURE REVIEW

This chapter focuses on past research related to optimizing the last mile delivery of rice products using the Optimization algorithm. It examines the domain of rice product delivery and explores other optimization techniques that can be applied in this domain. By comparing related works and domain article, techniques and factors that influence rice product delivery route will be identified that can be applied with our current domain. This will help to achieve the objective with the best result by comparing all the different techniques.

## 2.1 Optimization

Optimization lies at the heart of machine learning. Most machine learning problems reduce to optimization problems. Consider the machine learning analyst in action solving a problem for some set of data (Bennett, K. P., & Parrado-Hernández, E., 2006). Optimization is a process in machine learning that refers to finding the best set of parameters for a model to improve its accuracy and performance. This can be achieved by reducing loss function, which measures the difference between the model's predicted output and the actual output.

Some of the commonly used optimization algorithms are gradient descent, stochastic gradient descent, and Adam. These algorithms calculate the gradient of the loss function concerning the model's parameters and update the parameters in a direction that minimizes the loss. Optimization is an essential component of machine learning as it helps to improve the accuracy and performance of models over time. By finding the best set of parameters, machine learning models can make more accurate predictions and continue to improve as they can be implemented on more data.

Optimization is the process where we train the model iteratively resulting in a maximum and minimum function evaluation (Secherla S., 2022). It can be considered as one of the important aspects of machine learning to get most of the results. Optimizing machine learning models for a variety of reasons. Outcomes in each iteration will be compared, then the hyperparameters will be tweaked until the best results can be achieved. The best model is the model which is more accurate and has a lower error rate.

Algorithms for optimization can be classified into two groups. A deterministic algorithm, which includes branch and bound dynamic programming, and backtracking, is the first one. Approximation algorithms, biological algorithms, randomised algorithms, and evolutionary algorithms are examples of non-deterministic algorithms. (He et al, 2018). The deterministic and non-deterministic algorithms were employed to solve the same type of problem, which is a deterministic and non-deterministic problem. The deterministic method always returns the same result, but the nondeterministic algorithm returns a new result each time it is run.

### 2.1.1 Related Problem

a) Last mile Problem

The "last mile" in logistics and supply chain management refers to the final stage of the delivery process, from the retailer to the end-customer. Despite the critical role of last mile delivery in ensuring customer satisfaction and operational efficiency, it remains a significant challenge for businesses due to various factors such as congestion, distance, unpredictable demand, and cost. Figure 2.1 shows the scheme of delivery.

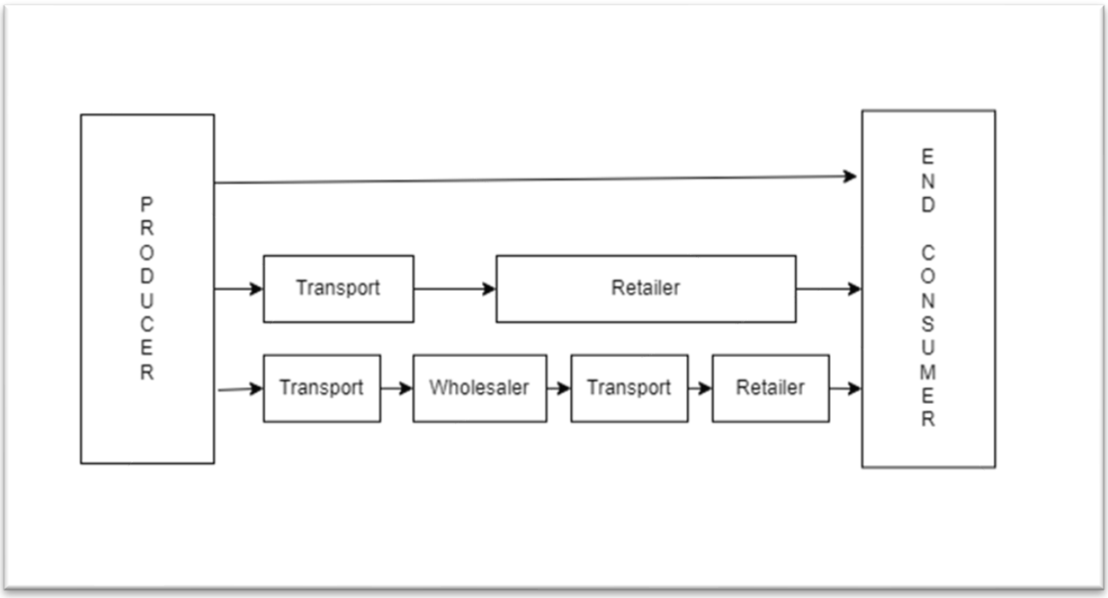


**Figure 2.1** Scheme of delivery.

Several studies have explored the last mile problem in the context of different industries, such as e-commerce, grocery, and food delivery. For example, a study by Chen and Chen (2019) found that the adoption of last mile delivery technologies such as drones and autonomous vehicles could significantly improve delivery efficiency and reduce delivery costs. Similarly, a study by Arif and Farooq (2019) explored the role of data analytics in improving last mile delivery, by using predictive models to forecast demand and optimize delivery routes.

Other research has focused on specific issues related to last mile delivery, such as the impact of urbanization on delivery efficiency (Tiwari et al., 2020), the use of crowdsourcing for last mile delivery (Silva et al., 2020), and the role of customer behavior in last mile delivery (Li et al., 2019). These studies highlight the complexity of the last mile problem and the need for multi-faceted solutions that address different factors such as infrastructure, technology, and consumer behavior.

b) Travelling Salesman Problem (TSP)

TSP is a problem faced by the traveling salesman. Given a set of cities, traveling salesmen must find or identify a minimum cost route which can visit all the cities but only required to visit each city for only once (Bernardino & Paias, 2018). TSP is a famous problem that was always used in the optimization algorithm implementation to solve the problem and produce an optimal result based on the algorithm used. In network theory terms, its only problem is to identify a minimum length cycle in a given maps or graph. The costs for every trip are different between the pairs of cities. The TSP is a classic problem for combinatorial optimization. The problem can be found in numerous applications and manufacturing. Finding an optimal or ideal production sequence is the basis of a TSP solution. The TSP belongs to the non-deterministic polynomial problems class. When the size of any non-deterministic polynomial problems increases, the exact solution cannot be found in a shorter or reasonable time because the computing time increases exponentially (Dudek-Dyducb & Dyducb, 1995).

c) Shortest Path Problem (SPP)

The shortest path problem is a fundamental problem in graph theory and has been studied extensively in the literature. The problem involves finding the shortest path between two vertices in a weighted graph. Many algorithms have been proposed for solving this problem, including Dijkstra's algorithm, Bellman-Ford algorithm, and the A* algorithm. These algorithms have different characteristics in terms of their computational complexity, accuracy, and ability to handle different types of graphs. Several variations of the shortest path problem have also been studied, including the multiple-source shortest path problem and the single-destination shortest path problem. Applications of the shortest path problem include routing in transportation networks, resource allocation in communication networks, and robot path planning (Magzhan & Jani, 2013).

### 2.1.2 Optimization Methods and Techniques

a) Ant Colony Optimization (ACO) Algorithm

Advanced stochastic optimization techniques called ACO make use of the pheromone model as their main concept. Using a defined set of solution components, the pheromone model is used to stochastically develop solutions based on the problem being studied. ACO will use previously created or produced solutions to update the pheromone values at runtime. The update seeks to concentrate the search space's high-quality solution-containing region. To be clearer, a key component of ACO is the reinforcement of solution components, which depends on the quality of the solution. Technically, it is presumptive that good solutions have good solution constituents (Dorigo & Blum, 2005)

.b) Genetic Algorithm (GA)

GA may require hundreds or thousands of function evaluations to solve some problem or find an optimal solution. Depending on the weight or size of each evaluation, it may take the GA for days, months, or even a year to find an acceptable or optimal solution. Luckily, GA work with a population of independent solutions, which makes it possible to distribute the computational load among several processors (Cantú-Paz & Goldberg, 2000).

c) Dijkstra’s Algorithm

Dijkstra’s algorithm is an algorithm to find the shortest path that has been used in our popular navigation application, Google Maps. There are many other applications that use Dijkstra’s algorithm such as surveying and mapping, multi-point routing and other map applications (Shu-xi, 2012). The algorithm is very good in finding the shortest path but there are some drawbacks of the algorithm. For example, when there is considerably a wide range of possible paths, it can result in a delay and consume too much capacity (Alwan, 2014). There are also some other disadvantages of Dijkstra’s algorithm which is that the algorithm cannot handle any negative edges and affect the accuracy to find the optimal or the shortest path (Gupta, Mangla, & Jha, 2016).

d) A* Algorithm

A-STAR algorithm combining the advantages of Best First Search and Dijkstra algorithms can not only guarantee the finding of optimal path in a static environment, but also improve the efficiency by heuristic search, which is suitable for accurate planning of demand (X. Li, X.Hu, Z. Wang and Z.Du, 2020). The A* algorithm is a powerful optimization algorithm that can be used to solve a variety of real-life problems. For example: you are lost in a large city and you want to find the quickest way to get to your hotel. You could use a navigation system that utilizes the A* algorithm to calculate the shortest route based on various factors such as the distance to your destination, the current traffic conditions, and road closures. The algorithm would consider the current location of your vehicle, the address of your hotel, and the city map, and use this information to generate the fastest route. In this scenario, the A* algorithm would start by creating a list of potential paths from your current location to the hotel. The algorithm would then calculate the estimated time for each of these paths, taking the distance to be covered, speed limits, and current traffic conditions. And finally, the algorithm would select the path with the shortest estimated time and guide you to your destination.

e) Breadth First Search Algorithm:

Breadth First Search is an algorithm which is considered as the optimization technique to find the optimal path and can be applied to many real-life problems.  For instance, you must determine the shortest path of connections between you and any other person. You can use the BFS algorithm to search through your network of friends and understand to find the shortest path to that person. In this scenario, the BFS algorithm would start by exploring all your direct connections, then all of their connections, and so on, until it finds that person or determines that they are not connected to you. The algorithm uses a queue to keep record of the individuals that need to be explored and continues to expand its search until it finds the destination or exhausts all possibilities. In this way, the BFS algorithm can be used to help you quickly and efficiently find the shortest path between you and a distant person in a social network.

According to Robbi Rahim et all, by using the Breadth First Search algorithm by approaching the search from the starting point to the destination point by examining the layer by layer against all the possibilities that can be passed and remove all the paths that are not possible to pass (Rahim, Robbi, et al, 2018).

f) Routing Algorithm

Determine an optimal route in a flow that was required in many fields such as computer science, social science, computer science, chemistry and mainly transportation that has been shown a number of practical problems in every 11 fields (Laan, 2017). Routing algorithms also can be implemented in transport networks to find the shortest path, the best part is that the routing algorithm can reroute the path and travel time. The reroute feature is very helpful in the transport network because it can adapt or dynamically change when there is a new traffic update and determine the current path or there is a new shortest path. The only drawback in the routing algorithm is the reserved traffic does not affect the already calculated routes and only affects a new traffic route (Agafonov & Myasnikov, 2017).

## 2.3 Consumer Purchasing Preferences

Consumer preference for rice is influenced by various factors, including sensory attributes, quality, packaging, and price. A study by Elam et al. (2018) examined consumer preferences for rice in the United States and found that the most important factors were taste, texture, and aroma, followed by price, packaging, and brand. Consumers preferred rice that was easy to cook, had a fluffy texture, and a pleasant aroma. The study also found that consumers were willing to pay more for rice that had a higher quality and better taste.

In addition to taste and quality, sustainability has become an important factor in consumer preference for rice. Consumers are increasingly concerned about the environmental impact of food production and are willing to pay more for sustainably produced rice. A study by Huynh et al. (2018) found that consumers in Vietnam were willing to pay a premium for rice that was produced using sustainable farming practices, such as organic or fair-trade farming. The study also found that consumers were willing to pay more for rice that had a lower environmental impact, such as rice that was produced using less water or had a smaller carbon footprint.

Another important factor in consumer preference for rice is the origin of the rice. Consumers are often willing to pay more for rice that is grown and produced locally or has a unique cultural heritage. A study by Kono et al. (2020) found that Japanese consumers were willing to pay more for rice that was produced in their local region or had a long history and cultural significance. The study also found that consumers were more likely to choose rice that had a unique flavour or was associated with a specific cooking method or recipe.

Determinants of consumer purchasing behaviour for rice in Malaysia.

| Author | Project | Factors | | | | |
|---|---|---|---|---|---|---|
| | | Price | Flavor | Taste of cooking | Location | X |
| Marlia Musa*, Nasuddin Othman** and Fazleen Abdul Fatah*** | Determinants of Consumers Purchasing Behavior for Rice in Malaysia | / | / | / | / | |
| Fazleen Abdul Fatah | | | | | / | |
| | | | | | / | |
| | | | | | / | |
| | | | | | / | |

## 2.4 Rice distribution

In the 21st Century, data and in conjunction information is rapidly generated due to the advent of the internet. These data are collected to empower the use of statistics as a reference or analysis to develop a model (Das, Parida, Bhaskar, & Katiyar, 2016). With the rise of big data, it is easier to do data processing, extraction, or data manipulation. Processing, extraction, or data processing, extraction or data manipulation is required to perform certain methods or techniques to achieve certain results. For example, based on a certain collection of data or dataset, prediction or classification techniques can be performed based on certain requirements. Prediction is based on past information or experience, it can predict the result or what will happen, from this prediction result many unwanted things can be avoided. While data classification is classifying the data based on information provided, for example the process of classifying or detecting certain files can be classified as a virus. The processing or extraction of data takes a lot of time based on the method or technique of processing and extracting data because the larger the data or the information, the more the complexity of the process. Therefore, optimization is introduced to advance and accelerate the data processing. Optimization is needed to achieve an effective and efficient solution for a process or activity, it is what we call the optimal or the best solution. For example, to search on millions of data or to find the shortest path.

Challenges faced during food distribution**.** Food distribution implies several challenges including providing the efficient and cost-effective movement of food, managing inventory and storage, optimizing delivery routes, and reducing food waste. Some of the specific issues that arise in food distribution include Transportation logistics: Finding the most efficient way to transport food from suppliers to distributors and retailers, while considering factors such as the distance, cost, and time involved. Storage and handling: Ensuring that food is stored at the right temperature and conditions to preserve its freshness, while also considering space constraints and the need for efficient loading and unloading operations. Freshness and quality control: Keeping track of the shelf life of different food products and guaranteeing that they are delivered promptly to maintain their freshness and quality. Consumer demand: Keeping up with changes in consumer demand and preferences and ensuring that the right products are available in the right quantities at the right time. Food waste reduction: Minimizing the amount of food that is lost or wasted during transportation and distribution, while also reducing the environmental impact of this waste. Delivery coordination: Supervising the coordination of deliveries to retail outlets, distributors, and consumers, considering factors such as traffic, road conditions, and delivery schedules.

Solving these challenges requires a complete and integrated approach, considering factors such as cost, efficiency, and environmental impact, to ensure that food is delivered to consumers in a timely, fresh, and sustainable manner. Food distribution is a complicated process that includes several interrelated challenges. Some of the specific problems that have been widely researched in the field of food distribution include Food safety: The management of food safety risks, including temperature control and the implementation of food safety standards (Kim et al., 2017).

## 2.5 Related Works (Last mile delivery)

## 2.5 Related Works (ACO)

a) Workforce Planning using ACO

Fidanova et al. (2017) proposed a new variant for workforce planning. In their study, they are using ACO algorithm to solve the workforce optimization problem. The workforce optimization problem contains two types of decision which is assignment and selection. The first type is to assign employees or the workers to the jobs that need to be performed and the second type is to select the employees from the larger set of available workers. ACO algorithm was tested using ten different set structured problems and ten different set unstructured problem. The computational results achieved by the ACO was then compared with other two metaheuristic methods, scatter search (SS) and GA that was tested with the same ten different set structure problems and ten different set unstructured problems. The results of SS, GA and ACO on workforce problem are shown on the Table 2.1. Table 2.1 below shows that the ACO algorithm achieves better solutions and faster execution time than the other two algorithms.

**Table 2.1** The results of SS, GA and ACO on workforce problem

| Test problem | Execution time, s | | |
|---|---|---|---|
| | SS | GA | ACO |
| S01 | 72 | 61 | 26 |
| S02 | 49 | 32 | 21 |
| S03 | 114 | 111 | 22 |
| S04 | 86 | 87 | 25 |
| S05 | 43 | 40 | 21 |
| S06 | 121 | 110 | 23 |
| S07 | 52 | 49 | 23 |
| S08 | 46 | 42 | 24 |
| S09 | 70 | 67 | 20 |
| S10 | 105 | 102 | 22 |

| Test problem | Execution time, s | | |
|---|---|---|---|
| | SS | GA | ACO |
| U01 | 102 | 95 | 22 |
| U02 | 94 | 87 | 20 |
| U03 | 58 | 51 | 20 |
| U04 | 83 | 79 | 20 |
| U05 | 62 | 57 | 23 |
| U06 | 111 | 75 | 22 |
| U07 | 80 | 79 | 21 |
| U08 | 123 | 89 | 20 |
| U09 | 75 | 72 | 26 |
| U10 | 99 | 95 | 20 |

b) Job Shop Scheduling using ACO

Flórez et al. (2013) proposed a new approach to optimize the problem in job shop scheduling. They implement the ACO model algorithm which is Elitist 27 Ant System (EAS) to the job shop scheduling problem. The aim or objective of using ACO algorithm is to minimize or reduce the delays to designate the available job shop operation immediately. Consider that the job shop operation availability is lack and have a large amount of pheromone. The result of using ACO model algorithm find a solution that is remarkably efficiency and a good solution.

| Algorithms | MACO | ACS | AS |
| --- | --- | --- | --- |
| **Average RPD** | 0.20 | 15.50 | 42.30 |

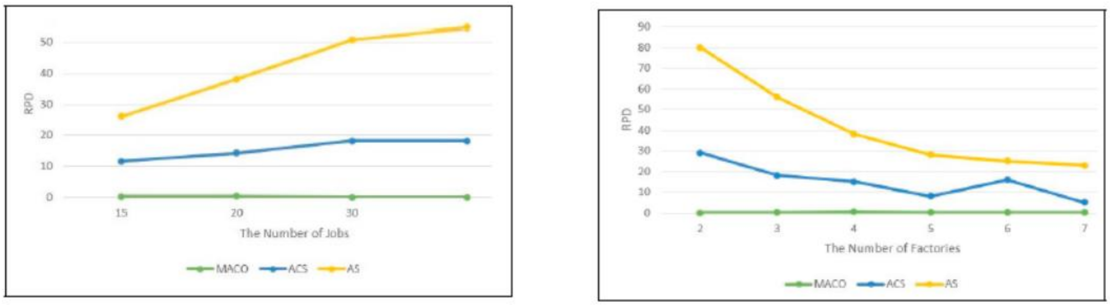


**Figure 2.2** comparison graph of average RPD with the number of jobs and factories

## 2.5 Summary

This chapter discussed about the previous works and studies that related with this. research techniques and domain. The related techniques that were included in this. chapter such as genetic algorithm, routing algorithm, Dijkstra algorithm and many more algorithm. Domain of this project is to find the. Based on the domain, the related studies include the optimization, transportation, route and similar system with this research study.

# CHAPTER 3

# RESEARCH METHODOLOGY

This method that will be used in this research will be explained thoroughly in this chapter to identify the optimal path for residents to find the nearest food rice distributor using ACO. This research will collect the simulation data that can relate with the research scope.

## 3.1 Methodology Overview

This subchapter provides a comprehensive review of the methodology utilized in this study, which will provide insight into how the research was conducted and how the data was analysed and the technique that was used to answer the research question. Figure 3.1 depicts the research's framework.

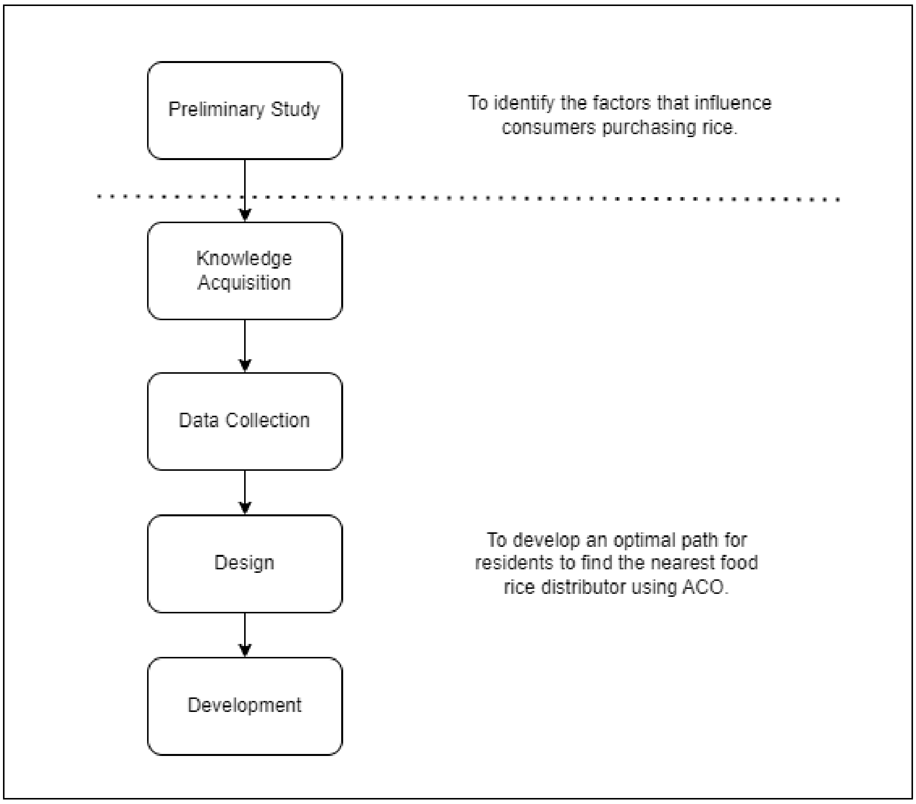


**Figure 3.1** Research Framework

The Table 3.1 shows the Methodology table that explains the research framework in greater detail.

**Table 3.1** Methodology

| Objectives | Phases | Activities | Deliverables |
|---|---|---|---|
| To identify the factors affecting people to purchase rice. | Preliminary Studies | Identify and understand what factors are influencing people's decision to buy packaged rice. | Research question and objectives are formulated |
| | | | Problem statements and research significance are defined |
| | | | Project scope is defined |
| | | Questionnaire on factors that influence people to | Factors are identified:<br>-Price of the packaged rice.<br>-Type of rice.<br>-Distance of store from house.<br>-Rice availability in a |

| Objectives | Phases | Activities | Deliverables |
|---|---|---|---|
| | | purchase rice. | store. |
| To develop an optimal path for residents to find the nearest food rice distributor using ACO. | Knowledge acquisition | Conduct Literature Reviews | Technique and method of simulation identified. |
| | Data Collection | Find any related data needed to make street network using OSMnx and OpenStreetMap<br><br>Collect data of packaged rice from Rice distributor in Seksyen 7, Shah Alam through direct observation. | Street Network of Seksyen 7 is acquired.<br><br>Data of available commercial packaged rice from Rice distributor in Seksyen 7 is acquired. |
| | Design | Determine the Problem Formulation, Objective function, Establish the steps of ACO for shortest distance. | The Problem Formulation, Objective function, The steps of ACO for shortest distance. |
| | Development | Construct ACO model using Phyton in Google Collab.<br><br>Develop a Prototype for the ACO algorithm. | ACO model for the shortest distance for residents to find the nearest food rice distributor.<br><br>Prototype. |

## 3.2 Preliminary Study

Preliminary studies are an essential part of the research process, providing a foundation for the development of a research project. At the outset of a research project, preliminary studies are conducted to gather information and identify key issues related to the research topic. Through this phase, problem statement, research questions, research objectives, research significance, project scope can be identified and formulated. An in-person questionnaire was used and sent to the resident of Seksyen 7, Shah Alam to gauge their preference in purchasing rice and factors affecting them to purchase rice in a particular store. Based on the response data that were collected from the questionnaire, the data are analysed to improve the research understanding and find appropriate research domain. This phase is crucial to ensure that the research process is conducted with clear understanding of the research topic.

## 3.3 Knowledge Acquisition

Knowledge acquisition is to identify the suitable optimization algorithm for the domain of this research. There are various types of optimization algorithms, and each algorithm has its own strength and limitations. Some of the popular optimization algorithm that were commonly used is GA, ACO, PSO, A*, Dijkstra's algorithm and others optimization algorithms. In this project, we will use ACO algorithm To shed light on consumer purchasing behaviour towards commercial rice products, such as packaged rice, relevant article will be the information gathered. Through this knowledge acquisition process will help to guide the implementation of this research.

## 3.4 Data Collection

Data collection is a critical process in any research project, as it provides the foundation for analysing and understanding the phenomenon under study. The data collected must be relevant and appropriate to the research objectives and questions. In general, there are two types of data that can be collected: primary and secondary. Primary data is information that is collected directly by the researcher through methods such as surveys, interviews, or experiments. For this research, a direct observation was done by visiting each store and noting down the types of rice and brand of each rice distributor in Seksyen 7, Shah Alam. On the other hand, secondary data is information that has already been collected by other researchers or organizations. For this research, a possible route was generated through the use of OpenStreetMap and OSMnx library.

### 3.4.1 Possible Routes

To develop the optimal path for this research, all the possible routes need to be identified and collected first. The use of OSMnx library for extracting data from OpenStreetMap has gained increasing popularity in recent years due to its ease of use and flexibility. In a recent study by Alattar et al. (2021), the authors employed OSMnx in conjunction with Strava data to model cyclists' route choice in the City of Glasgow. OSMnx provided a powerful tool for downloading and analysing OpenStreetMap data at the level of individual streets and intersections. This allowed the authors to construct a comprehensive network of the city's cycling infrastructure, including bike lanes, paths, and quiet streets. OpenStreetMap is an open-source mapping platform that provides users with free, detailed maps of roads, buildings, and other features. With OpenStreetMap, users can access detailed maps of local areas and navigate through different modes of transportation, such as walking, biking, and driving. Using OpenStreetMap Seksyen 7, Shah alam was set as a geographic boundary. Figure 3.2 shows the Open Street map.

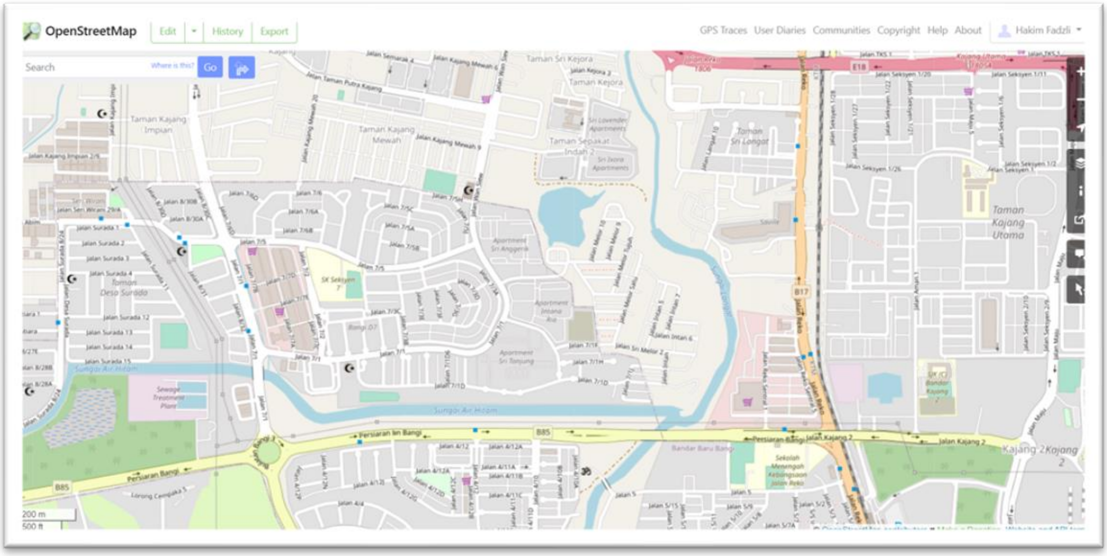


**Figure 3.2** Open Street map.

OSMnx is a Python library that allows users to download and analyse OpenStreetMap (OSM) data for any geographic area. OSMnx is specifically designed to extract street networks, including nodes and edges, and visualize them in a graph format. Using the OSMnx Python library in conjunction with OpenStreetMap enable to download data and get a node graph that can be a powerful tool for analysing and visualizing transportation networks. Figure 3.3 Shows the Street network of Seksyen 7, Shah Alam.

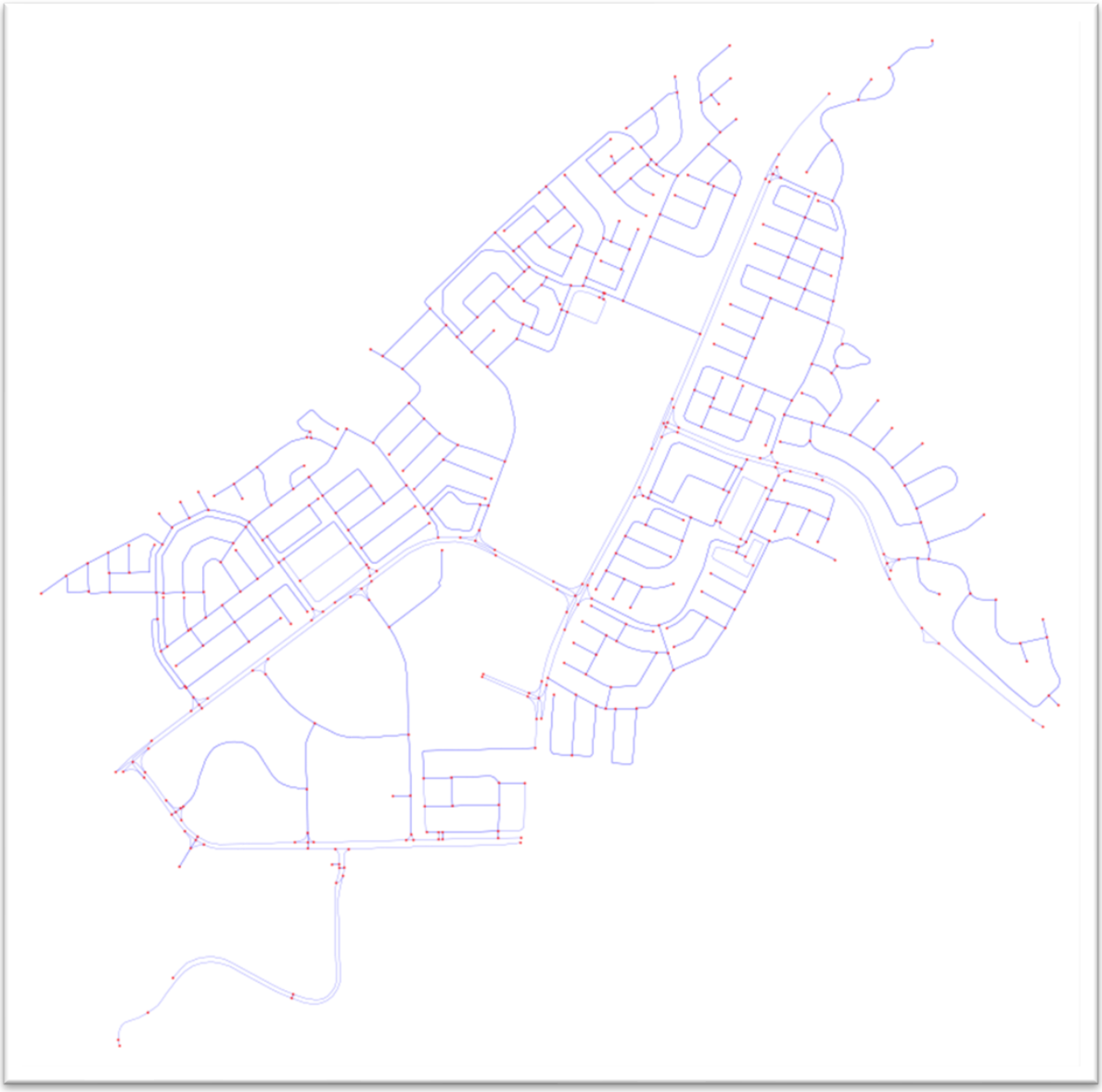

**Figure 3.3** Street network of Seksyen 7, Shah Alam.

NetworkX is a Python package for the creation, manipulation, and study of complex networks. It provides tools for representing and analysing networks, such as graphs and directed graphs, as well as a variety of algorithms for working with them. Using this library, the attribute of the street network can be identified. This street network has 483 nodes and 1071 edges with an average node degree of 4.434.

### 3.4.2 Rice Retailer Inventory Dataset

Commercial rice refers to rice that is produced and sold for the purpose of consumption. Commercial rice is widely consumed across the world and comes in many different varieties, including white rice, brown rice, basmati rice, jasmine rice, and many others. These different types of rice may have different taste, texture, and nutritional properties, and are often marketed to consumers based on their specific characteristics. In this research, rice inventory of each store available in Seksyen 7 Shah Alam was collected through direct observation. Direct observation is a research method that involves watching and recording events or behaviours as they occur in real time. This process was carried out to gather information on the different types of commercial rice available in the two areas and their prices, packaging, brands, and other relevant factors. Overall, the process of collecting commercial rice available in Seksyen 7 can provide valuable insights into the rice market and consumer preferences in the area. Table 3.2 shows snippets of the sample data of the Rice Retailer Dataset.

**Table 3.2** Sample of Rice retailer Dataset

| Store Name | Coordinates | Type of Rice available | Brand |
|---|---|---|---|
| Amirul Mart | 3.071572635365966, 101.50866492253954 | White Rice, Parboiled Rice, Basmathi Rice | Jasmine, Faiza |
| Syarikat Azam | 3.0712280869295707, 101.50832239587552 | Local rice | Saga |
| KK Mart | 3.082557703199105, 101.49296192241329 | Import Rice, Basmathi Rice, Local Rice, Thai rice, Sushi rice Fragrant rice | Sunflower, Jasmine, Super5, Sumo |
| 7 Eleven | 3.0773824160343537, 101.49748844147884 | Import rice, Fragrant thai rice | Sukahati, Double Phoenix Jewel |
| 99 Speed mart | 3.0759198883602585, 101.4969471138419 | Import Rice, Basmathi Rice, Local Rice, Thai rice, Fragrant rice, Brown rice | Jati,Saga, Jasmine, Super 5 |
| Syarikat Sri Alam | 3.076626827277639, 101.49727882280925 | Basmathi rice, | Jasmine, Sunflower |

## 3.5 Design

This section will provide a detailed explanation of the entire design process in this research, including problem formulation, architecture analysis, goal function, and ACO processes for the shortest route to the closest rice distributor.

### 3.5.1 Problem Formulation

The rice market is currently facing multiple issues related to the availability, quality, and consumer awareness of commercial rice. Consumers often struggle with uncertainty about the availability of desired rice types in local stores, leading to time-consuming and frustrating experiences, as well as negative environmental impacts due to increased transportation costs and carbon emissions. Businesses also face challenges in sourcing high-quality rice during peak hours, which can result in lower quality or counterfeit rice that negatively impacts consumers' health and satisfaction. Additionally, a lack of consumer awareness regarding the quality and origin of rice can lead to problems with health and sustainability. Therefore, there is a need for an optimal solution that can provide consumers and businesses with an efficient way to locate the nearest rice distributor with regards to distance to address these issues.

### 3.5.2 Proposed ACO algorithm

The basic ACO algorithm involves simulating the behaviours of ants that are searching for food. Ants deposit pheromone trails as they move around, and the pheromone trails attract other ants to follow the same path. In the ACO algorithm, the pheromone trails represent a measure of the desirability of a particular path, and ants simulate the search for the shortest path by probabilistically choosing paths with higher pheromone trails. To construct the optimization model, an objective function needs to be defined.

In this research, the objective function is defined as finding the shortest distance between the two node which are the local resident and the rice distributor that have been identified. Or in the network graph, the objective function is to minimize the total length of path between the starting node and the end node in the Street Network.

Equation 1: Objective Function

$$\text{obj } F = \Sigma i \ \Sigma j \ d(i,j) \ * \ \tau(i,j)$$

where:

- *d(i,j)* is the length of the edge between nodes i and j.
- *τ(i,j)* is the pheromone level on the edge between nodes i and j.
- *Σi* and *Σj* are the summation over all nodes i and j in the path from the starting node to the end node.

Equation 2: The pheromone level on each edge is updated at each iteration

$$\tau(i,j) \ = \ (1-p) \ * \ \tau(i,j) \ + \ Q/Lk$$

where:

- $\rho$ is the evaporation rate.
- $Q$ is a constant.
- $Lk$ is the length of the path found by the ant *k*.

Equation 3: The probability of an ant choosing an edge is given by:

$$P(i, j) = \tau(i, j)\alpha * (1/d(i, j))\beta / \Sigma k\ \tau(i, k)\alpha * (1/d(i, k))\beta$$

where:

- $\alpha$ and $\beta$ are constants.
- $k$ is the index of the ant.
- $\Sigma k$ is the summation over all nodes k that are neighbours of node $i$.

The path with the minimum total length between the starting node and the end node is the one found by the ants after multiple iterations of the algorithm.

There are also a few parameters that need to be initialized such as epoch, iteration, alpha, beta rate, number of ants, Pheromone concentrations rate and evaporation rate. Below is the fundamental ACO parameter that will be used in this research.

$e$ - Number of epochs

$m$ - Number of iterations

$n$ - Number of ants

$P$ - Pheromone matrix

$\alpha$ - Alpha rate

$\beta$ - Beta rate

$Q$ - Pheromone concentration rate

$W$ - weight

$i$ - Row index

$j$ - Column index

$er$ - evaporation rate.

These parameter needs to be initialized first before the ACO model is run. During the testing phase, these parameters are tuned to determine the good and bad result of the optimization. Because there are numerous optimization problems, including the vehicle routing problem, the travelling salesman problem, the knapsack problem, and the shortest path problem, it is necessary to understand the issues before proposing an appropriate ACO algorithm. In other words, the ant doesn't have to go through every node; it merely stops travelling through each node when it reaches a dead end or its final goal, and then it uses the same path that was previously stored in their memory to return to the first node.

Equation 4: Pheromone Matrix update

$$\tau(i,j) = (1 - \rho) * \tau(i,j) + Q/Lk$$

where $\tau(i, j)$ is the pheromone level on the edge between nodes i and j, $\rho$ is the evaporation rate, Q is a constant, and Lk is the length of the path found by the ant k.

This equation updates the pheromone level on the edge based on two factors. The first factor is the evaporation of the existing pheromone level, which is controlled by the evaporation rate $\rho$. The second factor is the addition of new pheromone to the edge, which is proportional to the quality of the path found by the ant, represented by Q/Lk.

The addition of pheromone to an edge by an ant is an indication that the path between the two nodes represented by the edge is a good path, and should be explored by other ants in the colony. Over time, the pheromone levels on the edges that represent good paths are increased, which attracts more ants to follow these paths, while the pheromone levels on the edges that represent poor paths are decreased, which reduces the likelihood that ants will follow these paths.

Finding the route that the ants have travelled the most times, which is regarded as the best route, is represented by this objective function. The proposed ACO algorithm's specifics were represented in pseudocode below. Figure 3.4 shows the pseudocode of the ACO.

| No. | Pseudocode |
|---|---|
| 0. | Initialize all the inputs given set |
| 1. | Initialize pheromone Levels on all edges |
| 2. | Loop over the specified number of epochs |
| 3. | Initialize ant positions to the start node. |
| 4. | Loop over the specified number of iterations for each epoch |
| 5. | Move each ant to a new node according to the pheromone levels |
| 6. | Check if any ants have found a shorter path than the current epoch |
| 7. | Update pheromone levels on edges in the ant's path |
| 8. | Check if the epoch best path is better than the global best path |

**Figure 3.4** ACO Pseudocode

The ACO method is implemented in this pseudocode as a procedure that accepts several parameters as input and outputs a dictionary of known routes along with their distance cost. The programme simulates ant behaviour, where each ant explores the graph and determines a path from the origin to the destination, by using nested loops. Pheromone concentrations and heuristics are used by the ants to probabilistically choose the next node to explore. Additionally, the algorithm incorporates pheromone updating rules, which at each iteration raise the pheromone concentrations on the edges of the paths travelled by each ant while decreasing the concentrations on all edges by a specific amount. The programme also maintains track of the routes that the ants find and returns those routes at the conclusion of execution.

### 3.5.3 Testing Dataset

For this Testing Dataset, we will utilize 3 different Starting and End location in seksyen 7, Shah Alam where these locations will be used to generate data for the simulation. The address is taken to simulate residents and businesses for the starting location and the end location are all are rice distributors. Table 3.2 shows the starting location and Table 3.3 shows the end location for this research.

**Table 3.2:** Starting Location

| Location | Address |
|---|---|
| R | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam. |
| B | Jalan Platinum 7/37, Seksyen 7, 40000 Shah Alam, Selangor (NASI LEMAK 3 JAM) |
| R2 | 1, Jalan Turmalin 7/12, Seksyen 7, 40000 Shah Alam, Selangor |

**Table 3.3:** End Location

| Location | Address |
|---|---|
| D1 | 32, Jalan Kristal J7/J, Seksyen 7, 40000 Shah Alam, Selangor (KK SUPER MART SHAH ALAM, SEKSYEN 7(SA7)) |
| D2 | No: QG 43 & QG 45, Jalan Plumbum U 7/U, Seksyen 7, 40000 Shah Alam, Selangor (99 Speedmart 1080 Shah Alam Sek 7 (1)) |
| D3 | 22, Jalan Zirkon E7/E, Seksyen 7, 40000 Shah Alam, Selangor (KK SUPER MART Shah Alam, Seksyen 7 (2) (SA72)) |

### 3.5.3 Testing Parameter

The computational test that will be performed on the proposed ACO algorithm will be based on the distance parameter. Through this parameter, the ACO will take it as its parameter to check whether the ACO will give a good performance or bad performance. Table 3.4 shows the testing parameter for the parameter tuning.

**Table 3.4** Testing parameter

| Parameter | Values |
|---|---|
| Number of epochs | 10, 20, 30,50,100 |
| Number of Iteration | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 |
| Alpha | 0.3, 0.7, 1, 2 |
| Beta | 0.3, 0.7, 1, 2 |
| Number of ants | 10, 50, 100 |
| Q Concentration of pheromones | 0.1, 0.5, 0.7, 1 |
| Evaporation rate | 0.1, 0.3, 0.7 |

## 3.6 Development

Development is a stage in this research's refers to the technical construction of the research. For this research, the development will be focused on 2 development which are the model and the prototype. Based on the Table 3.5, the development setup is explained in more detail.

**Table 3.5** Development setup

| Development | Hardware | Software/Website | Language | Framework/Library |
|---|---|---|---|---|
| Prototype | Laptop | Visual Studio Code<br>Google Map API | Html<br>PHP | Flask |
| Model | | Google Collab | Phyton | Networkx<br>Pandas<br>OSMnx<br>NumPy<br>Random<br>Matplotlib<br>CSV |
| | | OpenStreetMap | | |
| | | LatLong.net | | |
| | | Google Sheet | | |

## 3.7 Summary

To summarize this chapter, the steps taken in completing the research and achieve the objective were briefed in detail. The research framework was also included in this chapter to describe more specific about the flow of the research. The research methodology table explain the rest of this, which is preliminary study, analysis, knowledge acquisition, system design, system architecture, data collection, implementation and development were explained particularly in this chapter.

# CHAPTER 4

# RESULT AND FINDINGS

The result and findings of several experiments and observations are the main topics of this chapter. Based on the various performance achieved from the modification of the acquired data and Ant Colony Optimization parameters. This chapter seeks to accomplish the second goal which is to .

## 4.1 Shortest Path Result

For the shortest path result, all the path for the starting location to the destination location is shown in graph form. Table 4.1 Shows the Pairing of the Starting location with the End Location that was used in this Research.

**Table 4.1:** Pairing of the Starting location with the End Location

| Pairing | Location | Address |
|---|---|---|
| R1-D1 | R1 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam. |
| | D1 | 32, Jalan Kristal J7/J, Seksyen 7, 40000 Shah Alam, Selangor |
| B-D2 | B | Jalan Platinum 7/37, Seksyen 7, 40000 Shah Alam, Selangor |
| | D2 | No: QG 43 & QG 45, Jalan Plumbum U 7/U, Seksyen 7, 40000 Shah Alam, Selangor |
| R2-D3 | R2 | 1, Jalan Turmalin 7/12, Seksyen 7, 40000 Shah Alam, Selangor |
| | D3 | 22, Jalan Zirkon E7/E, Seksyen 7, 40000 Shah Alam, Selangor |

**Figure 4.1:** Shortest Path result for R-D1

**Figure 4.1:** Shortest Path result for R-D1

**Figure 4.2:** Shortest Path result for B-D2

**Figure 4.3:** Shortest Path result for R2-D3

## 4.2 Computational Result based on Distance.

Based on the prepared dataset, proposed ACO algorithm and the parameter testing, the result of the performance testing based on distance as below. The performance testing unit in this research were measured in meter to demonstrate the performance of the proposed ACO algorithm. Table 4.2, Table 4.3, and Table 4.4 shows the sample computational results for all the locations.

**Table 4.3:** R to D1 sample computational Result

| Location | Iteration | ants | Epoch | Alpha | Beta | Evaporation rate | Q | Distance Cost |
|---|---|---|---|---|---|---|---|---|
| R | 1 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.1 | 881.07 |
| | 2 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.5 | 431.08 |
| | 3 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.7 | 772.037 |
| | 4 | 500 | 10 | 0.3 | 0.7 | 0.1 | 4 | 543.166 |
| | 5 | 500 | 10 | 0.3 | 0.7 | 0.3 | 5 | 224.172 |
| | 6 | 500 | 10 | 0.3 | 0.7 | 0.3 | 6 | 513.125 |
| | 7 | 100 | 10 | 0.7 | 0.3 | 0.3 | 0.7 | 258.912 |
| | 8 | 100 | 10 | 0.7 | 0.3 | 0.3 | 1 | 353.628 |
| | 9 | 100 | 10 | 0.7 | 0.3 | 0.7 | 0.1 | 112.086 |

**Table 4.4:** B to D2 sample computational Result

| Location | Iteration | ants | Epoch | Alpha | Beta | Evaporation rate | Q | Distance Cost |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.1 | 881.07 |
| | 2 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.5 | 431.08 |
| | 3 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.7 | 772.037 |
| | 100 | 20 | 0.3 | 2 | 0.7 | 1 | 100 | 543.166 |
| | 100 | 20 | 0.3 | 2 | 0.99 | 0.1 | 100 | 224.172 |
| | 100 | 20 | 0.3 | 2 | 0.99 | 0.5 | 100 | 513.125 |
| | 50 | 20 | 0.7 | 2 | 0.7 | 0.1 | 50 | 258.912 |
| | 50 | 20 | 0.7 | 2 | 0.7 | 0.5 | 50 | 353.628 |
| | 50 | 20 | 0.7 | 2 | 0.7 | 0.7 | 50 | 112.086 |

| Location | Iteration | ants | Epoch | Alpha | Beta | Evaporation rate | Q | Distance Cost |
|---|---|---|---|---|---|---|---|---|
| R2 | 1 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.1 | 881.07 |
| | 2 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.5 | 431.08 |
| | 3 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.7 | 772.037 |
| | 4 | 10 | 10 | 0.3 | 0.3 | 0.1 | 1 | 543.166 |
| | 5 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.1 | 224.172 |
| | 6 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.5 | 513.125 |
| | 7 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.7 | 258.912 |
| | 8 | 10 | 10 | 0.3 | 0.3 | 0.3 | 1 | 353.628 |
| | 9 | 10 | 10 | 0.3 | 0.3 | 0.7 | 0.1 | 112.086 |

**Table 4.5:** R2 to D3 sample computational Result

## 4.3 Optimal ACO Parameter Value

The optimal ACO Parameter value is selected by choosing the parameter with the lowest distance for output from all 400 iterations for each location. Table 4.6, Table 4.7, and Table 4.8 shows the optimal parameter setting for all the locations.

**Table 4.6** Optimal ACO Parameter for R-D1

| **Parameter** | **Value** |
|---|---|
| Number of Iterations | 10 |
| Number of Ants | 10 |
| Number of Epoch | 10 |
| Alpha rate | 0.7 |
| Beta rate | 0.7 |
| Evaporation rate | 0.7 |
| Q Concentration of pheromones | 0.5 |

**Table 4.7** Optimal ACO Parameter for B-D2

| **Parameter** | **Value** |
|---|---|
| Number of Iterations | 5 |
| Number of Ants | 100 |
| Number of Epoch | 20 |
| Alpha rate | 0.7 |
| Beta rate | 0.7 |
| Evaporation rate | 0.7 |
| Q Concentration of pheromones | 0.7 |

**Table 4.8** Optimal ACO Parameter for R2-D3

| **Parameter** | **Value** |
|---|---|
| Number of Iterations | 8 |
| Number of Ants | 10 |
| Number of Epoch | 10 |

| | |
|---|---|
| Alpha rate | 1 |
| Beta rate | 1 |
| Evaporation rate | 0.3 |
| Q Concentration of pheromones | 0.5 |

## 4.4 Prototype

A simple prototype has been developed using HTML and the Google Maps API, with a Flask framework that utilizes Python code for the Ant Colony Optimization (ACO) algorithm. This prototype allows the user to perform parameter tuning for the ACO algorithm by inputting various values, such as the number of iterations, number of artificial ants, alpha rate, evaporation rate, number of epochs, and q. By allowing the user to adjust these parameters, the prototype enables them to analyse the effects of different parameter values on the ACO algorithm's performance. This research provides a approach to optimize the ACO algorithm by incorporating a web-based interface for the user to perform parameter tuning. Figure 4.4 shows the prototype.

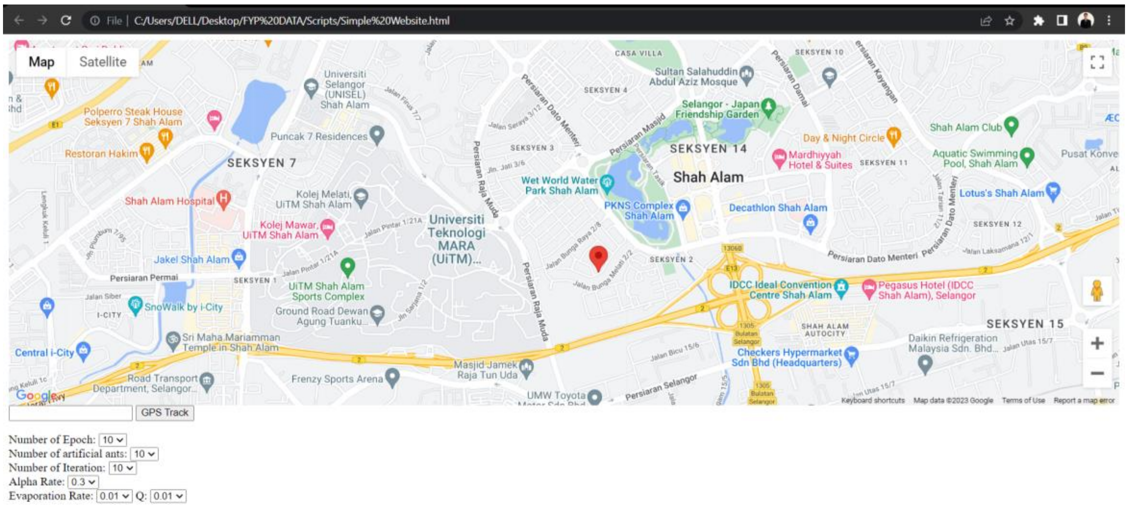


**Figure 4.4** Prototype

## 4.5 Summary

To conclude this finding, the aim of this research is to find the shortest distance between local residence and the nearest rice distributor. The best path was visualized, and the best parameter was selected by utilizing the possible route data from OpenStreetMap to test and validate the ACO algorithm to deliver the best result. A simple prototype was also created for user using the ACO model.

# CHAPTER 5

# CONCLUSION

This chapter will brief the conclusion derived and acquired in this research. background and rationale for the research. The achievement of the research objective, recommendations for future development or enhancement, the strengths and weakness of the research and finally, the summarizations of the whole research.

## 5.1 First Objective

The first objective of this research is to identify the factors that affect buyers to purchase rice that can be implement with the proposed ACO algorithm to achieve the objective function of to identify the factors affecting people to purchase rice.

This objective has been achieved in Chapter 2 and Chapter 3 which is preliminary studies and Literature Review. The factors that affect buyers to purchase rice have been collected from related articles and interviews have been made.

## 5.2 Second Objective

The second objective of this research is to develop an optimal path for residents to find the nearest food rice distributor using Ant Colony Optimization (ACO) method.

The optimal path was determined using proposed ACO algorithm from the implementation phase in Chapter 3. This objective has been achieved on the Chapter 3 which is in the development phase where we develop and Implement the ACO algorithm.

## 5.3 Project Advantages

These are the research strengths that was implemented in this research:

I. ACO parameter value such as number of ants, number of iterations, alpha rate, beta rate and evaporation rate can be adjusted.

II. Shortest path of the route can be determine using the ACO algorithm.

## 5.4 Limitation of the project

The following are the research weakness that were already used in this study:

I. The following result does not take any consideration of any road blockage or time delay.

II. Required multiple runs to have a global solution due to the stochastic characteristics of ACO.

III. The Street network created through OSMnx does not give the most detailed route.

IV. The Prototype is not user friendly.

## 5.5 Recommendation for future project

The following recommendations were made for next studies connected to this research:

I. Require more model instances to achieve a better global optima solution.

II. Integrate the ACO model with other optimization technique to have much more optimal solutions.

III. Integrate GPS function into the prototype.

IV. Integrate the rice inventory datasets to the Optimization.

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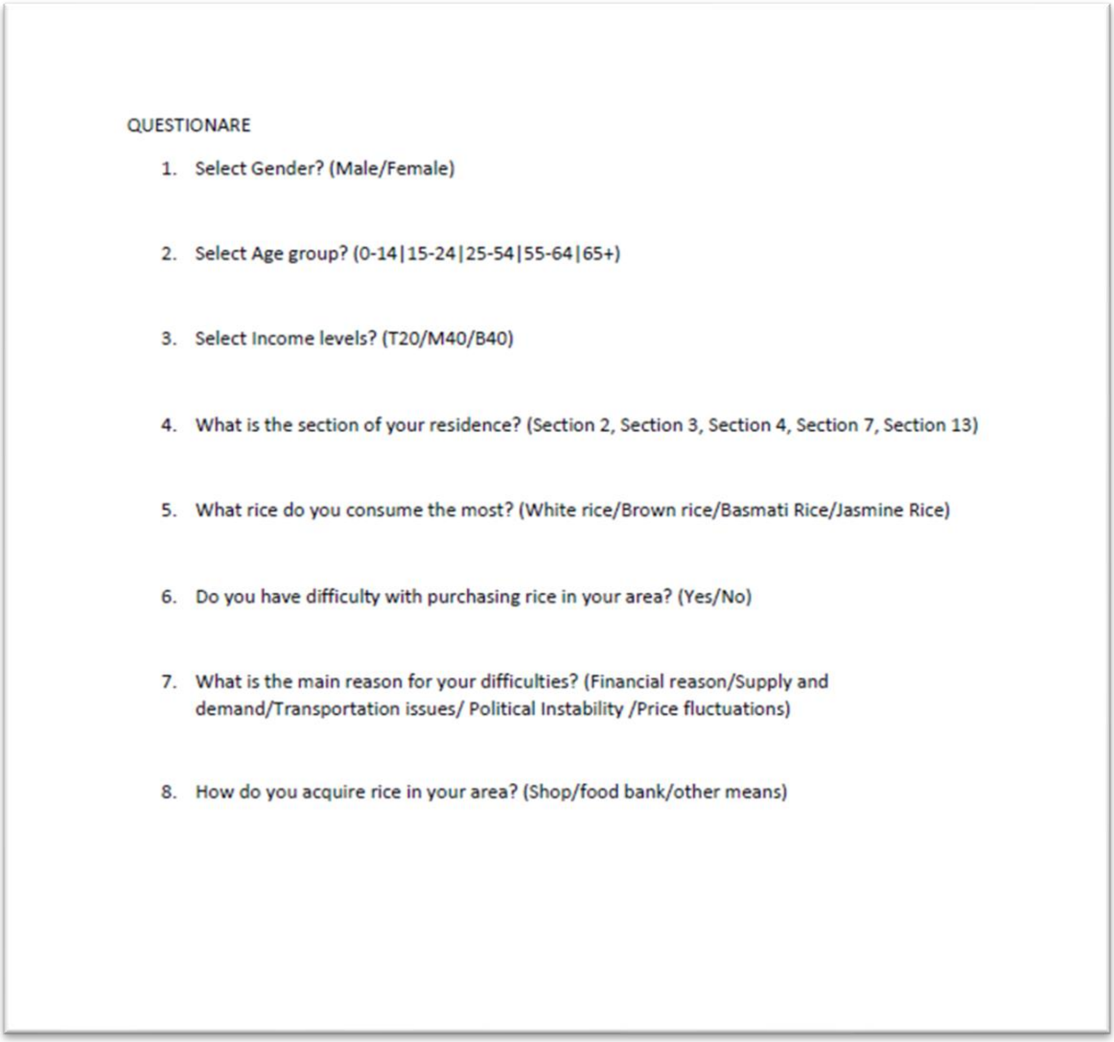
# APPENDICES

Picture of unsold rick stock in local store

(diorang send balik ke distributor)



QUESTIONARE

1. Select Gender? (Male/Female)
2. Select Age group? (0-14|15-24|25-54|55-64|65+)
3. Select Income levels? (T20/M40/B40)
4. What is the section of your residence? (Section 2, Section 3, Section 4, Section 7, Section 13)
5. What rice do you consume the most? (White rice/Brown rice/Basmati Rice/Jasmine Rice)
6. Do you have difficulty with purchasing rice in your area? (Yes/No)
7. What is the main reason for your difficulties? (Financial reason/Supply and demand/Transportation issues/ Political Instability /Price fluctuations)
8. How do you acquire rice in your area? (Shop/food bank/other means)

Questionare Questions


Picture of various package rice from local store

RESULTS PUSH 1F .XLSX

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| | Address | num_iteration | num_ants | num_epochs | alpha | beta | evaporation_rate | q | min() |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 1 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.1 | 568.797 |
| 3 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 2 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.5 | 469.225 |
| 4 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 3 | 10 | 10 | 0.3 | 0.3 | 0.1 | 0.7 | 611.568 |
| 5 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 4 | 10 | 10 | 0.3 | 0.3 | 0.1 | 1 | 563.167 |
| 6 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 5 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.1 | 469.483 |
| 7 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 6 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.5 | 129.537 |
| 8 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 7 | 10 | 10 | 0.3 | 0.3 | 0.3 | 0.7 | 205.857 |
| 9 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 8 | 10 | 10 | 0.3 | 0.3 | 0.3 | 1 | 233.403 |
| 10 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 9 | 10 | 10 | 0.3 | 0.3 | 0.7 | 0.1 | 205.857 |
| 11 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 10 | 10 | 10 | 0.3 | 0.3 | 0.7 | 0.5 | 325.713 |
| 12 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 1 | 10 | 10 | 0.3 | 0.3 | 0.7 | 0.7 | 645.497999 |
| 13 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 2 | 10 | 10 | 0.3 | 0.3 | 0.7 | 1 | 335.394 |
| 14 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 3 | 10 | 10 | 0.3 | 0.3 | 0.99 | 0.1 | 233.403 |
| 15 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 4 | 10 | 10 | 0.3 | 0.3 | 0.99 | 0.5 | 439.26 |
| 16 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 5 | 10 | 10 | 0.3 | 0.3 | 0.99 | 0.7 | 492.477 |
| 17 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 6 | 10 | 10 | 0.3 | 0.3 | 0.99 | 1 | 205.857 |
| 18 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 7 | 10 | 10 | 0.3 | 0.7 | 0.1 | 0.1 | 129.537 |
| 19 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 8 | 10 | 10 | 0.3 | 0.7 | 0.1 | 0.5 | 258.816 |
| 20 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 9 | 10 | 10 | 0.3 | 0.7 | 0.1 | 0.7 | 362.94 |
| 21 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 10 | 10 | 10 | 0.3 | 0.7 | 0.1 | 1 | 169.973 |
| 22 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 1 | 10 | 10 | 0.3 | 0.7 | 0.3 | 0.1 | 691.04 |
| 23 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 2 | 10 | 10 | 0.3 | 0.7 | 0.3 | 0.5 | 645.117 |
| 24 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 3 | 10 | 10 | 0.3 | 0.7 | 0.3 | 0.7 | 411.714 |
| 25 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 4 | 10 | 10 | 0.3 | 0.7 | 0.3 | 1 | 129.279 |
| 26 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 5 | 10 | 10 | 0.3 | 0.7 | 0.7 | 0.1 | 362.94 |
| 27 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 6 | 10 | 10 | 0.3 | 0.7 | 0.7 | 0.5 | 205.857 |
| 28 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 7 | 10 | 10 | 0.3 | 0.7 | 0.7 | 0.7 | 335.1599999 |
| 29 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 8 | 10 | 10 | 0.3 | 0.7 | 0.7 | 1 | 129.537 |
| 30 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 9 | 10 | 10 | 0.3 | 0.7 | 0.99 | 0.1 | 205.857 |
| 31 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 10 | 10 | 10 | 0.3 | 0.7 | 0.99 | 0.5 | 205.857 |
| 32 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 1 | 10 | 10 | 0.3 | 0.7 | 0.99 | 0.7 | 695.106 |
| 33 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 2 | 10 | 10 | 0.3 | 0.7 | 0.99 | 1 | 568.797 |
| 34 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 3 | 10 | 10 | 0.3 | 1 | 0.1 | 0.1 | 411.714 |
| 35 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 4 | 10 | 10 | 0.3 | 1 | 0.1 | 0.5 | 362.94 |
| 36 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 5 | 10 | 10 | 0.3 | 1 | 0.1 | 0.7 | 129.537 |
| 37 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 6 | 10 | 10 | 0.3 | 1 | 0.1 | 1 | 169.973 |
| 38 | 25, Jalan Kristal 7/72, Seksyen 7, 40000 Shah Alam, Selangor (AN HOMESTAY SHAH ALAM) | 7 | 10 | 10 | 0.3 | 1 | 0.3 | 0.1 | 335.1359999 |

Parameter Explanation | Location | RESULT R | RESULT R2 | RESULT R3

ACO Model Instances