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Graph Application in Finding the fastest Path From Subang City To Cirebon City

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Abstract - This paper discusses the application of one of the Discrete Mathematics materials, namely Graph Theory, in determining the fastest route from Subang City, more precisely from Subang Pusakanagara, Subang to Cirebon City. The fastest path is the route taken by considering the minimum travel time from one place to another. There are various ways to determine the minimum travel path, but the goal is the same, namely to find a travel path with the minimum travel time. The research process begins with formulating a problem using Graph Theory with the help of the Google Maps application and the experiences of the researchers. This Google Maps application is very useful when traveling long distances but want to use the path with minimal travel time. After formulating the problem, it is continued with the implementation of the Weighted Average Method and ends with the Floyd Warshall Algorithm. The result of this study is to find the fastest path from the starting point, namely Subang Pusakanagara to the end point, namely Cirebon City.

Keywords: The Fastest Path, Graph Theory, Weighted Average, Floyd Warshall Algorithm.

1. INTRODUCTION

In this day and age, transportation is a very important thing or a necessity that must exist and must be owned by those whose activities require transportation facilities. There are various means of transportation that are commonly used by our society. Some are in the form of private vehicles such as private/official cars or motorbikes, and some are in the form of public transportation such as Buses, Metro, City Transportation, and so on. In this paper, the author wants to discuss about a private vehicle which is definitely very

often used by the wider community, namely motorbikes, where this study requires two city objects as reference points, namely the City of Subang and Cirebon City.

The author chose this topic, because the author has experienced various difficulties when going out of town, especially Subang City using a motorcycle. First, of course we as users of transportation services want to reach our destination in the shortest possible time, according to an old proverb in Islam: *"Times is like a Sword"*. However, for writers who don't know which route is the fastest, the driver might get lost in the middle of the road or, maybe later just go around in circles without reaching the destination (the author himself has experienced getting lost due to the wrong lane). In fact, if this fastest path can be found easily, automatically more and more people will use private vehicles, especially motorbikes to travel out of town, which in the end when we find the fastest path, we indirectly contribute to many things, including decreasing carbon emissions due to the reduction in vehicles of a general nature, the reduction in the burden of fuel subsidies (not having to spend too much), etc. So, it can be seen that the need to know the fastest route that we will pass is quite urgent for private vehicle users, especially those who have no experience going out of town.

2. LITERATURE REVIEW

In a previous study in 2015 Sekar Anglila Hapsari [1] applied graphs to find the shortest path in the Global Positioning System. The techniques used include the Djikstra Algorithm to find the shortest path from one source and the Floyd-Warshall Algorithm to find the shortest path from all pairs of nodes. However, in the search for the shortest path, the author only focuses on the shortest path and does not see the direct state of the paths to be traversed.

His next research was carried out by Nicholas Rio in 2011 [2] the application of weighted graphs in determining the fastest angkot path. The author only presents data from angkot routes around ITB (Institute Technology of Bandung).

Subsequent research is still on the Fastest Path, namely research conducted in 2020 by Ningrum Citra and Wijayanti Eka [3] this research begins by formulating the problem of determining the fastest path for Mitigation of Mount Merapi Zone 1. Then the author uses a combination of the Floyd Warshall algorithm to optimize the implementation matrix of the Weighted method Average to find the fastest path from all existing starting points to the end point is Lumbungrejo by considering all possible paths formed, but with n = 7 this study takes a long time to do manual calculations and will be very long if n is larger.

Research conducted by Moch. Hannats Hanafi, Erni Yudaningtyas and M. Aziz Muslim (2012) [4] entitled Optimal Solution for Fastest Path Search with Hybrid Fuzzy-Dijkstra Algorithm. In this study, the fuzzy logic model used to model the multi-parameter path is zero-order fuzzy Sugeno and the search for the shortest path uses the Dijkstra algorithm [5].

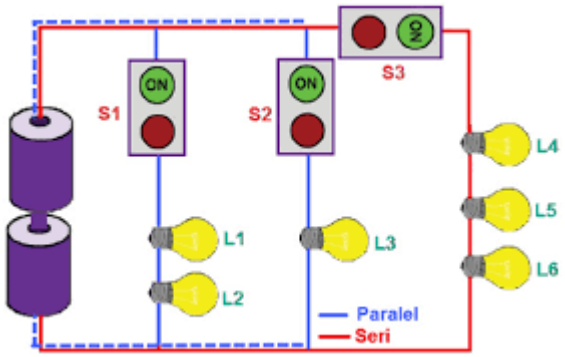
3. METHODS

Quantitative data in this study is the result of measuring the distance of the routes from the starting point of departure or Pusakanagara District to the destination or Cirebon City. The qualitative data in this study is a path map obtained from the Global Position system [6]. The research variable used in this study is the distance from each possible route that can be passed from the area or places that are along the path from Pusakanagara District to Cirebon City in the form of numbers from 1 to 27 which will be described in the results section and discussion.

The method used to solve the problem in finding the fastest path from Pusakanagara sub-district to Cirebon City is a theory related to the Discrete Structure Material, namely Graph.

a) The graph itself is a discrete structure that represents the relationship between discrete objects and describes the relationships between these discrete objects. Is depicted by a line [6]. The following are examples of graphs that we often see and do not realize that they are examples of graphs:

- Electrical Circuits



Picture 1. Electrical Circuit

- Map

Picture 2. West Java Map

- Mind Map

Picture 3. Mind map

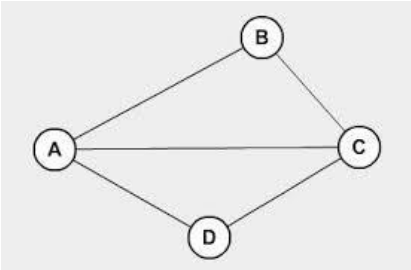
- V: Non-empty set of vertices or Nodes.

$$V = \{v_1, v_2, v_3, \dots, v_n\}$$

- E: Set of edges or Arcs connecting a pair of vertices.

$$E = \{e_1, e_2, e_3, \dots, e_n\}$$

Example:



Picture 4. Graph

The set of vertices is V = {A, B, C, D}

The sides set is E = {(A, B), (A, D), (B, C), (C, D), (A, C)}

It's can be seen from the definitions and examples above that a graph cannot have an empty vertexs set (V), but can have an empty edges set (E). There are two types of graphs based on the orientation of their edges, namely:

- A directed graph is a graph whose edges have direction orientation
- An undirected graph is that its edges have no direction orientation.

The graph theory that we will use is weighted graph theory. A weighted graph is a graph in which each edge is assigned a certain value (weight) [7]. A graph $G = (V, E)$ is called a weighted graph if each edge of graph G is assigned a non-negative number, then

it can be marked with $w(e)$ and is called the point weight *v* [8]. A weighted graph matrix can be denoted by $W = w(i,j)$ for $i,j = 0,1,\dots,n$ and with the following conditions:

$$w(i,j) = \{w(e) \quad v_i v_j \in E(G)\, 0 \quad i = j\, \infty \quad v_i v_j \notin E(G)$$

In general, the weights from point v_i to point v_j can be written as $w(i,j)$ while the weights from point v_j to point v_i can be written as $w(j,i)$. It can be concluded that the weighted directed graph matrix is not symmetrical with the weighted graph matrix or it can be written $w(i,j) \neq w(j,i)$ [9].

b) Wighted Average

Weigted Average is a method for calculating the weighted average based on the average calculations by giving the main weight to each variables value to take the average value [10]. The main weight of the variables can be marked with $w_{ap} = a_p = [a_0; a_1; \dots; a\_m]$ for $p = 0,1,\dots,m$. The results of this method can be represented in the form of a matrixs $W = w(i,j)$ for $i,j = 0,1,\dots,n$. The Weighted Average mechanism for combining numeric data from several data variables is as follows:

$$w(i,j) = \frac{\sum_{p=0}^{m} a_p . w_{ap}(i,j)}{\sum_{p=0}^{m} a_p}$$

c) Floyd Warshall's Algorithm

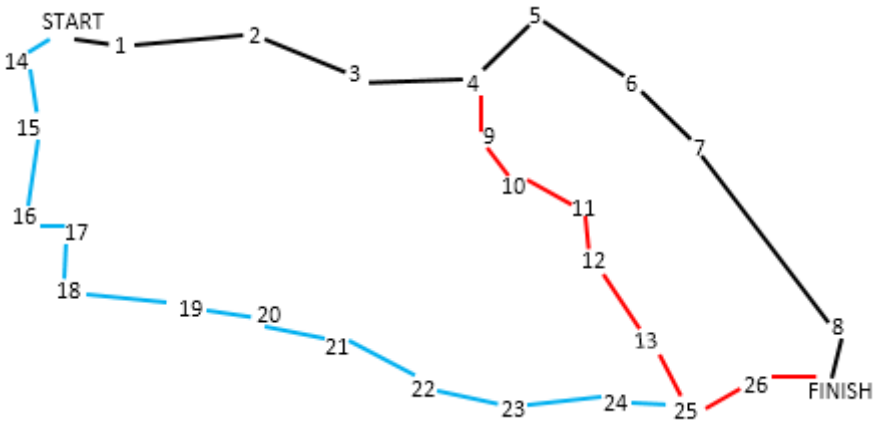
Floyd Warshall's Algorithm is a simple algorithm that can be used to determine the fastest path between all pairs of vertex element sets $V = \{v_1, v_2, v_3, \dots, v_n\}$ in a weighted graph [10]. The data used in the implementation of the Floyd Warshall Algorithm is the numeric of a graph with a positive weight. Iteration in determining the fastest path, by forming a matrixs of n according to k-iteration.

The following is the mechanism of Floyd Warsall's Algorithm in determining the fastest path:

1. The first step: For all i with $i = j$, then $w(i,j) = 0$. If $v_i v_j$ is an edge of the graph, then $w(i,j)$ is the weight of that edge, and for other than $w(i,j) \neq \infty$.
2. Second step: For $w(i,j) = \{w(i,j); w(i,k) + w(k,j)\}$ is the last solution of this method. Thus $w(i,j)$ is the shortest distance from $v_i\, ke\, v_j$. For $i,j,k = 0,1,\dots,n$ where n is the number of points.

4. RESULTS AND DISCUSSION

In this study, the researchers presented data from the routes traversed by vehicles, especially buses. This route is the route that the researchers described based on a survey



through the Google Positioning System. In this study, Cirebon City was determined as the end point and Subang City or more precisely the Pusakanagara District Area as the starting point.

Picture 5. Picture of the route from Pusakanagara District to Cirebon City

a) Description of the picture:
There are three routes from Pusakanagara District to Subang City, this route is distinguished by three different colors:
- Black line: indicates the first line, which is through the center of Indramayu City.
- Red line: indicates the second line, which this line passes through Jl. Pantura Kingdom.
- Blue line: indicates the third line, which is the path that passes through the Palimanan Toll Road

b) Description of the numbers from the picture:

Table 1. Explanation of the numbers in Picture 5

Numbers	Information
1	Sukra Market
2	Eretan Kulon Bridge
3	Losarang District
4	Lohbener District
5	Indramayu Square
6	Tirtamaya Beach
7	Karangampel District
8	Krucuk Cirebon Park
9	Sekar Wangi Restaurant
10	Bangkaloa police station
11	Kertasmaya Market

12	Bening Berkah Restaurant
13	Arjawinangun traffic light
14	Pamanukan District
15	Tambak Dahan sub-district office
16	Nacita Tugu Café
17	T-junction Jln. J. Amad Yani
18	Palimanan Subang Toll Intersection
19	Fly Over Bantar Waru (Palimanan Toll Road)
20	Rest Area Km 130 A (Palimanan Toll Road)
21	Fly Over Jln. Cijelag-Cikedung (Palimanan Toll Road)
22	Fly Over Jln. Kertajati (Palimanan Toll Road)
23	Rest Area KM 166 A (Palimanan Toll Road)
24	Bleneng Stone (Palimanan Toll Road)
25	Palimanan District
26	Plumbon Bridge

Based on the map in Figure 5 and based on Table 1. And based on a survey through the *Global Positioning System*, the following data were obtained:

Table 2. Travel Path Data

Tracks	Points	Distances (km)	Times (Minutes)
Pusakanagara District – Sukra Market	Start – 1	7,2	9
Sukra Market – Eretan Kulon Bridge	1 – 2	14	17
Eretan Kulon Bridge – Losarang District	2 – 3	15	18
Losarang District – Lohbener District	3 – 4	12	15
Lohbener District – Indramayu Plaza	4 – 5	11	19
Indramayu Plaza – Tirtamaya Beach	5 – 6	15	24
Beach Tirtamaya – Karangampel District	6 – 7	13	16
District Karangampel – Krucuk Cirebon Park	7 – 8	24	32
Krucuk Cirebon Park – Cirebon City	8 – Finish	4,3	11
District Lohbener – Sekar Wangi Restaurant	4 – 9	15	19
Sekar Wangi Restaurant – Bangkaloa police station	9 – 10	4,8	7
Bangkaloa police station – Kertasmaya Market	10 – 11	9,8	12
Kertasmaya Market – Bening Berkah Restaurant	11 – 12	4,2	6
Bening Berkah Restaurant – Arjawinangun traffic light	12 – 13	14	17
Arjawinangun traffic light – Palimanan District	13 – 25	6,7	10
Start – Pamanukan District	Start –	6,5	10

	14		
Pamanukan District – Tambak Dahan sub-district office	14 – 15	8,1	16
Tambak Dahan sub-district office – Nacita Tugu Café	15 – 16	11	17
Nacita Tugu Cafe – T-junction Jln. J. Amad Yani	16 – 17	3,4	7
T-junction Jln. J. Amad Yani – Palimanan Subang Toll Intersection	17 – 18	10	18
Palimanan Subang Toll Intersection – Fly Over Bantarwaru (Palimanan Toll)	18 – 19	18	18
Fly Over Bantarwaru (Palimanan Toll) – Rest Area km 130 A (Palimanan Toll)	19 – 20	7,1	6
Rest Area Km 130 A (Palimanan Toll) – Fly Over Jln. Cijelag-Cikedung (Palimanan Toll)	20 – 21	9	7
Fly Over Jln. Cijelag-Cikedung (Palimanan Toll) – Fly Over Jln. Kertajati (Palimanan Toll)	21 – 22	11	8
Fly Over Jln. Kertajati (Palimanan Toll) – Rest Area KM 166 A (Palimanan Toll)	22 – 23	16	13
Rest Area KM 166 A (Palimanan Toll) – The Bleneng Stone (Palimanan Toll)	23 – 24	16	12
The Bleneng Stone (Palimanan Toll) – Palimanan District	24 – 25	12	10
Palimanan District – Plumbon bridge	25 – 26	7	11
Plumbon Bridge – Ciebon City	26 – Finish	10	23

In determining the fastest route from Pusakanagara District to Cirebon City. The area traversed is represented as a point. The paths connecting one point to another are represented as edges. Numerical data variable data and travel time are represented as weights. The following is an explanation using the Weighted Average method and the Floyd Warshall algorithm:

a) Weighted Average

In applying this method to determine the main weight, the researchers set the main weight of $0{,}25$ for the distance variable (a_0) and $0{,}5$ for the time variable (a_1) and can be written as $w_{a_p} = [a_0\ ;\ a_0] = [0{,}25\ ;\ 0{,}50]$ for $p = 0{,}1$. Start is written as 0 or starting point, and Finish is written as 27 or end point.

So, the results of the overall calculation obtained are continued by using the next method, namely the Floyd Warshall Algorithm.

b) Floyd Warshal's Algorithm

In this method iteration for $k = 0$ has the same result as using the Wighted Average method, so the researcher continues iteration for $k = 1$ with $i = 0, 1, \dots, n$ with $n = 27$. The following is the result of calculating the implementation of the Floyd Warshall Algorithm for $k = 1, \dots, n$ with $i = 0, 1, \dots, n$

Based on the Weigted Average calculation, the results of the Floyd Warshall Algorithm calculation above are shown and grouped based on the color of each path, as in Figure 5. can be made into the following table:

Table 3. The results of the travel route data from Subang City - Cirebon City

Color Route	Point/path	Total Weight	Distances (km)	Times (Minutes)
Black	$0-1-2-3-4-5-6-7-8-27$	140,49	115,5	161
Black – Red	$0-1-2-3-4-9-10-11-12-13-25-26-27$	149,23	119,7	164
Blue – Red	$0-14-15-16-17-18-19-20-21-22-23-24-25-26-27$	165,64	145,1	176

The information we can take from Table 3 is as follows:

- The black color line starts from point 0 to point 27, with the path traversed is 0-1-2-3-4-5-6-7-8-27, namely Pusakanagara District - Sukra Market - Eretan Kulon Bridge - Losarang District - Lohbener District - Indramayu Square - Tirtamaya Beach - Karangampel District - Krucuk Park Cirebon - Cirebon City.
- For the black-red color path starting from point 0 to point 27, with the route traversed is 0-1-2-3-4-9-10-11-12-13-25-26-27, namely Pusakanagara District - Sukra Market – Eretan Kulon Bridge - Losarang District - Lohbener District - Sekar Wangi Restaurant - Bangkaloa Police Post - Kertasmaya Market - Bening Berkah Restaurant - Arjawinangun traffic light - Palimanan District - Plumbon Bridge - Cirebon City.
- For the blue-red line starting from point 0 to point 27, with the route traversed is 0-14-15-16-17-18-19-20-21-22-23-24-25-26-27, namely Pusakanagara District - Pamanukan District - Tambak Dahan Sub-district Office - Nacita Tugu Café - T-junction Jln. J. Ahmad Yani - Palimanan Subang Toll Intersection - Bantar Waru Fly Over (Palimanan Toll) - Km 130 A Rest Area (Palimanan Toll) - Fly Over Jln. Cijelag-Cikedung (Palimanan Toll) - Fly Over Jln. Kertajati (Palimanan Toll) - Batu Bleneng (Palimanan Toll) - Palimanan District - Plumbon Bridge - Cirebon City.

5. CONCLUSION

Based on the results of the research conducted and the results obtained based on table 3, we can conclude that the fastest path that can be taken by someone is marked with the number 0-1-2-3-4-5-6-7-8-27 where each number is named according to what has been explained, namely the path starts from Pusakanagara District - Sukra Market - Eretan Kulon Bridge - Losarang District - Lohbener District - Indramayu Square - Tirtamaya Beach - Karangampel District - Cirebon Krucuk Park - Cirebon City. In the table of research results it is clearly stated that the reason for the 0-1-2-3-4-5-6-7-8-27 route is because the distance covered is only 161 minutes, and the distance is only 115.5 km and the total weight 140.49.

Based on the conclusions described above, the Floyd Warshall algorithm can optimize the implementation matrix of the Weighted Average method to find the fastest path from all existing starting points to the end point, namely Cirebon City by considering all possible paths, but with $n = 27$. Actually, this research does not take a long time if the known n value is small, in contrast to the case if the is larger, it will take a long time to calculate it.

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