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The Application of Cruscal Algorithm in Determining the Shortest Routes Tourism in Medan

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ABSTRAK

Dengan berkembangnya kemajuan teknologi di zaman sekarang ini, penerapan ilmu dalam bidang matematika menjadi semakin luas, termasuk dalam menentukan jalur optimal pada suatu jalur dengan menggunakan graf. Seperti yang kita ketahui kota Medan dan sekitarnya merupakan salah satu kota destinasi wisata di Indonesia yang mempunyai banyak tempat – tempat yang menarik untuk dikunjungi. Wisatawan baik dalam dan luar bahkan sudah merencanakan jauh jauh hari untuk mengunjungi berbagai pusat pariwisata di kota Medan. Dengan banyaknya objek wisata yang akan dikunjungi, graf akan sangat membantu dalam menentukan jalur jalur yang memiliki jalur terpendek, jalur yang menghasilkan biaya terkecil, dan jalur yang paling optimal. Algoritma Kruskal adalah sebuah algoritma dalam teori graf yang mencari minimum spanning tree untuk sebuah graf yang berbobot dan yang terhubung. Algoritma Kruskal merupakan salah satu algoritma untuk menentukan rute terpendek dari lokasi objek wisata satu menuju objek wisata lainnya.

Kata kunci: *kruskal, graf, jalur terpendek, Objek Wisata.*

ABSTRACT

With technological advances today, the application of science in mathematics is becoming increasingly broad, including determining the optimal path on a path using a graph. As we know, the city of Medan and its surroundings is one of the tourist destinations in Indonesia, which has many interesting places to visit. Tourists inside and outside have even planned to visit various tourism centers in the city of Medan. With so many tourist objects to be visited, a graph will be very helpful in determining the paths that have the shortest path, the path that produces the least cost, and the path that is the most optimal. Kruskal's algorithm is an algorithm in graph theory that looks for the minimum spanning tree for a weighted and connected graph. Kruskal's algorithm is one of the algorithms for determining the shortest route from one tourist attraction to another.

Keywords: *kruskal, graph, shortest path, tourism object.*

A. Pendahuluan

Along with technological advances in today's era, the application of science in the field of mathematics is becoming increasingly widespread, including in determining the optimal path on a path using graphs. Graphs have a fairly broad role in their application in real life, one of which is to determine the path of a journey (Gunawan & Cahyani, 2018). Determining the cross path is an effort made to determine the path with a particular purpose; using graphs will get a path that has advantages, for example, the shortest path, the path that produces the smallest cost, and the most optimal path. In the graph, there are several basic concepts, one of which is the concept of a tree. Solving the graph with the concept of a tree to solve the problem is to build the graph into a minimum spanning tree. The minimum spanning tree is often applied to determine the most optimal path in determining the trajectory, one of which is the travel route for Tourist

Attractions in Medan City. There are several obstacles in determining the path of tourist attractions in the city of Medan. Namely, some places are not traversed or traversed twice, resulting in the travel route being less than optimal, so there is a waste of costs on the way. To create a travel route for tourist attractions in the city of Medan, it is necessary to study graph theory more deeply in determining distances and locations so that the travel path becomes more optimal. In 2019 (Annisa & Muliani, 2019) researched how to determine the optimal route in determining the minimum spanning tree. Algorithm integrated into the branch and tree framework, more robust problem formulation, combinatorial lower bound, heuristics, and adjusted branching rules show optimal time savings for the minimum multi-objective spanning tree problem that can be used with several criteria. It is based on a labeling algorithm for the multi-objective shortest path problem in the transformed network. Some restrictions are added to the path (minimal path) to obtain a one-to-one correspondence between the tree in the original network and the minimal path in the transformed path. The algorithm's accuracy is proven by presenting a brief sample problem. In the research that has been developed (Mengetahui et al., 2020), which combines genetic algorithms to determine the minimum spanning tree, a weighted graph is produced by calculating the fitness value so that the optimal solution will be eliminated by repeating iterations in gene replacement. The neighborhood vertex value is generated, which is interconnected. Based on the description above, the writer is interested in examining the application of the Kruskal algorithm in determining the optimal travel route for tourist attractions in Medan. Hence, the author chooses the thesis title, Application of the Kruskal Algorithm in Determining the Shortest Route for Tourist Attractions in Medan City and Surrounding Areas (Wahyuningsih & Syahreza, 2018).

B. Metode Penelitian

The graph is a branch of mathematics that deals with points and lines. Graph theory has broad benefits, for example, for designing networks, computers, and transportation infrastructure systems that have many applications. Graphs are used to represent discrete objects and the relationships between these objects. The visual representation of the graph states that the object is expressed as a dot, circle, or point, while A line indicates the relationship between objects (Des Welyyanti et al., 2021).

1. Graph

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2. Graph Teory

Mathematically, a graph is defined as follows, for example, Graph (G) defined as a set pair (V, E), which in this case :

V = non-empty set of points (vertices) = $\{v1, v2, \ldots, vn\}$

E = set of edges connecting a pair of points = $\{e1, e2, \ldots, en\}$ or can be written in short notation $G = (V, E)$.

The above definition states that V cannot be empty, while E can be empty. So, a graph may not have any edges, but there must be a vertex, at least one. A graph with only one vertex without an edge is called a trivial graph.

Points on a graph can be numbered by letters, such $as\ a, b, c, \ldots, v, w, \ldots$, with natural numbers 1, 2, 3, . . . , or a combination of both. Meanwhile, an edge that connects point vi to the point v j is represented by a pair (v_i, v_j) or with the symbols e_1, e_2, In other

words, if e is an edge that connects the point vi with the point v j , then e can be written as

$e = (v_i, v_j)$. Geometrically, the graph is described as a set of points (vertices) in a 2-dimensional plane connected by a set of edges (edges) (Priyono, 2021).

3. Kruskal's Algorithm

Kruskal's Algorithm was first popularized by Joseph Kruskal in 1956. Kruskal's Algorithm is an algorithm in graph theory that finds a Minimum Spanning Tree for a

weighted graph that con- nected. It means finding a subset of the edges that make up a Tree, which holds every vertex, where the total weight of all edges in the tree is minimum. Kruskal's Algorithm is an example of Greedy's Algorithm)

4. Kruskal's Algorithm Work

In this algorithm, the edges of the graph are selected one by one sequentially from the edges with the smallest weight, then connected to each other, provided that when connecting the vertices of each edge it does not form a cycle . If the number of connected edges is $n - 1$, where n is the number of points, then the connected edges will form a tree that has the smallest weight or minimum spanning tree. Formally, Kruskal's algorithm can be expressed as follows: Let G be the original graph with n vertices, T is the minimum spanning tree, E is the set of all edges of G

A. Fill T with all the dots without a line

B. m = 0

C. During m < (n − 1) do :

1. Determine the line e ∈ E with the minimum weight. If there are several e with these properties, choose one arbitrarily.

2. delete e from E

3. If e added to T does not result in a circuit, then :

i. Add e to T

ii. M = m + 1

5. Matlab Program

MATLAB is a programming language with functions and characteristics that are different from other existing programming languages such as Delphi, Basic and C++. MATLAB is a high-level programming language devoted to technical computing, visualization, and programming needs such as mathematical computing, data analysis, algorithm development, simulation, and modeling and computational graphs. MATLAB comes in different colors. MATLAB brings excellence in mathematical functions, physics, statistics, and visualization. MATLAB was developed by MathWorks and created to provide easy access to matrix data in LINPACK and EISPACK projects. Currently, MATLAB has hundreds of functions that can be used as problem solvers ranging from simple to complex problems from various disciplines (Hayu et al., 2017).

C. Hasil dan Pembahasan

Hasil dan Pembahasan: In this study, the author will look for the minimum distance to visit 10 tourist attractions in the city of Medan and its surroundings. First, we must know the points of the 10 tourist attractions under study. The data obtained are 10 tourist attractions in the city of Medan and its surroundings through secondary data from google maps. The following are the vertices of 10 tourist attractions to be studied:

Figure 1. Vertex tourist attractions in the city of Medan and its surroundings

Then the distance data between tourist attractions can be obtained which can be seen in table 1:

Table 1. Data on the distance between tourist attractions in the city of Medan and its surroundings

No	Origin	Destination	Distances(KM)	Edges
1	T Garden	Hairos	7,9	e1
2	T Garden	Kebun Binatang Simalingkar	12,5	e2
3	T Garden	The Le Hu Garden	12,7	e3
4	T Garden	Museum Sumatera Utara	19,8	e4
5	T Garden	Istana Maimun	19,8	e5
6	T Garden	Rahmat Gallery	17,5	e6
7	T Garden	Merdeka Walk	20,5	e7
8	T Garden	Maha Vihara Maitreya	34,9	e8
9	T Garden	Kebun Binatang Simalingkar	7,7	e9
10	Hairos	The Le Hu Garden	18,0	e10
11	Hairos	Merci Barn	13,7	e11
12	Hairos	Museum Sumatera Utara	15,4	e12
13	Hairos	Istana Maimun	14,9	e13
14	Hairos	Rahmat Gallery	12,7	e14
15	Hairos	Merdeka Walk	15,7	e15
16	Hairos	Maha Vihara Maitreya	31,0	e16
17	Hairos	The Le Hu Garden	12,7	e17
18	Kebun Binatang Simalingkar	Merci Barn	11,4	e18
19	Kebun Binatang Simalingkar	Museum Sumatera Utara	15,2	e19
20	Kebun Binatang Simalingkar	Istana Maimun	15,3	e20
21	Kebun Binatang Simalingkar	Rahmat Gallery	12,7	e21
22	Kebun Binatang Simalingkar	Merdeka Walk	15,7	e22
23	Kebun Binatang Simalingkar	Maha Vihara Maitreya	23,5	e23
24	Kebun Binatang Simalingkar	Merci Barn	6,4	e24
25	The Le Hu Garden	Museum Sumatera Utara	11,7	e25
26	The Le Hu Garden	Istana Maimun	12,8	e26
27	The Le Hu Garden	Rahmat Gallery	15,0	e27
28	The Le Hu Garden	Merdeka Walk	14,6	e28
29	The Le Hu Garden	Maha Vihara Maitreya	26,1	e29
30	Merci Barn	Museum Sumatera Utara	8,6	e30
31	Merci Barn	Istana Maimun	9,8	e31
32	Merci Barn	Rahmat Gallery	11,1	e32
33	Merci Barn	Merdeka Walk	14,1	e33
34	Merci Barn	Maha Vihara Maitreya	23,8	e34
35	Museum Sumatera Utara	Istana Maimun	1,8	e35
36	Museum Sumatera Utara	Rahmat Gallery	4,1	e36
37	Museum Sumatera Utara	Merdeka Walk	3,7	e37
38	Museum Sumatera Utara	Maha Vihara Maitreya	10,4	e38
39	Istana Maimun	Rahmat Gallery	4,8	e39
40	Istana Maimun	Merdeka Walk	2,9	e40
41	Istana Maimun	Maha Vihara Maitreya	10,3	e41
42	Rahmat Gallery	Merdeka Walk	3,5	e42
43	Rahmat Gallery	Maha Vihara Maitreya	11,0	e43
44	Merdeka Walk	Maha Vihara Maitreya	8,4	e44

1. Analytical using Kruskal's Algorithm

In determining the minimum spanning tree using the Kruskal algorithm, the steps are as follows: For example, T is the minimum spanning tree to be created. First, select a point as the starting point. In the table, select the side with the minimum weight or value, e_{36} with the smallest weight or value, and do not form a circuit. Then again, select the side with the minimum weight or value, namely e_{41}, e_{43}, too, e_9. The following order of the overall edges. In general, Kruskal's algorithm is written :

a. T is still empty
b. choose the side (i, j) with minimum weight
c. choose the side (i, j) with the next minimum weight that does not form a cycle in T, add (i, j) to T
d. Repeat step 3 $(n-2)$ times.
e. Total steps $(n-1)$ times

After sorting from the lowest to the highest edge, you can choose $e_{36}, e_{41}, e_{43}, e_2, e_{25}, e_{10}, e_{45}, e_{31}, e_{19}$ that meet the requirements of the Kruskal algorithm while the rest $e_{38}, e_{37}, e_{40}, e_1, e_{32}, e_{42}, e_{39}, e_{44}, e_{33}, e_{26}, e_3, e_4, , e_{15}, e_{22}, e_{18}, e_{27}, e_{12}, e_{34}, e_{29}, e_{14}, e_28, e_{20}, e_{21}, e_{13}, e_{23}, e_{16}, e_7, e_{11}, e_5, e_6, e_8, e_{24}, e_{35}, e_{30}, e_{17}$, e_9 contain cyclic. So that the results of the minimum spanning tree tree are obtained as follows:

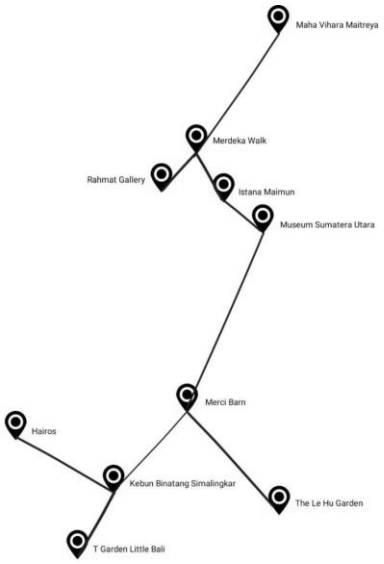

Figure 2. The results of the minimum spanning tree using the Kruskal algorithm

D. Kesimpulan dan Saran

1. Kesimpulan:

With this study, it was found that by using the Kruskal algorithm to determine the shortest route through a path with edges e_{36}, the distance between the North Sumatra Museum and Maimun Palace is 1.8 km, e_{41} the distance between Maimun Palace and Merdeka Walk is 2.9 km, e_{43} the distance between Rahmat Gallery and Merdeka Walk 3.5 km, e_2 distance between T Garden and Simalingkar Zoo 3.7 km, e_{25} distance between Merci Barn and The Le Hu Garden 6.4 km, e_{10} distance between Hairos and Simalingkar Zoo 7.7 km, e_{45} distance between Merdeka Walk and

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