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On Finding Shortest Path Over Vocational High School in Yogyakarta Based on Graph Theory Algorithm

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Abstract. Finding the shortest path is one of the problems in graph theory. This research aims to apply the Dijkstra algorithm in determining the shortest route for State Vocational School (SMK) students throughout Yogyakarta. State Vocational Schools throughout Yogyakarta have several locations spread across various regions, and determining the shortest path is crucial for students' time and transportation efficiency. Dijkstra's algorithm was chosen because of its ability to find the shortest path in a weighted graph, which can be applied to complex networks of school trajectories. The research method involved collecting geographic data on schools, available transportation, and distance between locations. This data is used to build a weighted graph representing the transportation network between State Vocational Schools throughout Yogyakarta. The implementation of Dijkstra's algorithm is then carried out using a python programming language. We hope the research results can map the shortest routes between schools, minimize student travel time, and increase transportation efficiency. The practical implications of this research include developing an information system or application that can help students, teachers, and schools plan daily trips. Apart from that, the research results can also be a basis for developing methods for determining the shortest route in the context of other schools or similar environments.

Keywords: Graph Theory, Optimization, Shortest Path, Dijkstra Algorithm, Vocational High School.

1 Introduction

The background to this research theme emerged from the practical need to increase the efficiency of the route management system in the State Vocational School environment in the city of Yogyakarta. In the context of discrete mathematics, using Dijkstra's algorithm is an effective method for finding the shortest path in a network. State Vocational Schools spread across Yogyakarta require an optimal route system to facilitate the movement of students, educators, and education staff between various facilities and locations in the school. The application of the Dijkstra algorithm will help optimize route settings by considering factors such as distance, travel time, or even the complexity of accessible roads, thereby increasing the overall operational efficiency of the school.

In addition, from a mathematical perspective, this research can be a real contribution to applying theoretical concepts to relevant practical contexts. The application of Dijkstra's algorithm not only presents an opportunity to dig deeper into the mathematical characteristics of the algorithm but also provides a concrete understanding of how mathematics can provide practical solutions to everyday problems. This algorithm was found by Edsger W. Dijkstra in 1956 [1,2,3]. Thus, the Dijkstra algorithm can be used to apply graph theory in determining the shortest route in the network of the package delivery service companies. The shortest route is generated by running the Dijkstra algorithm on the initial model graph, starting from the starting point to all other points and returning to the starting point. Therefore, this research can open opportunities to improve the understanding and application of mathematics in real-world contexts, especially in logistics and movement management in educational environments. This initial model graph is a connected weighted graph, where the weight is the mileage. We call a point in a graph a vertex. So, the starting point is the starting vertex. The shortest closed route generated from this algorithm can be either a cycle or a circuit. A cycle is a closed route that visits a vertex once. Otherwise, it is a circuit. For example, $S_1 = (2, 3, 4, 2)$ is a cycle, but $S_2 = (1, 2, 3, 4, 2, 3, 5, 1)$ is a circuit in a graph, where {1, 2, 3, 4, 5} is a vertex set of this graph [4].

Several related studies regarding the shortest route are the Fuzzy Dijkstra Algorithm [5], the Dijkstra Algorithm for the Traveling Salesman Problem [6], Finding the shortest path using a Minimum Spanning Tree with several algorithms [7, 9, 10, 11], and Logistics Distribution using Dijkstra Algorithm [8].

Finally, this research can positively impact time and resource management in State Vocational Schools throughout Yogyakarta, which in turn can improve operational efficiency and provide a better experience for school users. By combining mathematical understanding and technological applications, this research can be a model of how the discipline of mathematics can significantly contribute to overcoming practical challenges in the fields of education and school management.

2 Dijkstra Algorithm

2.1.Dijkstra Algorithm Experiment

We give the steps of the Dijkstra Algorithm below

a. Select the starting node (Node 0 / UNP student dormitory).

b. Determine the nodes that are directly connected to the initial.

c. Choose the node with the fastest travel time.

d. Make a permanent setting that connects the initial and the selected nodes in step 1.

e. Determine all nodes that are directly related to those in permanent settings.

f. Choose the node with the fastest travel time that is directly related to those on the permanent settings.

g. Repeat steps 4, 5 and 6 until the final node (Node T / UNP Library) is incorporated in the permanent settings.

2.2 Dijkstra Algorithm Pseudocode

To make calculations more accessible, we use software tools to find the shortest route using the Dijkstra algorithm [13].

```
function Dijkstra(Graph, source):
    for each vertex v in graph.Vertices:
        dist[v] ← INFINITY
        prev[v] ← UNDEFINED
        add v to Q
    dist[source] ← 0
    while Q is not empty:
      u ← vertex in Q with min dist[u]
      remove u from Q
      for each neighbor v of u still in Q:
          alt ← dist[u] + Graph.Edges(u, v)
```

```
        if alt < dist[v]:
            dist[v] ← alt
            prev[v] ← u
    return dist[], prev[]
```

3 Research Methods

The flow of research methodology can be described as follows. First, collecting of customer location/address data. Then, location data is processed into distance data from one location to another. Second, this data is constructed as an initial model, i.e., a connected weighted graph. Third, run the Dijkstra algorithm on this graph to obtain the shortest route. This shortest route should visit all schools and return to the first schools. Thus, this route is a subgraph of the initial model graph.

The steps for creating a Djikstra Algorithm table are as follows:

1. Create a table with columns as values or distance from nodes while rows are node positions.

2. Select the starting and destination nodes (the condition is that they must be directly connected).

3. Calculate the value or distance of several selected destination nodes.

4. Choose the smallest value or distance if all nodes have been tested.

5. The selected node becomes the reference node for the next stage.

6. Continue repeating from No.2 until all nodes have been tested or the destination node has found the shortest distance or value.

The initial model graph is obtained from the distance map between vocational schools in Yogyakarta based on the Google Maps application [12]. We give the map below.

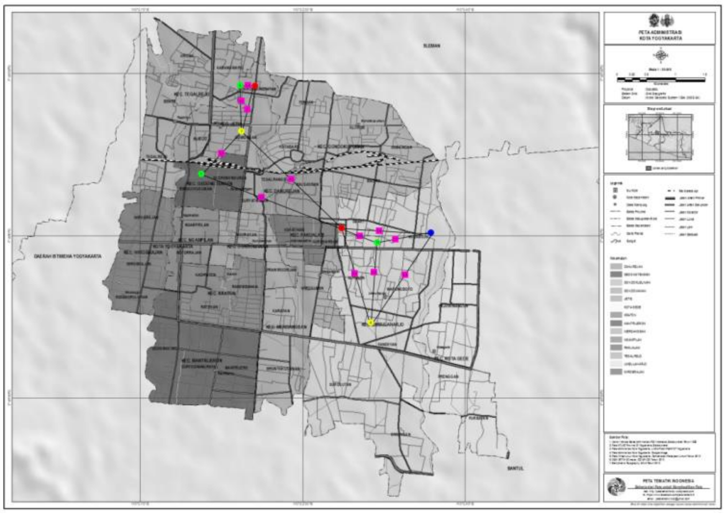

Figure 1. Maps of Vocational Highschool in Yogyakarta

Thus, the initial model graph of this algorithm is a connected weighted graph, namely D given below.

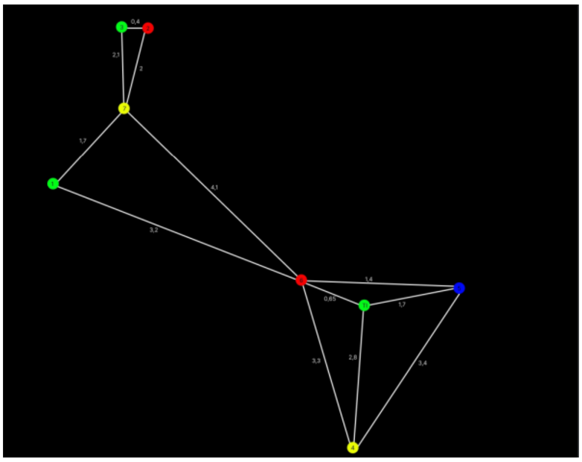

Figure 2. The initial model graph D

4 Results and Discussions

The results of the discussions are associated with the Network Map over Vocational High School in Yogyakarta. Then, we obtained the shortest path using the Dijkstra algorithm, shown in Table 1.

Table 1. Implementation Dijkstra Algorithm

W(u.v)	A	B	C	D	E	F	G	H
A	0*	∞	∞	∞	∞	3.2	1.7	∞
G	0*	3.7	3.8	∞	∞	3.2	1.7*	∞
F	0*	3.7	3.8	6.5	4.6	3.2*	1.7*	3.85
B	0*	3.7*	3.8	6.5	4.6	3.2*	1.7*	3.85
C	0*	3.7*	3.8*	6.5	4.6	3.2*	1.7*	3.85
H	0*	3.7*	3.8*	6.5	4.6	3.2*	1.7*	3.85*
E	0*	3.7*	3.8*	6.5	4.6*	3.2*	1.7*	3.85*
D	0*	3.7*	3.8*	6.5*	4.6*	3.2*	1.7*	3.85*

Table 2. Detail Route of Graph D

Initial Point – End Point	Route	Total Distance
A – A		0
A – B	A-G-B	3.7
A – C	A-G-C	3.8
A – D	A-F-D	6.5
A – E	A-F-E	4.6
A – F	A-F	3.2
A - G	A-G	1.7
A - H	A-F-H	3.85

Information:

A: SMK N 1 Yogyakarta

B : SMK N 2 Yogyakarta

C : SMK N 3 Yogyakarta

D : SMK N 4 Yogyakarta

E : SMK N 5 Yogyakarta

F : SMK N 6 Yogyakarta

G : SMK N 7 Yogyakarta

H : SMK N Teknologi Industri Yogyakarta

Table 1 shows the weight of every vertex to the others, and the shortest path from SMK N 1 Yogyakarta to other Vocational Schools is between 1,7 kilometers and 6,5 kilometers, with detail given in Table 2. Table 2 shows that all possible routes from point A to other points include the distance needed to reach them. So, we can conclude how to reach them effectively from point A.

4 Conclusions

According to Table 2, 7 alternative routes were obtained using the Dijkstra algorithm; the total distance is shown in Tables 1 and 2. Therefore, based on the findings, it is concluded that the travel distance from SMK N 1 Yogyakarta to SMTI Yogyakarta is 0,05 km shorter than that from Google Maps. So, we can get a model of how the discipline of mathematics can significantly contribute to overcoming practical challenges in education and school management.

References

[1] Aram M Ahmed, S.H. Ahmed, and Omed Hasan, "Dijkstra Algorithm Applied: Design and Implementation of a Framework to Find Nearest Hotels and Booking Systems in Iraqi", in *International Conference on Current Research in Computer Science and Information Technology (ICCIT)*, IEEE, 2017, pp. 126-32.

[2] R. Bellman, "On a routing problem", in *Tech report, DTIC Doc*,1956.

[3] R. W. Floyd, "Algorithm 97: shortest path", *Commun. ACM*, vol. 5, pp. 345., 1962.

[4] G. Chartrand, L.Lesniak, and P.Zhang. *Graphs & Digraphs. Textbook in Mathematics*, CRC Press, Boca Raton, FL, 2016.

[5] Y. Deng, Y.Chen, Y. Zhang, and S. Mahadevan, "Fuzzy Dijkstra Algorithm for Shortest Path Problem under Uncertain Environment", *Apllied Soft Computing* 12(3), pp. 1231-37, 2012

[6] H. N. Ginting, A.B. Osmond, and A. Aditsania, "Item Delivery Simulation Using Dijkstra Algorithm for Solving Traveling Salsman Problem", in *Journal of Physics: Conference Series*,IOP Publishing, 12608, 2019.

[7] A. Lusiani, E. Sartika, E. Habinudin, et al., “Algoritma Prim Dalam Penentuan Lintasan Terpendek Lintasan Terpendek Dan Lintasan Tercepat Pada Pendistribusian Logistik Bulog Jawa Barat”, in *Prosiding Industrial Research Workshop and National Seminar*, pp. 673-77, 2021.

[8] A. Lusiani, E. Sartika, A.Binarto, et al., "Determination of the Fastest Path on Logistics Distribution by Using Dijkstra Algorithm", in *2nd International Seminar of Science and Applied Technology (ISSAT 2021)*,Atlantis Press, pp. 246-50, 2021.

[9] N. A. Sudibyo, T. Purwanto, and D. Rahmadi, “Minimum Spanning Tree pada Distribusi Bahan Naskah USBN SD/MI di Kabupaten Sragen”, in *Riemann: Research of Mathematics and Mathematcs Education*, pp. 64, 2020

[10] D. Rahmadi and H. Sandariria, “Penerapan Minimum Spanning Tree dalam Menentukan Rute Terpendek Distribusi Naskah Soal USBN di SMA Negeri se-Sleman”, in *Basis: Jurnal Ilmiah Matematika*, pp. 66., 2023.

[11] W. F. Albar, D. Rahmadi, and K. R. Dewi, "The Implementation of Minimum Spanning Tree in Finding Algebraically the Shortest Path of National-Exam-Sheet Distribution in All Senior High Schools over Bantul Regency", in *Basis: Jurnal Ilmiah Matematika*, pp. 78, 2023.

[12] Google, "Google Map", 2022.

[13] https://www.freecodecamp.org/news/dijkstras-algorithm-explained-with-a-pseudocode-example/