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THE USE OF HILL CLIMBING ALGORITHM IN GRAPHIC INFORMATION SYSTEM TO FIND THE SHORTEST ROUTE FOR WASTE TRANSPORTATION IN MEDAN DENAI DISTRICT

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ABSTRACT

Factors causing environmental damage/disaster include internal and external damage. By maximizing the transportation system, we are able to address the social issues optimally so that we provide more positive impacts on public health, environmental health, and urban beauty. Factors related to distribution can make decisions about the routes of transportation. The purpose of this research is to optimize the route of truck transportation using the Hill Climbing Algorithm in the District of Medan Denai from one point to another towards the construction site of the Sentairai. Based on the results of this study, it shows that the route of truck transport to the top with a graphical information system using Ailgorithm Hill Climbing, the route of truck transport to the top with a graphical information system using Ailgorithm Hill Climbing in the District of Medan Aireai with the shortest route for transport to the top is through a route with a total distance of 32.25 km with a travel time of 85 minutess and a total time of 8 hours 20 minutess, namely through: Start Point (Kantor Camat Medan Area) - Pandau Hulu II Village - Kotamatsum II Village - Pasar Merah Timur Village - Kotamatsum III Village - Tegal Sari III Sub-district – Tegal Sari I Sub-district – Sei Rengas Permata Sub-district – Tegal Sari II Sub-district – Sei Rengas II Sub-district – Sukaramai II Sub-district – Sukaramai I Sub-district – Kotamatsum I Sub-district and TPA.

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1. INTRODUCTION

Environmental degradation is a major challenge at this time. This challenge is especially relevant in developing countries, due to various activities aimed at improving community welfare that have an impact on environmental changes (Huda et al., 2023). If development activities are not accompanied by proper and effective environmental management, it will result in environmental damage and harm to the community (Nugraha et al., 2021; Riyanto, 2023).

The increase in waste generation is a consequence of the improvement in quality and changes in the lifestyle of the community (Mustamin Rahim, 2021). The distribution of waste is an important part of the distribution of goods or services carried out by government agencies or certain companies (Malikhah et al., 2024). To address this issue, the role of the government is crucial, supported by the concern of the local city community (Nur Kasanah, 2021). Handling this issue requires consideration of several affected aspects, including cost efficiency. One of the waste management subsystems is waste transportation. In this case, by optimizing the waste transportation system, it is expected to address waste management issues effectively, thereby providing a more positive impact on public health, environmental health, and the beauty of the city. The transfer of waste from the source to the Final Disposal Site (TPA) is certainly carried out with various transportation facilities adjusted to the needs and infrastructure of an area.The problem of waste distribution involves several key considerations, including vehicle routes, vehicle capacity, and minimizing distribution costs so that the service area for waste collection can be expanded with a limited fleet. Issues related to waste distribution include making decisions about waste collection routes. The selection of vehicle routes will determine the total travel distance of the fleet. The characteristics of the problem of determining waste collection routes are that there is a depot where the vehicles depart and return, each consumer is served exactly once in a route, and the capacity transported in each route does not exceed the maximum capacity of the collection vehicle. Thus, the optimal route is the one that meets the characteristics of the problem of determining waste collection routes.

The Simple Hill Climbing Search algorithm is a method for determining nodes that have been assigned distances between nodes by comparing existing nodes based on the selection of the nearest distance from the current position. Searching is often used for climbing searches, which are part of the testing that uses heuristic functions. Common problems encountered include miscalculations in distance measurement, resulting in long travel distances, high costs, and very long times. To solve this case, it can be addressed by creating a graph structure by looking at the city's points from both sides of the route that will be traversed. By using algorithms, it can help simplify finding locations and save time and travel expenses.To find the shortest distance, various methods can be applied. One such method is the heuristic search approach, specifically the Hill Climbing method, which uses a heuristic function for testing. The problem commonly encountered is finding the shortest path to solve the geographic problem, which can be transformed into a graph structure, where points represent cities and edges represent the paths connecting two cities (Syakina & Nurdiati, 2021). With that logic, it is possible to find the destination location and save travel costs. This algorithm's benefit is that it will find and analyze all possible solutions from the left side, yielding the best one. In the application of the Hill Climbing method, geographic information systems are used as a decision-making aid by collecting, examining, and analyzing information related to digital maps. With the combination of the Hill Climbing method and geographic information systems, an application can be produced to solve the problem of finding the shortest path (Rully Rumaida et al., 2024).

2. RESEARCH METHOD

The research method used is quantitative research (Rijal Fadli, 2021). The quantitative research method is defined as part of a series of systematic investigations into phenomena by collecting data to be measured using mathematical or computational statistical techniques (Siregar, 2021). The data sources in this research are primary data obtained through direct observations and interviews.

Interviews are data collection methods that involve asking questions directly. Interviews are conducted to complement research data that are not found in the relevant official documents (Lince Leny, 2022). Amrozy Muharamin et al., 2022, conducted direct observation by following the waste collection process in the field. Secondary data is taken from the Medan Denai District, the Central Bureau of Statistics of Medan City, and the Parks and Sanitation Office of Medan City.

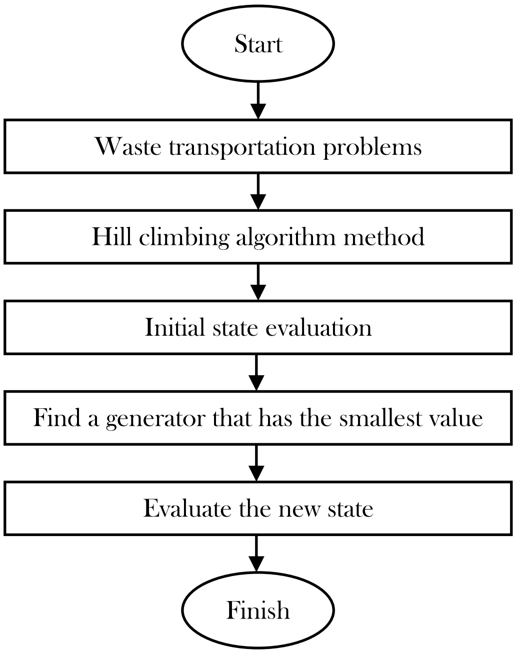

Figure 1. Research framework

3. RESULT AND ANALYSIS

The waste collection in Medan Denai District has been handed over by the Medan City Cleanliness and Parks Office to Medan Area District. Officers dispatched from the sub-district carry out waste collection, using waste collection trucks. Waste collection is carried out for 12 villages in the Area District, starting from the closest distance to the Medan Area Sub-district Office to the Terjun Paya Pasir landfill. Table 1 displays the distance between the sub-districts and the sub-district office.

Table 1. Distance from the Medan Denai Subdistrict Office to the Village

Number	Subdistrict	Distance Traveled	Time
1.	Kotamatsum I	350 m	2 minutes
2.	Sukaramai I	550 m	2 minutes
3.	Kotamatsum II	1 km	4 minutes
4.	Kotamatsum IV	1 km	4 minutes
5.	Tegal Sari I	1,1 km	4 minutes
6.	Sukaramai II	1,3 km	4 minutes
7.	Sei Rengas Permata	1,4 km	5 minutes
8.	Tegal Sari III	1,5 km	6 minutes
9.	Pandau Hulu II	1,5 km	6 minutes
10.	Pasar Merah Timur	1,5 km	6 minutes
11.	Tegal Sari II	1,7 km	8 minutes
12.	Sei Rengas II	2,4 km	10 minutes

Based on Table 1, the sub-district that is closest to the Medan Area Sub-district Office is Kotamatsum I Sub-district, which is 350 m away with a travel time of 2 minutes, and the sub-district that is furthest away is Medan Area Sub-district with a travel time of 2.4 km and a travel time of 10 minutes.

a. Implementation of the Hill-climbing Algorithm

Using the hill climbing algorithm in a graphic information system helps find the shortest route for waste transportation, resulting in the shortest path that includes details about waste transport, and it involves 12 sub-districts in the Medan Area District.

Table 2. Track Distance from Nearest to Farthest

Number	Waste Transportation Route	Distance Traveled	Travel Time	Visiting Hours
1.	Start poin – Kotamatsum I	350 m	2 minutes	30 minutes
2.	Kotamatsum I – Kotamatsum II	1 km	3 minutes	30 minutes
3.	Kotamatsum II – Pasar Merah Timur	1 km	3 minutes	30 minutes
4.	Pasar Merah Timur –Kotamatsum IV	2,3 km	7 minutes	30 minutes
5.	Kotamatsum IV –Tegal Sari III	3 km	7 minutes	30 minutes
...	...	...	...	...
13.	Pandau Hulu II – TPA Terjun Paya Sari, Marelan	24 km	47 minutes	45 minutes
	Total	41,95 km	105 minutes	405 minutes
	Total Travel Time			8 hours 30 minutes

The results above show that the waste collection routes go from the closest to the farthest. The information obtained includes the distance and travel time from one location to another. In addition, it can estimate that the visit time for each sub-district is 30 minutes, resulting in a total travel distance of 41.95 km. The travel time to pass through 12 sub-districts takes 105 minutes with a visit time of 405 minutes or 6 hours and 45 minutes, resulting in a total travel time of 8 hours and 30 minutes for the entire waste collection location in one day's journey. The route from the starting point to the last sub-district is shown in Figure 2.

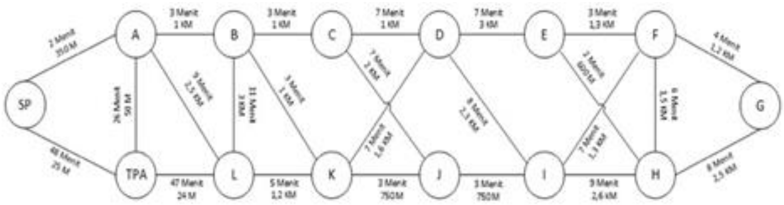

Figure 2. Start Point Route and Distance Between Villages Based on Graphic Information System

b. Determining Combinations to Find the Generator Value with the Lowest Value

Before determining the shortest route, the focus of this research is also on examining the points to be visited by selecting several sub-districts where the waste will be collected, considering the distance and time required. To find the shortest route, manual calculations are needed to determine how many points will be used to compare each route using the concept of the hill climbing method, and the results are as follows:

$$ {}_nC_r = \frac{n!}{r!\,(n-r)!} = \frac{12!}{2!\,(12-2)!} = \frac{12!}{2!\,10!} = 66 $$

66 combinations were obtained to find the shortest route, and all 66 combinations will be used. Next, route exchanges will be performed up to 66 times to determine a new route, which will be compared to each route that has the shortest path. After obtaining the new route, the distance of each route is then determined to find the shortest distance using the Hill Climbing Algorithm test based on the distances between the sub-districts in Figure 2. Manual calculations are used to determine the distance of each route that can be traversed by the predetermined initial path. The results of the calculations can be written in Table 3.

Table 3. Manual Testing of 66 Points Using the Hill Climbing Algorithm Method

Number	New Route	Distance Traveled (km)
1.	B-A-C-D-E-F-G-H-I-J-K-L	Disconnected from the original path
2.	C-B-A-D-E-F-G-H-I-J-K-L	Disconnected from the original path
3.	D-B-C-A-E-F-G-H-I-J-K-L	Disconnected from the original path
4.	E-B-C-D-A-F-G-H-I-J-K-L	Disconnected from the original path
5.	F-B-C-D-E-A-G-H-I-J-K-L	Disconnected from the original path
6.	G-B-C-D-E-F-A-H-I-J-K-L	Disconnected from the original path
7.	H-B-C-D-E-F-G-A-I-J-K-L	40,5km (106 minutes)
8.	I-B-C-D-E-F-G-H-A-J-K-L	46,6km (121 minutes)
9.	J-B-C-D-E-F-G-H-I-A-K-L	44,45km (113 minutes)
10.	K-B-C-D-E-F-G-H-I-J-A-L	44,50km (110minutes)
...	...	...
66.	A-B-C-D-E-F-G-H-I-J-L-K	Disconnected from the original path

Based on Table 3, the route with the shortest distance is L-B-C-D-E-F-G-H-I-J-K-A. If calculated from the start point to the TPA, the route is SP-L-B-C-D-E-F-G-H-I-J-K-A-TPA (Start Point - Medan Area Sub-District Office – Pandau Hulu II Village – Kotamatsum II Village – Pasar Merah Timur Village – Kotamatsum III Village – Tegal Sari III Village – Tegal Sari I Village – Sei Rengas Permata Village – Tegal Sari II Village – Sei Rengas II Village – Sukaramai II Village – Sukaramai I Village – Kotamatsum I Village – TPA) with a distance of 32.25 km and a time of 85 minutes.

4. CONCLUSION

Based on the research conducted, the route for transporting garbage trucks with a graphic information system using the Hill Climbing Algorithm in the Medan Area District from one point to another towards the temporary waste disposal site, the shortest route that can be used for waste transportation is through the route L-B-C-D-E-F-G-H-I-J-K-A. If calculated from the start point to the temporary waste disposal site (TPA), the route is SP-L-B-C-D-E-F-G-H-I-J-K-A-TPA with a total distance of 32.25 km and a travel time of 85 minutes, making the total time 8 hours and 20 minutes, which includes: Start Point (Medan Area Sub-District Office) – Pandau Hulu II Village – Kotamatsum II Village – Pasar Merah Timur Village – Kotamatsum III Village – Tegal Sari III Village – Tegal Sari I Village – Sei Rengas Permata Village – Tegal Sari II Village – Sei Rengas II Village – Sukaramai II Village – Sukaramai I Village – Kotamatsum I Village and TPA.

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