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Regular Research Article

Determination of the Shortest Route for the Efficiency of Aplousing Maintenance of Shipping Navigation Aids (SBNP)

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Abstract: This study aims to optimize shipping routes in the aplousing activity of Shipping Navigation Aids (SBNP) maintenance by applying the djikstra algorithm to improve operational efficiency. The research model uses a weighted graph approach where each strategic location such as ports and islands is represented as a node, while the distance between nodes as a trajectory is calculated using the haversine formula based on geographical coordinates. The djikstra algorithm is then implemented to determine the shortest trajectory that connects all the predetermined nodes. The results of the study showed a significant increase in route efficiency with the total sailing distance reduced from 1,210.30 km of manual routes to 1,110.44 km after optimization, or a saving of 99.86 km (8.25 km). This distance saving has direct implications for the reduction of shipping time, fuel consumption and exhaust gas emissions (CO_2 and SO_x). The application of the djikstra algorithm has been proven to provide real benefits in the context of maritime shipping, especially in supporting energy efficiency and sustainability of the marine environment. The results of this study are in line with the International Maritime Organization (IMO) policy through the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plant (SEEMPP). Thus, algorithm-based route optimization can be an effective decision-making tool for maritime authorities and operators in realizing an efficient, safe and sustainable sea transportation system.

Keywords: Efficiency; Ship Routes; Cruise; Djikstra algorithm; Route optimization.

1. Introduction

The Tanjung Perak Class I Type a Navigation District Pier is known as the Mirah Navigation Pier which is a strategic facility managed by the Ministry of Transportation through the Tanjung Perak Class I Type a Navigation District in Surabaya. This pier is about 120 meters and is located on Jalan Intan No. 1A, Surabaya. This facility is designed to serve ships owned by the Navigation District as well as ships owned by other agencies operating in the Tanjung Perak Port area. This pier has the main function, which includes planning, providing, operating, maintaining and supervising shipping navigation facilities, including the management of state ships and docks. In addition, the district is also responsible for the supervision of shipping flows and shipping telecommunications in its working areas.

This pier plays an important role in supporting operational activities on state ships and related agencies in the Tanjung Perak Port area and is part of efforts to improve shipping safety and efficiency in the pier area. One of the challenges that state ships often face is efforts

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to maintain fuel efficiency and shipping time and reduce environmental pollution in all conditions such as extreme weather and erratic sea conditions that always occur. Bad weather such as high waves, strong winds, and heavy rain can affect and slow down the ship's journey, forcing a change of route or even causing the ship to stop sailing temporarily. This has a direct impact on increased fuel consumption, longer travel times, and increased exhaust emissions into the environment.

Mutation Colony Optimization has been successfully implemented to find the shortest effective route thereby reducing mileage and improving operational efficiency [1]. Optimization of maritime navigation systems is important to improve fuel efficiency, travel time and environmental impact control. Big data analytics also play a role in identifying efficient routes to minimize fuel consumption without sacrificing operational effectiveness [2]. In a maritime context, technologies such as lighthouses aid navigation, but their reliability depends on effective management and regular maintenance. The challenges faced include limited trained personnel and a monitoring system that is not optimal [3]. Therefore, an effective risk management strategy through the application of advanced technology and collaboration between maritime authorities and a strong safety culture is an important factor in improving the safety and operational efficiency of the shipping industry [4].

In this situation, state ships need to implement careful navigation strategies, utilize accurate weather forecast technology and optimize fuel management systems. Synergy with the Navigation District and related agencies is essential to ensure shipping safety and support the preservation of the marine environment. It is proven to be able to improve route planning and travel efficiency. This algorithm is also known to be effective in determining the shortest path between nodes which have been adapted in various studies to optimize travel routes and improve operational efficiency [5].

The Dijkstra algorithm proposed by Edsger Dijkstra in 1959 was designed to find the shortest path between two vertices in a weighted graph [6]. The application of the dijkstra algorithm has been proven to provide effective performance in Geographic Information Systems with a user acceptance success rate of 81.44% [7]. In this problem, the weight of the graph represents the distance or cost of travel between points [8]. The concept of graphs in dynamic systems includes a variety of representations of cross-state behavior including trajectory graphs and Mouse graphs, each of which describes the structure of relationships between nodes in the system [9]. Logistic maps are one example of the application of graphs that show the direct relationship between nodes without cycles to represent the qualitative behavior of the system [10].

The Dijkstra algorithm can identify the shortest path by systematically comparing the smallest weights of the starting node to all the other nodes in the graph until the optimal path to the destination node is obtained [11]. This algorithm maintains two sets: one for nodes that are already included in the shortest path tree and nodes that are not included. Randomly selects nodes with minimum distance from source [12]. Based on the results of the study [13] The dijkstra algorithm can be applied to search for transportation costs based on the shortest route in Central Lombok Regency. The results show that the route with the shortest distance is not always identical to the cheapest cost such as the difference between the Lombok International Airport-Pantai Selong Belanak route (23 km, Rp. 54,000) and the Bukit Merese route (22.5 km, Rp. 77,000).

This algorithm has proven to be effective in a variety of scenarios that require high time efficiency such as freight forwarding and location search [14]. This research [15] shows that the application of the djikstra algorithm in determining the shortest route in the campus environment can increase operational efficiency with the result of the optimal route between the Faculty of Engineering (FT) and the Faculty of Education (FIP) as far as 1,400 meters. The djikstra algorithm has been widely used in land transportation networks and general routing applications due to its ability to determine the optimal path based on minimum distances.

This research offers novelty value through the application of the djikstra algorithm in the context of mileage optimization in the maritime transportation sector as an effort to improve energy efficiency and reduce exhaust gases. In contrast to previous research that focused on the terrestrial context and theoretical syllation. This research emphasizes the integration of the djikstra algorithm with the principles of maritime energy sustainability to support the implementation of International Maritime Organization (IMO) policies, especially the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP).

This approach shows that route optimization not only impacts fuel savings but also directly reduces CO_2 and SO_x generated from shipping activities. Thus, this research strengthens the practical relevance of the djikstra algorithm to global sustainability issues and contributes significantly to the achievement of the Sustainable Development Goals (SDGs) in sustainable marine transportation midwives. In addition, the application of this method in the context of critical activities such as the maintenance of Shipping Navigation Assistance Facilities (SBNP) is a concrete form of innovation that connects technical efficiency with integrated maritime sustainability policies.

2. Materials and Methods

2.1 Research Approach

This research uses an applied approach, and several literature studies aim to provide practical solutions in real-world problems [16]. Applied research builds on basic research findings with the choice of approach depending on the characteristics of the data, the research perspective and the objectives [17]. Literature studies are also conducted to gather relevant information from a variety of sources and can be used to explore new solutions and approaches [18].

2.2 Research Location

The location of the research is focused on the Tanjung Perak Port Pier, which is one of the strategic nodes in supporting the operations of state ships and related agencies. This dock was chosen because it has an important role in shipping efficiency, navigation safety and fuel management in various weather conditions.

2.3 Research Data

The research data used in this study consisted of: Primary data in the form of geographical coordinates (latitude and longitude) of shipping route node points connected to the maintenance aplousing activities of Shipping Navigation Assistance Facilities (SBNP). Secondary data in the form of literature from several previous studies related to the djikstra algorithm in the transportation system and its application in the tourism and maritime sectors.

2.4 Route Planning Model

The route planning model in this study is represented as a weighted graph where each node represents a strategic coordinate point, and each side shows the trajectory between points. The weight on each side is determined based on the geodesic distance between the two vertices calculated using the Haversine formula. The haversine formula is used to calculate the distance between points on the earth's surface using geographical coordinates in the form of latitude and longitude as input variables. This formula is one of the important equations in the field of navigation because it can give an estimate of the shortest trajectory distance between two points above the surface of the globe. [19]. Assuming that the earth is perfectly spherical with a radius of R=6.371 km, the distance between two points can be calculated using the following haversine equation [20]:

$$d = 2r * arcsin\left(\sqrt{\left(sin^{2\left(\frac{\Delta\varphi}{2}\right)} + \cos(\varphi_1)\cdot\cos(\varphi_2)\cdot sin^{2\left(\frac{\Delta\lambda}{2}\right)}\right)}\right) \quad (1)$$

In the distance calculation between two points on Earth, the Earth's radius $r$is taken as approximately 6,371 km. The coordinates of the two locations are expressed as latitude $\phi_1$and

ϕ_2, and longitude $\lambda_1$and λ_2, all converted into radians. The difference in latitude is defined as $\Delta\phi = \phi_1 - \phi_2$, and the difference in longitude is defined as $\Delta\lambda = \lambda_1 - \lambda_2$. These angular differences are then used to compute the geodesic distance between the two points.

The weight of the haversine calculation is the main input in the djikstra algorithm to determine the shortest trajectory of the node level. Thus, this approach focuses on geometric optimization, which is minimizing the total distance traveled based on geographical coordinates without considering non-geometric factors.in the developed model, route boundaries such as into waters (ship drafts) and limited navigation zones have not been explicitly considered in the process of calculating distances and determining trajectories. This model operates on the assumption that each path between nodes can be traversed without physical or regulatory barriers. This approach focuses research on proving the effectiveness of the djikstra algorithm in the context of determining the shortest distance mathematically on the earth's surface. However, these limitations have been identified as space for further research development

The integration of external factors such as shallow water conditions, ocean currents, waves and limited navigation zones is proposed as the direction of the next model development through the application of adaptive weighting factors. This integration is expected to produce a more realistic route planning model for maritime operational conditions and support safe, energy-efficient and sustainable shipping efficiency. In its application, this research utilizes several main instruments, including digital maps for mapping nodes and shipping lanes and gogle colab as a tool for computing to run distance calculation algorithms and route determination. The combination of the two tools allows integration between computational and spatial visualization aspects to support the process of analysis and planning of shipping routes efficiently. This research method is then carried out with several systematic stages described in the figure below.

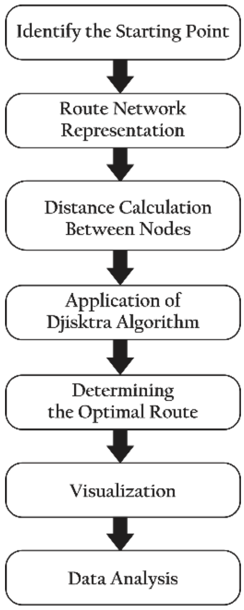

Figure 1. Research Method

2.5 Application of the Djikstra Algorithm

The determination of the optimal trajectory is performed using the Dijkstra algorithm, which is designed to identify the shortest path between a source node and other nodes in a positively weighted graph. The process begins with system initialization and graph preparation, where all vertices are assigned an initial distance value of infinity, except for the starting node (B1), which is set to zero to indicate a known reference point. The algorithm then iteratively evaluates neighboring nodes of the active node and updates their distance values if a newly identified path yields a smaller cumulative distance than previously recorded. Nodes that have been visited are marked and excluded from further evaluation. From the remaining unvisited nodes, the one with the minimum temporary distance is selected as the next active node. This procedure continues until all nodes have been evaluated. Finally, once the minimum distance values are established, the optimal path is reconstructed by tracing back from the destination node to the initial node, resulting in the shortest trajectory based on cumulative edge weights. The algorithm terminates after the optimal path has been successfully identified. The visualization of the computational process is shown in the figure below 2 below.

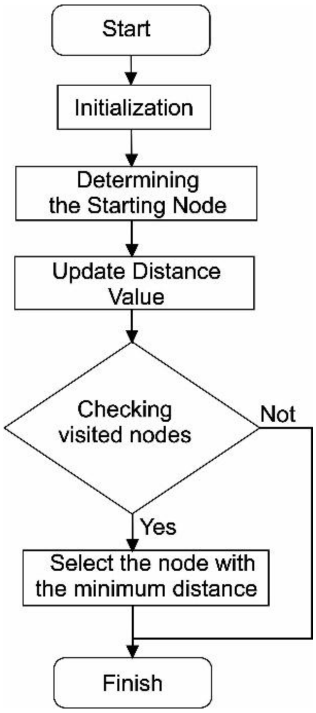

Figure 2. Dijkstra Algorithm Process Flow Diagram for Optimal Trajectory Determination

Algotima djikstra was chosen because it has high computational efficiency and optimal accuracy in determining the shortest trajectory on a positive-weighted graph. In contrast to A* which requires additional heuristic functions. The djikstra algorithm does not require distance estimation, so it is more suitable for shipping networks with deterministic geographic data. Compared to Floyd Warshall which calculates the shortest distance for all shortest path all-pair node pairs and has $O(n^3)$ complexity, the djikstra algorithm is more efficient for the single-source shortest path case as in this study. While genetic algorithms (GA) can provide global optimization results, they require complex iterative and parameterization processes and do not always guarantee the optimal solution for each iteration. With the characteristics of the shipping network possessed, the limited number of nodes and the deterministic weight, the djikstra algorithm is the most suitable and computationally efficient choice for this study.

3. Results

Before applying the shortest-path algorithm, it is essential to establish a spatial representation of the operational area under study. The maritime maintenance activities of SBNP are distributed across multiple navigation points within the Java Sea region, forming a connected network of ports and islands that serve as operational nodes. To transform this real-world sailing route into a computable structure, the geographic locations are first modeled as vertices (nodes), while the sailing distances between them are represented as edges with measurable weights. This graph-based abstraction enables the conversion of physical navigation routes into a mathematical framework suitable for algorithmic optimization and decision support in marine operations.

Figure 3. Visualization of Points that are SBNP aplousing and maintenance activities

The figure 3 shows a map that is an area that includes several points of SBNP maintenance aplousing activities which are used as sailing routes which are activities starting from the Surabaya Navigation Pier Tanjung Perak - Bawean Port - Karamian Island - Masalembo Island - Kalianget Port - Sapudi Island - Kamudi Island - Mamburit Island - Saebus Island - Panjang Island - Skala Island and finally back to Tanjung Perak. The red dot shows the location of the node used as an illustration of the destination point in the SBNP treatment aplousing activity. In the visualization above, it not only serves as a geographical picture but also becomes the basis for mathematical modeling that makes algorithm-based decisions to support marine transportation activities.

This approach not only emphasizes the computational aspect but is in line with international standards in the field of navigation and shipping safety such as the International Maritime Organization (IMO) guidelines on energy efficiency and emission reduction [4]. Simpul sebagai lokasi strategis yang menggambarkan pelabuhan, dermaga dan area navigasi laut as listed in the geographical coordinates in Table 1. Edge as the distance between nodes is calculated based on coordinate points using the haversine formula so that each side has a weight in the form of distance in kilometers. The point that will be the beginning of route modeling is determined based on the need for route simulation of SBNP maintenance aplousing activities. To ensure the accuracy of position and distance calculation in this study, google earth is used as a coordinate validation tool and field validation to obtain distance calculation results in graph modeling that can provide optimal results.

Table 1. Reference points and coordinate positions of shipping route nodes in the Tanjung Perak Type A Navigation District area

Point	Location	Coordinates	
B1	Dermaga Distrik Navigasi Tipe A Tanjung Perak	-7.2161	112.7365
B2	Pelabuhan Bawean	-5.8635	112.6213
B3	Pulau Karamian	-6.8500	115.2000
B4	Pulau Masalembo	-5.5050	114.4983
B5	Pelabuhan Kalianget	-7.0561	113.9286
B6	Pulau Sapudi	-6.9110	114.3500
B7	Pulau Kamudi	-7.1080	114.7930
B8	Pulau Mamburit	-6.8744	115.2706
B9	Pulau Saebus	-6.9274	115.2044
B10	Pulau Sepanjang	-7.0361	114.3578
B11	Pulau Sakala	-6.9000	116.2500

Based on table 1 above, the points are used as references (nodes) used in modeling weighted graphs for shipping route planning. Each node represents a strategic location in the Tanjung Perak Type A Navigation District work area which is connected in the shipping lane network. Geographic coordinate data is used as the main input in geodesic distance calculation using the haversine formula.

With the application of the djikstra algorithm, it is expected to be able to work with the principle of iteratively finding the path with the lowest cost starting from the B1 node to the destination node and back again. Each stage of the classification of the region includes modeling a graph at each location that is red. In its application, the djikstra algorithm is used to determine the optimal route by systematically updating the minimum distance until a route with the shortest total distance to the destination node is obtained. So that the results obtained can be used for the analysis of sea transportation routes, optimization of logical routes or planning of shipping route networks between surrounding islands.

4. Discussion

In the stages before the application of the djikstra algorithm in determining the travel route between nodes, it is carried out manually based on the order of the points that have been determined without considering the efficiency of the distance traveled optimally. This method only follows the order of the existing routes so that it does not get optimal results, namely getting the shortest route.

Table 2. Initial travel route sequence based on geodesic distance between nodes

Massage	From	To	Distance (km)	Cumulative Distance (km)
1	B1	B2	151.36	151.36
2	B2	B3	235.95	387.31
3	B3	B4	57.77	445.08
4	B4	B5	172.77	617.85
5	B5	B6	47.42	665.27
6	B6	B10	13.94	679.21
7	B10	B9	93.42	772.63
8	B9	B8	9.39	782.02
9	B8	B11	108.16	890.18
10	B11	B7	168.76	1058.94
11	B7	B1	151.36	1210.30
Total Mileage				1210.30 km

Table 2 shows the sequence of the initial shipping trajectories before optimization was carried out using the djikstra algorithm. Each segment of travel (from-to) shows the distance between the nodes calculated using the haversine formula based on the geographical coordinates of table 1. The cumulative distance describes the total length of the trajectory taken by the ship when following the initial route in sequence without optimization, the total distance value of 1,210.30 is used as a comparative reference for the optimal route results.

Based on the results of the calculation of travel routes without the application of the djikstra algorithm, data was obtained on the order of nodes starting from B1 to B2 sequentially until all points or nodes were visited to the starting point, namely B1 with a distance that varied at each point with the shortest distance of 9.39 km, namely points B9 to B8 and the longest distance of 235.95 km, namely points B2 to B3 so that the total distance traveled reached 1,210.30 km which can be seen in figure 2 below.

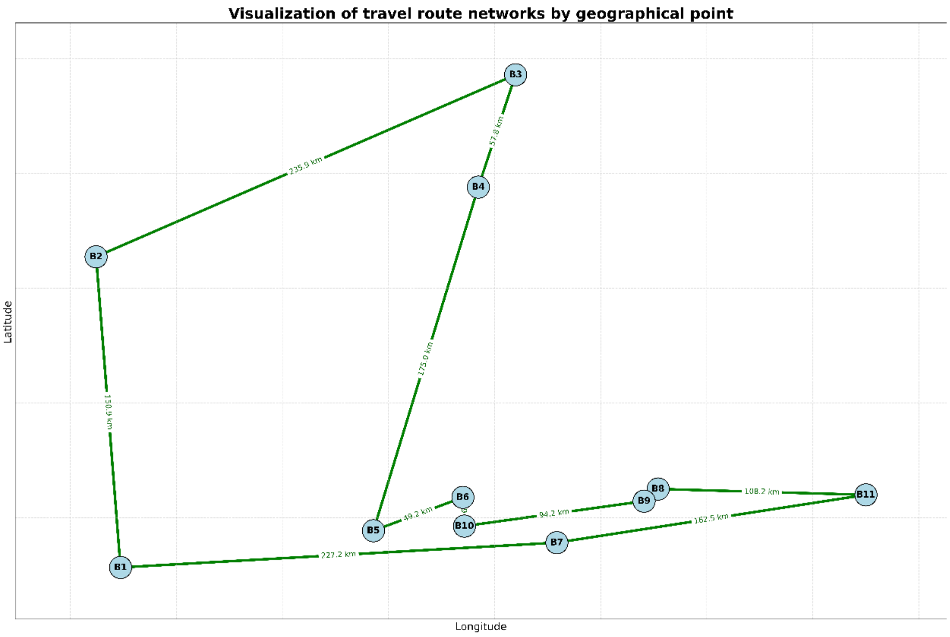

Figure 4. Visualization of travel route networks by geographical point

Figure 2 presents the network of travel routes between points and distances between nodes based on geographic coordinates data. Each node on the graph marked as B1 to B11 depicts the strategic location point visited for SBNP treatment aplousing activities. Each side or edge that connects between nodes shows the geographical relationship between the location points with a weight in the form of mileage calculated using the haversine formula. The calculation of the distance is carried out accurately based on the latitude and longitude coordinates of each node which has been validated through the help of google earth and observations.

In the visualization above, each graph is an important basis in modeling and simulation of finding the shortest route to the destination node in the SBNP treatment aplousing activity that can be associated with one of the nodes. With a weighted graph structure, the shortest path search algorithm or djikstra algorithm is expected to be able to effectively determine the optimal route from the starting point to the destination point by accurately considering the weight or distance of the node. With the approach of the network modeling method based on the djikstra algorithm which is modified into iterations to determine the optimal route on a set of geographic nodes. Each node representing the location point has latitude and longitude coordinates by calculating the distance between the nodes using the haversine formula that considers the curvature of the earth's surface to produce an accurate geodesic distance.

Recent studies have shown a methodological shift from pure distance-based optimization to an approach that integrates Automatic Identification System (AIS) operational data, meteorological-hydrodynamic parameters (wind, waves, currents) as well as energy efficiency and emissions metrics [21]. Weather-aware routing approaches and open data-based frameworks have been shown to reduce fuel consumption and emissions across various service corridors [22], At the same time, it addresses navigation safety constraints through a dynamic route cost weighting model [23], Compared to these studies, this study provides a clear quantitative starting point regarding distance efficiency based on haversine and djikstra and affirms the benefits of distance savings as a first step towards reducing fuel consumption and emissions while opening up development space to integrate operational factors (drafts, limited zones, currents and waves) so that the model can develop into a more realistic and harmonious multi-criteria optimization with maritime energy efficiency policy [24].

In the process of determining the starting route starting from the initial node B1 as the starting point of the journey, the djikstra algorithm is used to calculate the shortest route from the node it is visiting to all other nodes. From the results of the calculation, the nearest nodes that have never been visited before were selected using the nearest neighbor method to be the next destination. This process uses iterative repetition until all nodes are successfully visited. After all vertices are passed, the travel route is closed by returning to the starting point of the destination so that a complete route is formed with a minimum total mileage based on the principle of jara optimization on a weighted graph.

The results of the calculation using the djikstra algorithm are visualized in the form of a network map with light blue nodes and all routes that are gray connections as well as the optimized routes marked with red lines from each segment of the travel route equipped with distance labels in kilometers. In the analysis of the sea transportation network, the search for the shortest route is one of the stages in determining efficiency and reducing environmental pollution to determine the movement from one node to another. The determination of the shortest route in this study was carried out using the djiktra algorithm which utilizes the geographical coordinates of each node, namely B1-B11. The results of the application of the djikstra algorithm can be seen in table 3 below.

Table 3. Urutan rute hasil optimasi dan jarak tempuh setelah penerapan algoritma Dijkstra

Massage	From	To	Distance (km)	Cumulative Distance (km)
1	B1	B5	132.73	132.73
2	B5	B10	47.42	180.14
3	B10	B6	13.94	194.08
4	B6	B7	53.57	247.65
5	B7	B9	49.65	297.30
6	B9	B8	9.39	306.69
7	B8	B11	108.16	414.84
8	B11	B4	250.93	665.78
9	B4	B3	57.77	723.55
10	B3	B2	235.95	959.50
11	B2	B1	150.94	1110.44
Total Mileage				1110.44 km

From the table above, the route sequence and total distance were obtained through data processing using the Dijkstra algorithm, resulting in the shortest trajectory with a total travel distance of 1,110.44 km. The algorithm operates iteratively by selecting the nearest unvisited node from the starting point (B1) and updating cumulative distances until all nodes have been evaluated and the route returns to the origin. The resulting travel sequence, B1–B5–B10–B6–B7–B9–B8–B11–B4–B3–B2–B1, represents the optimal path within a weighted graph structure that minimizes total distance. In this model, edge weights are calculated based on the Euclidean distance between geographic coordinates, allowing the algorithm to determine the minimum-distance path between nodes. The optimized trajectory can therefore serve as a reference for shipping route planning and SBNP maintenance operations.

This phenomenon is in line with the principle of the shortest path problem in graph theory that the djikstra lagrhythm is used to determine the minimum path from the initial node to the other node that is the point of visit. The difference in distance between nodes based on the minimum and maximum is 9.39 km to 250.93 km which shows a significant variation in connectivity and distance distribution between each point. These results can be a reference in SBNP maintenance aplousing activities, transportation network planning, logistics distribution arrangements, and optimization of shipping route movements, especially in areas that have varying distances between points and indeed require high efficiency in mobility.

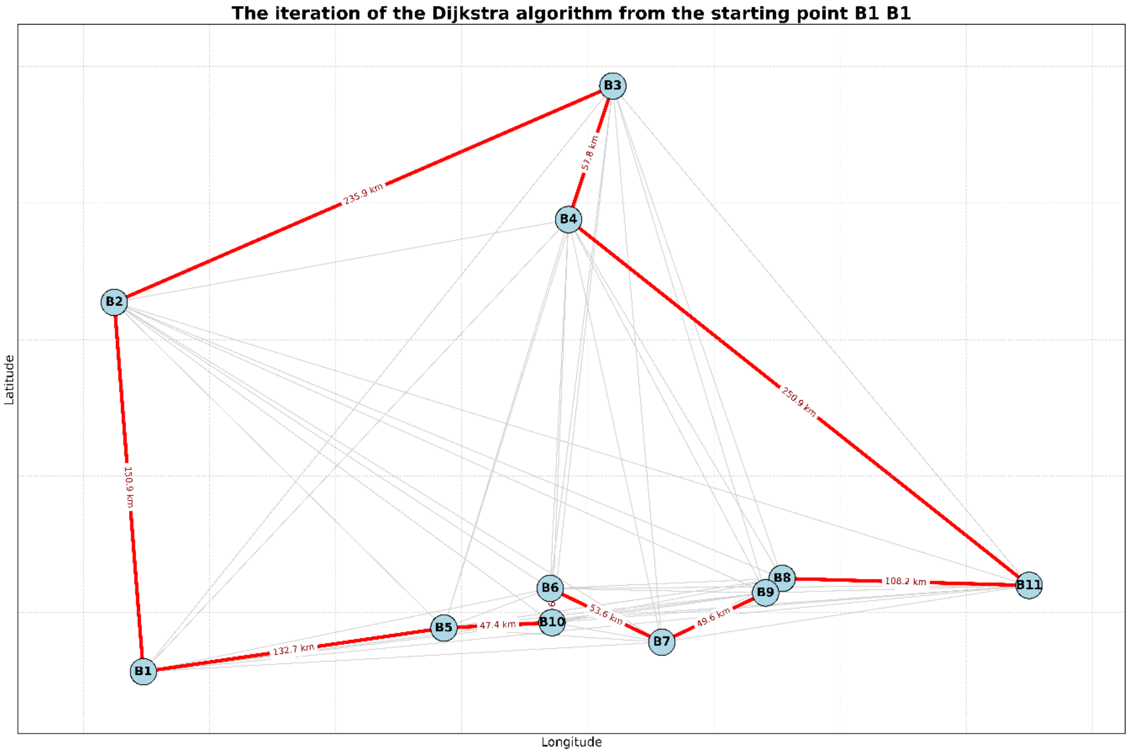

Figure 5. Visualization of the results of the iteration of the Dijkstra algorithm from the starting point B1

Based on the visualization image of the node network modeling which represents the location points B1 to B11 which is calculated the distance between nodes using the havesine method to obtain coordinates-based geodesic distances, which is then determined by determining the order of the travel route is carried out using the djiktra algorithm which is implemented iteratively with the nearest neighbor approach. This variation in distance shows an imbalance in the spatial distribution between nodes which has implications for the importance of path optimization for movement efficiency. The visualization of the graph in the image shows a representation of the relationship between nodes on the selected trajectory marked with a thick red line that depicts the path of the result of the djiktra algorithm. The thickness and color of the lines help distinguish the optimal path from the connections between other nodes shown with a thin gray line.

The analysis results indicate that the shortest trajectory begins and ends at node B1 after visiting all nodes in the sequence B1–B5–B10–B6–B7–B9–B8–B11–B4–B3–B2–B1. This optimized sequence provides a clear comparison with the non-optimized route. Based on the evaluation of distances between nodes, the manually determined route arranged sequentially without considering distance efficiency resulted in a total travel distance of 1,210.30 km. After applying the Dijkstra algorithm, the optimized route reduced the total distance to 1,110.44 km. This represents a distance saving of 99.86 km, demonstrating a significant improvement in route efficiency through algorithm-based optimization.

$$\text{Savings} = 1.210{,}30\ km - 1.110{,}44\ km = 99{,}86\ km \quad [25]$$

The percentage of distance efficiency can be calculated as follows [26]:

$$\text{Efficiency} = \frac{99{,}86}{1.210{,}30} x100\% = 8{,}25\%$$

Table 4. Comparison of mileage before and after route optimization

Aspects	Before Optimization	After Optimization	Changes/Impacts
Total Mileage	1,210.30 km	1,110.44 km	Efficiency 99.86 km (−8.25%)
Travel Time	Longer (depending on the speed of the boat)	Shorter	Potential to accelerate SBNP surgery and maintenance
Fuel Consumption	Higher	Lower	Significant operational cost savings
Exhaust Emissions (CO_2, SOx, NOx)	Larger	Smaller	Supports compliance with IMO standards (EEDI, SEEMP)
Navigation Safety	Less than optimal pathway, higher potential risk	More planned and efficient lines	In line with IALA guidelines for safe navigation
Economic Impact	Greater logistics costs	More efficient logistics costs	Increasing the competitiveness of sea transportation
Sustainability	Negative contribution to marine and air pollution	Positive contribution to carbon footprint reduction	Supporting the sustainable transport SDGs agenda

Based on the results above, the application of the djikstra algorithm was able to provide an increase in travel efficiency of 8.25%. Computationally, these results prove that the djikstra algorithm is effective in determining the shortest route based on geographic coordinate data. The 8.25% efficiency obtained is not only mathematically significant but also has implications for maritime strategic recommendations. From the perspective of maritime policy, mileage reduction supports the International Maritime Organization (IMO) initiative related to reducing greenhouse gas emissions through the implementation of the Energy Efficiency Design Index (EDDI) and the Ship Energy Efficiency Management Plan (SEEMP). From the safety aspect of more optimal route navigation, it helps ships operate with lower risks. A planned route can reduce crew workload, minimize the potential for navigation errors and be in line with IALA guidelines in the processing of Navigational Assistance Facilities.

From economic factors, the result of reducing mileage has a direct impact on fuel savings. Assuming a significant marine fuel crocodile, an efficiency of 8.25% can provide a large reduction in operational costs especially in long-term shipping and marine logistics activities. In terms of environmental sustainability, material efficiency of mileage contributes to the reduction of CO_2 and SO_x emissions. With the efficiency of ship travel, it can reduce emissions while improving compliance with international standards. This supports the global agenda to reduce air and ocean pollution and improve the sustainability of the maritime transport sector. Based on the above results, the application of the djikstra algorithm that has not been widely applied in maritime case studies has not only proven to be effective in the technical aspect of computing but also relevant for real practice in the maritime sector so that it can contribute to sustainability policies in the maritime sector.

5. Conclusions

This study proves that the application of the djikstra algorithm can produce significant mileage efficiency with savings of as far as 98.86 km or equivalent to 8.25% compared to routes without optimization. This efficiency has direct implications for reducing shipping time, saving fuel and reducing exhaust emissions that can support the sustainability agenda and protection of the marine environment.

This application successfully applied the djikstra algorithm in determining the shortest route in the aplousing activity of the maintenance of Shipping Navigation Assistance Facilities (SBNP) in the work area of the Tanjung Perak Type A Navigation District Office. The challenges faced are to reduce fuel requirements and gain efficiency and reduce shipping time and reduce environmental pollution caused by suboptimal routes. The results of this study show that the application of the djikstra algorithm can provide significant distance savings. From the initial route of the trip without optimization, the total distance of 1,210.30 km can be reduced after the application of the djikstra algorithm to get a more economical trip of 1,110.44 so that it produces 99.86 km or about 8.25% efficiency in travel.

For port authorities, the results of this research can be used as a basis for finalizing and planning policies for ship operational routes, especially in the aplousing activities for the maintenance of Shipping Navigation Assistance Facilities (SBNP). For maritime operators, route optimization with this algorithm can increase cost-effectiveness, minimize the risk of delays and improve navigation safety with a more structured route. In addition, the implementation of this algorithm is in line with international sustainability initiatives such as the recommendations of the International Maritime Organization (IMO) related to energy efficiency and reduction in the shipping sector.

This investment is expected to be an optimal route model that can be adopted on a larger scale both in domestic and international shipping routes. In the next research, it is necessary to add external factors such as sea currents, waves and wind so that the results of route planning are more accurate according to real geographical and operational conditions. Thus, the application of the djikstra algorithm is not only computationally beneficial but also makes a practical contribution to sustainability, safety and operational efficiency in the maritime transportation system.

References

[1] M. Rahmat Faizal, K. B. Alfauzi Sitorus, M. Tandililing, S. Hi Baharuddin, S. Informasi, And S. Profesional Makassar, "Sistem Pencarian Rute Terbaik Ekspedisi Barang

Menggunakan Metode Ant Colony Pada Pt. Pelindo Tpknm," 2024.

[2] A. Setiawan, A. R. Bin Abdul Hadi, U. Widyaningsih, And A. Pamungkas, "Optimalisasi Penentuan Rute Terbaik Pelayaran Berbasis Analisis Big Data Untuk Efisiensi Bahan Bakar Kapal Laut," Jurnal Riset & Teknologi Terapan Kemaritiman, Vol. 3, No. 1, Pp. 32–39, Jun. 2024, Doi: 10.25042/Jrt2k.062024.05.

[3] V. Anggeranika And A. T. Hidayatuloh, "Optimalisasi Kehandalan Sarana Bantu Navigasi Pelayaran Dalam Meningkatkan Keselamatan Kapal Di Indonesia," Journal Marine Inside, Pp. 33–43, Jun. 2024, Doi: 10.62391/Ejmi.V6i1.88.

[4] Muhammad Hendra Saputra, Rossy Armyn, And Hananto Prakoso, "Kajian Risiko Operasional Penyelenggaraan Pelabuhan Penyeberangan Dalam Rangka Meningkatkan Keselamatan Dan Keamanan Pelayaran Di Pelabuhan : Studi Kasi Pelabuhan Penyeberangan Merak," Oct. 2024.

[5] Y. Chen, "Application Of Improved Dijkstra Algorithm In Coastal Tourism Route Planning," J Coast Res, Vol. 106, P. 251, Apr. 2020, Doi: 10.2112/Si106-059.1.

[6] R. L. Sah, "Dijkstra's Algorithm For Determining Shortest Path," Vol. 7, Pp. 677–681, Apr. 2020.

[7] A. Purwanto, R. Wahid, S. Insani, D. Barry, And C. Octariadi, "Sistem Informasi Geografis Tour Guide Pencarian Rute Terpendek Wisata Kabupaten Ketapang Menggunakan Algoritma Dijkstra," 2021.

[8] N. F. Lakutu, S. L. Mahmud, M. R. Katili, And N. I. Yahya, "Algoritma Dijkstra Dan Algoritma Greedy Untuk Optimasi Rute Pengiriman Barang Pada Kantor Pos Gorontalo," Euler : Jurnal Ilmiah Matematika, Sains Dan Teknologi, Vol. 11, No. 1, Pp. 55–65, Jun. 2023, Doi: 10.34312/Euler.V11i1.18244.

[9] C. Adwani, R. De Leo, And J. A. Yorke, "What Is The Graph Of A Dynamical System?," Oct. 2024, [Online]. Available: Http://Arxiv.Org/Abs/2410.05520

[10] R. De Leo And J. A. Yorke, "The Graph Of The Logistic Map Is A Tower," Aug. 2020, [Online]. Available: Http://Arxiv.Org/Abs/2008.08338

[11] S. Garg And B. Devi, "Shortest Path Finding Using Modified Dijkstra's Algorithm With Adaptive Penalty Function," Apr. 2023, Pp. 1–9. Doi: 10.1109/Icccnt56998.2023.10308130.

[12] G. Deepa, P. Kumar, A. Manimaran, K. Rajakumar, And V. Krishnamoorthy, "Dijkstra Algorithm Application: Shortest Distance Between Buildings," 2018. [Online]. Available: Https://Www.Inf.Ed.Ac.Uk/Teaching/Courses/Dmmr/Slides/17-18/Lec-

[13] D. Fikri, H. Soeprianto, M. Turmuzi, And A. Amrullah, "Implementasi Algoritma Dijkstra Dalam Menentukan Biaya Transportasi Berdasarkan Rute Terpendek Pada Tempat Wisata Di Daerah Lombok Tengah," Jurnal Ilmiah Profesi Pendidikan, Vol. 8, No. 3, Pp. 1470–1476, Aug. 2023, Doi: 10.29303/Jipp.V8i3.1511.

[14] H. Pratiwi, "Application Of The Dijkstra Algorithm To Determine The Shortest Route From City Center Surabaya To Historical Places," Jurnal Teknologi Dan Sistem Informasi Bisnis, Vol. 4, No. 1, Pp. 213–223, Jan. 2022, Doi: 10.47233/Jteksis.V4i1.407.

[15] A. Ramadhan Et Al., "Jetbus Journal Of Education Transportation And Business," Dec. 2024.

[16] A. Asrin, "Metode Penelitian Eksperimen," Maqasiduna: Journal Of Education, Humanities, And Social Sciences, Vol. 2, Pp. 21–29, May 2022, Doi: 10.59174/Mqs.V2i01.24.

[17] A. N. Yovinda, "Konsep Filsafat Pendidikan Dan Kaitannya Dengan Konsep Pendidikan Di Indonesia," Jurnal Ilmiah Multidisiplin, Vol. 2, No. 11, Pp. 844–849, 2024, Doi: 10.5281/Zenodo.14497618.

[18] M. Adib, "Menuju Pembelajaran Madrasah Yang Lebih Efektif: Sebuah Solusi Dan Pendekatan Baru," Madrasah : Jurnal Pendidikan Madrasah, Vol. 1, May 2024, Doi: 10.61590/Mad.V1i1.1.

[19] I. Arfiani, P. Prasetyo, And M. D. Suratin, "Penerapan Haversine Formula Dalam Pencarian Lokasi Bank Sampah Di

Kabupaten Bantul," Sainteks, Vol. 19, No. 2, P. 129, Oct. 2022, Doi: 10.30595/Sainteks.V19i2.13470.

[20] Kushariyadi, Sono, T. W. Adi, S. Eka Aristantia, And M. Aviciena Taufiqurrahman, "Analisis Rute Distribusi Bbm Di Pertashop Menggunakan Metode Saving Matrik," Jurnal Sistim Informasi Dan Teknologi, Pp. 51–56, Jan. 2024, Doi: 10.60083/Jsisfotek.V5i4.332.

[21] "Improvement And Application Of Dijkstra Algorithms," Academic Journal Of Computing & Information Science, Vol. 5, No. 5, 2022, Doi: 10.25236/Ajcis.2022.050513.