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Implementation of the Haversine Formula Method in Geographic Information Systems for Searching the Nearest Sea Freight Expedition Services in East Jakarta

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Abstract

In export and import activities, a partner is needed for the shipping process. There are three types of shipping routes available for export and import: land, sea, and air. A company that offers shipping services via sea routes is known as an EMKL. This study designs a Geographic Information System (GIS) to facilitate the search for locations of Marine Cargo Expedition Services (EMKL) in East Jakarta using the Haversine Formula. The main problem faced is the difficulty in finding nearby and relevant expedition service providers in a large and densely populated area like East Jakarta. The proposed solution involves developing a system that integrates location data with the Haversine Formula to accurately calculate the distance between the user's location and the service providers. By using this method, the system can provide precise location information and help users select the nearest expedition service. The goal of this research is to enhance efficiency and accuracy in locating expedition services. The expected outcome is the creation of a user-friendly and effective system that simplifies the process of selecting expedition services by considering distance and service availability in real-time.

Keywords: *Geographic Information System, EMKL, Haversine Formula, East Jakarta.*

1. Introduction

As one of the largest economies in Southeast Asia, exports and imports play a vital role in the country's economic growth. Indonesia's exports include a variety of commodity products such as palm oil, coffee, coal, rubber, and textile products. On the other hand, Indonesia also imports goods such as industrial machinery and equipment, chemical raw materials, motor vehicles, and consumer goods. International trade has become one of the main drivers of Indonesia's economic growth. Especially in the East Jakarta area which contributes the highest export figures for shipments of rice and several other commodity goods abroad.

Sea Freight Expedition (EMKL) is a business entity that provides convenience to exporters and importers who do not want to take too big a risk. EMKL represents the interests of the owner of the goods to take care of all matters required for the delivery and receipt of goods by land, sea and air transportation, which can include receiving, storing, sorting, packing, labeling, measuring, weighing, handling. customs documents, issuing documents, transportation related to the delivery of goods, until the goods are received by the person authorized to receive them [1].

Importers and exporters in East Jakarta who will ship goods have problems in knowing the whereabouts of shipping services that are currently operating, so they need fast time and information on container orders so as not to experience delays in shipping. Furthermore, the problem that occurs is that on average exporters and importers who use shipping services must have cooperation with many services because each EMKL service has a shortage in the availability of containers for the shipping process. Therefore, to make it easier for exporters and importers to find the nearest EMKL service from their position and equipped with complete information from several shipping services, a Geographic Information System is needed.

Geographic Information System (GIS) is a special system where the processed data is in the form of spatially referenced information. This computer system can create, manage, store, and produce information related to geographic information such as location data into a database [2]. A computer system used to manipulate geographic data. This system is implemented with computer hardware and software that functions for data acquisition and verification, data compilation, data storage, data changes and updates, data management and exchange, data manipulation, data retrieval and presentation, and data analysis.

The use of Geographic Information Systems in this study uses the assistance of the Haversine Formula method. This formula contains navigation operation equations by measuring the circular distance between two coordinates on land in degrees of longitude and latitude

[3]. This formula assumes the shape of the earth as a curved plane, not flat. Internet software and databases provided by Google are used to measure distances in this area. The online software is called Google Maps which is in the form of a digital map that can be accessed via browser software both on computers and devices [4]. To use this Geographic Information System, Leaflet JS is needed. The Leaflet JS application is a library in the form of JavaScript.

The Haversine formula method helps research that will be carried out to determine the distance between points. The input variables in this haversine method use latitude and longitude assuming the shape of the earth is perfectly round with. The Haversine formula gives the great circle distance between two points on the surface of a sphere (the Earth) based on longitude and latitude assuming the radius R is 6,367.45 km, and the locations of the 2 points in spherical coordinates (latitude and longitude) are long1, lat1, and long2, lat2 respectively [5].

2. Research Method

2.1. Research Flow

The research steps taken to calculate or find the closest distance from our position use the Haversine method. To analyze the data, System need to identify the coordinate points, convert them to radians, calculate the coordinate differences, apply the formula, and obtain the final result.

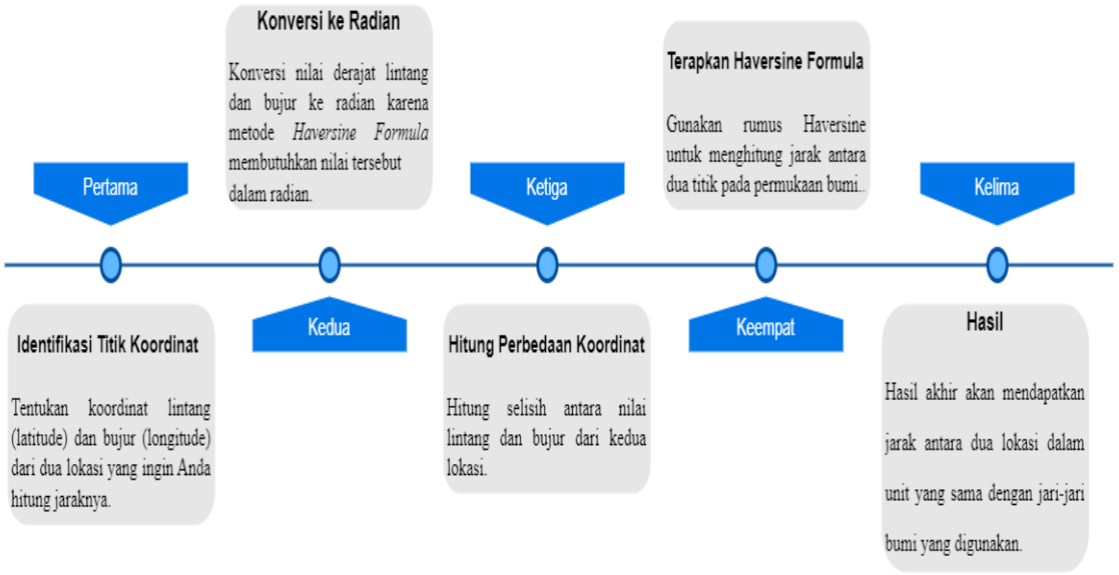

Fig. 1: Research Flow

2.2. Data Analysis

In implementing the Haversine Formula method, there are several stages. The stages are as follows:

1. First Stage: Identifying the Coordinate Points
   Determine the latitude and longitude coordinates of the two locations whose distance you want to calculate, for example, Location A and Location B. Retrieve the latitude and longitude data, and then align the distance between the two locations.
2. Second Stage: Convert to Radians
   Convert the latitude and longitude degree values into radians because the Haversine Formula requires these values in radians. Convert the degree values to radians using the formula:

   $$\text{radian} = \frac{\text{derajat} \times \pi}{180.} \quad (1)$$
3. Third Stage: Calculate the Coordinate Differences
   Calculate the difference between the latitude and longitude values of the two locations. Use the formula:
   $\Delta lat = lat2 - lat1$ dan $\Delta long = long2 - long1$ (2)
4. Fourth Stage: Apply the Haversine Formula
   Use the Haversine formula to calculate the distance between two points on the Earth's surface. The Haversine Formula is:

   $$a = sin^2(\frac{\Delta lat}{2}) + \cos(lat1) \cdot \cos(lat2) \cdot sin^2(\frac{\Delta long}{2}) \quad (3)$$

   $$c = 2.\, a\, tan^2\, (\sqrt{a}, \sqrt{(1-a)}) \quad (4)$$

   $$d = R.c \quad (5)$$
5. The final result will give the distance between the two locations in the same unit as the Earth's radius used (e.g., kilometers).

2.3. Analysis System

A use case describes the system's functionality or the requirements that the system must fulfill from a certain perspective. Based on the statement above, it can be concluded that a Use Case Diagram is a diagram used to succinctly illustrate who uses the system and what actions they can perform [6].

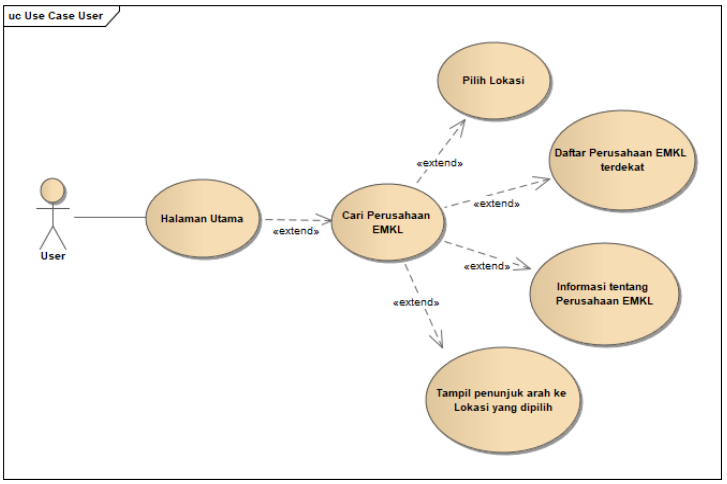

Fig. 2: Use Case Diagram User

An activity diagram is very useful for modeling process flows, interactions, and logic within a system or business process. This diagram can aid in the analysis and design of business processes or software development. Activity diagrams are also often used to illustrate user scenarios and interactions between users and the system.

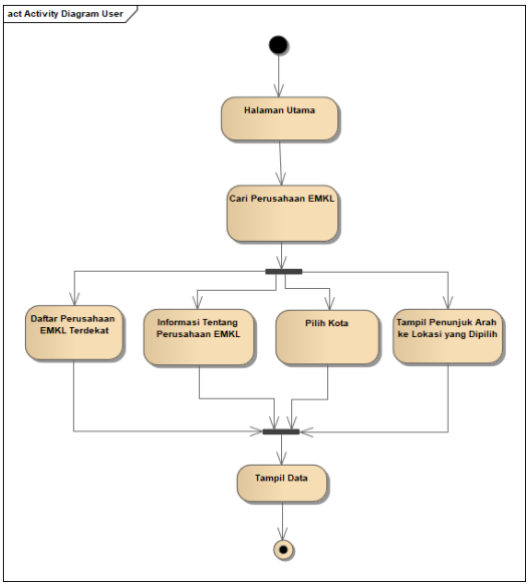

Fig. 3: Activity Diagram User

2.4. Database System

A database is a collection of several tables that are interconnected with each other, where the relationships or connections are represented as keys within each table. A single database can represent a population of data used within a work unit of an institution, company, or organization [7]. The following is the planned database to be used.

Table 1: Database User Plan

Number	Field	Type	Null	Key
1	Id Perusahaan	Int	No	Primary Key
2	Nama	Varchar	No	
3	Alamat	Varchar	No	
4	Latitude	Double	No	
5	Longitude	Double	No	
6	Gambar	Varchar	No	
7	Deskripsi	Text	Yes	
8	Kategori	Varchar	No	
9	Status_ketersediaan	Varchar	No	

3. Results And Discussions

3.1. System Implementation

Figure 4 shows the user location tagging page, displaying a map that automatically indicates the user's position. The user can also select a location point according to the desired position. By simply moving the marker, the location can be found, and the location marker is displayed as shown in Fig. 4 below.

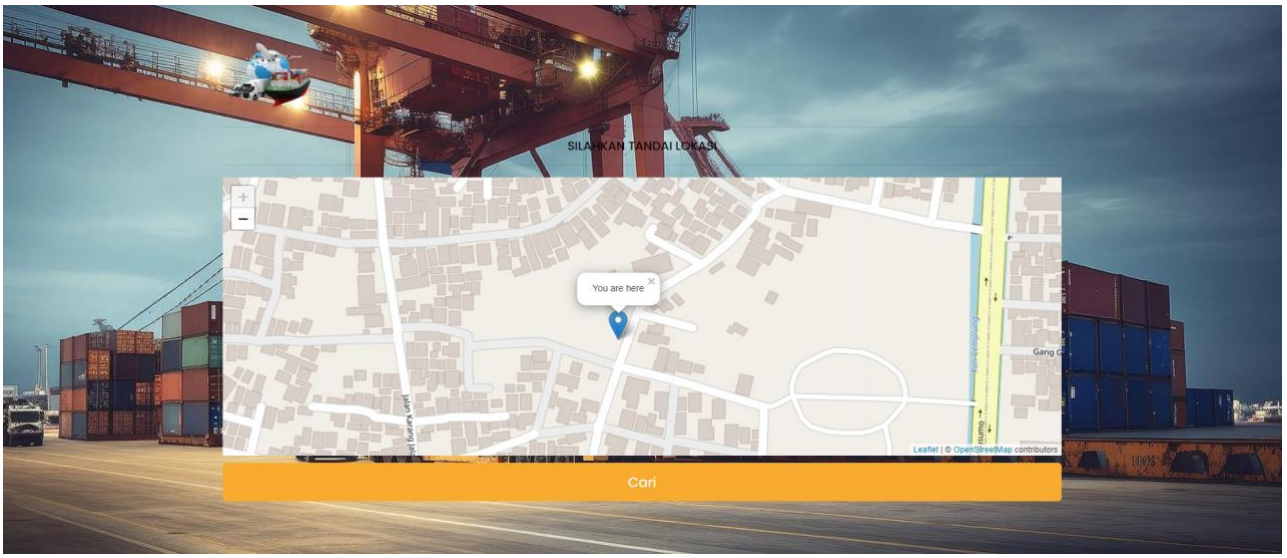

Fig. 4: Tag Location User

Figure 5 shows a list of the nearest EMKL locations relative to the user's location. After the user tags their location or uses the auto-find location feature, a display of several companies will appear, showing the distance to the nearest ones. As shown in Fig. 5 below.

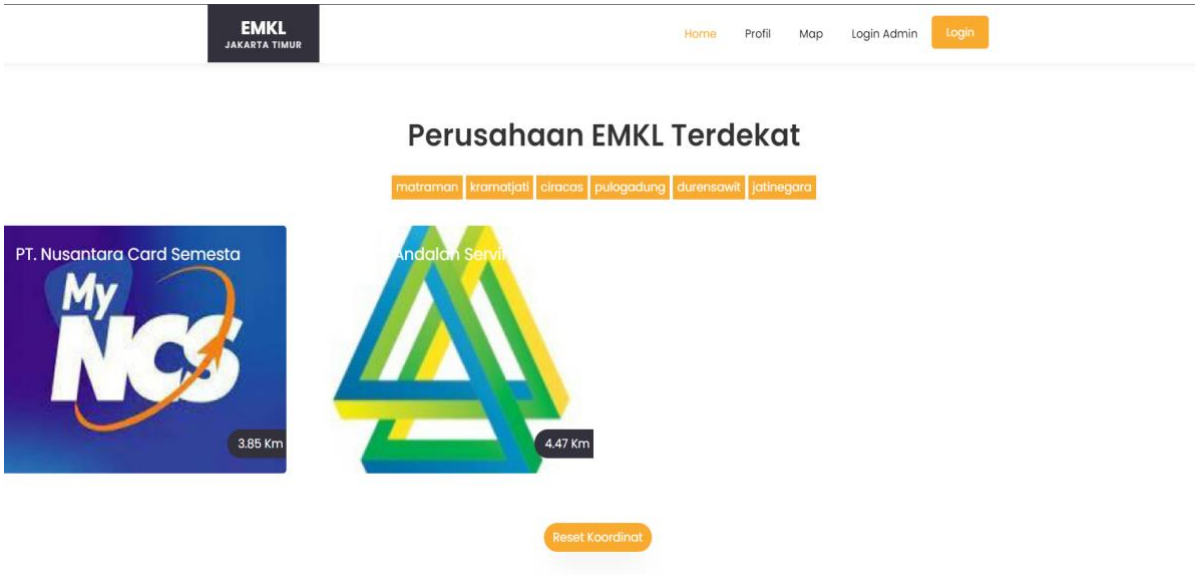

Fig. 5: List of Nearest Locations

Figure 6 shows the display after the user selects the nearest and most suitable company from the list of nearby companies. The details of the company will then appear, including the address and contact information. There is also a status of availability and route display, as shown in Figure 6 below.

Fig. 6: Company Information Details

Figure 7 shows the route display on the map, indicating the distance and direction the user will take to reach the EMKL company. The route display is shown in Figure 7 below.

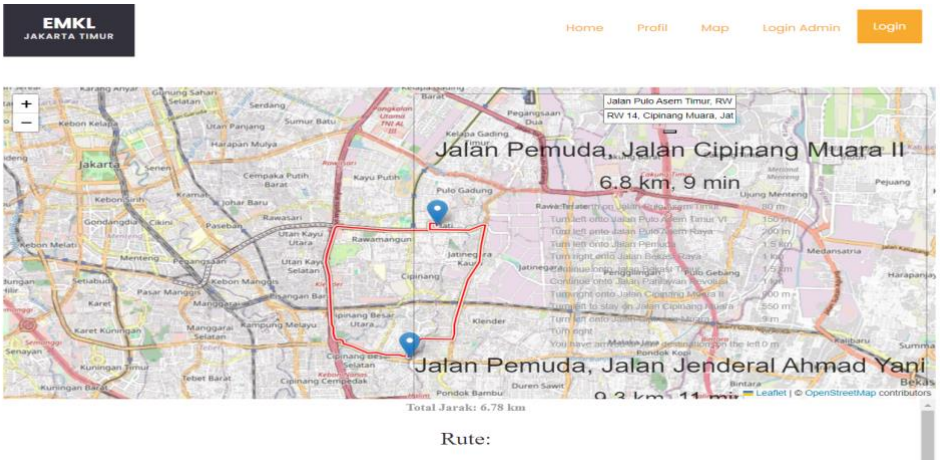

Fig. 7: Route Display

3.2. System Results

At this stage, the results show a significant outcome in calculating the nearest distance between EMKL companies in East Jakarta and the user's location used for testing. It is evident that using the Haversine Formula method brings the location distances closer, as we can see in the comparison with the actual distances in the table below:

Table. 2: Comparison of Haversine Distance and Map Distance

No.	Company name	Latitude	Longitude	Haversine Calculation Distance	Distance On Maps
1	PT. Indojaya Tahta Anugerah	-6.225004825	106.8665004	4,9 KM	8,6 KM
2	PT. Junindo Karya Logistik	-6.326322532	106.8544605	15,6 KM	21,3 KM
3	PT. Jua Sinar Indonesia	-6.248259041	106.8668055	7 KM	10 KM
4	PT. Mpm Frieght Forwading Indonesia	-6.171614494	106.8781324	3 KM	4,7 KM
5	PT. Julma Cahaya Mandiri	-6.175229146	106.8926405	1,9 KM	3,6 KM
6	PT. Golden Indah Pratama	-6.316044657	106.8797793	5,9 KM	8,5 KM
7	PT. Mandiri Sempurna Perkasa	-6.23793031	106.8693038	13,9 KM	20,6 KM
8	PT. Mon Bateung Mandiri	-6.229364594	106.9188309	4,8 KM	8,7 KM
9	PT. Melati Puspitasari	-6.228975773	106.9064925	4,2 KM	7,7 KM
10	PT. Trias Lintas Gemilang	-6.178583835	106.8961207	1,5 KM	2,8 KM
11	PT. Master Freight International	-6.219266331	106.8770895	3,6 KM	5,3 KM
12	PT. Cardig International	-6.251387877	106.8799574	6,8 KM	11,5 KM

Table 3 below shows the distances of the nearest companies from the user, calculated using the Haversine Formula.

Table. 3: Haversine Calculation Results

No.	Company name	Calculation of Shortest Distance with Haversine Formula
1	PT. Trias Lintas Gemilang	1,5 KM
2	PT. Julma Cahaya Mandiri	1,9 KM
3	PT. Mpm Frieght Forwading Indonesia	3 KM
4	PT. Master Freight International	3,6 KM
5	PT. Melati Puspitasari	4,2 KM
6	PT. Mon Bateung Mandiri	4,8 KM
7	PT. Indojaya Tahta Anugerah	4,9 KM
8	PT. Golden Indah Pratama	5,9 KM

9	PT. Cardig International	6,8 KM
10	PT. Jua Sinar Indonesia	7 KM
11	PT. Mandiri Sempurna Perkasa	13,9 KM
12	PT. Junindo Karya Logistik	15,6 KM

4. Conclusion

To assist importers and exporters in finding sea freight forwarding services in East Jakarta, a Geographic Information System (GIS) utilizing the Haversine Formula can be implemented. This GIS will automatically calculate and display the locations of the nearest freight forwarding services based on the user's position, making it easier for them to find the most efficient service and reducing search time. Thus, this GIS ensures that the process of finding freight forwarding services is faster and more accurate.

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