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Geographic Information System for Customer Distribution in PT. Dinamika Lubsindo Utama Using the Haversine Algorithm

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Abstract

The distribution of customers who do not have accurate location information results in couriers who will deliver products often traveling long distances to reach the location of the customer who placed the order because they repeat the route they have taken previously. The formulation of the research problem revolves around the application of the Haversine algorithm to calculate the distance between the courier's location and the customer's order location. Additionally, the focus is on designing and building geographic information systems for customer distribution, utilizing the Android-based Haversine algorithm. The research method used is Research & Development where researchers will collect information first and develop the system to be built. For system development, the Waterfall method is used. To calculate the distance from the courier's location to the customer's order location, the Haversine algorithm is used. From this research, results were obtained in the form of a geographic information system that will provide information on customers who make orders on that day as well as the distance from the courier's location to the location of customers who make orders using Android- based on the Haversine algorithm. The result of applying the Hasrsine algorithm to the existing problem is that the Hasrsine algorithm can calculate the distance from all customers who ordered products that day to the courier point that will make the delivery and the courier will get information on the distance starting from the closest to the farthest.

Keywords: Customer; Geographic; Haversine; Information; System

1. Introduction

The advancement of technology has significantly impacted different facets of human existence when engaging in day-to-day tasks. (Samsudin, 2019). And it has required many parties to be able to utilize cyberspace with the help of the internet (Samsudin et al., 2022). One technology that is currently developing is the presentation of information in the form of geographic data or mapping, better known as Geographic Information Systems (GIS) (Susanto & Handayani, 2022). A Geographic Information System (GIS) is a digital platform utilized for gathering, inspecting, combining, and assessing data concerning the surface of the Earth (Sodikin & Susanto, 2021)(Suendri, 2020). This role plays a significant part in aiding the decision-making process for the planning and administration of natural resources, the environment, transportation, and urban and administrative concerns. (Sulastio et al., 2021).

PT. Dinamika Lubsindo Utama is an official company that has distributed Shell oil products since 1997. They are a trusted distributor who prioritizes customer needs in marketing their products. they already have many customers, especially those spread across North Sumatra, around ±800 customers. The large number of customers who are spread out makes it difficult for them to deliver their products to customers efficiently, due to the lack of information on customer location distribution and not having a system for mapping the distribution of their customers.

As a result, couriers who go to customer locations often travel quite long distances due to repeating routes they have previously taken. To make travel more efficient, cost effective, and done

in one trip, it is important to choose the shortest route, so that the courier can be more effective in getting to the customer's location (Riswandi et al., 2023).

To calculate the distance between the system user's location and the customer's location, researchers used the haversine algorithm. The haversine algorithm is used to calculate the distance between two points by considering the curvature of the earth (Sa'ad et al., 2020). This algorithm is usually used to perform calculations to predict the distance between important point locations for managing time and organizing travel plans (Painem & Soetanto, 2020). This equation calculates distance based on the longitude and latitude of the earth, without ignoring the effects of curvature of the earth's ellipsoid shape (Dessisiliya et al., 2023).

The contribution to this research is to overcome the problems that exist there by building and developing an Android-based geographic information system that provides information on the distribution and distance of customers from couriers using the haversine algorithm which is then sorted from closest to farthest so that the product delivery process is more effective in terms of time and cost.

2. Method

2.1 Geographic Information Systems

A Geographic Information System (GIS) is a specialized system created to record, retain, process, examine, arrange, and exhibit various forms of geographical data. (Painem & Soetanto, 2020). To put it more simply, a geographic information system is a computerized system that can create, retain, control, and exhibit location-based data, such as information categorized based on its position in a database (Ramadhani et al., 2020).

2.2 Google Maps API

The Google Maps API (Application Programming Interface) is a software interface that can be utilized through JavaScript, enabling the integration of Google Maps into the web page being developed. Understanding the development of a Google Maps API entails knowledge of HTML, JavaScript, with the map data being supplied by Google. The Google Maps API is a Google service that can be utilized to incorporate maps into websites by employing JavaScript. The Google Maps API offers numerous tools and utilities for manipulating maps and integrating content into maps through diverse services (Utomo & Hamdani, 2021).

2.3 Firebase

The Firebase Realtime Database is a cloud-based database that operates in real time and is compatible with multiple platforms, including Android, iOS, and the Web. Information within Firebase will be organized in a JSON (JavaScript Object Notation) format. The Firebase database will automatically harmonize with client applications that are linked to it. Cross-platform applications utilizing the Android, iOS, and JavaScript SDKs will receive automatic updates of the most recent data when the application establishes a connection with the Firebase server. (Maulana, 2020).

2.4 Kodular

Kodular is a website that provides tools for building Android applications with the drag and drop block programming concept. Block programming is the core feature of Kodular, with this feature we no longer need to enter program code manually to create Android applications. Kodular also provides mini dBase and storage functions so that we can save and download data as desired. In terms of interface/GUI, the code can be adapted to the theme to make the application we create more modern and professional (Muyasir & Musfikar, 2022).

2.5 Haversine Algorithm

Haversine is used to calculate the distance between points on the earth's surface using latitude and longitude as input variables. The Haversine formula is an important equation in navigation, giving the great circle distance between two points on the surface of a sphere (the Earth). based on longitude and latitude. Assuming that the earth is a perfect circle with a radius of 6371 km and the location of 2 points on the spherical coordinates (latitude and longitude) (Antono & Dwiasnati, 2022) (Kartika et al., 2022). Haversine algorithm equation (Riswandi et al., 2023):

$$\Delta lat = lat2 - lat1$$

$$\Delta lng = lng2 - lng1$$

$$a = sin^2\left(\frac{\Delta lat}{2}\right) + cos(lat1).cos(lat2).sin^2\left(\frac{\Delta lng}{2}\right)$$

$$c = 2.asin\left(\sqrt{a}\right)$$

$$d = R.c$$

Information:

lat1 = initial latitude point
lat2 = final latitude point
lng1 = initial longitude point
lng2 = final longitude point
Δlat = large change in latitude value
Δlng = large change in longitude value
a = angle between two points
c = axis intersection
R = radius of the earth (6371 km)
d = distance (km)

2.6 Research & Development (R&D) Method

This study adopts the Research & Development (R&D) approach, gathering data through multiple techniques such as interviews, observations, and literature review. Subsequently, system planning and testing are conducted utilizing the Waterfall system development methodology (Taufiqy et al., 2022).

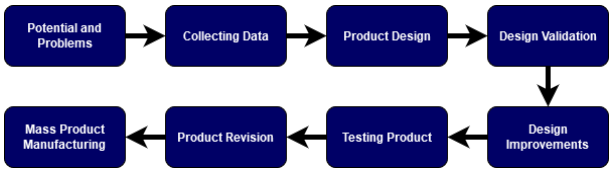

Figure 1. Stages of the R&D Method

The stages in the R&D method start from identifying potential and problems, then collecting data, then product design, then design validation, design improvement, product testing, product revision to mass product manufacture.

a. Potential and Problems

Research begins with a potential or problem. Potential is everything that if utilized will be has added value. Problems can also be used as potential, if you can use it. Problems will occur if there is a deviation between what is expected and what is expected happen. This problem can be overcome through research and development by researching so that it can be discovered an effective integrated model, pattern or treatment system which can be used to overcome this problem.

b. Collecting Data

Upon identification of existing potentials and issues, current and accurate data is gathered, along with comprehensive literature research, serving as the foundation for detailed product planning aimed at resolving the identified challenges.

Interview, Data collection starts from conducting interviews with managers and several couriers or salespeople. And the data obtained is customer data such as customer name and customer address.

Observation, After conducting interviews, the author made observations on the object of the research problem so that information was obtained on how couriers deliver products, what the existing workflow is and what problems couriers experience in making deliveries as well as what problems other sources may not provide information on.

Literature review, After making further observations, the researcher conducted a literature study by studying previous research regarding journals or books related to geographic information systems and hasrsine algorithms. So we get a comprehensive picture of the development of geographic information systems and the application of the haversine algorithm in calculating distances.

c. Product Design

Various types of products can emerge from research and development. To establish a novel operational system, a fresh action plan is essential, predicated on an evaluation of the existing operational system, thereby identifying weaknesses within the system.

d. Design Validation

Design validation is a procedure involving the evaluation of the product design activities, specifically in this context, the assessment of a new operational system. This aims to determine whether the new system would be more effective than the previous one, based on logical reasoning rather than empirical evidence.

e. Design Improvements

Following the product design phase, validation occurs through consultations with experts, who can identify potential weaknesses. These shortcomings are subsequently addressed and minimized through design enhancements.

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Researchers are responsible for improving the design in order to produce the desired product.

f. Testing Product

Product designs cannot be immediately tested and must be produced before testing can occur. The testing process involves experimentation, particularly comparing the efficiency and effectiveness of the new operational system with the previous one.

g. Product Revision

Testing the product on these restricted samples reveals that the performance of the new operational system is significantly superior to the old system. The differences are notably pronounced, validating the implementation of the new operational system.

h. Mass Product Manufacturing

Mass production of the product occurs once it has been tested and deemed effective and appropriate for large-scale manufacturing. For instance, the production of a waste conversion machine into a useful material undergoes mass production based on a feasibility study encompassing technological, economic, and environmental aspects. Collaboration between entrepreneurs and researchers is essential for successful production.

2.7 Waterfall Method

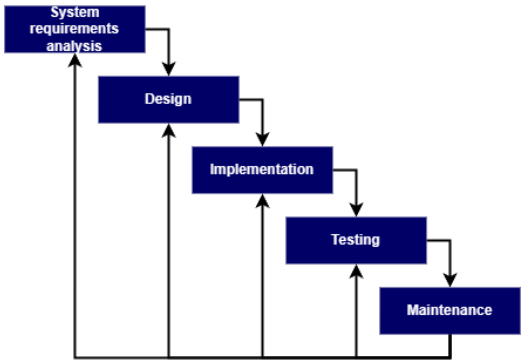

Figure 2. Waterfall Method

Stages in developing a system using the Waterfall method, namely (Sa'ad et al., 2020):

a. System Requirements Analysis

At this stage, the data needed to develop the system according to user needs is collected. Such as the features that must be in the system, how the system works and other user needs.

b. Design

The next stage is to create an overview of the user interface using design software and create an overview of the process flow in the system to be developed. The display design is developed so that users can more easily use the system, and the process flow design is developed to obtain a flow that suits the user's needs.

c. Implementation

At this stage, all design plans that have been made starting from system analysis and system design to appearance design will be implemented into a programming language. To implement the display design using the Kodular Framework. The database used is Firebase and uses the Google Maps API for mapping.

d. Testing

At this stage, the system that has been implemented will be tested to find out whether the system created is in accordance with the desired geographic information system and also whether the system still has bugs or deficiencies. Testing was carried out using the Black Box method.

e. Maintenance

During this phase, maintenance of the system is conducted to ensure its continuous functionality and usability for the end users.

2.8 System Analysis

The system will provide information on the location customers by taking the coordinates in the form of latitude and longitude, then the system will carry out calculations using the haversine algorithm to get the distance from the user's location to the customer's location which is available in the database.

a. Flowchart

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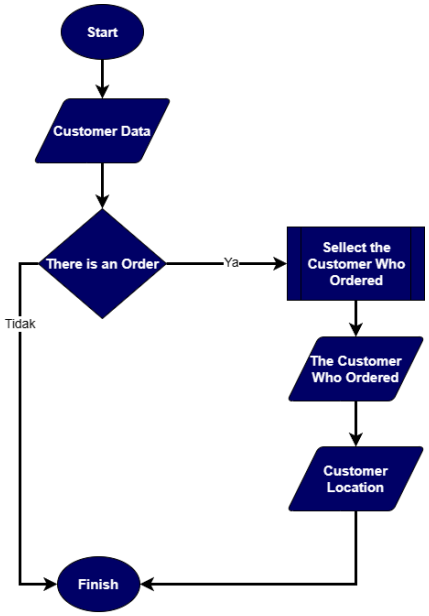

Figure 3. System Flowchart

The flow diagram in the system starts from accommodating all customer data from the database, then if the customer wants to order, the admin will add to the list of customers who want to order. Next, the courier will be able to see a list of customers who have placed an order, then the system will display the location of the customer who ordered and the courier is ready to send the order.

b. System Requirements

To complete the research, a system was built using the following hardware and software.

Hardware

The specifications required for the computer in the system creation process are as follows:

Table 1. Hardware Requirements

Components	Information
Processor	Intel Core i3 10105F 3.70 GHz
Memory	8 GB DDR 4
Storage	HDD 1 TB
VGA Card	AMD RX580 4 GB
Connection	Wifi

Software

The software requirements for the system creation process are:

Table 2. Software Requirements

Components	Information
Operation System	Windows 10
Database	Firebase
Web Browser	Chrome
Framework	Kodular
Emulator	Companion

Because the system is built on Android, to run the system you need an Android-based operating system with a minimum of Android 7.

c. Database Design

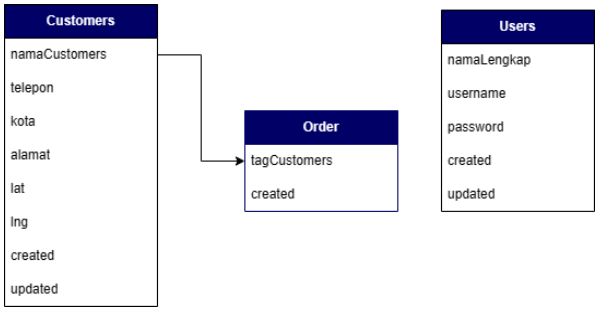

Figure 4. Database Design

The system will use a database from Firebase, namely a realtime database. In real-time databases, tags and values are needed to store data. The system will use 3 tags, namely Customers, Order and Users.

d. Use Case System

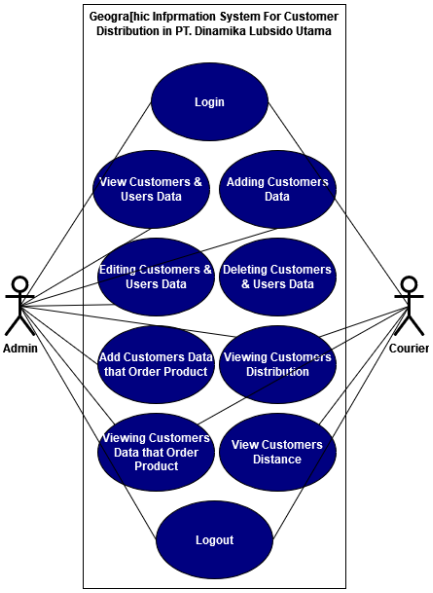

Figure 5. Use Case System

In the use case diagram there are 2 actors, namely admin and courier. Admins can manipulate customer data and see the distribution of customers on the map. Meanwhile, couriers can only see data from customers, location information and distance from customers who make orders.

3. Result

The results of this research will calculate the distance from the courier's location to the customer's location by considering the coordinates. For example, here is some sample customer data:

Table 3. Data Sample Customer Data

Customers Name	Address	Latitude	Longitude
PT.ABB Sakti Industri	Jl. Sisingamangaraja Km 6,5	3.55022	98.69819
PT.Abdi Rakyat Bakti	Jl. Gandhi No. 130	3.58305	98.68982

3.1 Analysis of the Haversine Algorithm

The starting point was at Office on Jl. Sutomo No. 232, Medan City with coordinates latitude 3.590348, and longitude 98.68445. The destination point is PT. ABB Sakti Industri on Jl. Sisingamangaraja Km 6.5, Medan City with coordinates latitude 3.55022, and longitude 98.69819. We can get:

lat1 = 3.59034 * 0.0174532925 radians
= 0.062663
lng1 = 98.68445 * 0.0174532925 radians
= 1.722369
lat2 = 3.55022 * 0.0174532925 radians
= 0.061963
lng2 = 98.69819 * 0.0174532925 radians
= 1.722608
Δlat = lat2 – lat1
= 0.061963 - 0.062663
= -0.0007
Δlng = lng2 – lng1
= 1.722608 - 1.722369
= 0.00024
a = $sin^2(\frac{\Delta lat}{2}) + cos(lat1).cos(lat2).sin^2(\frac{\Delta lng}{2})$
= 1.22628E-07+
0.998037*0.998081*1.4377E-08
= 1.36949E-07
c = $2.asin(\sqrt{a})$
= $2.\text{asin}(\sqrt{1.36949\text{E}-07})$
= 0.00074
d = R.c
= 6371 * 0.00074
= 4.715389 Km

So the distance from Office to PT. ABB Sakti Industri using the haversine algorithm is 4.71 Km.

The starting point was at Office on Jl. Sutomo No. 232, Medan City with coordinates latitude 3.590348, and longitude 98.68445. The destination point is PT. Abdi Rakyat Bakti on Jl. Gandhi No. 130, Medan City with coordinates latitude 3.58305, and longitude 98.68015. We can get:

lat1 = 3.59034 * 0.0174532925 radians
= 0.062663
lng1 = 98.68445 * 0.0174532925 radians
= 1.722369
lat2 = 3.58305 * 0.0174532925 radians
= 0.06253602
lng2 = 98.68015 * 0.0174532925 radians
= 1.722294
Δlat = lat2 – lat1
= 0.06253602 - 0.062663
= -0.00013
Δlng = lng2 – lng1
= 1.722294 - 1.722369
= 0.000075
a = $sin^2(\frac{\Delta lat}{2}) + cos(lat1).cos(lat2).sin^2(\frac{\Delta lng}{2})$
= 4,03098E-09+
0,998037317*0,99804526*1,40625E-09
= 5,43173E-09
c = $2.asin(\sqrt{a})$
= $2.\text{asin}(\sqrt{5{,}43173\text{E}-09})$
= 0,000147
d = R.c
= 6371 * 0,000147
= 0,939089 Km

So the distance from Office to PT. Abdi Rakyat Bakti using the haversine algorithm is 0.94 Km. From the calculations for the two customers above, PT. ABB Sakti Industri 4.71 Km and PT. Abdi Rakyat Bakti 0.94 Km, then it can be sorted that PT. Abdi Rakyat Bakti is closer to the office and will be delivered first.

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3.2 Implementation

To implement the haversine algorithm in an Android-based geographic information system for customer distribution, the Kodular framework was used to build the system and Firebase to store the data. The results of the implementation can be seen in the image below.

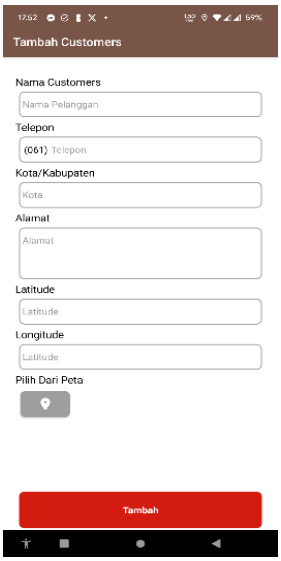

Figure 6. Screen Adding Customers Data

On the add customer data page, the admin can add new customer data by filling in name, telephone, city/district, address, latitude and longitude which can be obtained from the map. Then the data will be entered into the database.

Figure 7. Screen Custmers Data

In the customers navigation menu, will be displayed a list all customers, namely names, addresses and dates are entered into the system in alphabetical order. There is also a button to add new customer data.

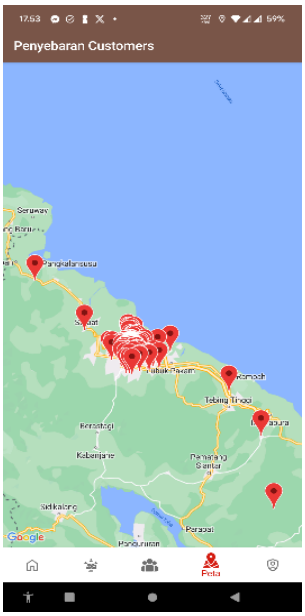

Figure 8. Screen Distribution of Customers

In the map navigation menu, admins can see the distribution of customers in North Sumatra on a map created using the Google Maps API. Each customer is displayed with a red mark.

Figure 9. Screen Customers for Courier

The user dashboard screen will display all customers that order. The system will display the customer's name, address, city/district and distance from the user's position using the haversine algorithm and sorted from the closest distance to the user to the farthest. And there is a navigation menu on the bottom screen which consists of dashboard, map and profile.

4. Conclusion

This research shows that the Haversine algorithm is an effective and accurate tool for calculating the distance between customers and couriers. Its accuracy in calculating distances on the Earth's surface allows the system to provide reliable results. By utilizing geographic information systems and the Haversine algorithm, this research proves that companies can plan and optimize their customer distribution. This can reduce operational costs, save time, and increase delivery efficiency.

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