Resolving the Shortest Path Problem using the Haversine Algorithm

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Abstract:

Route search requires a useful and accurate algorithm to calculate the distance between two objects, especially on a round surface such as the earth. This algorithm provides a considerable circle distance between two locations on a non-flat surface. The distance of the two objects is determined based on longitude and latitude. Haversine is an algorithm that can determine the distance between two objects on the surface of a sphere. Haversine has now been developed by using a simple formula, which with computer calculations, can provide a very accurate level of precision between two points. Research with Haversine will be applied to determine the closest location. A graph is a diagram that contains specific information if interpreted correctly. The graph is used to describe various kinds of existing structures. The purpose is as a visualization of objects to make them easier to understand. The Haversine algorithm can determine the distance of two coordinates of the earth. By applying this method, the distance between the two coordinates can be determined.

Key Words: Haversine, shortest path, artificial, intelligence

INTRODUCTION

Technological advances have been highly ordered so that information can be obtained directly from cyberspace without having to carry out physical activities. Calculation of the distance between locations is the most crucial thing in determining how quickly someone can find or get to the destination point. However, how to determine the distance of two locations on earth. It is comfortable with the help of latitude and longitude coordinates [1]. The position of a point on the earth can be adequately mapped so that the distance calculation can be done. Not all algorithms can calculate this distance. The haversine formula is one that can be used in determining the distance between two locations in a straight line on the coordinates of the earth. There are different ways of calculating distances on flat and round planes. Calculation of distances in spherical fields requires the concept of trigonometry. This calculation is used to find the shortest or optimal route [2].

Route search has several branches in the process of finding which points can be passed. This branching is a significant problem in the search process. Branching determines how close the distance is to the main destination [3]. The shortest path is one problem that can be solved using graphics [4]. If a weighted graph is given, the shortest path problem is how we find the path in the graph that minimizes the number of side weights that make up the path. Determination of the shortest route produces optimal time and distance. An application program is needed in determining the optimal distance. Inadvertent search cannot find the optimum solution in the shortest path problem. The search for this model cannot be carried out on an object that is round like the earth [5].

Earth is where humans live. Earth has an extensive surface. The earth is round, so it is not very easy for humans to calculate the distance of the two locations. However, with the times, the distance to the earth can be calculated easily. There is an algorithm that can calculate the distance of two coordinates that are on the surface of the earth. The algorithm is the Haversine algorithm. This algorithm calculates distances using latitude and longitude. The Haversine algorithm aims to find the nearest straight line distance from two different locations. The Haversine algorithm has a heuristic value that is used as a basis for consideration in which the estimated value/least cost will determine the shortest distance traveled.

THEORIES

2.1 Artificial Intelligence

Artificial Intelligence (AI) is computer science that studies how a system can mimic human intelligence [6]. Research that deals with artificial intelligence have tried to give projections to an object by imitating human ways or mindsets. Artificial intelligence is not only applied to robot-shaped objects. Artificial intelligence can also be applied to a method of solving problems, especially in optimizing a system. In general, intelligence is carried out to improve the performance of a system. Systems that have succeeded with current conditions will be upgraded so that the system becomes minimalist. Artificial intelligence is closer to optimization or arrangement to make the system smart [7].

Human thought can be put in a computer program to govern machines or algorithms to solve a problem. The computer will try to learn on its own and can update its database to add keywords and thought patterns. Artificial intelligence is now widely used in education and business. The goal is to reduce the human resources that will spend funds to pay their salaries. Application of AI in the world of education can help students or students in learning the systems used in artificial intelligence [8].

The implementation of artificial intelligence is very many and varied. Many companies have used artificial intelligence in serving customer complaints. One implementation of artificial intelligence is the use of chatbots or virtual assistants. Both of these examples can interact directly with humans in resolving customer complaints. Usually, this is done on online sales sites or online booking sites such as hotels and aeroplane tickets. The use of artificial intelligence is also proven in the field of robotics. This technique is applied to creating devices or machines. An example is a car without a driver that able to do automatic parking. Every environment related to digital data processing will also be related to artificial intelligence [9].

2.2 Distance

Distance is the sum of the differences between two coordinate points located at different locations. The distance position can be near or far from the variance position. Distance measurement is often used in everyday life. This calculation serves to determine the difference in value between the two locations. For example, the distance between two coordinates on the map . Distance is different from position coordinates, and the distance may not be negative. Even though the coordinate system will produce a negative value after the distance calculation, the negative result will be absolute. Distance is a scalar quantity, while displacement is a vector. The distance traveled by someone is usually indicated in meters or kilometers [10].

2.3 Haversine

The Haversine Formula is an essential equation in finding stright line distance between two coordinates on the earth using longitude and latitude parameters. The haversine algorithm is an example of modeling calculation in the form of trigonometry, which is applied to a round shape. This algorithm discusses the shapes of sides and angles in spherical triangles. In 1805, a scientist created a Haversine table to determine a distance between points [11].

Many methods can be occupied to find the distance among locations on the world map, one of which is the haversine algorithm / method. The haversine method is commonly used in the world of aviation to calculate the distance of an aircraft with the coordinates of the destination. Following is the haversine algorithm calculation:

$$\text{hav}\left(\frac{d}{r}\right) = \text{hav}(\phi_2 - \phi_1) + \cos(\phi_1)\cos(\phi_2)\,\text{h}$$

The haversine method calculates the distance between one coordinate with another in a straight line and ignores hills or valleys on the surface. The input of this method is latitude and longitude. It is the coordinates of the earth. The output is the value of the distance between the two locations.

Basically, the shape of the earth has a slight difference. Not all earth shapes are round. In fact, the shape of the earth is slightly elliptical. The Haversine formula works with a round object by giving three locations in determining its distance. It is included in the model for formula formation in trigonometry. The Haversine formula is closely related to the shape of a triangle drawn on the surface of the sphere.
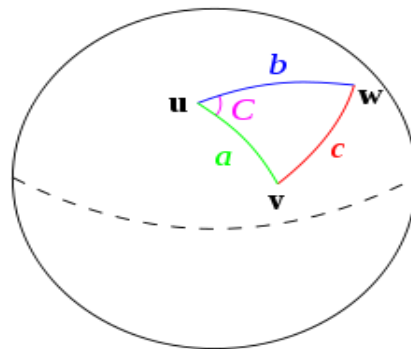

Figure 1. Havesine Triangles

Figure 1 is an explanation of the haversine method applied to the earth. There are three coordinates, "i", "v", and "w". These three coordinates form the distance builder in the Haversine calculation. Haversine calculations can be formulated into the following equation.

$$\text{arversine}(c) = \text{arversine}(a - b) + \sin(a)\sin(b)\,\text{arversine}(c)$$
$$a = sin^2(\Delta\varphi/2) + cos\,\varphi1 \cdot cos\,\varphi2 \cdot sin^2(\Delta\lambda/2)$$
$$c = 2 \cdot atan2(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R \cdot c$$

Where:
Φ = lattitude
λ = longitude
R = earth radius (6371)

METHODOLOGY

This section explains the data used in the Haversine algorithm. Five locations are calculated using this algorithm. Figure 2 is a map of the locations where the Haversine algorithm will be tested.

Table 1. Data of location

No.	Location	Latitude	Longitude
1	Millenium ICT	3.599420	98.644572
2	UNPAB	3.589862	98.645168
3	Fourpoint	3.589901	98.651423
4	Brastagi Supermarket	3.590886	98.654857
5	Carrefour	3.593120	98.663484
6	Gajah Mada Field	3.584169	98.658922
7	Aceh Sepakat	3.585413	98.662259
8	SDM-21	3.581287	98.660281
9	Ramayana	3.580285	98.660820
10	Sun Plaza	3.582472	98.671672

RESULT AND DISCUSSION

This study uses the unit of kilometers in determining the results of the distance test between two coordinates. The test results will be based on a predetermined sample. There are ten samples tested to determine the Haversine value. The following calculation will explain the Harvesine calculation.

Source   =   Millenium ICT
Latitute   =   3,599420
Longitude =   98,644572
Destination=   Sun Plaza

Latitute   =   3,582472
Longitude =   98,671672
Haversine =   ACOS((SIN(3,599420) * SIN(3,582472)) + (COS(3,599420) * COS(3,582472) * COS(98.671672 - 98.644572))) * 63713,549128345

The distance from Millenium ICT to Sun Plaza according to Haversine Formula is 3,549128345. The next test is to try to calculate the distance using Google Maps. The aim is to see how big the difference is between the Haversine Formula and Google Maps.
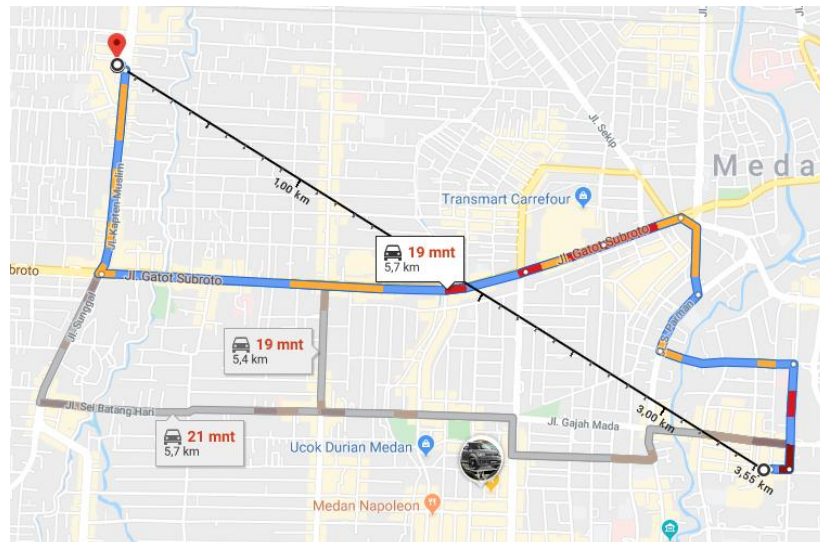

Figure 2. Google Map measurement

Measurements made by Google Maps do not have a significant difference. The measurement produced 3.55 km, while the Haversine measurement produced 3.549 km. Can be seen, both of these measurements produce accurate calculations. The Haversine algorithm is perfect for making measurements using latitude and longitude.

CONCLUSION

In determining the straight-line distance from two locations, the Haversine Formula is a great algorithm. Haversine performs calculations based on latitude and longitude. Haversine can only be used on a world map, so Haversine is not suitable for measuring distances with units other than latitude and longitude. The Haversine algorithm has excellent accuracy. By applying the Haversine algorithm, the distance of two coordinate points on the world map can be calculated.

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