Web-Based Geographic Information System (GIS) in Determining Shortest Path of MSME Medan City Using Bellman-Ford Algorithm

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Abstract. Micro, Small and Medium Enterprises (MSME) are one of the drivers of Indonesian economy but have problems in introducing their products to the public. In addition, public ignorance of MSME and their products is another problem experienced by MSME. Therefore, a system is needed that can become a forum for MSME to introduce their businesses and display complete information about the MSME business in Medan City, such as a geographical information system that contains a mapping of the shortest MSME routes, estimated distances and travel time to these MSME. This study uses Bellman-Ford algorithm and Euclidean Distance method to map the shortest route to MSME. Based on the testing, a system is obtained that allows administrators to input MSME data and allows users to search for information about a MSME and its address along with mapping the shortest route.

1. Introducing

UMKM (Micro small and Medium Enterprises) has a very important role in the main drivers of the economy in Indonesia because the MSME sector functions as a provider of employment for millions of people who are not accommodated in the formal sector, contributing to the formation of Gross Domestic Product (GDP), and as a source of foreign exchange. However, MSME also experience obstacles in marketing, business networks and technology. Basically, MSME have classic barriers, namely obstacles related to the low quality of human resources (HR), weak business management, low access to financing sources and markets, and low information and technology [1]. To reduce barriers in product marketing is to publish its business products so that more consumers or people are interested and buy the products of MSME. One way to publish it is to create an information system on MSME where the system contains information about MSME and their products. However, the information system that has been made so far is not enough to help MSME to market their products and not meet the information needs of these MSME for the community and the government.

Geographic Information Systems (GIS) technology has developed rapidly. GIS is made using information derived from processing a number of data, namely geographic data or data relating to the position of objects on the earth's surface. GIS technology integrates database-based data processing operations, such as typical visualization and various advantages that geographical analysis can offer through map maps. GIS can be presented in the form of mobile applications or web-based systems. GIS can also provide an explanation of an event, forecasting events, and other strategic planning and can help analyze common problems such as economic problems, population, social governance, defense and tourism [2].
Bellman-Ford is one of the shortest distance-based search algorithms based on dynamic programming that can work on the negative side, so that it can minimize costs for example in network development, this is because the Bellman-Ford algorithm will find the shortest path weight from the given subject node source to other nodes. Therefore, there is no need to build many routers to build paths from nodes to another [3].

2. Methodology

System design in this study includes several stages, namely input, process, and output. At the input stage, the design that appears in this system is in the form of a map where the map has several signs of the existence of MSME in the city of Medan, when one of the MSME signs is selected, information about the MSME and the button that is clicked serves shows the closest route to the location of the selected MSME. The location of the selected MSME is used as the destination coordinate input. Then the user is asked to enter a street name that is used as the original coordinate input. So this system takes 2 data as input. Then at the process stage, the system starts taking the closest coordinates from the user using the Euclidean method, all coordinates that have been taken, are collected and calculated the distance using the Bellman-Ford Algorithm. After all the distance calculation process by the Bellman-Ford Algorithm is complete, the output obtained is in the form of direction or the direction of the nearest road from the address that is input by the user with the location of the MSME that the user wants to go to. Explanation of each of these stages can be detailed based on the general architecture of the system to be built.

The general architecture of this research methodology can be seen in Figure 1.

2.1. Euclidean Distance Method

Euclidean Distance or Euclidean distance is the calculation of the distance from two points in Euclidean space. Euclidean space was introduced by Euclid, a mathematician from Greece around 300 B.C.E. to study the relationship between angle and distance. This euclidean is related to the Pythagorean Theorem and is usually applied to 1, 2 and 3 dimensions. Euclidean distance is the distance measured from the point of one coordinate to another coordinate point. Although this method is less realistic, but generally often used because this method is easy to understand and easy to model. Application from Euclidean distance we can generally find some
conveyor models, transportation and distribution systems. The formulation of Euclidean distance is as follows:

\[
    d = \sqrt{\sum_{i=1}^{k} (x_i - y_i)^2}
\]

where:
- \(d\) = distance between coordinate
- \(x_1\) = x value at the first coordinate
- \(x_2\) = x value at the second coordinate
- \(y_1\) = y value at the first coordinate
- \(y_2\) = y value at the second coordinate

The steps of the Euclidean Distance process can be seen in Figure 2.

The Bellman-Ford Algorithm

The Bellman-Ford algorithm is an algorithm that calculates the shortest path from a single point source (single source vertex) to all other vertices in a weighted digraph [9]. The Bellman-Ford algorithm calculates the shortest distance (from one source) at a weighted digraph. The point from one source is that the Bellman-Ford algorithm calculates all the shortest distances starting from one node point. The Bellman-Ford algorithm uses a time of \(O(V.E)\), where \(V\) and \(E\) are to state the number of sides and points. In this context, the weight is equivalent to the distance in a side [10].

In this study, Bellman-Ford is used to calculate the shortest distance from the route that can be traversed to the starting point to the destination point that is input by the user and produce the output of the shortest route to the destination.

Steps for calculating the Bellman-Ford algorithm:

a. Starting with filling the distance array \(d[]\) with an infinite value and starting vertex 1 is the initial vertex, then set \(d[1] = 0\).

b. Next fill in the previous array \(p[]\) with 0.

c. Then relax all sides of the graph as much as \(N-1\) times.

d. Do the \(N\)-loop to check whether the graph has a negative cycle.

\[
\text{relax}(u, v) \quad \text{if} \quad v.d > u.d + w(u, v) \quad \text{then}
\]

\[
v.d = u.d + w(u, v)\]

\[
v.p = u\]

Where:
- \(v.d\) = distance from source vertex 1 to vertex \(v\)

Figure 2. Euclidean distance steps
u.d = distance from source vertex 1 to vertex u
v.p = predecessor of vertex v
So, if there is a better way to go to vertex v then we update the distance and predecessor from vertex v (v.p).

3. Results and Discussion

System testing is carried out to check the performance of the components of the system in the Geographic Information System mapping the shortest route of Medan City MSME using the Bellman-Ford algorithm. The main purpose of system testing is to ensure that the elements or components of the system are functioning as expected. The system successfully displays information about the distance traveled and estimated travel time from the shortest route obtained using the Bellman-Ford algorithm. This system has an open nature where the admin of the system can add and update MSME data at any time. The system test results show that the system was successfully built which shows the location of all the MSMEs of Medan city by mapping the shortest routes. The proof of system testing can be seen in Figure 3 and Figure 4.

Figure 3. Mapping of Medan City MSME

Figure 4. Testing the shortest route
4. Conclusion

Based on the testing of the geographic information system mapping the shortest route of Medan City MSME, there were several conclusions, namely:

a. The application of the Bellman-Ford algorithm in completing the case of mapping the shortest route in the geographical information system mapping the shortest route of the MSME in Medan City can work well.

b. The system that is built makes it easy for the admin to retrieve the coordinate point data that is needed when you want to input it into the database.

c. The system still has less location data points, so the accuracy of determining the shortest path to the desired location is still less than optimal.

d. The system built has complete information, which includes information on MSME data along with turnover and assets, mapping the shortest route to the MSME and the distance traveled and estimated travel time.

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