Ambulance Management System using Web GIS for Determine Optimal Route of Emergency Rescue Based on Geospatial Data, GPS Technology and Shortest Path Algorithm

Ika Qutsiati Utami[1], Satrio Agung W., S.Kom, M.Kom[2], D.Sc. Fatwa Ramdani, S.Si.,[3]
[1,2,3], Information System, Computer Science Faculty,
University of Brawijaya, Jl. Veteran No.8 Malang

ABSTRACT
Ambulance is one of transportation mode that used to provide medical aid for victims of emergency situation. Management ambulance has a very important role to handling the emergency. It can affect the effectiveness of services such as response time and guarantee the safety of the victim. One management that can be set is the best route selection. The best route is a route that easily accessible by ambulance within a short time. Road network analysis only insufficient to determine the best route because every road has a level difference in terms of congestion, the condition of traffic lights, wide size, as well as the physical condition of the road if the road is in good condition or are inaccessible due to road damage. This study used dijkstra shortest path algorithm combined with geospatial data such as location of traffic lights, the physical condition data, the width of the road, and locations of traffic jams and traffic accidents. Geospatial data is processed in djikstra algorithms by changing all the parameters into units of distance (meters). The results of this study is the website of Geographic Information System (GIS) that capable to performing the management of the ambulance services and display the best route to reach the emergency and transport to the nearest hospital.

Keywords: Dijkstra Shortest Path Algorithm, Ambulance Management, Ambulance Route, Geographic Information System.

1. Introduction

Ambulance is one of the means of transport used to provide medical aid of emergency. Ambulance response time has a very important role in the handling of the emergency. The main cause of death of the victim at the time of the incident was how delayed medical attention [1]. One cause of delayed ambulance services because of errors in the handling of these elections.

Good service is a service that is easily accessible by ambulance with a short time. The problem that occurs is the density of population which make impact on traffic levels. One of them as happened in Malang city. The population of Malang city annually increased by 0.86%. In 2011 recorded a population of 894.653 inhabitants even in 2013 reached until 840.803 inhabitants [2]. Its descreasing population rate makes vehicles will also increase. This moment also make a traffic congestion every road segments more quickly, so that the ambulance delayed in reaching the location of emergency and take safety affection of the victim.

The next problem is the physical condition of the road. It's important to know how wide the street and whether the road is in good condition or not. Some segments of damaged roads can interfere the performance of the ambulance service and often the location of the jam. Pasha I. designing a prototype for management of the ambulance using network analysis to finding the road of emergency victims and how to transport the victims from the scene to a nearby hospital [3]. The network analysis to determine the shortest route only considered insufficient due to the characteristics of the road but exactly it has a level difference in terms of congestion, the condition of traffic lights, wide roads, as well as the physical condition of the road.

Ambulance management system to determine the best route using geographic information is very important because in term of emergency handling, health officials require precise position of victims. With geographic information, the system can display the location of the victim with geographic coordinates using Global Positioning System (GPS). A coordinates will be processed using the method of hortest path algorithm and coupled with geospatial data such as density data and road wide in order to obtain the best service. Malang have been selected for this research because three areas of the highest accident rates in East Java, Malang city is in 3rd position after Surabaya and Kediri city [4], so that Malang has a high possibility of emergency occurence.

2. Theoretical and empirical foundation

2.1 Emergency

Emergency is a situation where someone needs a help quickly and accurately. Delays can help lead to endangerment of a person's health both the safety of lives and physical condition. The causal factor of

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emergency incidents such as canflagration, sinking ships, planes crash and others. Traffic accidents are the main cause of the victims death on the highway [5]. Generally, emergency response time is 10 minutes. The rest will have an impact on the safety of the victim's life.

2.2 Google Maps API

Google maps is a web-based online service that serves map of entire region in the hemisphere, with more than 800,000 sites using googlemaps API. There are some features provided by googlemaps API include geocoding API that allows users to convert addresses into geographic coordinates and geolocation to determine the geographic coordinates of an object [6].

2.3 Global Positioning System

Global Positioning System is a positioning system of object with the help of a satellite system. First developed by the US Defense Department and used for military and civilian purposes (surveying and mapping). GPS systems or named NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning), consists of three segments, namely satellites, controller and receiver [7].

2.4 Djikstra Algorithm

Dijkstra's algorithm is an algorithm which applied to determine the shortest path in a number of steps that are sourced from one node to a graph. Knot on Dijkstra should not have a negative value. The analysis was performed by examining the node with the smallest weight and put it into the solution sets. The initial search (origin node) requires knowledge of all the trails and weight, so that it will make exchange of information with all the vertices. Dijkstra Algorithm has properties that are simple and plates (straightforward), in accordance with the principles of greedy [8].

Dijkstra's algorithm determining the shortest path to resolve the case with a weighted graph G = (V, E). The shortest distance is obtained from the two points if the total weight of all the nodes in the network is the most shortest or has minimal value. Some notation used and an explanation are described in Table 1:

Table 1. Djiktra Notation

Notation	Description
l(i,j)	Length from node *i* to node *j*
A	Initial Node
d_{ai}	The permanent shortest path from initial node to node (*i*) on the graph
q_i	Previous node as a shortest path from initial node to node (*i*) on the graph
C	The last permanent node

Calculation steps of Dijkstra's algorithm are as follows:

1. The process starts from the starting point (a), daa = 0. Then the point that the only thing permanent is the point a. And another point labeled and filled with infinite initials.
2. Check out the branch point of the last point which is permanent by equation 1:
   dai = min [dai, dac - 1 (c, i)] .... (1)
3. Determine the point which will pass from the label while being a permanent label by comparing the value of a point from the second step and take a minimum point value. Then determine the value of the previous permanent point, enter into the equation 2:
   [dai-l (i, j)] = dai .... (2)
4. After getting the point with the minimum value, the minimum-value point that is designated as the next permanent point.
5. If there are points that have not been labeled permanently then repeat from step 2.

3. Methodology

3.1 Literature Study

Literature study conducted to gain knowledge about the application of algorithms Djikstra using geospatial data. It would also require a greater understanding of the googlemaps API. The study of literature is done by reading books, scientific journals and other sources.

3.2 Data Collection

Collecting hospital data is done by observation process at a health center in Malang. Hospital data is then processed to obtain the geographical coordinates of the hospital. Road density data such congestion and traffic accidents points as well as the physical condition of the road is obtained from the results of observations in Malang Police Office. In addition to knowing the level of traffic congestion points, it also required traffic lights obtained from the data extraction process using Quantum GIS. Other data collection is a data density of the road. Road density data obtained by defenition of road width by categorizing the type of street. All data is converted into the weight and will be processed on Djikstra algorithm.

The geographic location of emergency is identified by geolocation and geocoding function. Both of these functions are provided by Google Maps API to permit access to the location of user. The first step in the implementation of geolocation is to add the type scripting javascript in the head tag of HTML pages. If the browser supports javascript then the next step is to run the function getCurrentPosition (). This method returns the coordinate object specified in the parameter showPosition. ShowPosition function is used to display the latitude and longitude coordinates

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of the location of victims. Geocoding is a googlemaps API feature to transform an address into latitude and longitude format. For example address Sumbersari road converted into (-7.797224, 112.36879).

Road density data is divided into four, namely, the traffic lights data, physical condition of the road, congestion points and sensitive location data of accident. A physical condition of the road, congestion points and sensitive location data of accident are formed on tabular data obtained directly from the observation. Sensitive location data of traffic jams and traffic accident in Malang are shown in Table 2:

Table 2. Sensitive location data of traffic jams (TJ) and traffic accident (TA)

No.	Nama Jalan	Kategori
1.	Jln. S. Supriadi	Sensitive TA
2.	Jln. Ki Ageng Gribig	Sensitive TA
3.	Jln. S. Priyo Sudarmo	Sensitive TA
4.	Jln. Kolonel Sugiono	Sensitive TA
5.	Jln. Ahmad Yani	Sensitive TJ
6.	Jln. Letjen S. Parman	Sensitive TJ
7.	Jln. Letjen Sutoyo	Sensitive TJ
8.	Jln. JA. Suprapto	Sensitive TJ
9.	Jln. Basuki Rahmat	Sensitive TJ
10.	Jln. Borobudur	Sensitive TJ
11.	Simpang 4 L.A Sucipto	Sensitive TJ
12.	Jln. Tlogomas	Sensitive TJ
13.	Simpang 3 Gajayana	Sensitive TJ
14.	Simpang 3 Sardo	Sensitive TJ
15.	Simpang 4 ITN	Sensitive TJ
16.	Simpang 4 Soekarno Hatta	Sensitive TJ
17.	Simpang 3 Kacuk	Sensitive TJ
18.	Simpang 4 Gadang	Sensitive TJ
19.	Jln. Pasar Besar	Sensitive TJ
20.	Jln. Agus Salim	Sensitive TJ
21.	Jln. Basuki Rahmad	Sensitive TJ
22.	Simpang 4 Ranu Grati	Sensitive TJ
23.	Jln. G. Subroto	Sensitive TJ
24.	Jln. Muharto	Sensitive TJ
25.	Jln. Mayjen Sungkono	Sensitive TJ

Density data is the width data of the road is defined by categorizing it. Categorizing width of the roads are indicated by Table 3:

Table 3. Categorizing Road Width

Road Type	Estimation Width
Highway	10 metres
Artery	8 metres
Local	6 metres

3.3 Transforming parameter into weight

Each road which connected by two points (nodes) has a weight value in the form of distance. The next step is how to transform all parameter data into weight that would be used in the calculation of algorithm. Weighting based on a combination of data. Data weighting in Table 4, 5, and 6:

1. Highway road

Road Criterion	Weight (m)
Width 10, Damaged roads	100
Width 10, Flow Congestion	100
Width 10, Accident Prone	100
Width 10, Damaged roads, Flow Congestion	200
Width 10, Damaged roads, Accident Prone	200
Width 10, Flow Congestion, Accident Prone	200
Width 10, Damaged roads, Flow Congestion, Accident Prone	300

2. Artery road

Road Criterion	Weight (m)
Width 8, Damaged roads	100
Width 8, Flow Congestion	100
Width 8, Accident Prone	100
Width 8, Damaged roads, Flow Congestion	200
Width 8, Damaged roads, Accident Prone	200
Width 8, Flow Congestion, Accident Prone	200
Width 8, Damaged roads, Flow Congestion, Accident Prone	300

3. Local road

Road Criterion	Weight (m)
Width 6, Damaged roads	100
Width 6, Flow Congestion	100
Width 6, Accident Prone	100
Width 6, Damaged roads, Flow Congestion	200
Width 6, Damaged roads, Accident Prone	200
Width 6, Flow Congestion, Accident Prone	200
Width 6, Damaged roads, Flow Congestion, Accident Prone	300

Weighting based on the number of traffic lights contained within one road section is calculated as the average speed by using the speed of the ambulance is 60 km / h. Using the distance formula, the obtained distance pending to reach the location of emergency. Here's an example of use in a road with a traffic light:

Speed : 60 km/hour
Delayed Time of Traffic Light : 1 minute
Distance : 60km/60minute x 1 minute : 1 km

Thus, if in the road are more than one traffic lights then pending distance multiplied by 1 km. This value can be used as addition weight in the calculation of algorithm.

3.4 Algorithm Implementation

The initial process at this stage is to conduct digitized road network of the city of Malang. The road network is used as a graph that will be processed in Djikstra algorithm. All steps in the process of implemention of algorithm can be viewed in Image 1.

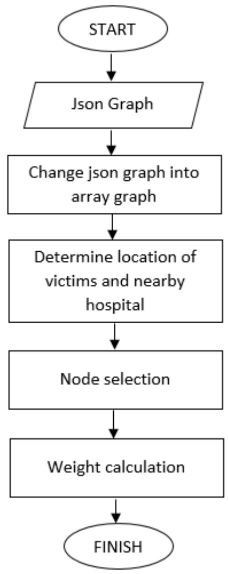

Image 1. Flowchart of Algorithm Implementation

4. Result

The result from this study is a Web GIS to determine a management of the ambulance service in the city of Malang to give the best service in emergency resque. The result is web GIS using Djikstra algorithm combined with all of the parameter data. The following are the results of the interface system:

4.1 Homepage

The starting page also serves as a B-Helper feature where users can make a complaint and use button panic that has been provided.

Image 2. Homepage

4.2 E-Helper Page

E-Helper is an interface that serves to make a complaint using a emergency form. Users are asked to input data such as location data.

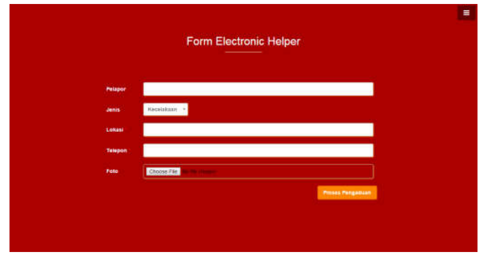

Image 3. E-Helper Page

4.3 Victim Management Page

This page is an interface for admin to manage data of victims. Management is divided into four activities, namely to add, delete, modify and view details of casualty.

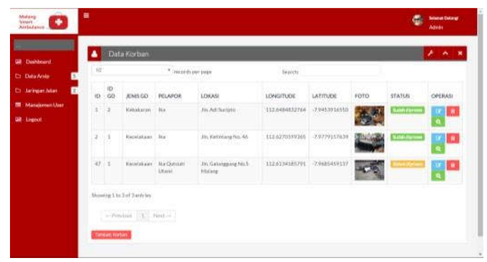

Image 4. Victim Management Page

4.4 Hospital Management Page

Hospital management page is an interface for administrators to perform management data of hospital.

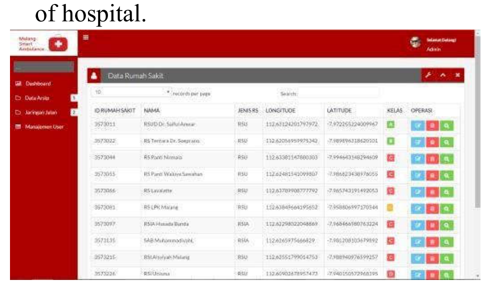

Image 5. Hospital Management Page

4.5 Routing Map Page

Routing Map is an interface for the emergency that process data into the optimal path. On page users can see the details of the road like directions.

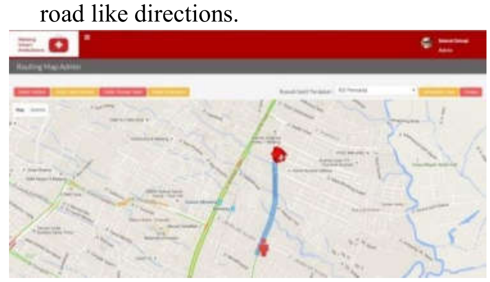

Image 6. Routing Map Page

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5. Discussion

Suggestions are given for future research are discussed below:

1. Other ways to define shortest path in reverse road.
2. Other ways to incorporate geospatial data parameters to the algorithm Djikstra.
3. Further analysis on the effectiveness of Djikstra algorithm used in this study.

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