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DEVELOPMENT OF LOCATION-BASED EMERGENCY MOBILE APPLICATION DURING DISASTER WITH HAVERSINE FORMULA AND QGIS

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ABSTRACT
Emergency cases in disasters are problems that must be handled quickly because they involve the safety of someone's life. This study aims to produce a mobile application that can be useful for evacuation, search, and rescue in emergency cases. The application we produce is useful for finding the nearest distance to emergency services, such as: hospitals, police stations, and other emergency assistance. This closest distance is calculated using the Haversine formula, which takes into account the longitude and latitude coordinates between two locations. The coordinates of a location are generated from map data from Google Maps and Quantum Geographical Information System (QGIS). There are six main modules in this mobile application, namely: Share Location, Nearest Hospital, Nearest Police, Emergency Call, Follow Me, and About Me. The test results of this application show that the Haversine formula calculation is in accordance with the distance indicated by Google Maps. This study still needs improvement in terms of determining the optimal route that is integrated with other methods, as well as the addition of features such as emergency alerts and warnings.
Keywords:emergency, disaster, shortest path, Haversine, mobile application, QGIS

1. Introduction.

Handling emergency cases requires a swift response in order to save lives. Emergency cases can occur in various ways, such as evacuating and rescuing disaster victims, handling someone suddenly attacked by an illness, and others. This study contributes as an application for handling emergency cases within the shortest distance to find help in case of emergencies. In emergency cases, a person must be treated quickly, so an application is needed to determine the nearest health or other emergency facilities, such as: police station, ambulance, that can be reached.

In this reseach, we focus on emergency cases which caused by disasters, such as floods, earthquakes, tsunamis, etc. Emergency management for disaster is a process that engages several stakeholders to cooperate and coordinate with each other [1]. The author in [2] mentions that emergencies happen in three phases: hazard, ongoing hazard effects, and ceased hazard effects. Related to emergencies, there are three types of pre-disaster response activities, i.e., (1) warning and evacuation, (2) prepositioning of resources, and (3) last-minute mitigation and preparedness [2].

There are various research utilizes technologies to enhance evacuation operations. Authors in [1] and [3] have started their research on disaster management, especially on evacuation, search, and rescue activities during and after disaster. Authors in [1] propose a peer-to-peer model to support collaborative resource sharing using trust and reputation concept; while in [3] they develop mobile application to assist search and rescue operations using Mobile Ad-hoc Network (MANET) to enable communication and coordination among mobile devices in emergency cases.

In this research, we develop a mobile application to support evacuation, search, and

rescue operations during and after a disaster. The method used in this study is to find the shortest path with the Haversine formula which calculates the distance with a mathematical equation based on longitude and latitude coordinates.
This article is divided into several sections; section one is an introduction, followed by related works in section two. Section three is a discussion of the Haversine method and how it works, while section four is the results and discussion of the application. Section five is the conclusion and suggestions from our research.

2. Methodology

There are several researches as solutions for finding shortest path in cases of disaster and emergency are discovered in the literatures. We summarized the related works as follows:

1. Nyaung and Yamaguchi [4] develop an application for reporting location-based services emergency cases in Myamnar using Quantum Geopgraphical Information Systems (QGIS) dan Djikstra algorithm. Their system applied client-server system with features: report the emergency case, calculate shortest route, and send the report to the relevant agency.
2. Sumaryo et al [5] build an application using Djikstra and Haversine method for mountain climbing route in order to find closest basecamp in case they have emergency cases (i.e. bad weather or critical health condition). Their research takes mountain Merapi climbing route located in Indonesia as a case study.
3. Rai et al [6] develop an application called as “Save Here” as medical emergency assistance in India. This application is calculated based on Euclidian distance by measuring the nearest medical facilities based on real-time location. The patient also can ask for medical emergency assistance and find nearest Ambulance driver.
4. Chen et al [7] accomplish path optimization study for vehicles evacuation for emergency cases. The path optimization study is performed in three different cases by utilizing Djikstra algorithm.
5. Jaya et al [8] develop an application to find nearest healthcare services using Haversine formula and Djikstra algorithm. They named their application as “Find Medical”.
6. Yogaswara and Suhartono [9] compare two different algorithms, i.e.: A star and Djikstra, in order to find shortest path for evacuating tsunami victim in Bantul, Indonesia.
7. Anisya and Yogaswara [10] implement Haversine formula and Best First Search (BFS) Method to discover evacuation route in pre-disaster Tsunami. They built an application using Haversine formula to find the nearest shelter so that they can reduce the number of victims due to the Tsunami disaster.
8. Sein et al [11] apply Haversine Formula, Djikstra algorithm, and Quantum Geographical Information System (QGIS) to find nearest emergency services and finding optimum route for fire-fighters vehicle in Yangon-Myanmar. The effective evacuation route selection is very important because the road infrastructure and network in Yangon-Myanmar is very complicated.

Table 1 below summarizes our findings of related works for finding shortest path in case of emergency.

Table 1. Summary of related works

Authors	System/ Application	Method used
[4]	Emergency case reporting location-based services in Myanmar	Djikstra algorithm, QGIS
[5]	Emergency cases reporting finding nearest basecamp in a mountain climbing route in Indonesia	Djikstra algorithm, Haversine formula
[6]	Medical emergency assistance application based on real-time location in India	Euclidian distance
[7]	Path optimization study for vehicles evacuation in emergency events	Djikstra algorithm
[8]	Application to find nearest healthcare services in case of emergency	Haversine formula, Djikstra algorithm
[9]	Application to find shortest path for Tsunami evacuation in Indonesia	Djikstra algorithm, A star algorithm
[10]	Application to find evacuation route and nearest shelters for Tsunami evacuation in Indonesia	Haversine formula, BFS method
[11]	Application to find nearest emergency services and optimal route for fire-fighter vehicle in Myanmar	Haversine formula, Djikstra algorithm, QGIS

Haversine formula is an important equation in navigation, where this formula gives the distance between two points on a circle of a sphere from each longitude and latitude [12]. There are several authors use Haversine formula to find shortest distance in terms of emergency cases [5, 7, 8, 10, 12]. This shows that Haversine formula is popular and relevant to be implemented in such emergency cases.

Meanwhile, according to authors in [12] integration of Haversine Formula, Google Map, and GIS is very useful and relatively easy method to determine the distance between two points by taking into account that the earth is not a flat plane but is a plane that has a degree of curvature. This case is a special case of a more general formula in circle trigonometry, the haversine formula connects the sides and angles of a spherical triangle.

The haversine formula in calculating the distance will use two GPS points. The two points are the user's GPS point and the destination GPS point, so that they become the main reference points in comparing distances to determine the closest distance. The haversine formula method is used to calculate the distance between points on the earth's surface using

latitude and longitude as input variables. The formula is worked as follow.

Given two points:

- Point 1: Latitude lat1, Longitude long1
- Point 2: Latitude lat2, Longitude long2

The Haversine formula for the distance between these two points is:

$$\Delta lat = lat2 - lat1 \quad (1)$$

$$\Delta long = long2 - long1 \quad (2)$$

$$a = \sin2(\Delta lat/2) + \cos(lat1).\cos(lat2).\sin2(\Delta long/2) \quad (3)$$

$$c = 2.\text{asin}(\sqrt{a}) \quad (4)$$

$$d = R.c \quad (5)$$

where:

R = the radius of the earth is 6371 (km)

Δlat = magnitude of change in latitude

Δlong = magnitude of change in longitude

d = distance (km)

1º = 0.0174532925 radian

From the formula above, we can see that Haversine Formula gives the distance between two points on a circle of a sphere based on each longitude and latitude. To use the haversine formula to calculate the distance between two points on a sphere, the calculation is given as below:

1. Convert the latitude and longitude coordinates of the two points into radians.
2. Calculate a.
3. Calculate c.
4. Calculate d (distance between two points).

Here is an example of the calculation of the haversine formula method. For example the user location has coordinate of Latitude -6.2088° and Longitude 106.8456°. We would like to find out the distance between the user location and nearest hospital (for example: RSCM Hospital) with Latitude -6.18083°and Longitude 106.84611°.

To calculate the distance between user current location in Jakarta, Indonesia and the nearest hospital using the Haversine formula, we present the calculation in table 2 below.

Table 2. Calculation between two locations with haversine formula

Number of step taken	Calculation	Result
1	Convert degrees to radians	lat1= - 0.1083 radians lon1= 1.8658 radians lat2=-0.1079 radians lon2=1.8658 radians
2	Compute differences	Δlat = 0.0004 radians Δlon = 0 radians

3	Apply Haversine formula	a = 0.00000004 c = 0.0004 radians d = 2.5484 km
4	Get the distance between two points	d = 2.55 km (approximately)

As we can see from the result in table 2 above, we get the distance between two coordinates is approximately 2.55 km. In this research we integrate the Haversine formula with QGIS and Google Map to get the coordinates information. The free and open-source software Quantum Geographic Information System (QGIS) is well suited for such an analysis. Author in [13] mentions that QGIS suitable to find network maps of certain areas [13].

3. Results and Discussion.

In this sub-section, we present our proposed application by developing and testing the calculation using Haversine formula. There are 6 main modules in the mobile-based application that we developed, namely:

1. Share Location Module. This module is useful for providing information on the location coordinates of the user.
2. Nearest Hospital Module. This module is useful for providing information on the nearest hospital/health facility from the user's location. The distance between the user and the hospital/health facility is calculated using the Haversine Formula.
3. Nearest Police Module. This module is useful for providing information on the nearest police station from the user's location. The distance between the user and the police station is calculated using the Haversine Formula.
4. Emergency Call Module. This module is useful for providing information on important telephone numbers during emergencies, such as ambulances.
5. About Me Module. This module is useful for providing information about the user's profile.
6. Follow Me Module. This module is useful for providing information on social media used by the user.

Figure 1 shows the architecture of the system, while figure 2 describes the workflow of the system.

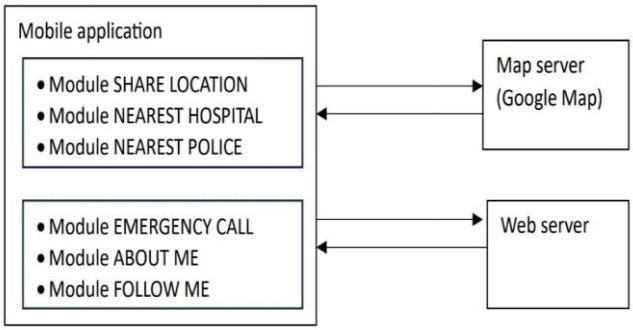

Fig 1. Architecture of the system

As we can see in figure 1, that module Share Location, Nearest Hospital, and Nearest Police are request to and get response from Map Database (Google Map and QGIS). Those modules need to get coordinates of location from the map. While the other three modules, i.e.: Emergency Call, Follow Me, and About Me are simply do not require response the location's coordinates from the map.

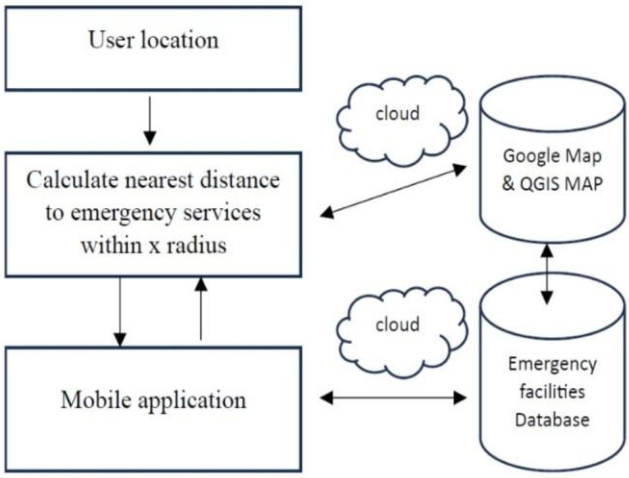

Fig 2. The workflow of the system

Figure 2 presents the workflow of the system in more detailed. Emergency facilities information and details, such as: hospital or medical facilities information is placed in Emergency facilities database. The information then will be showed in the application. Figure 3 shows the interface of the application's features.

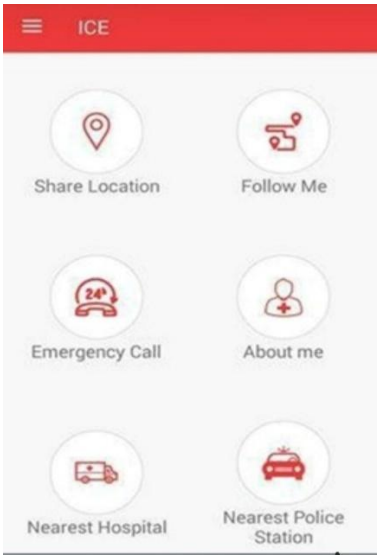

Fig 3. Interface of the application (1)

The next step in this research is to perform testing on the application related to the calculation of the distance between two points. This calculation assumes a spherical Earth and provides an approximate distance. Actual travel distance may vary based on the specific route taken. We present the calculation results in table 3 to find nearest hospital or healthcare services within 1 km from the user's location. As we can see from table 3, we find four healthcare services within 1 km from user's location, i.e. Puskesmas CB, Klinik P, RS IJ, and Klinik C. All healthcare services and user's location are located in Jakarta, Indonesia. We then get the location's coordinates, as User latitude and longitude, and MS latitude and longitude. As we can see from the calculation results, the nearest healthcare services is Puskesmas CB with distance approximately 0.36 km from the user's location.

Table 3. Testing result of calculation between two locations with haversine formula

User latitude	User longitude	Medical services (MS)	MS latitude	MS longitude	Distance (km)
-6.1710800	106.8631070	Puskesmas CB, Jakarta, Indonesia	-6.171854	106.859870	0.36
		Klinik P, Jakarta, Indonesia	-6.169728	106.869825	0.76
		RS IJ, Jakarta, Indonesia	-6.170677	106.870882	0.86
		Klinik C, Jakarta, Indonesia	-6.174722	106.860273	0.51

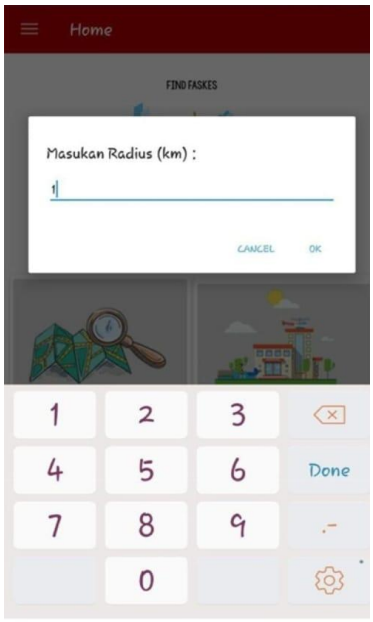

Fig 4. Interface of the application (2)

Fig 5. Interface of the application (3)

To check if the application work accurately as the calculation result, we run the application, as presented in figure 4 and 5. Figure 4 shows the radius selected by user is 1 km within the user's location. While figure 5 shows the result of the nearest healthcare services, which is calculated same as the calculation in table 3. The distance between user location and nearest healthcare facilities within radius 1 km, result in 0.36 km. This result is exactly same as what we expected through manual calculation using Haversine formula.

4. Conclusions

This research has successfully developed a mobile application to support evacuation, search, and rescue operations during and after disaster. We test our application to find nearest emergency services, such as healthcare facilities, using Haversine formula. The result shows that the calculation between two locations is the same as the result provided by Google Map. However, we still need some improvements related to real-time route selection to be integrated with other method. For further research, we should add more features, such as emergency alerts and warning.

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