Rural Road Mapping Geographic Information System Using Mobile Android

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Abstract

Road is a land transportation infrastructure which is used to connect one place to another. Since there are many roads in every province, it is a requirement for the government to conduct a road data collection. All this time the data collection is still conducted manually, therefore it is very complicated to do by considering the length of road that will be collected. A convenience in conducting the road data collection is important for efficiency and accuracy of the data. By utilizing GPS technology on smartphone, the road data collection can be conducted efficiently. Mobile GIS uses GPS to search for a location. This paper discusses about the system used to conduct road data collection which gives information about the name, length, condition of the road, as well as the type of road surface.

Keywords: mobile GIS, rural road, GPS, android, haversine formula, Google maps

1. Introduction

Rural road is transportation infrastructure which connects one settlement or small community to another and has a boundary between both of them. The road data collection tends to conduct manually such as measuring directly with using a manual length measurement device known as walking wheel. Road has its component such as length, surface, and condition of the road. Road surface which is meant referring to the structure of road in the form of asphalt, rocks, or soil, while the road condition which is meant referring to whether it is smooth road, damaged or in repair.

GIS (Geographic Information System) is a technology used as basic analysis tool for mapping which provides an effective platform for spatial data and database manipulation [1][2].

Development of application by utilizing Google Maps as platform and integrating spatial data from variety of sources to create service has revolutionized online mapping application in internet. Google Maps was introduced in 2005 which provides application mapping service in World Wide Web. In addition, Google also provides source code which is known as Application Programming Interface (API) that can be used by programmer [3]. Google Maps which is operated on smartphone being used by more than 54% users. This enables the users explore the map that provided by Google [4].

This paper discusses the convenience of road mapping which is conducted using system that utilizes Google Maps and GPS applied on the Android Smartphone. Displayed data is the data of road in the form of polyline which is saved in the database. Information is given in the form of length of road, condition of road and type of road surface.

2. Haversine Formula

Haversine formula is an equation in navigation which is used to calculate the distance between two points on sphere by using the longitude and latitude [5].

$$d = 2r\arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right) \tag{1}$$

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d is distance between two points which each point has longitude and latitude (λ, φ) and *r* is the radius of the earth [5]. Haversine formula is better used on GIS application because this formula considers earth in the form of ball by eliminating factor that the earth is slightly elliptical (ellipsoid factor) [6][7].

3. Mobile GIS

Mobile GIS is defined as mobile device which is capable displaying geospatial data, receiving, processing, and taking the requests of phone users. Mobile GIS can be divided into two types according to the way to access the data and the collection of information these are Field-based GIS and Location-based Services. Field-based GIS focuses on data collection, data validation, and update data in the field, such as adding new point coordinate or changing the table attribute from the data that has already existed. The Location-based services focus on management of location as navigation, road route, finding a specific location, and vehicle tracking [8].

4. GPS (Global Positioning System)

GPS is a global coordinate system that can determine the position coordinate of object anywhere on the earth either it is longitude, latitude or altitude [9]. GPS can be used as an efficient alternative to obtain spatial data automatically and in real time [10]. In this paper GPS is used for capturing coordinate point of polyline or commonly called path.

There are some reasons of using GPS; it can be used everywhere and anytime, information of position which is captured has good accuracy and easy to use [11].

5. Calculation of Haversine Formula

The calculation of road length is done by using two waypoints or two starting point coordinate at the time of road network created and end point coordinate at the time of road network is completed.

Example of the calculation of a road network by knowing the starting and end point coordinate (latitude and longitude).

Starting coordinate (latitude and longitude):

ϕ_2 = 36.12
λ_2 = -86.67

End coordinate (latitude and longitude):

ϕ_1 = 33.94
λ_1 = -118.40
r = 6372,8 (km)

Answer:

$$d = 2r\arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right)$$

$$d = 2(6372.8)\arcsin\left(\sqrt{\sin^2\left(\frac{36.12 - 33.94}{2}\right) + \cos(33.94)\cos(36.12)\sin^2\left(\frac{-86.67 - (-118.40)}{2}\right)}\right)$$

$$d = 2(6372.8)\arcsin\left(\sqrt{0.0504440249}\right)$$

$$d = 2887.25995$$

The road length is 2887.25995 kilometer.

6. System Overview

System design contains system overview of created system and structure of database used.
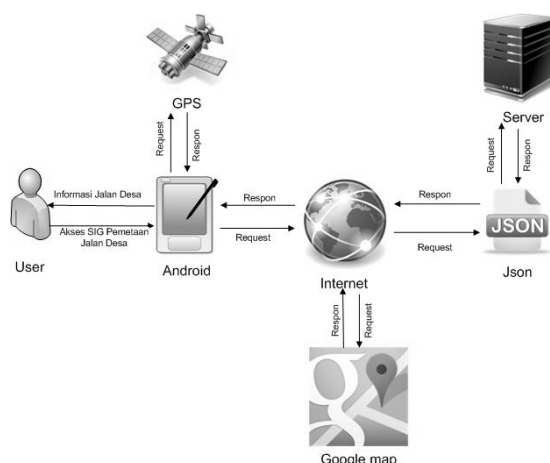

Figure 1 System Overview

Figure 1 is an overview of how this application system runs when it is used by the user. Process of displaying maps on the application utilizes maps which are provided by Google. The process of displaying maps definitely needs internet connection. Database of this geographic application must have global characteristic, therefore it must be handled with the use of web server. The process of accessing database on the web server can not be done directly, due to the use of different programming languages. Process of determining the coordinate accurately, this application

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utilizes the technology of GPS (Global Positioning System).

6.1 Context Diagram

Context diagram is diagram consists of a process and describing the scope of a system. The context diagram is the highest level of DFD which describing all input to the system or output from the system. The context diagram contains overview (an outline) of system which will be created. In this context diagram proceeds process of giving and receiving data from various entities which all processed in the geographic system module.
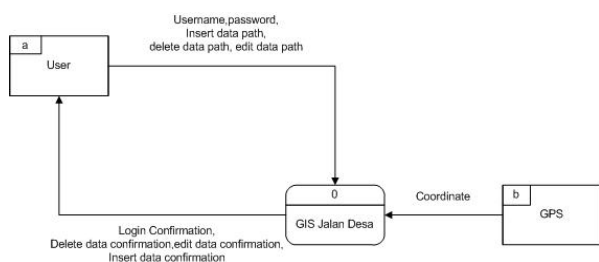

Figure 2 Context Diagram

Context diagram in the figure 2 has two entities and one process business, and the following will be explained about some entities found in the figure 2:
1. User Entity
   User entity is the user of this Geographic Information System. The process occurs in both directions from entity and system, starting from observing, adding, and renewing the rural road data.
2. GPS Entity
   GPS Entity is related to this Geographic Information System. This GPS entity occurs in one direction. This GPS entity has function of determining user coordinate when they use this system for doing addition of the rural road data.

6.2 Database Design

Table structure which is used on database of the Geographic Information System of rural road mapping is shown in the figure 3.
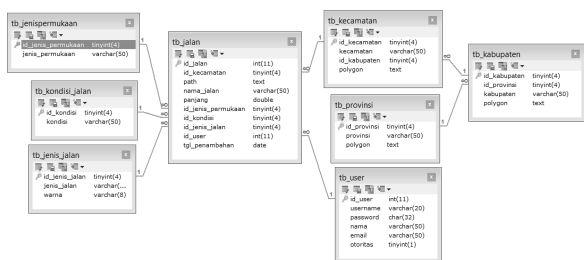

Figure 3 Database Structure

Figure 3 is database structure in the form of diagram scheme, which contains the table of road, sub-district, district, province, road surface, road condition, type of road, and user.

6.3 Application Testing

Geographic application which has been done designed must be tested. Test is important phase for programmer to discover the errors in the writing process or the other.
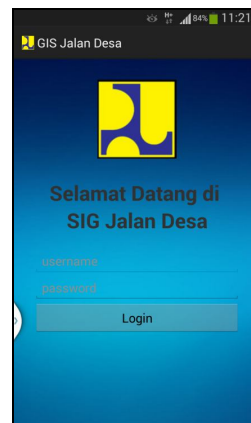

Figure 4 User Login

Figure 4 is form of user login. The user is required to do login first for being able to access this geographic application.
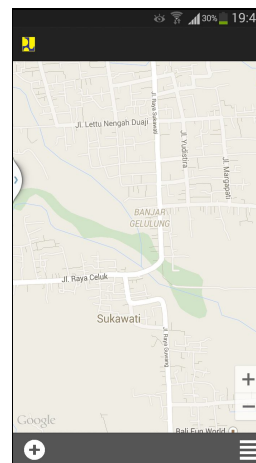

Figure 5 User Page

Figure 5 is user page that will be displayed after the login is successful. There are several menus on the action bar that are *tambah*, *data jalan*, *notifikasi* and *keluar*.

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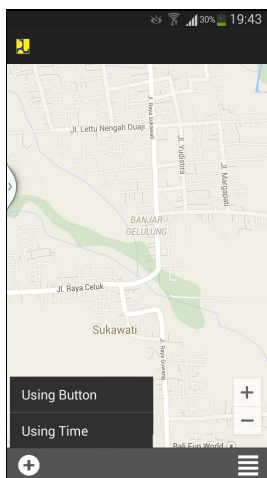ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
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Figure 6 Choice of Road Coordinate Determination

There are two choices of determining road coordinate; by using 'using button' or 'using time'. The two choices have similar purpose despite they have rather different ways. Mapping by using 'using button' requires the user always pressing button 'get' at the time of determining new coordinate. In other words the user must give more attention to the application when determining road coordinate. The coordinate determination by using 'using time' is rather different than using 'using button'. The coordinate determination by using 'using time' does not lead the user pressing 'button get' at the road point every time, by using 'using time' the user simply goes along the road and the application will determines the road coordinate using time interval. Time intervals which used in this application are 5 s, 10 s and 15 s, so that the application will determines the road coordinate every 5 s, 10 s or 15 s.
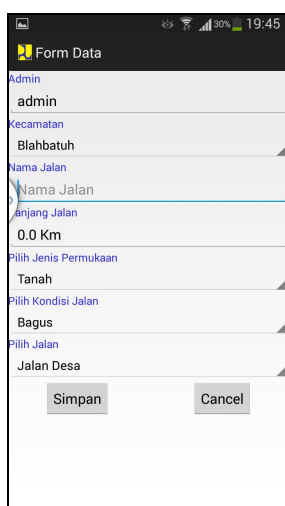

Figure 7 Road Collection

Required data of this application entered in the form of road collection. All required data must be input. Data input of road length is designed read-only (it can be read only but cannot be modified) by the application because the road length will be automatically calculated at the time of road coordinate determination.

Process of road coordinate determination is the first phase of data collection process. The addition of data related to new road can be done when road coordinate determination has been completed to do, and if all data have been added then the last phase to do is to store the data in to server.
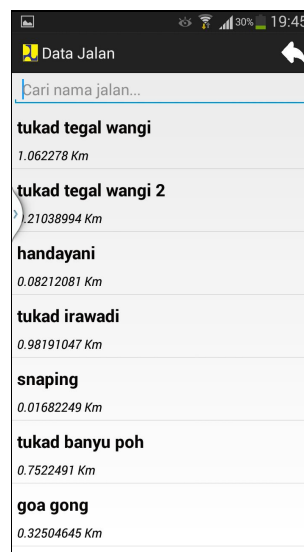

Figure 8 Road List

Page *Data Jalan* displays data of road; name of road and length of road. In this page the data of road are displayed in one page. This Geographic Application provides feature to display road position you want to see and connects with road which is uncompleted to be mapped. The display of feature can be seen in figure 9.

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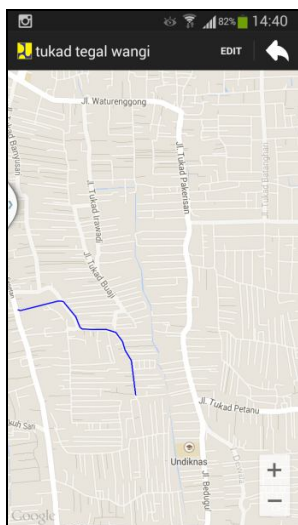www.IJCSI.org

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Figure 9 Chosen Road Editin

Edit button as shown in the figure used for starting road connecting process. At the time of connecting of road the user required staying at maximum distance 10 meters from last point of road which previously has been mapped and when the user far from the last point of the road. Determination of each road coordinate is done with two ways as at the process of road addition that is by using 'using button' and 'using time'. After the connecting of road is done, the road coordinate will be stored directly to the server.

7. Time Interval Analysis of Road Mapping

Road mapping by using 'using time' enables the user to determine road coordinate based on time interval. This Geographical Application provides 3 time intervals for the road coordinate determination; 5 s, 10 s, and 15 s. Test is done with measuring the mileage by time interval provided.

Table 1: Mileage

No	Time intervals	Distance
1	5 s	40 meters
2	10 s	68 meters
3	15 s	169 meters

The distance of 40 meters of time interval 5 s is good enough to be the distance of each road coordinate. With this distance, each related point is near enough so that the road view on the map becomes more detailed and required memory is not large.

The use of time interval 10 s makes longer distance than using time interval 5 s. The distance of 68 meters is

considered not to long from each road coordinate. The distance of 68 meters is not as detail as 40 meters however it is still well visible on the map.

Test uses time interval 15 s makes longer distance than using time interval 5 s and 10 s, with this distance the road view becomes not detailed as the results obtained by using the interval 5 s and 10 s. Time interval 15 s accepted as an alternative that can be used to the road with high traffic density. It also uses less memory but obtains the same result as using
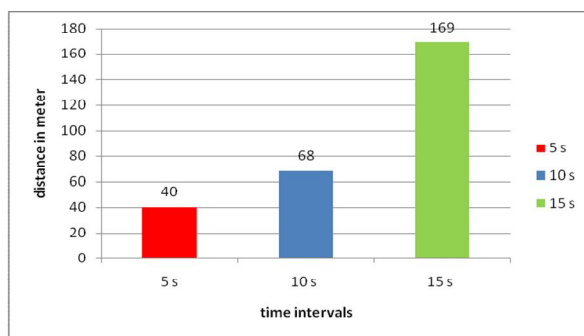

Figure 10 Mileage by Time Interval

Table 1 and Figure 10 Determining Mileage Based on Time Interval.

8. Conclussions

Rural Road Mapping Geographic Application using Mobile Android is an application which can performs the process of coordinate determination in real-time by using technology of GPS therefore the user can determines road coordinate of actual location and simultaneously observes the condition of road directly (in the field).

Road mapping is the main feature of this Geographic Application. Road mapping first done by determining road location that will be the starting point of the road, then continued by determining the other road point which done with two way; by using 'using button' or 'using time'. Overall, this application has been successfully performs the road mapping and the analysis of distance obtained by the time interval determined.

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