IJCSI International Journal of Computer Science Issues, Volume 13, Issue 4, July 2016
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org http://dx.doi.org/10.20943/01201604.8389

Android Navigation Application with Location-Based Augmented Reality

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Abstract

Navigation has become a common system used by a number of smartphone users. Needs of a precise, fast, and accurate route are the main points of a navigation system. Along with technology advancement, a new navigation system which is easy to use, less resource hungry, and technologically up-to-date is needed. Therefore, this Navigating Application with Location-Based Augmented Reality is made. This application is based on Android Operating System with Augmented Reality technology and API from Google Maps service. This application is able to ease users in doing many location-based works, such as navigation and Point of Interests search. Navigation and location search feature is able to shown in Augmented Reality technology. Augmented Reality in navigation is able to increase user's safety while riding or navigating, due to user's ability to still look at the road via camera while checking navigation information in the application.

Keywords: *Navigation, Augmented Reality, Android, GIS, GPS.*

1. Introduction

Location-based data and information are becoming more important these days. Many things can be done with those data and information, such as finding a route, finding each other location, socializing, and many more.

Many problems regarding location still happening until today, even though technologies are always developing. Trouble finding route and hard to find the exact location of one place are some frequent problems about location and navigation. If only current technology is used and developed properly, then those many problems regarding location and navigation can be solved easily.

Android Navigation Application with Location-Based Augmented Reality is made to simplify many users need for navigation to desired places. This application is able to show many Augmented Reality objects which can help users determining routes that they need in order to get to the destination. Those objects are shaped like dots along the road that they need to follow. Along with many road signs that will help users in navigating their way. Many other information are also available in the application such as distance, estimated duration, start / stop address, and many more.

2. Related Work

Many researches and applications about location-based service and Augmented Reality have been made. Some of them even had successful in combining location-based service and Augmented Reality, even though there were some limitations to the tools or hardwares that needed. Kumar et al conducted many usages of location-based service on Android smartphone. According to his paper, there are many different usages of location-based service, such as in emergency service, medical/health service, games, and in navigation.[1] Singhal et al implemented many location-based services in Android such as Location API, Places API, and Public Transportation API. Google's webservices are also used in the implementation. Those implementations is done using Android Éclair 2.1. There are three constraints about location-based service, Technology Constraint, Infrastructure Constraint and Market Failure.[2] Alappanavar et al conducted a research about Location-based Augmented Reality concepts named Six-degree of Freedom. Six-degree of Freedom concepts means Location-based Augmented Reality can be represented in six point of view.

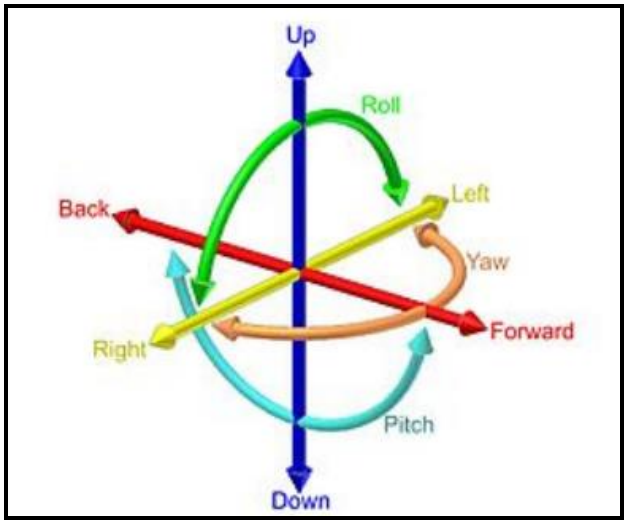


Fig. 1 Six-degree of Freedom [3]

According to Six-degree of Freedom illustration in Figure 1, there are six point of view in Location-based Augmented Reality, such as Back/Forward, Left/Right, Up/Down, Roll, Yaw, and Pitch.[3] Paucher et al conducted many calculation needed to make Location-based Augmented Reality. Those calculations are done with multiple algorithms, such as Levenberg-Marquardt algorithm and Zhang's algorithm. Sensors needed by Location-based Augmented Reality are also described in his paper. Main sensors used are Accelerometer and Magnetometer.[4] Narzt et al created a navigation application using Location-based Augmented Reality. This application is running on PC and PDA and using many kinds of different tools, such as video camera, GPS module, wheel sensor, Gyro sensor, compass, tracking receiver set and many more.[5] In positive, the application results near perfect tracking and Augmented Reality visualization due to those many tools and equipment that help it. However in negative, it's not really easy to use because of the setup needed. Narzt's application could be really useful if only car manufacturers supports it by installing required tools and equipment directly into the car. So users don't need to individually install those tools into their car, and just simply use it from their car's dashboard.

3. Background Knowledge

This section describes many base background knowledge which is needed to create the application.

3.1 Navigation

Navigation is a field of study which focusing on watching and controlling the movement of one thing or transportation. Navigation field of study is divided into four categories, marine navigation, land navigation, air navigation and space navigation.[6] Navigation can also be interpreted as a field of study about direction and position determination.[6] In this paper, the navigation is involving land navigation.

Latitude and Longitude are the two base concepts of navigation. In short, Latitude is defined as the angular distance from the northern and southern equator.[7] Latitude's unit is in degrees, which values are between 0 and 90 degrees. Latitude is shaped horizontally around the earth. Beside Latitude, there is also Longitude. Longitude can be defined as the angular distance from West to East center of Meridian, which is located in Greenwich.[7]

3.2 Global Positioning System

Global Positioning System (GPS) is a satellite-based navigation system that can acquire user's position and time in every weather condition.[8] GPS can get user's position if only three to four satellite is accessible from user's device. User's location is updated continuously as long as satellites still able to reach their position, which is known as tracking. Users are free to access this system by using their GPS receiver module. These days, this module is available in almost every smartphone in the market.

Almost every GPS modules have flaws, the most common one is mismatched location. This problem happens because of few reason, such as lost connection to satellite, lack of connectable satellite at the current position, or bad quality of the GPS module itself. Location-based services are susceptible to this problem. There are many solutions available to this problem, however, it's still quite hard to get the location as accurate as possible. In location-aware applications, a mismatched location will lead to many problems such as non-accurate location-based suggestions.

3.3 Augmented Reality

Augmented Reality is a technology which is able to merge computer generated digital objects into the real world in real time.[9] Augmented Reality was started back in 1957-1962 when Morton Heilig, a cinematographer, created and patented a simulator called Sensorama. There are many kinds of Augmented Reality such as Marker-based Augmented Reality, Markerless Augmented Reality, and Location-Based Augmented Reality. This application utilizes the third one, with two dimension Augmented Reality objects.

3.4 Location-Based Augmented Reality

Location-based Augmented Reality is one kind of Augmented Reality Technology which doesn't rely on markers or some real life objects. This kind of Augmented Reality uses location data (latitude and

longitude) to show the objects. This technology makes the application possible to change dynamically according to user's location in real life. Thus, able to create a more interactive application.

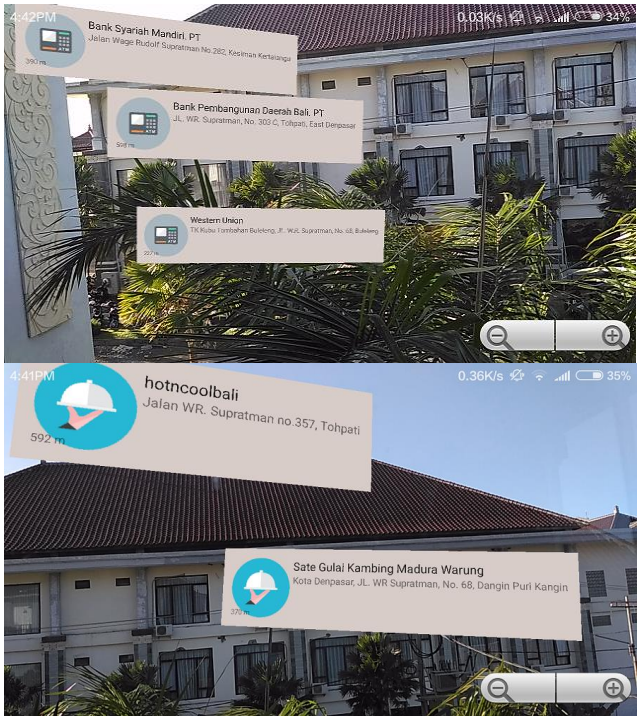


Fig. 2 Location-Based Augmented Reality Example

Figure 2 shows three Augmented Reality Objects in certain coordinates. The position of those objects are relative to user's location.

Location-based Augmented Reality is able to create a more dynamic application than other types of Augmented Reality. While other types of Augmented Reality only shows objects according to the marker, Location-based Augmented Reality is able to show objects according to user's preference and position. Thus, also creating a more interactive Augmented Reality environment between user and application itself. Such as, current road condition, weather condition, even advertising, with the help of webservice as backend of the application.

4. Development Material and Method

4.1 Development Flowchart

Development is done by a flowchart shown in Figure 3 below.

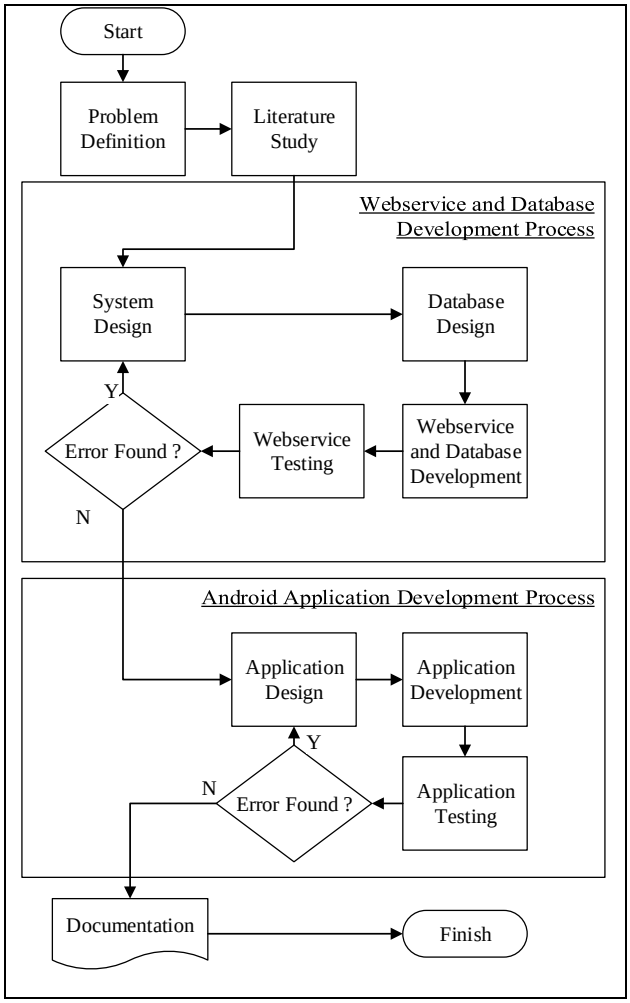


Fig. 3 System Development Flowchart

There are two main phases in the development process, webservice with database development and Android application development. Problem definition is a phase where the main problem is defined. Then, literature study on all required subjects in development is done. After those initial phases is done, the development process conducted from webservice and database to Android application. Documentation is done in the end to make sure everything is noted, including the testing results and the code documentation.

4.2 System Architecture

There are five entities involved in the system architecture, as shown as in Figure 4 below.

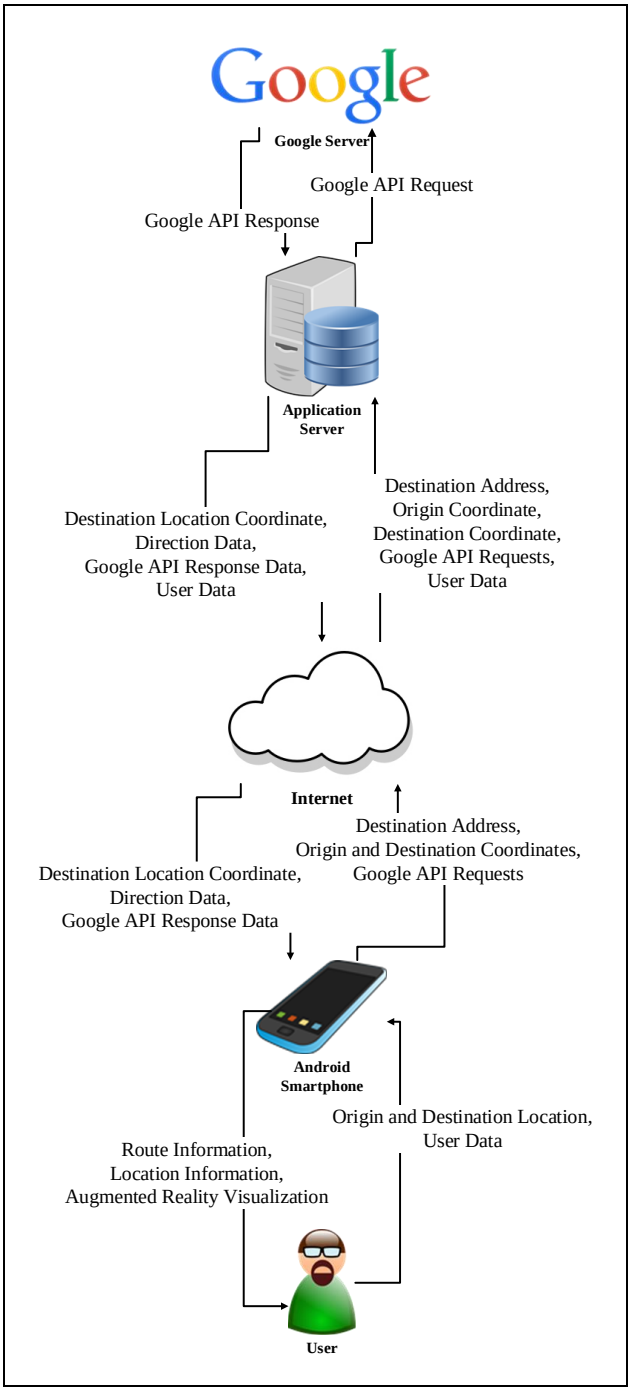


Fig. 4 System Architecture

This application is able to calculate the route needed from one location to another location based on user's needs. Location-based Augmented Reality is another main feature of navigation in this application. Inside the Augmented Reality environment, objects is shown to users according to the path or road that they need to take. For example, if users need to turn left, then a turn left road sign shaped Augmented Reality objects is shown. The objects is shown as two-dimensional object.

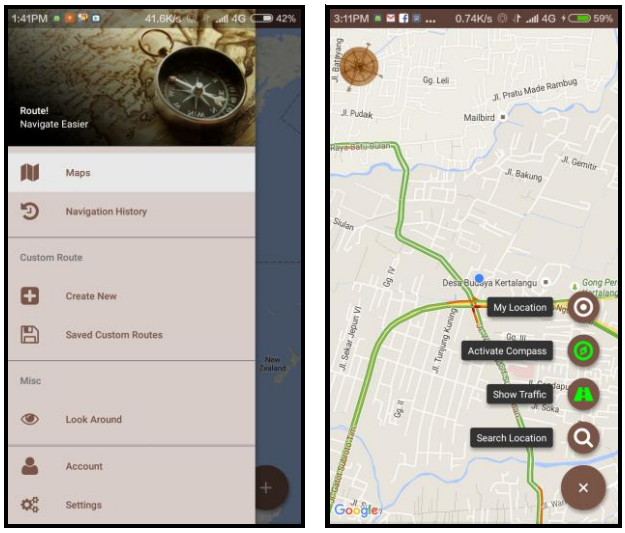
When users send a route request, the application will forward the request to the webservice, then webservice will decide if the request is related to the Google APIs. If the request is related to Google APIs, then a new request is sent from the webservice to the Google Server according to the request data. After API response is obtained, those responses are processed and forwarded to the user's smartphone.

5. Implementation

The implementation is done using Android smartphone running an Android 5.1 Lollipop as operating system.

5.1 System Interface

The system interfaces are made using Google Material Design Language.[10] These are the main interfaces for the user in using this application. Brown color with hex value #795548 is used as the primary color, while gray color #9E9E9E is used as the accent color.



(A) (B)

Fig. 5 Main Interfaces of Application: (A) Navigation Drawer (B) Main Maps

Figure 5 (A) shows the first interface when the application started, which is an opened navigation drawer. There are seven menus in the navigation drawer. While Figure 5 (B) shows the main maps behind the navigation drawer. There are four menus shown as floating buttons in the main maps.

5.2 Geocoding Feature

The user can use the geocoding feature to search places based on their names. This feature is accessible via search button in the floating menu. The search feature is shown in Figure 6.

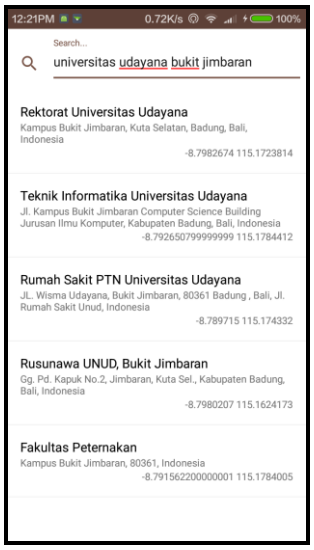


Fig. 6 Geocoding Feature

The reverse geocoding feature is also presented in the application. The user needs to click on the map to activate the reverse geocoding feature which will show the selected location's address, as shown in Figure 7.

Fig. 7 Reverse Geocoding Feature

The marker showing location's address is clickable and will trigger a dialog box containing options, (1) to see an overview route or (2) activate navigation feature to the selected location. This map-click navigation could make user easier in selecting a destination, because the selected destination is not limited to search results.

5.3 Maps Navigation

Maps navigation is the main feature in this application. Navigation data is provided by Google Direction API. Data response from Google is JSON formatted. Request to Google is done by the webservices, and then is sent back to the smartphone after processing. Users need to select the destination location via map click method or location search method, after that, choose to navigate button. Navigation interface then shows up as shown in Figure 8.

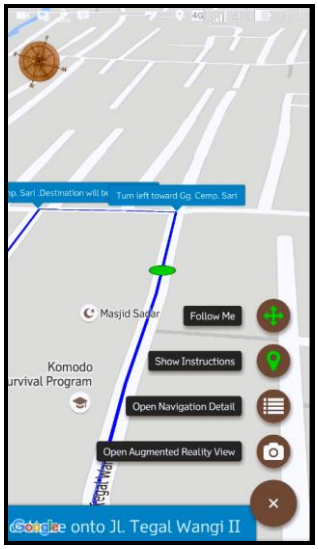


Fig. 8 Maps Navigation

The green circle represents user's location in real time, provided by smartphone's GPS. The blue polyline represents the navigation route. There is also a compass in the left up side of the view to help the users in navigating. Some floating menus are also available at the bottom right of the view which contains some configuration, additional data and button to show up the Augmented Reality Navigation.

Android smartphone GPS location updates is retrieved within interval amount of time. That gap between location updates makes a stuttering effect on user's location changes. Those stutters will also have an impact on Augmented Reality Navigation. Augmented Reality objects position will not be updated smoothly, and could lead to user's fault in following direction. In order to resolve that, the location updates data is interpolated to the same duration of the location updates interval. For example, if the interval between received location updates is 2 seconds, then the location data itself interpolated also for 2 seconds. The same duration used is to increase the smoothness of location updates shown in maps. The most recent received location update is interpolated to the previous data received. Interpolation is done with Android LinearInterpolator class.

5.4 Augmented Reality Navigation

Augmented Reality Navigation is another main feature of this application besides the maps navigation features. Augmented Reality Navigation is accessible from Maps

Navigation interface. The interface of Augmented Reality Navigation is shown in Figure 9.

Fig. 9 Augmented Reality Navigation

The camera is activated directly after the activity started. In the camera, Augmented Reality objects are shown as dots, which is representing the routes that needs to take. Dots is placed every 3 meters along the route. Coordinate calculation for each dots is done by using Haversine formula.

Haversine formula is mainly used in navigation for calculating the distance between two coordinates (in latitude and longitude).[11] The following PHP function is used in calculating the distance between two points.

```
function    distanceFrom($firstlat,    $firstlng,
$lastlat, $lastlng){
     $earth_radius = 6378137.0;
     $dLat = ($firstlat-$lastlat) * pi() /
       180;
     $dLng = ($firstlng-$lastlng) * pi() /
       180;
     $a = sin($dLat/2) * sin($dLat/2) +
       cos($lastlat * pi()/180) *
       cos($firstlat * pi()/180) *
       sin($dLng/2) * sin($dLng/2);
     $b = 2 * atan2(sqrt($a), sqrt(1-$a));
     $c = $earth_radius * $b;
     return $c;
}
```

At every junction, another Augmented Reality objects are shown according to the maneuver that the user needs to do, as shown in Figure 10.

Fig. 10 Maneuver Sign in Augmented Reality Navigation

Maneuver category and maneuver coordinates are obtained from Google Direction Service API. Every maneuver has its own unique name. Road sign objects saved in webserver and loaded to the smartphone when needed.

5.5 Additional Features

Additional features are also added to the application. The first additional features are Look Around, which is an Augmented Reality Point of Interests. This feature is used to find the point of interests around the user. ATM, Restaurant, Gas Station, Hospital, Shopping Centre, and Police Office are the point of interest category available in the application. The main interface of Look Around Feature is shown in Figure 11.

Fig. 11 Look Around Category Option

Users can adjust the Point of Interests searching radius via slider available at the top most of the view. Search location range is limited from 500 to 1500 meters. After user chooses the category, Augmented Reality view is shown as in Figure 12 below.

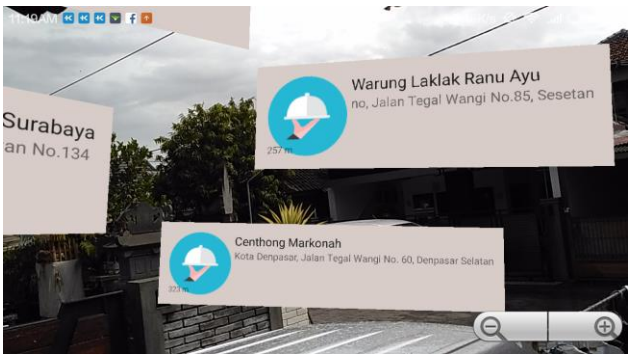


Fig. 12 Look Around Augmented Reality View

Results are shown around user via Augmented Reality environment. Each result is represented as a box with icon, name, address and distance field. The user can click on each Augmented Reality objects to interact with it. Those objects can be dismissed, or user can navigate their way to the selected Point of Interest. The Point of Interest data is obtained from Google Places API, in a JSON document.

5. Conclusion

In this paper, an application research and development of Augmented Reality Navigation is conducted. As other location-based service application, the main problem in this research is location accuracy, which is hardware-related. This system is built on Android Operating system because it has wide users around the world and open sourced.

Users are still able to view road's condition while checking the navigation information in the application, due to Augmented Reality Technology which is using device's camera. Therefore, user's safety in riding is increased because users do not need to look away from the road while navigating.

Augmented Reality, along with Virtual Reality is a developing technology. In the near future, we can expect a more advanced version of those technologies around. Smartphone GPS module is also developing with new technologies such as A-GPS, GLONASS, and BDS. For the future, it's not impossible that this kind of navigation is commonly used. Whether as a mobile application, wearable application, or even installed directly into car's front window.

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