City University of Hong Kong
Department of Computer Science

BSCCS Final Year Project 2013-2014

Interim Report

13CS082

Zroad, Android Augmented Reality Navigation Application

(Volume __1__ of __1__)

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Date : **4th November, 2013**

Zroad – *AUGMENTED REALITY NAVIGATION*

CITYU CS FYP INTERIM REPORT I

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In Oct, 2013

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1. INTRODUCTION

1.1. BACKGROUND

In this IT century, most people get at least one mobile phone, information flow media is changed from physical material to digital tool. It brings a lot of benefit. Time cost is reduced and more information can be displayed with one click.

Traditionally, people navigate themselves with a paper map but now, as the popularity of mobile device, people will use applications like Google Maps or Apple IOS 6 Maps, transportation application to find their destination.

Google collects geographical data over the world and provides a web mapping service, Google Maps. Google Maps for Android guides users to their destination with GPS navigation, public transit, biking or walking directions based on the geographic information. (Inc., 2013)

Google Maps also released standalone app IOS in December, 2012. After three months, Apple replaced Google Maps with its own Maps app to IOS 6 device. Apple Maps addressed Flyover feature which provides helicopter views around specific cities among U.S.A., Australia, Canada, France, Germany, Italy, Spain, U.K., Ireland, Denmark, New Zealand and Sweden. (http://flyovercities.com/)

Figure2.3.1. Flyover view in Apple IOS 6 Maps

1.2. LIMITATIONS

There are still limitations which make the instructions from both Google Maps and Apple IOS 6 Map less effective.

- **Inconvenience**

  When users get the path on 2D map, they need to integrate the path on the screen to the surrounding in the reality. If the users do not familiar with what the map represent in the reality, they may go to Google Street View and get more visual information about where they are. It is inconvenient to work on the integration and finding directions.

Figure1.2. Google Street View

- **Accuracy of user interpretation with path instructions**

  With input of destination and current location, both Google Maps generates a representation of suggested path displayed on 2D map. The visual aids are not sufficient for users to apply the path into the reality. How the path mapped to the reality is depended on the users. This costs inconsistent performance to the navigation.

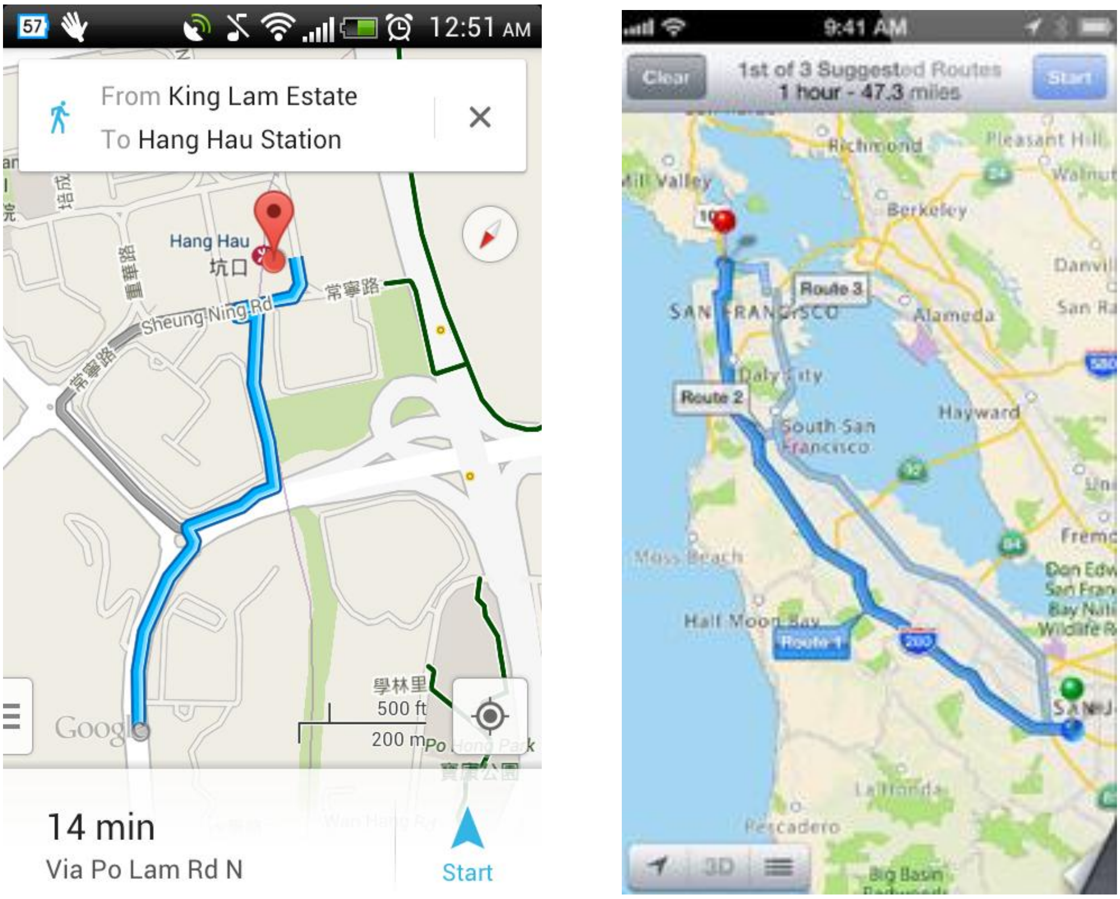


Figure1.1. Path generated from Google Maps for Android and Apple IOS 6 Map

- **Recognition**

  There may not be significant recognition for the surrounded building when users observe the environment in the reality. Users require time to locate themselves by investigating the surrounding environment.

1.3. PROJECT AIMS

To address the above problems, we propose an augmented reality navigation system, Zroad, to enhance the ability of Google Maps navigation. Zroad connects the geographic information from Google Maps with augmented reality with the help of GPS and the camera of mobile device. By recognizing the environment of surrounding, Zroad will do the integration between the suggested path and the reality for users. Through overlaying visual aids in the viewfinder, Zroad will guide users to their destination. All the users need to do is to follow the instructions from the visual aids. This will enhance the accuracy and effectiveness.

Moreover, the buildings which are within the specific distance from the users will be spot with its information (name, location). This will allow the users to get more understand on where they currently are.

1.4. PROJECT OBJECTIVES

Using an enhanced map on hand is the best choice for people who get loss easily. The more details can people get the information, the easier people to arrive the destination. The ability of the application responses the actual location and the surrounding environment can help the user to get the direction efficiently.

Zroad is a mobile application that provides augmented reality based on the instructions to get to the destination efficiently. Zroad, with the pronunciation 'See road', directs user to their destination with the camera and GPS in their mobile device. Even non-map readers now lose in the complicated road like 'Z' shape, they can still easily get their way with instructions from Zroad. After inputting the destination, all they need to do is to simply raise their mobile device with the camera, focus to the surroundings where they currently are. Zroad will give them directions with some visual aids. Users will not need to worry about the map and just follow the instruction from the given visual aids.

Zroad was also recommended to the tourists who visits Hong Kong. As they may not familiar with the geographic information in Hong Kong. They definitely need a navigation application which let them find the scenic spots or restaurants efficiently and accurately instead of reading Google Maps which may be quite challenging for tourists. For example, if the tourists are looking for a shopping mall from thousands building in Mong Kok, it might be quite confusing for them who do not know Mong Kok well to finish the task. Zroad, at this time, provides instructions overlaying in the camera viewfinder on the device and guide them to the destination directly and clearly.

To increase the efficiency of map navigation, AR-based map navigation brings more benefit to user.

- Recognize the surrounding building
- Navigate the direction of movement by overlaying visual aids in the camera viewfinder of mobile devices

1.5. ASSUMPTIONS

- Mobile devices setting allows Zroad to grasp their geographical location.
- Accuracy of GPS location is depended on the mobile devices.
- Required architecture on the mobile devices of users was the following:
    - Android 2.2 or above
    - Supporting OpenGL ES 2.0
    - Internet connection (Network/Wi-Fi)
    - GPS Access
    - Camera function and Camera Access
    - Phone Storage (To Be Confirm)

1.6. SCOPE

- Scoped within Mong Kok.
- Scoped for outdoor navigation only.
- Scoped for English only.
- Scoped users are in ground level.
- Data based on Google Walking directions which are in beta and its suggested route may be missing sidewalks or pedestrian paths.

2. LITERTURE REVIEW

2.1. LOCATION TRACKING TECHNOLOGY

2.1.1. GLOBAL POSITIONING SYSTEM (GPS)

GPS is a positioning, navigation and timing (PNT) utility maintained by the United States government and commonly used in military, civil and commercial users (driving navigation system). 24 GPS satellites involved and circles the Earth twice a day in order to provide worldwide and continuous coverage. They broadcast their locations, status and precise time in radio signals to users through space. After receiving the radio signals, GPS device will calculate the distance between at least 4 satellites and itself .Its geographic position (longitude, latitude and altitude) on the Earth can then be determined with geometry. (U.S. Government, 2013)

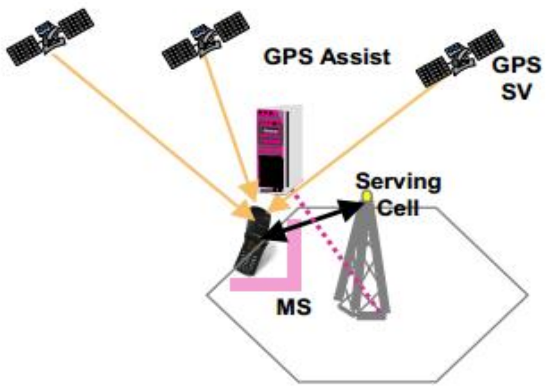


Figure2.1.1. Architecture of GPS

GPS was initially developed for military uses in 1970s. It became commercial in the mid-1980s.

Accuracy

The accuracy of GPS depends on the factors of transmission which will be affected by atmospheric effects and receiver quality. According to the data collected by Federal Aviation Administration of U.S. in 2011, the accuracy of GPS receiver with high-quality is within 1m usually. (U.S. Government, 2013)

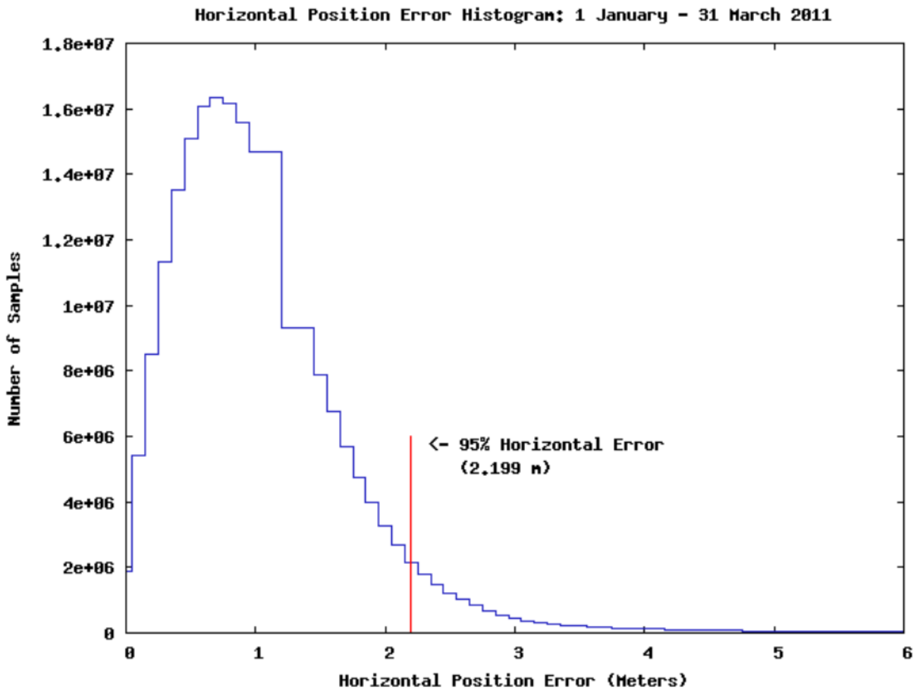


Figure2.1.2. FAA data collected in early 2011

2.1.2. GLOBAL SYSTEM FOR MOBILE (GSM)

GSM is a second-generation cellular system standard which consists of 3 components. They are Network and Switching Subsystem (NNS), Basic Station Subsystem (BSS) and Operation Support Subsystem (OSS). (Gu & Peng, 2010)

The positioning technology using GSM occurs in BBS and is SIM-based. Different methods can be used for positioning:

Method	Precision
Cell of Origin (COO)	100 m - 35 km
COO with Cell Sector	100 m - 35 km
COO with CS and Received Signal Strength	100 m - 20 km
Angle Of Arrival (AOA)	50 m - 150 m
Round-Trip-Time-of-Flight (RToF)	50 m - 150 m
Time Difference Of Arrival (TDOA)	50 m - 150 m
Enhanced Observed Time Difference (EOTD)	50 m - 150 m

Figure2.1.3. Precision of GSM Positioning

Detection of positioning method, Enhanced Observed Time Difference of Arrival (E-OTD), is depended on the base stations' triangulation and the signal strength. The cellular mobile device receives signals from 3 base transceiver stations (BTSs) and compares the time differences in order to determine its position.

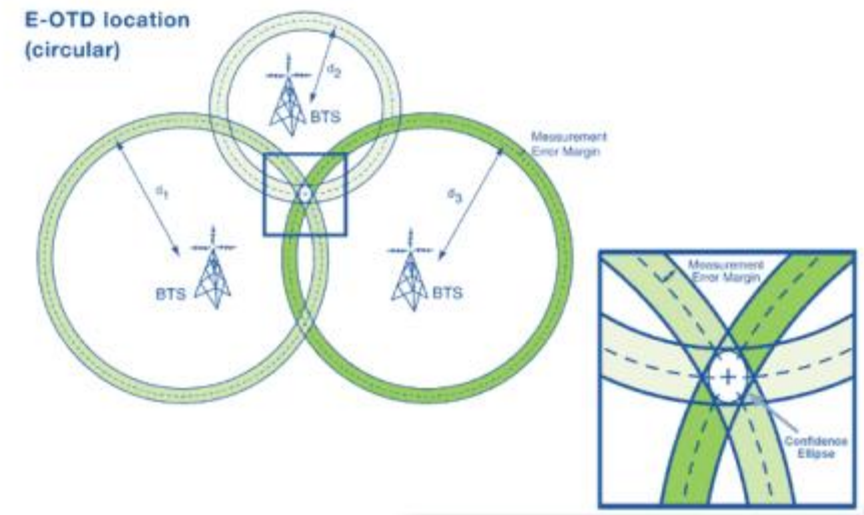


Figure2.1.4. Triangulation of E-OTD

2.1.3. WI-FI POSITIONING

Nowadays, wireless Access Points (APs) are everywhere in urban areas in Hong Kong, no matter in convenience stores, coffee shops, shopping malls or government buildings . According to the statistic from Office of the Telecommunications Authority (2012),

Month/Year	Number of Wi-Fi access points installed for provision of public	Registered number of Wi-Fi areas provided with public Wi-Fi-services
2/2012	10,365	5,249
2/2011	9,077	5,019
2/2010	8,894	4,906
2/2009	7,872	4,722

Figure2.1.5. Statistic on public Wi-Fi services in Hong Kong

Figure2.1.6. Distribution of Wi-Fi access points in Mong Kong, HK

Taking advantages of the rapid growth of AP, Wi-Fi positioning becomes popular these days. This causes more and more mobile applications related on positioning with Wi-Fi.

Wi-Fi Positioning may involves similar approach as GSM: signals (consisting the coordinates of the Wi-Fi access point and the angle between AP and the device) from multiple APs are detected in order to calculate the location of the device.

Another techniques, fingerprinting, can also be included in Wi-Fi positioning. The locations mapped before are compared in order to determine the distance of the device.

Limitation

As the signals transmitted from APs to the device utilized the same band with other analogical technologies, like wave from micro oven and Bluetooth, interferences which affect the accuracy may occur if multiple technologies exist in the same environment. (Chew, 2005)

2.1.4. COMPARISON LOCATION TRACKING TECHNOLOGIES

Technology	GPS	GSM	Wi-Fi
Precision	~20m	~200m	~100m
Coverage	Clear sky	GSM network	with Wi-Fi signal coverage
Advantages	+ All weather + Free with GPS receiver + time information	+ Can be used indoor	+ Can be used indoor + Free with Wi-Fi device
Limitation	- less effective in non-line-of-sight(NLOS) environments	- fee is needed for GSM network	- Must keep Wi-Fi hotspots database update

Figure2.1.7. COMPARISON AMONG GPS, GSM AND WI-FI

2.1.5. HYBRID LOCATION SERVICE IN ANDROID

Regarding from what we have investigated in different location tracking technologies, each of them consists its pros and cons. As our scope of location coverage mentioned in section 1.6 is Mong Kong which is a place with high density of tall buildings and non-line-of-sight (NLOS) environments in Hong Kong, a hybrid location service with both GPS, GSM, Wi-Fi would be the most suitable for Zroad.

The location strategies proposed by Android(N.A.) descripted the determination of location with multiple sources which are GPS, Cell-ID and Wi-Fi. There would be 2 different levels of accuracy for detecting user location: coarse and fine. In order the get the above 2 levels of location determination, requesting devices for permission is needed with the following codes in manifest.

```
<uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION"/>
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
```

ACCESS_COAESE_LOCATION includes permission only for NETWORK_PROVIDER while ACCESS_FINE_LOCATION is for both NETWORK_PROVIDER and GPS_PROVIDER. The process for Android to obtain user location is shown in Figure 2.1.8.

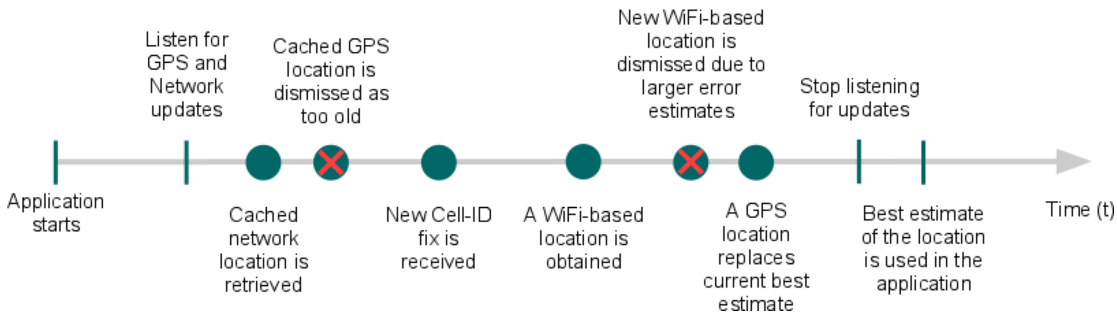


Figure2.1.8. Process of user location determination

2.2. INTERFACE DESIGN

2.2.1. NAVIGATION STRUCTURE

Besides the functionalities provided in the application, the user interface design is also critical as it will affect the usability and the frequency of usage of the application. Zroad, a navigation application, aims at providing instant directing services to user. That is what the appropriate navigation structure in Zroad is essential because we do not wish users waste plenty of time on learning how to use the application.

Following navigation styles are proposed in Chaudry, Connelly, Siek, & Welch's (2012) study report which investigated the usability issues among different navigation structures, the navigation style results in the fastest error recoveries and the least errors.

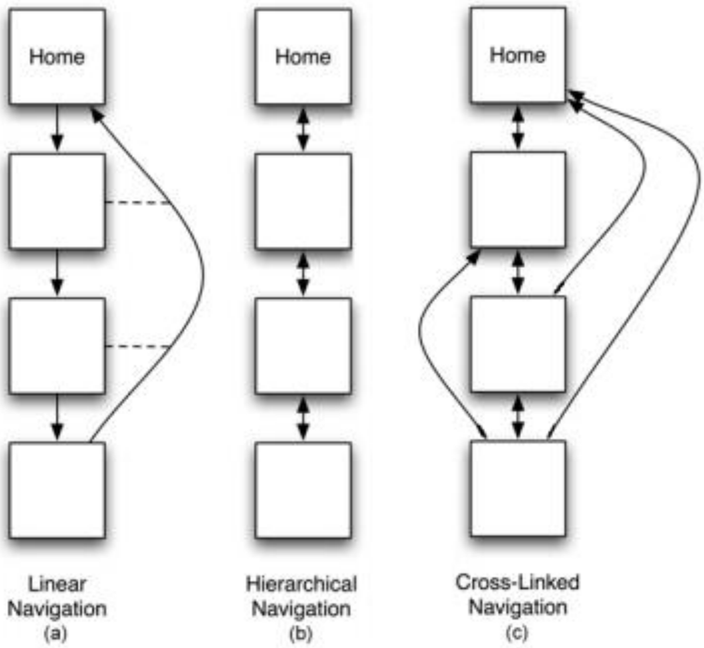


Figure2.2.1. Box and arrow diagrams for three navigation styles investigated in the report

The study tasks mentioned in the report were given to participants. They were asked to complete the given tasks which consisted the above navigations. The report collected the comments of the participants after the tasks and analyzed the results which demonstrated the relation between different navigation styles and the user performance.

Navigation Style	Completed Tasks		Incomplete Tasks
	Without Errors	With Errors	
Linear	69.7%	30.3%	0%
Hierarchical	46.1%	43.4%	10.5%
Cross-linked	59.2%	38.2%	2.6%

Figure2.2.2. Percentages of completed and incomplete tasks in the report

In the study, the linear navigation style leaded the least number of fail tasks. It also triggered the most number of error-absent completed tasks. The home icon which brings users back to the main screen was frequently used in the tasks in order to recover from errors. Participants expressed that the home button let them correct mistakes easily and know the screen which the home button directs.

2.3. EXISTING MAPS

We are going to study the navigation functions of different existing navigation applications.

2.3.1. GOOGLE MAPS

After inputting the starting location and the destination, Google Maps determines possible paths, calculates the viapoints and expected duration of the paths, provides scene in Figure 2.3.1 for users to choose from multiple paths according to the given information. Users are required to click the desire paths or slide the section which shows path information.

Figure2.3.1. Paths selection In Google Maps

After path selection, users will get the navigation instruction. To view the next instruction, users can slide the upper section which shows the instruction information (Green area in Figure 2.3.2.). If users wish to get an overview of the upcoming steps, they can select “Step-by-step list” from menu.

Figure2.3.2. Navigation instruction In Google Maps

2.3.2. APPLE MAPS

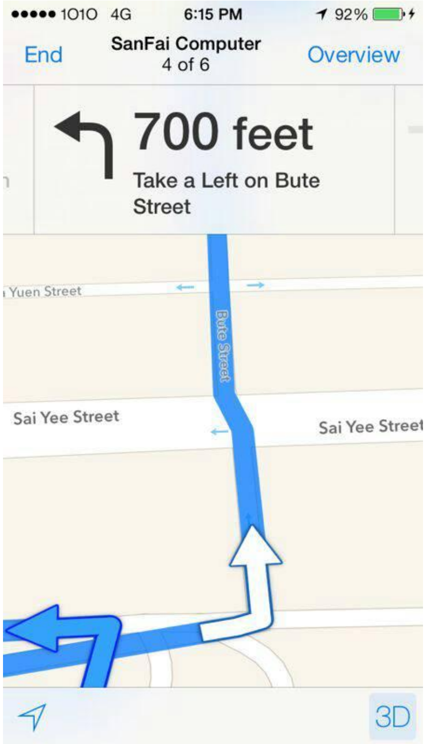


Figure2.3.3. Navigation instruction In Apple Maps

When I input the same set of data (starting point: Mong Kok Station; destination: Mong Kok Computer Centre) from above, Apple Maps database provides options according to the input. However, I could not find a suitable choice for “Mong Kok Computer Centre”. Instead I got “SanFai Computer” which are total different from my input.

After the user starts the navigation, Apple Maps displays similar instructions as Google Maps consisting arrows and direction information.

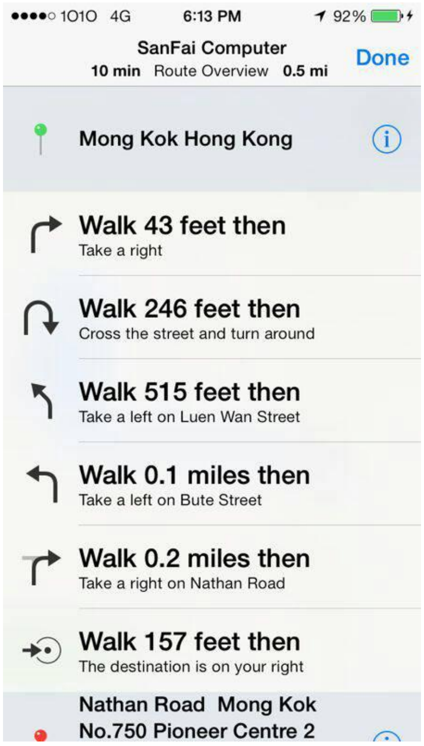


Figure2.3.4. list of navigation instructions In Apple Maps

What is the most special feature in Apple Maps is the 3D maps and flyover view. However, users cannot enjoy the above features in Apple Maps of Hong Kong as they are only available for list of the cities which have been mentioned in section 1.1.

Similar as Google Maps, Apple Maps also gives list of navigation instructions for users’ overview.

3. SYSTEM DESIGN

3.1. FUNCTIONALITIES

3.1.1. RECOGNIZE THE SURROUNDING BUILDINGS

After Zroad gets the current location with GPS and activates the cameras of the mobile devices, users need to raise their devices and capture the surrounding. The buildings in viewfinder will be spot and the information of the buildings will be displayed.

Figure3.1.1. Prototype of Zroad with camera viewfinder of mobile device

3.1.2. GET THE PATH INFORMATION TO THE DESTINATION

After getting the input of the destination and the information of current location, Zroad pass the data to Google Maps service. By searching in the data collection from Google Maps, the location of the destination is found and Google Maps will generate suggested path and return the path information to Zroad.

3.1.3. DISPLAY THE VISUAL AIDS TO GUIDE USERS WITH THE PATH

Zroad will process the path information received from Google Maps with the mobile viewfinder. Then Zroad will overlay the viewfinder with visual aids according the path information and gives instructions to users to turn, go straight or back.

Figure3.1.2. Prototype of Zroad with camera viewfinder of mobile device

3.2.GRAPHIC USER INTERFACE

In order to provide an user-friendly interface for different users (no matter youngsters, adults or elderlies), the navigation style of Zroad interface would be linear which always offers a button for users to get back in the index page as what we have studied in Section 2.2.1. We believe that would give users a comfortable interface and require them relatively little time to learn on Zroad when they are focusing on finding their destination.

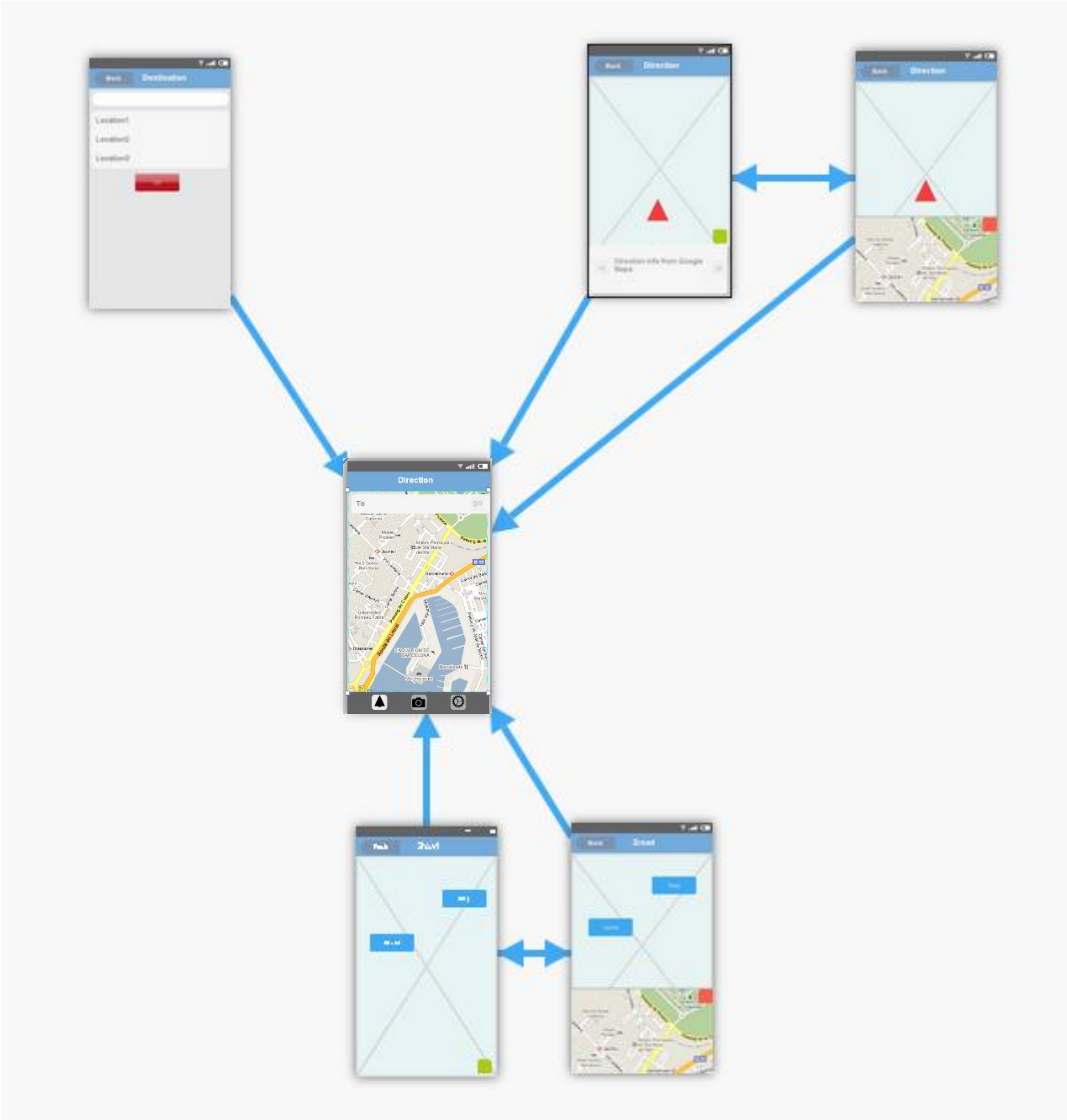


Figure3.2.1. Graphic User Interface Structure of Zroad

Users are provided with functions of direction, building recognition and setting in the index page. To search the path of users' destination, they need to input their destination. Once they press the textbox on the top, Zroad would suggest users with their location search history and the name of place similar to the user input.

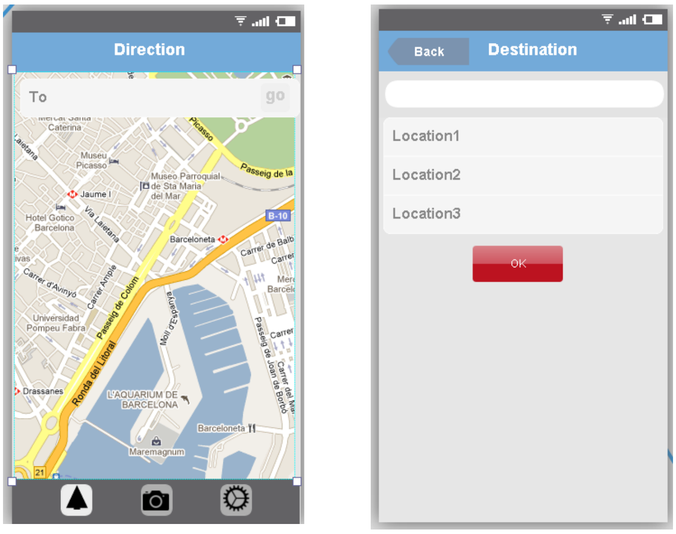


Figure3.2.2. Index page and location searching page in Zroad

After submitting the address of destination, Zroad would offer users the directions from their current location to their destination with visual aids in AR view. Once the users move, their position is detected and Zroad responses with updated instruction presented with the visual aids. In addition to the information of the directions, Zroad also allows users to view their path visually in the Google Maps.

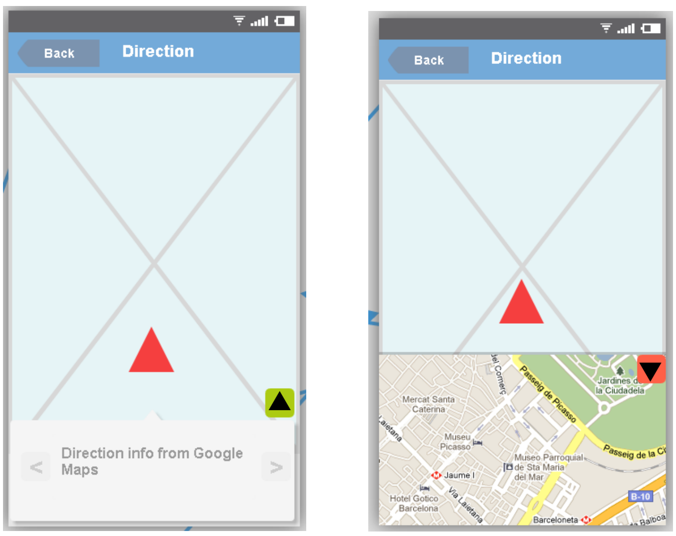


Figure3.2.3. Direction pages in Zroad

Besides navigation feature, Zroad also provides users with the building recogniation in surroundings. Users simply need to press camera icon on the lower part in index page and raise the device camera. The information of buildings appeared in the viewfinder will be displayed in bubbles. Current location of user in Google Maps is also available for this page.

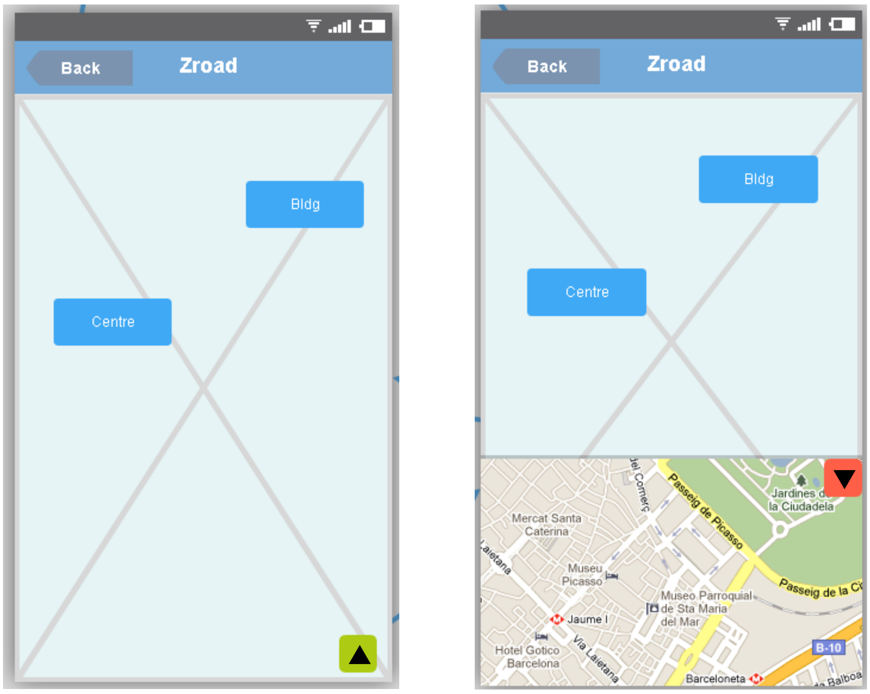


Figure3.2.4. Current location pages in Zroad

3.3.PROJECT STRUNCTURE

3.3.1. ARCHITECTURE AND DESIGN

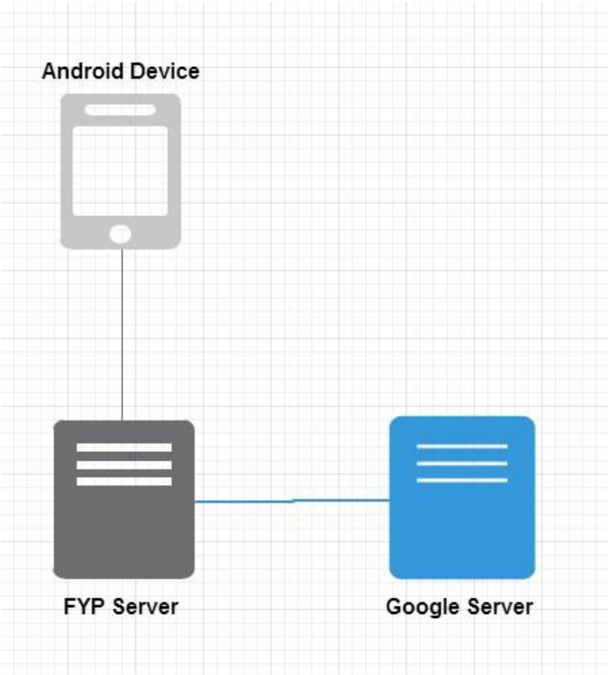


Figure3.3.1. FYP Server, android phone & Google Maps Server

3.3.2. USER TYPES

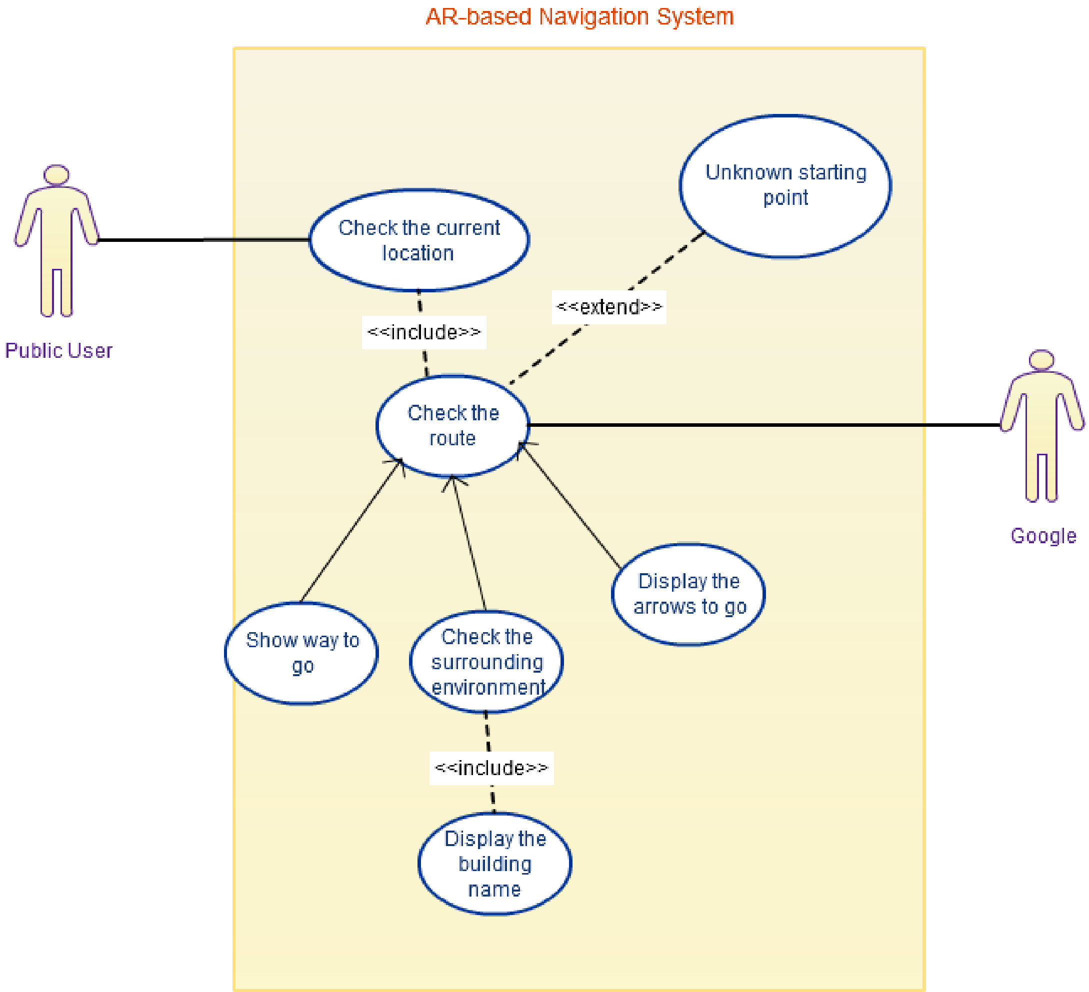


Figure3.3.2. Use Case Diagram of Zroad

4. IMPLEMENTATION

4.1. ENVIRONMENT

Hardwares	
Personal Computer	Samsung series 5 ULTRA
Testing Device	To be comfirm

Softwares	
FYP Server OS[1]	Window 7 Ultimate
IDE[2]	Eclipse Kepler Release

4.2.TECHNOLOGIES

4.2.1. GOOGLE MAPS API

Figure4.2.1. Logo of Google Maps API

As a web mapping service, Google Maps offers API which provides location searching, route planning for traveling by car or with public transports. There is also route for walking (Google Walking) and cycling in beta version.

[1] Final Year Project Server Operation System
[2] Integrated development environment

4.2.2. ANDROID SDK

Figure4.2.2. Logo of Android SDK

Android, an operation system which is popular in smartphones (Google) and tablets, provides SDK for developer to build Android applications and launch them to a platform, Google Play where allows users with Android devices to download variety application. There is also the Android Open Source Project which provides source code for developer to learn about Android (Google).

4.2.3. WIKITUDE SDK

Wikitude SDK provides the library which unifies Augmented Reality technologies and helps in overlaying text, images, graphics or 3D objects in the viewfinder. (Wikitude, 2012)

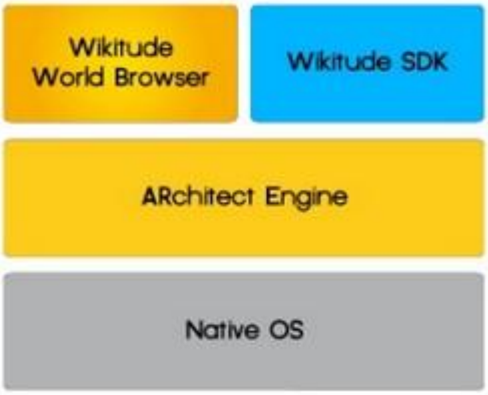


Figure4.2.3. Relation between OS and Wikitude SDK

A hotel searching application from HOTELS.COM applying AR[3] technology with Wikitude is similar to Zroad. It helps users to find hotels with Wikitude AR view. The detail information of the hotels, such as prices and rating from guests presenting with stars.

Figure4.2.4. hotel searching application from HOTELS.COM

[3] Augmented Reality

There are many other SDKs for augmented reality, like Layer which is also popular among the current market and provides similar functions as Wikitude. However, Layer is focusing on the functions of digital interactivities to magazines and product packaging for advertisers and publishers. It then introduces their new Layer SDK with geo on 24th October, 2013 while there are already many of location-based applications using Wikitude, like applications of HOTELS.COM, Tripadvisor and Lonely Planet.

Figure4.2.5. Interactive print which is the most common usage with Layer

Technology	Wikitude	Layer
IOS	✓	✓
Android	✓	✓
PhoneGap	✓	✗
GPS	✓	✓
Marker	✓	✗
Visual Search	✗	✓
Framework	Wikitude Studio	✗
Example Applications	hotel searching application from HOTELS.COM	Interactive content in ELLE Magazine & Inc. Magazine

Figure4.2.6. Comparison among Wikitude and Layer

4.2.4. GIT

Figure4.2.7. Logo of Git

As a source code management and distributed version control system, Git is a open source which is free and suitable for any project size. It is designed to handle everything with high efficiency.

To check in the updated source codes, user can specific the modified files in working directory (known as git add). The files is then stored in staging area(also called "index") where commits can be performed to send the changes to repository.

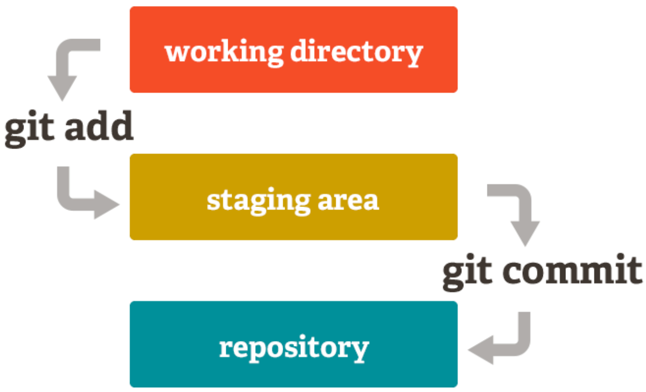
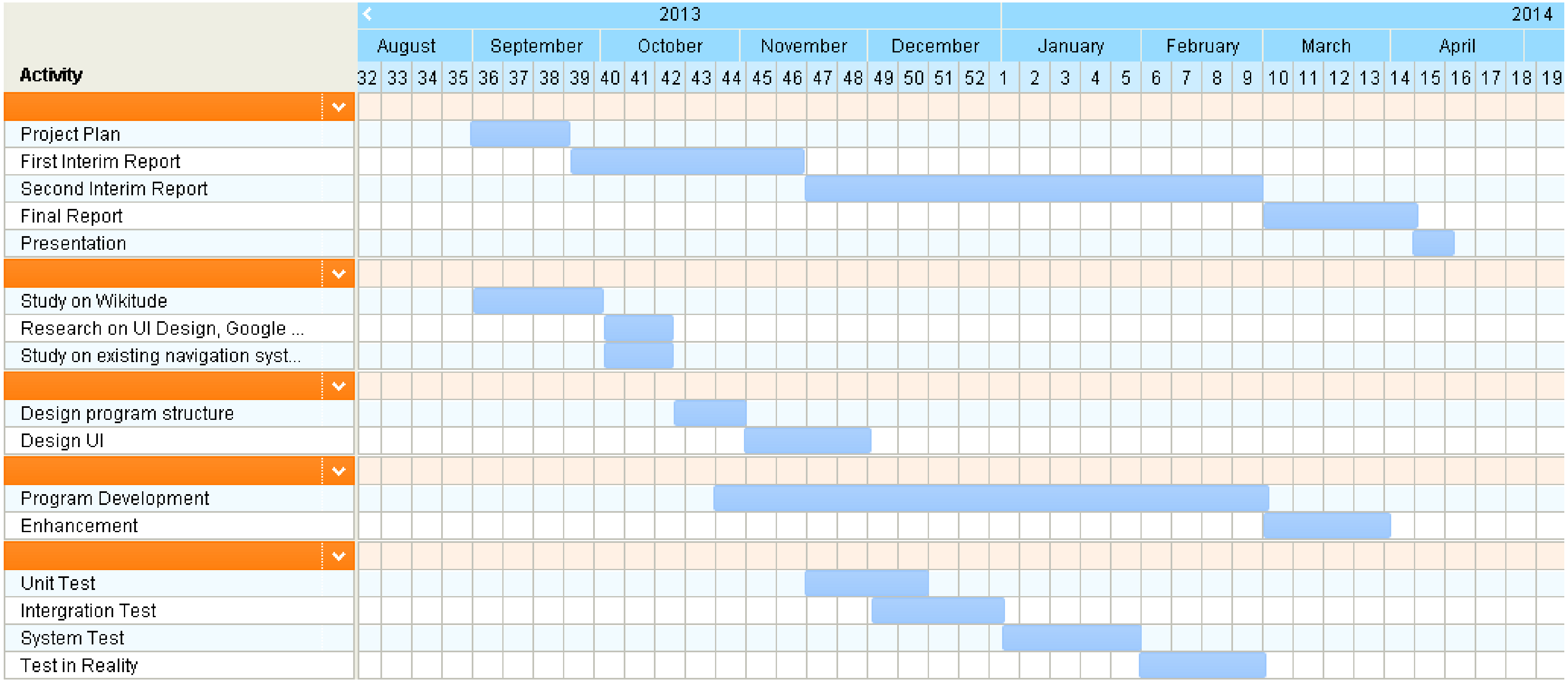


Figure4.2.8. Work flow in Git

Using Git in the development process brings the following advantages:

- Git allows multiple developers to work independently. At the same time, their works can be created, merged and deleted easily.
- Git allows users to share one, partly or all branches for a remote repository.
- There is no single point of failure with GIT. It provides "cloning" for each users in a distributed software configuration management (SCM).

5. PROJECT SCHEDULE



6. CONCLUSION

To conclude, Google Maps has been widely used on no matter mobile devices or websites. It is undoubtedly in contributing to publics. Zroad, with the advantages of Google Maps, enhances the existing navigation system and benefits for people who would like to have instructions to their destination, especially for those who are not familiar with map reading.

7. REFERENCES

Android. (N.A.). *Location Strategies*. Retrieved from Android Developers: http://developer.android.com/guide/topics/location/strategies.html#BestPerformance

Chaudry, B., Connelly, K., Siek, K., & Welch, J. (2012). Mobile Interface Design for Low-Literacy Populations. *the 2nd ACM SIGHIT International Health Informatics Symposium*, (pp. 91-100). New York.

Chew, T. Y. (2005). *The Integration of Positioning:Technologies for Precise Location Identification.* University of Wollongong.

Google. (n.d.). Retrieved from Android Developer: http://source.android.com/

Google. (n.d.). Retrieved from http://www.android.com/kitkat/index.html

Gu, G., & Peng, G. (2010). The Survey of GSM Wireless Communication System. *International Conference on Computer and Information Application*, (p. 121).

Inc., G. (2013). *Maps - Android Apps on Google Play*. Retrieved from https://play.google.com/store/apps/details?id=com.google.android.apps.maps

Office of the Telecommunications Authority. (2012). *Public Wi-Fi Services.* Retrieved from OFTA: http://tel_archives.ofca.gov.hk/en/datastat/wifi_stat.html

U.S. Government. (2013, Oct 23). *GPS Accuracy*. Retrieved from GPS.gov: http://www.gps.gov/systems/gps/performance/accuracy/

U.S. Government. (2013, Oct 23). *GPS Educational Poster*. Retrieved from GPS.gov: http://www.gps.gov/multimedia/poster/

Wikitude. (2012). *Webinar: Discovering Wikitude ARchitect engine 1.1.* Retrieved from SlideShare: http://www.slideshare.net/wikitude/wikitude-sdk-11-webinar

8. APPENDIX

8.1. MONTHLY LOG

Mar, 2013 – Aug, 2013

- Propose a topic of final year project
- Research for related technologies

Sep, 2013

- Initialize and finalize the Project Plan
- Set up Server
- Study on Wikitude

Oct, 2013

- Research on User Interface Design, Maps, Location Tracking Technologies
- Initialize Graphic User Interface
- Initialize the development of Zroad
- Initialize and finalize Interim Report 1