A GPS Navigation System with QR Code Decoding and Friend Positioning in Smart Phones

Yuan-Cheng Lai, Frannie Han
Department of Information Management
National Taiwan University of Science and Technology
Taipei, Taiwan
laiyc@cs.ntust.edu.tw

Yi-Hsuan Yeh
Department of Information Management
Oriental Institute of Technology
Taipei, Taiwan
amyyeh@mail.oit.edu.tw

Ching-Neng Lai
Department of Information Technology
Hsing Wu College
Taipei, Taiwan
Sebastian.lai@gmail.com

Yu-Chin Szu
Department of Information Management
St. John's University
Taipei, Taiwan
belinda@mail.sju.edu.tw

***Abstract*—Global Positioning System (GPS) navigation is a popular assistant during a trip. By using a GPS navigation system, the travelers can easily and quickly arrive to the destination in an unfamiliar area. However, there is no free and open-source GPS navigation system which integrates many useful applications. Thus, this paper proposes a GPS navigation system on the Android platform, called Android Mobile Navigation System (AMNS). AMNS not only provides users the GPS navigation function, but also supports Quick Response (QR) code decoding and friend positioning. Furthermore, AMNS is free and open-source software, so service providers or developers can easily extend their own services on this system.**

Keywords-Android; GPS; QR code; Navigation System.

I. Introduction

As rapid increases of national income and strong promotions to foreign tourists in Taiwan these years, improving the touring quality has become an urgent issue. Formerly, a tourist needed to look at the maps or tour guide books during the trip, resulting in taking time and easy missing the way. Therefore a navigation system with electronic maps has become more and more popular.

Currently, the commonly-used hardware of navigation systems includes vehicle devices and smart phones. A vehicle device is hard to be portable due to its large size and usually immovable on car. On the other hand, the handheld smart phones can be easily used in any kinds of transportation, so it is an excellent choice as the hardware platform of navigation systems. For software, most navigation systems use GPS (Global Positioning System) to get the current position, and start navigating after a user chooses destination or inputs its address. However, these steps are not very convenient to users. To avoid the inconvenience, many introductions of scenic spots or hotels have been transferred to easier symbols, namely, QR code, from the texts. Thus, the user can use the photographic function of a smart phone to get QR code and then directly obtain the coordinate of a scenic spot and related information. This user-friendly approach is very convenient to users at using navigation applications.

Since the navigation systems provided by the smart phone company and telecommunication operator are commercial products, which significantly limit developing some extended functions. Recently, Google has developed the Android platform [1], which is an open system, offering high flexibility on development. Due to this, it is very useful to develop a GPS navigation system on the Android platform with combing many Google resources.

Thus, this paper developed a GPS navigation system on the Android platform, called Android Mobile Navigation System (AMNS). AMNS is an open-source navigation system, which not only integrates Google Maps with GPS, but also supports decoding QR code, searching nearby scenic spots and positioning friends. Therefore, it can offer an impeccable traveling navigation service.

This paper first introduces some background, including QR code, the Android platform, as well as some related studies of electronic maps and navigation software. Section III formally describes the AMNS system. Then the functions and operating process of AMNS are presented in Section IV. Finally the conclusions and future works are given in Section V.

II. Background

This section first introduces QR code and the Android platform, then reviews related studies of electronic maps, and finally compares various navigation software.

A. QR code: Two-dimensional bar code

Bar code has become a popular technology due to high-speed decoding, great accuracy, and low cost. However, the one-dimensional bar code only stores little data. Thus, a two-dimensional bar code, QR code, was proposed in ISO/IEC 18004 [2]. Figure 1 shows an example of QR code about "National Taiwan University of Science Technology." QR code has small area, high-volume and error correction characteristics. A user can use a smart phone with camera to take a picture of QR code. Then the phone decodes QR code with a decoding program to obtain the embedded data.

Figure 1. QR code

B. Android platform

Android is a complete, open and free platform for smart phones. As shown in Figure 2, Android is a software stack composed of an operating system, middleware and application programs. The bottom layer of Android is an embedded operating system, Linux 2.6. By utilizing Application Framework and Libraries, the developers can easily build their applications. Android SDK [3] provided by Google is an important tool for developing applications on the Android platform.

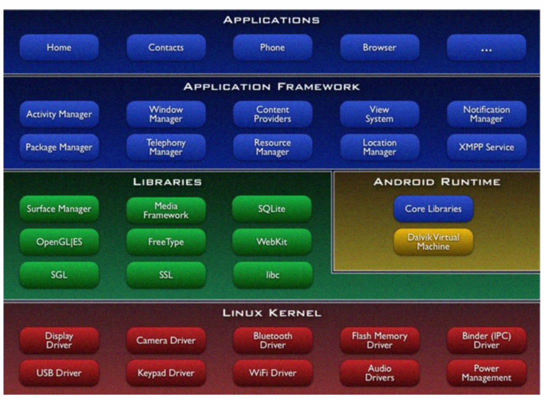


Figure 2. Android software stack

C. Electronic map

Currently, the researches of electronic maps are divided into two major categories. The first category is related to Geography Markup Language (GML) [4], which is provided by Open GIS Consortium (OGC) for unifying the format of geographic information on electronic maps. GML, based on XML, supports phase, the reference of space and time, various scales, metadata and grid. Some papers discussed the related issues of GML [5][6].

The second category studies the generating methods of electronic maps. In [7], an approach of storing geographic information to conveniently produce electronic maps from the database is designed. Bases on KML (Keyhole Markup Language) [8], OGC defines the description standard of geographic information for drawing electronic maps. Thus map producers can transform their specific geographic information into that of KML format, so any drawing tool does not need to be modified. A more correct way to position a user on an electronic map is developed when the GPS signal is interfered [9]. A multi-scale way to construct the electronic map is proposed in [10]. Liu stored two stages of geographic information for efficiency: first stage is for map display and second stage is for route selection [11].

D. Comparing different navigation software

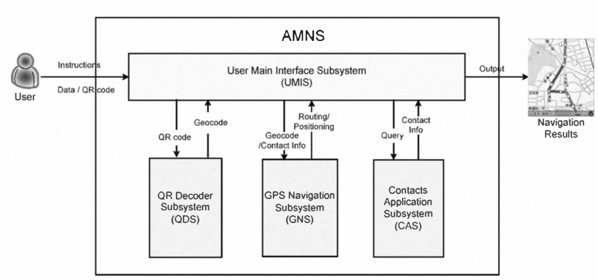
The main navigation software can be divided into two types. The first one integrates navigation system, electronic maps, and GPS on mobile devices. This type of software, for example, Papago! [12] and TomTom [13], can be used in an off-line manner. The second type has only installed the navigation system and GPS on mobile devices, and needs to download map information via internet. Thus they, for example, Google Maps [14] and Urmap [15], must be used in an on-line manner.

The first type of software is developed by GPS company or map providers, the accuracy of positioning is great and the functions about planning routes are excellent, but they are all commercial products and can not provide the source code for revising or extending other functions. Besides, these maps are slowly or hardly updated in user's devices and are generally not customized for creating user's preferred scenic spots. The second type of software is developed by ISP company or portal operator. The provided scenic spots, user's custom map, and programming flexibility are better. Among this type, Google Maps provides high flexible API and it is also most compatible with Android. However, its electronic maps are still needed to be downloaded via internet and currently GPS navigation services are not provided yet. Therefore for the Android platform, a free navigation system is required and worthily developed. Therefore, this paper focuses on developing this system.

III. Desgin of AMNS

AMNS is a GPS navigation system built in smart phones with Android. The system has four requirements listed below:

- It has user friendly interface.
- It provides convenient and reliable navigation services.
- It integrates some add-value services.
- It is open-source software.



AMNS software architecure

As Figure 3 shows, AMNS is composed of four subsystems: User Main Interface Subsystem (UMIS), QR

Decoder Subsystem (QDS), GPS Navigation Subsystem (GNS) and Contacts Application Subsystem (CAS). The function of each subsystem is briefed as follows:

- UMIS integrates all subsystems and display the executing results of other subsystems.
- QDS transforms captured QR code into corresponding geographic information (Geocode).
- GNS provides the user's current position, nearby scenic spot searching, and route planning.
- CAS uses instant GPS positioning function to perceive the friends' positions and track their paths on the map.

We mainly used Android SDK and J2SE to develop AMNS. Also Zxing Barcode Libraries [16] and Panoramio API [17] were used to assist the development of the QDS and CAS subsystems, respectively.

A. UMIS

UMIS is the main interface of AMNS. It offers loading/operating electronic maps, calling other subsystems, and showing the executing results of other subsystems. The user can click the control button to zoom in/out maps and can drag maps to change observed scope of maps. Besides, the user can choose "Scanner" in Menu to call the QDS subsystem for turning on the photographic function to capture QR code and obtain geographic information after decoding. The user uses "Driving directions'' in Menu to invoke the GNS subsystem to execute route planning after getting the geographic position. Finally, when the user wants to perceive the positions of friends, he/she clicks "Friend" in Menu to call the CAS subsystem and knows the friends' positions.

B. QDS

This subsystem majorly uses the libraries of Zxing Barcode [16] to decode QR code, which includes scenic spot information, into geographic information. The users first use camera on their phones to take a picture of QR code. Then the subsystem will atomically decode the obtained QR code and position the coordinate on the electronic map. The QDS subsystem includes controlling module, decoding module, format transforming module. The user executes controlling module to invoke an interface for taking a picture of QR code. QDS will automatically call decoding module to decode the obtained picture and call format transforming module to transform the decoded information into geographic information. Finally, it sends the geographic information to the UMIS subsystem to show the positioning results.

C. GNS

The map information of Google is used to assist developing the GNS subsystem. Android SDK provides enough APIs for supporting Google Maps. GNS includes controlling module, position searching module, scenic spot searching module, and route planning module. When the user inquires an address by using position searching interface, position searching module will match the address with the database. When the user further searches nearby scenic spots, scenic spots searching module works. In addition, route planning module will arrange the routes and produce the results when user executes the "Driving directions" function. Detailed illustration of each module is as follows:

(1) Controlling module
This module manages the operation of each module under the GNS subsystem and receives parameters passed from other subsystems. It also delivers operation and calculation results to other subsystems.

(2) Position searching module
This module mainly provides position searching. It supports Forward Geocoding and Reverse Geocoding functions. Forward Geocoding locates the position (longitude and latitude) from address. Reverse Geocoding finds out the address from a given position. When the user inputs the destination's address in searching interface, this module will execute Forward Geocoding function and find out its position. On the other hand, when the user utlizies the QDS subsystem to get the longitude and latitude of QR-code destination, this module will invoke Reverse Geocoding in order to find out its address. The UMIS subsystem will show the results and plot them on the electronic map after getting the position information.

(3) Scenic spot searching module
This module is developed with open source software "Panoramio" API [17]. Panoramio is a website which combines coordinates with pictures. Thus the users can share their pictures of scenic spots on the electronic maps. Using its provided API, this module can provide nearby scenic spots based on a given location and scope.

(4) Route planning module
This module mainly provides the shortest path from the starting point to the destination. Since Android SDK does not provide a route planning library, we propose an novel approach to achieve this goal. As Figure 4 shows, based on given starting and destination points, this module sends a request to the Google Map server for route planning services. The server will send back the route planning of KML format. Then this module decodes the required elements (for example, Lable <Placemark>, <Point>...) according to the results of KML format. Finally it draws navigational route on the electronic map.

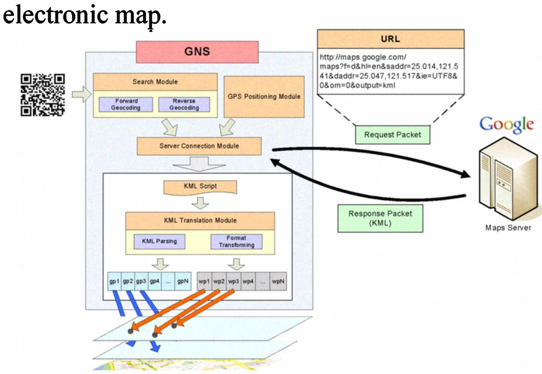


Figure 3. The operation process of GNS

D. *CAS*

The CAS subsystem includes two modules, directory module and friend positioning module. When user clicks "Friend" in the UMIS menu, the CAS subsystem acquires the user's current position via GPS, and uploads this position into our pre-installed positioning server, which gathers all persons' positions at all times. Then the user can choose the names of friends, that he/she wants to know their locations, in the directory by using directory module. The friend positioning module will send the list of selected friends to the positioning server and the server will respond to the client the searching results about friends' locations. Thus the CAS subsystem can provide real-time tracking of friends' locations on the UMIS electronic map.

Figure 5 shows the overall message flows between user's phone (client) and the positioning server (server) in the CAS subsystem.

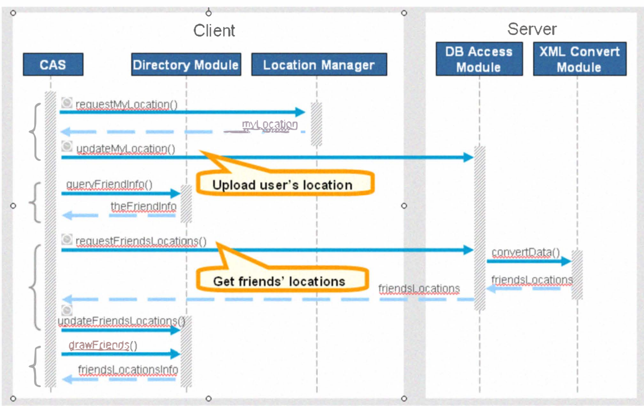


Figure 4. The overall message flows in the CAS subsystem

IV. SYSTEM FUNCTIONALITY OF AMNS

AMNS has some distinguished functions, like QR decoding, GPS navigation, and friend positioning, on the Android platform. This section is divided into three parts for introducing and testing these functions.

The development and test enviroments are described as follows. Operating system for the smart phone is Android 1.5. Programming languages are Java (version: 1.5.0_17) and ASP.NET 2.0. SQL Server 2005 is used as the database software in the positioning server. Furthermore, Eclipse (version: Ganymede) is a Java development tool in Windows. After pluging-in Android Development Tools package, we can develop Android applications on Eclipse.

A. *Decoding QR code*

AMNS decodes QR code via the QDS subsystem. As Figure 6, the user turns on the camera in his/her smart phone and uses QR code acquisition block to get QR code. Figure 7 shows the geographic information after QDS decoding (the content in this example is National Taiwan University of Science Technology), and Figure 8 presents that the UMIS subsystem positions this geographic information on the map.

Figure 5. Capturing QR code in the QDS subsystem

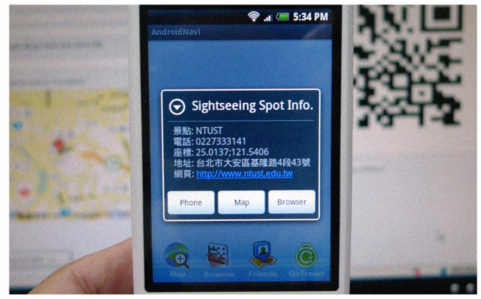


Figure 6. Decoding QR code in the QDS subsystem.

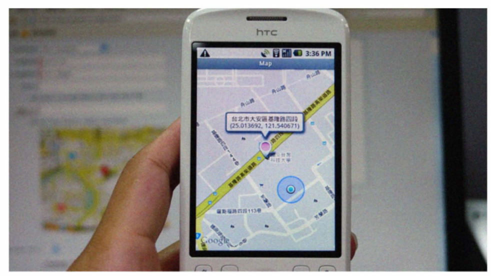


Figure 7. Positiong results in the UMIS subsystem

B. *Navigation services*

As Figure 9 shows, after the QDS subsystem successfully decoded QR code and got the position, the user can search nearby scenic spots around this position. By the way, the user can use the position or a selected scenic spot as the destination, and request the GNS subsystem to produce a route planning from user's current location. At this time, GNS will plot the planning route on electronic maps, providing navigation services to the user, as shown in Figure 10.

Figure 8. Nearby scenic spots searched in the GNS subsystem

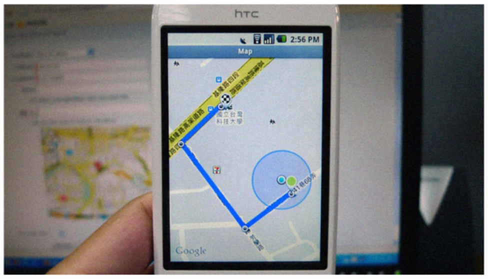


Figure 9. Planning route generated in the GNS subsystem

C. *Friend positioning*

CAS integrates directory with positiong to provide the friend positioning services, that is, the friends' locations will be displayed in the UMIS subsystem. As Figure 11, the user browses the directory saved in the CAS subsystem. In Figure 12, the user clicks "Show on the map" to track friends' locations and finally UMIS shows the results, as shown in Figure 13.

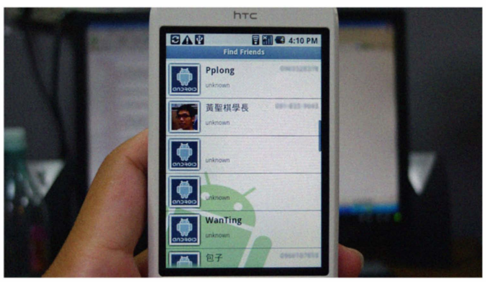


Figure 10. Directory saved in the CAS subsystem

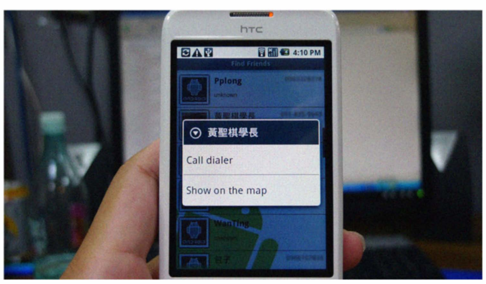


Figure 11. Selecting the friends in the CAS subsystem

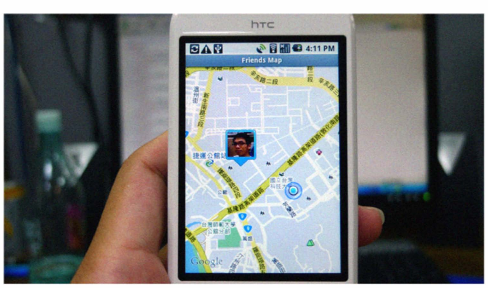


Figure 12. Showing friend's position in the UMIS subsystem

V. CONCLUSION

This paper proposes a navigation system, AMNS, in smart phones. AMNS provides many services, such as QR decoding, searching of nearby scenic spots, GPS naviagtion, and friend positioning, to improve the touring quality. In addition, AMNS can be used as a basic platform for the peoples who want to develop their GPS navigation systems or extend some enhanced functions .

Main contributions of AMNS includes:

- Provide a free and open-source navigation system.
- Support QR decoding for conveniently determining the destination location.
- Provide the seraching of nearby scenic spots and the positioning of friends.

AMNS is still in the development stage. Some enhanced functions are still needed to be added continuously. In the future, electonic maps should be pre-installed in smart phones, so the user can use the navigation services in an off-line manner. Furthermore, we want to develop a new route planning algorithm with considering the dynamic traffic to improve the accuracy of navigation.

ACKNOWLEDGMENT

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 97-2218-E011-013.

REFERENCES

[1] Android, http://developer.android.com/guide/basics/what-is-android.html

[2] ISO/IEC 18004:2006, "Information technology — Automatic identification and data capture techniques — QR Code 2005 bar code symbology specification," 2006.

[3] Android Developers, http://developer.android.com/index.html

[4] GML (Open GIS Consortium, OGC), http://www.opengeospatial.org/

[5] J. S. Krishna, A. Shuai, S. Yuan, K. Cai, and Y. Qin, "A pragmatic GIS-oriented ontology for location based services," 19th Australian Conference on Software Engineering, 2008, pp. 562-569.

[6] K. Lee, S. H. Moon, and B. D. Kwon, "GML-based representation architecture for digital Geo-science GIS layers: a case study using Korea digital geologic map sets," IEEE International Geoscience and Remote Sensing Symposium, 2003, pp. 3568-3570.

[7] P. Wang, C. Yang, Z. Yu, and Y. Ren, "MapBase－map service extensions embedded in spatial database," IEEE International conference on Geoscience and Remote Sensing Symposium, 2004, pp. 2957-2959.

[8] KML (Open GIS Consortium, OGC), http://www.opengeospatial.org/standards/kml

[9] S. Taghipour, M. R. Meybodi, and A. Taghipour, "An algorithm for map matching for car navigation system," 3rd International Conference on Information and Communication Technologies: From Theory to Applications, 2008, pp. 1-5.

[10] Y. Wang, W. Zhao, H. Gong, and X. Liu, "A design method for building a multi-scale navigation electronic map," IEEE International Geoscience and Remote Sensing Symposium, 2007, pp. 4643-4647.

[11] Y. Liu, Y. Xu, Z. Gui, J. Zheng, and S. Qin, "Feature-based two level structure road network model for navigation," IEEE International Geoscience and Remote Sensing Symposium, 2005.

[12] Papago!, http://www.papago.com.tw/

[13] TomTom, http://www.tomtom.com/

[14] Google Maps http://earth.google.com/intl/zh-TW/

[15] Urmap, http://www.urmap.com/

[16] Zxing, http://code.google.com/p/zxing/

[17] Panoramio http://code.google.com/p/apps-for-android/