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Final Report

M-Guide – Macau Tour Guide on Android

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Declaration of Originality

I, *Lo Man Fai, Ray*, declare that this report and the work reported herein was composed by and originated entirely from me. This report has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given in the bibliography.

2014/4/22

Abstract

According to research from Macao SAR Government Statistics and Census Service, Macau's tourism industry has been developing rapidly in the past 14 years at a growth rate of 290% [1]. The major problems for using a real paper map to travel are twofold. The visitors need to spend a lot of time to accurately locate current location and scenic spots location and to think about how to go to the scenic spots from their current location. Thus, this project - M-Guide is designed to enhance visitor self-travelling experience by using a smart phone. The Android is the main development platform chosen for this project because it was the most popular smartphone / tablet computer operating system in the world this year, even in the coming 4 years. [2]

The Android application with bi-lingual interface – the end product of this project provides some location-based functions (Scenic spots on map, navigation, nearby scenic spots) to user. This project is consisted of two databases on server and client devices respectively for storing information of scenic spots and others Macau related information (weather, transport and etc.). Visitor can obtain those kinds of information from database by using different technologies, such as scanning QR-code, reading NFC tag and Augmented Reality. Moreover, text-to-speech service and location-based service are also provided. Some improvements such as optimizing the scenic spots library, the ability of recognition of the Augmented Reality function, application stability and compatibility will be considered in the further work.

Acknowledgement

I would like to express my very great appreciation to my project supervisor Dr. Lai Sio Kuan. She offered her technical and writing supports in my project. This project would not be completed without all of those supports.

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1. INTRODUCTION

Most people would use a real paper map to travel. They spend a lot of time to find out an accurate location of them and scenic spots. In addition, they need time to think about how to go to the scenic spots from their current location. Moreover, they may not know some of the distinctive place in Macau. According to some researches from Government of Macao SAR Statistics and Census Service, Macau's tourism industry was developing rapidly in the past 14 years [1]. It has about 290% [Figure 1] growth of the number of visitor arrivals from 1999 to 2012 [1]. Moreover, the number of individual visitor accounted for the majority [1].

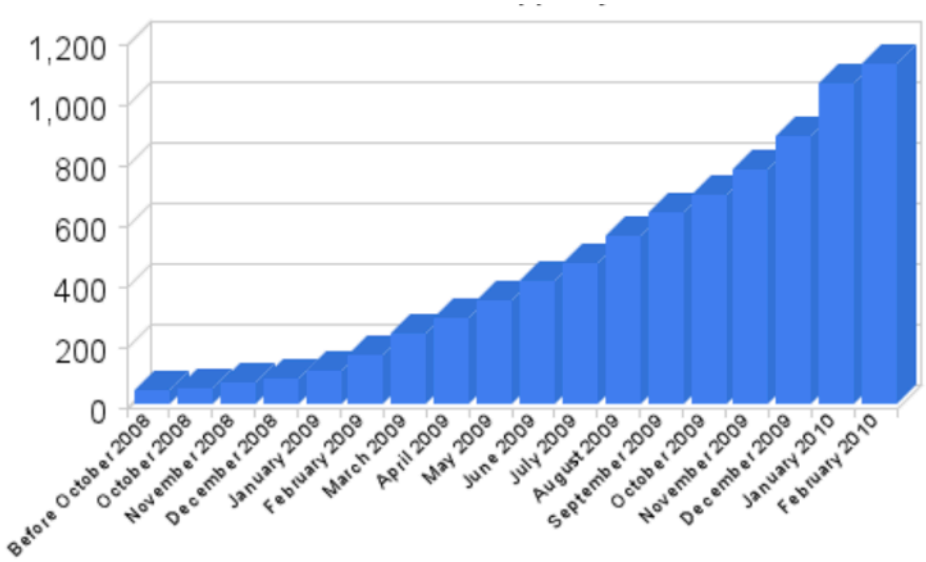
FIGURE 1 QUANTITIES OF VISITOR BETWEEN 1999 AND 2012

Source from DSEC (www.dsec.gov.mo)

On the other hand, Android is probably the most popular smartphone operating system in the world. According to a report from Techcrunch, market share of Android worldwide is 80% in global [4]. So that Android is chosen to be the development platform.

According to the Location Apps Research from Skyhook.com [5], it shows that the Android location-based services application increase quickly every month and there

express almost 22 times growth from Oct 2008 to Feb 2010 [Figure 2]. That means the use and need of location-based services in smartphone platform is increasing.



Source from Skyhook.com

FIGURE 2 TOTAL ANDROID LOCATION BASED SERVICE APPS BY MONT1H

Therefore, this project is mainly to provide a kind of interaction and convenience to visitor instead of using the traditional paper map. This application provides not only text information of scenic spots to tourist but also Location-based service, which is more important to a tourist to travel. Hence, mobile tour guide in Android is useful for the visitors and it can save more time for searching something on a real map and recommending some travel suggestions. After briefly explained the usage of this application, next is the depiction of the primary objectives that is followed by a general description, risk assessment of this project and structure of this report.

1.1 OBJECTIVE

The aim of this project is to develop an Android application for visitors travelling in Macau and enhances tourist's self-travelling experience. The project contains the following objectives:

- Providing Macau Scenic Spots information and Free Wi-Fi Locations on Google Maps.

- Incorporating different technologies including: Quick Response (QR) code, Near Field Communication (NFC) and Augmented Reality (AR) for obtaining scenic spot information.
- Showing local weather forecast, bus-stop information, and real time traffic and border gate condition.
- Offering text to speech to enable visitors to communicate with local people easily.
- Enabling travel planning with a Travel List.
- Constructing a bi-lingual database – to support both English & Chinese interface.
- Providing a user-friendly interface.

Consequently, an Android Application is the expected outcome of this project.

During the development of this project, the storage size of the application is a challenge especially when the mobile device is not connected to network and data must be installed locally on the mobile device. If the data size of this project is huge, it may affect the user experience.

1.2 SUMMARY

This report consist six sections. First of all, there is the introduction part of this project. In this section, the objectives, project description and risk assessment will be revealed. The second section is about the background information and some related work with this project. The third section is to introduce the design approach of this project. The fourth section is the implementation part, all implementation methods will be revealed in detail. The fifth section is the result and discussion. Finally, the last section is a conclusion and further work.

1.3 RISK ASSESSMENT

There are third major risks associated with the project.

The first risk is the network connection problem. Visitors may not have any network connection for their mobile devices. Therefore, visitor may not be able to use M-Guide. To solve this problem, it is necessary to cache if the application has the cache the scenic spots information. Some basic functions still can work fine without network connection. When the application is installed initially, database with brief information can be pre-loaded into the device. Therefore, most of the function (excluding navigation, text to speech and Augmented Reality) still can work fine without network connection.

The second risk is the Android Fragmentation Visualized problem. M-Guide might not be able to run perfectly in every android device since there are more than 7 version of android [8] in different devices. Moreover, difference screen size and resolution may affect the GUI. There is no solution to solve this problem completely. It is only can improve this situation that can reduce the effect of user. For improving this problem, optimizing the GUI and features of M-Guide for popular android devices is necessary. Such as the devices from some famous brand which like Samsung, Sony, HTC and etc.

The third risk is about the Augmented Reality. It is because AR function will be developed to a scenic spot recognition function. However, different angle and different weather of the image will affect the recognition. For improving this problem, it is necessary to provide several images with different angle and all of the images must be a high contrast image for one scenic spot.

2. BACKGROUND AND RELATED WORK

Most of the people would use a real paper map to travel. They spend a lot of time to find out an accurate location of them and scenic spots. In addition, they need time to think about how to go to the scenic spots from their current location. Moreover, they may not know some of the distinctive place in Macau. According to some researches from

Government of Macao SAR Statistics and Census Service, Macau's tourism industry was developing very rapidly in the past 14 years [1]. It has about 290% [Figure 3] growth of the number of visitor arrivals from 1999 to 2012 [1]. Moreover, the number of individual visitor accounted for the majority [1].

FIGURE 3 QUANTITIES OF VISITOR BETWEEN 1999 AND 2012 Source from DSEC (www.gsec.gov.mo)

2.1 LOCATION BASED SERVICE & POSITIONING

Follow the trend of smartphone and tablet computer, location-based services also becomes active. As Axel Kupper introduced location-based services in his paper [9], the GSM Association simply defines Location-based services as services that use the location of the target for adding value to the services which like selecting nearby points of interest, showing the location of a target on a map, or automatically activating the service when a target enters or leaves in a specific area.

However, there is one concern on Location-based services that is the accuracy of positioning data on smartphones. "Background Positioning for Mobile Devices" [10] introduce some location technologies will be used in mobile devices, as it reveal that there are three different technologies to get the positioning data, which are Satellite Positioning (GPS), Cellular Positioning and Wireless LAN Positioning. GPS is very accurate positioning technology. It can provide accuracy up to 20 meters but it does not support indoor positioning and need 15 minutes to locate. Cellular Positioning is a technology that gets the positioning data from cellular network. Although cellular

positioning can only provide accuracy up to 35km, cellular positioning has less power consumption than GPS. Wireless LAN Positioning take a similar approach as the Cell-ID algorithm in cellular positioning. The different is cellular positioning is using the data from cell tower to calculate the position and the Wireless LAN Positioning is using the data from Wireless Access Point. And it provides the accuracy range of 60 meters and short locate time. In above technologies, there are different characteristics, such as high accuracy, less power consumption and short locate time. Therefore, most of smartphone are using a technology, which call "Assisted GPS". Assisted GPS is a combination of GPS and Cellular Positioning. In Assisted GPS, the GPS module is assisted by Cellular positioning and some assisted data will download through IP connect. The Assisted GPS can provide better accuracy, short locate time and less power consumption. Hence, most of the smartphone have a good hardware to support Location-Based Services right now.

2.2 AUGMENTED REALITY

Augmented Reality provides the scenic spot recognition function in this project that is the combination of real world and computer rending virtual content [11]. That improves the user to take advantage over the surrounding environment as so called "background" and superimpose the virtual objects over that real background. Hence, it makes the user feels like he or she is viewing virtual objects as they have been really placed in the scene [14]. In the other words, this function can provide interaction with user. Qualcomm Vuforia SDK is a SDK for developing AR application with different Smartphone Operation System (Android and iOS) and it is a free SDK with no limitation. Object tracking and 3D content rendering are easily using in Vuforia SDK. Therefore, it is a good choice of this part of implementation.

2.3 QUICK RESPONSE CODE (QR CODE) & NEAR FIELD COMMUNICATION (NFC)

QR code and NFC are the methods of obtaining the scenic spot's information. QR code [12] is a two-dimensional barcode can be read for camera. The different between QR code and 1D barcode is the 1D barcode only can store up to 30 numbers and QR code can be 7089. Therefore, some text or hyperlink can be embedded into QR code; NFC [13]

is a form of contactless communication between devices like smartphones or tables. It allows user to communicate without some complex configuration steps. By using these two technologies, tourists can scan the QR code and tag the NFC to retrieve the information by using their smartphone easily.

2.4 OTHER RELATED APPS

Macau Government Tourist Office also offered an Android application "Experience Macau" [6]. For this application, it provides many common functions, such as scenic spots on a map, some planned trip provided by Macau Government Tourist Office, planning list, and Augmented Reality. Unlike "Experience Macau" that shows mainly the scenic spots information, this project will provide more extra services, such as location-based service. For example, navigation and showing near by scenic spot's information. Moreover, this project will provide a better GUI. In addition, Augmented Reality function is similar to "Info Eye" from Sony [7] that performs an analysis on a photo where this project will allow camera analyze an target object and render virtual content in real time.

In summary, the number of tourists to Macau is growing. This project is to produce an application in Android which to enhance the tourist self-travelling experience. Location-Based Service is one of the major features of this project. It also consists other features by using QR code, NFC and Augmented Reality. In the market, there are less travelling applications which are mainly focus on Macau. The most official one is "Experience Macau" from Macau Government Tourist Office. However, that application mainly provides text information about the scenic spots in Macau. This project will make up the lack of this application.

3. DESIGN APPROACH

3.1 SYSTEM ARCHITECTURE

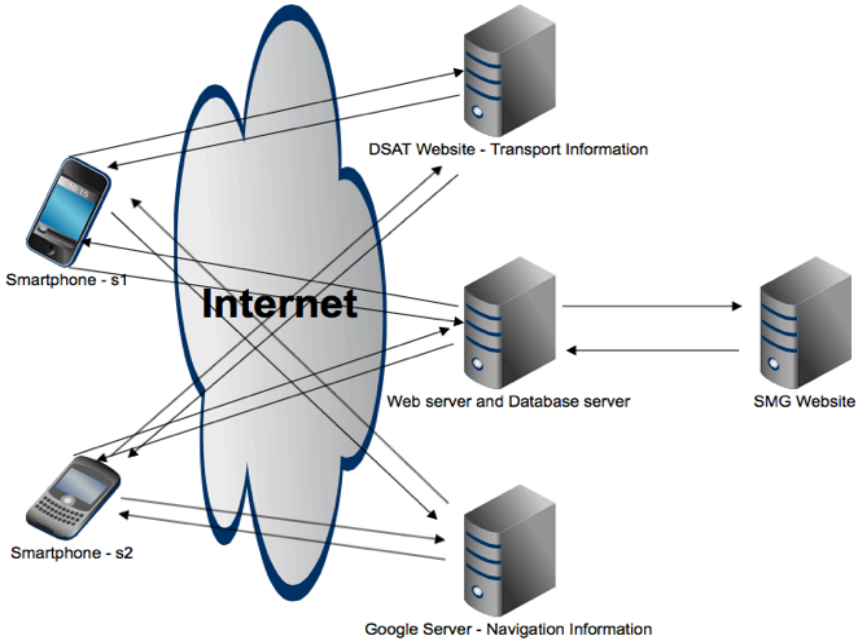


FIGURE 4 SYSTEM ARCHITECTURE

In order to obtain updated information, the architectural design of this project as shown above (Figure 4) illustrates that the client application (M-Guide) must communicate with different servers namely the Transportation Bureau (DSAT) server for real time traffic and border gate conditions, Google server for navigation information and a self-maintained server that will retrieve weather information from Bureau of Meteorology (SMG) website. Moreover, most of the scenic spot's information is stored locally in SQLite Database. Hence, the visitor can use some basic function without Internet connection.

Next, more design details of this project will be discussed. These include:

- **Script for retrieving external information.**
- **Database Design**
- **Graphical User Interface Design**
- **Fundamental function**
- **Augmented Reality (AR)**

3.2 SCRIPT FOR RETRIEVING EXTERNAL INFORMATION

In this project, some Macau related information are retrieved from other external websites including SMG website (for weather information), DSAT website (for transport information). Since the transport information obtained is the real time image, it must be acquired from the URL directly. However, most of the weather's information that is in text format, and required to be captured and parsed and stored in our server's database using a script. A java program was written to acquire the information every hour from www.smg.gov.mo and update to server or client database after retrieving. When the user requests that information, the server can return the information in XML format.

3.3 DATABASE

The whole project contains two databases that reside in the server and client respectively. MySQL will be used to develop a server database for storing the complete set of data about the scenic spots, weather and special events. SQLite would be installed initially as the default database in Android device for storing some brief information to keep some offline services running. The client cannot access data from server side database directly. The communication between client and server side database is thru the PHP interface with query parameter. The responsibility of the PHP interface is to handle the request from client and return the result in XML format.

3.4 GRAPHICAL USER INTERFACE DESIGN

The project should have a user friendly GUI. The design principle should follow Eight Golden Rules in Human Computer Interaction [15].

1. Strive for consistency	*2. Enable frequent users to use shortcuts*
3. Offer informative feedback	*4. Design dialog to yield closure*
5. Offer simple error handling	*6. Permit easy reversal of actions*
7. Support internal locus of control	*8. Reduce short-term memory load*

3.5 FUNDAMENTAL FUNCTIONS

This project includes at least six basic functions and two features. The six functions are scenic spots on map, navigation, weather forecast, transport information, text to speech and travel planning list while the users can also get the scenic spot information using different technologies such as, scanning a QR Code and tapping a NFC Tag.

As mentioned in Section 3.2, some local information like weather forecast and transport information are retrieved from different website. For other functions, some official APIs or the 3 sets of third party SDKs/Libraries are required. More details will be depicted below.

3.5.1 GOOGLE MAPS ANDROID API V2

Google Maps Android API v2 and GPS modules are used to show scenic spots information and navigation on map. Based on this API, the estimates for walking distance, walking duration and taxi price between current location and destination can be obtained.

3.5.2 ZXING LIBRARY

The library also provides another method which is scanning QR Code to get the information of a scenic spot. For QR Code implementation, Zxing Library is used and integrated into the application. That means user is not necessary to install extra application to use this function.

3.5.3 ISPEECH SDK

In this project, iSpeech SDK being a SDK for text to speech service that can support a lot of speech language and different voices, is used in speaking Cantonese that "I

want to go to xxx". (where xxx is the name of a Scenic Spots) – to help tourists to better communicate with local people.

3.6 AUGMENTED REALITY (AR)

For this project, the tracking pre-define object capability of Augmented Reality was adopted to achieve the scenic spot recognition. Qualcomm Vuforia SDK [3] is the main development kit for the AR function in which phone camera can be used to recognize and track the object (scenic spots) and display the corresponding information.

4. IMPLEMENTATION

After the depiction of the design, this section will show implementation details of this project.

The server side of this project is to obtain weather from www.smg.gov.mo and than store that information into the database. The client side can access the PHP interface in server to obtain data from server database and it can get transport information from www.dsat.gov.mo through the Internet. The overall system architecture (as in Figure 5) briefly shows the relationship between the server, client and others external websites.

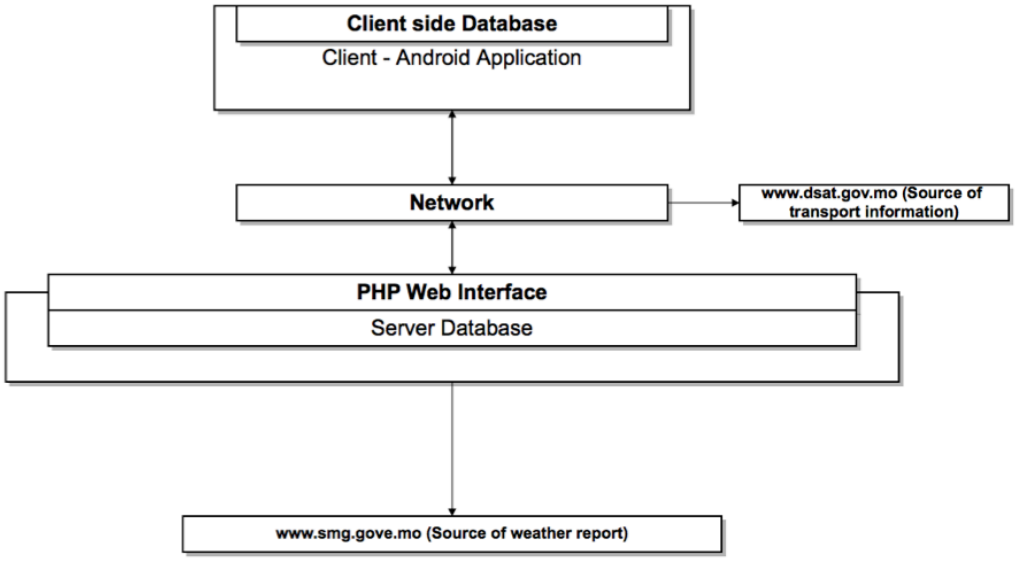


FIGURE 5 OVERALL SYSTEMS

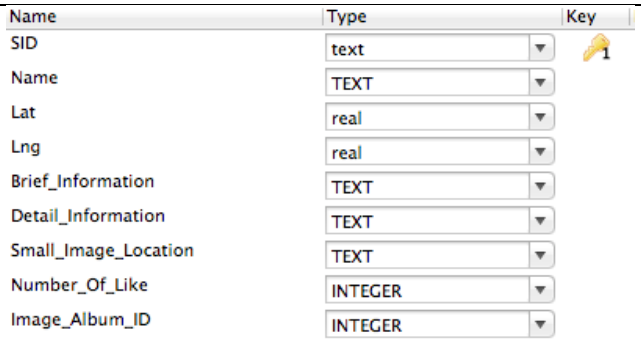
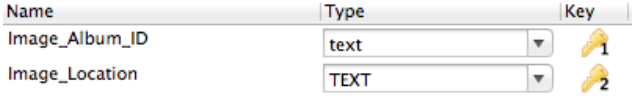
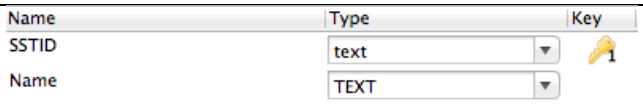
4.1 SERVER AND DATABASE IMPLEMENTATION

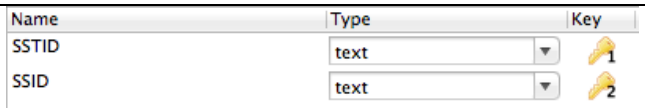
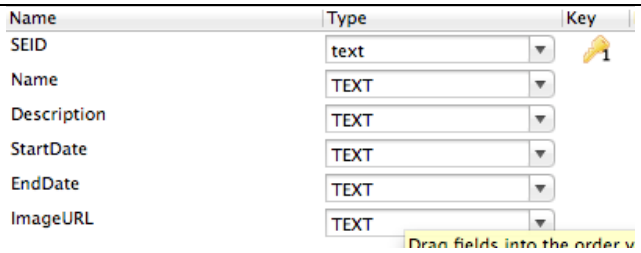
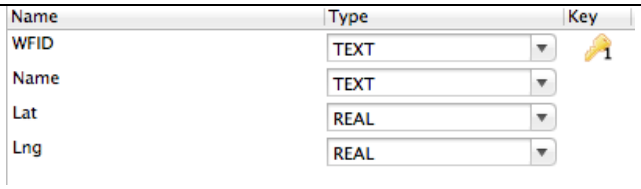
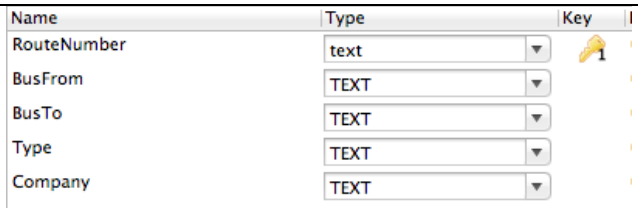
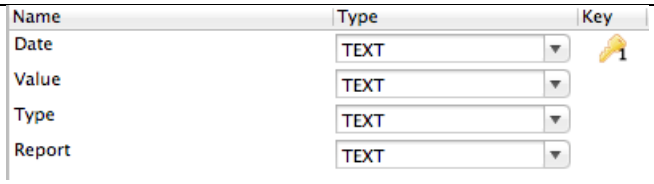
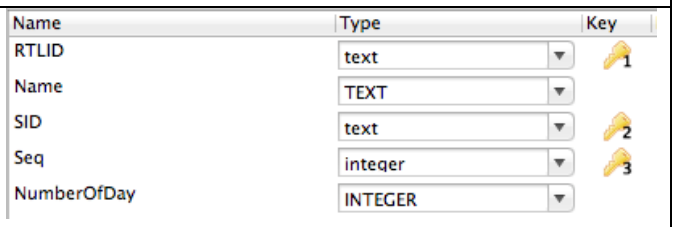
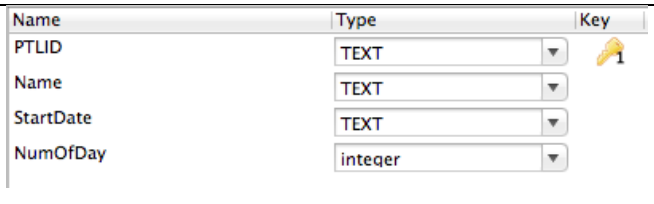
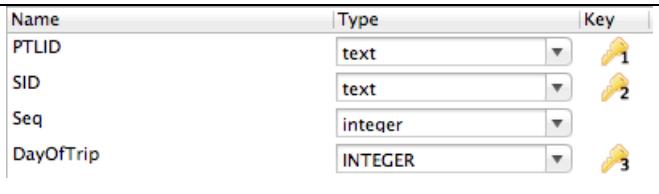
In this project, a server database is maintained for retrieving and storing information from external websites. Moreover, a PHP interface was designed to be used by the client application to access data from server. The technical details about the server can be found in the table below.

Server Information	
Operating System	Ubuntu 12.04.4 LTS (Linux 3.8.0-35-generic)
Web Engine	Apache 2.2.22
Database Engine	MySQL 5.5.34

Database Implementation

In this server, a MySQL database is used to maintain a set of information include the information of scenic spot, weather information, special event and etc. The detail database design is displayed in the table below.

Database information	
Database Engine	MySQL 5.5.34
Table	**Structure**
Scenic_Spots_cht / Scenic_Spots_en	
Scenic_Spots_Album_cht / Scenic_Spots_Album_en	
Scenic_Spots_Type_cht / Scenic_Spots_Type_en	

Scenic_Spots_Relation_cht / Scenic_Spots_Relation_en	
Special_Event_cht / Special Event_en	
FreeWiFiLocation_cht / FreeWiFiLocation_en	
BusInfo_cht / BusInfo_en	
Weather_7d_cht / Weather_7d_en	
Recommand_Travel_List_cht / Recommand_Travel_List_en	
Planning_Travel_Name_cht / Planning_Travel_Name_en	
Planning_Travel_List_cht / Planning_Travel_List_en	

Because this project supports multi-language for instance English and Traditional Chinese. There are two versions of a table that is English and Traditional Chinese, such as “Scenic_Spots_cht” and “Scenic_Spots_en”. On the other side, client side

database and the server side database are using a similar structure, the difference is that the client database (but not server database) will maintain a travel planning list which can be maintained by user.

4.2 Android Application Development Environment

The table below describes the development environment for this project.

Operating System	OS X 10.9.2 Mavericks
Integrated Development Environment (IDE)	Eclipse 4.2.2 / Unity 4.2.1f4
SDK	Android SDK, iSpeech SDK, Qualcomm Vuforia SDK
3rd Library / View	ZXING, SmartImageView

4.3 Retrieving data from external website

Since the weather forecast function requires the information from external website (www.smg.gov.mo), the server has a script to retrieve the information of that website. In the server, there is a java program for capturing the weather information from SMG website and it will run every hour. The following code (Figure 6) shows the process of capturing the weather information from SMG website. First of all, the program will obtain from www.smg.gov.mo/dm/report/c_forecast7dayXML.php source code which contains the weather forecast information. And then the program will use regular expression to filter the source code and get the weather information like temperature, humidity and description of the weather at that period of time.

```
try {
    url = new URL("http://www.smg.gov.mo/www/dm/report/c_forecast7dayXML.php");
    is = url.openStream();  // throws an IOException
    br = new BufferedReader(new InputStreamReader(is));

    int i = 0;
    String[] rawData = new String[8];
    while ((line = br.readLine()) != null) {
        //System.out.println(line);
        //System.out.println("************************************");
        String patternStr = "<tr>";
        Pattern pattern = Pattern.compile(patternStr);
        Matcher m = pattern.matcher(line);
        boolean matchFound = m.find();
        while(matchFound){
            rawData[i] = line.substring(m.end());
            rawData[i] = rawData[i].replaceAll("<td width='130'>", "");
            rawData[i] = rawData[i].replaceAll("<td width='100'>", "");
            rawData[i] = rawData[i].replaceAll("<sup>o</sup>C", "");
            rawData[i] = rawData[i].replaceAll("</tr>", "");
            rawData[i] = rawData[i].replaceAll("<img src='/www/dm/forecast/weatherIcon/icon/ww-c", "");
            rawData[i] = rawData[i].replaceAll(".gif'>", "");
            rawData[i] = rawData[i].replaceAll("%</td>", ",");
            rawData[i] = rawData[i].replaceAll("</td>", ",");
            rawData[i] = rawData[i].replaceAll("/", ", ");
            rawData[i] = rawData[i].replaceAll("<td>", "");
            i++;
            break;
        }
    }
```

FIGURE 6 CODE OF GETTING INFORMATION FROM SMG WEBSITE

After obtaining the data, the program will update all corresponding table into MySQL database. Java Database Connectivity (JDBC) is used to connect to the local MySQL database. The following code exhibits setting up of the JDBC connection.

```
String driver = "com.mysql.jdbc.Driver";
String dburl = "jdbc:mysql://127.0.0.1:3306/MGuide_TC?useUnicode=true&characterEncoding=utf-8";
String dbuser = "root";
```

Afterwards, the program (as shown in Figure 7) will try to connect to the MySQL database and update the above mentioned weather information. Moreover, it will convert the data collected from the SMG website to a correct data type before updating to the database as all information captured from SMG website is of the "String" data type. Therefore, it should be convert to the correct data type such as Integer, and then update to the MySQL database.

```
//*****Connect to mysql database by using JDBC*****
    try{
        Class.forName(driver);
        Connection conn = DriverManager.getConnection(dburl, dbuser, dbpassword);
        if(conn != null && !conn.isClosed()) {
            System.out.println("Connected.");
            Statement stmt = null;
            stmt = conn.createStatement();

            String test_sql = "DELETE FROM WeatherInfo";
            stmt.execute(test_sql);

            //*****Put the data into mysql database
            for(int a = 0; a < 7; a++){
                //System.out.println(rawData[a]);
                temp = rawData[a].split(",");
                wdate[a] = temp[0].substring(0, 10);
                wtype[a] = temp[1];
                minTemp[a] = Integer.parseInt(temp[2].replaceAll(" ", ""));
                maxTemp[a] = Integer.parseInt(temp[3].replaceAll(" ", ""));
                minHum[a] = Integer.parseInt(temp[4].replaceAll(" ", ""));
                maxHum[a] = Integer.parseInt(temp[5].replaceAll(" ", ""));
                wReport[a] = temp[6];

                String sql = "INSERT INTO WeatherInfo (Date, Type, MinTemp, MaxTemp, MinHum, MaxHum, Report, Typhoon_Signa
                + "VALUES ('" + wdate[a] + "', '" + wtype[a] + "', " + minTemp[a] + ", " + maxTemp[a] + ", " + minHum[a] +
                + maxHum[a] + ", '" + wReport[a] + "', '')";
                //System.out.println(sql);
                stmt.executeUpdate(sql);
                }
            conn.close();
            System.out.println("Completed.");
            Date odate = new Date();
            System.out.println(odate);
        }
    }
    catch(ClassNotFoundException e) {
        System.out.println("Driver not found.");
        e.printStackTrace();
    }
catch(SQLException e) {
        e.printStackTrace();
    }
} catch (MalformedURLException mue) {
    mue.printStackTrace();
} catch (IOException ioe) {
    ioe.printStackTrace();
} finally {
    try {
        if (is != null) is.close();
    } catch (IOException ioe) {
        // nothing to see here
    }
}
```

FIGURE 7 CODES OF JAVA PROGRAM UPDATE WEATHER INFORMATION TO DATABASE

In server, there is a PHP interface for handling the user request and return the XML object to user. When a client application requests for weather information from server database, it can obtain that information by using the PHP interface (as shown in Figure 8) in server.

```php
$query = "SELECT * FROM WeatherInfo";
$result = mysql_query($query);
if (!$result) {
  die('Invalid query: ' . mysql_error());
}

header("Content-type: text/xml");

// Start XML file, echo parent node
echo '<Weather_Report>';

// Iterate through the rows, printing XML nodes for each
while ($row = @mysql_fetch_assoc($result)){
  // ADD TO XML DOCUMENT NODE
  echo '<Day_Report>';
  echo '<Date>';
  echo $row['Date'];
  echo '</Date>';
  echo '<Type>';
  echo $row['Type'];
  echo '</Type>';
  echo '<MinTemp>';
  echo $row['MinTemp'];
  echo '</MinTemp>';
  echo '<MaxTemp>';
  echo $row['MaxTemp'];
  echo '</MaxTemp>';
  echo '<MinHum>';
  echo $row['MinHum'];
  echo '</MinHum>';
  echo '<MaxHum>';
```

FIGURE 8 A PART OF CODE OF THE PHP INTERFACE

On the server, there are two interfaces namely "getWeatherXML_tc.php" and "getWeatherXML_en.php" and they are used to handle and return the information in chosen language on the mobile (English or Traditional Chinese). If client requests this PHP interface, it will return a XML file (Figure 9-1).

192.168.1.8/getWeatherXML_en.php

```
    <MinHum>80</MinHum>
    <MaxHum>95</MaxHum>
    <Report>Mainly cloudy. Gentle to moderate</Report>
    <Typhoon_Signal/>
  </Day_Report>
▼<Day_Report>
    <Date>2014-03-12</Date>
    <Type>08</Type>
    <MinTemp>16</MinTemp>
    <MaxTemp>20</MaxTemp>
    <MinHum>80</MinHum>
    <MaxHum>98</MaxHum>
  ▼<Report>
      Mainly cloudy. Light to gentle east to southeasterly winds. Mist. Large wavelets on the sea.
    </Report>
    <Typhoon_Signal/>
  </Day_Report>
▼<Day_Report>
    <Date>2014-03-13</Date>
    <Type>06</Type>
    <MinTemp>17</MinTemp>
    <MaxTemp>22</MaxTemp>
    <MinHum>80</MinHum>
    <MaxHum>98</MaxHum>
  ▼<Report>
```

FIGURE 9-1 RESPOND XML OBJECT FROM PHP INTERFACE

4.4 LOCATION-BASED FUNCTION IMPLEMENTATION

This application offers thee location-based services namely: mapping, nearby service and navigation. More details are discussed below.

4.4.1 Mapping

In M-Guide, Map view is important because most of the location-based functions are based on that. Providing mapping service requires the use of Google Maps Android API v2 API that requires an API Key. The setting of the API Key is shown below.

```
<meta-data
    android:name="com.google.android.maps.v2.API_KEY"
    android:value="AIzaSyCq3TSAxTtkkjV8Q2FjeB18Wj2d5cbH-UI" />
```

The following code illustrates how to add Map view and a marker with corresponding information (Such as scenic spot's name, latitude and longitude), so that the scenic spot is displayed on the Google map with a marker.

```
map = ((MapFragment) getFragmentManager().findFragmentById(R.id.SSInfo_Map)).getMap();
Marker ss_marker = map.addMarker(new MarkerOptions().position(SS_Position).title(name).snippet(""));
ss_marker.showInfoWindow();
//Move the camera instantly to NKUT with a zoom of 16.
map.setMyLocationEnabled(true);
map.moveCamera(CameraUpdateFactory.newLatLngZoom(SS_Position, 16));
```

4.4.2 Nearby Scenic Spot

The function shows the nearby scenic spots requires an algorithm (as shown below [16]) to calculate the direct distance between two locations. Although this algorithm is not an accurate algorithm for calculate the distance, it only take around 5 meters deviation and it costs less resource to calculate.

Latitude:	*1 deg = 110.54 km*
Longitude:	*1 deg = 111.320 * COS(Current Latitude) km*

4.4.3 Navigation

The Google Maps Android API v2 also provides the navigation function requires that navigation information from Google server first. The URL format of getting that information is: https://maps.googleapis.com/maps/api/directions/output?parameters
The "output" is the output format of the return object, either in XML or JSON (XML in this project.) while "parameters" are consisted of latitude of source and destination, longitude of source and destination, sensor parameter and mode parameter (Mode can be walking or driving).

The following code presents how to formulate the URL.

```
//**************************************************************************************
private String getDirectionsUrl(LatLng origin, LatLng dest, String output, String mode) {
    String str_origin = "origin=" + origin.latitude + "," + origin.longitude;
    String str_dest = "destination=" + dest.latitude + "," + dest.longitude;
    String sensor = "sensor=false";
    String parameters = str_origin + "&" + str_dest + "&" + sensor + "&mode=" + mode;
    //String output = "json";
    String url = "https://maps.googleapis.com/maps/api/directions/" + output + "?" + parameters;
    return url;
}
```

Upon receiving URL request, the Google Server should return a XML object (as shown in Figure 10).

FIGURE 10 RESPOND XML OBJECT FROM GOOGLE SERVER

Google Maps Android API v2 can use those data to construct a route on the Map View. Moreover, that XML object from Google Server also contains the distance value of that route. Therefore, it can be used to estimate the price of taxi (Formula shown below [17]).

Price of Taxi:	***First 1600m***	***MOP$15.00***
	Every 230m	***MOP$1.50***

Formula: First Case: ***If distance <= 1600m, price = 15***

Second Case: ***If distance > 1600m,***

price = 15 + ((distance – 1600) / 230) * 1.5

if (distance-1600)%230 not equal 0, price = price + 1.5

4.5 QR CODE DECODING IMPLEMENTATION

QR Code implementation allows a visitor to use their smartphone to scan a QR Code and then obtain the scenic spot's information. ZXING Library (Figure 11) providing encoding and decoding QR Code function is used in this part of implementation for the decoding function.

When a user uses camera to scan a QR code, ZXING will execute the decoding method and read the value of QR Code which is the ID value of scenic spots. This ID value is then used to check whether the database contains this scenic or not. If yes, the application will show the information of that scenic spot.

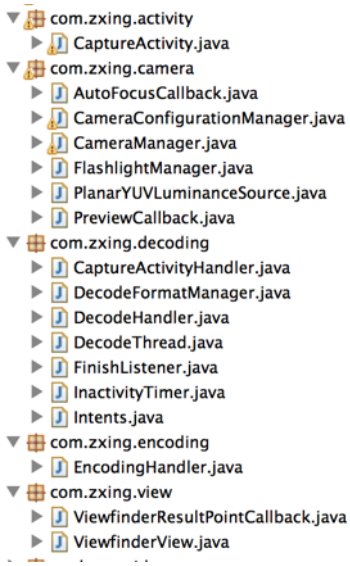


FIGURE 11 COMPONENTS IN ZXING

4.6 NFC COMMUNICATION IMPLEMENTATION

Since some Android devices contain NFC module which provides a quicker access than scanning QR Code, NFC is an alternate method for obtaining the scenic spot information. This part is implemented using Android SDK's built the NFC API. However, the four types of NFC tab discovered modes namely: NDEF_DISCOVERED, TECH_DISCOVERED, TAG_DISCOVERED, TAG_DISCOVERED must be registered in AndroidManifest.XML (as shown in Figure 12) before using those API.

```
        <activity
            android:name="ray.lo.mguide.SSNFCSearch"
            android:label="@string/title_activity_ssnfcsearch"
            android:launchMode="singleTop" >
            <intent-filter>
                <action android:name="android.nfc.action.NDEF_DISCOVERED" />

                <data android:mimeType="text/plain" />
            </intent-filter>
            <intent-filter>
                <action android:name="android.nfc.action.TECH_DISCOVERED" />
            </intent-filter>

            <meta-data
                android:name="android.nfc.action.TECH_DISCOVERED"
                android:resource="@xml/filter_nfc" />

            <intent-filter>
                <action android:name="android.nfc.action.TAG_DISCOVERED" />

                <category android:name="android.intent.category.DEFAULT" />
            </intent-filter>
        </activity>
```

FIGURE 12 CODES OF DEFINING NFC DISCOVERED MODE

For this project, NDEF_DISCOVERED is our main concern. The following code (Figure 13) shows how to detect and handle the NFC tag action.

```
if (NfcAdapter.ACTION_NDEF_DISCOVERED.equals(intent.getAction())) {
    //Log.e("TestingNow", intent.getAction());
    Parcelable[] rawMsgs = intent.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);
    if (rawMsgs != null){
        msgs = new NdefMessage[rawMsgs.length];
        for (int i = 0; i < rawMsgs.length; i++){
            msgs[i] = (NdefMessage) rawMsgs[i];
        }
    }else{
        byte[] empty = new byte[] {};
        NdefRecord record = new NdefRecord(NdefRecord.TNF_UNKNOWN, empty, empty, empty);
        NdefMessage msg = new NdefMessage(new NdefRecord[] { record });
    }
```

FIGURE 13 CODES FOR CHECKING NFC ACTION

4.7 AUGMENTED REALITY IMPLEMENTATION

In order to provide an interaction with the user, Augmented Reality technology is employed to allow users' us a phone camera to recognize a pre-defined object (scenic spot will be the pre-defined object in this project) and render the corresponding virtual content. For this implementation, Unity is the Integrated Development Environment (IDE) while Qualcomm Vuforia SDK is used to for the implementation of AR functions.

Each pre-defined tracking object should be imported to "Target Manager" in Vuforia Developer Website. That website will analyze the image and generate a result image (as shown in Figure14) that it is convertible to a package file to be used in Unity [18]. Comparing the result image and the original image (as shown in Figure 15), there are a lot of points generated on the result image and these points determines and reveal the quality of recognition of this image.

FIGURE 15 ORIGINAL IMAGE

FIGURE 15 ANALYZED IMAGE

The Unity IDE can import those image package generated by Vuforia Developer Website and show the images. The virtual content (for instance Virtual Button- the blue cube in Figure 16) generated by Unity needs to place on the top of each image that is recognized by the SDK.

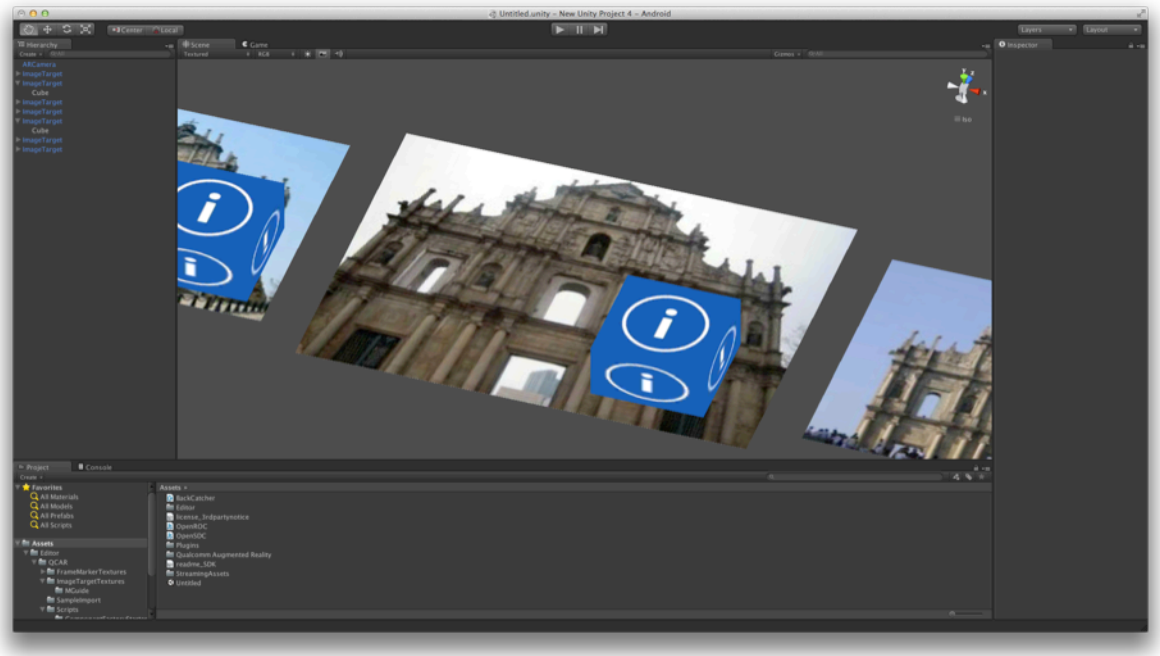


FIGURE 16 UNITY WITH VUFORIA PACKAGE

For each virtual button, it contains a script for handling the user touch event. Once the user touches the button, it will open a URL which contains the ID of the scenic spot or example “SID=SS00018” (As shown in Figure 17).

```
function OnMouseDown(){
    Application.OpenURL("m://my.com/?SID=SS00018");
}
```

FIGURE 17 CODES RELATED TO AR FUNCTION (JAVASCRIPT)

For the URL “m://my.com/?SID=’SS00018’”, “m://my.com” is a URL scheme for launch M-Guide application. In Android OS, all application can register an intent filter to launch that application with specific URL schemes. That means if M-Guide application had an intent filter like Figure 8, M-Guide will launch when the browser open a URL with “m://my.com”.

```
<intent-filter>
    <action android:name="android.intent.action.VIEW" />

    <category android:name="android.intent.category.DEFAULT" />
    <category android:name="android.intent.category.BROWSABLE" />

    <data
        android:host="my.com"
        android:scheme="m" />
</intent-filter>
```

FIGURE 18 CODES OF REGISTER AN INTENT FILTER OF LAUNCHING AN APPLICATION ACTIVITY BY URL

4.8 OTHER FUNCTIONS

"Speech to Text", "Travel List", "Bus information" and "Real-time traffic/border station conditions" functions are included in this project.

4.8.1 Speech To Text

In this project iSpeech SDK is employed to speak Cantonese from text and to enable visitors to communicate with local people easily. The API key was required for using iSpeech SDK (Figure 19).

```
<meta-data
    android:name="ispeech_api_key"
    android:value="a424153138aba4d6a6e48cfcb91a3acc" />
```

FIGURE 19 REGISTER AN ISPEECH API KEY

Figure 20 is the sample code for using iSpeech SDK to speak according to some parameters like the text of speech, the voice of speech (language).

```
speechbtn.setOnClickListener(
        new OnClickListener(){
            @Override
            public void onClick(View v){
                try {
                    String ttsText = "吾該, 我想去" + ssName_ch;
                    synthesis.setVoiceType("hkchinesefemale");
                    synthesis.speak(ttsText);

                } catch (BusyException e) {
                    Log.e("ispeech", "SDK is busy");
                    e.printStackTrace();
                    Toast.makeText(_context, "ERROR: SDK is busy", Toast.LENGTH_LONG).show();
                } catch (NoNetworkException e) {
                    Log.e("ispeech", "Network is not available\n" + e.getStackTrace());
                    Toast.makeText(_context, "ERROR: Network is not available", Toast.LENGTH_LONG).show();
                }
            }
        });
```

FIGURE 20 SAMPLE CODE OF USING ISPEECH SDK

4.8.2 Travel List

The purpose of this function is to provide some recommended travel list or maintain a travel list by user himself/herself. List View and Fragment are the most important components for this implementation. First of all, the data from the database need to be present using List View (as shown in Figure 21).

```
String querySID = "SELECT SID FROM Recommand_Travel_List" + dbLang + " WHERE Name LIKE ? AND NumberOfDay =? ORDER BY Seq";
Cursor cursorSID = mydb.rawQuery(querySID, new String[]{name, "3"});
int i = 0;
while(cursorSID.moveToNext()){
    String querySS = "SELECT Name, Small_Image_Location FROM Scenic_Spots" + dbLang + " WHERE SID = ?";
    Cursor cursorSS = mydb.rawQuery(querySS, new String[]{cursorSID.getString(0)});
    while(cursorSS.moveToNext()){
        ssName3[i] = cursorSS.getString(0);
        ssImage3[i] = cursorSS.getString(1);
        i++;
    }
}
adapter3.setData(ssName3, ssImage3);
RLInfoList.setAdapter(adapter3);
RLInfoList.setOnItemClickListener(
       new OnItemClickListener(){
           @Override
           public void onItemClick(AdapterView<?> arg0, View arg1, int position, long arg3) {
               Intent intent = new Intent(getActivity(), SSInfo.class);
               intent.putExtra("name", ssName3[position]);
               startActivity(intent);

           }
       });
```

FIGURE 21 CODES OF CREATING LIST VIEW WITH DATA FROM DATABASE

To cater that there might be more than one day planning on a travel list, the *"ViewPager"* is used. The "Swipe + Tab" interface can implemented by associating Fragment (as shown in Figure 22) with the ViewPager.

```
@Override
public Fragment getItem(int position) {
    Fragment fragment = new Fragment1();
    if (position == 0){
        fragment = new Fragment1();
    }else if(position == 1){
        fragment = new Fragment2();
    }else if(position == 2){
        fragment = new Fragment3();
    }else if(position == 3){
        fragment = new Fragment4();
```

FIGURE 22 CODES OF CREATING A FRAGMENT WITH DIFFERENT PAGE (TAB)

4.8.3 Real-time traffic/border station conditions

The purpose of these two function is showing the traffic and Border Gate condition image from DSAT website in real time to provide convenience to visitors.

In Android SDK, it does not have any image view to handle an image with URL directly and the original ImageView from Android SDK can only display the image

from local. However, the requirement of these functions is to access the images online. Therefore, there are two choices to solve this problem.

- First solution is using other technique (StreamReader) to obtain the image from the URL and then process it byte by byte and convert the "Bitmap" format before displaying in original ImageView.
- Second solution is using a 3rd party View like SmartImageView to display the online image directly.

The Second solution is adopted in this implementation because it can save more time to complete those functions. For real-time image, the image needs to update every 5 seconds. Therefore, a handler was created for updating the image (Figure 23).

```
final Handler handler = new Handler() {
    @Override
    public void handleMessage(Message msg) {
        super.handleMessage(msg);
        Date date = new Date();
        cache.clear();
        BorderLiveImage.setImageUrl(ImageURL +"?" + date.getTime());
        //Toast.makeText(TransBorderLive.this, ImageURL, Toast.LENGTH_SHORT).show();
    }
```

FIGURE 23 CODES OF USING SMARTIMAGEVIEW

4.8.4 Bus Information

Bus information provides the bus route table to visitor. The implementation method is similar to above 4.8.3, it also obtains the bus route table in image format thru URL. Therefore, SmartImageView is invoked.

4.8.5 Find Free Wi-Fi

The purpose of this function is showing the "Wi-Fi Go" access point in the Google Map. The implementation method is the same as showing scenic spot on the map. It will get the latitude and longitude of the Wi-Fi first and then place the market on the corresponding position. The related code was shown below.

```
map = ((MapFragment) getFragmentManager().findFragmentById(R.id.map)).getMap();
int indexOfMarker = 0;
while(cursor.moveToNext()){
    wifiLocation = new LatLng(cursor.getDouble(0), cursor.getDouble(1));
    wifiMarker[indexOfMarker] = map.addMarker(new MarkerOptions().position(wifiLocation).t
    indexOfMarker++;
}
// Marker nkut = map.addMarker(new MarkerOptions().position(NKUT).title(name).snippet(""));

//Move the camera instantly to NKUT with a zoom of 16.
map.setMyLocationEnabled(true);
```

4.8.6 Special Events

This function will provide a list of Macao Special Events. First of all, data are obtained from database and then put into a list view. However, the default List View in Android SDK does not contain an ImageView, it is necessary to create a custom List View if it requires displaying a small image in the List View.

For creating a customized List View, it is necessary to create a "special_event_item.xml" xml layout file that defines one ImageView and two TextView should define in this xml file (As shown below).

```
<ImageView
    android:id="@+id/se_icon"
    android:layout_width="80dp"
    android:layout_height="80dp"
    android:layout_margin="10dp"
    android:scaleType="centerCrop" />

<LinearLayout
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:orientation="vertical" >

    <TextView
        android:id="@+id/se_name"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_marginTop="10dp"
        android:textSize="14sp"
        android:textColor="#FFFFFF"
        android:textStyle="bold"/>

    <TextView
        android:id="@+id/se_date"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_marginBottom="10dp"
        android:textSize="10sp"
        android:textColor="#C0C0C0"/>
</LinearLayout>
```

After create the XML Layout file, the special event's information can be put in the custom list. The related code was shown below.

```
@Override
public View getView(int position, View convertView, ViewGroup parent) {
    convertView = myInflater.inflate(R.layout.special_event_item, null);

    ImageView seIcon = (ImageView) convertView.findViewById(R.id.se_icon);
    TextView seNameTV = (TextView) convertView.findViewById(R.id.se_name);
    TextView seDateTV = (TextView) convertView.findViewById(R.id.se_date);

    seNameTV.setText(seName[position]);
    seDateTV.setText(seDate[position]);

    AssetManager assetManager = getAssets();
    InputStream istr = null;
    try {
        istr = assetManager.open(seImage[position]);
    } catch (IOException e) {
        e.printStackTrace();
    }
    Bitmap se_image = BitmapFactory.decodeStream(istr);
    seIcon.setImageBitmap(se_image);

    return convertView;
}
```

5. RESULTS AND DISCUSSION

After discussing the implementation detail, this section will demonstrate the result of major functions of M-Guide.

5.1 LOCATION-BASED FUNCTION

M-Guide can show nearby scenic spots with a specific distance from the current location. User can choose the distance by using the drop down list.

Scenarios: On the home page of M-Guide, choose the "scenic spot" option and then choose "NearBy".

Figure 24 is the demonstration of this function. It shows the scenic spot within 500 meters, 1000 meters and showing all scenic spots respectively.

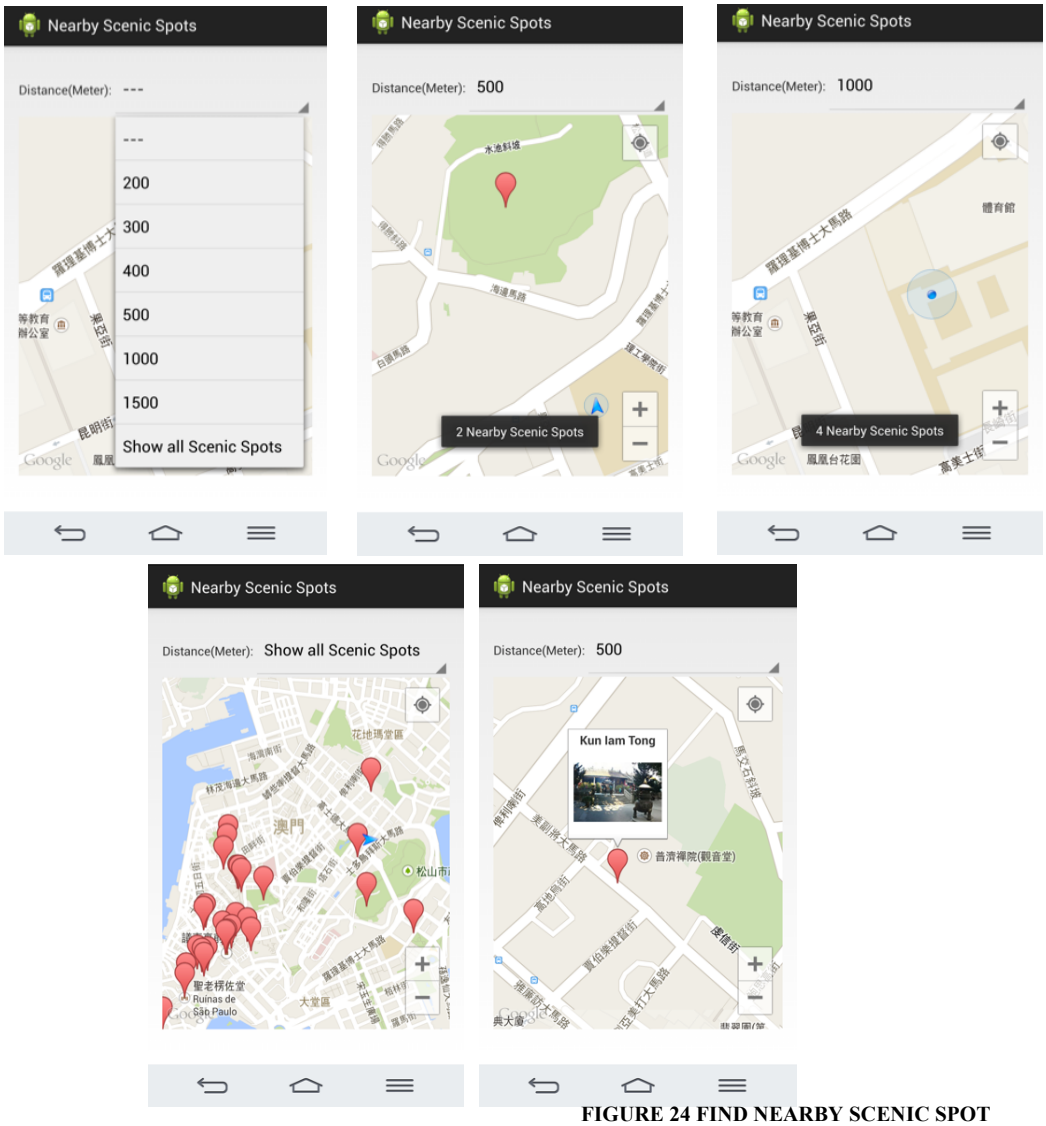


FIGURE 24 FIND NEARBY SCENIC SPOT

M-Guide also can provide to users some navigation information like walking information (such as walking distance, walking path and walking duration) and the taxi price estimate.

Scenarios: On the home page of M-Guide, choose the "scenic spots" option and it can use any of 6 methods (e.g. Search by keywords, NearBy, NFC, QR Code, AR, List of scenic spots) to find a scenic spot. In each detail information of the scenic spot, Navigation function can triggered by pressing the "Navigate" button.

Figure 25 is the demostration of getting navigation information. M-Guide will provide the walking path on Google Map, walking distance, duration and price of taxi (The price is for reference only because it does not consider the traffic condition).

FIGURE 25 NAVIGATION INFORMATION

5.2 Obtaining Scenic Spots Information (QR Code, NFC and AR)

There are several ways to obtain scenic spots information in M-Guide. For example, choosing a scenic spot on a Map, searching scenic spot by key word, scanning QR Code, tapping NFC tag and image recognition (Using the AR). This section will focus on scanning QR Code, image recognition and tapping NFC tag. The usage of QR Code and NFC is that Macau government can design some posters with corresponding QR Code and NFC tag which used to promote the scenic spots in Macau. Therefore, the visitor can easily obtain detail information of scenic spot when they look at the poster. For the QR Code and image recognition, user only needs to use the phone camera to scan the image/QR Code, and then the application will show the detail information of the corresponding scenic spots.

Scenarios: On the home page of M-Guide, choose the "scenic spot" option. And then all functions will available there.

Figure 26 is the demonstration of scanning QR Code. When the application scans a QR Code, it will decode the QR Code to get the scenic spot ID value and launch the detail information of that scenic spots.

FIGURE 26 SCANNING QR CODE

Figure 27 is the demonstration of AR function. After visitor use the camera on their Android device to scan the image or focus on that scenic spot, the Android device will display a virtual button, the visitor can get the detail information of that scenic spot by touching that virtual button.

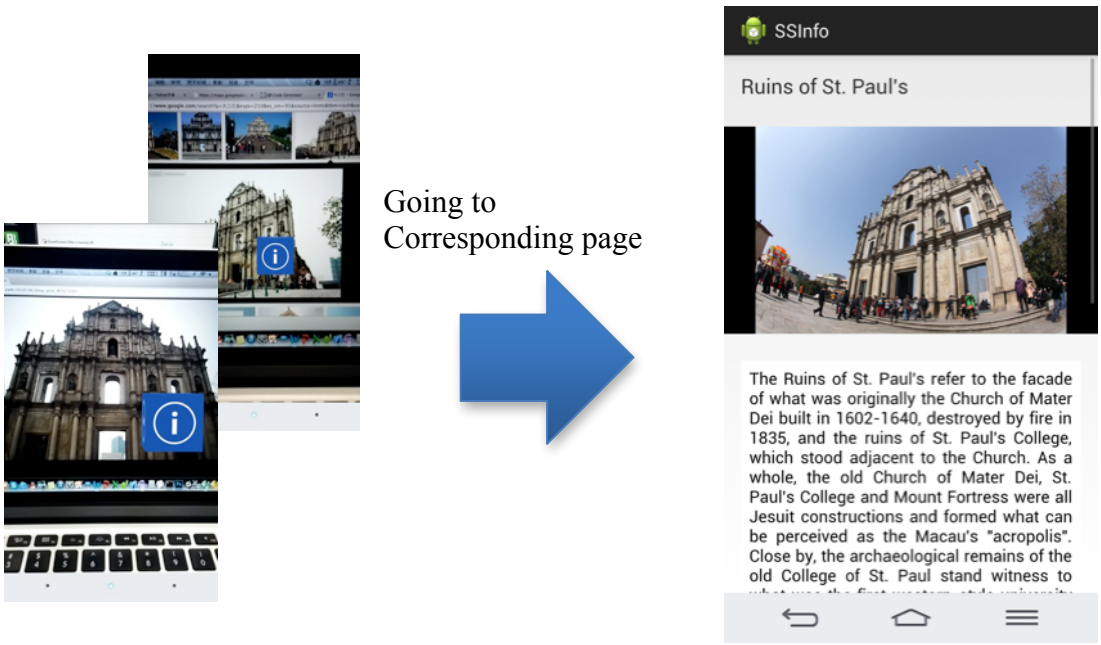


FIGURE 27 SCANNING A PHOTO OF SCENIC SPOT AND VUFORIA SDK GENERATE VIRTUAL CONTENT]

As some Android devices contain a NFC module, when tapped on some correspond information can be obtained directly. Figure 28 is the demonstration that when tapping NFC tag, the Android device can obtain corresponding information and display the detail information. Each NFC tag contains the scenic spots ID information.

FIGURE 28 TAPPING NFC TAG

5.3 OTHER FUNCTIONS

Weather and travel list function also used the list view and ViewPager components. It seems to a tab interface but it can swipe. The visitors can swipe the pages to obtain the current weather status and 7 days weather forecast in weather function. In travel list function, the visitors can swipe the pages to get the planning list in different days in the a trip.

Scenarios of Weather Report: On the home page of M-Guide, choose the weather icon.

Figure 29 showing the layout of weather report. It contains two pages, one is the current weather information, and the other is the 7 days forecast.

FIGURE 29 WEATHER REPORT

Scenarios of Travel List: On the home page of M-Guide, choosing "Travel List" icon

Figure 30 is the demonstration of travel list. Similar to the function of weather report, it also uses the ViewPager component so that user can swipe left or right to change the tab. In each tab, it contains the itinerary of each day on the planning list.

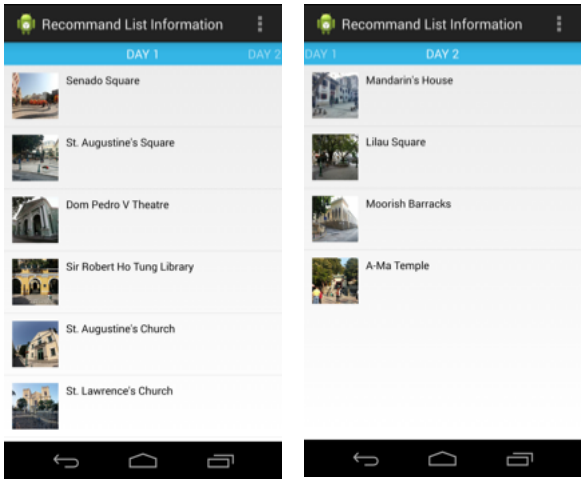


FIGURE 30 TRAVEL LIST

Finally, that is the demonstration of traffic function. This function will display some real-time image and bus information. The real-time image contains the real-time traffic condition and border gate. The visitors can conveniently understand the real-time situation of traffic and border gate. The bus function provides a list which contains all the bus route information.

Scenarios: On the home page of M-Guide, choose traffic icon.

Figure 31 is showing the Real-time traffic conditions and Real-time border station condition. These two functions will invoke the SmartImageView. When user choose the Closed-Circuit Television (CCTV) location, the SmartImageView will update real time image every 5 seconds.

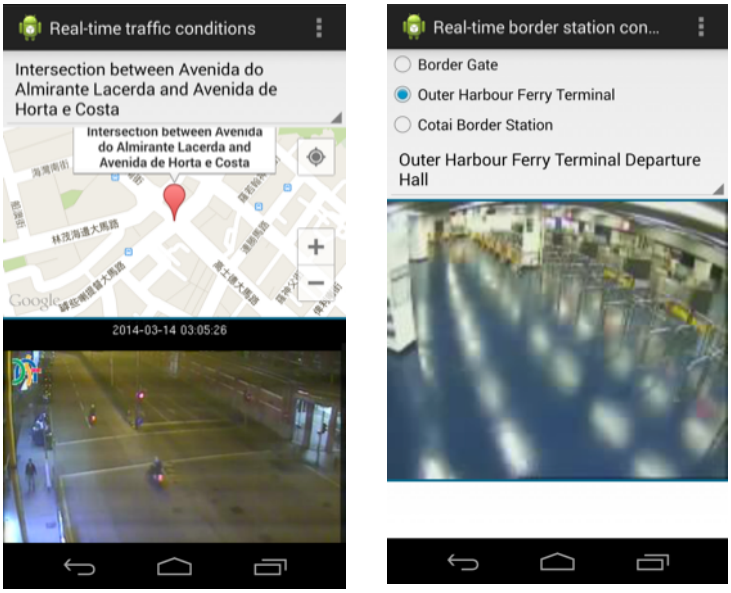


FIGURE 31 SMARTIMAGEVIEW IMPLEMENTATION

6. CONCLUSION AND FURTHER WORK

In this eight months endeavor, this project has accomplished all seven objectives and its primary goal - enhancing the tourism self-travelling experience. With this Android Apps, tourist is provided with Location, Navigation, Tracking, Mapping, Timing functions to travel around Macau. Concerning future development, the data collection should be expanded to include most of the scenic spot information. The "bus function" can be enhanced by searching for possible routes from given source to the destination. Moreover, effort should be made to improve the recognition capability of the Augmented Reality function and in terms of stability and compatibility.

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[15] University of Maryland. The Eight Golden Rules of Interface Design. https://www.cs.umd.edu/users/ben/goldenrules.html

[16] Stack Overflow. Answer one of Simple Calculations for working with lat/lon + km distance? http://stackoverflow.com/questions/1253499/simple-calculations-for-working-with-lat-lon-km-distance?lq=1

[17] DSAT. Taxi Fares. http://www.dsat.gov.mo/en/taxi_price.aspx

[18] Unity 3D. Game Engine, tools and multiplatform. http://unity3d.com/unity

PROJECT MANAGEMENT

Task Mode	任務名稱	Duration	Start	Finish	Predecessors
	Initiating	**1 day**	**Tue 13/8/27**	**Tue 13/8/27**	
	Meeting - Topic Confirmation	1 day	Tue 13/8/27	Tue 13/8/27	
	Planning	**13 days**	**Wed 13/8/28**	**Fri 13/9/13**	
	Proposal Writing	12 days	Wed 13/8/28	Thu 13/9/12	2
	Proposal Submission	1 day	Fri 13/9/13	Fri 13/9/13	4
	Analysis and Specification	**11 days**	**Sat 13/9/14**	**Fri 13/9/27**	
	Analysis	4 days	Sat 13/9/14	Wed 13/9/18	5
	Requirement Specification Document	4 days	Thu 13/9/19	Tue 13/9/24	7
	Requirement Validation	2 days	Tue 13/9/24	Wed 13/9/25	8
	Document	2 days	Wed 13/9/25	Fri 13/9/27	9
	Design	**16 days**	**Fri 13/9/27**	**Mon 13/10/21**	
	Database Design	5 days	Fri 13/9/27	Fri 13/10/4	10
	Architectural Design	2 days	Fri 13/10/4	Tue 13/10/8	12
	Component/Module Design	3 days	Tue 13/10/8	Fri 13/10/11	13
	Test Plan Design	3 days	Mon 13/10/14	Wed 13/10/16	14
	Report Writing - Design	3 days	Wed 13/10/16	Mon 13/10/21	12,13,14,15
	Coding and Implementation	**106 days**	**Fri 13/9/27**	**Mon 14/2/24**	
	Implement Database	5 days	Mon 13/10/21	Mon 13/10/28	16
	Collect data and photo	20 days	Fri 13/9/27	Fri 13/10/25	10
	Implement the common functions	40 days	Mon 13/10/28	Mon 13/12/23	18
	Implement the Augmented Reality function	40 days	Mon 13/12/23	Mon 14/2/17	20
	System Integration	5 days	Mon 14/2/17	Mon 14/2/24	18,19,20,21
	Progress Checking	**96 days**	**Fri 13/10/4**	**Fri 14/2/14**	
	Progress check form Submission	1 day	Fri 13/10/4	Fri 13/10/4	
	Progress Report	7 days	Fri 13/10/25	Mon 13/11/4	
	Progree Presentation	5 days	Mon 13/11/18	Fri 13/11/22	
	Progree check form Submission	1 day	Fri 14/2/14	Fri 14/2/14	
	System Testing	**10 days**	**Thu 14/1/23**	**Wed 14/2/5**	
	System Testing	3 days	Mon 14/2/24	Thu 14/2/27	22
	User Acceptance Test	7 days	Thu 14/2/27	Mon 14/3/10	29
	Finishing up	**27 days**	**Tue 14/3/11**	**Wed 14/4/16**	
	Poster Design	2 days	Tue 14/3/11	Wed 14/3/12	30
	Prepare the Final Report	15 days	Wed 14/3/12	Wed 14/4/2	32
	Prepare the Final Presentation	10 days	Wed 14/4/2	Wed 14/4/16	33