A Navigation System for Wheelchair Users

(Group 2)

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III. Abbreviations

API  Application Programming Interface
AR  Augmented Reality
CMS  Content Management System
OS  Operating System
UI  User Interface
UX  User Experience
3D  3 Dimensions
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We would like to express our gratitude to all those who have helped us during the project.

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Abstract

Although there are some map applications in the market, these applications do not consider the needs of the disabled. Wheelchair users may not be suitable to access the resulting paths from those map applications as it may contain inaccessible facilities such as stairs and escalators. Thus, this application aims to take care of the wheelchair users’ needs. The Navigation System for Wheelchair Users is an android application for displaying the path which is accessible for wheelchair users from the locations input by users.

This report consists of designs, implementations, work flows, the progress and the screens of the product of our application. The algorithm for finding the shortest path between two places which is accessible for wheelchair users and the method of displaying objects such as direction indicator and facility markers in the Augmented Reality (AR) are also mentioned in the implementations.
1. Project Introduction

1.1 Project Background

As smartphones have become a trend in mobile phones for a decade, many people use map applications for finding the path to destination. However, those resulting paths may not be suitable for the wheelchair users because some paths may be inaccessible for them such as stairs. This project is a navigation system for the disabled, especially for wheelchair users, helping them to find the accessible paths.

It will be published as an android map application, with the user reporting system (figure 1-1) and the AR camera (figure 1-2). The scope of our application will be focused on the area of the University of Hong Kong first.

Figure 1-1 User-report System

Figure 1-2 showing the direction indicator and labels in camera with AR technology
1.2 Definition of accessible path and inaccessible path for wheelchair users

The inaccessible path for wheelchair users can be a narrow path or containing inaccessible facility such as stairs or escalators so that the wheelchair users cannot pass through it easily. They need to choose an accessible path which is wide or containing accessible facility such as stair lift (figure 1-3), ramp (figure 1-4) and wide gate which helps them to pass through the path.

1.3 Project Objective

The Objective of this project is to build a navigation system in mobile platform for wheel chair users so that they can look for a suitable path to travel between current position and destination with accessible facilities.

If no suitable path is found, there will be a popup message to remind users that cannot go through there by themselves. The navigation system locates all the facilities in the map, including both accessible and inaccessible facilities. For those users who are not good at reading maps, they may choose to follow the direction indicator by turning on the camera with Augmented Reality technology. There is a user report system in the application which allows users to add the information of accessible or inaccessible facilities onto the map.
1.4 Previous Work in the Field

There is a map for wheelchair users called Wheelmap (Figure 1-5) in web and mobile application platform. It locates the facilities onto the map and users can mark these facilities as fully wheelchair accessible, partly wheelchair accessible or not wheelchair accessible (Figure 1-6). However, most of the facilities in Hong Kong are marked as unknown status and Wheelmap does not provide route searching between two places for wheelchair users.

![Figure 1-5 The University of Hong Kong in Wheelmap](image)

![Figure 1-6 Types of markers in Wheelmap](image)

Also, there is a map called Open Route Service in web platform. It provides route planning for wheelchair users in Germany only and it does not provide the information of facilities on the map.

As a result, our application aims at providing path finding for wheelchair users and providing the information of accessible facilities on the map, especially covering the Hong Kong area.
1.5 Project Scope

The application divides mainly into three parts, which are map, user-report system and the camera with augmented reality technology. The map is embedded into an android application, as it is used for locating all the accessible facilities and inaccessible facilities for wheelchair users. Also, route planning algorithm is implemented in the map to find the accessible path for wheelchair users.

The user-report system connects to the server with a database. It is for adding information and the location into the map by inserting data into the database. The user-report system contains a form for users to edit the details of the facility. The camera with augmented reality technology displays the direction indicator and building information. The direction indicator and information labels need to be placed correctly by 3D tracking in the camera.
2 System Functions Overview

2.1 Function List

The table below (Table 2-1) shows the functions which users can do in the system.

<table>
<thead>
<tr>
<th>Function</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve a detail map</td>
<td>User can retrieve the map from the database. The map is detailed enough so the user can know the geography of the campus and where they can go and where they cannot go.</td>
</tr>
<tr>
<td>Check current location</td>
<td>Users can know where they are currently at by the GPS function of their phone and their location will be displayed on the map-form screen.</td>
</tr>
<tr>
<td>Look for facilities nearby</td>
<td>Users can know the nearby facilities by looking the markers in map.</td>
</tr>
<tr>
<td>Marker Filter</td>
<td>Users can choose what kinds of markers displaying in map.</td>
</tr>
<tr>
<td>Report facility’s accessibility</td>
<td>Users can report the accessibility of that facility to help the system to extend the coverage.</td>
</tr>
<tr>
<td>Look for a path to target location</td>
<td>Users can select a point in the map and the system will find a shortest and accessible path connected to the selected point from the current location.</td>
</tr>
<tr>
<td>Show the distance</td>
<td>Users can see how far the destination from the current point by using AR camera.</td>
</tr>
<tr>
<td>Display a direction indicator point to destination point</td>
<td>Users can open their camera to know the destination point by the polar angle with the direction indicator.</td>
</tr>
</tbody>
</table>

Table 2-1 Table of Function List
2.2 Prototype

2.2.1 A detail map

2.2.1.1 Outdoor Map and Indoor Map

![Outdoor Map](image1)

![Indoor Map](image2)

**Figure 2-1 Outdoor Map**  
**Figure 2-2 Indoor Map**

2.2.1.2 Floor plan of one floor inside a building

![Floor Plan](image3)

**Figure 2-3 Example of an indoor map on 5th floor of Haking Wong Building**

In the above figure (Figure 2-3), there are also some markers to represent the facilities in map.
2.2.1.3 Markers of facilities

<table>
<thead>
<tr>
<th>Wheelchair user-friendly facilities</th>
<th>Not for wheelchair-user facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp</td>
<td>Stair</td>
</tr>
<tr>
<td>Stair Lift</td>
<td>Escalator</td>
</tr>
<tr>
<td>Toilet for wheelchair users</td>
<td>Gents Toilet</td>
</tr>
<tr>
<td>Passenger Lift</td>
<td>Ladies Toilet</td>
</tr>
</tbody>
</table>

Table 2-2 Table of Marker of Facilities

2.2.2 Marker Filter

Marker Filter can be turned on by clicking the filter button in the application (Figure 2-4). In Marker Filter, users can select or unselect each facility (Figure 2-5). The unselected facilities will be disappear in map after closing the Marker Filter.
2.2.3 User Report System for Map

Figure 2-6 Screen of User Report System

2.2.4 A best path from current location to the destination location

Figure 2-7 Example of a best path to the destination point
2.2.5 AR-technology with navigation system

In the above figure (Figure 2-8), the direction indicator points to the direction of the path to the destination. The name and distance of buildings are also shown in the AR camera.
3 Project Methodology

3.1 Project Architecture

3.1.1 Platform setup

In the latest market share report, Android contained 80% in average in the operating system market share (Figure 3-1 and Table 3-1). As a result, our application is determined to be built in android app in order to target for more potential users.

![Worldwide Smartphone OS Market Share](image)

*Figure 3-1 Mobile OS Market Share in 2016 by IDC [1]*

<table>
<thead>
<tr>
<th>Period</th>
<th>Android</th>
<th>iOS</th>
<th>Windows Phone</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015Q1</td>
<td>84.2%</td>
<td>13.4%</td>
<td>1.8%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2015Q2</td>
<td>79.0%</td>
<td>18.0%</td>
<td>1.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>2015Q3</td>
<td>81.4%</td>
<td>15.4%</td>
<td>0.8%</td>
<td>0.4%</td>
</tr>
<tr>
<td>2015Q4</td>
<td>87.6%</td>
<td>11.7%</td>
<td>0.4%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

*Table 3-1 Worldwide Smartphone OS Market Share*

There is low complexity for Android developers to build the applications as Android does not require developing license. It is easier to get the approval to the App store comparing to other platform as Android does not have limitations on the user interface of the application.

The application can be built by hybrid app or native app. As Wikitude Javascript SDK for AR supports more features than the Wikitude Android SDK (Table 3-2), this project will be implemented in hybrid application.
Table 3-2 Comparison between JavaScript API and Native API

<table>
<thead>
<tr>
<th></th>
<th>JavaScript API</th>
<th>Native API</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location &amp; Timing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoor Tracking</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Indoor 3D Map Tracking</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Indoor 3D Map Tracking Head</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Outdoor 3D Map Tracking</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Outdoor 3D Map Tracking Head</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Outdoor 3D Map Tracking</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Location &amp; Timing</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Distance to Planned Target</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### 3.1.2 Project Structure

The project consists of application, server and the database (Figure 3-2). Users request the map data such as facilities and buildings from the database through the web server in the application. Users also send the data to database through the web server for adding, editing or deleting markers in User Report System of the application. Administrator can have the data validation and update the data in database.
3.1.3 Structure In Application

3.1.3.1 Overall Structure

The navigation system is a map which consists of Buildings as it contains indoor maps. Every building consists of Floors as it stores the different floor maps. Also, the navigation system contains a marker list to store the markers located outside the buildings and a visible marker list to store the temporarily visible markers displaying on the map. There is also a Suggested Route between the buildings stored in the navigation system.

![Figure 3-3 Simple Structure of Application]
3.1.3.2 Building

In building (Figure 3-4), it contains its unique building ID, name, centre latitude and centre longitude. It also contains north east latitude, north east longitude, south west latitude, south west longitude and bearing for locating the indoor maps in the map. Also, each building contains floors, current floor ID and last floor ID for displaying different floor plans.

Figure 3-4 UML Diagram of Building
3.1.3.3 Floor

In floor (Figure 3-5), it contains unique floor ID and the bitmap of its floor plan. The name of that floor, for example, UG, G or LG is also included. It also contains a marker list which stores all the markers on that floor such as lifts, ramps and stairs. To support route searching function in indoor maps, floor contains a route object and a corridor list which consists of points.

![UML Diagram of Floor](image)

*Figure 3-5 UML Diagram of Floor*
3.1.3.4 Point

A path consists of points. In point (Figure 3-6), it contains the latitude and longitude of the point in the map, its unique point ID, the building ID of its location’s building and the floor ID of its location’s floor. If the point is not located in a building, both building ID and floor ID are set to be zero. The points which can be connected by this point are stored into neighbor list. Also, it contains two Boolean variables to identify the type of the point, which are lift and exit. If this point is an exit, it will contain the information of the exit region location, storing the latitude and longitude of the north-east point and the south-west point. If this point is a lift, it will contain a lift neighbor list which storing the points with same location but located on different floors.

![Figure 3-6 UML Diagram of Point](image-url)
3.1.3.5 Custom Marker

In Custom Marker (Figure 3-7), it has its unique ID, remarks and a marker object. It contains its location information such as latitude and longitude, the building ID of the building which the marker are located and the floor ID of the floor. It also contains its accessibility and type of marker and such as stairs, ramp, lift or accessible toilet.

![Figure 3-7 UML Diagram of Custom Marker](image-url)
3.1.3.6 Suggested Route

Suggested Route is a user-defined class storing the route information. In Suggested Route (Figure 3-8), it contains a suggested route list to store all the routes between two places. To indicate each route is accessible for wheelchair user or not, it contains an accessible list. For the route showing on the map, it contains a displaying route which is one of the route in suggested route list and a displaying index for storing the index from the suggested route list. It also contains a displaying index between floors for the route showing on indoor map.
3.2 Theory

3.2.1 Detailed Map

The navigation system retrieves a detail map of the University of Hong Kong from database, which consists of outdoor map and indoor map.

3.2.1.1 Outdoor Map

The application use Google Maps to be the basis for the system. The Google Maps can be retrieved by Google Maps API. In MapsActivity of the application, it requests the Google Maps through the Google Maps API from the Google server during the onCreate process (Figure 3-9).

![Figure 3-9 Life Cycle of an Activity][5]
3.2.1.2 Indoor Map

The indoor map is an image of the floor plan from HKU safety office displayed as a Grounds Overlay Object in the application. Ground overlay objects are the image overlays which are tied to its location (latitude and longitude coordinates) [6]. These objects also move when users drag or zoom the map. In each building, there are several ground overlay objects. The number of the ground overlay objects depends on the number of floors in the building.

3.2.1.3 Displaying Indoor Map

During the initialization of the application, it loads all the floor plans into Bitmap object and stores it into different floors in different buildings according to its building ID and floor ID. The locations of the Ground Overlay object (the latitude and longitude of north-east point and south-west point) of each building are also set during the initialization. When users move the map, it triggers the OnCameraMove function in the application. It calculates whether the map camera’s location is in the range of the building or not. If the map camera’s location is in the building, the bitmap of the current floor is set into the Ground Overlay object of that building and set the Ground Overlay object to be visible. If the map camera’s location moves out of the building, the Ground Overlay object of that building is set to be invisible.
3.2.2 User Report System for the Map

3.2.2.1 Adding Facility

If users want to add a facility into map, they need to have a long press where they want to add a facility in the map first. This action triggers the function OnMapLongClick in the application which create a red marker in the map where users pressed. Then, users need to click the red marker to switch to the form. This action triggers the function OnMarkerClick in the application to switch the Activity from MapsActivity to FormActivity. After clicking the submit button in FormActivity, the function OnClick in the button is triggered to check whether the form is completed. If the form is completed, the application will connect to insertMarker.php in the server with the parameters about the new marker. In insertMarker.php, it insert a new record of marker into database and return successful message to the application. When the application receives the successful message, it returns to MapsActivity and displays the new marker of facility in map.

3.2.2.2 Editing Facility

If users want to edit a facility in map, they need to click the marker of that facility, which triggers the function ShowInfoWindow of that marker in the application to show the information window. Then, users need to click the information window to switch to the form. This action triggers the function OnInfoWindowClick in the application to switch the Activity from MapsActivity to FormActivity with the data of that marker. After clicking the submit button in FormActivity, the function OnClick in the button is triggered to check whether the form is completed. If the form is completed, the application will connect to updateMarker.php in the server with the parameters about the edited marker. In updateMarker.php, it updates the record of marker with the same ID in database and return
successful message to the application. When the application receives the successful message, it returns to MapsActivity and displays the edited marker of facility in map.

3.2.2.3 Deleting Facility

If users want to delete a facility in map, they need to click the marker of that facility, which triggers the function ShowInfoWindow of that marker in the application to show the information window. Then, users need to click the information window to switch to the form. This action triggers the function OnInfoWindowClick in the application to switch the Activity from MapsActivity to FormActivity with the data of that marker. In FormActivity, there is a delete button. After clicking the delete button in FormActivity, the function OnClick in the button is triggered to connect to deleteMarker.php in the server with the parameters about the marker. In deleteMarker.php, it remove the record of marker with the same ID in database and return successful message to the application. When the application receives the successful message, it returns to MapsActivity and displays the map without that marker.

3.2.3 Marker Filter

Marker Filter can be turned on by clicking Filter button in the application. The function onTouch in filter button will be triggered and set the filter layout to be visible if the motion action is Action-up. In the filter layout, there are some CheckBoxes representing different kinds of markers. User can check or uncheck those CheckBoxes. When close button of the filter layout is clicked, it will trigger its onClick function. In this function, it set the filter layout to be invisible. Also, it sets the visibility of the markers in visible marker list in the application referring to the corresponding checkbox. If the marker is set to be invisible, it is also removed in visible marker list.
3.2.4 Route

3.2.4.1 Route Composition

The route is consists of the path between buildings and the paths and the paths in indoor. For the route between buildings, Google Maps Directions API is used to get the paths with walking mode. The shortest path without stairs will be put in highest priority and will be shown in the map. The paths with stairs will be put in low priority and marked as red line. Users can click the route in the map to edit the route by choosing other paths suggested. For the route inside building, path-finding algorithm (Section 3.2.2.2) is used to calculate the path instead of using Google Maps Directions API.

3.2.4.2 Path-finding Algorithm

A* Searching Algorithm is the path-finding algorithm used in the system. It searches the next node from all possible paths with the small cost (shortest time, shortest distance, etc.) and choose the path which appearing to lead most quickly to the destination[4]. In this system, distance is considered to be the cost. Only accessible paths are considered in the algorithm so that the result is the shortest accessible path by using this algorithm in the application.

3.2.5 AR Technology

The system uses Wikitude JavaScript SDK in Augmented Reality. When the AR button is clicked in the application, user needs to choose using GPS location or defining the location for current location. After that, the application passes the data needed and switches to an Activity with a web view which trigger the AR JavaScript. The data passed into the new Activity are the current location, visible markers and buildings. Routes are also be passed into the new Activity if the users searching the route. The markers and buildings are displayed in the camera based on its latitude and longitude. For the distance of buildings, it is calculated by the location of building and the current location. If routes are enabled, there is a direction indicator in AR.
3.3 Technologies Selection Criteria

3.3.1 Global Pointing System (GPS)

GPS is being used because it is available in most of the smartphone nowadays. The precision is about 5 meters which is quite accurate. Also there is APIs in Android for accessing the GPS and getting the current location.

3.3.2 Google Maps API

The map is implemented by using Google Maps API. Google Maps API is being chosen for the map application because Google Maps API is an open-source API. Also, Google Map data has high accuracy as Google hired a team to update the map data [2].

3.3.3 Wikitude JavaScript SDK for Augmented Reality

Wikitude JavaScript SDK is used as it supports location services comparing with Wikitude Native SDK and other AR SDK like ARToolKit. Also, it has EDU license for students to use it in an academic context. It is easy to use and it has a lot of simple example application for users to learn.

3.3.4 PHPMyAdmin

PHPMyAdmin is used to store the map data as the database. HKU CS department provides a server which is available for access all the time. Therefore, the map data needed for the application can be retrieved at any time.
4 Project Schedule and Milestones

4.1 Project Schedule

<table>
<thead>
<tr>
<th>Month</th>
<th>Scheduled Task</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>• Project website</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td>• Project scheme</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td>• Project plan</td>
<td>Finished</td>
</tr>
<tr>
<td>October</td>
<td>• Research for Library for AR technology</td>
<td>Finished</td>
</tr>
<tr>
<td>November</td>
<td>• Project analysis and setting up the server side</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td>• Collection of indoor map data</td>
<td>Finished</td>
</tr>
<tr>
<td>December</td>
<td>• Project Interim Report</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td>• Implementation of user report system</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td>• Processing the indoor map</td>
<td>Finished</td>
</tr>
<tr>
<td>January</td>
<td>• Implementation of path finding algorithm</td>
<td>Finished</td>
</tr>
<tr>
<td>February</td>
<td>• Implementation of AR technology with the map</td>
<td>Finished</td>
</tr>
<tr>
<td>March</td>
<td>• Finalized tested implementation</td>
<td>Finished</td>
</tr>
<tr>
<td>April</td>
<td>• Final presentation</td>
<td>TBD</td>
</tr>
<tr>
<td>May</td>
<td>• Project exhibition</td>
<td>TBD</td>
</tr>
</tbody>
</table>

The above table (Table 4-1) is the schedule of this project. The schedule in every month is caught up so that the project can be finished on time.
4.2 Deliveries in First Semester

After the first Semester, the Android application with .apk format was available. It can display a detailed map from database. In the database, some buildings inside campus have their own indoor map. Moreover, a user report system was available for user to insert the facilities like toilet, stairs, and lift into the map. A room searching function was also available for user to search where a room of a building inside campus is.

4.3 Deliveries in Second Semester

The user-report system was improved to allow editing and deleting the facilities instead of just adding facilities at the beginning second semester. In the second semester, the Path searching function between buildings was finished first. Then it was improved by allowing searching the route at the same floor in the building. The route searching function with different floors inside a building was implemented in the last. The camera with Augmented Reality technology was delivered after implementing all the functions in route searching. The UI of the application in user-report system was also improved in second semester for enhancing the user experience.
5 Limitations and Risk Management

5.1 Technical and Skill Acquirement Limitations/ Risks

The technical and skill acquirement limitations and risks can be divided into 3 aspects which are general aspect, map and AR camera. These limitations and risks are listed into below table (Table 5-1).

<table>
<thead>
<tr>
<th>General:</th>
<th>Consume battery rapidly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map:</td>
<td></td>
</tr>
<tr>
<td>Insufficient data from Google Maps</td>
<td></td>
</tr>
<tr>
<td>Inaccurate facility labels in the map</td>
<td></td>
</tr>
<tr>
<td>GPS signal might be inaccurate</td>
<td></td>
</tr>
<tr>
<td>The privacy of geographical data of users can be a concern</td>
<td></td>
</tr>
<tr>
<td>AR Camera:</td>
<td>3D tracking for Augmented Reality technology</td>
</tr>
</tbody>
</table>

Table 5-1 Table of Technical and Acquirement Limitation and Risks

5.1.1 Consume battery rapidly

The system require users keep turning on the screen which keep consuming battery. Furthermore, The AR technology requires users to turn on the camera which consume battery rapidly.

Available solution:

Our group will pay more afford on optimizing the algorithm in order to lower the number of process the smartphone have to proceed. AR mode can only be turned on if necessary in order to save battery.
5.1.2 Insufficient data from Google Maps

As our map is based on Google Maps, it may display outdated result due to the insufficient data from Google Maps. Although Google Maps has high data accuracy and efficient data correction, it still has a chance for the application to display outdated data in a short period of time.

Available solution:

With the built-in user-report system in our application, the data can be corrected into our database which can helps lower the chance for displaying mismatch results.

5.1.3 Inaccurate facility labels in the map

Some facility information might be incorrect or some facilities are located incorrectly due to the incorrect input.

Available solution:

A report system will be built for users to report these errors so that users can edit or delete the incorrect facilities. Besides, there is an administrator accesses the database for managing the data of facilities.

5.1.4 GPS signal might be inaccurate

GPS signal might be inaccurate if the user goes indoors or is moving too fast.

Available solution:

It is acceptable without AR-mode. For AR-mode, users can choose using user-defined location or using current location estimated by GPS in the beginning.
5.1.5 The privacy of geographical data of users can be a concern

The geographical data of users need to be accessed in the navigation system. The users may think it is a concern about collecting these geographical data.

Available solution:

The application will ask for the permission to access user location before installing the application. Users need to agree with it in order to install the application. Also, the geographical data of user will not be uploaded to the database and it is used within the application only.

5.1.6 3D tracking for Augmented Reality technology

As there are no background label for the augmented reality recognizing the size and the angle of the objects in the camera, the 3D Tracking may not have high accuracy. This may lead to the direction indicator to be displayed in wrong angle.

Available solution:

The application will also access the accelerometer in the phone to determine the angle with the ground so as to make the direction indicator in camera to be displayed accurately.
5.2 Scope and Schedule Limitations/ Risks

5.2.1 keeping up with the schedule and progress

It is the first time to work on a large scale project, the progresses or schedule may not be on track as there are some factors like assignments and examinations.

Available Solution

Set a loose schedule instead of a tight schedule, so that group members can easily catch up with the schedule. Limiting and verifying the scope of the project also helps group members to focus on the major functions and keeping up with the schedule.

5.2.2 Making up time for meeting

There are no lessons for the final year project. It may be difficult to have a meeting as the group members have different time slot.

Available Solution

Google Calendar is used to keep track of group members’ timetable. It is easier to have a meeting by looking at the Google Calendar. Also, calling for a meeting earlier is easier to have a meeting. Sometimes, a software called TeamViewer can be used if group members work separately.

5.2.3 Conflicts between working files

The working files may have conflicts if group members edit the same files.

Available Solution

Git is used to store the project. When group members edited the files, they need to commit to Git and synchronize it. Git updates and merges the files if it is in conflicts. It helps to keep the project in the latest version.
6 Product Results

6.1 Loading Screen

![Loading Screen of the Application](image)

*Figure 6-1 Loading Screen of the Application*
6.2 Maps

6.2.1 Outdoor Map

![Outdoor Map in the Application](image1)

*Figure 6-2 Outdoor Map in the Application*

6.2.2 Indoor Map

![Indoor Map of Chow Yei Ching Building](image2)

*Figure 6-3 Indoor Map of Chow Yei Ching Building*
6.2.3 Searching Place

![Figure 6-4 Searching a Building](image)

![Figure 6-5 Searching a Room](image)

6.3 User Report System

6.3.1 Showing Marker Information

![Figure 6-6 Markers on Map](image)

![Figure 6-7 Showing Information of a Marker](image)
6.3.2 Marker Filter

Figure 6-8 Markers on Chow Yei Ching’s 6th floor

Figure 6-9 Unselecting Lifts in Marker Filter

Figure 6-10 Lift Markers Disappear in Map

6.3.3 Adding Marker

Figure 6-11 A Map Before Adding a Marker

Figure 6-12 A Red Marker After Long Clicking in Map

Figure 6-13 User Report System After Clicking the Red Marker

Figure 6-14 Marker in Map After Submitting the Form
6.3.4 Editing Marker

Figure 6-15 Map Before Editing a Marker

Figure 6-16 Information Window of Marker Before Editing

Figure 6-17 Report Form Before Editing

Figure 6-18 Report Form After Editing

Figure 6-19 Information Window of Marker After Editing
6.3.5 Deleting Marker

Figure 6-20 Map Before Deleting a Marker

Figure 6-21 Information Window of Marker Before Deleting

Figure 6-22 Report Form of Marker

Figure 6-23 Warning of Deleting a Marker

Figure 6-24 Map After Deleting a Marker
6.4 Route Searching

6.4.1 Route at a floor

Figure 6-25 Route at a floor

6.4.2 Route between floors

Figure 6-26 Route at Starting Point’s Floor
Figure 6-27 Map in Other Floors
Figure 6-28 Route at Destination Floor

6.4.3 Route between buildings

Figure 6-29 Displaying Route Between Buildings
Figure 6-30 Route suggestions After Clicking the Displaying Route
Figure 6-31 Another Displaying Route Between Buildings
6.5 Augmented Reality

6.5.1 Showing Building Names

Figure 6-32 Showing Name with Haking Wong Building

Figure 6-33 Showing Name with Composite Building
6.5.2 Showing Nearby Facilities

![Figure 6-34 Showing Lift in AR](image1)

![Figure 6-35 Showing Accessible Toilet in AR](image2)

6.5.3 Showing Direction Indicator to the Route and Route in Radar

![Figure 6-36 Showing Route in Radar and Direction Indicator in AR](image3)
7 Future Work

7.1 Expanding the Application Coverage Area

In the current stage, the application can be used in the area within the University of Hong Kong only. In theory, it can not only be used in the area within the University of Hong Kong, but also can be used in Hong Kong, or even can be used in the world. However, it needs some modifications in order to apply theories into practical.

7.1.1 Search Engine

Search Engine needs to be modified to expand the coverage area for the application. It provides the location searching function for the buildings or rooms in the University of Hong Kong only with a suggestion list in search view when users change the keywords in Search View. In future, Google Places API will be implemented into Search Engine. Apart from the suggestion list with the buildings or rooms in the University of Hong Kong, it will be possible for users to search a place or building by inputting keywords into Search View and then pressing the search or enter button in the keyboard.

7.1.2 Content Management System (CMS)

The information of buildings and its floors in the University of Hong Kong are implemented by developers, who are the students in this final year project team now. As the application expands its coverage area, there will be more buildings are in coverage. As a result, it will become a huge burden to the developers as they may not be familiar with those buildings or they do not have the information about those buildings. In this case, a Content Management system (CMS) is needed. It may be a website or another application so that building owners can input their building’s information such as the name, the number of floors and the location.
into the database of this application. Also, they can upload the floor plan of each floors to the CMS and provide the paths which are available in the floor.

7.2 Route Searching

In the current stage, A* searching algorithm is used in the indoor path finding and Google Maps Directions API is used in the paths outside buildings. To enhance the accuracy of the route suggestion for wheelchair users, some modifications are needed in both indoor route searching and outdoor route searching.

7.2.1 Indoor Path Finding

In the current stage, indoor path searching only analyzes accessible paths for wheelchair users and ignore the inaccessible paths for wheelchair users. The resulting path of A* search algorithm is the path with the lowest cost from starting point to the destination point. The cost of the path is calculated with the distance now. However, there may be some cases that wheelchair users can go through an inaccessible path. For example, there may be an inaccessible path which is the shortest path and may contains one stage of stairs only. Wheelchair users may go through this path without too many difficulties as they only need a help in that one stage stairs. In future, these paths will also be displayed in route suggestion. The indoor path searching will also analyze inaccessible path but the method of calculating the cost of the paths will be changed. The cost will not only consider the distance, but also the ease of passing through the path. The path containing inaccessible facilities such as stairs will have higher cost, while the indoor path searching results the lowest cost path.
7.2.2 Machine Learning for the Paths Between Buildings

In current phase, the paths between buildings depend on Google Maps Directions API. To enhance the accuracy, a machine learning can be implemented into the system. There will be a database storing all the possible paths between buildings. When user queries a route between buildings, the system will look for the result from the database by A* searching algorithm. If there is no result from the algorithm, the system will use Google Maps Directions API for finding the possible paths. At this same moment, all the suggested paths will be copied into database. User can report the accessibility of the paths suggested by Google Maps Directions API to the database so that the system will use the data from the database in next time.

7.3 Augmented Reality

In current phase, only the buildings’ information, the markers and the route direction indicator are shown in AR camera. The suggested route is shown in the radar. In future, there will be a change to put the suggested route into the AR camera and it will automatically update the distance and the route direction indicator during the movement of users.

7.4 User Experience Enhancement

The user experience (UX) can be enhanced by making some changes in the application. Users may feel more convenient when using the application after the changes. For example, user needs to input the starting location and the destination location when turning on the route searching now. In future, the UX can be enhanced by inputting the current location to the starting point and the searching place to the destination point if the user used the place searching function before.
7.5 Application Optimization

To enhance the performance, optimization is needed in the application. In the current stage, all the data of the map including the indoor plans and indoor paths of all buildings will be loaded into the application during the initialization. As there will be a large increase of the coverage area in the system, there will also be more data loaded into the map during initialization. It may affect the system performance and the system stability. For examples, there will be a long loading time in the loading screen and it may cause some problems like out of memory in the application.

7.5.1 Region

To prevent the system stability and the system performance problems, all the data should be stored into different regions base on its location. The application only get the necessary data to display each time. During the initialization, the application loads the data in the same region with the map’s camera location only. As a result, the necessary information can still be displayed but it shortens the loading time at initialization stage. If user moves the map’s camera to other places, it triggers the function OnCameraMove(). In OnCameraMove function, it compares the region of new camera location with that of the current camera location. If the region is changed, the application downloads all the data of the new region from the server asynchronously. The data of the old region will be removed at an appropriate time. This method can make the system stable and prevent the problems like out of memory as it will only keep the necessary data and discard the data not in use.
8 Summary

To conclude, map applications in market have the route planning and path suggestion which may contains some inaccessible facilities. Wheelchair users may feel inconvenience when using these applications. As a result, the application of our project is to show the paths with accessible facilities. The facilities in our application will become more accurate as users can add, edit and deleting the facilities into the application. Also, user can follow the direction indicator to the destination and find the nearby facilities in the augmented reality.
9 References


