

TOURISM GUIDANCE USING AUGMENTED REALITY

BY

Chong Chee Kim

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2020

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ABSTRACT

This project proposes the idea to develop a mobile based solution application that combines the tourism field and the current AR technology. The present tourism applications do not fully utilize all the aspects of AR technology such as AR navigation, scanning maps and building. As a result of not utilizing such technology, most of the tourism applications remain unfamiliar and outdated for the community and eventually they are getting eliminated from the market. In order to increase the popularity and remains updated among the community for the application, the focus areas of this project will be placed under the AR navigation and maps scanning features which can provide a better accuracy and interactive visual navigation for the user. A number of tourism mobile application reviews are attached to further enhance the proposed application's features based on the reviewed strengths and weaknesses. The AR technology that will be applied in this project is Google ARCore after the reviewing several AR technologies such as ARKit and Vuforia. This project will be the first application to apply AR navigation and maps scanning in the tourism field. This project consists of 5 modules which are tutorial, map service, AR object generator, navigation and POI information module. The target platform of this application is Android and is developed mainly using Unity and Android Studio. In other words, it requires the integration between Unity and Android Studio. The settings between both IDE needs to be handle carefully to ensure the integration works perfectly. The implementation of this project is expected to increase the user experience on AR in the field of tourism, to promote local attractions to the tourism and to simplify the complexity of the tourism and subway exit area maps.

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LIST OF ABBREVIATIONS

<i>API</i>	Application Programming Interface
<i>AR</i>	Augmented Reality
<i>GUI</i>	Graphical User Interface
<i>IDE</i>	Integrated Development Environment
<i>OS</i>	Operating System
<i>POI</i>	Point of Interest
<i>SDK</i>	Software Development Kit
<i>SLAM</i>	Simultaneous Localization and Mapping
<i>UI</i>	User Interface

Chapter 1: Introduction

1.1 Problem Statement/Motivation

As the tourism sector has become an important part to account for GDP of government, government has put a lot of efforts in promoting tourism attraction. Government have carried out many steps especially in the year of travelling in Malaysia known as *Cuti-Cuti Malaysia*. One of the steps taken by the government is the installing of tourist information kiosk central (see Figure 1.1) in the tourism attraction. These information kiosks can often be seen in the crowded places or roads and it can be either a large building or a merely small pavilion.



Figure 1.1: Tourist information kiosk central (Alamy.com, 2018).

These centrals assist tourist by providing the information about the tourism attraction and the tourism map to the tourists. Many tourists can be seen in these centrals specifically during the peak durations of holiday. However, these maps have 2 significant limitations in giving assistance to the tourist which are the **complexity and navigation issue**.

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1.1.1 Maps

The **utilization of tourism maps and subway exit area maps** should be given attention as the maps are the most common things in the tourism attraction and subway. Although board and subway exit area maps are provided to guide the tourist about the city direction, most of the **maps are over complicated** for tourist to analyze (Burch et al., 2016). Most of them take a certain amount of time to finally figure out the path to the destination. As a result of that, the centrals maybe crowded with the tourists due to the inefficiency use of the maps.



Figure 1.2: Complicated map (Coomes, 2008).

The Figure 1.6 above shows a complicated map overloaded with paths, legends etc. Even the letters and words in the map are very small and unclear to read. Although the paths are highlighted with multiple colours, yet it still looks messy and irritates the eye which instead, it creates a contrary effect. These maps are supposed to aid and help the tourists but in contrast, they are wasting their time to understand the map and find the related path.

The map itself is just showing the route to different POIs but do not navigate the tourists to the destination. This makes the tourists to keep looking at the map to confirm their current locations and to make sure they are on the right track to the destination. Once they detach with the original route, they need to figure out the new route to that destination. Hence, it creates another problem in term of navigation.

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1.1.2 Navigation

Tourism maps and station maps show the route to the destination, but it does not navigate the tourist step-by-step to the destination. Therefore, navigation is becoming the most major concern for tourists, tourism mobile applications started to put effort on bringing navigation to their applications. However, it is still seldom used by the society because of the **imperfection of navigation feature**. Some of them employ a navigation feature on their tourism applications by just simply showing out or switching to the Google Maps which is a general function used by other applications. It reflects the **non-user-friendly concern** on these applications. The navigation feature does not actually fulfil the responsibility on bringing the tourist to the preferred POI. They are just providing the almost similar function as the tourism board map or subway exit area map that showing the paths with a slightly differ of highlighting the selected POI's path. The non-user-friendly mobile applications are somehow giving a bad impression for the user on the tourism application and make them to uninstall these applications. Thus, the lifespan of these applications is very short. These tourists rather to use the navigation applications such as Waze and Google Maps, causing the tourism applications to become meaningless.

Other than that, the tourists that comes from other country may have no idea on how the building of a POI looks like and a normal navigation is unable to provide guidance to the tourists. When the tourists reached the destination through the normal navigation, he or she may not able to find the building for the destination due to the lack of geographical knowledge of the country.

In conclusion, for both discussed issues, the complexity of maps and imperfection of navigation problem inhibits the advancement of in tourism. Hence, an innovative, creative and interesting way to utilize the maps combining with the **AR and pedestrian navigation** should be considered to create a killer mobile tourism application so that the user achieves “one stone three birds” condition to rise the trend of using AR by tourist. Not to be forgotten is that the tourism board map and subway exit area map should act as a supporting tool to achieve resonance and make these maps become more “alive”.

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1.2 Project Scope

This project is to develop an android mobile application for tourism using AR. Objects such as tourism board map or subway exit area map will act as a supporting tool to use together with the applications. The focus area in this project is the map scanning and pedestrian navigation feature for the mobile application with the purpose to navigate the tourists to their preferred POIs. The tourists are able to click on the augmented picture of the POIs in a tourism board map or subway exit area map and it will direct the user to the details of the POIs where the tourist can choose whether to start the navigation such as the Figure 1.3 shown.

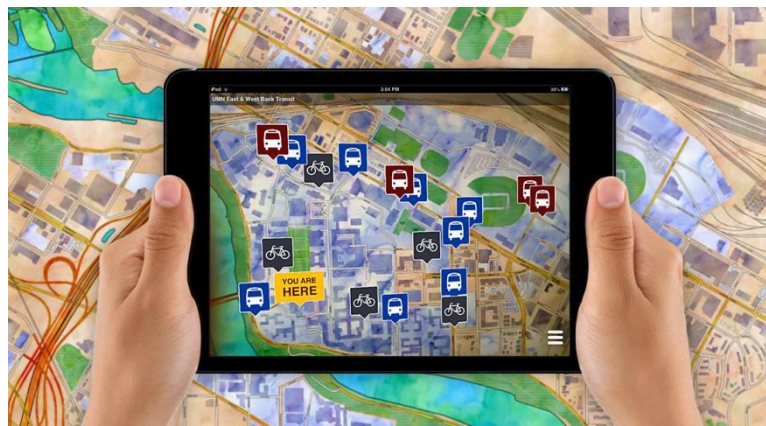


Figure 1.3: Example of using AR on map (Adamson, n.d.).

Besides the pedestrian navigation, filtering AR content is also a concern in this project. Separating the POIs to different categories will be comprised within this project. It will also give suggestions for the tourists to a certain POIs based on the current special events occur at the POIs. The integration between various APIs, SDKs and IDEs is one of the major components as well.

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1.3 Project Objectives

- To provide a basic map service for the tourism attractions and subway exit area in the application.

Tourism attraction and subway exit area maps can find within the application that allow the user to interact with the maps. The pictures and names of POIs will overlay in the offline maps. Users can click on the POIs shown in the maps and retrieve its additional information. The services include retrieving real-time information, searching a location and navigation.

- To display pictures of POIs in the tourist board map or subway exit area map with AR through mobile application.

AR technology is applied to simplify the tourist board map and subway exit area map. With the help of AR, the POIs are categorized into different categories to eliminate the information overload problem. The pictures of POIs will show according to the selected category. These pictures will be clickable to shows more details of the POI.

- To navigate the user to the selected POI by showing augmented arrows in the smart phone.

Augmented arrows that point the path to the POI's direction is visualized in the smart phone once the users active the AR mode for the navigation. Whenever the user detached from the calculated route, the augmented arrows will be updated based on the user's real time location.

- To provide additional POI's information after clicking the pictures of POIs in the maps.

The additional information of the selected POI such as operation hours, description, rating, menu and etc will be displayed in new page to make these AR pictures more interactive.

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1.4 Impact, Significance/Contribution

This project is innovating from current AR tourism mobile application as **it targets the tourism board map and subway exit area map** instead of the building in the tourism attraction. This will ease the difficulties that the tourists encounter when viewing these maps aimlessness. It highlights the famous places on the map in an augmented way which illustrate the picture and name of the POIs on the map. This project also highlights the POIs that are having special events such as promotion, discount and etc. Indirectly, it gives some ideas about where they can go especially when their travel schedule has ended, yet still have plenty of time for them to hang around at the tourism attraction.

Apart from that, **this project benefits the tourists in reaching their destination with the pedestrian navigation feature**. It leads the tourists with the augmented arrow by highlighting the path to the destination and the tourists can follow the arrow through the mobile. The tourists can have more enjoyment during the navigation as they interact with the surrounding environments that are more preferably than looking on the same maps during the whole navigation progress.

From the POI's perspective, the application helps them to bring more tourists to their place. It helps the POIs to promote their events and reach out to more tourists which reduces their advertising expenses indirectly, achieving a win-win situation for both tourists and POIs.

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1.5 Background Information

The concept of Augmented Reality has existed since the 1960s, and with the technology advancement in today have made this concept successfully being employed and becoming more mainstream over the world. AR is a feature that enhances the real-world visualization by bringing virtual to the real-world environment which is an opposite of Virtual Reality. Smartphones with built-in cameras, integrated GPS have further driven the formulation of AR which increase the accessibility of this feature to everyone. Consumers can interact with the surrounding using the smartphone camera through AR features.

The usage of AR becomes wider and wider when the killer game, PokemonGO strikes in this industry as it makes everyone recognizes AR. It raises the trend of using AR in different kinds of fields such as education, medicine, entertainment etc. It is also used extensively within the tourism field in order to improve the tourist exploration experience. AR can aid tourists in reaching valuable information and strengthen their knowledge about a tourist destination, leading to increased enjoyment during the whole process (Kourouthanassis et al., 2015). On top of that, it minimizes the time wasted for tourist to navigate, search and get familiar with the tourist attraction as the AR can guide and lead the tourist to their preferred destination or POI. The usage of AR in museum and heritage sites like Archeoguide Project (Figure 1.4) can further bring a whole new level of visual enjoyments by aligning the virtual and real-world objects. For example, in a museum, AR enriches the static objects inside there by providing information and 3D model for user interaction. It can be a feature for the museum and attracts the visitors especially the children.

Thus, each tourism mobile applications started to include different kind of features in their application such as search and browse, context-aware push, m-Commerce, feedback, pedestrian navigation, tour generation, map services, communication, exploration of visible surroundings, interactive AR view and filtering AR content to become the number one tourism mobile application. The current applications' features will be further deliberated in the following section.

Despite the AR trends is raising every year, the trend remains within the technician and developer. There are many end users out there does not have knowledge about AR. Thus, developers in different type of applications started to implement the AR features

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to improve the application. In fact, there are many mobile applications today uses AR effects and most of the users are not even alert of it. For instance, Snapchat, a social mobile application uses AR by allowing user to select different effects while capturing photo or video that contains human face. Whenever the system detects human face, the AR effects will be superimposed in the screen of the mobile. Many users are just using the effects without knowing that it is an AR technology. In order to achieve resonance between developers and users, the users themselves need to have certain AR knowledge to meet the best experience while using the AR.



Figure 1.4: Archeoguide AR project for heritage site (Vlahakis et al., 2002).

One of the most important criteria in AR, the tracking and navigation techniques have been the main research area by most of the researchers. In today's AR tracking technologies, it can be categorized as marker and marker-less tracking. Marker-based AR is where the images to be registered in the application are provided beforehand where it requires a more specific environment for the applications to do image recognition (see Figure 1.5). Once the camera detects the registered images, certain actions can be made such as superimposing the AR elements. On the other side, the marker-less recognizes images or things in a more flexible environment by using the SLAM technique. It uses the GPS data receives from the device to make further similar actions mentioned in the marker-based tracking above.

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Figure 1.5: AR using marker-based tracking (Singh, 2018).

For both tracking technologies, a slight error can result in the incorrect alignment between the virtual and real-world object (Rabbi & Ullah, 2013). Most of the AR applications are moving towards to the marker-less based tracking especially for outdoor application in order to make use of all the resources of real-world environments rather than just images itself in marker-based tracking. Unlike indoor, outdoor environments are often unpredictable and uncontrollable. Thus, a marker-less based tracking is often applied, and it utilized the SLAM technique or in more detailed, the GPS satellite signal. However, GPS satellite signal may be weakened and unreachable when someone is inside a building area unless with the help of High Sensitivity GPS (HGPS) or Ultra-wide Band (UWB) (Nirjon et al., 2014; Kurkovsky et al., 2012). Navigation requires a continuous localization of the user by integrating with the GPS reception to locate the user's position and calculate the path to the destination. Once the GPS signal is weakened, the navigation becomes non-precise and may further lead to fault destination. For pedestrian navigation (street view perspective) that are being used in the AR, it requires a more precise tracking than normal navigation as it constantly updates the path to a destination when detecting the user walking and the user orientation (Figure 1.6).

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Figure 1.6: MapFan AR Global for pedestrian navigation (Businesswire.com, 2014).

Thus, Virtual Positioning System (VPS), a visual system is announced by the Google to be included in the Google Maps where it uses AR feature on pedestrian navigation that is more accurate and ubiquitous than ordinary GPS (Figure 1.7). VPS analyses surrounding environments through smart phone's camera and Google's back-end data to identify the current location of a user (Feist, 2018). It can detect the user's orientation when using the smartphone. However, this system is still currently being developing and the successful launching of this system will bring a huge forward step in AR tourism. Until today, different SDKs of AR have been created and are improving over the time. For example, Wikitude, ARCore, Vuforia, EasyAR, ARKit, 8th wall AR etc. Each of these possess distinct features and advantages to suit different user requirements. These AR SDKs will be discussed in detail in the following chapter to identify the best SDK for this project.

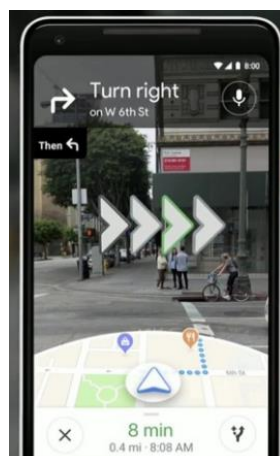


Figure 1.7: VPS that contain pedestrian navigation feature (Fingas, 2018).

Chapter 2: Literature Review

2.0 Literature Review

Different kinds of mobile applications have been created for enhancing the tourism experience regardless of the usage of AR. They are established to assist the tourists to face distinct problems such as the getting lost, insufficient information, language barriers and etc. to increase the convenience level that the application can bring to the tourists. 4 tourism mobile applications that will be studied deeply are MapFan AR Eye, Dublin AR, ExplorAR and mTrip Travel Guide. They applied AR technology in 2 aspects which are navigation and local context. Other than that, the current AR technologies such as ARCore, Vuforia, ARKit will be studied as well to identify the best AR SDK to be used in this project.

Chapter 2: Literature Review

2.1 Application

2.1.1 MapFan AR Eye

MapFan AR Eye is a navigation mobile application that can be used for tourism purpose developed by a Japan software company known as Increment P Corporation. The applications operated through inputting a POIs' name or address by the user to locate the POI and then, the user can start to navigate to the selected POI. A user can activate the AR navigation feature and begin to hold their phone to scan for the augmented path navigate to the destination. During the navigation, it will display both the street view and the map simultaneously (see Figure 2.1). There will be a small vibration indicating the tourists had reached the destination. This application is built to support only IOS operating system devices. Such navigation features can be act as a reference for the proposed application.

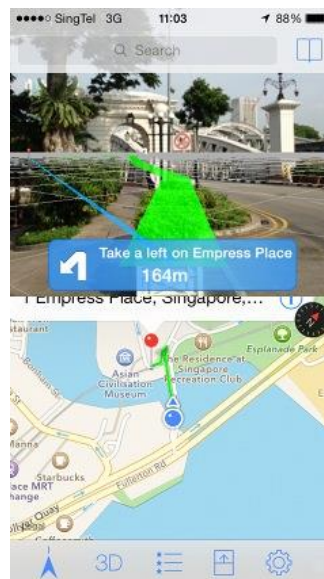


Figure 2.1: Dual display of navigation in MapFan AR Eye (AppAdvice, 2018).

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Strengths of MapFan AR Eye

MapFan AR Eye put a lot of effort in the navigation feature as it included an **AR real-time navigation feature**. Real-time navigation is undeniably able to bring the navigation process to a new phase since it is proven to be a better way to guide the tourists compared to the map service navigation in term of visual enjoyment and accuracy. AR real-time navigation can identify the route for tourist more clearly because the tourist can hold their phone 360° degree to discover the augmented path that points exactly to the destination. On the other hand, tourists are sometimes unable to differentiate left and right, thus the AR real-time navigation can show the way while the map-service navigation is unable to do so. However, the AR feature in MapFan AR Eye does not completely replace the map service navigation but it is being used together with the map service navigation to cover up each of their disadvantage for either AR or map navigation. Other than the augmented path, the AR navigation also shows the navigation information like when to turn, the distance until next turn and the remaining distance to destination.

The dual navigation mode of MapFan AR Eye can **provide a better visual direction** to the user to the destination. The user can always keep tracking of their current location in either AR navigation or map navigation. When the user confuses about the map navigation location, the AR navigation can assist the user indirectly to obtain a more precise and real-life location. On the other hand, the map navigation provides a more general location to the user which allows the user one step faster to know the turning point. When both navigation modes are combined, they can make up the weaknesses of each other and the chances of getting lost during the navigation can be greatly reduced.

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Weaknesses of MapFan AR Eye

Since the MapFan AR Eye application's main purpose is for navigation, the only standalone navigation feature is insufficient to bring a better experience to tourists. It does not provide enough tourism information to support the tourist throughout the whole travelling process. One of the conditions for navigation in this application is that it **requires the tourist to input the building name or address of the POI** in the application such that the tourist knew where he wanted to go. This is non-reliable for a tourist that are unfamiliar with the tourism place especially the first time they come for travelling. They do not have any single idea on the address and the specific name of the building and thus, they are unable to utilize such amazing AR navigation features and wasted the AR technology.

Since MapFan AR Eye only contains navigation part for the whole travelling process, it does not benefit the tourists very much in term of information, AR interaction etc. The tourists are unable to experience the AR technique in a deeper way without the AR interaction. Lack of information may cause the navigation to become pointless as the POI may close during the arrival time of the navigation. As a result, the tourists wasted his time on the way to the POI.

Non-cross platform compatible of MapFan AR Eye is one of the reasons that this application remains unfamiliar and unpopular in the worldwide. As mentioned previously, MapFan AR Eye supports only IOS platform and hence, it loses the other mobile OS users' support such as Android, Window and some minor OS. In fact, according to the latest Mobile Operating System Market Share Worldwide on April 2019, IOS accounted only 21.23% while Android hold the highest market share which is 75.56% (StatCounter Global Stats, 2019). Such data demonstrated that MapFan AR Eye had lost huge amount of users' support and unable to reach to a large user community.

Chapter 2: Literature Review

2.1.2 Dublin AR and ExplorAR

Dublin AR is a mobile tourism application that focuses on the Urban Heritage site by applying AR. The project is the collaboration between the Dublin City Council, Manchester Metropolitan University and Dublin Institute of Technology with the purpose of transforming the Dublin, a heritage city into an innovative AR city to attract more tourists. The application works by superimposing tourism related information to rebuild and revitalize past stories that create an emotional experience on the tourists about the heritage site (Han, Jung & Gibson, 2013). Information such as the nearby POIs' name, rating, category and distance will be shown in the application using AR as shown in Figure 2.2. In a nutshell, Dublin AR is a tourism information sharing application.

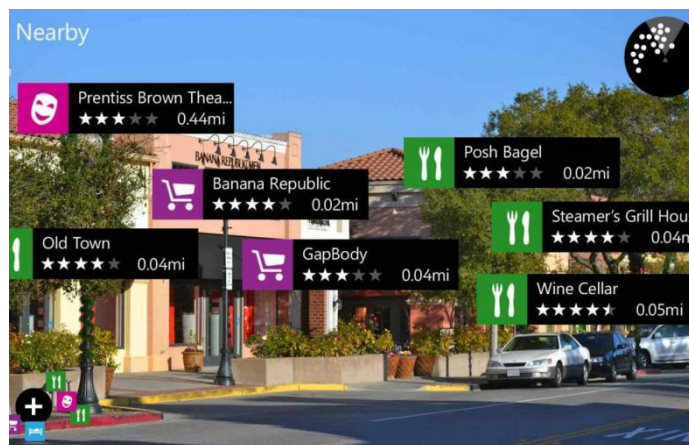


Figure 2.2: Dublin AR mobile application user interface in camera (Han, Jung & Gibson, 2013).

ExplorAR is also a tourism mobile application that shares most of the common characteristics with the Dublin AR stated above. However, ExplorAR targets merchant that wanted to be registered in the application which differs from the Dublin AR that detects all POIs in the Dublin City. Merchants like restaurant and shopping mall can take initiation to register in the application and it will appear in the application. Thus, it needs the participation of the merchants in this application. With an adequate cooperation between both parties which is the merchants and the application, it can achieve an acoustical resonance. In this application, the tourist's phone will act as a radar, detect the surrounding building and mark down the business place using AR like

Chapter 2: Literature Review

Figure 2.3a shown. Figure 2.3b shows the 3D map view when the phone is being tilted down. Both user interface can be easily switched based by tilting up and down the phone.

Both applications mentioned above share most of the common AR characteristics unless otherwise specified. Thus, their strengths and weaknesses will be reviewed together.

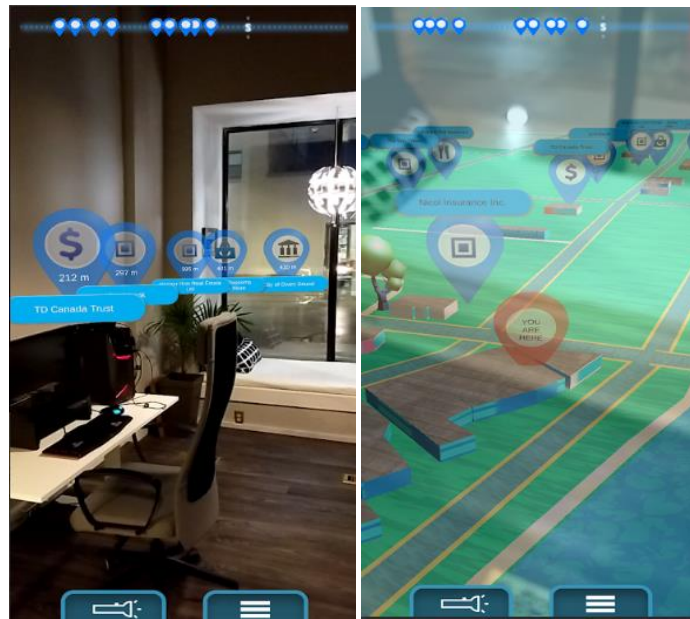


Figure 2.3: The user interface of ExplorAR: (A) The line of sight AR wayfinding of ExplorAR (left), and (B) The 3D map view of ExplorAR (right) (Kp9, 2018).

Strengths of ExplorAR and Dublin AR

Although ExplorAR and Dublin AR does not make use of the maps in their application to guide the tourists, it brings a different tourism experience by just pointing surrounding environments and it shows the POIs around the user. The **applications itself can standalone** without any supporting tool which means that it can be used anytime and anywhere. Although it does not solve the complexity of a station map, in exchange, the tourists can just straightly use the applications to navigate them to their preferred POIs.

Figure 2.2 and Figure 2.3a above shows the user interface for the camera in Dublin AR and ExplorAR respectively. Both applications did a significant job in the **local context** for its applications. The application of automatic labels and shows the nearby POIs information such as name, categories and etc. give a general idea to the tourists

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about the location before going to the place. The ratings shown in the AR allows tourists to do comparison within the category. The reviews for each POI can be referenced by the tourists during the planning of itinerary to prevent bad experiences in the related POI.

Weaknesses of ExplorAR and Dublin AR

Since ExplorAR makes the phone become a radar to scan surrounding POIs and appear in the screen while Dublin AR requires building to be in the line of sight, thus the POIs' shown in the phone for both applications can be within a very **limited distance**. ExplorAR sets the radar to scan within a diameter. Such measures may be appropriate when the user has no idea about where they wanted to go. If the tourist has planned schedule and he wanted to go to a specific POI that exceeded the radar's distance or the POI are not within the line of sight, this measure may not come in a handful way. Thus, the tourist must be within the POI's distance set by the application so that the application can bring benefits to the tourist.

The most apparent weakness that can be observed in Dublin AR is the **ease of information overload** in the user interface where the phone screen is over packed with different kinds of information. Although the applications fulfilled the requirement of tourists by displaying the POIs' information, the tourists may be overwhelmed by the information when they point their camera to a certain location which is full of POIs. **No filtering or separation according to the classification of the POIs** such as restaurant, museum, shopping mall and etc. become the trigger to this visual clutter issue (Kourouthanassis, Boletsis & Lekakos, 2015). It will somehow decrease the user-acceptance on AR feature and give a bad impression to the user for both the application and AR technology.

Dublin AR and ExplorAR have navigation feature included in their application that is not being innovated. Their **navigation feature** is just a portable map that guides the user to the destination without a street view AR effect. Tourists would rather to use the Google Maps for the navigation due to its better reputation and recognition by the other users.

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Additional Strengths of Dublin AR

Dublin AR provides the **user's orientation** when using the application. The tourists can know their direction of where they are currently pointing at easily through the small compass-like function. This feature turns out to be useful when the tourists are trying to inform others about their current location especially instructing the Grab drivers for picking up and dropping off. The white dots in the Figure 2.4 represents the POIs. It allows user to know how many POIs are in front of them and the distance between each of the POIs in general.

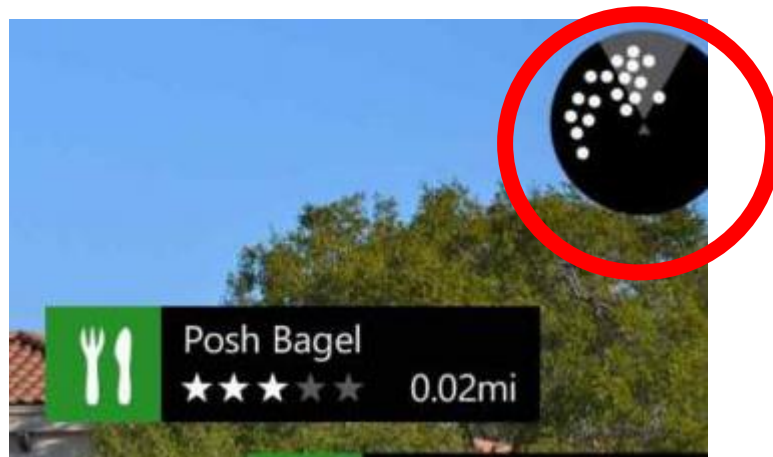


Figure 2.4: Highlighted user's orientation when using the Dublin AR (Han, Jung & Gibson, 2013).

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2.1.3 mTrip Travel Guide

mTrip Travel Guide is a platform that allows tourists to manipulate their travel schedule at any time either before, during or even after travelling. Tourists can choose the POIs and add them to an itinerary to let tourists have a better planning and manage their time better (Yovcheva, Buhalis & Gatzidis, 2012). Initially, mTrip's main attraction is the tour generation features and when the application included AR features, it brings the application to an up-to-date level but not a breakthrough level. This is because the application's AR features are just like the others specifically the Dublin AR and ExplorAR.



Figure 2.5: User interface of mTrip (Tech, 2011).

Strengths of mTrip

mTrip's strength is **the tour generation features**. Once a tourist adds or deletes a POI on its itinerary, the travelling schedule will be updated to match the shortest distance for the whole travelling to maximize the efficiency in term of timing usage. For instance, the application will investigate the current selected POIs in the itinerary and schedules along the ways. According to the Pardieu, CEO of mTrip, one of the selling features in mTrip is the Trip genius which is generating an itinerary of a visit for the traveller based on his tastes, location and operation hours of the POIs etc. The user can tell the application how much he interested in different kinds of POIs. The application will then adjust the POIs' visibility accordingly to the user's preference.

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Other than that, the application will adapt its POIs' visibility to the user's preference according to the past itinerary generated by the user. For example, if the past itineraries of user have never gone to clubbing area, the clubbing POI becomes invisible for the user. Since the application stored the past itinerary, it can be revised by the user and share the whole itinerary in the social media to provide review about the journey. The other users can review the posted itinerary to make a better itinerary.

Another inconspicuous strength is the **categorizing of POIs**. Based on the Figure 2.5, it shows that the application separates the POIs into attractions, shopping, bar, restaurant, hotel and others. Such strengths avoid the user from getting overloaded information and undergoing visual clutter.

Weaknesses of mTrip

mTrip shares a number of common weaknesses with the reviewed ExplorAR and Dublin AR which is the limited distance and navigation problems explained in the previous review. Besides that, mTrip provides only normal map service where it **does not include the application of subway exit area map** in the application. Although the application contains the Google Maps alike map, it does not have the subway exit area maps. It means that the tourists especially the public transit user are unable to receive the direction to the selected POI in a subway station.

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2.1.4 Summary of All Reviewed Applications

Functionality

Table 2-1: Brief Explanation of the Functionality for Tourism Mobile Application (Yovcheva, Buhalis & Gatzidis, 2012).

Functionality	Description
1. Context-aware push	The mechanism to push important or interesting information to tourist.
2. Feedback	The mechanism to give and receive feedback from/to another tourist.
3. Pedestrian navigation	Navigate the tourist to the targeted POI in a street view effect.
4. Map services	Provides the overview of surrounding place.
5. Interactive AR view	A “clickable” AR icon to provide an interactive interface.
6. Filtering of AR content	The options to filter the visualized content in AR view.

Each functionality shown in the Table 2-1 above are important criteria that contributes to the success of a tourism application. Thus, the mentioned applications in the previous section and the proposed application will be justified with the functionalities.

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Table 2-2: Functionality of Tourism Mobile Application.

Functionality	MapFan Eye	AR	Dublin AR	ExplorAR	mTrip Travel Guide	Proposed Application
1. Context-aware push	×		×	×	×	√
2. Feedback	×		√	√	√	√
3. Pedestrian navigation	√		×	×	×	√
4. Map services	√		√	√	√	√
5. Interactive AR view	×		×	√	×	√
6. Filtering of AR content	×		×	×	×	√

Based on the Table 2-2 above, it shows the functionality of different applications for tourism. Different applications intend to bring convenience in different aspect such as the search and browse, context-awareness push and etc. As we can see, most of the applications do not emphasize the **pedestrian navigation, the filtering of AR content and context-push awareness yet**. Pedestrian navigation is a street view navigation that navigates the tourist to the destination. Using the AR in the pedestrian navigation will further give a better direction to tourist by using the augmented arrows. Hence, the proposed application in this project will be focusing on **pedestrian navigation, the filtering of AR content and context-push awareness** to make the proposed application distinctive from other tourism application.

Context-push awareness and filtering AR contents must be done simultaneously so that the information provided to the tourist achieves a balancing beam. Filtering out the non-interesting information and capturing or pushing the important information such as promotion, discount on certain POIs are important criteria to be considered. If the balancing beam is one-sided, it will result in either information overloading or outdated information transferring.

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Summarized Strengths and Weaknesses

Table 2-3: Summarizes of Strengths and Weaknesses of Reviewed Applications.

Application	Strengths	Weaknesses
1. MapFan AR Eye	<ol style="list-style-type: none">1. AR real time navigation2. Dual navigation	<ol style="list-style-type: none">1. Require word input of an address or building name.2. Insufficient features for tourism.3. Does not support subway exit area maps.
2. Dublin AR	<ol style="list-style-type: none">1. Do not require maps as supporting tool.2. Show user's orientation3. Appropriate local context.	<ol style="list-style-type: none">1. Limited distance. (line of sight)2. Ease of information overload.3. Immature of navigation.4. Single city supported.
3. ExplorAR	<ol style="list-style-type: none">1. Do not require maps as supporting tool.2. Appropriate local context.	<ol style="list-style-type: none">1. Limited distance. (radar's distance)2. Ease of information overload.3. Immature of navigation.
4. mTrip Travel Global	<ol style="list-style-type: none">1. Intelligence tour generation.2. Categorized POIs.	<ol style="list-style-type: none">1. Limited distance. (line of sight)2. Immature of navigation.3. Does not include subway exit area maps.

The weaknesses of all the reviewed applications shown in Table 2-3 above will be solved according to the suitability of the application and become the strengths in this project without neglecting the current strengths of the reviewed applications. Some of the important strengths are the AR real-time navigation, categorized POIs, appropriate local context.

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2.2 AR Technologies

2.2.1 Google ARCore

ARCore is a SDK developed by Google and released on 1 March 2018. In order to use ARCore SDK, the device must be within the list of supported devices provided by the Google. The cost of using the SDK is free and the target platforms of the SDK are Android and IOS. According to the Google ARCore Official WebPage, ARCore uses 8 fundamental concepts to integrate virtual content with the real-world environment. The 8 fundamental concepts are motion tracking, environmental understanding, light estimation, user interaction, oriented points, anchors and trackable, augmented images and sharing (Google Developers, 2019).

Motion Tracking

ARCore's motion tracking understands the current position of the phone relative to the world coordinates through tracking the surrounding environment with the help of concurrent odometry and mappings (COM). During the tracking session, feature points (see Figure 2.6) that form a sparse point cloud can be seen through the camera and it will be used to compute the changing phone location. Position and orientation of the camera can then be estimated with the data received from the accelerometer and gyroscope (Inertial Measurement Unit) (Google ARCore, 2019).

Environmental Understanding

Based on the clusters of features points that appear in horizontal and vertical surfaces, a plane which known as plane detection is formed. Placing 3D objects and 2D annotations resting on the flat surfaces become possible through plane detection (see Figure 2.6). For example, you can place a virtual doll on the real-world bed using ArAnchor (Lanham, 2018).

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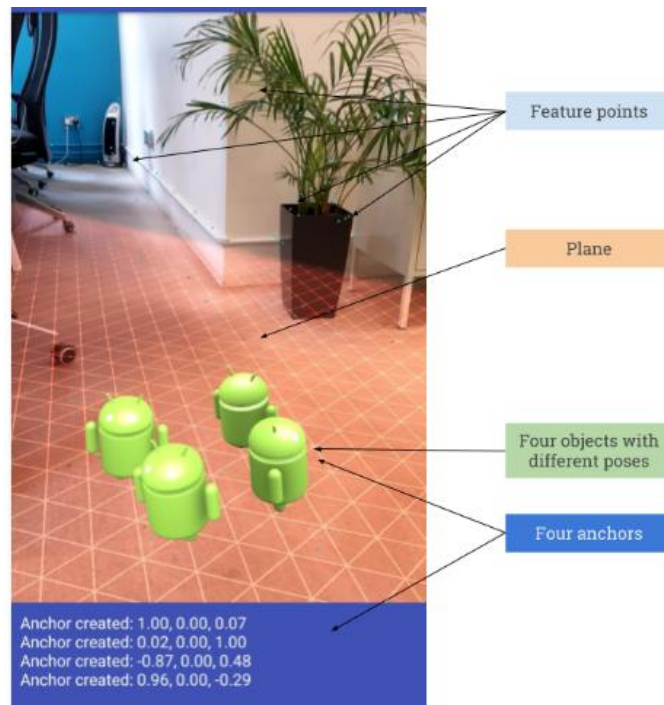


Figure 2.6: Example of feature points, plane, objects and anchors (The Labs | Novoda, 2018, May 1.).

Light Estimation

ARCore's light estimation works with the light in an actual environment. It can capture the information of the lighting condition of an environment such as the average intensity and color correction. Such information allows the system to differentiate light and darkness environment. For example, different virtual objects can be displayed in different lightning condition (see Figure 2.7).

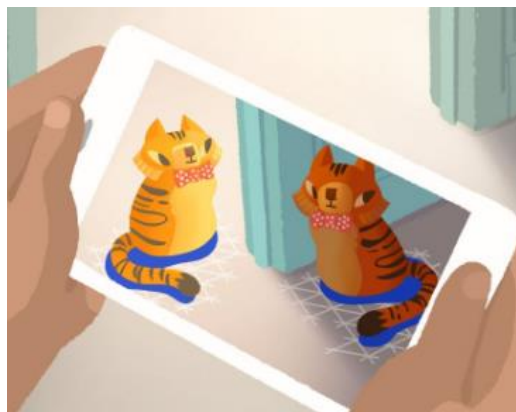


Figure 2.7: Lightning estimation of ARCore.

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User Interaction

ARCore also provides user interaction where the user can simply click on the plane, objects to bring different desired specified outcomes. It can be achieved through the projection of ray into the camera's view of the world, which results in returning any planes or feature point that the ray intersects, as well as the pose of the intersection. Multiple user interaction can also be achieved through the sharing features.

Oriented Points

Oriented points deal with the feature points located around an angled surface to provide AR experiences. When there is a hit test that returns a feature point, ARCore will look at nearby feature points and use those to attempt to estimate the angle of the surface at the given feature point.

Augmented Images

Augmented images are a kind of image marker tracking that offered by ARCore. By configuring the augmented images database, the user can trigger the AR experiences if the camera captured a specific image that matches with the database. Other than the static image tracking, a moving image tracking is also supported by ARCore.

Sharing

The purpose of sharing in ARCore is to allow the creation of collaborative and multiplayer apps for both Android and IOS device. In other words, different users can share the same AR experience through the device's camera although they are using different devices. The generated AR elements can be seen in all sharing devices. This creates the opportunity to perform multiple user interactions.

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2.2.2 Vuforia

Vuforia is an AR technology that focuses on marker-based tracking. In the aspects of tracking, it consists of 6 techniques which are model target, image target, multi targets, cylinder targets, object targets and vumarks. Each of these techniques aim to provide a better image tracking experience for the user in different scenarios. With the latest release version of Vuforia 8.1, advance model target 360 becomes available where it combines the today trends of 360 camera view with AR. The devices supported by Vuforia is wider than the ARCore and hence it gives a competitive advantage for Vuforia over ARCore. Vuforia contains both paid and free versions that designed for different user. Vuforia is only a free SDK for the developers that used for education purpose with limited and restricted features. While for company uses, the company have to pay a license fee to be able to fully access to all of the features. Combining ARCore, ARKit and Vuforia AR technologies become a possible thing when Vuforia Fusion is introduced. Vuforia Fusion allows the integration of ARCore, ARKit and Vuforia by utilizing each of their advantages for different devices. For example, the devices will adopt ARCore or ARKit technologies if the devices are within the supported list, otherwise, Vuforia technologies will be adopted if it is not supported by ARCore or ARKit.

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2.2.3 ARKit

ARKit, an AR technology developed by Apple that only provides support to the IOS devices. Hence, the devices supported by ARKit is very limited out of all of the reviewed AR technologies. ARKit allows the developers to freely integrates the AR technology to their project. In overall, ARkit typically does 3 main things to support the AR. The 3 main things are tracking, scene understanding and rendering. According to the Apple, it is expected to have more features in the newer release that makes ARKit to be able to compete in the AR market.

Tracking

ARKit has 2 in build tracking types, orientation and world tracking. Orientation tracking serves the purpose of understanding the phone's degree and rotation by using the internal sensors while world tracking further includes the phone's physical location which can generate a world map (a virtual coordinate space). For example, ARKit can understand the user's walking distance and direction (Axon, 2018).

Scene Understanding

Scene understanding of ARKit allows the device to actually know the surrounding environment features such as the light condition, the surface and the angles. Plane detection that fall under this technique can detect horizontal and vertical surfaces that aids the developer in placing the objects in a world map.

Rendering

After the tracking, scene understanding, it comes to the final progress of the AR which is rendering that means placing the 3D object on the targeted places either through plane detection or image recognition. It allows the 3D objects to be placed contextually in the scene showed in the device's camera.

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2.2.4 Summarized and Comparison of AR Technologies

Table 2-4: Comparison of the AR Technologies.

	ARCore	Vuforia	ARKit
Platform	Android, IOS	Android, IOS	IOS
Devices Supported	Medium	High	Low
Charges	Free	Free/Paid	Free
Image Tracking	Available	Available	Available
Stability	High	Medium	High
Markerless Tracking	Available	Unavailable	Available

As the table 2-4 shown, the most suitable AR technologies to be applied in this project is ARCore. Although the devices supported by the ARCore is lesser than Vuforia, the charge of ARCore is free and the stability of ARCore in term of tracking is better than Vuforia. Moreover, the markerless tracking is very important in this project to generate the augmented arrows for the AR navigation which is currently not supported by Vuforia. ARKit is eliminated in this project's choice of selection due to its limited devices supported (IOS only) and hence, ARCore will be used in this project.

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3.1 System Design

In this project, it consists of 5 modules, which are the tutorial module, map service module, AR objects generator module, navigation module and POI information module. Each of the modules are represented in block, use case, activity, flow chart diagram. User interface of the application is also defined and designed to meet the different requirements of all modules.

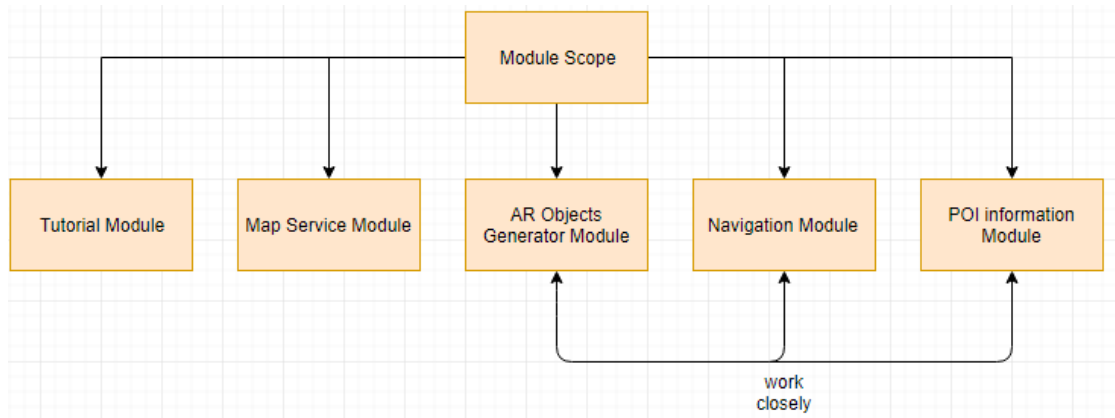


Figure 3.1: Modules of the project.

Tutorial Module

This module serves the responsibility to guide the user on how to operate and utilize each function of the application. Different scenes for the tutorial must be designed in a meaningful and understandable way that allows user to perform the similar action by knowing the outcomes showed in the scenes. Furthermore, the ability to skip tutorials is provided for the experienced users. This module will utilize the fragment to complete and simplify into 3 fragments to reduce the wordy of the application.

Map Service Module

Upon the selection of the maps within the application, the corresponding map service will be shown and the basic functions of map service such as highlighting POI, providing POI information, route direction and distance estimation is offered. This module will work closely with the navigation module. This module will apply the Google Maps API to provide the map service. The map service includes the search, autocomplete and place API.

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AR Objects Generator Module

As AR technology is one of the main selling points for this project, it becomes important to carefully manage each of the AR objects to be generated. Hence, this module will take care of the AR objects such as the 2D pictures, POI information board and arrows to be shown in the device. Showing these AR objects according to the category chosen is part of this module's responsibility. This module will act as a supporting module to provide AR objects to navigation module and POI information module. In order to generate the AR objects, ARCore will be used for the purpose of tracking and aligning.

Basic concept:

```
If (scanningImage == imagedatabase)
{
    If(imagedatabase.index == 0)
    {
        Relevance GameObject of the POI pictures appears above the scanning
        image.
    }
    Else
    {
        The GameObject will not appear.
    }
}
```

Navigation Module

Navigation module handles both normal and AR navigation. With the GPS data provided by the user, route direction to destination is generated. For normal navigation, the route will appear in the map service while for the AR navigation, augmented arrows will appear in the screen instead. Due to the limitation of Google Maps API in term of

Chapter 3: System Design

navigation, Mapbox SDK is used in this module instead to provide the both AR and non-AR navigation.

Basic concept:

startNavigation button is clicked. A route is generated from the current user's location known as origin to the destination (marker in the maps).

```
If (origin is detached from the route)
```

```
{
```

```
    New route generated
```

```
}
```

POI Information Module

Displaying the information of POI based on the user selection is to be worked over in this module. Retrieving the correct information corresponds to the selected POI so that the user can gain the accurate and updated information regarding the POI. Information such as operation hours, discount, menu, rating, brief description will be shown. For displaying the information of POI in AR mode, the information is required to be organized systematically inside a picture. Then, the picture contained with the information will appear in an AR form by using ARCore tracking technology.

Basic concept:

AR pictures is clicked.

```
switch(name of the clicked AR picture)
```

```
{
```

```
    Case "ABC restaurant": ABC restaurant additional information appears in AR form. Break;
```

```
    Case "Penang Hall": Penang Hall additional information appears in AR form. Break;
```

```
}
```

The switch case goes on until all POI is covered.

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3.2 Flow of the Application

Figure 3.2 shows the flow chart and it gives an overview on how the system progress in each phase. First of all, there are 2 type of inputs (virtual map and real map) accepted by the system. Map service will pop out whenever an offline map is clicked by the user whereas map recognition will be carried out if the user scans a real map object. After that, the user can select the category and by default the selected category is restaurant. The selected category will prompt the system to display the only POI inside the category. Clicking on the POI will retrieve the additional information and allow the user to get the direction of the POI from their current location. In the same time, the system checks the GPS data constantly for the navigation process. Normal navigation and pedestrian navigation are interchangeable throughout the process for user to double check the route to the destination.

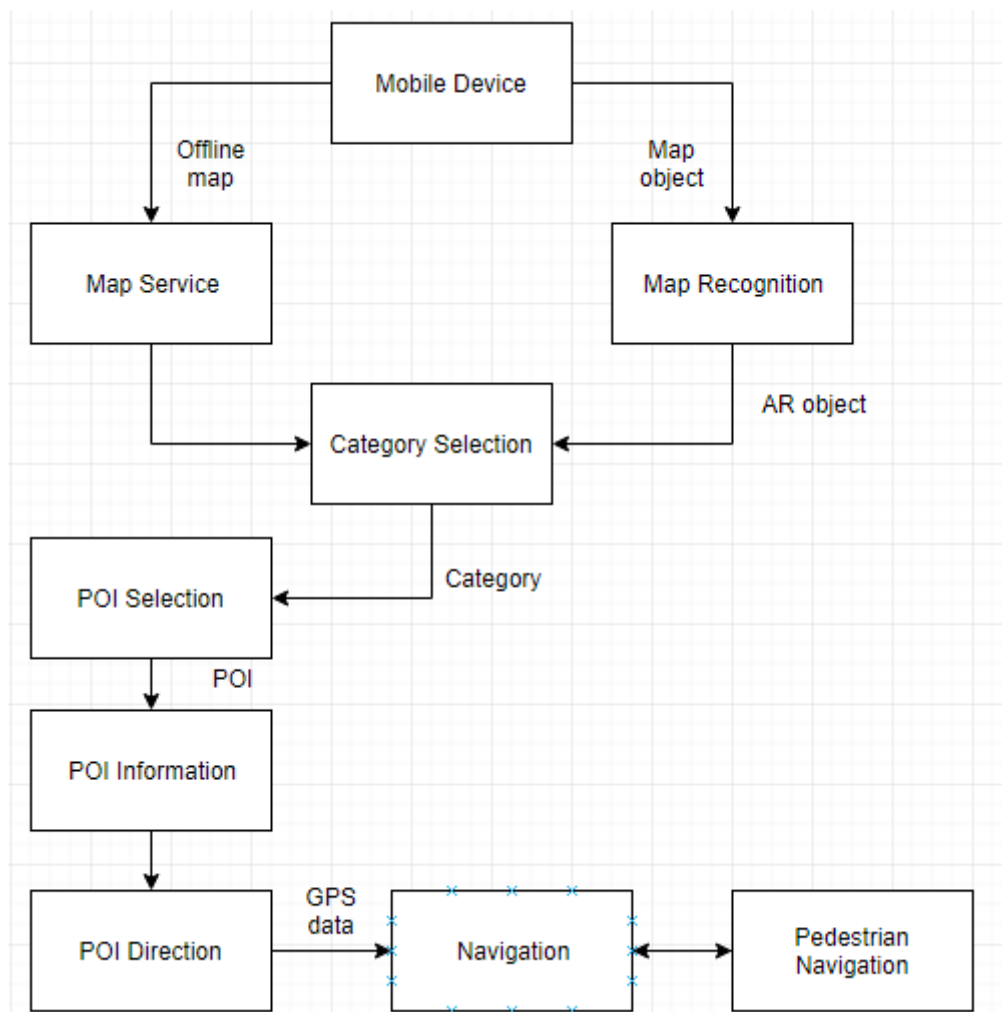


Figure 3.2: Flow of the action for the user and system.

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3.3 Use Case Diagram

Figure shows the use case diagram for all the modules combining. Each module has its own use cases which will be used as a reference for the activity diagram. Each of the use cases are further explained in the following activity diagram section.

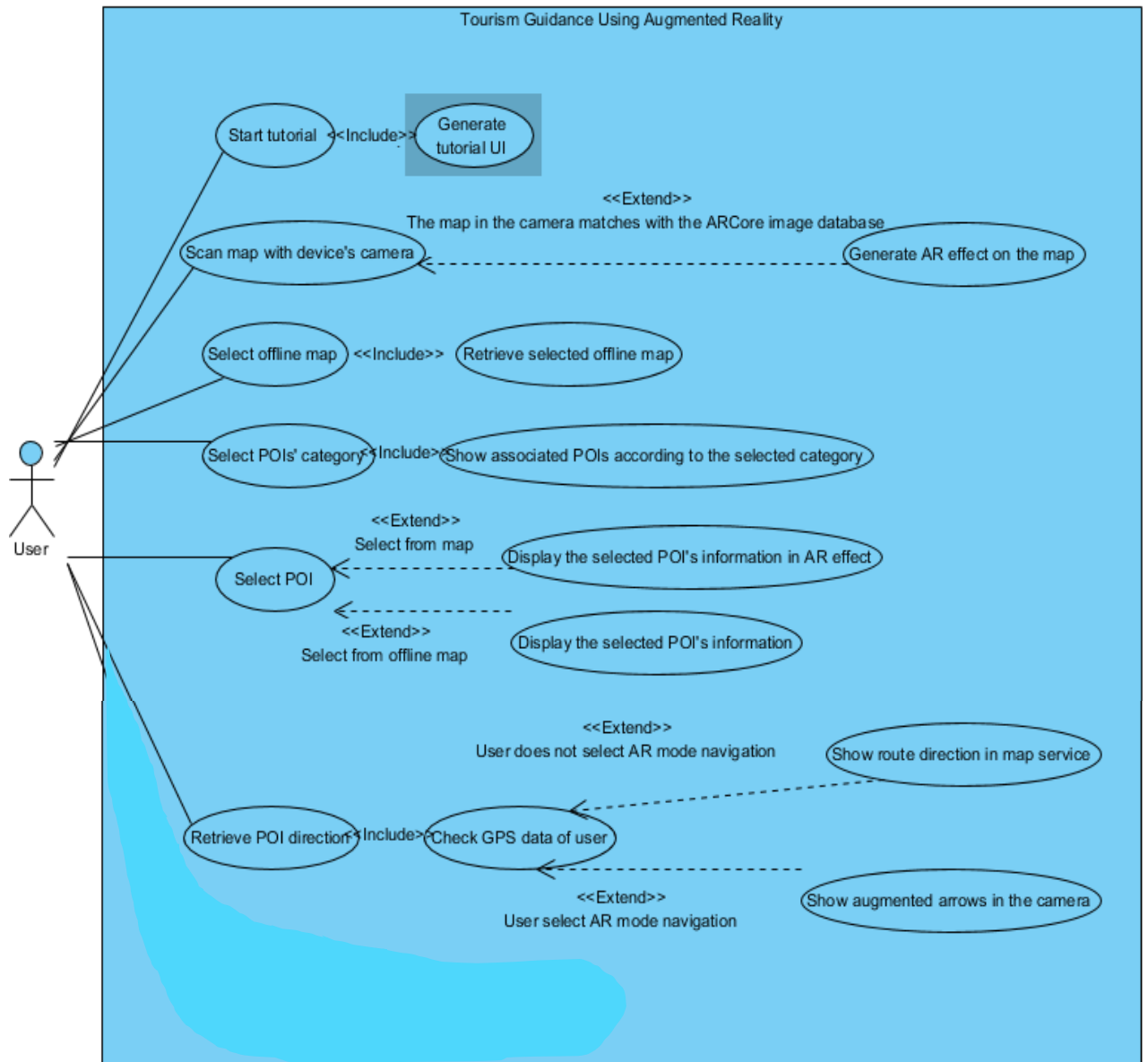


Figure 3.3: Use case diagram.

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3.4 Activity Diagram

D) Tutorial Module

Use Case: Start tutorial

Every time the user launches the application, when the user selects the start tutorial option, a series of tutorial UI scenes will be displayed, and user is required to either select next or previous to move to associated scene. Once the last UI scene is generated, the user can end the tutorial and move on to the main page UI of the application.

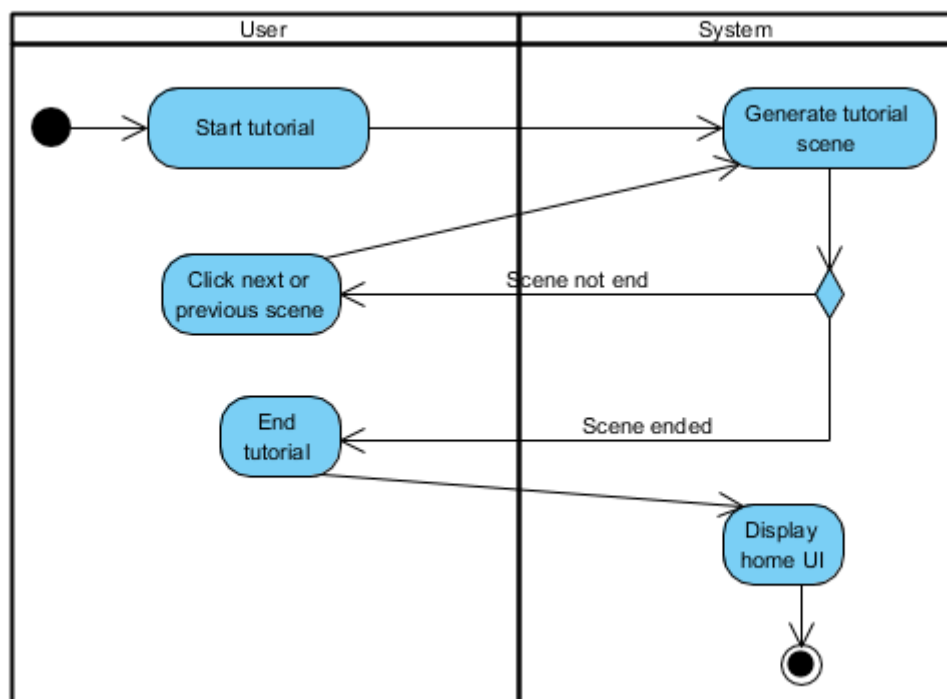


Figure 3.4: Activity diagram for start tutorial use case.

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II) Map Service Module

Use Case: Select offline map

The user can select the map within the application and the system will retrieve the selected offline map.

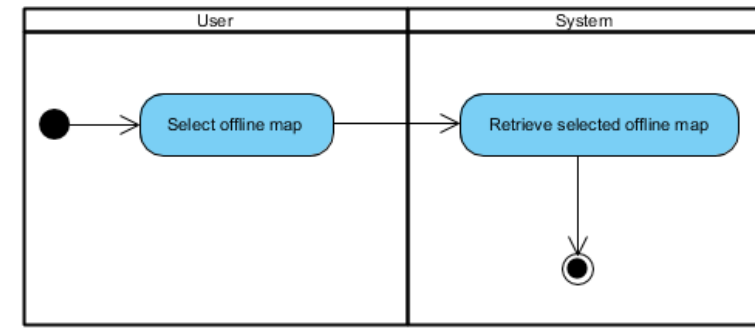


Figure 3.5: Activity diagram for select offline map use case.

III) AR Objects Generator Module

Use Case: Scan map with device's camera

The user scans the real map object and the system will keep tracking the scanning image with the ARCore image database. If the scanning image is matched, AR objects will be generated. Otherwise, the user is required to continue scanning.

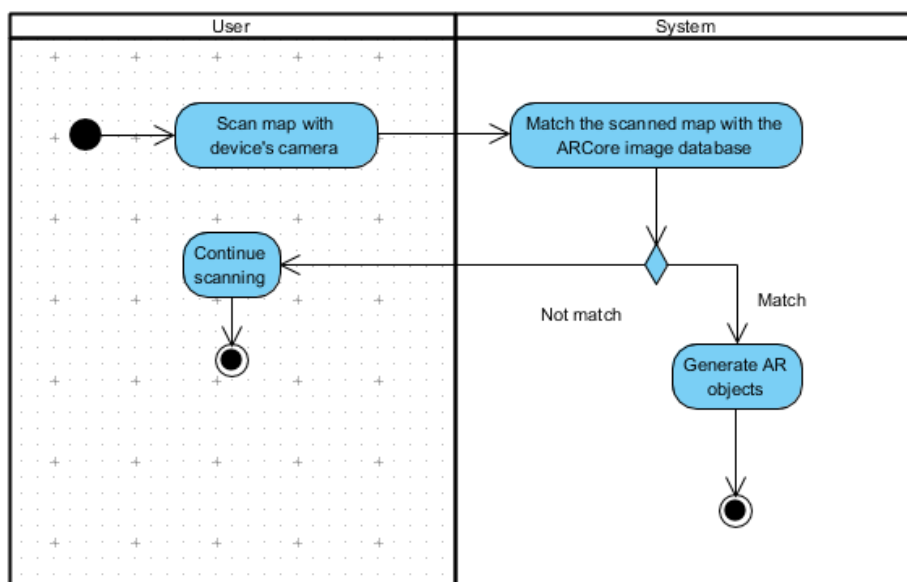


Figure 3.6: Activity diagram for scan map with device's camera use case.

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Use Case: Select POIs' Category

For both maps either obtained from the scanning or within the application, the user can interact with the map by selecting the category of POI such as hotel, restaurant, entertainment and etc. Each category selected will be directed to the system to show the only POI that suits the category.

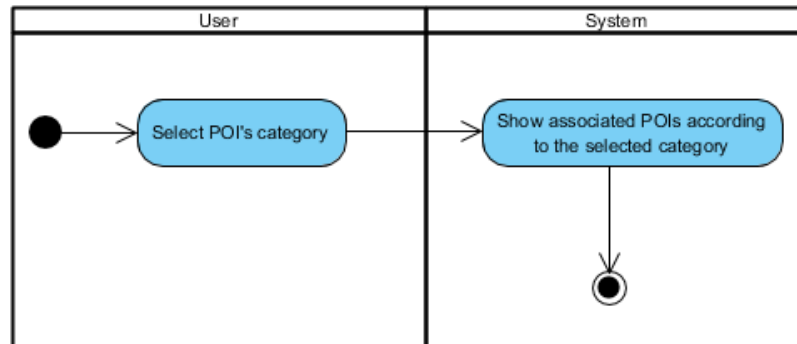


Figure 3.7: Activity diagram for select POIs' category use case.

IV) POI Information Module

Use Case: Select POI

For both maps either obtained from the scanning or within the application, the user can select the POI (pictures or names) to retrieve additional information. However, if the user is selecting the POI from the real map object (camera), AR effect will be generated.

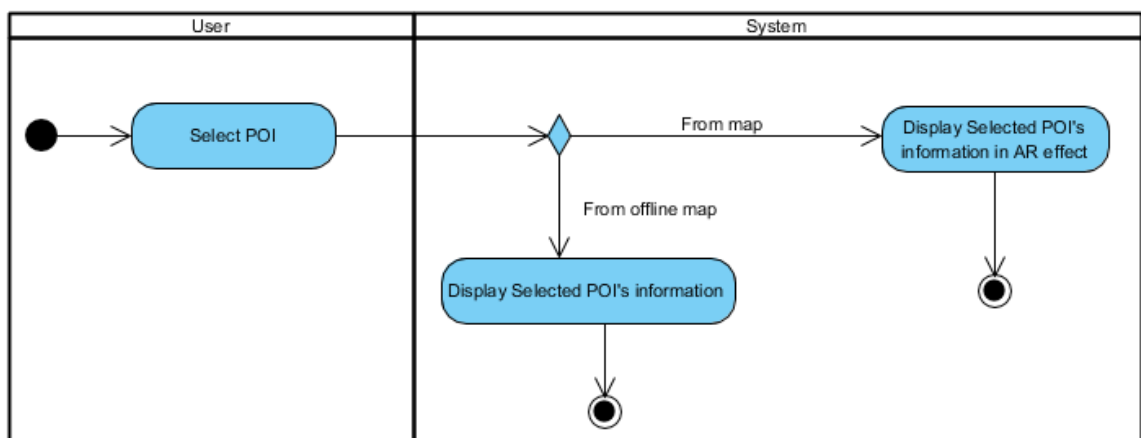


Figure 3.8: Activity diagram for select POI use case.

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V) Navigation Module

Use Case: Retrieve POI's direction

In navigation module, once the user retrieves the direction of the POI, the system will check the current GPS data of the user. With the GPS data, route direction is generated and displayed to the user in the map service. If the user activates the AR mode, augmented arrows will be displayed instead. The tracking process of GPS data is continued until the user reach the destination. In case of offrouting happens, the system will determine the new route to the destination.

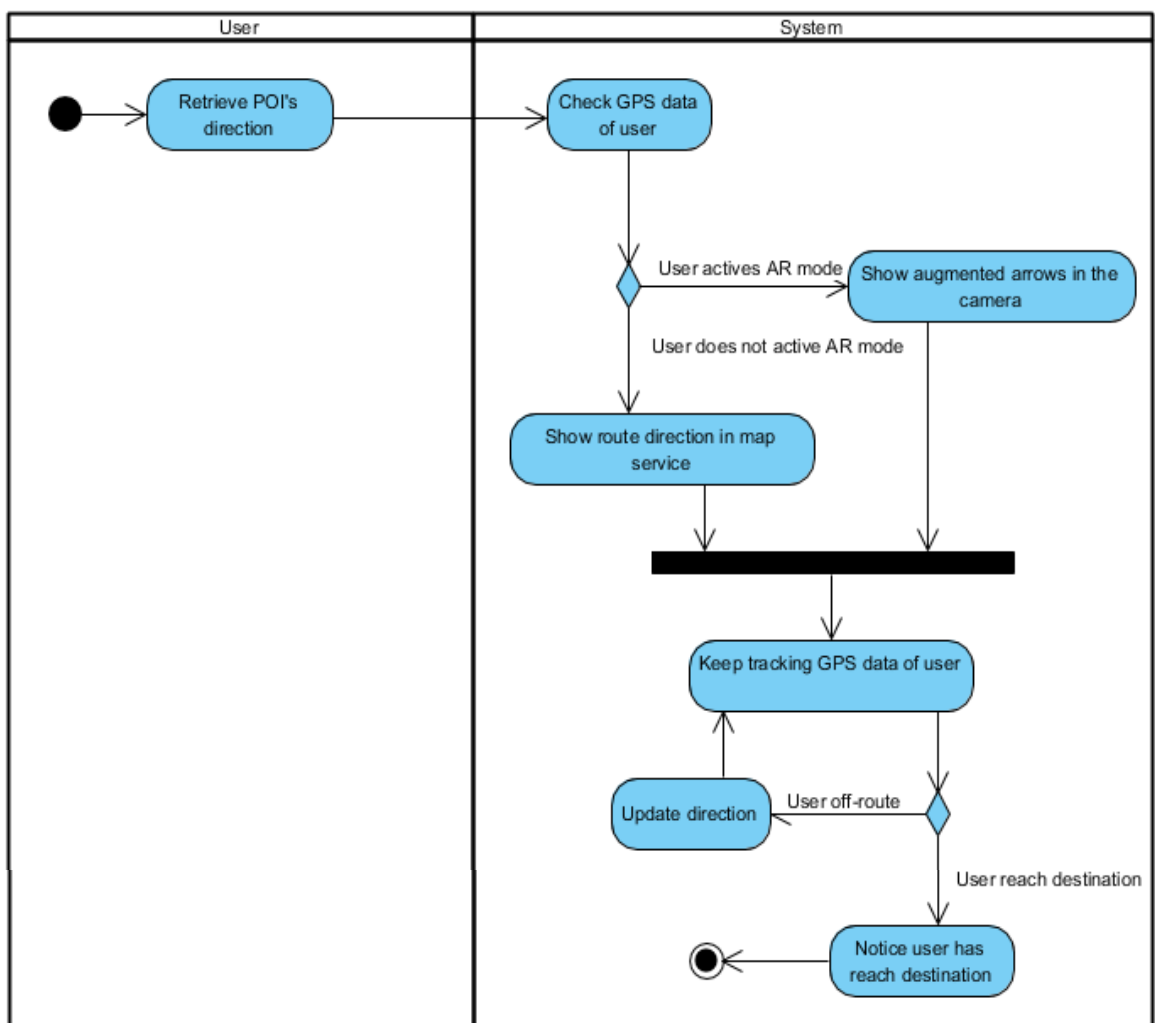


Figure 3.9: Activity diagram for retrieve POI use case.

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3.5 User Interface Design

Tutorial

The way to use this application will be shown to the user in Figure 3.10 tutorial scenes UI to make sure the features of the application are being fully utilized. The application will begin with the tutorial scene for first time launching the application in the device. After that, the tutorial scene will be skipped to homepage for the user next time opening the application.

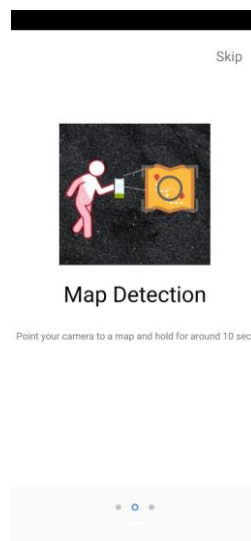


Figure 3.10: First scene of scanning map UI.

Homepage

Figure 3.11 UI is the homepage of the application where the user can select the maps in the application to retrieve the information about the selected map. To provide a better differentiation of the tourism and metro exit maps, the maps are separated into 2 columns. Other than that, a small float button located in the right-below corner as shown in Figure 3.11 allows the user to scan the real-life map.

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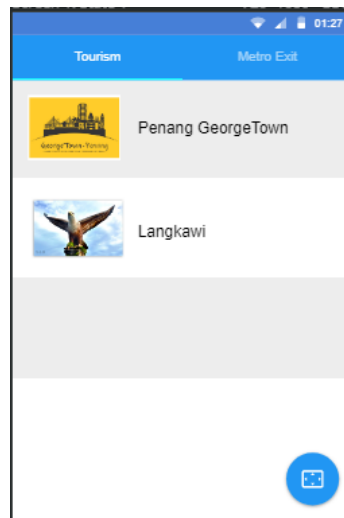


Figure 3.11: Map selection UI (Homepage).

Map Scanning

Figure 3.12 UI is for map scanning purpose and once the scanning map matched to the system's image database, the AR objects are generated (see Figure 3.14).



Figure 3.12: Map scanning and POI information UI

Navigation and AR Navigation

Figure 3.13a shows the UI for the navigation process while Figure 3.13b shows the UI for the whole AR navigation process. An arrow will be appeared in the device's screen that will lead the user to the destination.

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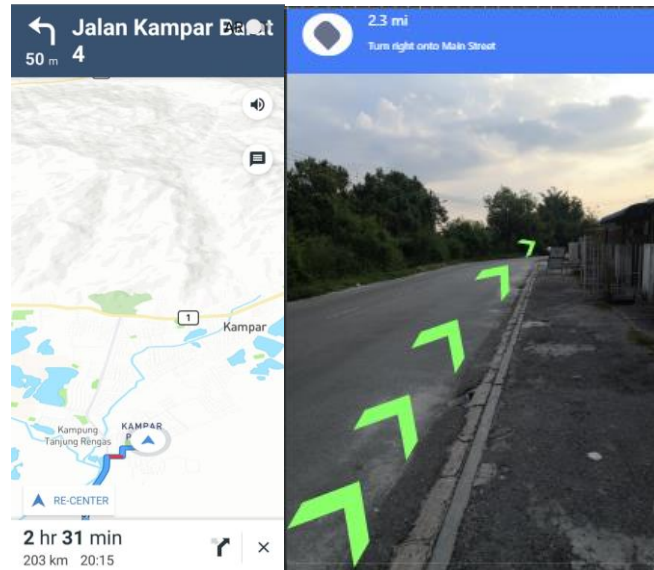


Figure 3.13a: Navigation UI (left); Figure 3.13b: AR Navigation UI (right).

Map Service

Figure 3.16 UI will be useful when the users have no maps available in their hands. It provides most of the services similar to Google Maps, such as highlighting POIs and normal navigation.

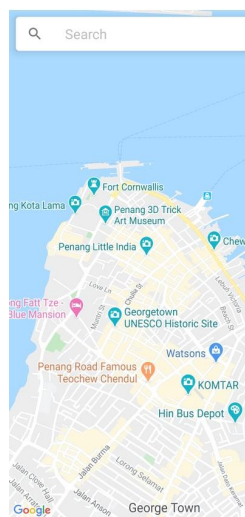


Figure 3.16: Map service UI

Chapter 4: Design Specification

4.1 Methodologies

Agile development methodology will be employed in this project. The reason of using this methodology is because of the user requirement may have changes over the whole development period (>1year) for this project. Agile development methodology divides the software developments into several short iterations called as Sprint that includes all SDLC phases, the planning, analysis design and implementation phases. Each functionality of the mobile application in this project is separated to different iterations. Each iteration will bring the application to adapt to different or latest user requirement and accumulate more functionality. Thus, it is suitable to a dynamic user requirement for a frequent redesign, incremental delivery and a higher customer interaction. It also reduces the chances of project failure as the application can be evaluated and getting feedback from the ending phases of each iteration. Activities to be done in each phase will be discussed in below. Figure 3.17 illustrate the flow of agile development.

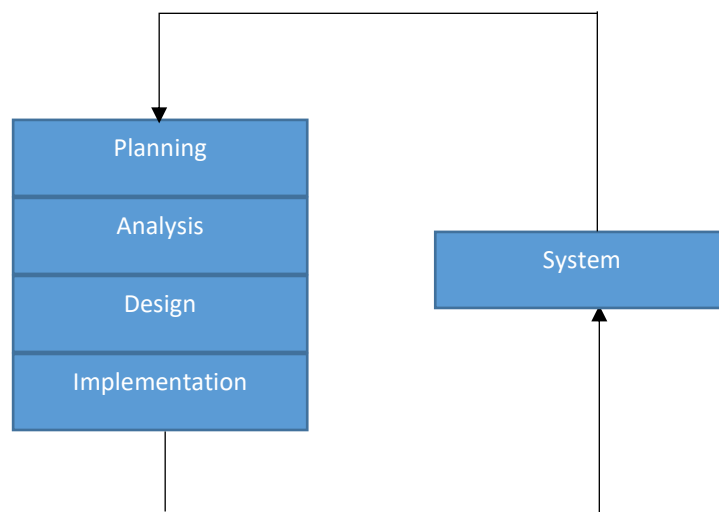


Figure 4.1: Agile Development.

Planning

In the planning phase, the significant problems faced by the user in this tourism issue are identified. Brainstorming occurs to generate idea to solve these problems effectively. The project scope and objectives of the projects in solving the problems are determined to finalize the project deliverables for each iteration and the target user of

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this project is well-recognized. Time management through schedule with the help of gantt chart is built to allow the whole process of development application runs smoothly and efficiently. For this project, the idea of combining AR and tourism field in a mobile application is generated during the brainstorming and discussion with the supervisor.

Analysis

In the analysis phase, the user requirements of the application are gathered and analyzed. Research and survey will be carried out to collect the feedback of the current tourism mobile application and their possible advancement. The collected feedback is then being analyzed to determine the user requirement for the current iterations. For example, the study on the current tourism mobile application and AR technology is carried out to identify the possible user requirement in this project.

Design

In the design phase, the physical design of the system is being idealized according to the logical design of the system. The user interface of the application will be designed to handle the user requirements in an attractive GUI. The user interface will then become a sample for the implementation phase to develop the GUI. In this phase, the 5 modules of this project are being defined to act as a criterion for evaluation.

Implementation

In the implementation phase, the coding and programming activities of the application are carried out to fulfill the user requirements determined in the design phase. Before forwarding to the next iterations, it will undergo several testings to test whether the function of the application is well-design and meet the user requirements. Testing by downloading the project's application with the device or android emulator and trying out their functionality. A verification plan is going to be developed in this project to test each module' functionality.

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4.2 Tools for Developer

4.2.1 Software/Technology

The software used in this project are:

➤ ARCore

ARCore is chosen in this project because ARCore allows item such as icon, picture and etc. to be placed in the AR world using real-world GPS coordinates which is the longitude and latitude. Thus, the pictures of the POIs can be registered in line with the locations in this project. Motion tracking occurs with the movement of the phone itself and hence, the location of the user can be kept track along the navigation and the path to the preferred POI can be updated as well.

In order to possess the benefits of ARCore like environment understanding and motion tracking, ARCore API can be simply called to include in the application since it is a public source API (Riddick, 2018). It means that all the functionality of ARCore can be used, unlike the Vuforia SDK where it needs payment to be able to access to the full functionality.

➤ Google Maps API

To retrieve the map and the information of the POI such as the operation status, address, photo etc. This information will appear in the map services of the application. Other than that, the Autocomplete API, one of the API inside Google Maps is used to perform the search function to ease the process for user to search for a location. Although Google Maps API provides navigation function, it features by redirecting the user to the Google Maps Apps which is aligned with the proposed application's feature. Mapbox SDK is used to support the navigation function of the proposed application.

➤ Mapbox SDK for Android

Mapbox SDK for Android can add navigation service to an application. It handles the back-end maps data such as data downloading, Google Maps servers, and response

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to map gestures. It also allows other APIs to modify the design of the navigation. Thus, it covers up the disadvantages of the Google Maps API in term of the navigation.

➤ Android Studio

Android Studio is used to design the UI of the system that does not require the functionality of AR features. For example, the tutorial scene, homepage and the offline map services. The reason for using Android Studio for the UI design is due to the simplicity of the IDE as it allows drag and drop designs. As compared to Unity, Unity takes much efforts in order to complete a similar UI that completed in Android Studio. Thus, the UI design in Android Studio will be combined with the AR features completed in the Unity.

➤ Unity

Unity is an IDE that is one of the standard programming environments for AR application similarity to the Eclipse as one of the Java IDE. Unity is a suitable tool when it comes to 3D related project and hence it will be used to create any 3D augmented reality figures such as the arrows, pictures, icons and etc. In this project, Unity will also integrate with the ARCore to deliver a tourism AR mobile application in order to build the 3D AR figures and control their settings through the C# language coding. Once the AR related works are built, it will be exported to Android Studio and integrated with the UI design and the system will then be completed.

4.2.2 Hardware

The hardware used in this project are:

➤ Android smart device

The Android smart device (Huawei Nova 3) is used for the purpose of testing through installing the application. Since ARCore will be used as a software in this project, it requires a decent high-end mobile specification. The minimum Android version is the Android 7.0 (Nougat) and the device must be originally shipped with the

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Google Play Store. The following Figure 4.2 shows some of the compatible device for ARCore.

Huawei	Honor 8X, Honor 10
	Honor View 10 Lite
	Mate 20 Lite, Mate 20, Mate 20 Pro, Mate 20 X
	nova 3, nova 3i
	P20, P20 Pro
	Porsche Design Mate RS, Porsche Design Mate 20 RS
	Y9 2019

Figure 4.2: Compatible Devices for ARCore.

➤ Personal Computer/Laptop

The PC/Laptop will be mainly used to program the application. The processor and RAM of the PC/Laptop need to be in a standard performance since it may be a number of software opened simultaneously such as Unity, Visual Studio and etc. The Table 4-1 below shows the minimum requirement of the device. PC/Laptop can also test the basic function of the application that does not require the AR application through an Android Emulator.

Table 4-1: Minimum requirements of the PC/Laptop.

Components	Specification
OS	Window 7.0
RAM	4GB
Processor	Intel(R) Core (TM) i7-3537U CPU @ 2.00Ghz 2.50Ghz

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4.3 User Requirements

4.3.1 Connectivity Requirements

Table 4-2: Connectivity Requirements for Users

Connectivity	Requirement
WiFi/Data Connection	Recommended
Bluetooth	Not Required
GPS service	Recommended

As table 4-2 shown, both WiFi/Data connection and GPS service are not an essential requirement to use this application. The application is workable in an offline status with a limited number of features. However, GPS service is required for the pedestrian navigation feature as it will provide the location information for the application so that the feature is able to function well. WiFi/Data connection is recommended as well when using the pedestrian navigation feature to improve the accuracy of the location information as it can help to retrieve the longitude and latitude data from Geolocation API.

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4.3.2 Hardware Requirements

Table 4-3: Minimum Hardware Requirements for Users.

Hardware	Requirement
RAM	2GB or higher
Storage	200MB or higher
CPU	4.0GHz or higher
Processor	Snapdragon 650, 710, 8xx with Open CL support

Table 4-3 shows the minimum hardware requirements of a smart phone in order to run the proposed application smoothly. 2GB RAM and 4.0Ghz CPU of a device make sure that the application able to operate without crashing. The proposed application's size is expected to be within 200MB and thus, the device should have a minimum of 500MB storage size so that it can install the application. Mapbox Vision SDK requires processor with snapdragon to work with and hence, the device's processor has to be snapdragon.

4.3.3 Software Requirements

Table 4-4: Minimum Software Requirements for Users.

Software	Requirement
ARCore	1.10+ or newer version
Android Version	7.0+ (Nougat) or newer version

For the software requirements, the device has to be able to support the ARCore that can be found in the Google Play Store (see Table 4-4). As long as the device is within the device supported list of ARCore, the proposed application can work perfectly.

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4.4 Survey Analysis

In order to receive different feedbacks from the user's perspective in term of the user requirement, face-to-face interview were carried out. Face-to-face interview is a more personal form of survey compared to other form of surveys. This allows direct interaction with the user and receives the feedback and communication more effectively. Their non-vocal actions like gestures, facial expression and body movements can further enhance the given feedbacks and better understanding of their feeling toward the importance of a user requirement.

10 target users that are from different faculties were selected to interview in order to expand the perspectives. Ranging from FICT who possesses technical knowledge about the AR technology to other faculties such as FBF who may look for the business value of the application. Feedbacks from different fields of professional can help to improve the application and become more popularization.

Several questions regarding the current tourism application's limitations were set and majority of them marked a similar concerning issue which is the popularity of these tourism applications are way too low. They mentioned that these applications do not have any outstanding features that grabs the users' attention. They expected a more interesting or attracting features in these tourism applications. This expectation was inline with the proposed application where AR technique (map scanning and AR navigation) is adopted and it can be very interesting for the user to interact with the application. The respondents were very looking forward with the proposed application when AR technique was mentioned.

Other than that, some of the respondents commented on the details of the POI were very important. It acts as a basic for a tourism application. Details such as operation hours, addresses etc. should be able to retrieve whenever they requested for it. In order to fulfill this requirement, the proposed application will utilize the Google Place API to retrieve the information of the places stored in Google Database. This requirement allows the user to plan their travel place ahead by knowing the POI's operation hours. They do not need to check one-by-one the operation hours of each POI in the website during the trip planning.

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Finally, all target respondents were asked to provide one most important user requirement for a tourism application and the listed user requirements will be act as a reference for the proposed application. The user requirements are as follow (see Table 4-5):

Table 4-5: List of user requirements by the respondents.

Respondents	User Requirement
User 1	As a user, I wish to know more information about the POI in the application.
User 2	As a user, I wish for an AR navigation feature in the application.
User 3	As a user, I wish for an updated information about the POI in the application.
User 4	As a user, I wish for an AR element in the camera view of the application.
User 5	As a user, I wish to know the POIs that exists in certain areas in the application.
User 6	As a user, the application must able to navigate me to the destination.
User 7	As a user, I wish for a categorized POI in the application to prevent information overloading.
User 8	As a user, I wish to know whether the selected POI is currently operating.
User 9	As a user, I need a tutorial before using the application.
User 10	As a user, I wish for an interactable AR element in the application.

According to the user requirements in Table 4-5, it matched with the proposed application's functions. The proposed application should be able to provide benefits to the user.

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4.5 Verification Plan

Tutorial Module

Table 4-6: Verification plan of tutorial module.

Input	Expected Output	Meet Expectation (√/×)
User taps on “Start Tutorial”.	System generates a series of tutorial UI.	
User taps on “Next” or “Previous”.	System is able to display the previous or upcoming UI scene accordingly.	
User taps on “End”.	System directs the user to the homepage of the application	

Map Service Module

Table 4-7: Verification plan of map service module.

Input	Expected Output	Meet Expectation (√/×)
User taps on “Tourism” or “Metro Exit”.	System is able to switch among the tab and display the maps for each tab.	
User clicks the map.	System is able to display the offline map with highlighted POI.	
User selects the category.	System is able to display the POIs that inside the category.	
User selects the POI.	System is able to provide additional information of POI.	

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AR Object Generator Module

Table 4-8: Verification plan of AR object generator module.

Input	Expected Output	Meet Expectation (√/×)
User taps on “Scan” button.	System switches to the camera view.	
User scans the map.	System is able to display the picture or name of the POI with AR effect in the camera view.	
User selects the category.	System is able to display the POIs that inside the category with similar AR effect in the camera view.	

POI Information Module

Table 4-9: Verification plan of POI information module.

Input	Expected Output	Meet Expectation (√/×)
User selects the POI in the map service.	System display the additional information of POI and a “Get Direction” button is created.	
User selects the POI in the camera view.	System display the additional information of POI with AR effect in the camera view and a “Get Direction” button is created.	

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Navigation Module

Table 4-10: Verification plan of navigation module.

Input	Expected Output	Meet Expectation (√/×)
User taps on “Get Direction” in map service.	System shows the route direction of the POI from the location of user.	
User taps on “Get Direction” in camera view.	System shows the augmented arrow pointing to the direction of the POI from the location of user.	
User starts moving.	System is able to navigate the user to the POI.	
User off-route during the navigation.	System generates a new route direction of the POI from the location of user.	
User reaches the destination.	System makes the phone to vibrate.	

From Table 4-6 to Table 4-10, it shows the verification plan of each of the modules. It verifies whether the modules meet the output expectation and each of the modules can perform their responsibilities well.

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4.6 Implementation Issue and Challenge

Throughout the whole project development, several issues and challenges are encountered. Since Unity platform is the main tool that will be used to build the project, certain understanding on this platform has to be possessed. The programming language, library and features of Unity require to undergo a thoroughly research in order to fully utilize such platform especially for a beginner. The **version of Unity platform must always up to date** to the version as listed in the Unity portal. However, it tends to create a problem of **incompatible issue** with the project built from previous version, causing the project development progress to slow down. When it comes to the integration of AR in Unity,

Other than the platform, the AR technology used in this project which is the **ARCore requires a decent high-end compatible device**. It only supports limited devices as mentioned previously. In other words, an ARCore supported device is a must to test the proposed application. Moreover, the tutorials of ARCore found online is much lesser and harder to be found compared to the other AR technology like Vuforia, ARKit, EasyAR etc.

Finding suitable API and SDK for this project is a time-consuming action. Research and testing on the API and SDK found have to be done so that the best and most suitable API and SDK is utilized, and it gives the greatest performance to the application. Other than that, the integration between various APIs, SDKs and IDEs must be configured carefully as they may clash with each other.

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4.7 Timeline

Table 4-10: Gantt Chart

	Task	Start	End	Dur	2019			2020		
					Q2	Q3	Q4	Q1	Q2	Q3
	AR Tourism Guidance (FYP) ⊖	6/1/19	3/31/20	305						
1	Planning ⊖	6/1/19	6/6/19	6						
1.1	Project Conceptualization	6/1/19	6/2/19	2						
1.2	Discussion with Supervisor	6/3/19	6/4/19	2						
1.3	Exploration of Development Tools	6/5/19	6/6/19	2						
2	Analysis ⊖	6/7/19	6/18/19	12						
2.1	Research and Literature Review	6/7/19	6/9/19	3						
2.2	User Requirements Gathering	6/7/19	6/9/19	3						
2.3	Project Objectives Definition	6/11/19	6/12/19	2						
2.4	Drafting Application Design	6/15/19	6/18/19	4						
3	Project Development ⊖	6/19/19	2/15/20	242						
3.1	Prototyping ⊖	6/19/19	8/2/19	45						
3.1.1	Modules Development	6/19/19	7/8/19	20						
3.1.2	Modules Integration	7/9/19	7/22/19	14						
3.1.3	Modules Testing	7/23/19	8/2/19	11						
3.2	Developing Complete Application	8/3/19	2/15/20	197						
4	Project Testing ⊖	2/16/20	3/25/20	39						
4.1	Application Testing	2/16/20	3/1/20	15						
4.2	Collecting Users Feedback	3/2/20	3/7/20	6						
4.3	Application Enhancement and Maintenance	3/8/20	3/25/20	18						
5	Documentation	3/26/20	3/31/20	6						

Table 4-10 above shows the estimated overall timeline for the development of proposed application. In this timeline, it consists of 5 sections which is planning, analysis, project development, project testing and documentation. Planning is a section where the project idea is conceptualized and follow by the analysis section to define the project objectives based on the research and user requirements. Project development is where the coding start. Developing prototype is fall under this section and a prototype will be developed according to the defined objectives. Prototype will act as a reference for the complete application development. Testing, feedback and maintenance will be executing to ensure the application work perfectly fine. Finally, a report is written to record down the whole project's progress to communicate with the other interested parties.

Chapter 5: System Implementation and Testing

5.1 System Implementation

As discussed earlier in the chapter before, the application's main page has 2 segmentation lines. First line begins with map service to navigation while second line begins with camera scene to navigation. The first-time user must go through the tutorial scene and as soon as the user finished the scene, they will enter the main page.

First Line Flow

Once user selects the map in the menu, the user will be directed to the selected map's zone. In the displayed map, the user can click on the POI or search for a location. An info window will appear after the clicking or searching and a navigation button will be shown. Click the navigation button will begin the navigation activity and can be switched to AR navigation by clicking the AR check button.

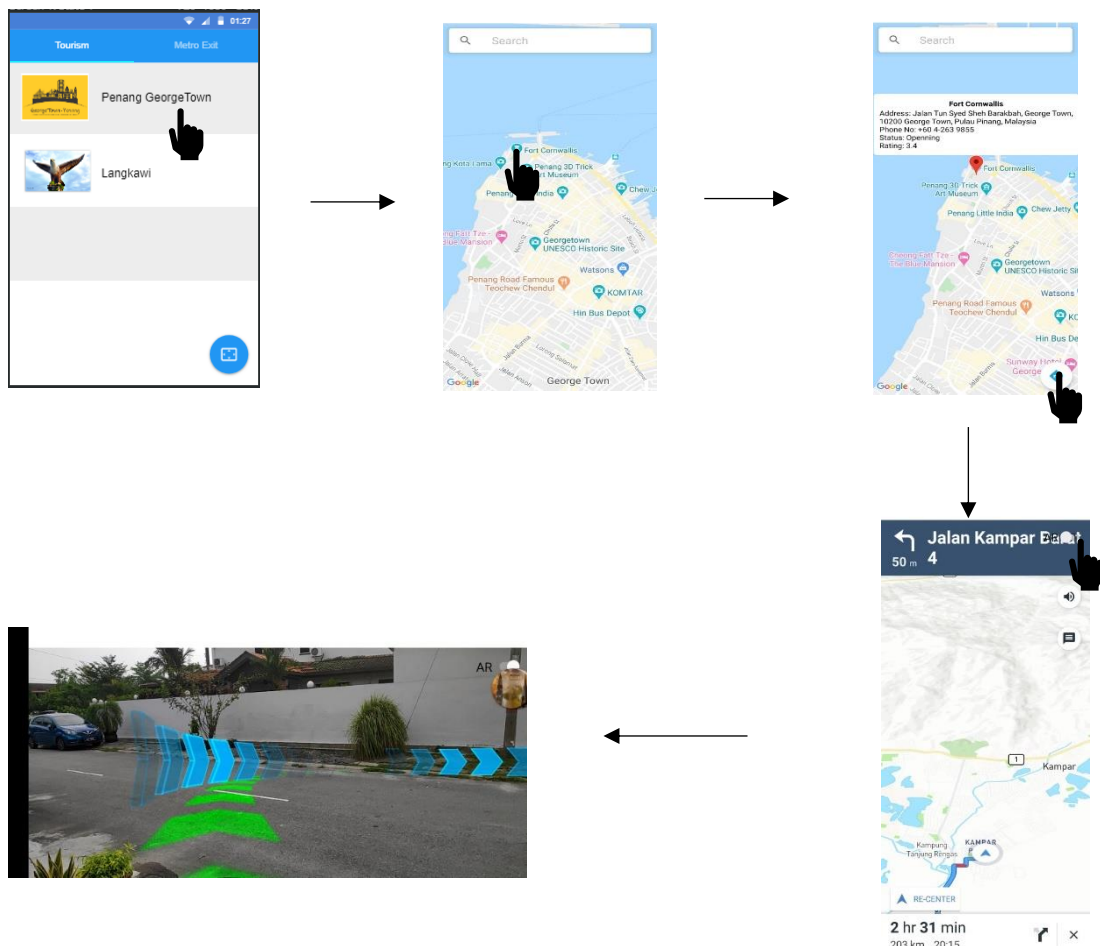


Figure 5.1: First line flow of the application.

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Second Line Flow

Once user click the scanning float button in the menu, the user will be directed to the camera view that requires the user to provide physical image of the map as input. The registered map for the camera view is similar to the place shown in the menu earlier. When a map is placed within the frame, it may take up to maximum of 10 seconds scanning time. Once the application managed to detect the picture, AR elements will be generated. User can click the category to filter out non-relevant POI. Otherwise, the user can directly click on the AR elements to retrieve more information. By clicking the navigation button as shown in the Figure 5.2 below, it will direct the user to the navigation activity.

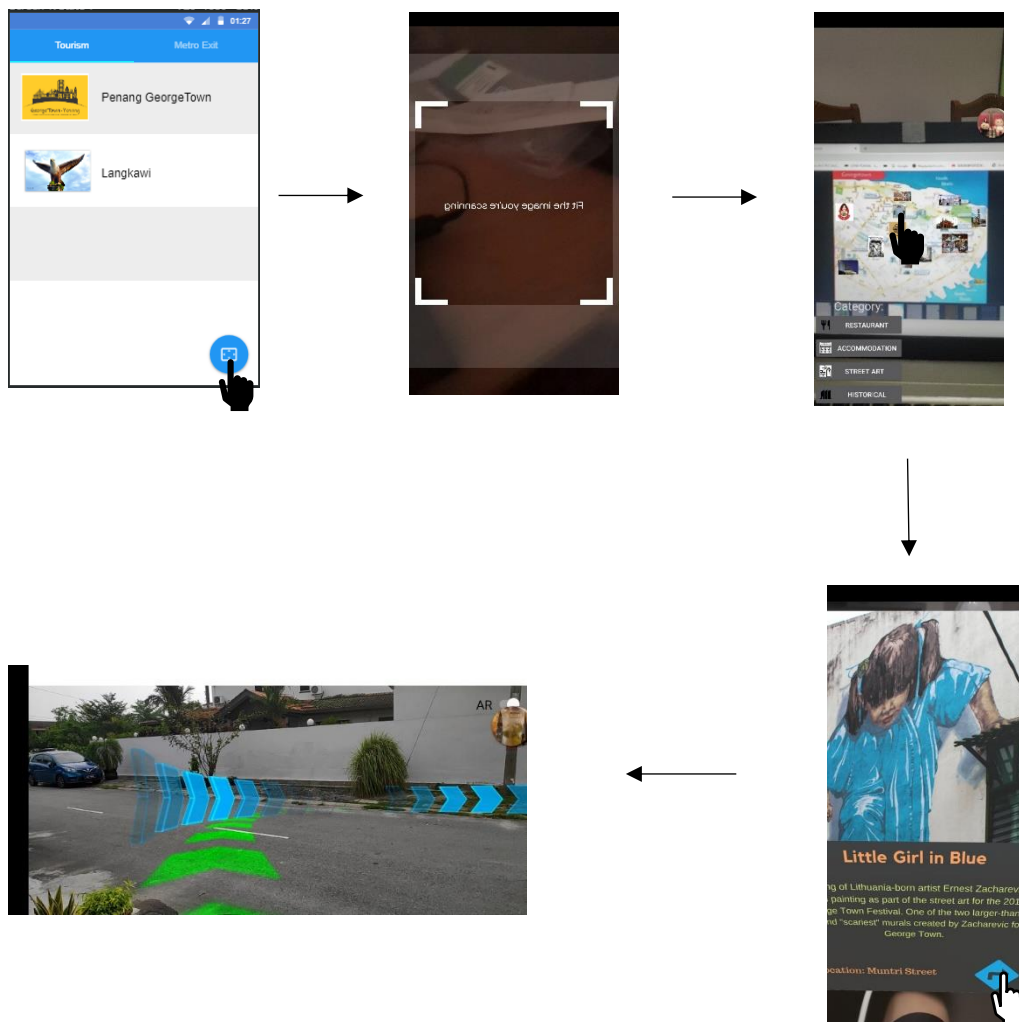


Figure 5.2: Second line flow of the application.

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5.2 Functionalities Testing

The application's functionalities are being tested according to each of the module respectively in this section. They are tested with the verification plan provided in the chapter earlier. This is to ensure the flow shown in the above section work according to the expectation

5.2.1 Test Objective: Tutorial Module

Table 5-1: Testing Result for Tutorial Module.

Input	Expected Output	Actual Output	Meet Expectation (√/×)
User launches the application.	System generates a series of tutorial UI.	Application started with a welcome scene and a series of tutorial UI.	√
User swipes left or right on the device.	System is able to display the previous or upcoming UI scene accordingly.	The tutorial scenes can move on to next scene or go back to previous scene.	√
User taps on "Skip".	System directs the user to the homepage of the application.	The tutorial scene can be skipped and direct to homepage.	√

Once the user installs the application and launching it, the tutorial scenes will be shown in the application. The tutorial scenes can be swiped left or right to go to previous or next scene respectively. The user is allowed to skip the tutorial scene and directly proceed to the homepage through the "Skip" word in the top right of the device as shown in Figure 5.3. If the application detects that the application was launched before in the device, the tutorial scene will be skipped to prevent the redundant input by user. The tutorial scenes consist of three scenes which are welcome scene, guidance on map scanning scene and getting started scene. Although the tutorial scenes are quite short, it is still managed to provide a guideline to user for the most important and complicated feature (Map Scanning). For the other functions, the application applies the industry common icon for each button and therefore, the user is able to understand the function

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of each button instantly. In short, the actual output of the module meets the expected output according to Table 5-1.



Figure 5.3: Tutorial scene.

5.2.2 Test Objective: Map Service Module

Table 5-2: Testing Result for Map Service Module.

Input	Expected Output	Actual Output	Meet Expectation (√/×)
User taps on “Tourism” or “Metro Exit”.	System is able to switch among the tab and display the maps for each tab.	Penang Georgetown selection appear in the tourism tab and KLCC subway area selection exists in Metro Exit tab.	√
User clicks the map.	System is able to display the map with highlighted POI.	A map is generated and zoom to the specific location selected by the user. Surrounding POIs are visible as well.	√
User selects the category.	System is able to display the POIs that inside the category.	The map shows the POI category by using certain icons.	√
User searches for a location.	System provides suggestion on the keyword and places a marker upon	A list of suggestion location is listed using the keywords input by the user (see Figure 5.2b). An info window	√

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selection. An info window containing the POI details shows up of the selected place shows up. The application also places a marker on the selected POI.

Before entering the map service page, the user needs to provide input on which maps to be selected in the homepage of the application. In the homepage, there is “Tourism” and “Metro Exit” tabs that places related maps on the tab. Once the input is provided by the user, map service will be redirected. The POI’s category icon can be seen in the page as shown as Figure 5.4a. There is a small defect in the category selection where it shows the POI category instead of allowing the user to choose the category. It does not affect the performance in the map service much because the map will auto filter out the POI to prevent information loading through zooming in and zooming out. This filtering approach match with the purpose of category selection where both aimed to prevent the visual clutter issue due to huge number of POI appears in the map at the same time. Overall, the map service module performs its outputs expectedly according to Table 5-2.

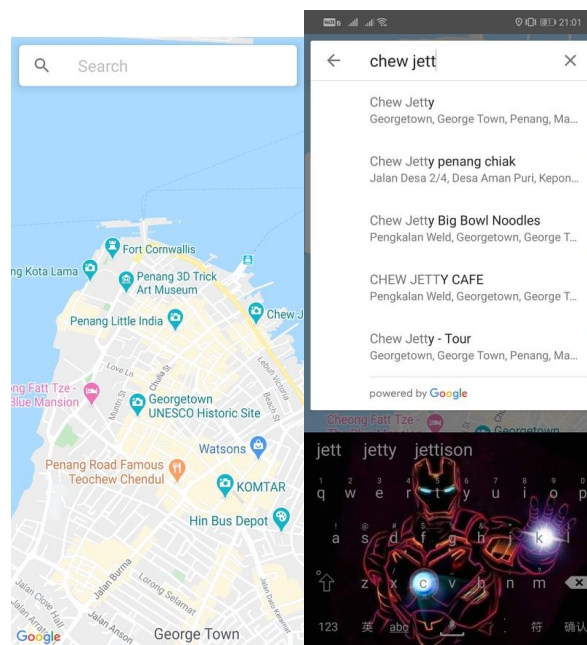


Figure 5.4a: Map service (left); Figure 5.4b: Autocomplete function (right).

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5.2.3 Test Objective: POI Information Module

Table 5-3: Testing Result for POI Information Module.

Input	Expected Output	Actual Output	Meet Expectation (√/×)
User selects the POI in the map service.	System display the additional information of POI and a “Get Direction” button is created.	Information such as name, address, opening status and rating is displayed. A “Get Direction” button is created.	√
User selects the POI in the camera view.	System display the additional information of POI with AR effect in the camera view and a “Get Direction” button is created.	An object contains the information of POI is displayed in AR effect and a “Get Direction” button is attached to the object.	√

Information that most tourists interested about a POI is retrieved in this module. For example, the address used to navigation, phone number for booking, status and rating for trip planning (see Figure 5.5a). There is a bifurcation point in the POI information where camera view shows different information about a POI to prevent redundancy. It shows the picture, history and general information of the POI. In a nutshell, the POI information module managed to retrieve the information of a POI for the user based on the result shown in Table 5-3.

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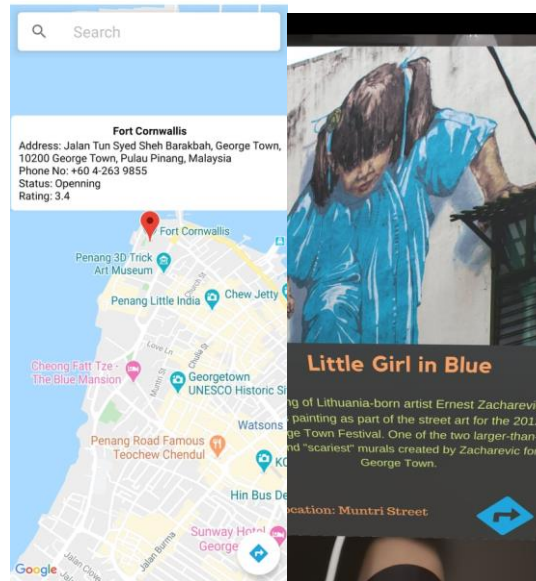


Figure 5.5a: Additional Information of POI in map service (left); Figure 5.5b: Additional information of POI in camera view (right).

5.2.4 Test Objective: AR Object Generator Module

Table 5-4: Testing Result for AR Object Generator Module.

Input	Expected Output	Actual Output	Meet Expectation (√/×)
User taps on "Scan" button.	System switches to the camera view.	Camera is opened in the system.	√
User scans the map.	System is able to display the picture or name of the POI with AR effect in the camera view.	AR effects is superimposing on the map when the map is detected. Otherwise, the AR effects will not be shown.	√
User selects the category.	System is able to display the POIs that inside the category with similar AR effect in the camera view.	Selecting a category will filter out the non-related POI AR objects.	√

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AR effects, the selling features of the proposed application accomplished in this module. A camera view is redirected when the user taps on the scan icon button in homepage. It will switch to the Unity platform and perform the map scanning to generate the AR objects. Current state of the application recognizes 2 physical maps and basically, it shows different AR objects for 2 different maps. There is a category button that allow user to filter out non-selected categories' POI (see Figure 5.6). The generated AR objects are interactable and the function is performed in the previous module, POI module.

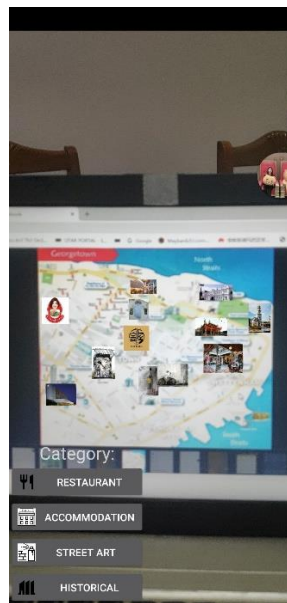


Figure 5.6: Map scanning on Penang Georgetown.

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5.2.5 Test Objective: Navigation Module

Table 5-5: Testing Result for Navigation Module.

Input	Expected Output	Actual Output	Meet Expectation (√/×)
User taps on “Get Direction” in map service.	System shows the route direction of the POI from the location of user.	A navigation view UI is displayed, and the route direction is highlighted in blue.	√
User taps on “Get Direction” in camera view.	System shows the augmented arrow pointing to the direction of the POI from the location of user.	An AR navigation view UI is displayed, and the route direction is highlighted in blue and green.	√
User starts moving.	System is able to navigate the user to the POI.	The application keeps updating the user location in the navigation view until the user reach the destination.	√
User off-route during the navigation.	System generates a new route direction of the POI from the location of user.	A new route is generated whenever the user off-route during the navigation.	√
User reaches the destination.	System notifies the user upon arrival.	The system will notify the user upon arrival with voice command.	√

Navigation, the most important function for this project and the result is very delighted and optimistic. This is because Table 5-5 illustrates the successful of the module. From registering destination to navigating the user, it managed to perform all the functions. Even the off-route situation is premeditated for both normal and AR navigation.

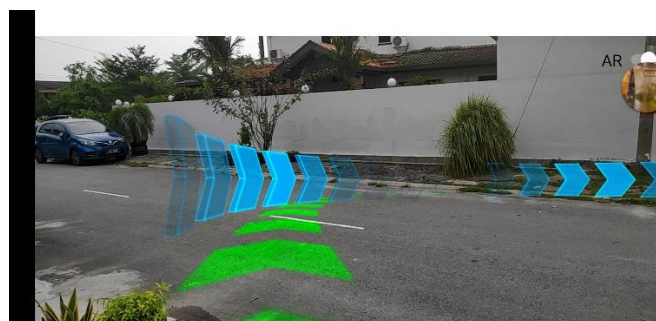


Figure 5.7: AR Navigation showing direction (U-turn).

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5.3 User Acceptance Testing/Feedbacks

User acceptance testing (UAT), also known as Beta, Application, or End-User Testing is a process to verify whether a solution works for the user. It is a very important step in software development as it is the usage of software by people from the intended audience and recording and correcting any defects which are discovered (Setter, n.d.). It provides user the chance to interact with the software and acts as a final testing before the application was launched. Features overlooking, miscommunicated, or malfunctioning in the application were able to detect by UAT which can help to improve the application in the next version of the application.

10 volunteers from different faculties had been randomly invited to participate the UAT of the proposed application. Among the volunteers, 5 of them were from FICT, 3 were from FEGT and the remaining were from FBF. This diversity was to ensure the perspectives from different field of professionals as mentioned earlier in the chapter above (survey analysis). The UAT process was carried out in UTAR Kampar campus Block C, the flea market. The feedbacks from the volunteers were as follow:

Table 5-1: The feedbacks received from UAT.

Participants	Summary Feedbacks/ Respondent's Emotions
Name: Ting Gen Liang Faculty: FICT	<ul style="list-style-type: none">• Easy to use the application.• Amazed with the ability of AR in a tourism application.• Requested for the APK of the application for study purpose.
Name: Er Sheng Jian Faculty: FICT	<ul style="list-style-type: none">• The application is user friendly.• Completed whole application without any guidance provided.
Name: Law Jia Wei Faculty: FICT	<ul style="list-style-type: none">• Curious with the API, SDK used in the application.• He compared the application's navigation with Google Maps and found out that the AR navigation is very special.
Name: Wan Chi Chong Faculty: FICT	<ul style="list-style-type: none">• The data of AR elements in the map scanning can be more dynamic.• He doubted the accuracy of the navigation but will give it a try if the application is launched.
Name: Lim Wei Jin	<ul style="list-style-type: none">• He commented the UI design of the application is close to real-world design.

Chapter 5: System Implementation and Testing

Faculty: FICT	<ul style="list-style-type: none"> • More features can be included in future such as trip planning.
Name: Chan Bo Er Faculty: FEGT	<ul style="list-style-type: none"> • Surprised with the AR navigation function. • He is satisfied with the real-time information retrieved in the map service.
Name: Chew Jing Rou Faculty: FEGT	<ul style="list-style-type: none"> • She didn't know that AR features can be adopted in a tourism application. • The application is simple and direct. No complicated input required. • She feels enjoyed throughout the whole testing.
Name: Chee Zhen Fei Faculty: FEGT	<ul style="list-style-type: none"> • He hoped for more maps can be unlocked in future. • Requested for the APK for the self-use purpose. • The camera of the phone may need high resolution for the best performance.
Name: Ng Khang Wei Faculty: FBF	<ul style="list-style-type: none"> • He saw the business value of the application. • He feels engagement when using the AR function of the application. • The AR UI design can be further improved in the camera view.
Name: Lam Kah Weng Faculty: FBF	<ul style="list-style-type: none"> • The waiting time for the map scanning is quite longer than he expected. • Overall, the application is quite useful for him.

Table 5-1 showed that all the users from UAT were satisfied with the application. There were some critics received from the process, it was not a big issue and it can be taken as future improvements for the application. Majority of them likes the UI design and the AR features of the application.

Chapter 6: Discussion and Conclusion

6.1 Project Overview

The current tourism applications are still lacking a breakthrough point. A creative integration of AR technologies is able to create the breakthrough point in the tourism field. As such, the tourism guidance application proposed in this project named as GoTour that applies AR navigation and AR tracking techniques will be developed to enhance the tourism field in mobile application. By applying AR navigation and AR tracking techniques, the issues of getting lost in tourism attraction and map complexity can be solved respectively. AR navigation provides a better guidance compared to the normal map navigation and AR tracking techniques can help tourists to transform the standing still, not attractive and complicated tourism board map into an interact-able, attractive and simple map. Moreover, the other useful features of the existing tourism applications are retained such as the map service including normal map navigation and providing POIs' information.

Other than taking effort to advertise a tourism attraction that helps to achieve a win-win situation to the tourist and POI in the tourism attraction, this project also intends to implement in a subway station area by targeting the subway exit maps. The people inside a subway station are usually in a rushing condition to catch up the subway and hence, this application reduces the time for the user in figuring out the location of a subway station by making use of the AR tracking techniques as well. Overall, it reduces the time wasted for the user to understand a map particularly a tourism board map and subway station exit map.

Lastly, this project implemented only 2 places which are Penang Georgetown and KLCC station due to the designs and models that vary for all different places. Although there are only 2 places implemented, these 2 places will act as a reference in future updates and maintenances to include more places which can improve this application's usage availability.

Chapter 6: Discussion and Conclusion

6.2 System Strengths and Limitations

Although the proposed application successfully achieved all the modules' functionality, the functionalities of each modules can still be improved. The linking between each module can be strengthen as well to create a smooth experience for the user when using the application.

Strengths

The strengths of the application are more on the collateral effects from the usage of map scanning and AR navigation. Map scanning creates an economy stimulation as it allows the promotion of the POI, even without the POI's owner effort at the moment. Tourists are more likely to spend their money on these POIs if they find the POI in the application is enjoyable. Moreover, the AR navigation may bring a new trend to the current navigation application or even to the other industries such as in game industry. For example, a game may adopt the AR navigation which requires the user to travel around for a certain mission. There exist also other strengths that mentioned earlier such as innovative features, attractive layouts etc.

Limitations

There exist some limitations in the application in term of hardware issues and the software of application itself. Since this application relies on the GPS to work for the navigation features, the application may lose its competitiveness when it comes to a low GPS signal places such as inside building. This statement is supported by a United States Patent owned by MacGougan, Grosman, Huang, and Mayor, Apple Inc in 2017. It states that GPS signal is often weaken in the urban area that full of skyscraping buildings as the building's physical structure will block the signal from the satellite. Furthermore, the usage of GPS is proven to increase the battery consumption of the device. The limited supported devices issue is also one of the limitations. The integration of Mapbox Vision SDK and ARCore gradually reduces the number of supported devices. IOS, Android devices with Kirin processors are not compatible with the application. Although these devices can enjoy some of the features such as map scanning and map services, they cannot work with the AR navigation function. Lastly, the requirement to access camera and GPS of the device drains the device's battery quicker. Thus, the user should ensure the battery level is adequate before using it.

Chapter 6: Discussion and Conclusion

On the other hand, in software part, the information in the map scanning function has a significant drawback. The information is static, and it is not updated according to the latest information. More information should also be provided in the AR navigation function such as speed, distance etc.

6.3 Future Work

The availability of the maps can be increased since the current application supports only Penang Georgetown and KLCC subway station area. Local or foreign maps can be included in the application in future. This increases the usage of the application for all end users.

Type of users can be increased. The application can expand the users to the POI and should not be limited to only the tourists. In other word, the application allows the user to register its shop, restaurant etc. into the application to promote the POI. Such implementation increases the business value of the application as register fees or subscription-based payment can be charged to the owner of POI. This results in a win-win situation for POI's owner and the application. The application itself can sustain with the fees and the POI can be promoted through the application.

Moreover, **the database should be created to support the suggestions provided above.** The current application does not have a database to store the POI data. When the number of maps increased, more and more data will be generated and hence, a database was needed to store these data. Moreover, when the payment method is being implemented for different type of users, a database to manage these users' information is needed.

Finally, **building recognition** can be included in future (see Figure 6.1). It helps the tourists to better identify and verify a POI. Building recognition also adds in new attraction for the POI to interact with the user. The location of the user can be identified as well when the GPS signal is lost. For example, when the user current located at a place where the GPS signal is weak or blocked, the user can scan the building to obtain the name and address of the building. The user will have a slightly idea on his location so he can do something with the information.

Chapter 6: Discussion and Conclusion



Figure 6.1: Building recognition.

6.4 Conclusion

In conclusion, the proposed application managed to meet all the requirements specified especially the fundamental modules, AR navigation and map scanning. These 2 modules are the solutions to the problem statements stated in the chapter earlier. The first problem statement, map complexity that confuses the tourists due to the multiple legends, paths, colours and names overlaying with each other within a map, causing visual trouble to the tourists. Thus, the map scanning function is able to enrich the map and reduce its complexity by only focusing on the important POI within a map.

While for the solution to the second problem statement, the navigation issue is more on improving the current navigation function of the navigation application. Navigation in a tourism mobile application plays an important role as the tourists are always keen to know the direction towards a POI. However, the single standalone navigation may not be able to satisfy the tourists. With today's technology, integrating the AR technique in navigation is no longer a miracle but a possibility. Therefore, the proposed application came out with an AR navigation to enhance the navigation experience for the tourists.

By solving the map complexity issue and improving the navigation function, a powerful tourism application is created and will dominate the tourism industry. This statement is supported by Vakhnenko (n.d.)'s argument where he believes that AR in tourism provides three main benefits which are increase tourist interest, timesaving and security enhancement.

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FINAL YEAR PROJECT
Tourism Guidance Using Augmented Reality

GO TOUR

What is Go Tour?
Tourism mobile based application which involving Augmented Reality to simplify the map and to enrich the navigation process.

Objectives
To Integrate AR effects on 2 elements:

- Map
- Navigation

Map Chosen - Penang GeorgeTown

Commercial Participation

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