Interactive Directory for Shopping Mall via Augmented Reality

BY

LEE JIA QI

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfilment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (Honours)

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2021

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DECLARATION OF ORIGINALITY

I declare that this report entitled "**Interactive Directory for Shopping Mall via Augmented Reality**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : 

Name : LEE JIA QI

Date : 15/04/2021

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First and foremost, I would like to express my gratefulness and appreciation to my supervisor of this project, Ts. Saw Seow Hui who has willing to accept my proposed title for this final year project, which is Interactive Directory for Shopping Mall via Augmented Reality. She has guided me throughout the project with her knowledge and experiences which has led me to come out with several great ideas during the development of this project.

Lastly, I would like to express my gratitude towards my parents and friends who are always supportive and encouraging during the whole development process. This project would not be built successfully without their support emotionally.

ABSTRACT

Most of the existing shopping mall directory is provided in the form of kiosk in the shopping mall, although there are some mall directories provided online in the form of website, but still, both forms of mall directory have the problem of giving confusing instructions to guide the users to their destination. Furthermore, smart devices are nearly categorized as a necessity in life during the current era, and users are prone to use their smart devices to view the mall directory or navigation route since it is portable and convenient, unlike traditional mall directory kiosk provided in the shopping mall which is lack of portability. An interactive directory via Augmented Reality (AR) in the form of mobile application will further improve the function of a mall directory. AR technology allow the presentation of clear and simple navigation instructions and a mobile interactive directory via AR allow users to navigate in the correct way and direction without any confusion. The 3D point map localization that works well for indoor environment with rich visual features is added to this application to make it more convenient for the users as it can identify the current location of the user, which can provide help to the user who do not know their exact location. Users can choose their destination by selecting the shop name provided and get a route displayed in real-time to guide them to their desired destination. The AR navigation function provided by this project is highly specific on the location, it will be functioning well provided the user is physically located in the specific shopping mall environment. Additionally, this project enables users to view the general details of the shopping mall, such as shop list and the floor plan of the mall. Lastly, due to the COVID-19 pandemic occurring in Malaysia, an alternative indoor environment has been chosen to replace the real shopping mall environment.

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LIST OF ABBREVIATIONS

RFID	Radio-Frequency Identification
AR	Augmented Reality
3D	Three Dimensional
GPS	Global Positioning System
VR	Virtual Reality
RAD	Rapid Application Development
SDLC	Software Development Life Cycle
UI	User Interface
API	Application Programming Interface

CHAPTER 1: INTRODUCTION

1.1 Problem Statement

1. Cost of indoor location positioning.

Most common indoor location positioning systems usually use sensors, RFID or Bluetooth beacons to establish user location. These systems require extra equipment to locate the user, and the equipment should place at several places in the indoor environment so that it can locate the user position more accurately. This will highly increase the costs of developing the system and various work should be done to install all the equipment around the place.

2. Confusing instruction in presenting directions of the navigation route.

Users may be confused even they have the suggested navigation route to lead them to their destination due to the layout of the map is not identical to the real-time location of the user position. They may have to spend time in identifying which way to start their navigation, at worst, they might have proceeded to a totally opposite direction too, hence, it will be time consuming for the users to analyze the map and the route before they can start their navigation.

3. Use of AR markers or specific labels.

Another way to utilize AR services in indoor location positioning system is to use AR markers or specific generated labels. The cost of printing these markers is far lower than setting up the sensors, nevertheless, the AR markers or labels that will be most likely attached to the floor or walls in the shopping mall, will eventually torn off or missing after sometimes. Users will also need to put in some effort to search for the nearest marker around them to use the application, hence, it may be inconvenient for the users.

4. The limitation of traditional mall directory.

Traditional mall directory is lack of portability as it is in the form of kiosk, hence, users must remember the suggested route because they could not bring the directory board or kiosk together with them. There is some improved version of mall directory which is in the form of

smartphone application or mobile website, but it does not solve the confusion on the direction and thus, create a challenge for user who do not have a good sense of direction.

1.2 Background and Motivation

Augmented Reality (AR) has become a trend in this era, even though it only gained popularity in few years back, but the idea of AR has been developed since 1968. Ivan Sutherland builds the first AR system that can display simple skeletal 3D drawings in real time (Sutherland, 1968). The AR concept has evolved rapidly and following the current trend in the market. Nowadays, mobile devices are ubiquitous and almost necessary in our daily life, therefore mobile AR has been a popular research among researchers to integrate AR concepts into mobile devices to solve the users' problem more effectively.

AR application in mobile devices has evolved with time, according to Wagner and Schmalstieg (2009), there are 4 major stages of mobile AR evolution as in Figure 1.2.1. Currently, mobile devices such as smartphones and tablets are the most common devices in daily life, hence, mobile applications that can perform different functions to help user in solving their problems are important. One of the most useful and demanding application with AR implementation is the navigation application for outdoor or even indoor environment as it can give user clearer instructions and navigate them to their destination without any confusion. However, based on observation, there are a lot of outdoor AR navigation applications exitst in the market, but there are only a few for indoor environment mainly due to the challenge in positioning the current location of users in indoor environment. There are a few technologies that can do so but it is usually expensive and requires a lot of extra equipment.

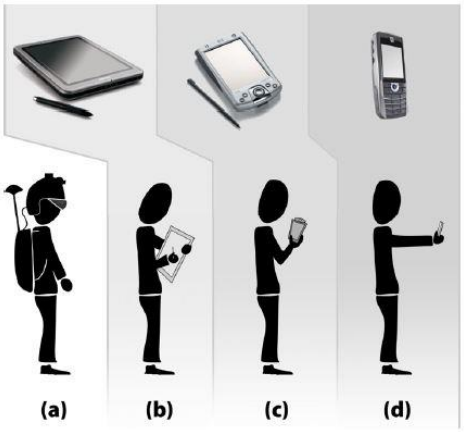


Figure 1.2.1: Evolution of mobile AR: (a) Mounted camera with HMD, (b) UMPC, (c) PDA, (d) Smartphone (Wagner and Schmalstieg, 2009, p.7).

Thus, to further improve the implementation of AR in indoor navigation applications for the ease of users, an Interactive Directory for Shopping Mall using AR which can locate the user's position in an indoor environment and generate suggested route to the user's desired destination is crucial to help the users that are not familiar with the specific indoor environment. Additionally, beside AR is trending in the market, Virtual Reality (VR) is also a popular option implemented on mobile application. According to Gupton (2017), AR is a technology that add digital elements to real-time view using built in camera on smartphones, whereas VR is a technology that provides users a full immersion experience that will shuts them out from the physical world, and VR usually needs extra VR devices to display the virtual world. In this project, AR surpass VR due to its ability to connect the digital elements, which will be the navigation instructions to the user's view in real-time, so that at instance, user can know if they are walking towards a correct direction.

The basic function of indoor navigation application is to provide guidance for people who feel confused when they are physically located in an unknown building or building complexes (What is indoor navigation and what are its possibilities?, n.d.). This is important and yet necessary in the process of digitalized paper maps with smartphones. It may contribute by guiding the users independently to their destination without intervention and help businesses to save costs in hiring help desk staff to provide appropriate help to the customers. Also, in shopping malls, it is common to have an interactive directory kiosk provided to help the users know more about the shops available in the mall. Interactive directory kiosk usually provides engaging information about the mall and make the navigation in a mall easier since it provides wayfinding solutions (Mewherter, 2016). Although traditional interactive directory kiosk does provide wayfinding solution, but as mentioned earlier, these kiosks are lack of portability and users are required to remember the suggested route to their destination as they are unable to bring the kiosk with them. Hence, a mobile application that combines the function of indoor navigation using AR and interactive directory is necessary to improve the user experience.

The motive of adapting AR into a shopping mall directory is that the traditional mall directory provided is either showing only the floor plan, which does not display routes to help the users, or some newer ones, route is suggested, however, users must remember the suggested route because they could not bring the kiosk together with them. There are some improved versions of mall directory which is in the form smartphone application, but it does not solve the confusion about the direction of route, for example, the map is drawn facing North, but the user is facing South or any other directions, this will be a challenge for user who do not have a

good sense of direction. Therefore, in this project, an interactive directory using AR technique will be developed on Android platform to further improve the existing mall directories.

1.3 Objectives

1. Develop an indoor location positioning function that has a low development cost.

This project aims to lower the cost of indoor location positioning by not using equipment such as sensors to determine the user location, which require manpower for the setup process and purchasing more sensors for a better result. This project would not involve any sensors to cut the cost of development.

2. Develop an indoor navigation application that provides a simple, clear, and distinct instruction for the user.

The focus of this project is to develop an AR navigation application for a shopping mall that can navigate the users from their current location to their selected destination without having any confusion on the direction to save their time as much as possible.

3. Develop an indoor location positioning function that can track on real-time objects instead of specifically generated AR markers or QR Code.

The purpose of this project is to reduce the use of specifically generated AR markers or QR code for location positioning, this is to keep the setup process of this application minimal. Real-time objects such as signboards which is already available in the shopping mall will be used to replace the AR markers.

4. Develop a shopping mall directory application that is portable and usable at any time in the shopping mall.

This project focuses on the usability of the mall directory, it should bring convenience to the users as they do not need to seek help from the help desk or searching for directory board or kiosk in the shopping mall to save their time and energy.

1.4 Proposed Approach/Study

In this project, an Interactive Directory for Shopping Mall via Augmented Reality based on the Android platform will be developed. This application will act as a mall directory and guide the users to their destination with suggested route display in real-time. Users should be able to locate themselves by scanning their surroundings in the mall, and their current location will be set as the starting point of the navigation, user will then select their destination. According to the proposed solution by Huey et al. (2011), location positioning can be done by scanning on a marker placed in the library, and directions will be displayed on top of the marker in real-time. This solution has the potential to be improved using the current AR technologies, therefore, the idea of this solution is used as the base for the solution proposed in this project. This project was initially targeted to be done at a specified shopping mall, however, in this project, the concept is being presented in the author's house due to the COVID-19 pandemic and the Conditional Movement Control Order of the country.

1.5 Achievement

This project has provided an inexpensive method for indoor location positioning without having the need of purchasing and installing any sensors or equipment. The primary contribution of this project is that it solves the confusing instructions given by the traditional mall directories which may cause the users to spend more time to arrive at their destination.

By implementing the 3D point map localization to determine the user current location, the use of QR codes or markers can be eliminated since the location is determined by the real-world objects existed in the environment.

Lastly, this project served the same purpose as what a mall directory that are placed in the shopping mall by providing all the information and shop details that are supposed to be informative to the users. Overall floorplan of the shopping mall and the list of stores located in the mall are all listed in the application.

1.6 Report Organization

This report consists of six chapters that explain different details of this project. Chapter One will discuss the problem statements, background information, motivation, project objectives, and the achievements of this project.

Chapter Two is the literature review section of the project. Research and reviews are done on three mobile application with similar concept and one research paper on relevant topic. The functionality provided in these projects are listed, together with their respective pros and cons.

Then, the third chapter is all about the system design. The functionalities provided in the project are explained in a more detail manner. A few types of diagrams such as use case diagram, activity diagram, class diagram and object diagram are used to further clarify the flow of the system. Other than that, this chapter will include the project interface design for a better understanding of the overall functionalities provided.

In Chapter Four, methodology and tools that have been chosen to develop the project are clearly stated. Besides the methodology and tools or software needed to build this project, the version requirements of software are stated as well.

After that, the fifth chapter will discuss the implementation and the test cases done on the system. Some of the initial setup and configurations are clearly documented in Chapter Five along with some screenshots that is crucial for the development of the project.

Lastly, Chapter Six will be the conclusion section which contains the summary of the whole project and discussion about the potential improvements that can be done on the system in the future.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter will focus on reviewing the previous work done on similar idea, which is indoor navigation mobile application. Mobile application such as MallDash, a Malaysia shopping mall indoor navigation mobile application, WayIn, an indoor navigation application uses AR markers for location positioning, and an indoor navigation with ARCore called WayFinder is reviewed. Additionally, a research paper on indoor location positioning method will be reviewed. The pros and cons of these work done will be discussed in this chapter.

2.2 Review on Indoor Navigation Mobile Applications

2.2.1 MallDash

MallDash is a shopping mall directory for a variety of shopping malls in Malaysia. It allows the users to check on the mall directory of different shopping malls, view the floor plan and store location at any time. It also enables the users to check on the route from one store to another by displaying the suggested route. Other than serving as a mall directory, it provides information of the shopping malls, such as the address, operating hours, and parking rates. This application helps user that are visiting the shopping mall for the first time or unfamiliar with the mall to get to their desired destination faster by providing them the floor plan and directions to reach the destination.

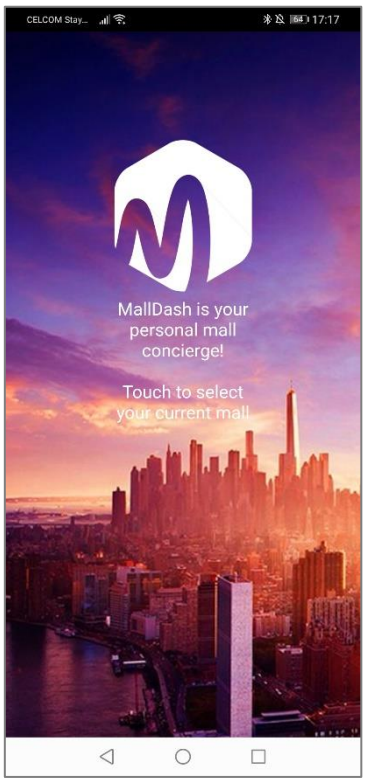


Figure 2.2.1.1: Home Page of MallDash.

Figure 2.2.1.2: Shopping mall offered.

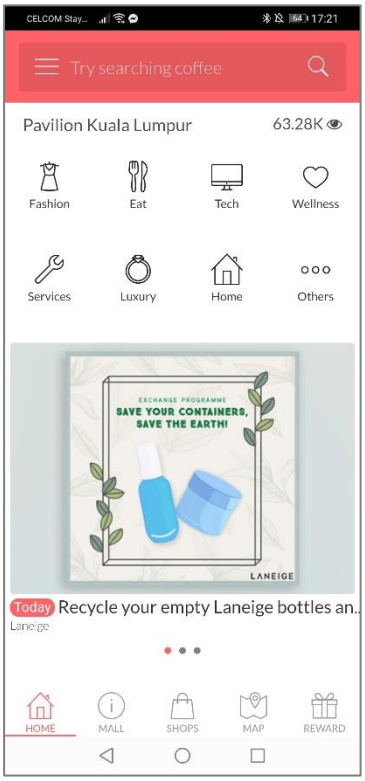


Figure 2.2.1.3: Mall Directory.

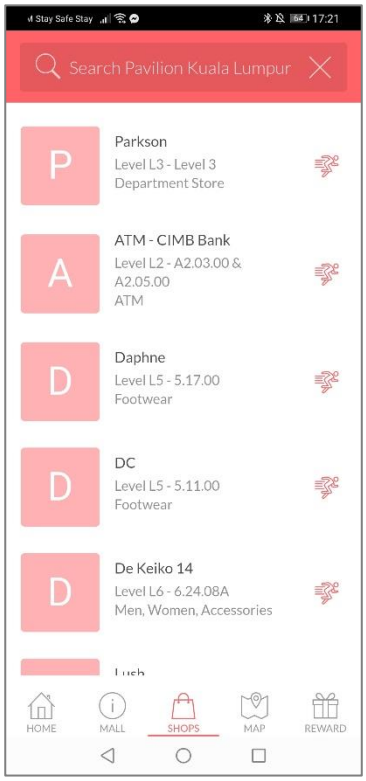


Figure 2.2.1.4: List of shops in the mall.

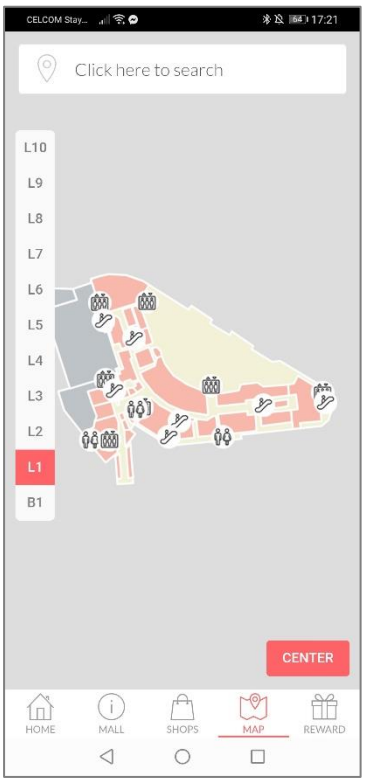


Figure 2.2.1.5: Floor Plan.

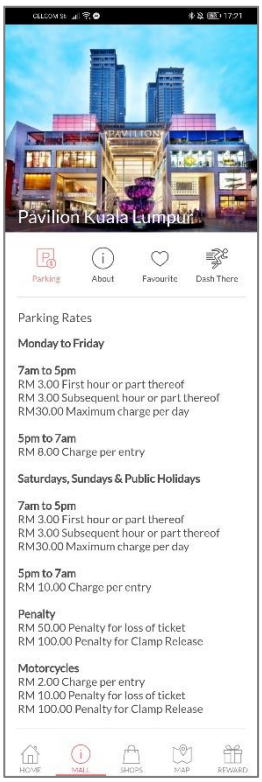


Figure 2.2.1.6: Information of shopping mall.

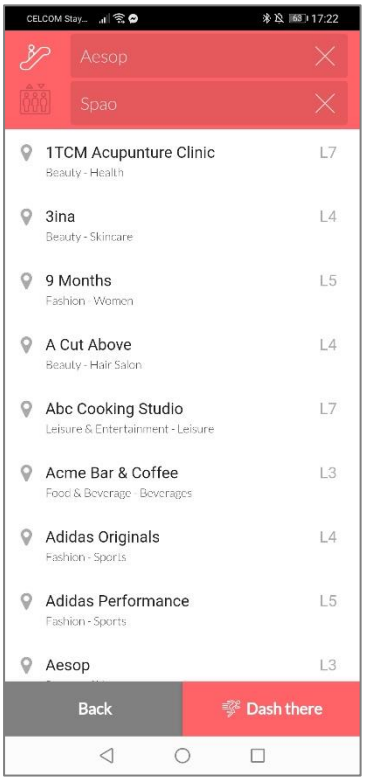


Figure 2.2.1.7: Select current location and destination.

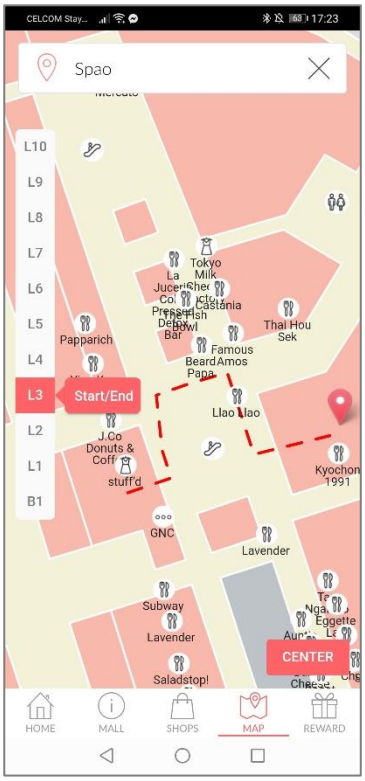


Figure 2.2.1.8: Display route.

Strengths of MallDash

Firstly, MallDash is convenient as it merges directory of various shopping malls in Malaysia into a single application, users do not need to install different applications for every shopping malls. The next advantage of this mobile application is that it can display the suggested route from one store to another in a shopping mall without requiring the users to physically locate in the shopping mall. Users can plan their routes in advance before they go to the mall to save time if they are in a rush. The application works well even if the starting location of store and destination store is in a different floor, it will guide users to the nearest escalator, then requires users to click on the "Go Up" button as shown in Figure 2.2.1.9, after that, it will show the route from the escalator to the destination. This method of displaying is clear and easy to understand as it divides a long route into smaller pieces, so that user will not feel that it is complicated and confusing.

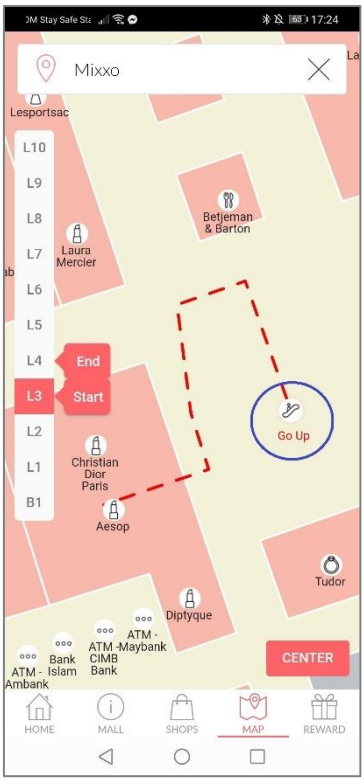


Figure 2.2.1.9: The "Go Up" button that will show users the route on another floor.

Limitations of MallDash

MallDash provides two-dimensional floor plan of a shopping mall, the floor plan illustrates simple structure of the mall and only some of the store names are displayed on the floor plan. This may confuse the users when they are deciding which direction to start off, for example, the floor plan in the application is drawn facing north and all the route suggested will display the directions based on the north side. However, when the user is physically in the mall, they may face the other side and the direction will be different from the floor plan. User must spend time in analyzing the surrounding store location and determine the correct direction to start using the suggested route. This process is a burden for user that has bad sense of direction. They may follow the route exactly, but in a completely opposite direction, at the end, user did not reach their desired destination and wasted a lot of their time and energy. Also, this application does not implement AR technology that can highly increase the understandability of the navigation instruction, which considered as one of its weaknesses too.

Solution to Solve the Limitations

Since showing only the floor plan with suggested route may confuse the users, hence, the navigation route can be displayed using AR in real-time so that the user can know if they are facing the correct direction, they can follow the route displayed wholly to get to their destination. The navigation route will guide the user step by step from their current location to the destination.

2.2.2 WayIn

This application is an AR indoor navigation application developed for the developer's house. It uses AR markers that are placed in specific points of the house to get the current position of the user. WayIn allows user to scan the nearest AR marker to pin their current location, then select destination by clicking on the floor plan of the indoor environment. This application provides two modes of navigation, which is the AR mode, or the regular map mode. It generates routes in real-time via AR to guide the user to the destination without causing any confusion.

Figure 2.2.2.1: Scan an AR Marker.

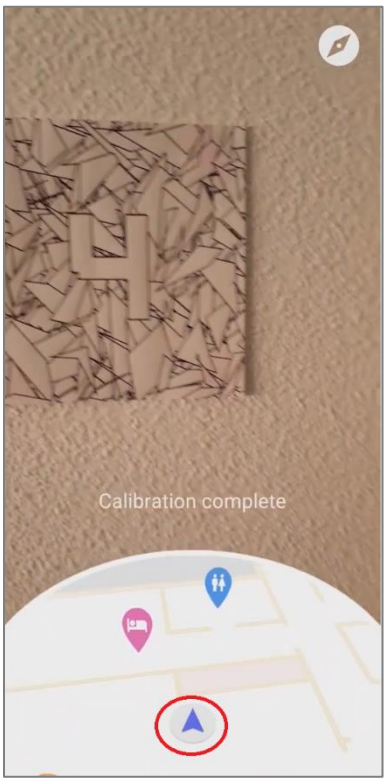


Figure 2.2.2.2: Get the current location.

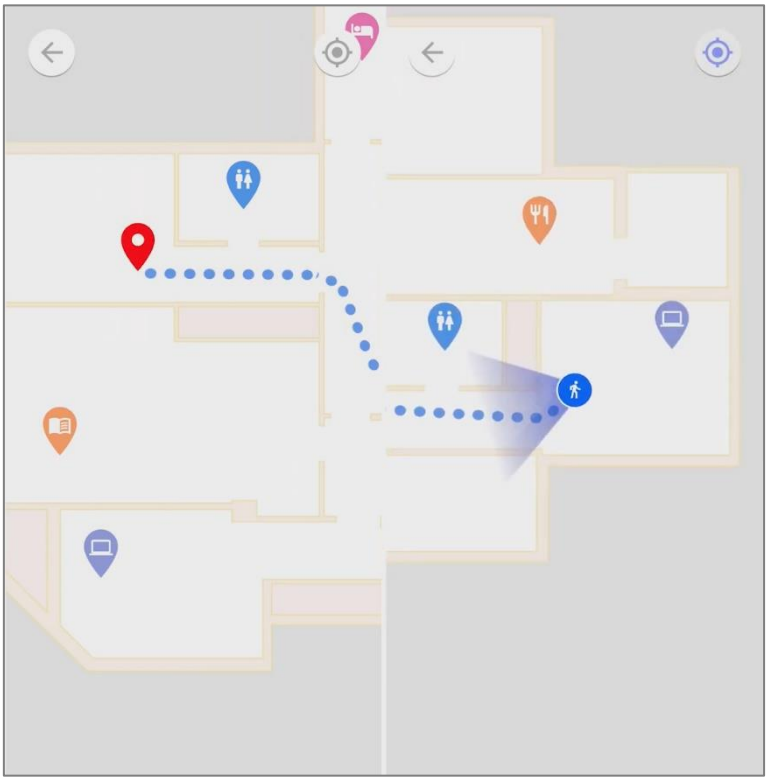


Figure 2.2.2.3: Users can view their current location and select their destination in the floor plan.

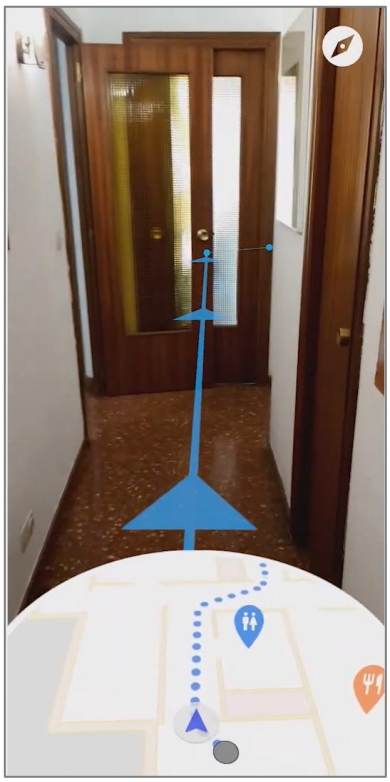


Figure 2.2.2.4: Navigation in AR mode.

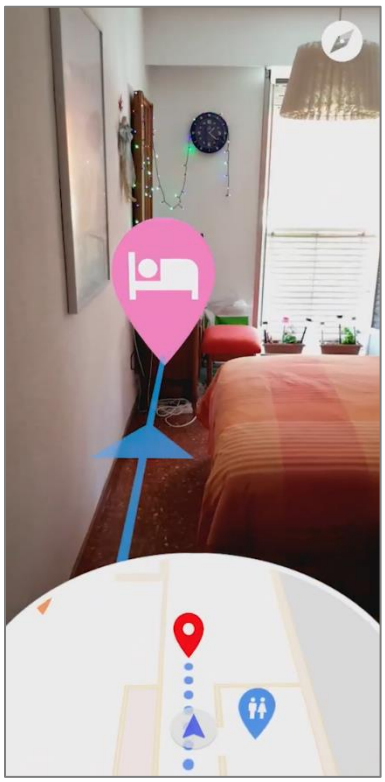


Figure 2.2.2.5: Destination icon.

Strengths of WayIn

WayIn did a good job in guiding the users to the correct direction, there are a few things in this application that can help users to identify their current direction. Firstly, after getting the users' current location, users can see an icon indicating the user with direction provided as shown in Figure 2.2.2.6. The blue shadow that represents the view of user will change when the user turns around in the regular map view. On the other hand, there is also a small hint displayed for the users when they are in the AR navigation mode, the blue arrow that is circled in red in Figure 2.2.2.7 is used to inform the users to turn towards their right-hand side to see the real-time navigation arrows. The next advantage is, the users can simply pin a destination point on the floor plan, it does not need to be a labeled location to act as the destination as in Figure 2.2.2.8.

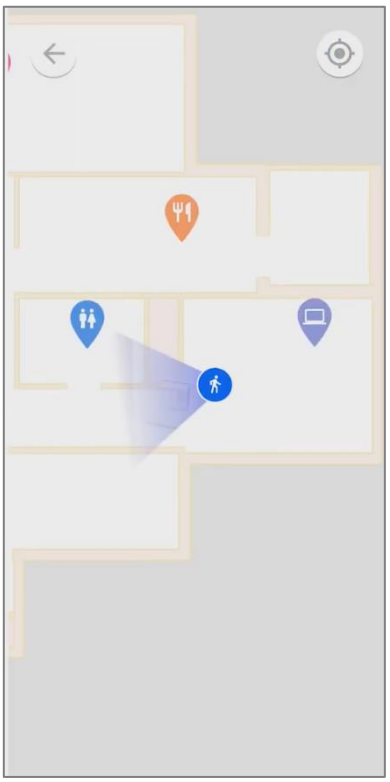


Figure 2.2.2.6: Direction hint in regular map mode.

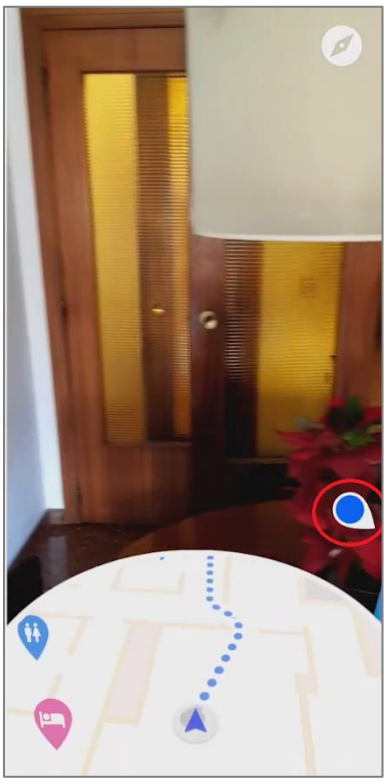


Figure 2.2.2.7: Direction hint in AR mode.

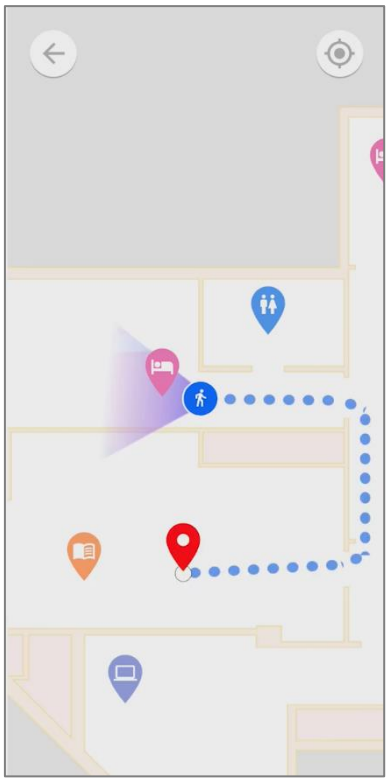


Figure 2.2.2.8: Any point in the floor plan can be the destination.

Limitations of WayIn

WayIn is quite a simple application which mainly focused on indoor navigation only. Therefore, there are a few weaknesses to be improve in the future. First, users cannot search for a destination from a search bar, they must find the destination in the floor plan and click on it. This method is acceptable for small indoor environment such as office, however, when the indoor environment is large and complex, such as shopping malls or airports that consist of several different levels, it will be difficult for user to select the destination on the floor plan. This will be a trouble for users that do not visit to the environment before, they have no idea about where their destination will be located. Then, WayIn scans fixed AR markers placed in the environment to get the current location of the users. The disadvantage of these AR markers is that the location positioning function will not work if the AR markers are missing or faded off. Also, the users need to spend time to find out the nearest marker around them.

Solution to Solve the Limitations

A search bar should be implemented in the application to allow users to choose and search the destination from a list of labelled location, with this function, users will not need to look through the floor plans of a huge indoor environment to find their destination. To further enhance the application, users should be able to select their current location from a list of labelled location, this will save some time of the users to find the nearest AR marker if they already know their current location.

2.2.3 WayFinder

WayFinder is an Android application that performs AR indoor navigation in a shop using marker-based localization. The position of user is determined by scanning the fixed intuitive AR markers in the shop. It requires user to select the destination and scan one of the two fixed markers in the shop as the current position. This application helps the user to find their desired items quicker by directing them to the shelf displaying the items using real-time instructions.

Figure 2.2.3.1: Home Page of WayFinder.

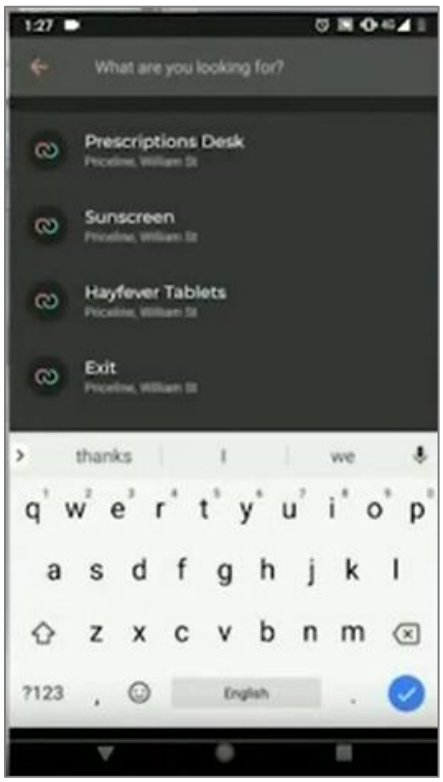


Figure 2.2.3.2: List of destination.

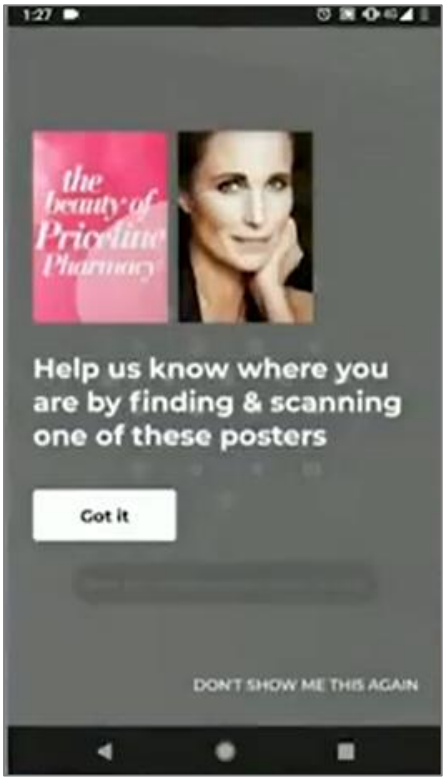


Figure 2.2.3.3: Supported intuitive markers.

Figure 2.2.3.4: Scan the marker.

Figure 2.2.3.5: Show route in real-time.

Figure 2.2.3.6: Destination indicator.

Strengths of WayFinder

WayFinder is convenient in the sense that the developers will not need to generate and print out the AR markers to attached in the shop for location positioning since it uses intuitive markers, which are posters in the shop. It also shows a clear path to guide user to the destination in real-time, it uses illustration of a pair of footprints with a bright colour, which is eye-catching and easy to be recognized.

Limitations of WayFinder

This application only provides 2 supported intuitive markers that can locate the current location of users, this means that users have only 2 options to use as their starting point, and they need to find out where did these posters located at. This may work well to navigate users within a shop, but it is clearly not convenient if it is adapted in a larger indoor environment. Additionally, posters are advertisements that may be replaced frequently, hence, it may not be the best intuitive marker for location positioning.

Solution to Solve the Limitations

A few improvements can be done to solve the limitations of WayFinder, more intuitive markers can be added to increase the flexibility of choices for the starting point, for example in a shopping mall, a unique logo or image in the shop can act as the marker for location positioning. Then, the intuitive markers should change to objects that are stable and will not altered frequently to maintain the usability of this application.

2.3 Review on Indoor Navigation Research Paper

2.3.1 Indoor Navigation for Visually Impaired Using AR Markers

According to Yang and Saniie (2017), indoor location positioning can be done by scanning AR markers placed in the environment using devices with camera, such as smartphones and tablets. This research paper has proposed a solution to help visually impaired users to aware of their current location and guide them to a destination. The users can simply run their camera on the smartphone, then the algorithm will detect the AR markers and calculate the position of the camera to get a more accurate current position of the user. The AR markers are not a simple label with illustration, but it is a specific marker generated using the Mixed Integer Linear Programming (MILP) which can encode a unique identification number to each AR marker generated. Since this application is meant for visually impaired users, hence, the instructions for navigation is in the form of voice instructions.

Strengths of the Proposed Solution

The solution proposed in this research paper has the advantage of automatic AR markers detection. Visually impaired users are unable to search and find the AR markers placed in the environment by visual perception, therefore it is impossible for them to find the nearest marker and scan them to get the current position. This solution makes this process automated by using incremental registration of the markers to assist in the work of determining position and pose of the AR markers. By using this approach, any markers can be identified and registered if there is a registered marker being detected in the same frame.

Limitations of the Proposed Solution

The solution proposed is wholly designed for visually impaired users, thus, this solution only provide voice instructions to guide the user to their destination. Voice instructions sometimes are not as clear as illustrated instructions because noises in the environment may interrupt the users from fully understanding it. Also, according to the requirements stated in the research paper, all the AR markers must be generated from the same dictionary, have different identification number and have the same size when it is printed out for installation in the environment. This will use up a lot of time in building up all the AR markers especially if the environment is a huge shopping complex and may not have enough unique identification numbers for all the AR markers.

Solution to Solve the Limitations

To improve the usability of the proposed solution, suggested route should display in real-time so that not only visually impaired user can use the application. After that, instead of using AR markers that requires a complex process to generate, other substitution such as natural markers should be implemented to get the user position. The natural markers selected must be stable, eye-catching, and unique for different points of location in the environment.

2.4 Comparison of Proposed System and Previous Work Done

Table 2.4.1: Comparison Table for the proposed system and the existing systems.

Systems / Features	**Proposed Solution**	**MallDash**	**WayIn**	**WayFinder**	**Indoor Navigation for Visually Impaired**
AR Technology	✔	✗	✔	✔	✗
AR markers	✗	✗	✔	✔	✔
Voice Instruction	✗	✗	✗	✗	✔
Display floor plan	✗	✔	✔	✗	✗
Display navigation route	✔	✔	✔	✔	✗
Select current location	✗	✔	✗	✗	✗
Free	✔	✔	✔	✔	✔

CHAPTER 3: SYSTEM DESIGN

3.1 Requirement Specifications

3.1.1 Functional Requirements

1. User should be able to view the tutorial of how to use the AR navigation function.
2. User should be able to view the shop available in the shopping mall.
3. User should be able to view details of each shop in the application.
4. User should be able to direct to the shop's official website in the application.
5. User should be able to scan their surroundings to locate their current location.
6. User should be able to select their destination.
7. User should be able to view the navigation route in real time.
8. User should be able to change their destination during the navigation.
9. User should be able to view the overall floor plan of the shopping mall in the application.

3.1.2 Non-Functional Requirements

1. The system should be able to retrieve the sparse spatial map of the mall from the EasyAR SpatialMap database within 1 minute.
2. The system should be able to track objects in real time when the sparse spatial map is successfully retrieved.
3. The system should be able to connect all the destination points to form routes.
4. The system should be able to continuously recalculate the distance between the user and the destination point.
5. The system should be able to retrieve destination information from the local storage of the device.

3.2 System Specifications

The system design of this mobile shopping mall directory with AR navigation function will be illustrated in detail in the below sections. The diagrams provided below are used to illustrate how the system interact with users.

3.2.1 Use Case Diagram

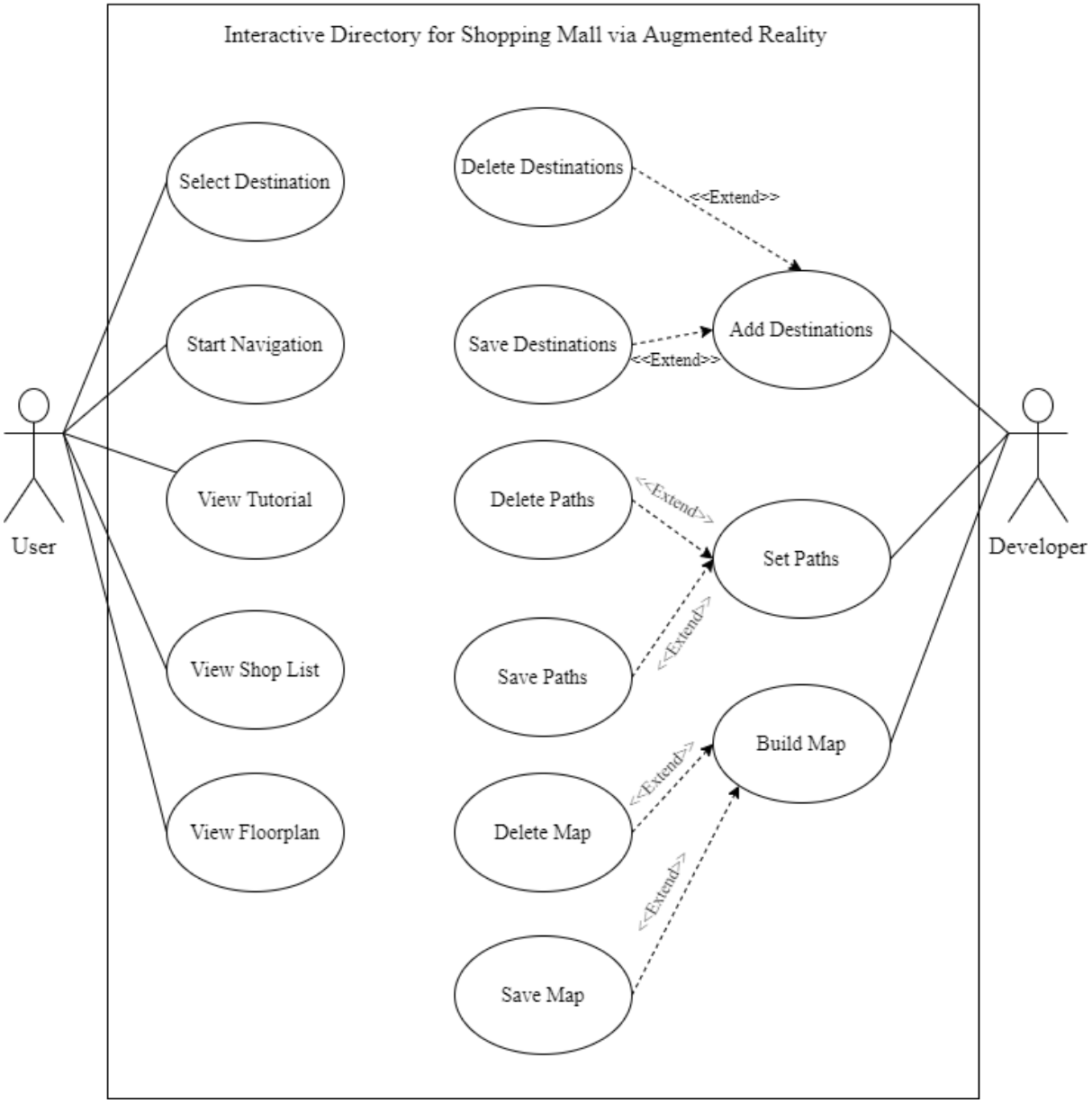


Figure 3.2.1.1: Use Case Diagram for Interactive Directory for Shopping Mall via Augmented Reality.

3.2.2 Activity Diagram

User Panel

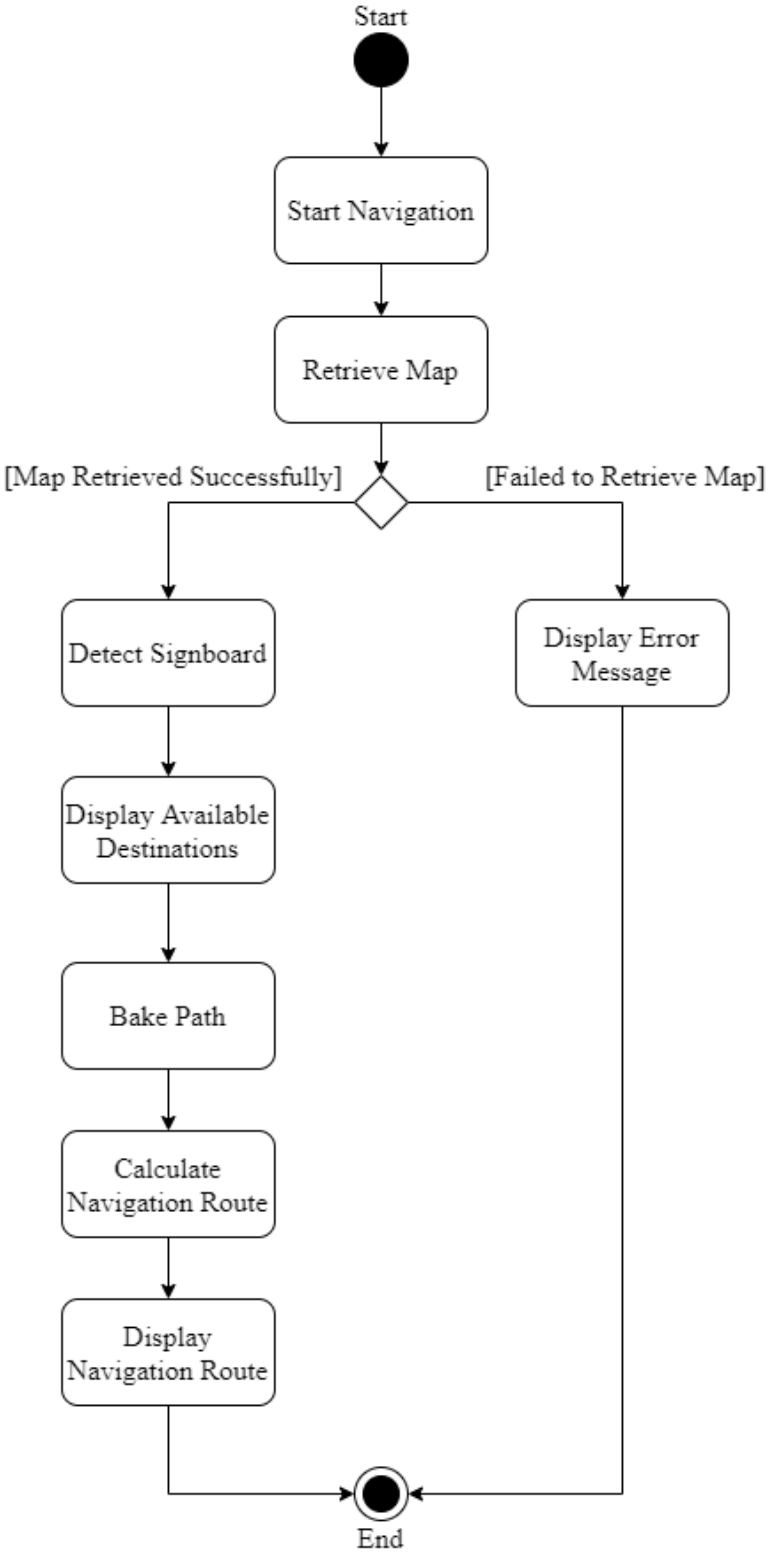


Figure 3.2.2.1: Activity Diagram for Start Navigation Function.

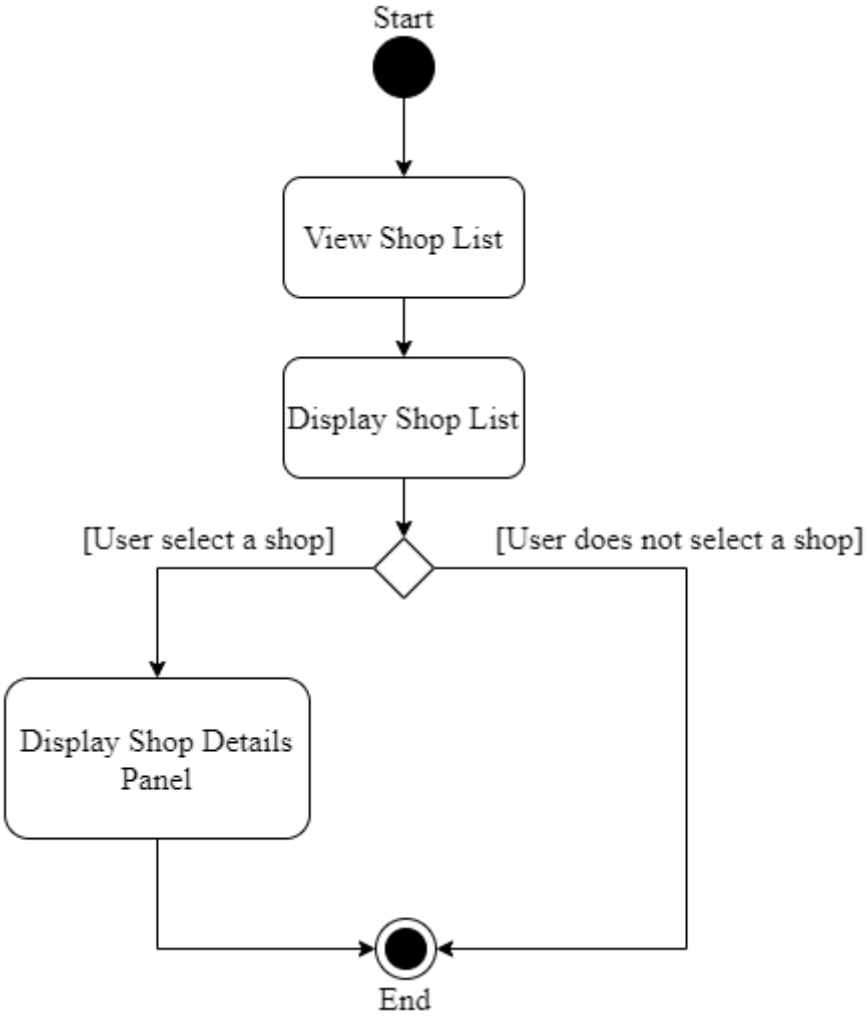


Figure 3.2.2.2: Activity Diagram for Shop List.

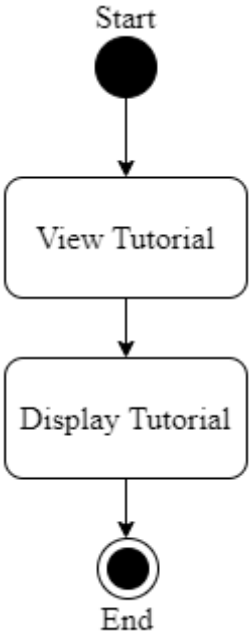


Figure 3.2.2.3: Activity Diagram for Tutorial.

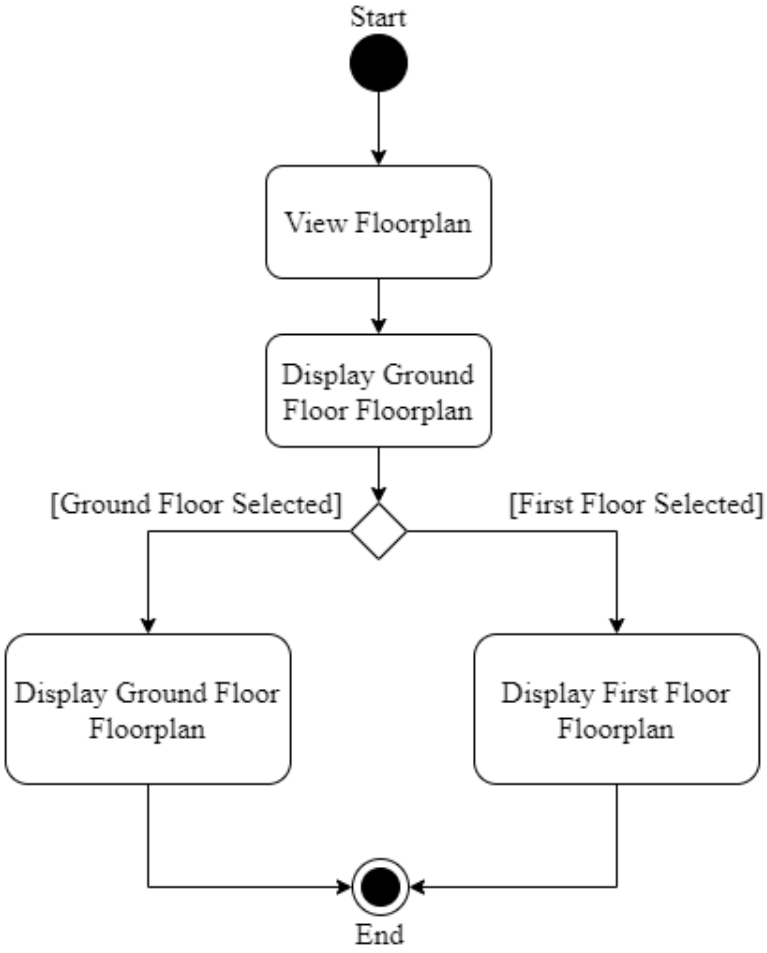


Figure 3.2.2.4: Activity Diagram for Floor Plan.

Developer Panel

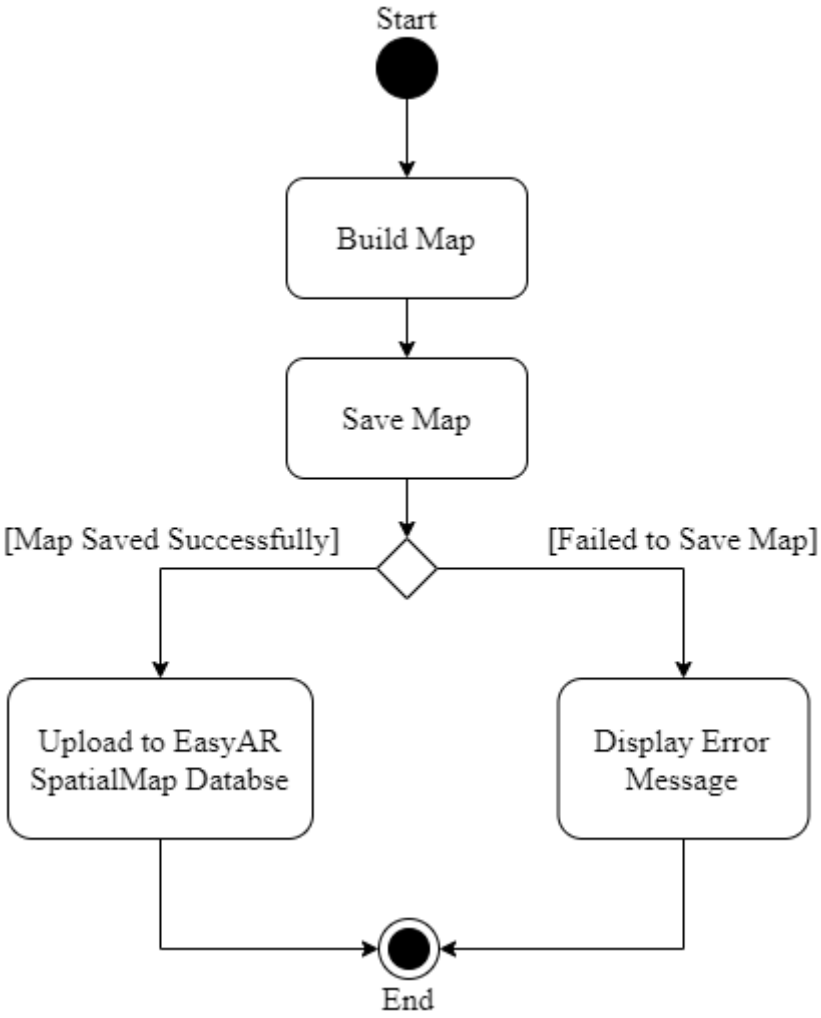


Figure 3.2.2.5: Activity Diagram for Build Map Function.

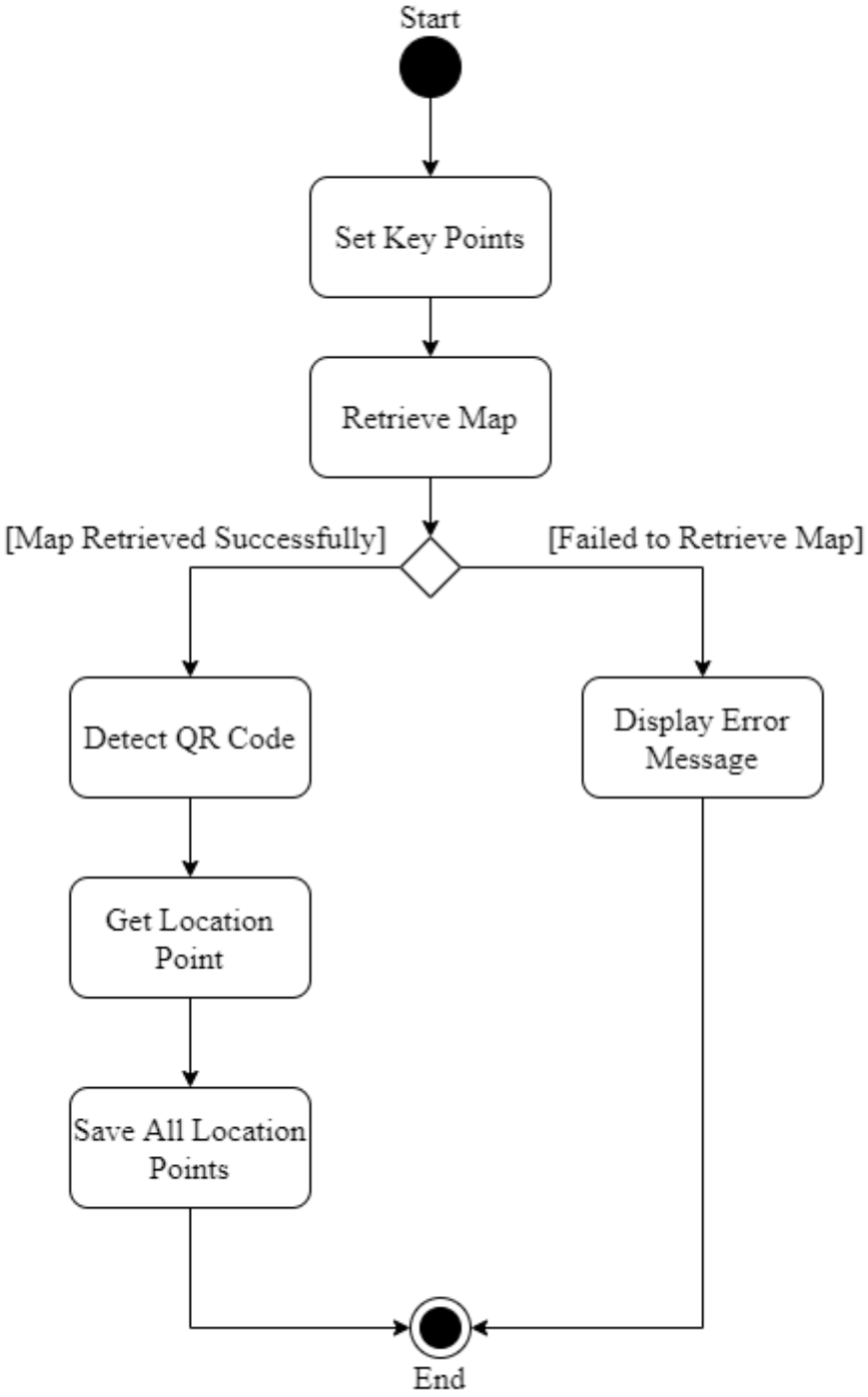


Figure 3.2.2.6: Activity Diagram for Set Key Points Function.

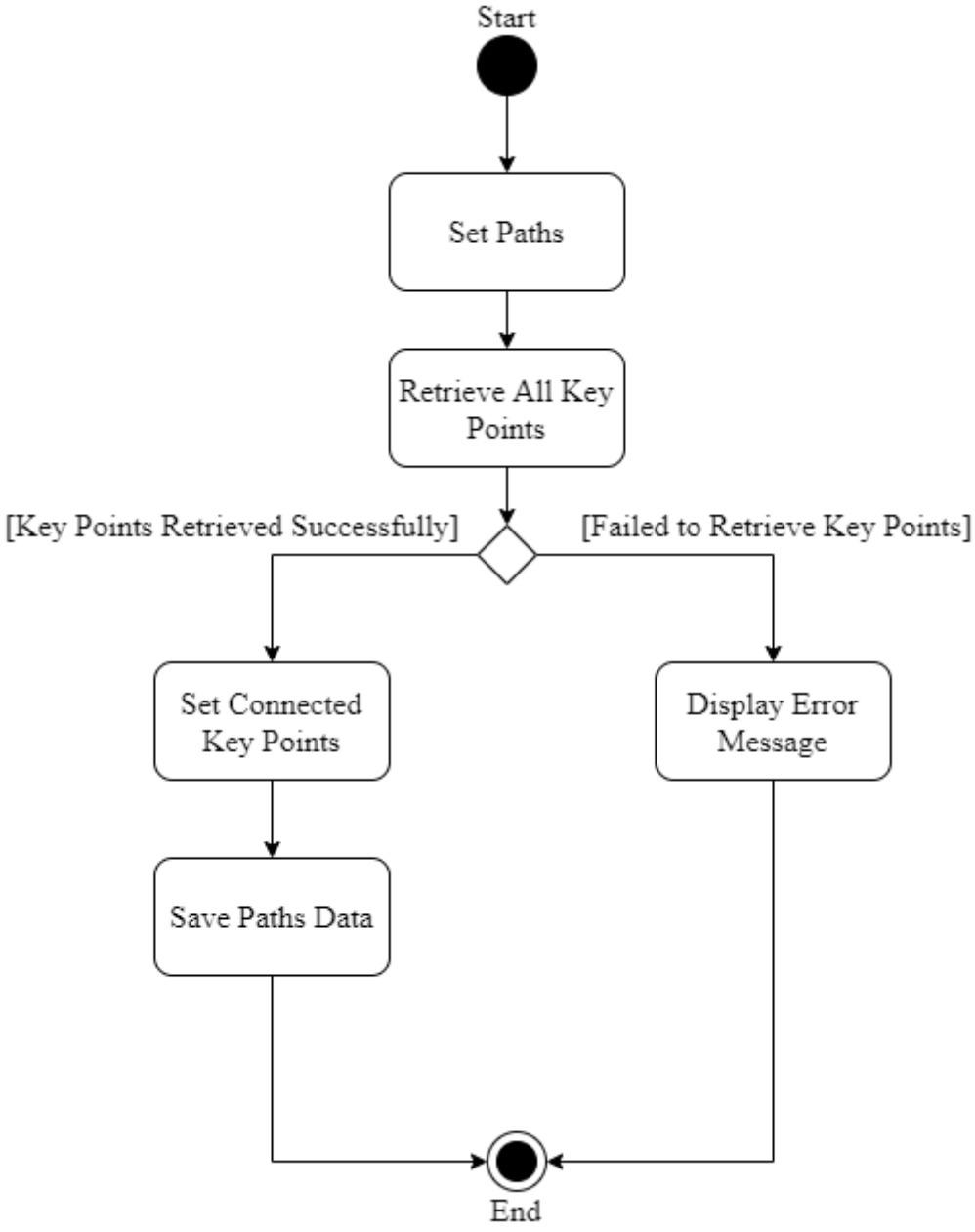


Figure 3.2.2.7: Activity Diagram for Set Paths Function.

3.2.3 Use Case Description

Use Case Name: Build Sparse Spatial Map	**ID:** 01	**Importance Level:** High
Primary Actor: Developer	**Use Case Type:** Details, Essential	
Stakeholders and Interests: Developer – Scan the selected shopping mall environment to build the sparse spatial map.		
Brief Description: This use case describes how the system handle the process of building the sparse spatial map of the shopping mall environment.		
Trigger: Developer wants to build a sparse spatial map for the shopping mall. **Type:** External		
Relationships: **Association:** Developer **Include: -** **Extend:** Save Map, Delete Map **Generalization: -**		
Normal Flow of Events: 1. The developer enter the *Build Map* scene. 2. The developer scan the environment using the camera of smart device. 3. The system will start to detect the visual features of the indoor environment. 4. The indoor environment is saved as a sparse spatial map in the EasyAR SpatialMap database.		
Sub Flows: Not applicable.		
Alternate/Exceptional Flows: -		

Use Case Name: Set Key Points	**ID:** 02	**Importance Level:** High
Primary Actor: Developer	**Use Case Type:** Details, Essential	
Stakeholders and Interests: Developer – Create location points for each shop in the mall.		
Brief Description: This use case describes how the system handle the process of setting a point of location in the shopping mall to act as the destination points for the navigation function.		
Trigger: Developer wants to set a point of location as a destination. **Type:** External		
Relationships: **Association:** Developer **Include: -** **Extend:** Save Destination, Delete Destination **Generalization: -**		
Normal Flow of Events: 1. The developer enter the *Key Points* scene. 2. The developer scan the surrounding environment to locate their current location. 3. The developer scan a QR code placed on the point that needs to be set as a destination point. 4. The system will get the location point information and save it in JSON format.		
Sub Flows: Not applicable.		
Alternate/Exceptional Flows: -		

Use Case Name: Set Paths	**ID:** 03	**Importance Level:** High
Primary Actor: Developer	**Use Case Type:** Details, Essential	
Stakeholders and Interests: Developer – Join the key points that are connected.		
Brief Description: This use case describes how the system handle the process of joining key point set beforehand to form a route from one destination to another.		
Trigger: Developer wants to indicate which key points set are connected. **Type:** External		
Relationships: **Association:** Developer **Include: -** **Extend:** Save Path, Delete Path **Generalization: -**		
Normal Flow of Events: 1. The developer enter the *Roads* scene. 2. The developer select the starting key point and arrival key point. 3. The system will save the information in JSON format.		
Sub Flows: Not applicable.		
Alternate/Exceptional Flows: -		

Use Case Name: Start Navigation	**ID:** 04	**Importance Level:** High
Primary Actor: User	**Use Case Type:** Details, Essential	
Stakeholders and Interests: User – Get navigation route to their destination.		
Brief Description: This use case describes how the system handle the process of displaying the navigation route in real-time.		
Trigger: User wants to get the navigation route to their destination. **Type:** External		
Relationships: **Association:** User **Include:** - **Extend:** - **Generalization:** -		
Normal Flow of Events: 1. The user enter the *Start Navigation* scene. 2. The user scan the surrounding environment to locate their current location. 3. The system will analyze the user current location. 4. The user will select their destination. 5. The system will calculate the path from the user current location to the destination. 6. The system will display the navigation route in real-time using AR.		
Sub Flows: Not applicable.		
Alternate/Exceptional Flows: -		

Use Case Name: View Shop List	**ID:** 05	**Importance Level:** High
Primary Actor: User	**Use Case Type:** Details, Essential	
Stakeholders and Interests: User – View shops available in the mall.		
Brief Description: This use case describes how the system handle the process of informing the users about the shop available in the mall and to display the shop details.		
Trigger: User wants to check the shops available in the mall. **Type:** External		
Relationships: **Association:** User **Include: -** **Extend: -** **Generalization: -**		
Normal Flow of Events: 1. The user enter the *Shop List* scene. 2. The system will list out all the shops available in the mall. 3. The user will select a shop from the list. 4. The system will display the details of the selected shop.		
Sub Flows: Not applicable.		
Alternate/Exceptional Flows: -		

3.2.4 Class Diagram

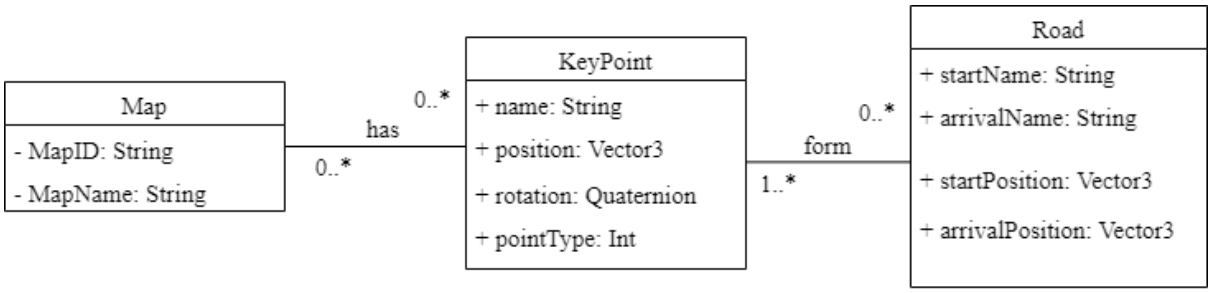


Figure 3.2.4.1: Class Diagram for Interactive Directory for Shopping Mall via Augmented Reality.

3.2.5 Sequence Diagram

User Panel

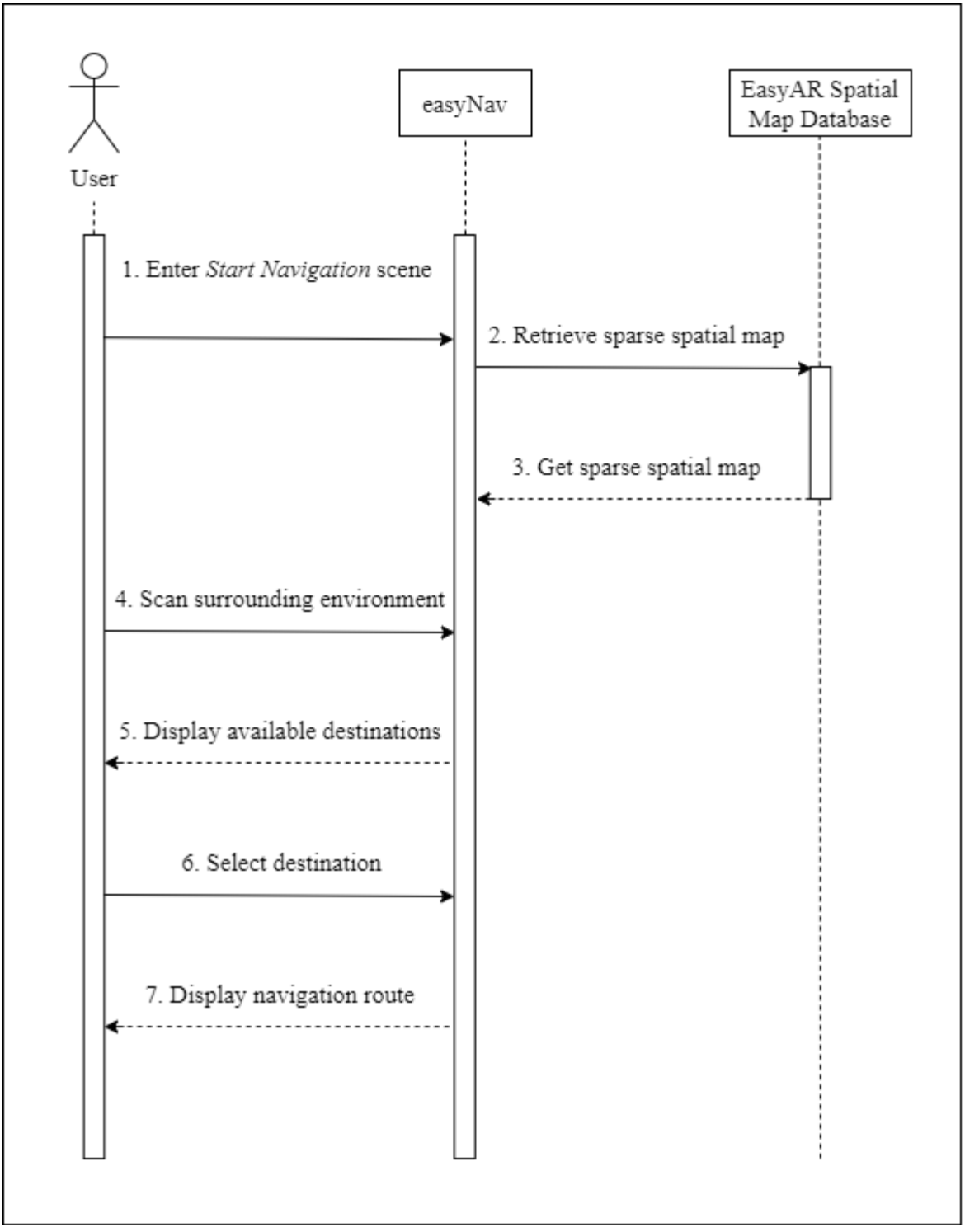


Figure 3.2.5.1: Sequence Diagram for Start Navigation Function.

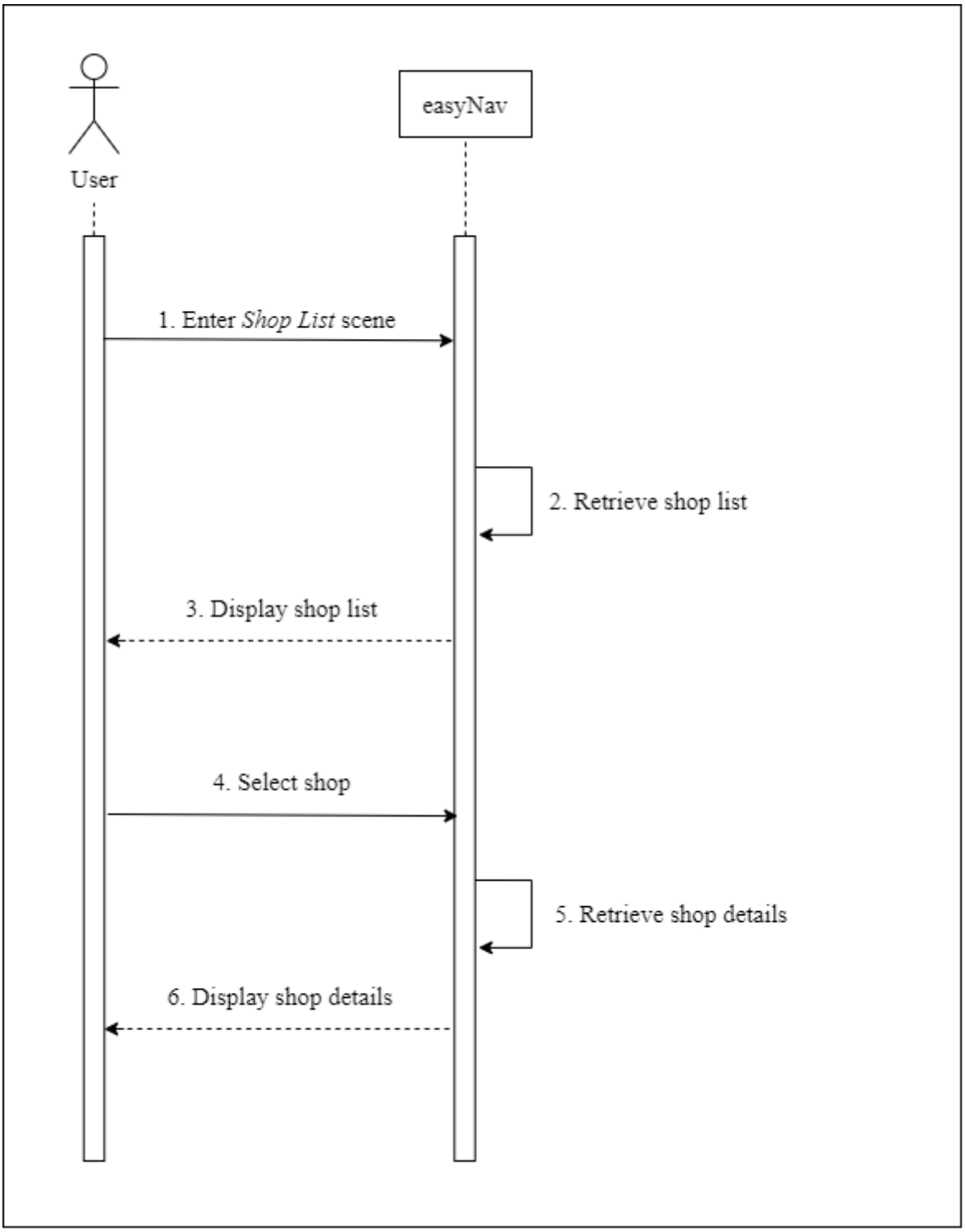


Figure 3.2.5.2: Sequence Diagram for Shop List.

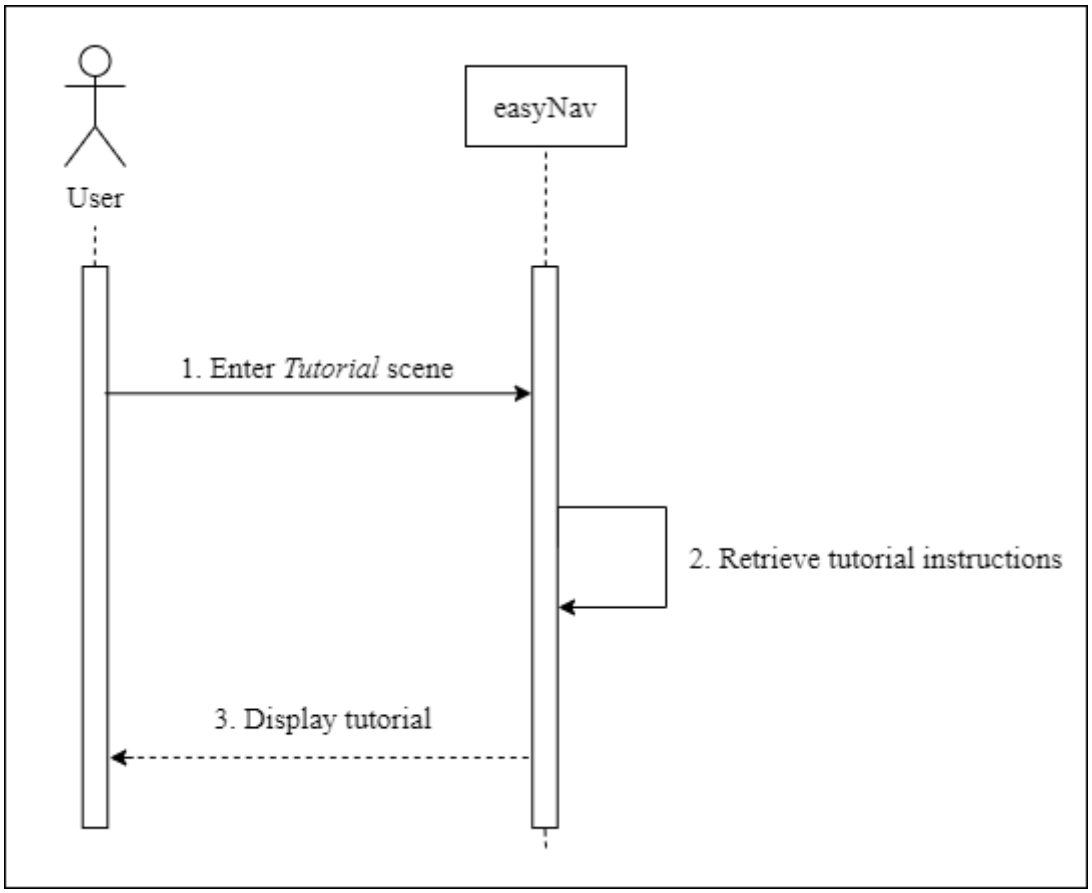


Figure 3.2.5.3: Sequence Diagram for Tutorial.

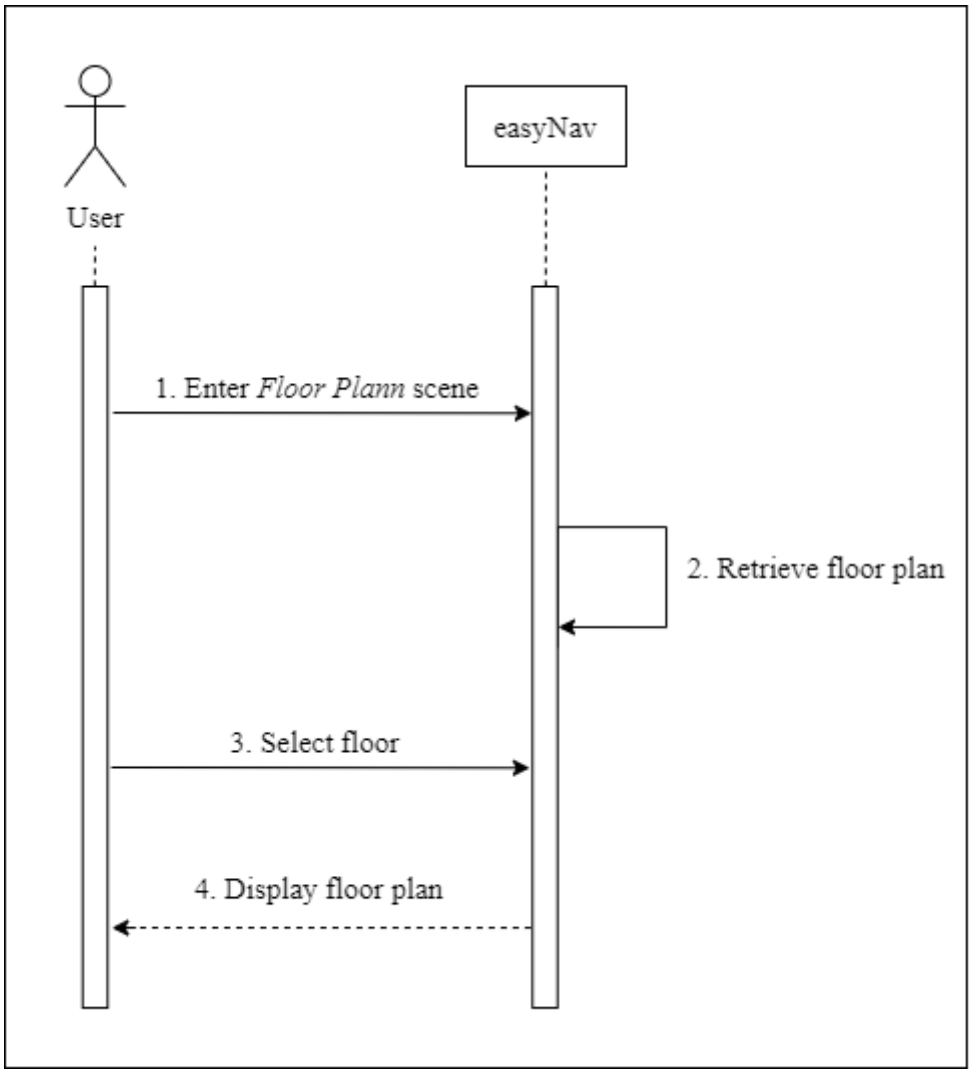


Figure 3.2.5.4: Sequence Diagram for Floor Plan.

Developer Panel

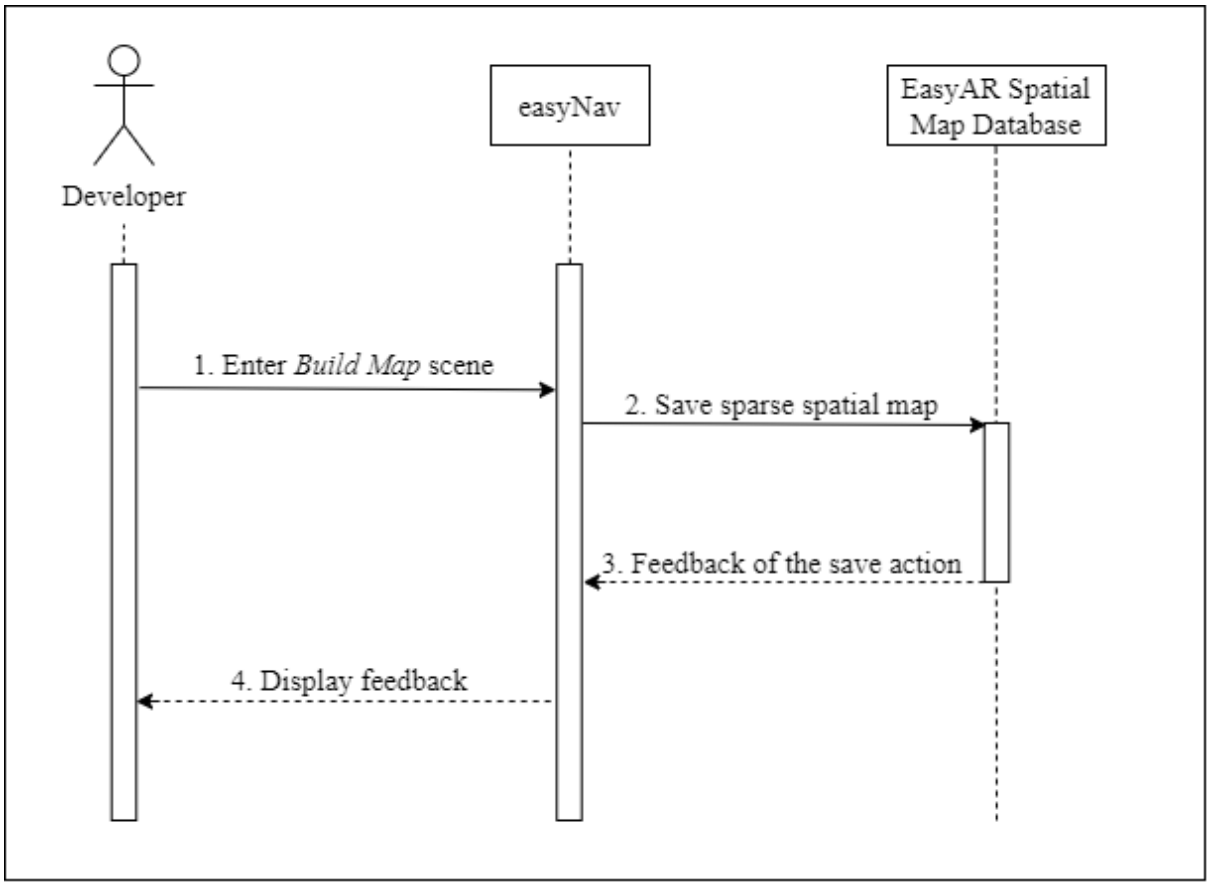


Figure 3.2.5.5: Sequence Diagram for Build Map Function.

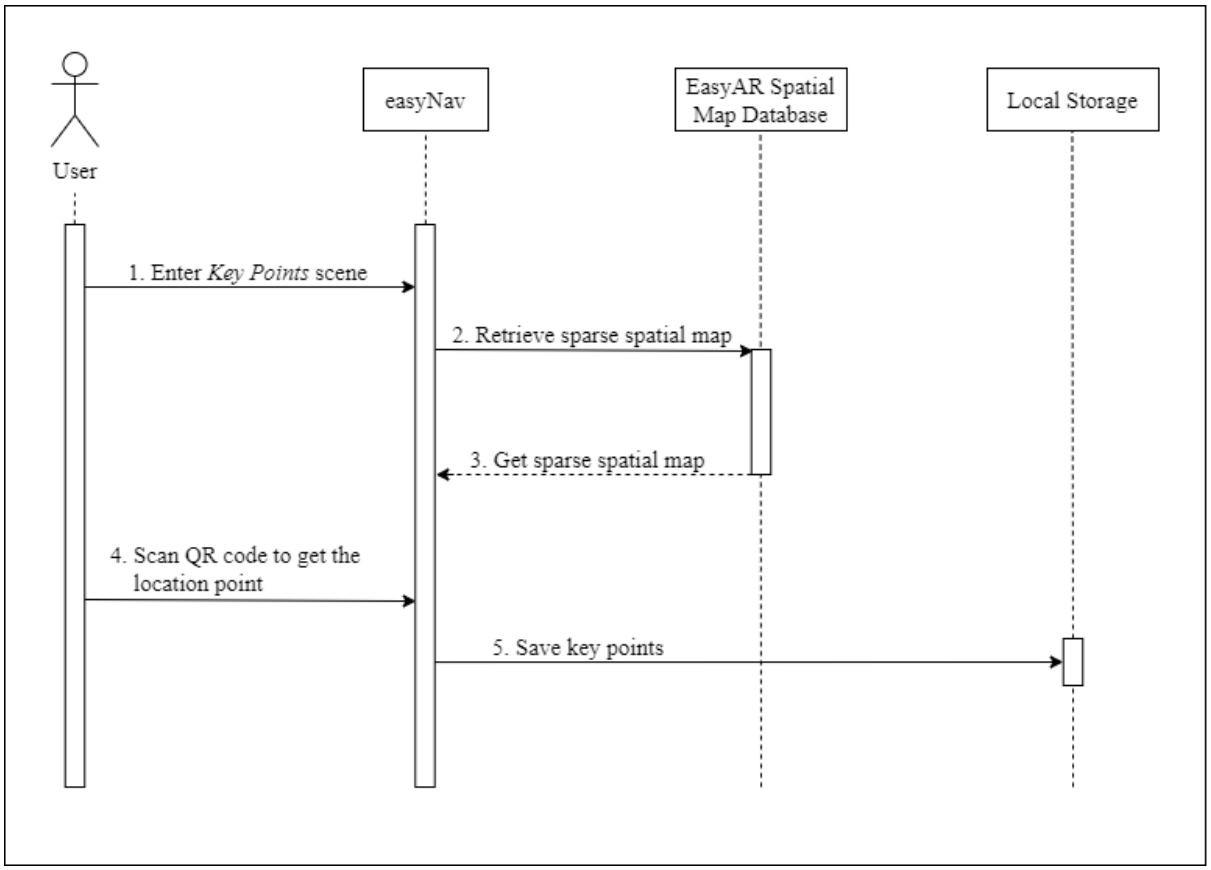


Figure 3.2.5.6: Sequence Diagram for Set Key Points Function.

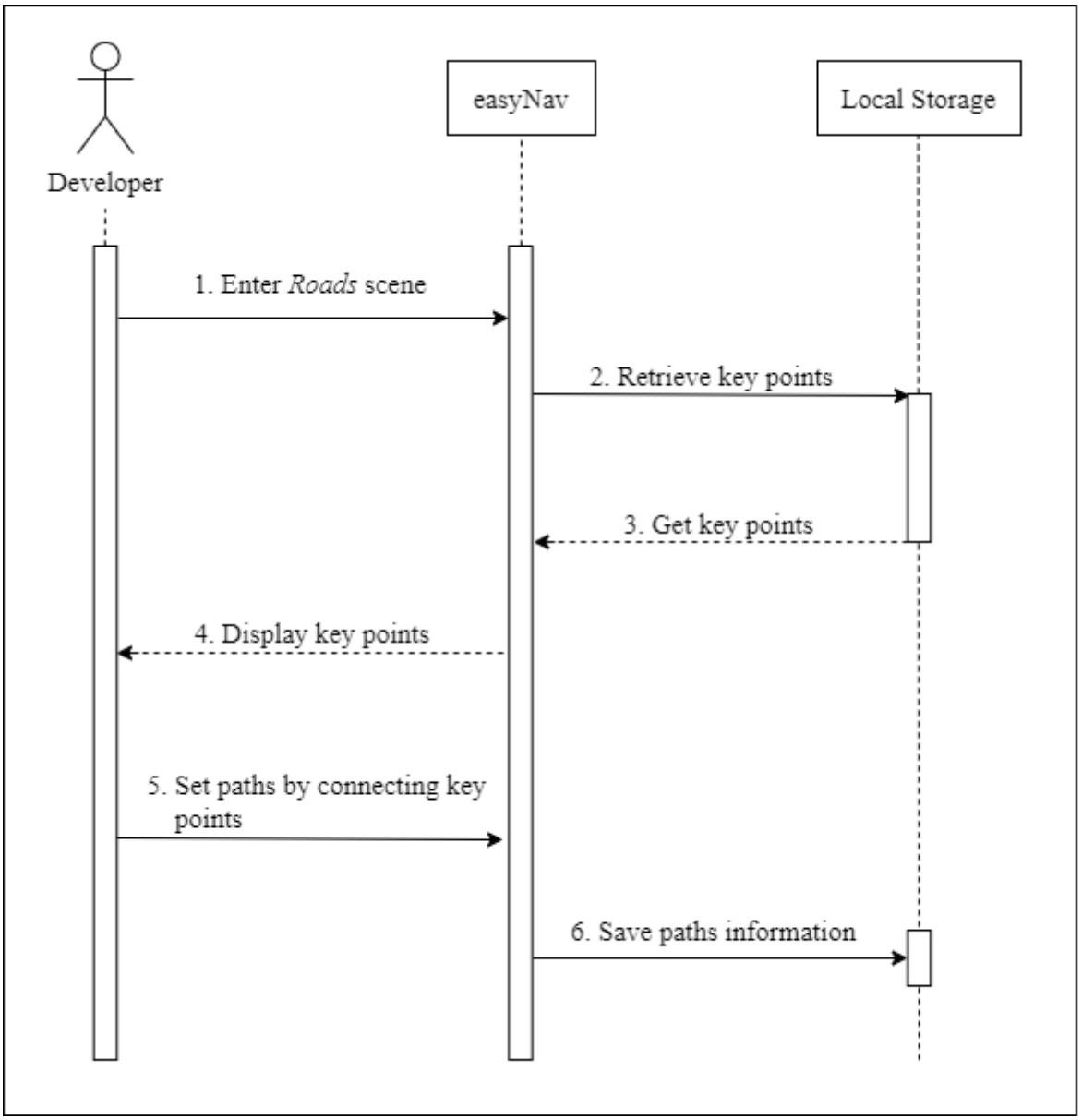


Figure 3.2.5.7: Sequence Diagram for Set Paths Function.

3.2.6 Object Diagram

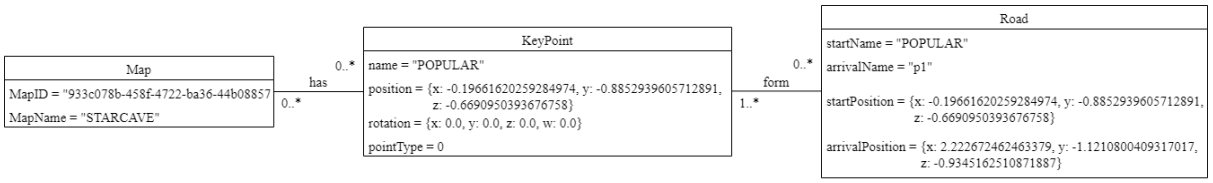


Figure 3.2.6.1: Object Diagram for Interactive Directory for Shopping Mall via Augmented Reality.

3.3 System Architecture Design

This system allow developer to build a sparse spatial map for the indoor shopping mall environment for the sake of 3D point map localization to function well. The sparse spatial map will then be uploaded to the EasyAR SpatialMap database. Then, the location point of each shop is added manually by setting the key points and save to the local storage, then, these saved key points are used to form paths that connect one key point to another to form a navigation route, these information are stored in local storage as well. After all these setups, the indoor location positioning function will be able to work perfectly by identifying the current position of the user using the visual features of real-world objects in the shopping mall.

3.4 System Flowchart

User Panel

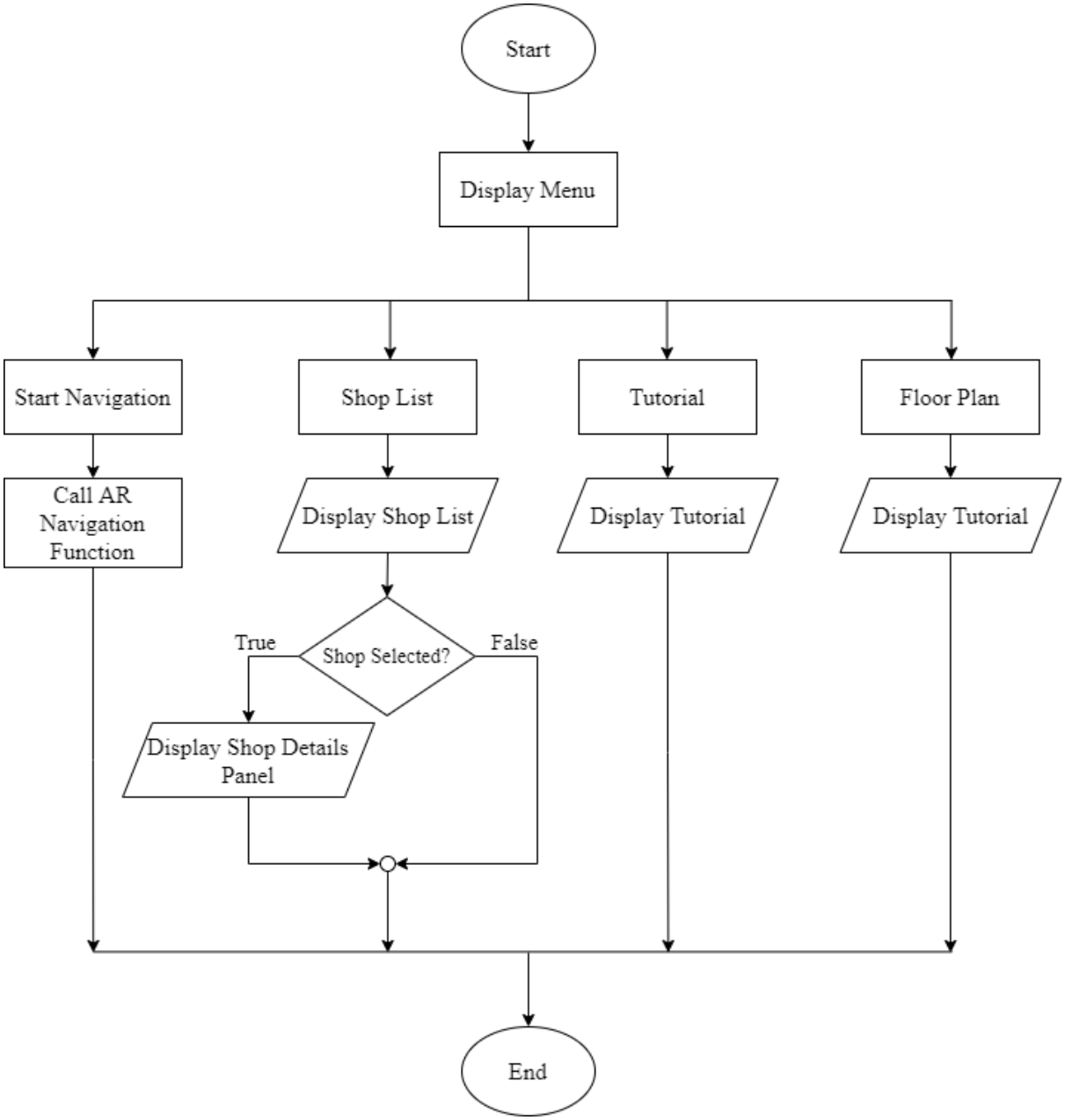


Figure 3.4.1: System Flowchart of User Panel for Interactive Directory for Shopping Mall via Augmented Reality.

Developer Panel

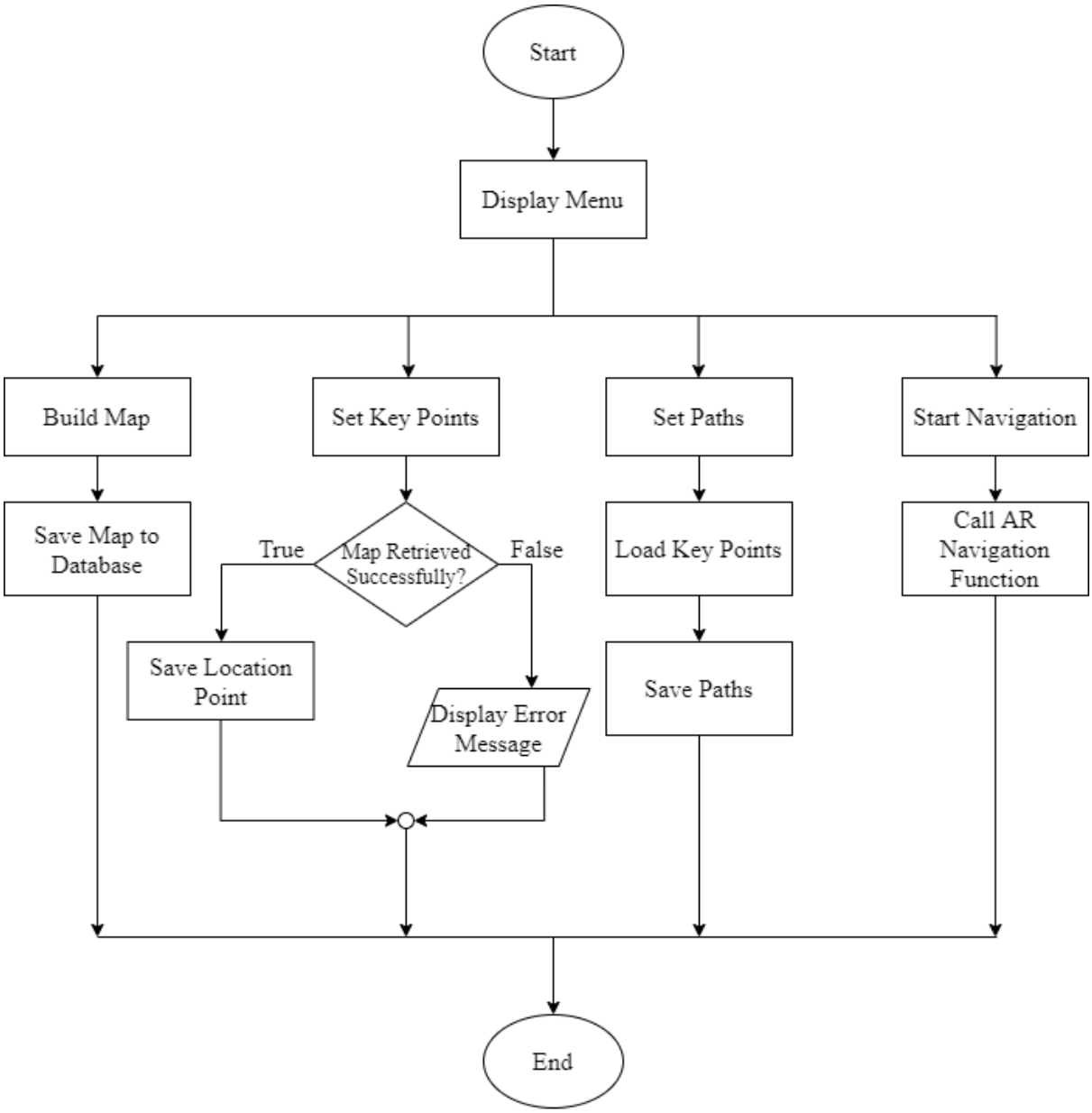


Figure 3.4.2: System Flowchart of Developer Panel for Interactive Directory for Shopping Mall via Augmented Reality.

AR Navigation Function

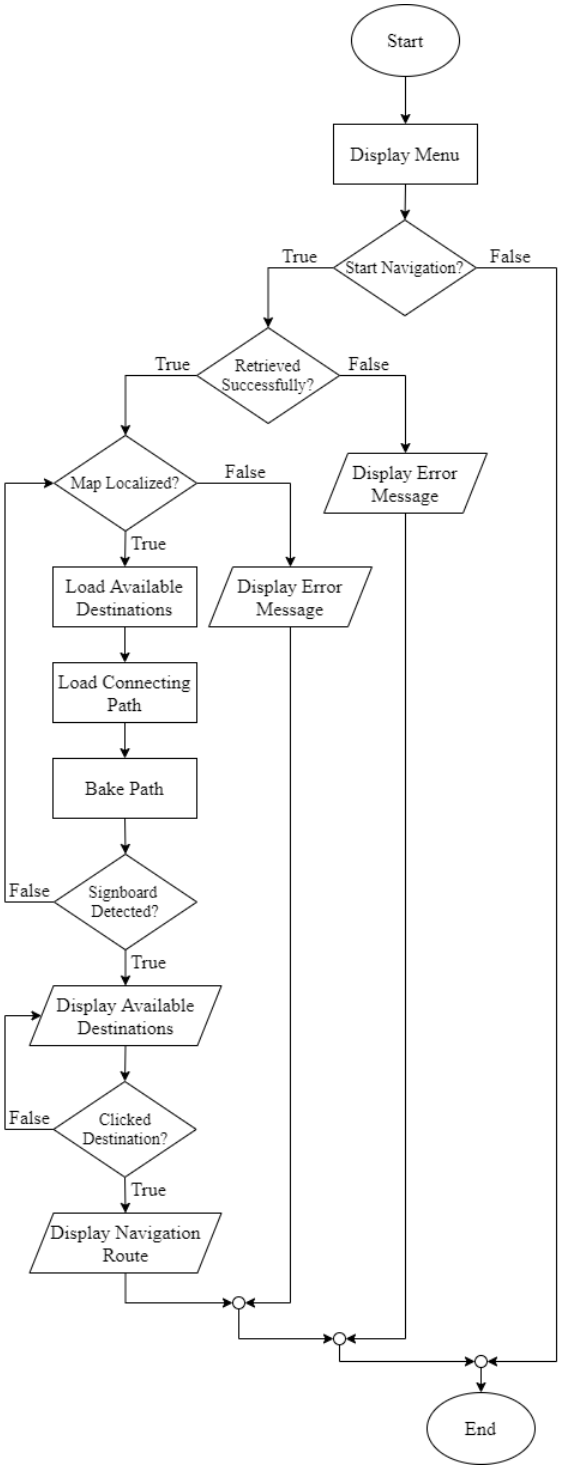


Figure 3.4.3: Flowchart for AR Navigation Function.

Based on the Figure 3.4.3, when the application is launched, it will direct the user to the Menu scene. In the Menu, if user chooses to start navigation, then the application will request the sparse spatial map of the shopping mall from the EasyAR sparse spatial map database. After successfully retrieved the sparse spatial map of the mall, the application will then require user to scan their surroundings, recommended the signboard of the nearest shop. After that, when the user is being localized, the available destinations will be displayed, and user need to select their destination from the list. At the same time, the application will load all the pre-set path from one target to another in background, the Figure 3.4.4 is an example of how the pre-set path looks like, the green dots are the destination points, and the grey lines are how these destinations are connected.

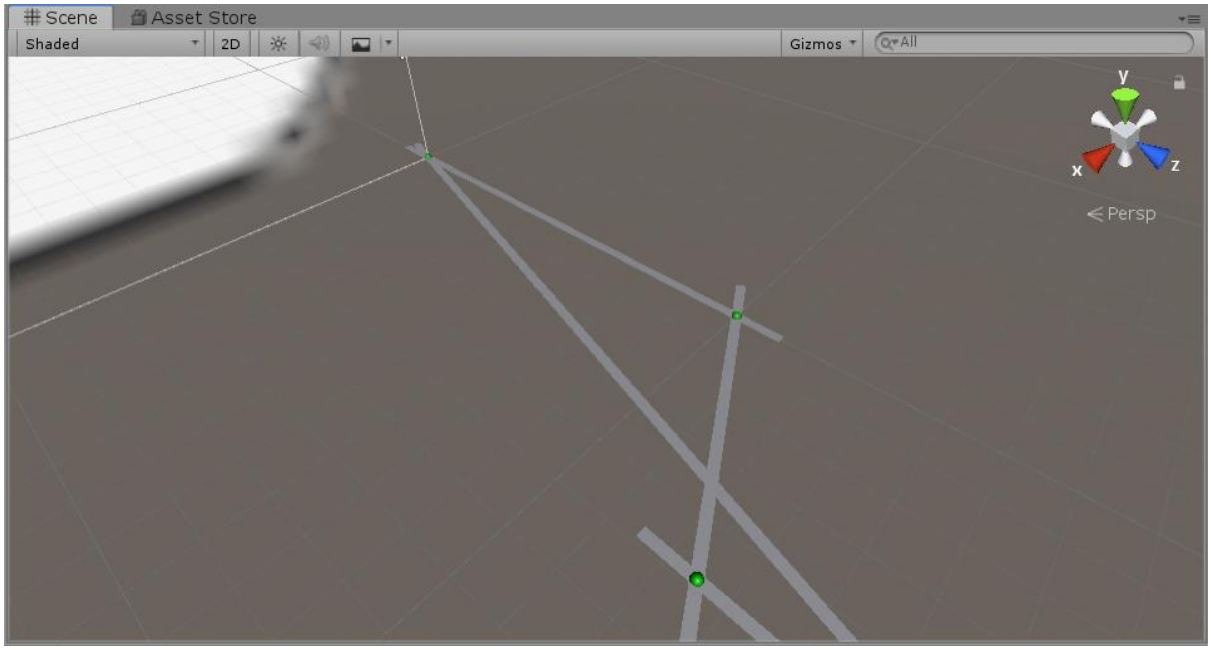


Figure 3.4.4: Example of pre-set path loaded into the application.

After that, the loaded pre-set path will be baked to ensure that the pre-set path will be the only walkable path in the environment, by doing this, the calculate path function being called later will calculate the path to the destination according to the walkable path only, hence, making the navigation route has the ability the turn left or right to avoid walls in the real-world. The Figure 3.4.5 show that the path being baked is in light blue, and the area covered with light blue will be the walkable path for the player and enable the player to avoid the walls automatically.

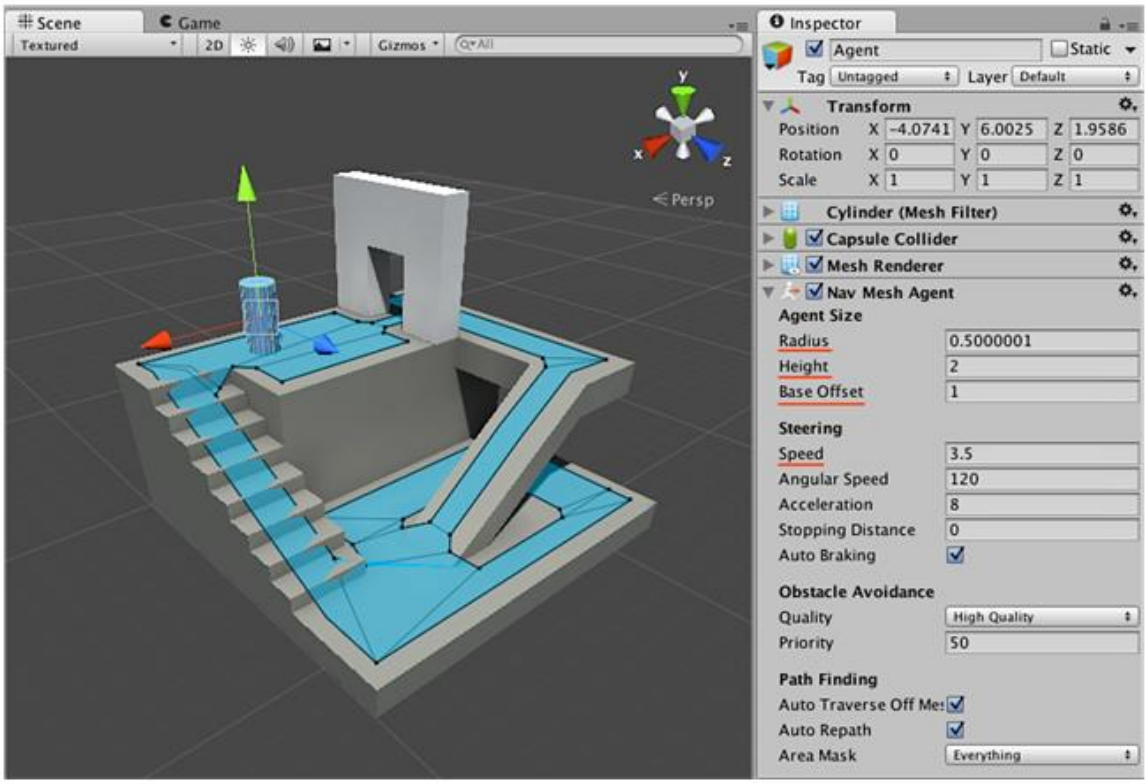


Figure 3.4.5: Example of baking function in Unity.

Then, the application will detect the environment and determine the position of user in the sparse spatial map, if the application is able to do so, then users can choose their destination from the list of destinations displayed. The navigation route will be calculated and display to the user in real-time if users has selected their destination.

3.5 Application User Interface Design

3.5.1 User Panel

Menu Page

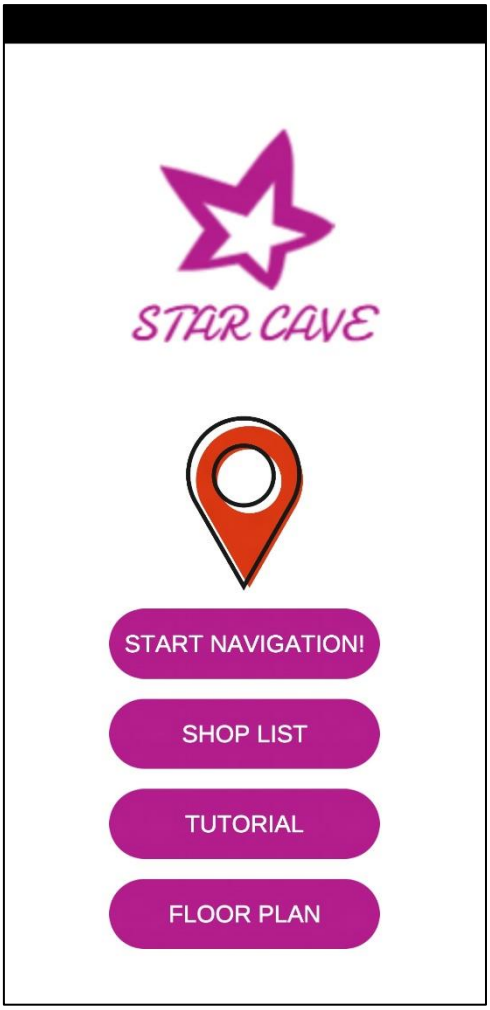


Figure 3.5.1.1: Screenshot of Menu Page for User Panel.

In the Menu Page for the User Panel illustrated in Figure 3.5.1.1, there are a few options for the user. “Start Navigation!” will direct user to the AR navigation function where user can select their destination and check the navigation route in real time. Then, “Shop List” will display all the available shops in the shopping mall with their respective details. After that, “Tutorial” will be instructions for the user that do not know how to use the AR navigation function provided in the application. Lastly, “Floor Plan” enable the user to check on the overall floor plan of the shopping mall.

Start Navigation Page

Figure 3.5.1.2: Screenshot of Start Navigation scene.

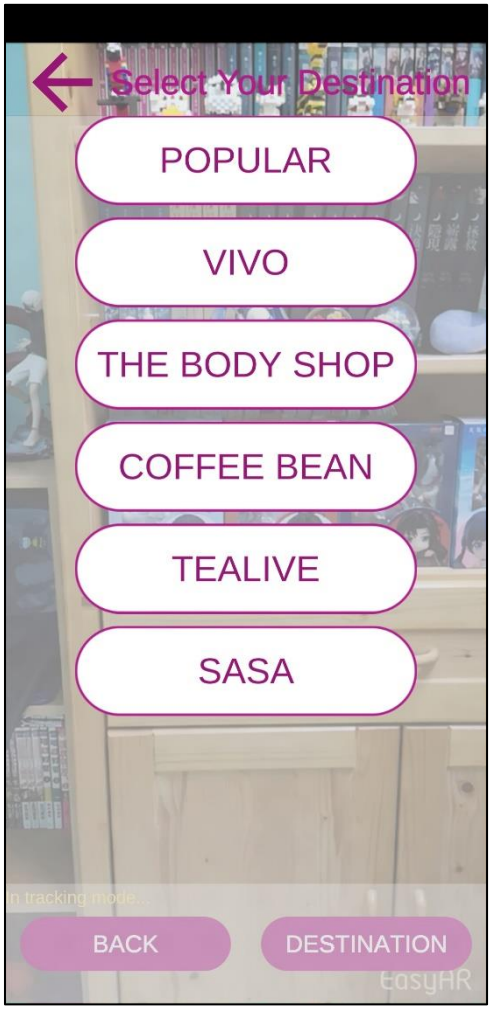


Figure 3.5.1.3: Available destinations.

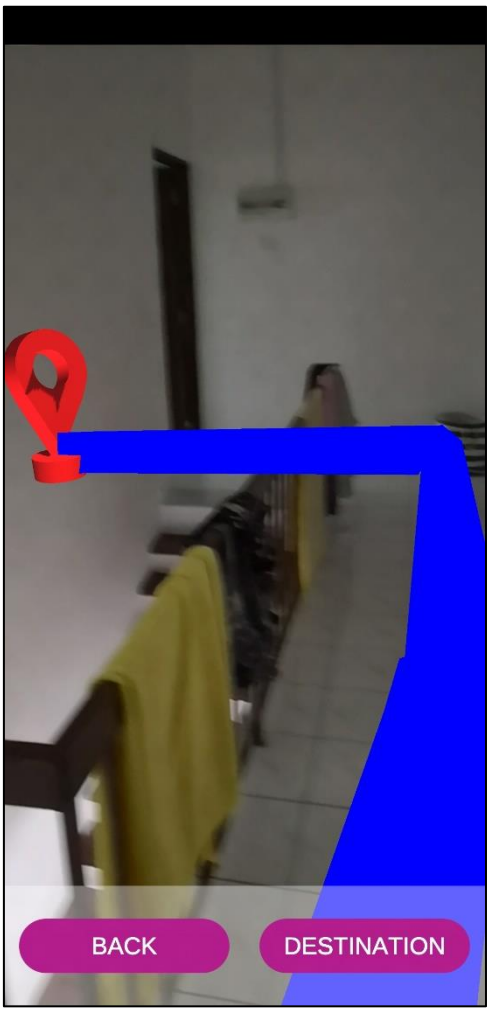


Figure 3.5.1.4: Navigation route display in real-time.

Start Navigation Page shown in Figure 3.5.1.2 is where the AR navigation route will be displayed. Firstly, when user came to this page, they are required to scan their surrounding using the camera of their smart device. Then, the system will detect the visual features of the real-world objects to identify the user current position. By the time the system determined the user current position, all the available destinations will be listed for the user to select as in Figure 3.5.1.3. Once the user selected a destination, the navigation route will be displayed in real-time via AR, the displayed route is shown in Figure 3.5.1.4.

Shop List Page

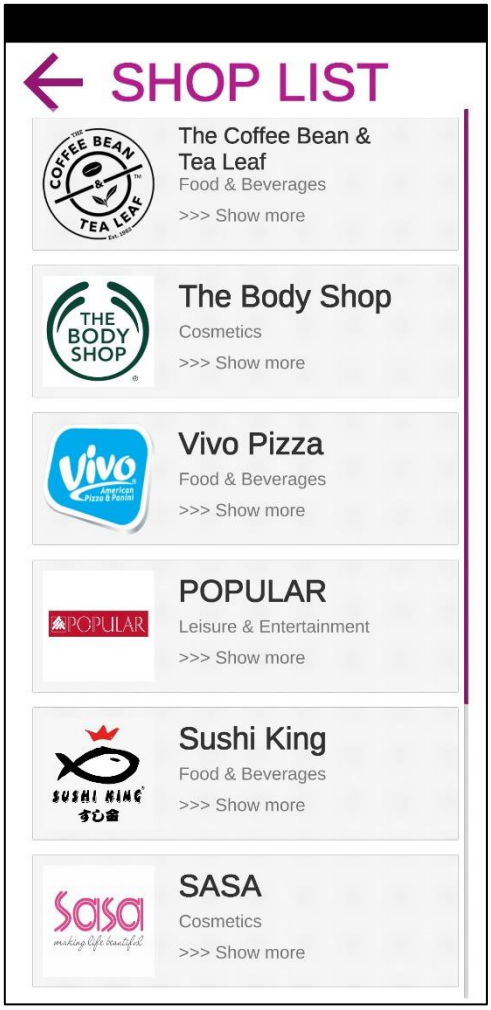


Figure 3.5.1.5: Screenshot of Shop List Page.

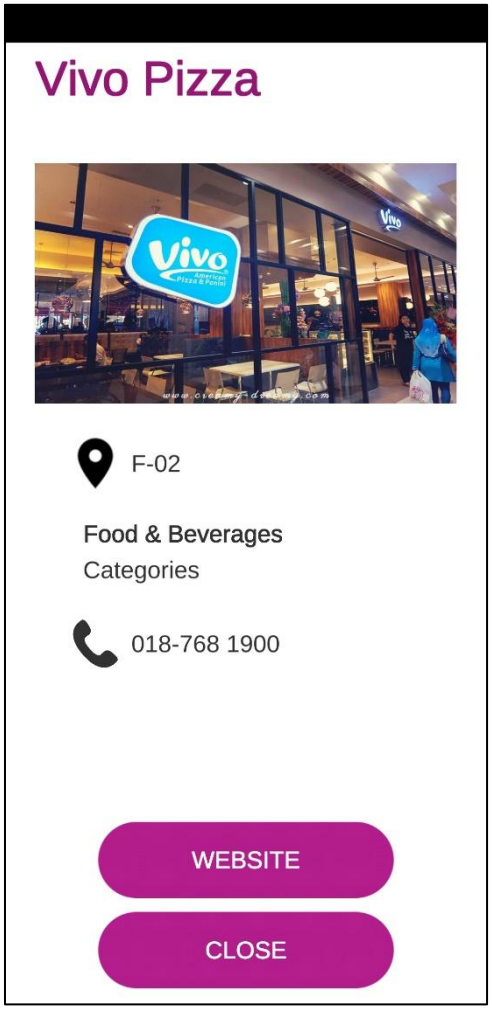


Figure 3.5.1.6: Shop details panel.

Figure 3.5.1.5 shows the Shop List Page that display all the available shops in the shopping mall. User can click on a shop to view the details of the shop, such as their phone number, shop lot number and a link to the shop's official website as in Figure 3.5.1.6.

Tutorial Page

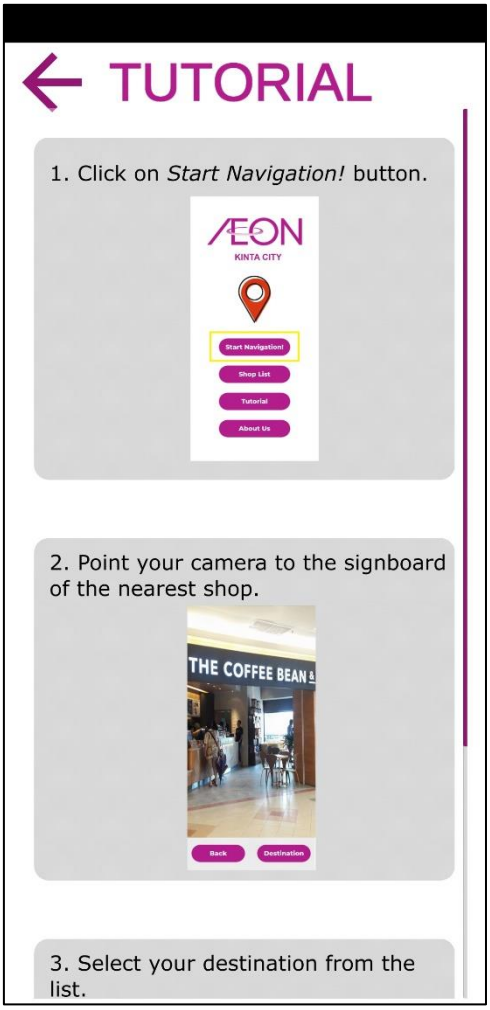


Figure 3.5.1.7: Screenshot of the Tutorial Page.

Figure 3.5.1.7 shows the Tutorial Page where user can find step to step instructions of how to utilize the AR navigation function provided by this application.

Floor Plan Page

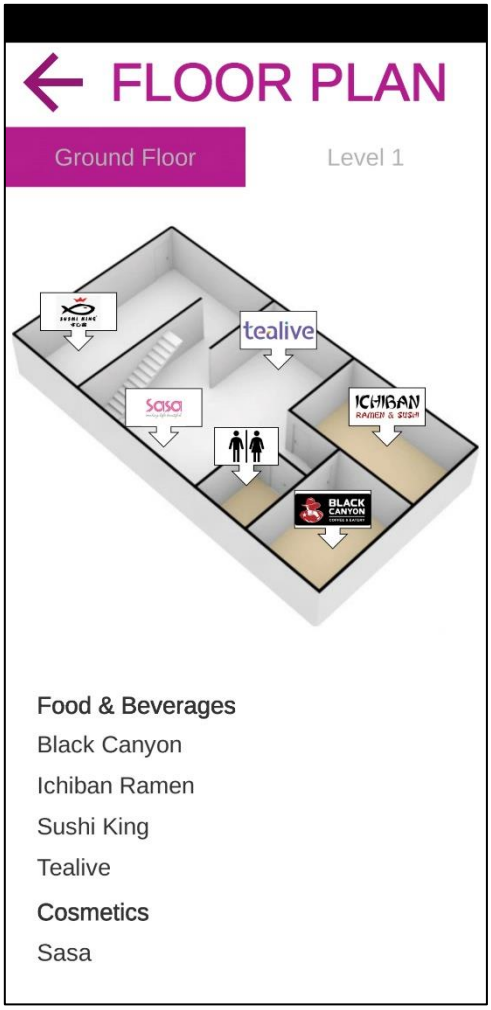


Figure 3.5.1.8: Floor Plan of Ground Floor.

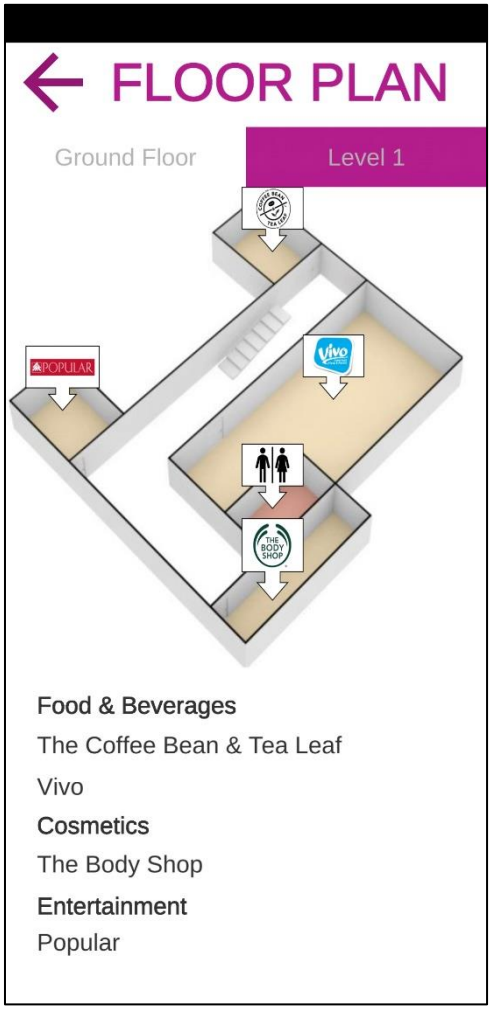


Figure 3.5.1.9: Floor Plan of First Floor.

When user selected the option “Floor Plan” in the Menu Page, they will first see the user interface provided in Figure 3.5.1.8, which contain the floor plan of the ground floor. Then, user has the option to switch to the floor plan of first floor by clicking the “Level 1” button, and the user interface will change to the interface shown in Figure 3.5.1.9.

3.5.2 Developer Panel

Menu Page

Figure 3.5.2.1: Screenshot of Menu Page for Developer Panel.

Figure 3.5.2.1 illustrate the Menu Page of the Developer Panel of this project. There are six options in this Menu Page. The components on the first row are to build a sparse spatial map for the shopping mall. The developer will need to enter a name for the map in the input field, then only they can proceed with the “Build Map” option. After that, “Key Points” will lead developer to a scene where they can set a destination point for the navigation function. Other than that, “Roads” is where developer can connect all the key points that are interconnected to form routes from one destination to another. Then, “Start Navigate!” is the same with the Start Navigation Page in the user panel, it is to ease the testing done by the developer. Finally, “Exit” option will exit the developer panel.

Build Map Page

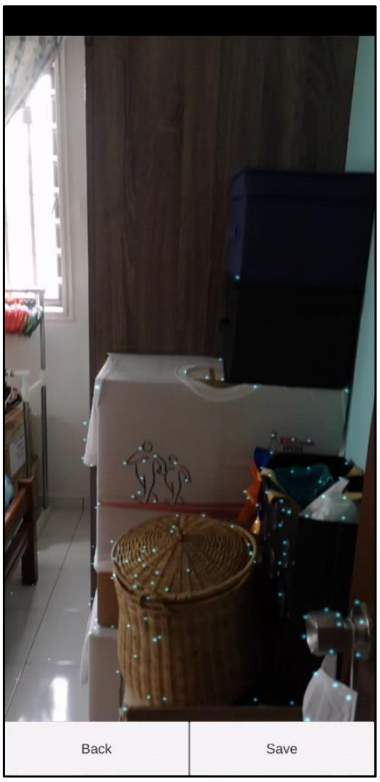


Figure 3.5.2.2: Screenshot of the Build Map Scene.

Before the application can locate the user position, the sparse spatial map of the environment must be created and uploaded to the EasyAR SpatialMap database. Developer must click on the *Build Map* button provided in the Menu Page and start the scanning of the mall environment patiently and detailly. Reference to Figure 3.5.2.2, when scanning the environment, observable blue dots will appear, and it will be better if there are more blue dots on the environment as this indicate that the object scanned have more visual features that can be detected easily. Tap on the *Save* button and the map will be uploaded to the database.

Key Points Page

The next step is to pin the points of each destination in the sparse spatial map. First, tap on the *Key Points* button and wait for the message "In Tracking Mode…" to show up. This tracking mode means that the sparse spatial map of the environment has been retrieved from the database and the developer's location has been located and sync to the map. At this moment, prepare an image that has been set as the image target to spawn a yellow cube and place it in front of the camera.

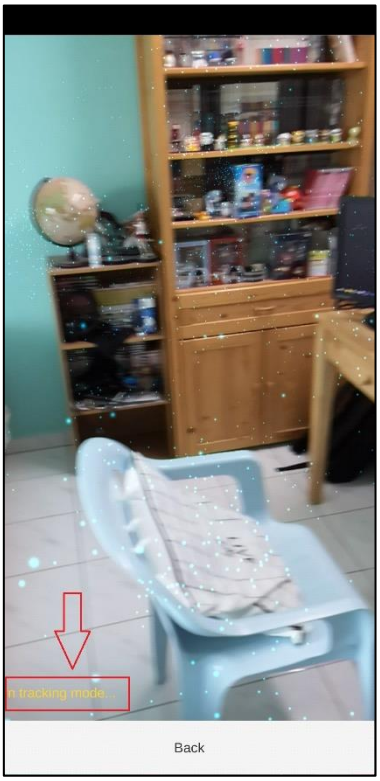


Figure 3.5.2.3: When the retrieved map is localized. **Figure 3.5.2.4:** Scan an image target.

After the yellow cube is spawned, tap on the yellow cube to obtain the current position and the Key Points UI will be displayed as in Figure 3.5.2.5. This UI shows all the existing destination points and path points that is used to connect two destinations together. The key points will then be saved and available for the navigation purpose.

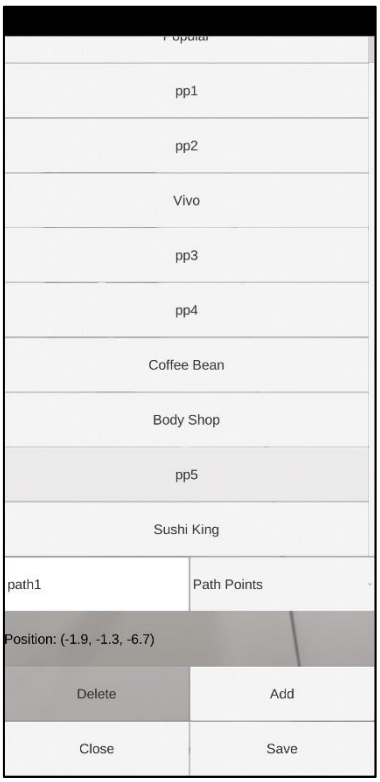


Figure 3.5.2.5: List of key points.

Roads Page

Now, the key points are separate game objects, to illustrate a navigation route, the destination points must connect to form a line. To achieve this, tap on the *Roads* button in the Menu page, and the UI in Figure 3.5.2.6 will be displayed, then, connect all the destination points and the path points that are interconnected to build up all the route from one destination to another.

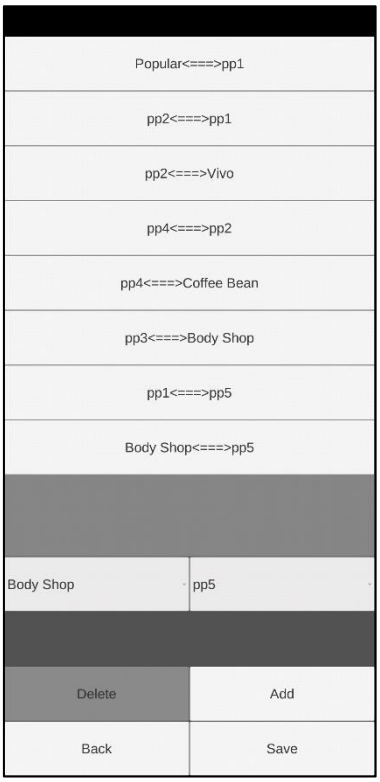


Figure 3.5.2.6: Connect the key points.

Start Navigation Page

The Start Navigation Page of the developer panel is the same with the Start Navigation Page in the user panel that has been discussed in the earlier section, and the event flow of this page are similar with the user panel one as well.

3.6 Timeline

The Gantt Charts below shows the timeline of this project for the previous semester as well as the current semester. This project is expected to complete in around 21 weeks, and it is separated into two parts, Project I and Project II. A prototype consisting of the basic functionalities will be developed during Project I and the final system should be presented during Project II.

Task Name	Duration	Start Date	End Date	Week						
				1	2	3	4	5	6	7
Final Year Project 1	**47 Days**	**26/10/2020**	**11/12/2020**							
Report for FYP 1	**40 Days**	**26/10/2020**	**04/12/2020**							
1 Planning	**8 Days**									
1.1 Identify the problem statements	1 Day	26/10/2020	26/10/2020							
1.2 Define the project objectives	1 Day	26/10/2020	26/10/2020							
1.3 Define the project motivation	1 Day	27/10/2020	27/10/2020							
1.4 Review on previous work done	3 Days	28/10/2020	30/10/2020							
1.5 Identify the project scope	2 Days	31/10/2020	01/11/2020							
1.6 Schedule the timeline	1 Day	02/11/2020	02/11/2020							
2 Analysis	**6 Days**									
2.1 Review on similar applications	4 Days	03/11/2020	06/11/2020							
2.2 Propose solution	2 Days	07/11/2020	08/11/2020							
3 Design	**6 Days**									
3.1 Research on suitable methodology	2 Days	09/11/2020	10/11/2020							
3.2 Confirm on the system methodology	1 Day	11/11/2020	11/11/2020							
3.3 System Design	3 Days	12/11/2020	14/11/2020							
4 Implementation	**19 Days**									
4.1 System Prototyping	14 Days	15/11/2020	28/11/2020							
4.2 Prototype testing	5 Days	29/11/2020	04/12/2020							
Presentation	**1 Day**	**08/12/2020**	**08/12/2020**							
Submission for FYP 1 Report	**1 Day**	**04/12/2020**	**04/12/2020**							

Figure 3.6.1: Gantt Chart for the previous semester.

Task Name	Duration	Start Date	End Date	Week													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
Final Year Project 2	**96 Days**	**18/01/2021**	**23/04/2021**														
Report for FYP 2	**89 Days**	**18/01/2021**	**16/04/2021**														
1 Analysis	**5 Days**																
1.1 Requirements analysis	5 Days	18/01/2021	22/01/2021														
2 Implementation	**84 Days**																
2.1 System Development	54 Days	23/01/2021	19/03/2021														
2.2 System Testing	15 Days	20/03/2021	09/04/2021														
2.3 System Refinement	10 Days	10/04/2021	19/04/2021														
2.4 System Evaluation	5 Days	19/04/2021	23/04/2021														
Submission for FYP 2 Report	**1 Day**	**16/04/2021**	**16/04/2021**														
Presentation	**1 Day**	**19/04/2021**	**23/04/2021**														

Figure 3.6.2: Gantt Chart for the current semester.

CHAPTER 4: METHODOLOGY AND TOOLS

4.1 Design Specifications

This project will be build based on the Rapid Application Development (RAD) with prototyping, Figure 4.1.1 illustrates the basic flow of the RAD prototyping model. The reason why RAD is chosen for this project is because its flexibility in confining the requirements repeatedly until the system function as what the users require and according to Beynon-Davies et al. (1999), RAD methodology is suitable for projects that are relatively small and expected to complete in a short period. The normal project duration for implementing RAD is around 2 to 6 months, which totally suits this project well. Also, any fatal system errors can be identified earlier in the prototyping phase and proper fixes can be apply to the next prototype design before the final system is presented to the users. The details of each phase in the RAD with prototyping will be discussed in the next subsections.

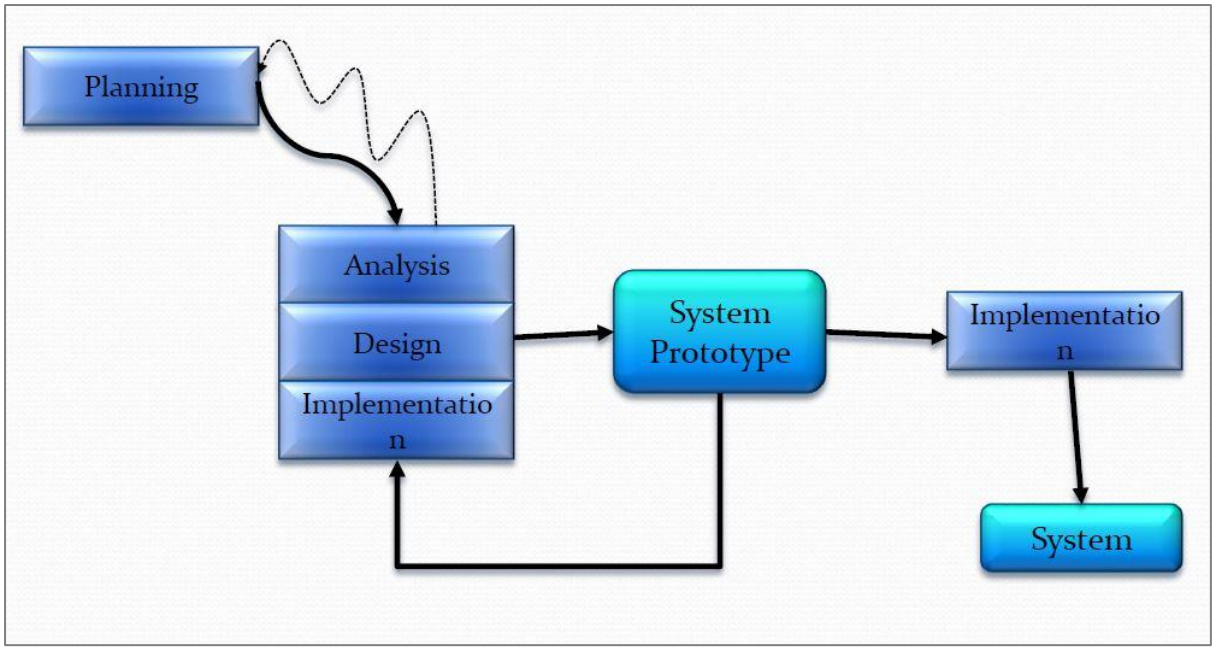


Figure 4.1.1: Model of a prototyping-based RAD methodology.

Planning

In the planning phase, the inconveniences of the traditional mall directories and the expected improvements are identified. Then, these requirements have made up the project scope, which is developing a mall directory mobile application to guide the users to their

destination with suggested route display in real-time using AR, the application should be able to locate the current position of the user after the object in the environment is detected. Also, the existing and potential challenges in developing this project will be discussed as well in this phase. Then, the recommended object to be detected in this application will be the signboard of a shop to ensure that the map localization works properly.

Prototype Cycle

There are 3 phases in SDLC included in the prototype cycle, which is the analysis, design, and implementation phase. These 3 phases will be carried out concurrently and form a system prototype. Firstly, some mobile applications related to mall directory and indoor navigation are reviewed to identify their pros and cons. After that, this system prototype is designed by implementing some of the improvements and extra requirements that can be done to improve the reviewed applications, which is adding AR navigation route and eliminate the use of specifically generated AR marker or QR Code for location positioning. Then, the first version of system prototype will be developed and present to the users to gain their feedbacks, the errors occurred, and additional requirements should be fixed and added to the second system prototype. This prototype cycle will be performed iteratively until the system is complete and ideal according to the user requirements.

Testing/Implementation

Finally, this phase will be conducted when the prototype cycle has delivered the ideal system that fulfill the user requirements. In the final system that will be publish to the public, this application should be able to retrieve the sparse spatial map from the database, enable users to select their destination location, enable user to locate their current position using object such as the signboard in the shopping mall environment and display navigation route in real-time. Detailed documentation is needed to ease the future maintenance and improvements.

4.2 Tools to Use

Table 4.2.1: Software involved in the development of this project.

Software	Specification
Platform	Android 8.0 Oreo (API 26) or higher
Integrated Development Environment	Visual Studio 2019
Programming Language	C# (C Sharp)
Game Engine	Unity 2018.4.29f1
Augmented Reality API	EasyAR Sense 4.0

Table 4.2.2: Hardware involved in the development of this project.

Hardware	Specification
Laptop	• HP Pavilion Gaming • AMD Ryzen 5 3550H with Radeon Vega Mobile Gfx 2.10 GHz • 16.0 GB RAM • 64-bit Operating System • x64-based Processor
Android Devices	• Huawei P20, Android 9.0 Pie • Huawei P30 Pro, Android 10.0 Android 10

4.3 System Requirements

To make sure that this application works well, there are a few basic requirements that need to be fulfilled, the requirements are listed below:

1. The Android version of the device used to run this project must be equal or higher than Android 8.0 Oreo (API 26).
2. The device must be connected to internet, either mobile data or Wi-Fi to retrieve the sparse spatial map from the EasyAR SpatialMap database.

The Android version required in this project is Android 8.0 Oreo (API 26) or higher, any Android version that is lower than the required version, the installation of the Android Package (APK) file may fail. Then, to ensure that the sparse spatial map of the indoor environment can be retrieved successfully from the EasyAR SpatialMap database, internet connection is necessary when using the AR navigation function provided in the application.

CHAPTER 5: IMPLEMENTATION AND TESTING

5.1 Implementation

The following section serve as the documentation of some important software installation steps and configurations. This documentation will decrease the workload of maintaining this project and decrease the initial setup time for the development of similar projects in the future.

5.1.1 Unity Setup and Installation

Unity is the main framework used to develop this project. It is a game engine which helps in developing the AR navigation function and the UI of the application. Unity can be downloaded from Unity Official Website, provided link https://unity3d.com/get-unity/download . The debugging of this project requires an Android smart device because camera is a necessary component for the AR navigation function to work well.

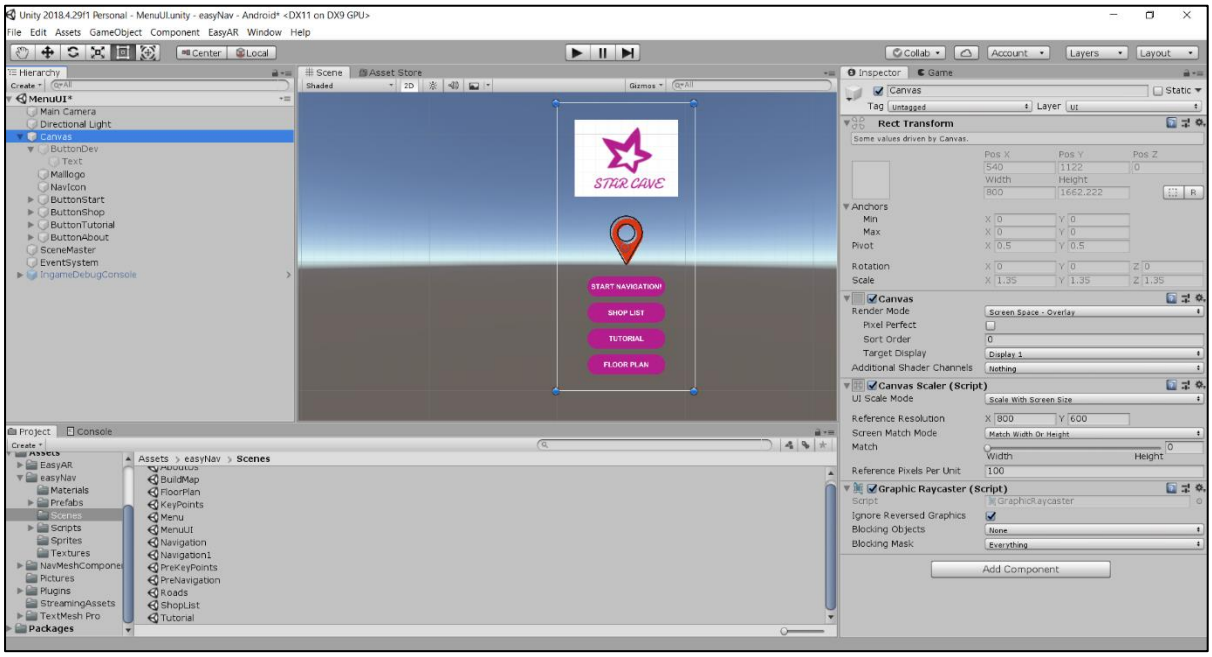


Figure 5.1.1.1: Interface of Unity.

Before creating the Unity project using the selected editor version, the Android Build Support should be added to the editor to ensure that the project can be build and run on Android platform devices.

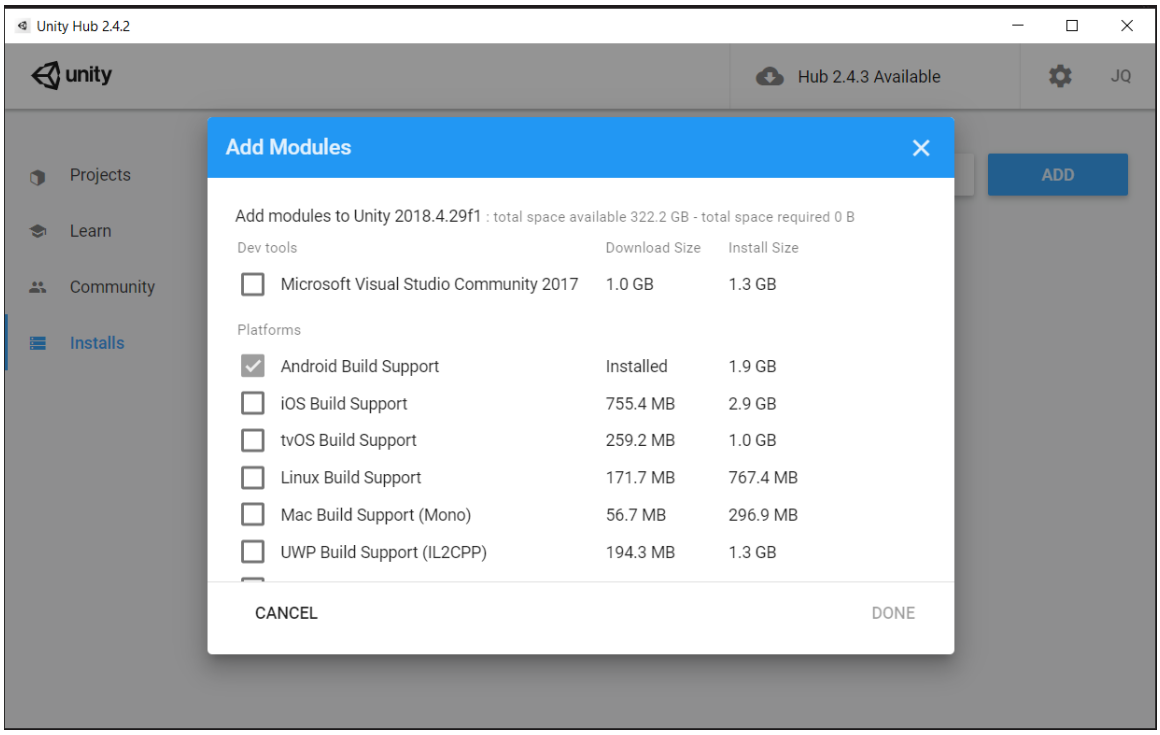


Figure 5.1.1.2: Add the Android Build Support module to the selected editor.

Then, after creating a Unity project, make sure to set the minimum API level to Android 8.0 Oreo as it is the minimum Android version supported by the EasyAR SDK which will be integrated to Unity later. The minimum API level can be found in File -> Build Settings -> Player Settings -> Settings for Android -> Other Settings.

Figure 5.1.1.3: Set the minimum API level for the Unity project.

5.1.2 Visual Studio 2019 Setup and Installation

Besides Unity, Visual Studio 2019 is another main software that will be used frequently during the development of this project. Visual Studio 2019 is the IDE used to write the C# scripts that are necessary for handling the events of the project. Visual Studio 2019 Community installation file is free and available for download from https:// visualstudio.microsoft.com/downloads/.

To set Visual Studio 2019 as the default IDE for script writing in Unity, go to Edit -> Preference -> External Tools to select Visual Studio 2019 as the external script editor as shown in Figure 5.1.2.2.

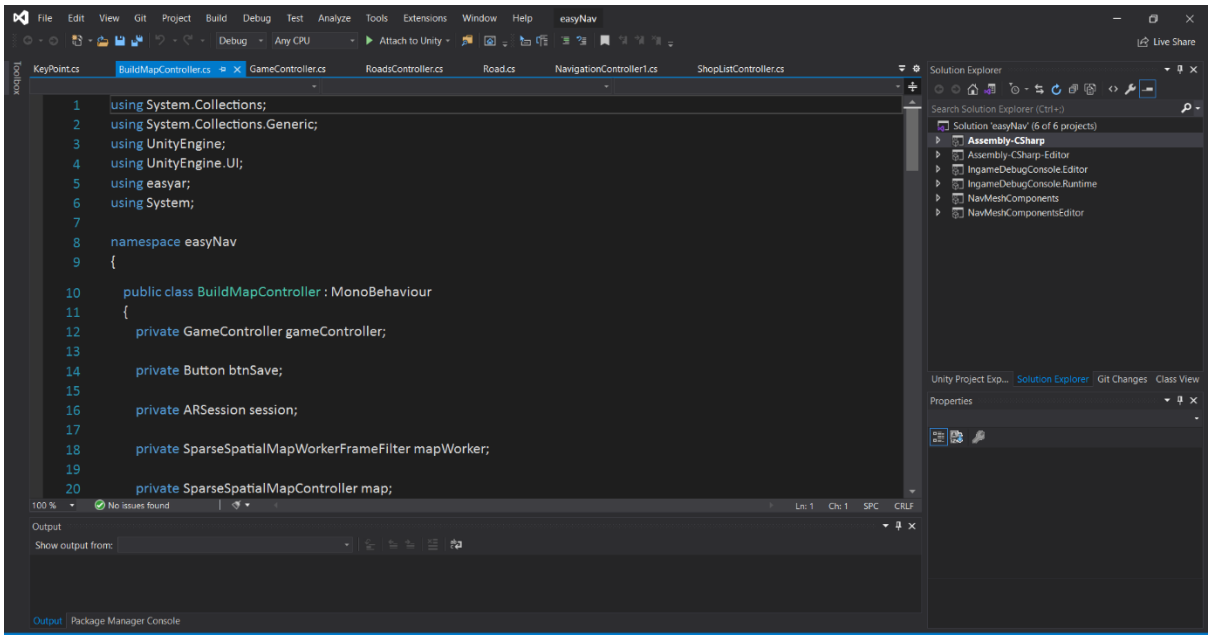


Figure 5.1.2.1: Visual Studio 2019 Community.

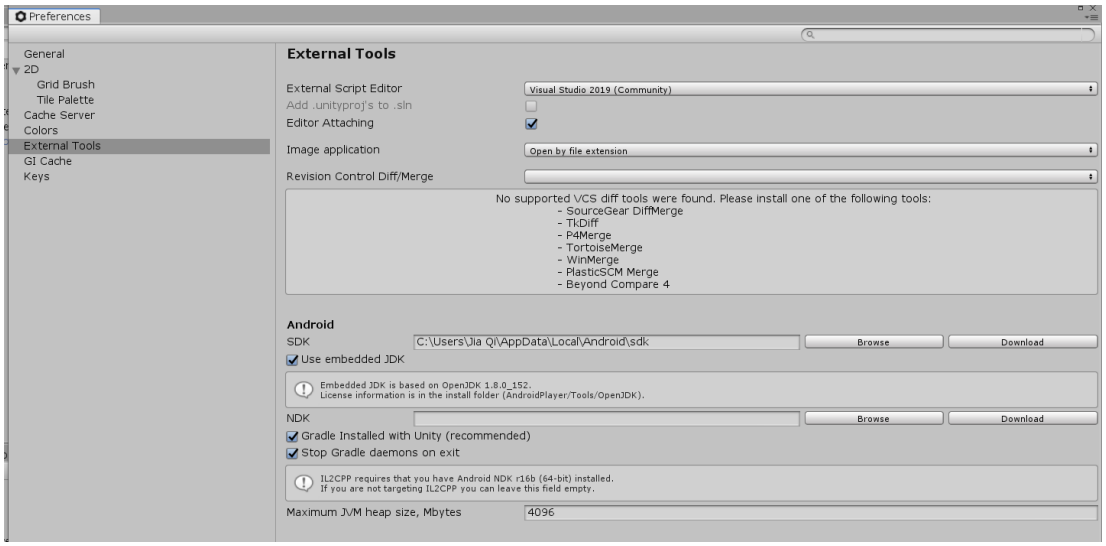


Figure 5.1.2.2: Set external script editor to Visual Studio 2019 in Unity.

5.1.3 EasyAR SDK Integration

To integrate EasyAR SDK into Unity, get the free Unity plugin from the EasyAR official website https://www.easyar.com/view/download.html#download-nav3, then import the package into the project created in Unity. Custom packages can be imported to Unity by accessing Assets -> Import Package -> Custom Package.

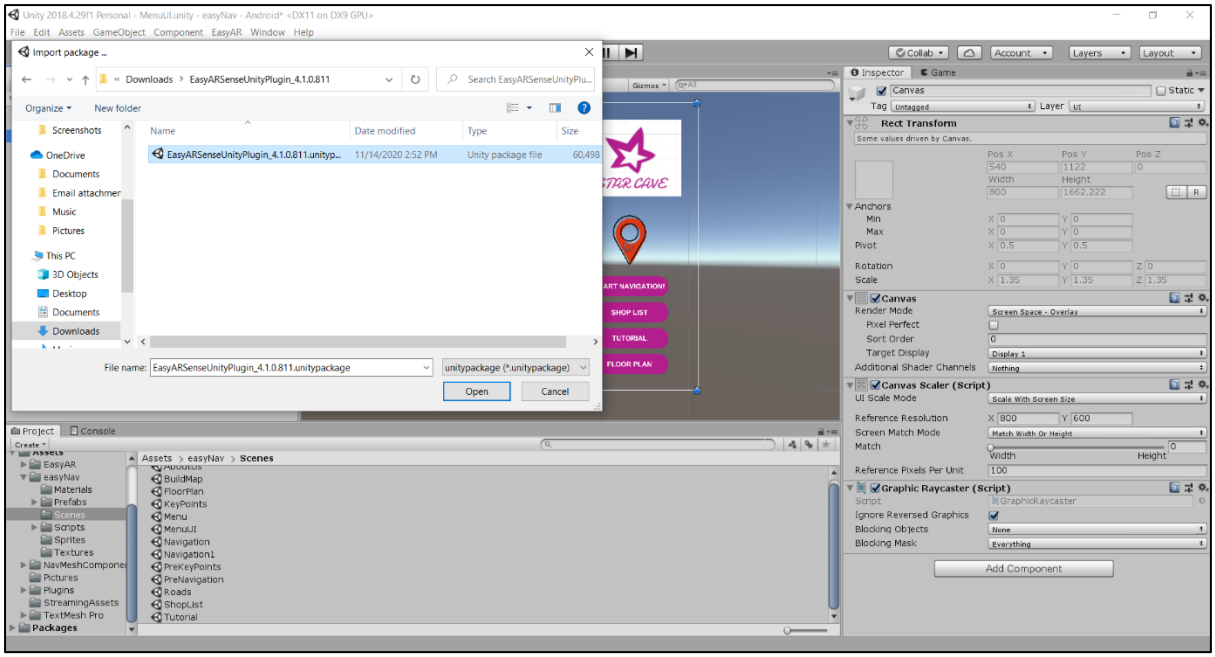


Figure 5.1.3.1: Import EasyAR SDK Unity Plugin.

When the import process has completed, create a EasyAR developer account on https://www.easyar.com/view/login.html . This action will ensure that the developer is able to upload the sparse spatial map of the mall into the EasyAR SpatialMap database. There are a few configurations needed to link the developer account to the Unity project. Get the information of the Sense License Key, API Key, API Secret, and the SpatialMap AppId from the EasyAR Developer Centre. EasyAR SDK Unity Plugin will need these values to link the project to the EasyAR SpatialMap database. By accessing EasyAR -> Change License Key, the interface shown in Figure 5.1.3.5 will appear and developer should paste in all the values copied from EasyAR Developer Centre.

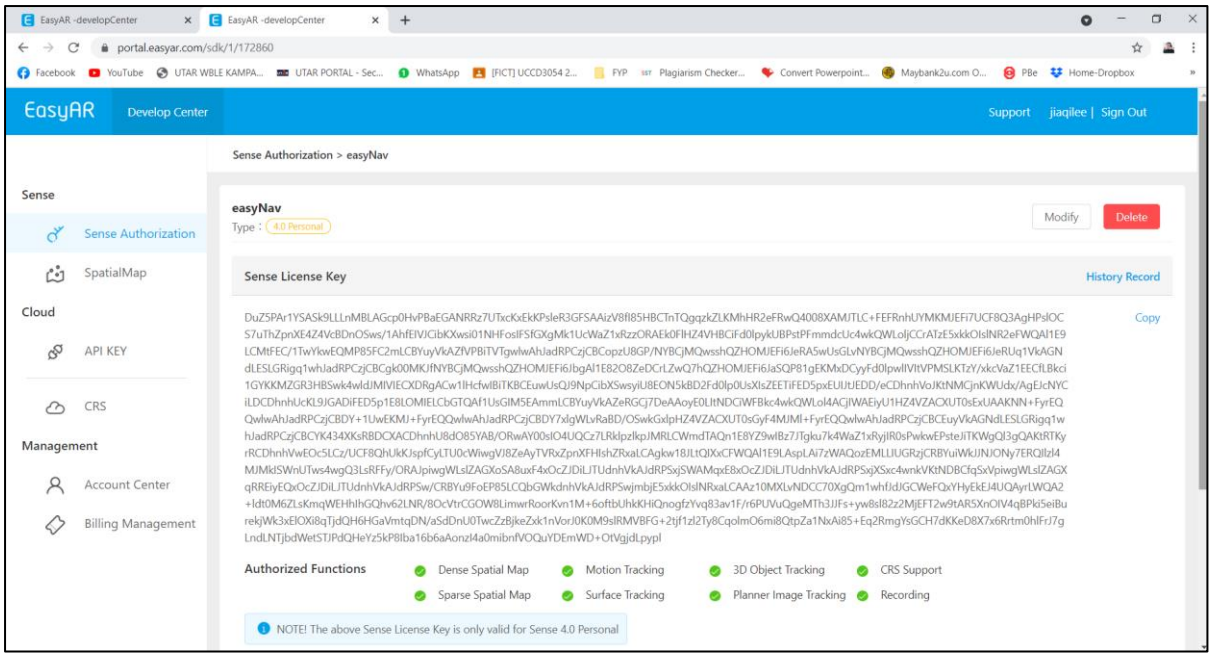


Figure 5.1.3.2: Sense License Key from EasyAR Developer Centre.

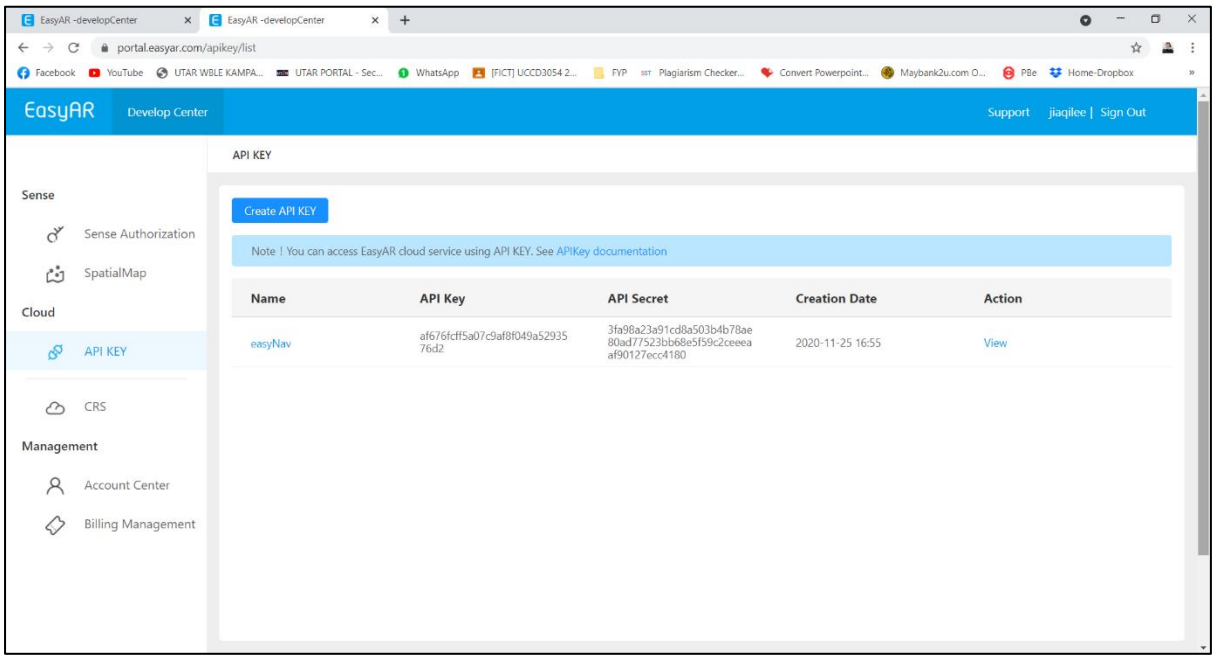


Figure 5.1.3.3: API Key and API Secret from EasyAR Developer Centre.

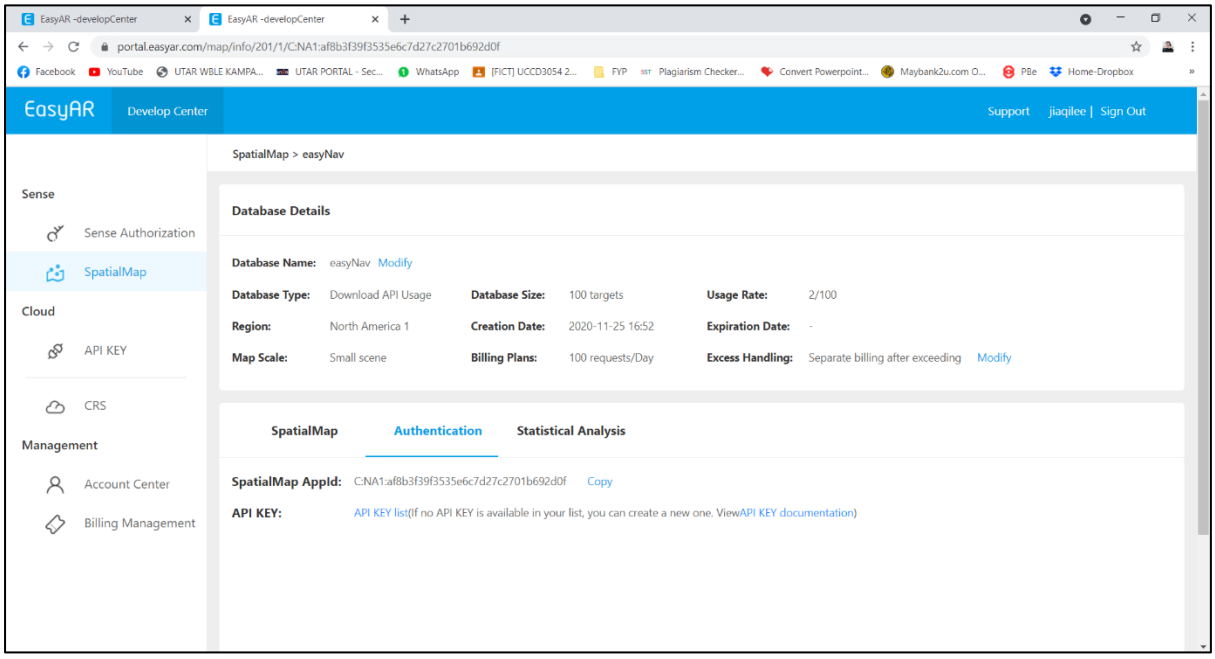


Figure 5.1.3.4: SpatialMap AppId from EasyAR Developer Centre.

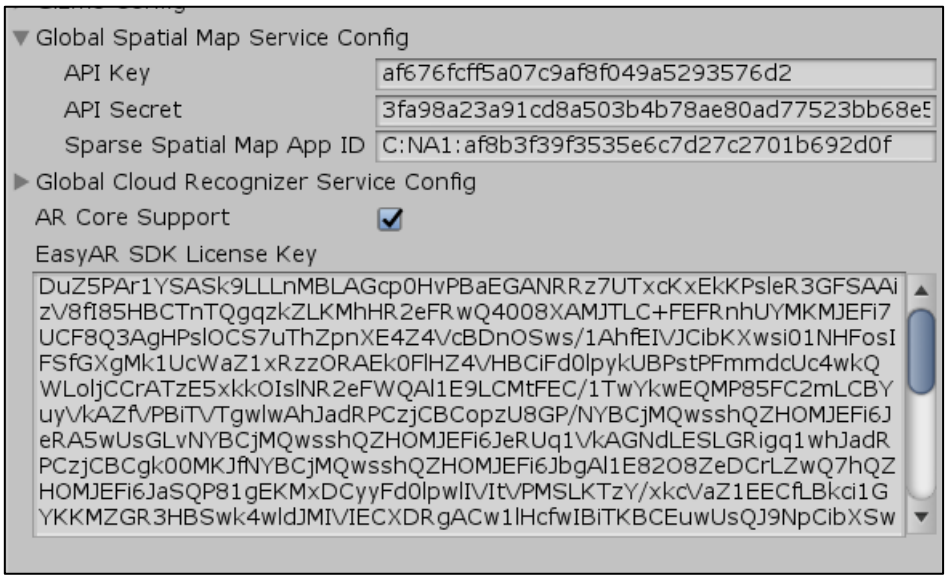


Figure 5.1.3.5: Insert all the required key in the Unity project.

5.2 Testing

There are various methods to test software to observe it performance according to different action done. In this project, a type of behavioural testing, the Black Box Testing is chosen to test the correctness of the output from this project. Black Box testing is chosen because it is a software testing method that will hide the internal code, functions, and modules of the project from the tester (What is BLACK Box Testing? Techniques, Example & Types, n.d.). Hence, the tester will be testing the functionalities of the application without any knowledge of how the application is being developed. It also does not require the tester to have any knowledge on software development to test the application.

5.2.1 User Panel

Menu

Table 5.2.1.1: Test actions being done on the Menu of User Panel.

Case	Test Action	Result	Status
1	Tap on *Start Navigation* button.	Directed to the navigation scene.	Pass
2	Tap on *Shop List* button.	Directed to the shop list page.	Pass
3	Tap on *Tutorial* button.	Directed to the tutorial page.	Pass
4	Tap on *Floor Plan* button.	Directed to the tutorial page.	Pass

Start Navigation Module

Table 5.2.1.2: Test actions being done on the Start Navigation Module of User Panel.

Case	Test Action	Result	Status
1	Scan the indoor environment.	Display list of available destinations.	Pass
2	Select a destination.	Display navigation route in real-time.	Pass
3	Tap on *Destination* button during the navigation process.	Display list of available destinations.	Pass

4	Select another destination during the navigation process.	Change the navigation route to a route that guide user to the new destination.	Pass
5	Tap on *Back* button.	Return to the Menu Page.	Pass

Shop List Module

Table 5.2.1.3: Test actions being done on the Shop List Module of User Panel.

Case	Test Action	Result	Status
1	Select a shop.	Display details of the shop.	Pass
2	Tap on *Website* button.	Direct user to the shop's official website.	Pass
3	Tap on *Close* button.	Close the shop details panel.	Pass
4	Tap on *Back* button.	Return to the Menu Page.	Pass

Tutorial Module

Table 5.2.1.4: Test actions being done on the Tutorial Module of User Panel.

Case	Test Action	Result	Status
1	Tap on *Back* button.	Return to the Menu Page.	Pass

Floor Plan Module

Table 5.2.1.5: Test actions being done on the Floor Plan Module of User Panel.

Case	Test Action	Result	Status
1	Tap on *Level 1* button.	Display floor plan of first floor.	Pass
2	Tap on *Ground Floor* button.	Display floor plan of ground floor.	Pass
3	Tap on *Back* button.	Return to the Menu Page.	Pass

5.2.2 Developer Panel

Menu

Table 5.2.2.1: Test actions being done on the Menu of Developer Panel.

Case	Test Action	Result	Status
1	Enter map name in the input field.	Save the name as the sparse spatial map name.	Pass
2	Tap on *Build Map* button.	Direct to the Build Map scene.	Pass
3	Tap on *Key Points* button.	Direct to the Key Points scene.	Pass
4	Tap on *Roads* button.	Direct to the Roads scene.	Pass
5	Tap on *Start Navigate!* button.	Directed to the navigation scene.	Pass
6	Tap on *Exit* button.	Exit from the developer panel.	Pass

Build Map Module

Table 5.2.2.2: Test actions being done on the Build Map Module of Developer Panel.

Case	Test Action	Result	Status
1	Scan the indoor environment.	Point clouds illustrated as blue dots appear.	Pass
2	Tap on *Save* button.	The sparse spatial map appears in the EasyAR SpatialMap database.	Pass
3	Tap on *Back* button.	Return to the Menu Page.	Pass

Key Points Module

Table 5.2.2.3: Test actions being done on the Key Points Module of Developer Panel.

Case	Test Action	Result	Status
1	Scan the indoor environment.	Receive feedback message "In Tracking Mode…".	Pass
2	Scan on an image target.	A yellow cube appears on top of the image target.	Pass

3	Tap on the yellow cube.	Display key points panel, list of key points and the location point of the yellow cube.	Pass
4	Tap on *Add* button.	Display the newly added key point on the list.	Pass
5	Tap on *Save* button.	Save the list of key points into a text file in JSON format.	Pass
6	Tap on *Delete* button.	Delete the key point from the list of key point.	Pass
7	Tap on *Close* button.	Return to the Key Points scene.	Pass
8	Tap on *Back* button.	Return to the Menu Page.	Pass

Roads Module

Table 5.2.2.4: Test actions being done on the Roads Module of Developer Panel.

Case	Test Action	Result	Status
1	Select key point from the dropdown.	Display the name of selected key point as the dropdown text.	Pass
2	Tap on *Add* button.	Display the newly added path on the list.	Pass
3	Tap on *Save* button.	Save the list of paths into a text file in JSON format.	Pass
4	Tap on *Delete* button.	Delete the path from the list of paths.	Pass
5	Tap on *Back* button.	Return to the Menu Page.	Pass

Start Navigate Module

Table 5.2.2.5: Test actions being done on the Start Navigate Module of Developer Panel.

Case	Test Action	Result	Status
1	Scan the indoor environment.	Display list of available destinations.	Pass
2	Select a destination.	Display navigation route in real-time.	Pass

3	Tap on *Destination* button during the navigation process.	Display list of available destinations.	Pass
4	Select another destination during the navigation process.	Change the navigation route to a route that guide lead to the new destination.	Pass
5	Tap on *Back* button.	Return to the Menu Page.	Pass

CHAPTER 6: CONCLUSION

6.1 Project Review

Research that are related to indoor location positioning system and AR navigation function for indoor environment are being done before this project is developed to enhance the knowledge on the concept needed by this project and identify the suitable methodology to be implemented in this project, for example, few methods to achieve indoor location positioning such as use of sensors, AR markers or specifically generated markers or 3D point map localization are studied before the project is developed. After all the research on similar concept and topic, the pros and cons of each system are listed to ensure that this project will act as an improve version of these systems. Additionally, critical remarks for these systems had been done as well so that this project can avoid the weaknesses exist in the previous work done.

The core function of this project is to allow user in a shopping mall to locate their current location by scanning their surrounding environment and observe the navigation route that will lead them to their desired destination in real-time. Also, this project is developed for Android platform to allow most of the smart device users in Malaysia to be able to install the application in their smartphones or tablets to check the mall directory of the shopping mall.

Besides the AR navigation function, this project also provides some basic information about the shopping mall which includes the list of shops available in the shopping mall, their respective information such as phone number, shop lot number and link to their official website. Other than that, this project provides the overall floorplan of the shopping mall if user wants to briefly browse through the shop location in the mall.

6.2 Discussion

Based on the research done before developing this project, mall directory in the form of mobile application mostly does not include the AR navigation function, although indoor navigation application via AR does exist in the market, however, it is not widely implemented in mobile mall directories. AR technology is brought into mobile mall directory because the traditional method of displaying the navigation route is confusing. Hence, AR technology is implemented into the mobile mall directory to improve the understandability of the navigation route by ensuring that the instructions given on the navigation directions are clear and precise to reduce the confusion of users.

This project implemented the 3D point map localization and sparse spatial map to achieve the indoor location positioning function. First, the sparse spatial map for the indoor environment needs to be created and saved to the EasyAR SpatialMap database, this will enable the application to determine the user current location by analyzing the visual features of real-world objects compare the feature points with the feature points saved in the sparse spatial map.

Additionally, to ensure that the sparse spatial map function and 3D point map localization provided by EasyAR SDK can be integrated into the project, the EasyAR SDK package for Unity must be loaded into the project. This will enable all the functions provided by EasyAR can be used in the project without any errors.

Lastly, to setup a route from one destination to another, two key components are needed. First, it will be the key point. A key point holds the information of the location point for a shop relative to the sparse spatial map. Then, path is the second major component which will be responsible to teach the system of how the key points are interconnected with each other. The key points and paths are stored in local storage in JSON format to ease the process of data retrieving for the AR navigation function.

6.3 Contribution

This project has included the indoor location positioning function without using the usual way, which will make use of sensors, Wi-Fi, or Bluetooth beacons to do so. Therefore, projects in the future may further improve the work done in this project to achieve a higher accuracy of indoor location positioning without the use of equipment. This indoor location positioning function is a popular topic among navigation application developers because the most popular technology for location positioning, the Global Positioning System (GPS) will not work well for indoor environment because it could not penetrate well through building walls. Hence, the solution of this project, which is lower cost and lower setup time, and at the same time, does not required GPS technology in location positioning for indoor environment should be worth the time of developers who has limited. Also, this application is completely free of charge, users do not need to pay before they can use the application.

Additionally, this project is developed for Android platform, therefore it will greatly improve the portability of the mall directory compare to the traditionally mall directory in a kiosk form. Since, the use of smart devices has increased drastically, users are able to check the mall directory on their smart devices anywhere and at any time. Users can check the shops available, details of the shop and the overall floorplan of the mall any time they wish, however, the AR navigation function can only perform its job when the users are physically located in the shopping mall, this function is highly location dependent and it will not work and display the navigation route when the users at located other places.

Other than that, the existing mall directory mobile application does not include the AR navigation function that can provide users a clear, simple understandable navigation route to their desired destination by displaying the route in real-time. Users will not need to worry about proceeding to the wrong direction as they clearly observe which direction to proceed. This will ensure that the user can get to their destination in the shortest time and with the least effort.

In conclusion, this mobile application developed from this project can provide the users a mobile shopping mall directory with high portability and mobility with an additional function of AR navigation where most of the mobile mall directory existed in the market does not have to provide a better experience.

6.4 Future Work

Finally, there are some weaknesses of the approach used in this project. There are some requirements of the indoor environment during the process of building the sparse spatial map. According to the sparse spatial map documentation from the EasyAR Official Website, the map should not build in a poor texture area, reflective area such as mirrors and areas with a lot of repetitive textures (EasyAR Sparse Spatial Map — EasyAR Sense 4.0.1 documentation, n.d.). Hence, not every shopping mall meet these requirements and the sparse spatial map may not be built successfully. The future work should put in effort to improve the possibility of building a sparse spatial map successfully in a huge and spacious environment with less visual features.

Then, according to the documentation of EasyAR, the map localization will be easily affected by the illumination of the environment, therefore, map built during the day may not be able to detect the user position during night-time with different illumination level. Additionally, if the system loss track of the user current position during the navigation process, all the destination points or routes may displace and not in the correct point anymore, this may result in guiding the user to a wrong destination. Hence, in future projects, work should be done on eliminate the environment factors that may affect the performance of indoor location positioning function.

Next, it will be better if voice instructions can be added to further improve the navigation function. Currently, the users must constantly observe their smart device's screen during the navigation process to make sure that they are on the right path. However, looking at smart devices while walking may not be the best choice sometimes especially for users who have kids to look over. Hence, the voice instruction may further help these users so that they can have an eye on their children at the same time getting informed on how to reach their destination.

In the current project, users could not search for their destination from a search bar, instead, they need to manually scroll through the list of destination to select it, thus, a search function is necessary to improve the efficiency of selecting destination as the shop list grows.

Lastly, as mentioned in the earlier sections, the information of the location points of each shop and the path information are stored locally. This will need more effort for the developer to update some of the data for the shops. Hence, online database such as Firebase

should be considered so that all the information will be retrieved from online database, and the application can always get the most updated version of data from the online database. The developer will not need to release a new version of the application for the sake of slight data changes.

BIBLIOGRAPHY

Beynon-Davies, P., Carne, C., Mackay, H. and Tudhope, D., 1999. Rapid application development (RAD): an empirical review. *European Journal of Information Systems*, *8*(3), pp.211-223.

Guru99.com. n.d. *What is BLACK Box Testing? Techniques, Example & Types*. [online] Available at: <https://www.guru99.com/black-box-testing.html> [Accessed 13 April 2021].

Help.easyar.com. n.d. *Easyar Sparse Spatial Map — Easyar Sense 4.0.1 Documentation*. [online] Available at: <https://help.easyar.com/EasyAR%20Sense/v4/Guides/EasyAR-Sparse-Spatial-Map.html> [Accessed 2 December 2020].

Favendo. n.d. *What Is Indoor Navigation And What Are Its Possibilities?*. [online] Available at: <https://www.favendo.com/wayfinding/what-is-indoor-navigation> [Accessed 2 December 2020].

Gupton, N., 2017. *What'S The Difference Between AR, VR, And MR?*. [online] The Franklin Institute. Available at: <https://www.fi.edu/difference-between-ar-vr-and-mr#:~:text=Augmented%20reality%20(AR)%20adds%20digital,the%20camera%20on%20a%20smartphone.&text=Virtual%20reality%20(VR)%20implies%20a,shuts%20out%20the%20physical%20world.> [Accessed 2 December 2020].

Huey, L.C., Sebastian, P. and Drieberg, M., 2011, September. Augmented reality based indoor positioning navigation tool. In *2011 IEEE Conference on Open Systems* (pp. 256-260). IEEE.

Koch, C., Neges, M., König, M. and Abramovici, M., 2014. Natural markers for augmented reality-based indoor navigation and facility maintenance. *Automation in Construction*, *48*, pp.18-30.

Mewherter, S., 2016. *How Interactive Directory Kiosks Are Changing The Wayfinding Game*. [online] Meridian Kiosks. Available at: <https://www.meridiankiosks.com/interactive-directory-kiosks-changing-wayfinding-

game/#:~:text=Businesses%20and%20organizations%20are%20leveraging,to%20navigate%20buildings%20and%20campuses.> [Accessed 23 November 2020].

Sutherland, I.E., 1968, December. A head-mounted three dimensional display. In *Proceedings of the December 9-11, 1968, fall joint computer conference, part I* (pp. 757-764).

Wagner, D. and Schmalstieg, D., 2009, July. History and future of tracking for mobile phone augmented reality. In *2009 International Symposium on Ubiquitous Virtual Reality* (pp. 7-10). IEEE.

Yang, G. and Saniie, J., 2017, May. Indoor navigation for visually impaired using AR markers. In *2017 IEEE International Conference on Electro Information Technology (EIT)* (pp. 1-5). IEEE.

APPENDIX A – BIWEEKLY REPORT

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 1 & 2
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Improve the UI of the application.
- Added a tutorial panel to teach the guide the users on using the AR navigation function.

2. WORK TO BE DONE

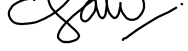
- Create a shop list panel with shop details provided.

3. PROBLEMS ENCOUNTERED

- Considering on what information should be included in the details panel of a shop since the opening hours of shops in a shopping mall will be the same.

4. SELF EVALUATION OF THE PROGRESS

- The UI design of the application has almost completed, should focus more on the AR navigation functionalities later.



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 3 & 4
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Created a shop list and shop details panel.

2. WORK TO BE DONE

- Build a new sparse spatial map.
- Setup new key points.
- Setup new paths.

3. PROBLEMS ENCOUNTERED

- Does not know if the sparse spatial map would work for different floors of the indoor environment.

4. SELF EVALUATION OF THE PROGRESS

- Slow progress due to assignments and test from other courses. Need to complete the important functionalities as soon as possible.

_____ _____

Supervisor's signature Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 5 & 6
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Built a new sparse spatial map of the environment for both floors.
- Set new key points.
- Set new paths.

2. WORK TO BE DONE

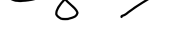
- Create floor plan for the indoor environment.

3. PROBLEMS ENCOUNTERED

- The process of building the sparse spatial map may fail for a bigger area of indoor environment if the illumination of the environment is not stable.

4. SELF EVALUATION OF THE PROGRESS

- The basic functionalities are almost complete, should think about some innovative functions to be included.



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.: 7** & 8
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Create the floor plan for both floors of the indoor environment.

2. WORK TO BE DONE

- Include the floor plan in the application.
- Add shop details to the details panel.
- Change the shopping mall logo of the application.

3. PROBLEMS ENCOUNTERED

- The floor plan does not create using the real dimension of the indoor environment because the original floor plan of the environment is not available.

4. SELF EVALUATION OF THE PROGRESS

- Too little progress on the AR navigation function, should focus more on that.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 9 & 10
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Changed the shopping mall logo to an imaginary shopping mall.
- Added the overall floorplan for the shopping mall (both floors).
- Completed the shop details panel with relevant and useful information of the shop.

2. WORK TO BE DONE

- Include a button to lead the users to the shop's official website in the shop details panel.

3. PROBLEMS ENCOUNTERED

- Searching for suitable online databases that can be integrate with the application well.

4. SELF EVALUATION OF THE PROGRESS

- Not much of progress in improving the AR navigation function, focuses a lot more on the user interface.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(~~Project I~~ / Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 11 & 12
Student Name & ID: LEE JIA QI (17ACB02175)	
Supervisor: Ms. Saw Seow Hui	
Project Title: Interactive Directory for Shopping Mall via Augmented Reality	

1. WORK DONE

- Done report Chapter 1 to 4.
- Added the button to lead the users to the shop's official website in the shop details panel.

2. WORK TO BE DONE

- Show a pop-up panel when users are near their destination.
- Try to integrate online database into the application.

3. PROBLEMS ENCOUNTERED

- Firebase SDK provided for Unity has greatly increase the file size of the APK file, and it crashes whenever it is trying to retrieve information from the firebase.

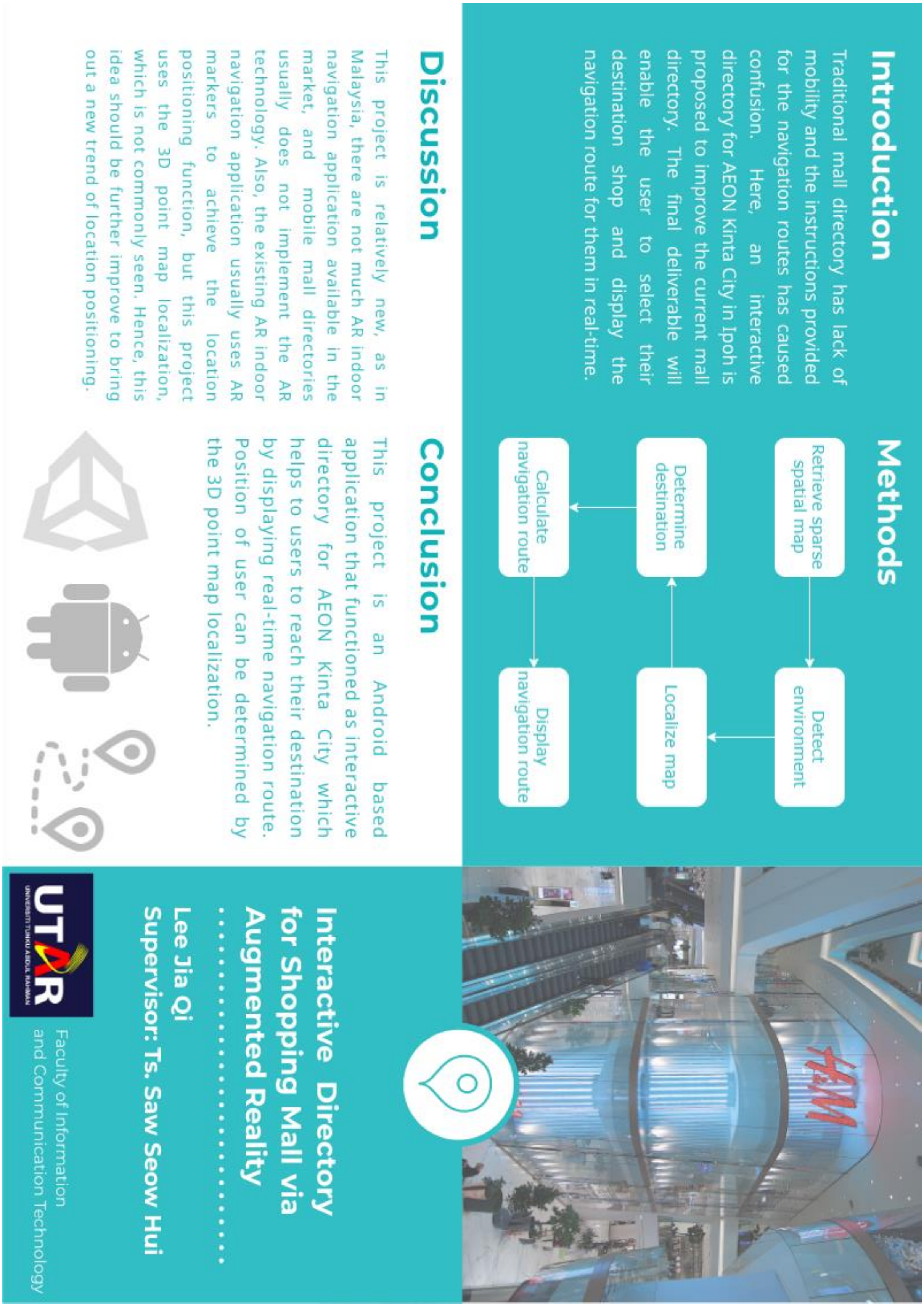
4. SELF EVALUATION OF THE PROGRESS

- Does not have enough time to complete all the suggested functionalities for the application as the implementation of Firebase used up too much time and the integration is not successful.

Supervisor's signature

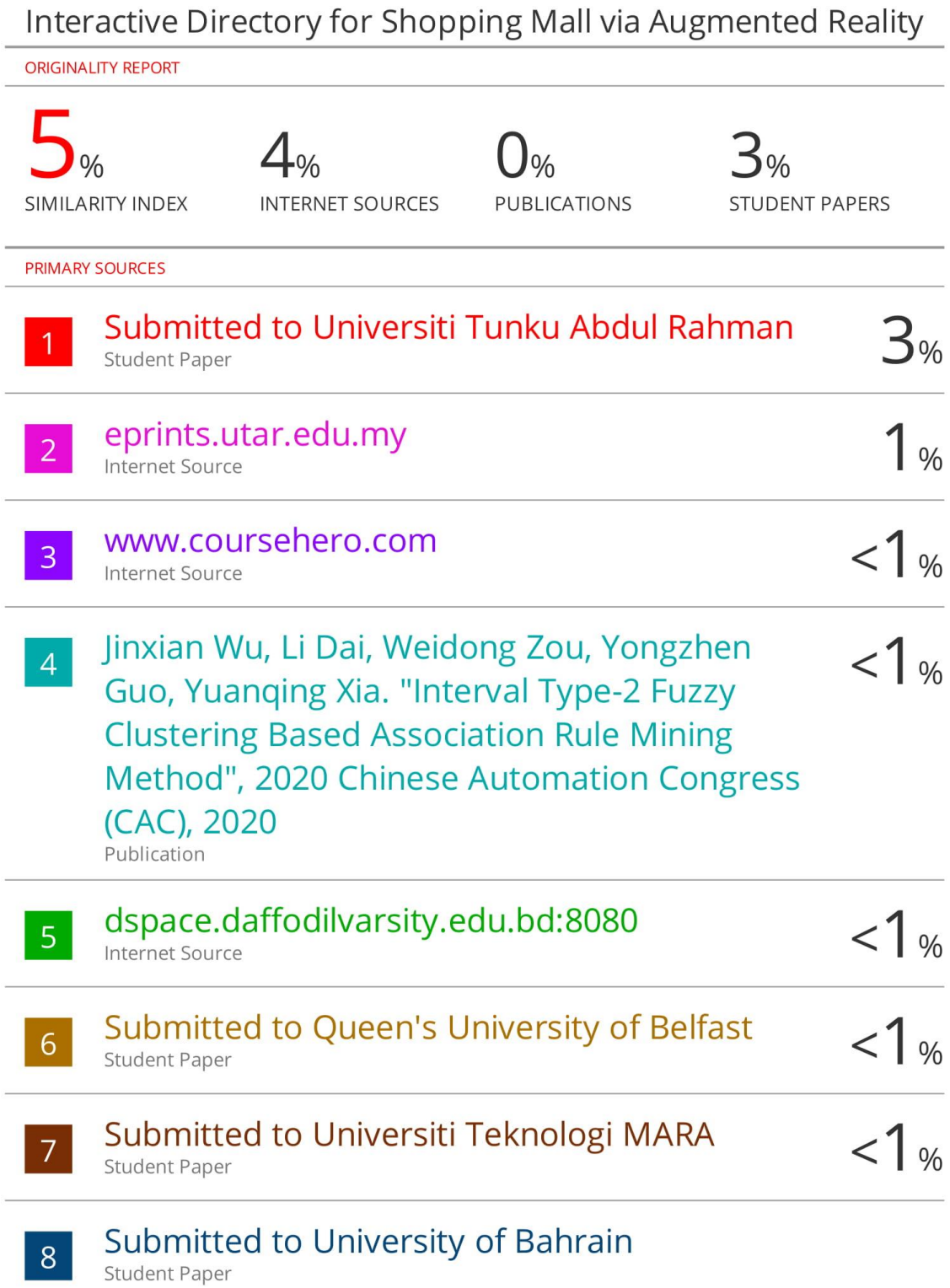
Student's signature

POSTER



Interactive Directory for Shopping Mall via Augmented Reality
Lee Jia Qi
Supervisor: Ts. Saw Seow Hui
UTAR
UNIVERSITI TUNKU ABDUL RAHMAN
Faculty of Information and Communication Technology
Introduction
Traditional mall directory has lack of mobility and the instructions provided for the navigation routes has caused confusion. Here, an interactive directory for AEON Kinta City in Ipoh is proposed to improve the current mall directory. The final deliverable will enable the user to select their destination shop and display the navigation route for them in real-time.
Methods
Retrieve sparse spatial map
Detect environment
Localize map
Determine destination
Calculate navigation route
Display navigation route
Discussion
This project is relatively new, as in Malaysia, there are not much AR indoor navigation application available in the market, and mobile mall directories usually does not implement the AR technology. Also, the existing AR indoor navigation application usually uses AR markers to achieve the location positioning function, but this project uses the 3D point map localization, which is not commonly seen. Hence, this idea should be further improve to bring out a new trend of location positioning.
Conclusion
This project is an Android based application that functioned as interactive directory for AEON Kinta City which helps to users to reach their destination by displaying real-time navigation route. Position of user can be determined by the 3D point map localization.

PLAGIARISM CHECK RESULT



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Title of Final Year Project	Interactive Directory for Shopping Mall via Augmented Reality

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Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor
Name: Ts. SAW SEOW HUI

Date: 15/4/2021

Signature of Co-Supervisor
Name: _____

Date: _____

FINAL YEAR REPORT 2 CHECKLIST

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FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

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Student Id	17ACB02175
Student Name	LEE JIA QI
Supervisor Name	TS. SAW SEOW HUI

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*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report. _____ (Signature of Student) Date: 15/04/2021	Supervisor verification. Report with incorrect format can get 5 mark (1 grade) reduction. _____ (Signature of Supervisor) Date: 15/04/2021