An Augmented Reality (AR) Indoor Navigation Mobile Application for the Faculty of Information and Communication Technology (FICT)

BY

Goh Brian Joon Jian

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONOURS)

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2024

UNIVERSITI TUNKU ABDUL RAHMAN

REPORT STATUS DECLARATION FORM

Title: **An Augmented Reality (AR) Indoor Navigation Mobile Application for the Faculty of Information and Communication Technology (FICT)**

Academic Session: Jan 2024

I GOH BRIAN JOON JIAN

(CAPITAL LETTER)

declare that I allow this Final Year Project Report to be kept in Universiti Tunku Abdul Rahman Library subject to the regulations as follows:

1. The dissertation is a property of the Library.
2. The Library is allowed to make copies of this dissertation for academic purposes.

Verified by,

(Author's signature)

(Supervisor's signature)

Address:
13, Lorong Sutera 4
Taman Sutera
13700 Seberang Jaya

TS Saw Seow Hui
Supervisor's name

Date: 25/4/2024

Date: 26/4/2024

Universiti Tunku Abdul Rahman			
Form Title : **Sample of Submission Sheet for FYP/Dissertation/Thesis**			
Form Number: **FM-IAD-004**	Rev No.: **0**	Effective Date: **21 JUNE**	Page No.: **1 of 1**

FACULTY/INSTITUTE* OF INFORMATION AND COMMUNICATION TECNOLOGY

UNIVERSITI TUNKU ABDUL RAHMAN

Date: 25/4/2024

SUBMISSION OF FINAL YEAR PROJECT /DISSERTATION/THESIS

It is hereby certified that ______***Goh Brian Joon Jian***______ (ID No: __***20ACB02750***___) has completed this final year project/ dissertation/ thesis* entitled "FICT AR Indoor Navigation" under the supervision of TS Saw Seow Hui (Supervisor) from the Department of __________________________, Faculty/Institute* of **INFORMATION AND COMMUNICATION TECNOLOGY** , and _____________________ (Co-Supervisor)* from the Department of _________________________, Faculty/Institute* of ___________________________.

I understand that University will upload softcopy of my final year project / dissertation/ thesis* in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

____
(*Goh Brian Joon Jian*)

*Delete whichever not applicable

DECLARATION OF ORIGINALITY

I declare that this report entitled "**METHODOLOGY, CONCEPT AND DESIGN OF A 2-MICRON CMOS DIGITAL BASED TEACHING CHIP USING FULL-CUSTOM DESIGN STYLE**" 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 : Goh Brian Joon Jian

Date : 20-4-2024

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisors, Ts Saw Seow Hui who has given me this bright opportunity to have a chance to venture into the world of AR. Moreover, I would also like to thanks my family and friend who always giving me support in completing this project

ABSTRACT

Outdoor navigation applications have been widely used nowadays, with the help of GPS technology these outdoor navigation application able to help users to navigate through the streets easily even not knowing the place. However, there is not much indoor navigation application in the market, as GPS signal does not work effectively indoor. Moreover, much hardware installation is needed to build an indoor navigation system. Hence the aim of this project is to develop an AR indoor navigation application that helps the students at University Tunku Abdul Rahman to find their way when first entering the vast compound of UTAR Kampar. The application created from this project will also help the student to know the purpose of certain room such as lecture hall, tutorial class and so on to prevent students from walking into the wrong classroom. The application uses AR technology to provide the user with accurate direction and information about the classroom and buildings. AR technology is used to ensure that user had an immersive navigation experience compared with traditional 2-D map. A few existing applications on the market will be reviewed and methodology to develop this application will be provided.

Table Of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AR	Augmented Reality
GPS	Global Positioning System
NeRF	Neural radiance fields

Chapter 1

Introduction

1.1 Background

Ever imagine walking in a huge indoor building seamlessly and going straight to the intended destination even though it is your first time entering the indoor building? This project is to develop an indoor navigation app using Augmented Reality (AR) technology as an enhancement. AR is the real-time overlaid of digital information into the user’s surrounding environment. This technology is widely used to enrich the user experience with computer-generated perceptual information and turn one’s surroundings into an interactive learning environment [1]. AR can be used for a variety of purposes such as architecture and home design, gaming, product visualisation and more. Numerous industries and manufacturers have started to embrace the technology of AR because it drives operational efficiencies by reducing production downtime, identifying problems quickly, and keeping processes moving. One example of AR technology that can be used in the industry is IoT product designers who use the prototype virtual objects to test and adjust them before anything physical is built.

GPS-based outdoor navigation applications are very common now in the market. Outdoor navigation applications such as Waze and Google Maps are widely used to guide users to the intended destination. However, indoor navigation isn’t as widespread as outdoor navigation, primarily due to the impracticality of GPS signals within intricate multi-story buildings, GPS signals can be easily disrupted by the walls of the buildings. As a result, there are not many indoor navigation applications in the market. The primary goal of this project is to provide direction to users onscreen, overlaid on top of real environments seen through the camera of a smartphone [2]. This simplifies the challenge of users trying to compare the real world against a reference like a map while navigating indoors.

1.2 Problem Statement and Motivation

1.2.1 Overwhelmed in large indoor building.

The premise of indoor buildings such as airports, and shopping malls are getting larger day by day. People often experience the feeling of being lost and not knowing how to reach their destination inside an unknown building. Trying to find a specific store in a mall with just the help of sign boards and static maps can be overwhelming sometimes especially when you are pressed for time and don’t know the building well. A live update indoor navigation mobile application will be useful in this situation to guide the user to the destination.

1.2.2 GPS does not work indoors.

As we all know GPS technology is great for outdoor navigation, but it is not in the case of indoor navigation because the walls of the buildings might affect the GPS signal strength. Consequently, there are not many indoor navigation applications in the market that can guide users in an enclosed environment that has a weak GPS signal. Hence an alternative solution will be used to allow indoor navigation to work even without using GPS technology.

1.2.2 Inefficiency of traditional 2D indoor map.

It is very common for public indoor places to provide 2D digital maps on each floor of the building but these maps can be confusing. On many occasions, you would need to click the picture of the map, and then use your sense of direction to move around, and that isn’t convenient for people who do not have much sense of direction. Often, in a foreign city, visitors face the issue of reading direction boards due to the language problem. A user-friendly indoor mobile application with the use of AR technology that will provide direction to users onscreen will be able to solve this problem.

1.3 Objectives

1.3.1 To develop an indoor navigation mobile application for students in FICT.

The main objective of this project is to develop a user-friendly indoor navigation mobile application so that students in FICT can navigate through the indoor building easily. The target audience of this project is mainly the new intake students who are not familiar with their surroundings environment, this app will act as a virtual tour guide for them.

1.3.2 To implement AR technology into the application for immersive view.

There will be a line renderer on the user screen, integrating with the real-world environment to guide users to their intended destination. AR technology will be used to display the guiding path on user mobile devices with their camera on. This allows users to have a clearer vision of which direction they should go.

1.3.3 To calculate the shortest route to the destination.

There could be many ways to walk to a certain destination, but this mobile application will always choose the shortest route for the user. By using the A* algorithm, the shortest path can be calculated easily.

1.3.4 To use a QR code to locate the user's current position.

Every routable location such as classrooms or toilets will be pasted a QR code. When the user scans the QR code, it will mark the location as the starting point of the navigation. This is also known as the marker-based positioning technique.

1.4 Project Scope and Direction

At the end of this project, an indoor navigation mobile application with AR technology will be developed. This mobile application will help the FICT students in UTAR Kampar to navigate through the faculty seamlessly with the immersive view of the AR technology. There will be a live viewing mipmap on the top right of the screen to show the current location of the user. A QR code is scanned to locate the position of the user.

1.5 Contributions

This project will act as a stepping stone to future indoor navigation work. We can see that people highly rely on outdoor navigation to guide them through traffic so that they can reach their destination without any delay. So, I hope that one day in the future, an indoor navigation app can guide people who are walking inside an indoor building to their desired destination, for example, foreigners can easily find the boarding place with the help of an indoor navigation mobile application. As for now, there are not many reliable technologies that can be used to build an indoor navigation mobile application, in this project we will discover on what are the most effective and possible ways to build an efficient indoor navigation application.

Furthermore, this project will be implemented with AR technology, I believe that by implementing AR technology in our navigation application it can bring a more immersive view to the user and bring more convenience to them, as users can see clearly what is in the real world. Therefore, adding a virtual-navigation line in the real world will help the user to reach their destination on time.

Chapter 2

Literature Review

2.1 Review of existing navigation applications

2.1.1 Microsoft Path Guide

This Indoor navigation application is developed by Microsoft Research Asia's Cloud & Mobile Research group. Microsoft Path Guide is a completely plug-and-play indoor navigation service that do not need any additional equipment such as map to operate. Unlike outdoor navigation, Microsoft does not have the choice of using the satellite data to map the indoor places. Besides, it is impractical for the officials of Microsoft to visit every public indoor place and map them [3]. So, crowdsourcing is the solution Microsoft used to develop an indoor navigation system. With Path Guide, every user can generate their own routes by capturing sensory data with their smartphone while walking indoors, these users are known as the "leaders". The data of the route will be uploaded directly to the app's online database. After the route is created by the leaders, others can simply follow the routes to the same destination in a real-time manner.

As mentioned above, Microsoft Path Guide is a "peer-to-peer leader/follower" model. One can use the path recorded by other users by using the app. Every path recorded by users can be combined, hence the more the data users collect the more useful the application will be. During a leader's walk, location-specific features that are extracted from sensory data will be combined with his/her walking patterns such as steps, turns, going upstairs or downstairs to build reference traces that can be stored in cloud and share with the other user [4]. When users navigate using Path Guide, it will compare and synchronize sensor readings and the reference route recorded by the "Leader", providing real-time guidance from their starting point to destination [4].

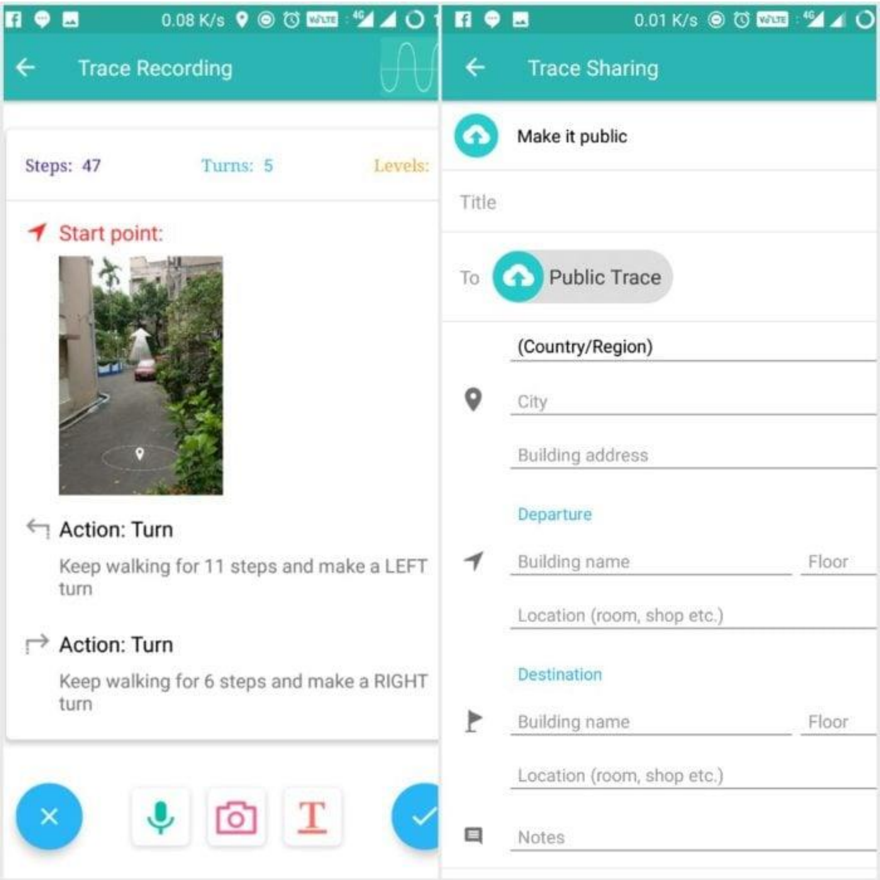


Figure 2.1.1-1 Microsoft Path Guide trace recording and trace sharing

For example, this model can be used by colleagues who have come to attend a meeting in a hotel, or a group of friends planning to catch up in a huge mall. After arriving at the designated place, the “leader” clicks the “finish recording” button to upload the path data trace to Path Guide’s backend in the Cloud [5]. Anyone in his group (the “followers”) who enter later the building later can then use Path Guide to follow the shared trace step-by-step to easily locate the correct room. Another useful function of this app is to trace unfamiliar places, user can record a route from his car to his destination and later follow it in reverse to find the car in car park easily. Text, audio, and photos along a path (refer to figure 2.1.2) can added to provide more information and interactivity.

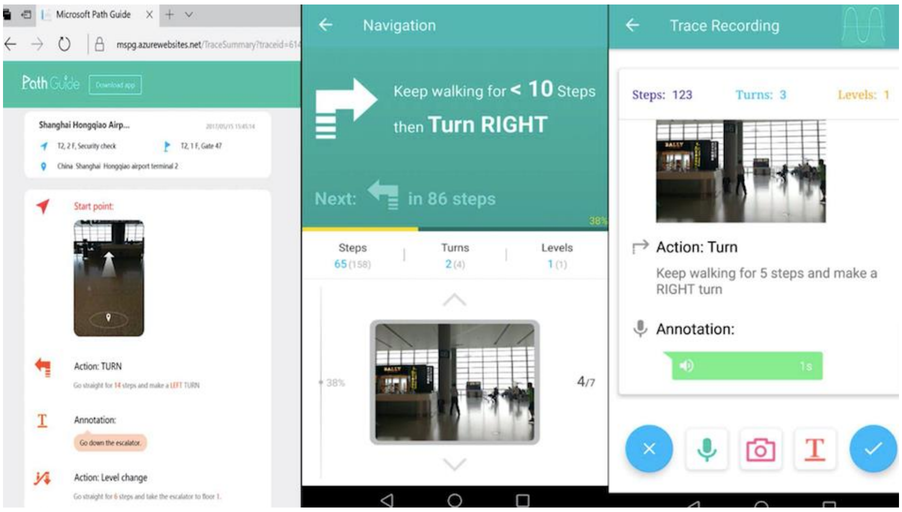


Figure 2.1.1-2 Trace route with text and annotation.

In conclusion, the benefits of the **Microsoft Path Guide** indoor navigation system are as below:

1) The system is complete plug-and-play and can be used in any indoor building.
2) Does not require any other additional equipment or map.
3) All recorded routes are stored in cloud, user experience will increase if the stored routes increase.

2.1.2 Google Map

Google Map is one of the most popular navigation apps in the market. To ensure that the information about the real world around us is accurate and up-to-date, Google Maps constantly rake in huge amounts of data from diverse sources. So, Google Map is one of the most reliable navigation application on the market. Google Map is a versatile mapping and navigation app, no matter whether you are a pedestrian, cyclist or driver, you can use google map to navigate to your destination and also estimate the arrival time based on the transportation you are using.

Finding a route to reach a destination can be intimidating using normal navigation apps. Google map has a Life View function (Figure 2.1.2-1) which is an AR technology, Follow the on-screen instructions to help Google Maps find your location, and once it knows where you are, you'll get directions through the camera view on your screen.

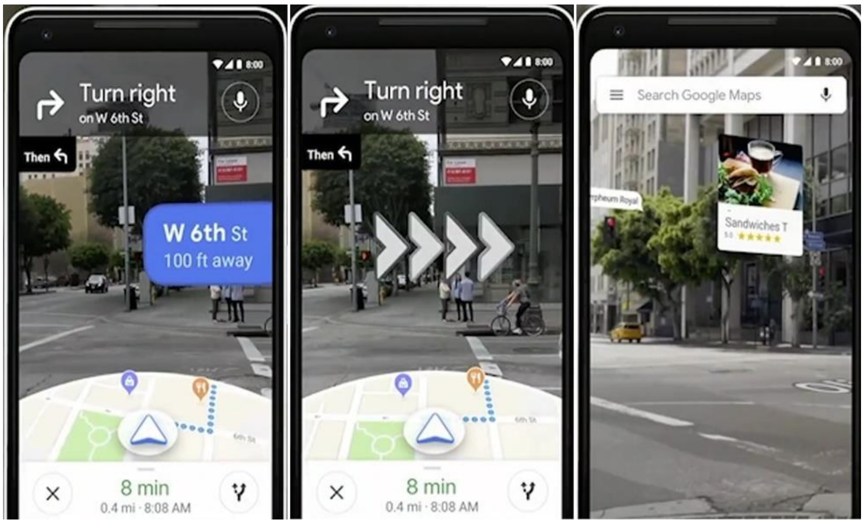


Figure 2.1.2-1 Google Map AR navigation

Google Map is now working on an immersive intuitive map that reimagines how people explore and navigate. To create these true-to-life scenes, Google use neural radiance fields (NeRF), a type of AI technique which will transforms ordinary pictures into 3D representations. With NeRF, Google recreate the full context of a place including its lighting, the texture of materials and what's in the background [6].

Augmented reality can be especially helpful when navigating tricky places, like an unfamiliar airport. In 2021, Google had introduced indoor Live View in the U.S., Zurich and Tokyo to help with just that (Figure 2.1.4). It uses AR-powered arrows to point you in the right direction so you can quickly find the closest restrooms, lounges, taxi stands, car rentals and more with confidence. As GPS is not reliable to triangulate inside buildings, Google's Street View team collected a vast amount of data using Google's 360° camera backpacks to create a digital twin of the public airport area, which would become the reference model for Google Indoor Live View to work [7].

Now, Google are embarking on the largest expansion of indoor Live View to date, bringing it to more than 1,000 new airports, train stations, and malls.

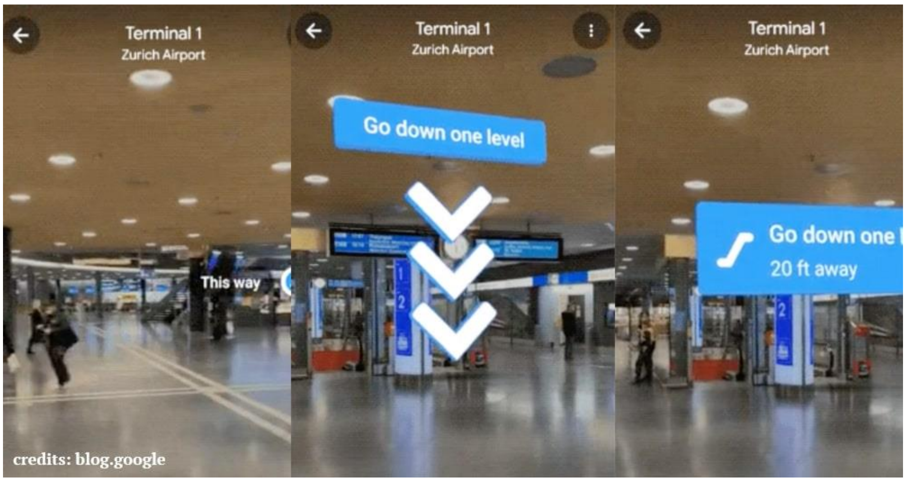


Figure 2.1.2-2: AR Indoor Navigation in Zurich Airport

As conclusion the benefits of **Google Maps** are as below:

1) AR technology is used in outdoor navigation with GPS.
2) Suitable to use for many other transportations such as walking, cycling and driving.
3) Neural radiance fields (NeRF) to transforms ordinary picture into 3D representations, allow user to have an immersive view of a place on the map.

2.1.3 Waze

Waze is one of the top navigation application on today's market. It is one of the largest crowd-sourcing navigation applications in the market, the data collected by the apps included travel times and real-time traffic updates. Moreover, Waze also encourages users to provide mapping information, allowing anyone to add places or correct mistakes on the existing maps. These data collected are used to enhance the accuracy of navigation route, estimation time, road condition and many other features. Thus, majority of the major features of Waze require GPS support and internet connection.

Waze was primarily designed for city driving, so most of the details are poured into populated city areas. GPS navigation only works with an internet connection, but most of the maps are also downloadable offline. Unfortunately, offline maps do not include real-time traffic information. When GPS enabled, Waze can keep up with your real-time location and provide real-time visual instructions. There's also a hands-free guide that involves the app giving you directions through voice-prompts. There's also turn-by-turn guidance so that you won't need to hold on to your phone while driving. The app primarily gives traffic information. The voice navigation function will warn you about roadblocks, road closures, and speed cameras.

Figure 2.1.3-1: Waze function and feature

Furthermore, the app allows you to plan a route towards any inputted direction. It shows you multiple routes and chooses the best route for you. The app chooses the fastest route by default. Some of the fastest route requires to pay toll fee so if you don't agree with its recommendations, you can override its recommendations and select your own. Besides that, Waze will automatically help user to change route when there is other route that is less traffic and will reach to the destination faster(Figure 2.1.5).

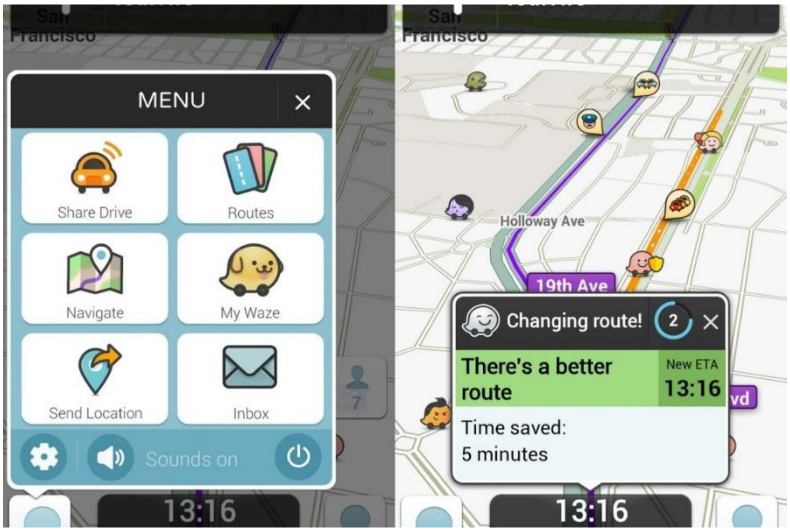


Figure 2.1.3-2: Waze change to a better route halfway

As conclusion the benefits of **Waze** are as below:

1) Automatic choose the fastest route for user to arrive to the destination.
2) Shows real time-traffic information.

3) Collect data from millions of users, keeps the map updated.

2.2 Review on research paper

2.2.1 Design of a Mobile Augmented Reality-based Indoor Navigation System

This article focuses on the development of an indoor navigation system utilizing augmented reality (AR) technology within the campus of Sunway University. The proposed approach leverages the inherent sensors of mobile devices to establish an efficient and cost-effective solution for real-time indoor navigation. By integrating AR technology, the system aims to enhance the overall navigation experience within the university premises.

According to the article, the indoor navigation system consists of three important component which are positioning, wayfinding, and route guidance [8]. Positioning involves determining the user's current location, wayfinding entails identifying the most optimal route from the user's position to a specified destination, and route guidance provides directional instructions that illustrate the chosen navigation path [8].

Furthermore, this article presents several indoor positioning techniques available in the market. Popular methods include GPS, Wi-Fi-based positioning, BLE beacon-based positioning, magnetic-field-based positioning, and vision-based positioning. The table below provides a comparison of these methods based on cost and robustness.

Indoor Position Techniques	**Cost Effectiveness**	**Working Range**	**Robustness**
Beacon-Based positioning	High Cost	10 -20m	• Small and easy to set up. • Design for indoor positioning
GPS	Low Cost	>40m	• Weak signal strength when there are obstacles. • Difficult to determine floor level.
Wi-Fi-based positioning	Low Cost	30-40m	• Uses fingerprint technique to collect Wi-Fi signals is time consuming
Magnetic field signals	Low Cost	2-6m	• Metal elements interference

			• Time consuming for fingerprinting
Vision Based Positioning	Low Cost	Unlimited	• Relative accurate for tracking object in spaces with small dimensions • Affected by light source

Table 2.2.1-1 Indoor positioning technique

In this research, the author uses a fusion of techniques by combining two methods to enhance accuracy. As per the author's explanation, relying solely on GPS signals for indoor positioning is inadequate due to signal blockage by building walls. Similarly, Wi-Fi and BLE beacon signals are will also be interfere by the building structures, while vision-based positioning is impacted by varying light sources [3]. To address these limitations, the author opts for a hybrid approach, combining Wi-Fi and magnetic field signals, resulting in a median accuracy of 1.20 meters. Furthermore, through the fusion of Wi-Fi and magnetic field signals, the system reliably achieves an improved accuracy of 0.836 meters [3].

Pathfinding Technique Name	**Description**
Dijkstra's algorithm	A mature algorithm (greedy algorithm) to find the shortest path between two nodes
A*algorithm	An extension of Dijkstra's algorithm that combines the features of uniform-cost search and pure heuristic search to search for optimal path
Ant Colony Optimization (ACO) algorithm	It replicates the behavior of ants walking in a graph, where the ants will tends to follow the trail that has more pheromones. The Ant Colony Optimization (ACO) algorithm employs a similar strategy to calculate the optimal path.

Table 2.2.1-2 Pathfinding Techniques

A few popular pathfinding techniques were also discussed in this paper. This includes Dijkstra's algorithm, A*algorithm and ACO algorithm. The techniques and explanations will be explained in a table below.

Based on the conducted tests, the ACO algorithm perform a higher accuracy and efficiency in route search compared to the A* algorithm. Although there are instances where the A* algorithm able to identifies shorter paths, the time required for A* is 8 times longer than that of the ACO algorithm [8]. Consequently, the ACO algorithm proves to be more suitable for indoor pathfinding.

The development of the mobile application is carried out in Android Studio, integrating both the IndoorAtlas Android SDK and ARCore Android SDK. For efficient database management, the application employs a local SQLite database to store comprehensive venue information. The architectural design of the application is visually represented in Figure 2.1.

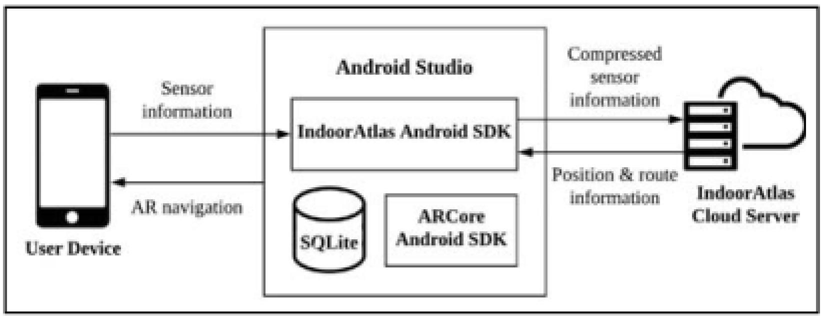


Figure 2.2.1-1 Architecture Diagram

The user interface and design are crafted using Android Studio. Pertinent details of Sunway University's venues, such as name, category, and floor level, are stored in the database. The IndoorAtlas SDK facilitates indoor positioning, with Sunway University's floor plans uploaded to the IndoorAtlas web application. Subsequently, points of interest are incorporated into the floor plan, as depicted in Figure 2.2.

Figure 2.2.1-2 Adding point of interest.

After that is fingerprinting process, the device's sensors undergo calibration, requiring physical movement across Sunway University campus to gather location information, including magnetic field and Wi-Fi signals within the buildings [8]. The collected data is then stored in the cloud, and a signals map is generated for computing the user's position.

After selecting a destination in the mobile application, the user's current position will be detected, and a route will be established to the venue. After successfully computing the route, an Augmented Reality (AR) robot guide is superimposed on the camera view, instructing the user to follow its navigation. The robot guide dynamically moves and turns in alignment with the route, utilizing the variance between the current device heading and the heading of the next node [8]. Upon reaching the destination, a prompt dialog informs the user of their arrival.

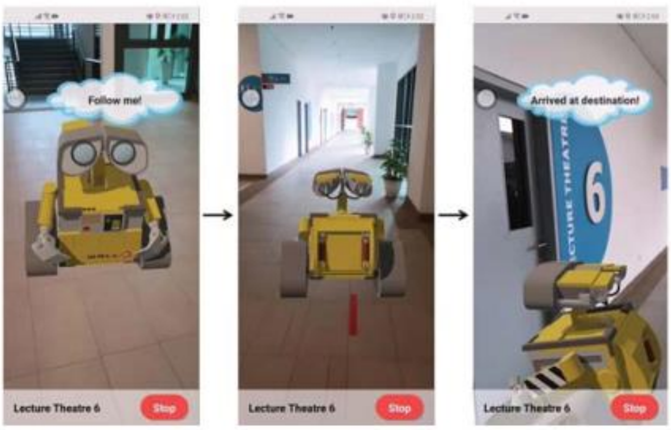


Figure 2.3.1-3 AR navigation

2.3 Limitation of Previous Studies

Crowd-Sourcing navigation system.

Both Microsoft Path Guide and Waze are crowd-sourcing navigation systems which they collect user data and used it to improve their system accuracy. This could be a benefit to a system if the number of user is large enough, the data collected can be used to provide more information to the other users. Microsoft Path Guide needs users to record an indoor route and upload to the cloud database so that the other users able to search for the route. Look on the other perspective, this could be a limitation if the number of users is less, then the most route in an indoor building will not be found.

Not suitable for indoor navigation.

Both Google Map and Waze use GPS as their main technology to allow people to navigate in the outdoor. GPS signal can be known as a mature technology in navigation system, but GPS cannot be worked indoor because the signal could be blocked by the walls and roof of the indoor building.

Need to collect vast amounts of data.

To implement an indoor navigation application in an airport, Google Live View collected a vast amount of data using Google's 360° camera backpacks. Which I think is a limitation, because there is a lot of data need to be collected if the indoor building is too large.

Limited to same floor navigation only

The application that was developed in the article is only designed for floor level navigation only. The navigation system cannot create route that needs to go up a stairs or escalator.

To conclude things up a table is made to make a comparison between the strength and weakness of the application reviewed.

Application	**Strength**	**Weakness**
Microsoft Path Guide	It is complete plug-and-play, can be use in any indoor building and do not need any maps or additional equipment. AR technology is used to	Crowd-sourcing navigation system, need large amount of user to record down the indoor

	superimpose digital information onto the real world.	path for others to use. Some route might not be found if there is no “leader” to record down first.
Google Map	Neural radiance fields (NeRF) to transforms ordinary picture into 3D representations. AR technology is used to superimpose digital information onto the real world. Can be used with any transportation such as walking, cycling, and driving.	Without GPS signal, Google had to collect a vast amount of data about the information inside the indoor building, this could be a tedious job if the people who want to develop an app does not have a large team behind.
Waze	One of the best outdoor navigation applications, uses GPS signal and data collected from user to estimate the arrival time and display traffic info on the map, moreover it can automatically choose the fastest route for user based on the traffic condition.	Did not use AR in their navigation system. This app is only suitable for driving only and don’t have the function on pedestrian navigation.

Table 2.3 Strength and weakness of application review

2.4 Proposed Solutions

This project aims to propose an AR indoor navigation application in Faculty of Information System UTAR Kampar. This project mainly focusses on helping student in finding their destination easily with the help of immersive vision of AR technology. With this application, new intake students able to go to their class or finding lecturer's office with ease.

Based on the weakness and limitations of the existing application, we can see that GPS signal is the best solution for outdoor navigation. But this is not the case for indoor navigation, as the signal will be block by the roofs and walls of the indoor buildings, hence marker-based positioning techniques is proposed in this project. This method aims to localize an entity by scanning a distinct marker such as QR codes, images, or objects in the indoor environment to estimate the entity's position. Marker-based positioning is a cost-effective method because it does not require any another hardware, just a smartphone is enough. The users need to scan a nearby QR code to identify their current location, this will act as a starting point of the navigation. Afterwards, user need to choose a location as the designated destination, navigation will start, and an AR line renderer will display onscreen to guide the user.

	Microsoft Path Guide	Google Map	Waze	FICT indoor Navigation Mobile app
AR tech	Yes	Yes	No	Yes
Indoor Navigation	Path needs to record by other user and shared to the cloud database	Still developing on the indoor navigation, still mainly focus on outdoor navigation	Only applicable for outdoor navigation using GPS technology	Yes, QR code is used to locate user's current location
Notable Features	Non applicable	Can be used with any transportation such as walking, cycling, and driving.	Will change the route according to the traffic conditions	• A Mipmap on top to let user have different a view. • Choose the shortest Path. • AR line renderer and navigate instructions. • A virtual map of the building

Table 2.4 Comparison between others application

Chapter 3

System Methodology/Approach OR System Model

3.1 System Methodology

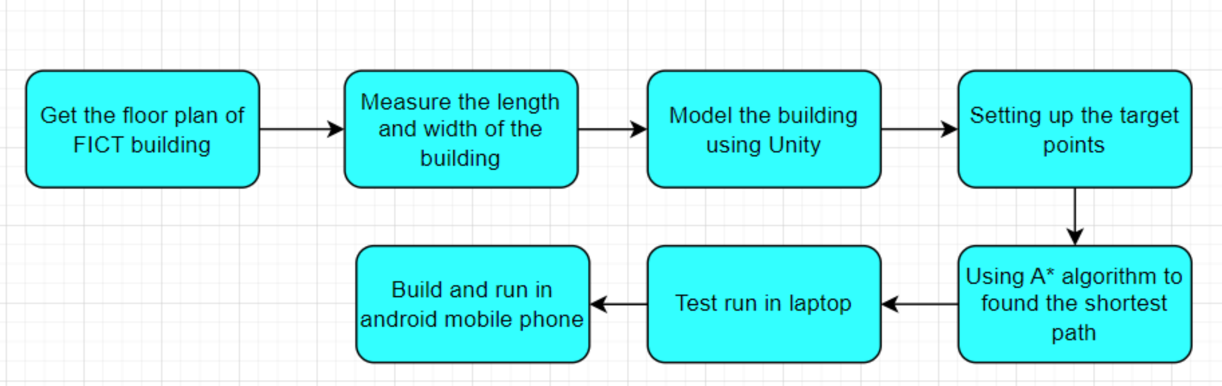


Figure 3.1 Developing flow of the project.

First and foremost, set up the Unity editor working environment into android platform. Then a FICT building floor plan is get from UTAR official website to start the virtual modelling of the building. The width and length of the building is measured by using Meesure app. By walking through the building while opening the app, an approximate width and length of the building can be determined easily. After that modelling of the building can be started by using the walls in Unity. After finish modelling the building, a few target points are set. A build in function in Unity known as NavMesh is used to calculate the shortest path. After setting up everything, a prototype is run on the laptop first before building it into android device.

3.2 System Requirement

3.2.1 Hardware

The hardware involved in this project is laptop and android mobile device. A laptop is used to design the mobile application and implement AR technology. A mobile device is used for testing and deploying this AR application in FICT building.

Description	**Specifications**
Model	Asus Vivo Book
Processor	Intel(R) Core(TM) i7-1065G7 CPU @ 1.30GHz 1.50 GHz

Operating System	Windows 11
Graphic	NVIDIA GeForce MX330
Memory	20GB
Storage	476GB

Table 3.2.1 Specifications of laptop

3.2.2 Software/Technologies used.

Software/Technologies name	**Description**
Unity Editor	Unity Editor will be the main platform to build this mobile application. It is used to model the indoor building, running simulations before build, and run in the mobile phone
Visual Studio	The main IDE used to write the script for this project, it can integrate well with unity editor. All the scripting such as set navigation target, finding the path will be using visual studio and attach it into unity editor.
ARCore	A plugin that must be download in the mobile android device to use AR function.
Meesure: Measuring by moving	Used to measure the length and width of a premise easily

Chapter 4

System Design

4.1 System Design Diagram

4.1.1 Flowchart

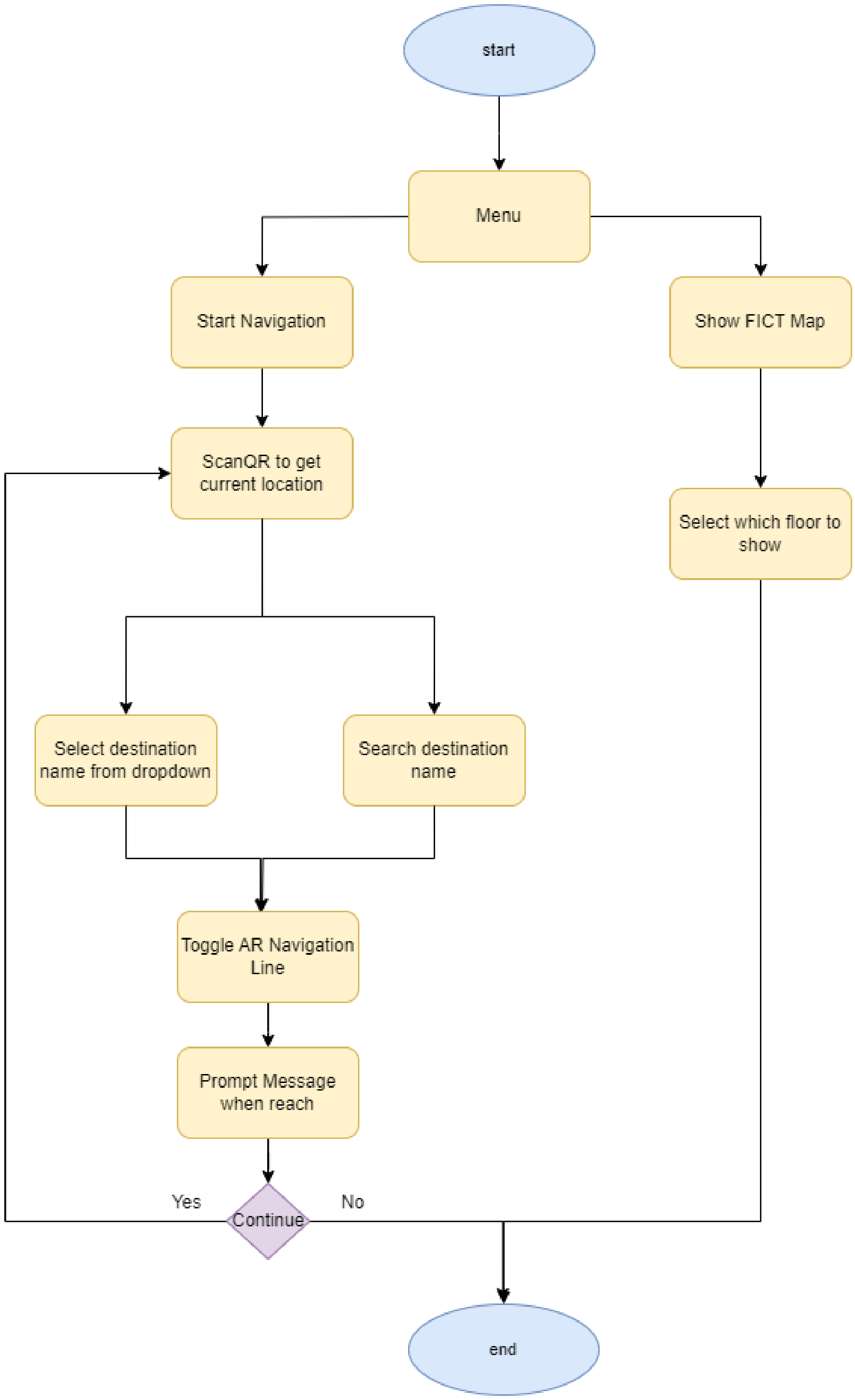


Figure 4.1.1 Flowchart

After Starting the app, user can choose to navigate straight away or choose to get a lay of the land of the FICT indoor map before starting to navigate. Going into the navigation screen, user needs to toggle the scanner frame to scan the QR code and determine their current location in the building. After the current location is determined, user can choose which destination they wanted to go by scrolling the dropdown box or searching the name of the location such as "N003" directly. An AR guiding path will appear on the screen right after user choose their destination. This guiding path will overlay directional arrows into the real-world view through user's smartphone camera. User can also choose to toggle on or off the guiding path, as there will be also a mini map on top right of the screen to let user have another view on their current location. Once user reach the destination, the guiding path will disappear, and a message will be prompt to tell user the destination is reached. User can now choose to continue navigating by scanning the QR code or choose to end the program.

If the user chooses to have a look on the FICT indoor map, then they can choose either to view the first floor or the second floor one. After that user can choose to go back to the menu screen or start navigating.

4.1.2 Architecture Diagram

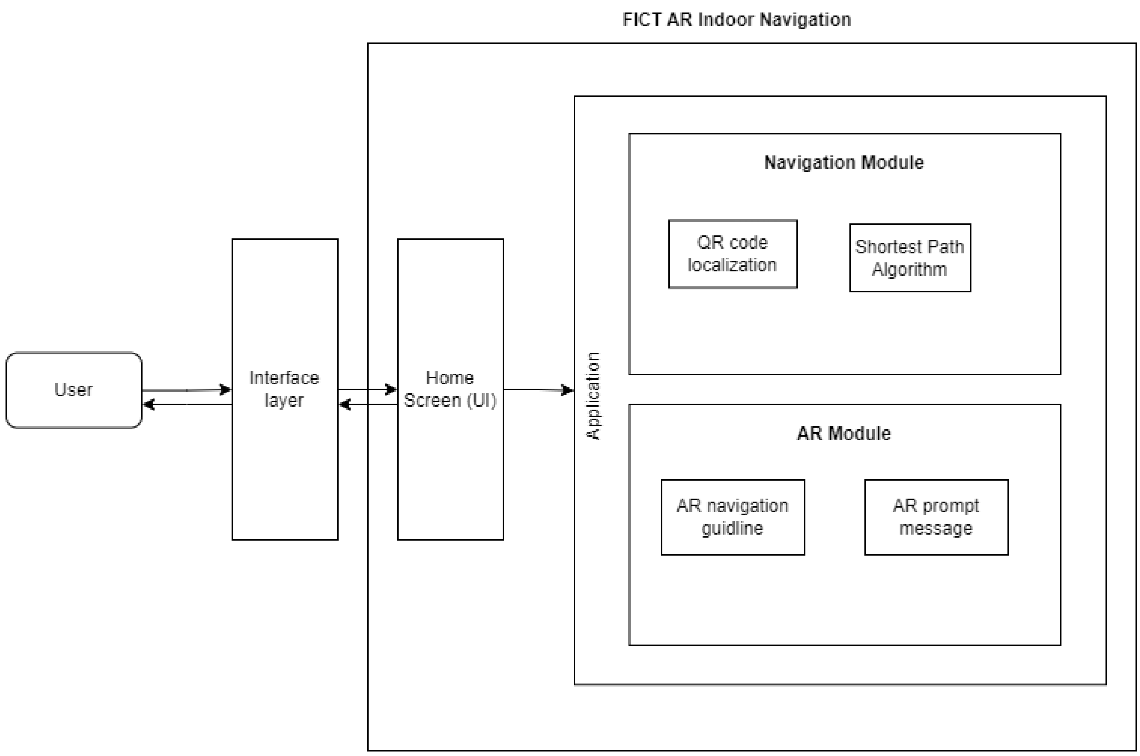


Figure 4.1.2 Architecture Diagram

This whole application consists of mainly 2 module which is the “Navigation Module” and “AR Module”.

Navigation Module

This is the main module for the application. In this module user can user QR Code to determine their current location. Upon scanning the scanner will decodes the QR code and retrieve the embedded location data such as the name of the target location, this method is known as QR code localization. FICT indoor map is built into a model and A* algorithm is used to find the shortest path, it will calculate all the possible routes when user select a destination from a starting point, the shortest path is display to the user on the screen.

AR Module

This module will overlay the digital information into the real-world surroundings and provide user a more immersive view. A navigation guideline will display into the real-world surroundings through the smartphone cameras providing user navigation assistance.

Both two modules need to integrate to successfully build an AR indoor navigation application which will provide more immersive view and more user friendly.

4.1.3 Use Case Diagram

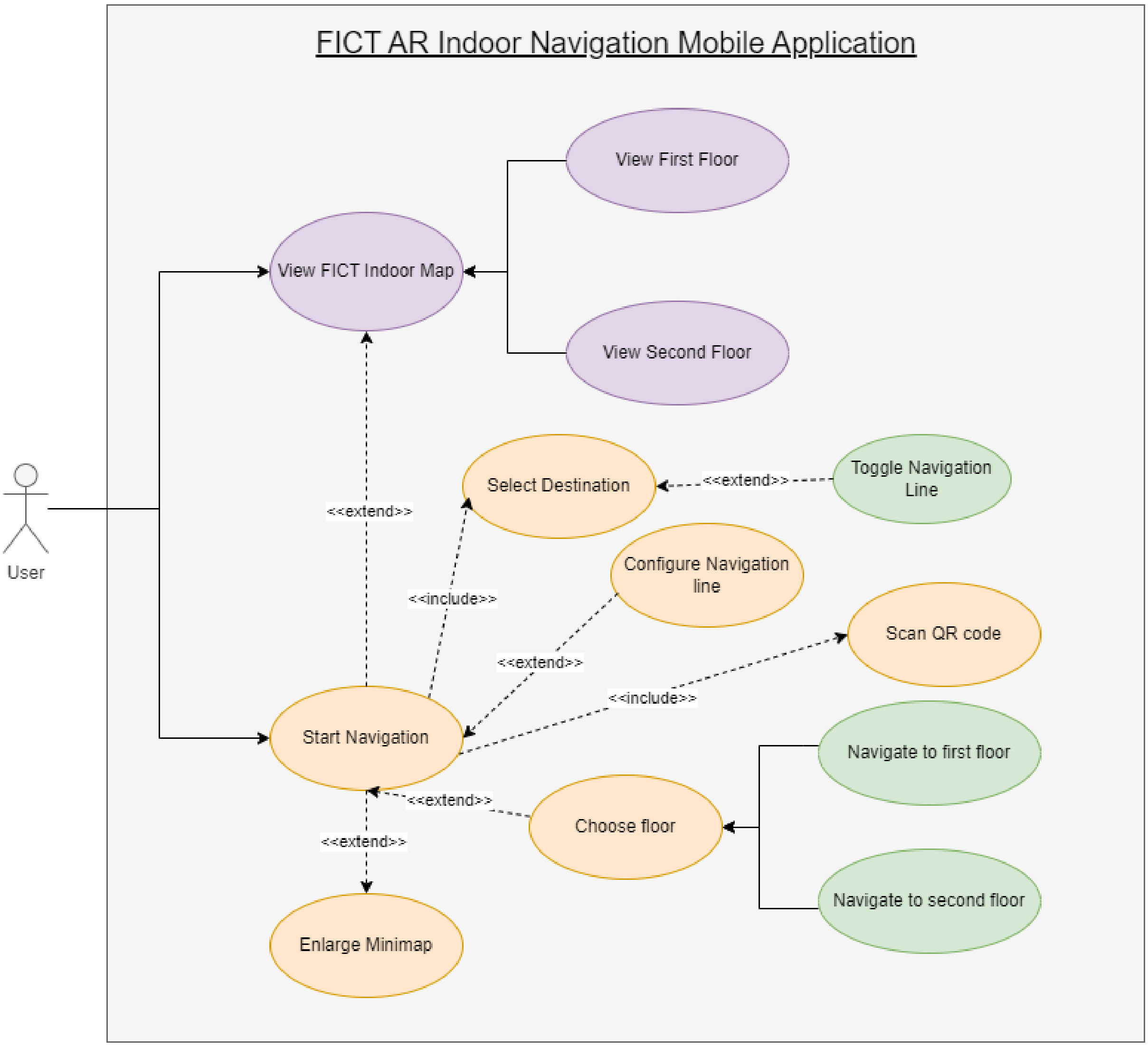


Figure 4.1.3 Figure 4.1.3

Figure 4.1.3 is the use case diagram where shows how user can interact with the system. User can interact with the system mainly in two ways, which is view the FICT Indoor Map and start the navigation straight away. User can choose to view the first floor or second floor of the indoor map in the "view indoor map" scene.

Inside the navigating screen, user have 4 option to choose, "Select Destination", "Navigation line settings", "Scan QR" and "Choose floor". To navigate to the destination successfully, user need to scan the QR, and then select the destination name they intend to go. During navigation, user can also try to change the settings of the navigation line such as the line height and the line type. If user cannot find a certain room in the floor, then user may need to select the change floor button to navigate to the second floor or vice versa. Moreover, user can also press the mini map to enlarge it to have a better look on the navigation route.

4.1.4 Activity Diagram

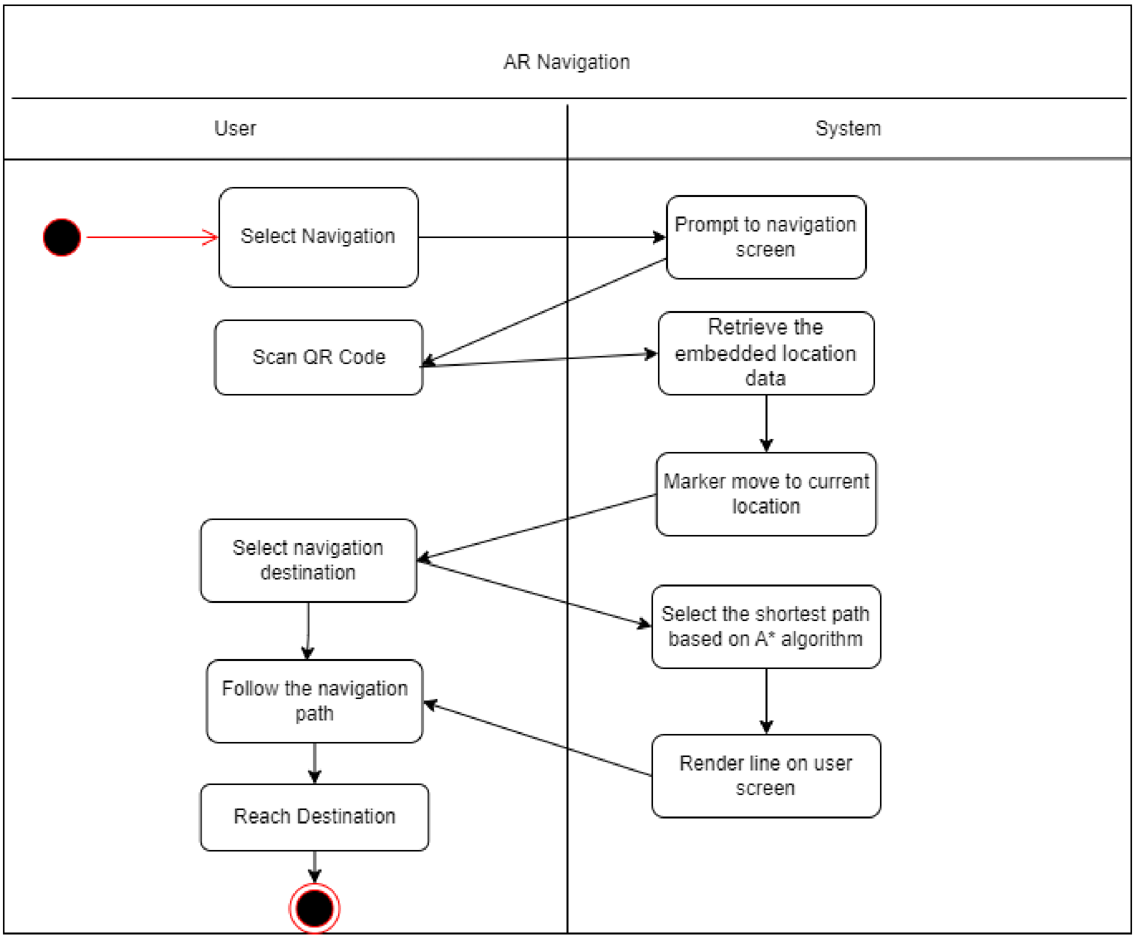


Figure 4.1.4-1 AR Navigation Activity Diagram

Figure 4.1.4-1 shows the activity flow of the navigating module. User need to first Scan the QR code of the location, the system will retrieve the embedded location data and the marker will move to the current location in the map. User can now select the navigation destination. The system will automatically provide user the shortest path based on the A* algorithm. The navigation path will be appeared on user's screen for immersive view. User follow the path until the destination is reached.

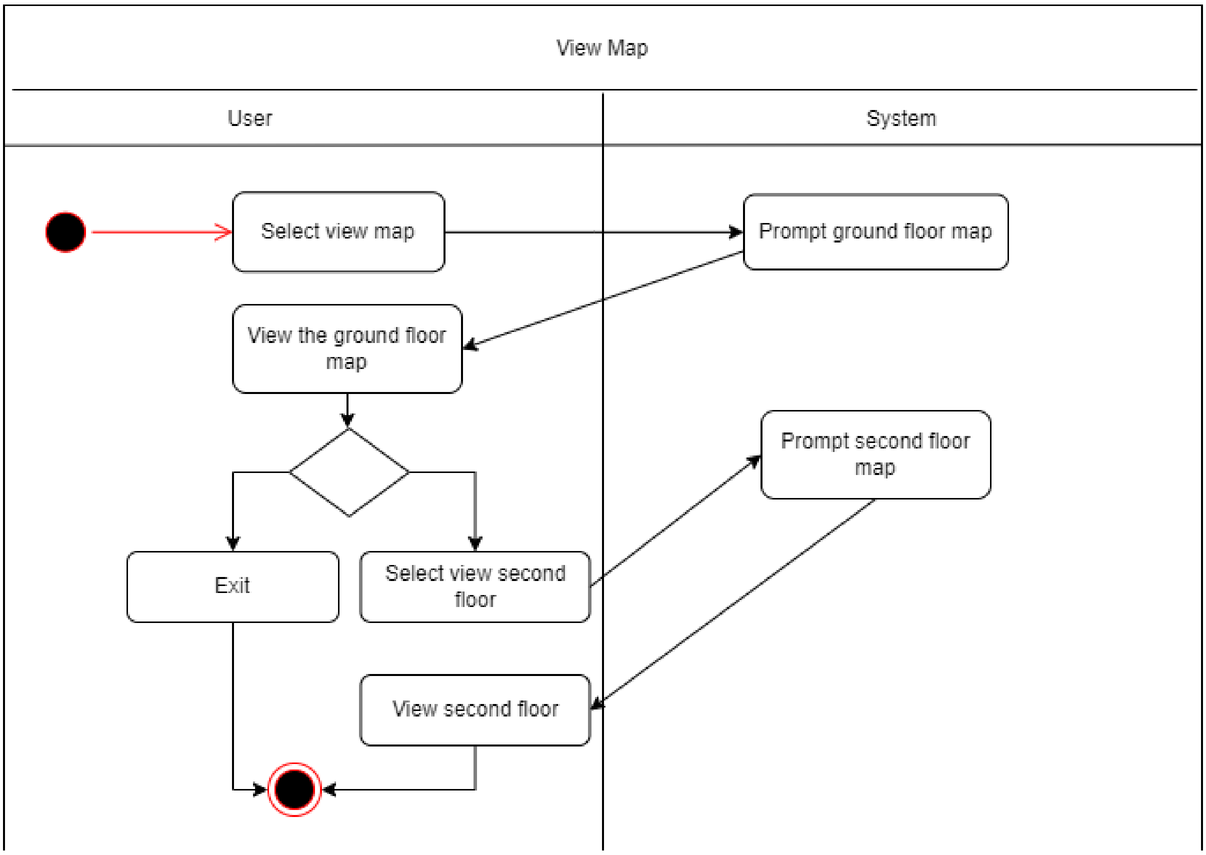


Figure 4.1.4-2 View Map Activity Diagram

Figure 4.1.4-2 shows the activity diagram for user choosing to have a view on the FICT indoor map. The first floor will be shown by default from the system and then user can choose to view the second floor of the indoor map by selecting it in the menu. This is to let user to have a better view on the FICT indoor map, so that they can briefly understand where their destination is before start navigating.

Chapter 5

System Implementation

5.1 Project Environment Setup

5.1.1 Unity Setup for developing AR applications.

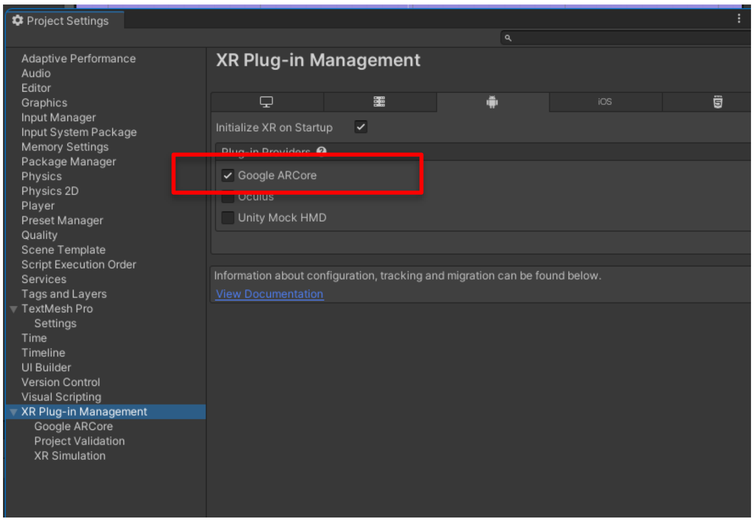


Figure 5.1.1-1 Enabling GoogleARCore

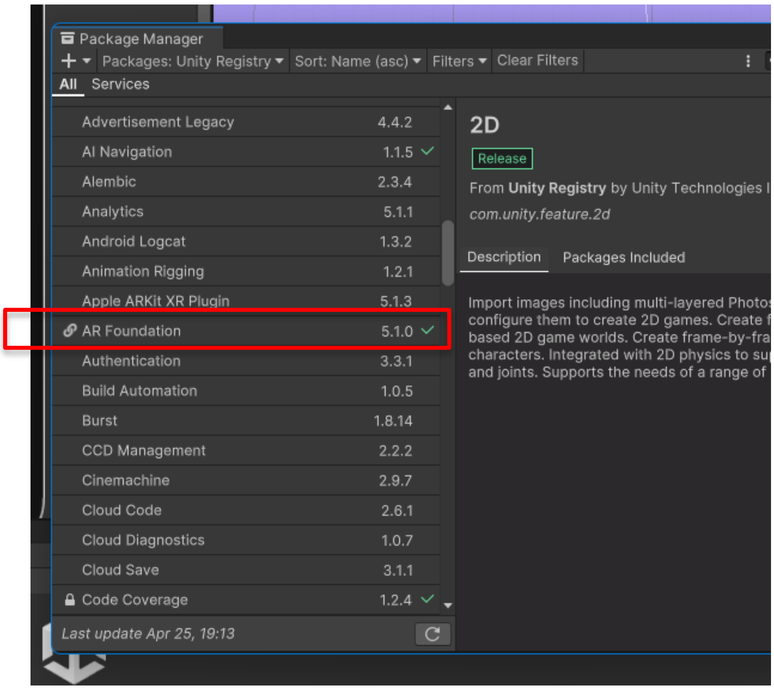


Figure 5.1.1-2 Download AR Foundation Package

Unity will be used as the main platform to develop this system. A few necessary setups are needed to build an AR application. Google ARCore plugin and AR Foundation package had to ready in the unity platform to start developing the AR indoor navigation system. Below are the details:

Go to edit >> project settings >> XR plug-in Management to tick the GoogleARCore

Window >> package manager >>Unity Registry to download the AR Foundation

5.1.2 Modelling building of FICT

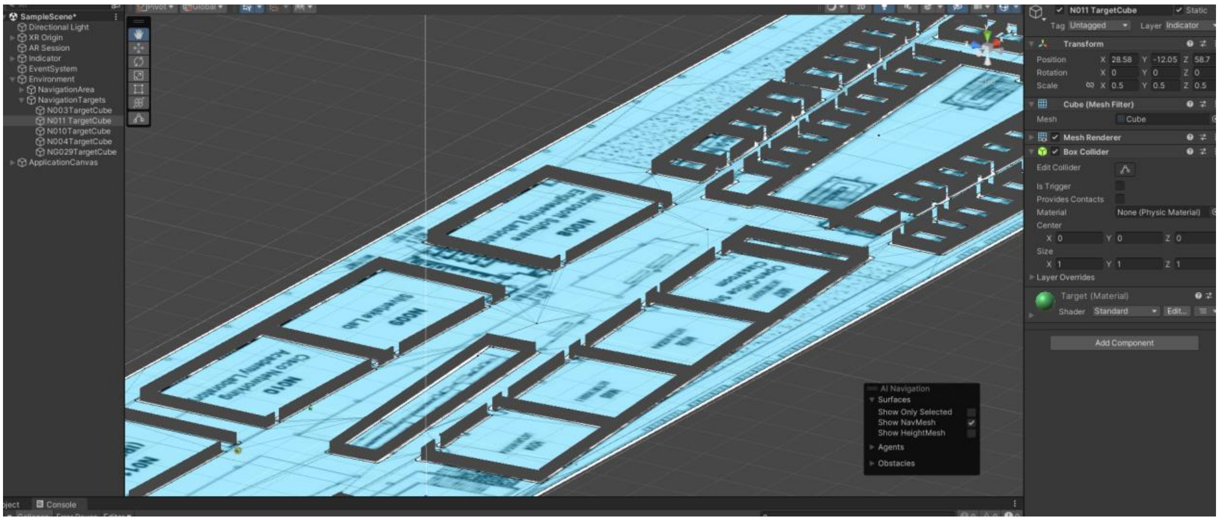


Figure 5.1.2 Model of FICT

After finish setting up the unity platform, a model of FICT building is built. Firstly, a floor plan is used as guidance to build up the walls on it. A cube game object in unity is used to create the walls one by one. After setting up the building, using the NavMesh function to calculate the walkable path in the map, the wall in the model is set as an obstacle so that the navigation line will not pass through the walls.

5.1.3 Setting up target location

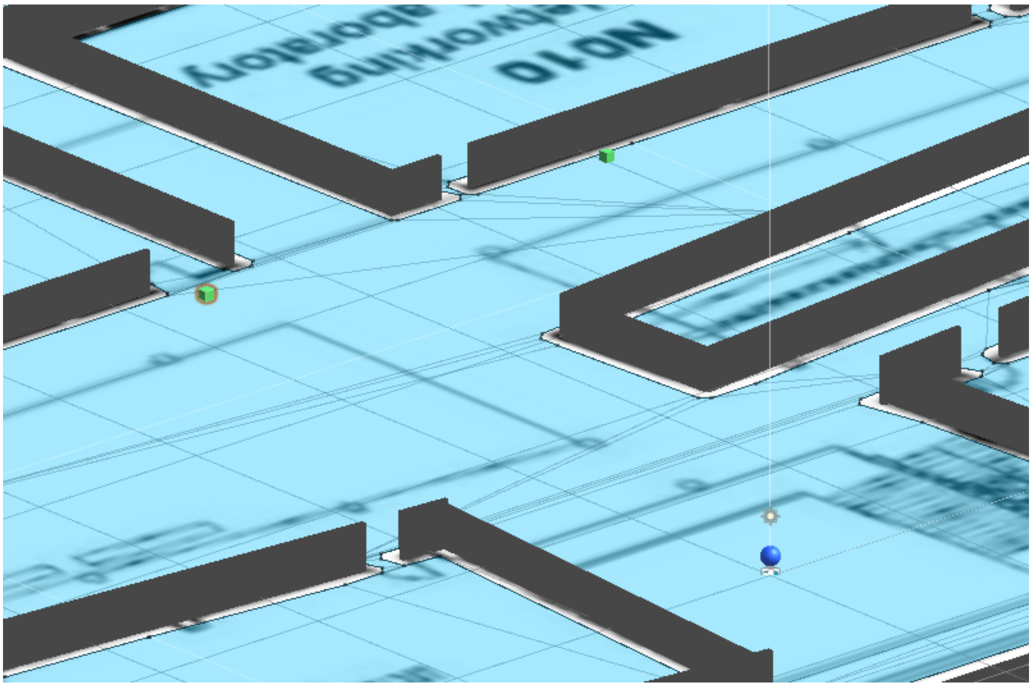


Figure 5.1.3 Indicator and target location

The green block is the target location then user can navigate to, while the blue sphere is the indicator. The indicator will be placed in the origin of the map which has the coordinate of (0,0), this will act as a starting point of the navigation. An AR camera will be placed in the component of the indicator so that it is able to capture the surroundings of and overlay a navigation path to the environment. Besides that, a top-down camera is place on top of the indicator, so a mipmap can be formed to show user an alternative view.

5.1.4 ZXing.Net Library

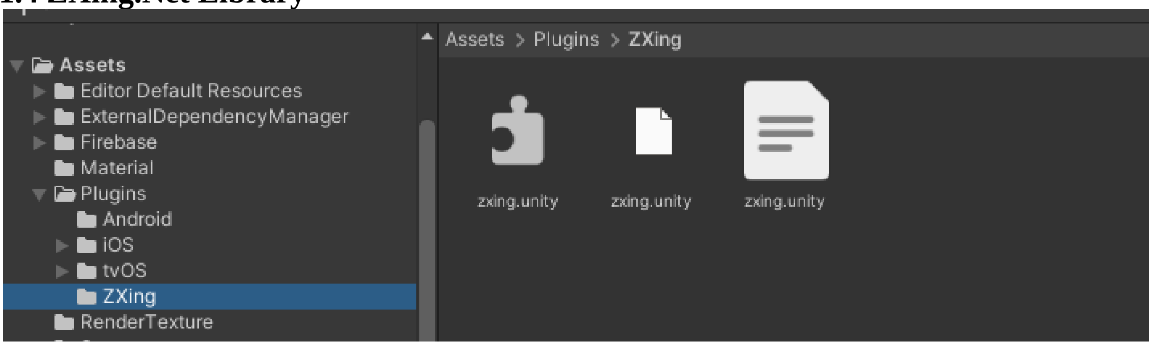


Figure 5.1.4 Zxing.Net Library plugin

Zxing.Net Library is a free open-source library which supports decoding and generating of barcodes. QR code decoding will allows the application to interpret the data encoded within a scanned QR code. This library is import to the project as a plugin to allow QR code scanning for localization later.

5.1.5 QR Code Generator

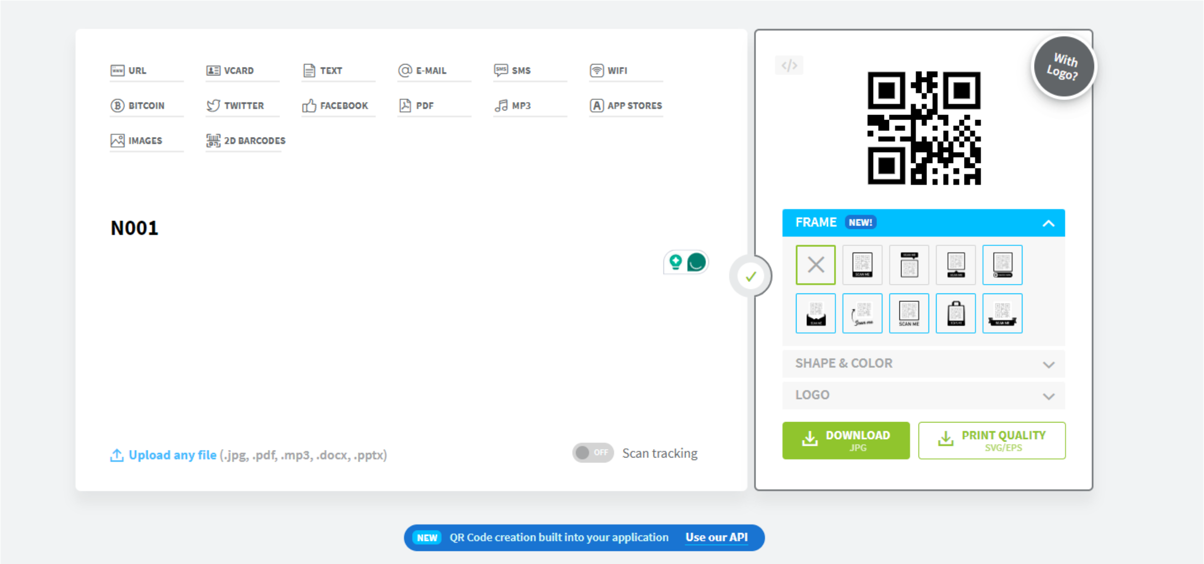


Figure 5.1.5 Generating the QR code

Use a free QR code generator website to generate the QR code for localization later. The name of the QR code is used to track back the location in the unity map, so the name place while generating the code must be the same with the one inside the Unity project so that the system is able track the correct information while scanning.

5.2 Software Setup

5.2.1 Linkage between software

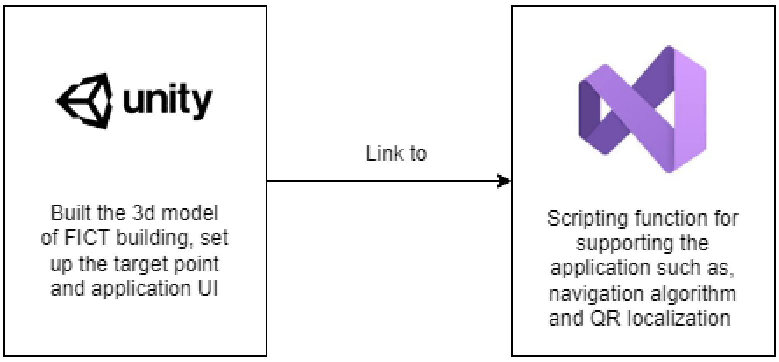


Figure 5.2.1 Relationship among software

Visual Studio 2019 is required to be linked with Unity for scripting the functions of the applications. The steps for linking the Unity and Visual Studio 2019 are as follow:

1. **Open Unity Editor**
2. **Go to Edit > Preferences > External Tools**
3. **Set the External Script Editor as Visual Studio 2019**

5.2.2 ARCore

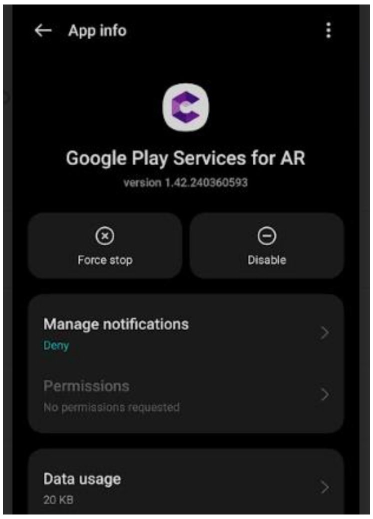


Figure 5.2.2 Google Play Service for AR

ARCore or also known as Google play service for AR is a built-in application for most of the android phone. ARCore is needed for the navigation line to display over the real-world object. Oppo Reno 7z 5G with the ARCore installed is used to test run the application built.

5.3 System Operation (with Screenshot)

5.3.1 Home Page

Figure 5.3.1 Home Page

Figure 5.3.1 shows a simple menu implemented in this system as this application is made focus on the group of new intake students of UTAR. The intention of this app is to allow new intake students to navigate to their destination in the shortest and easiest way, so there is no need for user to sign up and login in this application. Moreover, there is no need of student's data to keep in this application because the main function of this application is just indoor navigation. In the main menu page, user have two options which is to start the navigation straight away or have a detail look on the FICT map.

5.3.2 Navigation Home Screen

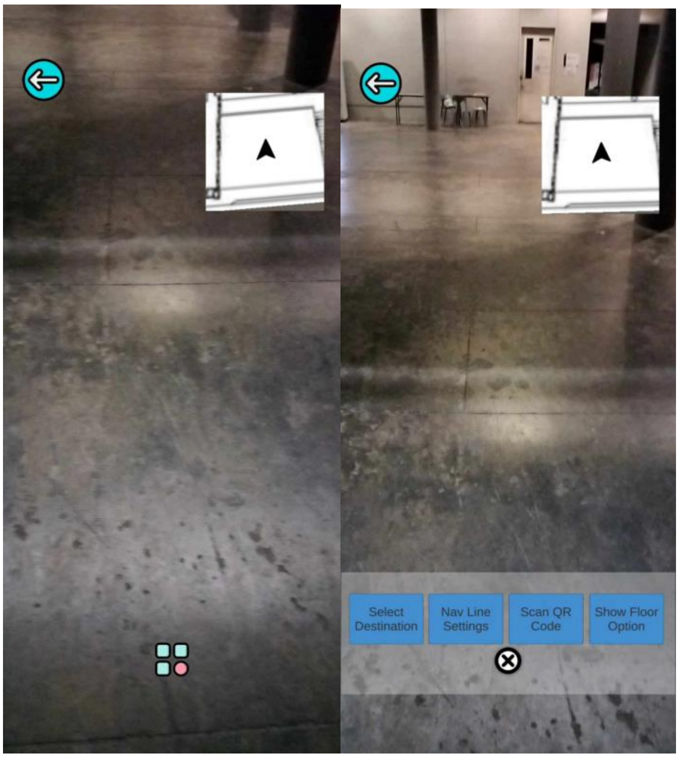


Figure 5.3.2 Navigation screen and Menu

Figure 5.3.2 shows the Navigation screen when user first starts the navigation session. There is a menu button below of the screen, inside the panel of the menu button, it consists of different functions that will help users to navigate to his/her destination. There are four functions inside the menu which are “Select Destination” , “Nav Line Settings”, “Scan QR Code”, and show “Floor Option”.

5.3.3 Scan QR Code for localization

Figure 5.3.3 Scanning N003 QR Code

Figure 5.3.3 shows a demo when user press the “Scan QR code” button, a frame will appear on the screen. Fit the location’s QR code into the frame then it will scan it. After successfully scanned, the marker in the mini map will immediately change its position to N001. This is how the indoor localization by QR code works. Improving from FYP1, QR code scanner is only toggle out when user wants to scan QR code, this is to prevent the mobile phone from capturing image non-stop so that the app will no lag due to insufficient cache memory.

5.3.4 Choose destination and start navigating.

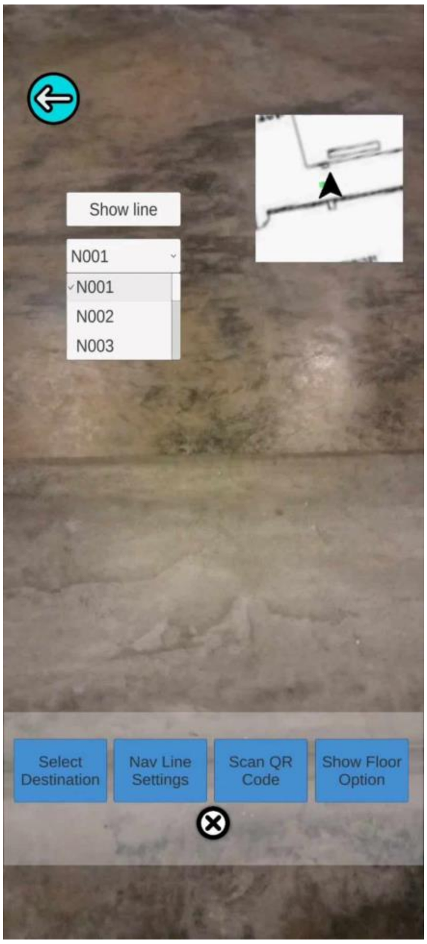


Figure 5.3.4-1 Choosing the destination after postioning

Figure 5.3.4-2 Start navigating

User can now select the destination they want to navigate to after determining their current position in the building. Clicking the “Select Destination” button in the menu panel will prompt two buttons on the top left which is “show line” and a drop-down list of locations. User can now choose their desire destination and press show line to toggle the AR navigation line on the screen. The system allow user to hide the line is to prevent it from blocking the user’s vision when choosing the destination.

5.3.4 Choose Floor Option

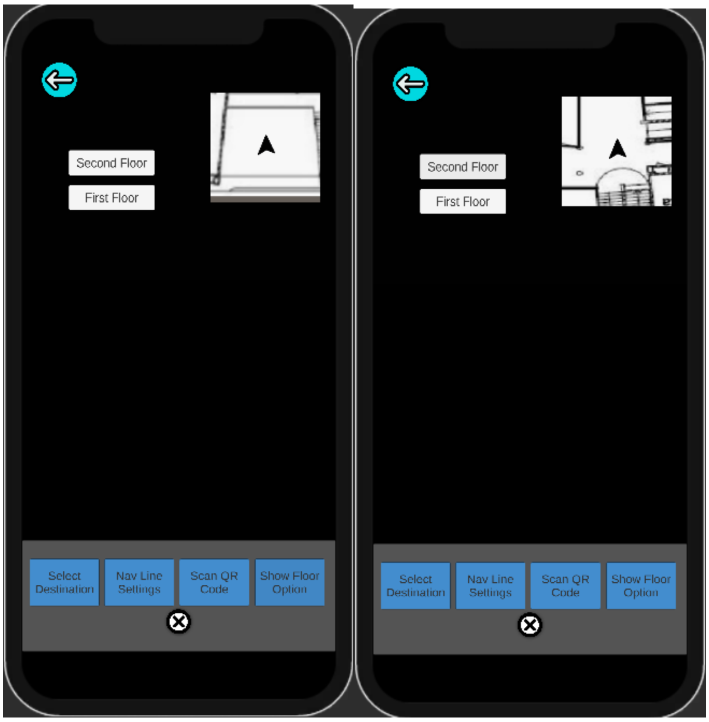


Figure5.3.4 Choose different level

To navigate from first floor to the second floor or vice versa, user had to manually toggle the “Select Floor Option” to prompt “Second Floor” and “First Floor” button. Whenever user toggle to the second floor, the destination drop-down list will also change to all the destination available in second floor. User can try to toggle to the second floor if cannot find the desire destination in the first floor.

5.3.5 Mini Map Enlargement

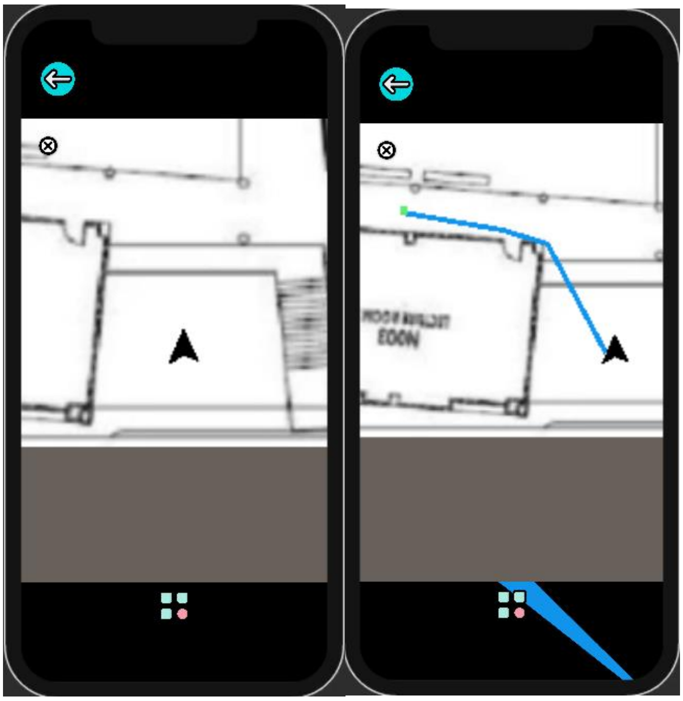


Figure5.3.5 Enlarge mini map

User can click the mini map on the top right corner to enlarge it. This expanded view provides a clearer understanding of the overall building layout, the navigation route, and their current location within a broader context and have a bigger view on where the navigation line is leading them to. Users can pan and zoom around the map to explore the surrounding areas. This lets them identify nearby points of interest (POIs) like restrooms and staircase enhancing their spatial awareness within the building.

5.3.6 Toggle height

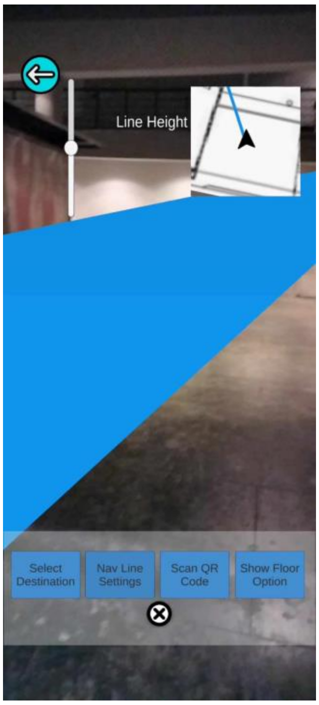


Figure5.5.6 Line blocking user vision

Figure 5.3.6 shows the example of the navigation line blocking the user visions. Sometimes due to some bug the AR navigation line will block the user vision, so a toggle bar that can adjust the height of the navigation is very helpful. It can lower the line when it is blocking and adjust higher when user cannot see the line.

Chapter 6

System Testing and Performance Metrics

6.1 System Testing

To ensure the system functions correctly before release, system testing is needed to discover the flaws and bugs in the code. Component testing is the method used to test out the feasibility of the application. Component testing is a type of software testing in which the testing is performed on each individual component separately without integrating with other components. This technique is used to test the lowest or smallest unit in the application, each of the unit will pass as an input and the output must match with the expected output, if both are matched then the test is considered as pass.

Firstly, each component in a screen is tested individually to ensure that every component is working fine. For example, there are a few buttons in the navigation page of this application, each function of the button is test separately by clicking it and observe the output, it is considering pass if output and the expected output matched. Furthermore, a few test cases have been prepared to test the functionalities of the system build.

6.2 Testing setups and testing results

6.2.1 Component Testing

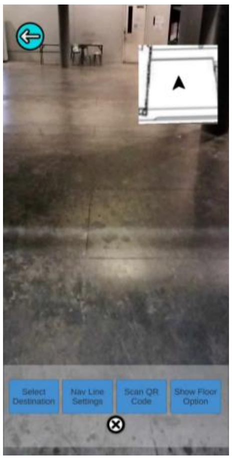


Figure 6.2 Testing

An android device (Oppo Reno 7z 5G) is used to run and test the application. Each of the button in the screen will be test one by one. The test result is shown below:

Inputs	Expected output	Pass
User press back button	Back to home page	Yes
User press “Select Destination” button	Prompt “show line” button and destination drop-down list	Yes
User select destination such as “N001” in the drop-down list.	Navigation line will direct to the location	Yes
User press “show line” button	AR navigation line will be shown on the screen	Yes
User press “Nav line settings” button	Prompt a toggle bar to allow user to adjust the height	Yes
User press “Scan QR Code” button	A QR scanner will appear on the screen	Yes
Scan the QR code with scanner	Navigation indicator will move to the location based on the QR code	Yes
User press “Show floor option” button	Prompt “First Floor” and “Second Floor” button	Yes
User press “First Floor” button	Navigation indicator move to first floor	Yes
User press “Second Floor” button	Navigation indicator move to second floor	Yes
User press the mini map	Mini map enlarges	Yes

Table 6.2 Component test results

After testing, all the outputs of the components are match with the expected output, we can conclude that each of the component are able to work fine individually without any integration within each other.

6.2.2 Test Cases

To further test on the application, a few test cases based on the real-life situation is used to simulate the real situation when user is using this application. The test cases and the result are shown below. T for test cases, S for solution or recommendation.

1) T: User start the application at the main entrance
   S: User do not need to scan QR code for localization as the default starting point in this application is the main entrance of FICT. But, scanning the QR code is recommended for better accuracy performance.

2) T: User start the navigation other than the main entrance
   S: User need to open scanner to scan the nearby QR code to get their current location

3) T: The destination drop-down list will only show all the destination that belongs to the same floor.
   S: User need to try to choose the other floor if they cannot find their desire destination in the current floor.

4) T: User scan the QR code from the second floor
   S: As mentioned above the default starting point of the application is the first-floor main entrance, so when user start up the application in the second floor and scan the QR code the navigation indicator will change its position and the location in the destination drop-down list will also change, do not need to press "second floor" button again.

6.3 Project Challenges

There are a few issues and challenges faced while developing this project. Below are some of the major challenges during the implementation of this project.

Measuring and Scaling problem

The building of FICT is too large for us to measure manually using a ruler so an approximate scale is used to model the building in Unity at the beginning of this development. But the accuracy of the navigation is extremely low using this method. The navigation line is totally out of scale and cannot guide the user correctly. This issue is solved by using a virtual measuring app known as Meesure, length and width can be calculated easily by opening this app while walking through the indoor building.

6.4 Objectives Evaluation

Objective 1: To develop an indoor navigation mobile application for students in FICT.

Aligned with the project title, the mobile application is created to help students to navigate through the indoor building of Faculty of Information and Communication Technology. With the help of a build in component in Unity Editor known as Nav Mesh the navigation line can avoid all the obstacles build in the model and successfully navigate to the destination. A* path finding algorithm is also used to find the shortest path before the navigation starts. As sum, this application can guide students to their respective destination, but in terms of accuracy it might be a bit low due to lack of modelling and positioning techniques.

Objective 2: To implement AR technology into the application for immersive view.

With the help of Google ARCore plugin and AR Foundation package, an AR technology can successfully build and implement into the application using Unity Editor. The AR technology is used in the navigation line that will guide user to their destination. Although the coordination of the line will be off sometimes, but implementing a height adjustment for the navigation line helps a lot so that it will not block the vision of the user while navigating.

Objective 3: To calculate the shortest route to the destination.

By using NavMesh to prevent the line renderer from colliding into the real-world object and A* algorithm is used to calculate the shortest path. The A* algorithm is already implemented in the Nav Mesh component, so I do not need to code it manually. Therefor this objective has been successfully achieved, every path that the application guide user to is the shortest path it can be.

Objective 4: To use QR code for localization.

To successfully build a scanner in the application, Zxing.Net library is used. After that the QR code for each of the location is created using free QR code generator online, each of the QR are given their classroom name such as “N001”. The name of the QR code had to be match with the one build in the Unity model so that the marker will be set to the correct position when the QR code is scanned. As sum, this objective is successfully achieved.

6.5 Concluding Remark

After reviewing all the testing and evaluation of the application, the application passed all of the test, besides that all of the objective has also been achieved, but there is still more room for improvement.

Chapter 7

Conclusion and Recommendations

7.1 Conclusion

Throughout the entire development process, there are a lot of issues and challenges that have been encountered, such as the needing more time to learn the new tools and software that are required to develop this project, setting up the project environment alone takes a long time. Moreover, AR and VR are the field that I have not learnt before, so it requires extra effort to learn and understand the theory behind it. Furthermore, when trying to create a mobile application using Unity, there are a lot of issues that I have encountered, the most common issue is regarding the user interface. The interface is quite complicated for a new user, I need to keep on try and error on how some of the functions work.

As conclusion, this project has fulfilled all the objectives stated above and successfully come out with an AR indoor navigation mobile app that is able to guide students and visitors through FICT building. By integrating AR technology with the faculty surrounding, it gives user a more immersive experience. This project had also successfully demonstrated the potential of AR technology in helping human to solve future problems easily.

7.2 Recommendations

There is still a lot of room for improvement in this mobile application. As this application is only build for FICT students, this application could scale up more into UTAR Kampar Campus indoor and outdoor navigation application. Moreover, the navigation accuracy of this mobile application is still not yet 100%. Other positioning methods such as WiFi, beacons positioning can be used so that the distance between each point can be more accurate, with that the navigation route can achieve a 100% accuracy.

References

[1] Alexander S. Gillis, "Augmented Reality(AR)," [Online]. Available: https://www.techtarget.com/whatis/definition/augmented-reality-AR. [Accessed 20 11 2023].

[2] A. Makarov, "A Guide to Developing Augmented Reality Indoor Navigation Applications," 7 April 2023. [Online]. Available: https://mobidev.biz/blog/augmented-reality-indoor-navigation-app-development. [Accessed 20 11 2023].

[3] S. Sarkar, "How Microsoft Path Guide has the Potential to Define the Future of Indoor Navigation," 30 May 2017. [Online]. Available: https://techpp.com/2017/05/30/microsoft-path-guide-indoor-navigation/ .

[4] Y. Shu, "Path Guide: A New Approach to Indoor Navigation," 14 July 2017. [Online]. Available: https://www.microsoft.com/en-us/research/blog/path-guide-new-approach-indoor-navigation/. [Accessed 09 September 2023].

[5] A. Datta, "Microsoft launches Path Guide for easy low-cost indoor navigation," 18 July 2017. [Online]. Available: https://www.geospatialworld.net/blogs/microsoft-launches-path-guide-indoor-navigation-app/ . [Accessed 09 September 2023].

[6] C. Phillips, "New ways Maps is getting more immersive and sustainable," 08 February 2023. [Online]. Available: https://blog.google/products/maps/sustainable-immersive-maps-announcements/ . [Accessed 10 September 2023].

[7] M. Schwarz, "Finding your way at Zurich Airport with Google Maps," 5 January 2022. [Online]. Available: https://www.internationalairportreview.com/article/172868/finding-your-way-at-zurich-airport-with-google-maps/. [Accessed 10 September 2023].

[8] X. H. Ng, "Design of a Mobile Augmented Reality-based Indoor," IEEE, 2020.

.

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimeseter3, Year 3	**Study week no.:** 2
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE Review FYP 1
2. WORK TO BE DONE Brainstorm how to implement new things in FYP2
3. PROBLEMS ENCOUNTERED No
4. SELF EVALUATION OF THE PROGRESS Good progress

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimeseter3, Year 3	**Study week no.:** 4
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE Brainstorm how to implement new things in FYP2
2. WORK TO BE DONE Make it more user friendly
3. PROBLEMS ENCOUNTERED NO
4. SELF EVALUATION OF THE PROGRESS Everything going find

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimeseter3, Year 3	**Study week no.: 6**
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE Make the UI more friendly.
2. WORK TO BE DONE Implement new functions.
3. PROBLEMS ENCOUNTERED Everything ok
4. SELF EVALUATION OF THE PROGRESS Avoid procrastination.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimeseter3, Year 3	**Study week no.: 8**
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE Develop the home screen and menu for the navigation screen.
2. WORK TO BE DONE Set up the scanner to scan QR code.
3. PROBLEMS ENCOUNTERED No
4. SELF EVALUATION OF THE PROGRESS On track

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimeseter3, Year 3	**Study week no.: 10**
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE QR code scanner
2. WORK TO BE DONE Implement multiple floor.
3. PROBLEMS ENCOUNTERED Need to use AI for automate multi-level navigation.
4. SELF EVALUATION OF THE PROGRESS Need to try harder

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

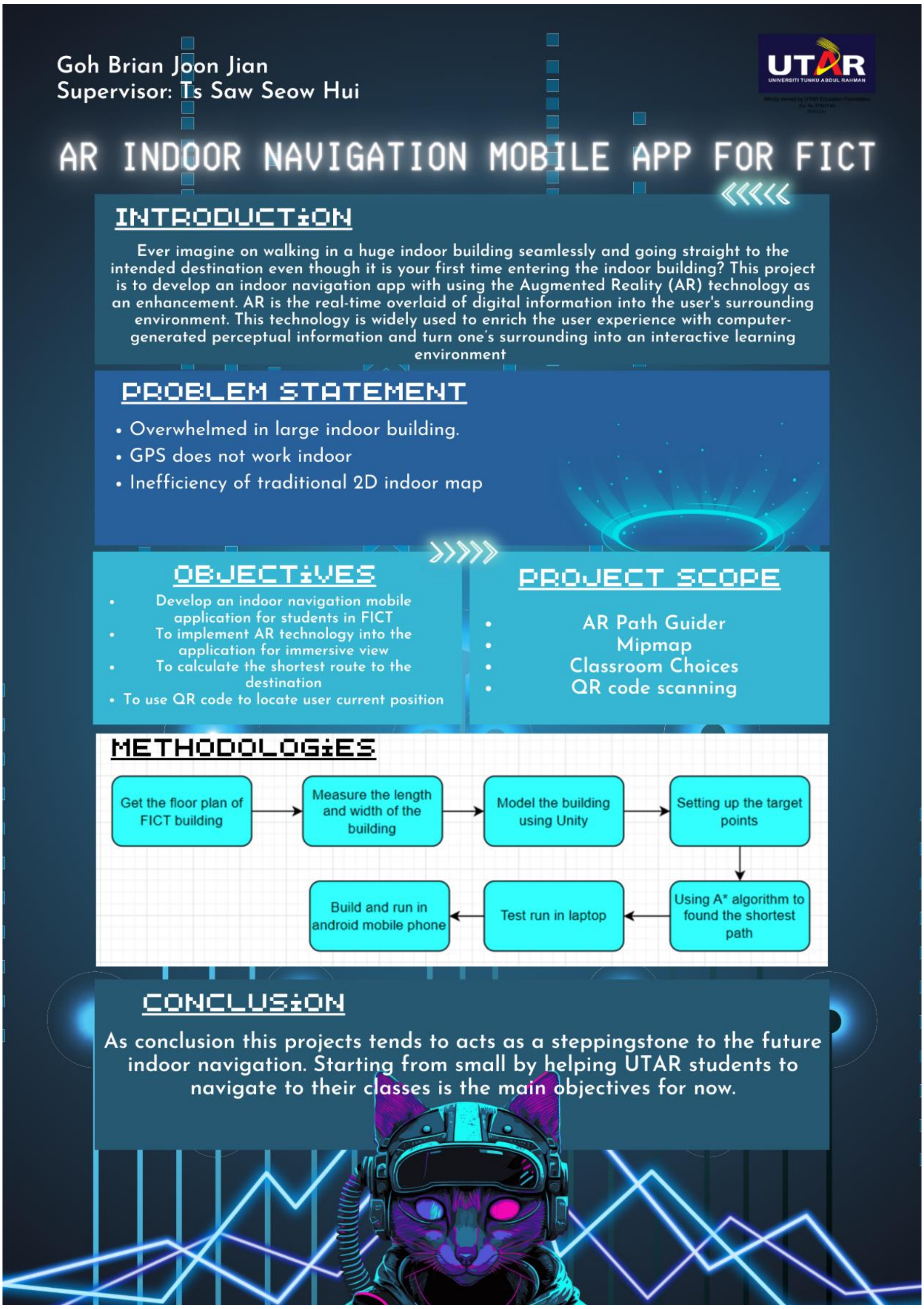
Trimester, Year: Trimeseter3, Year 3	**Study week no.: 12**
Student Name & ID: Goh Brian Joon Jian 20ACB02750	
Supervisor: Ts Saw Seow Hui	
Project Title: AR Indoor Navigation For FICT	

1. WORK DONE Implement manual multi-level navigation.
2. WORK TO BE DONE Integrate everything together, start report.
3. PROBLEMS ENCOUNTERED No
4. SELF EVALUATION OF THE PROGRESS On track

Supervisor's signature

Student's signature

POSTER


Goh Brian Joon Jian
Supervisor: Ts Saw Seow Hui
UTAR
UNIVERSITI TUNKU ABDUL RAHMAN
AR INDOOR NAVIGATION MOBILE APP FOR FICT
INTRODUCTION
Ever imagine on walking in a huge indoor building seamlessly and going straight to the intended destination even though it is your first time entering the indoor building? This project is to develop an indoor navigation app with using the Augmented Reality (AR) technology as an enhancement. AR is the real-time overlaid of digital information into the user's surrounding environment. This technology is widely used to enrich the user experience with computer-generated perceptual information and turn one's surrounding into an interactive learning environment
PROBLEM STATEMENT
• Overwhelmed in large indoor building.
• GPS does not work indoor
• Inefficiency of traditional 2D indoor map
OBJECTIVES
• Develop an indoor navigation mobile application for students in FICT
• To implement AR technology into the application for immersive view
• To calculate the shortest route to the destination
• To use QR code to locate user current position
PROJECT SCOPE
• AR Path Guider
• Mipmap
• Classroom Choices
• QR code scanning
METHODOLOGIES
Get the floor plan of FICT building
Measure the length and width of the building
Model the building using Unity
Setting up the target points
Using A* algorithm to found the shortest path
Test run in laptop
Build and run in android mobile phone
CONCLUSION
As conclusion this projects tends to acts as a steppingstone to the future indoor navigation. Starting from small by helping UTAR students to navigate to their classes is the main objectives for now.

PLAGIARISM CHECK RESULT

FYP2

ORIGINALITY REPORT

5%	%	5%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Xin Hui Ng, Woan Ning Lim. "Design of a Mobile Augmented Reality-based Indoor Navigation System", 2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), 2020 Publication	3%
2	Richard Deaves. "Notes", Oxford University Press (OUP), 2024 Publication	1%
3	Yuanchao Shu, Kang G. Shin, Tian He, Jiming Chen. "Last-Mile Navigation Using Smartphones", Proceedings of the 21st Annual International Conference on Mobile Computing and Networking - MobiCom '15, 2015 Publication	<1%
4	Ali Raza, Lazar Lolic, Shahmir Akhter, Michael Liut. "Comparing and Evaluating Indoor Positioning Techniques", 2021 International Conference on Indoor Positioning and Indoor Navigation (IPIN), 2021 Publication	<1%

5	Ton Duc Thang University Publication	<1 %
6	Ziad M. Elias. "Finite elements for Mindlin and Kirchhoff plates based on a mixed variational principle", International Journal for Numerical Methods in Engineering, 2021 Publication	<1 %
7	Elena Denia Navarro. "Percepción social de la ciencia y participación digital: impacto de la comunicación científica en Twitter", Universitat Politecnica de Valencia, 2020 Publication	<1 %
8	Rosen Ivanov. "An algorithm for on-the-fly K shortest paths finding in multi-storey buildings using a hierarchical topology model", International Journal of Geographical Information Science, 2018 Publication	<1 %
9	"Deriving configurable process models using process mining", Pontificia Universidad Catolica de Chile, 2019 Publication	<1 %
10	Babeș-Bolyai University Publication	<1 %

Universiti Tunku Abdul Rahman			
Form Title : Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Goh Brian Joon Jian
ID Number(s)	20ACB02750
Programme / Course	Bachelor of Computer Science (Honours)
Title of Final Year Project	AR Indoor Navigation For FICT

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)**
Overall similarity index: 5 % **Similarity by source** Internet Sources: 0% Publications: 5 % Student Papers: 0 %	The percentage meets the requirement.
Number of individual sources listed of more than 3% similarity: 1	He frequently consults this paper that is directly relevant to his work. Thus, the percentage is 3%

Parameters of originality required and limits approved by UTAR are as Follows:

- **(i) Overall similarity index is 20% and below, and**
- **(ii) Matching of individual sources listed must be less than 3% each, and**
- **(iii) Matching texts in continuous block must not exceed 8 words**

Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.

Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

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 Dr Saw Seow Hui

Date: 26/4/2024

____
Signature of Co-Supervisor

Name: ______________________

Date: ______________________

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY
(KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	20ACB02750
Student Name	Goh Brian Joon Jian
Supervisor Name	Ts Saw Seow Hui

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*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: 25-4-2024