AR-UTAR Kampar Campus Navigation

BY

HEW TENG WEI

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology

(Perak Campus)

MAY 2018

UNIVERSITI TUNKU ABDUL RAHMAN

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DECLARATION OF ORIGINALITY

I declare that this report entitled "**AR-UTAR Kampar Campus Navigation**" 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 : ________________________

Date : ________________________

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank all the parties that have been supporting me throughout the development of this project. Without their help, this project would not be completed smoothly and with expected quality.

I would first like to express my gratitude towards Ms Saw Seow Hui, my project supervisor, for providing me with guidance and appropriate criticism. She has provided the clearest project guidelines and suggestions along with her past experiences allowing the project to be a success.

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ABSTRACT

Augmented reality simulations of any imaginable 3D objects have created a whole new possibility for product demonstration, product testing, building simulations and more to come. The use of augmented reality technology increases day by day as technology proceeds to progress exponentially, where smartphones are already capable of processing computer grade graphics, allowing complex 3D models and architectures to be simulated through the graphic processing units of smartphones. Hence, this makes it the perfect opportunity to provide a convenient way to visualize buildings that are not within our reach.

Although any form of simulation may not be able to provide touring experiences as near as visiting to a place physically, it can help to avoid the troubles visitors need to go through to visit a distant area. In this case, since UTAR is located relatively far away from all major cities in Malaysia, creating an augmented reality application to simulate the campus buildings can possibly attract more visitors to check out the campus.

This project will be going through a series of prototyping methodology to allow constant feedback, as well as shorten the development duration. The system is expected to allow users to simulate UTAR Kampar Campus in an augmented reality environment, providing a general overview of how the actual campus might look like.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
IDE	Integrated Development Environment
SLAM	Simultaneous Localization and Mapping
VR	Virtual Reality
UI	User Interface
UTAR	Universiti Tunku Abdul Rahman
WWDC	Worldwide Developers Conference

Chapter 1: Introduction

1.1 Background

Augmented Reality (AR) as one of the most rapidly growing technology aside of Virtual Reality (VR), can be simply defined as a captured camera view superimposed with computer generated images, creating a combined scene of both real world and user desired contents; hence, augmenting the view of actual reality. 'Augmented Reality is a term used for interactive computer graphics which overlays a view of the physical world' (McGrath, 2012). According to the reality-virtuality continuum which is a scale that ranges between real environments and completely virtual environments (P. Milgram and F. Kishino, 1994), augmented reality occupies a fairly large general part within the scale, defining that it works when the reality is combined with virtual components. In short, augmented reality systems generally combines real environments with virtual objects, such as placing a virtual table on the floor, with or without the detection of a marker. A marker can be understood as a piece of physical world image that serves as a trigger when detected by the augmented reality system in order to generate virtual objects. In marker-based systems, a system registered marker has to be detected before a virtual object can to generated. As for marker-less systems, the system will detect surfaces and generate virtual planes that a virtual object can be simulated on.

While this technology has only begun to receive massive attention from developers in recent years, the concept of AR originally emerged as early as in the 1960s, where the first AR prototypes were created by computer graphics pioneer Ivan Sutherland and his students at Harvard University and the University of Utah, using a see-through to present 3D graphics (D.W.F. Krevelen and R. Poelman, 2010). As of today, beta systems of augmented reality see-through eye-pieces, such as Google Glass and Microsoft HoloLens have already been opened to developers to discover the possibilities of AR, such as it's ability to simulate realistic 3D models of educational materials, and its capabilities to enhance visual and gaming experiences.

1.2 Problem Statement

1.2.1 Absence at Physical Campus Location

AR related tour guide projects usually require users to physically be present in a specific location in order for their AR systems to work, mainly because they are more directed towards marker-based systems, where they require users to detect a specific marker in a touring area before any guidance can be provided by their systems. This heavily limits the system's potential and diversity, because users who intend to tour in the specific area cannot do so due to their absence in the physical area. From the point of view of a university application, campus tours cannot be given to users who are far away from the campus who may want to learn about the institution prior to enrolling into the university.

1.2.2 Augmented Reality Technology Overshadowed by Virtual Reality Technology

In 2016, the total sum of investments in the mixed reality field have increased to over USD1.1 billion (L. Matney, 2016). While AR technology may have received massive attention and development within a short span of time, VR on the other hand has greatly overshadowed the AR community due to its ability to provide a more immersive visual experience. However, both AR and VR technologies require AR or VR enabled devices in order work, and the price for the said devices are not consumer friendly. One may argue that as of 2017, smartphones with powerful processors are already capable of running AR applications, but it's only at a very entry level. On top of that, Google has even come up with a product specially made for its AR systems called Google Tango and Google Daydream to work at an optimal level. This shows that with our current AR technology, the issues with smartphone battery consumption and AR graphics performance is still at an arguable level.

1.2.3 UTAR Kampar Currently Do Not Possess Such System

Last but not least, since UTAR Kampar currently do not possess an AR navigation system, it is a great opportunity to introduce such system to the visitors of the university. It allows the visitors to visualize the campus prior to actually visiting.

1.3 Motivation

UTAR Kampar Campus is built on a 1300-acre land with 15 buildings housing multiple faculties and campus facilities. Top that up with the sunny weather in Malaysia, it renders it extremely difficult if every single corner of the campus needs to be visited in a day. However, if AR technology can be used to simulate the entire structure of UTAR Kampar Campus, it could save the users from having to go through the process of visiting the campus physically, as the campus is also located in a fairly distant town from major cities in Malaysia.

UTAR is one of the largest campuses in Malaysia possessing breath-taking sceneries in possibly every corner of the campus. Each of the 15 buildings of the campus is built around a relatively huge lake, giving the campus a touch of magnificence. An AR simulation of the campus can allow people from around the world to have a view of this gorgeous campus in Malaysia.

Since UTAR currently do not possess a simulation of the campus through the technologies of AR yet, this could be the opportunity to be the first among many, since this application only requires a smartphone that is AR capable, although it only supports iOS devices for the time being.

1.4 Project Scope

This project will include the development of an independent marker-free AR driven campus navigation system on a smartphone platform, in which users are not required to be present in the physical vicinity of the campus in order to view the campus virtually. The application will concentrate solely on the development on iOS platforms only, meaning that only Apple iPhones, iPads and iPods will be able to run the application.

The proposed application will feature a 3D Model simulation of the overview of UTAR Kampar Campus as well as individual building views of each of the buildings in the campus. There is a total of 15 buildings housing various faculties in the university. A general 3D model of the overview of the campus should be delivered by the end of the development, along with one detailed modelling of one of the campus buildings for the individual detailed view.

The 3D model delivered by the end of the development should include all 15 buildings of UTAR Kampar Campus with only its exterior silhouettes which should provide an overview of the whole campus, along with one building that comes with detailed interior design.

1.5 Project Objectives

This project aims to provide AR experiences to users who may or may not be associated with UTAR, particularly students who may want to enroll into the university. Users are given a platform to simulate the entire UTAR Kampar Campus on any detected surface, allowing practically anyone to have an overview of the campus layout prior to enrolling into it, or just to have a view. Below are the main objectives to the development of this project.

- To provide the community with better exposure on AR technologies and how it excels in 3D model demonstration.
- To produce a marker-less AR navigation system to prevent the need of carrying a physical marker whenever the application needs to be used.
- To allow campus layout simulation without the need to be present within the physical campus vicinity.
- To aid new students in getting familiarized with the huge campus layout.
- To allow interior exploration and navigation of university buildings.

1.6 Impact, Significance and Contribution

The main concept of this project is to provide UTAR with an AR campus navigation system instead of using its traditional printout of campus map for a more environmental friendly approach, since AR technology is being adopted pace by pace by many educational bodies for its robustness in providing users with interactivities and changing the users' perspective of view towards a real physical environment. This project could serve as a platform for AR related studies to explore its possibilities.

This project will utilize the most advanced existing methods of AR, augmenting the view of what is visible to the human eye with more informative projection of information. This project could bring about a fresh experience for UTAR to promote its campus to anybody anywhere in the world through the installation of a mobile application since UTAR do not currently possess this kind of application.

Chapter 2: Literature Review

2.1 Application Review

2.1.1 NUS AR Map

NUS AR Map is a smartphone application developed by the Augmented Reality Laboratory of NUS (National University of Singapore) that utilizes the technology of AR to improve campus navigation experiences in the university. This application is a fully marker-based system, in which users are required to search for markers located all over the campus, and it claims to have 156 markers to be found for improved user experience and ease of use. The system also features directory search and adding a favorite location of the user within the application.

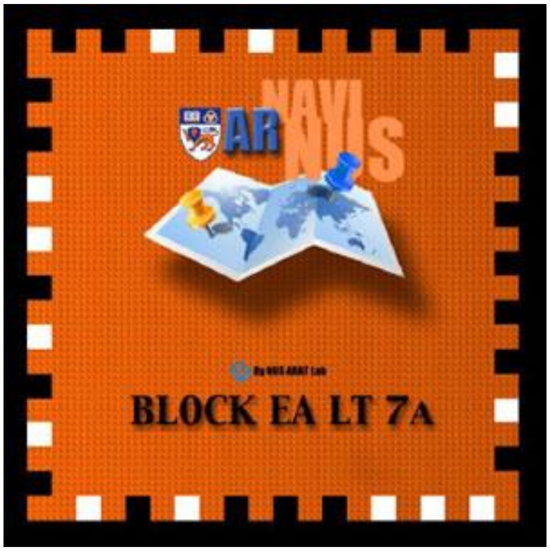

Figure 2-1-F1 Specially-designed marker for NUS AR Map

The system is able to superimpose realistic virtual objects as guidance or to provide campus-related information as well as histories to the application users. Besides, the system is also capable of estimating the distance between target campus buildings and users, providing navigation specially for new visitors.

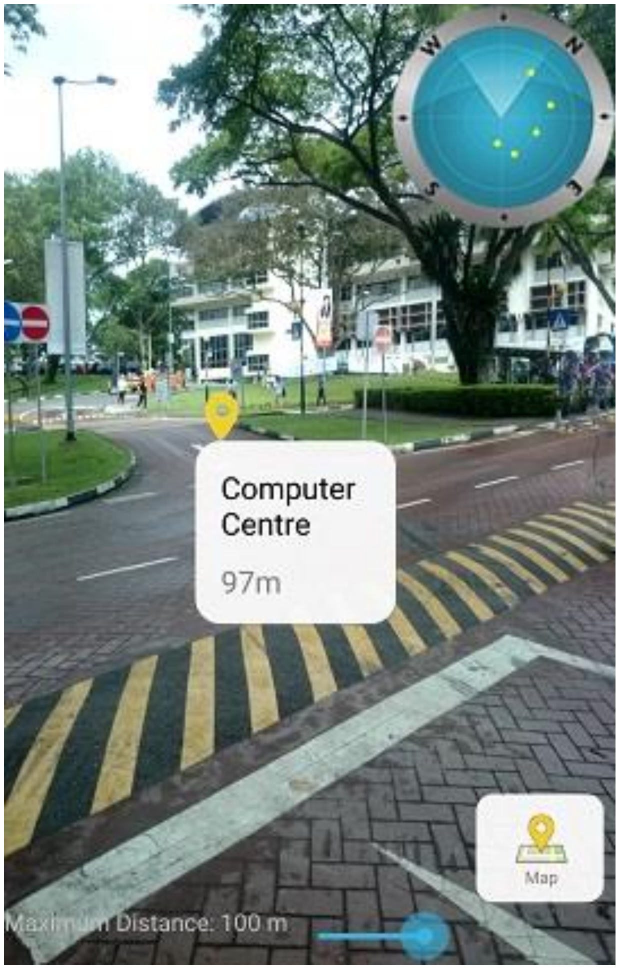

Figure 2-2-F2 Distance estimation between user and destination building

2.1.1.1 Strengths

NUS AR Map provides seamless superimposition of virtual objects onto the physical environment, providing a realistic and friendly guidance. Since this system is embedded with GPS (Global Positioning System) location detection, the application is able to provide a map view and key locations within the campus vicinity. Upon selecting a desired target building, for example Computer Centre as shown in figure 2-2-F2, an estimation of distance will be shown to navigate users. On top of that, users are able to save their favorite current locations into the application for future references.

2.1.1.2 Weaknesses and Limitations

This application is only available for Android operating systems running on Android version 2.1 and above. Devices running on older hardware are unable to install and run the application. On the other hand, this application requires user to be physically present in the NUS campus, else nothing will be shown and the application will generally not work as intended.

2.1.2 AR-Campus

AR-Campus is an AR campus guidance project built by a group of students during a course designed for non-computer scientist students. Media arts students built the 3D-model and the application was built with the aid of 2 computer science students. The main focus of this application is to generate a 3D map of the campus area, providing guidance to different buildings and name tag recognition of university staffs. Users will be displayed staff information upon marker detection that is embedded on the name tags of the university staffs.

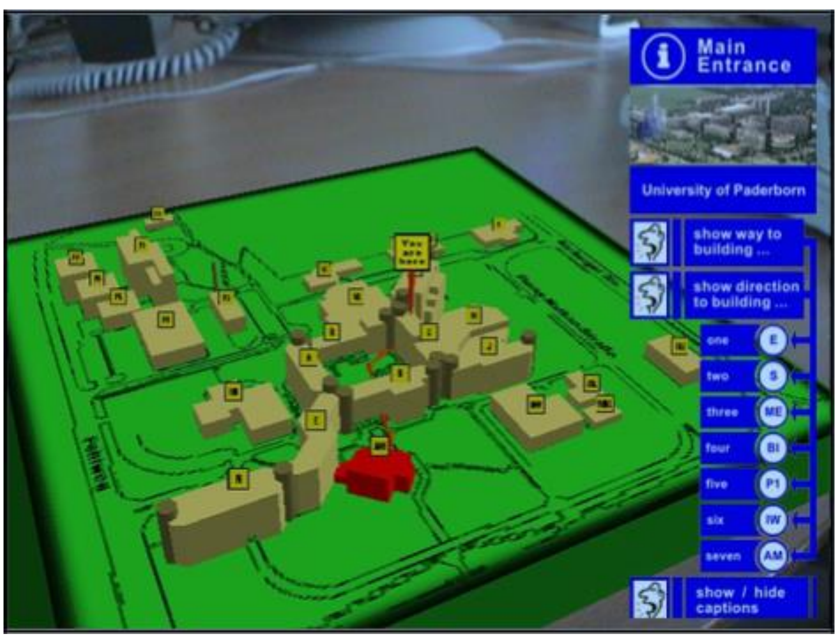

Figure 2-3-F3 3D campus map of AR-Campus

The AR-Campus also uses voice recognition for system instructions. Textual annotations including the name of the buildings will be projected on the buildings. Users may select the destination building from the 3D map to begin navigation and the precision may go up to a specific office within a building. As shown in figure 2-3-F3, upon selecting a destination, a red path will show up to indicate the pathway to the destination building. However, this system requires a special AR headset device designed by the students; thus, it is unavailable to users not associated with the university.

2.1.2.1 Strengths

The system uses voice recognition which is a creative approach to application implementation. An AR map can also be displayed without needing to be physically present in the campus, although the application is meant for in-campus navigation. Users are able to display a list of information regarding a particular name tag detected staff in the sidebar of the users' view.

2.1.2.2 Weaknesses and Limitations

The application only works when the specially made headset is used. The simulated AR map is also non-textured, giving it a very plain and flat appearance.

2.1.3 Augmented Reality Campus Tour (ARct)

ARct is an application built by a software engineer K. Ngo from Idaho in year 2010. The application utilizes the GPS, compass, accelerometer, camera and Internet access to provide AR features in the users' smartphone view. The system works on image recognition to detect various campus buildings instead of marker detection. Upon building detection, information of the building is displayed as virtual objects on the buildings. One distinct function in this application is that is detects buildings from any angle and any distance, as well as display only buildings within the user's vicinity by excluding all distant and obscured buildings.

Figure 2-4 Building upon detection in ARct application

2.1.3.1 Strengths

This application is built dynamically in such a way that content providers are able to categorize or include any other campus information. Users are able to search for a destination building then navigating to the desired location. Since the system works on image recognition instead of markers, it is able to distinguish between different buildings independent from distance and angle, and its ability to distinguish between foregrounds and obscured buildings allows it to exclude information display on buildings too far away that could affect user experience.

2.1.3.2 Weaknesses and Limitations

This application can only be used within the physical vicinity of the actual campus; thus, users from a distant location are unable to tour around the campus virtually. Besides, this application is Android exclusive and has never been updated since its debut.

2.2 Comparison Between Reviewed Systems and Proposed System

Table 2-2-T1 Comparison between reviewed systems and proposed system

Features	NUS AR Map	AR Campus	ARct	Proposed System
Able to work without image recognition	Yes	Yes	No	Yes
Able to work without being present in campus vicinity	No	Yes	No	Yes
Has 3D model simulation	No	Yes	No	Yes
Able to work without marker	No	No	No	Yes
Able to work without specially made hardware	Yes	No	Yes	Yes
Able to simulate individual campus building	No	No	No	Yes

2.3 Augmented Reality Campus Navigation

The use of AR in campus navigation is able to provide a significantly improved user interactivity whilst being guided to tour around the campus. However, most applications require users to be physically present in the campus. This could be a huge obstacle for anyone who is very far away from the actual campus. Besides, the actual touring in campuses requires an extended amount of walking, needless to say the process will become very tedious as the campus size increases. It becomes very inconvenient when factors such as availability of tour guide, size of campus to be toured and weather conditions become crucial criteria to the judgment of a university's reputation.

The solution to the above issue is to provide a self-directed mobile touring system. AR technology has been applied in various mobile devices as a self-guided tour, example include Columbia University where the mobile AR campus navigation system was started as early as in 1996 (Chou & ChanLin 2012). Effective and user centered touring system not only provides environment information to users, but also allow users to quickly utilize resources and enhance environment awareness (Educause 2005). However, in Malaysia, students tend to enroll into overseas universities without actually visiting the physical campus, as it could be costly and time consuming to do so. This could potentially lead to dissatisfaction upon arrival at the university that was never visited prior to enrolment.

By implementing the concept of virtual campus navigation systems, students from distant locations are able to have an overview of their desired campuses. Research demonstrates that a student who visits a college campus is twice as likely to matriculate compared to a student who does not visit prior to applying (Brown 2010). AR is a great approach to virtual touring as it as an innovative alternative for bringing experiential and location based learning to students (Chou & ChanLin 2012).

Through the augmented reality technology, by attaching different people and buildings from different eras, users can investigate the virtual environment of different cities historically. This way, it increases the user's sense of presence and sense of reality (Yu, Chiu, Lee & Chi 2015).

Based on the statement above, the approach of using AR for virtual campus navigation allows users to familiarize themselves with the university they would like to enroll into. As wireless communication technology proceeds to develop rapidly, smartphones as of 2017 is capable of rendering high quality graphics alongside with the aid of GPS and gyroscope to provide realistic and immersive AR experiences.

2.4 Apple Inc.'s Involvement in Augmented Reality

During WWDC (Worldwide Developers Conference) Keynote Special Event held by Apple Inc. in June 2017, Apple announced a new AR developer kit, namely ARKit featuring the technology of seamless marker-less surface detection done within a matter of seconds. Wingnut AR, the application demonstrated by Apple during the keynote event is able to instantly track a table-top surface from a couple of meters away (Zeitler 2017), also mentioning that the area was fairly large but the application is able to solidly track the surface throughout several minutes of the application showcase.

According to Apple, iOS 11 introduces ARKit, a new framework that allows you to easily create unparalleled augmented reality experiences for iPhone and iPad. By blending digital objects and information with environment around you, ARKit takes apps beyond the screen, freeing them to interact with real world in entirely new ways (Apple Inc 2017).

ARKit is now one of the most advanced AR technology existing in the world, providing flawless marker-less tracking and most importantly, it will soon be available to all iOS 11 compatible devices built with Apple A9 chip. However, those iPhones equipped with A8 chips and below will not be able to use the said technology. The iOS 11 release as announced supports the iPhone 5s and newer, the iPad Air and newer, and the latest iPod Touch (Wuerthele 2017). This justifies that even though there will be ARKit incompatible Apple devices, they are mostly models from 2012 and earlier, which are already 6 years behind from now. The technology will be supported starting devices such as the iPhone 6s and iPhone SE, both released in year 2015, and will be available for future Apple devices for years to come.

Chapter 3: Proposed Method/Approach

3.1 Project Methodology

Amongst all of the existing software development methodologies that excels in different perspectives, the Agile Software Development method is chosen to develop this project in a prototyping manner. The justifications for this choice includes the considerations for user involvement, time constraints and project size.

In terms of user involvement, the agile approach carries an important principle, in which users are expected to be closely involved in the project throughout its development. The role of the users is to provide and prioritize new system requirements and to evaluate the iterations of the system.

In considerations of the project duration and project scope, the project is better to be kept simple with minimal emphasis on documentation, allowing more time allocation to software development. In addition, errors might occur occasionally during the early stages of development; hence, problems can be troubleshot beforehand to improve system-wise stability before developing the later features.

The agile approach can be described in the following stages:

1. Planning Phase
   First of all, identification of requirements is done in this stage. A schedule is created to accommodate all different tasks. Besides, the basic requirements such as 3D model layout planning, functions within the application and design of user requirements and feedback forms are determined.

2. Analysis and Design Phase

   This phase consists of processing the initial user requirements prior to designing the functionalities of the application. Analysis on how the system can meet user specifications is done to determine suitable programming language involved, hardware and software requirements, and 3D Model designing engine. Since agile approach is adopted, this stage could be iterated when a different requirement is in demand, such as addition or removal of certain system functionalities.

3. Prototyping Phase

   In the first iteration, an initial model of the application prototype is developed to allow user feedbacks. The prototype is expected to include several vital components, such as 3D model of UTAR Kampar Campus, virtually projecting it in an AR approach via marker-less surface detection and building selection. Users shall then test on the initial prototype to provide feedbacks for further improvement in following iterations.

4. Improvement Phase in Future Iterations

   User feedbacks are a crucial factor to the final outcome of this project. The feedbacks from each iteration of prototype is analyzed for any system modifications, such as addition of new or improvised controls and improvement on quality of the interface. In each stage of iteration, user feedbacks will be taken into consideration and set for testing before implementing it in the latest prototypes.

5. Implementation Stage

   Towards the end of the development timeline, once the project is determined to be error-free and receives satisfaction from users, the most stable and improved prototype will be compiled into a final product to be implemented as a working application, publishing it for public use. At this point, the application should run smoothly and provide users with satisfying system performances. Most importantly, the intended function of the application which is to provide users with virtual campus overview should be achieved.

3.2 Technologies Involved

This project will be developed with several devices, programs, and libraries.

- Apple ARKit library
- Xcode 9
- Blender

Blender is chosen as the platform to build 3D models due to its compatibility with Apple ARKit and its huge resource of assets. Xcode 9 is used to develop the user interface of the iOS application as well as import the built 3D models to be projected.

This project will be tested and deployed on the following devices:

- Apple iPhone 6s Plus
- Apple iPhone 7 Plus
- Apple iPhone SE
- Xcode iPhone simulator

The listed devices above are fully compatible with ARKit, which requires Apple A9 chip and above. However, views that require the use of AR technology cannot be tested on simulators; hence, simulators will only be used to test the UI of the application.

3.3 System Design/Overview

3.3.1 System Flowchart

Do take note that iOS applications do not end until application is killed via multitasking, which is considered as unnatural termination of application. Hence, termination is not included in the flowchart. The application will work as an endless cycle.

Part 1

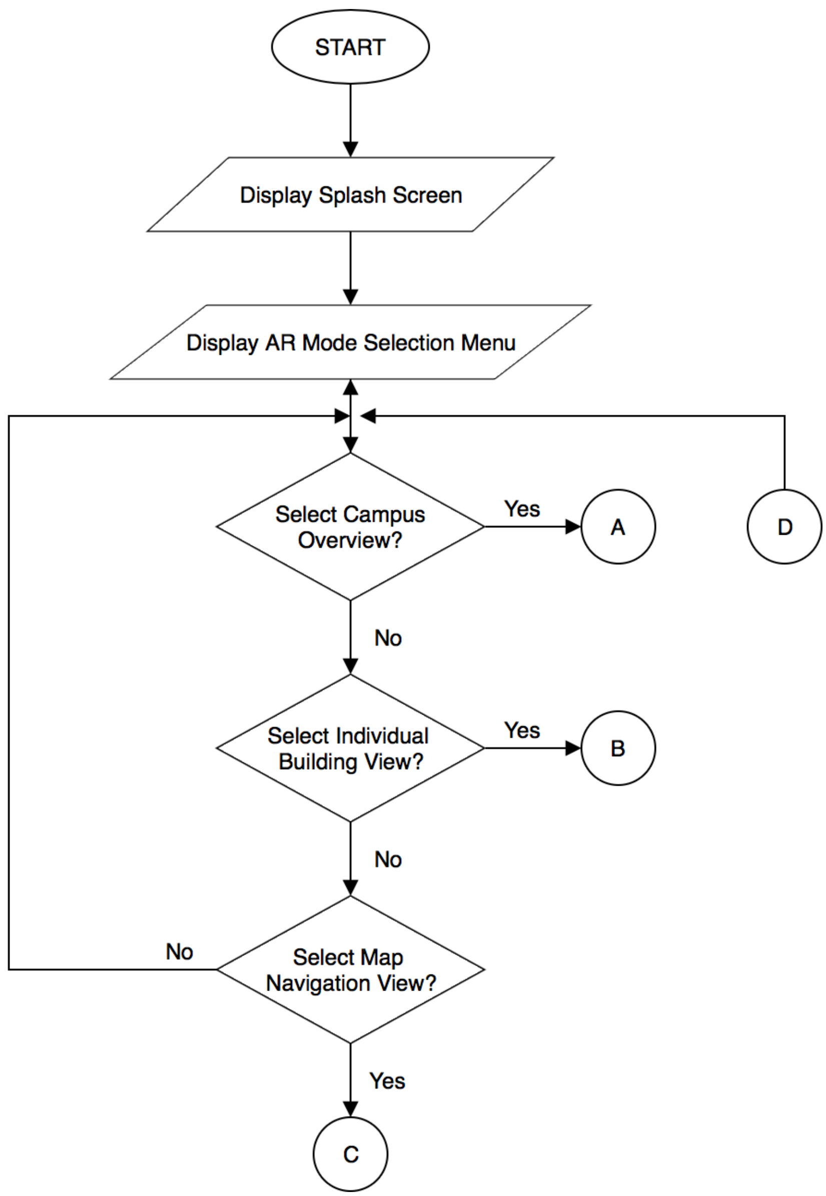

Figure 3-1-F1 Flowchart part 1

Part 2

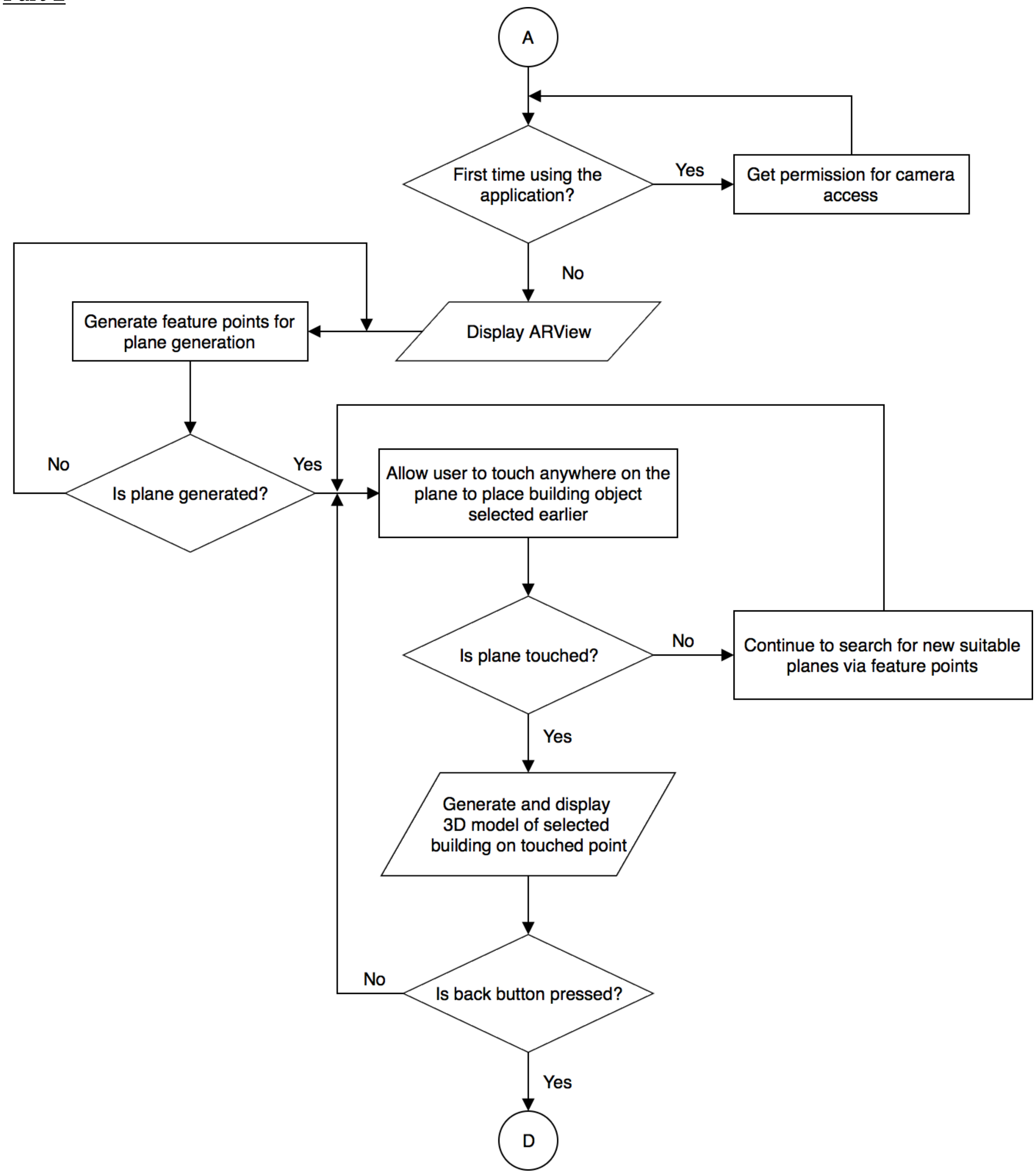

Figure 3-1-F1 Flowchart part 2

Part 3

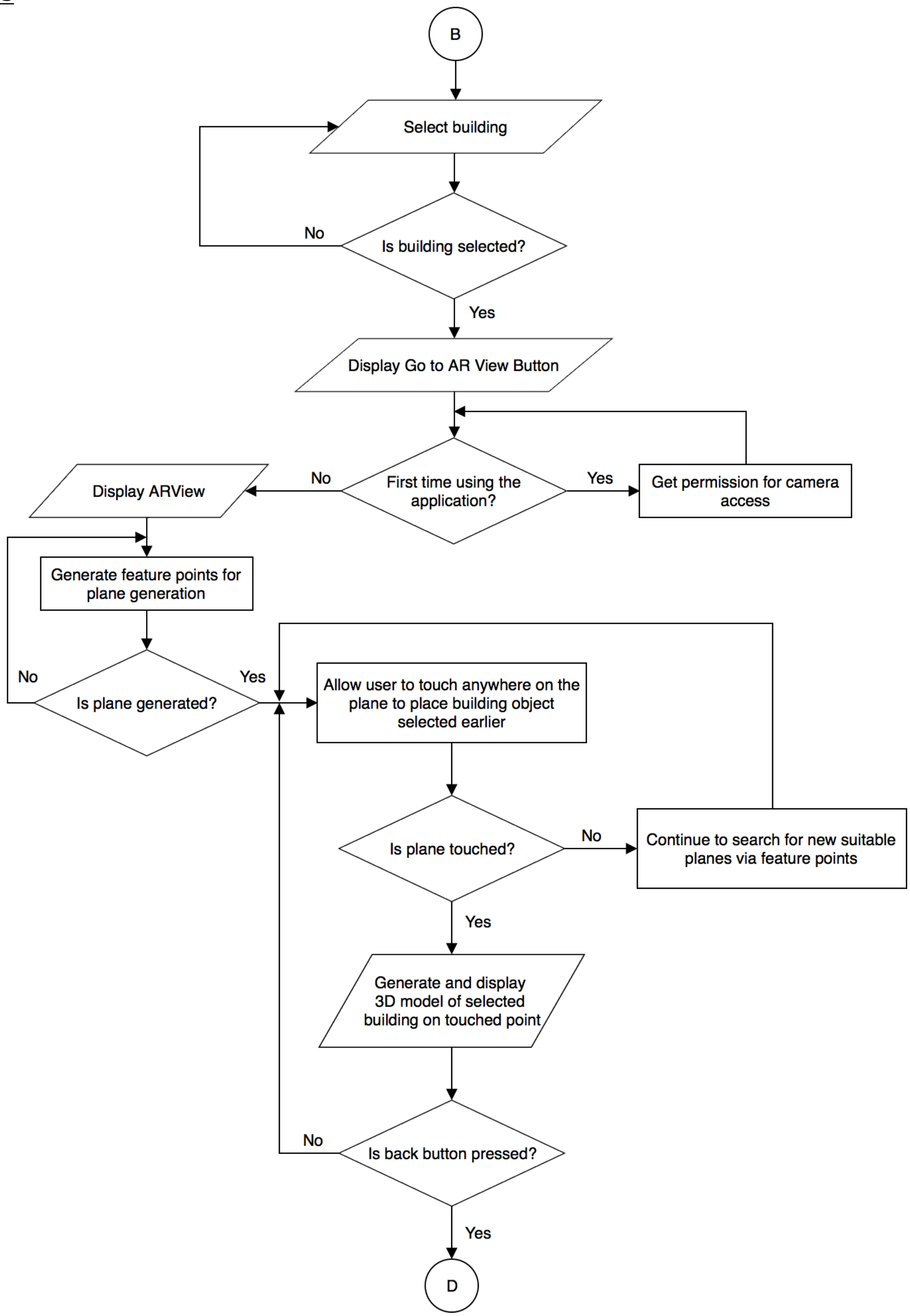

Figure 3-1-F1 Flowchart part 3

Part 4

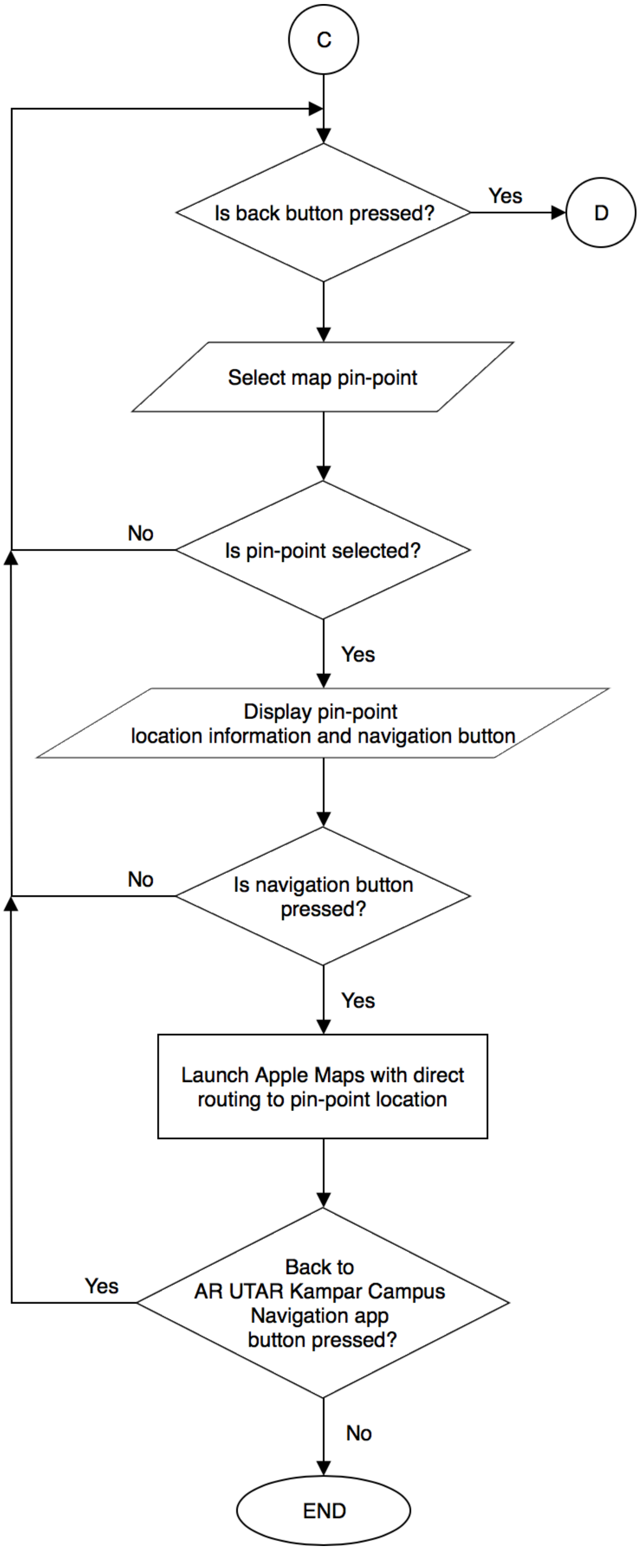

Figure 3-1-F1 Flowchart part 4

3.3.2 Application Modules Diagram

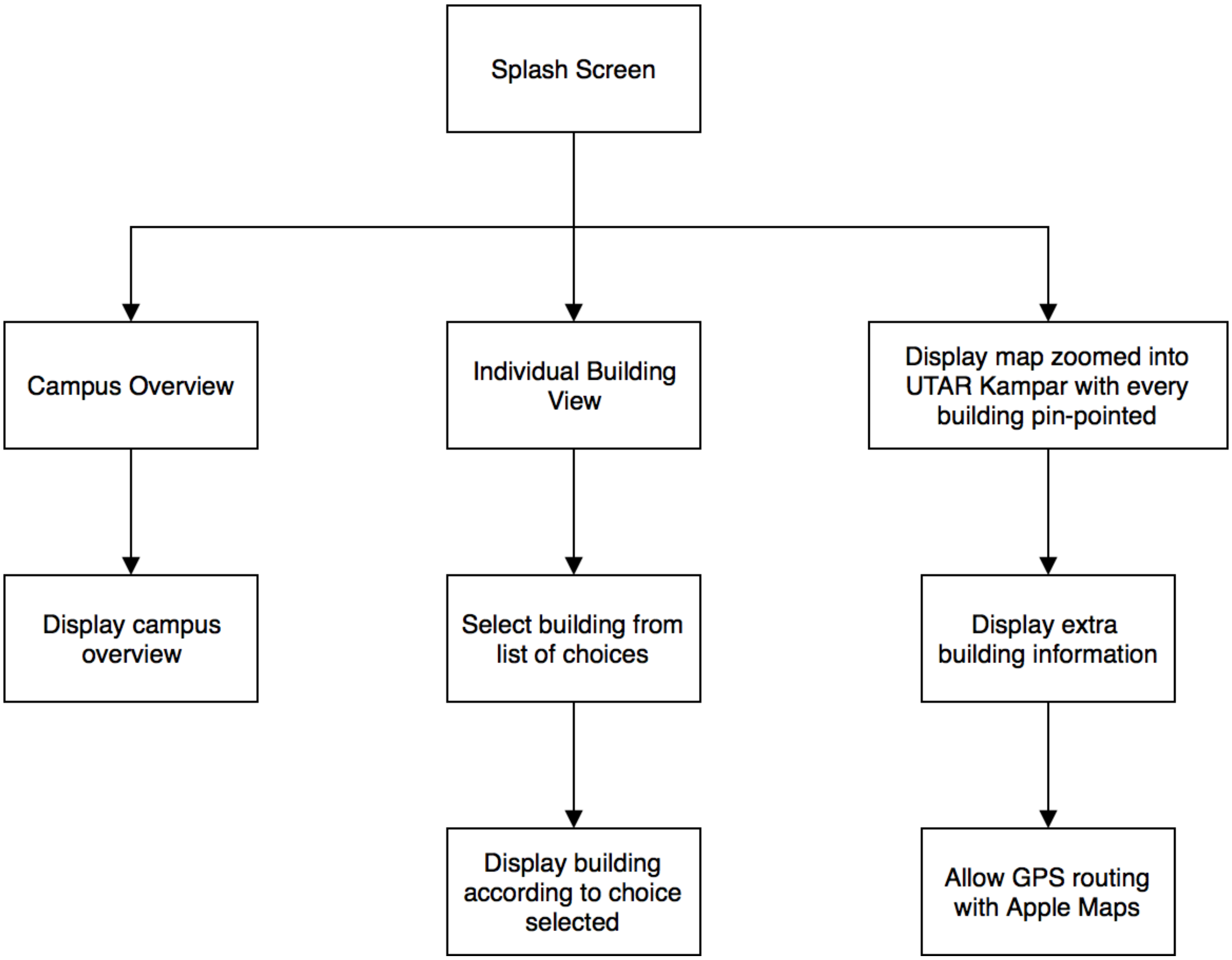

Figure 3-2-F1 Application Modules Diagram

3.3.3 Algorithms and Approaches

1. Splash Screen
   a. The design of the splash screen is a photo of Dewan Tun Dr Ling Liong Sik captured and designed on Snapseed application available on the AppStore.
   b. The splash screen is implemented by adding the desired image into Xcode's Launchscreen function.

2. Campus Overview / Individual Building View Selection Page
   a. Two buttons are displayed as even rows on horizontal layout views with pictures of the campus buildings as the background of the buttons.
      i. If Campus Overview is selected, user will be directed to the ARView right away.
      ii. If Individual Building View is selected, user will be directed to another view that requests for the user's desired building to be simulated on ARView.

3. Individual Building View – Building Selection
   a. User will be asked to select a building from a picker. The user should then be directed to the ARView and it shall display the user's desired building.

4. ARView
   a. First time users will be prompted with a permission request to access the user's camera. Once the user grants permission, a scene will be created and starts searching for valid planes for buildings to be simulated on.
   b. The scene first generates feature points, which can be described as surface detection markings that identifies and contours the surface detected in the real world.
   c. Once there are sufficient feature points generated, the system will compute and find the best match for plane generation in terms of scale, orientation and position.

d. Upon successful generation of planes, the user will now be able to place objects, in this case the campus buildings onto the virtual planes created. The user is only allowed to place objects on planes and no other areas.
e. When an object is placed, the user is allowed to scale the object by pinching gestures, as well as move the object along the plane by dragging gestures.
f. All objects will be removed once the user exits the ARView, such as going back to the previous view.

5. Marker-less Detection Methods
    a. Sometimes called the marker-less SLAM (Simultaneous Localization and Mapping) based AR, it is an instant tracking algorithm that allows the scanning of real environments, seeking for flat surfaces to generate feature points on, thereby generating a virtual plane for objects to be placed on.
        i. **Feature points** are generated when the camera takes in a footage from the reality to be calculated through an algorithm in the ARKit library. The feature points are simulated on surfaces that are considered to be similar in terms of surface flatness. The factors considered into this calculation includes surface texture, surface color, surface depth and surface lighting. However, since it heavily relies on what the camera captures, it renders the algorithm difficult to produce good results when the environment is relatively dark.
        ii. **Virtual plane** is generated once the system detects enough feature points, signifying that there is sufficient surface for an object to be placed on. A plane is generated across all the feature points, taking their average, allowing the most optimum sized and aligned plane to be generated for objects to be placed on.
    b. Object placement on a virtual plane is done when the user taps on any area within the virtual plane. The system calculates the coordinates of the tapped area along with the object's size to allow the best alignment when the object is placed. Since resizing and dragging of the placed object is allowed, the system continuously

calculates the finger gestures of the user to resize and translate the object accordingly. The velocity of the finger gestures is taken into account as well.

c. Once the object is placed, the ARanchor, a function that hooks the object to the tapped coordinates begins to work by linking the object to the environment according to the environment color, lighting and texture similar to that of feature points generation, so that the user can still find the object anchored at the exact same position even if the camera moves away from where the object is placed. The object should remain at the same spot of simulation.

6. Map Navigation Methods
    a. The map initially shows the user the map of the entire world. In order to zoom in to a particular area, the global longitude and latitude of the desired location needs to be provided to the system, along with a radius of zoom, allowing the system to zoom in to a set radius of a particular location upon launching the map view.
    b. Multiple locations can be pinned by providing the system with each of their longitudes and latitudes. These pins are called artworks, and should go under an array of locations so that they can all be displayed at the same time on the desired map radius.
    c. Each pin can be tapped on to show more information about the location. GPS navigation via Apple Maps can then be triggered if the user taps on the navigate icon.
        i. The application sends the longitude and latitude of the target destination to Apple Maps application.
        ii. Apple Maps receives the location upon launching. It then retrieves the current location of the user to calculate the shortest possible route and estimated arrival time for the user. The user may now navigate to the target destination at will.

3.3.4 Activity Diagram

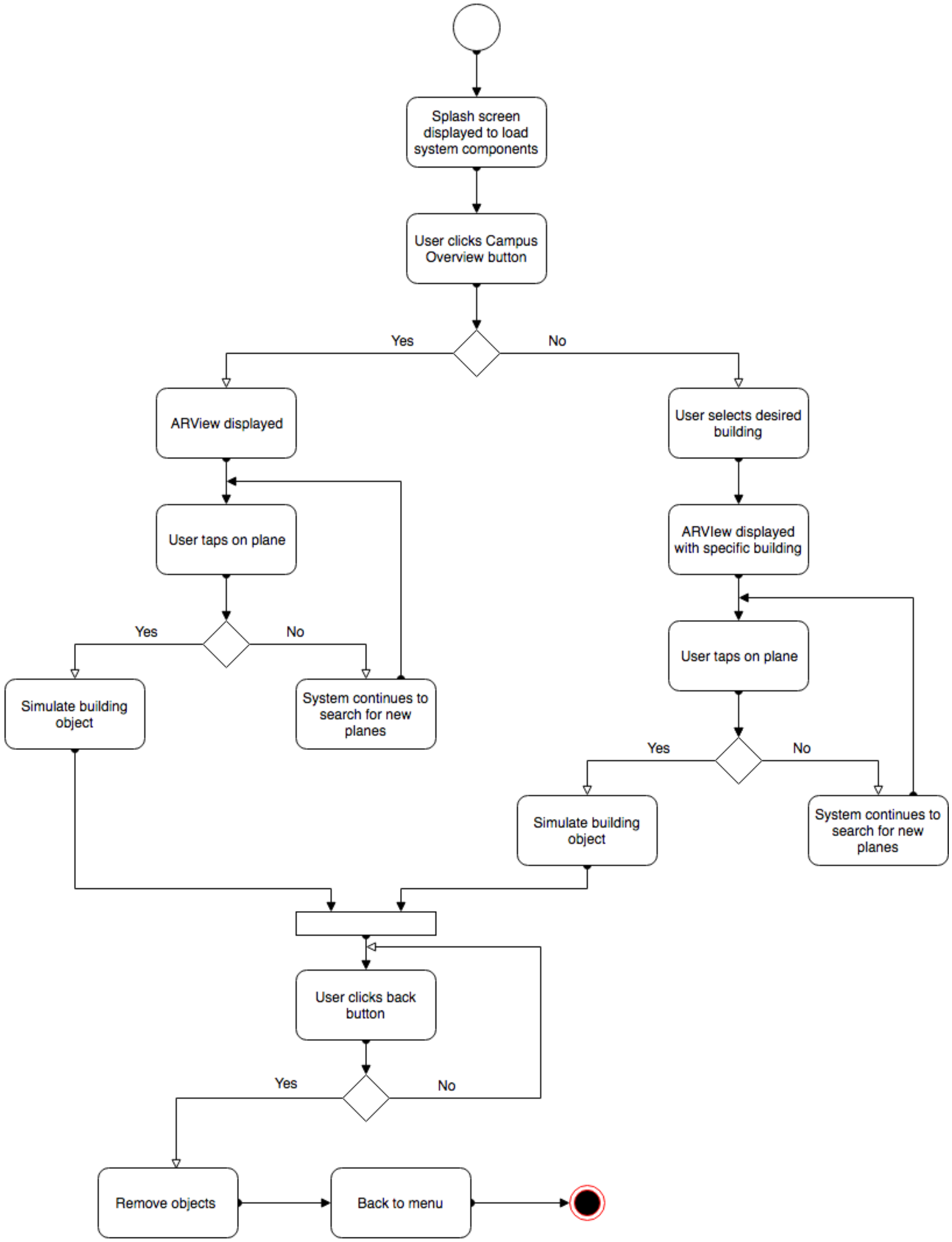

Figure 3-3-F1 Activity Diagram

Chapter 4: Implementation

4.1.1 Software Used

4.1.1.1 Xcode 9

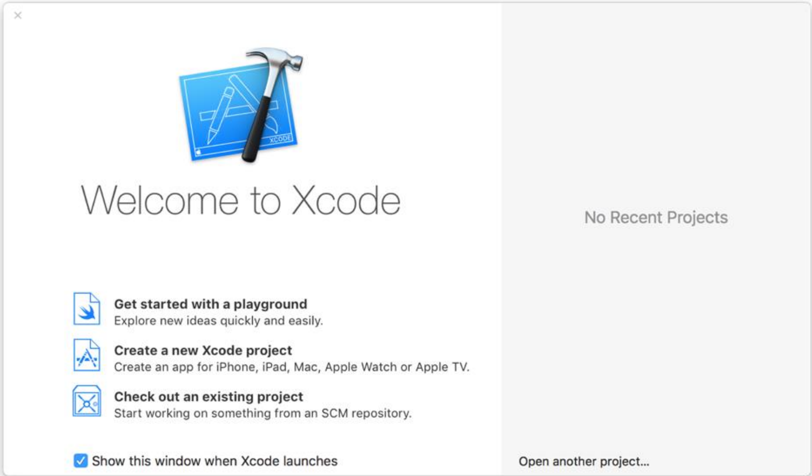

Figure 4-1-F1 Xcode 9

Xcode is a free Integrated Development Environment (IDE) that is only available on Apple Macintosh for OS X and macOS. It is required for Apple software developments for platforms such as OS X and macOS, iOS, tvOS and watchOS. Since the project will be built for iOS platform, Xcode is a mandatory for the project development. All UI designs and AR implementation in the application will be done using Xcode.

In addition, Xcode of version 9 and above is required, for ARKit is only available starting version 9 and above.

Installation steps:

1. Open AppStore on macOS.
2. Search for Xcode 9.
3. Ensure that AppStore is logged in with a valid AppleID.
4. Click GET to install.

4.1.1.2 Blender 2.79

Figure 3-4-F2 Blender 2.79

Blender is an open source and free 3D modelling suite. Although not as sophisticated as Unity 3D and Unreal Engine 4, it is chosen as the main modelling platform for this project due to its simplicity and ease to learn comprising to project time constraints.

Installation steps:

1. Browse to https://www.blender.org, homepage of Blender.
2. Click on Download Blender 2.79a on the homepage. Take note that this button always provides the latest version of Blender available at the time.
3. Click on the downloaded installer (.dmg) item.
4. Drag Blender into Application folder.
5. Launch Blender from Application from now onwards.

4.1.1.3 Unity 3D

Figure 3-4-F3 Unity 3D

Unity is a cross-platform game engine developed by Unity Technologies, first announced and released in June 2005 at Apple Inc.'s Worldwide Developers Conference as an OS X-exclusive game engine. It is now compatible for multiple platforms. Unity is selected as the engine to pre-load the building's interior view as part of the application, similar to a game environment, with the aid of ARKit library.

Installation steps:

1. Browse to https://unity3d.com/get-unity/download, select Choose your Unity + download. On a Mac, it should display the choice for macOS version download.
2. Install the Unity Downloader by clicking on the installer (.dmg) item.
3. Unity will begin to download. Once it is done, follow through the installation steps.
4. Launch Unity from Application from now onwards.

4.1.2 Hardware Used

4.1.2.1 Apple MacBook Pro (Early 2011)

Figure 3-4-F4 Apple MacBook Pro (Early 2011)

Since Xcode is a mandatory to develop and iOS platforms and can only be installed on Apple Macintosh, MacBook Pro is used for this project development. The MacBook Pro is the line of notebook computers under the Pro series designed and manufactured by Apple Inc. since May 2006 until present. The notebook ships with OS X or macOS operating systems, but installation of other operating systems is readily available.

4.1.2.2 Apple iPhone 6s Plus, 7 plus and SE

Figure 3-4-F5 Apple iPhone 7 Plus

ARKit can only be tested on Apple devices; hence, the iPhone 6s Plus, 7 plus and SE will be used as testing platforms and target deployment platforms for this project. The iPhone is the line of smartphones designed and manufactured by Apple Inc. starting year 2007 and runs only the iOS mobile operating system.

4.1.3 Issues and Challenges

One of the most challenging part in the development of this project is the 3D modelling process of UTAR Kampar Campus buildings. Each individual building needs to be modelled separately then combined into the final overview of the entire campus. The modelling process becomes tedious because the campus comprises 15 different buildings housing different faculties and facilities of the university.

Another issue faced is the detection for suitable planes via feature points detection prior to generating planes. Since smartphone AR technology fully relies on the footage seen through a smartphone camera, it takes a significant amount of time for the system the accurately detect a suitable flat surface before a plane can be generated to avoid inaccurate placement of 3D objects upon user tapping. Feature points may find difficulties to be generated in dark conditions as well, which may occasionally cause failures in generating a plane.

4.1.4 Testing

There are 4 conditions upon launching the ARView in the application, which are as below:

1. Initialized

   Upon entering the ARView, the system will be continuously generating feature points until a flat surface is detected suitable for a plane to be generated.

2. Ready

   A plane is generated and the user can now tap anywhere on the plane to place an object.

3. Temporarily Unavailable

   If the user taps on the screen before a plane is generated, an error message will be generated. Users are not allowed to place object without a plane.

4. Failed

   The system fails to search for a suitable surface for a plane to be generated at all. This should not be happening throughout the lifecycle of the application and if it happens, troubleshooting needs to be done immediately. The user will be asked to reboot the application upon this failure.

4.2 Timeline

4.2.1 Gantt Chart

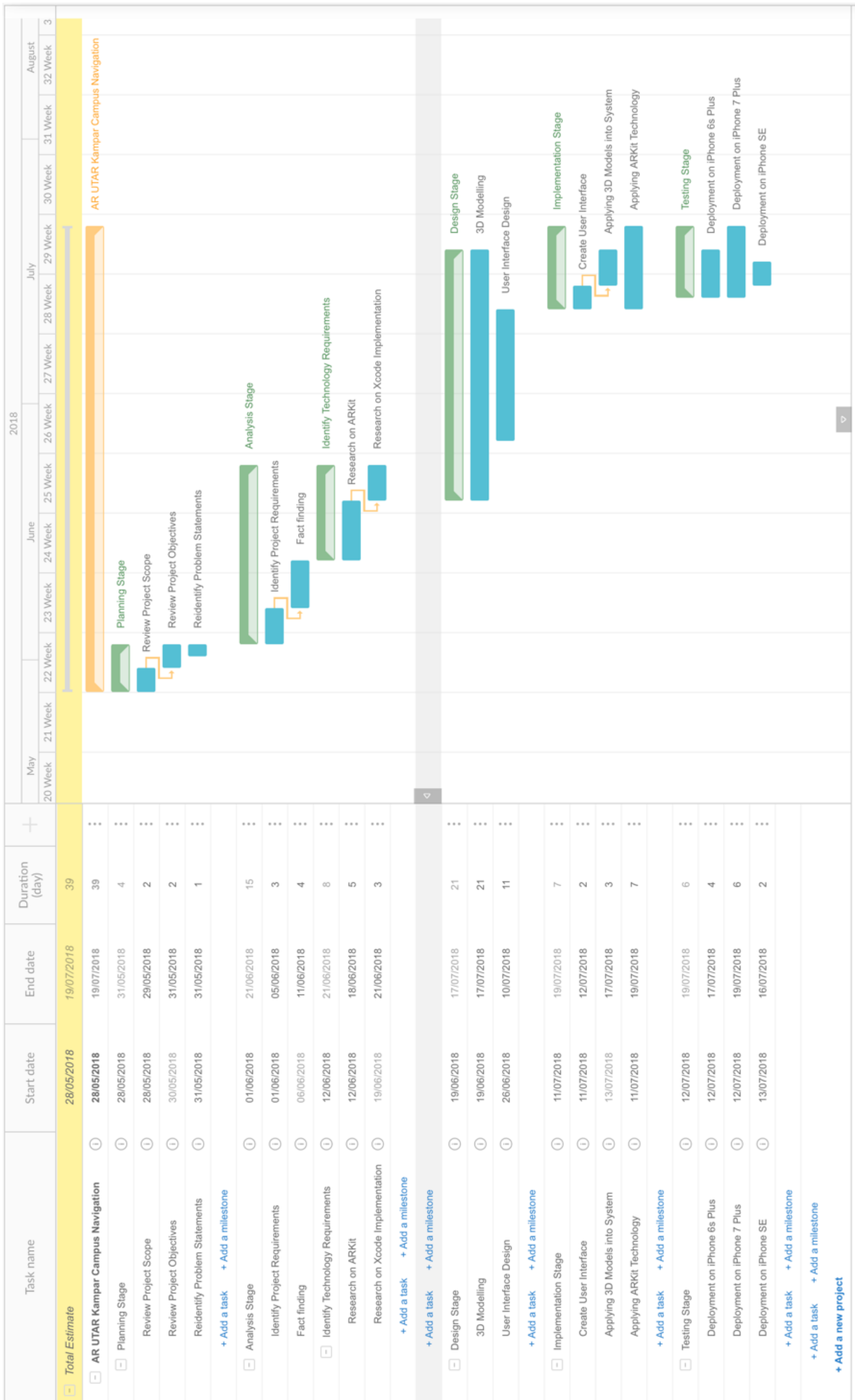

Figure 3-5-F1 Gantt Chart

Chapter 5: Results and Testing

5.1 Graphical User Interface

5.1.1 Splash Screen

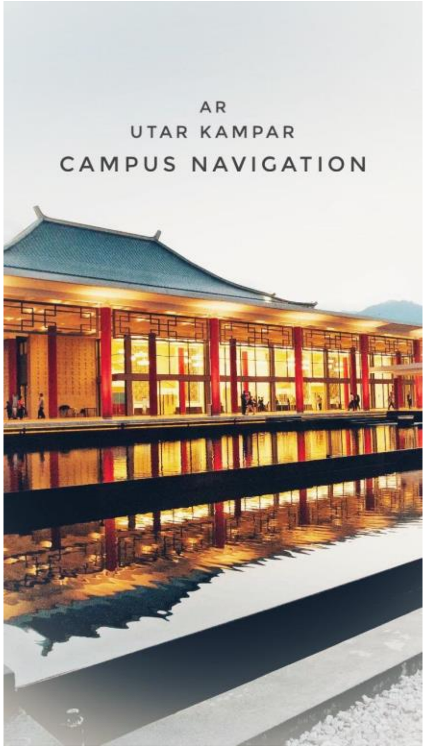

Figure 5-1-F1 Splash screen

Upon launching the application, user will be shown a splash screen that shows the most iconic building of UTAR Kampar Campus, Dewan Tun Dr. Ling Liong Sik. The splash screen functions as a buffer for assets in the background to load before entering the application.

5.1.2 AR Mode Selection

Figure 5-1-F2 AR Mode Selection

User will be given 3 choices to select from, namely Campus Overview, Individual Building View or Map Navigation View. For Campus Overview, the whole UTAR Kampar Campus will be simulated at once on a detected surface. For Individual Building View, user will be given choices to select which building to simulate. For Map Navigation View, a map with all building locations plotted and zoomed on the campus area is displayed. User will be allowed to navigate to the building location via Apple Maps from this view.

5.1.3 Campus Overview

An overall view of all buildings for UTAR Kampar Campus is simulated on a detected surface.

5.1.4 Individual Building View

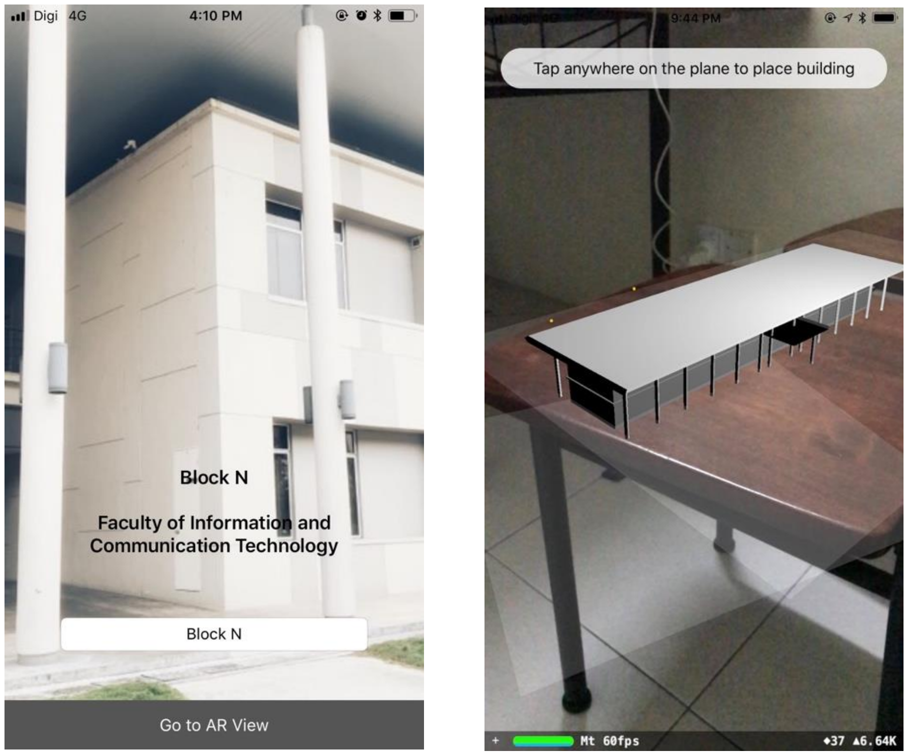

Figure 5-1-F3 Individual Building View

Each individual building of UTAR Kampar Campus can be simulated upon user’s building selection choice. User may select their desired building to simulate on a detected surface.

5.1.5 Map Navigation View

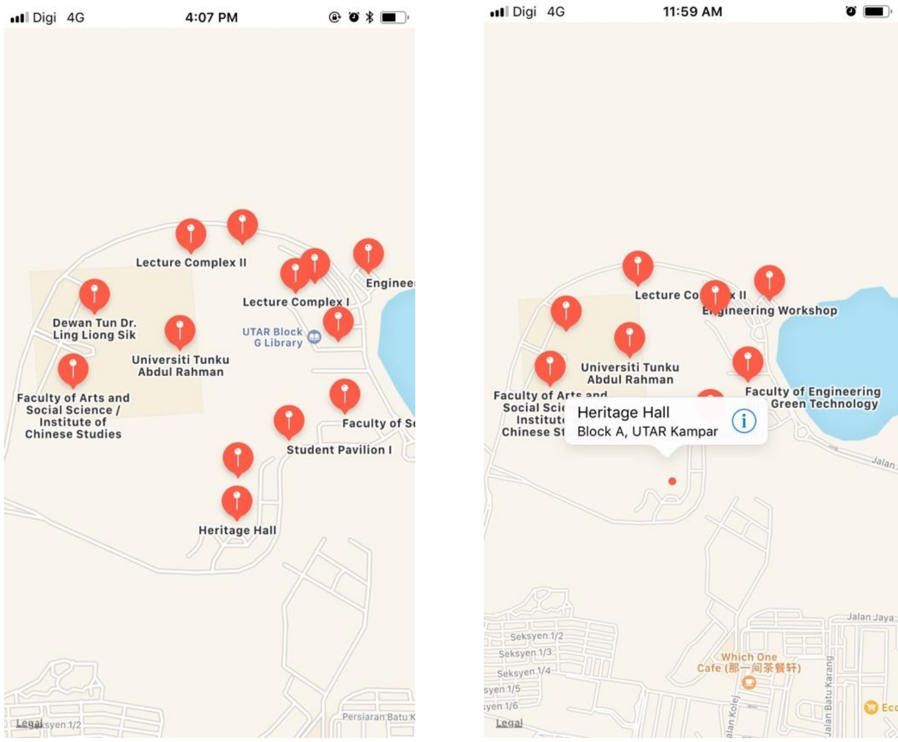

Figure 5-1-F4 Map Navigation View

All buildings in the campus are pinned on a general map view of the entire UTAR Kampar Campus. User may tap on each pin to display more information regarding the building. Tapping on the ‘i’ icon beside the information pop up will launch the user into Apple Maps for direct navigation to the selected building via GPS navigation.

5.1.6 Interior Building View

Figure 5-1-F5 Interior Building View

This is built via Unity on a separate application. This application allows the user to freely view the interiors of the building of the Main Library in UTAR Kampar Campus by moving the camera around as if the building is right in the surrounding of the user.

5.2 Testing

5.2.1 Survey and Questionnaire

A survey had been conducted to study the feedbacks on the application. The target audiences are mostly students are outsiders.

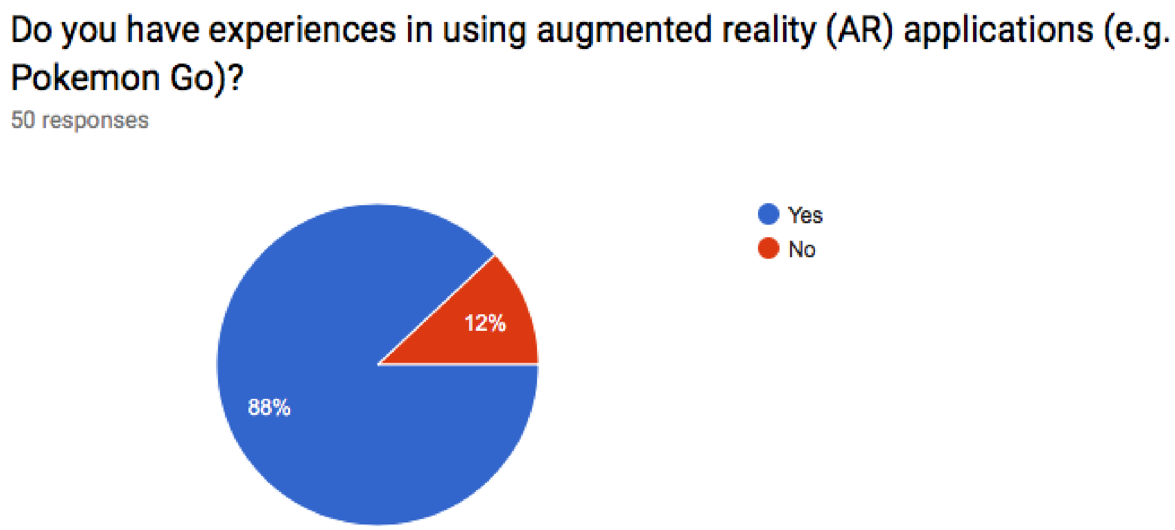

Figure 5-2-F1 Question 1

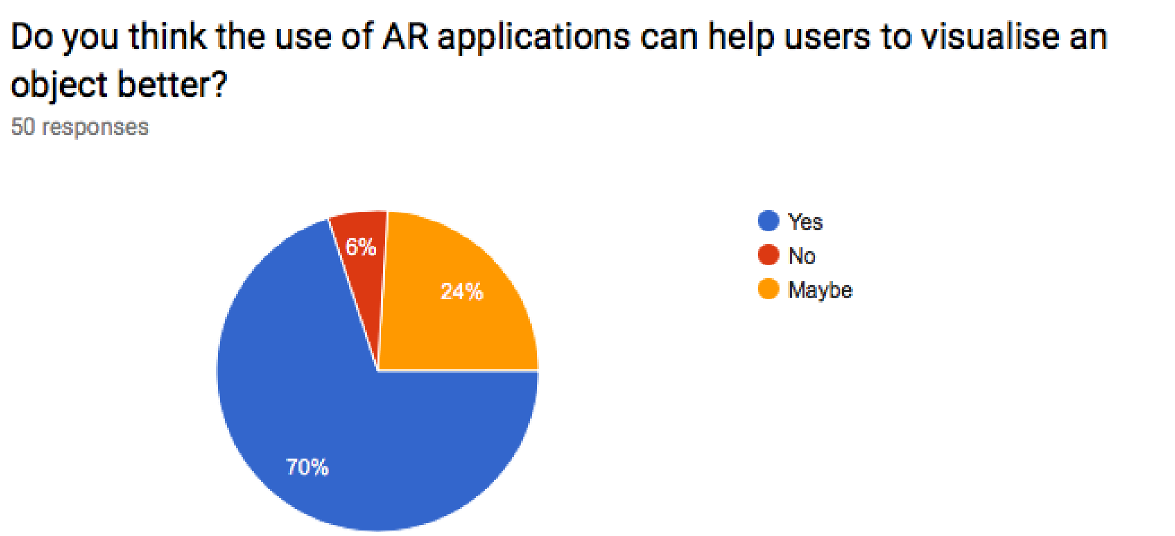

Figure 5-2-F2 Question 2

Based on figure 5-2-F1 and figure 5-2-F2, most of the audience have experienced an augmented reality application on their smartphones before, and believe that it could help to visualize an object better.

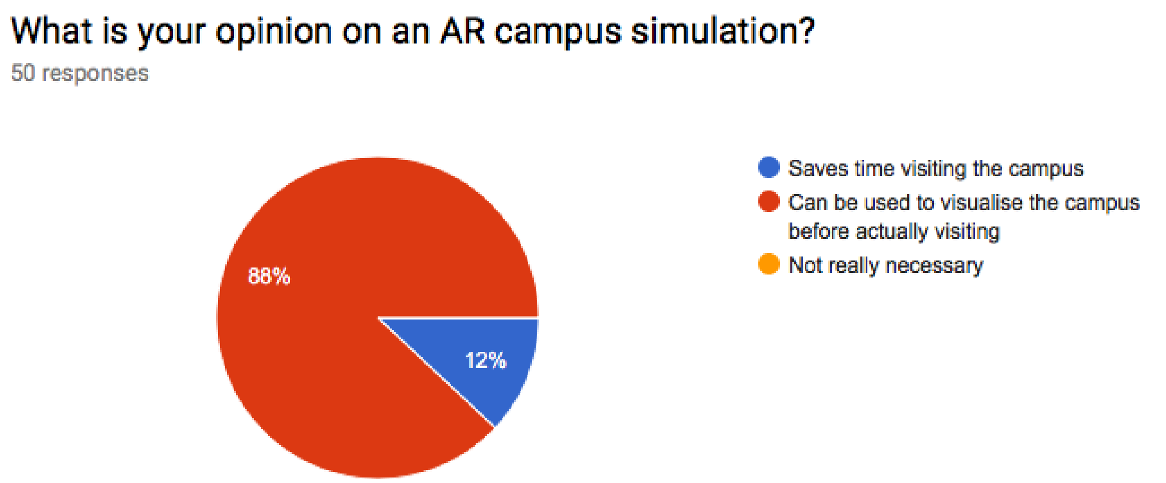

Figure 5-2-F3 Question 3

The audiences strictly think that an augmented reality campus simulation can help to save time or visualize the campus better before actually visiting to the campus. Should the campus look undesiring to the visitor, they can choose not to visit, hence, saving time.

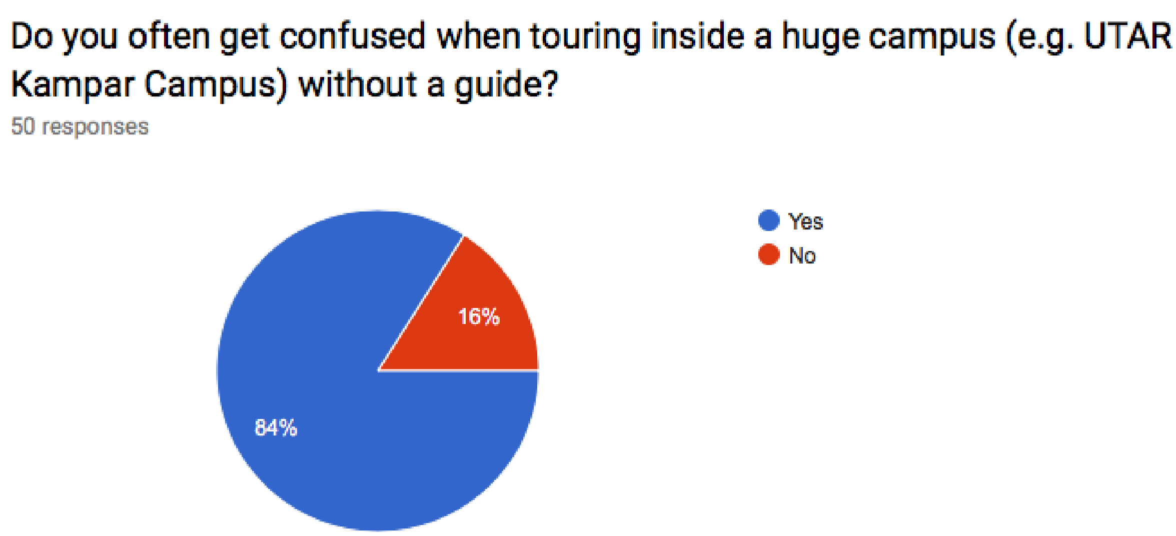

Figure 5-2-F4 Question 4

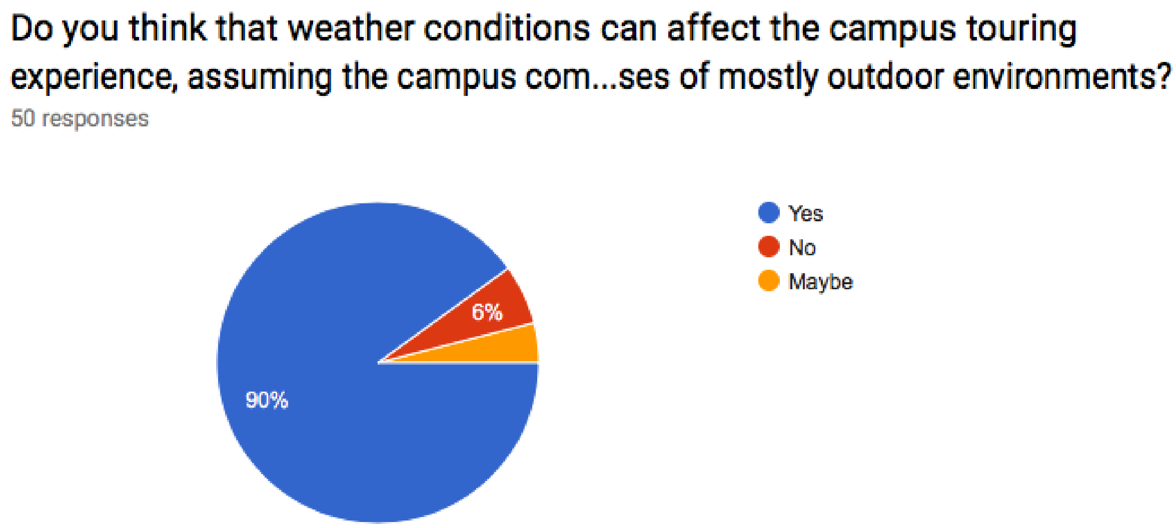

Figure 5-2-F5 Question 5

Majority of the audiences get confused when touring a huge sized campus. Aside from that, Weather conditions are among their concerns when visiting the campus since it's mostly outdoor.

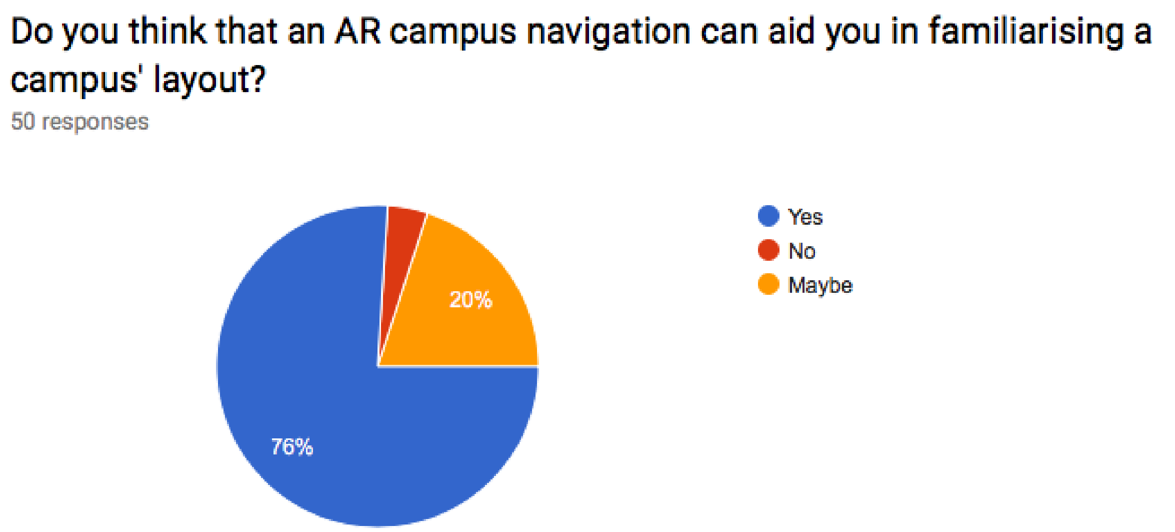

Figure 5-2-F6 Question 6

The audiences believe that an AR campus navigation application can help them when it comes to familiarizing the campus design.

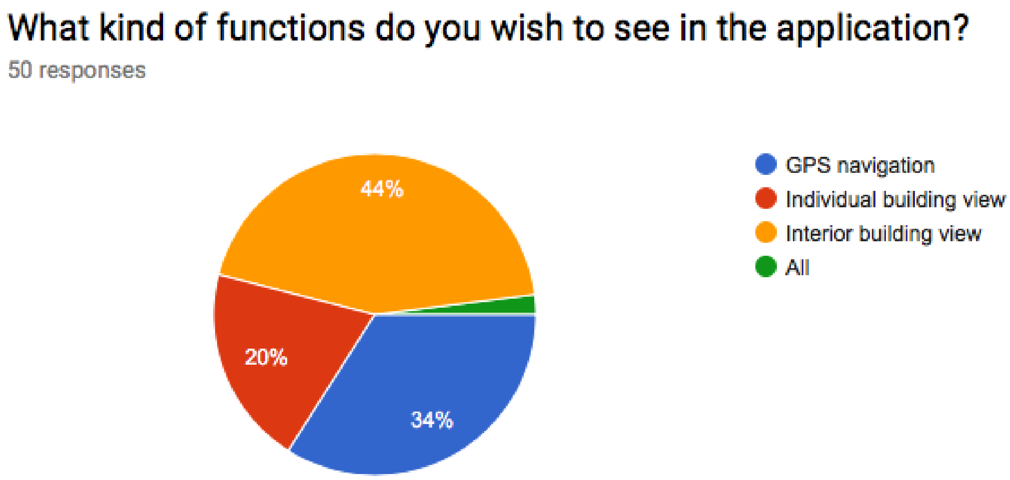

Figure 5-2-F7 Question 7

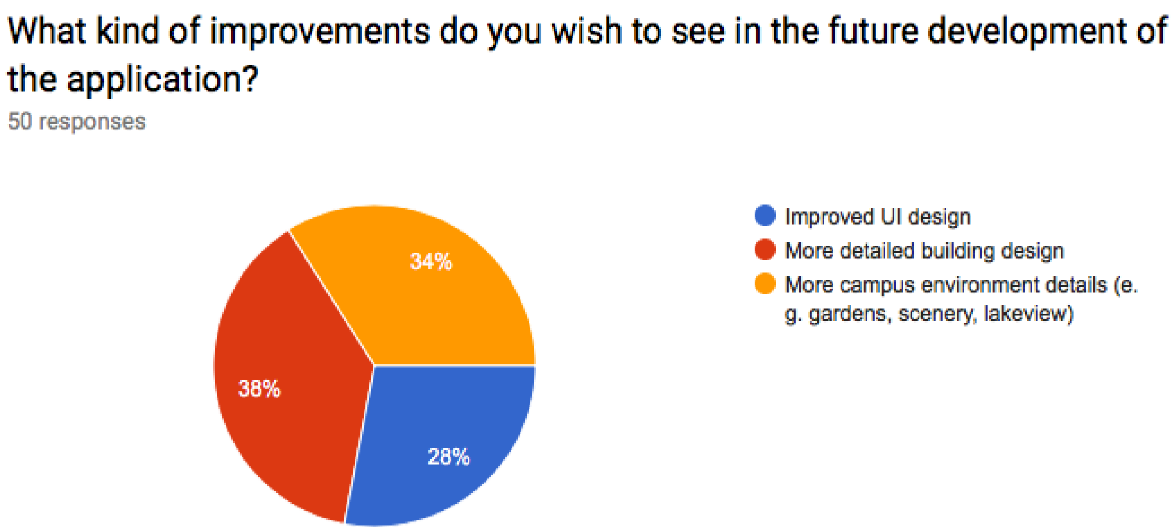

Figure 5-2-F8 Question 8

In general, audiences wish to see all kinds of different functions depending on their personal preferences. In figure 5-2-1 F7, all 3 stated functions that already exists in the application are equally desired by the audiences. In figure 5-2-1 F8 however, user shares equal desires to see improvements on various aspects. This shows that the project can see better future improvements in days to come.

Chapter 6: Conclusion

6.1 Conclusion

AR technologies have made the impossible possible in the past years, realizing the dreams to view any imaginable objects in an augmented camera view. By utilizing this technology, the visualization of the entire UTAR Kampar Campus can be made possible through the development of this project. Traditionally, students or visitors are required to travel physically to the target campus in order to have a good view of the actual buildings and facilities. In the case of distant campuses or even oversea universities, the process of visiting becomes very tedious and costly, not to mention highly risky in terms of travel expenditure if the visited campus is not desired.

The above issue becomes a strong motivation for the development of an AR campus navigation mobile application as it will provide a low cost yet convenient way to visualize the target campus. The application is decided to be built on mobile platform due to its portability and embedded camera in every smartphone available in the market. The application will allow anyone to have a view of the campus anywhere in the world, as long as they have the application installed.

Although the 3D modelling process may require expertise and could take a long period to be done, simple building silhouettes can be built for initial prototyping purposes before further shaping the campuses into detailed models.

6.2 Discussion

After reviewing some of the existing AR applications, most of the applications requires the users to be physically present in the vicinity of the campus. Apart from that, markers need to be detected before any projection or simulation can be done in order to provide AR environments. The aim of this project is to overcome the said issues by providing a markerless AR simulation of UTAR Kampar Campus to any surface anywhere the user desires.

While most of the navigation or visualization application exiting in the market nowadays such as the Google Earth view provides actual photos taken in that particular environment for realistic navigation, the user is not allowed to freely tour around the area. Hence, providing a 3D model of the campus for AR simulation may easily overcome this issue.

6.3 Future Work

As 3D modelling can be infinitely perfected to the tiniest possible details in years of technologies to come, it would be best if the whole of UTAR Kampar Campus can be modelled to their actual and accurate dimensions in the days to come. If at all possible, the interior environment of the buildings can be modelled in order to be projected via AR simulation, allowing the users to navigate in the interiors of the building at actual dimensions. This could possible bring about a whole new market for AR campus tours since the technology is capable of realizing this simulation.

A databased system can also be implemented to store visitor screenshots of the university. This could create a new community to feature exciting and breath-taking corners of the university to promote UTAR’s exquisite architecture.

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APPENDIX

USER MANUAL / APPLICATION INSTALLATION GUIDELINE

Users are required to have the following applications and hardware before the project can be installed or deployed.

List of Applications Required:

1. Xcode 9
2. Blender 2.79 or above
3. Unity 3D

List of Hardware Required:

1. Apple Macintosh running on macOS High Sierra Version 10.13.6 or above
2. Apple iPhone / iPad released from year 2015 or above.
3. Apple Lightning cable

Below are the installation steps for the applications required.

Installation steps for Xcode:

5. Open AppStore on macOS.
6. Search for Xcode 9.
7. Ensure that AppStore is logged in with a valid AppleID.
8. Click GET to install.
9. Launch Xcode from Application from now onwards.

Installation steps for Blender:

1. Open AppStore on macOS.
2. Search for Xcode 9.
3. Ensure that AppStore is logged in with a valid AppleID.
4. Click GET to install.
5. Launch Blender from Application from now onwards.

Installation steps for Unity 3D:

5. Browse to https://unity3d.com/get-unity/download, select Choose your Unity + download. On a Mac, it should display the choice for macOS version download.
6. Install the Unity Downloader by clicking on the installer (.dmg) item.
7. Unity will begin to download. Once it is done, follow through the installation steps.
8. Launch Unity from Application from now onwards.

AR UTAR Kampar Application Installation Guideline

1. On an Apple Macintosh, open the AR UTAR Kampar Navigation folder.
2. Double-click on AR UTAR Kampar Navigation.xcodeproj to open the project on Xcode.
3. In Project Navigator from the left sidebar, select the first item with a blue Xcode icon named AR UTAR Kampar Navigation.
    a. Under General tab, go to Team under Signing column. Select your Apple Developer Account team.
    b. If the certificate cannot be generated, modify the Bundle Identifier to your liking (e.g. com.YourName.YourProjectName). The signing should then be complete.
4. Connect your iPhone / iPad to the Macintosh. Make sure you allow the Macintosh to access your device by selecting Allow from the Allow Access prompt.
5. Select your target build device for the application to be installed in.
    a. On the topmost toolbar in Xcode, find the project name next to a Play and Stop button. Next to the project name would be the target build device.
    b. By default, the target device is a simulator built into Xcode. Select your device which is displayed as the topmost choice from the dropdown list.
6. Click the Play button on the topmost toolbar to build.

Opening the Models on Blender / Unity 3D

1. On any computer, open the AR UTAR Kampar Navigation folder.
2. Open art.scnassets folder.
3. In this folder, all the 3D models are being stored here.
    a. User may right click on the desired model to select which application to open with.
    b. Both Blender and Unity3D allows the opening of these models of .dae extension.
    c. If the item fails to open, copy the item into your computer. Then, open your desired application and open the file within the application.
    d. Unity allows the model to be dragged into the assets column at the bottom of the application.

Interior Building View Installation Guideline

1. Similar to AR UTAR Kampar Application, open the Interior View folder.
2. Double-click on Interior View.xcodeproj item to open the project on Xcode.
3. Follow the steps shown above to install the project.

Opening the Interior Building View on Unity 3D

1. Open the AR Campus folder.
2. In the folder, navigate into Assets > Scenes.
3. Double-click on SampleScene.unity.
4. The project will then be opened in Unity 3D.

FYP Interview

What the project is about:
The project is an Augmented Reality (AR) application that simulates the 3D models of the university buildings in UTAR Kampar campus. It works in such a way that once a flat surface is detected on the user's smartphone camera via the application, he/she will be able to place the virtual 3D model of the building in the real world. The application also allows users to navigate to any building in the campus via GPS navigation.

Objectives of the project:
UTAR Kampar campus is a relatively huge sized compound that comprises of 15 individual buildings surrounding a lake, rendering the campus tour process difficult to be conducted due to unexpected weather conditions and campus size. The project aims to help any potential visitors of the campus to visualize the general silhouette and architecture of the campus prior to visiting. It should also serve to allow potential future students from overseas or faraway places to visualize the campus should they find it difficult to visit to the campus physically.

Why you are being selected for the interview:
First of all, I would like to express my gratitude for having you to provide the project with suggestions, feedbacks and insights allowing us to understand how the project may affect the attraction of future students to enroll into the university.

Please provide your feedback for the questions below. Any suggestions and honest criticisms are very welcomed.

1. Do you agree that the unique architectures of each building in UTAR Kampar campus is one of the attractions for students to enroll into the university? If yes, what are your opinions on 'students tend to enroll into a university that provides a better study environment'? Do justify your choice.

2. What are your opinions on the size of the campus? Taking weather conditions, the extremely long walk and time taken to tour around the campus into consideration, do visitors often find it hassling to completely tour around the campus?

3. Based on your understanding on the project, and considering your opinions on the questions above, do you think it can facilitate the process of introducing the university to outsiders? Please do provide any suggestions and criticisms.

4. How can the project be improved to achieve its objectives? Are there any functions that can be introduced to further polish the project based on your opinion?

End of interview.
Thank you for completing this interview. Your participation and opinions are greatly appreciated!

FYP Interview (Mr Tan Kien Hwa's response)

1. Do you agree that the unique architectures of each building in UTAR Kampar campus is one of the attractions for students to enroll into the university? If yes, what are your opinions on 'students tend to enroll into a university that provides a better study environment'? Do justify your choice.

   - Yes, totally agree that we should emphasize on the campus facilities, architecture and study environment for student enrollment. Although the core for UTAR are to providing same education platform for every student. However, nowadays, we are living in "information fast food" era (信息快餐时代), where the public are bombarded with tons of information and only particular information with attractive picture able to capture people attention.

   - In order to survive in such fast pacing environment, I think we need be more agile and creative by projecting the campus environment and student lifestyle. Then only follow by our core value. And this idea is fantastic to promote our university. Is more than just the product or idea, where this project is fully made in UTAR, from our lecturer and student hard work.

2. What are your opinions on the size of the campus? Taking weather conditions, the extremely long walk and time taken to tour around the campus into consideration, do visitors often find it hassling to completely tour around the campus?

   - For campus tour, we do provide shuttle bus/van service. It will not be a major issue to complete the tour.

   - For myself, I think that Kampar campus size are good enough, not too big nor too small. Student can access to any building by walking, cycling or taking bus. Compared to other local university (UPM, UTM) where student might need to drive 15-20mins in order to reach other blocks.

   - Parents also impress by our Kampar facilities and the size of the campus. The slight disadvantage is where some grandparents/parents are inconvenient for walking might not able to enjoy the tour.

3. Based on your understanding on the project, and considering your opinions on the questions above, do you think it can facilitate the process of introducing the university to outsiders? Please do provide any suggestions and criticisms.

- Yes, it provides an easy platform for everyone to view our campus environment at any time, any place without any physical obstacle.

- But I do concern that for AR technology, example for Pokemon Go are using AR, where it allows us to "see" pokemon appear at our desk, bed, etc. If the same theory applies, which mean our campus can appear at any background? Will it be cultural sensitive when our campus appears at inconvenient place, like toilet?
- And the model will be fully 3D (where it allows to rotate left and right) or partially 3D? (look 3D but not allowing to rotate the model)

4. How can the project be improved to achieve its objectives? Are there any functions that can be introduced to further polish the project based on your opinion?

   - I believed at this stage, the project will be focus on the exterior for each of our building (Block A – Tun Ling hall). To further extend this project, would you mind consider include the interior as well (lecture hall, tutorial room, practical lab, engineering lab, cafeteria, gym room, etc). Although this will be a very challenging and huge expansion.

   - Besides, this application should be able to provide simple explanation for every building. And support at both android and iOS platform.

FYP Interview (Ms Wong Pui Mun's Response)

1. Do you agree that the unique architectures of each building in UTAR Kampar campus is one of the attractions for students to enrol into the university? If yes, what are your opinions on 'students tend to enrol into a university that provides a better study environment'? Do justify your choice.

   - University environment is one of the attractions for student to enrol into the university. My other opinions for student to enrol to UTAR is affordable course fees, a combination private university where can offer Business, IT, Science, Engineering, Medicine and Arts and Social Science, high employment rate, recognise by most of the Asia country. I enrol to UTAR because of affordable course fees.

2. What are your opinions on the size of the campus? Taking weather conditions, the extremely long walk and time taken to tour around the campus into consideration, do visitors often find it hassling to completely tour around the campus?

   - For my opinion, the size of the campus is big. If in good weather long walk and tour around the campus is good especially visit by school. Most of the students are willing to complete the campus tour by walking around. However, during Open Day, we do provide transport for visitor to tour around the campus.

3. Based on your understanding on the project, and considering your opinions on the questions above, do you think it can facilitate the process of introducing the university to outsiders? Please do provide any suggestions and criticisms.
   - Yes, although UTAR founded less than 20, but UTAR obtain good ranking in 2017 and 2018. Other than that, UTAR is establish hospital in Kampar and offer different new course in future to fulfil the market need.

4. How can the project be improved to achieve its objectives? Are there any functions that can be introduced to further polish the project based on your opinion?
   - Offer more scholarship to attract local student. Discuss with MOHE to simplistic the process for international student application. Collaboration with different universities (local or oversea) and companies to build up image.

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FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

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Student Name	Hew Teng Wei
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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Hew Teng Wei
ID Number(s)	1405178
Programme / Course	Bachelor of Computer Science (Hons)
Title of Final Year Project	AR-UTAR Kampar Campus Navigation

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)**
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Number of individual sources listed of more than 3% similarity: 0	
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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: __________________________

Date: ___________________________

______________________________ Signature of Co-Supervisor

Name: __________________________

Date: ___________________________

FYP2 Report

ORIGINALITY REPORT

6%	3%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Te-Lien Chou, Lih-Juan ChanLin. "Augmented Reality Smartphone Environment Orientation Application: A Case Study of the Fu-Jen University Mobile Campus Touring System", Procedia - Social and Behavioral Sciences, 2012 Publication	1%
2	australiancurriculumtfel.edublogs.org Internet Source	1%
3	Kun-Ming Yu, Jo-Chi Chiu, Ming-Gong Lee, Shih-Shih Chi. "A mobile application for an ecological campus navigation system using augmented reality", 2015 8th International Conference on Ubi-Media Computing (UMEDIA), 2015 Publication	1%
4	en.wikipedia.org Internet Source	<1%
5	publish.wm.edu Internet Source	<1%

6	Submitted to The Hong Kong Polytechnic University Student Paper	<1%
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Exclude quotes	On	Exclude matches	< 8 words
Exclude bibliography	On		

FINAL YEAR PROJECT WEEKLY REPORT
*(Project I / **Project II**)*

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 2
Student Name & ID: Hew Teng Wei 1405178	
Supervisor: Ms Saw Seow Hui	
Project Title: AR-UTAR Kampar Campus Navigation	

1. WORK DONE Planned the refinements that need to be done from the prototype in FYP1. Drafts of each individual buildings are sketched in terms of dimensions and exterior view.
2. WORK TO BE DONE Model all 15 buildings on Blender, starting from Block A onwards.
3. PROBLEMS ENCOUNTERED So far so good.
4. SELF EVALUATION OF THE PROGRESS Need to speed up modelling process to catch up with project deadline.

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Supervisor's signature Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
*(Project I / **<u>Project II</u>**)*

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 4
Student Name & ID: Hew Teng Wei 1405178	
Supervisor: Ms Saw Seow Hui	
Project Title: AR-UTAR Kampar Campus Navigation	

1. WORK DONE 2 models are built. Included a new button UI for map navigation.
2. WORK TO BE DONE Pin point all campus building locations into the map navigation view for routing. Build more 3D models.
3. PROBLEMS ENCOUNTERED So far so good.
4. SELF EVALUATION OF THE PROGRESS Again need to speed up to finish up all the buildings.

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Supervisor's signature Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
*(Project I / **Project II**)*

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 6
Student Name & ID: Hew Teng Wei 1405178	
Supervisor: Ms Saw Seow Hui	
Project Title: AR-UTAR Kampar Campus Navigation	

1. WORK DONE 6 buildings are built. Map navigation is done.
2. WORK TO BE DONE Model more buildings, and link them to the map navigation.
3. PROBLEMS ENCOUNTERED Passing values are quite troublesome in terms of map information. Will try to link the buildings to their locations respectively.
4. SELF EVALUATION OF THE PROGRESS Seeing improvements in 3D modelling speed.

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Supervisor's signature Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
*(Project I / **Project II**)*

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 8
Student Name & ID: Hew Teng Wei 1405178	
Supervisor: Ms Saw Seow Hui	
Project Title: AR-UTAR Kampar Campus Navigation	

1. WORK DONE 9 buildings are up.
2. WORK TO BE DONE Link buildings to their respective locations in map view.
3. PROBLEMS ENCOUNTERED So far so good.
4. SELF EVALUATION OF THE PROGRESS Progress is slightly behind schedule.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
*(Project I / **Project II**)*

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 10
Student Name & ID: Hew Teng Wei 1405178	
Supervisor: Ms Saw Seow Hui	
Project Title: AR-UTAR Kampar Campus Navigation	

1. WORK DONE 13 buildings are up.
2. WORK TO BE DONE Link the buildings to the map, try on interior view simulation.
3. PROBLEMS ENCOUNTERED Interior view building cannot be simulated since the model is very detailed and the size is too big. Will try to use the Unity preload game environment approach.
4. SELF EVALUATION OF THE PROGRESS Project is behind schedule. Need to speed up.

_________________________ Supervisor's signature

_________________________ Student's signature