AR MARKER BASED LENGTH MEASUREMENT APP

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Lastly, I am glad to study at Multimedia University, which providing me such a great opportunity to face the challenges. I am able to learn new knowledge and experiences while implementing ideas in writing a full documentation about developing an AR application on phone devices.

Abstract

Augmented reality (AR) software development has rapidly increased its popularity these years as it has fulfilled the requirements of bringing components of digital world into the reality world. In 2008, the first AR application was available in smart phone device and people were able to enjoy this technology. In this project, a size measuring app will be developed to test the portability of AR techniques and explain the principles behind of running an AR application. Unity Editor has been chosen to be the development platform and Vuforia SDK will be used in integrating with Unity, in order to enhance the development experience.

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Preface

This project is an industry-collaboration project and the industry collaborator, Dr. Koh Aik Siong has suggested a modification on this project. The original title "Exploring Google Flutter, Dart and Fuchsia for AR/VR" has altered as some problems are unable to be solved and stopped the progression of the project.

According to the official site of Google Flutter, SDK is a mobile app of building high- performance, high- fidelity apps for iOS and Android. It fulfilled the requirement of achieving cross-platform development from a single code base. It can be coded using Dart language, which is based on C++ engine and libraries. However, the website had mentioned that Google Flutter is designed as a mobile UI framework, which crafts native interfaces on both iOS and Android. It also mentioned that Google Flutter is heavily optimized for 2D mobile apps and no support is provided for 3D development (Teegarden, 2018). In order to continue the project of developing multiplatform for AR/VR mobile app, the discussion has shifted by changing it to other environment.

Fuchsia is an operating system developed by Google, first appeared on GitHub on August 2016. However, it has been proven that the development of the operating system remains unknown since the last demo released on January 2018. There is no evidence shows that Fuchsia is mature enough to develop a simple app as the only available information on Fuchsia is its source code. Some experts believed that Google Fuchsia OS will be released within the next five years, and all information about Fuchsia OS is still a mystery (Osborne, 2018). Besides, some of the components of the source code are also unavailable for explorers (Crider, 2018).

Since the concept of testing Google Flutter SDK had been abandoned, Unity 3D takes over the lead. However, there is still a problem of deciding which **virtual reality (VR)** or **augmented reality (AR)** project should be focused in the next two semesters. During the discussion with project supervisor in week 4, we found that developing a VR project needs some specific devices such as VR glasses and a VR controller. Besides, a VR app is unable to fulfil the requirement of having multiplatform since there is no VR related device for mobile phone released by Apple Inc in the current era. Due to the difficulties of purchasing VR related devices, the idea of developing VR app is recalled and changed to develop the AR project instead.

Therefore, I request to change the title to "AR Marker Based Length Measurement App". A measuring app will be developed by using two markers to recognize the positions and calculate the distance between them. The measuring app requires Unity as an editor, and Vuforia SDK as a development platform. C# language will be the main script language for giving command to detect and localize the marker's position to calculate the distance with its algorithm.

1 Introduction

The popularity of Augmented Reality is increasing recently, AR is convenient for humankind to reduce some of the efforts and unnecessary spaces to carry various instruments. As the result shown in these few years, many companies develop their AR product in order to fulfill a dream of "One all-purpose device". This does not only decrease the equipment needs of human being but also contributed to our environmental protection as there will have less materials to be used in producing the items.

The measuring app, initially based on the Unity engine and the extension of Vuforia SDK, has become the development idea with the techniques of AR. The project will focus on the measurement from different distances with one mobile phone, the detection of images, and the markers tracking system. The measuring app is considered as hand-held display in AR display techniques. The measuring app will measure the lengths between two markers, since coordinates of x (horizontal), y (vertical) and z (distance from camera) are given.

In this report, a literature review will be shown in chapter 2, which related to the recent measuring systems and similar works of AR measuring app. An overall explanation about augmented reality and implemented software will be provided as well. In the end of chapter 2, a comparison of similar systems, development platforms, AR SDKs will be discussed.

Chapter 3 will provide an overall review of the requirements, which the user requirements will be presented using case diagram and context diagram. A list of hardware and software requirements specification will be shown.

Chapter 4 discuss the overall design of the application by using flow charts and sequence diagrams. Besides, the purpose of designing the marker will be explained, and the design of the application will be shown.

Chapter 5 will further discuss the implementation of the project in Unity. Few tables are provided as attaching the Unity GameObject and C# scripts in various ways. The algorithm of calculating the length and other solutions of solving problems are given as well.

In Chapter 6, the test result will be discussed with the requirements given in Chapter 3. The accuracy of the measurement is shown in this chapter.

Based on the contents given, the development process is split to two phases, which phase 1 concludes the overall research of the project, and developing a simply prototype when platform, environment is decided. In phase 2, the project continues with the enhancements held. A lot of conditions such as the copyright issues related with markers design, the ways of presenting the length, or the final output is considered in order to provide a better experience for user.

1.1 Problem Statement

For the app, there are several problems when measuring. Firstly, as the progress of the experiment, the operating on the several equipment has some potential in causing some measurement errors or observational errors. Additionally, as the current stage of the AR app is not perfect, it is lacking of the accuracy on the result. Therefore, it required some time to double check the result which wasted the time throughout the project.

The problems mentioned above will be concluded in the project and the solutions will be found to solve all of them.

1.2 Project Objective

This final year project will be based on the objectives below:

- Develop an AR app and learn the applications of using Unity Editor
- Develop a measuring AR app in order to have more understanding of how AR apps work
- Implement the calculating and measuring algorithms provided by various developers from the researches, journals and web pages
- Develop an AR app which includes the feature of multiplatform

1.3 Project Scope

- The measuring app shall able to measure the length between two markers
- The measuring app shall able to show the length represented as a line between two markers
- The measuring app shall able to perform changing unit function, which includes various unit, such as in centimetre, in meter, in inch and in foot.
- The measuring app shall able to measure the length with different distances away from camera and detect different markers
- The measuring app shall able to let user to download the markers with actual size, including the printing instructions

2 Literature Review

There were some similar researches available in investigating the usage and the expansible of developing the portable camera measurement. In this chapter, the reviews of each study published will be given in order to execute the project more efficiently in the future. A quick explanation of the implemented software is provided as well.

2.1 Augmented Reality

Augmented reality is defined as an interactive experience of which 3D virtual objects are integrated into a 3D real environment in real time (Azuma, 1997). It is a technology which combines digital image processing, computer graphics, artificial intelligence, multimedia technology and other areas (Amin, D. & Govilkar, S., 2015). There are three steps of AR need to be fulfilled, which are recognition, tracking and mix.

In the beginning, any image, object, face, body or space will be recognized as a marker for a virtual object to superimpose. While scanning an empty space, the marker will be shown as a ground plane on the targeted surface for further implementation. Secondly, the system will have real-time localization tracking of the recognized object. It will produce its coordinates (x, y, z) on the virtual environment and the coordinates will update any time when the target object moved to another position. Lastly, the form of virtual objects will then superimposed over the recognized object. This step is set by the developers about superimposing the virtual objects and animations needed to be shown. Some of the software may provide the features of extending tracking, performing virtual animation and object once the camera detects the target object and moves the camera away from the target to a large area.

Figure 2-1 Animation and virtual objects in AR app

Augmented reality can be classified by the methods of display, which are **head-worn**, **handheld** and **projective** (Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B., 2001). These three methods involve different interactions. Head-worn displays (HWD) require users to mount it on their heads and provide virtual imagery in front of their eyes. The second method, handheld displays use an attached camera to act as a window in providing augmentations that shows the real environment with AR overlay influence. The third method, projection displays project the desired virtual image directly on a physical object, and thus it becomes augmented. Among these three methods, handheld display is the most common method in the mobile devices market.

2.2 Recent Measuring Systems

2.2.1 The programmable Optical 3D Measuring System POM – Applications and Performance

This system is a programmable 3D multi-sensor measuring system for non-contact optical measurements of points and elements by applying digital image processing and close-range photogrammetry techniques (Loser, R., Luhmann, T., & PMU, L. H., 1993). It is initially developed for measuring large components in the automobile industry. The system can measure an object made from different materials in 3D spaces,

as the system enables detection of the object, then setting up some points on the object edges. Each of the geometric elements, such as a circle, sphere, line and cylinder involve in different measurements and image processing algorithms. The measurements can be performed in either manual or automatic mode.

Figure 2-2 shows the overall software structure of the POM system. At the beginning, the users will enter a graphical user-interface to control and insert the commands needed to measure the elements. For the central control unit, program interpreter will check the correct syntax and executes the commands given. In program interpreter, there are tons of processes implemented, including the process control, sensor groups and image processing. The data executed will run through the calculation programs and algorithms, and finally shows the result.

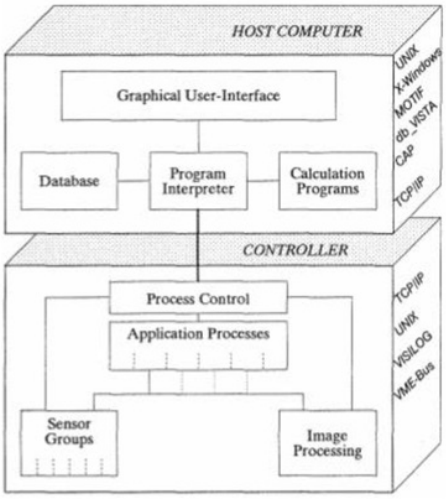

Figure 2-2 Software structure of POM (Loser, R., Luhmann, T., & PMU, L. H., 1993)

The system requires to work with various suitable imaging sensors and cameras, such as Pollei Reseai-Scanning Camera (RSC), CCD video cameras and digital rotary table. Besides, it also needs a light source for defining and positioning the object to measure the size.

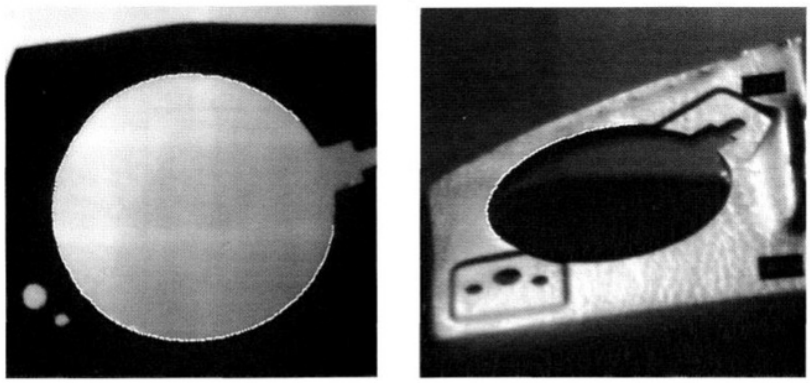

Figure 2-3 Sample element to measure in POM (a circular loudspeaker hole)

The white dots beyond the edges of the circular loudspeaker hole represent the points detected by the sensors, this allows the system to continue its measurement with accurate data. The left figure was taken from the bottom, and the right figure was taken from the top.

After the measurement and calculation have been done, all data including observation processes, sensors data and results will be stored in a network database. The data stored will be arranged according to the measured elements, which allows user to track back the previous result easily.

2.2.2 3D Measuring of Complex Automotive Parts Using Video-Laser Scanning

In this research, the researchers aim to discuss the applications and the advantages of measuring 3D complex objects by using the techniques of 3D scanning, especially

video-laser scanning (Voicu, A., Gheorghe, G. I., & Badita, L., 2013). It mentioned that 3D scanning is a process that uses a contact or non-contact digitizing detector to scan and capture an object form and recreate it into a virtual environment as a 3D graph presentation. The graph will be saved as various CAD formats, and the data will be modeled by using algorithms with the support of the sensors and detectors.

Nevertheless, 3D video-laser scanning has a great advantage among other measuring methods, which is fast and efficient. As 3D measuring systems are able to measure all necessary parameters without errors, it may stand as an important development for some specific industries, such as biomedical and architecture industries. An accurate and low tolerance result is very important to a doctor who needs to know the volume and sizes of organs, or an architect who wants to know the length and width of the materials.

2.2.3 PC-Based 3D Image Measuring Station with Digital Camera: an Example of Its Actual Application on a Historical Ruin

This system is a PC-based photogrammetry system, that can be used to accomplish plotting and original image creation in real time (Kochi, N., Ito, T., Noma, T., Otani, H., Nishimura, S., & Ito, J. , 2003). It aims to be convenient and reduce time needed to calculate either a building or a historical ruin, whereby the experts may proceed to next step faster. The system can identify the images provided and measure the images, transform it into a 3D display with detailed information. It has developed using few simple tools: a digital camera and a laptop computer.

The way of using this software is taking pictures by a digital camera on a fixed spot, which camera-parameter has already installed in the computer. The numbers of image taken in different calibrated zooms will affect the accuracy of the elements. The

pictures will be imported to the laptop computer and visualized in a 3 dimensions graph. Finally, the system will execute the detailed measurement and plotting of the 3D graph to get the outputs, and the results will be implemented in the final plan.

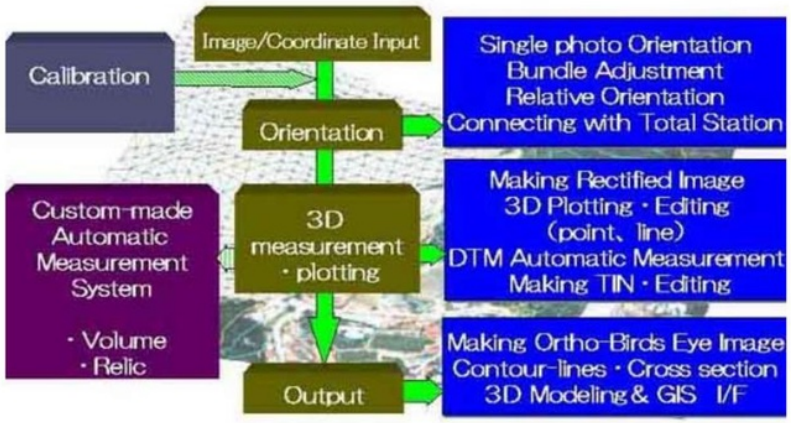

Figure 2-4 The system structure of 3D Image measuring Station (Kochi, N., Ito, T., Noma, T., Otani, H., Nishimura, S., & Ito, J. , 2003)

The system is able to achieve and collect a positive and satisfactory result using measuring techniques, which the accuracy is around ±1 pixel = ±1cm. Besides, the 3D modelling of the elements can be finished in less than 10 minutes and the measurement will only take a few seconds.

2.3 Similar Works

2.3.1 On 3D-Camera Measure

On 3D-Camera Measure is an AR measuring app on Android that performs a non-contact measurement. It can measure an object's size in any direction and plane in 3D space. The requirements for using this app is placing a small rectangle object on the object measured. It has various features for users to measure, which are length, angle, area and diameter. It can measure a round object as well.

To measure the required object, the user should take a full-size photo with the small object place on it. The small rectangle object placed on the plane is to adjust the AR's ground plane by dragging the points to the exact spots. The small circle at the right bottom is for micro-adjusting of both small object and the target object.

Figure 2-5 Adjustment of ON 3D-Camera Measure

After finished the adjustment, the ground plane is ready to be used to measure the area of the tennis table. Figure 2-6 is the result of the measurement. The unit of the result can be changed to centimetre, inches and feet.

Figure 2-6 Output of the measurement

2.3.2 AirMeasure

AirMeasure is a measuring app released on iOS and Android (beta version). It performs non-contact measurement by providing a pointer and button to user in the app. No object is required in AirMeasure, the app is able to identify the distance between mobile device and the target object to measure the length of the target including complex object, such as sofa. There is a feature called Surface mode, which the ground plane shown in the app will appear automatically after the application finished detecting the surface of the object.

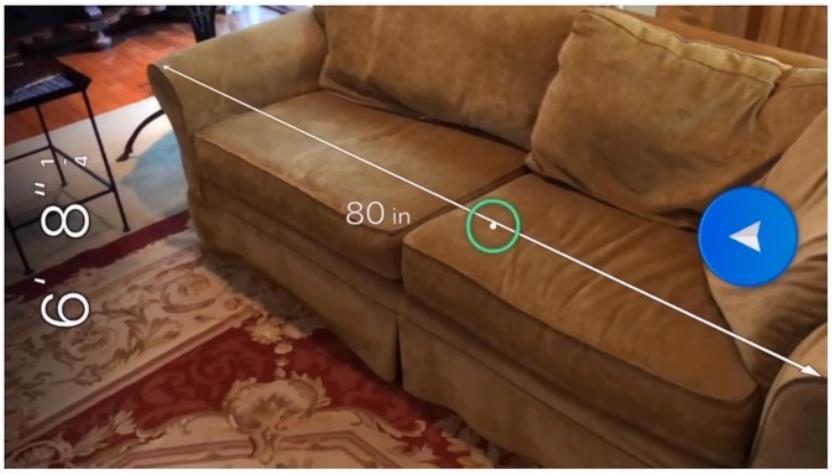

Figure 2-7 Normal measurement of AirMeasure

Figure 2-8 Surface Mode feature

Although the normal function of AirMeasure is measuring the length of the object, it does provide the Floorplans feature, which the user can measure the area of the housing surface. Circular surface and area are the exception for the app as it can only measure the area which has exact angles.

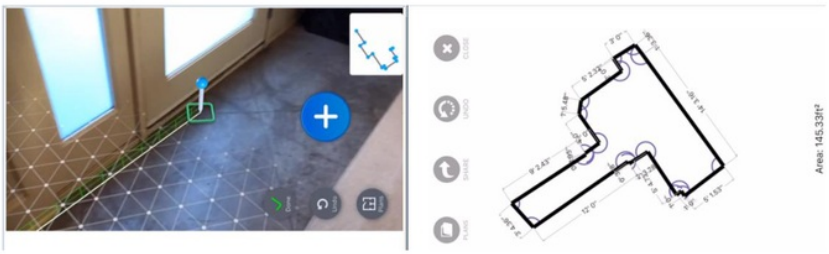

Figure 2-9 Floorplans feature and its' output

2.3.3 Measure

Measure is a measuring app released by Google in September of 2016 for project Tango devices. It can measure an object's length and area by dragging the point to adjust the angles or spots of the object. A ground plane will be shown in anytime for measuring an object or the floor surface. It also provides unit switch features and precision display features. It shows the possible error of the measurement as well. In Figure 2-10, the measurement is shown and the possible error shown by system is ±1inch.

Figure 2-10 Result and possible error on Measure app

2.4 Comparison on Similar Works

The table below shows the overall differences between three similar works reviewed.

System / Feature	ON 3D-Camera Measure	AirMeasure	Measure	Planned System
Object required for measuring	✓			✓
Circular measurement	✓			
Unit Switch	✓	✓	✓	✓
Photo/ real-time video	Photo	Real-time video	Real-time video	Real-time video
Platforms	Own libraries	ARCore	ARCore	Vuforia

Table 2-1 Comparison on similar works

From Table 2-1 given, we can see that ON 3D-Camera Measure is considered as the most convenient and portability measuring app due to the reason that ARCore only allows its supported devices to be used for the app because of the ARCore's API level. However, ON 3D-Camera Measure does not considered as an AR app as it does not fulfil the requirement of being an AR system, which is real-time localization tracking.

2.5 Overview of Implemented Techniques and Software

2.5.1 Unity

About Unity Game Engine, it is integrated by a custom rendering engine with the nVidia PhysX physics engine and an open source implementation of Microsoft's.Net libraries, called Mono (Craighead, J., Burke, J., & Murphy, R., 2008). It has four major characteristics that makes Unity Game Engine a great development platform, which is **completed documentation** with examples for its API, **active online developer community** which experienced developer may provide assistance to new users, an **easier development environment** in a drag-and-drop manner, and **multiplatform distribution**. Compared to Unreal, Source and Torque, Unity has a better experience and lower cost to development, and thus Unity will be used for further exploitation.

2.5.1.1 Comparison of Unity and Unreal Engines

The comparison of Unity and Unreal engines is a debatable topic in this industry. Although both Unity and Unreal engines are having some similarities at some extent, their pros and cons will be discussed in this section.

Unity is having a competitive edge in regard to its larger development community as people are able to find the solutions or resources more easily whenever they are having trouble. Considering customer's experience, Unity is more intuitive to be used and better quality of demos are produced to provide incentives for people in learning more about it. On the other hand, Unity is having a longer existence compared to Unreal which means the system is more familiar for people in this industry and better technical support can be found. However, as some of the features that required for some sort of contents are not free and need to purchase from the asset store.

For Unreal, it is superior in terms of providing the higher quality of image using their graphics production techniques. It offers larger contents of free add-ons which is winning out in this part compared to Unity. However, due to the use of different programmer language, C++, it is relatively more complicated for programmer and not user friendly. The lack of documentation is one of the drawbacks that influenced the quality of the software as the effectiveness and efficiency of using this engine will be affected due to the lack of up-to-date guidelines and information.

In conclusion, Unity has a better user community and longer existence compare to Unreal Engine. Besides, Unity has a better technical support which the user is able to get their development done easily, while the benefit of Unreal Engine is only provides higher quality of the images, which is not very necessary for AR. Therefore, Unity becomes the platform for developing the app.

2.5.2 Vuforia SDK

Vuforia is an AR SDK for smart mobile devices to execute AR applications into a real time video obtained from the devices (Ibañez, A. S., & Figueras, J. P., 2013). It supports both native development for iOS and Android, while also acts as an extension of Unity Engine as that is easily portable to both iOS and Android platforms. The developers may upload the input images or resources for the target that he wants to track, and then access it either through cloud link or directly from the application's local storage (Amin, D. & Govilkar, S., 2015). This is due to the traceable features and binary files that contain traceable database are compiled into the app installer package and can be used at run-time.

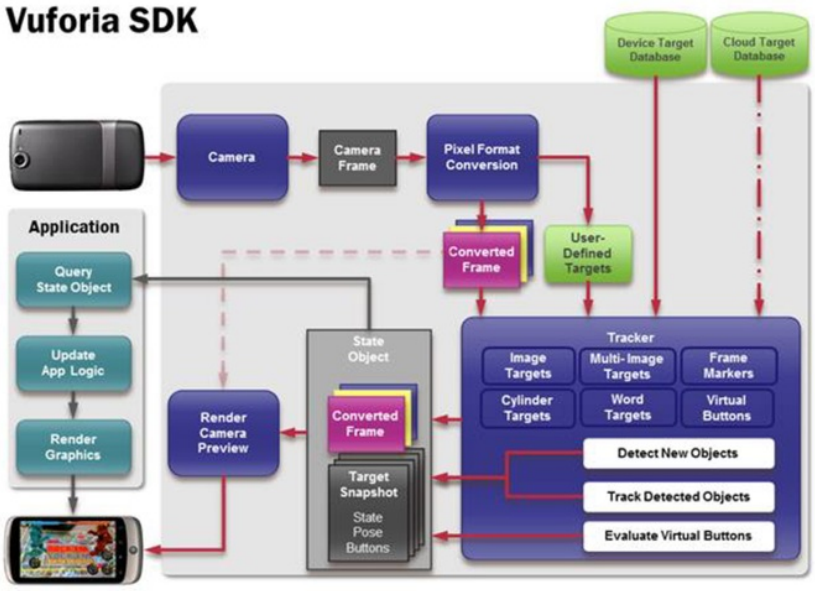

Figure 2-11 Vuforia SDK architecture (Akanksha, 2014)

Vuforia SDK supports both 2D and 3D targets, it enables user to place AR content on a 2D image, simple 3D shape such as cube, cylinder or even conical.

2.5.2.1 Comparison of Vuforia and other AR SDK

SDKs / Feature	Vuforia	ARCore	ARKit
Platform	iOS and Android	iOS and Android	iOS
Device specifications	Suitable for most phone device	Android 7.0 and iOS 11.0, specified phone device	iOS 11.0, iPhone 6s and newer
Main way of imposing virtual object	Image based	Ground plane detection	Ground plane detection
Cost	Free version with Vuforia watermark (Development license provided)	Free	Free

Table 2-2 Comparison of AR SDKs

After exploring and researching which AR SDKs is going to be used, ARCore is the one outstanding compared to others. However, it only supports the phone devices that are listed at its official site. Most of them are released since 2017, which are newer, and higher hardware specs. Besides, the accuracy of measuring an item is always complained by users since Google publishes their measuring app due to its anchoring

issues when users orient the screen. Although Vuforia is in marker-based, it will generate a great result with the calculations implemented. Therefore, Vuforia is decided to be used as the tool in this project.

3 Requirements and Theoretical Framework

3.1 Use Case Diagram

A use case diagram is a graph representation of the elements interact in a system. It is used to identify, clarify and organize the requirements of a system needed. A use case diagram contains 4 components, which are the boundaries, actors, use cases and relationships. The boundary defines the system of interest. The actor represents an individual involves with the system according to their roles. The use cases are the modules which will be used by the actors in the system. The relationships are the links among actors and use cases.

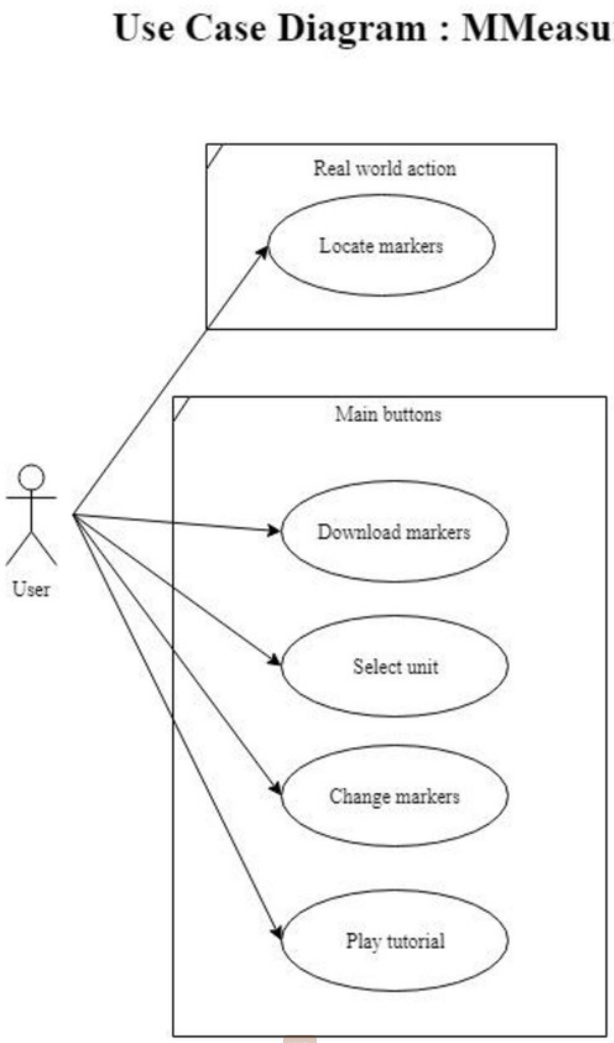

Figure 3-1 Use case diagram

The use case diagram represents a summary of the MMeasure. As a marker based AR application, the system will have detection on the markers, but the user needs to locate its' position manually. The user plays as a role of downloading the markers, which a link is provided to perform the action. The markers will have two sets of the sizes, depends on the range of the distances from camera. The system will calculate the length between two markers with default of centimetre. Therefore, a function of

changing unit will be provided for users, and the choices are in centimetre, meter, inch and foot. A tutorial is given as well; in case the user has misunderstanding of confusion when using the app.

3.2 Context Diagram

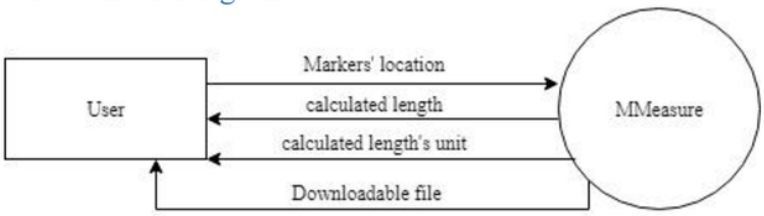

Figure 3-2 Context Diagram

The context diagram represents a general requirement of MMeasure provides. However, the arrows only show the data flows of the whole system, while some functions do not relate with data (swapping scene or clicking buttons), therefore they are not included in this diagram.

3.3 Software and Hardware Requirements Specification to Develop Proposed System

3.3.1 Hardware Requirements

Recommended specifications:

- 2.4GHz Intel Core i7 processor (Max Turbo frequency 3.4)
- 8GB RAM
- Up to Hybrid 24GB Nand,1TB 5400rpm storage
- NVIDIA GeForce GT740M graphics

3.3.2 Software Requirements

- Unity
    - Android Build Support

- Vuforia SDK (as Unity extension)
- Android Studio (an environment variable for developing Android app)
- Visual Studio 2017
- Heroku CLI
- GIT
- Composer

3.3.3 Software Language Used

- C#
- PHP
- HTML

3.4 Software and Hardware Requirement to Run Proposed System

3.4.1 Hardware Requirements

- An Android device
- Android 4.1 APIs (Jelly beans)

4 Design and Research Methodology

4.1 Proposed Methodology

In every application-based project, a software development model shall be determined and implemented to have a better and more efficient development. A software development model is a methodology that used to develop the project depending on its scope and purposes. It also enhances the development experiences and provides a more comfortable development process for developers. Each development model has its characteristics to achieve to project's requirements and objectives in a more convenient way.

4.1.1 Prototyping Model

In this report, the prototyping model will be the development model of the project. The prototyping model is a system development method that a prototype is built and tested based on the project scopes. The prototype will be reworked again and again until an acceptable prototype is finally achieving the actual requirements which the complete system can start to be developed (Rouse, 2005).

Prototyping model has been chosen for this project due to the high contact of user experience. The user's feedback is highly emphasized to provide better performance and satisfaction. Besides, the requirements need to be changed more often based on the user requirements. Therefore, prototyping model will be a better solution.

The advantages of using prototyping model are:

- Highly involved users and testers during development
- Earlier errors detection
- Obtaining user feedback for solving system errors
- Shorter development process
- Easier user comprehension of the system

4.2 Structure Design

4.2.1 Flowchart Diagram

In this section, the structure and design of the app is explained using flowchart diagram, which will provide a better understanding of how MMeasure works. First of all, the main flow of the app is shown as Figure 4-1, as the app will not exit unless the user hits "Exit" button. When running the app, the user may perform any function, which shown as Figure 4-2.

4.2.1.1 Main Flow

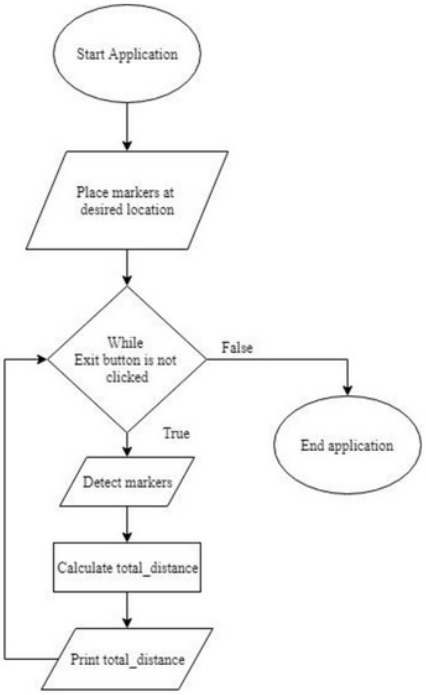

Figure 4-1 MMeasure main flow

4.2.1.2 Main Functions

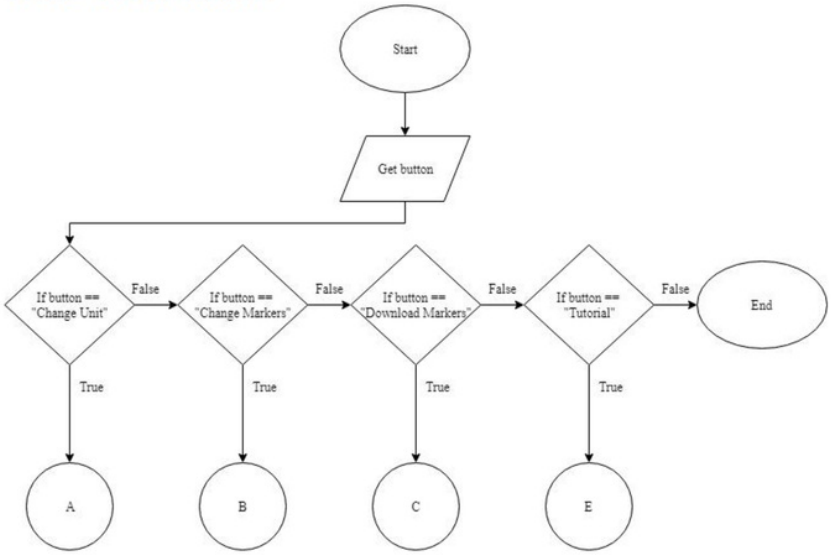

Figure 4-2 MMeasure's main buttons and functions

4.2.1.3 Changing Unit Function

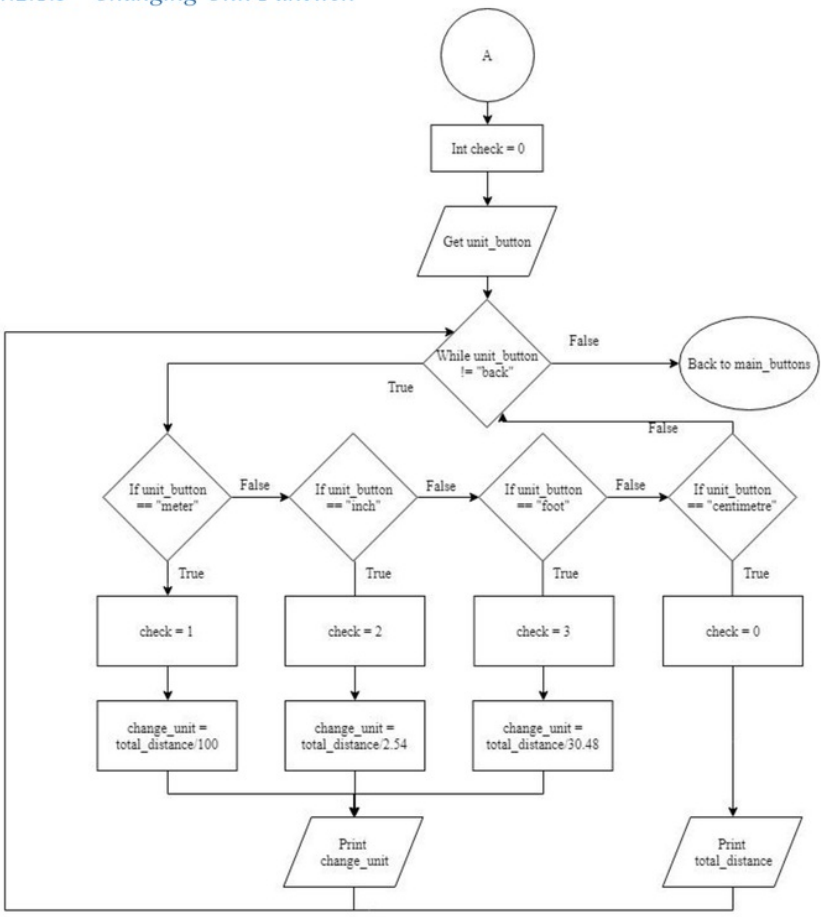

Figure 4-3 Changing unit function

By clicking "Change Unit" button, four options will be given to user, which are "meter", "inch", "foot", and "centimetre". Choose any option will execute the calculations, and the trigger "check" will be changed to current unit. Hit "back" button will hide the unit_buttons, and shows main_buttons.

4.2.1.4 Change Markers Function

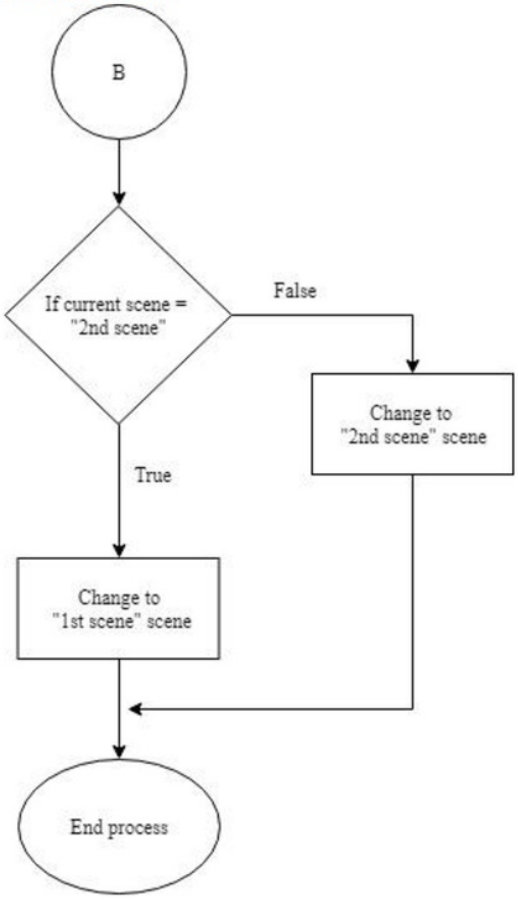

Figure 4-4 Change markers function

There are three scenes in total inside MMeasure, which are "1st scene", "2nd scene", and "HowToUse". "1st scene" and "2nd scene" are used for two different sets of markers to handle different range of distance away from camera, while "HowToUse" scene is created for showing the tutorial. Only "1st scene" and "2nd scene" are involved in this function to perform change markers function by clicking "Change Markers" button.

4.2.1.5 Download Markers Function

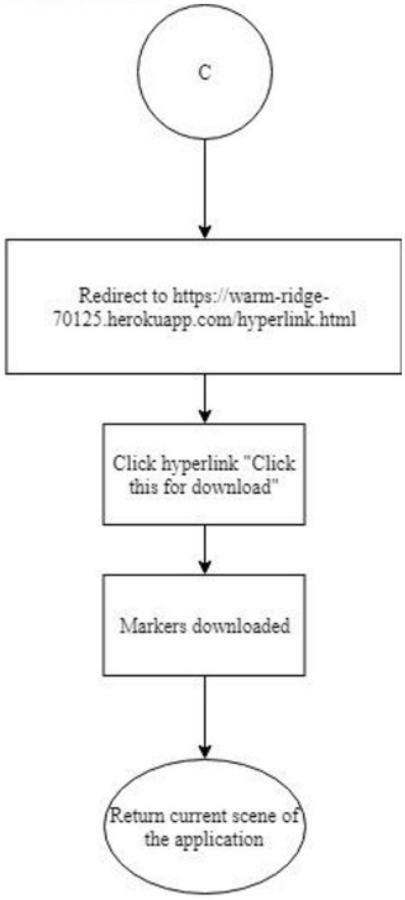

Figure 4-5 Download markers function

By clicking "Download Markers" button, the app will redirect user to link: https://warm-ridge-70125.herokuapp.com/hyperlink.html, which a hyperlink is provided. Click the hyperlink and the user may download the markers needed.

4.2.1.6 Tutorial

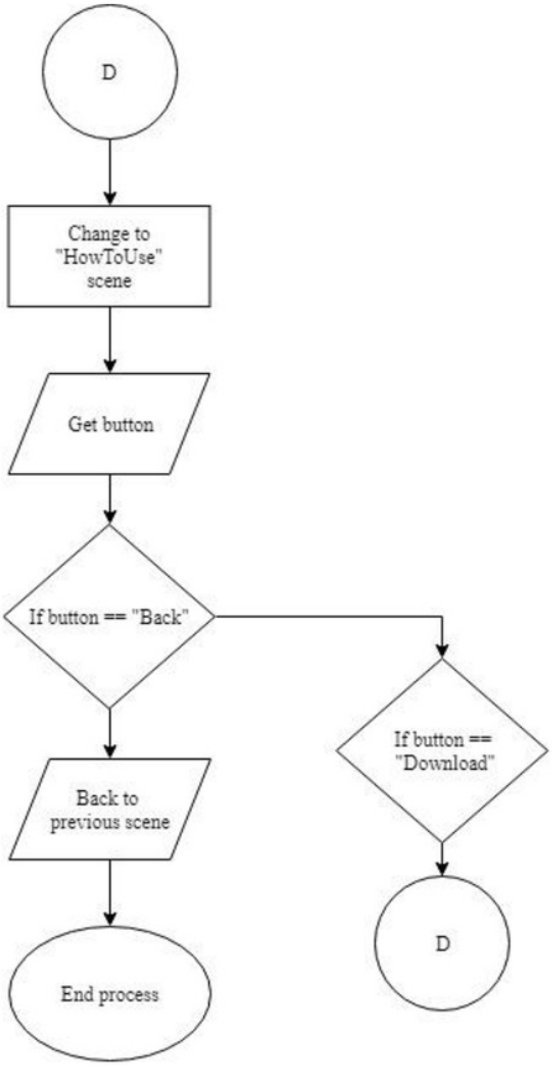

Figure 4-6 Tutorial

After clicking “Tutorial” button, the scene will redirect to “HowToUse” scene. There are two buttons provided, which are “Back” button and “Download” button. Click “Back” button will redirect user to the previous scene, which are either “1st scene” or “2nd scene”. Hit “Download” button will have the steps of Figure 4-5 given above.

4.2.2 Sequence Diagram

4.2.2.1 Locate Markers

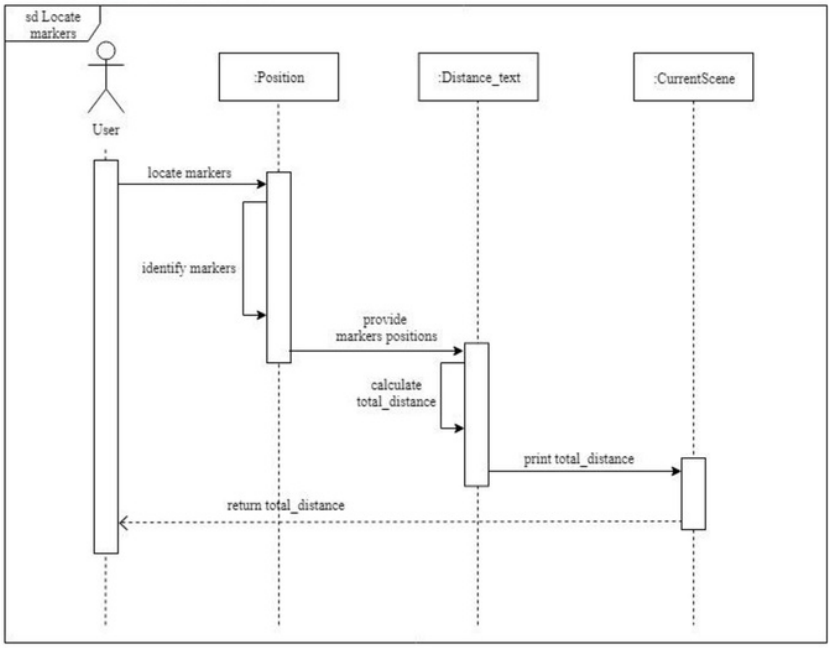

Figure 4-7 Locate markers sequence diagram

4.2.3 Change Markers

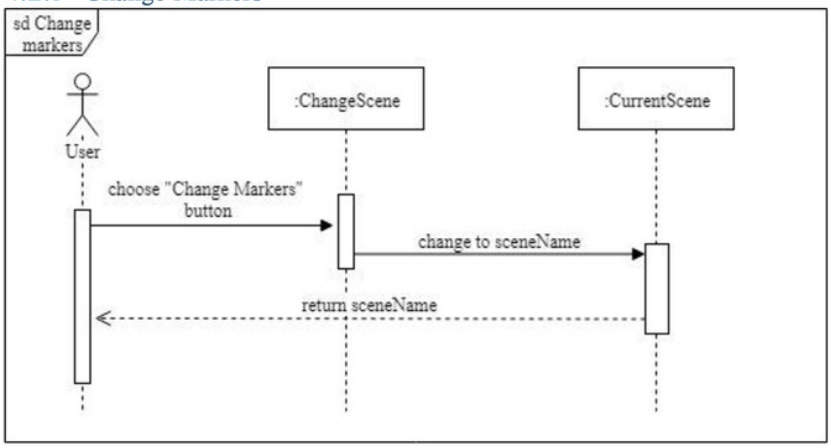

Figure 4-8 Change markers seuqence diagram

4.2.3.1 Select unit

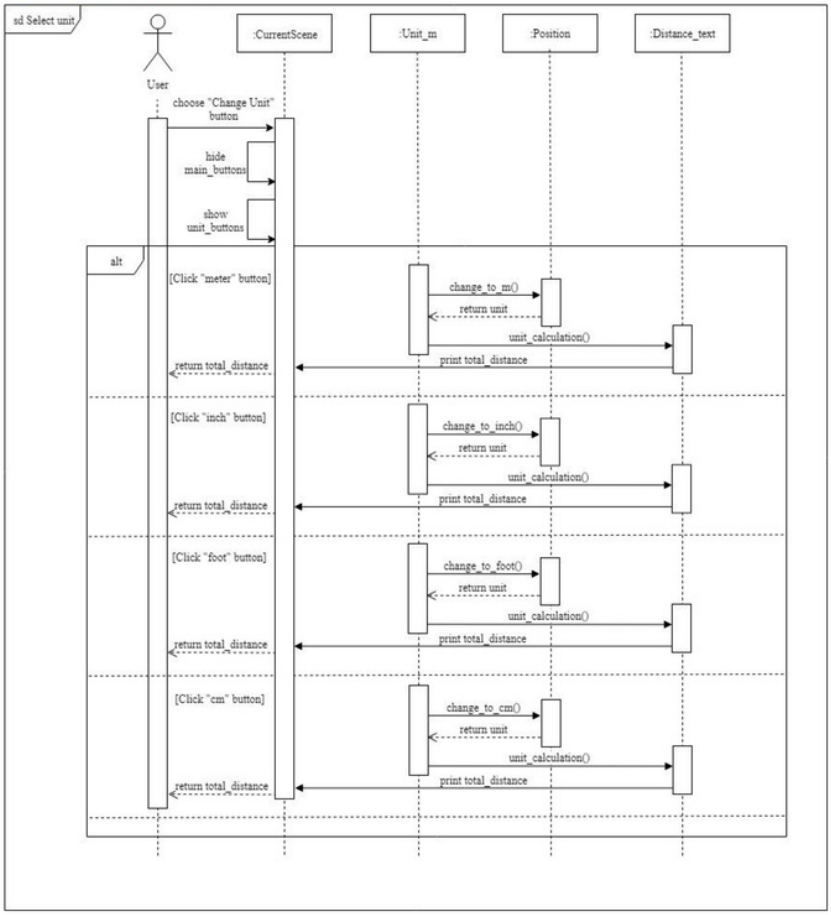

Figure 4-9 Select unit sequence diagram

4.2.3.2 Download Markers

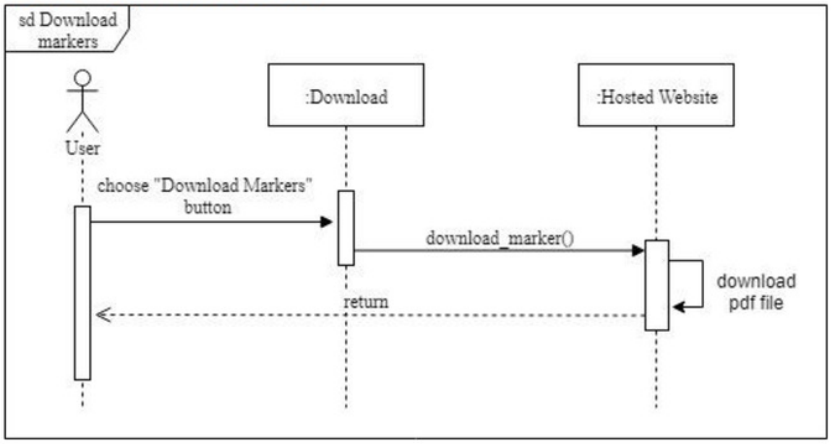

Figure 4-10 Download markers sequence diagram

4.2.3.3 Play Tutorial

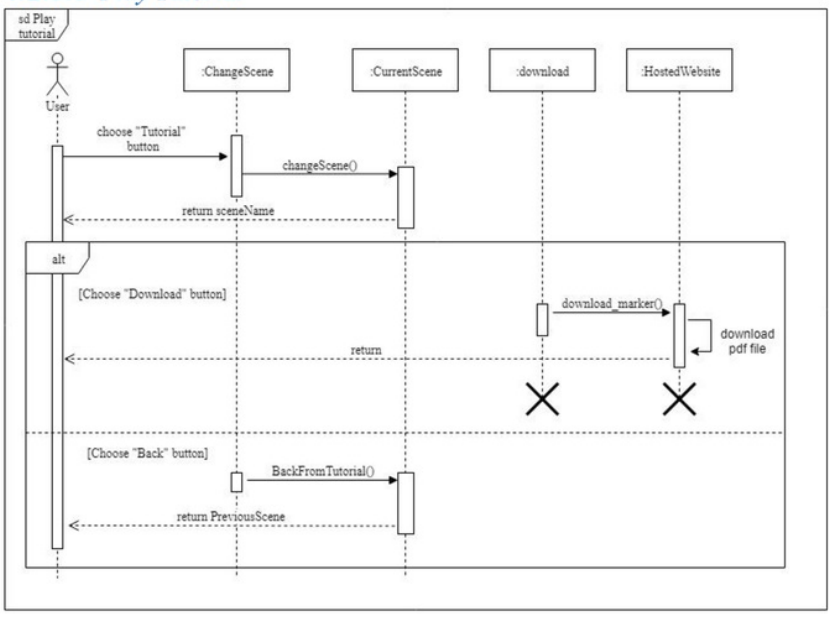

Figure 4-11 Play tutorial sequence diagram

**Note: Please refer to appendix C: Source Code for more understanding of the attributes, class and methods.*

4.3 Application Design

4.3.1 Image Target Design

Since the Vuforia SDK is highly relied on the markers (image target), its design will influence the output with a critical rate. First of all, the size of the marker must be exactly the same with the one in real world due to the implementation of the tracker itself. The tracker needs to get information from real world, such as the distance from camera, the identifications marked on the markers, and the position of the markers. The information will be returned to the tracker when tracking in same scale.

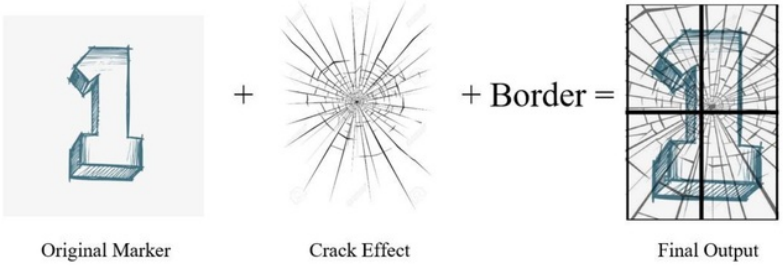

Figure 4-12 Materials of creating a marker

Apart from that, four markers are layered with four different effects. This action will help to increase the contrast of the markers and become easier to tracked by tracker. According to Vuforia Developer Portal, an ideal marker should have three attributes, which are:

1. Rich in details
2. Good contrast
3. No repetitive patterns

With all attributes included, the image target will contain more natural features for Vuforia SDK to be detected and tracked easily. Figure 4-13 shows the features of

a marker, which the yellow crosses are the features initialized by Vuforia Target Manager.

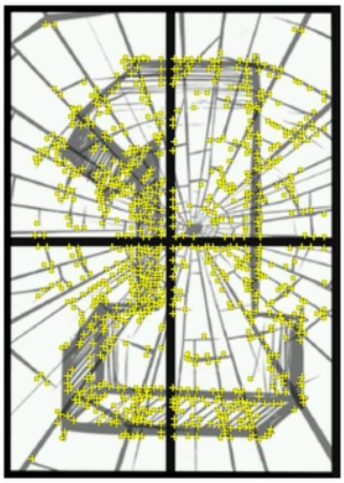

Figure 4-13 Natural features of a marker

There are four markers in total, and these markers are divided into two sets for handling different distances away from the camera. Marker 1 and marker 2 are handling a maximum distance of 2 meters, while marker 3 and marker 4 handle a maximum distance of 15 meters. However, the markers shall be visible for camera, or the tracker will not able to track them.

Due to copyright issue, the markers are re-designed. The markers are bundled into a PDF file named image_for_print. Inside the PDF file, some instructions are written for user to follow. The full PDF file is attached and can be referred in Appendix.

4.3.2 GUI Design

44
Figure 4-14 Interface of 2nd scene

Figure 4-15 Interface of 1st scene

Figure 4-14 and Figure 4-15 shows the overall design of the application. A length, which is the final result is showed initially at top-left side. The samples are provided at bottom-left side as a reference for user to understand which markers they need to use. The markers sizes are provided beside the samples. At bottom-right side, the four

buttons: “Tutorial”, “Download Markers”, “Change Markers”, and “Change Unit” are named as a group called main_buttons. An exit button is provided at top-right side.

Figure 4-16 Interface after hitting "Change Unit" button

After clicking “Change Unit” button, the main_buttons will be hided (setActive(false)), and shows unit_buttons, formed by five buttons: “meter”, “inch”, “foot”, “cm”, and “back” button. If the user wants to shows the interface as Figure 4-14 or Figure 4-15, hits “back” button is the way.

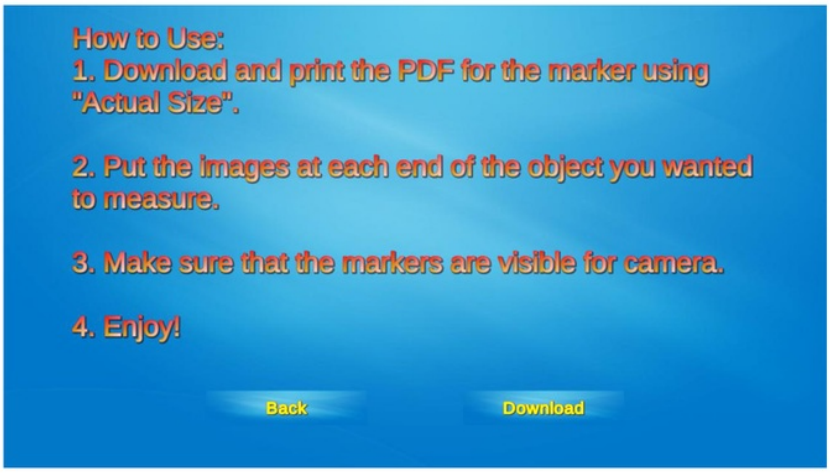

Figure 4-17 Interface of HowToUse (scene)

The application will redirect user to HowToUse scene after "Tutorial" button is clicked.

Figure 4-18 Interface of hyperlink.html

The application will redirect user to hyperlink.html after "Download Markers" button is clicked. The hyperlink will then help user to download the markers in pdf file format.

5 Implementation and Solution

5.1 Deploying Markers

5.1.1 Vuforia License Manager

Before developing the app, a development key must be created by using Vuforia License Manager in order to use the tools and information needed. Each license key created can only be used in a single app. Once a license key is created, the developer is able to assign the image as a marker using Vuforia Target Manager.

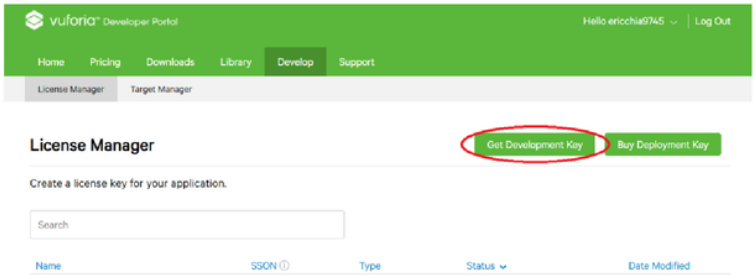

Figure 5-1 Creating a development key

By clicking the "Get Development Key", the developer is required to enter the license name. After entering the license name and click "Confirm" button, a license key will be created named as the input entered before.

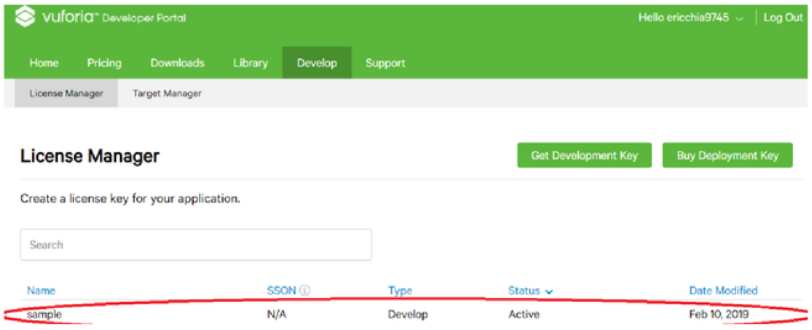

Figure 5-2 Created license key

The license key is showed after clicking the created license key. The developer is required to copy the generated license key to Unity.

5.1.2 Vuforia Target Manager

The Vuforia Target Manager is a web-based tool that enables developer to create and manage image based targets as markers online. A database will be created, and the developer may download it as the whole package of targets. Vuforia Target Manager supports both image based targets and VuMarks (a customized Vuforia Engine target), but it does not support all image based targets. The developer must create the targets with the following standard.

1. 8 or 24 bit PNG or JPG files
2. JPG files with RGB or greyscale
3. Maximum file size of 2.25MB

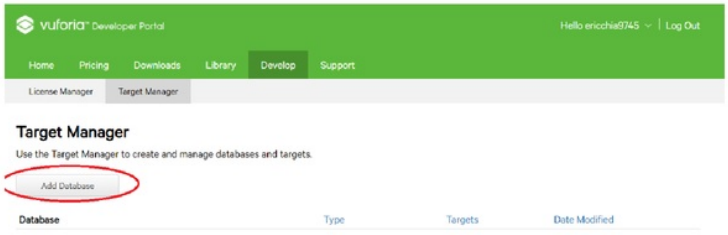

Figure 5-3 Creating a database

After clicking the "Add Database" button, the developer is required to enter the database name as well.

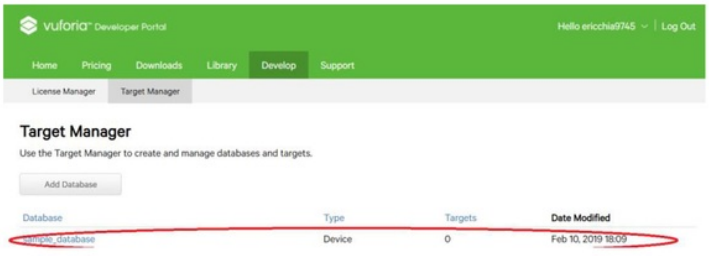

Figure 5-4 Created database

As the database is created, click it and the developer may use it to create and manage the targets. Figure 5-5 shows the information needed to create a target.

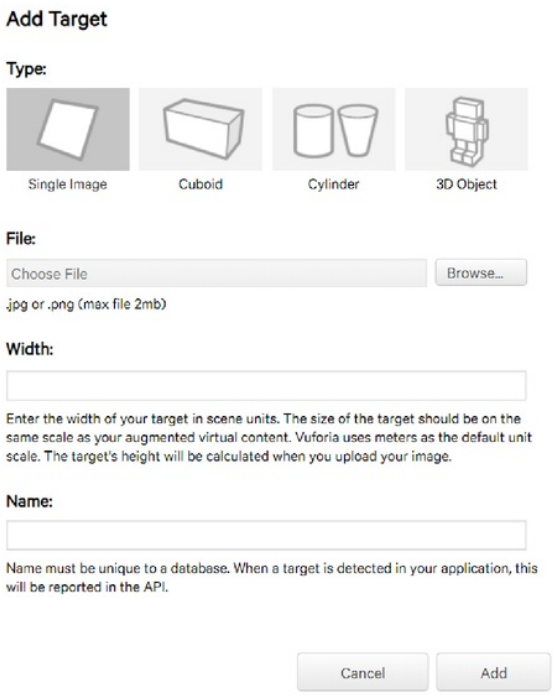

Figure 5-5 Target setup

5.2 GameObject types and descriptions

The types and descriptions of each GameObject is shown as Table 5-1.

GameObject	Type	Description
1st scene/ 2nd scene		
number 1/ number 3	**Vuforia-Image**	Marker 1
number 2/ number 4	**Vuforia-Image**	Marker 2
Canvas	**UI-Canvas**	Interface
distance	UI-TextMeshPro	Text of showing the measured length
sample image 1/ sample image 3	UI-Image	Sample marker 1 for user to identify
sample text 1/ sample text 3	UI-TextMeshPro	Sample marker 1 text
sample image 2/ sample image 4	UI-Image	Sample marker 2 for user to identify
sample text 2/ sample text 4	UI-TextMeshPro	Sample marker 2 text
Image size warning	UI-TextMeshPro	Marker size format in text form
main_buttons	EmptyGameObject	GameObject grouped by the following four buttons
Change Unit	*UI-button*	Button of casting change unit function

Change Markers	*UI-button*	Button of casting change markers function
Download	*UI-button*	Button of casting download markers function
Tutorial	*UI-button*	Button of casting play tutorial function
unit_buttons	EmptyGameObject	GameObject grouped by the following five buttons
change unit_m	*UI-button*	Button of changing unit to meter
change unit_inch	*UI-button*	Button of changing unit to inch
change unit_foot	*UI-button*	Button of changing unit to foot
change unit_cm	*UI-button*	Button of changing unit to centimetre
unit back button	*UI-button*	Button of showing main_buttons
exit button	*UI-button*	Button of exiting the app
Hyperlink	**EmptyGameObject**	**For attaching script Download**

distance_text	**EmptyGameObject**	**For attaching script Distance_text**
ExitScript	**EmptyGameObject**	**For attaching script Exit**
position_parent	**EmptyGameObject**	**For attaching script Position**
drawnLine	**EmptyGameObject**	**For attaching script Line_dis**
HowToUse		
Canvas	**UI-Canvas**	Interface
Panel	UI-Panel	Background Image
Tutorial text	UI-TextMeshPro	Text of showing tutorial
Back	UI-button	Button of redirecting user to previous scene
Download sample	UI-button	Button of casting download markers function

Table 5-1 Types and descriptions of GameObject

**Note: Each button text is using TextMeshPro type.*

5.3 Scripts Attached in Unity

In Unity, a script is usually attached to a GameObject and implemented to other GameObjects. In Figure 5-6 and Figure 5-7, the highlighted GameObjects are attaching one script each, and the attached scripts will be shown as Table 5-2.Table 5-3 shows the GameObject or scripts attached to attributes in each script, and Table 5-4 and Table 5-5 shows the method used in each button.

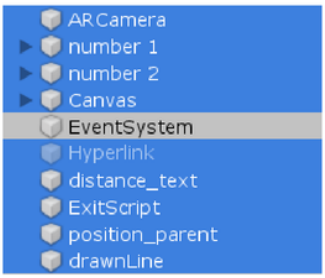

Figure 5-6 Highlighted GameObjects in Unity (1st scene and 2nd scene)

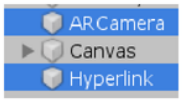

Figure 5-7 Highlighted GameObjects in Unity (HotToUse)

GameObject	script attached
2nd scene/ 1st scene	
AR Camera	ChangeScene
number 1/ number 3	ImageTrackableBehaviour
number 2/ number 4	ImageTrackableBehaviour
Canvas	Unit_m
Hyperlink	Download
distance_text	Distance_text
ExitScript	Exit

position_parent	Position
drawnLine	Line_dis
HowToUse	
ARCamera	ChangeScene
Hyperlink	Download

Table 5-2 Scripts attached to each GameObject

5.3.1 GameObjects/ Scripts Attached to Attributes in Each Script

Attributes	Attached script/ GameObject
Position	
Object 1	Cube
Object 2	Sphere
Pos_x	position1_x (TextMeshProUGUI)
Pos_y	position1_y (TextMeshProUGUI)
Pos_z	position1_z (TextMeshProUGUI)
Pos2_x	position2_x (TextMeshProUGUI)
Pos2_y	position2_y (TextMeshProUGUI)
Pos2_z	position2_z (TextMeshProUGUI)
Distance_text	
Change	position_parent (Position)
Distance	distance (TextMeshProUGUI)
Line_dis	
Cube	Cube (Transform)
Sphere	Sphere (Transform)

Trackable_status	number 1/ number 3 (ImageTrackableBehaviour)
Trackable_status	number 2/ number 4 (ImageTrackableBehaviour)
Unit_m	
Dis_txt	distance_text (Distance_text)
Change	position_parent (Position)

Table 5-3 GameObjects/ scripts attached to attributes in each script

5.3.2 Methods Attached in each button (OnClick())

5.3.2.1 1st scene/ 2nd scene

Button	GameObject/script attached	Method used
main_buttons		
Change Unit	unit_buttons	GameObject.SetActive(true)
	main_buttons	GameObject.SetActive(false)
Change Markers	AR Camera	ChangeScene.changeScene(1st scene) *2nd scene ChangeScene.changeScene(2nd scene) *1st scene
Download	Hyperlink	Download.download_marker
Tutorial	AR Camera	ChangeScene.changeScene(HowToUse)

unit_buttons		
change unit_m	Canvas	Unit_m.change_to_m
Change unit_inch	Canvas	Unit_m.change_to_m
Change unit_foot	Canvas	Unit_m.change_to_m
Change unit_cm	Canvas	Unit_m.change_to_m
Back	unit_buttons	GameObject.SetActive(false)
	main_buttons	GameObject.SetActive(true)
Exit button	ExitScript	Exit.ExitApp

Table 5-4 Methods Used in each button (1st scene/ 2nd scene)

5.3.2.2 HowToUse

Button	GameObject/script attached	Method used
Back	AR Camera	ChangeScene.BackFromTutorial
Download sample	Hyperlink	Download.download_marker

Table 5-5 Methods used in each button (HowToUse)

5.4 Solution/ Algorithm

5.4.1 Calculating Length Between 2 Objects

The algorithm is using the method of Pythagorean Theorem, which the concept is as Figure 5-8.

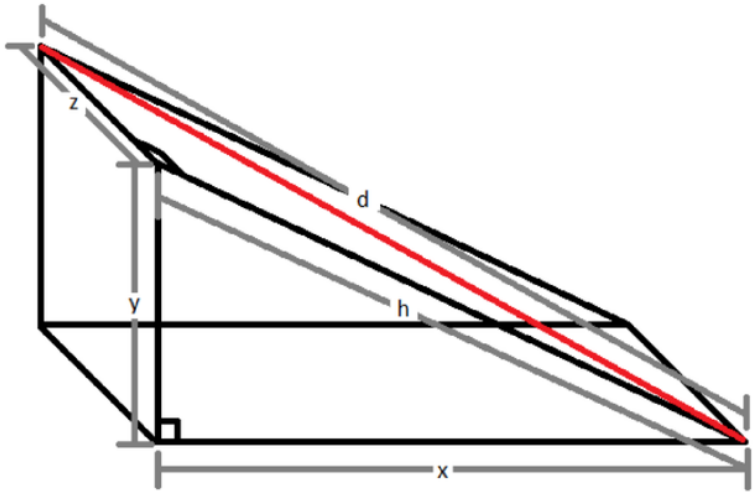

Figure 5-8 Example of using Pythagorean Theorem to calculate 3D space length

D is the length wanted to be measured, where $d^2 = z^2 + h^2$, where $h^2 = x^2 + y^2$. Therefore, the equation will be $d = \sqrt{(x^2 + y^2 + z^2)}$. x, y, and z are represented as the subtractions of each axis respectively. (Refer to Distance_text source code)

5.4.2 Length line

In phase 1, there are 3 lines represented as the lengths between the markers, which are x-axis, y-axis, and z-axis. This concept is abandoned in phase 2 as it does not show the length clearly, and it may cause errors on the alighment of the markers. One LineRenderer called drawnLine is used to replace the old concept.

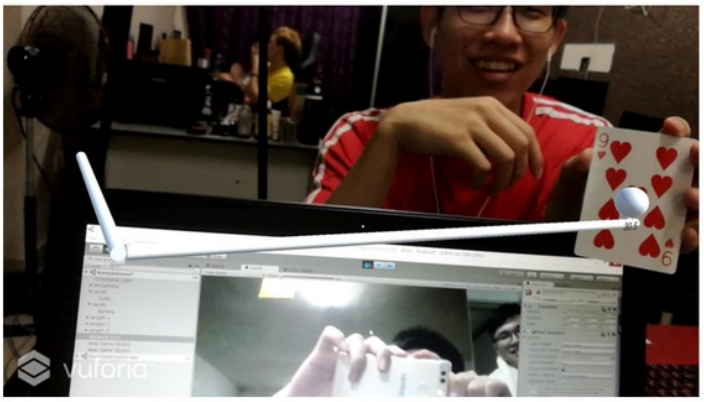

Figure 5-9 Length lines in phase 1

As mentioned in Table 5-2, both number 1/ number 3 and number 2/ number 4 are attached with ImageTrackableBehaviour. This script is used to identify whether the markers are being tracked or not. This is important that the result is used inside Line_dis script. If either one marker is not being tracked, the line will not be drawn. The purpose of doing this is to make the interface cleaner and prevent misunderstanding of the calculated length.

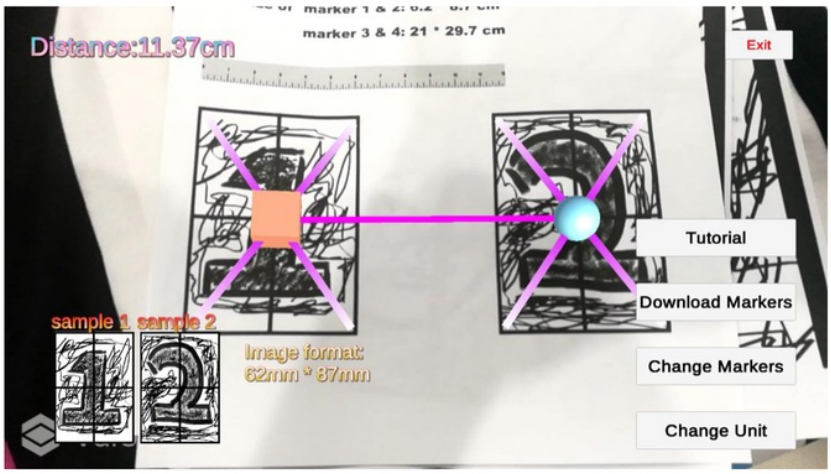

Figure 5-10 two markers tracked

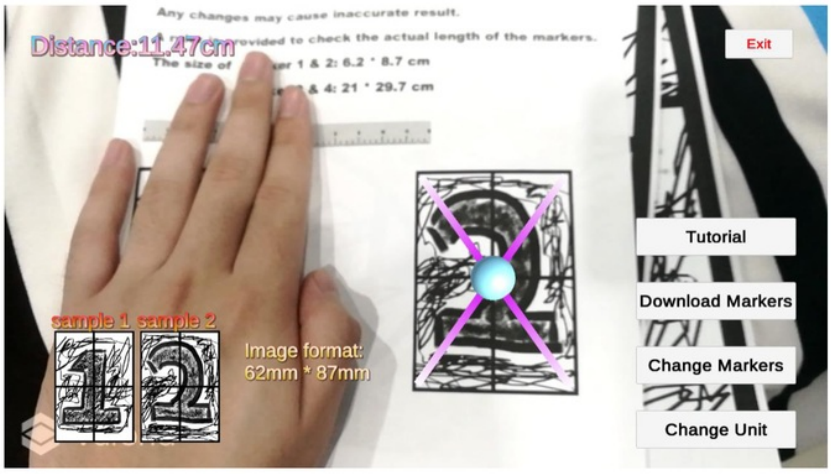

Figure 5-11 One marker tracked

5.4.3 Downloadable markers

Since this is a marker based AR application, the markers are necessary for user. The markers are in a PDF file, which is convenient for user to print. However, the user should print the PDF file in "actual size", in case of causing inaccurate result due to the marker size.

A host is created using Heroku, it also provides SSL support for the website. SSL support is important in providing link, as the link provide in script must have HTTPS. During the process, a tools called Composer is needed for accessing the host.

6 Testing

6.1 Test Plan

6.1.1 Purpose

A test plan will support the following objectives:

- To detail the activities required to prepare and conduct the system test.
- To define the sources of the information used to prepare the plan
- To define the environment needed to conduct the system test

6.1.2 Scope

The scope of testing shall only cover black box-functional testing for the features developed in MMeasure. This test plan shall only cover the system level test, excluding unit test, static test, integration test, acceptance test, regression test, confirmation test, and any other tests that did not mention in this Test Plan. The focus of this document is to meet the requirements of the system and making sure the system fits its intended purpose.

6.1.3 Test Environment

To test the application, a Huawei P9 with Android version 7.0 will be used.

6.1.4 Feature to be tested

The following documents will provide the basis for defining correct operation:

- Use Case Diagram: MMeasure (Chp 3.1)

Feature ID	Description	Risk Level
F001	Locate markers	High
F002	Change unit	Medium
F003	Download markers	High
F004	Change markers	Medium
F005	Play tutorial	Low

Table 6-1 Functionalities to be tested

6.1.5 Test Priorities

F001 should be tested first and it need to be considered as the highest priority as the error may occur if the application does not locate well. F005 will be the lowest priority of testing as it only plays as a role of guiding user about the steps of using the application.

6.1.6 Pass/ Fail Criteria

The system must satisfy the following criteria in order to pass:

- All test cases must be passed.
- The system does not crash or goes into an unknown state during operation.

6.1.7 Suspension and Resumption Requirements

- Suspension criteria: If an issue cannot be solved, do not test the specific function as it cannot be tested at all.
- Resumption criteria: If the issue is solved, the test can be conducted.

6.1.8 Test result

Functionality ID	Expected Result	Actual Results
F001	The markers are able to be tracked, and the virtual objects are imposed well.	As expected.
F002	The unit is able to change to the required ones, and the calculation is well-performed.	As expected.

F003	The app shall redirect user to the expected site, and the PDF file can be downloaded.	As expected.
F004	The scene is able to be changed.	As expected.
F005	The app is able to show HowToUse scene.	As expected.

Table 6-2 Test result

6.2 Accuracy

Since accuracy is the focal point of MMeasure, it was tested using different angles and distances away from camera.

The angles are referring as the angles of the rotating the camera. There are three angles to be tested: 0°, 45°, and 90°. The distances away from camera will have three tests as well, which are: 20cm, 30cm, and 50cm.

Each test will have 10 attempts and the app is rebooted in each attempt. It aims to test the stability of the measurement. The tested markers are marker 1 and marker 2, and the tested length is 11.4cm. Each test will be divided by 10 in order to find the average result, and the result is shown as below.

Degree Distance	0°	45°	90°
20cm	11.41cm	11.44cm	11.41cm
30cm	11.39cm	11.51cm	11.41cm
50cm	11.45cm	11.43cm	11.40cm

Table 6-3 Result of different angles and distances

The result shows that the error is around ±0.1cm, which is good. Different lengths are going to be tested on next testing. The angle is fixed as 0° and the distance away from camera is fixed as 50 cm. Three lengths are provided, which are: 20cm, 30cm, and 50cm. Each test will have 10 attempts as well, and the average result will be shown as the table below.

Actual length	Measured length
20cm	20.04cm
30cm	30.01cm
50cm	49.98cm

Table 6-4 Result of measured length

The result shows that the error is around ±0.1cm, but the error may become bigger when the length is longer. A testing by using marker 3 and marker 4, with the 0° angle, 2 meters distance from camera, and the actual length of 180cm may cause error around ±0.4cm. However, the result seems to be more accurate as the error is within ±1cm.

6.3 Usability Testing

In non-functional testing, a google form that contains 7 questions is created to test the usability of the app. 20 people has been responded about their impression of MMeasure.

The questions asked are:

- How easy do you find to use the system?
- How accurate do you find the measured length is?
- Do find MMeasure is useful?
- Do you think the feature of downloading markers is convenient?
- Do you think the instructions given in Tutorial is understandable?
- What area do you think the system can be improved?
- How would you rate the overall app?

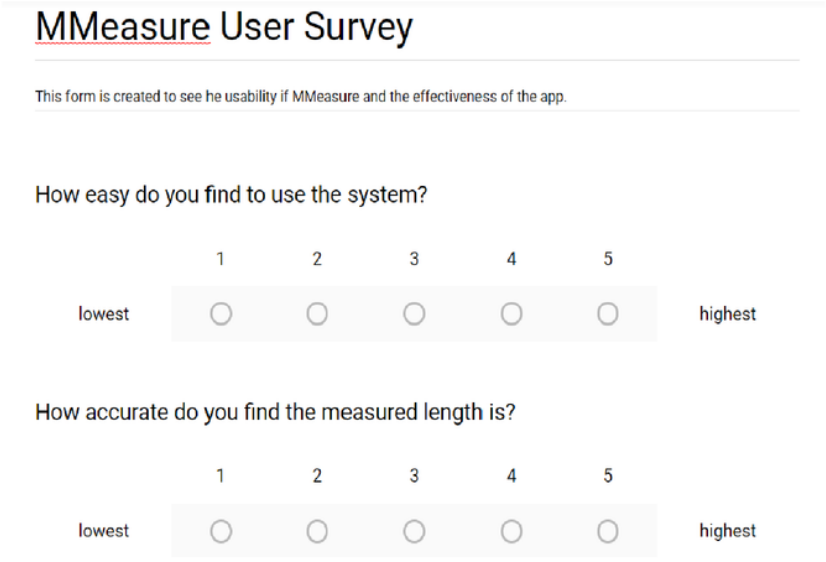

Figure 6-1 User evaluation form 1

Figure 6-2 User evaluation form 1

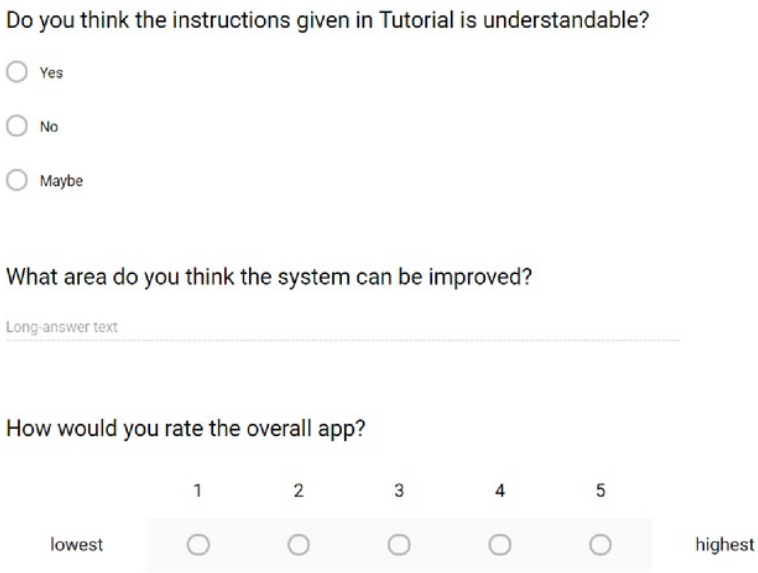

Figure 6-3 User evaluation form 3

6.3.1 Evaluation Form Response

After evaluating 20 people, the responses are shown as the figures below.

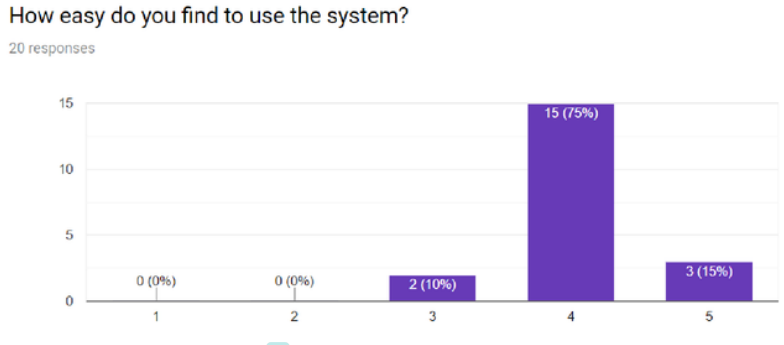

Figure 6-4 Question 1 result

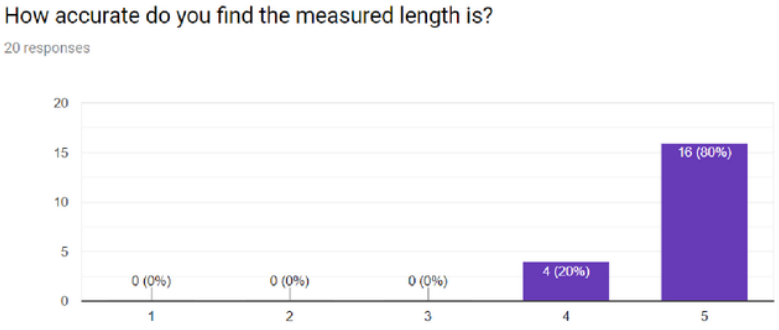

Figure 6-5 Question 2 result

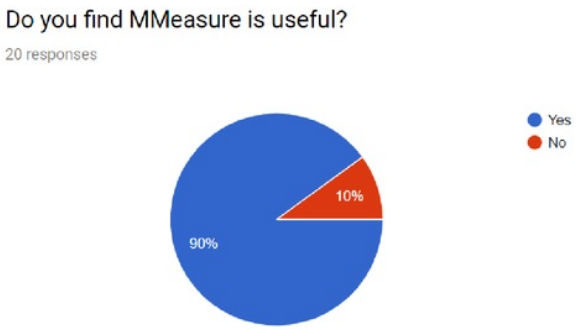

Figure 6-6 Question 3 result

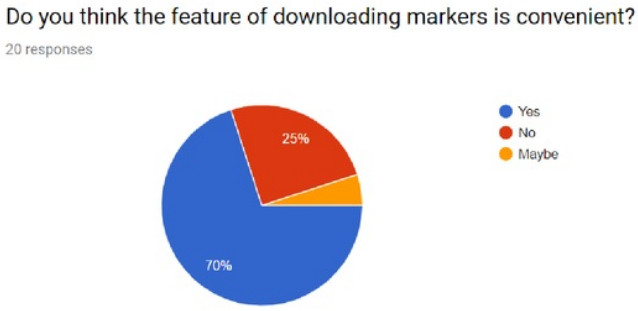

Figure 6-7 Question 4 result

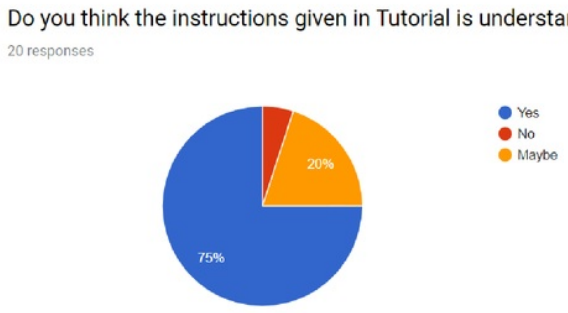

Figure 6-8 Question 5 result

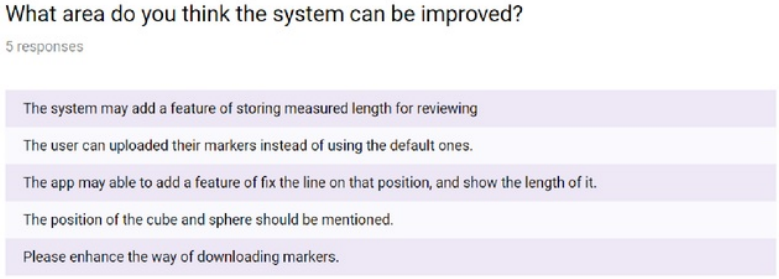

Figure 6-9 Question 6 result

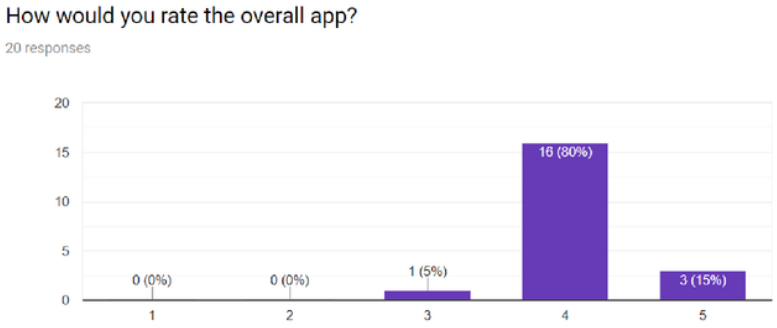

Figure 6-10 Question 7 result

In overall, the responses are quite positive. The people are satisfying about the accuracy of the app, and they find that the app is easy to use. In Figure 6-10, most of the people rate the app above 4. However, there are a few difficulties of downloading the markers, which the method and the effort of printing the markers are probably the reason of causing troubles. The responses about playing tutorial are interesting, that the people may not try that part during the testing, and therefore choose option of "Maybe".

7 Conclusion

In the first phase, the project succeeds in building a measuring app with high accuracy from nothing to a prototype.

During the development process, I have achieved designing a prototype with the basic functions. It works well in Android devices, the markers are able to be detected and superimposed while the calculation for the measurement is well performed. The link between two markers has no glitches. Throughout the process of developing the app, the advantages and disadvantages of SDK are explored and the research determined the final decision of using Vuforia. The researches support and provide more understanding about how an AR app works. In the end, the result is satisfying, as the algorithm of calculating length is chosen and implemented well.

7.1 Problem Encountered

The development processes are very challenging, as there is no reference about the concept of building a measuring app in phone devices using Vuforia SDK. Although Google and Apple had published their own measuring application, the device requirements are very high due to the specs of the devices. In order to solve the problems, I am able to have many communications with other professionals. Some ideas came out when seeking advice and brainstorming with them helps a lot for the progression.

7.2 Limitation/ Future Work

Basically, an AR app developed by using Vuforia can be published in both iOS and Android devices. However, there are some difficulties if the app published on iOS platform as the user need to have actions of jail breaking the device. Besides, Vuforia SDK does not support builds on any desktop device, only the devices intended for VR/AR capabilities are able to run it. If the developer insisted of opening the app, it can be tested in Unity Editor mode with web camera attached.

However, there are still a lot of improvements can be done in the future. As mentioned above, the feature of multiplatform is one of the possible enhancements that allow more users to use. Besides, an area can be drawn by storing the length of each side, and therefore form a graph of showing the result of the area. The set of markers can be added to handle further distance away from camera. Nevertheless, users may upload their own markers with rectangle size and enter the width and height.

In the end, a package of importing the project and the project assets are zipped and uploaded at Github and Google Cloud. If there is anyone interested to take over the project, please contact Dr. Ian Chai for further process.

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Appendices

Appendix A: Commercialization Proposal

1. Executive Summary

The commercialization proposal contains 4 pages of information and analysis of the app. This includes the market and business analysis of the app, the strengths and weakness, and the project outcomes.

2. Market Analysis

The target and potential customers are the people who involved in construction of building industry. Besides, the people who planned to have DIY for his house are also one of the target customer.

3. Problem Statement

The operating on the several equipment has some potential in causing some measurement errors or observational errors Besides, the current stage of the AR measuring app is not perfect as it is lacking of the accuracy on the result.

4. Unique Value Proposition

The basis of MMeasure is using Image Detection in AR techniques. Image Detection may decrease the rate of showing inaccurate result since it does not use the gyroscope installed inside phone devices.

5. Objectives

- Provides a high accuracy and portable measuring app which the accuracy is below ±1cm.
- Provides a measuring app that is simple to use, with understandable instructions given.

- The measuring app will not require high hardware requirements of phone devices

6. Methods and Scope of Work

With Image Detection techniques, the system will able to calculate the distance between camera and the image targets based on the image targets' scale, and simulates the real world environment. This allows the measured result is same as the real world ones. A line is drawn as the measured length for user to verify, and the user may change the unit of the measured length as well.

7. Business Model

Financial Snapshot (Income Statement)

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue (RM)	5000	10000	20000	35000	55000
Research & Development (RM)	800	800	800	800	800
Operating Expenses (RM)	20000	20000	20000	25000	25000
Operating Income (RM)	0	0	5000	10000	15000

Income before Tax (RM)	-5000	0	5000	10000	15000
Income Tax Expense (RM)			1000	1670	2340
Net Income (RM)	-5000	0	4000	8330	12660

The business model of the app will collect 10% profit of each sale. Apart from that, the app will have advertising fees to some social networks.

8. Milestones and Key metrics

Milestones 1: Publish the system in iOS platform

This milestone will allow the range of user base get expanded. The estimated time of achieving the milestone will be within 1 month, with sufficient budget given.

Milestone 2: Expand the app coverage to nearby countries (Singapore, Indonesia) App Store.

The milestone will allow the business to gain more profits with larger user base from different countries. The estimated time of achieving it will be 9 months with appropriate fund invested.

9. Project Outcome

The outcome of the project will benefit the target customers by reducing the effort of bringing various measurement equipment and ease their loads. Furthermore, the

company invested will gain a higher popularity and impression of producing high accuracy result in measuring length among the community.

10. Strength, Weakness, Opportunity, and Threat (SWOT) analysis

Strengths:

The strength of the app is the high accuracy rate of the result. There are a few apps exist currently, but the base technique is different with this project and the hardware requirements are higher. This allows MMeasure to have advantages in terms of market to the app.

Weaknesses:

The weakness of the app is the method of downloading the markers. The steps require a few efforts, but the markers play the most important in the app. This may cause users to change another app.

Opportunities:

The smartphone users who uses lower hardware requirements doesn't have sufficient resources of using existed measuring app. It seems to be an opportunity to the app as it provides a platform to enhance they measurement experience.

Threats:

The current competitors of the app are Measure published by Google, Measure published by Apple, AirMeasure and other measuring apps. However, these app are only available for selected phone devices, therefore our app stands out in the market with other unselected phone devices users.

Appendix B: FYP Meeting Logs

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Faculty of Computing & Informatics
Final Year Project Meeting Log

MEETING DATE: 18th July 2018	**MEETING NO.: 1**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE
- Exploring the usage of Flutter SDK
- Install Fuchsia & Ubuntu for future use

2. WORK TO BE DONE
- Doing researches about the relationship between Flutter, Dart and AR/VR

3. PROBLEMS ENCOUNTERED
- Researches said that Flutter can be only used for 2D mobile app, and after discussion with Mr. Koh, the programming platform will be changed to Unity.

4. COMMENTS
- So the conclusion is that you need to switch from using Flutter, Dart & Fuchsia to Unity.
- So this week you need to do the tutorials on Unity, to learn how to use it.
- Look at Progressive Web App to determine if it supports 3D/AR/
- When you get clearer what the app is going to do, then we can look into whether we need to change the title.

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Supervisor's Signature

Student's Signature

NOTES:
1. Items 1 – 3 are to be completed by the students before coming for the meeting. Item 4 is to be completed by the supervisor.
2. Minimum six log sheets are to be submitted (at least one every other week).
3. Log sheets are compulsory assessment criteria for FYP. Student who fails to meet the requirements of log sheets will not be allowed to submit FYP report.

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Final Year Project Meeting Log

MEETING DATE: 26th July 2018	**MEETING NO.: 2**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Decide the project that going to develop (an AR measuring camera)

- It can measure a thing's height and width by taking a shot on it

-Decide the tools to be used (Unity AR, an test phone)

-Some researches which related about the unavailability of making 3D on Google Flutter and progressive web app

-Meeting with Mr. Koh will reduced from two (Wednesday, Saturday) to one (Wednesday) due to some communications can be done by WhatsApp.

2. WORK TO BE DONE

- start literature review since the main scope has been determined
- more tutorials on Unity AR and measurement tools program

3. PROBLEMS ENCOUNTERED

- As my grandmother had passed away at 21st July (Friday), I was preparing her funeral from Saturday to Monday, the Saturday's meeting had been canceled.

4. COMMENTS

Ok, then you need to get started on your prototype.

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Final Year Project Meeting Log

MEETING DATE: 1st August 2018	**MEETING NO.: 3**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE - working on documentation of Chapter 1:Overview, project objective and project scope - start doing a demo of measuring app
2. WORK TO BE DONE - continue working on the demo and documentation
3. PROBLEMS ENCOUNTERED - The demo started too late, has to put more efforts for completing it as soon as possible in order to discuss the capabilities needed.
4. COMMENTS Prepare this app demo for the next meeting.

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Final Year Project Meeting Log

MEETING DATE: 8th August 2018	**MEETING NO.: 4**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- a overall demo had been done
- Editing documentation on Chapter 1

2. WORK TO BE DONE

- continue working on improving demo with adding specific functions, and the documentation

3. PROBLEMS ENCOUNTERED

4. COMMENTS

Complete the measuring app.

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Final Year Project Meeting Log

MEETING DATE: 15th August 2018	**MEETING NO.: 5**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- discovered the coordinate system of Unity for enhancing the application
- discuss the title of the project
- a length text which shows the measured value function added

2. WORK TO BE DONE

- understand the Unity position and tracking system fully
- continue working on improving demo with adding specific functions, and the documentation

3. PROBLEMS ENCOUNTERED

- some errors occurred during the development of demo, such as the connection line between two markers haven't solved since last week

4. COMMENTS

Continue debugging and fully understand the principles behind how it works. Then go on to do the other features.

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Final Year Project Meeting Log

MEETING DATE: 24th August 2018	**MEETING NO.: 6**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- discovered the Unity scale system
- test system with all size based on 1 unit
- chapter 2 Literature review done

2. WORK TO BE DONE

- understand the Unity position and tracking system fully
- continue working on improving demo with adding specific functions, and the documentation

3. PROBLEMS ENCOUNTERED

4. COMMENTS

Need to figure out what the units are so that you can get real measurements.

Need to figure out the connection problem.

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NOTES:

1. Items 1 – 3 are to be completed by the students before coming for the meeting. Item 4 is to be completed by the supervisor.

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Final Year Project Meeting Log

MEETING DATE: 29th August 2018	**MEETING NO.: 7**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- writing a script of exchanging default units (meter to centimetre)
- the demo continued by changing some information related to real world
- fixing the problem of unconnected link between marker1 and marker 2 (still in process)

2. WORK TO BE DONE

- Chapter 3: methodologies documentation
- creating new scripts about calculating the length as the old one have a few information errors, such as incorrect measurement and detection of the marker's current position

3. PROBLEMS ENCOUNTERED

- feature of adding different images to measure different scale of distances delayed
- The second point of WORK TO BE DONE, if it has found that the error came from Vuforia itself, the project will consider of using ARCore to go further

4. COMMENTS

Since you can get the x, y, and z for each card, you can then figure out using algebra for the distance between the cards.

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Final Year Project Meeting Log

MEETING DATE: 5th September 2018	**MEETING NO.:** 8
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- the problem of the linking line solved (the cylinder size object)
- some content of chapter 3

2. WORK TO BE DONE

- creating a 3D measuring line which allows to change to any direction
- start writing chapter 4: proposed solution
- edit chapter 3

3. PROBLEMS ENCOUNTERED

-

4. COMMENTS

Go ahead fix the line to go directly to the two markers, and how far they are apart.

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Final Year Project Meeting Log

MEETING DATE: 13th September 2018	**MEETING NO.: 9**
PROJECT ID: 938	
PROJECT TITLE: Exploring Google Flutter, Dart and Fuchsia for AR/VR	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- Adding y-axis line and z-axis line
- A 3D text of showing the result added
- Pythagorean theorem added to calculate the final distance
- some contents in chapter 4

2. WORK TO BE DONE

- Adding more content in chapter 4
- Think of the enhancement can be done and worked in next phase of FYP

3. PROBLEMS ENCOUNTERED

- the idea of having only one line seems to be complicated, it can't be done in current phase, therefore it will be added to the enhancement part
- the final prototype in current stage has a few error comparing to actual distance, which the accuracy of the calculation is around ±10cm. The accuracy will be decreased followed by the high number of position z

4. COMMENTS

You can try usmg ImageMagik for the picture file conversion.

Text needs to be rotated to show properly.

Eventually, it needs to be a user-friendly app.

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Final Year Project Meeting Log

MEETING DATE: 28th November 2018	**MEETING NO.: 10**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Re-doing the project.

-Editing documentation.

2. WORK TO BE DONE

- Continue to work with unit change function (Started during holidays).
- Continue editing documentation.
- Discuss the time of meeting with Mr. Aik.

3. PROBLEMS ENCOUNTERED

- Got a few problems with windows update, the system seems to be corrupted due to some missing files. The result ended with formatting computer. Some major files are missing with no backups. Fortunately, the scripts are safe.

4. COMMENTS

Make sure to back up all your data to prevent future loss. You can use the MMU Google Drive which has 5TB of quota.

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Final Year Project Meeting Log

MEETING DATE: 12th December 2018	**MEETING NO.: 11**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-A basic function of changing unit from cm to m done.

2. WORK TO BE DONE

- Enhance the changing unit function up to 3 units, which are cm, m and inches (unit in foot still in discuss)
- Start working on improving the UI

3. PROBLEMS ENCOUNTERED

-

4. COMMENTS

You can't be modifying the pos.x pos.y pos.z in one function and displaying that while the other function is changing it!

You should have a flag for the meter button that it'll change the way things are being displayed, and in your display function, check the flag and do the division.

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Final Year Project Meeting Log

MEETING DATE: 19th December 2018	**MEETING NO.: 12**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Modify change unit function

-fix some related scripts

-single line which represents the distance done

-starting reading Vuforia documentation to understand the accuracy of the app and improve it

2. WORK TO BE DONE

- Continue on change unit function
- Start different image function (Modify the documentation part: using different image for different distance z instead of using different image to represent as unit, the distance will be set as well)
- Modify documentation
- Improve UI

3. PROBLEMS ENCOUNTERED

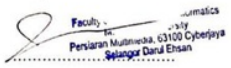
- problems in change unit function occurred, which values of marker 1 is able to change its value, but marker 2 does not.

4. COMMENTS

The numbers are hard to read. They need to be much bigger, and they need to be contrasting outline and colour, e.g. 232 so that no matter what the background colour is, you can read it.

The reason your code is not working is that you have a lot of extra needless complications. Just use 1 code for each of the units. Clicking the unit buttons will just change that code. When you display, you just check which code it is and display accordingly.

Also change all your names to make sense. Your use of confusing names makes it much easier to make mistakes.



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Final Year Project Meeting Log

MEETING DATE: 26th December 2018	**MEETING NO.: 13**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Improving UI

-Modifying the changing unit function

-Had tests and researches on the stability of the image

2. WORK TO BE DONE

- Modifying documentation
- Continue on different image function
- Screenshot function will be added

3. PROBLEMS ENCOUNTERED

- Same problem in change unit function occurred, which values of marker 1 is able to change its value, but marker 2 does not.

-https://library.vuforia.com/articles/Solution/Optimizing-Target-Detection-and-Tracking-Stability.html

The following link is about the stability of the marker. It mentioned about the contrast and details of the image are huge factor of affecting the camera to sense it. Therefore, the old images will be replaced by new ones in order to get a better result.

https://library.vuforia.com/content/vuforia-library/en/articles/Training/VuMark.html

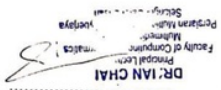
Vumarks are considered as well.

4. COMMENTS

You should not be making two "pose" classes. There should be just one "position" class and both marker objects inherit from that same class. Then whatever fixes you do in the class will affect both objects.

You don't put code into the class to do two positions. You create two objects of that same class, each object

handles one position.



Supervisor's Signature

DR: IAN CHAI
Principal Lecturer
Faculty of Computing and Informatics

Student's Signature

NOTES:

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2. Minimum six log sheets are to be submitted (at least one every other week).
3. Log sheets are compulsory assessment criteria for FYP. Student who fails to meet the requirements of log sheets will not be allowed to submit FYP report.

MULTIMEDIA UNIVERSITY

Faculty of Computing & Informatics

Final Year Project Meeting Log

MEETING DATE: 2nd January 2018	**MEETING NO.: 14**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Done changing unit function

-Testing the app in phone device

2. WORK TO BE DONE

- Continue on different image function
- Screenshot function will be added

3. PROBLEMS ENCOUNTERED

- The origin position in laptop webcam is at the middle of the screen. However, when it comes to phone device, the origin loses itself randomly. The origin position is changing constantly with either increasing x axis or y axis. Various methods had been tested but the problem is not affected.

Position 2 is used for tracking the origin currently.

4. COMMENTS

- The numbers are too hard to read – use bigger font, and also outline in contrasting colours
- The card design should be something that makes it easier for the user to align to the object being measured.
- Fix the bugs.

DR. IAN CHAI
Lecturer
Faculty of Computing and Ir
Multimedia Univers

.....
Supervisor's Signature

.....
Student's Signature

MULTIMEDIA UNIVERSITY

Faculty of Computing & Informatics

Final Year Project Meeting Log

MEETING DATE: 2nd January 2018	**MEETING NO.: 15**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

-Redesigning font size with TextMeshPro

-Alignment for card created

-Redesigning image targets

-Fixing position bugs

2. WORK TO BE DONE

- Add screenshot function
- Create new scene to implement different image function
- Fix bugs

3. PROBLEMS ENCOUNTERED

- An 3D object at (0,0, 20) is created for testing the bugs.

4. COMMENTS

1. It'll be easier to use if you print the alignment lines on the cards itself instead of needing to look through the virtual view to align.
2. Different sized cards can indicate on the card itself for the ranges of distances that are needed.
3. The debugging numbers can default to not be shown, and only be an option if they really want to know.
4. Need to have info box for all the instructions, as well as library licenses.
5. Send me a copy of the APK for testing.
6. Upload your full project into MMU Google Cloud and share with ianchai@staff.mmu.edu.my (and then inform me).

DR. IAN CHAI
Senior Lecturer
Faculty of Computing and Informatics
Multimedia University
Persiaran Multimedia, 63100 Cyberjaya
Selangor Darul Ehsan

Supervisor's Signature

.....

Student's Signature

NOTES:

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MULTIMEDIA UNIVERSITY

Faculty of Computing & Informatics

Final Year Project Meeting Log

MEETING DATE: 16th January 2018	**MEETING NO.: 16**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- Adding another set of markers
- Add another scene for bigger set of markers
- Add a tutorial scene of showing how to use the app
- Working on sending images through email
- Fix bugs

2. WORK TO BE DONE

- Add screenshot function (still on progress)
- Modify documentation
- Fix bugs

3. PROBLEMS ENCOUNTERED

- Started to seek advice for other lecturers for the position issue.
- Changing Unit function works on 2nd scene (smaller set of markers) but doesn't work on 1st scene (larger set of markers).
- Sending email function works well on Unity Editor but not on Android device. Some Android permission issues involved.

4. COMMENTS

The images you want to print should be PDF so that the size will be the same when printed. Must put instructions that the print must be done "Actual Size" and not "Fit" or "Shrink".

Change "download" to "Email the markers for printing".

You might even want to print a ruler so that people can check that the printout is the correct size. "Take a real ruler and put it next to this ruler to see if the size printed is correct or not."

When you put your source into the repository, please check the package you upload on another PC to see if

everything can open properly, to make sure nothing is missing.

DR. IAN CHAI
Principal Lecturer
Faculty of Computing and Informatics
Multimedia University
Persiaran Multimedia, 63100 Cyberjaya
Selangor Darul Ehsan

Supervisor's Signature

Student's Signature

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MULTIMEDIA UNIVERSITY

Faculty of Computing & Informatics

Final Year Project Meeting Log

MEETING DATE: 23rd January 2018	**MEETING NO.: 17**
PROJECT ID: 938	
PROJECT TITLE: AR Marker Based Length Measurement App	
SESSION: Application Based Project	**SUPERVISOR:** Dr. Ian Chai
STUDENT ID & Name: 1151101246 Eric Chia Teck Han	

1. WORK DONE

- Fix bugs
- Method of downloading the markers changed from sending email to provide download link
- Modify markers pdf file by adding a 12 cm ruler for user to measure the markers
- building a free host using HerokuApp
- Modify documentation

2. WORK TO BE DONE

- Modify documentation
- Fixing position bugs

3. PROBLEMS ENCOUNTERED

- Two midterm tests encountered this week, hence there have only a few efforts of building the host and domain.

4. COMMENTS

- Make the pictures black and white instead of black and grey for better contrast.
- The buttons are too close to each other, too easy to press the wrong button
- The measurement unit should be shown.
- Make the measurement number come in one line instead of two lines
- Tutorial needs to be updated.
  - Download and print the PDF for the markers using "Actual Size".
  - Place the images at each end of the object you want to measure.
- Change sample should be "change markers"
- Unable to exit the app except by killing it.

DR. IAN CHAI
Principal Lecturer
Computing and Informatics
Multimedia University
63100 Cyberjaya
Selangor Darul Ehsan

Supervisor's Signature

Student's Signature

NOTES:

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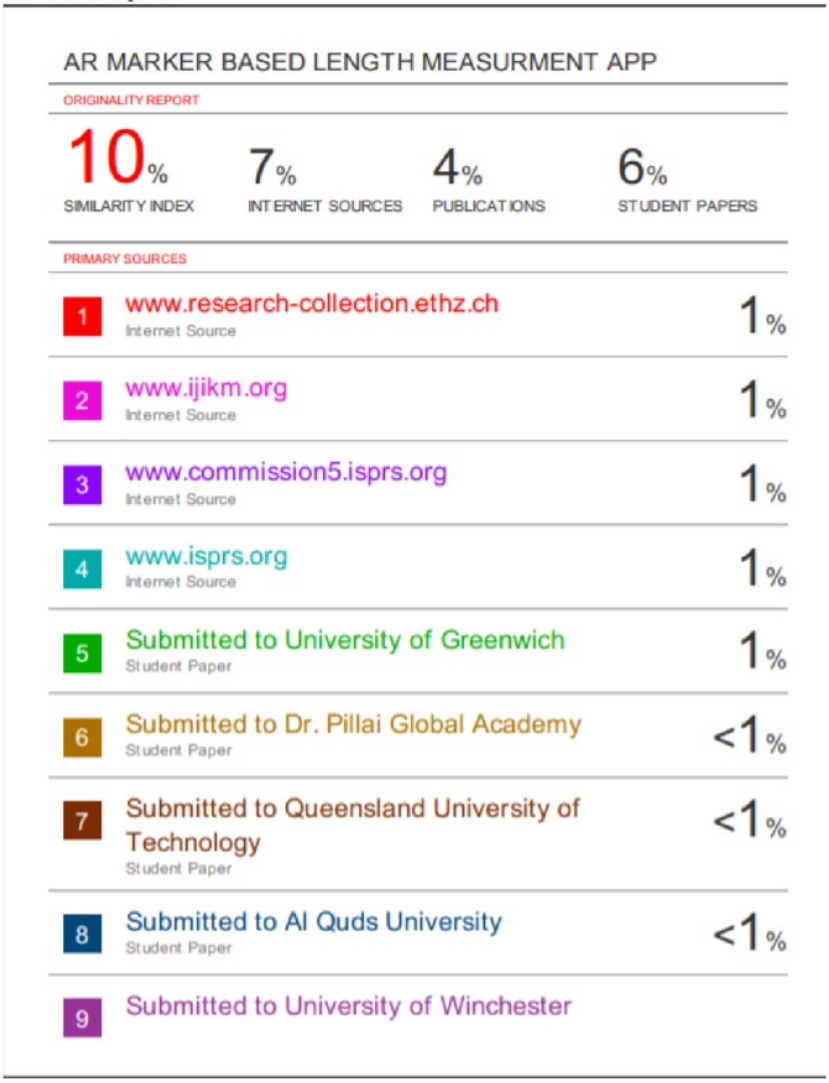
Appendix C: Turnitin Report, Downloadable File & Source Code

Turnitin Report



AR MARKER BASED LENGTH MEASURMENT APP

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Exclude matches Off
Exclude bibliography Off

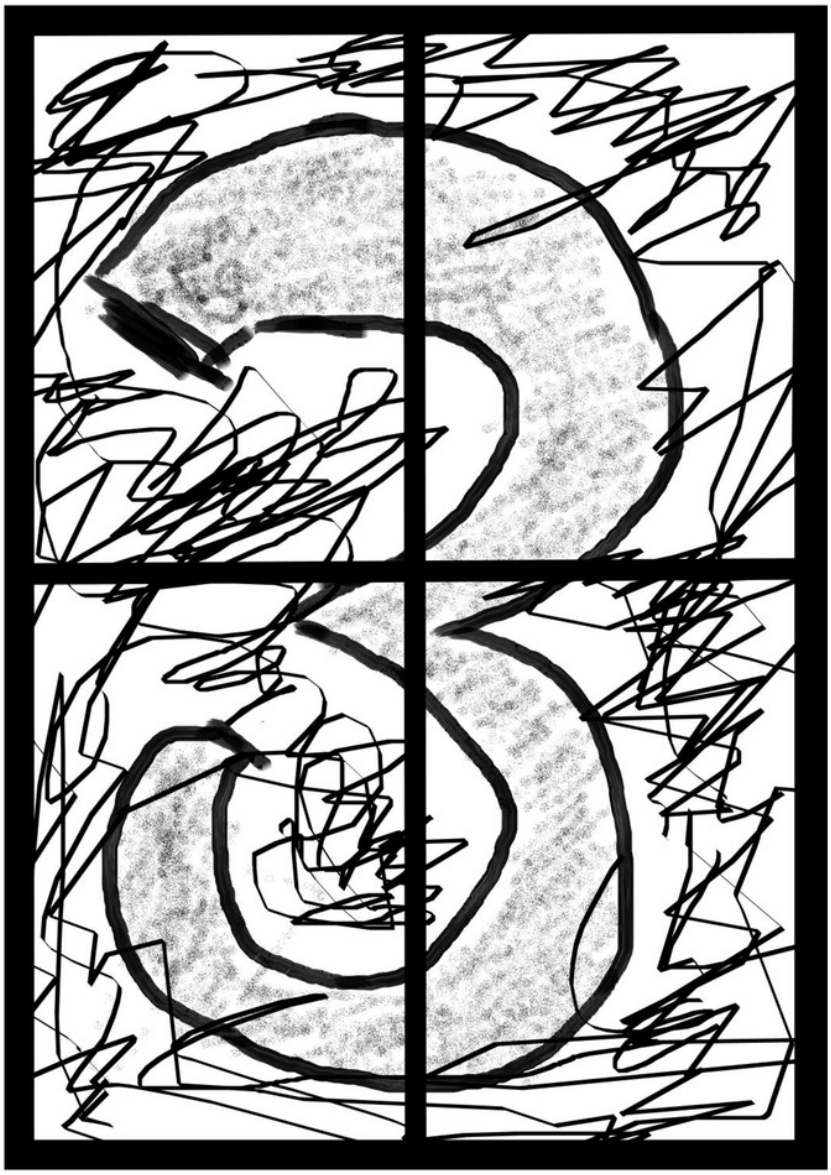
PDF File

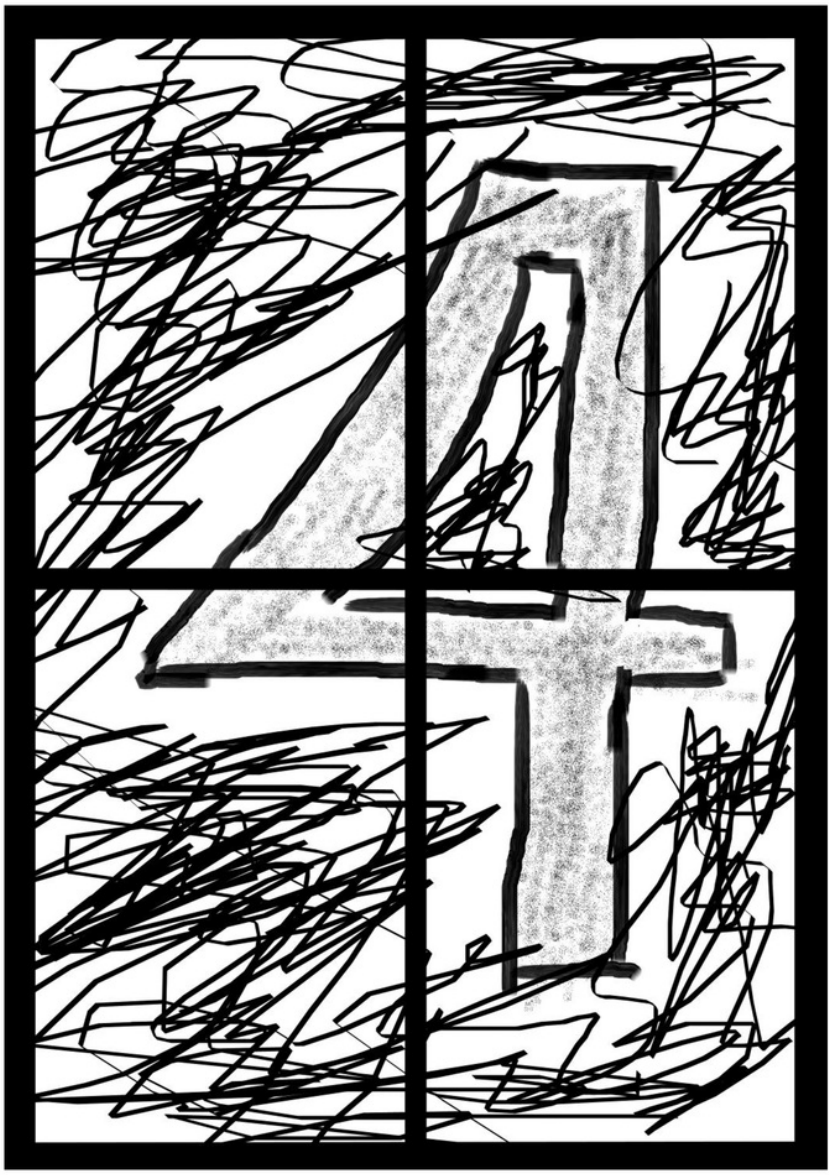
PLEASE PRINT THE IMAGES
WITHOUT ANY CHANGES.
CHOOSE ACTUAL SIZE OPTION
DURING PRINTING.

Any changes may cause inaccurate result.

A ruler is provided to check the actual length of the markers.

The size of marker 1 & 2: 6.2 * 8.7 cm
marker 3 & 4: 21 * 29.7 cm





Source Code

Position.cs

```
using UnityEngine;
using UnityEngine.UI;
using System.Collections;
using TMPro;

public class Position : MonoBehaviour
{
    public GameObject object1, object2;
    public TextMeshProUGUI pos_x;
    public TextMeshProUGUI pos_y;
    public TextMeshProUGUI pos_z;
    public TextMeshProUGUI pos2_x;
    public TextMeshProUGUI pos2_y;
    public TextMeshProUGUI pos2_z;
    public int unit;
    public Vector3 pos, pos2;

    void Start()
    {
        unit = 0;
    }

    void Update()
    {
        pos = object1.transform.position;
        pos_x.text = "1_X:" + pos.x.ToString("F2");
        pos_y.text = "1_Y:" + pos.y.ToString("F2");
        pos_z.text = "1_Z:" + pos.z.ToString("F2");

        pos2 = object2.transform.position;
        pos2_x.text = "2_X:" + pos2.x.ToString("F2");
        pos2_y.text = "2_Y:" + pos2.y.ToString("F2");
        pos2_z.text = "2_Z:" + pos2.z.ToString("F2");
    }



}

//unit is a flag of changing the units, the following numbers will
//be a trigger to change the curent unit.
// 0 = cm,
// 1 = m,
// 2 = inch,
// 3 = foot
```

Distance_text.cs

```
using UnityEngine;
using UnityEngine.UI;
using System.Collections;
using TMPro;

public class Distance_text : MonoBehaviour
{

    public Position change;
    public TextMeshProUGUI distance;
    public float total_Distance;

    void Update()
    {

        float distanceX = change.pos2.x - change.pos.x;
        float distanceY = change.pos.y - change.pos2.y;
        float distanceZ = change.pos.z - change.pos2.z;
        total_Distance = Mathf.Sqrt(distanceX * distanceX + distanceY *
distanceY + distanceZ * distanceZ);



        distance.text = "Distance:" + total_Distance.ToString("F2") + "cm";

    }


}
```

ImageTrackableBehaviour.cs

```
using UnityEngine;
using Vuforia;
//Attach to the image tracker
public class ImageTrackableBehaviour : MonoBehaviour, ITrackableEventHandler
{
    public int counter_image;
    private TrackableBehaviour trackableBehaviour;
    void Start()
    {
        trackableBehaviour = GetComponent<TrackableBehaviour>();
        if (trackableBehaviour)
            trackableBehaviour.RegisterTrackableEventHandler(this);
    }

    public void OnTrackableStateChanged(
      TrackableBehaviour.Status previousStatus,
      TrackableBehaviour.Status newStatus)
    {
        if (newStatus == TrackableBehaviour.Status.DETECTED ||
            newStatus == TrackableBehaviour.Status.TRACKED ||
            newStatus == TrackableBehaviour.Status.EXTENDED_TRACKED)
            counter_image = 1;
        else
            counter_image = 0;
    }

}
```

Line_dis.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Line_dis : MonoBehaviour {

    private LineRenderer line_render;
    public Transform Cube;
    public Transform Sphere;
    public ImageTrackableBehaviour trackable_status, trackable_status2;
    Vector3 disable = new Vector3(0, 0, 0);


       void Start () {

       }

       void Update () {
        line_render = GetComponent<LineRenderer>();
        if (Cube != null || Sphere != null)
        {
                if (trackable_status.counter_image == 1 &&
trackable_status2.counter_image == 1)
                {
                    line_render.SetPosition(0, Cube.position);
                    line_render.SetPosition(1, Sphere.position);
                }
                else
                {
                    line_render.SetPosition(0, disable);
                    line_render.SetPosition(1, disable);
                }
        }
    }
}
```

Unit_m

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;

public class Unit_m : MonoBehaviour
{
    public Distance_text dis_txt;
    public Position change;
    float _M = 100, _INCH = 2.54f, _FOOT = 30.48f;

    float change_unit;


    void Update()
    {

        unit_calculation();

    }


    public void unit_calculation()
    {
        if (change.unit == 0 )
        {
        }
        else if (change.unit == 1)
        {
            change_unit = dis_txt.total_Distance / _M;
            dis_txt.distance.text = "Distance:" + change_unit.ToString("F2") +
"m";

        }
        else if (change.unit == 2 )
        {

            change_unit = dis_txt.total_Distance / _INCH;
            dis_txt.distance.text = "Distance:" + change_unit.ToString("F2") +
"in";
        }
        else if (change.unit == 3)
        {

            change_unit = dis_txt.total_Distance / _FOOT;
            dis_txt.distance.text = "Distance:" + change_unit.ToString("F2") +
"ft";
        }
    }



    public void change_to_m()
    {
        change.unit = 1;

    }
```

```
    public void change_to_inch()
    {
        change.unit = 2;

    }

    public void change_to_foot()
    {
        change.unit = 3;

    }

    public void change_to_cm()
    {
        change.unit = 0;
    }
}
```

ChangeScene.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class ChangeScene : MonoBehaviour {

    protected static string PreviousScene = "";

    public void changeScene (string sceneName)
    {

        PreviousScene = SceneManager.GetActiveScene().name;
        SceneManager.LoadScene(sceneName);
    }

    public void BackFromTutorial ()
    {
        SceneManager.LoadScene(PreviousScene);
    }
}
```

Download.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class download : MonoBehaviour
{
    public void download_marker()
    {
        Application.OpenURL("https://warm-ridge-
70125.herokuapp.com/hyperlink.html");
    }
}
```

5

Exit.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Exit : MonoBehaviour
{
    public void ExitApp()
    {
        Application.Quit();
    }
}
```

Hyperlink.html

```
<!DOCTYPE html>

<html>

<body>


<h2>Download PDF Files</h2>

<p><a href="https://warm-ridge-70125.herokuapp.com/image_for_print.php">Click
this for download</a></p>


</body>

</html>
```

Image_for_print.php

```
<?php

header("Content-disposition: attachment; filename=image_for_print.pdf");

header("Content-type: application/pdf");

readfile("image_for_print.pdf");

?>
```

AR MARKER BASED LENGTH MEASUREMENT APP

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FINAL GRADE

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GENERAL COMMENTS

Instructor

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