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Date: 9 April 2018

Date: ______________________
ONLINE FURNITURE SHOPPING USING AUGMENTED REALITY

By

Harrison Seow Wenbing

A REPORT
SUBMITTED TO
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for the degree of
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INFORMATION SYSTEMS ENGINEERING
Faculty of Information and Communication Technology
(Perak Campus)

JAN 2018
DECLARATION OF ORIGINALITY

I declare that this report entitled “ONLINE FURNITURE SHOPPING USING AUGMENTED REALITY” is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : __________________________

Name : HARRISON SEOW WENBING

Date : 9 APRIL 2018
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ABSTRACT

“Science fiction is becoming a reality!” has been exceptionally true in 21st century where cars are starting to fly, and factories are occupied by robots and machines. In this Internet-globalization era, where more than 3.7 billion users around the world are connected in a virtual space, is simply unimaginable ten years before now (Internet World Stat 2017). New technologies are flooding into our world without a halt, making us wonder what kind of surprise should we expect in the coming years. On the other hand, a certain technology has already brought science fiction into reality, although it currently lacks physical interaction but has definitely made an impact to the world – Augmented Reality (AR).

Augmented Reality is not a very recent technology. It first started in 1968, where the head-mounted display is suspended from the ceiling and the viewer is shown computer images (Shore, 2012). However, AR is starting to become a trend nowadays and people’s life could totally be changed with the integration of AR into daily life routine. A common routine is online shopping, and by integrating AR technology, people can then see their products right before their eyes in 3-Dimensional model, by just using their smartphone camera.

Therefore, this proposal writing focuses creating a mobile application to support online furniture shopping with AR technology, which will help online shoppers to take a good look of how the actual furniture may look like when it arrives. Besides, furniture sellers will also be able to create showrooms using AR, thus, the actual product does not need to physically exist at that particular location. Moreover, the actual product may not exist at all until an order is received from the customer.
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<td>2-Dimensional</td>
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<tr>
<td>3D</td>
<td>3-Dimensional</td>
</tr>
<tr>
<td>App</td>
<td>Application</td>
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<td>AR</td>
<td>Augmented Reality</td>
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<tr>
<td>CGI</td>
<td>Computer-Generated Imagery</td>
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<tr>
<td>dp</td>
<td>Density-independent pixel</td>
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<td>MEMS</td>
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CHAPTER 1: INTRODUCTION

1.1 Problem Statement and Motivation

Recently, online shopping is becoming a trend as customers no longer need to drive all the way to shopping mall just to buy a few items and take them back home. With the continuous advancement of online shopping, many varieties of companies have offered different products ranging from daily groceries to even luxuries such as branded cars. At one of the largest “online shopping complex” TaoBao, has made around 18 billion US dollar in just one day during the last “Double Eleven” (Shuangshiyi) in 2016 (2016 Tianmao Shuangshiyi 2016). While the total sales of furniture alone during Shuangshiyi in 2012 has made 179 million US dollar, with more than 730 thousand deals worldwide (see Appendix B.1). Thus, proving that online furniture shopping is already a trend among the world. However, a recent discussion forum raised a topic wondering whether buying furniture online (in TaoBao) is applicable (Wanggou Jiaju 2016). Many responders made few comments on their experiences and a few common problems faced by the customers are described below and how the application would solve these issues.

1.1.1 Purchased product does not fit

Many of the customers are facing difficulties of finding the perfect furniture in online shopping without any disappointment. Occasionally, customers would only realise that the drawers of a table or doors of a cupboard are unable to be opened due to the clamped space. While others found out that the furniture just do not fit into the desired spot as some customers are lazy to measure the length and width accurately. Some of the furniture with bigger sizes even requires the customer to assemble it by themselves. Thus, if an interactive application that can give customers a try on the preview of how the product would look like in the real-world environment, certainly it would boost the confidence of the customers on the particular product. Besides, it can be made as a reference during assembly to make sure that the assembled furniture will be placed at the same spot as the customer originally wanted to.

1.1.2 Purchased product does not match with surrounding

On the other hand, many customers are unsatisfied with the shape or colour of the furniture as it does not match the surrounding, hence making the room unpleasing to the eye or just simply ugly. The main reason is because customers may not be good at imagining the product being placed at the desired spot, or has thought that the product
that looks good should naturally match with the surrounding. Thus, by providing an AR application, where the customer can easily swipe the position of the product around the room will help the customer better decide if the selected product would match with its surroundings.

1.2 Project Scope

In this proposal, the main delivery is an Android application capable of producing robust performance available to as many devices as possible. The application should be developed on KitKat or Jellybean Android versions, as it supports majority of the Android users (see Appendix B.2). The details will be as followed:

1. Application runs on Android platform
   a. Jellybean version supports 98.6% users
   b. KitKat version supports 91% users
2. Application enhances user’s furniture shopping experience:
   a. Able to see live size virtual object
   b. Able to position the virtual object on real-world environment
   c. Able to rotate the virtual object on X-axis and Y-axis
   d. Able to move around different angles revolving the virtual object
3. Application with minimal maintenance and user friendly
4. Application that is dependent on smartphone’s camera condition
   a. Poor camera quality may affect tracker efficiency
   b. Poor camera quality may affect virtual object’s relative colour
5. Application that is dependent on smartphone’s MEMS sensor condition
   a. Smartphones with poor sensor calibration may affect virtual object’s positioning
   b. Smartphones without MEMS sensor (or broken) will perform poorly
1.3 Project Objectives

The application aims to achieve a number of objectives. The project objectives of this application are as follow:

1. **Enhance customer’s online shopping experience**
   The project aims to provide users with real-time life view of the furniture wherever they aim using their smartphones. Hence, after the user selects a product from the list, the user can then activate the smartphone’s camera to view the selected product in AR. Therefore, users can immediately recognise how well is the product and whether it meets their needs and preferences, without the hassle of travelling out or going to showrooms.

2. **Provide realistic 3D view of the featured product**
   It is not enough if users can only view the furniture from one angle, thus, the project should be able to calibrate the 3D model with the information given to place the furniture correctly. Users can also then move around the furniture to get a clearer picture on how it would look like from multiple perspectives. Furthermore, the application should anchor the object to a specific position on the plane surface where the camera is directed to. This will avoid the furniture to move together with the smartphone, making it difficult to view from another angle.

3. **Provide accurate live size scale at 1:1 ratio to real-world environment**
   The project must be able to show the furniture at live size so that users can ensure the furniture fits into the physical space available. In addition, bringing furniture into users’ household helps to create experiential learning of the augmented furniture, bringing up users’ desires (Riva et al., 2016). Therefore, providing a live size view helps to create a realistic experience for users as if they have acquired the product, but disappears immediately when closing the application.

4. **Allow easy maintenance of the application**
   As the project is used on online platform, managers must be able to perform maintenance on the application easily. Thus, managers should be able to add models into the application’s database, which should then reflect immediately on the next data retrieval on the application. Hence, users will be able to view new products instantly and take a good look on the product using AR.
1.4 Impact, Significance and Contribution

As this application has both users and customers which can be generally divided as seller for the former and buyer as the latter, a few groups of audience target are listed below:

1. **Furniture Sellers**
   This would refer to any company or personnel that sells any sort of furniture or even plain objects including art sculptures or even electronic devices such as air conditioner and surround speakers. As the application would be capable of displaying the 3D model object in the real-world environment, it would help them to sell their products easier.

2. **Online Shoppers**
   This application mainly targets online shoppers as online shopping is the one of the main platform where customers would purchase a product without physically touching the product. Hence, it would be in their interest if a live view of the product can be seen at the real-world environment.

3. **Showroom Creators**
   Showrooms often needs to be used when a company is trying to launch a new product. However, the showrooms are often changing as there are always new products to be displayed (Petersen 2012). Hence, by implementing an AR showroom, not only it would save costs, it can also allow multiple showrooms to exist at a time, as long as different viewers are looking at a different display. Therefore, by using the application, the showroom is capable of swiftly switching among different sets of showroom styles without any cost. Once the layout is being laid, users are able to view the showroom as long as they are connected to the required resources.

Simply put, it can heavily reduce manufacturing costs as 3D models are required for display, instead of the actual end product.

1.5 Background Information

Augmented Reality in simple words is to bring imaginative elements into the real-world environment, using video, audio or GPS data. AR is often simulated in real-time, making it highly convincing as a reality to the users. A very recent AR game called Pokémon Go has been suggested to be one of the main reasons of AR trend with
its more than a hundred million downloads in Google Play Store (Google Play Store 2017). It’s unique feature of catching Pokémon live by travelling around the city or even the world has piqued the interest of many Pokémon fans globally. Besides, AR technology has been used in many areas of field including architecture since the capability of visualising an entire building before construction is very helpful for the stakeholders to take a look at the predicted actual view instead of just scaled models (Divecha, 2010). Furthermore, showrooms can now be filled with any 3-Dimensional (3D) model objects that needs to be positioned on prior, making it reusable and easy to switch different views accordingly (Architectural dreams in 2012).

Other fields of AR technology include education where the objective is to provide relative information to its users when scanning or pointing at an object. A common implementation to provide information is by adding a distinct “marker” for the program to recognise and act as a unique identifier to bring up relative information. A real-life example of this implementation is a Japanese textbook that will help the readers to study high school level English in a more interactive way. The textbook has unique markers that can play predefined videos on top of the textbook with the support of a smartphone application. Hence, 2-Dimensional (2D) animations can be seen talking in English on top of the textbook by hovering the smartphone camera at the designated section of the page. This provides a fresh experience and fairly attractive to the human eye as it would “deceive” us as if its bringing animations to reality.

Therefore, the application aims to provide online furniture shoppers with the ability to “try and see” how it would look like in the real-world environment. Customers would be able to select their desired furniture and by using their smartphone, directing the camera to the preferred spot, then the selected furniture would appear as an overlay image on top of the surrounding. Moreover, the customer can slide left or right to see how the furniture looks like at different angles. Besides, the application should allow an easy swapping among other furniture or even create additional items or furniture beside the original furniture. Hence, providing the customer some combination choices among few selected furniture, which will help them decide better if the desired item would suit their taste.

On the other hand, the users (furniture seller) of this application would be required to provide 3D models of every furniture that needs to be included in this AR
feature. However, the 3D model required only need to provide the most outer layer of the object, which is the outer shape, size, colour and surface texture. Nevertheless, meaningful properties such as the height, width and weight should be included as the accuracy of the application will vary accordingly to the camera and smartphone used. In addition, users may also include different 3D models for different states for the furniture, for example, a table model with drawers opened or a cupboard model with both doors opened. As such, users are capable enough to maintain the application by themselves as long as they do not make mistakes in referencing their product with the respective 3D models. Thus, it is to be expected that the application would be user-friendly and there are not much to be taken care about during maintenance.

Incidentally, have you ever wondered what is happening behind the scenes in order to make this technology a success? As this technology emerges, many different approaches have been taken to achieve its goal especially when there are all sorts of different purposes intended for the application. A common approach that is similar to the title is by using the following four steps:

**Step 1:** Video input – Gives the application a real-time video footage of the real-world environment.

**Step 2:** Registration – Which provides references to the application by retrieving data from Microelectromechanical systems (MEMS) sensors such as accelerometers, orientation sensors, and barometric sensors (from the smartphone).

**Step 3:** Computing Vision – The application then interprets the video footage by combining the data retrieved from Step 2 and computes the size and location of the Computer-Generated Imagery (CGI) object.

**Step 4:** Display View – Lastly, providing the real-time view of the overlay image (may include audio) on top of the real-world environment.
CHAPTER 2: LITERATURE REVIEW

2.1 Similar application

2.1.1 Houzz Interior Design Ideas

A similar application named “Houzz Interior Design Ideas” shown in Figure 2.1 was launched not long ago by Houzz allows users to place a virtual furniture on the surrounding (Goode, 2017). The early versions of this application require users to first snap a photo of their room (or any preferred location), then position the virtual furniture by dragging it to the correct spot and panning the display using two fingers to resize the furniture. Hence, it can be seen that the application does not provide any depth or shape, so users need to snap a photo that is similar to the angle of the virtual furniture provided to have a clear picture on how the furniture would look like. However, the company emphasised that their target was “solving what everyone needs right now” (Goode, 2017).

Figure 2.1: Houzz Interior Design Ideas user interface.

The technology behind Houzz’s application is simple; the application prompts user to pick a photo as the background, then the selected furniture will appear on top of the background, with the ability to move and resize the overlay image. Hence, it can only be considered as a photo editing application.
Strengths

1. **Very easy and fast to use** – The application is very easy to use because there are only limited simple features. It can be simply explained to the user, or the user can learn how to use by just testing the application. Besides, the small storage size of the application allows users to quickly download and use it.

2. **Supports wide variety of devices** – The application can be downloaded on devices running on Android or iOS. Furthermore, since the application’s only need access to the smartphone’s camera, old devices with camera are supported as well.

Limitations

1. **Does not support 3D views** – Since the application uses flat 2D image, when the camera is pointing from a higher or lower angle will make the virtual object skewed. Besides, the object can only be rotated on one axis, hence you can only flip the image around but you are not able to see the virtual object at different angles.

2. **Does not scale well** – As customers are very concerned whether the piece of furniture could fit into their room, the ability to scale relatively similar to the real-world environment is very important. However, this application does not take live scaling into account, providing only an option for users to scale the virtual object by themselves.

2.1.2 Furniture Drop: AR Room Planning App

Furniture Drop is an iOS application made by Asher Vollmer that is currently under pre-release according to his tweet (Vollmer, 2017). Vollmer shared a video tweet on this application during 21st of July where the application can display an augmented circle on the floor horizon and a predefined set of furniture can be selected and dropped onto the circle. Adjustments can be made immediately after placing a furniture, and the application seems to be capable of displaying live size furniture of 1:1 scale. The application can also “drop” decorations on top of the existing furniture, for example, a flower vase on top of a table. In addition, this application is capable of dropping a repeated 3D model object, such as a firepit with some burnt firewood sound effects (see Appendix A.1).
The application was planned to be released for Apple devices running at iOS 11. The application relies on a new framework called ARKit that is recently developed by Apple with the aim to integrate iOS device camera and motion features to help create an immersive experience of augmented reality in an app or game. ARKit is only available for devices running at iOS 11.0 and later (which is currently in Beta) with A9 or later processors.

Strengths

1. **Supports 3D views** – This pre-release application is capable of adding virtual objects in the display and user can walk around to add more virtual objects and see how they would look like at a different angle.

2. **Supports live size scaling** – The application will scale up or down the virtual object accordingly when user moves towards or away from the virtual object, also claims to be capable of automatically scaling to the life size of real-world environment at 1:1 ratio.

Limitations

1. **Supports limited devices** – The application is planned to be released when Apple release iOS 11 which is currently still in Beta. The application’s platform depends on iOS 11 which provides ARKit, hence only newer devices or devices that can be upgraded to iOS 11 are able to use this application.

2. **Still in pre-release** – As mentioned, the application is still in testing state and there is no exact date of when it will be released. Thus, users are unable to use it yet and in the worst-case scenario, the application is canceled for release.

2.1.3 Jerome’s Furniture Smart Shopper

Jerome’s Furniture is a company founded in 1954 by Jim Navara and currently has about 611 employees (Jerome’s Furniture 2017). Jerome’s Furniture has created an application called Jerome’s Furniture Smart Shopper that suggests users to download an additional application named “Augment - 3D Augmented Reality” in order to view their virtual products in Augmented Reality, shown in Figure 2.2.
By using this application, users may select predefined 3D models and a virtual furniture will be shown on the display along with the real-world environment taken using the smartphone’s camera. Then, users can drag the virtual object around and rotate or resize the object using two fingers. However, after reviewing the said application and the information provided by official websites, the application does not currently support 3D view. Thus, users are unable move around or over the virtual object and the scale is not 1:1 ratio. Nevertheless, the application will automatically scale the object down when it is being moved further away from the user’s stand point.

**Strengths**

1. **Supports 3D rotation** – The application allows user to rotate the selected virtual object on X-axis and Y-axis. Hence, users can rotate the object to understand how it would look like at different angle.

2. **Automatic scaling** – The application will automatically scale the virtual object down or up when the user drags the virtual object forward or backward.

**Limitations**

1. **Poor position detection** – The application is unable to fix the virtual object on a specific position, thus, when users move forward, the object will also move forward accordingly.
2.2 Comparison with similar application

A simple comparison among some of the popular features and requirements are shown in below Table 2.1. Houzz referees to the Houzz Interior Design Ideas, Furniture Drop refers to Furniture Drop: AR Room Planning App and Jerome’s Furniture refers to Jerome’s Furniture Smart Shopper.

Table 2.1: Comparison among reviewed applications.

<table>
<thead>
<tr>
<th>Application</th>
<th>Houzz</th>
<th>Furniture Drop</th>
<th>Jerome’s Furniture</th>
<th>Proposed Application</th>
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<tr>
<td>Supports 3D View</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Has Depth</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3D Rotation</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Live Size Scale</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Supports iOS Devices</td>
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<td>No</td>
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<td>Supports Android Devices</td>
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<td>Low</td>
<td>High</td>
<td>Medium</td>
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The details of above-mentioned features are explained as below:

- **Supports 3D view** indicates that the application is able to locate and identify the placed position and users are able to move around the virtual object to view different dimensions of the object, including moving over the object or even under (in theory).
- **Has depth** refers to the automatic scaling when users are moving forward or backward, or by moving the virtual object towards the user or away from the user.
- **3D rotation** is the application’s capability to rotate the virtual object to see how the virtual object would look like at different angles.
• **Live size scaling** is the ability to determine the actual size of the virtual object in the real-world environment, hence the virtual object can provide relative measurements.

• **Supports iOS or Android devices** refers to the applications platform dependency whether it supports smartphones running on iOS or Android.

• **Required technical specifications** indicates the technology required to run the application, determining whether a cutting-edge smartphone is required to support the operations behind the scenes. Thus, lower requirements can generally support much wider majority of the devices, while higher requirements often support only the latest devices (usually devices within half a year from current date).

### 2.3 Resolved solution

Among the reviewed applications, there are only few devices with the correct application allows user to have an immersive view of a virtual object. A very recent device developed by Google and Lenovo that has **Google Tango** technology named *Lenovo Phab 2 Pro* (Goode, 2016). **Google Tango** is developed by Google and it utilises the smartphone’s camera sensors (only available on *Lenovo Phab 2 Pro*) combined with a fisheye camera and an infrared distance sensor, which help the device to detect the surroundings easily. This is an advanced 3D recognition technology which currently only works on *Lenovo Phab 2 Pro*, making it less suitable for the application. However, an update from Google Tango’s Twitter account on 15th Dec 2017 states that Google Tango project will be shut down and deprecated on 31st of March. Google will switch focus and continue their AR development on Google ARCore (Kastrenakes, 2017). On contrast, the application aims to achieve the following features without relying on high-end technology or devices:

- **Supports 3D view**
- **Has depth**
- **3D rotation**
- **Live size scale**
- **Supports Android devices**
- **Medium technical specifications required**

By referring to Table 2.1, it can be seen that the reviewed applications do not possess the qualities mentioned except for Furniture Drop which has not been released.
yet and only supports iOS devices with high technical specifications required. Besides, medium technical specifications refer to the huge majority of the smartphone that everyone possesses. Hence, the application will be useful for a very large crowd without the need to change their smartphones to the latest smartphone on sale.

Therefore, it is generally a better idea to create an application that is able to meet the needs of the majority. Since creating an application that can only be used by high-end devices has limited users, creating a slightly less advanced application with strong and robust features is clearly a better choice that will be able to be promoted to a larger market of users. The main benefits are as follow:

1. **Large target market** – A larger market crowd would naturally impose a smaller risk as there are more possible buyers, incurring smaller costs in worst cases (Kokemuller, n.d.). Having a large market crowd would also allow the application to receive massive feedback, making it easier for error finding and opinions on future improvements.

2. **Robust feature** – Most application reviewed are only capable on providing attractive features by using high end devices, while others provide limited feature but is able to be used on almost all smartphones. On the contrast, the application aims to achieve similar results by using trackers which will then be usable on fairly most smartphones.
CHAPTER 3: PROPOSED METHOD/APPROACH

3.1 Design Specifications

3.1.1 Methodology

The methodology selected for this application is Agile Software Development Methodology which is very effective for developing a mobile application which will constantly require upgrades and updates for error patches. Since the application will be available to a wide variety of users, the possibilities of receiving useful feedbacks on application improvements are higher than usual. Thus, changes might be needed once in every short term and Agile approach is considered a suitable methodology in the current situation (see Figure 3.1).

![Agile Software Development flowchart](image)

**Figure 3.1:** Agile Software Development flowchart.

**Agile Software Development**

The four main processes in Agile software development is to Plan, Build, Launch and Feedback. Plan includes creating the project scope and the main deliverables required, also giving priorities to important modules. Next, build will be the actual coding where developers need to program the software to perform certain
functions. Then, launch is to distribute the software with to a predetermined group of people who uses or tests the software. Then, feedback is concerned on collecting the opinions regarding further software improvements or errors and bugs found within the system. Lastly, if there are remaining functions yet to be released or errors yet to be fixed, the process will repeat itself with planning.

1. Plan
   
   During the planning phase, it is important to create lists of functions that will be performed by the application according to priorities. Main function such as selected predefined 3D models should be completed first, although a smaller set of models can be created before adding more models. Besides, deadlines should be decided based on the difficulty, complexity and work amount of the task. Certain task might be easy but could still eat up huge amount of time in order to complete them. Needless to mention, predecessor tasks should also be completed prior to dependent tasks.

2. Build
   
   After completing the initial planning, it is the time to start building the application. This process may seem to be the hardest among others, however, good planning with realistic goals can make building the application a whole lot easier. As a realistic goal can help motivate programmers because the goal would seem to be reachable instead of ambiguous goals where programmers are concerned and uncertain on how or when can the task be completed. Building the application relies much on the programmer and thus resting in between work is important for a fresh mind.

3. Launch
   
   Next, launching the application will involve testers or may directly be distributed to consumers, either users or customers. An important factor is to launch the application with the advertised functions at the afore-mentioned release date. This will greatly increase the confidence of the consumers as the application kept its promise of providing the featured functions.

4. Feedback
   
   Last but not least, feedback is mainly relying on the suggestions given by the testers or consumers. Suggestions may include opinions, error reports and user experiences. These feedbacks are important because it can help the application to further improve by fixing the bug and adding new features with high demands. Hence,
whenever there are new updates from feedback, the whole process will start over from planning once again to introduce new functions into the application.

3.1.2 Tools and Technology

The development tool that was previously used is Android Studio, which is an official development software for developing Google’s Android OS (Ducrohet, 2013). However, the development platform has been switched to Unity which can easily cater for the need of multi-platform and 3D object manipulation. The technology required for the application can be categorised into hardware specifications and software specifications. Hardware specifications will determine the minimum hardware components required in a smartphone in order to achieve the basic features that will be provided in the application. While software requirements will focus on the Android version that will be compatible with the final refined application.

3.1.3 System Performance Definition

The project is only considered as successful if it meets the performance benchmark that has been decided in prior. Therefore, a list of targeted system performance has been listed below to serve as a reminder and achievements required:

1. **Real-time Object Calibration**
   This is to ensure that the application is capable of creating the augmented object immediately and will calibrate (make adjustments) accordingly based on user’s movement to create a realistic view.

2. **Online Sync Database**
   The application must be able to retrieve models from an online database that is manageable by managers. Hence, the application needs to constantly be in sync with the online database to ensure that the new products can be displayed quickly.

3. **Poor Video Quality Compensation**
   Not all smartphones can have a good camera quality or condition, thus, it is important that the application can use other sensors to help with the object model calibration. Accelerometer and gravity sensors can be used to help determine the angle and speed of the smartphone.
3.1.4 Verification Plan

It is important to have a good verification plan so that the application can be expected to perform well if it has passed the verification tests. A good verification plan will expose the defects of an application by intentionally breaking the application that may not reflect the normal use. Therefore, the list below shows what kind of procedures and measurements that will be taken during verification:

1. Upload different model types into the sync database
2. Rapidly provide continuous motion data for calibration
3. Provide poor quality videos for 3D perspective calibration

3.2 System Design and Overview

One of the best methods to fully achieve the objectives of the application is to implement a marker as a tracker to allow the device better understand its surroundings. A marker is defined as a standard piece of static image taken by the camera which has high colour contrast and distinctive patterns. A tracker is defined as the software embedded to compute and identify the position and relative size of the selected marker using a smartphone’s camera. By implementing a marker and a tracker, it will greatly enhance the capability of the application to detect the surrounding accurately.

Next, it is important for the device to register its original position where the marker is located at by using position sensors. Position sensors include orientation sensors and magnetometers, hence, by using orientation sensors, the application is able to detect the smartphone’s current angle relative to earth’s gravity. Then, by using magnetometers, the application can retrieve the current direction that the smartphone is facing relative to the earth’s ambient magnetic field. Thus, allowing the application to mark down the original smartphone angle position and direction.

Then, the motion sensors which includes accelerometers, gravity sensors, gyroscopes, and rotational vector sensors in a smartphone will be used to calibrate movements as it can be detected faster than a tracker and orientation sensors. Accelerometers can detect the smartphone’s acceleration at high accuracy, gravity sensors can understand the smartphone’s angle relative to the floor level, gyroscope is able to detect the X, Y and Z position of the smartphone and rotational vector sensors will determine the rotation velocity of the smartphone. Hence, it will be prioritised during motion detection and the tracker will reconfirm the position thereafter.
Lastly, the application will need to move the virtual object forward and backward or within and without the display screen accordingly based on all the data collected.

The above design can be summarised as below:

1. **Register a tracker** – Point the smartphone’s camera towards a marker to calibrate relative size and perception angle.
2. **Register original position** – The application automatically registers the smartphone’s current angle and direction after registering the tracker.
3. **Calibrate smartphone movement** – By using the fore-mentioned sensors, the application will detect the relative position of the virtual object.
4. **Creating the view** – Lastly, display the virtual object accordingly with the combined data obtained from the tracker and sensors.

### 3.2.1 Flowcharts

Three flowcharts have been drawn and shown below to better illustrate the process flow involved while running the application.

The first flowchart is a part of predefined process called “Marker Registration”, which is responsible for registering a new marker as a tracker. The predefined process starts by asking users to select how they want to register the marker. Either way will provide the application an image that will be cropped accordingly by users to indicate the marker’s size and shape. The application will then identify the distinct patterns on the image and determine the suitability as a marker. A qualified marker will then be registered and saved into the user’s local database as a new default marker that can be used in the future (see Figure 3.2).
Figure 3.2: The flowchart for the predefined process “Marker Registration”.

The below flowchart is used to describe the process flow for the predefined process “Calibration”, which is responsible for measuring and calibrating the size and angle of the augmented object. The process starts by receiving video information, accelerometer and gravitational data, then measures the object distance based on the marker pattern found. Subsequently, adjust the angle based on the smartphone’s angle and position (see Figure 3.3).
Figure 3.3: The flowchart for the predefined process called “Calibration”.

The below flowchart displays the full process flow after starting the application. The application will first display the menu for users, then carry out different activities accordingly. Next, if the user selects product, they will be able to choose a product from the categories section. Later, the application will seek for user’s preference on the marker and generate an augmented view after calibration on the selected marker. These processes will continue as long as no action has been initiated by the user. The application will exit if the user chooses to do so (see Figure 3.4).
Figure 3.4: Flowchart diagram for the overall process of the application.
3.2.2 Block Diagram

The block diagram shown below shows that a user can interact with the application using a mobile device. The application will download object models from an online database, and generate an AR view based on the video data (including other relevant information given). The manager is able to upload application updates and also object models into the online database that will be reflected during the next data fetching by the application (see Figure 3.5).

![Figure 3.5: The block diagram for a general view on how a user and a manager can interact with the application.](image)

3.3 Implementation Issues and Challenges

A few implementation issues and challenges have been foreseen during application development. The main challenge is to work with 3D object models which can be highly complicated and complex, especially if a new 3D object has to be created. 3D objects are tough to deal with because almost all display systems are in 2D, while
3D is only an imaginary object which shapes and sizes change when rotated. Therefore, it is important to have the correct formula and algorithm to accurately display 3D models in AR.

Besides, online mobile application is the next challenge that will be faced during development. Mobile application has yet to be learned from the courses taken throughout the degree, while minimal knowledge is known, it is relatively difficult to take up a project that belongs to a new field; although the programming language used is Java which has been learnt and is familiar with the syntax. In addition, creating an application that utilises online platform is fairly demanding because of security issues, too many options available, connection problems, large file size and data reliability issues.
3.4 Timeline

A Gantt chart has been created for FYP 1 Oct Session 2017 to mark down important tasks and deadlines that has to be completed within this trimester. The timeline for the chart is by weekly and daily respectively for the upper and lower tier.

![Gantt chart with lists of tasks expected to be performed during FYP 1 Oct Session 2017](image)

**Figure 3.6:** The Gantt chart with lists of tasks expected to be performed during FYP 1 Oct Session 2017.
Another Gantt chart has been prepared in advance to plan future work to be done during FYP 2 Jan Session 2018. The timeline is based on months and weeks over the 13 weeks of next trimester.

![Gantt chart]

Figure 3.7: The Gantt chart with lists of tasks expected to be performed during FYP 2 Jan Session 2018.
CHAPTER 4: MARKER REGISTRATION

4.1 Technology Background

When Augmented Reality was first introduced, there were 2 main methods to achieve this technology. These two are marker AR and marker-less AR respectively, marker is done by attaching the AR object to a predefined marker, which is usually embedded in an image, while marker-less AR tries to calibrate the surrounding with camera movement to understand the 3D environment, then attach the AR object to a plane (or table) (Kudan, 2017).

An application that uses a marker for tracking has some major benefit over the marker-less method. The first one being capable of achieving a faster tracking speed and accuracy on the real-world environment, meaning that the application can almost immediately identify the marker and make necessary adjustment to create a realistic view of an AR object. Besides, the marker will also allow more random user movement while maintaining the AR object on place in the environment, usually as long as the marker is still in the camera’s view. In addition, marker tracking also uses less computing power when compared to marker-less tracking as it only requires to continuously search for the “marker” instead of tracking the whole camera’s view to understand more about the environment.

Nevertheless, marker-less also has its own advantages such as being able to be used anywhere the user goes without the need of bringing a marker around with them. Marker-less technology also allows the application to create a more realistic view of an AR object if the device is capable of providing a clear video input and processing power, such as creating an AR object with the field of depth, like a virtual dog going under a table. However, it is inevitable that marker-less AR is incapable to administer the need of an accurate sized AR object as video input alone is insufficient.

4.2 Marker Characteristics

A marker is usually designed as a 2D image that has its width and height specified in centimetres or meters, which is essential in providing a reference to the AR object on how to scale accordingly. The design of a marker usually consists of 3 important areas, distinct pattern, high contrast and size relative to AR object. The reason being a marker needs to be clearly identifiable by an application, which will not be similar to the surrounding. Also has high contrast, which helps the application to detect
the marker in low light or strong light environment. And lastly, the size which is very important because distance of user and the AR object will be relative to the distance of an AR object size. A bigger AR object will usually cause users to stand further away in order to see the full view, therefore requiring a larger marker size to be detected by the application through video input.

4.2.1 Marker Quality

The quality of a marker is categorized into 2 parts, the clarity of an image and the size specifications. As aforementioned, a marker with more distinct patterns and high contrast will be considered as higher quality as the application can easily detect movements of the user’s smartphone or the movements of the marker itself, providing a more realistic view of the AR object in the environment. The size specification is very crucial in delivering an accurate sized AR object in the real-world, as only an exactly detailed size specification can produce a perfect sized AR object.

4.2.2 Marker Size

The marker’s size is an important factor that should be determined when deciding the AR objects to be placed in the real-world environment. A larger AR object would naturally require a larger marker size while a smaller AR object would then involve a smaller marker size. However, in certain cases, smaller marker can still be used for large AR objects if you can place at least 2 or more smaller markers accurately in a specific distance. Therefore, the application would be able to scale accordingly to the distance between the markers relative to the AR object.

4.2.3 Marker Creation

In this project, in order to enhance user experience, a feature to create a new marker has been thought and added into the application. However, to create a new marker, it is important to ensure that the marker has all qualities mentioned above. Thus, users will be given the information on how to identify a high-quality marker, and then they will be asked to take a photo and to be loaded into the application. The application will then determine the quality of the marker and register the marker as a new image target for tracking purposes. Additionally, users will be able to input the actual measurement of the marker to help the application calibrate and scale the AR object accordingly.
4.3 Implementation

During developing the project, marker registration is the most critical area as it is the fundamental function that will provide users an AR experience. Without a marker, AR objects are more likely to flicker and move around by themselves or just floating and slanting at a funny position and direction. Hence, it is one of the first function that has to be developed before considering how to switch AR objects in the application.

It was determined that the application will be using a predefined marker and user defined marker, which allows more flexibility for users to choose if they want to print an A4 paper or to just take a photo of their RM 1 bank note. A predefined marker would immediately work and also perform better in general when compared to user defined marker, however it limits the user to carry the marker around with them. On the other hand, in order to further enhance user experience, extended tracking will also be used on device that are capable to provide more processing power. Extended tracking is the ability to slightly track the surroundings of the marker, combining with sensors on the phone and tries to determine the estimated position of the marker when it is out of the screen.

A predefined marker was created in this project by taking advantage of the technologies readily available online. The easiest way to do create a marker is to generate a QR code, which can contain your company’s domain name or any other information. This is because a QR code is distinct in its pattern and can provide the application a clear method of differentiating the front, back, left and right of the image. Printing a QR code on an A4 paper is also very convenient and can brought anywhere easily. For this project, this method has been adopted, where an A4 paper printed with an QR code has been used for testing purposes during application development to ensure the capability and limitations of the application’s features.

4.3.1 Tracking Capability

The tracking capability of marker technology in this project is quite accurate as users can move either the smartphone around or the marker around and the AR object would move accordingly with high accuracy. The reason being that the algorithm used for tracking was also utilizing the gyro sensor and accelerometer information to determine user movement. The only downsides are when the marker is out of the screen.
or when the user movements are too random and quick, AR object will then disappear for while until the marker can be identified again.

4.4 Future Research

There are still a lot of possibilities that can be made using this technology and therefore it is very suitable for future research for new features. For example, creating moving AR objects which can then provide even more information to the user. Also, an interesting idea that can be considered is to create a 3D target which specifies the length, width and height and therefore allowing AR objects to move behind or get on and off of an object.

Besides, this application can also be used in other sectors than business, such as for education purposes, which users are able to interact with textbook graphics, which can be very useful for students that rely more on interaction learning. Also, the working sector can finally have a better manual on maintaining a machine, device or even a software. They would not require to intermittently to swap between the manuals and back to their operations frequently, and also being able to see a more clear and concise picture on what and how to perform the recommended actions.
CHAPTER 5: RENDER 3D VIEW

5.1 Pre-View Requirements

Before the application developed in this project can render the 3D AR object in the camera view, it is important for the application to detect and identify a marker beforehand. Besides, the application would also need to pre-render the object’s view while waiting for the marker tracking to come online. Therefore, there are 2 main processes to complete before being able to generate the preview of an AR object.

The first process is marker tracking, which will require user’s permission to access the camera in order to retrieve the video input. Marker tracking is essential in providing the application a reference to the AR object’s position that will be displayed on user’s screen. Additionally, the marker tracking also provides the marker’s relative size on the user’s screen to create the scaling required when displaying the AR object on user’s screen. Therefore, the pre-rendered AR object can be placed on user’s screen instantly and users are also able to swap between AR objects quickly.

5.2 Object Calibration

After rendering the 3D view, it is important to have object calibration process to ensure that the AR object matches to user’s movement and marker’s movement. Object calibration will continuously run in a loop of thread where the marker will be tracked and at the same time gyro sensor and accelerometer sensor will be used to determine the user’s movement and marker’s position at real-time. Hence, with object calibration, the user will have a better overall experience as if the AR object happens to be right in front of their eyes as the size and movement are realistic, creating the illusion of Augmented Reality.

5.3 Generate Live Preview

In order to generate live preview, user’s smartphone camera has to be switched on at all times. The application is also required to run non-stop to constantly provide user the AR preview experience. An added function to rotate the AR object was added in live preview helps to enable users to preview the furniture from different angles and perspective. This rotate function will be toggled by a button which will make the AR object slowly rotating clockwise, then anti-clockwise when toggled on the next time and vice versa. This greatly helps user to take a good look of the object without the need of actually moving around the object physically.
Besides, a mini-preview function is also added to allow users to take a preview on the AR object at a smaller scale on their table. This is useful when users do not want to move to a bigger empty area for furniture preview or when they are not concerned about the actual size of the furniture.

5.3.1 User Movement

While rendering the 3D view of an AR object, user movement plays a big role in ensuring that the marker can be clearly tracked and therefore producing a stable AR object on user’s screen. Although the application does not intend to restrict too much of user’s movement which may affect user’s experience, it is also incapable of catering to a movement too quick for calibration. Thus, the application will inform users that high speed movements are not recommended in order to provide the best user experience, which is the current limitations of this application.

5.3.2 Life-Size Scaling

One of the most important factor to assess the application’s success is the ability to provide life-size scaling for the AR object. Therefore, the application will need to have the ability to track the marker’s size to scale the AR object accordingly.

Thus, life-size scaling is implemented where users are able to move back and forth will seeing the AR object staying stable and scale the size accordingly. The size of the AR object is also being scaled accurately at a maximum difference of 5 cm. However, the larger the AR object, the lesser the accuracy of life-size scaling. This is due to the size of the marker and difference percentage, which causes larger AR object to be more inaccurate although the difference is similar in percentage.

5.4 Unresolved Problems and Challenges

One of the main problems encountered in this project is to store AR objects in a cloud. The main reason is because of the facilitating complexity of downloading the AR objects and updating the furniture list in user’s application. It is not the best practice to allow users to store seller’s furniture 3D model in plain storage as it could easily be stolen by malicious users for malicious usage. Besides, the application will be more prone to error if the AR object is stored in user’s local storage, as users might delete them or move them around accidentally. Therefore, there is a huge gap of security and integrity issue in implementing online sync database in this application. Hence, a more
plausible solution would be providing updates to users when there are new AR objects to be added, which can be added in future development.

Secondly, a challenge was encountered during developing the application when trying to search for image processing algorithm. Image processing algorithm is not the main focus of the application, but it is a tool that is required to register a marker and to identify it. Lots of time were taken to look for a suitable image processing algorithm that can be easily used by the application as a plugin or imported function. Therefore, a few open sources of image processing algorithm have to be used in this project to ensure that the project can be completed in time.
CHAPTER 6: CONCLUSION

What shopping experience can be better when augmented furniture can be placed instantly in a house? Therefore, the project is focused on using the new AR technology which is the near-to-come trend in the coming years to fulfil the requirements and needs of customers and sellers for online shopping purposes. The final application serves to meet the needs of customer purchasing desired products in their home with preview capability and provide a new platform for sellers to promote their products better, easier and cheaper. Therefore, the application achieves these objectives by bringing virtual objects into real life, creating an augmented object that can be viewed from the smartphone’s display screen.

To make this possible, it is important to have an online platform that can be managed by managers and accessed by customers (the application). Moreover, the smartphone plays an important role to assist customer’s perspective on the augmented view. In addition, a tracker in the real world object can be served as a marker that can help the application identify the relative distance and angle between the smartphone and the plane surface directed. Hence, these components are essential to ensure that the application can provide the best experience to the users.

Simply put, the application can be used as a powerful module that can solve customer’s problems especially finding the right furniture online by using augmented 3D view at live size scale. Also, the application can help online sellers and showroom creators to promote their products to millions of customers by injecting 3D object models into the application without the need to manufacture the product. Therefore, there can be so many possibilities of what the application are capable of achieving, such as displaying 3D interactive education or 3D information on products by scanning a unique barcode.
REFERENCES


APPENDIX A: APPLICATION SNAPSHOTS

Appendix A.1

Snapshot of Asher Vollmer’s tweet regarding his pre-released Furniture Drop application

 Been playing around with #ARKit lately and I'm really impressed with it! I built a little tool for laying out rooms 🤖

Can be accessed at Asher Vollmer’s tweet post during 21st July

<https://twitter.com/AsherVo>
Appendix B.1

Chart below shows the sales of Alibaba from 2011 to 2016
Appendix B.2

Table shows relative number of Android devices running at respective versions

Versions with distribution less than 0.1% are not shown on the table.

[Updated on: 8th August 2017]
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