INTERNAL DESIGN FOR HOUSING USING AR

BY

KHONG LIN YAN

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfilment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONOURS)

Faculty of Information and Communication Technology

(Kampar Campus)

JANUARY 2021

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BCS (HONOURS) Computer Science

Faculty of Information and Communication Technology (Kampar Campus), UTAR

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I declare that this report entitled "**INTERNAL DESIGN FOR HOUSING USING AR**" 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.

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Name   :   Khong Lin Yan

Date   :   15/4/2021

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I would like to express my sincere thanks and appreciation to my supervisor, Dr. Ng Hui Fuang who has given me this bright opportunity to engage in an Internal Design for Housing using AR project. It is my first step to establish a career in AR field. A million thanks to you.

Finally, I must say thanks to my parents and my family for their love, support and continuous encouragement throughout the course.

ABSTRACT

This project is about using AR technology to perform ease for interior designing a house. Augmented Reality is a technology where it helps users to see virtual things in a more realistic point of view. People nowadays are using measuring tape to tape around their house in order to image out their house so that they could choose the right furniture needed. The AR technology that were used here are measuring the room outline and showing the furniture. It allows furniture to be inserted with a correct measurement as the real world and helps users to measure their room then outline them. In this project, the room is outlined according to the corners that were manually declared by users and the furniture will change the view size when moving around the room. The best thing of this project is where the "dream house" could be a reality after designing it as it will include a tracking for those who would like to see how their room could go from not expected to the way they designed.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
2D	2-Dimension
3D	3-Dimension
UI	User Interface
iOS	iPhone Operating System
FYP	Final Year Project
API	Application Programming Interface
CPU	Central Processing Unit
UHD	Ultra-high-definition
GTX	Gore-Tex Lining
RAM	Random-access Memory
DDR4	Double Data Rate 4
PDAF	Probabilistic data association filter
SDK	Software Development Kit

CHAPTER 1: INTRODUCTION

In this chapter, we present the problem statement, project scope, objectives, contribution and the background information.

1.1   Problem Statement and Motivation

There were lots of applications in the App market recently, most of them could do interior designs and wall painting, however, most of them could either only show the furniture in AR view or only allow designs within 2D. These apps may be easy for users who could really understand and image out the output but for those who would prefer more on looking the real one, this project would be a better choice for them as the furniture that were added insides could be viewed well and clear apart from imaging out self. For example, one might not exactly imagine out how thick will 5cm be exactly but with AR view you could simply just look at it and you know how thick it is.

1.2   Project Scope

At the end of this project, a piece of Android AR mobile application on interior design will be delivered. The main purpose of this project is to convenience interior designers and some of the other users who would like to design the interior of a house. As from what we saw in the past projects done, there are some limitations of them such as without an AR view which help users to clearly identify the situation. This project will decrease the communication difficulties between users to designer and designer to constructors with the use of AR viewing. Also, an AR view will actually help users to understand well with the final output on how exactly their house would look like before construction starts. This way, users who do not have basic knowledge on interior design can also easily design a house of their own wish. Basically, in this application users can be able to design their house in their desired way and show it to the constructor about the designs done.

This project is actually used to help those who could not express well on what they need and also some of the poor families who would like to get a new view of their house to save some money on finding themselves a designer which some of them are costly. It is also useful for those who may have problems in speaking to express out what they need to the constructors so that they can have the rights to have what they need too.

1.3 Project Objectives

In this project there are few objectives to be achieved:

- To allow users insert 3D models to AR view.
- To allow users get a list of what furniture and household appliances to be bought after modification is done.

This project will be more focusing on how to allow users check on correct measurements instead of making it more fascinating as how the other application has themselves.

1.4 Impact, Significance and Contribution

This project will help most of the families who would like to renew their room or making their dream house instead. This will help them in a very quick start on deciding what to do before renewing a house. This project targeted designers as its user too as there are designer who teach their customers to choose suitable furniture for their house, that way this will help them in explaining to the customer as image could help more than 1000 words. We believe that this project will give a better help to starters and some normal house renewal. Since most of the people today hope to renew their house by self but will always not sure what to start first, this project helps and guide them to have a start, it might not be very specific but basics will be there.

We believe that most people nowadays will not want to spend money on finding someone to help them design their place on putting what type of furniture as they are the ones who stay in the house not the designer. Most of the parents would also prefer to let their children decide what kind of room they would like to have. In this project, we truly help them with designing and looking around to preview on how it will look like in the future.

1.5   Background Information

AR technology is where virtual objects are to be inserted into the real world and can be view within smart phones easily. An actual computer system on AR was developed in the 1968 at Harvard where one of the computer scientists Ivan Sutherland brought it to this world.

The most famous AR application for furniture displaying was IKEA Place where most of the customers from IKEA had been using it to try out the furniture in their house and buy the furniture from their shop online and just wait for the arrival of it without needing to head to the IKEA shop for any purchase. However, the application that brings AR technology to heat was the "PokemonGO" application. It was an AR application game where most of the teenagers were in love with it by running around in the city to catch Pokémon that were set to be in different places of the city.

AR technology actually helps to show the product for example if you would like to buy a phone but are not sure if the phone will be too thick or the screen will be too big to be hold or not. With the help of AR technology, you can easily check out the thickness of the phone and see if you could use it in ease before purchasing it. That way, consumers will not waste money on things that are of not their needs.

The most common AR application creator are AR Core, Vuforia and AR Kit. AR Core is mostly used for android phones and AR Kit is meant for Apple devices with iOS only. Since our target market for this project is for android devices, we will be using AR Core SDK in this project during implementation.

1.6 Proposed Approach/ Study
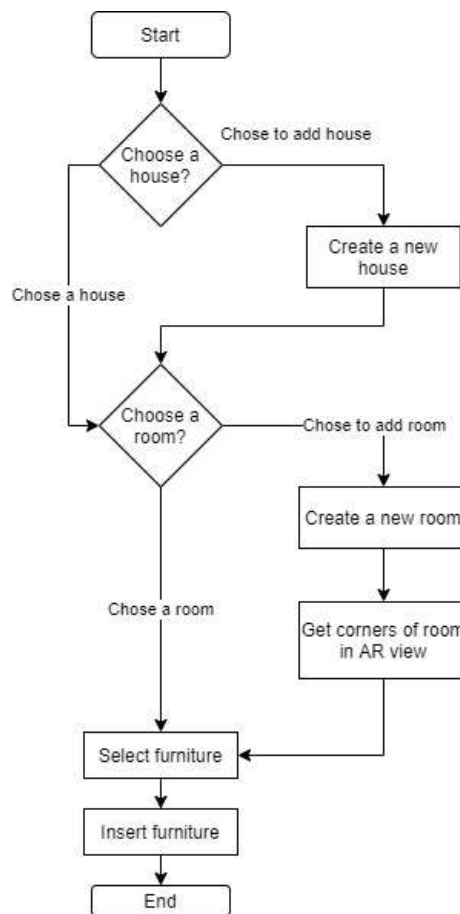
Figure 1 Flowchart of application

The figure above shows the flowchart of the whole application on the functions that it has. Firstly, the user will be asked if they would like to create a new house project or choose an existing house project. If the user requests to create a new house project, they will be asked for the house project name and a new house project will be added into their local devices. Later, the user who chose to edit an existing house and the user who created a new house project could either choose to create a new room or look into the existing room. For users who selected create a new room, they will be prompted for the room name and the AR scene will be loaded in order to get the outline of the room by manually adding the corner from an AR view. As the room environment is ready, users can repeat to select furniture from the UI page and add them into the room environment. The room environment and the furniture positions will be saved so that there won't be repetitive work for users to do.

1.7   Highlights of What Have Been Achieved

This project is now able to allow users add in furniture that are in the application itself to the room environment of the user. It allows users to manually add corners into the room and when all the corners are linked together, it will create a plane which indicates the user's room. The changes will be saved in the local device storage so that next time users use the application they will not need to redo everything again. Apart from that, the application also supports furniture inserting to the room environment. The furniture will not be able to added out of the room so that this looks more realistic as no matter how the user moves the furniture it will not appeared on the wall.

Furthermore, the application also supports plenty of furniture for the users to select. Users will not need to add furniture into the environment one by one but they can simply just add it into the list of selected furniture then only add them one by one easily into the environment. The application also shows some of the furniture details such as measurement of the furniture, materials used to make the furniture and also the price of the furniture.

1.8   Report Organization

In this report's content chapters, an overall of the application functions and aim to start work on the application is stated clearly in the first chapter where readers should have gone through the whole of chapter one and have a basic idea of what will be going on in the application.

Therefore, in the next chapter this report will discuss about some of the existing application in the market that are now being used by thousand or millions of people all over the world. These applications also include some of the ideas that are suitable and are implemented in this project. A summary for ideas used will be listed in the last part of chapter 2 for a clear view.

In chapter 3 there is a more detailed description on the flow in order to use this application. A few diagrams are shown in order to have a better view on the flow. In chapter 3 it also shows the approach used while this application was being implemented which is the phase development methodology, a more detailed description for each phase could be seen in that section.

In chapter 4, the overall system design specifications, tools needed and methodology used when starting up this project will be clearly listed. Total of 3 diagrams are provided to clearly show the flow of the whole project. A timeline was also included so that a basic time used for this project will be estimated.

In chapter 5, the implementation of the whole project will be detailly described. Basically, on how each feature was implemented will be shown. Apart from that, some of the testing handled in order to check if the function is working is also discussed in that section.

Last but not least the conclusion is a brief summary on all the objectives, discussing whether all of these objectives are achieved and some discussion on the problem came across to. Some of the future works that could be added into this project are also discussed at that part.

CHAPTER 2: LITERATURE REVIEW

2.1   Literature Review

In today's world, most of the people would like to customize their own house design according to their own desire. This is due to some people might not have a very good communication skills which limits them from explaining well to the designer on what they need. Even with a very good communications, people would rather choose to hands-on design their own house instead of looking for a designer who are actually more expert. This is due to designers are not the ones living in the house, they might not know if their taste of design meets the people's need. Therefore, here comes the technology of interior design applications which allows the users to design a house of their own wish.

2.1.1   Existing Applications on Interior Design

"Room Planner", an application that is a very user-friendly application for users who would like to design out how their dream house would look like. It allows users to get a better idea of how their output of the house would look like with the use of 2D and 3D views. It also allows users to customize the picture range from their colours on the walls to the layout of the furniture. During design, user can interchange different views of 2D or 3D while inserting the selected furniture. This application had even included some of the pre-designed themes for different parts of the house. In order to have a realistic view of the design, this application allows users to take a photo of the designed workspace and it will change the photo from artistic view to realistic view as shown in Figure 2. Users can choose the theme for different parts of the house and modify on it rather than getting whole thing done by self. (Rysenko, 2014) This application supports photo-realistic snapshots and a 2D floor plan view for better understanding of the house outline.

Figure 2 Workspace for Designing in 3D View

Figure 3 Realistic Image Generated After Taking Photo

"Homestyler Interior Design", an application that supports real world room measure and uses 3D object to show the images. It allows the users to take photo of their room then upload to the application to get a visual calculation of the whole room according to the outline of the image. (Figure 3) After that, users are allowed to add in the furniture that comes along with the application which include some of the other furniture stores that have 3D view of the product. It also has a very attracting feature that is allowing users to post the designed view to other application users and discuss with each other about home design and renovation trends. (Topping Homestyler(Shanghai)Technology Co. Ltd., 2017)

Figure 4 Outline Measurement of Room Image

However, all these features of the above applications only fulfil the users' desire of understanding how exactly their house would be after inserting all these new designs. The view of house is only in the phone, users could not view exactly and it is quite difficult for users to imagine how the exact output of the design would be. Sometimes there might be some minor mistakes such as the path for users to walk may not be enough since users could not try that out yet. To solve this, some of the applications had come out with the idea of AR.

2.1.2 Existing Augmented Reality Applications on Interior Design

"Houzz Interior Design" and the once most popular application "IKEA Place" are applications that has AR view for users to get the better view of their interior designs. Both of these applications have a similarity that is to show the product in AR view where users can move their phone near to the AR object to check out the zoomed in result. Houzz which is told to be the No.1 app for improving and designing your home (Houzz Inc., 2019) has a similar feature of the previously discussed application, "Homestyler Interior Design" that is the news feed feature. For Houzz, they provide the news feed only for the professionals such as architects, contractors, interior decorators and repair professionals. Users can search for professionals that meet their needs to get their household get constructed to how they designed.

Figure 5 AR view of Houzz on browsed sofa

IKEA Place on the other hand had not include this feature in their applications, but they do have a very helpful feature that is to allow users to scan the product that they saw which refers to one of the products in the IKEA furniture list. (Inter IKEA Systems B.V., 2017) This feature allows user to get their desired product in a quicker way, without needed to scroll out for the item and adjusting the filters, this scanning feature is just amazing.
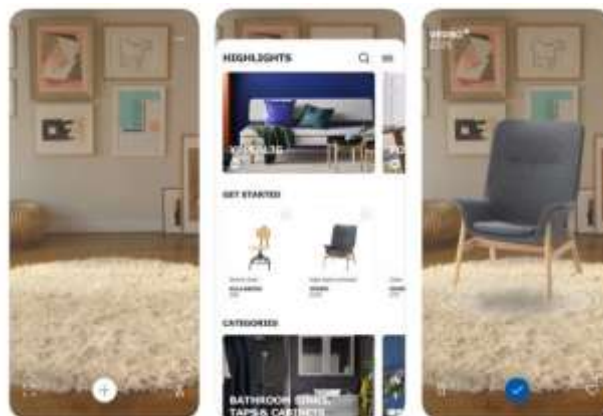

Figure 6 AR view of IKEA Place on browsed chair

Both of these AR supported applications are actually great designs however both of them could not remove the original furniture in the users' house, which shows that the product may be viewed but the users might not get a very great view of the final output after removing the unneeded furniture. In order to include this feature, Sandu and Scarlet had come out with a solution to resolve it.

2.1.3 Papers Reviewed on Solving Weakness of Reviewed Applications

In order to allow users to view their designed house in a better view, a solution was introduced on removing all of the objects in a specific room which needs to be designed. (SANDU & SCARLAT, 2018) Both of the inventors proposed an application that could resolve the issue of random objects in the designed room. The users first scan the room from corner to corner by walking around the room to the indicated points from the smart phone, as for furniture that is not correctly identified, users can use a point-to-point scan for that object. After that, users will be able to remove certain objects and place an AR generated object on that place without getting the original furniture to block the way of the AR object.
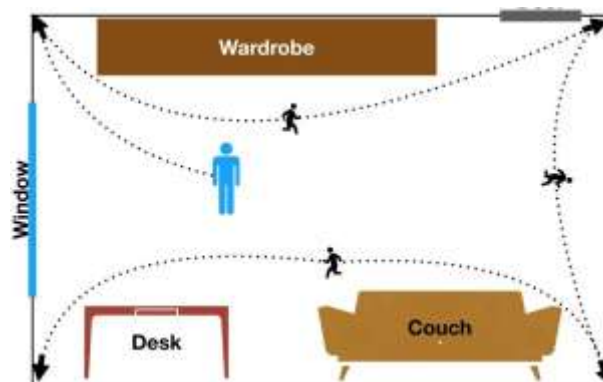
Figure 7 Overview of how users should scan their room corner to corner

An upgraded version of scanning objects was done by (Armond et al., 2018) on scanning an object using the tool ARKit Scanner. In his paper, he showed how he used ARKit Scanner to get the product scanned in 3D view and tested the scan result by using the camera detecting feature. This 3D scanning technique used was amazing which can help users to add in more furniture of their desired to the application so that they can include it in their house design. However due to the time constraint, I will not focus on this in my Final Year Project.

2.1.4   Education with AR Interior Design Applications

A good interior design application should actually include a very well interior design features which can help out the future designers in deducting their work load and allow them to do easy works. A research on whether AR could help the future designers was done by the interior design project lecture in Istanbul's Arel University. A total of 14 students were selected to attend this lecture and their feedbacks on using AR for interior design was recorded. Most of them agreed that with an AR application, it will improve the perception of the given space, the students' motivation and creativity on designing. Most of them also feedback that the application helps them to do space arrangement effectively and functionality. They also didn't not mind about using mobile phone as their designing equipment. (Gürçınar & Esen, 2018)

Theme	Disagree	Neutral	Agree
1. Improved Perception of the given space	0%	7%	93%
3. Improved Motivation	7%	21%	72%
4. Improved Creativity	7%	28%	65%
5. Effectiveness and functionality of AR on space arrangement	5%	14%	81%
6. Mobile phones preferred as Equipment	7%	21%	72%

Table 1 Themes and Percentage of Students' Feedback

From the research above, even though there are not many students asked to try out designing with mobile AR application, we still can clearly see that the probability of future designers using AR applications can help with their work is quite high.

2.1.5 Summarize of Reviewed Products

There were a lot of papers being reviewed, most of the applications were having wonderful ideas and were very helpful for the users as seen from the reviews given from the downloading store such as Play Store and Apple Store. To summarize things up, the features that will be included for this project are as follows:

1.) *Room Planner:*
   - Providing different themes of design.

2.) *Homestyler Interior Design:*
   - Visual calculation of the room so that the application can give a better calculation of size after adding in the furniture.

3.) *Houzz Interior Design:*
   - Viewing the furniture in the room with AR technology

4.) *IKEA Place:*
   - Inserting more than one furniture in the AR view

5.) *(SANDU & SCARLAT, 2018)*
   - Scanning the room from corner to corner so that it is able to remove the background furniture when new furniture is going to be inserted into it.

Even though these are the features to be used in the future products, a review on some other features and proofs to show that this product can be invented better in the future. The feature that was found in a paper shows that there's an ARKit in the market for iOS devices to take their phone as a 3D scanner to scan the product and show it in AR form. (Armond et al., 2018) Another paper found was a survey done to a target of 14 design course students on how they feel by using the AR application to perform their designing process. Most of them agreed that AR had actually give them an easier way to finish their task. (Gürçınar & Esen, 2018)

CHAPTER 3: SYSTEM DESIGN

3.1   Use Case Diagram

3.1.1   Use Case Diagram

In this project, there will be total of 3 use cases that allows the user to perform which are as shown in the use case diagram below. Users are allowed to create a new house project or room project since there will be houses with lots of different rooms and users who might not just have a house. Therefore, it is a must for the users to create new room or house projects into their platform. By creating a room project, the user is able to scan their respective room for the selected project too. Another thing is that users are able to add in furniture from the furniture menu list to their room environment so that they could see if the furniture suites their room in size.
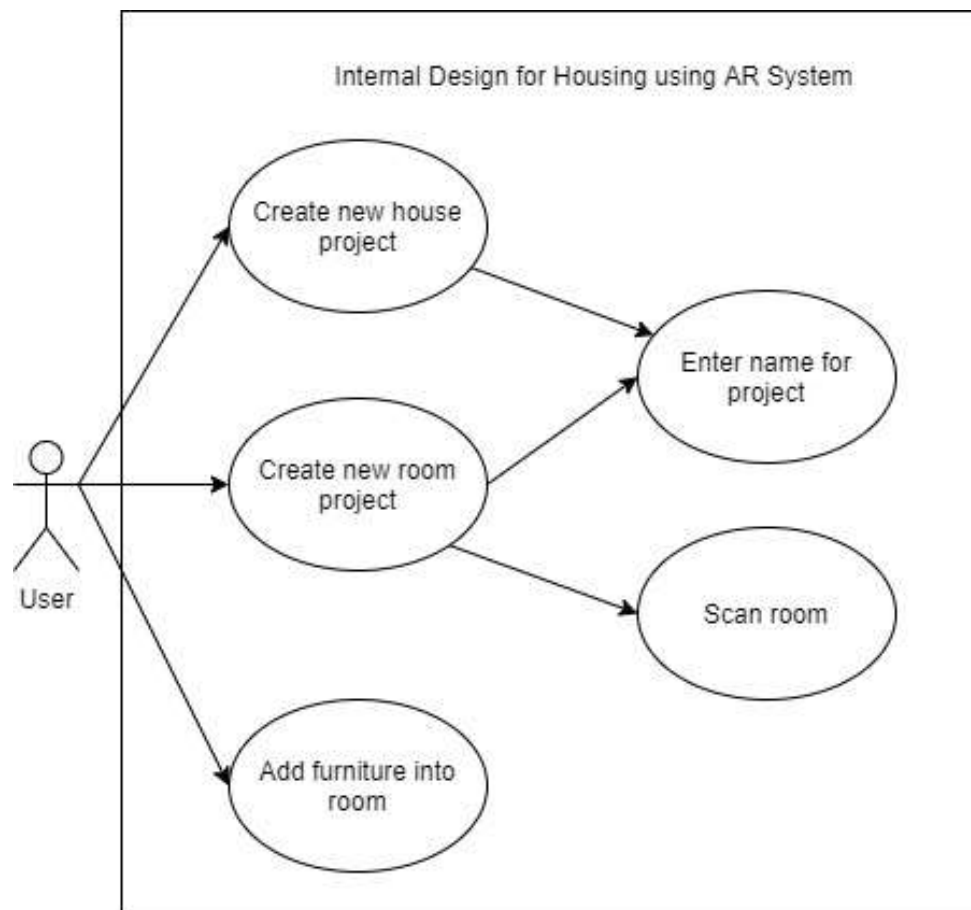

Figure 8 Use Case Diagram of Project

3.1.2 Use Case Description

Use Case Name: Create new house project	ID: 1	Primary Actor: User

Normal Flow of Events:

1. User click on create new house project button
2. User enter new house project name

Sub Flows:

Not applicable

Alternate/ Exceptional Flows:

Not applicable

Use Case Name: Create new room project	ID: 2	Primary Actor: User

Normal Flow of Events:

1. User click on create new room project button
2. User enter new room project name

Sub Flows: Room scanning for room project

1. User scan the room's floor for horizontal plane detection.
2. User click on add button to add a sphere (corner) in the scene.
3. User move the sphere (corner) to the exact place where the corner should be in real.
4. User repeating step 1 to 3 until the first sphere and last sphere collides.
5. User click on done button to generate a floor plane mesh.

Alternate/ Exceptional Flows:

Not applicable

Use Case Name: Add furniture into room	**ID:** 3	**Primary Actor:** User

Normal Flow of Events:

1. User choose desired furniture from the furniture menu.

2. User add the desired furniture into the list of furniture.

3. User head back to room project page to enter specific room for modification.

4. User select furniture to be added from the left scrollable panel.

5. User tap on screen to insert the furniture into the scene.

6. User use two fingers to rotate the furniture.

7. User use one finger to move the furniture along the floor plane.

Sub Flows:

Not applicable

Alternate/ Exceptional Flows:

Not applicable

3.2 Activity Diagram

Each of the flow for these actions to be perform could handle in a few steps itself. Before modifying any projects, the users will need to create an empty project first and get the room scanned before any modification are to be done. It is also a step for users to scan their room before inserting the furniture, therefore, users will be asked for room scan as long as a new room project is built. Before getting a list of furniture, users will need to add the furniture from the furniture menu. After that user could insert furniture according to the selection they chose from the previous section. The below activity diagram shows the flow of this project's system.
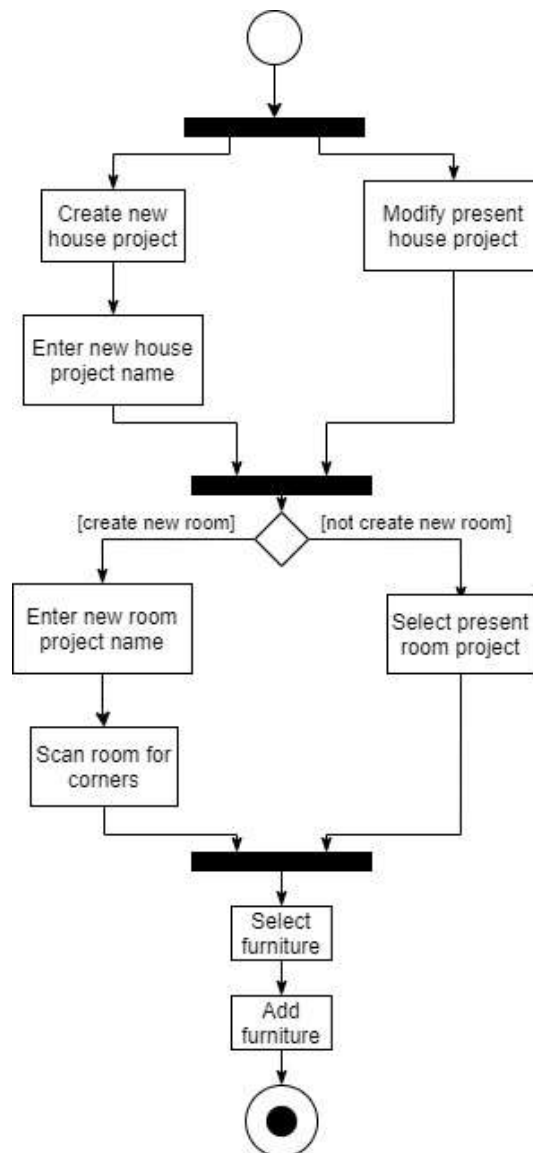

Figure 9 Activity Diagram of Project

3.3 Sequence Diagram

With the help of sequence diagram, we can clearly see that for each action to be performed by users will have a detailed flow on where the data are received from and where the data are stored into. First action shows where users perform create new house project action. The second action shows where user would like to create a new room environment. By creating the room, the user will be requested to scan the room. The last action is where users select furniture and add them into the list only then they are able to insert the furniture into the room environment.
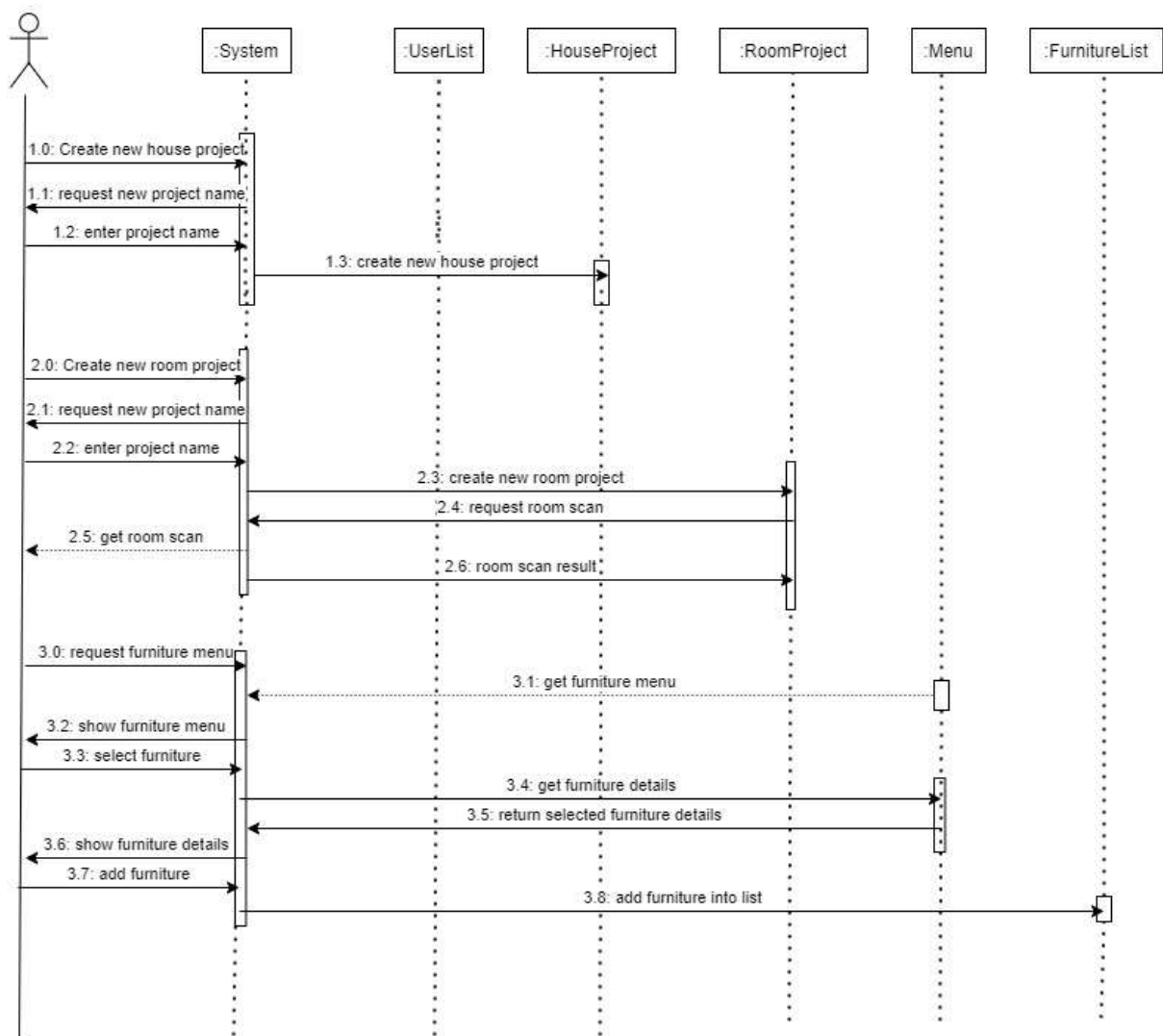
Figure 10 Sequence Diagram of Project

3.4   Project Outline

On start of the application, a page where house that were created and a create new house button will be shown on screen.

Figure 11 House project page

If the user chooses to add a new house project in the page, they will be brought to the page where it asked for their new house project name as shown below.
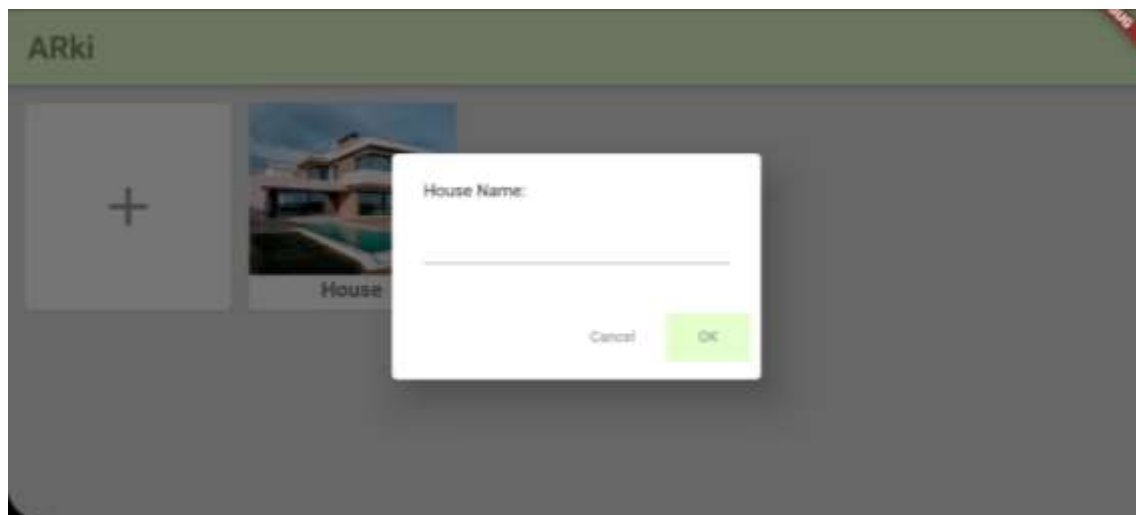
Figure 12 Create new house project page

If the user chooses to go for the project that exists in the page, they will be brought to the room projects page. In the page, the users could choose to either create a new room project or go to the existing room project.

Figure 13 Room project page

If the user chooses to create a new room project, they will first be asked for the new room project name from the page shown below.
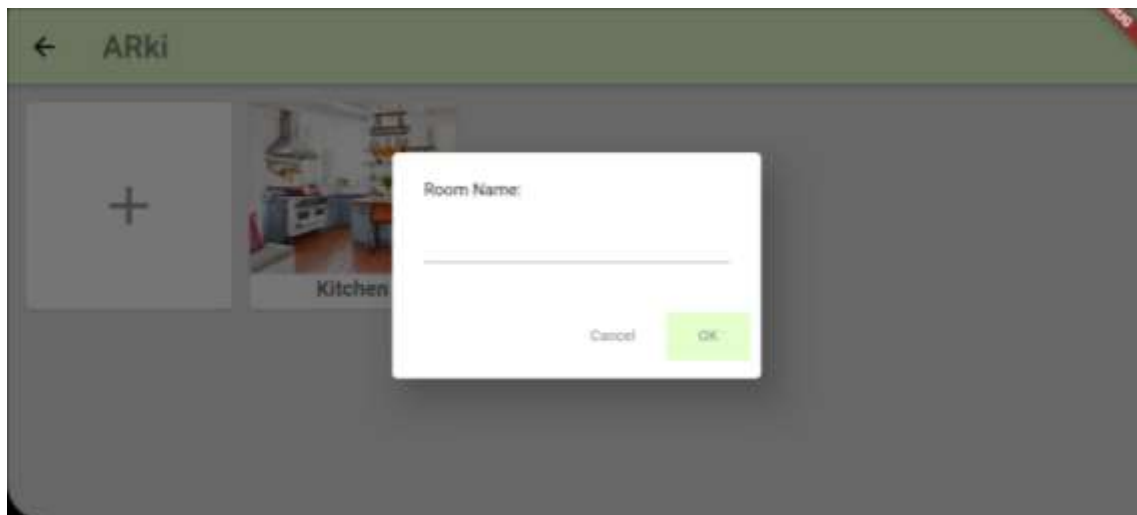
Figure 14 Create new room project page

After creating the new room project, users will be asked to scan the new room in AR view by inserting a black sphere to indicate the corners in the real room. Users could use the bottom right button to insert spheres and the spheres will appear at the placement indicator shown.

Figure 15 Scan room page

When the placement indicator detects that the user is inserting the last corner, it will change the colour of the sphere and connects the points just in case users could not accurately insert the corner.

Figure 16 Corner Auto Positioning

When all of the corners are added, a done button will show on screen so that users could confirm the corners added.

Figure 17 Corners insertion success

If the done button is clicked, users will be asked to add furniture to the list so that the furniture could be added into the room environment.

Figure 18 Request for Furniture List Page

With the plus button on bottom left clicked, the user will be navigated to the furniture menu page where it allows them to choose their desired furniture.
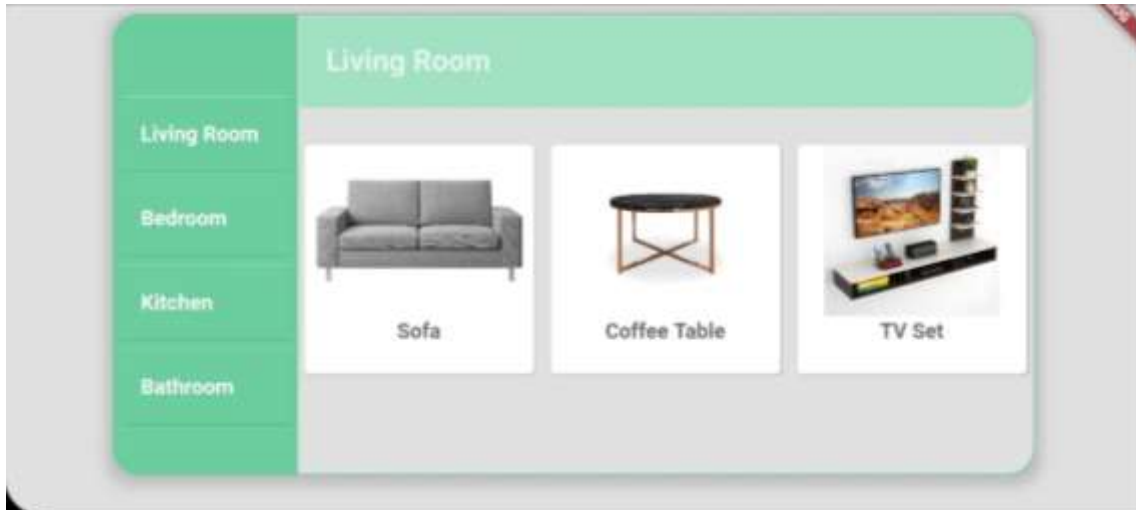
Figure 19 Furniture menu page

After choosing the furniture, users could browse for the furniture of the type they chose.
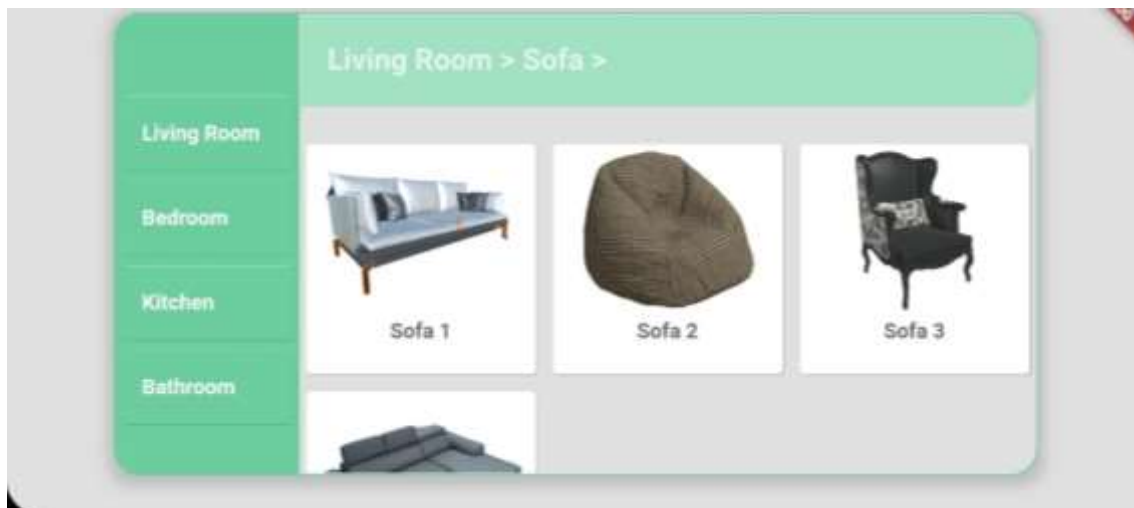

Figure 20 Furniture with same category menu page

When users select on any of the furniture, the details of the furniture will be shown on screen.

Figure 21 Furniture details page

By clicking on the add button at the bottom right, the furniture will be added into the list of selected furniture. After all the preferable furniture are added into the list, user can simply click back on the choose room function and they will be asked to resolve their previous room scanned feature before doing additional changes.

Figure 22 AR corners resolving Page

After the resolve button is clicked, the user will need to wait a while for the last saved session to be resolved. After that user could find the left panel showing the furniture selected just now. Users could just click on the furniture that they want to add into the environment and by touching on the screen the furniture will again show in front at the middle of the screen.

Figure 23 Adding Furniture Page

CHAPTER 4: DESIGN SPECIFICATIONS

4.1 Methodology and Tools

4.1.1 Methodologies and General Work Procedures

In this project, the methodology of rapid application development is used and steps are to be organized into 3 versions where each version tends to achieve an output itself. The reason for choosing phase development instead of all the other development methodology is because it helps to break down the whole project into few versions which is also a guide for where to start. Apart from that, rapid application development also allows future changes to it, which means it can be upgraded itself. That way the project can be improved from time to time without needed to redo everything again most of the time.
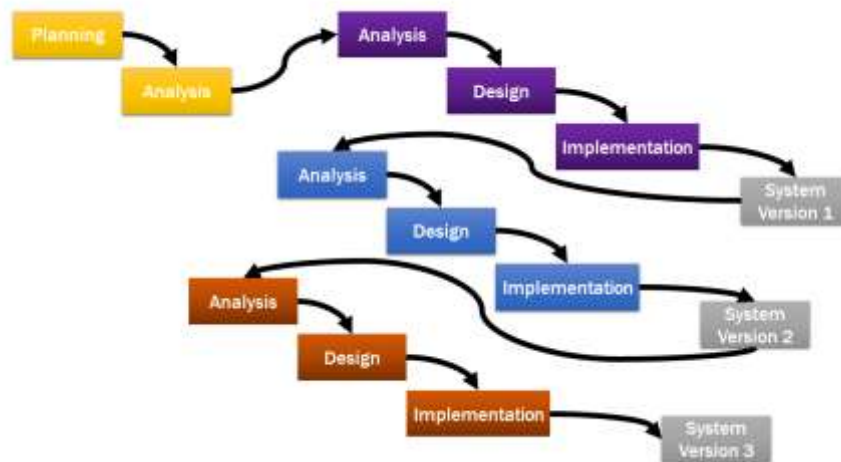
Figure 24 Work flow of phase development

From figure 8 we can easily image out that the process is where in each version, different things are added inside the project. The output for all the 3 versions is as shown below:

- *System version 1 (Room Scanning Feature)*
  Users manually add in corners of the room and a 2D room floor plan will be shown to the users for an easier insertion of furniture in the future. The corners added will can also create a plane so that furniture will not appear on the wall accidentally which makes the measurement more accurate.

- *System version 2 (Insert furniture in AR view)*

  Users are allowed to select the furniture that they would like to add into the room and insert them into the room in AR view. The furniture itself could be rotated and moved around in the room to the position where the users would like it to be at.

- *System version 3 (Interact between UI and AR)*

  Users are allowed to add rooms or houses into the application and have an AR environment for each of the rooms. Users could also select all the preferred furniture before showing the furniture in AR view. A furniture menu allows user to choose furniture easily as image explains everything.

4.1.2 Tools to use

4.1.2.1 Software

ARCore logo	**1. ARCore (Save furniture and corner placement)** - Google's platform that helps to build AR experiences with the usage of API. - It will track the position of the mobile device as it moves building its own understanding of the real world. - In this project, this software will be used to scan the room and showing the AR views of product.
unity logo	**2. Unity 3D (Develop the AR scene view)** - A cross-platform game engine development by the Unity Technologies. - Unity's real-time 3D development platform allows artists, designers and developers to work together in one project creating amazing immersive and interactive experiences. - In this project, this software will help in showing the 2D and 3D views during our user's designing progress which is the project's system version 2.
Sketchfab logo	**3. Sketchfab (getting free 3d furniture models)** - An online 3D modelling shop with rich categories - It has a large amount of interior design 3D models available for download. - In this project, this software provides 3D models of the furniture so that there is no needed of making 3D model by self which will save some time for other feature.
Flutter logo	**4. Flutter (designing user interface)** - Official integrated development environment for Google's Android operating system. - The UI and navigation for has more feature and more user friendly. - In this project, this software will be used for building the UI.

Table 2 Software Tools to use

4.1.2.2 Hardware

1.) Laptop

System Type	64-bit Operating System
Processor	Intel® Core™ i7-8750H CPU @ 2.20GHz
Graphics Processor	Intel® UHD Graphics 630
Graphics Card	NVIDIA GeForce GTX 1050 Ti
RAM	16 GB DDR4 2667MHz
Operating System	Microsoft Windows 10 version 1909

Table 3 Laptop Specifications

2.) Smartphone

Model	Galaxy A71
Processor	Android 10, One UI 2.1
Graphic Processor	Adreno 618
RAM	8GB
Storage	128GB
Rear Camera	Main: 64MP, f/1.8, 26mm (wide), 1/1.72", 0.8μm, PDAF Second: 12MP, f/2.2, 123º (ultrawide) Third: 5MP, f/2.4, (macro) Forth: 5MP, f/2.2, (depth)
Front Camera	32MP, f/2.2, 26mm (wide), ½.8", 0.8μm
Software Version	Android 10.0

Table 4 Smartphone Specifications

4.2   System Performance Definition

The accuracy of measurements will be increased to avoid some of the problems faced such as the furniture that were inserted was few millimetres above ground or the corners detected does not give a straight plane for inserting. The project should not have the problem of furniture showing up through the wall which makes it not realistic. The size of the room and the furniture should match well as it is not good to let user use it and shows a different result from the expected with the real.

4.3   Verification Plan

In the testing phase of this project, a test on comparison of the real-world furniture with the AR view furniture is compared to make sure the size meets the normal size in physical. The furniture should not be able to added intersect with other furniture or through the wall.

The furniture that are inserted into the application should always remain in the same place where it was last moved to instead of inserting the furniture every time the application is being closed. The distance calculated for the floor plane should be accurate.

4.4 Timeline

The project was planned to be done in within 21 weeks starting from 25th October 2020 to 17th April 2021. In this period of time, the first 8 weeks and the last 13 weeks will be used to implement the whole application.

The below table shows Gantt Chart of first part in the timeline. During these 8 weeks, 2 different applications are implemented which are the furniture placement application and the corner indication application.

Tasks	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8
Drawing out prototype	■							
Decide on which platform to use	■							
Work on Plane detection	■							
Work on Instantiate Object		■	■					
Work on add corner in AR view				■	■			
Work on positioning line between corners							■	
Work on calculating real world distance								■

Table 5 Gantt Chart of First Session

The following table shows the Gantt Chart of the second part of the timeline. The first 6 weeks the application is still being implemented separately, starting from week 7, both applications are being combined. Starting from week 8, all of the UI are slowly adding into the application itself. Lastly since week 11, the AR application is being combined with the UI application.

Tasks	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	week 13
Work on generate floor plane	■												
Work on limiting furniture's movement in floor			■										
Work on allowing individual furniture to move					■								
Work on cloud anchors							■						
Work on side menu for furniture inserting								■					
Work on project page										■			
Work on furniture menu											■		
Work on combining all scenes together												■	■

Table 6 Gantt Chart of Second Session

CHAPTER 5: IMPLEMENTATION AND TESTING

5.1 Room Scanning Feature

5.1.1 Implementation of Room Scanning Feature

In the room scanning feature of the application,5. it allows users to insert corners into the room environment right after plane detection is done. The users are recommended to plane detect the whole room only then start to insert corners as this helps the position to be more accurate. In the room scanning feature, point cloud were also added in order to mark each point so that the accuracy on positions will be more accurate.

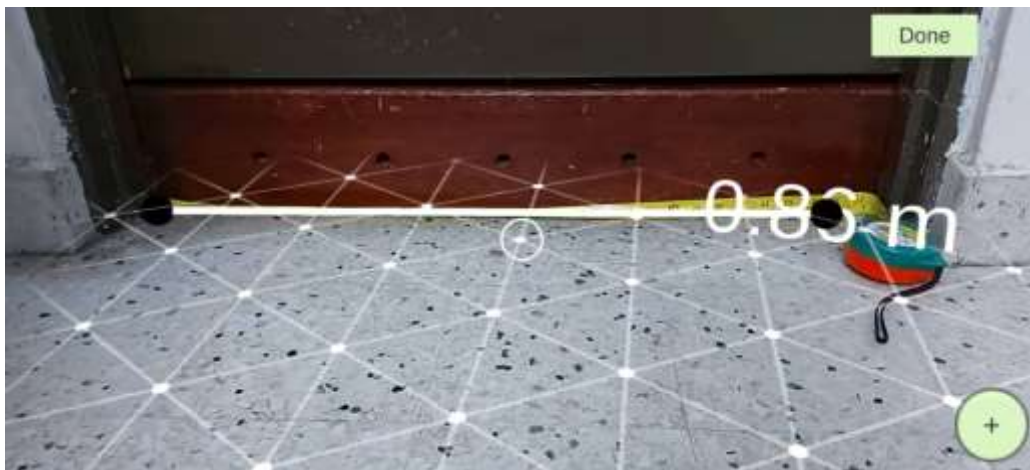The first implemented version for this feature in this application was as shown below:

Figure 25 Previous version of accuracy measurement

This version shows the accuracy of measurement; therefore, this calculation was used for the second updated version room scanning feature. However, the first version of room scanning feature was not user friendly as the centre indicator was always inaccurate and by moving the corner indicator was a difficult job unless it was in the centre of the screen.

Therefore, an updated version was implemented as shown below:

Figure 26 Updated Version Feature

In the updated version that was implemented, the centre indicator tends to appear as an AR view so that it is much easier for user to add the corners according to where the centre indicator went. The centre indicator will also control from not exiting the plane detected so that users will not add corners out of the detection. However, if users need to move the corner to a specific place where the plane detection was not detecting, users could simply use their finger to drag it to the place where its height will not exit the original inserted y position.

Apart from that, the new version also had improved by including with the colliders so that the centre indicator will change the colour of the first added corner when the whole room is connected. Moreover, a mesh which is the floor plane was created dynamically according to the corner placement of the users. This mesh itself contains a mesh collider so that furniture could place on it and will stay on it as collided.

An improvement on saving the corners using the Cloud Anchor from ARCore Extension which translates the real-world position of the corner into a string ID and it could be resolved during the next start-up.

5.1.2 Testing for Room Scanning Feature

During the testing phase of this feature, after corners were added to the scene and the distance between both corners are shown, we took the distance to compare with the real-world distance and the result is as shown below:

Figure 27 AR measurement of real-world object

Figure 28 Physical measurement of real-world object

As we can see from the result above, the accuracy for the application to achieve a correct measurement is possible.

The second test for the implementation of room scanning feature is the accuracy of the resolved corners if it will remain in the same position after exiting the application. The below shows the comparison of original mesh created floor plane which was created on the application start and the resolved mesh created floor plane.

Figure 29 Plane and points position before exiting application

Figure 30 Plane and points after exiting application

As we could see there wasn't much difference on it, therefore this function is working!

5.2 Insert Furniture in AR view

5.2.1 Implementation of Insert Furniture in AR view

In the previous version of inserting furniture in AR view, the application is only able to insert one furniture and could be rotated and drag along the plane as shown below:

Figure 31 Previous version of furniture insertion

However, in the new version, the furniture had improved in its scale where the size of the furniture suits the size of real-world needs. The new version also allows more furniture to be inserted and move along or rotate individually.

In this new version of insert furniture feature, users are able to select the furniture from the furniture menu as shown below which categories each type of furniture so that users could select them easily.
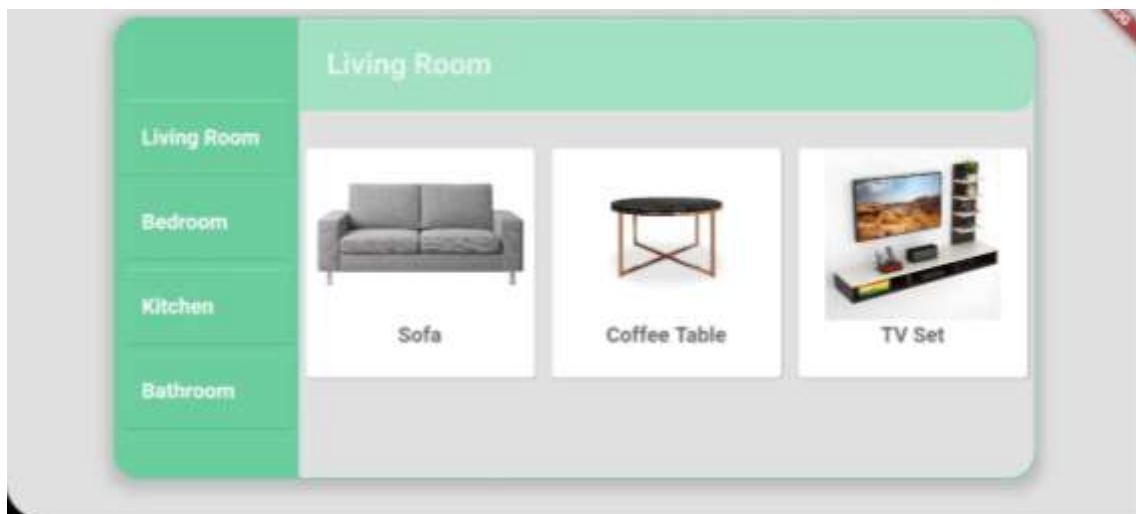

Figure 32 UI Furniture Menu Page

After user had selected all their desired furniture, they could head back to the room project page and enter to the room environment for adding furniture. The furniture selected will be shown as below in the room environment so that it is easier for the user to insert to the environment.

Figure 33 Furniture inserting page

From the left panel, user could click on the furniture that could like to add into the environment and tap on the screen to instantiate it. After all the furniture are added or the user think its enough for everything, user could just click on the save button so that the next the furniture could be resolved.

5.2.2 Testing Insert Furniture in AR view

In this feature, the most important thing to test is whether the furniture size matches the real-world size. The below is the comparison of the real-world bathroom washing sink and the bathroom washing sink in AR view.

Figure 34 Comparison between real-world furniture and AR world furniture

As we can from the image above, the size of the AR viewed furniture is acceptable as compare to the real-world.

Another test that was carried out is the collision test for furniture, as everyone know in real-world furniture should not be intersecting each other, therefore in the application the same will happen to the furniture. The furniture will not be intersecting each other, in fact, they will automatically set in with a place near to that point. The below shows that the furniture did not intersects each other.
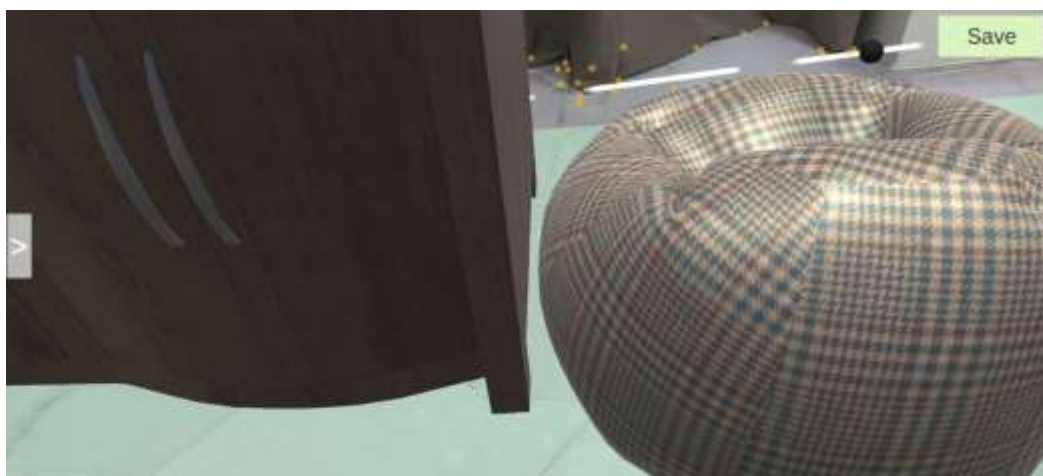

Figure 35 Furniture having collision will not intersect

5.3 Interact between UI and AR view

5.3.1 Implementation of Interact between UI and AR view

This is a newly implemented feature which helps users to manage their application that supports more rooms to create and also more furniture to choose.

What were included in this feature are the basic UI of the application such as creating a new room, creating a new house which have multiple rooms in it, multiple furniture which tells the price and some information of it so that user could choose wisely before adding into the environment.

This UI will save down all the furniture selected by the user for the respective room and save the name of these selected furniture in the user's local device storage. The reason this application stores file in local storage is because the application hopes that user could use the application as soon as they had downloaded it instead of the login or sign up flow which most of the time drag for at least few minutes.

5.3.2 Testing of Interact between UI and AR view

In this phase of implementation, the test of selecting furniture from UI page and from UI page navigate to the AR page. Since the UI page is build from Flutter application while AR view is built from Unity, there might be some issues changing platforms.

CHAPTER 6: CONCLUSION

All in all, the project is to allow users in household to have a better experience on meeting the new technologies and allowing them to in fact upgrade their house into a next level with the new technologies. Most of the housewife who rarely go out of the house might not meet the new technology in Information Technology, we should not leave them downgrading themselves in the world, therefore, we will need to let them keep in touch with these technologies. Since most of the housewife will spend plenty of their time on improving the house environment, this application will solve their problem and on the other hand teach them to be more familiar on the new technology. The project has a user-friendly interface where it is more suitable for those who do not need too many of specific performance which helps users to get used to it easily.

Apart from that, the existing application of AR furniture do help in showing the furniture in a way that it should be, however, they do not give a way that the users might need such as the users might like to get a list of furniture that they added into the environment and get the total price of it so that they could start keeping money for it. These AR furniture applications do not allow users to insert furniture room by room, they just allow u to look at it for the first time, as for the next time, you will need to choose again and place to the place again. Due to this, our project helps to perform it by separating all the furniture into rooms and also allow users to view it at the same place the next time so that they will not need to always place and adjust for the view.

Since nowadays people might not always around in the house and also they might be busy which cause them to be forgetful, this project allows tracking purpose to allow user schedule down the reaching day and time of the furniture into the project system so that the system will remind them before the arrival of their furniture, this could help them to prepare well before anything.

This project is mainly developed with Unity, AR Core and C# language. C# language is needed for writing scripts in Unity for some of the actions to be performed. AR Core SDK package was used for the plane detection and some of its functions in the package. In this project we had also added in Lean Touch for Unity which allows object position moving, scaling and rotating purpose.

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APPENDICES

POSTER

PLAGIARISM CHECK RESULT

Internal Design for Housing using AR

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Khong Lin Yan
ID Number(s)	17ACB00423
Programme / Course	Computer Science (CS)
Title of Final Year Project	Internal Design for Housing using AR

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

_____   _____
Signature of Supervisor   Signature of Co-Supervisor
Name: Ng Hui Fuang_____   Name: _____
Date: 16/4/2021_____   Date: _____

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