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AR based Measurement with Gesture Recognition

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Contents

List of Figures

Chapter 1

Project Outlines

1.1 Introduction

1.1.1 Augmented Reality Technology

Augmented reality is from the new terms that appeared recently, it is type from the virtual world that aims to enhance the Real world with virtual data that wasn't part of it.

Augmented reality is an interactive experience was created to improve the Sensory perception of the Real world the users see and interact with, by building a virtual system the simulates and supports the real world with virtual data, to deliver unified and enhanced vision to the users across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory.[1]

Figure 1.1: AR Technology

1.1.2 Uses of Augmented Reality Technology

Augmented reality can be used and implemented in many different aspects, as well as on many models to deliver rich audio and visual experience to the users. For example, but not limited to, we can use the Augmented reality in the education, Health Care, games, maps, measurements processes and so on.[2]

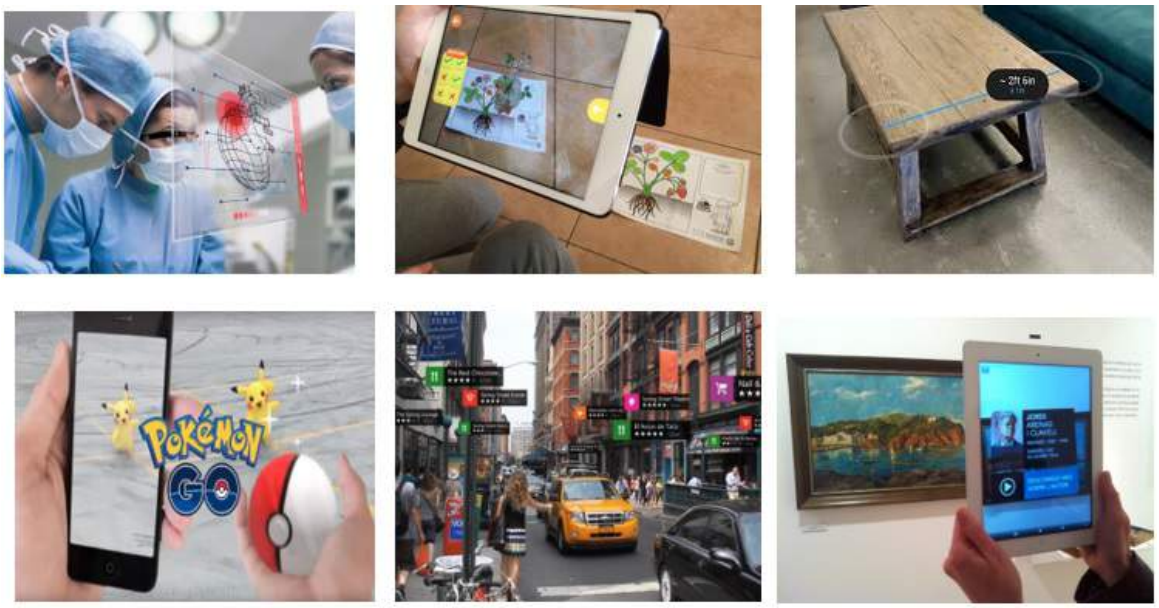


Figure 1.2: Uses of AR Technology

1.1.3 Application

Paper, pencil, and tape measure! you do not need to carry these with you anymore, whenever you want to measure, our project is going to replaces all these things we mentioned above, by giving you the power in your hand, the ability to measure the distance between any two points and the spaces anytime and anywhere by your phone Through the Augmented reality technology through dropping the 3D objects.
Furthermore, our application can be used by the blind since it provides several features that can help them in their movement in limited spaces.
By using the XCode environment Through ARkit Framework we are going to provide This

application to use it by your iPhones or iPads camera.

1.2 Problem statement

The problem has two aspects, the first one is related to the traditional method people use when they conduct any Measurement processes by using the tape measure and the pencil and paper which it is inaccurate, tired as well as restricted method for the users.
The second aspect is about the Blind people and how they encounter difficulties moving in environments with limited spaces.

1.3 Project Aims

At the End of this project, we aim to provide measurement application through Augmented reality technology. this application will allows the users to measure the length by measuring the distance between two points, as well as measuring the length and width (Areas), as well as enables the user to assign and save notes to each measurement process online and offline, in addition measuring the distance between the user's device and the Vertical or horizontal surfaces, which can used to assist the blind in several situations.

These various tools will extend the application's scope to be used in many various aspects and serving specifically two types of users, Anyone who want to conduct measurement processes to calculate the distance between two points or the spaces, in addition enables the user to assign notes to each measurement process As well as the blinds people in somehow, by measuring the distance between their devices and the vertical or horizontal surfaces in order to facilitate their movement and assist them by launching warning sounds whenever they become very close to the wall ,moreover, facilitate the interaction between the blind users and the application Interface.

1.4 Methodology

1.4.1 Software development life cycle

Software development life cycle (SDLC) is a series of phases that provide a common understanding of the software building process. How the software will be realized and developed from the business understanding and requirements elicitation phase to convert these business ideas and requirements into functions and features until its usage and operation to achieve the business needs.
Therefore, it may be required to choose the right SDLC model according to the specific concerns and requirements of the project to ensure its success.

You can think of SDLC models as tools that you can use to better deliver your software project. Therefore, knowing and understanding each model and when to use it, the advantages and disadvantages of each one is important to know which one is suitable for the project context.[3]

1.4.2 Agile Model

It is based on iterative and incremental development, where requirements and solutions evolve through collaboration between cross-functional teams.
It can be used with any type of the project, but it needs more engagement from the customer and to be interactive. Also, we can use it when the customer needs to have some functional requirement ready in less than three weeks and the requirements are not clear enough. This will enable more valuable and workable piece for software early which also increase the customer satisfaction.[4]

Advantages	Disadvantages
Decrease the time required to avail some system features. Face to face communication and continuous inputs from customer representative leaves no space for guesswork. The end result is the high-quality software in the least possible time duration and satisfied customer.	Scalability. The ability and collaboration of the customer to express user needs. Documentation is done at later stages. Reduce the usability of components. Needs special skills for the team.

Figure 1.3: Agile Model

1.4.3 Chosen Model (Agile Model)

The methodology we are going to use in building our project is called the Agile Model, we selected this methodology because it is the most appropriate model to our project.
We are going to use Agile Model because it focuses on the iteration of the development phases, in addition to it gives you space for the modifications and changes as well as it depends on the testing which will decrease error percentage, moreover that the testing activities will be concurrent with them unlike the waterfall methodology. satisfaction.

Figure 1.4: Agile Model

1.5 Project Plan

1.5.1 Clear Task Specification

Figure 1.5: Clear Task Specification

1.5.2 Task Duration - (Gantt Chart)

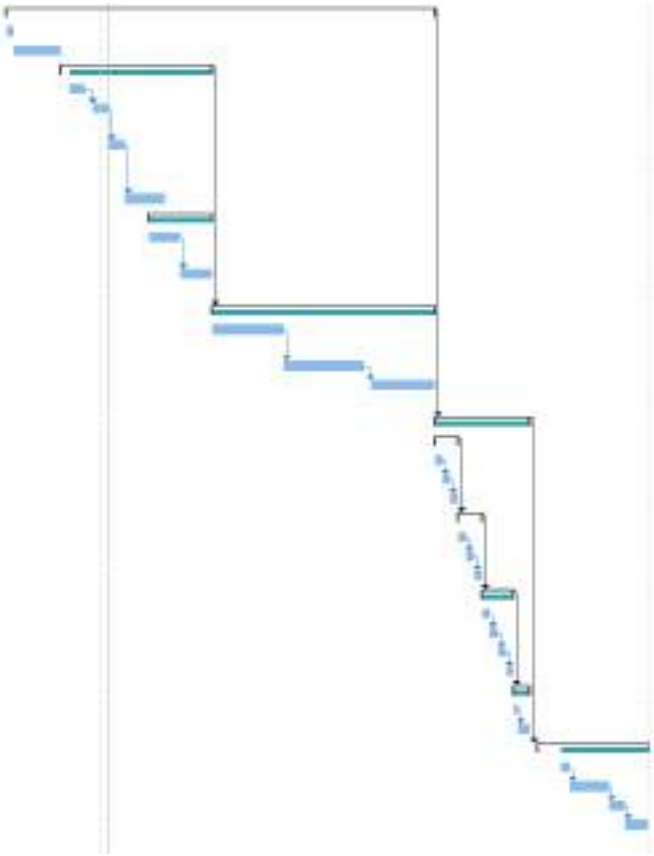


Figure 1.6: Gantt Chart

Chapter 2

Literature Review

2.1 Introduction

Since Augmented reality technology enhances the Real world with virtual data that wasn't part of it to deliver unified and enhanced vision to the users, it can be used and implemented in many different aspects, as well as on plenty of models. For example, but not limited to, the Augmented reality technology can be used in the education, Health Care, games, maps, measurements and so on...
And based on the difficulty the user encountering in the measurement's aspect, we decided to build measurement application through Augmented Reality Technology to make the user's life easier.
And Since there are already some related apps that provide to the user to measure through the Augmented reality, we are going to discuss these apps and analyze them to look where did they reach and stop? to continue the optimization process for an easier life.

2.2 Background and Overview and Analysis Of Related Work

2.2.1 Smart Meter - AR Application

Figure 2.1: Smart Meter 1

Figure 2.2: Smart Meter 2

- **Problem statement :**
  Measuring the distance between two points by the traditional way using the tape measure and pencil and paper is a tired and inaccurate way.

- **Problem analysis :**
  As we mentioned above that the tape measure and pencil and paper is a tired and inaccurate way to measure the lengths, we have to answer now Why is it tired and inaccurate way? Tired way, from the aspect of the user that he can not measure the lengths at any time in anywhere unless the tape measure, pencil and the paper with him. inaccurate way because the user movements may affect the measurement.

- **Problem solved :**
  Provide an application that enables the user to measure the distance between two points by using the Augmented reality technology that will solve the previous two issues we mentioned above.

- **Application,s Advantages, and disadvantages :**
  Three of the most important advantages that The application provided to the user are, Accuracy in measuring, Usability, and clarity. In addition to, that the application has some disadvantages and one of these disadvantages is that the application does not provide to the user measure the area, the app just measure The distance between two points when the user also need measuring the area , in addition to that there are some measurement units in the application does not work. from another perspective specifically from the user's aspect the competitive business climate today made the customers more power and less loyal, so the customers are looking forward the diversity of the services in any app and this app does not provide that, which we will Consider it as disadvantage thing.

2.2.2 Ruler AR- Camera Measure Tape

Figure 2.3: Ruler Ar1

Figure 2.4: Ruler Ar 2

- **Problem statement :**
  The users encounter difficulty's in measuring the Triangles and angles by the traditional way, in addition to measuring with various measurement units.

- **Problem analysis :**
  Most of the users agree on the difficulty of measuring the Triangles and angles by using the tape measure, and using the tape measure to measure these things will absolutely lead the user to inaccurate result mostly. in addition to, the user can not measure things with different units using one tape measure, which is also Considered as a problem that should be solved.

- **Problem solved :**
  Provide an application that enables the users to measure not only the distance between two points but also the triangles and angles by using the augmented reality technology, as well as providing various measurement units.

- **Application,s Advantages, and disadvantages :**
  The application provides a diversity of measurements such as the distance between two points and the triangles and angles, in addition to that it enables the user to measure things with different measurements units in an easy way, therefore all of these things Considered as advantages. about the other aspect, the most important disadvantages in this app are that the customer still can not measure the area as well as the three dimension,s objects, and the app also did not succeed to provide accurate measurements.

2.2.3 IOS 12 Apple measure app

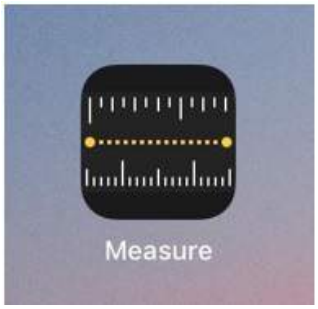
[5] 

Figure 2.5: Apple Measure

- **Problem statement :**
  You no longer must go searching for a tape measure while hanging pictures or when trying to determine if a couch will fit in your living room.

- **Problem analysis :**
  The traditional way of measuring things takes a lot of effort and time, and it is sometimes difficult to measure the panels hanging up above the ground, so how make it easy for you to measure two dimensions if the plate is high with the measuring tape? When you are outside, often the measuring tape will not be in your pocket, you will not be able to measure a piece of land or space.

- **Problem solved :**
  The measure is built into the iPhone with Apple's new iOS 12 operating system. It utilizes Apple's augmented reality framework, ARKit, to measure objects and spaces in the real world with the phone's camera. It can measure a piece of furniture or the distance between points, and there's also a level built in that makes it easy to ensure floating shelves or paintings are straight. The Measure app is only available on iOS 12, but it should work with any iPhone or iPad running iOS 11 in the future.

2

- **Application,s Advantages, and disadvantages :**
  The application provides several advantages such as accuracy in measurement, the error rate during the measurement is very small, and also the Usability, you will not find it difficult or complicated in the use of the program during measurement. Also, there are some disadvantages in the program such as a few measurement units, that it provides only two units, and you can not measure with three-dimensional, that you can not measure the length and width and height, in addition to it is only works on IOS12.

2.2.4 EasyMeasure

[6]

Figure 2.6: EasyMeasure1

Figure 2.7: EasyMeasure2

- **Problem statement :**
  It is difficult to measure the height of buildings and measure the distance between you and the other side of the lake in the traditional way.

- **Problem analysis :**
  To measure the buildings, you need to measure tape is too large and it is the almost impossible task, there is no way to measure them. Also, you can not measure the distance between you and anything else, such as measuring the distance between you and the TV or measuring the distance between you and the boat on the sea.

- **Problem solved :**
  EasyMeasure shows you the distance to objects seen through the camera lens of your iPhone, iPad or Android device. And Find out how far it is towards that boat on the other side of the lake. Measure how tall buildings are. Use the app as a golf-aid. Measure your friend's height and width. The possibilities are endless.

- **Application,s Advantages, and disadvantages :**
  The program provides an easy user-friendly interface for all users to deal with the application without difficulties and complications, and the application provides the user with many units of measurement without going back to sites and applications conversion units. The disadvantages of the application are that you can not measure with three dimensions, you can not measure all dimensions of the building, and also sometimes there is not enough accuracy during the measurement, it is possible that the measurement is wrong.

2.2.5 PLNAR

[7]

Figure 2.8: PLNAR

- **Problem statement :**
  People encounter difficulties in measuring the rooms and its components.

- **Problem analysis :**
  taking all the room measurements by the traditional way by using the tape measure requires long time and it's an arduous process for the users since they have to measure each component separately, and finally they have to collect their measurements to get the final result.

- **Problem solved :**
  The PLNAR App measures and creates 3D models of rooms in real-time using the latest in AR technology. Simply outline and optionally take a few photos of your space / room and PLNAR will generate a picture-packed PRO Report, an interactive 3D model, and ready-to-export CAD files. All output is saved to our PLNAR Portal for easy access and sharing

  4

- **Application,s Advantages, and disadvantages :**
  The most important advantages in Plnar App that it is enables the user to measure all the room components , such as the walls, roof, Mirrors and so on, as well as it builds a separate database file for each room contain it's components. In addition to, it creat for the user 2D and 3D room plans. From the disadvatage's aspects, it does not provide to the user measure all the objects, it just measure the rooms, it has difficulty in use.

2.3 Critical Analysis

Application	Advantages	Disadvantages
Smart Meter – AR Application	Accuracy in measuring, Usability, Clarity	Can't measure the area, doesn't provide various measurement units, doesn't provide diversity of services
Ruler AR – Camera Measure Tape	diversity of measurements, Usability, provide various measurement units	Can't measure the area & three dimensions, inaccurate measurements
IOS 12 Apple measure app	accuracy in measurement, Usability	Has a few measurement units, can't measure three dimensions
Easy Measure	Easy user-friendly interface, provide many units of measurement	can't measure three dimensions, sometimes there is not enough accuracy
PLNAR	measure all the room components, make a separate database file for each room that contains its components	Can't measure all the objects, difficulty in use

Figure 2.9: Critical Analysis

2.3.1 Discussion

We will discuss what we are going to provide to the user based on many aspects, from the aspect of the measurement tools and from the aspects of the usability and from the aspect of the competitive business climate.
From the aspect of the measurement tools, we are going to provide the ability to the user measure the distance between any two points, the spaces and the distance between his phone and the wall.
From the usability aspect we are going to facilitate the interaction between the user and the interface by using gesture recognition in some situations. in addition, build clear, resilient and simple interface.
From the aspect of the competitive business climate, today the customer become more power and less loyal and always looking forward diversity of services, therefore our competitive advantage will be that we will not enable the users only measure the distance between any two points, or calculate room space but also we are going to enable them to measure the distance between their devices and the walls after detecting the vertical and the horizontal surfaces, this function might serve blind people in some situation associated to their movement.
Furthermore, we are going to provide offline and online Database to the users to store the measurement results and add some notes to it. as well as enable them in some situation to interact with the interface with their hands.

2.4 Conclusion

After we analysed related applications the vision became clear to us, based on that we hope that our solution will meets the users' desires and requirements. Our solution will Enables the users to measure the distance between two points, the spaces, and measure the distance between their devices and the walls after detecting the vertical and the horizontal surfaces, this function might serve blind people in some situation associated to their movement. through Augmented reality technology in a way that will improve the quality of the measurement processes and make the user life easy.

Moreover, we are going to provide offline and online Database to the users to store the measurement results and add some notes to it, as well as enable them in some situation to interact with the interface with their hands.

Chapter 3

Analysis

3.1 Introduction

During the analysis phase we will start in collecting data through conducting a questionnaire then we will list all the functional requirements and Non-functional requirements and External interface requirements then we will refer our potential user as well as answer the questions, whom will use our system? why will they use it? Where it can be used? Then we will clarify how will user interact with our System by writing scenarios. All the tasks we referred to above are critical to the success of the project, as well as it plays an important role in the software development process. [8]

3.2 Data collection

In the collecting data phase, we selected questionnaire method, because it is flexible and easy method to collect the data, as well as it has the propagation property on a large segment of society members in short time as well as it is inexpensive method. We used web-based questionnaires rather than printed questionnaires and We distributed the questionnaire to gather particular information from the users, and we got many answers, the number of responses reached 382.

3.2.1 Questionnaire

Here we will show all the questions listed in the questionnaire and we will clarify the significance of each question, as well as we will show the results we got through texts and graphs.

Question1:

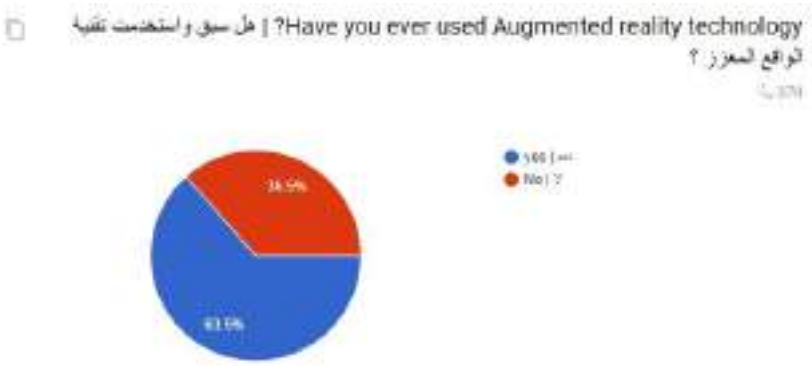


Figure 3.1: Question 1

We started the questionnaire by asking whether the user has used the Augmented reality technology, or he has an experience in using it. We found that more than half of the participants have used the augmented reality technology as shown below in the graph:

Question2:

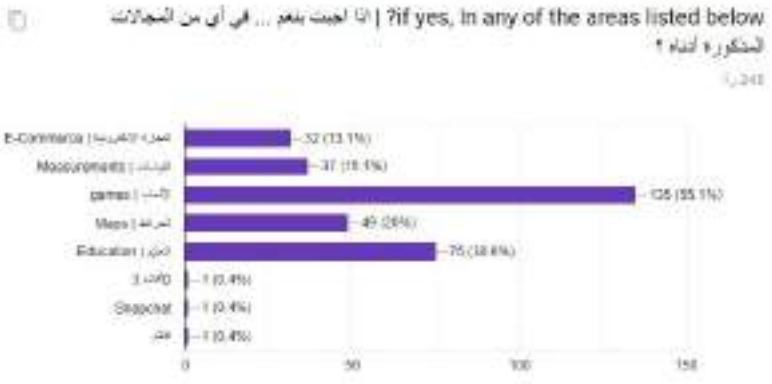


Figure 3.2: Question 2

If the participant answered the previous question with yes, he has to answer this question by mention which Augmented reality's field he has used in the field we listed below, to know which field is most used in Augmented reality, as shown below in the graph:

Question3:

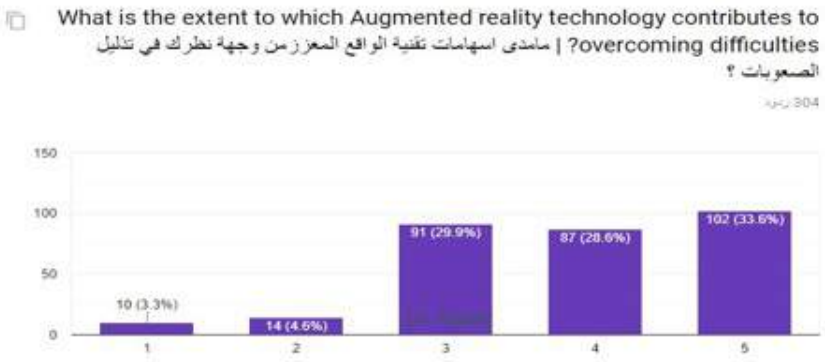


Figure 3.3: Question 3

Through this question We may know the society's idea of the augmented reality technology, and what the extent to which Augmented reality contributes to overcoming the difficulties from their opinion. We have set a range to indicate whether the contribution is great or little as shown below:

Question4:

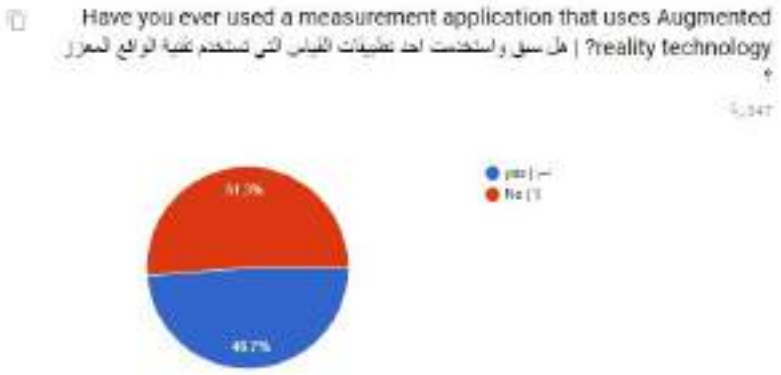


Figure 3.4: Question 4

Here we asked the participants, whether have they used the measurement applications over augmented reality technology previously? and We found that more than half of them have

used it, the picture below shows that:

Question5:

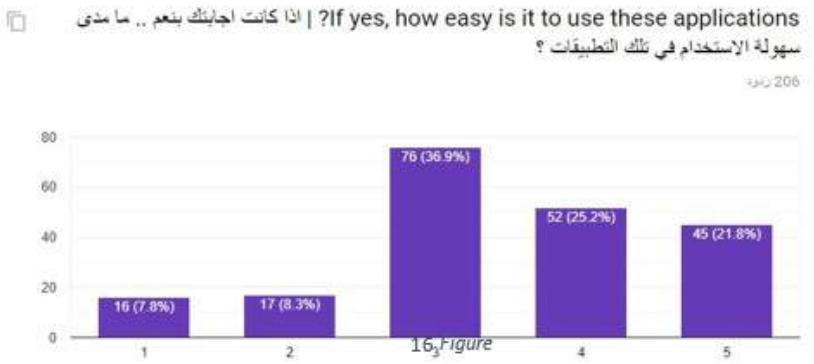


Figure 3.5: Question 5

15 Figure If the participant answered with yes in the previous question, this question to see how easy it was to use those applications. We expressed it with a range of 1 (difficult to use) to 5 (easy to use.) The average of Usability was about 3, as shown below:

Question6:

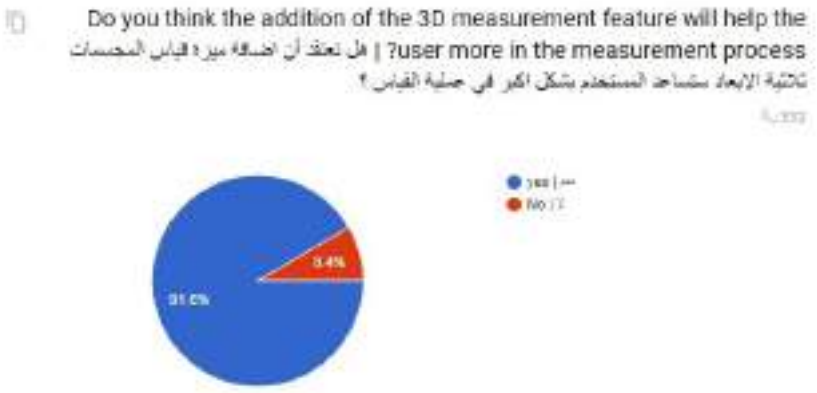


Figure 3.6: Question 6

Here we asked the participants, do they think the addition of the 3D measurement feature will help the user more in the measurement process? The majority agreed that adding 3D measurement feature will be very helpful in measurement process, with a positive response rate of 91.6%, and the percentage of participants who answered (No) only 8.4%, As shown below :

Question7:

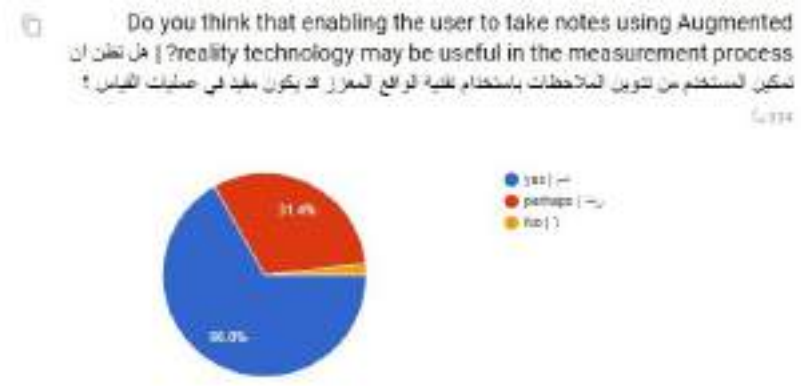


Figure 3.7: Question 7

According to the participants answers, enabling the user to add some notes during the measurement is an excellent advantage to be added in the field of measurement through the

augmented reality. The answer rate (yes) is 66.8% and the answer (perhaps) is 31.4%The rate of response (No) was very small, as shown below:

Question8:

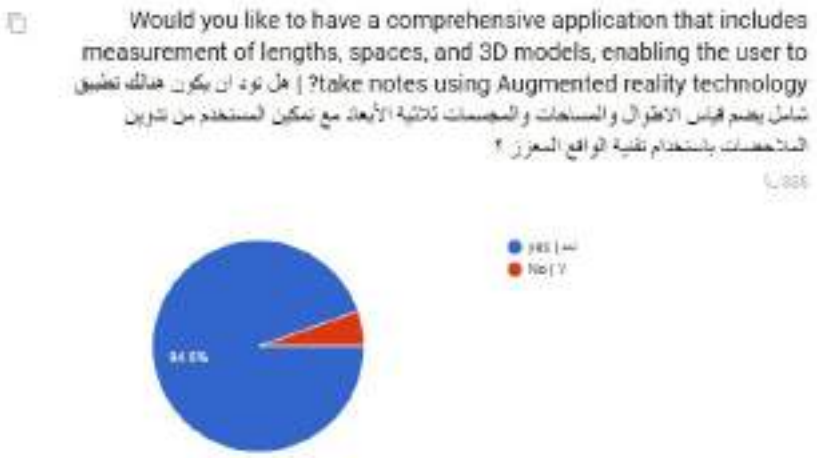


Figure 3.8: Question 8

We found that most participants would like to have a comprehensive application that includes measurement of the lengths, spaces, and 3D models, and in addition to, prefer to take notes, this encourages us to develop an application like this.

3.2.2 Conclusion

After reviewing the questionnaire and gathering users' answers, the vision became clear to us, about the user's wishes and preferences, which is comply with what are we going to provide.

3.3 Requirement Specification

3.3.1 Functional requirement

- Enable the user to measure the distance between two points.
- The user will be capable to detect the vertical and the horizontal surfaces by his phone.
- The user should be able to measure the distance between his phone and any wall.
- Enable the user to store the measurement details and add some notes associated to it online and offline.
- The user should be able to cancel the measurement processes.
- The user should be able to measure the area (length, width).
- The user should interact with the interface by his hand in some situations through the Machine Learning, gesture recognition technology.
- Enable the user to reset the measurement processes.
- The user should be able to turn on the Flashlight.
- The user should be capable to drop 3D object and retrieval in order to save it offline.
- Sing up and log in.
- The user should receive warning sounds if he became very close to the wall, in the wall function, after detecting vertical or horizontal surfaces and calculating the distance

3.3.2 Non-functional requirements

- Reliability
  All information the user will get from the application should be true and comply to highest quality standards
- Performance
  Augmented reality requires high performance capabilities which may affect to user's phone in a negative way, therefore we have to develop our system in a manner that won't affect to the phone's performance, at the same time all system's actions should response fast to achieve User's Satisfaction.

- Usability
  All system's functions should be clear and suitable for all user's categories to deal with it, as well as The User should be able to interact with all System's functions easily without need any help or guidelines book.

- Maintainability
  Our system should be designed to be flexible to adapt with any changes and improvements in future.

- Scalability
  Our system should be designed in a flexible way to fit with the increment of the users, as well as to adapt with all changes of user requirements in the future for adding any features.

- Availability
  The system should be available for the user to use all time since he downloaded.

3.3.3 External interface requirements

- Hardware requirement

  - Computer device
    MacBook device.
  - Smart Phone
    Apple Smartphone that support the Augmented reality technology.
  - High Performance Hardware
    That has strong processor Because ARKit runs on the Apple A9, A10, and A11 processors.
  - Camera
    Strong cameras to improve the quality of picture to get high Resolution in the application.
  - Sensor
    Sensors in smartphone (accelerometer, gyroscope) to detect the user's movements.

- Software requirement

  - Operating System
    IOS version 10.14.
  - XCode version 10.0
    Is an integrated development environment (IDE) for macOS containing a suite of software Development tools developed by Apple for developing software for macOS.
  - Azure Custom vision From
    Azure Custom Vision is a cognitive service that lets you build, deploy and improve your own image classifiers. An image classifier is an AI service that applies labels (which represent classes) to images, according to their visual characteristics. Unlike the Computer Vision service, Custom Vision allows you to determine the labels to apply.
    The Custom Vision service enables the developer to use a machine learning algorithm to apply labels to images.
  - Preview
    Preview is the image viewer and PDF viewer of the macOS operating system; it enables users to view and print digital images and Portable Document Format (PDF) files. Preview uses Apple's implementation of the PDF specification, the Aqua graphical user interface, the Quartz graphics layer, and the Image IO and Core Image frameworks.
  - Core ML (Machine Learning
    Core ML is the foundation for domain-specific frameworks and functionality. Core ML supports Vision for image analysis, Natural Language for natural language processing, and GameplayKit for evaluating learned decision trees. Core ML itself builds on top of low-level primitives like Accelerate and BNNS, as well as Metal Performance Shaders.
    We use Core ML to Integrate machine learning models into our app
  - ARKIt
    Is a modern framework that enables the developers to deal with the Augmented reality technology to build amazing applications through it.
  - Swift language
    Swift is a language developed by apple to write software in Apple IOS.

  - Google Firebase (Database)
    Firebase is a Back end-as-a-Service that started as a YC11 startup and grew up into a next-generation app-development platform on Google Cloud Platform.
  - LaTeX
    LaTeX is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation.

- User interface requirement

  1. The AR camera will be on in all pages
  2. There will be a dropdown menu to enable the user to choose which page
  3. There will be a button to enable the user to store his information.
  4. There will be a button to enable the user to cancel the processes.
  5. 3D object will be appeared when the user clicks on the three dimensions option.
  6. The user will interact with system by touch the screen to create points when he measures the length as well as the area
  7. The system will shows the measurement's result above the object.
  8. The user will interact with system by his hand in some situations.

3.4 User Profile

3.4.1 User categories

- **Normal User:** We target engineers, workers and those interested in taking dimensional measurements.
- **Blind User:** provided some solution that could help the blind people in situation that associated with their movement.

- **Admin:** Who is responsible for controlling the system, repairing some of the bugs in the application and responsible for database.

3.4.2 User characteristics

Age	18 – 30 years old.
Gender	70% Male
Computer skills	mostly average
Interested in technology	mostly average
Education level	High school or more

Figure 3.9: User characteristics

3.4.3 Environment

Our system is not restricted to a particular environment, it can be applied on many environments serving many people such as, engineers, workers in furniture store, or anyone want to measure an existing object as well as the blind people in some situation that associated with their movement.

3.5 Structuring System Requirements

3.5.1 Scenario (Normal User)

Bander wants to take measurement of the space of the room. He opened the application after he logging in to the system, then he chose measure by area from the menu, the application drop the Grid to him after he clicked the option by using augmented reality technology, then he attempts to fit the grid with size of the room, then the result will appear above the grid to him.

3.5.2 Scenario (Admin)

Faisal is the admin of the system, He opened the application after he log in to the system, to check if the function measure the area is work well or not, so he clicked on the menu, then he selected measure the area then the application called the function to enable him to measure the area , then he started measuring by touch the screen to create 4 points , then after he finished the measuring, text label appeared to show the result to him, then he checked that the measurements is correct and everything is well.

3.6 Storyboard

3.6.1 Blind people (The wall detecting function)

Figure 3.10: Blind people (Storyboard)

3.6.2 Measure the room space

Figure 3.11: Area (Storyboard)

3.6.3 Adding notes to the measurement result

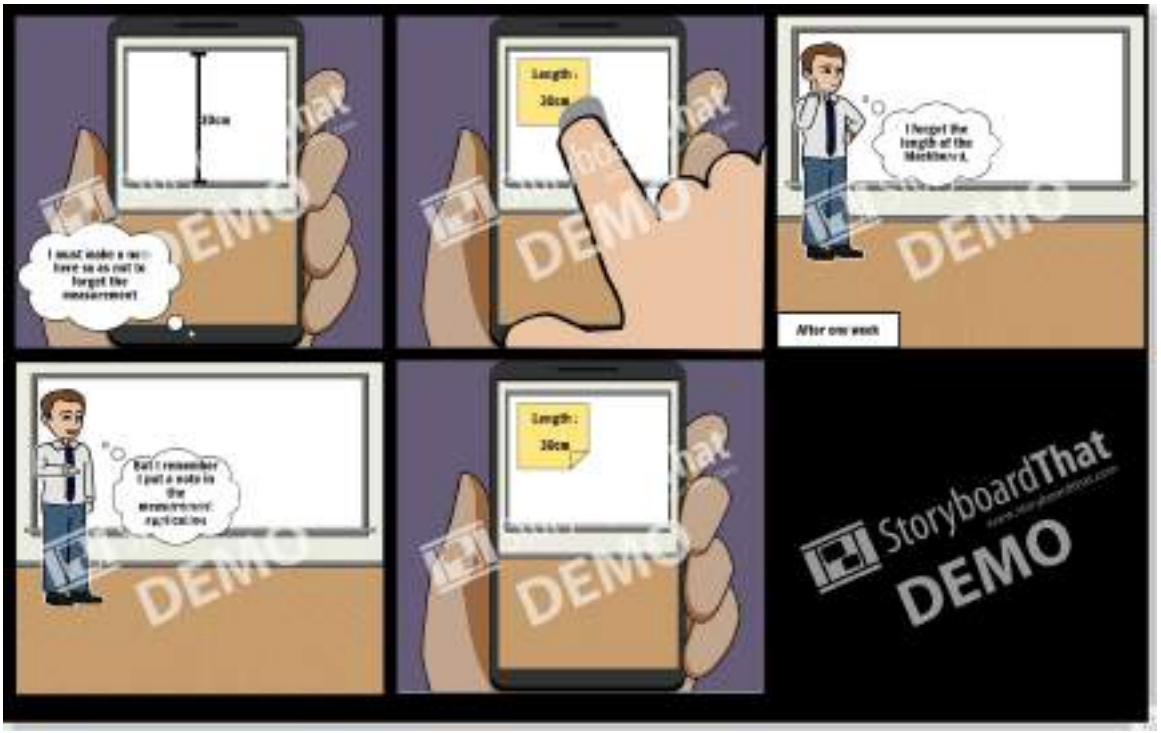


Figure 3.12: Adding Note (Storyboard)

Chapter 4

Design

4.0.1 Use Case Diagram

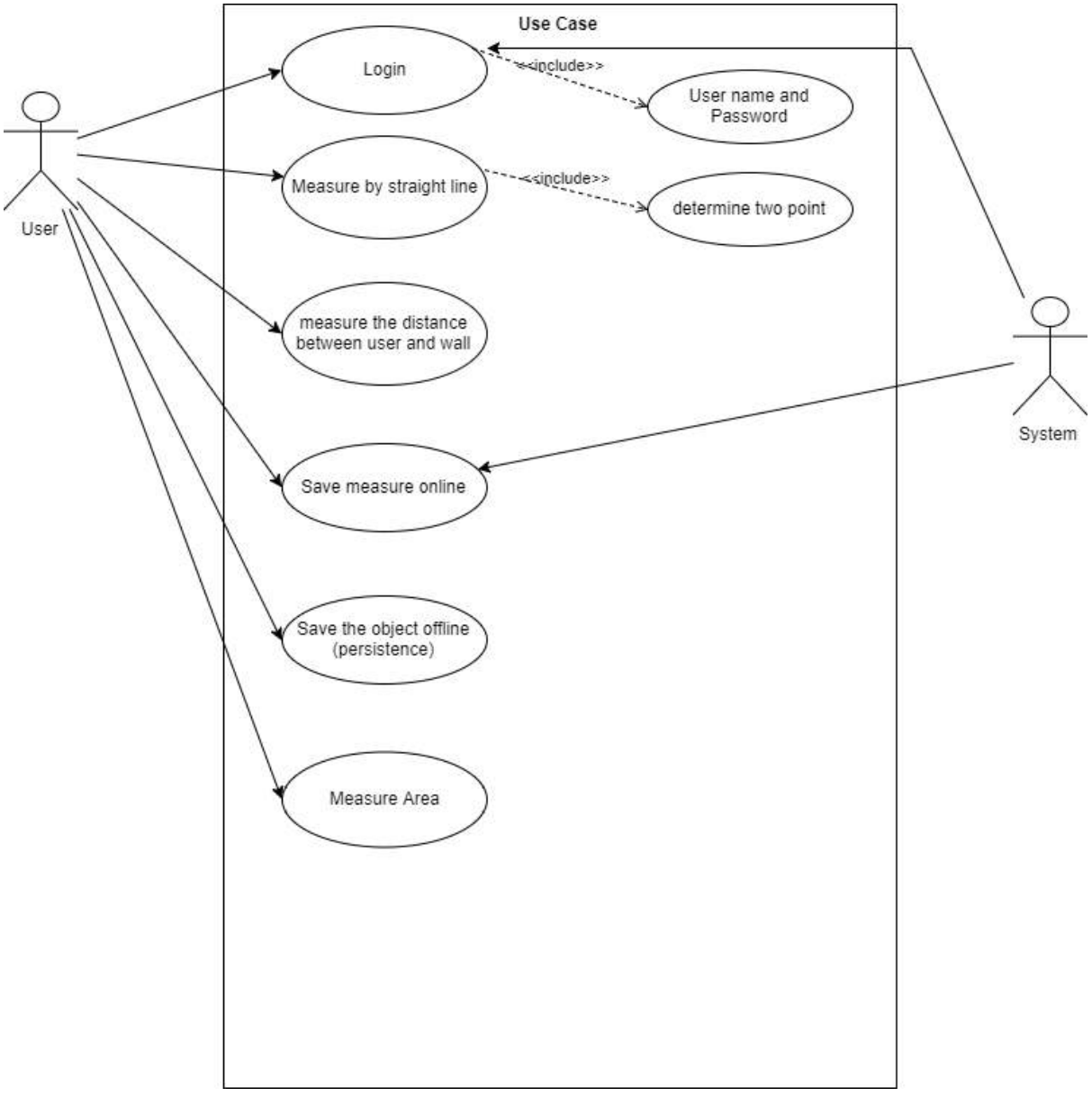


Figure 4.1: Use Case Diagram

4.0.2 Sequence Diagram (line)

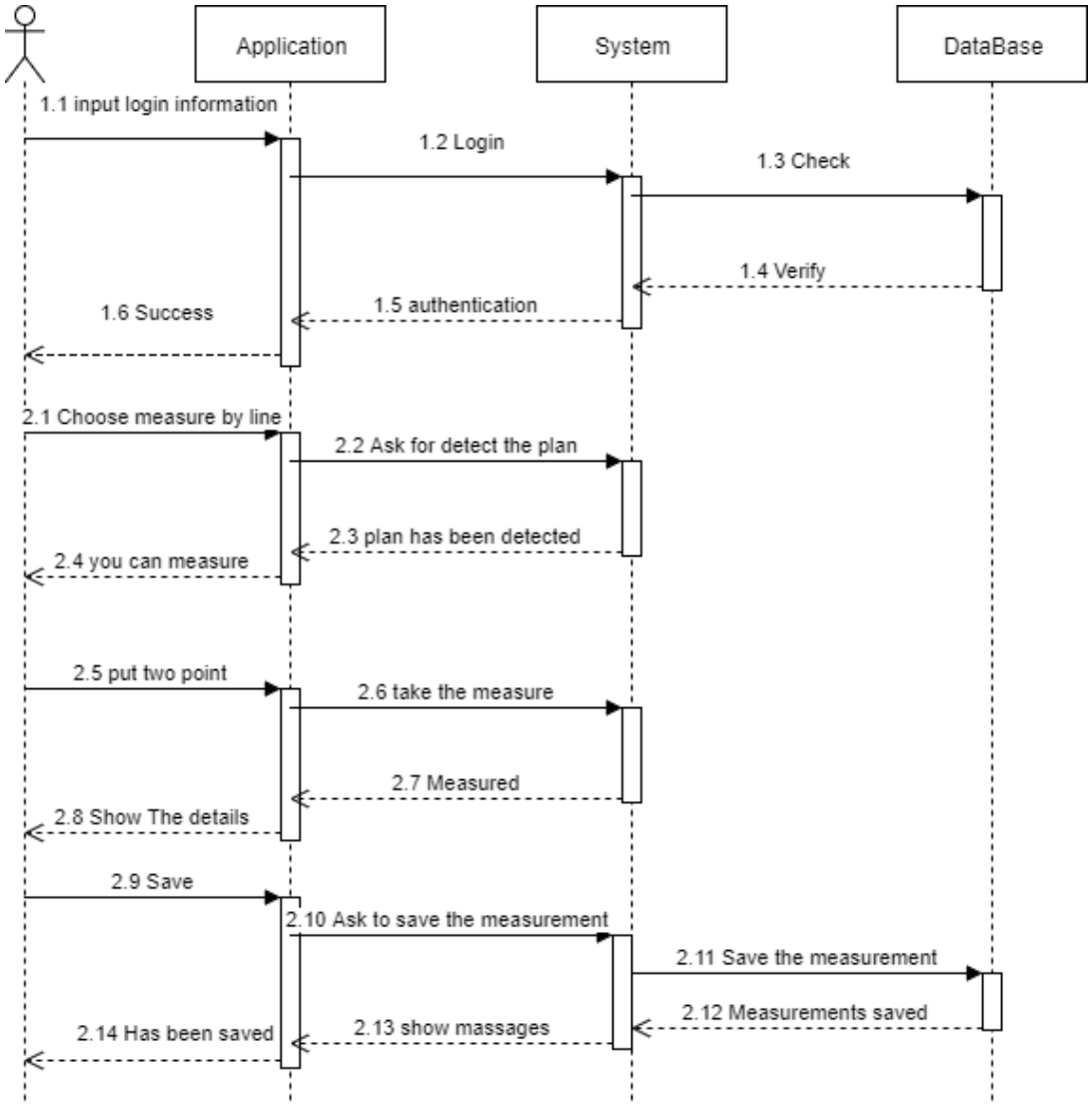


Figure 4.2: Sequence Diagram (line)

4.0.3 Sequence Diagram (Area)

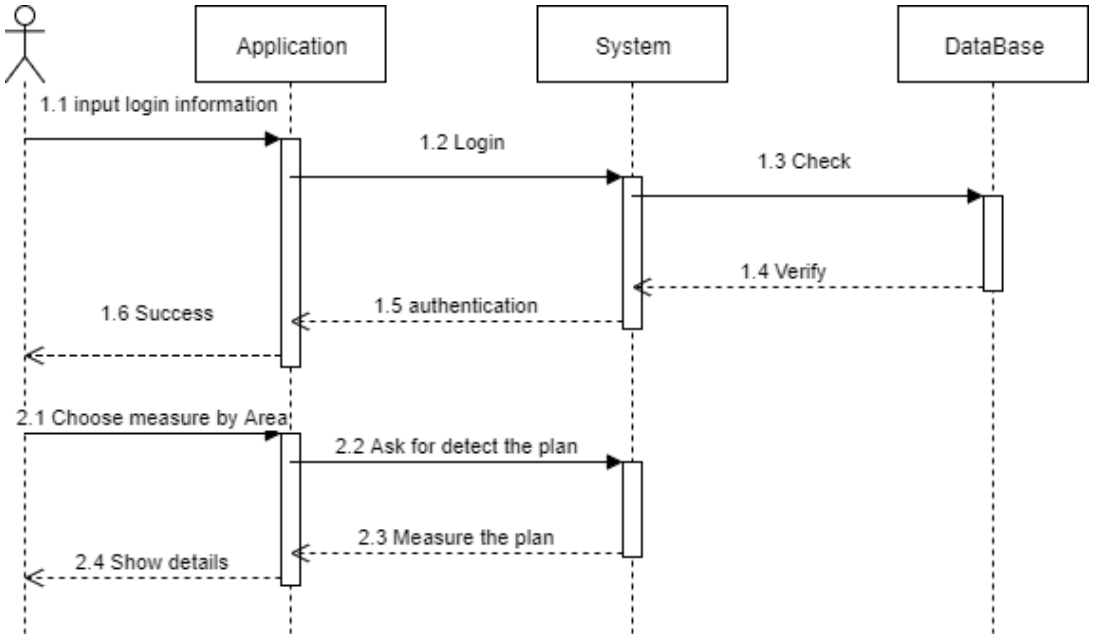


Figure 4.3: Sequence Diagram (Area)

4.0.4 Class Diagram

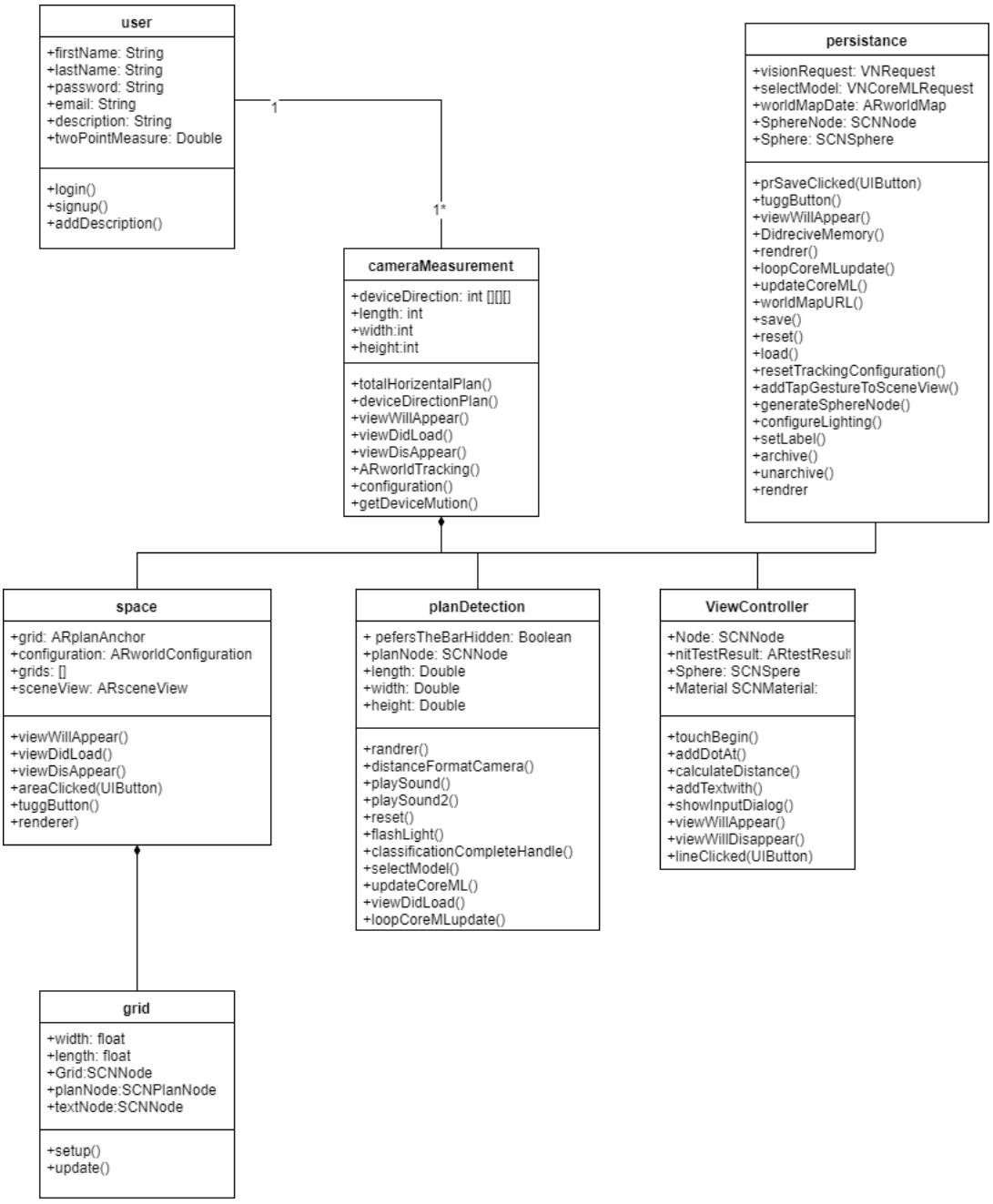


Figure 4.4: Class Diagram

We have in our system 7 classes each class represent a component and all components will interact with each other to make the system work. First class will start implemented once the user open the system is the (Camera Measurement Class) it's a parent class that has many subclasses such as viewController class, persistence Class , space Class, the Camera measurement class has 4 attributes and many functions and its responsible for starting the camera to calculate the device direction by calculating the three dimensions Length, width, and height and getting the device motion then detecting the horizontal plan to enable the subclasses to work. viewCotroller Class, space Class, planDetection and persistence class are subclasses from the Camera.
grid class is a subclass from the space, its for drop the object (Grid) to measure by space.
user class Measurement Class and has composition relationship with it, each class of them inherits the attributes and the functions of the parent class, to work and apply it's required mission.
The User Class has the user Attributes and function as shown in the Class diagram and has a relationship with the camera measurement class (1...1*) which is responsible for displaying the final result as well as the user's Information.

4.0.5 Entity Relationship Diagram

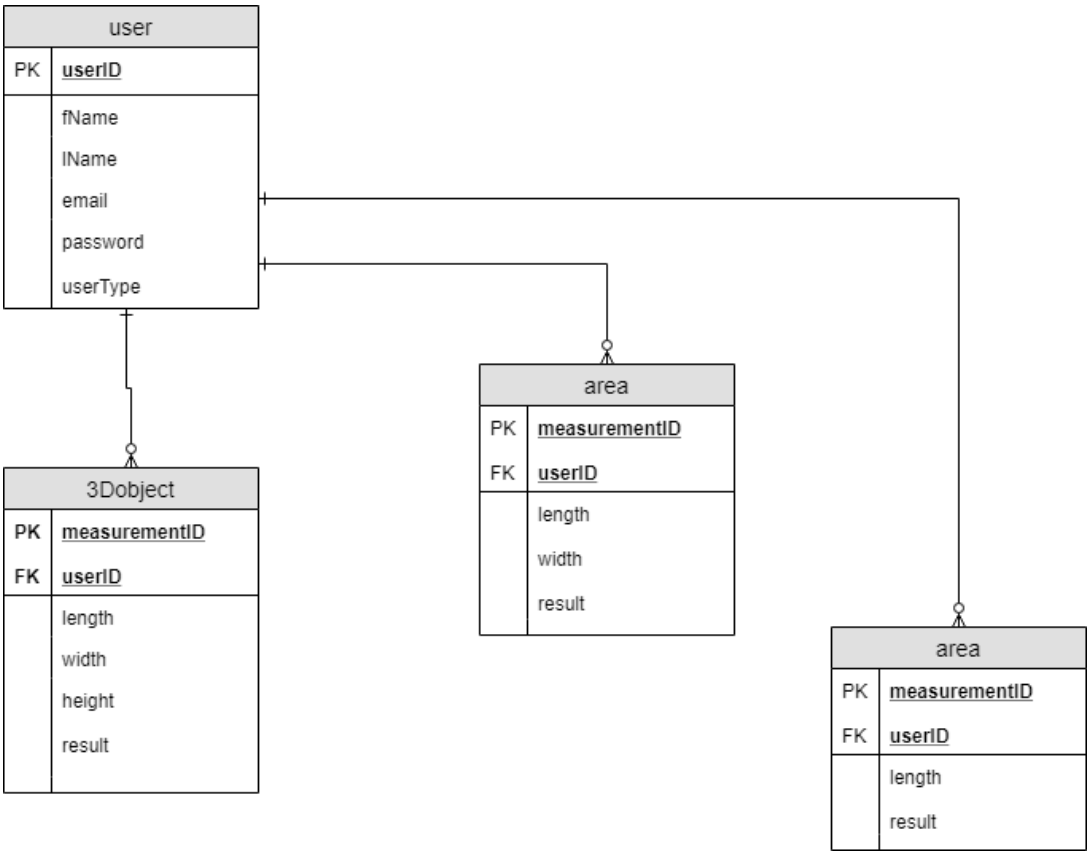


Figure 4.5: Entity Relationship Diagram (ERD)

In the ERD Diagram we have four tables, the user table which contains the user ID as a primary key and all the user Information, and the 3D object table which has the user ID as foreign key and the measurement ID as a primary key and its information and result, the relationship between them is (1...0*) and it is the same for the other tables with the user. The relationships between the user table and the three other tables explain that one user it could take many measurements, or not, represented in this relationship (1...0*).

4.0.6 interface design (Sign in page)

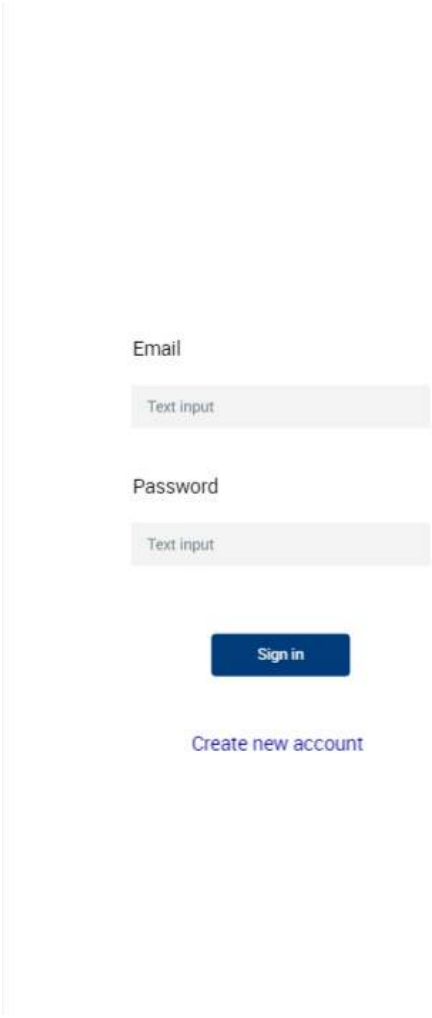


Figure 4.6: interface design (Sign in)

4.0.7 interface design (Sign up page)

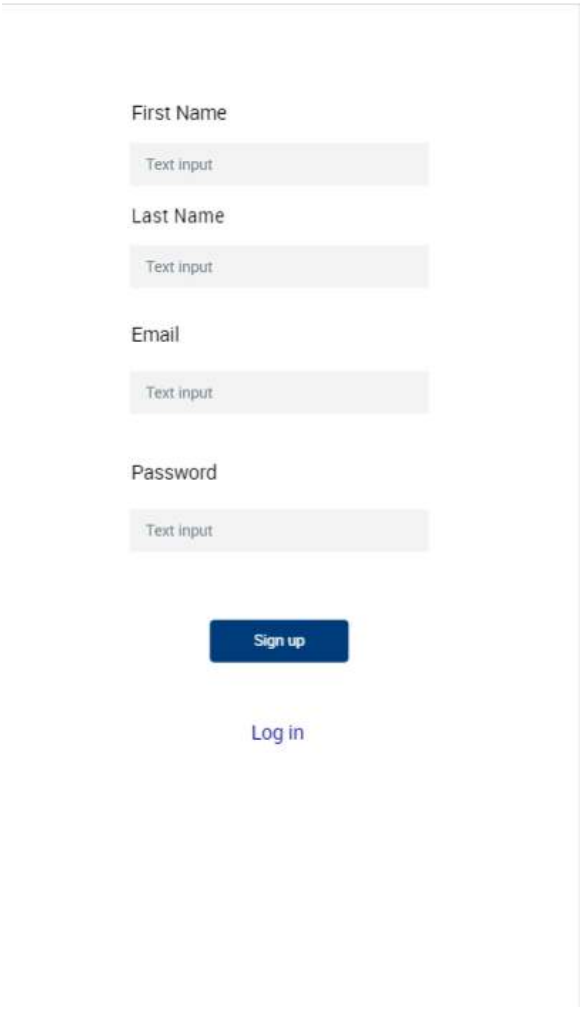


Figure 4.7: interface design (Sign up)

4.0.8 interface design (Sign up page)

Figure 4.8: interface design (Sign up)

Chapter 5

Implementation

5.1 Tools

5.1.1 XCode

Figure 5.1: XCode

Xcode is an environment provided by Apple, to develop IOS application using swift language, it has multiple tools such as ARkit and other environments inside it, we have used ARkit to build our application, it's environment for developing Augmented reality applications.

5.1.2 ARKit

Figure 5.2: ARKIT

Is a modern framework that enables the developers to deal with the Augmented reality technology to build amazing applications through it.

5.1.3 Google Firebase

Figure 5.3: Firebase

Fire base is a web service provided by Google, it delivers variety of services, such as local free Databases, besides real integrated databases with IOS and Android applications, in addition to it also delivers API service.

From another perspective it also provides to the developers the ability to log in by various methods, based on all these characteristics we decided to utilize it in our system.

5.1.4 Azure Custom Vision

Figure 5.4: Azure Custom Vision

Azure Custom Vision is a cognitive service that lets you build, deploy and improve your own image classifiers. An image classifier is an AI service that applies labels (which represent classes) to images, according to their visual characteristics. Unlike the Computer Vision service, Custom Vision allows you to determine the labels to apply.
The Custom Vision service enables the developer to use a machine learning algorithm to apply labels to images.[9]

5.1.5 Core ML (Machine Learning)

Figure 5.5: CoreML

Core ML is the foundation for domain-specific frameworks and functionality. Core ML supports Vision for image analysis, Natural Language for natural language processing, and GameplayKit for evaluating learned decision trees.
Core ML itself builds on top of low-level primitives like Accelerate and BNNS, as well as Metal Performance Shaders.
We used Core ML to Integrate the machine learning models into our app.

5.1.6 Preview

Figure 5.6: Preview

Preview is the image viewer and PDF viewer of the macOS operating system; it enables users to view and print digital images and Portable Document Format (PDF) files. Preview uses Apple's implementation of the PDF specification, the Aqua graphical user interface, the Quartz graphics layer, and the Image IO and Core Image frameworks.

5.2 Walkthrough the System

5.2.1 Google Firebase

Figure 5.7: Firebase

We used Google Firebase Database to enable the users to store their personal details as well as the measurement processes results.
We built sign up and Log in pages, in addition we provided a page that shows the last measurement process the user did as well as any description the user has been added.
The pictures below demonstrate what we did by some examples.

Figure 5.8: Firebase

Figure 5.9: Firebase,Database

5.2.2 Azure Custom Vision

Figure 5.10: Azure

Figure 5.11: Detect Hand

We utilized Azure Custom vision to train a Model to recognize the gestures to facilitate the interaction that will occurs between the users and the interface in some situations.
As shown on this picture, we have used Classification techniques, ANN classifier as well as we have defined two classes, OpenHand Class and NoHand Class and we downloaded various pictures to each class after following the rules that governs it and applying best practices to achieve accuracy in the result as much as possible.[10]

As demonstrated below, after we trained the model several times, we decided to measure the accuracy since the custom vision provides some model to estimate the accuracy, we used one of these Model Called the Confusion Matrix.
Confusion Matrix is estimation accuracy model for the classification techniques.

Confusion Matrix		PREDICTED PATTERNS	
		SI	NO
ACTUAL PATTERNS	SI	**True Positives** (some patterns)	**False Negatives** (some patterns)
	NO	**False Positives** (some patterns)	**True Negatives** (some patterns)

$$precision = \frac{|TP|}{|TP| + |FP|}$$

$$recall = \frac{|TP|}{|TP| + |FN|}$$

$$F_1 = \frac{2 * recall * precision}{} = \frac{2|TP|}{}$$

Figure 5.12: Confusion Matrix

The screenshots below show the results of the (Precision + Recall + AP) of our Model.

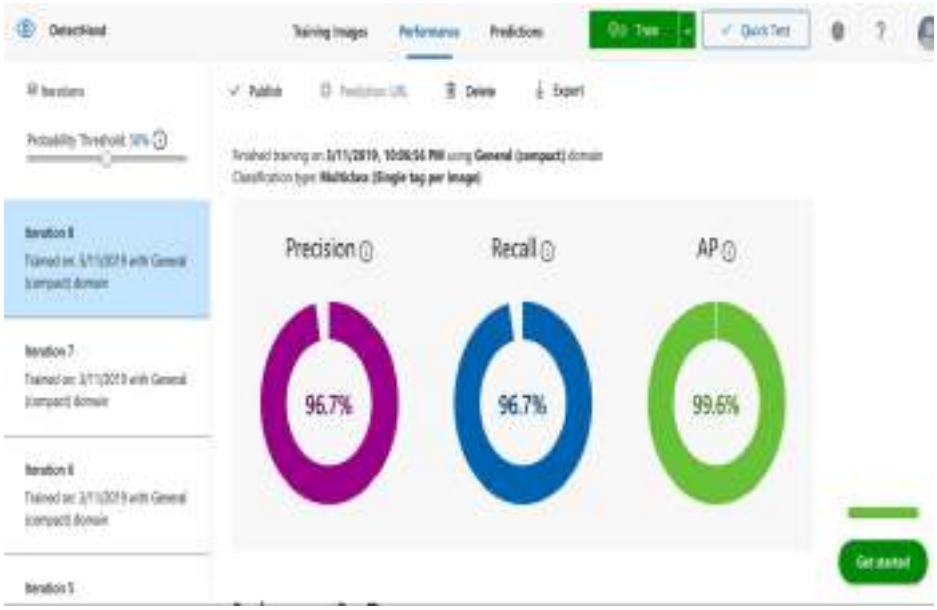


Figure 5.13: Result og Precision + Recall + AP

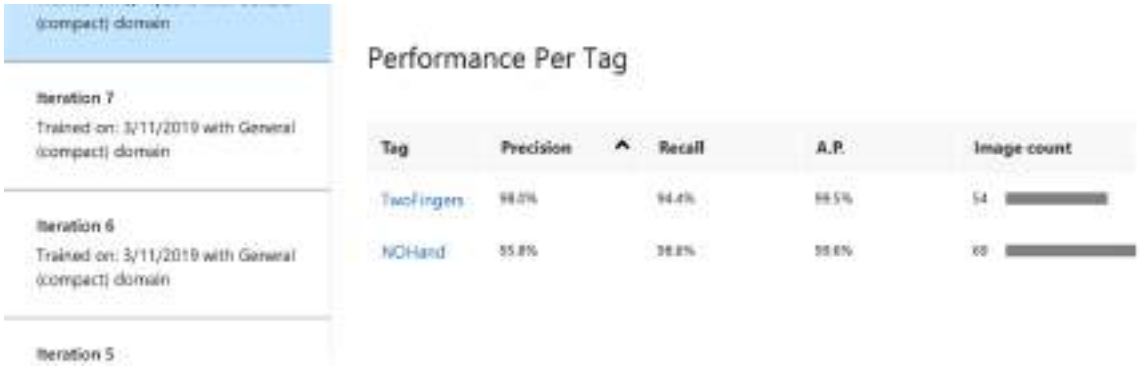


Figure 5.14: Result og Precision + Recall + AP(2)

The two pictures below show the photos of the Open Hand Class.

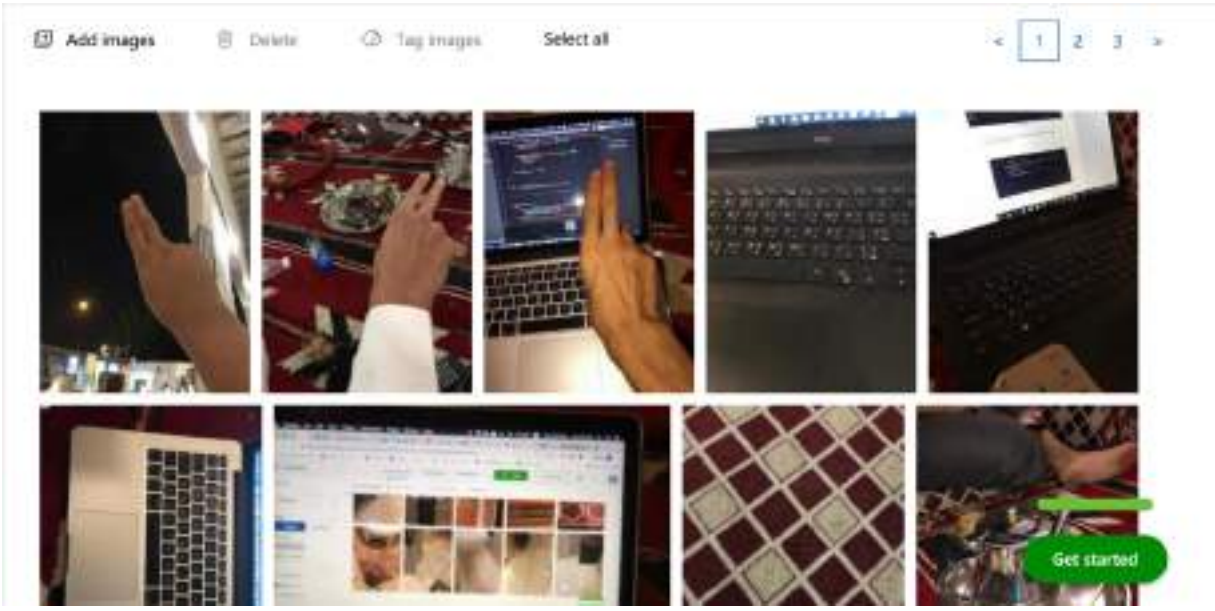


Figure 5.15: Open Hand Class

Figure 5.16: Open Hand Class (2)

The two pictures below show the photos of the No Hand class.

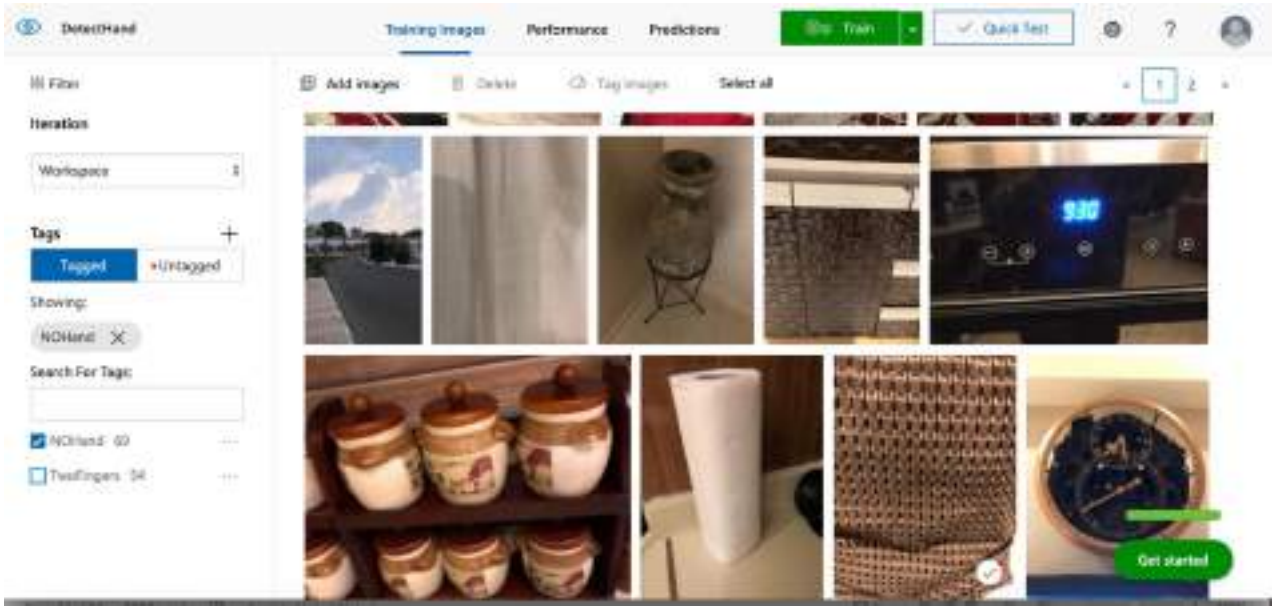


Figure 5.17: No Hand Class

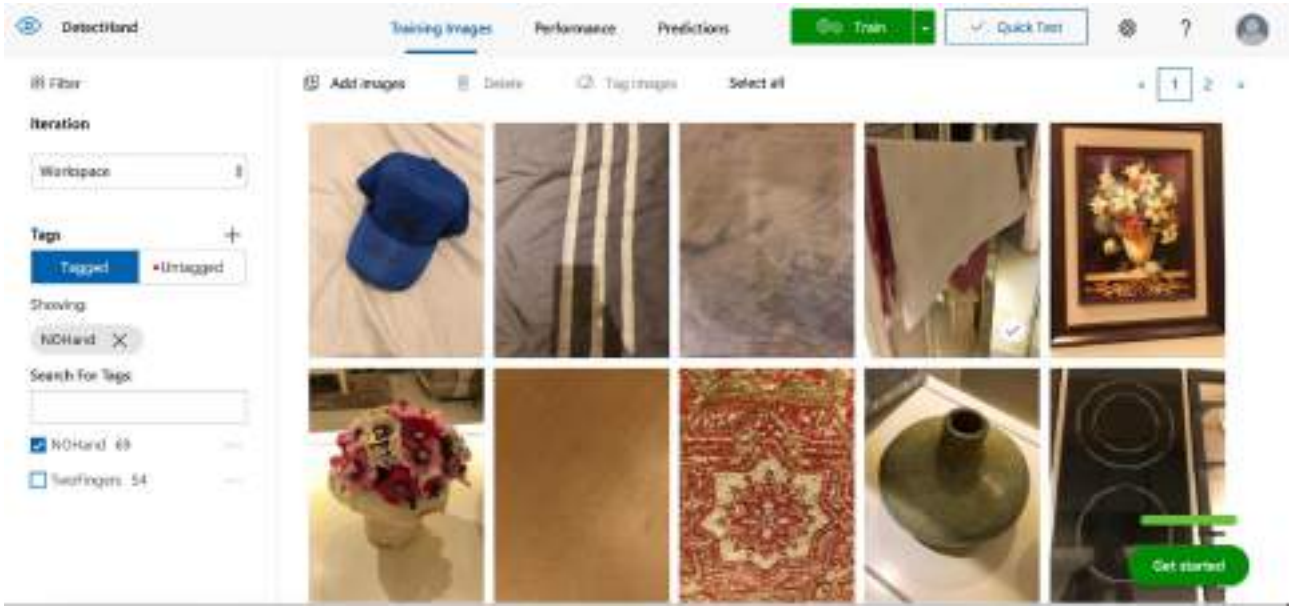


Figure 5.18: No Hand Class (2)

Custom vision provides tool to test your model, so we tested our model and the pictures below demonstrate the results.

Figure 5.19: Result of the test model

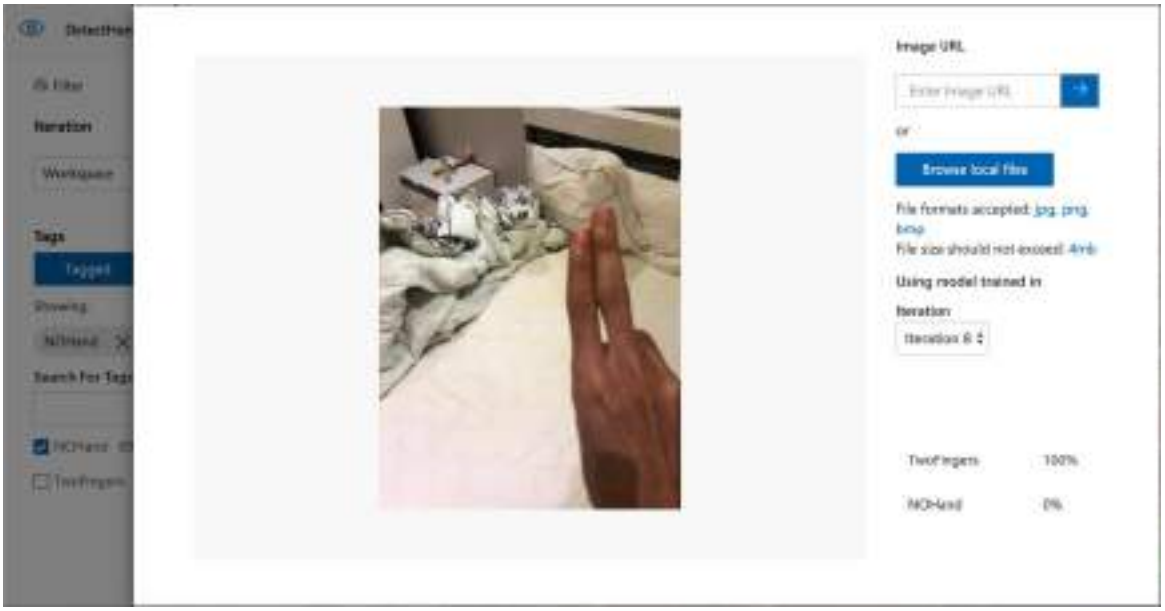


Figure 5.20: Result of the test model(2)

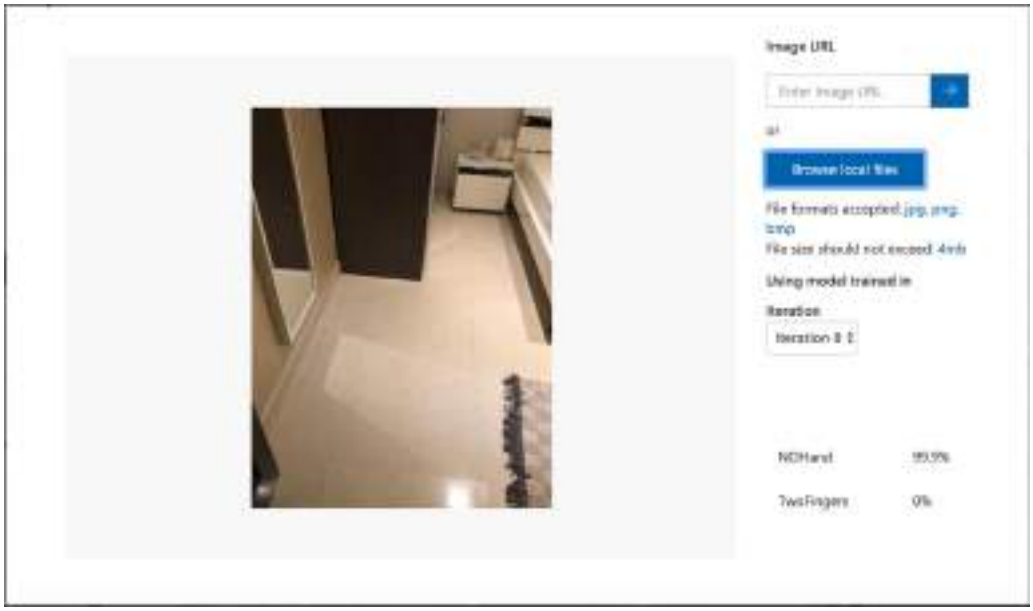


Figure 5.21: Result of the test model(3)

After training the Model and do all the processes associated with it, ultimately, we can convert our model to Core ML Model to operate it in IOS operating system as well as upload it in XCode environment to start import the libraries related to ML and computer vision to deal with the Model to integrate it to our System. [11]

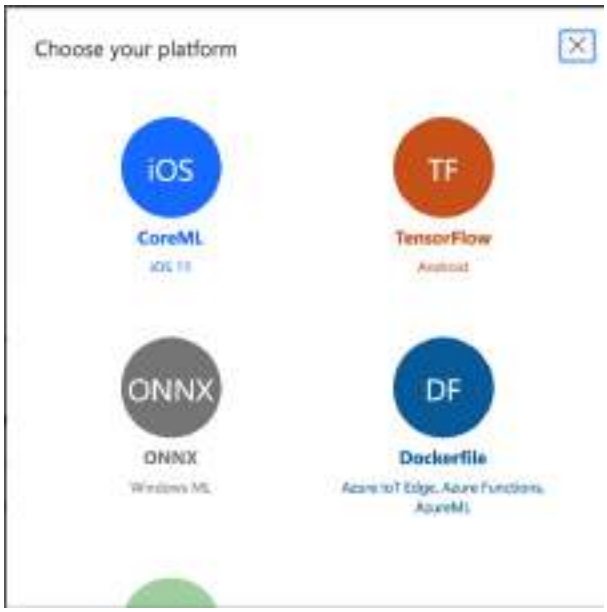


Figure 5.22: Choose The Platform

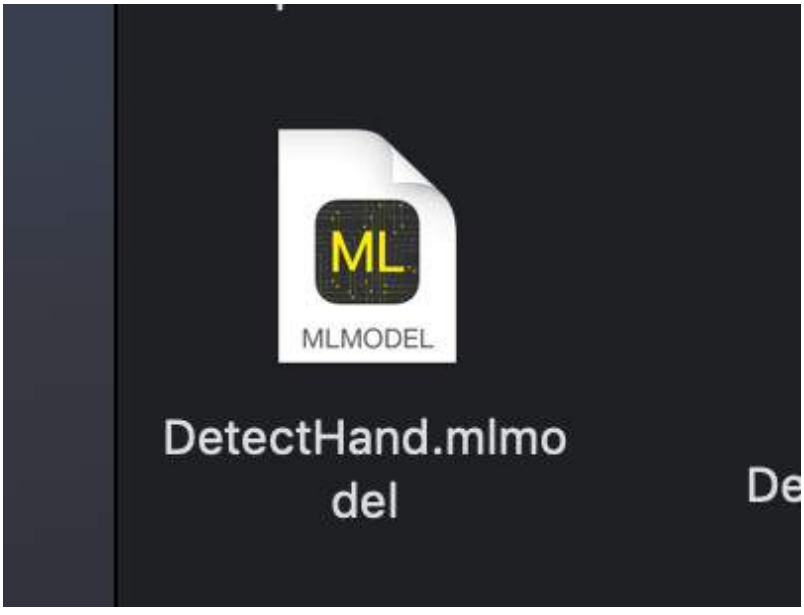


Figure 5.23: File of Model

5.2.3 Preview

Figure 5.24: Preview

We used the preview program provided by Apple after we collected the all images for our ML Model, for the OpenHand Class and the NoHand Class to resize all images and adjust the width to 300 px to get accuracy as much as possible in our Model, and to follow the rules and the best practices provided by Microsoft Documentation in Azure Custom vision classifier As show below in the two pictures.

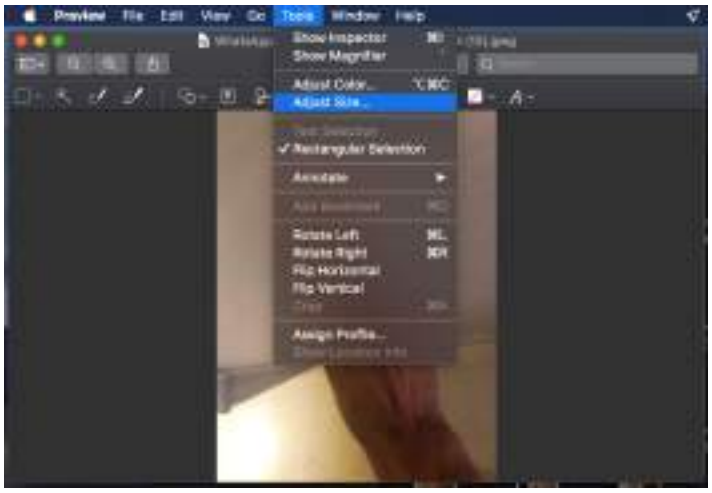


Figure 5.25: Resize images

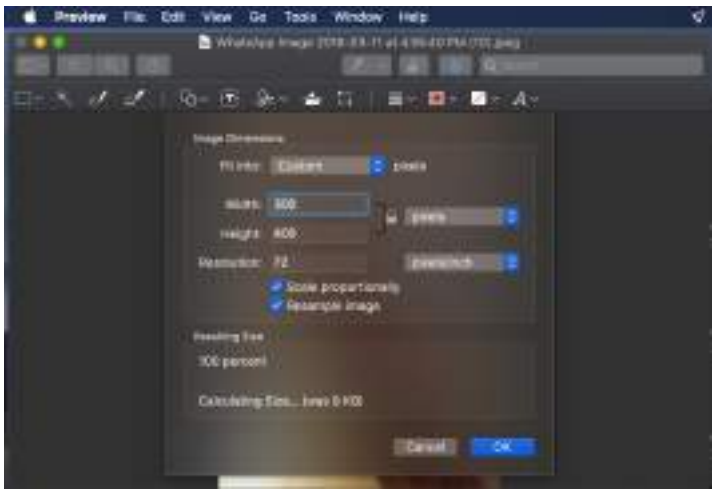


Figure 5.26: Resize images(2)

5.2.4 XCode, ARKit and Core ML

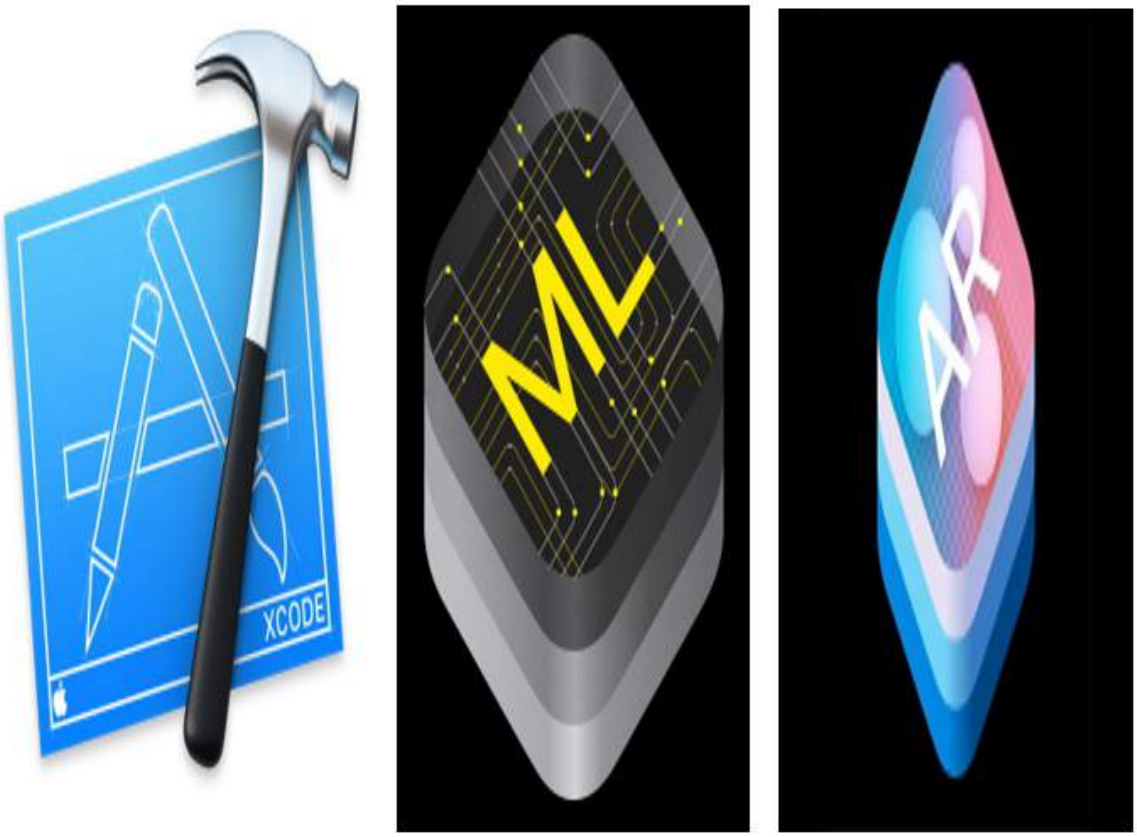


Figure 5.27: Sign up Code

The picture above demonstrates the code of the Sign-up page that is integrated with the Firebase Database.

Figure 5.28: Sign in Code

The screenshot above shows the sign in page and how way apply authorization technique to check the sign in processes.

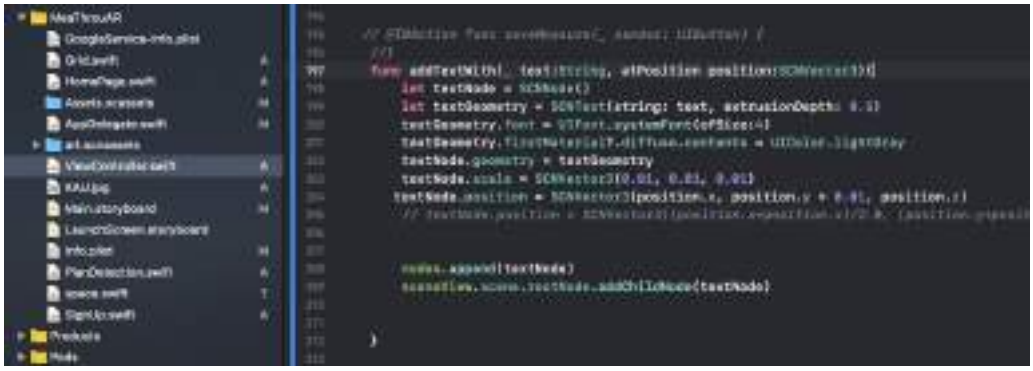


Figure 5.29: Measure Two Point

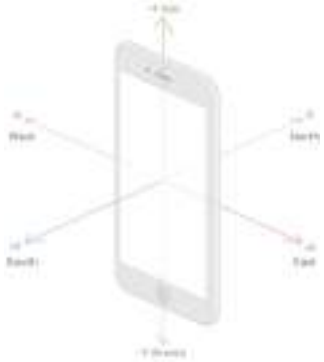


Figure 5.30: Measure Two Point (2)

The picture above shows the code of the result that will appear to the user when he measures the distance between two points in 3D figure.

Figure 5.31: Calculate The Distance

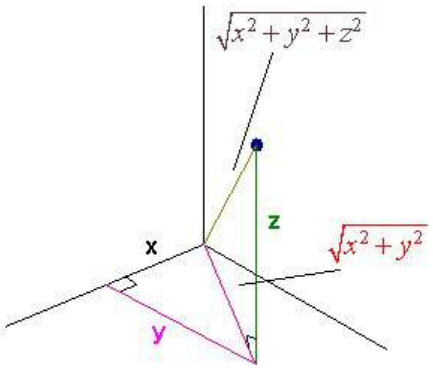


Figure 5.32: Calculate The Distance (2)

The code above describes how we calculated the distance between the 3D figures when the user touches the screen.
First of all, we subtracted the value of the X and Y and Z axis of the first 3D object than the X and Y and Z axis of the second object, then we calculated the distance using Pythagoras's equation shown below.

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

Figure 5.33: Calculate The Distance (3)

Figure 5.34: Add Dot

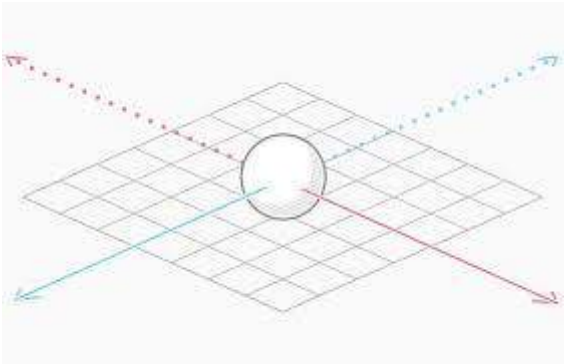


Figure 5.35: SCNSohere (radios)

The code above is about adding the 3D object to the scene view (3D Screen) from type SCNSphere (radius).

Figure 5.36: Touch

The picture above shows the code of the touching processes and how we get the position when the user touches the screen and how we assign the object to the same place the user touched

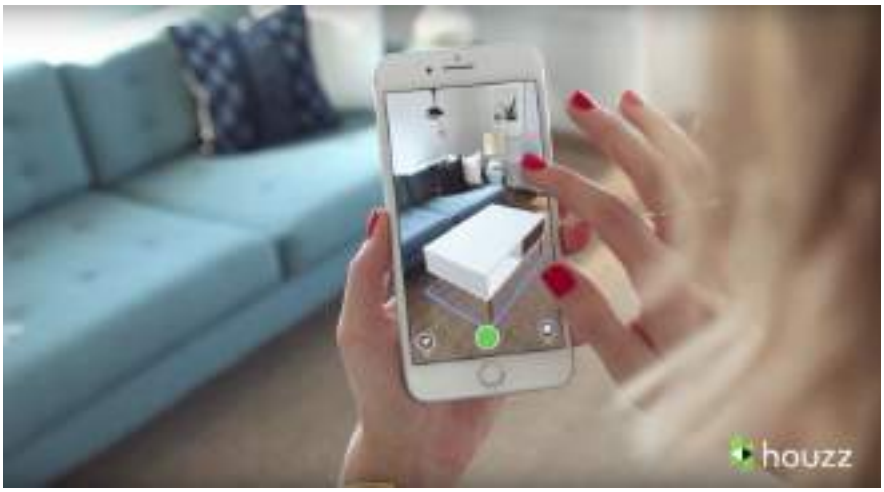


Figure 5.37: Touch(2)

Figure 5.38: Grid

Figure 5.39: Grid example

The picture above is for measuring the spaces, when the user measures the area the application will drop a grid and by the grid the user will be capable to measure.

Figure 5.40: Update the Grid

The code above shows the function that is responsible for updating the result of the grid when the user moves and while he detects the plans.

Figure 5.41: Distance from the camera

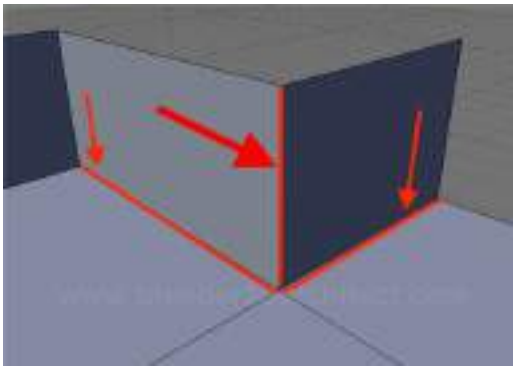


Figure 5.42: Distance from the camera (2)

The picture above shows the third function, that enable the user to measure the distance between his device and the wall.

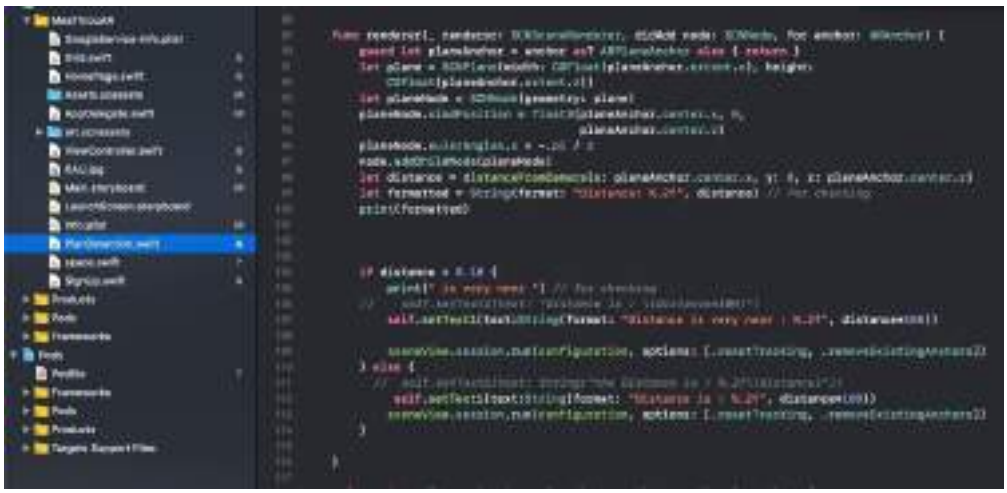


Figure 5.43: Plan Detection

The code above is for detecting the plans when the user tries to calculate the distance between his device and the walls.[12]

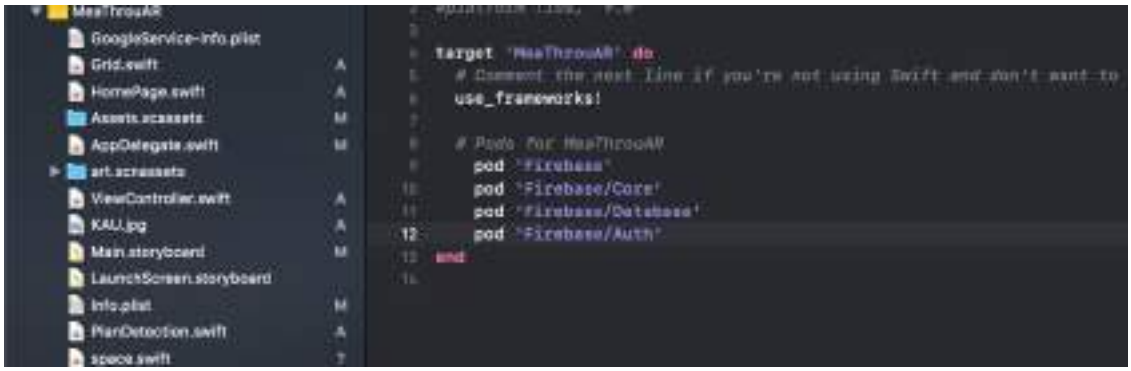


Figure 5.44: Integrated with Firebase

The screenshot above shows the firebase required keys to integrate with our system.

Figure 5.45: Storyboard (Interface)

The picture above shows the storyboard of our systems (the Interface) which include so far, many pages.

Figure 5.46: Google Firebase Information

The screenshot above shows the Google information regarding to the firebase integration processes.

Figure 5.47: Menu Code

The screenshot above demonstrates how we build our menu and how the user will interact with it.[13]

The five pictures below show demonstrate how we integrate the ML Model to our system by import the required library and writing the required code.

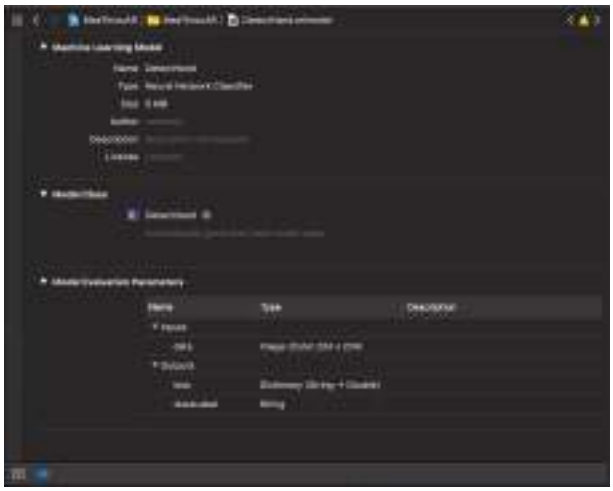


Figure 5.48: Integrate ML Model

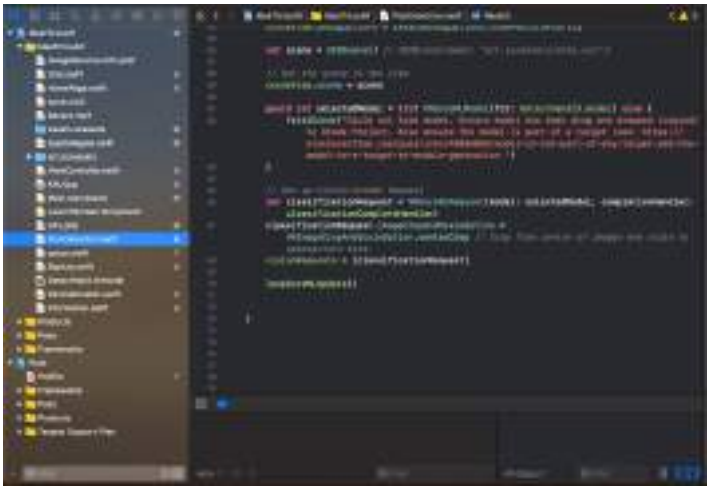


Figure 5.49: Integrate ML Model (2)

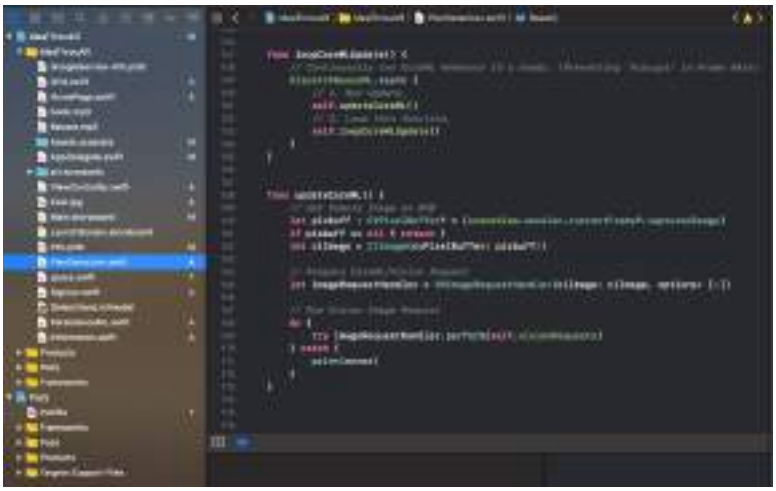


Figure 5.50: Integrate ML Model (3)

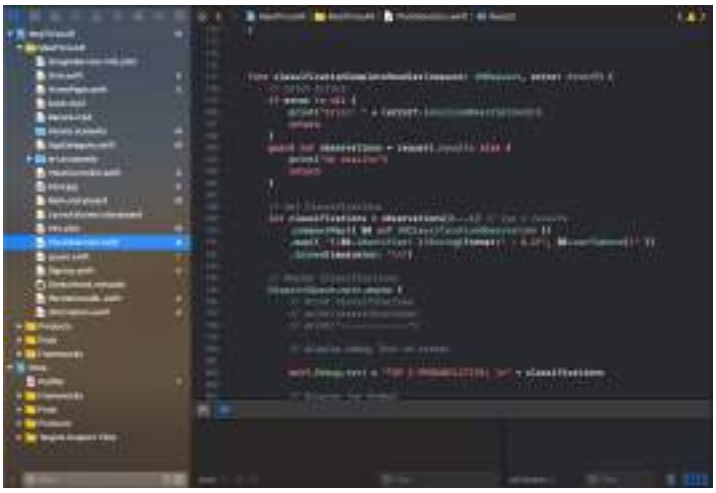


Figure 5.51: Integrate ML Model(4)

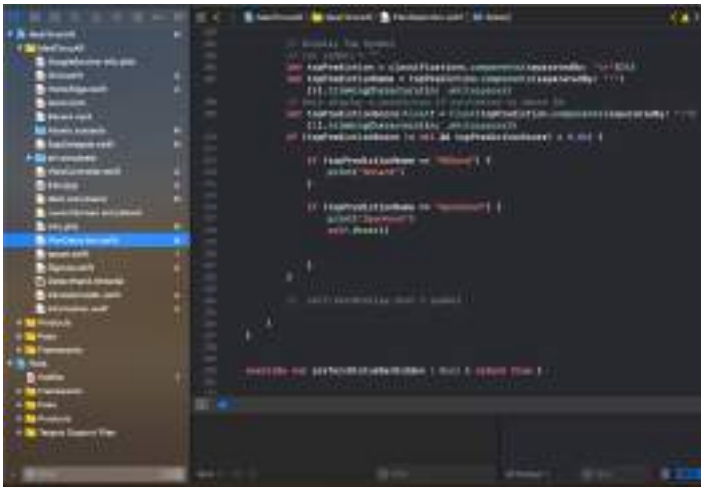


Figure 5.52: Integrate ML Model(5)

The six pictures below show how we built the persistence, to enable the user to store the notes offline by assign it to specific place on the X and Y and Z axis.
So far, we dropped 3d Object and we enabled the user to save it and load it, in order to enable the user in future to write note on it. [2] .

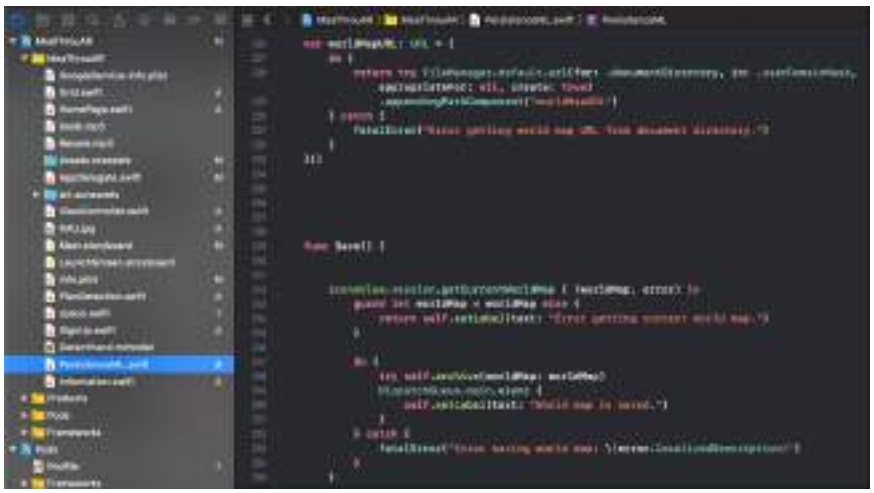


Figure 5.53: Persistence

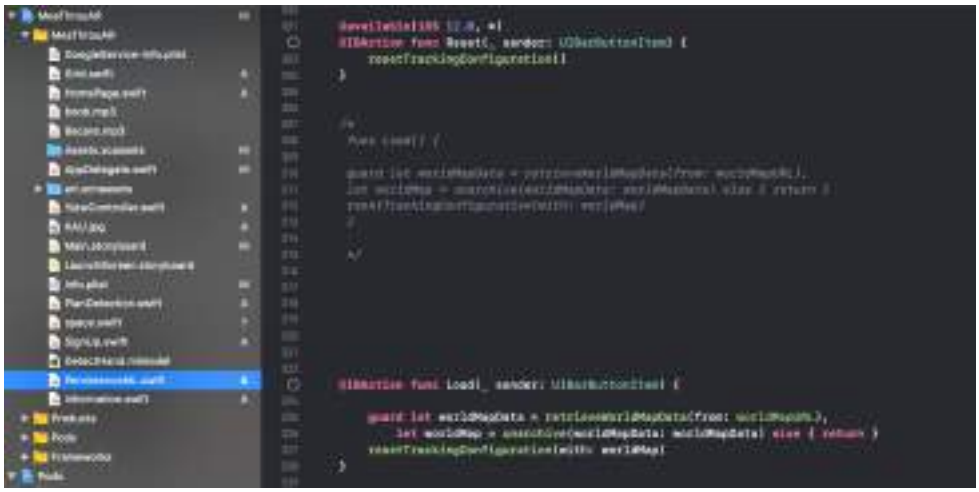


Figure 5.54: Persistence (2)

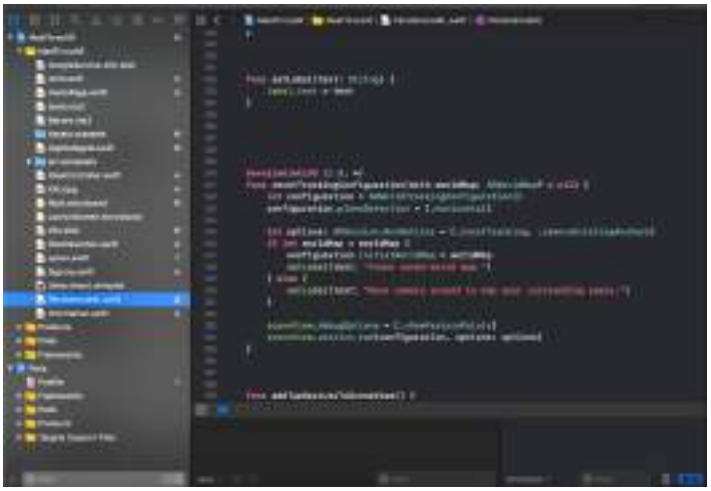


Figure 5.55: Persistence (3)

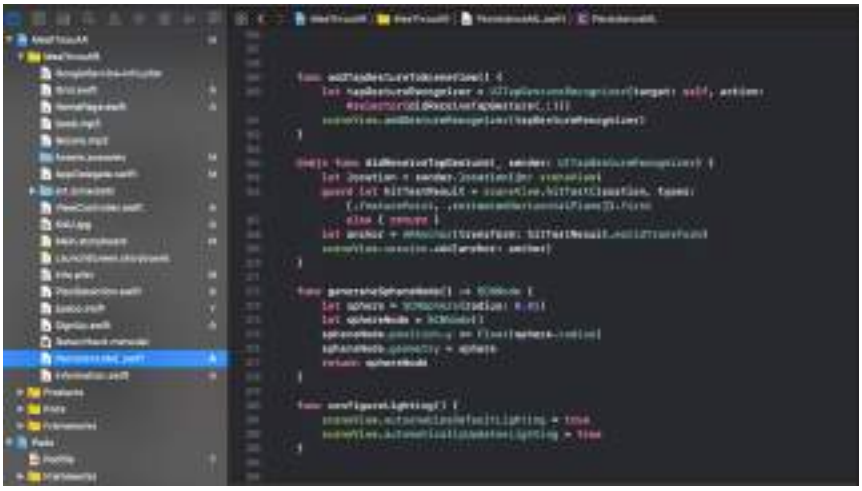


Figure 5.56: Persistencel(4)

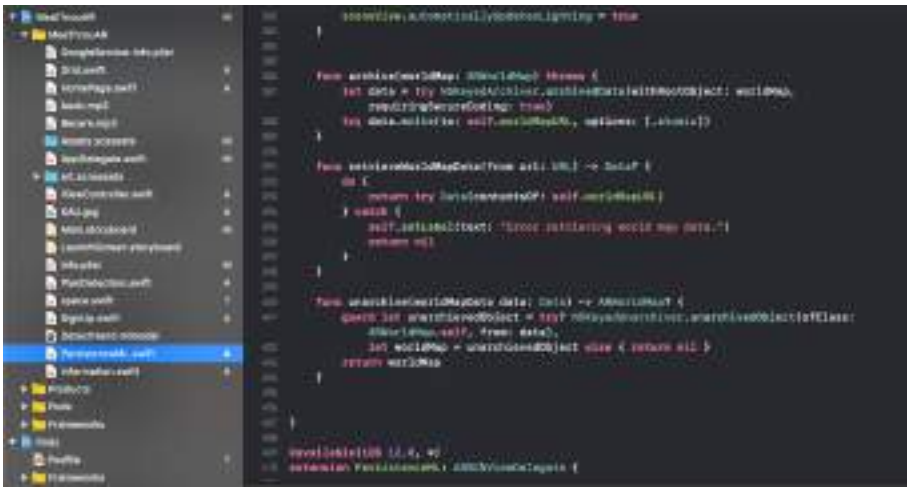


Figure 5.57: Persistence(5)

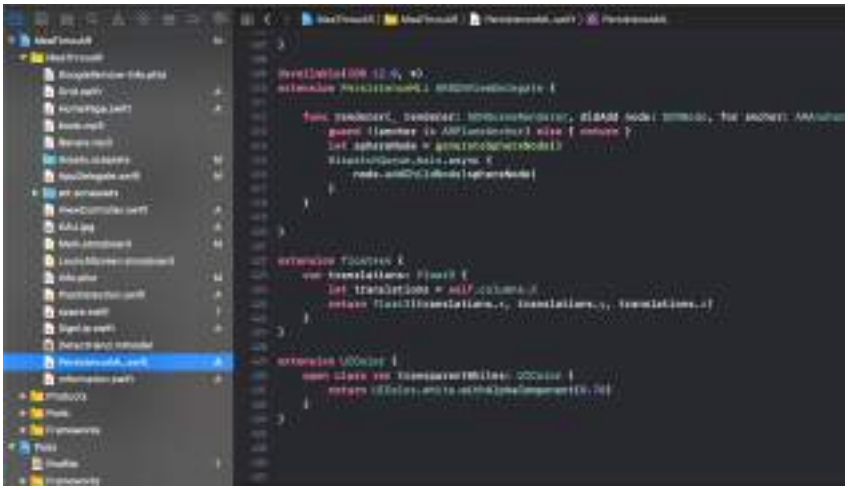


Figure 5.58: Persistence(6)

The two pictures below show the warning sounds we used it in the wall detecting function.

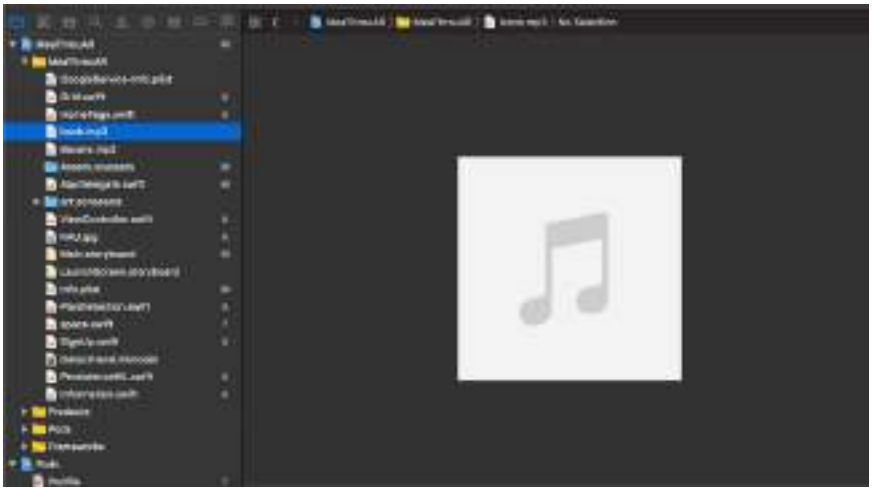


Figure 5.59: Warning sound

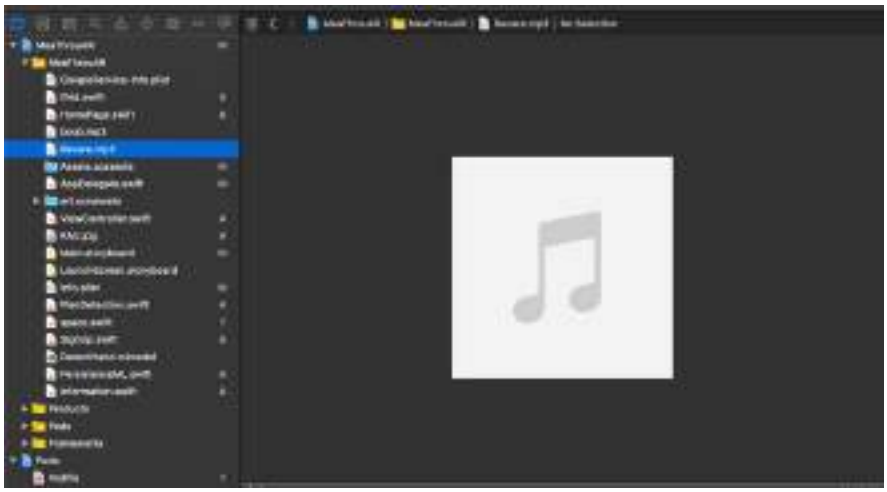


Figure 5.60: Warning sound(2)

The picture below demonstrates what photo we used to cover the 3D object in the distance between two points function.

Figure 5.61: logo of FCIT used to cover the 3D object

Chapter 6

Testing

6.1 Method used in Usability Testing

There are various types for usability testing, and in our system, we will be using laboratory-based (or lab-based) usability testing. This testing method enables the testing of mobile applications by involving real users using real devices. In it, the evaluator has full control over the test and can easily set the tasks – thus enabling him/her to test all usability aspects.[14]

6.2 Criteria of Measuring Usability

- The acceptable Accuracy of the Measurement processes.
- Real-time detecting of vertical and the horizontal plans.
- Objects placement and retrieval.
- Data flow.
- validate gesture recognition technology.

6.3 Conducting the Test and Result

Figure 6.1: the result of distance

The picture above demonstrates how the system measured the distance between the two points and showed the result in 3D figure.
Furthermore, the result has given by the system as shown is analogous to the result showed by the tape measure.

6.3.0.1 Adding Description

These 3 pictures demonstrate the phase of adding description process and how the data flow from one stage to another

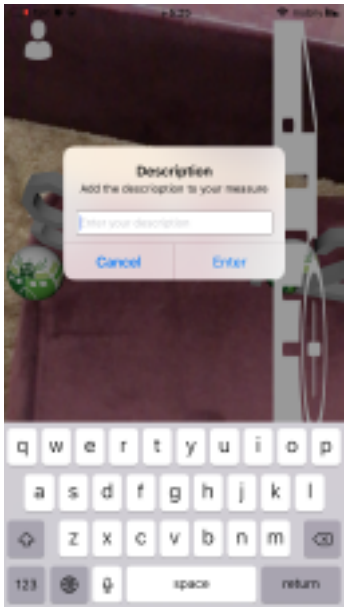


Figure 6.2: Window for add description

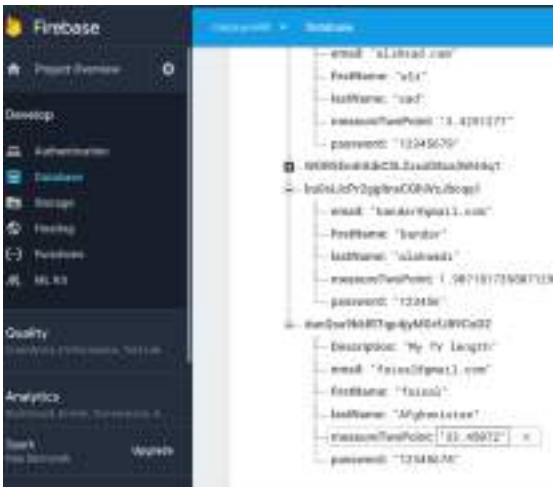


Figure 6.3: Database

Figure 6.4: page to show last measure and Description

6.3.0.2 Detecting the Wall

The picture below shows 3D figure that had been dropped when the camera detected the Vertical surface.

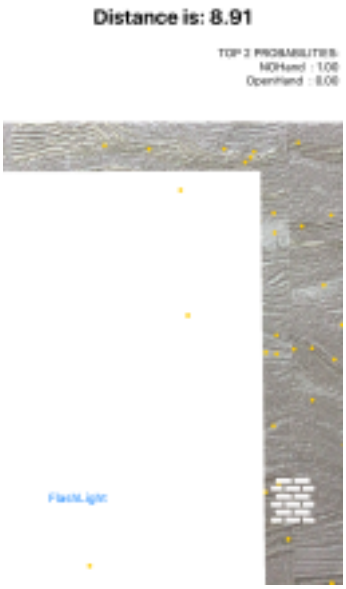


Figure 6.5: object dropped when the camera detected the wall

6.3.0.3 The Persistence

The picture below shows how the system saves the object through the Persistence offline by recognize the user hand and showing a message to him on the bottom (“World Map is saved”).

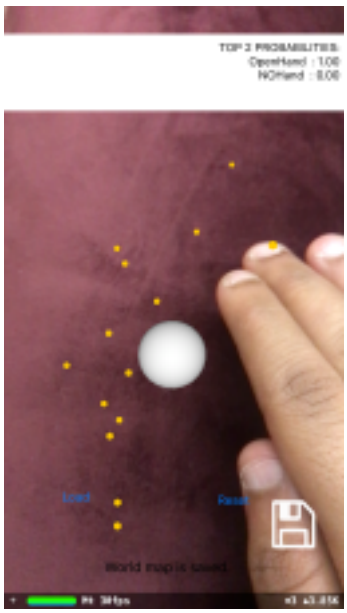


Figure 6.6: save the object by user hand

6.3.0.4 Measuring the Space

The screenshot below shows how the system measures the spaces, first it will detect the vertical surface then drop a grid, then the grid will extend based on the phone movement and it will measure the distance based on these phases.

Figure 6.7: Measuring the space

6.3.0.5 Sign up and Log in

Figure 6.8: Sign Up

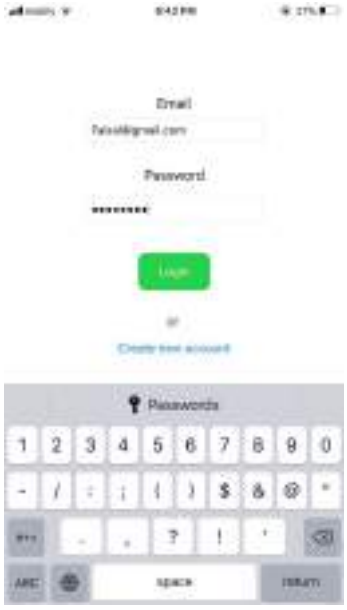


Figure 6.9: Log In

6.3.0.6 Detecting vertical and horizontal surfaces

Figure 6.10: Detection

Chapter 7

Conclusion

7.1 Problem and difficulties:

During our work in the senior project, we encountered few challenges related to time, and other few reasons associated with the OS and the camera capabilities, but we adapted with all these challenges and managed to override.

7.2 Future work:

We have built the basis that can supports us to apply many ideas on our system such as the ML Model and the persistence, and we are looking forward to building Augmented reality-based notes system, that will use the persistence, and the gestures recognition technology.

The notes system we want to build it will reduces the gap between the traditional notes and the AR technology and it might makes boom in various fields associated to the Communications, since it will enables the user to interact resiliently with the interface by the gestures recognition technology, and it will enables the user to store his details based on the X and Y and Z axis, these features might has widely positive dimensions in information security and other fields.

7.3 Conclusion:

Ultimately, Our system will Enables the users to measure the distance between two points, the spaces, and measure the distance between their devices and the walls after detecting

the vertical and the horizontal surfaces, this function might serve blind people in some situation associated to their movement Through Augmented reality technology in a way that will improve the quality of the measurement processes and make the user life easy.

Moreover, we are going to provide offline and online Database to the users to store the measurement results and add some notes to it, as well as enable them in some situation to interact with the interface with their hands by using the gestures recognition technology.

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