AUGMENTED REALITY RULER APPLICATION

by

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AUGMENTED REALITY RULER APPLICATION

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ABSTRACT

Augmented Reality Ruler Application

The Augmented Reality Ruler Application is a project which is formed by augmented reality principles to be used in users' daily lives. This application, there are also similar versions nowadays; helps the users to calculate length, angle, and area of an object.

Users can only run this application by using their smart phones or tablets, whose have IOS. When the program is executed, it is enough for the user to use the device camera and display the object they want to measure. After the object is displayed on the device screen, the desired calculation of the object to be measured is marked on the screen and then scanned by the camera to take the result.

Augmented Reality Ruler Application is an application that helps everyone to solve many problems in their lifes. For example, a person who wants to decorate their house can easily measure the dimensions of a furniture and set up the house accordingly, or a person who is operating in the production area who is paying accordingly to the measure worth helps to calculate a quick average cost.

Users can record the measurements using the application for their purposes. This is helping to users for their future purposes. With the help of Core Data, users can keep track of every measurement calculation they ever can need. For example, a carpet manufacturer can store the size of hundreds of carpets in their smartphone and reach this information when necessary.

Users will be able to measure quickly and easily for desired purposes without any technical knowledge or skills. This application, which can be easily used in everyone's pocket, produces practical solutions.

ÖZET

Augmented Reality Ruler Application

Augmented Reality Ruler Application Projesi sanal gerçeklik ilkelerini kullanarak, kullanicilarin gunluk yasamlarinda ihtiyaç duyabileceği bir aplikasyon olmuştur. Günümüzde benzerleri bulunan bu uygulama; kullanıcılarin bir cismin uzunluğunu hesaplamasına yardımcı olmaktadir.

Kullanıcılar sadece sahip olduklari IOS işletim sistemli akilli telefonlarini ya da tabletlerini kullanarak bu aplikasyonu çalıştırabilmektedir. Program çalıştırıldığında kullanıcının cihaz kamerasini kullanması ve ölçüm yapmak istediği cismi kamera ile görüntülemesi yeterlidir. Kamera ile cisim, cihaz ekranından görüntülendikten sonra cismin ölçüm yapılmak istenilen bölgesi ekrandan işaretlenir ve sonuç alınmış olur.

Augmented Reality Ruler Application uygulaması herkesin hayatında bir çok sorunu çözebilmesine yardımcı olan bir uygulamadır. Örneğin evini dekore etmek isteyen bir kişi kolaylıkla mobilyaların boyutlarını ölçüp evine gore bir düzen kurabilir veya üretim alanında faaliyet gosteren ve ölçü hesabına göre ücretlendirme yapan bir kişinin hızlı bir ortalama maliyet hesaplamasına yardımcı olur.

Kullanıcılar uygulamayı kullanarak amaçları doğrultusunda ölçümleri kaydedebilir. Bu kullanıcılara gelecekteki amaçları için yardımcı olur. Core Data'nın yardımıyla kullanıcılar, ihtiyaç duyabilecekleri her ölçüm hesaplamasını takip edebilirler. Örneğin bir halı imalatcısı, elindeki yüzlerce halının ölçüsünü akıllı telefonunda saklayıp bu bilgilere gerektiğinde ulaşabilir.

Kulanıcılar hiçbir teknik bilgi veya beceriye ihtiyaç duymadan istenilen amaçlar için hızlıca ve kolayca ölçüm yapabilecektir. Herkesin cebinde kolayca bulundurup kullanabileceği bu uygulama, pratik çözümler üretmektedir.

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IOS – iPhone Operating System

AR - Augmented Reality

SDK - Software Development Kit

UI - User Interface

GPS - Global Positioning System

IDE - Integrated Development Environment

APK - Android Package Kit

3D - Three Dimensional

UML - Unified Modeling Language

API - Application Programming Interface

1. INTRODUCTION

The augmented reality is the most popular title of recent times, and the reason for this is that large companies have begun to use augmented reality technology in all areas. This invention, which has gained great place in the market, has added great advantages to human life. The market value is expected to rise above $100 billion in 2020 with the studies carried out in the area of augmented reality. Ever since Pokémon Go and Snapchat popularized augmented reality for the masses, tech giants have been scheming ways to provide more of it to users. Since the launch of Apple's ARKit august 2017, over 13 million AR apps have been downloaded from the app store.

1.1. Aim of the Project

Tape measures are one of those things that anyone never seem to be able to find when they need them. Fortunately, it’s likely that they have their smart phones somewhere near them every day. The aim of the Augmented Reality Ruler Application project is to assist users in simple life events with an entertaining way that augmented reality technology provides. Furthermore, the project can help users in various business lines.

Project is an IOS application that works with smart phones or tablets. User can use the camera that opens by the application to see the object that they want to get a measurement result.There are three options of calculations in the application. Firstly the "Distance" option, which calculates the displacement of two points that the user picks from the camera. Secondly the "Angle" option, which calculates an angle by choosing three points from the object with the help of the camera. Thirdly the "Area" option, which calculates the area of an object or a surface by adding four points to the screen of the device by the camera.

Project consists a database which is Core Data, that helps to store data to users own device. With the help of Core Data, measurements that users obtained are stored and they can collect many results to fulfill a quest. Once the user obtains a result from the application, they can choose the option "Save" on the application. When the user uses the saving option, they can add a title and a description to their measurement and all of them goes to the database. Of course, users can see all of their saved data with their titles and descriptions together.

1.2. User Guide

In order to operate the program, users must have one of the appropriate devices. Application is only supported by IOS devices. While most of the IOS devices will support ARKit, there are still minimum requirements for the hardware to be able to run. Apple has announced that any device that has A9 chip or later will support ARKit apps. More information about which devices are able for Augmented Reality Ruler Application is covered at section 3.2. Hardware Requirements.

Once the application is downloaded to the smart phone, it can be opened by the user. When the program is opened, the user will be asked to have the necessary permissions, such as 'the application is trying to open the camera, would you allow it?'. Then the main screen opens which displays the view from the camera and the user can do what they want from the application's possibilities. The user can choose one from the options 'Distance', 'Angle', 'Area' from their desires. For making the calculation, user should display the object that they want to measure. By adding 3D points on the object based on their option. When the measurement process finishes and the results are shown on the screen, users also can save those results with a title from the button 'Save' that appears on top right side of the screen. All the saves that users made can be shown any time from the button 'Records' which is on top left side of the main screen. After the user finishes the purpose of them for using the application, they can just close the program, this does not harm users' records.

2. BACKGROUND

2.1. Previous works

There are multiple tools in the market that offer AR applications to the non-technical user. Common feature for these products is that they offer their services without requiring any coding skill or any other technical knowledge. The AR feature can be used for many goals.

Following products are the most popular examples of AR technology that people uses for entertainment, education or business.

2.1.1. Pokémon GO - Niantic

Pokémon GO [1] is a game that quickly captured everyone's attention and given them a reason to go out into the world, walk around and catch Pokémon as shown in Figure 2.1.1. The game uses GPS to mark the location of the user and move their in-game avatar, while their smartphone camera is used to show Pokémon in the real world. For the most part, it works, provided the game hasn't crashed or frozen. There aren't a lot of instructions when players first start, or information regarding game mechanics like the colored rings around wild Pokémon, but thanks to the nature of the internet, figuring out what to do isn't that tough.

Figure 2.1.1 Pokémon GO

2.1.2. The Civilizations AR - BBC

Education is a great use for augmented reality, and it's apps like this one that are really starting to pave the way for an AR-centric future. The Civilizations AR [2] app from the BBC gives users the ability to admire various historical artifacts, locating, rotating and resizing them as shown in Figure 2.1.2. There's an extremely handy tutorial when the user first starts the app, which guides them through checking out an Egyptian mummy, hearing about its history, and even seeing inside it with an X-ray function. There are more than 30 historical items for users to admire, explore, and photograph in their living room. This is a great application for anyone interested in history, or those seeking a sneak peek at the likely future of museums.

Figure 2.1.2 The Civilizations AR - BBC

2.1.3. GPS Fields Area Measure - Farmis

GPS Fields Area Measure [3] is one of the most incredible applications on the best measuring apps for Android list because it uses existing technology in an effective way. As the name might have given it away, this application allows users to measure area by using GPS data. All the users need to do is run this application, then selecting the starting and ending points.

In order to measure an area simply make a loop. The only downside is, as the application is using GPS data, it won't be able to measure small areas. So, if a farmer wants to measure their field, this is the right application for the job. With global positioning services becoming more and more accurate, there will be a time when this application will accurately measure users every step. GPS Fields Area Measure application is shown in Figure 2.1.3.

Figure 2.1.3 GPS Fields Area Measure

2.1.4. Measure - Apple

Measure [4] 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.

2.1.5. AR Ruler Tool

AR Ruler Tool [5] is a handy tool that allows users to measure any object or angles using virtual ruler. Just pointing the camera, selecting start and end points is enough for getting the results. This app is the most similar application to Augmented Reality Ruler Application on the market. Because they have so many features that looks same, but there are still big differences that will be covered on the section 2.2. Comparison between Applications and 6.1.2 Application Success Test Comparison.

2.2. Comparison between Applications

Augmented Reality Ruler Application, Measure, and AR Ruler Tool are the measurement calculation applications that has some similar and unique features. As shown in Table 2.2, all three applications can measure the distance between two marked places. Measure application has a unique feature which is spirit level, but it is understandable because other two applications are demonstrating the augmented reality principles and spirit level feature has nothing to do with augmented reality. Area calculation and Recording is the unique features of Augmented Reality Ruler Application. The angle calculation can be done by both Augmented Reality Ruler Application and AR Ruler Tool.

	Distance	Angle	Area	Record	Spirit Level
Measure	✓				✓
Augmented Reality Ruler Application	✓	✓	✓	✓	
AR Ruler Tool	✓	✓			

Table 2.2 Comparison between Applications

3. ANALYSIS

3.1. Software Requirements

When a project is developed for Apple devices, the platform Xcode can be used. This project is also prepared with it because it is very powerful. It is the official Integrated Development Environment (IDE) for Apple application development. Xcode supports source code for the programming languages C, C++, Objective-C, Objective-C++, Java, AppleScript, Python, Ruby, and Swift.

As the Augmented Reality Technology is used in the project, there must be a SDK implemented in the system. Which is ARKit, it contains a nice engineering that needed in the project. ARKit (Apple ARKit) is a development kit for building augmented reality apps (AR apps) for Apple mobile devices.

ArgoUML is a software methodology design tool that where UML diagrams are created. For the project, use case diagram and class diagram are created in form of UML that means all around the world can understand these diagrams and understands how the project works.

3.1.1. Augmented Reality

Augmented Reality [6] is the integration of virtual objects with a person's reality. It is not like virtual reality which is makes a fully digital environment, AR is adding a new digital object to the real-world environment of the user by overlaying the virtual item on top of it.

The "Augmented Reality" term first mentioned in 1990 as its describing what it is. The technology is becoming stronger and increasing its popularity so fast. In 2016, the success of Pokémon Go shows the people's interests in augmented reality. Then innovative ad formats by Snapchat popularized by people.

People see Augmented Reality technology very useful as it is increasing their horizons and it’s being very interesting. It can increase people’s imagination and see the world as the one they try to imagine.

3.1.2. Xcode

Xcode [7] is an integrated development environment (IDE) for macOS containing a suite of software development tools developed by Apple for developing software for macOS, iOS, watchOS, and tvOS. First released in 2003, the latest stable release is version 10.2 and is available via the Mac App Store free of charge for macOS High Sierra and macOS Mojave users. Registered developers can download preview releases and prior versions of the suite through the Apple Developer website.

Xcode supports source code for the programming languages C, C++, Objective-C, Objective-C++, Java, AppleScript, Python, Ruby, ResEdit (Rez), and Swift, with an assortment of programming models. Third parties have included help for GNU Pascal, Pascal, Ada, C#, Perl and D.

Xcode can build fat binary files containing code for various structures with the Mach-O executable arrangement. These are called universal binary files, which enable software to keep running on both PowerPC and Intel-based (x86) stages and that can incorporate both 32-bit and 64-bit code for the two models. Utilizing the iOS SDK, Xcode can also be used to compile and debug applications for iOS that run on ARM architecture processors.

Xcode incorporates the GUI apparatus Instruments, which keeps running on a dynamic tracing framework, DTrace, made by Sun Microsystems and discharged as a major aspect of OpenSolaris.

3.1.3. Swift4

Swift [8] is an amazing and powerful a programming language for macOS, iOS, watchOS, tvOS and past. Composing Swift code is interactive and fun, the syntax is brief yet expressive, and Swift incorporates present day highlights developers love. Swift code is safe by its design, yet additionally creates programming that runs exceptionally quick. Swift 4 (4.0) is released in 19-SEP-2017.

Swift is an alternative to the Objective-C language that employs modern programming-language theory concepts and strives to present a simpler syntax. During its introduction, it was described simply as "Objective-C without the C".

By default, Swift does not expose pointers and other unsafe accessors, in contrast to Objective-C, which uses pointers pervasively to refer to object instances. Also, Objective-C's use of a Smalltalk-like syntax for making method calls has been replaced with a dot-notation style and namespace system more familiar to programmers from other common object-oriented languages like Java or C#. Swift introduces true named parameters and retains key Objective-C concepts, including protocols, closures and categories, often replacing former syntax with cleaner versions and allowing these concepts to be applied to other language structures, like enumerated types (enums).

3.1.4. Apple ARKit

ARKit [9] is a software development kit for designers to make increased reality applications for the iPhone and iPad. With ARKit, applications now accessible for everybody to utilize. ARKit is what Apple calls its set of software development tools to enable developers to build augmented-reality apps for iOS. The greater part of us will never really use ARKit, yet we see its outcomes and interface with ARKit applications in iOS 11.

Anyone using an iOS device that runs on Apple's A9, A10 or A11 Bionic processors. That includes the iPhone 6s and 6s Plus, iPhone 7 and iPhone 7 Plus, all iPad Pro models, the 9.7-inch iPad released in 2017, the iPhone 8, 8 Plus and iPhone X. That's millions of devices that are able to use AR apps.

ARKit takes advantage of existing iPhone and iPad hardware, including motion-tracking sensors and camera sensors, to make augmented-reality apps possible. ARKit applications put three-dimensional pictures in your reality utilizing what's called visual inertial odometry, which exploits your device's sensors to track your world and sense your device's introduction and position in respect to the scene you're viewing at.

3.1.5. Google ARCore

Both Apple and Google have been investing heavily in Augmented Reality, as we see with their development of ARkit (by Apple) and ARCore (by Google) [10]. These technologies have brought the power of AR to the hands of individual developers which was not conceivable a few years ago.

ARkit is used to make products to IOS and ARCore is used for Android Operating System. As the AR Ruler App project is running on Android device, only ARCore technology is a must.

ARCore uses three key technologies to integrate virtual content with the real environment, whose are Motion Tracking, Environmental Understanding and Light Estimation.

Motion Tracking is allowing the phone to understand its position relative to the world. Environmental understanding is allowing the phone to detect the size and location of all type of surfaces, vertical, horizontal and angled. Light Estimation is allowing the phone to estimate the environment's current lighting conditions.

3.1.6. Apple ARKit and Google ARCore Comparison

Apple's ARKit will be restricted to iOS devices (running iOS 11), while Google's ARCore will be limited to Android 7.0 (Nougat) or higher. In terms of market exposure in this technology, Google holds a slight advantage having already dabbled in similar areas with its earlier experiments with Project Tango and Google Cardboard. For Apple though, this is their first major foray in this area.

For software requirements, both ARKit and ARCore are pretty similar. Both work with Java/OpenGL, Unity and Unreal and utilize environmental understanding, motion sensors and light detection.

One of the areas ARCore holds a distinct advantage though, is in mapping. This is the ability to gather and store localization information about the 3D real world that can be used for localization later. ARKit utilizes a so-called 'sliding window' which only stores a limited amount of location data constrained to the 'recent past'. Alternatively, ARCore has the ability to manage much larger map data leading to a more stable data set. [11]

3.2. Hardware Requirements

In this project, there are hardware and software requirements. For implementing ARKit in the project, there is a specific list for the hardware requirements, whose are the smart-phones that can work with ARKit. ARKit is not supported by all gadgets and only available for Apple devices.

Right after iOS 11's release App Store is going to get flooded with ARKit based applications that will allow users to do fun and useful things using their device's camera.

While most of the iOS devices will support ARKit, there are still minimum requirements for the hardware to be able to run the power-hungry AR applications. Apple has already announced that any device that has A9 chip or later will support ARKit apps, provided it is running iOS 11 or later. So, a device with A9 chip, A9X chip, A10 chip and A10X chip will fully support ARKit apps once you update it to iOS 11.

Full compatibility list of iOS devices that will support ARKit Augmented Reality Apps: iPhone X, iPhone 8 Plus, iPhone 8, iPhone 7 Plus, iPhone 7, iPhone 6s Plus, iPhone 6s, iPhone SE, iPad 2018, iPad Pro

4. DESIGN

4.1. Use Case Diagram

A use case diagram is a graphic depiction of the interactions among the elements of a system. A use case is a methodology used in system analysis to identify, clarify, and organize system requirements.Use Case Diagram of Augmented Reality Ruler Application is shown in Figure 4.1.

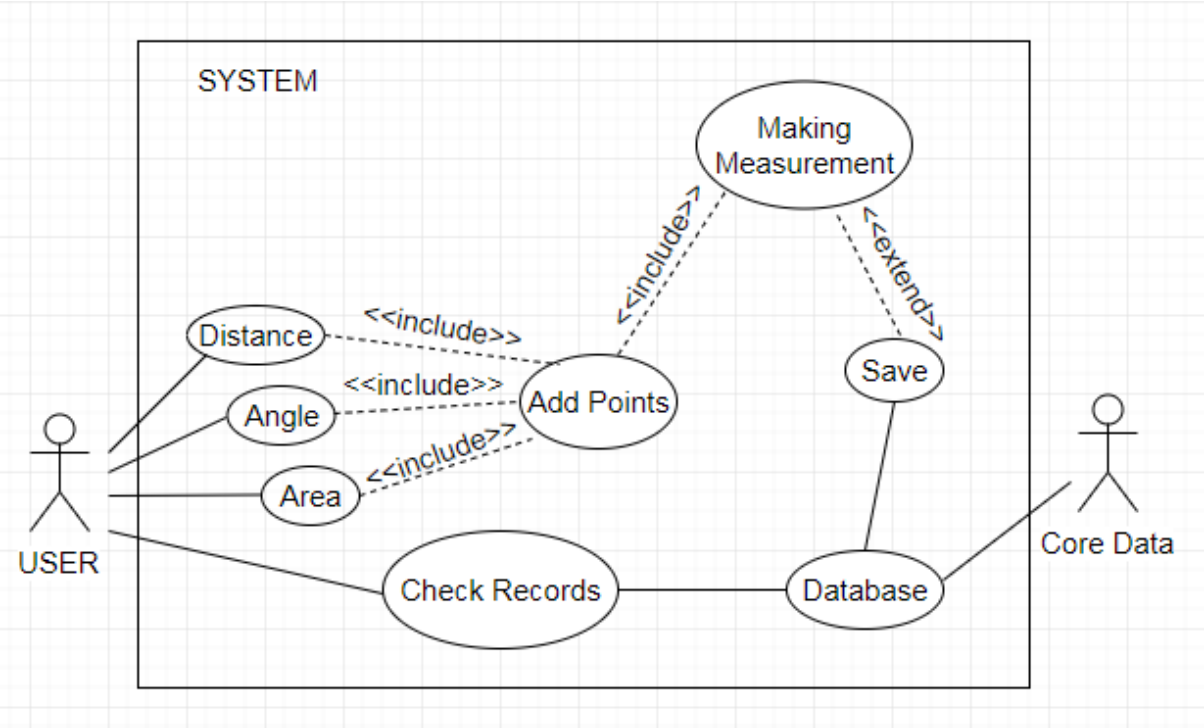

Figure 4.1 Use Case Diagram

4.2. Flow Chart

A flow chart is a graphical portrayal of a procedure. Each progression in the process is spoken to by an alternate symbol and contains a short portrayal of the procedure steps. The stream outline images are connected together with arrows demonstrating the procedure flow heading.

Augmented Reality Ruler Application's user measurement process is shown as a flow chart in the Figure 4.2.

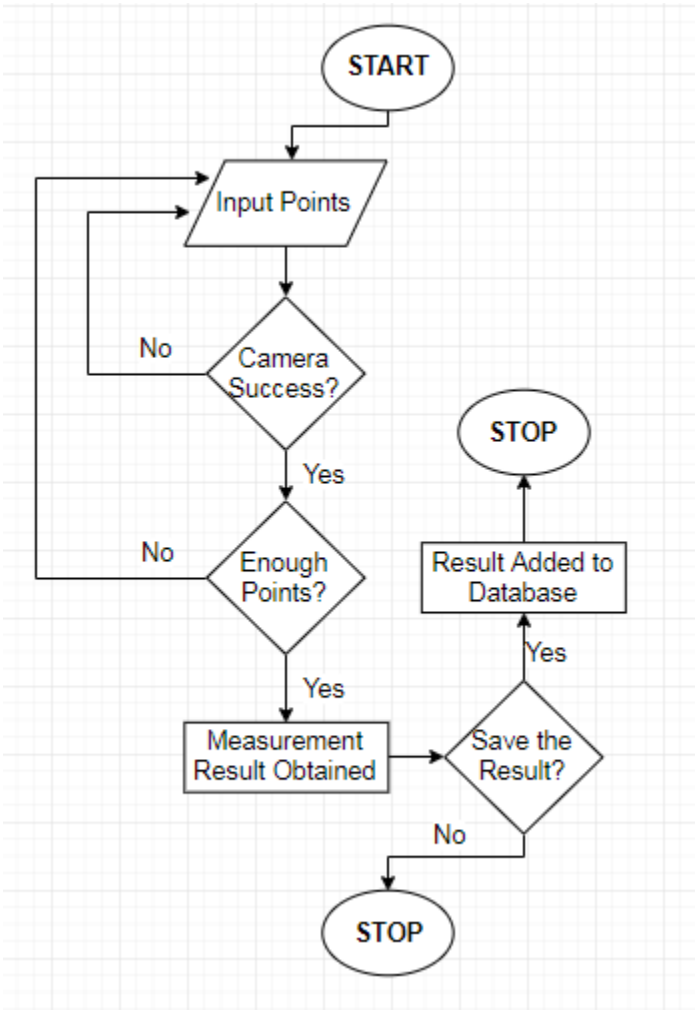

Figure 4.2 Flow Chart

4.3. Application Design

Mobile Application industry growing very fast because of the interest that customers show. Providing a flawless yet engaging experience on the mobile phone is now a real competitive advantage for businesses that are trying to keep up with the peak of the market. A great mobile app can exponentially help businesses in many ways. But this is not easy, because the necessary research, a serious plan and needs analysis should be done.

There are 9 steps to follow when performing a project. Tracking and maintenance of these steps are very important in terms of life and revenue of the project.

i- Defining the Objective. Before starting to figure out how to create the project, defining the reasons why the project is going to be produced is a must. Augmented Reality Ruler Application is being produced to be a helpful tool for various business lines.

ii- Deciding Application Functions and Features. As the producer knows what they want to achieve with the project, it is easier to define the project scope. This is the period to be creative by scratching the functionalities and the features needed to be done.

iii- Competitor Research. Checking the successful competitors for better path understanding is a good solution for most problems and the thoughts as the project is being in a research state. Before starting the development of Augmented Reality Ruler Application project, big projects that already fruit harvesting were observed.

iv- Diagramming and Wireframing. This is very important for understanding and looking the project from a perspective. Use Case and Class Diagrams scratched before starting the development of AR Ruler. Also, wireframing is a nice visual guide that represents the applications layout and the flow between the screens without the graphic and design distractions. Augmented Reality Ruler Application Projects Wireframe is shown in the Figure 4.3.

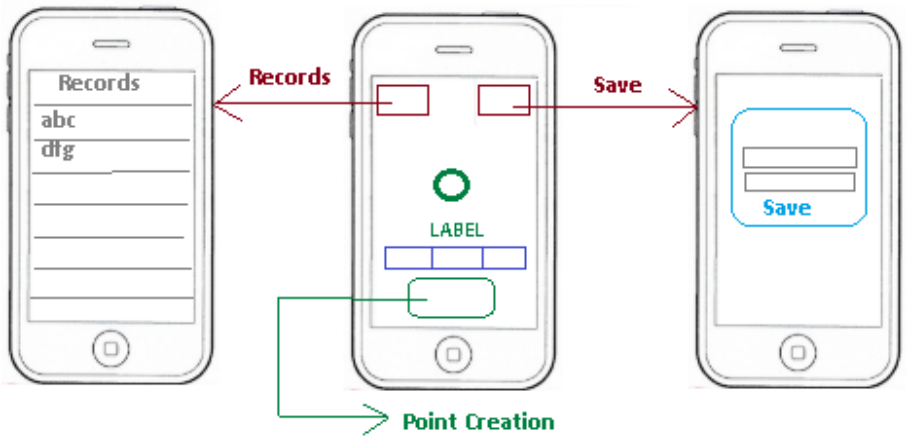

Figure 4.3 Wireframe

v- Test. After all the feedback and guides were taken in pocket, collecting all pieces together and building a task list for the project is a good option. When a a problem has been detected thru this moment, an update should have been done on the wireframe of the project.

vi- Development Path. As everything a project needs mapped out, building it is easier. A development path should be created by determining the technologies, programming languages and building platforms. Augmented Reality Ruler Application is using Augmented Reality, User Interface, Database and many programming technologies. It is coded by Swift4 as it is active on IOS with Apple devices. XCode is a very strong IDE to create mobile apps for Apple devices, that's why the project is created with it.

vii- Building. A project is ready to be developed if all the steps before are done.

viii- Test. Once development is finished and the application is ready to play, test stages must happen. Testing a program is not easy as it looks. Both internal and external users should test it for different purposes and give feedback of their experience. Augmented Reality Ruler Application is tested by many users in Yeditepe University and by the developer himself.

ix- Launching. If the project needs to be submitted, it is ready to do so. Augmented Reality Ruler Application will be submitted on App Store of Apple when its procedures are done (Terms of Service - Privacy & Terms, contract with Apple, Store Price).

4.3.1. Icon Design

Designing the icon of an application is one of the most important things if the application is going to be shown in the stores. Because when a customer is checking the store, icons are the first thing that they see and if it's interesting, customers would like to give it a chance and checks it out. An icon of an application should be simple and gives some information about what the program is doing. Some big popular companies are showing their sign on the corner of the icon to show they made it.

Augmented Reality Ruler Application's icon that shown in the Figure 4.3.1, displays a ruler because it is simple and informing, also the icon displays the sign of the developer. It is designed and created with Microsoft Paint.

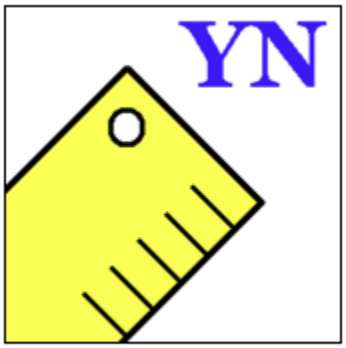

Figure 4.3.1 Icon

4.3.2. User Interface

There are many UI elements in the application. As shown in the Figure 4.3.2, at the main screen, there are 2 buttons, one is to demonstrate the records from the database and the other one is to add an augmented reality item on the screen to start measurement process. When a calculation is finished, another button is appearing which is to save the data obtained from the calculation. There is an aiming target on the middle of the screen, that is a label and it is helping users to add the virtual point on the screen for the process of calculation. There is another label which is also appearing after the program needs to show a message. The message can be the result of the measurement or a warning for the user. The last UI element on the main screen is a segmented control which is used for choosing one from some many options.

Augmented Reality Ruler Application has three options for measuring. Those are Distance, Angle and Area calculations. In the Figure 4.3.2.1, main screen with all UI elements are shown.

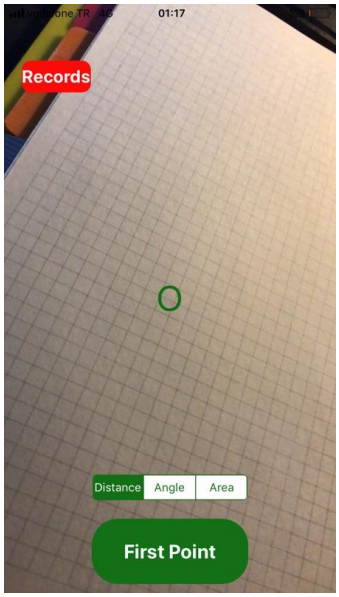

Figure 4.3.2. User Interface Main

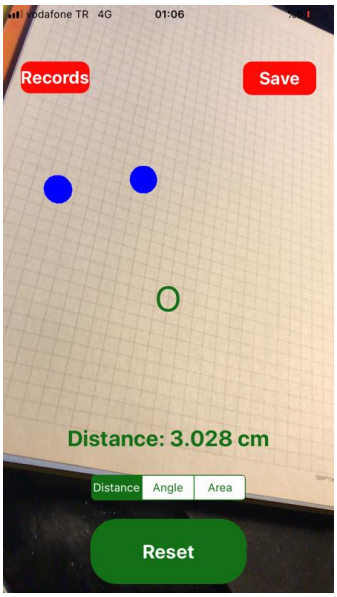

Figure 4.3.2.1 User Interface Secondary

When the user uses the Save feature, a pop-up window is appearing in the middle of the screen. In that screen, user can add a title and description to the obtained measurement result and save all of them to the database. The Records feature is used for accessing the database and displays the records of all the saves that user created by time.

4.3.3. Augmented Reality Points

This project is an Augmented Reality Project, because users adding virtual objects on their reality. When the user wants to measure a pencils length or an area of a carpet, they use AR Ruler Application's feature of adding an augmented reality point on the screen by tapping on the UI button. All the points on the screen are sides of the object that user wants to measure. When a point is added on the screen, the program gets the coordinates of that point with the help of ARKit and the camera. That points that added on the real world's view whose are three dimensioned, looks like a ball and they have values of X, Y, and Z planes that the project is using for making the necessary calculations for the measuring process.

4.3.4. Calculations Design

In the project there are three measurements exists that user can obtain a result from. When the user adds an Augmented Reality Point on the screen by using the UI button, the program acts like that point is really an existing object in the real world and that object has values of X, Y, Z planes as shown in the Figure 4.3.4, like a real-world object has. All the measurement calculations are making with those coordinate values.

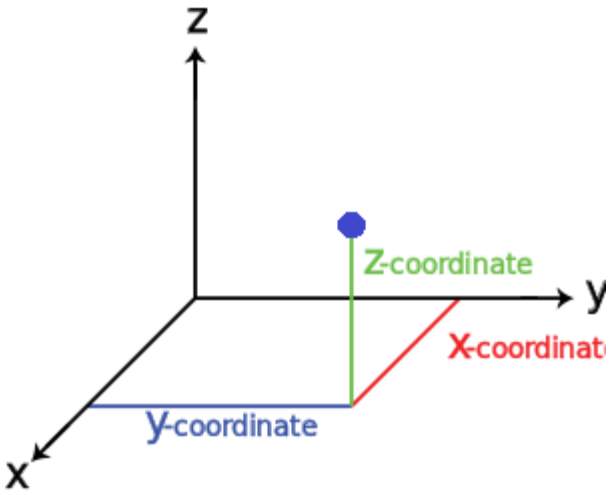

Figure 4.3.4 Coordinates on Space

4.3.4.1. Distance Calculation

As the user chooses the option "Distance" from the segmented control, he/she can add two augmented reality objects on the screen. First point that added on the screen is one side of the line that the user wants to measure the length of and second point that added is the other side of the line as shown in Figure 4.3.4.1. The purpose here is to obtain the displacement value between the two points.

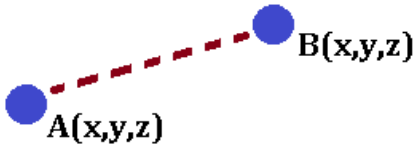

Figure 4.3.4.1. Distance Calculation

For getting the result, the application uses 3D space mathematics. The formula for obtaining the result is shown in the Equation 4.3.4.1. The formula uses X, Y, Z values of both points.

$$Displacement = \sqrt{[B(x) - A(x)]^2 + [B(y) - A(y)]^2 + [B(z) - A(z)]^2} \quad (4.3.4.1)$$

4.3.4.2. Angle Calculation

The option "Angle" is the second option of segmented control, which is used to measure an angle between two lines that intersects with each other. User adds three points on the screen as shown in Figure 4.3.4.2. Those three points makes the intersected lines. The middle point added is the intersection point.

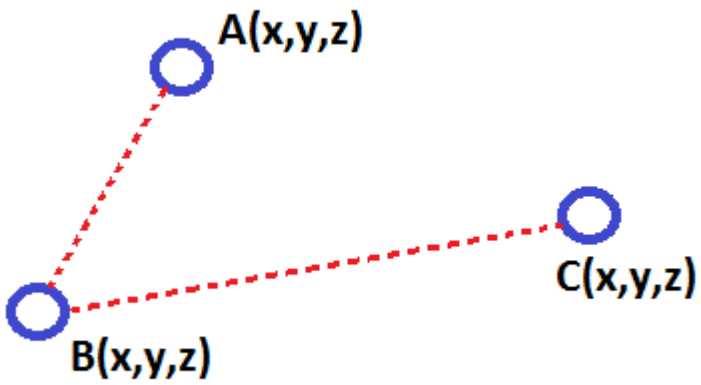

Figure 4.3.4.2. Angle Calculation

For achieving the result, the program uses advanced 3D space mathematics which seems a bit complicated but very effective. The formula for obtaining the result is shown in the Equation 4.3.4.2. The formula uses three points' X, Y, Z plane values. Program uses 3.1415926536 as Pi (π) value.

$$Formula = \frac{B(x)-A(x)*C(x)-B(x)+B(y)-A(y)*C(y)-B(y)+B(z)-A(z)*C(z)-B(z)}{\sqrt{[B(x)-A(x)]^2+[B(y)-A(y)]^2+[B(z)-A(z)]^2}*\sqrt{[C(x)-B(x)]^2+[C(y)-B(y)]^2+[C(z)-B(z)]^2}}$$

$$\underbrace{Cos(X)} = Formula$$

X here is the angle that the program is calculating

$$\pi = 3.1415926536$$

$$Angle\ X = 180 - arccos(Formula) * 180 / \pi$$

(4.3.4.2)

4.3.4.3. Area Calculation

If the user chooses the option "Area" from the segmented control, there can be four points added to the screen. Two lines are created from the four points and those lines' lengths are multiplying with each other as shown in Figure 4.3.4.3.

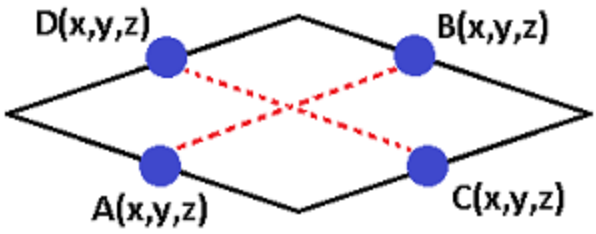

Figure 4.3.4.3. Area Calculation

The formula for obtaining the result is shown in the Equation 4.3.4.3, the formula uses X, Y, Z values of all four points.

$$Area = \sqrt{[B(x)-A(x)]^2+[B(y)-A(y)]^2+[B(z)-A(z)]^2}*\sqrt{[D(x)-C(x)]^2+[D(y)-C(y)]^2+[D(z)-C(z)]^2}$$

(4.3.4.3)

4.3.5. Core Data

One of the features of Augmented Reality Ruler Application which differs it from other measurement applications is the users can save any data that they obtained from the measurements. It is very useful for many different business lines because there can be a lot of calculation to do and it can be very expensive and difficult to note them. For example, a carpenter would need to measure hundreds of different type of wood items every day and it is very hard for them to record it. With the "Save" feature provided by the AR Ruler Application, it is being very easy.

Core Data is a framework that acts like a database, it is really manages the application's object graph. An object diagram is an accumulation of objects that are associated with each other. The Core Data structure exceeds expectations at overseeing complex object graphs. The Core Data structure deals with managing the existence cycle of the items in the object graphs. It can alternatively persevere the object graph to disk and it additionally offers a ground-breaking interface for looking through the object graph it manages. The system is helpful that it includes various other convincing highlights, for example, input approval, data model forming, and change tracking.

5. IMPLEMENTATION

5.1. Class Diagram

In software engineering, a class diagram in the UML is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, methods and the relationships between objects. Class Diagram of Augmented Reality Ruler Application is shown in the Figure 5.1.

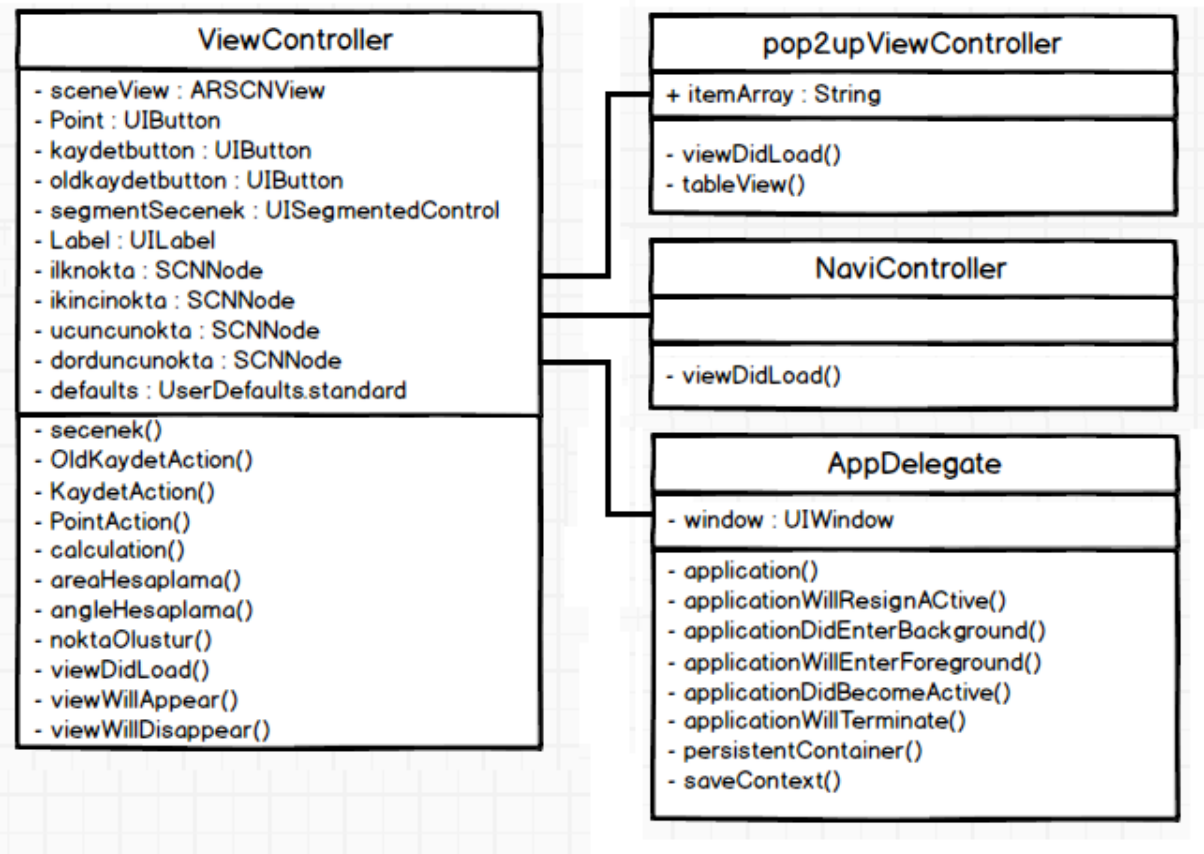

Figure 5.1. Class Diagram

5.2. User Interface Elements

User Interface is the means by which the user and a computer system interact, in particular the use of input devices and software. Like all the methods and classes of Augmented Reality Ruler Application, UI elements are also implemented with Swift4 by Xcode and stored by a nib file. A nib file is a special type of resource file that is used to store the user interfaces of IOS and Mac apps. A nib file is an Interface Builder document.

When the program lunches by the user pressing the icon of the application, 'AppDelegate' class starting to run. This class has many functions inside for the applications functionality. These functions are very crucial for the program's life span. The following functions are used by the 'ARRuler>AppDelegate.swift'; applicationWillResignActive(), applicationDidEnterBackground(), applicationWillEnterBackground(), applicationDidBecomeActive(), applicationWillTerminate(), persistentController(), saveContext(). persistentController() and saveContext() functions are used by Core Data which is covered more detailed in section 5.5. Database. There is also one more function in AppDelegate which is application(). This function starts the app and triggers the 'ViewController' class, this class contains all the main screen UI elements.

For User Interfaces, ViewController has IBAction and IBOutlets. IBAction and IBOutlet are interface Builder Constants. A Controller class can refer to the object in the nib file using a special constant called IBOutlet. Interface objects in the nib file can be set to trigger specific methods in controller class using IBAction as return type of the method.

ViewController has the IBOutlet and IBActions of these UI elements; sceneView: ARSCNView(This is the screen of camera view, covered more detailed in Section 5.2. Scene View), Point: UIButton(This point button is used by user for adding 3D object on the Scene View), kaydetbutton: UIButton(The save button for recording a calculation that appears on top right of the screen), oldkaydetbutton: UIButton (The button for accessing the saved records which situated on top left of the screen), segmentSecenek: UISegmentedControl (Options of 'Distance', 'Angle', 'Area' whose are shown in the segmented control, it is a multiple choice button), Label: UILabel(This is the label that shows the result of the calculation). The outlook of all UI elements is shown in Figure 5.2.

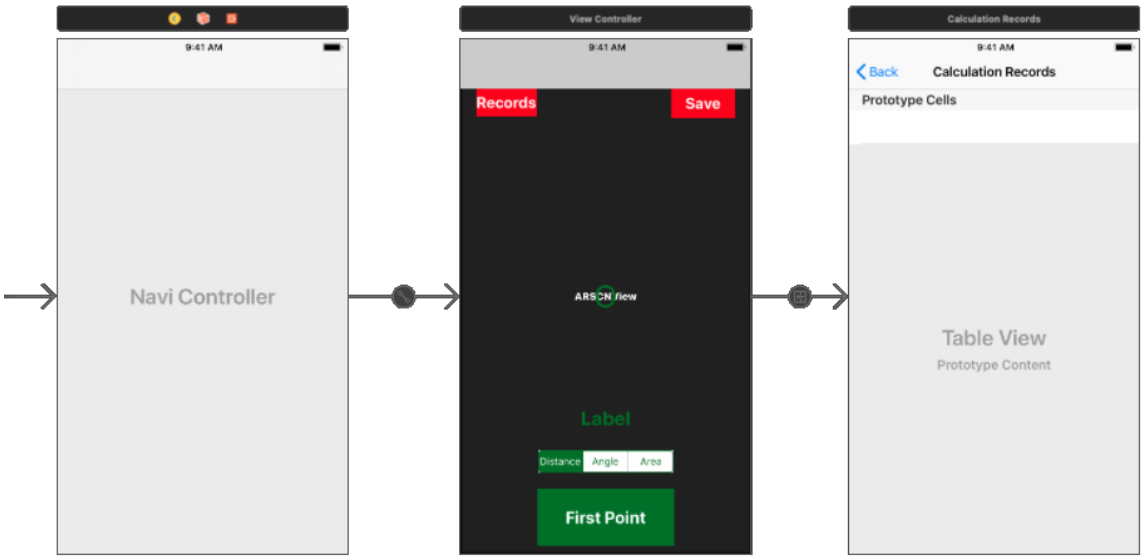

Figure 5.2. User Interface Elements

5.3. Scene View

SceneKit combines a rendering engine and descriptive API. SceneView is a feature of SceneKit. In mac OS, SceneView or SCNView is a subclass of NSView. In IOS and tvOS, SCNView is a subclass of UIView. As part of either operating system's view hierarchy, a SCNView object provides a place for SceneKit content in the app's user interface. Developers can create a SceneKit view by using its init(frame:options:) method or by adding it to a nib file or storyboard. To provide content for a SceneKit view, assigning an SCNScene object to its scene property is enough. [12]

Augmented Reality Ruler Applications uses ARSCNView(Augmented Reality Scene View), it is a view for displaying AR experiences that augment the camera view with 3D SceneKit content. By implementing ARSCNViewDelegate methods, SceneKit content (contents can be the 3D objects that added to the scene) to any anchors that are automatically detected by ARKit is added.

5.4. Point Creation

When pronouncing Point Creation, creating a 3D augmented reality object node that looks as a point is meant. There are five different variables used for creating five different node, these variables are ortanokta: SCNNode, ilknokta: SCNNode, ikincinokta: SCNNode, ucuncunokta: SCNNode, dorduncunokta: SCNNode .

For creating a point, PointAction() function is called which is methodically calling another function noktaOlustur(). noktaOlustur() function is working with sceneView for adding the point in the middle of SceneView. When the function terminates, it returns the value of NoktaNode that creates the 3D point object on the scene. The materials, dimensions, looks, 3D vector space values and the position on the real world to put the object on are all determined.

5.5. Measurement Calculations

There are three measurement calculations happen in the program, those are all works with their own functions. For calculating the distance, calculation() function is called. For calculating the angle, the function angleHesaplama() is used. For the area calculation, areaHesaplama() function is used. Those functions are called when their option on segmented control is selected and their required points are added on the scene. Distance calculations key operation is shown in the Figure 5.4. Angle calculations key mathematical operations are shown in Figure 5.4.1. Area calculations key features are shown in Figure 5.4.2.

```
385
386             //*** 3 boyutlu olarak calıstıgımız icin vector olarak hesaplamamız gerekiyor.
387             let vec = SCNVector3Make(ikincinokta.position.x - ilknokta.position.x,
388                                      ikincinokta.position.y - ilknokta.position.y,
389                                      ikincinokta.position.z - ilknokta.position.z)
390
391             let uzunluk = sqrt(vec.x * vec.x + vec.y * vec.y + vec.z * vec.z);
392
393
```

Figure 5.5 Distance Calculation Code

```
476
477                 let vec1 = SCNVector3Make(ortanokta.position.x - ilknokta.position.x,
478                                           ortanokta.position.y - ilknokta.position.y,
479                                           ortanokta.position.z - ilknokta.position.z)
480                 let vec2 = SCNVector3Make(ikincinokta.position.x - ortanokta.position.x,
481                                           ikincinokta.position.y - ortanokta.position.y,
482                                           ikincinokta.position.z - ortanokta.position.z)
483                 let ust = (vec1.x * vec2.x) + (vec1.y * vec2.y) + (vec1.z * vec2.z)
484                 let alt1 = sqrt((vec1.x * vec1.x) + (vec1.y * vec1.y) + (vec1.z * vec1.z))
485                 let alt2 = sqrt((vec2.x * vec2.x) + (vec2.y * vec2.y) + (vec2.z * vec2.z))
486                 let alt = alt1 * alt2
487                 let formul = ust / alt
488                 let π = 3.1415926536
489                 let sonuc = 180 - ( Double(acos(formul)) * Double(180) / Double(π) )
```

Figure 5.5.1 Angle Calculation Code

```
430
431             let vecEn = SCNVector3Make(ikincinokta.position.x - ilknokta.position.x,
432                                        ikincinokta.position.y - ilknokta.position.y,
433                                        ikincinokta.position.z - ilknokta.position.z)
434             let uzunlukEn = (sqrt(vecEn.x * vecEn.x + vecEn.y * vecEn.y + vecEn.z * vecEn.z)) * 100;
435
436             let vecBoy = SCNVector3Make(dorduncunokta.position.x - ucuncunokta.position.x,
437                                         dorduncunokta.position.y - ucuncunokta.position.y,
438                                         dorduncunokta.position.z - ucuncunokta.position.z)
439             let uzunlukBoy = (sqrt(vecBoy.x * vecBoy.x + vecBoy.y * vecBoy.y + vecBoy.z * vecBoy.z)) * 100;
440
441             let Alan = uzunlukEn * uzunlukBoy;
```

Figure 5.5.2 Area Calculation Code

5.6. Database

Core Data is used for saving the measurement calculations for the project because it is providing the best performance and giving the least load to the mobile device. Core Data is developed and maintained by Apple. It is a framework for managing an object graph. An object graph is a collection of objects that exists in an application.

For implementing the Core Data, there is an option when a new project is started to be created. That option adds the features persistentContainer and saveContext to the AppDelegate class in the project if selected. persistentContainer: NSPersistentContainer is a lazy var(variable), which means its creation is delayed until it is needed. persistentContainer has a container object in it which is working like a stack. Errors and exceptions also handled by this object. saveContext() is a function which provides saving support for the Core Data. It has a context object created inside that checks if a change occurs at data saved. There is an API for Apple OS named Cocoa which consists of the Foundation Kit, Application Kit, and Core Data frameworks. In the saveContext() an NSError could be cached which is a Cocoa feature. NSError gives the information about an error condition including a domain, a domain-specific error code and application-specific information.

When Core Data added to the project, it enables developer to add extensions (a Swift extension allows you to add functionality to a type, a class, a struct, an enum, or a protocol) for data saving. In Augmented Reality Ruler Application, there is one extension added for recording which is CalcData, it contains a public class function named fetchRequest()(function returns the NSFetchRequest to the entity that named "CalcData") and public variables whose are calcAns: Float (the result from the calculation) and calcBaslik: String(the title of the recording that user decided). The public class of the extension is CalcData: NSManagedObjects(which is handling saved objects management).

All the records are added to an item array which leads the data to a table view. pop2upViewController class reloads the data's (self.tableView.reloadData()). Every cell that is in the table view is identified by CalcCell and every item in itemArray goes in the specific rows of cells.

6. TESTS AND RESULTS

6.1. Application Testing

Augmented Reality Ruler Application is a project that helps users by giving them some results they need. Those results can also be obtained from other methods like measuring with a real ruler or a tape measure instead. For testing the project, tape measures are used to compare the tape measurement results with Augmented Reality Ruler Project results. Also, there is a comparison section (6.1.2 Application Success Test Comparison), which is a comparison between Augmented Reality Ruler Application and AR Ruler Tool Application which is also mentioned at Section '2.1.5. AR Ruler Tool'.

6.1.1. Measurement Tests and Errors

For testing Augmented Reality Ruler Application, 28 measurement tests were made. 9 of the tests were made for distance measurement which shown in Table 6.1.1.1, 9 of the tests were made for angle measurement which shown in Table 6.1.1.2, and 10 of the tests were made for area measurement which shown in Table 6.1.1.3.

Table 6.1.1.1 Distance Measurement Test

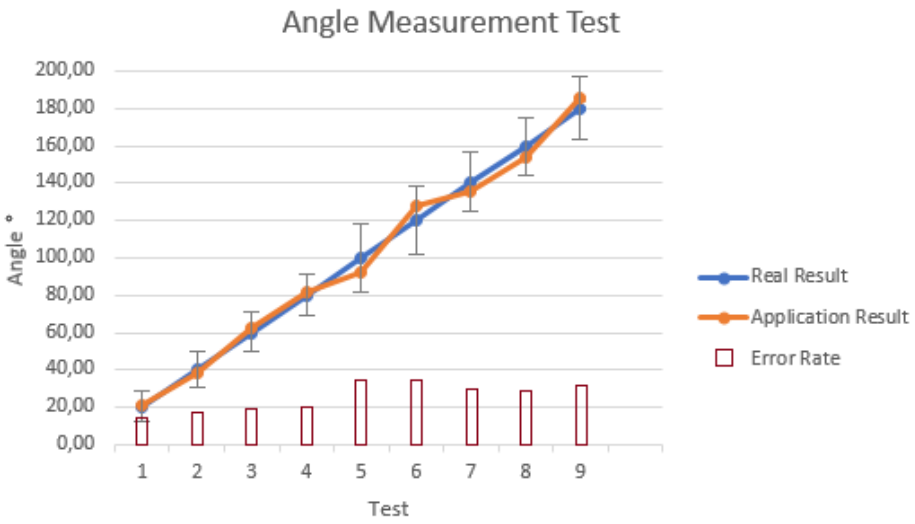

Table 6.1.1.2 Angle Measurement Test

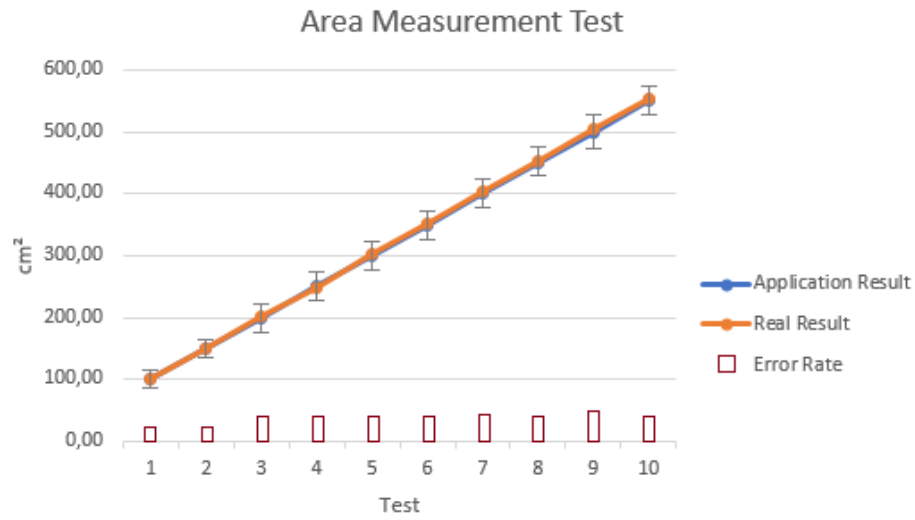

Table 6.1.1.3 Area Measurement Test

6.1.2. Application Success Test Comparison

Augmented Reality Ruler Application and AR Ruler Tool are very similar measurement applications, even though they have significant differences. These applications both are able to measure distance and angle. Augmented Reality Ruler Application has an extra feature that enables users to record calculations. The testing comparison table is shown in Table 6.1.2. For the testing, ten measurements calculated for each operation by two applications (Augmented Reality Ruler Application and AR Ruler Tool). Then the overall result for both applications are added to table for comparison. As seen in Table 6.1.2, even if the Augmented Reality Ruler Application project is more successful, it is possible to have a small error rate because these tests are done by a human hand and the camera measurement is very sensitive. Therefore, it can be accepted that the two projects are nearly equally successful.

	DISTANCE	ANGLE
Augmented Reality Ruler Application	14.96 cm	55.12°
AR Ruler Tool	15.08 cm	54.46°
Real Result	15 cm	60°

Table 6.1.2 Application Test Comparison

7. CONCLUSION

Eyes are the most important sense organ that people most care about and fear to lose. Because being without it means getting lost in the dark and being in space. Thanks to it, we see the facts. Augmented Reality expands the horizon by adding to the seen reality, that is why it is so important. Augmented Reality Ruler Application is a good way to show the beauty of Augmented Reality.

Nowadays, almost all major companies use Augmented Reality. In addition to companies that market AR products, some companies use AR technology to advertise, some to educate or give a subject, others to work faster. Augmented Reality Ruler Application can significantly increase the speed of work except for the pleasure or hobbies and can be used in many different business sectors.

In the future, Augmented Reality will always be so popular. Therefore, companies with high perspective spend a lot of money to develop this new technology. People are gradually getting their eyes on this fun innovation.

7.1. Feature Works

In the future works, as demand analysis shows, this project can be put up for sale in the application markets and a good income can be achieved as expected. Because there is no other application in the markets that offers the features provided by Augmented Reality Ruler Application.

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