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Augmented Reality in E-Commerce

Bachelor of Science in Information Technology

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Certificate

This is certifying that the report of the final year project entitled "Augmented Reality in E-commerce", submitted to the Department of Computer Science, Bahria University Islamabad Campus, in partial fulfillment for the award of the Bachelor of Science in Information Technology.

The project is carried out by Mr. Hamza Dar, Enrollment No. 01-235161-012 and Mr. Babar Ali, Enrollment 01-235161-005 under my supervision and guidance.

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Abstract

The fast evolution in computing power over the past couple of years helped to overcome the gap between technology and the traditional pen and paper approach. Designing and implementing an augmented reality application to provide enriched shopping experience is a conceptual understanding of computer science. In the augmented reality the information about the surrounding becomes interactive and digitally manipulated, it also has the potential to gather the tacit knowledge.

Unlike other technologies like virtual reality (VR) or Extended Reality (XR), Augmented reality creates totally artificial world, that augment the virtual objects into real world which means it overlays virtual objects onto the real world surrounding. The main objective of this project is to develop an Augmented Reality Application that utilizes the AR technique to augment the virtual 3D object into real world, 3D objects include furniture's and watches etc. when the application runs, user can view various product of furniture's and to investigate in real world, user starts the AR mode where user can place any type of furniture in the house where the actual product going to be placed and investigate it by moving around. We also provide the rotation and resizing technique so user can investigate the product better, also user drag the 3D object along the surface to change the position of the product.

Acknowledgments

We would like to thanks our supervisor "Talha Naqash" for his effort and support which helps us to achieve our goals to complete our project and also, he taught us various approaches to view Augmented Reality from different angles we didn't expected. His experience, ideas and expectations were a great source of much inspirational. Despite his busy schedule, he has been extremely forthcoming in supporting and helping us to complete our project on time.

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Acronyms and Abbreviations

UMP	Universal Windows Platform
SDK	Software Development Kit
API	Application programming interface
GUI	Graphical User Interface
AR	Augmented Reality
3D	Three-Dimensional
COM	Concurrent Odometry and Mapping
IDE	Integrated Development Environment
NNC	Nearest Neighbor Classification

Chapter 1

Introduction

Augmented reality going to impact all of us in an interesting way. Augmented reality is a technology that works on computer vision-based recognition algorithms to augment virtual objects, sound, video, graphics and other sensor-based inputs on real world objects using the camera of your device. It is an interesting way to render the real-world information and display it in an interesting way so that virtual elements or objects become part of the real world [1].

We decided to develop an augmented reality application for E-commerce business. Our application will help the users to buy the product while investigating the product in real environment. Suppose you bought new house before shifting you need to buy some furniture like beds, tables, chairs, paintings, wall clocks, lamps or exercise machine, matching these things with your surrounding would be your main objectives and that objective can be achieved by our application, in which you can augment products in real time. The application has its own limitation as we are using ARcore SDK of Google that is supported by modern smartphones [2]. Our application will provide the best experience of interior designing and provide next level shopping while using Augment Reality, which is stated, checking how it looks like in real life when it would deliver to your house. Using our Application, user simple drag and drop the bed, chair, painting, clock, table

or lamp to the scene and investigate that product while walking around to determine how it looks like in real life. Investigating the product through our app is same as someone visit the store to buy it.

1.1   Problem Description

The intended application will initially focus on detecting the surface and placing the chosen set of 3D elements into real world surrounding. The initial version of application is planned to detect the surface or grounds and then placement of 3D elements onto it, to visualize the elements in real surroundings for better understanding and visualization before buying the product. Traditional people use marker less technology that was unreliable [3].

1.2   Project Objective

The Project is aimed at developing an application that will allow the user to augment 3D model or virtual elements of products onto the detected surface, ground or table top etc.

1.3   Project Scope

The Project will provide the platform for E-commerce where consumer will experience next level of shopping. We will use AR technique to provide consumer pre visualization of product before actual buying of paying for that product. Consumers will detect the surface where they want to place the product and then 3D element will be place onto it so consumer can determine all aspects and attributes of product while visualizing into real surrounding.

1.4   Benefit

Our Application will be very beneficial for E commerce consumers and will helped them in:

- Consumers will modify and customize the product from the comfort of their homes before buying. Customization involves design, colors, pattern and much more using augmented reality technique.

- Using our Application consumers not only interact with the product but they will also able to explore the functionalities of product as well.

- Our Application grants the consumers who typical shop online the chance to view the product in form of 3D model in real surrounding and they will interact with the same manners as they would visit the physical store.

- Consumer can detect the surface and place the 3D object onto it and also drag along the surface for better view as the product is actual delivered to them.

1.5   Outline

This report is consisting of seven chapter. Chapter one includes, introduction section and moved to the problem, object, scope and benefits of augmented reality in e commerce. Chapter two present the literature review of previous studies relevant to the topic and rest of the report is organized as follows.

Chapter 2

Literature Review

The term AR was introduced in 1990 by Tom Caudill. Since then, a lot of researches are done and a lot of application have been developed using AR for various fields that include education, health and medicine, Video Games, Interior Design, Architecture Design, Online Shopping, Military Training and Employee Training. And recently many researchers are working on AR to develop application for pure E-Commerce use and world leading company are using AR technology now like Amazon, IKEA, Ali Baba. Google developed ARcore API/SDK to provide platform for augmented reality which is open source and free. In this section all the techniques, topics, concepts, theories and methods that are related to our topic will be discussed.

2.1 8th wall Augmented reality platform for developing AR application

8th wall is AR developing platform which breaks the barrier between digital and physical, and fill the development gap between iOS and Android development and also provide the access to AR content through web browser. 8th wall provide 3 features for AR content. First one is, 8th Wall Web which provide features of AR content through web browser, which helps

to enable augmented reality content to run directly on any kind of existing web. Basically, it runs on web browser and its first AR platform which is one of its own kind. It creates seamless user experience that removed the inconvenience need to download the mobile apps to run AR content. Anyone who has access to mobile phone can now easily access to AR content. Second feature is, 8th Wall XR to develop AR application for both iOS and for android. This SDK is used to develop AR application inside unity platform so the application can be developed and run on both iOS and Android devices. Third feature is, AR Camera that provide rapid protype and share AR content on mobile web so user can access through mobile web browser without need to download the application. No coding required, user simply upload 3D models for prototype and drag and drop interface provided by 8th wall helps to investigate the content through web browser.

Figure 2.1: 8th wall prototype

2.2 Construct 3D Augmented Reality Application

This application provides basic set of geometric shapes i.e. cubes, sphere, cylinders, lines, cones, planes and points [4]. It enables the user to take measurements, learn about curves intersection, surfaces and also support and provide analytical behavior of dynamic geometry which means it provide knowledge to investigate the behavior of moving one point on sphere and results in change of its radius.
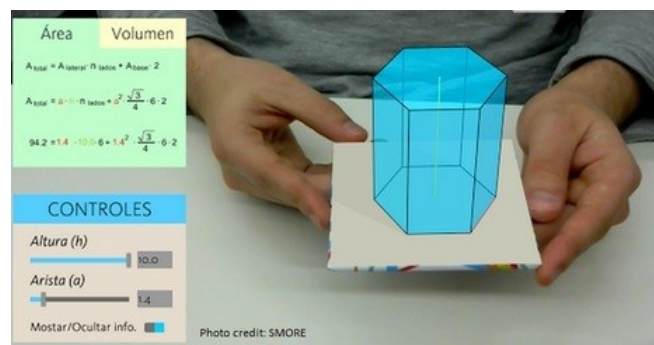
Figure 2.2: Construct3D app

2.3 Existing AR application IKEA, Amazon and Alibaba and Google

During last few years, many world leading companies hired professional developers and researchers to develop practical theories and application for the adoption of AR techniques in their business. Due to these studies many innovated projects have been developed like "Project Glass" [5]. Project Glass is one of the most enthusiastic enterprise of google. It's one of its kind which displays the information just like mobile phone.
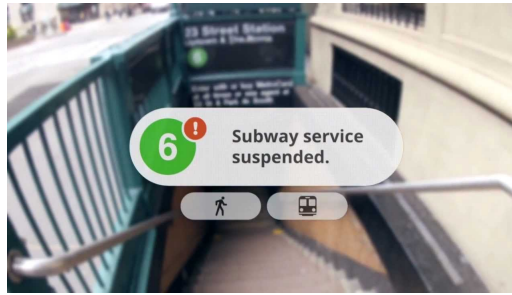
Figure 2.3: Project Glass

The world leading E-commerce companies like IKEA, Alibaba and Amazon recently implemented the AR mode in their application for better shopping experience but the feature is only available for the limited mobile devices having certain requirements.

2.4 Vuforia Engine SDK used for developing AR-application

Vuforia is most famous SDK tool and widely used for developing AR applications for Android, iOS and UWP platform. This SDK includes features of user defined targets, image recognition, tracking, text recognition, object recognition, image targets. It enables the developer to develop an AR application for Android, iOS devices [6]. This SDK is supported by Android Studio, Unity, XCode and Visual Studio. Let's cover its feature "User define targets". User define target is image target that is created during run-time using camera frame which is selected by user. This feature allow user to select or choose image during run-time from the available environment without having to carry around the pre-defined targets. Basically, Vuforia Engine API handles the process of capturing, building and tracking a target defined by user.

Figure 2.4: Vuforia user define target

Chapter 3

Software Requirements Specification

3.1　Proposed System

The system we have proposed is AR application that can run on mobile device. The proposed AR application will detect the surface through mobile camera and then augment the 3D elements onto detected surface of real surrounding, though which user of application can visualize and investigate the 3D element. The 3D element may include chair, table, bed, dining table, painting, clock or any other item of user's choice. On starting the application, the GUI will be displayed, by selecting appropriate option the list of 3D elements will be displayed with icon and description of that element. The user will click on one of the items of his/her own choice to view in AR mode. Now first user has to select or detect the surface of appropriate real surrounding on which user want to augment the item. The user will detect the surface of real environment using phone camera in the presence of appropriate light. The surface detection engine running in the background will detect the surface and augment the 3D model of element selected by user. Once the 3D element is augmented or displayed onto detected surface the user can drag it along the surface for better view, modify and customize the 3D element and also add to cart to buy it.

3.2   Existing System

There are many AR application for e-commerce available on the internet but all of them have their own limitation. IKEA company provide AR feature to buy feature but it's only operating in United States, Amazon and Alibaba also provide AR technique to augment the item which you want to buy into real surrounding but they are complicated, hard to operate, all devices doesn't support that feature and these might be useful but sometimes the user doesn't have the internet connection to visualize the 3D element [7]. So, they all have their own limitation. From limitation of device specification to internet connection.

3.3   Requirement Specification

This section of requirement specification will provide the both functional and non-functional requirements of our AR application.

3.4   Functional Requirements

This section provides functional requirement overview of the system. Various functional modules that can be implemented by the system will be:

- System should able to detect the surface on which the 3D element will going to be displayed.

- System should able to detect the image target onto which the 3D model going to be placed.

- System should able to visualize the 3D element of selected item onto the detected surface and onto the image target.

- System should fulfil the requirements of ARCore SDK [8].

- Mobile Device which is supposed to run the AR-application should have a camera and for better augmentation there shall be appropriate light should be available in the room.

3.5 Non-Functional Requirements

The non-functional requirements of the application are discussed below:

- **Availability**

  The application should be installed on the device and should be connected to internet. The system should be available all the times, in case of hardware failure or database corruption am alternative page will be shown.

- **Portability**

  The system should run on iOS and Android devices as well.

- **Usability**

  The system should be very user friendly, keeping in mind that user who will be using this application doesn't know about AR content. So, the interface should be simple and easily understandable by the user and also there should be tutorial or guidance to use the application.

- **Effectiveness**

  Application should provide user with accurate result in case of ground detection or augmentation of 3D model.

- **Robustness**

  The application should and must be stable.

- **Reliability**

The application should and must be run on all android devices that fulfil the ARCore requirements and provide accurate result in respond of user input.

3.6 Use Cases

Use Case diagram is an essential requirement of any hardware system design or software system design because it provide the substantial information related to that hardware or software system. Following diagram is use case diagram of our application. This diagram describes the interaction of different actors and system activities.
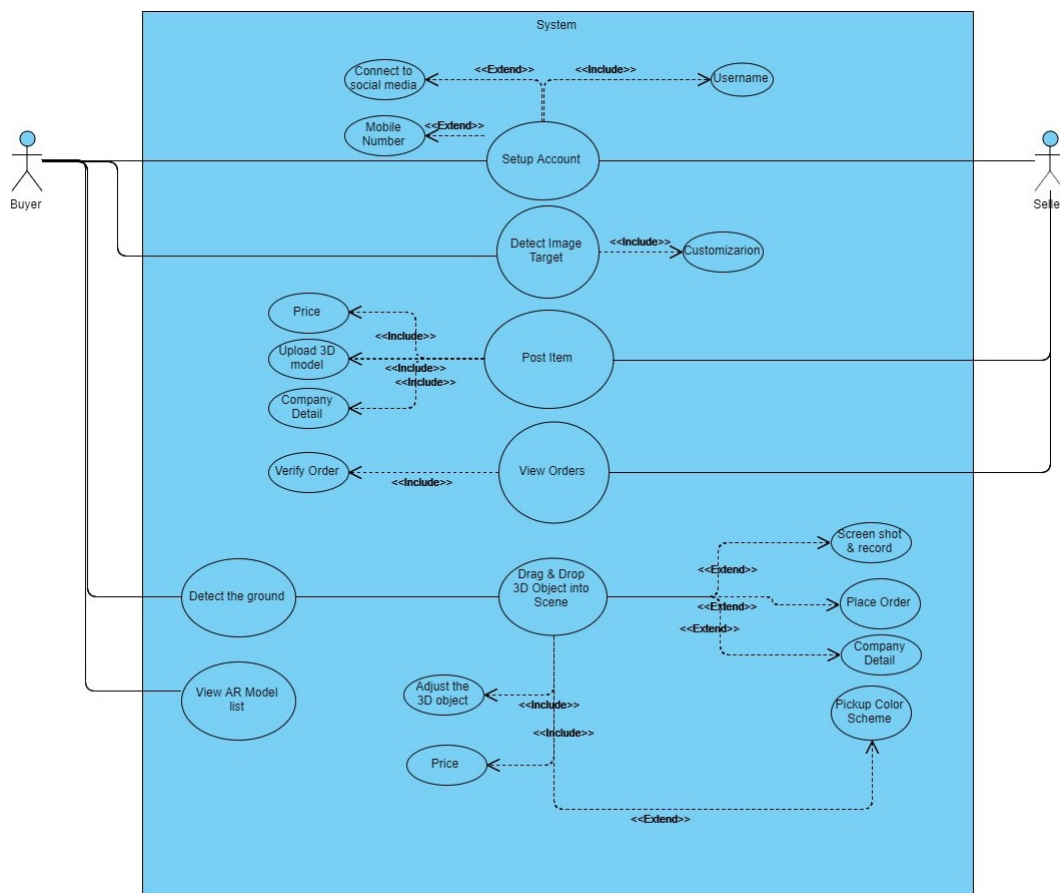
Figure 3.1: Use Case Diagram of AR Bazaar application

3.7   Use Case Description

1. Setup Account
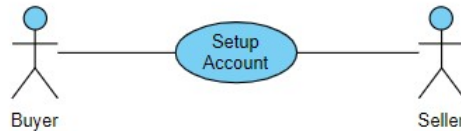
Figure 3.2: Setup Account

This use case describes the registration process of buyer and seller, where buyers can setup their account by either using phone number of by connecting to one of their social account that include Google, Gmail and LinkedIn etc.

Table 3.1: Setup Account

Use case Id	UC-1
Name	Setup Account
Brief Description	The Setup Account use case allows the User to register themselves
Actor(s)	Buyer and Seller
Pre-Conditions	User must download the application and have access to internet.
Post-Conditions	
Title	**Description**
Success	The User entered data is stored in the user account. Confirmation is sent to the appropriate email address.
Unsuccessfully	The User entered invalid data or chose to cancel the account creation request. In either case, no account will be created.

2. View AR Model List
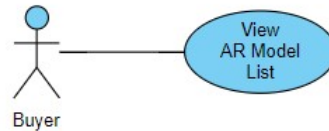
Figure 3.3: View AR Model List

This use case is an individual use case of the system, where catalogue of the product will be displayed to the user and from where user can select on of the product or module to view in AR mode.

Table 3.2: View AR Model List

Use case Id	UC-2
Name	View AR model list
Brief Description	The "View AR model list" use case allows the User to view the items which he/she want to buy and also augment it.
Actor(s)	Buyer
Pre-Conditions	User must be registered and must be login to access the features.
Post-Conditions	
Title	**Description**
Success	3D object would be displayed/augmented on the scene.
No Detection	No 3D object would be augmented from the given criterion as the ground is not detected, select again/ detect the ground again.

3. View Order
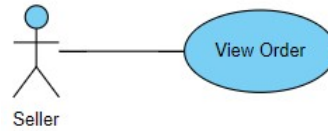
Figure 3.4: View Order

Table 3.3: View Order

Use case Id	UC-3
Name	View Order
Brief Description	The View Order use case allows the Seller to view the orders from the buyer
Actor(s)	Seller
Pre-Conditions	Seller must post or upload the item on the application viewing the order list.
Post-Conditions	If the order placed, then seller verify the order and ship the goods to the address given by the buyer.

4. Ground Detection
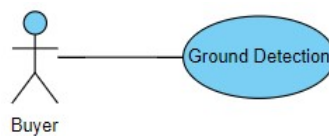
Figure 3.5: Ground Detection

After the catalogue, when user will select the product then camera will open to detect the ground where user want to place the product for investigation.

Table 3.4: Ground Detection

Use case Id	UC-4
Name	Ground Detection
Brief Description	The Ground Detection use case allows the buyer to detect the surface of real surrounding to augment the 3D element.
Actor(s)	Buyer
Pre-Conditions	Item must be selected by buyer in order to view and detect the ground.
Post-Conditions	If the ground is detected, then the selected item will automatically augment onto it.

5. Detection of Image Target
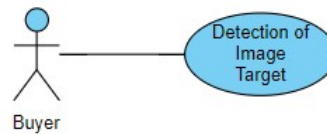
Figure 3.6: Detection of Image Target

This use case is created to check the detection of image target where 3D model of watch going to be placed.

Table 3.5: Detection of Image Target

Use case Id	UC-5
Name	Image Target
Brief Description	The Image Target use case allows the buyer to detect the image target to augment 3D watch model.
Actor(s)	Buyer
Pre-Conditions	Item must be selected by buyer in order to view and detect the ground.
Post-Conditions	If the image target is detected, then the selected item will automatically augment onto it.

Chapter 4

System Design

This chapter involve the software development phase and that is based on the detailed analysis of the system. Basically, the system design means converting the requirements into reality. Hence it should meet the requirements of the system. The core purpose of this chapter is to make or create a technical solution that should satisfy the functional requirements for Augment Reality Application. In this chapter the system design and diagram which are related to our AR-application going to discuss. To explain the working model and architecture of our application the diagrams are used. Also, in this chapter the components of our application, the architecture of our application and interface of our application will going to discuss.

4.1   System Architecture

This section will describe the system architecture of our application. Basically, System Architecture is the conceptual model of any system or software that describe the structure, behavior and view of any system.
The System architecture of our application is 2-Tier Architecture; there are two-layer, Presentation layer that include user interaction with our application through rich graphical user interface and Second layer is logical

layer that handles all backend processing, handling errors and all logical implementation of our system.

Our Application is dividing into following component:

- GUI that contains list of products with icon and description.

- Motion Tracking and Environment Understanding.

- Virtual element, object or 3D model of a products.

- Detection of surface on which the 3D virtual element going to displayed.

- Detection of image target on which 3D model of watch going to be displayed.

- Image Targets and ground should be viewed under bright lighting. Ground should have texture so it'll be easy to extract feature points and image should be clear to.

- Plotting the 3D virtual element in augmented reality view.
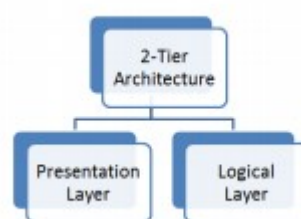
Figure 4.1: Architecture Diagram

4.1.1 Presentation Layer

The Presentation layer includes the interface design of our application, the user going to interact with it. This layer mostly contains all the markup files of application. The interface files of our application are markup files

that are written using extensible markup language known as XML. The graphical elements that are noticeable or shown to user while interacting with application are designed or created using XML language, so we've used this language i.e. XML, to design our user interface.

4.1.2 Logical Layer

The logical layer of our application contains the code-behind language. In our project this layer perform all the processing either its ground detection or its placement of 3D model, calculation and all kind of input from user either for modification of 3D model or customization of that model and return the result back to presentation layer so user can perform further operation either to buy it or add that item to cart. This part contains the actual working of our application that handles the action and behavior of the application.

4.2 Design Constraints

This section refers to as limitation on the requirement and/or operation condition under which our application going to run or operate. As we've discussed the constraints and limitation of our application in previous chapter so we've made certain adaptations to. To make it user-friendly we've made very simple procedures for each functionality of our application.

4.2.1 Surface Detection Constraint

Our application uses cluster of feature point to detect the surface, table top, plane or any flat surface. The surface without texture such as white wall may not detected properly or under dark light the surface is hard to detect because our application can't locate the feature points due to dark light and poor camera result.

4.2.2 Image Target

In our application we are also going to use image target which refers to as images that Vuforia Engine can detect and track. Unlike traditional marker i.e. QR or bar code, image target doesn't use black and white codes that need to be recognized. The engine will detect the feature that may found in the image by comparing these features against the known database of Vuforia engine. These features will be detected under suitable light and through phone camera.

4.2.3 Lightening constraint

Lightening is important factor in our application, user required to augment the 3D model under suitable and appropriate light. If there is low light then our application can't able to locate the cluster of features point of surface to detect the surface of ground, place or flat surface.

4.2.4 Camera Availability

The mobile device on which our AR-application is going to run should have high Mega-Pixel camera in order to render and view the 3D model in higher quality for better view and better augmentation. Our application will also detect the information about the lighting of the real surrounding and will provide the color correction and intensity, this information about the light will let the 3D model with same condition as the real surrounding to provide realism.

4.2.5 Virtual 3D-model constraint

As user going to augment the 3D virtual model into real surrounding so the texture and shading of 3D model should be appropriate to provide the sense

of realism. Just like the user physically visiting the store and investigating the item.

4.3   Design Methodology

This section contains the principles, techniques, methods and processes to design the application. In order to design the whole processing of our application we'll use the procedural structure approach. Spiral Model is used to develop the application [9].

- User will select the product from list of items which he intended to visualize into real surrounding or use the augmented reality mode.

- Application will run the motion tracking technology through phone camera to identify the interesting points called features points that appear to lie on common surfaces like tables and walls which helps to detect the surface.

- If the surface is detected then the 3D model of selected item by the user will be place onto the detected surface so user can augment or visualize it.

- User can drag the 3D model along the detected surface i.e. changing its rotation and position for better view.

- Application will also run the Vuforia API which will detect the image target and place the selected model onto it i.e. 3D model of watch.

- User can also modify and customize the 3D model i.e. color and size of product.

- User is satisfied from the customization or from the product, user needs to press the "Add to cart" or "buy the product" button.

- Application asked for users' location on which the product should be deliver and display the cost of product and mode of payment i.e. most probably cash on delivery.

4.4 High-Level-Design

This part covers the high-level design of our application. High-level design contains the overall architecture of software, workflow or application, behavior of the application i.e. relationship between the modules and also contains the follow of the application or software. When user will launch our application the list of products will be display to the user, where he can select one of the products to view in augmented reality. When user select the product, the camera will open to detect the surface onto which user want to place the object, user can rotate and change the position of the 3D model to visual better. Then user can also place an order by remember code of the product and place the order.
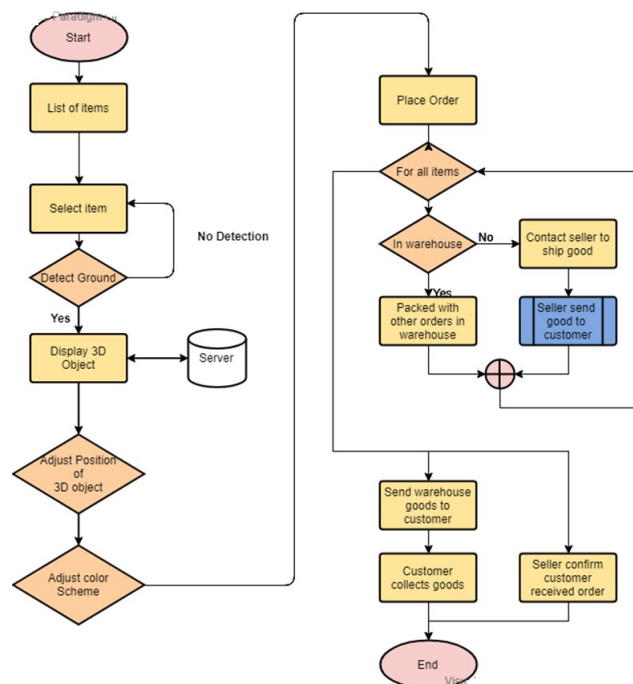
Figure 4.2: Workflow Diagram (describe the flow of the application

4.4.1   Sequence Diagram:

When user start the application, the list of AR model will be displayed when user select one of them then the 3D object of that model will be loaded from the server and camera would be start to augment the object in 3D view, before augmented the system first detect the ground. If ground is detected then the object will be loaded from the server and displayed on the screen of user.
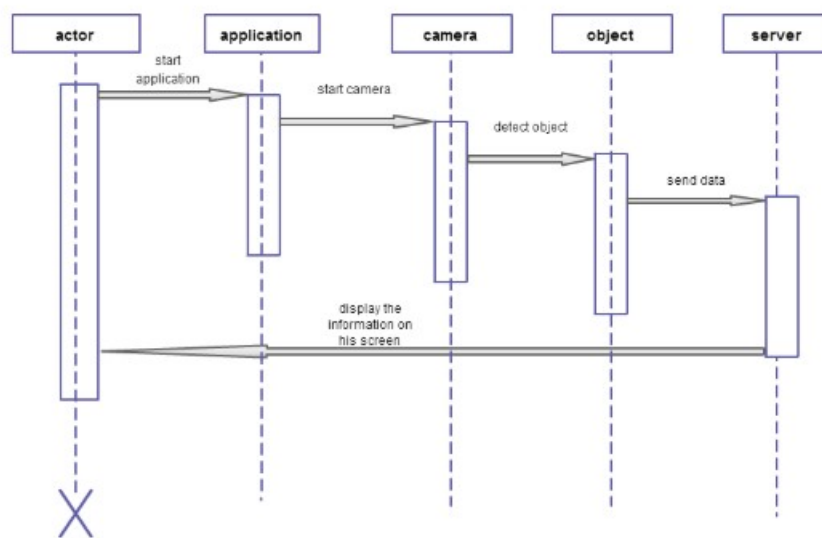
Figure 4.3: Sequence Diagram

4.5   GUI Design

Graphical User Interface (GUI) of any application should be user friendly and simple, as our application include augmented reality and is going to be used by people who probably are unaware of augmented reality i.e. how to use or how to interact with product in 3D view, so that's why we make it simple and easy to interact. First step of Any Application is icon and its name so we decided to name our application as "Bazaar" which means a place or market where goods are exchange or sold.

4.5.1 Iconography

Iconography represent the logo of any application, application launcher icon and also used

Figure 4.4: Logo of Bazaar AR Application

4.5.2 Splash Layout

When user start our application the splash screen will be displayed for only 10 second and then the dashboard of our application will be shown.

Figure 4.5: Splash Screen of Bazaar AR Application

4.5.3 Home Page Layout

In the home layout the user will be shown menu from where the user can view the various option of product i.e. product selection for AR view, view price and description etc.
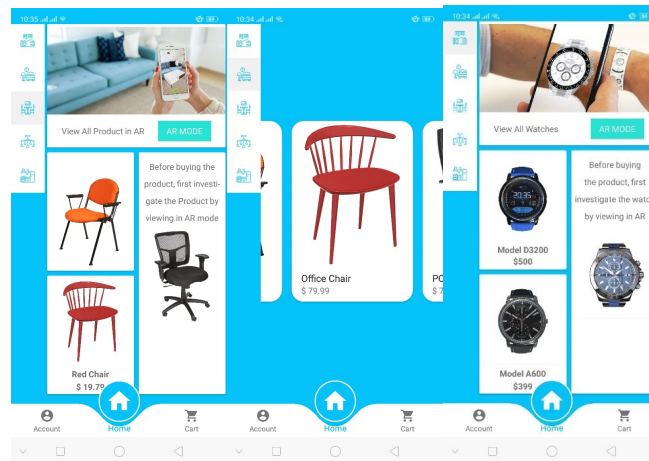
Figure 4.6: Home Page of our Application

4.5.4 Detect Ground Layout

When user will open AR mode, the catalogue of the products will be displayed but first user need to detect the ground in order to view the product in 3D. Users need to follow the instruction i.e. camera facing the place where he want to place the object and rotation of phone in a circular way so the camera will detect the feature points of ground that will help to make a place/surface where user can place the object. Make sure the ground doesn't have white texture, or with less texture else it's difficult to find the feature points.

Figure 4.7: Home Page of our Application

4.5.5 3D Object Placement Layout

When the ground is detected the circular white points will be displayed as shown in figure 4.6, then user can place the 3D object onto it where user can rotate, resize the 3D object. User can place multiple 3D object in one scene or only one object as shown:

Figure 4.8: 3D object Placement

4.5.6 Detect Target Image Layout

When user will open the watch module in AR mode, the catalogue of the watches will be displayed but first user needs to detect the image target in order to investigate the watch onto his wrist. User must place the image target onto his wrist then select any watch from the catalogue. The image target is shown as below:

Figure 4.9: Image Targe

When the image target will be detected then the watch which is selected by user will be displayed onto the wrist of the user. When the 3D model of the watch will be displayed onto his wrist user can investigate by changing colors and investigating various watches etc.

Figure 4.10: 3D Watch Placement onto image target

4.5.7 About Us Layout

This layout shows the information of our company, including contact information etc.

Figure 4.11: About Us Layout

Chapter 5

System Implementation

This chapter uses the structure which was created during the architectural design and the uses the outcome of system analysis to implement the techniques to develop our application that meet the requirements of the stakeholder. This chapter involves the implementation of system requirements that was developed in the initial life cycle phases to construct the system elements.

5.1   System Architecture

This application is totally based on two tier architecture, Basically, first layer is presentation layer that involve the rich graphical user interface (GUI) through which user going to interacts with our application. Second layer or tier is the logical layer of the application that handles all kind of errors that will take place and also handle the processing of our application I.e. detection of the surface or detecting the image target. In order to develop our application different kind of tools and techniques are used.

5.1.1   Motion Tracking

Motion tracking is done for recognizing the location of camera or person using ARCore SDK. As person moves around the place, ARCore uses a pro-

cedure called "concurrent odometry and mapping", or COM, to understand where is the person relative to the world around the camera. ARcore detects the visually distinct points or features through camera of phone called feature points and use these features to calculate the variation of location and also these features help the application to understand the environment. These features also used for ground detection.
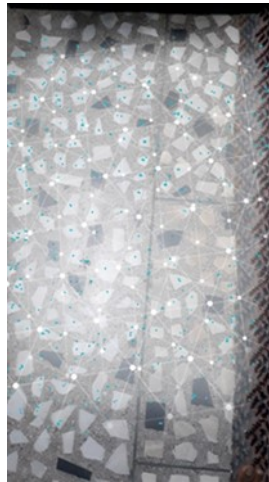
Figure 5.1: Feature Extraction

5.1.2 Ground Recognition

For recognition of ground, classification is used. In order to classify the features points which, we obtained during process of motion tracking, we have used Nearest Neighbor Classification (NNC). In this technique the feature points that are nearest to each other are group together to create clusters or groups. These groups or clusters of feature points that seems to extract from the common surface makes them available to our application as plane, which will used to place the 3D content. So, these clusters of feature points are used to detect the surface with proper texture on it, surfaces without textures may not detect properly because of the gap between feature points or there might be fewer number of feature points extracted from the place. Also, user have to move the camera in a circular form so camera

focus onto that area and identify more clusters of feature points, when the surface is detected user.

5.1.3 Visualization of 3D model

For visualization of 3D content, Application asks the user to rotate the phone in a circular way, camera facing the place where user want to place the 3D model. Once the clusters of feature points are identified and surface is detected then user can place the 3D object by pressing onto the place.

Figure 5.2: Detected surface.

5.2 Tools and Technology

Tools used in developing our application are mentioned below:

- **Unity3D Engine**

  Unity is a real-time development platform and cross-platform game engine which was developed by Unity Technologies and support more than 25 platform. Unity only support three scripting languages, C(Hash), Boo and Unity Script also known as JavaScript. We used C(Hash) to develop few modules inside unity software.

- **Android Studio**

  It's the official IDE for android operating system, which was designed especially for android development. Java, kotlin and XML are main languages supported by the Android Studio.

- **ARcore Software development kit**

  ARCore is an augmented reality software development kit which was developed by Google that allow for augmented reality application to be built and it's supported by Android Studio, Unity, iOS and Unreal Engine to build AR applications.

- **Vuforia**

  Vuforia is an augmented reality software development kit (SDK) that is used to create the AR-app. It practices the computer vision technology to track or detect the It uses computer vision technology to recognize and detect the images.

- **Adobe Suit**

  During development of our project we need to create logo, icon for our app and for rich graphical user interface, we used Adobe Illustrator and Photoshop.

- **Blender and Maya Software**

  Blender and Maya is 3D computer graphic software which is used to create 3D models, as we download the 3D models from the internet but somewhere we need to edit those models so we use these software to resize the size of the model, change the texture of the model, change the color of the model etc.

- **Firebase**

  Its mobile and web application development platform used for real time-database.

5.3 Environment Language used

- **C(Hash)**

  It's a scripting language which is develop by Microsoft which we used to develop few modules inside Unity Software.

- **Java**

  The 70 percent of the project is done in Java language. We used java language inside android studio because java is widely used OOP language that supports the integration with large number of libraries.

- **XML**

  Extensible Markup Language (XML) is developed by Microsoft and we used this language inside Android Studio for rich Graphical User Interface. Android Studio used this language for front-end design to create the GUI. As designing GUI is an essential part of development as user is going to interact with application through GUI.

Chapter 6

System Testing and Evaluation

In this chapter the performance and evaluation of our application will be discussed, we are going to test our application by using different scenario and techniques. The core purpose for developing such application is to provide the best shopping experience to potential customer in an efficient way and easy way. This phase involves the system testing and all of its modules. If the outcome from the tested system match the specified requirement then testing is said to be successful.

6.1 Graphical User Interface Testing

Graphical user interface (GUI) is main component of any application. Making GUI simple and user-friendly should be main objective of any developer keeping in mind that user with no knowledge will going to interact with the application. So, testing the graphical user interface (GUI) is a process to evaluate the performance and evaluate that how easily user is interacting with the application by simply reading the text or image as the augmented reality is a complex topic or technology and majority of people don't have knowledge related to it. Thus, making GUI simple and user friendly so that user can easily experience the augmented reality technology.

6.2   Usability Testing

This testing is done to ensure that user with no technical knowledge can easily experience the augmented reality technology and able to investigate the product before actually buying or visiting store personally.

6.3   Compatibility Testing

This testing technique deals with the installation of application on platform where user going to install. As our application is android based and we're using ARCore SDK which has its own limitation. So, our application should run on ARCore compatible devices.

6.4   Application Performance Testing

Application performance testing deals with the verification of all non-functional requirements of our application, that include efficiency, availability, portability, usability and compatibility.

6.5   Exceptional Handling

Exceptional handling deals that if any particular function is not working then error or alternative function should be performed.

- In the ground detection mode, if the ground is not detected properly then error message will be shown and ask the user to detect the ground again with better texture.

- If the target image is not detected then error message will be shown saying the unavailability of image target.

- If the 3D model is not available then error message will be shown saying that model is not available right now.

6.6 Installation Testing

Installation testing deals with the installation of the application on different android smart phone devices having different versions i.e. Oreo and Nougat etc.

6.7 Load Testing

Load testing deals with the response time of our application as we are using static 3D model, so placement of 3D model into scene is in second. This testing also performed to measure the time to detect the ground, image target and placement of 3D object.

6.8 Test cases

1. Application Installation

Table 6.1: Application Installation

Test Case ID	TC-1
Function to be tested	Installation of the application
Revision history	Created by Hamza Dar at 10:30 A.M.
Initial State	Device on which application going to install must be compatible.
Test Setup	Availability of apk file.
Input	Open apk file of our application wherever it is saved.
Expected Output	Application should be installed successfully.
Actual Output	Application is installed successfully.
Status	Pass.

2. Running the Application

Table 6.2: Running the Application

Test Case ID	TC-2
Function to be tested	Application launched successfully or not.
Revision history	Created by Hamza Dar at 10:35 A.M.
Initial State	Application must be installed.
Test Setup	Apk file should be installed.
Input	Tap on the icon of application.
Expected Output	Application should launch successfully.
Actual Output	Application is launched successfully.
Status	Pass.

3. Detection of the ground

Table 6.3: Detection of the ground

Test Case ID	TC-3
Function to be tested	Ground detected Successfully or not.
Revision history	Created by Hamza Dar at 10:40 A.M.
Initial State	Availability of the phone camera and texture of ground should be clear.
Test Setup	Camera should be enabled.
Input	Tap on AR mode button. it is saved.
Expected Output	Ground should be detected; white circle should be displayed.
Actual Output	White circles are displayed hence ground is detected.
Status	Pass.

4. Placement of 3D model

Table 6.4: Placement of 3D model

Test Case ID	TC-4
Function to be tested	Placement of 3D model onto detected surface.
Revision history	Created by Hamza Dar at 10:45 A.M.
Initial State	Ground should be detected
Test Setup	Availability of 3D model in the database.
Input	Tap on the detected surface to place the 3D object.
Expected Output	Successfully placement of the 3D model onto detected surface.
Actual Output	3D model is successfully placed onto detected surface.
Status	Pass.

5. Detection of the image target

Table 6.5: Detection of the image target

Test Case ID	TC-5
Function to be tested	Image target detected successfully or not. surface.
Revision history	Created by Hamza Dar at 10:50 A.M.
Initial State	Camera should be enabled
Test Setup	Availability of image target.
Input	Tap on the image of watch.
Expected Output	3D model of the watch should be place onto image target.
Actual Output	3D model is placed onto image target.
Status	Pass.

6. Splash Screen

Table 6.6: Splash Screen

Test Case ID	TC-6
Function to be tested	Splash Screen should be displayed for 10 second
Revision history	Created by Hamza Dar at 10:55 A.M.
Initial State	Application must be installed
Test Setup	Application availability.
Input	Tap on the icon of the application.
Expected Output	Splash screen should be displayed for 10 second.
Actual Output	Splash Screen is displayed for 10 second
Status	Pass.

7. Buttons

Table 6.7: Buttons

Test Case ID	TC-7
Function to be tested	All the button should perform respectable activity.
Revision history	Created by Hamza Dar at 11:05 A.M.
Initial State	Application should be running
Test Setup	Application Availability.
Input	Click the buttons
Expected Output	All button should perform respectable activity.
Actual Output	All buttons are performing respectable activity.
Status	Pass.

8. Controlling 3D object in real-time

Table 6.8: Controlling 3D object in real-time

Test Case ID	TC-8
Function to be tested	3D model should be rotatable and resizable when placed.
Revision history	Created by Hamza Dar at 11:10 A.M.
Initial State	Object should be placed onto the detected surface.
Test Setup	Availability of 3D model of the product.
Input	Hold the 3D model with one finger and swipe with another for rotation and tapping the object once with two fingers for resizing.
Expected Output	3D object should be rotatable and resizable.
Actual Output	3D object is rotating and resizable in real time.
Status	Pass.

9. Changing the position of 3D model

Table 6.9: Changing the position of 3D mode

Test Case ID	TC-9
Function to be tested	Position of the 3D model is changeable or not.
Revision history	Created by Hamza Dar at 11:15 A.M.
Initial State	3D model should be placed onto the detected surface.
Test Setup	Availability of the 3D model.
Input	Tap the 3D object and drag along to change the position.
Expected Output	Position of the 3D model should be changeable.
Actual Output	3D model is moving onto another position.
Status	Pass.

10. Customization and Modification

Table 6.10: Customization and Modification

Test Case ID	TC-10
Function to be tested	Colour of 3D model of the watch is changing in real time or not.
Revision history	Created by Hamza Dar at 11:30 A.M.
Initial State	Image target where 3D object going to augment should be detected.
Test Setup	Availability of 3D model of watch.
Input	Click on button to change the colour of watch band.
Expected Output	Colour of the watch band should be changing accordingly.
Actual Output	Colour of the watch band is changing accordingly.
Status	Pass.

Chapter 7

Conclusion And Future Work

Developing an augmented reality application was totally new as well as a quite interesting and challenging task. We accept this challenge to make the application which will going to help the people augment the product before buying or before payment. Embedding different kind of APIs, SDKs and software was challenging task and yet a bit difficult and time consuming. We chose to develop the augmented reality application because of huge market gap, huge market of AR and scope. This project was a programming project, which taught is disciple, time value, teamwork, hard work and learning new skills and languages and enhance our coding skills and practices. It also polished our programming skills i.e. java and C(Hash) and helped us to learn the market leading software i.e. Android Studio, Unity and Blender and also learn a lot related to Vuforia and ARcore SDK. During developing the application, we tried to look at the issue and problem from different perspectives that helps us to produced new ideas that could discovered in the future. We also learn the techniques used in developing the software which includes:

- Gathering requirements of the system.
- System Design and Implementation.
- Testing different modules i.e. Unit Testing.

- Integration of modules and test them i.e. Integration.
- Testing System as a whole.
- How to resolve error by searching online (stack overflow).
- How to manage time and teamwork.
- Designing icons and GUI using Adobe Suite.
- Integration of different APIs and SDK.
- Integration of different modules created on different platform.
- How to develop complex system and manage time.
- How to design simple and user-friendly graphical user interface.
- Testing modules and solving complex problems.
- How to design GUI elements on Adobe suit.

7.1   Future Work

Due to limited time frame we had to develop this project, we are placing 3D static 3D model in our application and only devices that support the ARcore SDK are able to run the application. For future improvement we will use dynamic 3D model and will develop our own algorithm that may support or cover major percentage of devices.

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