

Virtual Reality Based E-Commerce Web Application



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Declaration

We declare that the work contained in this thesis is our own, except where explicitly stated otherwise. In addition, this work has not been submitted to obtain another degree or professional qualification.

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Abbreviations

VR	Virtual Reality
AR	Augmented Reality
SDK	Software DDevelopment Kit
FR	Function Requirements
NFR	Non Functional Requirements

Abstract

The Virtual Reality-based E-commerce Web Application is an advanced website inspired by the meta verse concept. The unique thing about this web application is that it provides virtual reality mode to the customer so that the customers can experience the real-time feeling of the e-commerce store if they have VR headsets. Without a VR headset, they can visit the website and can also do a 3d virtual tour of the store. On the basis of user body measurement inputs, we are also providing the best suggestion for the size that will fit the customer's body. Other than these major functionalities this application is delivering advanced features to the customers like advanced searching, User-friendly navigation, Advanced Searching, Product Filtering, Latest news section in which the latest discount and sales will be displayed to the customer, Conversion of currencies to different country's currencies etc.

Executive Summary

Online shopping has become a major trend nowadays. Customers prefer it rather than going shopping physically as it is less costly and less time-consuming. That is why many shopping stores are going digital and enabling E-commerce features in their setup. However, customers face issues and satisfaction is less while shopping online as they cannot see how the product might look in reality. All they see is a 2d image, description, and reviews of previous customers. Showing 3d models of the products in the virtually created store which can be accessed through VR headsets can make the customers feel as if they are shopping physically. Metaverse concepts are used for this application. So Virtual reality-based E-Commerce store is created that would provide a positive and realistic experience to the customers in the metaverse. The core technology is virtual reality. First, we create a basic E-commerce website named MetaMart with all related features and functionalities. Then 3d tour and VR mode that is created in Unity 3D is integrated with the website. For VR mode, an oculus headset is required. Initially in the application, garments, and outerwear will be the main products. 3D garments will be placed upon avatars with customized measurements so that customers can map them to themselves and choose the best suitable one. In this way, customers can explore MetaMart with virtual reality functionalities so that they can experience this innovative way of buying products satisfactorily by roaming around the store and viewing products that are mostly garments in 3D view and exploring the latest Metaverse technology in the application.

Chapter 1

Introduction

1.1 Overview of the Project

We are making a Virtual Reality based E-commerce web application. This project is inspired by the meta-verse concept. The previous E-Commerce work never used any virtual stores or virtual environments in which different products were placed and customers can visit virtual stores in their homes just by wearing VR headsets. Currently, no website is having a virtual environment where customers can come with or without a VR headset and shop for wearable or other products just like they are shopping physically at the store. As for buying outerwear, customers have two options i.e to order online or to go to the mall or store. Another option is augmented reality in which the customer just opens up the camera and tries on different outfits

We will be catering to two types of customers, the ones having VR headsets will be able to visit the virtual store while wearing a VR headset where the customer can touch, and hold different products and can move in the virtual store. If the customer wants to try different outerwear like jackets so they can check the outerwear on their related Avatar in the virtual store and can experience it from all angles. Customers without VR headsets can visit the website and avail themselves of the virtual tour of the store where they don't need any VR headsets. So basically, our modules consist of an E-commerce website, a Virtual tour environment, a Virtual Reality Environment that requires a VR headset, and proper and customized measurements of avatars and products so that customers can map them to themselves for a better virtual shopping experience.// Other than these, this application is providing advanced features to the customers like User-friendly navigation, Advanced Searching, Product Filtering, the Latest news section in which the latest discount and sales will be displayed to the customer, Conversion of currencies to different country's currencies, etc.

1.2 Background

In the previous already existing applications, implementation of the virtual reality mode of the E-commerce store was missing. It means the custosmers can see only the 2D images and lengthy descriptions of the product. Hence, there was a gap between the virtual and physical visits to the E-commerce store. Customers have to go to the store physically for a better experience of buying products. We overcome this situation by making an application in which we are going to implement 3D virtual reality mode and a 3D virtual tour of the E-commerce store integrated with the website having multiple features that every E-commerce website has. One huge feature that is going to be implemented is the customized product sizes for customers so that they can choose products according to their body measurements and requirements and experience this metaverse way of shopping to the next level.

1.3 Problem Statement

There exists a huge gap between physical shopping and online shopping through web/-mobile applications. To bridge the gap between the physical and digital worlds we are creating a virtual reality-based E-Commerce store that would provide a positive and realistic experience to the customers in the metaverse.

1.4 Motivation

Our motivation is customer satisfaction by visiting the 3D virtual store in meta verse made with the latest technologies. Because there are lots of issues while visiting the shopping mall like time, conveyance issues, etc. So we are providing a positive digital virtual experience of shopping where customers with Oculus VR headsets can experience shopping that will be closer to real-time shopping in the shopping mall.

On the other hand, customers without VR headsets can do a virtual tour of the 3D E-commerce store. Based on customers' body measurements, they can also map their sizes and choose a suitable product by customized measurements of avatars and other products.

1.5 Objectives of the Project

Our objective is to remove the huge gap in the customer experience of online and physical shopping by introducing the virtual reality of the E-commerce store and providing real-time feeling to the customer with the help of a 3D virtual reality store and 3D Tour of virtual store.

The main objective is to create a VR-based E-commerce environment with the state of the art technologies to revolutionize the experience for online shopping experience for customers by introducing metaverse. One of our objectives is also to provide personalized customized fitting solutions for individual customers by introducing Meta-verse concepts and technologies.

1.5.1 Industry Objective

Our industrial objective is to commercialize this application. This web application is to sell products in a virtual E-commerce store in Metaverse. But this application can be extended to other fields such as education, healthcare, etc. For example, some virtual online schools in our metaverse can be added.

1.5.2 Research Objectives

We are doing research on Meta verse concepts and how the real-world experience could be created in the digital world using advanced tools and technologies to provide customized/personalized fitting solutions according to the individual customers' body measurements. We are going to use our best knowledge and advanced technologies and frameworks to make a virtual 3D store in meta verse as there exists no E-commerce

system that provides a virtual reality-based online store with digital versions of the actual product, virtual avatars with different sizes, and customized positive experiences. Virtual reality with advanced technologies will shape the future of electronic retailing.[?]

[

1.5.3 Academic Objectives

The technologies and tools that we are using in our project will help us in our advanced learning and will fulfill our academic objectives as well.

1.5.4 Business objectives

Following are some of the business objectives of the virtual reality-based e-commerce web application:

- Profit maximisation
- Sales maximisation
- Revenue maximisation
- Surviving in the market

1.6 Rules and assumptions

Following are rules and cases of assumptions that are assumed to be true while experiencing virtual reality mode working:

- The customer has an Oculus VR headset and the configurations/setting for Oculus VR Headset is also done by the customer before going into VR mode.

Following are rules and cases of assumptions that are assumed to be true while normally working:

- The internet connection is stable.

1.7 Scope of the Project

To bridge the gap between the physical and Digital worlds by creating a Virtual Reality-Based E-commerce Store that would provide positive and realistic experiences to customers in the metaverse. Currently, this application is limited to E-Commerce but this web application can be extended for virtual reality-based healthcare and educational systems.

1.8 Target Audience

Our Virtual reality-based e-commerce web application is dealing with average as well as professional customers. Professional customers who don't have much time to buy outerwear by going physically to shopping malls can just experience 3d virtual e-commerce

stores for buying outerwear. On the other hand, average customers can do a 3D virtual tour of the e-commerce store. Those customers who don't know which size bests fits suits them can also avail of the best fitting size suggestion on our website.

1.9 Challenges

1.9.1 VR Headset cost

The Oculus VR Headset price is about two lac that is not easily affordable by us and without this VR Headset, it's impossible to experience the virtual reality mode of the e-commerce store. So, buying VR Headset was one of the biggest challenges during the project working.

1.9.2 Integration of Web-based and Unity Framework

This was the second biggest challenge for us during the project. Because it was the first time for us when we were going to integrate the web with the unity and also the helping material for this was not available too much and the configurations of the VR Headset might affect the integration process.



FIGURE 1.1: VR Headset

A head-mounted device used to experience virtual reality. A hardware device that is connected to PC or mobile to experience VR environments and VR video games. VR headsets are mostly used in applications like trainers and simulators.

1.9.3 Configurations of VR Headset

To experience the virtual environment of unity in the oculus VR Headset we had to do configurations or settings in unity and it was not an easy task for us as after these configurations we were also going to integrate the unity environment with the Web.

1.9.4 Understanding of payment API Integration

In our project, we used payment API for the first tie. It was quite difficult for us because this was the first time when we were going to integrate payment API in some web applications.

1.9.5 Understanding how to integrate the processes

One of the challenges during project making was how to integrate the processes and what will be the sequence of the processes.

1.9.6 Understanding of delivery method

One of the challenges was the understanding of the delivery method like when the customer order the product(i.e jacket) then the product should be delivered to the customer and on the successful delivery, we also need feedback from the customer. So handling all of this alone for us is difficult and we need a third party like Tcs etc for the delivery purpose the selection process for delivery and its API integration was also a big task for us.

1.10 Constraints

The constraint of Virtual reality-based e-commerce web applications is that without VR headsets the customer cannot avail of the virtual reality mode. Because without an oculus VR headset the customer is unable to go into the 3D virtual store in meta verse but he can only do 3D of the store.

1.11 Limitations

This Virtual reality-based e-commerce web application is currently limited to clothes(only outerwear i.e jackets) only but it can be extended to further items that are part of future work. etc. Following are some of the limitations of our system as follow:

- Our Virtual Reality based e-commerce store can work only on the desktop system, not on mobile phones or tablets, etc.
- Real-time avatar creation through customer inputs is not currently implemented.
- Without a VR headset the virtual reality base e-commerce store cannot be experienced.

1.12 Applications of Project

People can use this application to experience 3D virtual e-commerce at any place just by wearing an oculus VR headset. Without a VR headset customers can do a 3D tour of the store. Currently, our project is restricted to e-commerce only but it can be extended to various other fields as well like education, healthcare, buying and Decorating a House,

1.13 Benefits of our Project to customer

Following are some of the possible applications of the virtual reality-based e-commerce web application:

1.13.1 Better experience of buying a product online

The customer without a VR headset like average customers can enjoy the 3D tour of the virtual 3D e-commerce store.

1.13.2 Online 3D Tour facility

The customer without a VR headset like average customers can enjoy the 3D tour of the virtual 3D e-commerce store.

1.13.3 Ease to Customer

This application will provide ease to the customer can experience the 3D virtual store by using an oculus VR headset at any location which can be home, office, etc. On the other hand, customers without an oculus VR Headset can also do a 3D virtual tour of the E-commerce store. The 3D images with 3D avatars will also give a realistic feeling to the customer and increase his/her engrossment.

1.13.4 Customer Time Saving

It's a tedious task to go to a shopping mall and visit the whole store/mall to find your desired item. For example, you want to buy a jacket and you go to the mall and then visit the store to find your desired jacket. Let us suppose you did not find the desired one then you will have to return home and it's a real waste of time like you are wasting your time. Through this application, people can just experience a real-time 3D Virtual E-commerce store by using an oculus VR headset at any location which can be a home, office, etc.

Chapter 2

Literature Review

In this section, we are going to discuss virtual reality, applications that did work on E-Commerce applications with VR, AR, and a comparison of different web applications.

2.1 Details of Existing Work

We are living in an era where technology is evolving at a rapid pace and so is the traditional way of work or business. For example, On-site classes are slowly switching to online classes, cash-on-hand payment is slowly switching to online payment, manual Registration, reservations, booking, etc are also being switched to online, so technology has greatly affected our traditional tasks. Now, it is evolving to virtual reality-based works to facilitate the users even more than before. The term “metaverse” has been on-trend in recent times. It is a concept in which people can collaborate and live their life virtually in the virtual world using VR headsets. So far it is in the initial stages but many single-purpose apps have already implemented this feature. In our relevant cases, many e-commerce and clothing stores have started working on this virtual try-before-you-buy feature. Usually, the try-before-you-buy technique is used by customers when shopping physically but many stores such as [?] Ikea have started Kitchen virtual reality in which a person can walk freely and interact with the virtual kitchen using a VR headset. Virtual 3-D Kitchen items can be tested in this environment. They also [?] has launched a new augmented reality application that allows users to test their products in real-time. So far it can only be used with Apple technology(ARKit). The app automatically scales products based on the given environment with 98 percent accuracy. The E-Commerce websites like Amazon, Alibaba, AliExpress, Walmart, etc., and outerwear websites like Zeitgeist, breakout have traditional approaches where customers go on the websites and then see different product items and add to card method. In today’s modern world, the need for technology with an E-commerce system has become a basic need. People need a more personalized and immersive shopping experience which makes the way for the meta verse concept. With the expansion of the industrial metaverse, Virtual shopping still needs learning, priorities, and insights for experience delivery [?]

2.2 What is Virtual Reality?

Virtual Reality is the future and it’s a 3D complete environment in which everything provides a real-time feeling. Virtual reality is a buzzword today and it is popular nowadays in the future students can take lessons and classes in a virtual environment and companies like Amazon is also working on e-commerce virtual reality-based application. People can just wear a VR headset and in their homes, they can go to virtual e-commerce stores, and explore mental health treatment. There are lots of applications of virtual reality like VR in fashion design, mental health treatment, education, sports, military, medical training, etc.

2.3 Difference between Virtual Reality and Augmented Reality

No external AR headset is required for experiencing augmented reality while a VR headset is required for experiencing a virtual environment. In virtual reality, everything is virtual like objects in a virtual environment while Augmented reality augments the real-world scene. Snapchat uses augmented reality when we open a Snapchat camera then Snapchat provides different filters in which we can see different objects. The filters in which Snapchat lens scans our face and applies different cartoon shapes or filters or face changers etc. all possible because of augmented reality.

2.4 Current State of Art

	Name	Category	Status	Function
1	Yihaodian	AR Store	Onsite	AR stores created on open spaces that give customers the experience of real-world stores in smartphones .[1]
2	IKEA	Catalog Application	Online	Customers can use AR technology in their smartphones to preview how furniture will look in that surrounding by augmenting furniture objects in real-world [2]
3	Lacoste	LCST Augmented Reality Retail Campaign	Online	Customers can try different shoes . [3]

	Name	Category	Status	Function
4	Audi	VR-Based Application	On-Site	Passengers traveling with a driver and feeling bored can experience amusing 3D environments configured with real-world vehicle speed, and bumps on the road in the real world by wearing VR headsets provided by AUDI .[4]
5	Converse	Shoe Sampler	Online	Customers can try shoes by using AR-based applications.[5]
6	Topshop	AR Mirror	In-Store	Customers can try-on outfits in-store by using AR change room. [6]
7	Sephora	AR-based application	Online	Customers can get virtual makeup and try different shades by using Sephora virtual assist in their mobile phones[7]
8	L'Oréal	AR-based application	Online	Customers can try out all L'Oréal products by using virtual makeovers and can try different beauty trends on their mobile phones, and tablets.[8]

	Name	Category	Status	Function
9	Burberry	Virtual Store	Online	Customers will experience the virtual store by navigating through the 3D store environment and would be selecting products by selecting digital icons in the environment. [9]
10	Mister Spex	Virtual Mirror	Online	Customers can try different frames of glasses virtually using AR-based applications and can find his/her favorite model.[10]
11	Timber Land	AR Magic mirror	In-Store	Customers can tryout different outfits by standing in front of their avatar in mirror screen .[11]
12	Uniqlo	AR Mirror	In-Store	Customers can try different colors of a single cloth product by just wearing that single product in front of an AR-based mirror called “magical mirror”.[12]
13	Gapinc	AR-based application	Online	Customers can virtually try on clothes using an AR app called Dressing Room by GAP[13]

TABLE 2.1: Comparison of existing AR and VR-based applications.

This table discussed the existing AR/VR-based applications and their functionalities. These applications were developed by some famous companies like Audi, Converse, Sephora, and many others listed in the table. These companies brought new innovations to their respective field by using AR/VR technology. Such that Audi developed an application to kill the boring time of their users by providing them with a VR headset

with amusing VR environments. The fusion of these amusing and enjoyable VR environments with car speed, acceleration and road bumps, and cuts made Audi's customers attracted to this innovation.

2.4.1 IKEA

IKEA made an application that used augmented reality by which customers can place the IKEA furniture at any place and can see how it will look at that place. For example, if you want to see how the table will look in your room then using the IKEA application you just have to open the camera same as Snapchat, and then you can see the place the object anywhere. So customers can place different IKEA furniture in any place like in their home. They just have to open the IKEA application and select a product and using the back camera of their mobile phone they can see how the furniture i.e table will look in their room. [2]

2.4.2 Yihaodian

Yihaodian is launching a virtual online grocery store based on augmented reality where customers. Yihaodian is one of the largest grocery online stores that work on buying groceries with AR experience to improve customer satisfaction and customer experience of buying products online. [1]

2.4.3 Lacoste

Customers can try different shoes with AR experience. Using our extensive AR experience we developed a LCST app allowing consumers to “Bring the Colour” to their city by scanning store window displays, in-store signage, and promotional postcards to reveal exclusive 3D video animation content to consumers across 6 global territories. The AR activity helped successfully launch the new Lacoste streetwear brand by showcasing LCST as the bold, edgy choice in the urban sportswear market.[3]

2.4.4 Audi

Audi has developed a project named “holoride” in which they have tried to improve passenger rides. They have stated the problem situation when someone travels with a driver in an Audi car. At that time driver enjoys the ride but the passenger considers that time as wasted time. So Audi has tried to kill that boring time with a unique AR/VR experience. So they have used “Extended Reality(XR)” to build some beautiful and enjoyable VR experiences that passengers can experience while having a ride just by wearing a VR headset. The cool thing in this “holoride” is the relationship between the real world and the virtual environment. In the virtual world, passengers will be riding on some 3d objects like a cart, or an animal-like dinosaur based on the VR environment the passenger would be in. So there would be a fusion of real-world data with a VR environment such that the speed of the ride in the environment would be the same as the speed of the car in the real world. Similarly, with each bend on the road, with each application of the brake, the virtual reality experience would be shaped just like the real

world. They have just replaced the boring passenger experience of the real world with a fascinating, colorful, and amusing virtual reality experience. [4]

2.4.5 Converse

The converse is a shoemaker company that has created an AR app to ease users with a fitting facility without leaving home. Converse not only solved customers' pain but also reduced its sales funnel. They have created an AR app in which users can see if the shoes fit him/her by using AR technology. The user just has to open the AR camera and select his/her favorite shoes and just point the camera toward his feet to see shoes fit or not. There was a gap in online shoe shopping which was size fitting. But this technology eliminated this gap in online shopping. [5]

2.4.6 Topshop

TOPSHOP a renowned fashion brand launched an augmented reality shopping tool, TOPSHOP Kinect, that helps their customers to try on their selected collections in an augmented dressing room. They worked with the Russian agency AR Door and launched the augmented reality dressing room in Moscow. They use Microsoft's Xbox Kinect software to create virtual mirrors. Users simply must pose with their arms headed upward and allow the Kinect to take the picture. Then viewers can move their hands and check different styles that are inside the application. Kinect's built-in camera scans the body and places the selected dress concerning the user's every movement. Its changing room is the first of its kind to hit major retail stores.[6]

2.4.7 Sephora

Sephora introduced a mirror-like application in which a person can test the makeup toolkit accurately with the actual motive to make the person through AR and not with the conventional technique. It checks for the precise location of a user's facial features, making it to be the world's first photo-realistic 3D mirror. Try-on technology and Digital dress-up are its two major functionalities. [7]

2.4.8 L'Oreal

L'Oréal's Modiface brings an AI-powered Virtual Makeup setup. Customers can apply makeup and try different shades to use virtual artists on their mobile phones. ModiFace, a leader in augmented reality and artificial intelligence in the beauty industry provided its AI-powered technology for cosmetic try-on virtually. [7]

2.4.9 Burberry

Burberry, a fashion house, collaborated with ELLE Digital Japan in its latest move to create an interactive virtual copy of the Ginza store. They upgraded themselves through creative innovations and explored the relationship between physical and digital experiences for creating new concepts. Customers can now roam around the virtual store and purchase items from Burberry's inventory. The store is built over three floors: the ground floor contains signature bags. The first floor contains womenswear from key

outerwear. The top floor includes menswear and outerwear. Burberry and ELLE Digital Japan and in collaboration with actress Elaiza Ikeda created styling films that can be accessed through the virtual store.[9]

2.4.10 Mister Spex

It provides an amazing experience in that you can see how different glass frames will look on you in the virtual mirror and this is all you can do in your home on the Mister Spex website.

2.4.11 Timber Land

This clothing brand took the relationship with the audience and the experience to a new level. The mobile app was used initially for fitting in AR mode. Now people don't even have to go to the store. They just have to reach an 80-inch monitor and a full-length character appears on the screen. This approach resulted in a positive and incredible review by people and they started to use this AR fitting service in queues. Sharing of results of virtual fitting via Facebook and email is also possible.[11]

2.4.12 Uniqlo

UNIQLO started initiatives to decrease environmental waste and support hawker culture, where people from over Singapore gather at hawker centers to dine. They created exhibition displays and augmented reality murals at UNIQLO stores. They provided an interactive experience by pointing to their mobile phones. Customers can also unlock face filters on Instagram after scanning the AR mural, granting them access to take selfies.

The company aims to incorporate its efforts into eradicating environmental waste combined with AR technology. The company is looking to further its efforts into environmental waste, combined with newly released AR technology.[12]

2.4.13 Gapinc

Gapinc.Gap introduced Virtual Dressing and unveiled a new pilot app called the Dressing Room by Gap. The app was created to help customers virtually “try on” clothing through a smartphone, Augmented Reality experience. This is how it works – shoppers choose a Gap style that they might be interested in purchasing. Next, they select one of five body types featured in the app so they can “try on” the piece of clothing from anywhere on a Google Tango-enabled device, and if they love it, they can buy it online. The fashion industry has not traditionally been geared toward helping people understand how clothes will fit. But Gapinc is determined and passionate about winning customer trust by consistently presenting and delivering products that make them look and feel great.[?]

2.5 Research Gap

The previous E-Commerce work never used any virtual stores or virtual environments in which different products were placed and customers can visit the virtual store in their homes just by wearing VR headsets. In short, there is no current such a website that is having a virtual environment where customers can just come into the virtual store while wearing a VR headset and when a customer clicks on the dress he/she can see the avatars wearing the outfits like a jacket and the customer can also see the detailed information like different sizes of outfits (For example jackets). As to buying outerwear customers have two options first one is to order online and the second one is to go to the mall or store to buy outerwear. Another option is the augmented reality the customer just opens the camera and can try on different outfits because of the augmented reality. Another, gap we found is that there are 2D images of outfits and the models wearing those outfits are also in 2D images instead of the 3D model. Like a 3D image in which a person wearing outfit and customers can see back and forth how actually outfit will look like when any person will wear it.

TABLE 2.2: Research work on AR/VR

	Research Paper Name	Description
1	The rise of 3D E-Commerce: online shopping gets real with virtual reality and augmented reality during COVID-19	<p>This paper has focused on some points which are listed below.</p> <ul style="list-style-type: none"> ● COVID-19 has affected the business field. All physical businesses are trying to shift towards online business. ● E-commerce websites provide a well professional 2D website for online shopping but this is not enough for users. ● User must get the experience of the physical world (real world). So that they can make a good choice and can get a better experience. ● AR and VR technology increase customer satisfaction. ● Users can get more precise information using AR and VR technologies. ● User experience is increased by an AR assistant providing the user with all the required information in audio form or using an avatar.[14]
2	Multi-Dimensional Interface Design of E-Commerce for Virtual Museum System	<ul style="list-style-type: none"> ● This research paper focused on the interface design of virtual museum systems. ● The Paper suggested that interface design can be displayed in multi-dimensions. ● The 2D view was good but not good enough as all the images of antiques are displayed in 2D in front of the user. ● Navigation was difficult for human cognition. To make the system productive, panorama functionality was used. VR technology was used that makes users able to walk through the museum. Also, they provided the functionality of zooming to users. ● The result of this implementation was that information presented using VR and panorama technology was more effective as compared to 2D images. This increased usability of the system. <p>[15]</p>

Research Paper Name	Description
3 A Free Virtual Reality Experience to Prepare Pediatric Patients for Magnetic Resonance Imaging: Cross-Sectional Questionnaire Study	<ul style="list-style-type: none"> A magnetic resonance image (MRI) is a test that requires patients to lie still until the test is done. MRI is difficult for children to tolerate. So doctors use general anesthetic (GA) to ensure patient safety. So this paper was written to make a VR resource that can be used to prepare patients for MRI by reducing their anxieties about the MRI process. This resource was consist of an app with a preparation book. This app used 360-degree videos of MRI machines to create a real-world simulation so that patients could be prepared for the real MRI test. In the end, the VR resource was smart enough for educating patients about the MRI process.[16]
4	<p>Points which are discussed in this research paper are listed below</p> <ul style="list-style-type: none"> There are two general classifications of Virtual reality. The first one is that in which we visualized the real world using 3D technologies like Unity. The second one is that which is a reflection of reality, the type of VR classification created using spherical or 360 images or videos. This research paper explains both systems. Technologies used for these systems are Cardboard SDK and Gear VR SDK. Cardboard SDK is used to create systems for a wide range of glasses and devices. Gear VR SDK is used to create a virtual experience for Gear VR For the 360 content system Samsung gear 360 camera was used. For visualized VR system Unity 3D gaming engine was used. The system facilitated medical students to perform practices in the virtual world instead of with real patients.[17]

This table discussed some research work on AR and VR technologies as well as the need to integrate these technologies with other fields like business and medicine. In the first paper effect of COVID-19 on business and how AR/VR can overcome the gap due to this pandemic is discussed. Similarly, the role of AR/VR technologies in the medical field is talked through in other papers. For example, VR technology was used to simulate the MRI process for children patients. So that they could lie still during the real-world MRI process.

2.6 Functional Requirement

Functional Requirement Number	Description
FR1	3D Virtual Store that can be experienced using VR Headset
FR2	3D Virtual tour of E-Commerce Store
FR3	3D images/models instead of 2D images
FR4	Avatar in different measurements (height, weight, waist, etc.) will be placed in a virtual store that will try the products (i.e jackets) that will be selected by the customer.
FR5	Website content translation to different Languages
FR6	Proper and concise details of products should be shown to the user in the virtual store as well on the website.
FR7	Conversion of currencies to different country's currencies
FR8	3Multiple Payment Options
FR9	User-friendly navigation
FR10	Advanced Security features like passwords, and credit card information will be stored in encrypted form in the database
FR11	Add to Wish List button
FR12	Rating and Feedback from the customer
FR13	Social Media Integration
FR14	When
FR15	Advanced Searching, Product Filtering
FR16	Special Offers and Discounts
FR17	Website content translation to different Languages
FR18	3D images/models instead of 2D images
FR19	Latest news section in which the latest discount and sales will be displayed to the customer

TABLE 2.4: Application's functional requirements

This table discussed all the desired operations of the application. For example making 3D avatars, making 3D environments, and all other specifications on which the application is mainly concentrated are listed in the table.

2.7 Non Functional Requirement

Following are some of the non-functional requirements of our web application.

NFR No.	NFR Name	Description
NFR1	Security	Passwords of customers must be in encrypted form.
NFR2	Scalability	The store shall support 10k to 15k users on a single server without harming the website speed and load.
NFR3	Maintainability	Because we are looking to grow, the website shall remove all the back-end complexities for in-house engineers to make changes to the system in the future.
NFR4	Usability	A customer should easily find the right product for them, understand what problems it solves, and purchase without contacting us.

TABLE 2.5: Application's non-functional requirements

This table discussed all the nonfunctional requirements of the application. For example scalability, maintainability, and usability as listed in the table. These requirements would be fulfilling some constraints e.g system must be able to support 10k to 15k users on one server without any negative impact on the system's speed.

2.8 Gap Analysis or Research Gap

There is currently no website that is providing the Virtual reality mode customers are unable to visit and buy products at any sort of virtual 3D store in the metaverse just by wearing an Oculus VR headset. We are going to remove the gap in the customer experience of buying outerwear between physical means and online means by introducing a 3D virtual E-commerce store and a 3D virtual tour of the E-commerce store. Other than these major functionalities this application is providing advanced features to the customers like advanced searching, User-friendly navigation, Advanced Searching, Product Filtering, the Latest news section in which the latest discount and sales will be displayed to the customer, Conversion of currencies to different country's currencies, etc.

Application Name	Unique Features				
	3D Virtual Tour	3D Virtual Store	AR	Personalized Size Suggestion	Product Request
Topshop	x	x	✓	x	x
Amazon	x	✓	✓	x	x
AliBaba	x	x	✓	x	x
Burberry	✓	✓	x	x	x
IKEA ARKit	x	x	✓	x	x
IKEA Kitchen VR	✓	✓	x	x	x
Sephora	x	x	✓	x	x
L'Oreal	x	x	✓	x	x
Mister Spex	x	x	✓	x	x
Timberland	x	x	✓	x	x
Uniqlo	x	x	✓	x	x
Gapinc	x	x	✓	x	x
MetaMart	✓	✓	x	✓	✓

FIGURE 2.1: Comparison of existing AR/VR application's key features

This table lists some key features and their availability status in existing AR/VR applications. The table shows some features like a 3D virtual tour, 3D virtual store, AR, and personalized size suggestions. Every existing AR/VR application listed in the table has used some of these features not all. But our system would be focusing on all these features.

Chapter 3

Proposed Methodology

3.1 General Flow

The web application we developed offers a wide range of key functionalities and is easy to use. Our application is designed primarily for administrators and online users having VR headsets and those who don't have VR headsets as well. The admin can add new products, delete products, update deleted products, view reports/statistics, customer lists, and pending and completed orders. The admin can also update his account setting if necessary. While on the other hand, the customer can visit the website with and without a VR headset as well. Those customers having Oculus VR headsets can experience virtual reality-based MetaMart while customers without VR headsets can do a 3D tour of the MetaMart. The customer can also request some products if not available in our store. Following are some of the diagrams that will help you to understand the sequence flow of our application.

3.2 Software development methodology

We are using Agile methodology.

3.2.1 Road map

Our main goal is to revolutionize the idea of E-Commerce business to facilitate the customer with an immersive and modern virtual platform to bridge the gap between the real and virtual shopping experience. So, to accomplish this goal we came after with the following steps:

1. Exploring related existing past work (if any), wade through the research papers, articles, and generals. Endeavor to perceive the gaps of prior related works.
2. Defining a working methodology, which software development approach we are going to manipulate throughout the whole development process.
3. Specifying the functional and non-functional requirements for the targeted vision.
4. Conducting feasibility study to contemplate all the aspects of the purposed application model to assemble an estimation in respect to accomplishment extent.
5. Creating a general flow diagram to accentuate the workflow of the proposed application. Then, design several diagrams including a general diagram, data flow diagram (level0 and level1), use case diagram (general and detailed), flow chart, class diagram, entity-relationship diagram, and sequence diagram to clarify every aspect in a detailed way.
6. Note down all the use cases for the MetaMart application.
7. Afterwards, select the tools and technology going to operate throughout the entire proposal implementation.
8. Designing the wireframes for web configuration of the virtual environment.

9. Designing a virtual 3D virtual store in meta verse , 3D clothes, 3D avatars.
10. Designing the prototype to delineate an explicit scheme of how the proposed application is going to operate.
11. Finally, developing the MetaMart website and integrating it with the 3D virtual environment made with Unity framework to make the complete system in a fine useable form.
12. Testing the entire developed system and performing the test case scenarios and evaluating the project according to the test case scenarios.

Feasibility Study: i) Economic feasibility: 1. Web development: almost cost none. 2. API: some APIs require purchase, so it will account for cost. 3. Hardware: Our project requires some hardware devices (VR Headsets) which add to the cost of our project. So, to fulfill our economical requirements, we have applied for funding assistance on Ignite FYP funding assistance through the NGIRI portal.

3.2.2 Technical feasibility

The 3D virtual tour and 3D virtual store experience with a VR headset are achievable. With the help of currently available tools to us, it's difficult to make avatars with customized customer input sizes. Regular MetaMart with advanced features like advanced searching filtering, easy navigation, and social media sharing button integration can be done.

3.2.3 Operational feasibility

we will analyze whether our project will work accordingly in the same way as decided. we will also check whether all the features are implemented in the project. So, all the requirements will be fulfilled. we will also keep in the view that our website will be easy to use for customers and should be understandable.

3.2.4 Schedule feasibility

As for the development process, we will follow the agile methodology in which we will design weekly sprints and in each scheduled meeting, we will improve our system timely. So in his way, the proper schedule will be followed and our product will be completed by the end within the due timeline.

3.3 General Proposed Model

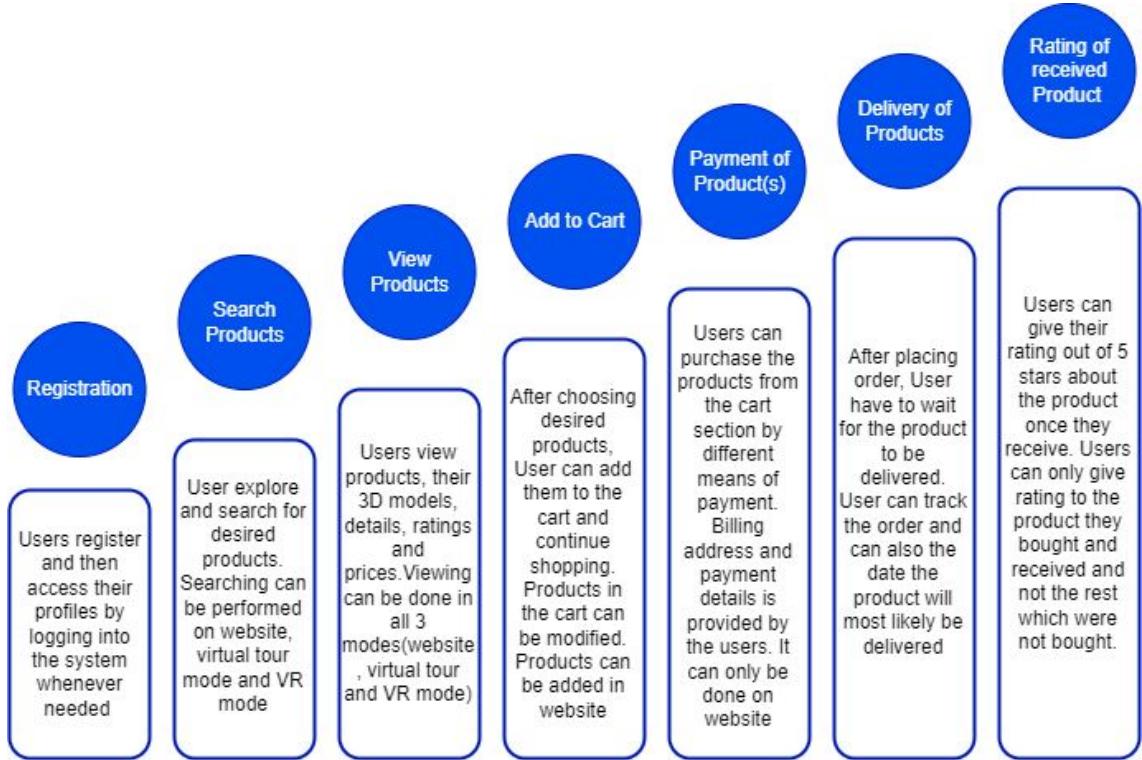


FIGURE 3.1: General Proposed Model of Virtual Reality-based MetaMart Web Application

General Proposed Model of Virtual Reality-based MetaMart Web Applications.

3.4 Data Flow Diagram

Following are the data flow diagrams of the Virtual reality-based MetaMart web application:

3.4.1 Data Flow Diagram Level0

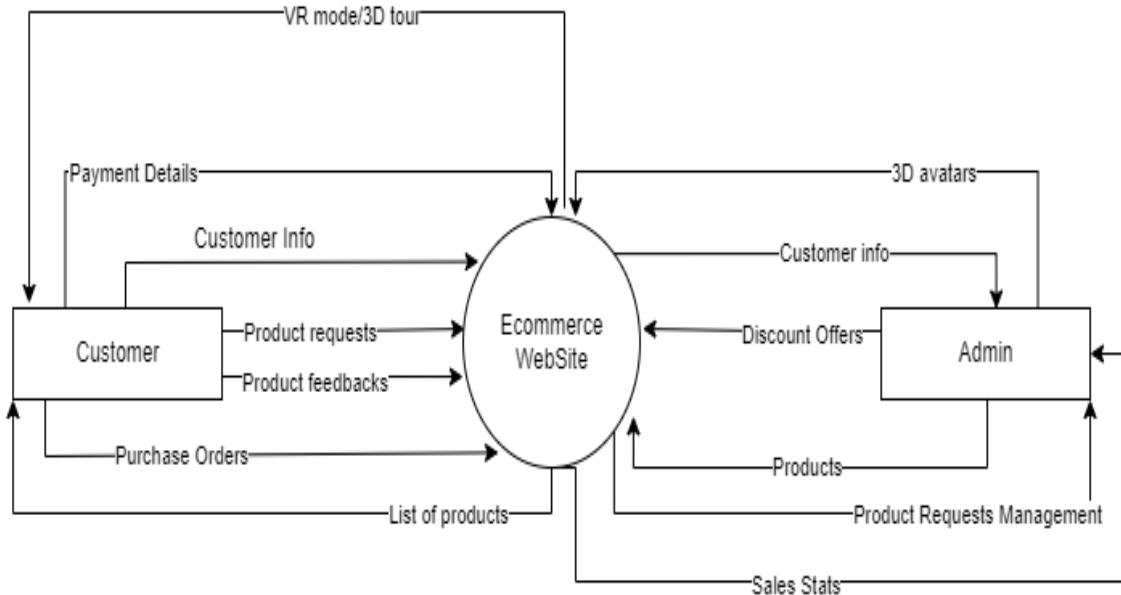


FIGURE 3.2: System's Data Flow Diagram (Level-0)

This diagram illustrates the flow of data between 3 major components of the system which are the customer, admin, and web application. This figure describes which data would be flowing from which source to which destination. As some data like customer information would be flowing from customers towards the application. Similarly, product data would be entered by the admin so this data would be flowing from the admin toward the application.

3.4.2 Data Flow Diagram Level1

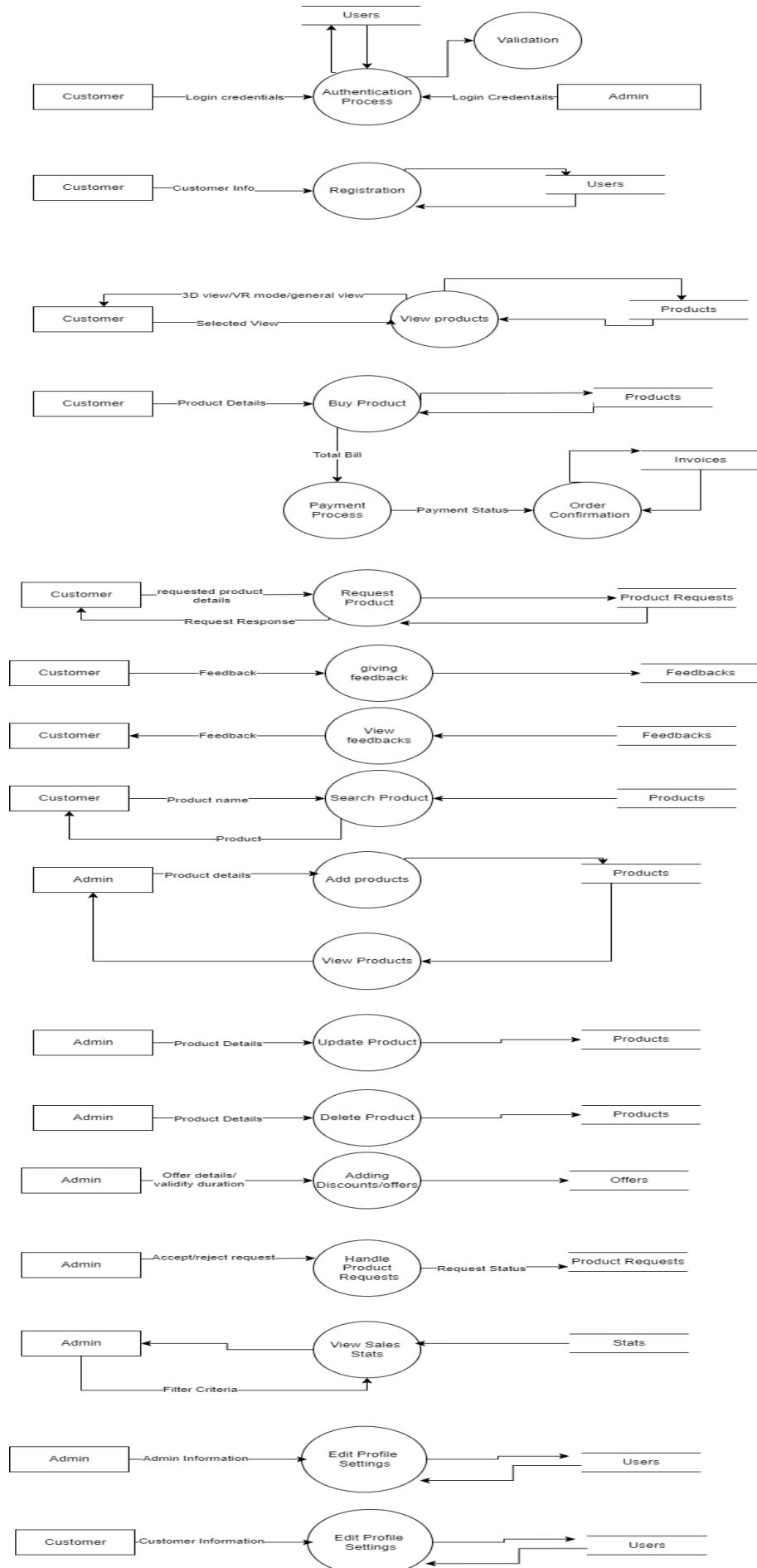


FIGURE 3.3: System's Data Flow Diagram (Level-1)

This diagram illustrates the flow of data between the system's components by reducing the abstraction level. In this diagram application component in the level-0 diagram is divided into some important modules like giving feedback, making an order, making payment, updating customers' information, handling request, and many others shown in the diagram. All these modules represent the direction of data, the data which a module consumes or sends to any other dependent module or database.

3.5 Use Case Diagram

In the below section, you will see the General use case diagram and detailed use case diagram of the website as well that describe the high-level functions and scope of a system.

3.5.1 General Diagram

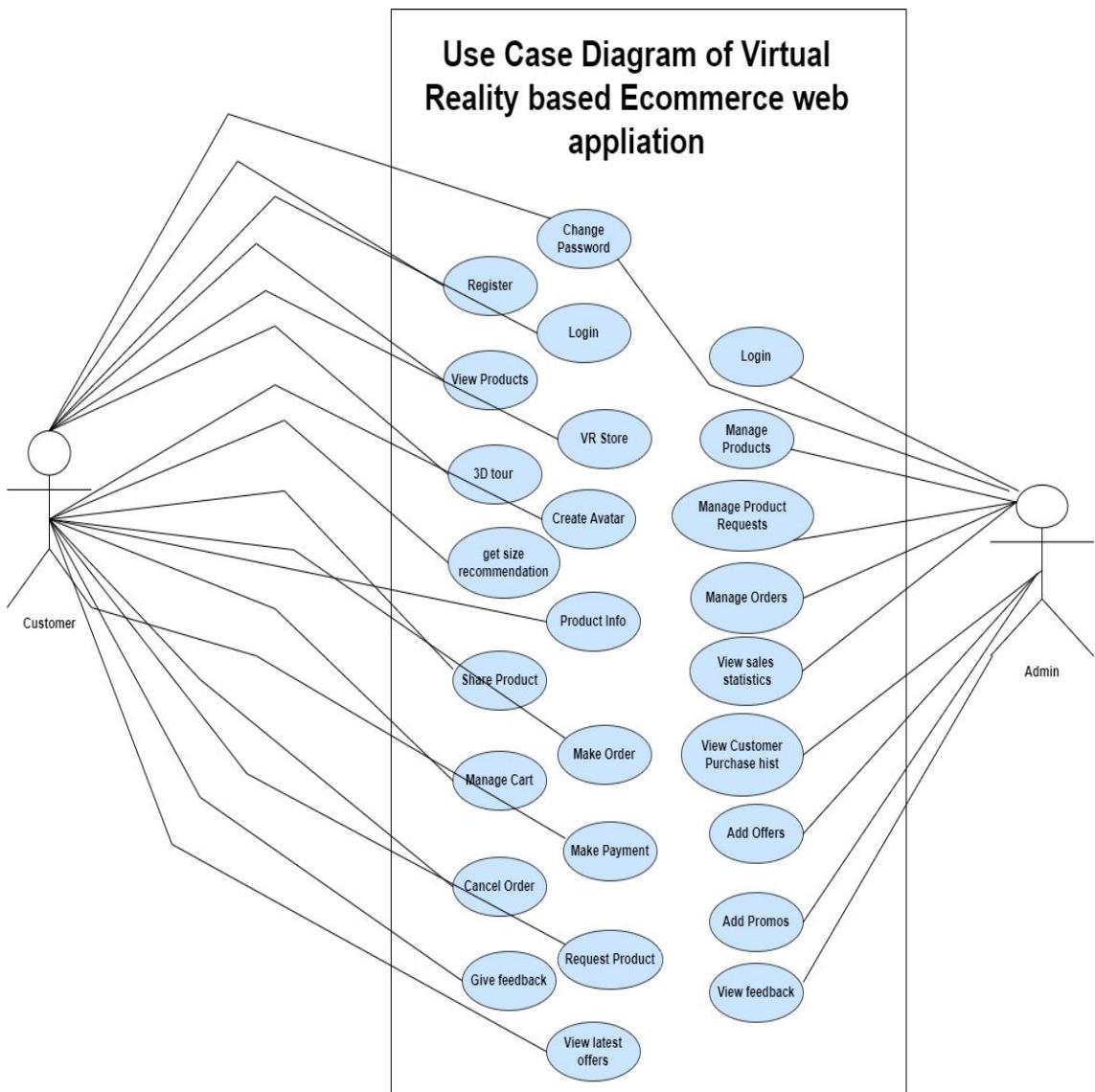


FIGURE 3.4: General class Diagram

This diagram represents the general use cases with higher abstraction levels. All the use cases of entities (customer and admin represented by avatars in the diagram) are listed by associating them with the respective entity's avatar. For example, login is a use case so this use case is associated with the admin's as well as the customer's avatar.

3.5.2 Detailed Use case diagram

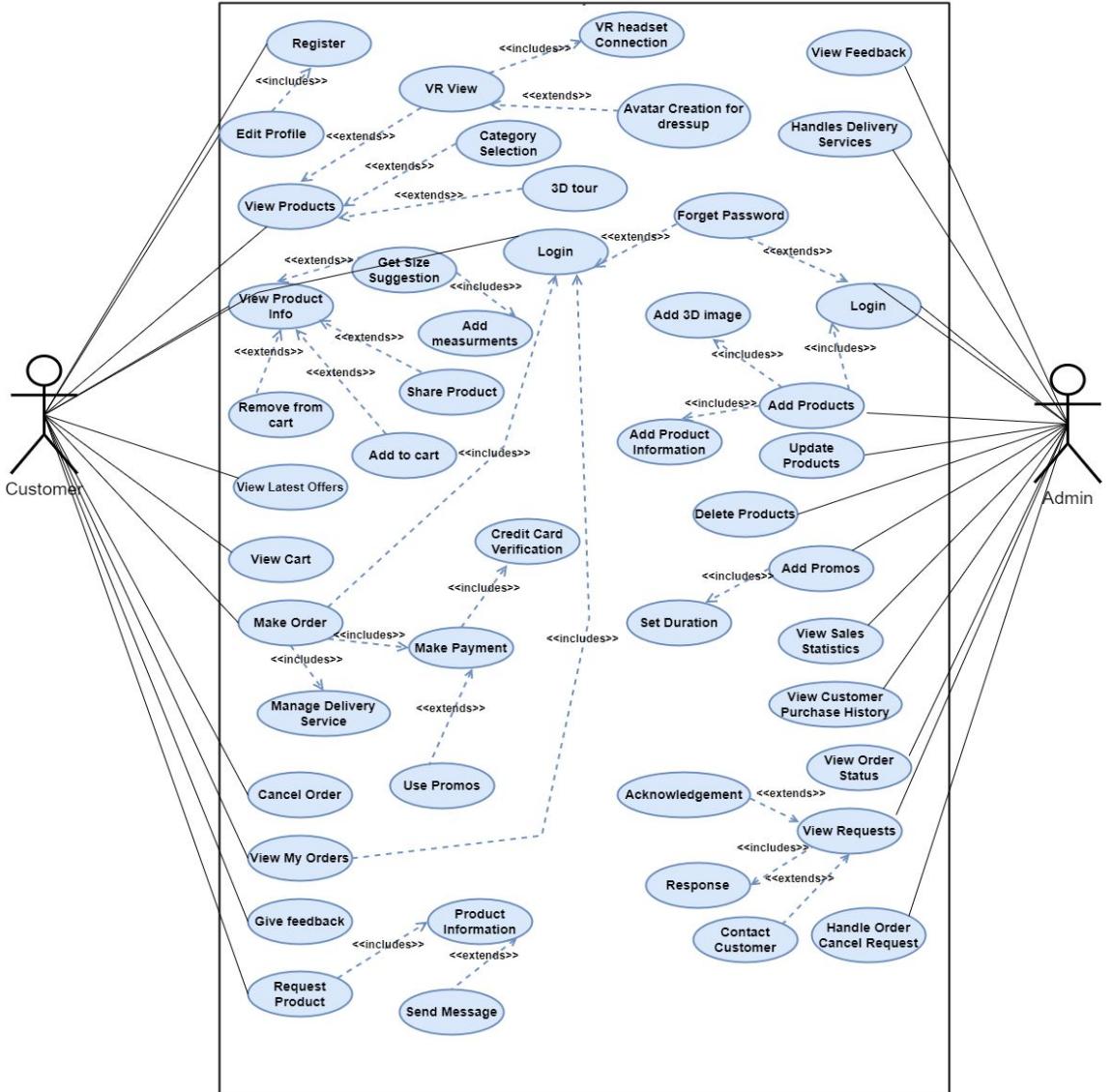


FIGURE 3.5: Detailed Use case diagram

This diagram represents the detailed use cases. All the use cases of entities are listed along with the relationship(extend/includes) between use cases. For example, login is a use case but another use case which is forgetting the password extends this use case. Similarly, making an order includes making a payment because to complete the first use case (make order), it is necessary to fulfill included use case which makes payment.

3.6 Use Cases

Following are the actors in our virtual Reality-based MetaMart web application:

1. Admin
2. Customer

3.6.1 Use Case of Admin Section

3.6.1.1 Use Case UC-1: Admin Login

Description:

The following use case is about successful administrator login after providing valid login details.

Pre-Conditions:

1. Admin should have already been registered.
2. All required information about the admin should be available in the database.
3. Databases should be available.

Normal Flow:

1. The administrator enters valid login details.
2. Administrator clicks on the login button.
3. System confirms and validates the data.
4. Admin successfully logs in the account.

Post-Conditions:

1. Admin successfully logs in the account.

Authority:

 Administrator

3.6.1.2 Use Case UC-2: Add Products

Description:

The following use case is about managing and adding products to the existing system.

Pre-Conditions:

1. All required information about the admin should be available.
2. Databases should be available.

Normal Flow:

1. Administrator has the option to add a new product.
2. System asks for necessary information regarding the product.

3. Administrator provides all the required information to complete the operation.
4. System after confirmation adds the new product.

Post-Conditions:

1. A new user account is successfully created.

Authority: Administrator**3.6.1.3 Use Case UC-3: Edit Product Details****Description:**

The following use case is about managing editing/modifying Product details in the existing system.

Pre-Conditions:

1. All required information about the admin should be available.
2. Databases should be available.

Normal Flow:

1. Administrator options to edit the product details(title, description, images, etc).
2. Administrator changes the desired details of the product options to complete the operation.
3. System after confirmation updates the details of the product in the database and the website as well.

Post-Conditions:

1. The product will be live on the website with updated new details successfully.

Authority: Administrator**3.6.1.4 Use Case UC-4: Delete Products****Description:**

The following use case is about managing to delete products in the existing system.

Pre-Conditions:

1. All required information about the admin should be available.
2. Databases should be available.

Normal Flow:

1. Administrator options to delete a product.
2. The administrator will click on the delete product option and then the system will ask for confirmation before deleting the product from the database.
3. System after confirmation deletes the product from the database.

Post-Conditions:

1. The desired product is successfully deleted from the database.

Authority: Administrator**3.6.1.5 Use Case UC-5: View Products****Description:**

The following use case is about viewing products in the existing system.

Pre-Conditions:

1. Admin must be logged in to the system.
2. All required information about the admin should be available.
3. Database should be available.

Normal Flow:

1. Administrator options to view a new product.
2. Administrator can see all the products.

Post-Conditions:

1. All the products will be displayed to the administrator.

Authority: Administrator**3.6.1.6 Use Case UC-6: Search Products****Description:**

The following use case is about searching for products in the existing system.

Pre-Conditions:

1. All required information about the admin should be available.

2. Database should be available.

Normal Flow:

1. Administrator options to search a product.
2. System asks for necessary information.
3. Administrator provides the name of the product or sets the price range.
4. System after taking administrator shows the results.

Post-Conditions:

1. The desired products will be displayed to the admin

Authority: Administrator**3.6.1.7 Use Case UC-7: View Orders and purchase history of Products****Description:**

The following use case is about viewing orders and the purchase history of products in the existing system.

Pre-Conditions:

1. All required information about the admin should be available.
2. Database should be available.

Normal Flow:

1. Administrator options to about viewing orders and purchase history of products in the existing system.
2. The system will display the orders and purchase history.

Post-Conditions:

1. The orders and purchase history of products will be displayed to the admin

Authority: Administrator

3.6.1.8 Use Case UC-8: View Customer Details except for Personal information (account password, credit card password, etc)**Description:**

The following use case is about viewing customers in the existing system.

Pre-Conditions:

1. Information about the signed-up customers should be available in the existing system.
2. Database should be available.

Normal Flow:

1. Administrator options about viewing customer details in the existing system.
2. The system will display the customer details(name, total purchasing amount, etc).

Post-Conditions:

1. The customer details(name,total purchasing amount etc) will be displayed to the admin

Authority: Administrator**3.6.1.9 Use Case UC-9: Set discounts and special offers****Description:**

The following use case is about setting the discount price on the products.

Pre-Conditions:

1. All required information about the admin should be available.
2. Database should be available.

Normal Flow:

1. While adding a new product the admin can set the discount on the product or the option will be provided to the admin from which the admin can set the discount prices on the products based on the price range etc.

Post-Conditions:

1. The product with a discount price will be shown to the customer will be displayed to the admin

Authority: Administrator

3.6.1.10 Use Case UC-10: Administrator Logout

Description:

The following use case is about successfully logging out administrators.

Pre-Conditions:

1. Admin must be logged in through valid login details.
2. Admin must be able to perform all the required operations.
3. There must be an option to log out as an administrator.
4. Databases should be available.

Normal Flow:

1. Administrator logs in the account.
2. System validates the data.
3. Administrator successfully logs into the account.
4. Administrator performs all the required operations.
5. Administrator clicks on the logout button.
6. System successfully logs out the administrator.

Alternative flow:

2a. There is a problem with the Admin login account.

- Admin can recover password using forgot password.
- Admin can again try to login Admin continues from step 1.

Post-Conditions:

1. The administrator successfully logs out of the system.

Authority:

 Administrator

3.6.2 Use Case of Customer Section

3.6.2.1 Use Case UC-1: User Sign Up

Description:

The following use case is about adding a new user to an existing system. A new user can sign up any time he wants if he hasn't already made an account.

Pre-Conditions:

1. All required information about the admin should be available.
2. Databases should be available.

Normal Flow:

1. New User by clicking on the signup button opts for creating a new account.
2. System asks for necessary information.
3. User provides all the required information and opts to complete the operation.
4. System confirms and validates the data.
5. System creates a new account successfully.
6. System sends the account creation email to the administrator's email id and user's email

Alternative flow:

1a. There is a problem with the User's login details. Required information is not provided.

- Users can check the login details and correct them.
- The user continues from step 1.

3a. There is a problem with the data provided, some data needs to be corrected.

- The user checks the available information and corrects the error.
- The user continues from step 3.

4a. There is a problem with the data validation. The data provided is not valid.

- The user checks the validation of data and corrects the information.
- The user continues from step 3.

Post-Conditions:

1. A new User account was successfully created.
2. New Users can log in to the account using his/her login details.

Authority: User**3.6.2.2 Use Case UC-2: User Login****Description:**

The following use case is about successful User login after providing valid login details.

Pre-Conditions:

1. Users should have already been registered.
2. All required information about the admin should be available in the database.
3. Databases should be available.

Normal Flow:

1. User enters valid login details.
2. User clicks on the login button.
3. System confirms and validates the data. The user successfully logs in to the account.

Alternative flow:

- 1a. There is a problem with the User's login details.
 - The user provides the required login details.
 - The User continues from step 1.
- 3a. There is a problem with the data provided, some data needs to be corrected.
 - The user checks the available information and corrects the error.
 - The user continues from step 3.
- 3b. There is a problem with the data validation. The data provided is not valid.
 - The user checks the validation of data and corrects the information.
 - User recovers password if forgotten using forgot password link.

- The user continues from step 3.

Post-Conditions:

1. The user successfully logs in to the account. Open Issues: if the database fails to connect, the user may need to wait for days to connect.

Authority: User**3.6.2.3 Use Case UC-3: User Profile Creation****Description:**

The following use case is about the successful creation of a user profile after providing valid profile details.

Pre-Conditions:

1. Users should have already been registered.
2. All required information about the admin should be available in the database.
3. Databases should be available.

Normal Flow:

1. User enters valid required details for creating a profile.
2. User clicks on the create profile button.
3. System confirms and validates the data.
4. User successfully creates a profile.

Alternative flow:

- 1a. There is a problem with the User's profile details.
 - The user provides the required details when creating a profile.
 - The user continues from step 1.
- 3a. There is a problem with the data provided, some data needs to be corrected.
 - The user checks the available information and corrects the error.
 - The user continues from step 3.
- 3b. There is a problem with the data validation. The data provided is not valid.

- The user checks the validation of data and corrects the information.
- The user continues from step 3

Post-Conditions:

1. The user successfully creates a profile. Open Issues: if the database fails to connect, the user may need to wait for days to connect.

Authority: User**3.6.2.4 Use Case UC-4: Edit Account Information****Description:**

The following use case is about the user changing their account details successfully.

Pre-Conditions:

1. Users should be already logged in.
2. All required information about the admin should be available in the database.
3. Databases should be available.

Normal Flow:

1. User navigates to the account setting page.
2. User edits its details and saves.
3. For confirmation, the user is asked to write the password twice.
4. System confirms and validates the data.
5. User account is successfully updated.

Alternative flow:

2a. There is a problem with the User's profile details.

- The user will be provided with validation in case they enter invalid data such as number in name etc.
- The user continues from step 2.

3a. There is a problem with the data provided, some data needs to be corrected.

- If the user enters the wrong password, then they will be asked to provide the correct password to continue to update details.

- The user continues from step 3.

Post-Conditions:

1. The user successfully updates their profile details.

Authority: User**3.6.2.5 Use Case UC-5: Switching to Virtual tour mode****Description:**

The following use case is about users switching to virtual tour mode on the website for a better experience of products and a realistic feel.

Pre-Conditions:

1. Users should be logged in.
2. Option will be available on the website for virtual tour mode.
3. User will have to select his desired avatar from the available ones.
4. Proper description and measurement of avatar will be provided.
5. Databases should be available.

Normal Flow:

1. User clicks the virtual tour option and switches to virtual tour mode for a better experience.
2. User controls the avatar and roams around the virtual store and views products.
3. After viewing user can also add the item to the cart in the same mode.

Alternative flow:

2a. In case the user has not selected his/her avatar previously

- The user will first be provided with the list of avatars and their measurement details.
- The user selects the avatar according to his/her preference.
- The user continues from step 2.

Post-Conditions:

1. The user successfully explores the virtual tour mode.
2. The option will be available which can navigate the user back to the website

Authority: User

3.6.2.6 Use Case UC-6: Switching to VR mode

Description:

The following use case is about users switching to VR mode from the website for a better experience of products and a realistic feel.

Pre-Conditions:

1. Users should be logged in.
2. Users should have VR headsets compatible with the system.
3. Option will be available on the website for switching to VR mode.
4. User will have to select his desired avatar from the available ones.
5. Proper description and measurement of avatar will be provided.
6. Databases should be available.

Normal Flow:

1. The user clicks the VR mode option on the website.
2. The user configures a VR headset (such as Oculus) with the system
3. After configuration, the user is connected to his/her selected avatar and can roam around the virtual store and view products.
4. After viewing user can also add the item to the cart in the same mode.

Alternative flow:

2a. In case the user's VR headset is not compatible

- Users cannot experience VR mode and have to continue to the website or virtual tour mode.

3a. In case the user has not selected his/her avatar previously.

- The user will first be provided with the list of avatars and their measurement details.
- The user selects the avatar according to his/her preference.
- The user continues from step 3.

Post-Conditions:

1. The user successfully explores the VR mode.
2. The option will be available which can navigate the user back to the website and the VR headset will be disconnected from the system.

Authority: User

3.6.2.7 Use Case UC-7: Add to Cart (Website)

Description:

The following use case is about adding products to the cart so that users could checkout.

Pre-Conditions:

1. User may or may not be logged in for an add-to-cart operation.
2. Similar items can be added more than one time.
3. Number will be shown on the cart icon displaying the number of products in the cart.
4. Add to cart button will only be shown on in-stock available products.
5. Databases should be available.

Normal Flow:

1. User picks a product and presses add to cart button.
2. Users can search for more products and add those as well.
3. User clicks on the cart icon to navigate to the cart page.
4. User validates the selected products and proceeds to the checkout page.
5. If the user is not satisfied, products added to the cart can be removed and the user can get navigated back to the products page.

Alternative flow:

- 1a. In case the user picks a product but it is not available in stock.
 - Add to cart button won't be clickable.
 - User continues from step 1 for different(available) products.
- 4a. In case the user is not logged in.
 - After clicking the checkout button, the user will first be directed to the login page and asked for credentials

- After successful login, the user will be redirected back to the checkout page.
- The user proceeds to checkout.

Post-Conditions:

1. The user successfully adds products to the cart.

Authority: User**3.6.2.8 Use Case UC-8: Add to Cart (Virtual Tour mode)****Description:**

The following use case is about adding products to the cart in Virtual tour mode so that users could checkout.

Pre-Conditions:

1. The user must be logged in for an add-to-cart operation in virtual tour mode.
2. The user will be in virtual tour mode.
3. Similar items can be added more than one time.
4. Number will be shown on the cart icon displaying the number of products in the cart.
5. Add to cart button will only be shown on in-stock available products
6. Databases should be available.

Normal Flow:

1. User picks a product and presses add to cart button.
2. Users can search for more products by roaming around the virtual store.
3. User clicks on the cart icon to navigate to the cart page.
4. User validates the selected products and proceeds to the checkout page.
5. If the user is not satisfied, products added to the cart can be removed and the user can get navigated back to virtual tour mode.

Alternative flow:

- 1a. In case the user picks a product but it is not available in stock.
 - Add to cart button won't be clickable.

- User continues from step 1 for different(available) products.

Post-Conditions:

1. User successfully adds products to cart in virtual tour mode.

Authority: User**3.6.2.9 Use Case UC-9: Add to Cart (VR mode)****Description:**

The following use case is about adding products to the cart in VR mode so that users could checkout.

Pre-Conditions:

1. The user must be logged in for an add-to-cart operation in VR mode.
2. The user will be in VR mode.
3. Similar items can be added more than one time.
4. Number will be shown on the VR headset screen displaying the number of products in the cart.
5. Add to cart option will only be shown on in-stock available products
6. Databases should be available.

Normal Flow:

1. User picks a product and moves the hand to the add-to-cart option for adding it to the cart.
2. Users can search for more products by roaming around the VR mode.
3. User moves the hand on the cart icon on the headset screen to navigate to the cart page.
4. User validates the selected products and proceeds to the checkout page.
5. If the user is not satisfied, products added to the cart can be removed and the user can get back to product view in VR mode.

Post-Conditions:

1. Admin successfully logins the account.

Authority: Administrator

3.6.2.10 Use Case UC-10: View Products (Website)

Description:

The following use case is about viewing available products on the web page.

Pre-Conditions:

1. User may or may not be logged in for viewing products.
2. Search and product filtering options will be provided.
3. Different sorts of options for products will be available.
4. Image and proper description with feedback and ratings will be provided when any particular product is selected.
5. Databases should be available.

Normal Flow:

1. With or Without login, the User views the products page.
2. Users can use the search option and filter for quick desired output.
3. User clicks the particular product and is directed to a page including all of the details of that product.
4. User checks all descriptions, feedback, rating, etc of the product and adds it to the cart if satisfied.

Alternative flow:

- 3a. In case the user does not want to visit the page consisting of that particular product.
 - Users can add them to the cart the product without having to see its details.
 - The user continues from step 1 for more products or visits the cart page.
- 4a. In case the user is not satisfied fully and wants to test the product (wearable item).
 - Users can go to a 3D environment or VR mode.
 - There they can test the wearable item with different on its selected custom virtual avatar for fitting issues.
 - After satisfaction, the user can add to the cart that product from the 3D environment/VR mode.
 - The user either continues in the same environment for viewing more products or goes back to website mode.

Post-Conditions:

1. Users can efficiently view products in website mode.

Authority: User**3.6.2.11 Use Case UC-11: View Products (Virtual Tour mode)****Description:**

The following use case is about viewing available products in the virtual tour mode.

Pre-Conditions:

1. User must be logged in for viewing products in virtual tour mode.
2. 3D models Products will be placed in the virtual store already.
3. Proper description with feedback and ratings will be provided when any particular 3d model of the product is selected.
4. Databases should be available.

Normal Flow:

1. The user roams around the store using a selected avatar to see 3D models of products.
2. User clicks the particular 3D model of details and the description of the product is shown.
3. For wearable items, the user can virtually try on the item on the avatar and check the fitting of any size by rotating the avatar
4. User checks all descriptions, feedback, rating, and virtual try-on of the product and adds it to the cart if satisfied.

Post-Conditions:

1. Users can efficiently view products in virtual tour mode.

Authority: User**3.6.2.12 Use Case UC-12: View Products (VR mode)****Description:**

The following use case is about viewing available products in VR mode.

Pre-Conditions:

1. User must be logged in for viewing products in VR mode.
2. 3D models Products will be placed in the virtual store already.
3. Proper description with feedback and ratings will be provided when any particular 3d model of the product is selected.
4. Databases should be available.

Normal Flow:

1. The user roams around the store using a VR headset as an avatar to see 3D models of products.
2. Users can grab the particular 3D model virtually.
3. User hovers over the particular 3D model of details and the description of the product is shown.
4. For wearable items, the user can virtually try on the item on the avatar and check the fitting of any size by rotating the avatar
5. User checks all descriptions, feedback, rating, and virtual try-on of the product and adds it to the cart if satisfied.

Post-Conditions:

1. Users can efficiently view products in VR mode.

Authority: User**3.6.2.13 Use Case UC-13: Giving feedback (Website)****Description:**

The following use case is about giving feedback on the web page.

Pre-Conditions:

1. The user must be logged in for giving feedback.
2. Previous feedback given by others should be visible to the user.
3. Databases should be available.

Normal Flow:

1. The user selects any products.

2. The user writes their feedback on the feedback area about that product or can ask any question regarding it.
3. The user clicks the submit button to send feedback.
4. The user waits for a response from the administrator side

Post-Conditions:

1. Users can efficiently give feedback about products, delivery responses, etc.

Authority: User**3.6.2.14 Use Case UC-14: Giving rating (Website)****Description:**

The following use case is about giving a rating on the web page.

Pre-Conditions:

1. The user must be logged in for giving a rating to the product.
2. The current rating of the product and the number of ratings should be visible to the user.
3. Databases should be available.

Normal Flow:

1. The user selects any products.
2. The user will be shown five empty stars.
3. The user has to give their rating from one to five stars about that product.
4. User selects the rating and their rating will be added to the product.

Alternative flow:

2a. If the user already gave a rating to the product

- User will be shown their previous rating
- Users can edit the rating by clicking it and choosing a new rating.

Post-Conditions:

1. Users can efficiently give a rating to a product.

Authority: User

3.6.2.15 Use Case UC-15: Order History of Products

Description:

The following use case is about user viewing their all order history on the web page.

Pre-Conditions:

1. The user must be logged in for viewing their order history.
2. Databases should be available.

Normal Flow:

1. The user goes to the order history page.
2. The user sees all details and pricing of all previously completed or uncompleted orders.

Alternative Flow:

2a. In case the user has not purchased anything previously.

- An empty message will be displayed stating that No previous completed orders yet

Post-Conditions:

1. Users can efficiently view previous history details.

Authority:

 User

3.6.2.16 Use Case UC-16: Pending Orders (Website)

Description:

The following use case is about the user viewing all pending (yet to be delivered) order history on the web page.

Pre-Conditions:

1. The user must be logged in for viewing pending orders.
2. Databases should be available.

Normal Flow:

1. The user goes to the pending orders.

2. The user sees all details of the upcoming product(s) to be delivered with the delivery date.

Alternative Flow:

2a. In case the user has nothing yet to be delivered.

- An empty message will be displayed stating that nothing is to be delivered yet

Post-Conditions:

1. Users can efficiently view previous history details.

Authority: User**3.6.2.17 Use Case UC-17: User Logout****Description:**

The following use case is about successfully logging out users.

Pre-Conditions:

1. Users must be logged in through valid login details.
2. Users must be able to perform all the required operations.
3. There must be an option to log out for Users.
4. Databases should be available.

Normal Flow:

1. User logs in to the account.
2. System validates the data.
3. Users successfully log in to the account.
4. Users perform all the required operations.
5. Users click on the logout button.
6. System successfully logs out the user.

Alternative flow:

2a. There is a problem with the user's login account.

- Users can recover passwords using the forgotten password option.

- Users can again try to log in.
- User continues from step 1

Post-Conditions:

1. The user successfully logs out of the system.

Authority: User

3.7 Flow Chart

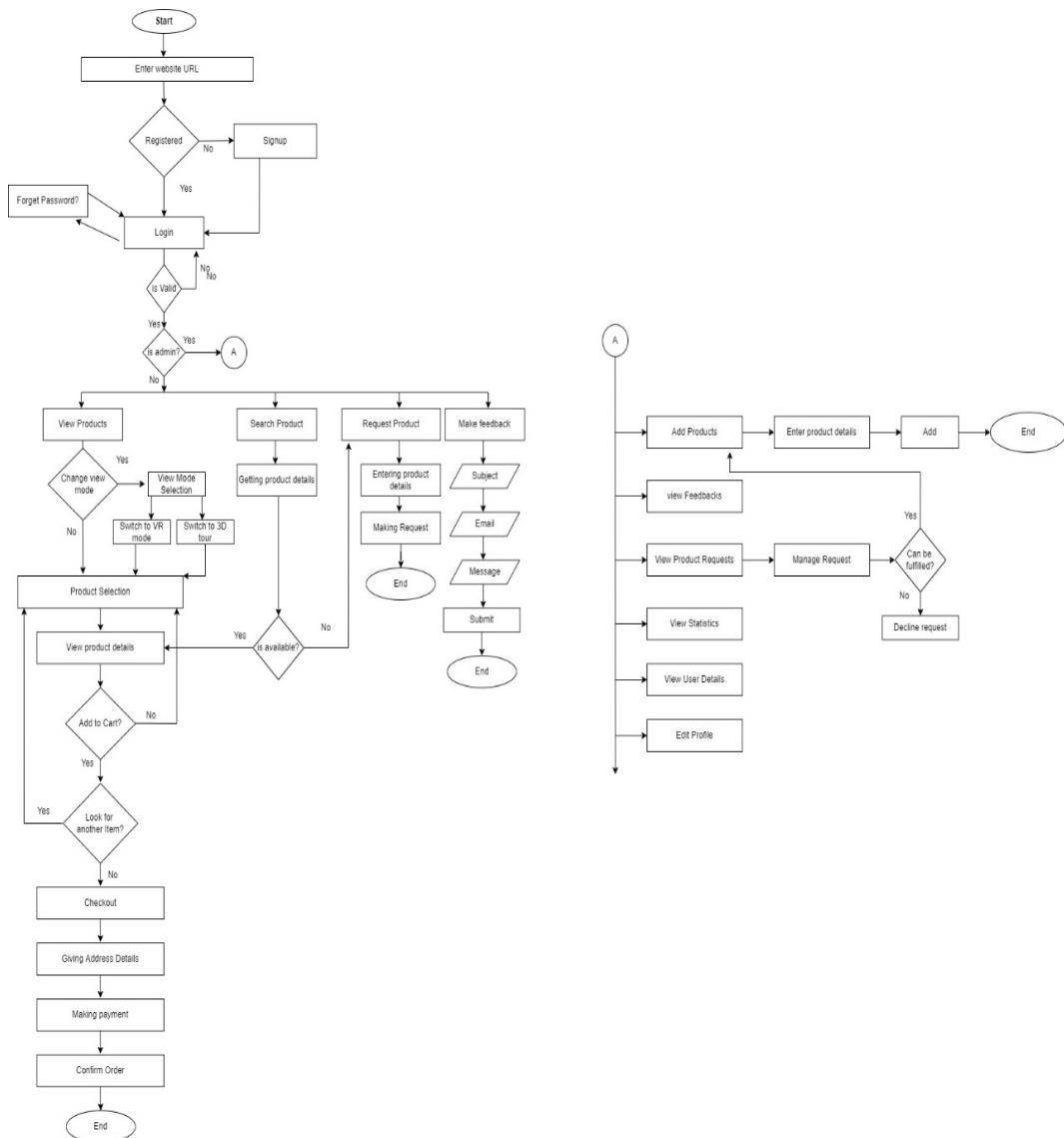


FIGURE 3.6: System's flowchart diagram

This diagram represents the flow of processes. These processes are those which are highly focused during the development of the system. From start to end, the diagram

covers all the important steps that are necessary to list there. On the customer side majorly three processes have been listed which are buying a product, requesting a product, and making feedback for the purchased product. Similarly, all processes done by the admin are listed there.

3.8 Architectural Diagram

3.8.1 Contextual Diagram

Level 01: Contextual Diagram

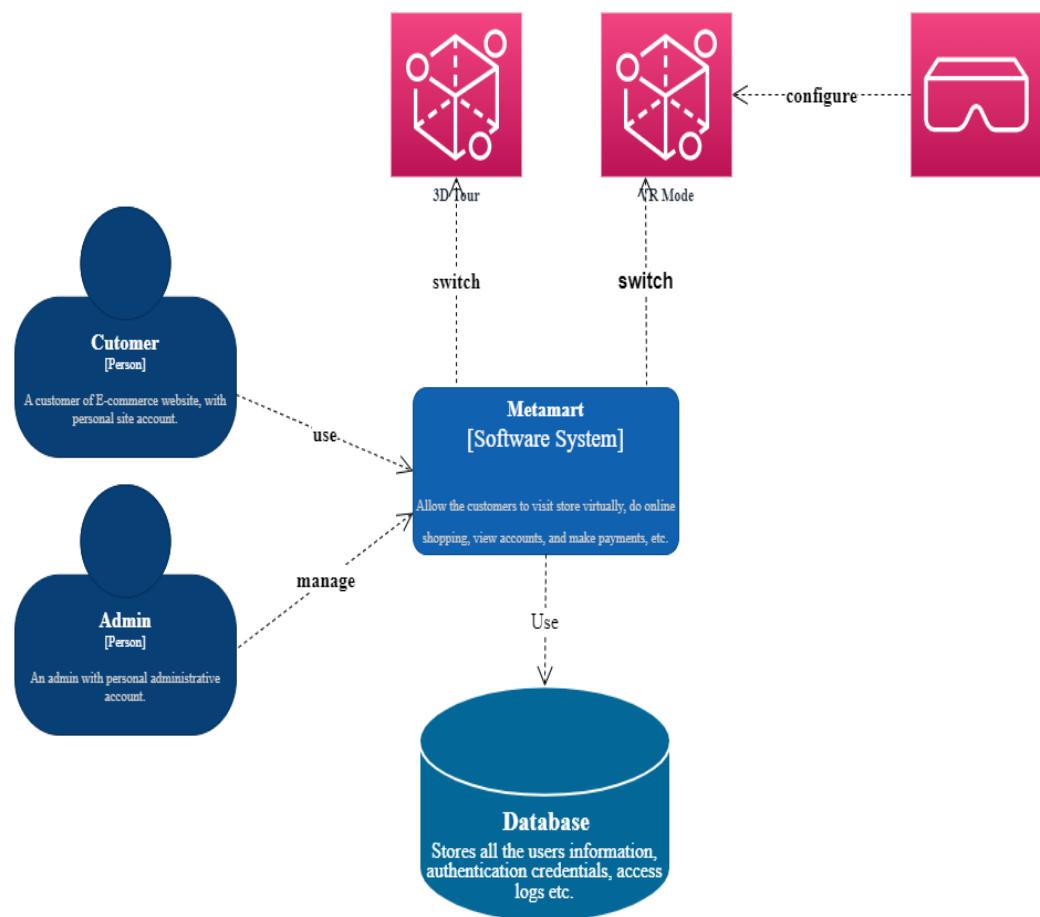


FIGURE 3.7: Contextual Diagram

3.8.2 Container Diagram

Level 02: Container Diagram

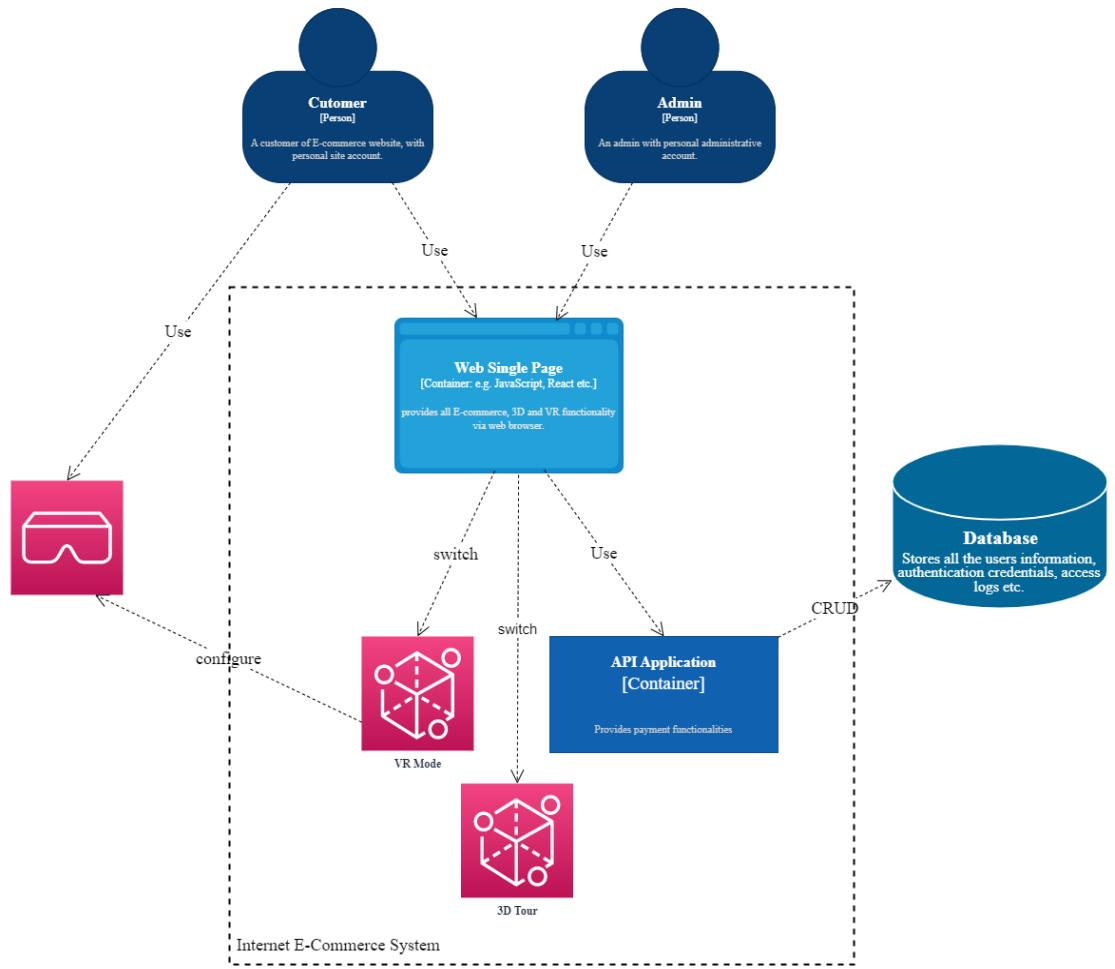


FIGURE 3.8: Container Diagram

3.8.3 Component Diagram

Level 03: Component Diagram

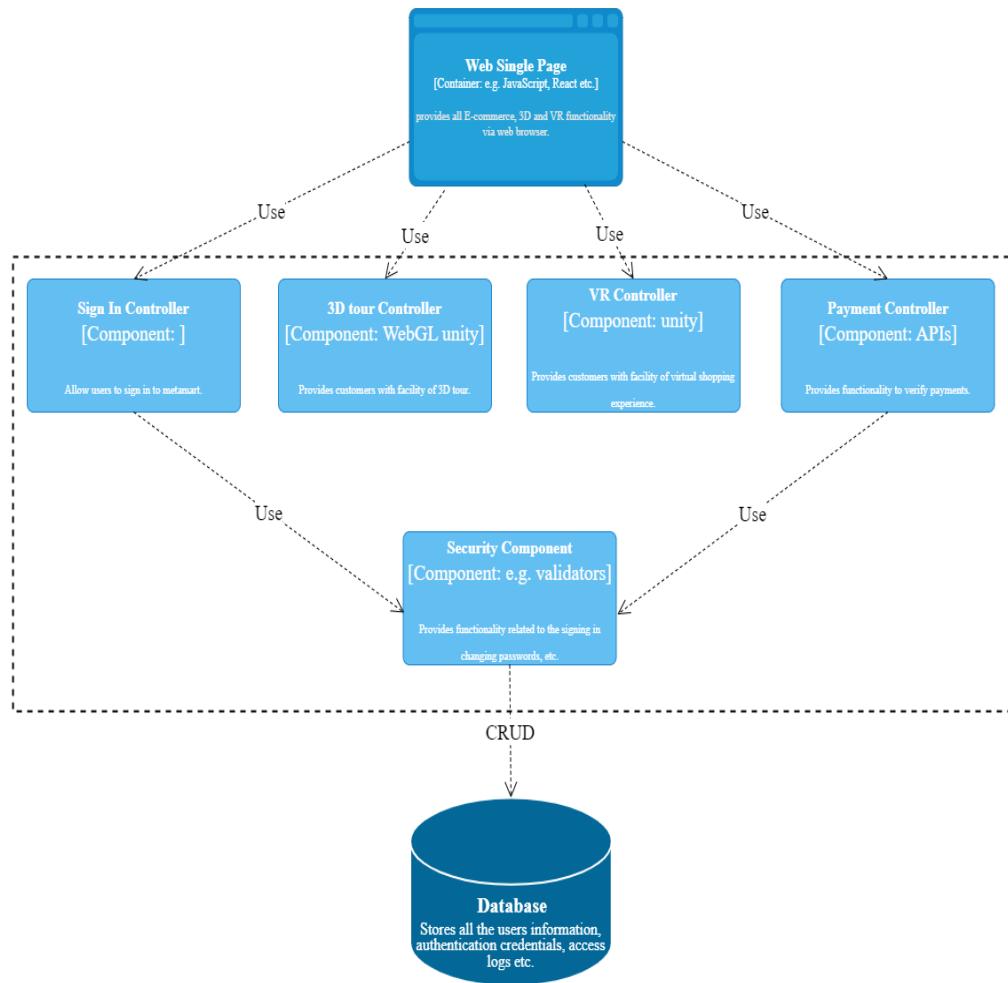


FIGURE 3.9: Component Diagram

3.9 Class Diagram

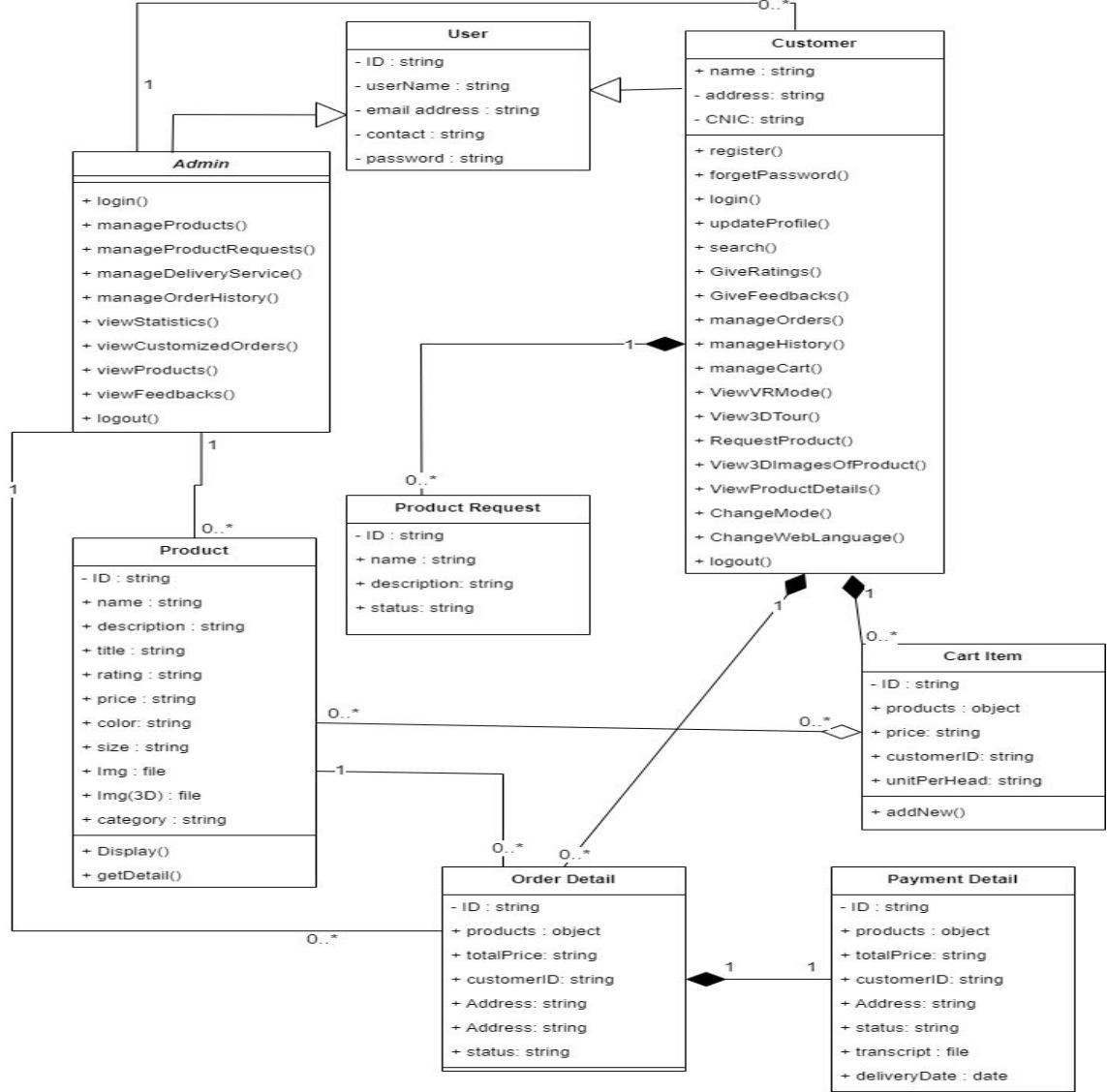


FIGURE 3.10: System's class diagram

This class diagram represents the structure of our system. Classes, attributes of those classes, and relationships between classes are shown diagrammatically. Classes are represented by boxes for example user, and customer. Similarly, attributes of a class have been written inside the class box such as the id, username, and email of the class user. Relationships between classes have been represented by arrows between classes. Some arrows represent aggregation/composition.

3.10 Entity Relationship Diagram

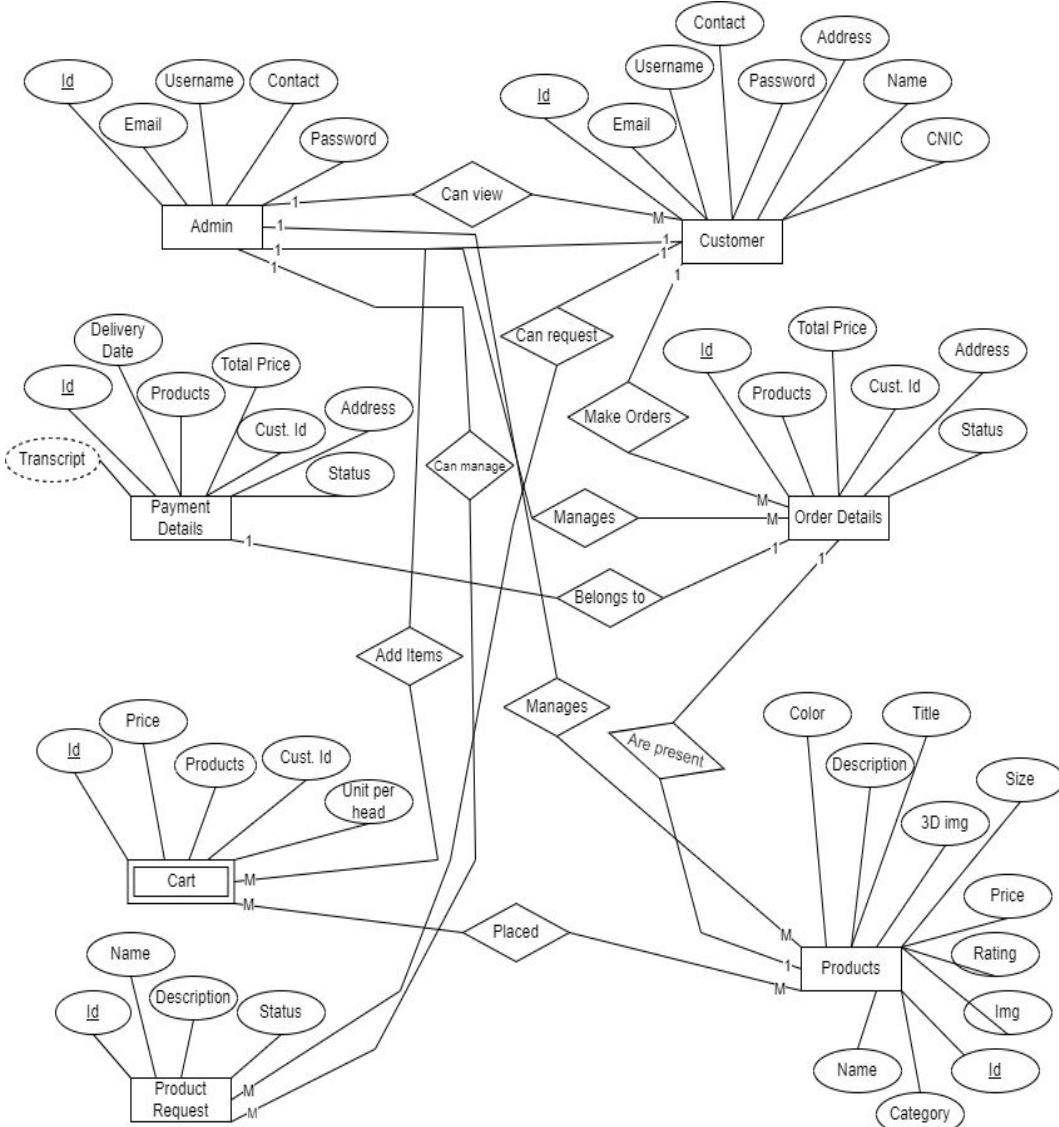


FIGURE 3.11: System's ERD(Entity Relationship Diagram)

This class diagram also represents the structure of the system. ERD diagram contains some symbols like rectangles, oval shapes, and lines. Rectangles represent entities which are customer, admin, payment details, cart e.t.c. Oval shapes are attributes of that entity. Similarly, the relationship between two entities is represented by a diamond in an arrow. And types of relationships such as one-to-one, one-to-many, and many-to-many are represented by small numbers near connecting points of the arrow.

3.11 Sequence Diagram

Following are the sequence diagrams of the customer and admin of the web application that show the control structures between objects.

3.11.1 Sequence Diagram for Admin

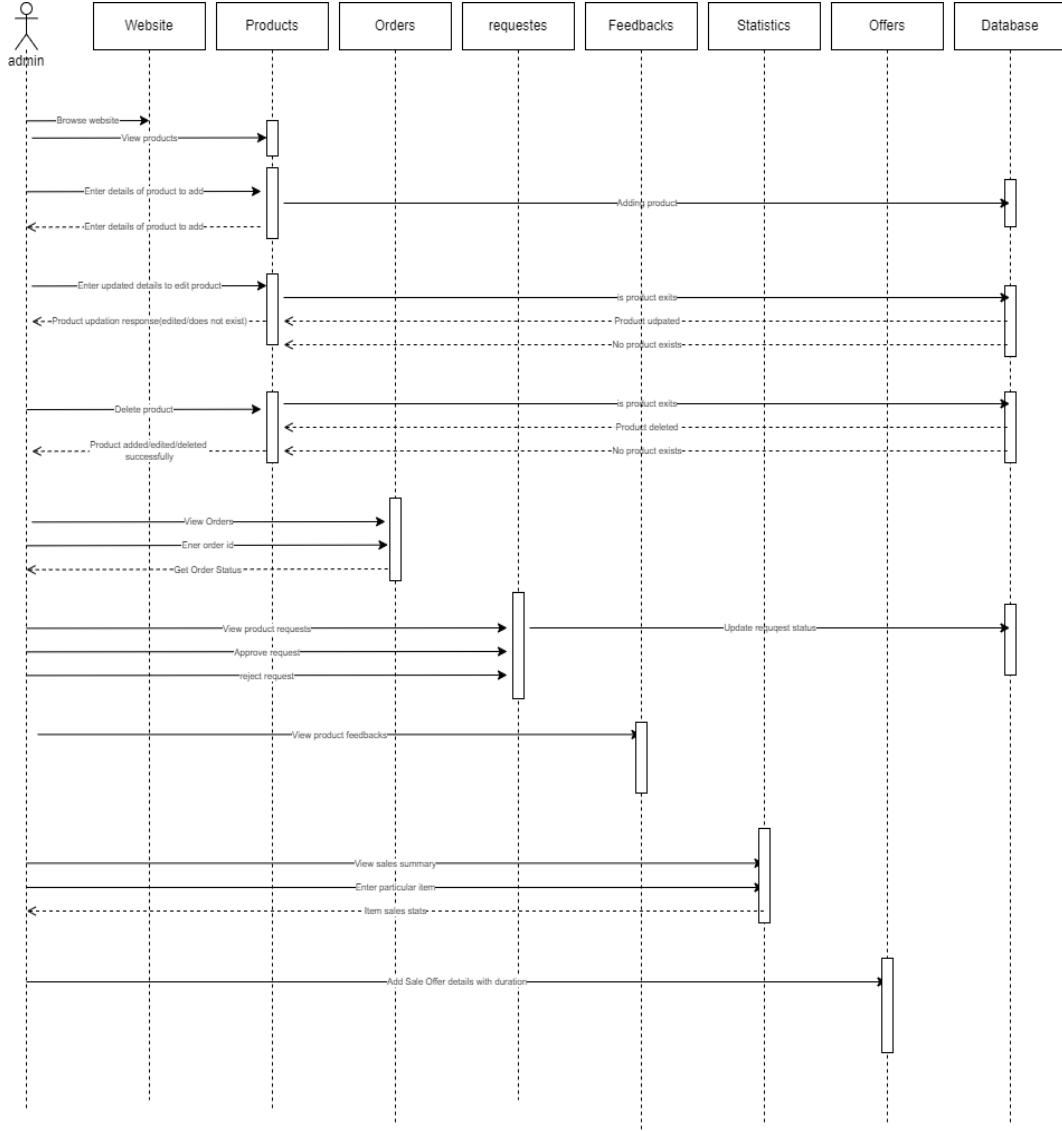


FIGURE 3.12: System's Sequence Diagram (Admin)

This diagram shows the whole sequence of steps required by the admin to accomplish different tasks. For example view products, add products, view product requests, give responses to those requests e.t.c. In the diagram rectangles can be seen, these rectangles are modules of the system e.g products, orders, requests, feedback, e.t.c. Where the long bar under every module represents the lifetime for which the user would be interacting with that module. Arrows from user entities to different bars show the user's purpose of interaction with that module. For example, the admin would interact with the product module to view the product shown in the diagram.

3.11.2 Sequence Diagram for Customer

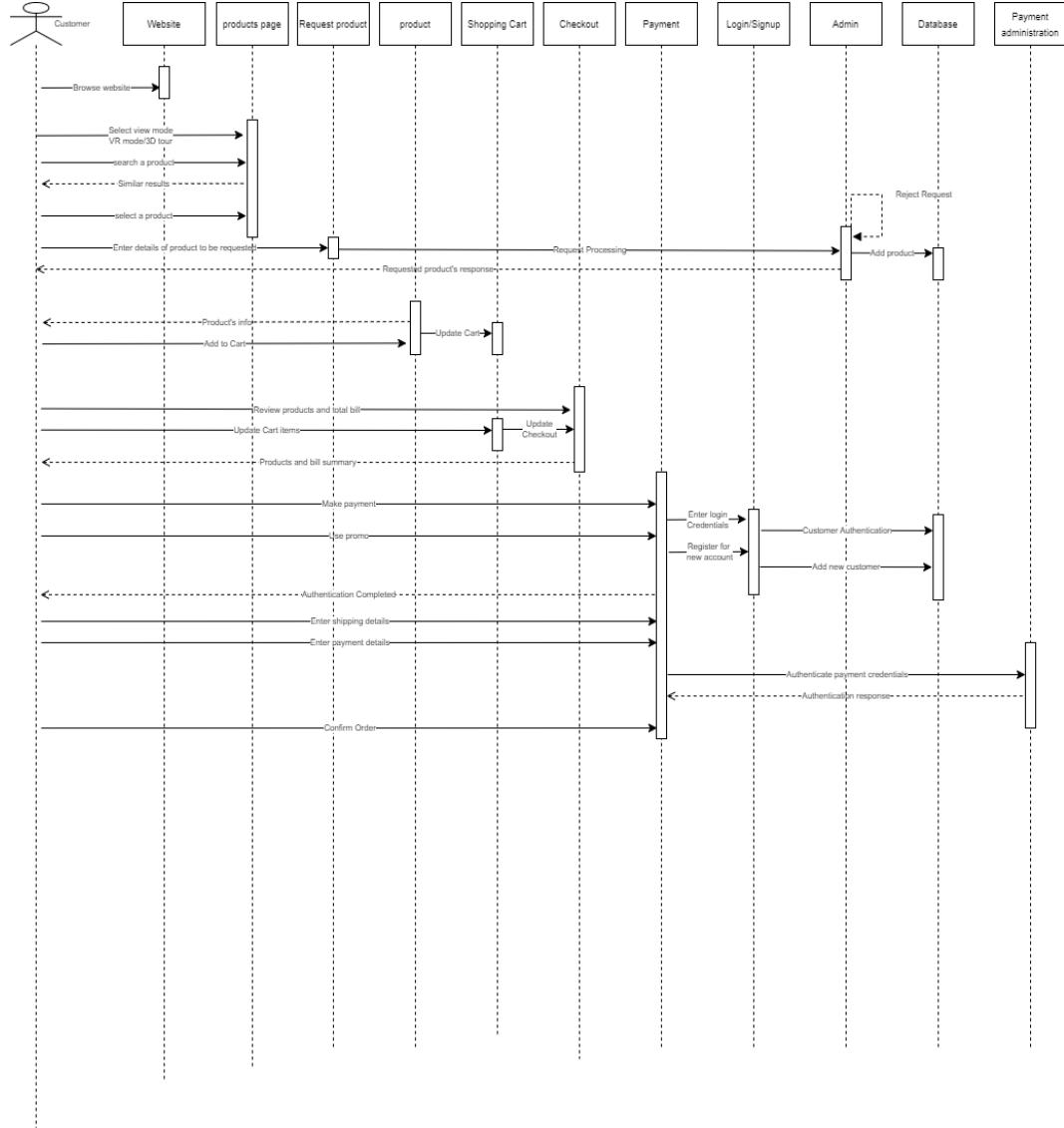


FIGURE 3.13: System's Sequence Diagram (Customer)

This diagram shows the whole sequence of steps required by customers to accomplish different tasks. For example viewing products, taking orders, making product requests, giving feedback to products e.t.c. In the diagram rectangles can be seen, these rectangles are modules of the system e.g products, shopping cart, payment, e.t.c. Where the long bar under every module represents the lifetime for which the user would be interacting with that module. Arrows from the user entity to different bars show the user's purpose of interaction with that module. For example, customers would interact with the product module to view the product shown in the diagram.

Chapter 4

Implementation

4.1 Implementation Details

The system consists of different modules like an E-commerce website, a 3D tour of a MetaMart store, Virtual reality mode, and fitting size suggestions for customers. These are the main modules of our web application. The implementation detail of each of the following modules is discussed in detail below.

4.2 Rules and assumptions

Following are rules and cases of assumptions that are assumed to be true while experiencing virtual reality mode working:

- The customer has an Oculus VR headset and the configurations/setting for Oculus VR Headset is also done by the customer before going into VR mode.

Following are rules and cases of assumptions that are assumed to be true while normally working:

- The internet connection is stable.

4.3 Technology Used

4.3.1 Frontend

Following are the languages we used in this project:

- HTML5
- CSS
- Bootstrap5
- JavaScript
- React
- NodeJs
- Redux

4.3.2 Database

We used **MongoDb** database which is one of the popular NoSQL databases. We used mongodb with NodeJs.

We also used express as it is also one of the popular backend frameworks for node.

4.3.3 API

Express.Js: It is an open source for node js used to integrate frontend and backend.

4.4 System Requirement

To be able to use certain hardware or software, the system requirements are required specifications. The configurations for VR headsets are necessary so that the VR headset will work fine and the customer can experience virtual reality mode without any problems. A computer may need certain input and output ports to work with peripheral devices. So as our application requires a VR headset with its configurations on the system, that's why ports should work fine because different cables i.HDMI cables need to be inserted into respective ports.

4.4.1 Hardware Requirement

Following are some of the hardware requirements for this project:

- Processor Intel(R)
- Installed RAM 8.00GB
- Window 8,10,11
- Wireless Adapter(WIFI) or Ethernet connections(LAN)
- Oculus VR Headset(For experiencing Virtual reality-based E-commerce store)

4.4.2 Software Requirement

- Software Stack: MERN
- IDE: Visual Studio
- Database: MongoDB
- Testing API: Postman

4.5 Tools Used

A list of all the software that is used to develop and needed to operate the developed module is detailed below:

Tools	Description
Make-Human	MakeHuman is a free and open-source application used for making 3D avatars with custom inputs. Like we just have to set input measurements for the avatars. We can also import and export avatars. Make-Human is developed by a community of programmers.
Clo3D	Clo3D enables you to create virtual 3D samples using best practices and workflow and provides you with basic knowledge of pattern making and digital pattern files. You learn how to instantly modify patterns, fit, and fabrication, with the ability to view changes in colors, prints, and graphics. We can easily make 3D clothes using clo3D.
Balsamiq	Balsamiq Cloud is a web-based user interface design tool for creating wireframes. It can be used to generate digital sketches of your idea or concept for an application or website and to facilitate discussion and understanding before any code is written. You can use Balsamiq to make wireframes. We can make low-fidelity prototypes of our application.
Asana	Asana is a web and mobile work management platform designed to help teams and organizations organize, track, and manage their tasks or work.
Github	GitHub is an online software development platform. It's used for storing, tracking, and collaborating on software projects. GitHub is a great platform for source code sharing and tracking changes in it. With the help of Github, you can easily share your source code with another person.
VS Code	With VS Code, a free coding editor, you can quickly begin coding. Use it to code in any programming language, without switching editors.
Overleaf	Overleaf is a collaborative cloud-based LaTeX editor used for writing, editing, and publishing scientific documents.
Visual Studio	You can get started coding right away with the help of the free coding editor Visual Studio Code. Visual Studio Code has support for many programming languages, including Python, Java, C++, JavaScript, and many more.
Zoom	Zoom is a communication Platform. You can use it for users to connect with video, audio, phone, and chat.
Postman	Postman is an API platform for building and using APIs. Postman simplifies each step of the API lifecycle and streamlines collaboration so you can create better APIs—faster.

TABLE 4.1: Tools required for the development of proposed system

The given table shows the list of different tools that are going to be used for the proposed system's development. For example, in the first place, there is a tool named "make human". This tool would be helping out developers in making 3D avatars by giving custom measurements (height, weight, chest size, arm size e.t.c) to the application and getting avatars of that size as output. Similarly, clo3d will be used for making 3D clothes models to give customers 360-degree exposure.

4.6 3D Jackets View

4.6.1 For Males



FIGURE 4.1: 3D Model of the grey jacket (Male)

A 3D model of a grey color jacket for men made in clo3d. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.2: 3D Model of the jacket (Male)

A 3D model of khaaki color jacket for men made in clo3d. The purpose of this model is to put it on an avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.3: 3D Model of the yellow jacket (Male)

A 3D model of a yellow color jacket for men made in clo3d. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.4: 3D Model of sleeveless black puffer jacket (Male)

A 3D model of black color puffer jacket for men made in clo3d. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.5: 3D Model of the jacket (Male)

A 3D model of a jacket for men made in clo3d. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.

4.6.2 For Females



FIGURE 4.6: 3D Model of puffer jacket (Female)

A 3D model of a black color jacket for females. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.7: 3D Model of the stylish designed jacket (Female)

A 3D model of a well-designed jacket for females. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.8: 3D Model of the green leather jacket (Female)

A 3D model of a well-designed leather jacket for females. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in the 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.



FIGURE 4.9: 3D Model of beautifully designed puffer jacket (Female)

A 3D model of a well-designed puffer jacket for females. The purpose of this model is to put it on the avatar and render it as a 360-degree rotatable object for customers in a 3D environment. This jacket is made by making some patterns and then sewing that patterns according to some measurements.

4.7 3D Avatars wearing Jackets View

4.7.1 For Males



FIGURE 4.10: Male Avatar wearing t-shirt and pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.



FIGURE 4.11: Male Avatar wearing jacket and pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.



FIGURE 4.12: Asian Male Avatar wearing jacket and pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.



FIGURE 4.13: Male Avatar wearing jacket and black pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying of 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.

4.7.2 For Females



FIGURE 4.14: Female Avatar wearing a puffer jacket and white pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.



FIGURE 4.15: Female Avatar wearing a stylish black puffer jacket and white pants

Avatar is a 3D rotatable object made in make humans with customer inputs. It would be used for displaying 3D clothes to the customer just like in the real world there are statues for displaying clothes and customers can move around that statue for checking cloth.

4.8 Unity Environment View

4.8.1 Virtual city in Meta verse

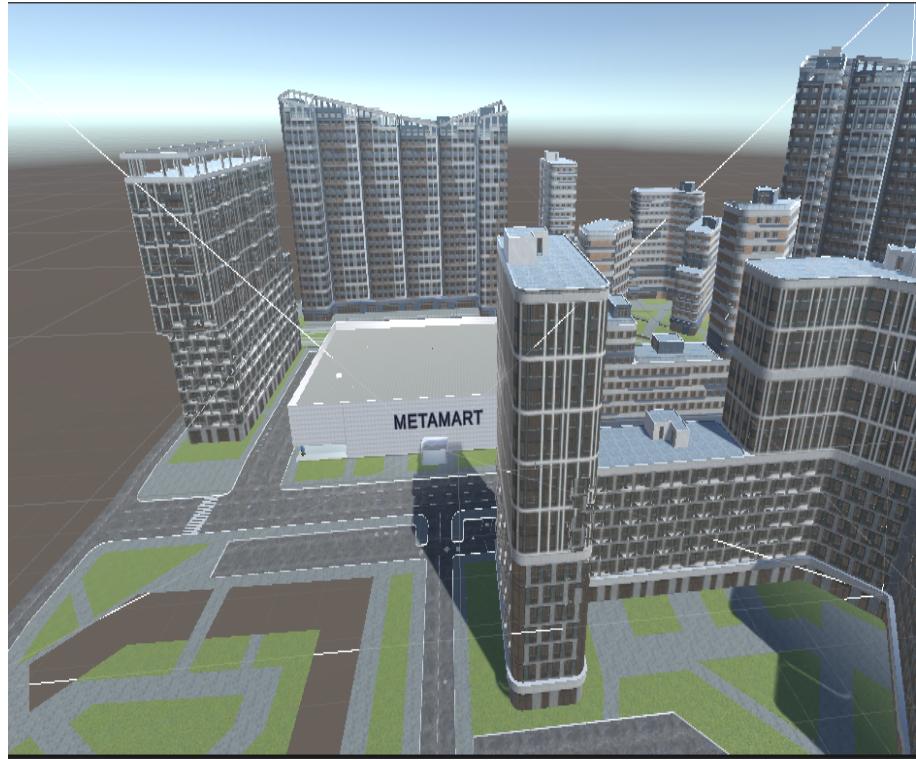


FIGURE 4.16: Virtual store outer view

The virtual store's outer view is shown in this image.

4.8.2 Entrance of MetaMart



FIGURE 4.17: Entrance of MetaMart

Entrance of MetaMart through which the customer will enter in the MetaMart.

4.8.3 Inside View of MetaMart

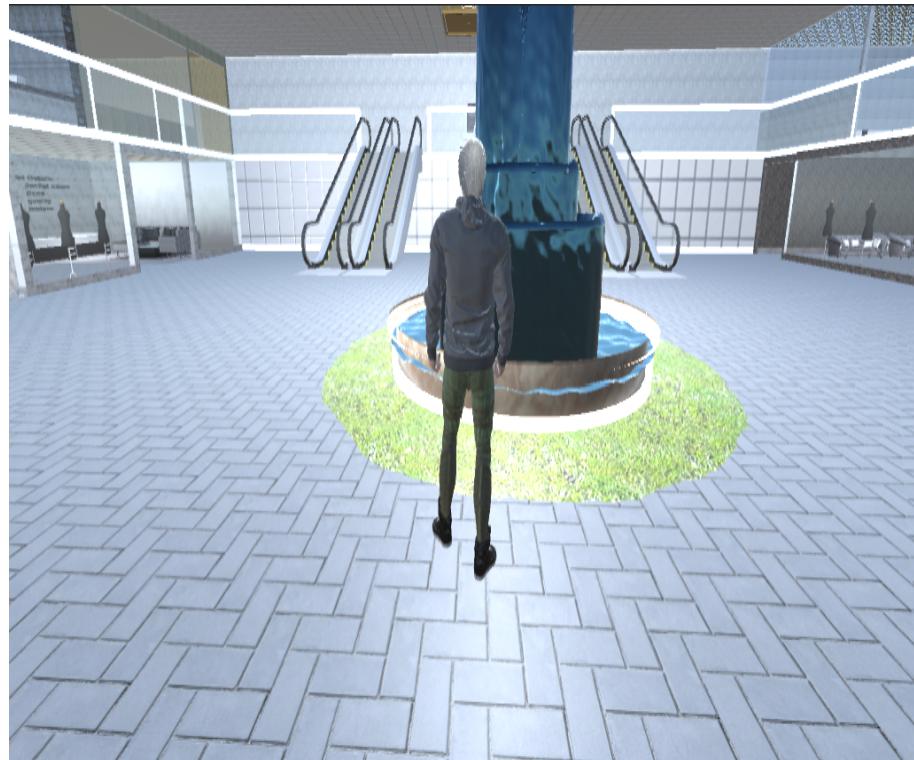


FIGURE 4.18: Inside view of MetaMart

The front view of shops in MetaMart is in this image is shown.

4.8.4 Inside View of MetaMart



FIGURE 4.19: Shop View of MetaMart

The front view of shop in MetaMart in this image is shown.

4.8.5 Inside Shop view in MetaMart



FIGURE 4.20: Inside View of MetaMart

Inside View of MetaMart like when the customer enters the shop in MetaMart this view will be shown to the customer.



FIGURE 4.21: Inside View of MetaMart (2)

Inside View of MetaMart like when the customer enters the shop in MetaMart this view will be shown to the customer.



FIGURE 4.22: Inside View of MetaMart(2)

There are different shops inside the MetaMart like when the customer enters in the MetaMart this is the first shop in which there will be different outerwears for men.



FIGURE 4.23: Jacket details shown to the customer

When a customer approaches a product, its details will be displayed to the user, just like this.

4.9 Virtual Reality-based E-commerce Web Application Interface

4.9.1 Admin Section

Following are some of the screenshots of the Admin section:

4.9.1.1 Sign-In Screen

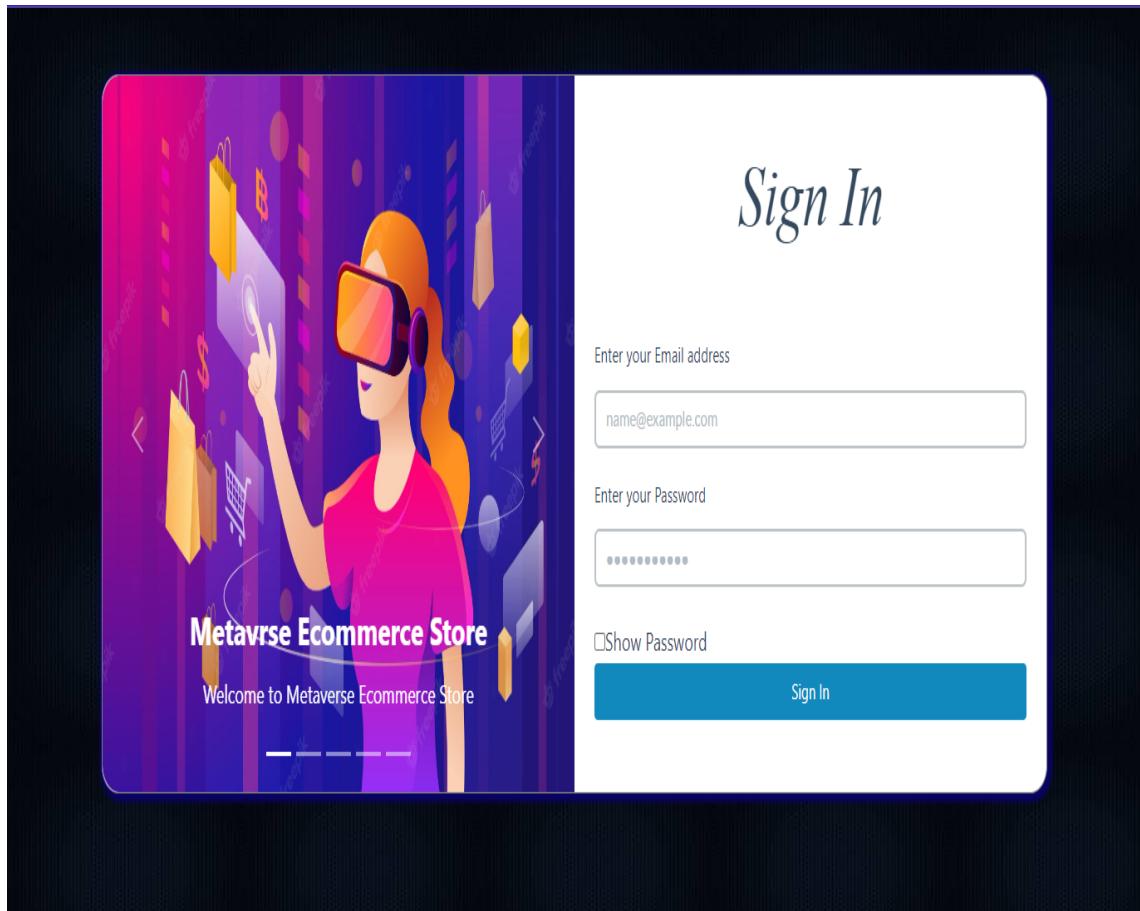


FIGURE 4.24: System's sign-in screen (Admin)
It is the sign In page for the Admin of the website.

This image shows the sign-in screen that we have developed for our MetaMart Application for admin of the application. On this screen, there is a login form that contains email and password fields. This form is fulfilling all validations.

4.9.1.2 Profile Setting Page

The screenshot shows the Metaverse Mart Dashboard with a dark blue header. The header includes the brand name "Metaverse Mart" and three horizontal bars. To the right of the header are icons for a bell, a globe, and a dollar sign. The main content area has a light gray background and features a large title "Profile Setting" in bold blue text at the top center. Below the title is a form for updating user profile information. The form fields include:

- Enter User Name: A text input field with a person icon and placeholder text "Enter User Name".
- Enter Email: A text input field with a checkmark icon and placeholder text "ali123@gmail.com".
- Enter Old Password: A text input field with a keyhole icon and placeholder text "Enter Old Password".
- Show Password: A checkbox labeled "Show Password".
- Enter New Password: A text input field with a keyhole icon and placeholder text "Enter New Password".
- Show Password: A checkbox labeled "Show Password".
- Re-enter New Password: A text input field with a keyhole icon and placeholder text "Re-enter New Password".
- Show Password: A checkbox labeled "Show Password".

At the bottom of the form are two buttons: "Reset" on the left and "Submit" on the right.

FIGURE 4.25: Admin Profile Setting

This image shows the profile setting screen that we have developed for our MetaMart Application for admin of the application. In this screen, there is a form that contains all the fields related to the admin's profile. This form is fulfilling all validations and valid error messages that would be shown to the user in case of invalid inputs.

4.9.1.3 Pending Order

The screenshot shows the 'Pending' orders section of the MetaMart Admin Dashboard. The left sidebar includes links for Dashboard, Users, Products, Analytics, History (which is selected), User Orders, User Feedbacks, Profile Setting, and Log Out. The main content area has a title 'Pending' and a search bar. A table lists four pending orders for 'Jacket' items, each costing 3000Rs. The table columns are Sr.no., Title, Size, Quantity, and Price. At the bottom right are navigation buttons for Previous, 1, 2, 3, and Next.

Sr.no.	Title	Size	Quantity	Price
1	Jacket	Medium	3	3000Rs
1	Jacket	Medium	3	3000Rs
1	Jacket	Medium	3	3000Rs
1	Jacket	Medium	3	3000Rs

FIGURE 4.26: Admin's pending orders page

This image shows the pending orders screen that we have developed for our MetaMart Application for admin of application. In this screen, there is a table that contains all the orders that are in the queue such that they are not yet received by the customer. Admin can search for an order by order id or simply can explore all orders by next and previous buttons.

4.9.2 Customer Section

4.9.2.1 Home Screen

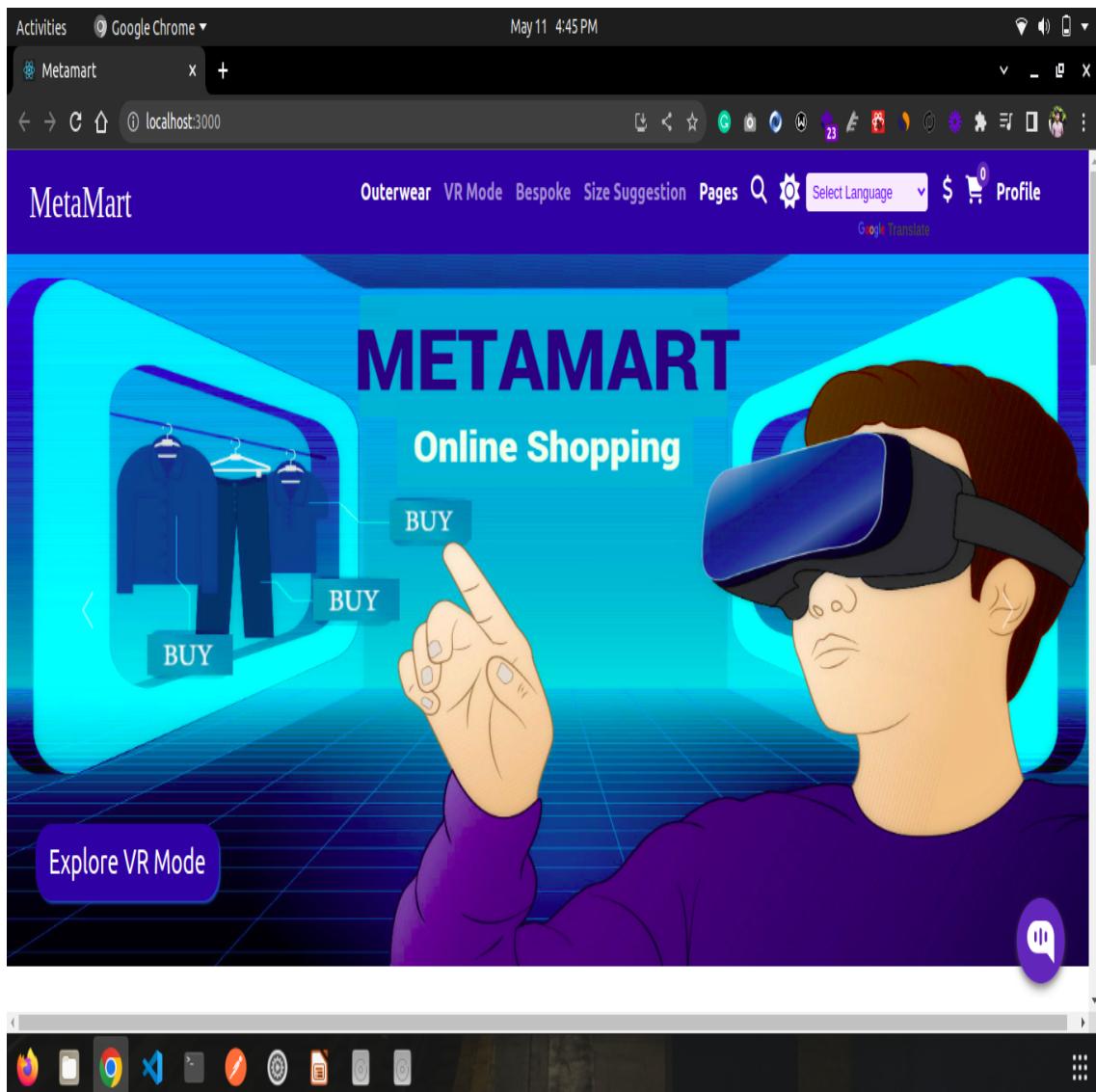


FIGURE 4.27: Customer's home page

Home screen for the customer like when the customer will open a virtual reality-based e-commerce web application then this is the main entry point of the website that will be shown to the customer.

This image shows the customer's home page where the customer would find an option to explore the 3D environment that we have developed for our MetaMart Application. Customers would be able to explore different products just like in the real world.

4.9.2.2 Product Section

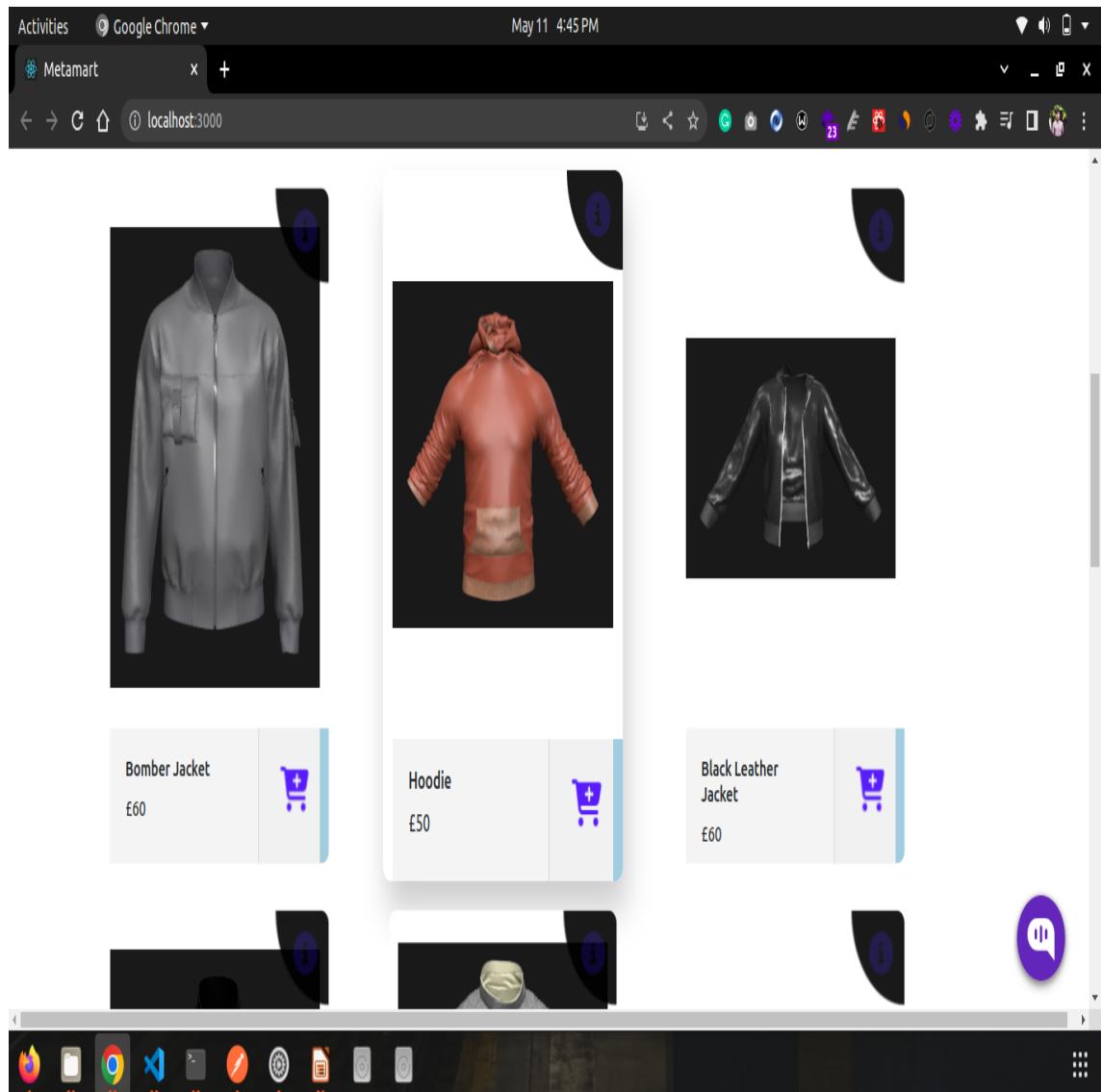


FIGURE 4.28: Customer's products page

This image shows the customer's products page where customers would find all products in a general view(2D) just like other e-commerce websites. Here customers can search for a particular product and can see the details of that product by clicking on the details button rendered under every product's image.

4.9.2.3 Signin Section

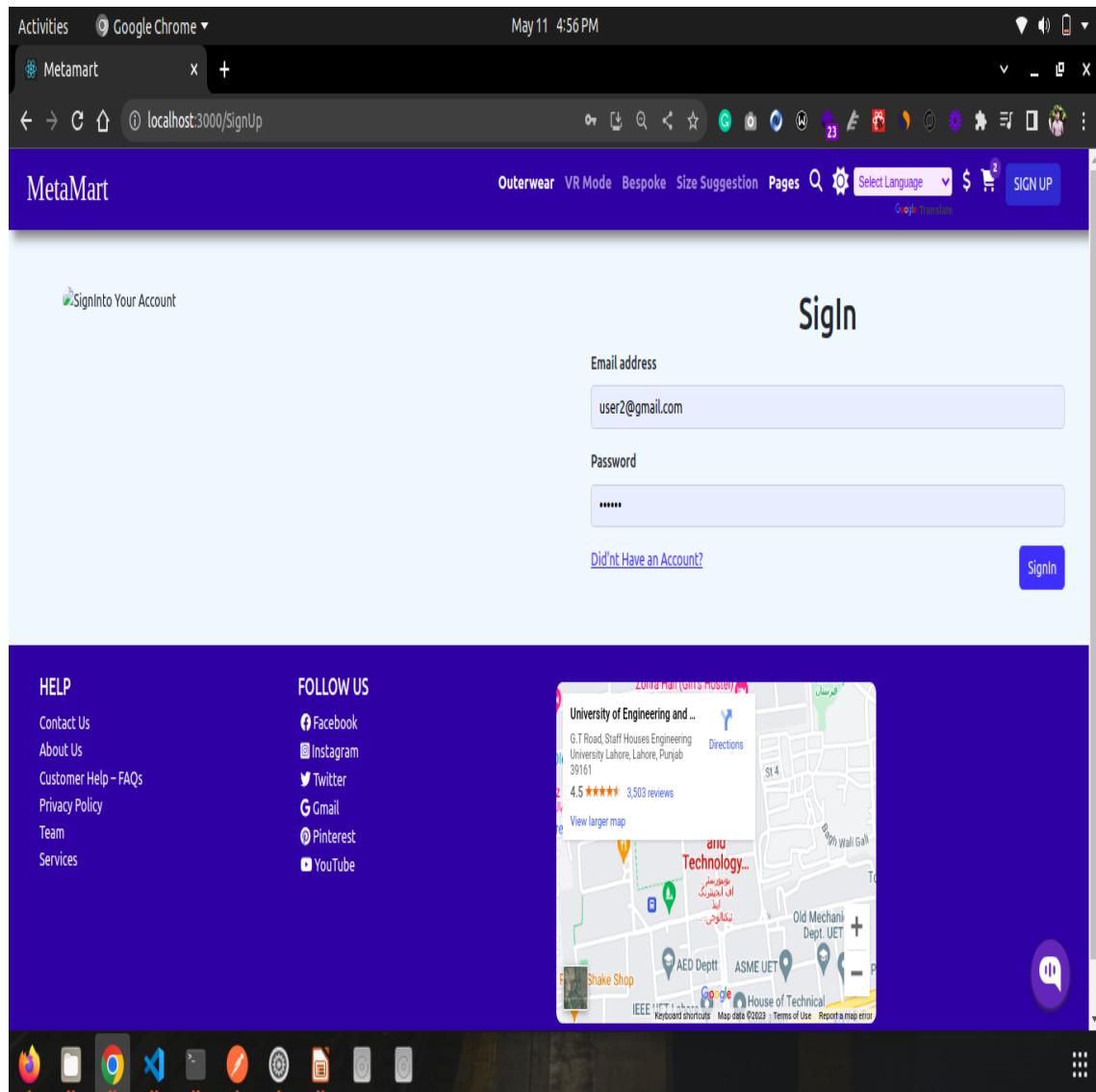


FIGURE 4.29: Customer's products page

This is the sign-in page where customers can enter their credentials to make a payment for the products they have added to their cart.

4.9.2.4 Size suggestion Section

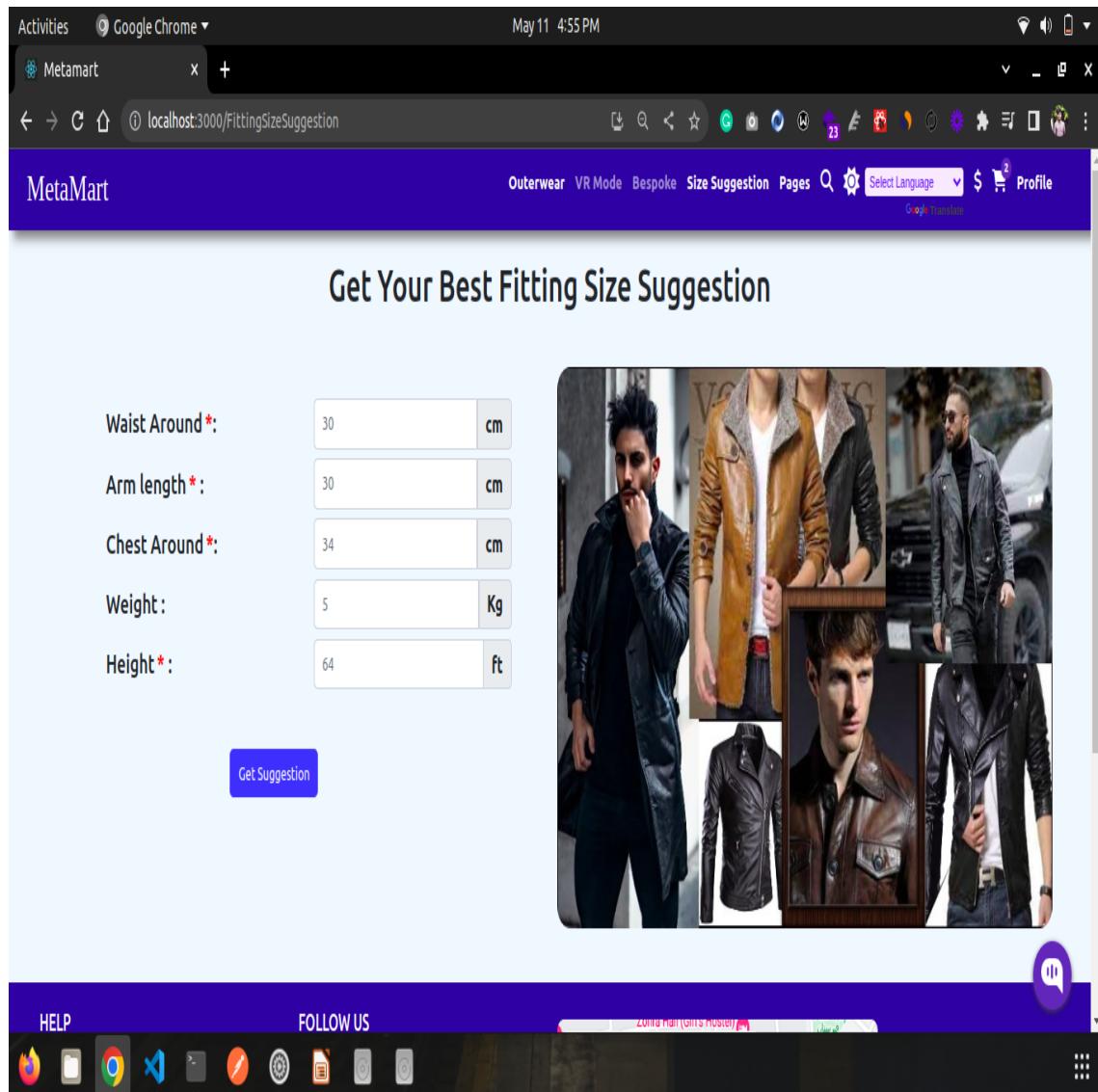


FIGURE 4.30: Customer's Size suggestion Section

This is the customer size suggestion section.

Chapter 5

Evaluation Criteria

5.1 TS-1: User Registration Functionality (Customer)

5.1.1 Post-Condition:

1. User is successfully registered and approved by admin.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Enter all valid credentials	Successful registration, and “successfully registered message” displayed.	Successful registration, and “successfully registered message” displayed.	Ali	Pass
TC-2	Enter invalid username	Register button should be disable.	Register button disabled.	Ali	Pass
TC-3	Enter invalid email	Register button should be disable.	Register button disabled.	Ali	Pass
TC-2	Enter invalid password	Register button should be disable.	Register button disabled.	Ali	Pass
TC-2	Enter invalid contact info	Register button should be disable.	Register button disabled.	Ali	Pass

TABLE 5.1: Test Scenario TS-1 Results

5.2 TS-2: User Login Functionality

5.2.1 Pre-Condition:

1. User is already registered and approved by admin (except admin).
2. User is identified and authenticated.

5.2.2 Post-Condition:

1. User is successfully logged into the system.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Enter all valid credentials	Successful logged in, and “logged in successfully” message should displayed.	Successful logged in, and “logged in successfully” message is displayed.	Ali	Pass
TC-2	Enter invalid username	Login button should be disable.	Login button disabled.	Ali	Pass
TC-3	Enter invalid pass	Login button should be disable.	Login button disabled.	Ali	Pass

TABLE 5.2: Test Scenario TS-2 Results

5.3 TS-3: Manage Product Functionality (Admin)

5.3.1 Pre-Condition:

1. Admin must be logged in to the system.

5.3.2 Post-Condition:

1. Admin has access to all functionalities to manage products.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Adding new product with valid details	Successful add new product, and “product added successfully” message should display.	Successful add new product, and “product added successfully” message displayed.	Ehtesham	Pass
TC-2	Adding new product with any invalid detail	Add button should be disabled.	Add button disabled.	Ehtesham	Pass
TC-3	Entering valid ID to Delete/Remove any unwanted product	Deleted successfully, a “product removed successfully” message should be displayed, and redirects admin to the dashboard main section.	Deleted successfully, a “product removed successfully” message should be displayed, and redirects admin to the dashboard main section.	Ehtesham	Pass
TC-4	Entering invalid ID to Delete/Remove any unwanted product	“Incorrect product ID”/ “Product id does not exist” error message should display.	“Incorrect product ID”/ “Product id does not exist” error message is displayed.	Ehtesham	Pass
TC-5	Entering valid ID to search product	Product should display successfully	Product displayed successfully.	Ehtesham	Pass
TC-6	Entering invalid ID to search product	“Incorrect product ID”/ “Product id does not exist” error message should display.	“Incorrect product ID”/ “Product id does not exist” error message is displayed.	Ehtesham	Pass
TC-7	Update any product with valid details	Successfully update product, and “product updated successfully” message should display.	Successfully update product, and “product updated successfully” message is displayed.	Ehtesham	Pass
TC-8	Update any product with any invalid details	Update button should remain disable.	Update button remain disable.	Ehtesham	Pass

TABLE 5.3: Test Scenario TS-3 Results

5.4 TS-4: Manage Customize orders Functionality (Admin)

5.4.1 Pre-Condition:

1. Admin must be logged in to the system.

5.4.2 Post-Condition:

1. Admin has access to manage customized orders of customers.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Checking customers customized orders' requests.	All customize orders' request should displayed.	All customize orders' request are displayed.	Ali	Pass

TABLE 5.4: Test Scenario TS-4 Results

5.5 TS-5: Manage Profile Functionality

5.5.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.

5.5.2 Post-Condition:

1. Customer Profile will get updated.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Update profile with valid details	Successfully update profile, and “profile updated successfully” message should display.	Successfully update profile, and “profile updated successfully” message is display.	Abdullah	Pass
TC-2	Update profile with invalid details	Update button should remain disable.	Update button remain disable.	Abdullah	Pass

TABLE 5.5: Test Scenario TS-5 Results

5.6 TS-6: Virtual Tour Functionality (customer)

5.6.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.
4. Customer must have entered in virtual tour mode.

5.6.2 Post-Condition:

1. Customer can experience all real time shopping functionalities.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Experiencing virtual tour without any issue	Virtual view of mall and functionalities should be visible to the user.	Virtual view of mall and functionalities is visible to the user.	Maham	Pass
TC-2	Experiencing virtual tour with any issue	Virtual view of mall should not be visible to the user, and appropriate error message should be displayed.	Virtual view of mall is not visible to the user, and appropriate error message is displayed.	Maham	Pass
TC-3	Visit virtual store	Customer's avatar should roam around the virtual store to take a tour.	Customer's avatar can take the tour of virtual store.	Maham	Pass
TC-4	Showing Jackets details	Jackets' details should be popped up on triggering with the avatar.	Jackets' details are popping on a panel when avatar is triggered with the any jacket.	Maham	Pass
TC-5	Jackets Size Options	There should be four size displaying options available for jackets for 4 standard body sizes.	Options for 4 standard sizes jackets are available in the store with details.	Maham	Pass
TC-6	Mannequin Avatar dynamic Size	The avatar size should be change during run-time according to the customers' selected jacket size.	The avatar size can be change during run-time according to the selected jacket size.	Maham	Pass
TC-7	Add to cart	Customers should add the choosed jackets to cart from virtual store also.	Customer can also add to cart the choosed items from the virtual store.	Maham	Pass

TABLE 5.6: Test Scenario TS-6 Results

5.7 TS-7: Manage cart Functionality(customer)

5.7.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.

5.7.2 Post-Condition:

1. Customer can manage personal cart section.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Adding items to cart	Selected item should be added in the cart list and should stay even after logged out until gets removed or delivered.	Selected item gets added in the cart list and remain in list even after logged out until gets removed or delivered.	Abdullah	Pass
TC-2	Updating cart items	Items added in the cart should get updated.	Cart items gets updated.	Abdullah	Pass

TABLE 5.7: Test Scenario TS-7 Results

5.8 TS-8: Customize Order Request(customer)

5.8.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.

5.8.2 Post-Condition:

1. Customer can request for any customized order.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Adding customized order details	Customized order details should get added into the request section and notification should be sent to the admin.	Customized order details get add into the request section and notification has sent to the admin.	Maham	Pass
TC-2	Checking response status from store service about customized order request.	The request status should be displayed in the request status.	The request status displays in the request status.	Maham	Pass

TABLE 5.8: Test Scenario TS-8 Results

5.9 TS-9: Payment Section Functionality (customer)

5.9.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.

5.9.2 Post-Condition:

1. Customer can request for any customized order.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Entering all valid credentials for payment	Payment gets done and “payment done successfully” message should display on screen.	Payment gets done and “payment done successfully” message displays on screen.	Ali	Pass
TC-2	Entering any invalid credentials for payment	Payment proceeds button should remain disable.	Payment proceeds button remain disable.	Ali	Pass

TABLE 5.9: Test Scenario TS-9 Results

5.10 TS-10: Product Rating Functionality (customer)

5.10.1 Pre-Condition:

1. Customer must be registered.
2. Customer must be authenticated and identified.
3. Customer must be logged in to the system.
4. Customer must has already received that specific product.

5.10.2 Post-Condition:

1. Customer will be able to give rating about any received product.

Test Case ID	Description	Expected Result	Actual Result	Executed By	Status
TC-1	Rating received products	Rating should be added and a “Thank you!” message should be displayed.	Rating is added and a “Thank you!” message is displayed.	Ehtesham	Failed

TABLE 5.10: Test Scenario TS-10 Results

Chapter 6

Future Work

We aimed to develop a virtual reality-based E-Commerce web application called Meta-Mart, which provides customers with a realistic shopping experience in the Metaverse. This project involves developing a basic E-Commerce website with all necessary features, integrating a 3D tour and VR mode created in Unity 3D into the website, placing 3D clothing on an avatar with custom dimensions focused on providing customers with a personalized shopping experience. The use of virtual reality technology in your application allows you to provide your customers with an immersive and realistic shopping experience. This is a vast improvement over traditional online shopping experiences based on 2D images and descriptions. By implementing the metaverse concept, applications can get a glimpse into the future of shopping in virtual worlds.

6.1 Future Work

The current project has achieved the desired goals. However, there is still room for improvement and further development in the future. The next section outlines future work that can be done to improve the MetaMart application.

1. Product extensions:

The current MetaMart application focuses on providing an apparel and outerwear shopping experience. In the future, the application can be extended to other products such as accessories, shoes and electronics. This allows you to have more product diversity for your customers and attract a wider audience.

2. Artificial intelligence integration:

MetaMart applications can be further enhanced by integrating artificial intelligence (AI) technology to provide personalized recommendations based on the customer's shopping history, preferences, and behavior. AI algorithms can analyze customer data and suggest products that match customer interests to improve customer satisfaction and sales.

3. Enhanced virtual reality experience:

VR experiences can be enhanced by incorporating haptic feedback and better graphics to create a more immersive and realistic shopping experience. This can be achieved through the use of advanced VR technologies such as haptic gloves and full-body tracking systems.

4. Integration with social media:

MetaMart's integration with social media platforms allows customers to share their shopping experience with friends and family, creating a sense of community around the application. Additionally, you can use social media integration to promote your products and increase brand awareness.

5. Integration with blockchain technology:

Blockchain technology can be integrated into his MetaMart application for greater security and transparency. This can be achieved by implementing a decentralized system

that tracks transaction and product authenticity, ensuring that customers receive genuine products.

6. Multilingual support:

MetaMart can be extended to support multiple languages, making it accessible to more users. This allows customers in different regions to access the application in their native language, improving user experience and customer satisfaction.

7. Performance optimization:

MetaMart application performance can be further optimized by reducing load times, reducing latency, and minimizing crashes and errors. This improves the overall user experience and ensures your application runs smoothly and efficiently.

In summary, the MetaMart project has demonstrated the potential of virtual reality technology in the e-commerce industry. Future work outlined above may help further develop and improve the application and provide customers with a more satisfying and immersive shopping experience in the Metaverse.

Appendix A

Virtual Reality

A.1 What is Virtual Reality

Virtual Reality is the future and it's a 3D complete environment in which everything provides a real-time feeling. Virtual reality is a buzzword today and it is popular nowadays in the future students can take lessons and classes in a virtual environment and companies like Amazon is also working on e-commerce virtual reality-based application. People can just wear a VR headset and in their homes, they can go to virtual e-commerce stores, and explore mental health treatment. There are lots of applications of virtual reality like VR in fashion design, mental health treatment, education, sports, military, medical training, etc.

A.1.1 What is Augmented Reality

In augmented reality, we used a real environment instead of the virtual environment. Snapchat uses augmented reality when we open a Snapchat camera then Snapchat provides different filters in which we can different objects The filters in which Snapchat lens scans our face and applies different cartoon shapes or filters or face changers etc. all possible because of augmented reality.

A.1.2 Difference between Virtual Reality and Augmented Reality

No external AR headset is required for experiencing augmented reality while a VR headset is required for experiencing a virtual environment. In virtual reality, everything is virtual like objects in a virtual environment while Augmented reality augments the real-world scene. Snapchat uses augmented reality when we open a Snapchat camera then Snapchat provides different filters in which we can different objects The filters in which Snapchat lens scans our face and the apply different cartoon shapes or filters or face changers etc. all possible because of augmented reality.

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