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Enhancing Textbooks using Augmented Reality

MAIN PROJECT REPORT

Meera E Thimothy **(JEC17CS066)**

Muhammed Raneesh C M **(JEC17CS071)**

Naveen P R **(JEC17CS073)**

in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY (B.Tech)

in

COMPUTER SCIENCE & ENGINEERING

of

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Under the guidance of

Mr. Shaiju Paul

CREATING TECHNOLOGY LEADERS OF TOMORROW

DECEMBER 2020

Department of Computer Science & Engineering

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DECEMBER 2020

BONAFIDE CERTIFICATE

This is to certify that the main project report entitled **Enhancing Textbooks using Augmented Reality** submitted by **Meera E Thimothy (JEC17CS066), Muhammed Raneesh C M (JEC17CS071), and Naveen P R (JEC17CS073)**in partial fulfillment of the requirements for the award of **Bachelor of Technology** degree in **Computer Science and Engineering** of **A P J Abdul Kalam Technological University** is the bonafide work carried out by them under our supervision and guidance.

Mr. Shaiju Paul	**Dr. Swapna B Sasi**	**Dr. Vinith R**
Project Guide	Project Coordinator	Head of The Dept.
Assistant Professor	Associate professor	Associate Professor
Dept. of CSE	Dept. of CSE	Dept. of CSE

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2. The graduates shall be able to establish themselves as practising professionals, researchers or Entrepreneurs in computer science or allied areas and shall also be able to pursue higher education in reputed institutes.
3. The graduates shall be able to communicate effectively and work in multidisciplinary teams with team spirit demonstrating value driven and ethical leadership.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. An ability to apply knowledge of data structures and algorithms appropriate to computational problems.
2. An ability to apply knowledge of operating systems, programming languages, data management, or networking principles to computational assignments.
3. An ability to apply design, development, maintenance or evaluation of software engineering principles in the construction of computer and software systems of varying complexity and quality.
4. An ability to understand concepts involved in modeling and design of computer science applications in a way that demonstrates comprehension of the fundamentals and tradeoffs involved in design choices.

COURSE OUTCOMES (COs)

C410.1 The students will be able to analyse a current topic of professional interest and present it before an audience.

C410.2 Students will be able to identify an engineering problem, analyse it and propose a work plan to solve it.

C410.3 Students will have gained thorough knowledge in design, implementations and execution of Computer science related projects.

C410.4 Students will have attained the practical knowledge of what they learned in theory subjects.

C410.5 Students will become familiar with usage of modern tools.

C410.6 Students will have ability to plan and work in a team.

ACKNOWLEDGEMENT

We take this opportunity to express our heartfelt gratitude to all respected personalities who had guided, inspired and helped us in the successful completion of this interim project. First and foremost, we express my thanks to **The Lord Almighty** for guiding us in this endeavour and making it a success.

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ABSTRACT

The leaning became smart now way days. The classroom became a smart classroom, the blackboards replaced by television and projectors. But the textbooks remain the same for a certain extent. The textbooks contain QR code for external reference. But they do not provide any change since it is a website that just shows some text. There is no interaction in the learning procedure. Also with the pandemic, understanding textbooks become very difficult for an ordinary student, due to the lack of contact classes. In this context, we introduce a mobile application that helps the students to understand the concept in a textbook using Augmented Reality. By just scanning the images in the textbook, the students will be able to visualize the 3D view of the image or a video lesson that explains the concepts etc. We also make sure that each 3D models and video lesson contain some interaction from students by introducing quizzes and points. With this, students will have confidence about the topics in the textbook and can learn each topic in a small-time.

Keywords: Augmented Reality, Marker-based AR, Smart Textbook, 3D Models, Smart learning

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List of Abbreviations

API	: *Application Programming Interface*
APP	: *Application*
AR	: *Augmented Reality*
CV	: *Computer Vision*
DEP	: *Dependencies*
E – learning	: *Electronic Learning*
FR	: *Functional Requirements*
GPS	: *Global Positioning System*
GB	: *Gigabyte*
JS	: *JavaScript*
MP	: *Megapixel*
OS	: *Operating System*
QR Code	: *Quick Response Code*
RAT	: *Rational*
SDLC	: *System Development Life Cycle*
SDK	: *Software Development Kit*
URL	: *Uniform Resource Locator*
VR	: *Virtual Reality*
WebGL	: *Web Graphics Library*
WebRTC	: *Web Real – Time Communications*

CHAPTER 1
INTRODUCTION

1.1 Overview

The training of the new generation students is a popular discussion theme. Every teacher wants to use the appropriate mix of innovative training technologies and methodologies to attract today's students, and more important - to enhance the effectiveness of his training. Today's learners are "digital learners" and do not prefer to read hard copy books. The new generation learners prefer to use e-learning books, because they do not want to read the whole book. They use a search engine with keywords to easy find what they need in the book. They prefer watching the movie than reading the whole book, because they haven't got the patience to wait until the end of the book. The hard copy books are not so attractive for the new generation learners. The little kids nowadays are born in the digital world and prefer interactive books which have more 3D effects and more visual effects. On the other hand, there are still learners, who prefer to read hard copy learning materials. They use the e-learning platform to watch movies, use Virtual 3D environments, download lectures, but they print them and prefer to read the textbooks without any computer devices - to keep their eyes and good health.

This project aims for all users mentioned above by creating a mobile application in augmented reality that contains the textbook of kerala state students. It combines traditional hard copy learning texts, e-learning lecture notes, mobile learning, 3D learning models and augmented reality technology for more attractive educational books.

1.2 Objectives

The main objective of this project is to help students to understand the concepts in textbook quickly. It will help students to promote self-study. It gives us a experience of visual learning.

1.3 Organization of the project

The report is organised as follow:

- **Chapter 1:Introduction** Gives an introduction to "an augmented reality application for textbooks.".
- **Chapter 2:Literature Survey** Summarizes the various existing techniques and reference that helps in achieving the desired result.
- **Chapter 3: Problem Statement** Discuses about the need for the proposed system
- **Chapter 4:Project Management** Contains the effective project management model to be used for the project.
- **Chapter 5:Methodology** Describes the various steps involved to produce this project.
- **Chapter 6:Results**Describes the result of experiment conducted.
- **Chapter 7:Conclusion** Concludes with the future scope of implementation.
- **References** Includes the references for the project.

CHAPTER 2
LITERATURE SURVEY

2.1 Augmented Reality

Augmented Reality or AR is a combination of a real and virtual world[2]. It is achieved by augmenting computer-generated images in the real world. Augmented Reality is overlapping or augmenting of digital images on real-world objects using various AR apps. AR can be defined as a system in which real and virtual worlds have combined. Here, the augmentation is done in real-time. One can say that AR is a technology in between Real Reality and Virtual Reality.

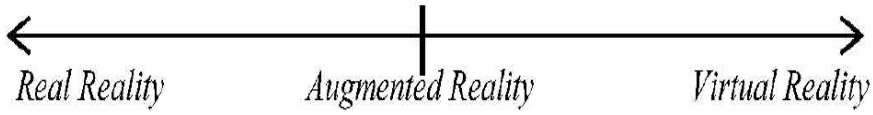

Figure 2.1: RR, AR, and VR

AR includes graphics, sounds and touches feedback which are then added to the real world. This creates an enriched user experience. All in all, AR helps improve user experience, helps in spreading knowledge, education and health. AR includes the concepts of Computer Vision and Computer Graphics. It needs the vision to get a clear understanding of the real world and needs graphics to create false elements to augment it.

2.1.1 Different Types of AR

There are four types of AR observed namely,

1. Marker-based AR
2. Markerless AR
3. Projection-based AR
4. Superimposition based AR

Marker-based AR

The Marker-Based AR is also known as Image Recognition or Recognition based AR. This type of AR provides us with more information about the object after it focuses on the recognition of objects. Marker-based AR technology has diverse uses according to market purposes. It detects the object in front of the camera and provides information about the object on the screen. The recognition of the object is based on the marker where it replaces the marker on the screen with a 3D version of the corresponding object. Therefore, the user can view the object in more detail and from various angles. Apart from that while rotating the marker user can rotate the 3D imagery as well. This acts as a reference for the AR app running on the system.[1]

Figure 2.2: Marker-based AR

Markerless AR

Markerless Augmented Reality is one of the most widely implemented applications in the industry. It is also known as Location-based AR for the reason for the easy availability of the features in the smartphones that provide location detection. This type of app is mostly used to help travellers. Apart from that, it helps users to discover interesting places within their current location. This method works by reading data from the mobile's GPS, digital compass and accelerometer while predicting where the user is focusing. This AR is all about adding location information on screen about the objects that can be seen from the user's camera.[1]

Figure 2.3: Markerless AR

Projection-based AR

This is one of the simplest types of AR which is the projection of light on a surface. Projection-based AR is appealing and interactive where light is blown onto a surface and the interaction is done by touching the projected surface with hand. The widespread uses of projection-based AR techniques can be used to create deception about the position, orientation, and depth of an object. In such a case this allows the user to take different objects into consideration and its structure to study in-depth. This technology offers a whole lot more in every sense. This piece of tech is used for creating a virtual object for much larger deployments for experiencing Augmented Reality.[1]

Figure 2.4: Projection-based AR

Superimposition Based AR

It is the superimposition of the objects. This AR provides a replacement view of the object in focus. This is done by replacing the entire or partial view with an augmented view of the object. Here, object recognition plays an important role. E.g. IKEA - Augmented Reality Furniture catalogue. It is a virtual furniture app that augments furniture onto the real floor.[1]

Figure 2.5: Superimposition Based AR[1]

2.1.2 Applications of AR

Since AR allows us to interact with the real world and the virtual world at the same time, it had a lot of applications in various fields. Some of them are mentioned below.

Entertainment

Augmented Reality can be proved to be a game-changer for entertainment and games. AR can be used in Television Broadcasting. Many sports channels and news channels use AR thus allowing the audience to view graphic overlays. The AR is used in games also. Games like Pokemon GO, Ingress etc. are the best examples of AR Games.[2]

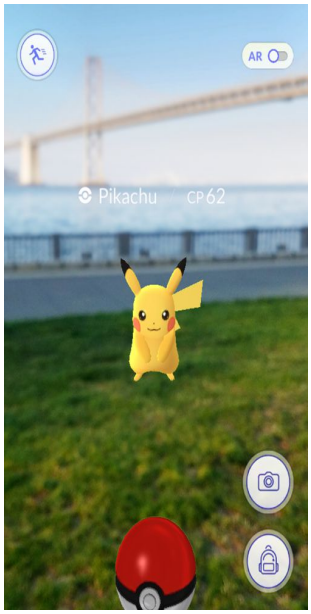

Figure 2.6: Pokemon Go app

Education

AR in education is growing day-by-day. Due to Covid 19, Governments of various countries encouraged learning from home. Schools are shut down in various countries which also affected the growth of AR in the education field. With AR apps students can learn easily and effectively nowadays. Quiver, Elements 4D are some of the AR apps in the Educational field.[2]

Figure 2.7: Element 4D app

Manufacturing

Augmented Reality has helped in improving the understanding of the product assembly tasks to be carried out. Information overload and the training required for assembly operation can be reduced using the AR approach. In manufacturing, AR can help in complex assembly of machinery, in the maintenance of parts and in providing expert support.[2]

Figure 2.8: AR in Service and Maintenance

2.2 Working of Augmented Reality

Now we can look at how AR works at a very high level. In general, two primary things need to happen for every time step of an augmented reality application.

1. The application needs to figure out the current state of both the physical world and the virtual world.
2. The application needs to display the virtual world in registration with the real world in a manner that will cause the participant(s) to sense the virtual world elements as part of his or her physical world and then return to step 1 to move on to the next time step.

2.2.1 Components of AR System

There are three major components to an augmented reality system to support the steps just listed. They are,

1. Processors
2. Display
3. Sensors

Processors

At the heart of any augmented reality system is a processor that coordinates and analyzes sensor inputs, stores and retrieves data, carries out the tasks of the AR application program, and generates the appropriate signals to display. In other words, every augmented reality system includes a computer of some sort. Computing systems for augmented reality can range in complexity from simple handheld devices such as smartphones and tablets to laptops, desktop computers, and workstation-class machines through powerful distributed systems.

Display

The display is the component that causes an appropriate signal to impinge on a participant's senses. For example, a visual display shows visual imagery to the participant. One example of a visual display is a computer monitor. An audio display causes the sounds made by the system to be audible to the participant. An example of an audio display would be headphones or a loudspeaker.

Sensors

They are used to determine the state of the physical world where the application is deployed. Three primary categories of sensors are used in AR systems:

- Sensors used for tracking
- Sensors for gathering environmental information
- Sensors for gathering user input

a. Sensors Used for Tracking

Because AR depends on being spatially registered, there must be some mechanism to determine information about the position of the participant, the real world, and any AR devices. Note that position includes both location and orientation. To fully determine position requires information about six degrees of freedom of the entity being tracked. The six degrees of freedom, in this case, include X location, Y location, Z location, yaw, pitch, and roll. The main sensors in this category are Camera, GPS, Gyroscopes, Accelerometers, Compass etc.

- **Camera** - Many current augmented reality applications use techniques from computer vision to determine the participant's location and perspective concerning the real world. To enable computer vision, the sensor required is a camera
- **GPS** - It is a navigation system that utilizes a network of 24 satellites in outer space. The receiver can determine its location in X and Y if it can receive 3 satellites by measuring the amount of time it takes for the GPS signal to travel from the satellite to the receiver.
- **Gyroscopes** - They report values related to orientation, that is, they can provide information including yaw, pitch, and roll.
- **Compasses** - They provide information regarding what direction they are pointing.
- **Accelerometers** - They report acceleration. They can be used to determine the direction something is moving and changes in movement, and they do not depend on the presence of GPS signals.

b. Sensors for gathering environmental information

Sensors that are used less commonly in AR systems but can provide information about the physical world at the time and place that the AR application is being used. For example,

temperature sensors, humidity sensors, and other sensors can be used to overlay atmospheric information on a scene in an AR application.

c. Sensors for Gathering User Input

Some of the most common sensors that gather user input would include buttons, touch-screens, keyboards, and other typical user interface devices. Most portable devices such as smartphones and tablets have a set of sensors in the form of buttons and keyboards (whether real or virtual) that an AR application designer can make use of to provide the participant with a way to directly interact with and control an application.

2.3 Mobile AR

Mobile AR is the most common form of AR available in the market. It is the AR that you can take with you wherever you go. You can enjoy the AR content in any corner of the world. There is an important distinction between mobile augmented reality and portable augmented reality. Portable augmented reality uses technology that you can move from place to place. A desk-side computer with a monitor is somewhat portable in that it can be moved from one place to another relatively easily. A laptop computer is more portable. If the batteries are charged you can carry it easily from place to place. You can even operate the laptop while you are walking, but it is awkward and not something you want to do regularly. Smartphone, Tablet computers etc. are good examples of mobile AR devices. We can carry them wherever we want. We did not have any wires around it. They are lightweight. They have better processing powers and long battery life due to the high-performing optimized smartphone processors. The devices like Microsoft Hololens, Magic leap one etc. also came under the Mobile AR. They can be carried anywhere. They have powerful processors and they are designed for the AR experience.

2.3.1 Mobile AR process

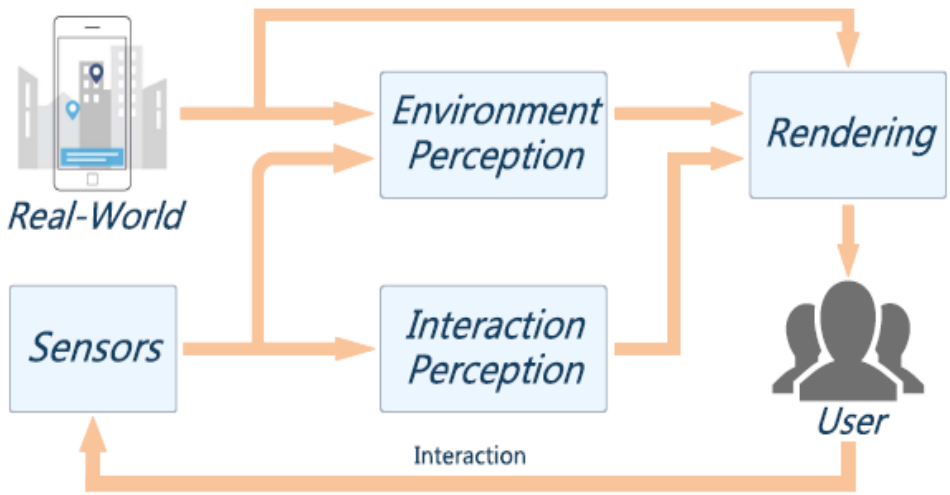

Figure 2.9: Mobile AR Process

Here the camera and other types of sensors in the device are used to continually gather user ambient information. The environment perception analyzes the captured information such as image video etc. for real-world recognition and perception. At the same time, the user's interaction information is also gathered by the sensors and then analyzed to track objects. Both

the results of the perception of the environment and the interaction are used for seamless integration of virtual contents with the real world, i.e., a rendering operation is performed, after which the AR will be presented to the user.

2.3.2 App-Based AR

The App-based AR is one of the main implementation of Mobile AR. it is the most popular version of Mobile AR. As the name indicates they are Application which allows us to experience AR in smartphones, tablets, etc. There are plenty of Apps that are available in the Apple App store and Google play store for experience AR in our mobile devices. The IKEA place App, Snapchat AR stickers etc. are good examples of app-based AR.[6]

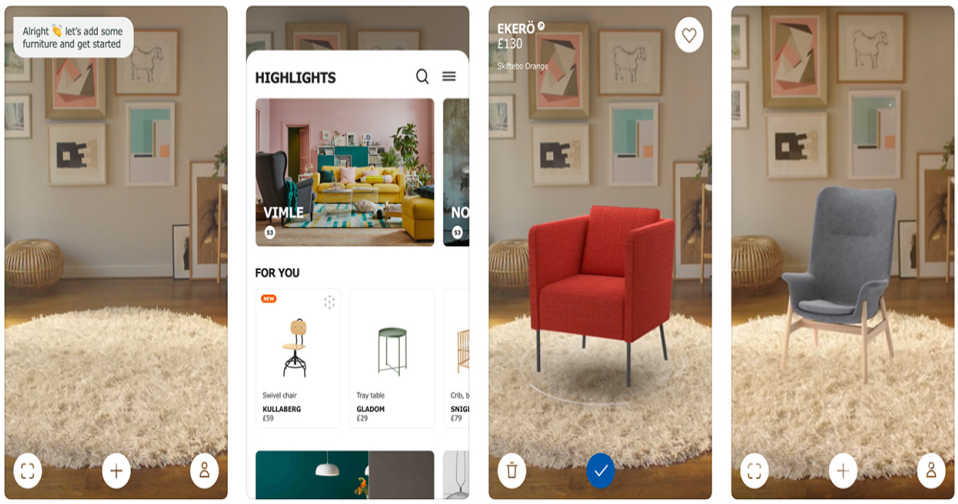

Figure 2.10: IKEA place app

2.3.3 Advantages and Disadvantages of App-based AR

Advantages

- Only a Mobile phone is required
- Portable
- Low cost
- A large number of users
- Availability of robust Software Development Kits (SDKs) for development

Figure 2.11: Snapchat AR

- be developed using Game Engines like Unity 3D, Unreal engine etc.

Disadvantages

- Limited computing capability of Mobile devices
- Limited battery capacity
- Platform dependent
- High development cost
- Require installation of applications
- Big size of the applications

2.4 Web AR: A Promising Future for Mobile Augmented Reality—State of the Art, Challenges, and Insights

This paper discusses Web AR. It is a recent development in Mobile AR and it allows us to enjoy the AR content through web browsers. Currently there two dominant platforms in Mobile AR. The App-based AR and Hardware-based AR. The App-based AR is a low-cost AR platform. The user can enjoy the AR content in their smartphone. But user wants to download multiple AR apps in their phones which affect their device performance. Also, smartphones are limited in processing data and battery. The Hardware-based AR is costly and lacks flexibility. But it provides a good AR experience because of the powerful hardware.

The Web AR solves the above problems. The Web AR is cross-platform and lightweight compared to other AR platforms. The introduction of 5G also boosts the development of web AR. The technologies that enable web AR are WebAssembly, WebGL, Web Workers, WebRTC. There are mainly two implementation approaches for Web AR.

- Self-Contained Method
- Computation Outsourcing

In Self-contained methods, the task is executed on the mobile devices locally. It is an offline approach. This method is less dependent on the network. So the performance is not affected by the delay in networks. The main disadvantage is the inefficient computing capabilities of mobile devices.

Another method is Computation outsourcing. It uses the computing and storage capabilities of cloud servers. It is more dependent on the network.

This paper also discusses various challenges in Web AR like security, privacy, cost of maintaining server etc.[6]

2.4.1 Role in our project

We are developing a marker-based Mobile AR application for students to visualize the contents of the textbooks in 3D. The current network speed is not efficient for Web AR implementation. This situation will change once 5G came. So we are planning to implement the Web AR app in future.

2.5 ARkit and ARCore in serve to augmented reality

This paper compares ARkit by Apple and ARCore by Google. ARkit and ARcore are two dominant SDKs for developing AR Application for Mobile devices.

Apple's ARkit was released in June 2017. This SDK is only for developing apps for iPhone and iPads that running in IOS 11 or higher. The main features of ARKit are Motion tracking, Environment understanding, Tracking 2D images, Multiple Face tracking, Motion Capture etc.

Google ARCore is the successor of Project Tango. The Tango SDK was launched in 2014. The ARCore was released in March 2018. Unlike Tango, The ARCore was usable in many devices that running android 7.0 or later. The main features of ARCore are Augmented Images, Motion Tracking, Understanding environment, Light Estimation, Augmented Faces etc.[5]

Figure 2.12: ARkit and ARCore

2.5.1 Role in our project

We are developing our Mobile AR application using Google ARCore. We are using Unity Game Engine for developing the AR Application. The ARCore is open source and had good documentation. It also supports a large number of devices. So we are developing the app using the ARCore SDK.

2.6 Marker Tracing For Video-Based Augmented Reality

In the AR system , virtual objects are added to real scenes to improve person perception. Virtual and real info must be aligned strictly in combination with scenes. The key of AR is 3D registration technology which is based on tracking artificial markers. Using linear programming theory, this paper presents a tracking in AR. The key issue of AR is tracking and registration. AR System (tracking method)

- Sensor tracking
- Computer vision

2.6.1 Working Principle Of Marker Based AR

1. The live video of the real scene captured.
2. Image processing.
3. If the image is found(specific shape), it will be matched.
4. Position and direction of the camera can be calculated.
5. Virtual fig is drawn.
6. Final output consists of a virtual fig and image of the real world.

Markers used in marker based AR for 3D registration are more black and white planar. Typical type of marker used is ARtoolkit and ARtag. This paper presents a tracing method which can recognise vertices of any polygon in an AR system.[3]

2.6.2 Role in our project

We are developing a marker based mobile AR application for students to visualize content textbook in 3D model. This paper shows us the tracking and mapping/registration of objects. It also help us to design the marker based AR application, since it gives the steps to build an marker based AR application

2.7 Education and Knowledge based Augmented Reality

This paper mainly deals with augmented reality. AR is an interactive experience of a real world environment where the objects that reside in the real world are enhanced by computer generated information, visuals, haptic, etc. It enhances a user's perception of and interaction with the real world. The virtual objects display information that the user cannot directly detect with his own senses. The information conveyed by the virtual objects helps a user perform real-world tasks.

The goal of Augmented Reality is to create a system in which the user cannot tell the difference between the real world and the virtual augmentation of it and to add information and meaning to a real object or place.

Then in this paper, it discusses how AR is different from VR. Basically Augmented reality (AR) is closely tied to virtual reality (VR), since the concept of AR evolved as an extension or variation of VR. But both are a little different. VR technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. But in AR, it allows the user to see the real world, with virtual objects superimposed upon or composited with the real world.

This paper shows the different applications of AR. The main application is how AR is used in the educational system. It has been used to complement a standard curriculum. Text, graphics, video and audio were superimposed into a student's real time environment. Textbooks, ash cards and other educational reading material contained embedded markers or triggers that, when scanned by an AR device, produced supplementary information to the student rendered in a multimedia format. There are some benefits of AR in education. Augmented Reality (AR) in education features aspects that enhance learning of abilities like problem-solving, collaboration, and creation to better prepare students for the future. It is also good for traditional pedagogy focused on technical knowledge and proficiency. It maximizes students' ability to spend their time learning curricular subjects while minimizing the time spent learning how to use the new tech.[4]

CHAPTER 3

PROBLEM STATEMENT

The project "Enhancing Textbooks using Augmented Reality" aims to develop an Augmented Reality application which helps the students to understand the concepts in the textbook easily. Due to the pandemic, students in our country faces a lot of problems. The lack of contact classes caused difficulty in understanding the concept in the textbook. The textbook contains a lot of information. But an ordinary student finds it difficult to understand them. With the help of Augmented Reality, we can solve the problem for a certain extent. By Augmenting 3D models, videos, audios etc. on the 2D images in the textbook, students will able to understand the concepts easily. We also aim to make sure that each 3D models and video lesson contain some interaction from students by introducing quizzes and points. With this, students will have confidence about the topics in the textbook and can learn each topic in a small-time. Also, we aim to provide class notes, video lessons that can be viewed and downloaded through the application which also helps to understand each of the lessons. The study materials are organised based on their class, topic etc. so that students do not face any difficulty in understanding the concepts.

CHAPTER 4
PROJECT MANAGEMENT

4.1 Introduction

Project management is the discipline of planning, organizing, securing, managing, leading, and controlling resources to achieve specific goals. A project is a temporary endeavor with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables), undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. The temporary nature of projects stands in contrast with business as usual (or operations), which are repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of these two systems is often quite different, and as such requires the development of distinct technical skills and management strategies.

In our project we are following the typical development phases of an engineering project

1. Initiation
2. Planning and Design
3. Execution and Construction
4. Monitoring and Controlling Systems
5. Completion

4.1.1 Initiation

The initiating processes determine the nature and scope of the project. The initiating stage should include a plan that encompasses the following areas :

1. Analysing the business needs/requirements in measurable goals
2. Reviewing of the current operations
3. Financial analysis of the costs and benefits including a budget
4. Stakeholder analysis, including users, and support personal for the project

5. Project charter including costs, tasks, deliverables, and schedule

4.1.2 Planing and design

After the initiation stage, the project is planned to an appropriate level of detail (see example of a flow-chart). The main purpose is to plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution. As with the initiation process, a failure to adequately plan greatly reduces the project's chances of successfully accomplishing its goals.

- Determining how to plan
- Developing the scope statement
- Selecting the planning team
- Identifying deliverables and creating the work breakdown structure
- Identifying the activities needed to complete those deliverables
- Developing the schedule
- Risk planning

4.1.3 Execution

Executing consists of the processes used to complete the work defined in the project plan to accomplish the project's requirements. The execution process involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan. The deliverables are produced as outputs from the processes performed as defined in the project management plan and other frameworks that might be applicable to the type of project at hand.

4.1.4 Monitoring & controlling

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan.

4.2 System Development Life Cycle

The Systems development life cycle (SDLC), or Software development process in systems engineering, information systems, and software engineering, is a process of creating or altering information systems, and the models and methodologies that people use to develop these systems. In software engineering, the SDLC concept underpins many kinds of software development methodologies. These methodologies form the framework for planning and controlling the creation of an information system.

The SDLC phases serve as a programmatic guide to project activity and provide a flexible but consistent way to conduct projects to a depth matching the scope of the project. Each of the SDLC phase objectives is described in this section with key deliverables, a description of recommended tasks, and a summary of related control objectives for effective management. The project manager must establish and monitor control objectives during each SDLC phase while executing projects. Control objectives help to provide a clear statement of the desired result or purpose and should be used throughout the entire SDLC process.

4.2.1 Spiral Model

We have used the Spiral model in our project. The Spiral model incorporates the best characteristics of both- waterfall and prototyping model. In addition, the Spiral model also contains a new component called Risk Analysis, which is not there in the waterfall and prototype model. In the Spiral model, the basic structure of the software product is developed first. After the basic structure is developed, new features such as user interface and data administration are added to the existing software product. This functionality of the Spiral model is similar to a spiral where the circles of the spiral increase in diameter. Each circle represents a more complete version of the software product. The spiral is a risk-reduction oriented model that breaks a software project up into main projects, each addressing one or major risks. After major risks have been addressed the spiral model terminates as a waterfall model. Spiral iteration involves six steps:

1. Determine objectives, alternatives and constraints.
2. Identify and resolve risks.
3. Evaluate alternatives.
4. Develop the deliverables for the iteration and verify that they are correct.
5. Plan the next iteration.

6. Commit to an approach for the next iteration.

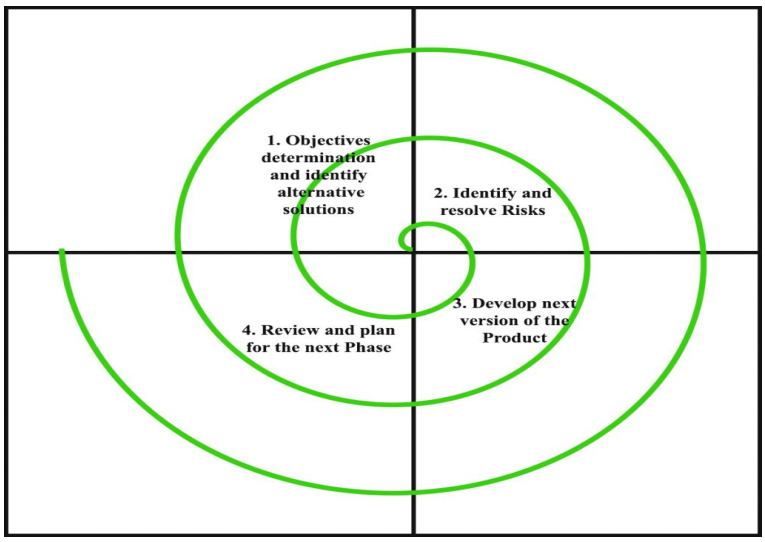

Figure 4.1: Spiral Model

CHAPTER 5
METHODOLOGY

5.1 System Requirement Specification

5.1.1 Introduction

Purpose

The purpose of the project is to design an AR Textbook application for school students. It covers Performance consideration, User Interface, Hardware and software requirements and use cases.

Project Scope

The AR Textbook application will help the school students to understand their textbook easily with the help of augmented reality. The app will detect the 2D images in the textbook and augment the images with 3D objects, video, etc. This will help them to understand the concepts in the textbook very easily.

The main goal of the project is to encourage self-study among students. The textbooks are good sources of knowledge. But understanding them is very difficult for normal students. So our aim is to provide good resources while reading the textbook.

5.1.2 Overall Description

Product Perspective

The students are facing a lot of problems during the pandemic. Learning becomes difficult due to the lack of contact classes from schools. Even Though the textbooks are good resources for learning, understanding them without a mentor is very difficult for normal students. To overcome this we introduce the AR textbook app, which helps the students understand the concepts of the textbook very easily without a mentor and also to improve self study capability of students.

Product Features

The major feature of the application is detecting 2D images from textbook and augmenting contents like 3D models, videos, audios etc. on top of it. Besides that, we also provide study materials like pdf notes, video lectures etc. inside the App.

User Classes and Characteristics

Students are the main users of our app since the app will help them to understand the concept in the textbook very easily. Beside students the teachers can also use the app to recommend the lessons for students to easily understand what they taught in the class and also provide proper feedback to the app developers.

Operating Environment

The app can be used by anyone if he/she has an android phone that runs in android version greater than or equal to 7.0 and also ARCore is supported hardware. The devices that support ARCore can be found in the link below.

`https://developers.google.com/ar/discover/supported-devices`

Assumptions and Dependencies

- Assume the phone is Android 7.0 or later (some devices will need at least Android 8.0 in order for ARCore to work)
- Assume that the phone has a good working camera
- Assume user provide permission for the app to use the camera

5.1.3 Specific Requirements

This section contains more detailed information regarding the needed functionalities of our application, including interfaces, internal functions, and testing requirements.

External interface Requirements

User Interfaces A first time user should see a log-in page when he/she opens the app. The user could be able to register for the app. After login he/she will be directed to the main home

page or dashboard. From here the user can go for either AR based study or looking for other study materials like pdf notes, Video lectures, etc. These facilities should be easily accessible from the home screens.

Software Interfaces The mobile app needs to communicate with various databases that contain the study materials like videos, pdf notes etc. Since users are only viewing the content the communication only contains reading operations.

Functional Requirements

Functional requirement 1.1
ID : FR1
Title : Download mobile application
DESC : The user should be able to download the application from a trusted store for free.
RAT : In order for a user to download the application
DEP : None

Functional requirement 1.2
ID : FR2
Title : Download and notify user for a new release
DESC : The user should be able to update the application either directly from the app or from a trusted store. The user should be notified of this.
RAT : In order for a user to download the new update/release of the application
DEP : FR1

Functional requirement 1.3
ID : FR3
Title : User login
DESC : The user should be able to login to the application. If he/she is not registered there should be an option to that.
RAT : In order for a user to login to the application
DEP : FR1

Functional requirement 1.4
ID : FR4
Title : Home screen
DESC : The user should be directed to the home screen or the dashboard of the application

immediately after login for the ease of accessing the features of the application.
RAT : In order to help users find the resources.
DEP : FR3

Functional requirement 1.5
ID : FR 5
Title : Help options
DESC : The user should be directed how to use the application. For that there should be good manuals or proper documentation that can be accessed from the home screen.
RAT : In order to identify the various options available in the application
DEP : FR3

Functional requirement 1.6
ID : FR6
Title : Custom Languages
DESC : Allows the user to change to language of his choice.
RAT : In order to help the user who didn't know english
DEP : None

Functional requirement 2.1
ID : FR7
Title : Camera Permissions
DESC : Ask user to access the camera
RAT : Needed for AR functionality
DEP : None

Functional requirement 2.2
ID : FR8
Title : Recognize markers
DESC : For identifying the markers in the textbook
RAT : Needed for AR functionality
DEP : FR8

Functional requirement 2.3
ID : FR9
Title : Placing content on the markers
DESC : The content corresponding to the markers should be placed on top of the marker

RAT : To provide AR experience to the user
DEP : FR7, FR 8

Functional requirement 3.1
ID : FR10
Title : Accessing the non AR contents like notes, class videos etc.
DESC : The user should be able to access the study materials easily and efficiently from the home screen of the app.
RAT : In order to access study materials
DEP : None

5.1.4 Other Nonfunctional Requirements

Performance Requirements

The performance of the application should be very good. There should not be any delays when switching between different pages. The Camera opening, Marker detection should not take too much time.

Safety Requirements

When comparing to other AR types like Markerless AR and Location-based AR, the marker based AR is more safe since the user did not want to move around.

Security Requirements

The details of the user like name, class, etc. should be collected with the proper permission of the user. There will be an option for students to skip all information except their class.

Software Quality Attributes

Adaptability The application can be run on any android device that is listed in ARCore official website. The features other than AR can be accessed by normal devices also.

Reliability The app would not crash while using it except the error caused by external reasons like OS error.

Availability The app should be available in the app store to download. The downloading and installation procedures should be smooth.

5.2 Modules

1. **Authentication**

   Authentication includes sign up and sign in option. At first user has to provide information like name, class, medium(english or malayalam). These information are stored in local database. The database used is sqlite. After that user need to login with the given details.

2. **AR Contents**

   A marker based augmented reality is been developed.The SDK used is ARCore which is given by google.The core function of ARCore are motion tracking, environment understanding and light estimation. ARCore contains an Augmented image API's which helps to build AR applications that can detect and augment 2D images in the user's environment. ARCore uses computer vision algorithm to extract the features from greyscale information in each image and store these features in one or more augmented image databases. During runtime, searches for these features in a flat surface in the user's environment.This lets ARCore detects these images in the world and estimate their position orientation and size if one is not provided.

3. **Non-AR Contents**

   The non AR contents are available in various sites. The samagra by the education department contain a lot of resources. It contain staff copies of textbook, question bank etc. The first bell by IT victors provides good video link for each chapter. Our aim is to gather all these resorces to a single place by providing links to each of the resources. Also we aim to develop a portal for the administrator to upload various contents like notes, videos etc. Youtube is being used for video hosting as it's free. Google drive or dropbox is being used for uploading pdf, pptx etc.

4. **Unity Development**

Unity development is used to add interaction in AR. It includes object transformation, adding physics in AR.

Advantages Of Unity

1. It is the best platform to develop AR appication.
2. It is effective while rendering.
3. It is easier to develop.

5.3 Structure Chart

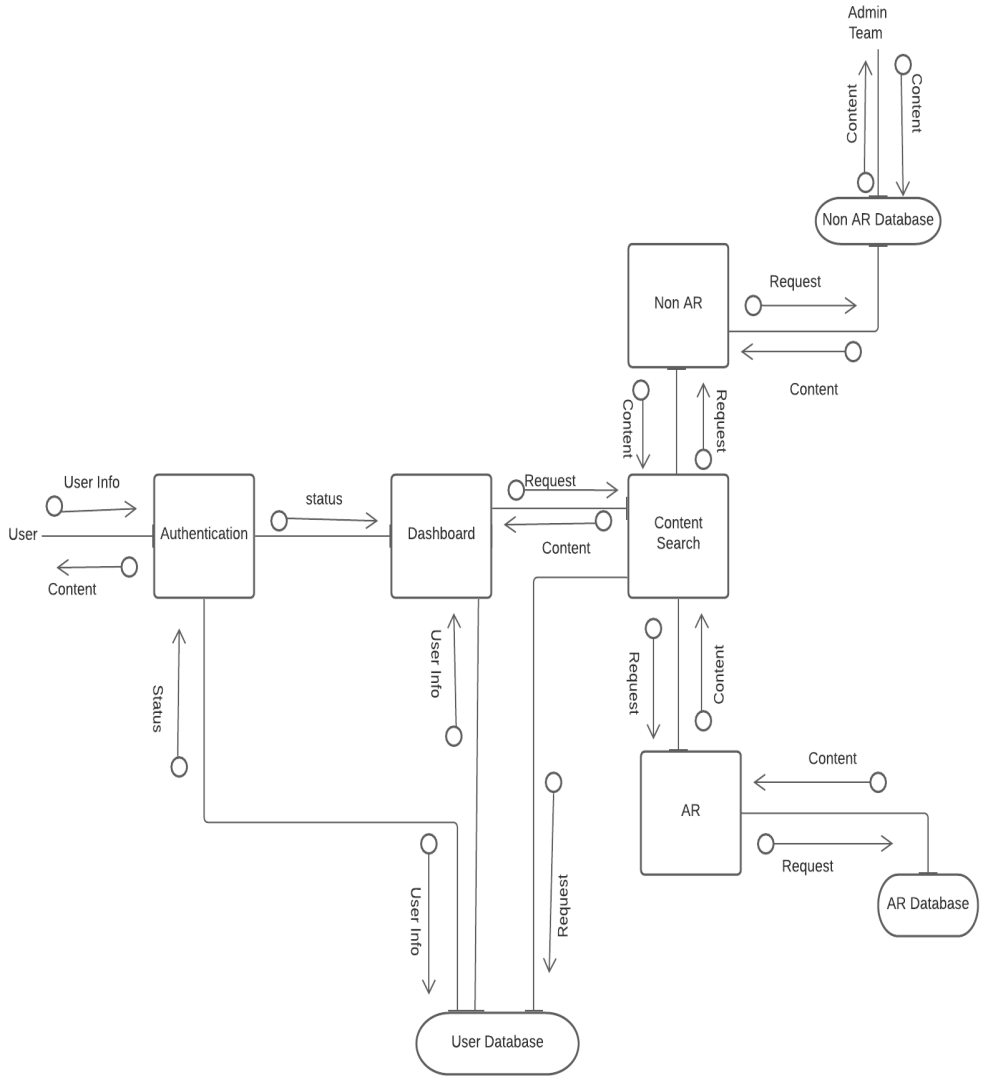

Figure 5.1: Module wise interaction of the application

5.4 Data Flow Diagrams

5.4.1 Data Flow Diagrams Level 0

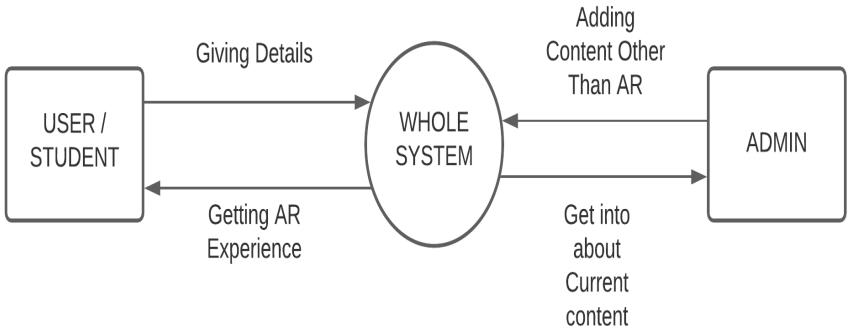

Figure 5.2: DFD - Level 0

5.4.2 Data Flow Diagrams Level 1

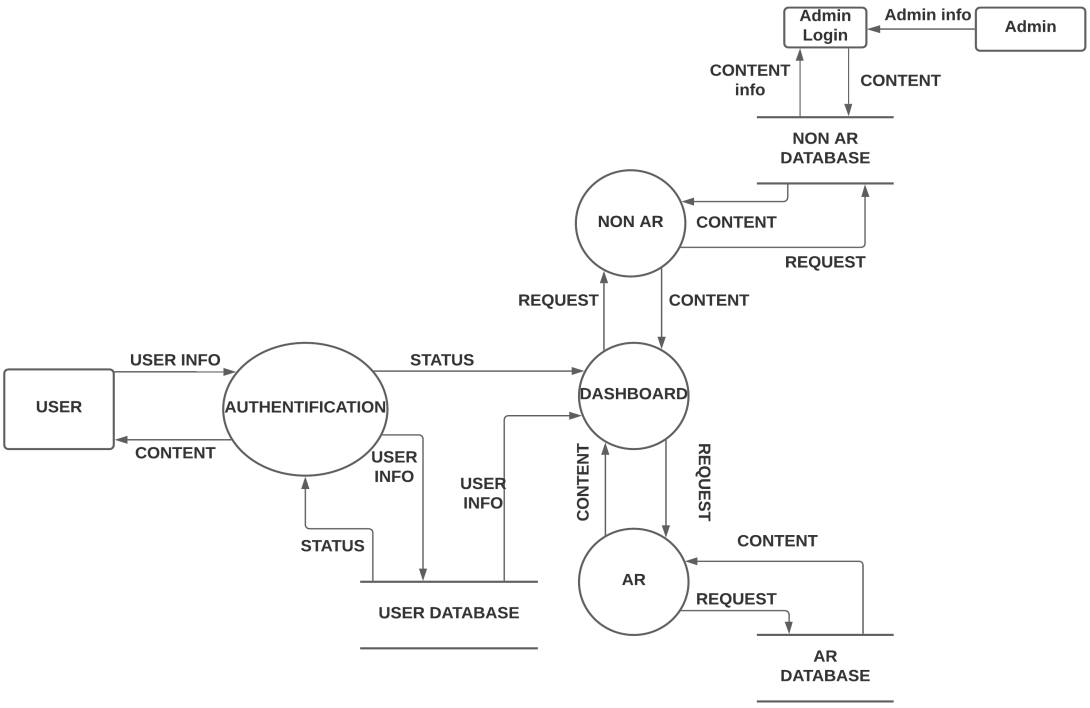

Figure 5.3: DFD - Level 1

5.4.3 Data Flow Diagrams Level 2

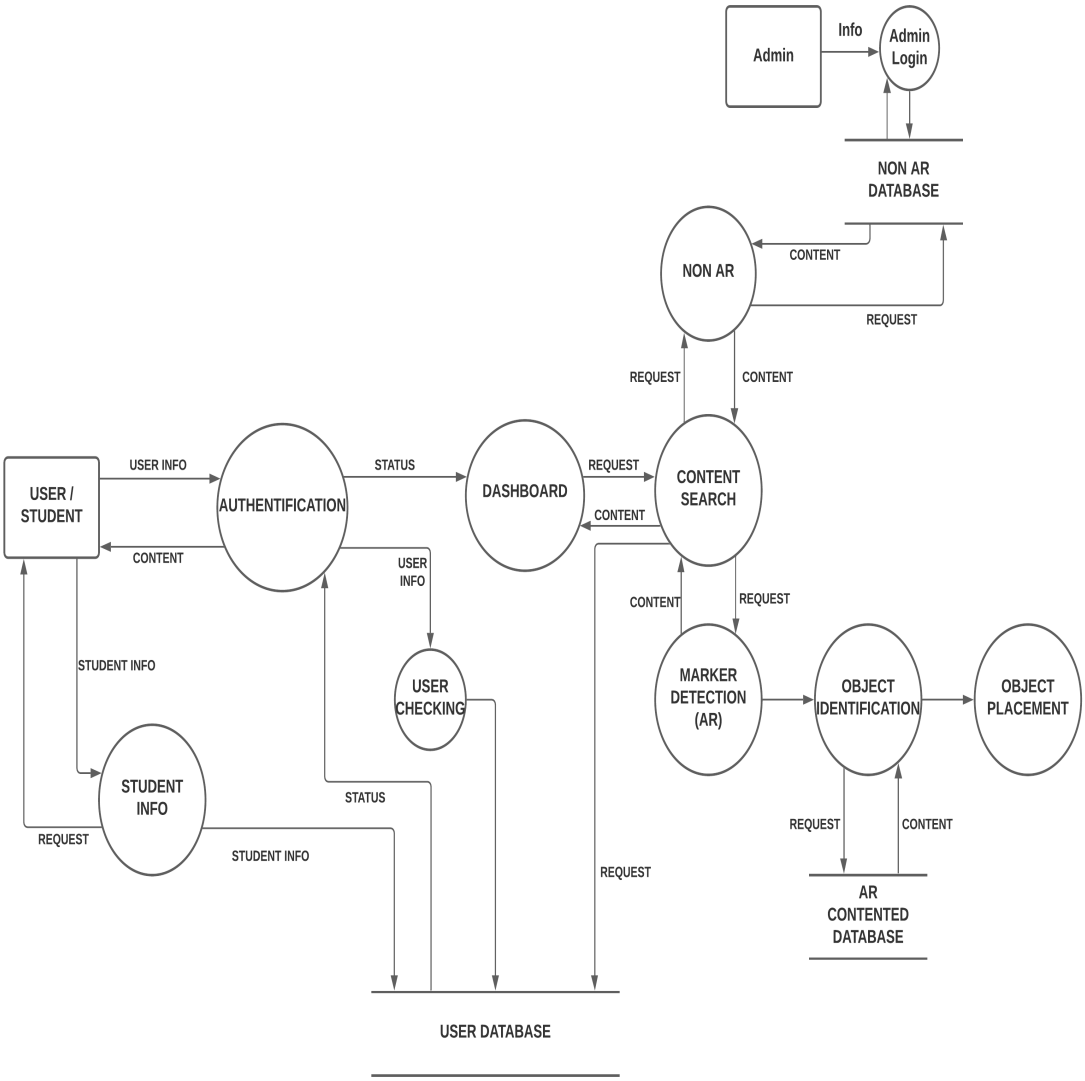

Figure 5.4: DFD - Level 2

5.5 UML Interaction Diagram

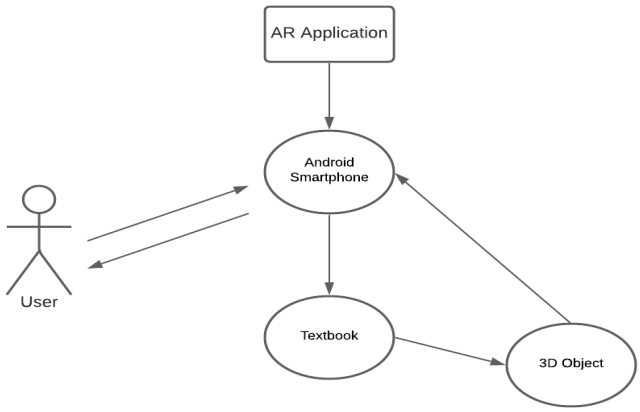

Figure 5.5: UML Interaction Diagram

5.6 User interface wireframe

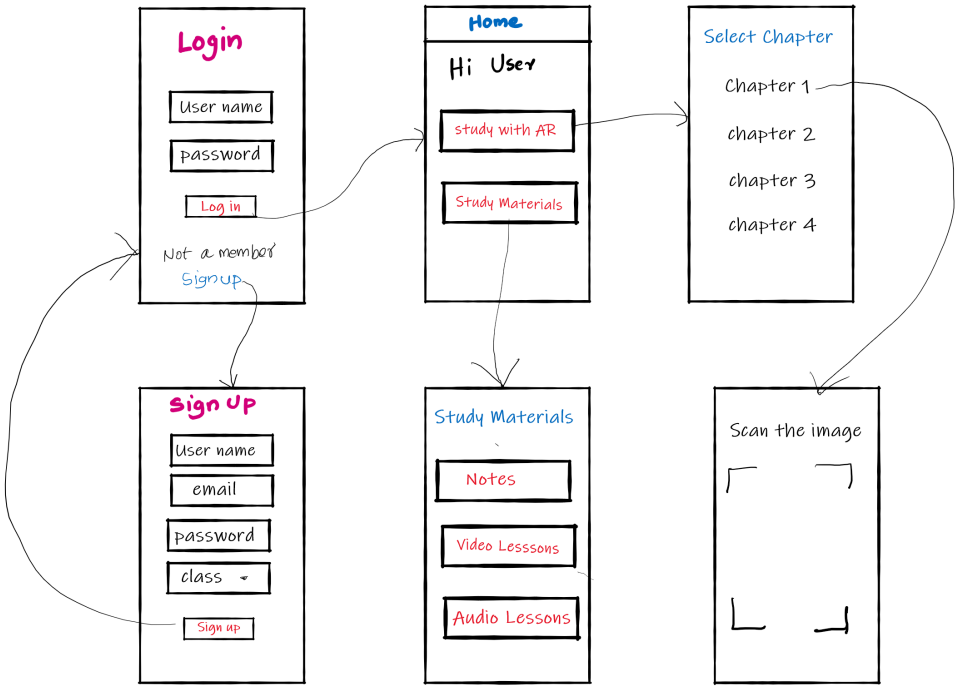

Figure 5.6: UI wireframe

CHAPTER 6

RESULTS

We tried to implement a basic AR application that detect the pictures in the textbook and augment the images with basic objects like cube, Sphere using Unity Engine and ARCOre SDK. The application identified the two images very well and able to project the cube and sphere in each of them.

CHAPTER 7

CONCLUSION

The leaning became smart now way days. The classroom became a smart classroom, the blackboards replaced by television and projectors. But the textbooks remain the same for a certain extent. The textbooks contain QR code for external reference. But they do not provide any change since it is a website that just shows some text.The project "Enhancing Textbooks using Augmented Reality" aims to develop an Augmented Reality application which helps the students to understand the concepts in the textbook easily. Due to the pandemic, students in our country faces a lot of problems. The lack of contact classes caused difficulty in understanding the concept in the textbook. The textbook contains a lot of information. But an ordinary student finds it difficult to understand them.

With the help of Augmented Reality, we can solve the problem for a certain extent. By Augmenting 3D models, videos, audios etc. on the 2D images in the textbook, students will able to understand the concepts easily. We also aim to make sure that each 3D models and video lesson contain some interaction from students by introducing quizzes and points. With this, students will have confidence about the topics in the textbook and can learn each topic in a small-time. Also, we aim to provide class notes, video lessons that can be viewed and downloaded through the application which also helps to understand each of the lessons. The study materials are organised based on their class, topic etc.

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Appendix A
GitHub Repository

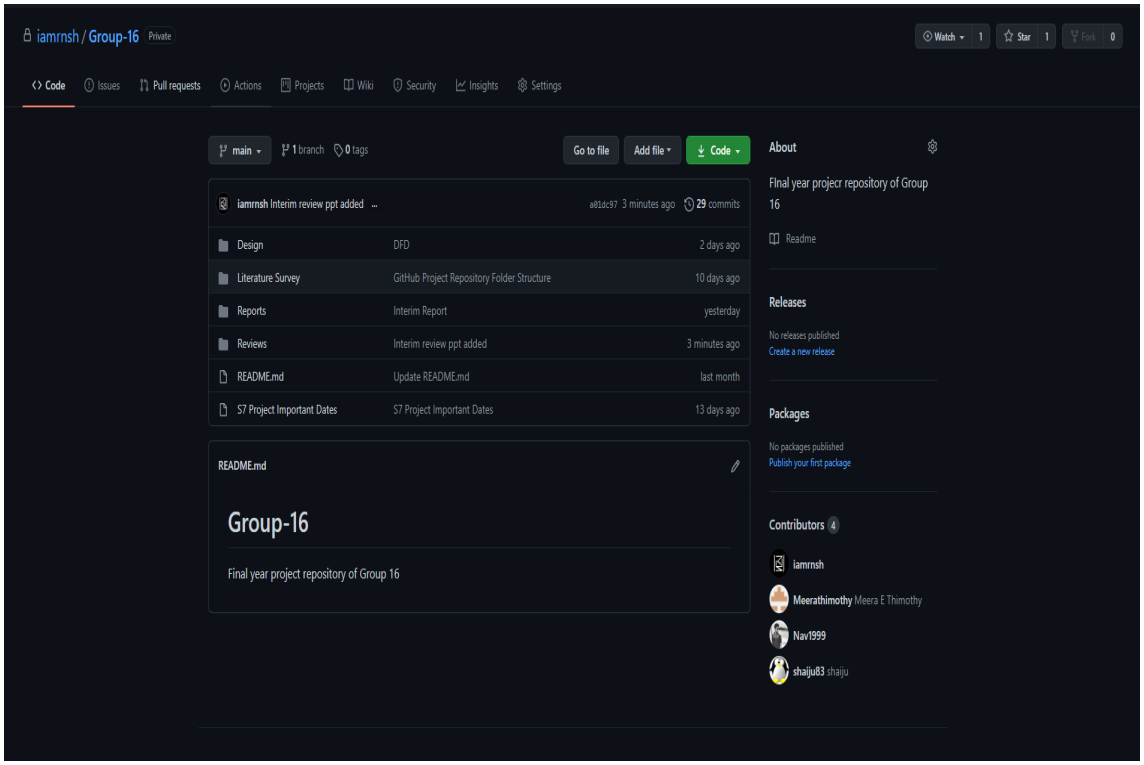

Figure A.1: GitHub Repository

URL : `https://github.com/iamrnsh/Group-16`