Tribhuvan University

Faculty of Humanities and Social Sciences

A Major Project on

"AR Mobile App for Interactive Learning"

A Major Project Report submitted in partial fulfillment of the requirements for the degree of Bachelor in Information Management awarded by Tribhuvan University

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ABSTRACT

This project presents the development of an Augmented Reality (AR) Educational App aimed at enhancing interactive learning experiences for students. The application utilizes AR technology to overlay digital content onto real-world environments, making abstract concepts more tangible and engaging. Built using Unity and C#, the app incorporates tools such as AR Foundation or Vuforia to deliver 3D models, animations, and visual aids that support educational topics.

The initial version focuses on a limited set of subjects, with core functionalities like marker-based as well as markerless AR interaction, topic selection, and content visualization already implemented. Agile methodology has been followed to ensure iterative development and continuous feedback integration. This approach allows for gradual improvements while maintaining flexibility in feature enhancement. The project aims to bridge the gap between traditional learning and immersive technology, offering a more effective and enjoyable learning experience for students.

Keyword: Augmented Reality(AR), Interactive Learning, Educational App, Unity,C#.

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LIST OF ABBREVIATION

AR – Augmented Reality

API – Application Programming Interface

C# - C-Sharp (Programming Language)

Firebase SDK – Firebase Software Development Kit

GCP – Google Cloud Platform

SDK – Software Development Kit

SDLC – Software Development Life Cycle

UI – User Interface

UX – User Experience

XR – Extended Reality

XR Plugin – Extended Reality Plugin Framework

CHAPTER 1:INTRODUCTION

1.1 Introduction

In today's rapidly evolving educational landscape, the integration of technology will become essential for enhancing student engagement and improving learning outcomes. Augmented Reality (AR), a cutting-edge technology that will overlay digital content onto the real world, will prove to be a powerful tool for creating immersive learning experiences. This project, titled "AR Educational App for Interactive Learning," will aim to bridge the gap between theoretical concepts and practical understanding by offering students and educators an interactive platform to visualize and manipulate 3D educational models in real-world settings.

The app will be developed using Unity, C#, and AR Foundation, ensuring a versatile and robust framework for AR-based educational applications. By using AR technology, the app will allow learners to experience content in a more engaging and hands-on manner, making abstract or complex concepts easier to grasp. The core feature will include marker-based and markerless AR tracking, real-time interaction with 3D objects, and detailed informational panels to provide comprehensive learning materials.

This project will be designed to cater to various educational domains, including science, history, and engineering, offering users the flexibility to explore topics at their own pace. The app's interactive nature will promote active learning, encouraging users to engage with the content rather than passively consume it. Furthermore, the app will be optimized for both mobile and web platforms, ensuring accessibility and scalability across different devices.

The project's goal will not only be to develop a functional AR app but also to highlight the potential of augmented reality in transforming traditional learning environments. By fostering deeper engagement and improving retention of knowledge, this AR Educational App will aim to redefine how educational content is delivered and experienced in modern learning contexts.

1.2 Problem Statement

Traditional educational methods will often rely heavily on textbooks, static images, and verbal explanations, which may not be sufficient for students to fully comprehend complex concepts. These methods will lead to disengagement, decreased retention of information, and a lack of hands-on learning opportunities. Furthermore, students with different learning styles—such as visual and kinesthetic learners—may struggle to effectively grasp abstract or multi-dimensional concepts through text-based or lecture-driven approaches.

With the increasing availability of digital technology, there will be a growing need for innovative educational tools that will enhance engagement and understanding. Augmented Reality (AR) will have the potential to address these challenges by offering interactive, real-time 3D visualizations that will bring learning content to life. However, many existing educational applications will lack robust interactivity, scalability, and accessibility across various platforms, limiting their effectiveness in diverse learning environments.

This project will aim to solve these issues by developing an AR Educational App for Interactive Learning, which will leverage AR technology to enhance student engagement and comprehension. By providing a dynamic platform for visualizing and interacting with 3D educational content in real-world settings, this app will address the limitations of traditional learning methods and will create a more immersive and inclusive learning experience for students and educators alike.

1.3 Objectives

The primary objective of this project will be to design and develop an Augmented Reality (AR) Educational App for Interactive Learning that will enhance the learning experience by integrating interactive 3D models with real-world environments.

The key objectives of the project will be as follows:

- **Create an Interactive Learning Environment**: To develop a user-friendly mobile and web-based platform that will allow users to interact with 3D models, fostering an engaging and participatory learning experience.

- **Leverage AR Technology for Visualization**: To integrate AR technology that will overlay educational content in the real-world environment, allowing students to manipulate and explore virtual objects in real time.
- **Enhance Concept Comprehension**: To improve the understanding of complex or abstract concepts by providing visual and interactive representations, which will cater to various learning styles.
- **Ensure Accessibility and Scalability**: To create an app that will work seamlessly across both mobile devices and web platforms, ensuring accessibility for a wide range of users.
- **Provide Educational Tools for Self-Directed Learning**: To offer features such as quizzes, informational panels, and interactive 3D objects that will allow users to engage in self-guided learning and reinforce key concepts.
- **Support Continuous Learning and Future Improvements**: To develop a flexible system that will be easily expanded to include more educational topics and interactive features in the future, such as personalized learning paths and collaborative AR sessions.

1.4 Scope

The AR Educational App for Interactive Learning will aim to enhance education through Augmented Reality (AR) technology by providing an engaging, interactive learning experience for students and educators.

Key features will include:

- **AR Visualization:** will display 3D models in the real-world environment using marker based and markerless.
- **Interactive Learning:** will allow users to manipulate 3D objects, rotate, scale, and zoom for better comprehension.
- **Educational Content:** will focus on subjects like science, engineering, and mathematics, with interactive quizzes and information panels.
- **User Interface:** will have a simple and intuitive design for easy navigation, suitable for learners of all ages.
- **Mobile and Web compatibility:** will be optimized for both mobile and web platforms to ensure accessibility for a broad audience.

1.5 Limitation

As a beginner in Augmented Reality (AR) development, several challenges and limitations may impact the development and execution of the project. These include:

- **Learning Curve**: The complexity of tools such as Unity, C#, and AR Foundation can slow down progress due to the time required to become familiar with the technology.
- **Hardware Limitations**: App performance may vary across different mobile devices, particularly on lower-end phones, potentially affecting the user experience.
- **Immersion Constraints**: AR on mobile devices may not offer the same level of immersion as Virtual Reality (VR), which can limit user engagement.
- **Content and Feature Limitations**: The initial version may include a limited set of educational topics, with future expansions requiring additional time and expertise.
- **Time Constraints**: Balancing the learning of new tools alongside development tasks can lead to delays or a reduced feature set in the initial release.

CHAPTER 2
BACKGROUND STUDY AND LITERATURE REVIEW

2.1 Background Study

Augmented Reality (AR) enhances the real world by adding digital elements through mobile devices. With Unity's XR toolkit, developers can create AR apps without relying on third-party tools like Vuforia. This project uses Unity XR to build an interactive educational app, aiming to make learning more engaging through 3D visual content and real-time interaction.

2.2 Literature Review

Augmented Reality (AR) will gain popularity in education due to its ability to create interactive and immersive learning experiences. By overlaying digital content on the real world, AR will help students visualize and understand complex concepts, especially in fields like science and engineering. Studies will show that AR will significantly improve engagement and motivation, with students interacting with 3D models to better grasp abstract topics [1]. It will also promote active learning, allowing students to engage directly with the material, improving retention and comprehension [2].

The integration of AR with mobile devices will make it more accessible to both students and educators. Mobile AR applications will offer the flexibility for students to learn on-the-go, leading to increased participation [3]. However, challenges like limited screen size and processing power may affect the quality of the AR experience on mobile devices [4].

Despite the benefits, there will be challenges in adopting AR for education. High-quality, curriculum-aligned content will be scarce, and educators will often face difficulties in integrating AR into their teaching. Additionally, more immersive AR experiences, such as those offered through VR headsets, will require specialized hardware that will always be accessible [5].

Looking ahead, AR's potential in education will be vast. The combination of AR with Artificial Intelligence (AI) will personalize learning, while multi-user AR experiences will

foster collaboration among students. As AR technology advances and content improves, it is expected to play a key role in enhancing student engagement and providing more interactive, personalized learning experiences.

CHAPTER 3: SYSTEM ANALYSIS

3.1 System Analysis

The system is designed to run on Android and iOS devices using Unity's XR framework. It detects surfaces through the device camera and overlays 3D educational content in real time. The app includes user interaction features such as tapping to trigger animations or sounds. Key components include input handling, AR tracking, content rendering, and UI management. The system aims to provide a smooth and interactive learning experience with minimal hardware requirements.

3.2 Software Development Lifecycle

A Software Development Life Cycle (SDLC) is a process followed for software building within a software organization. SDLC consists of a precise plan that describes how to develop, maintain, replace, and enhance specific software.

For this project, the Agile Methodology was followed, which emphasizes iterative development, continuous feedback, and flexibility. Agile enables the system to be developed in smaller incremental cycles, making it easier to adapt to changing requirements. Given that healthcare appointment systems require real-time updates and a user-friendly interface, Agile proved to be the most suitable approach.

Each iteration included planning, designing, developing, testing, and reviewing the system. This approach facilitated regular feedback from supervisors, users, and peers, which helped refine features such as doctor availability management, appointment scheduling, and notification systems. The incremental nature of Agile ensured that essential functionalities were tested and improved in each cycle before final deployment.

By using Agile, the project-maintained flexibility, efficiency, and a user-centered development process, resulting in a seamless experience for patients, doctors, and administrators.

Figure 1:Agile Model

CHAPTER 4: SYSTEM DESIGN

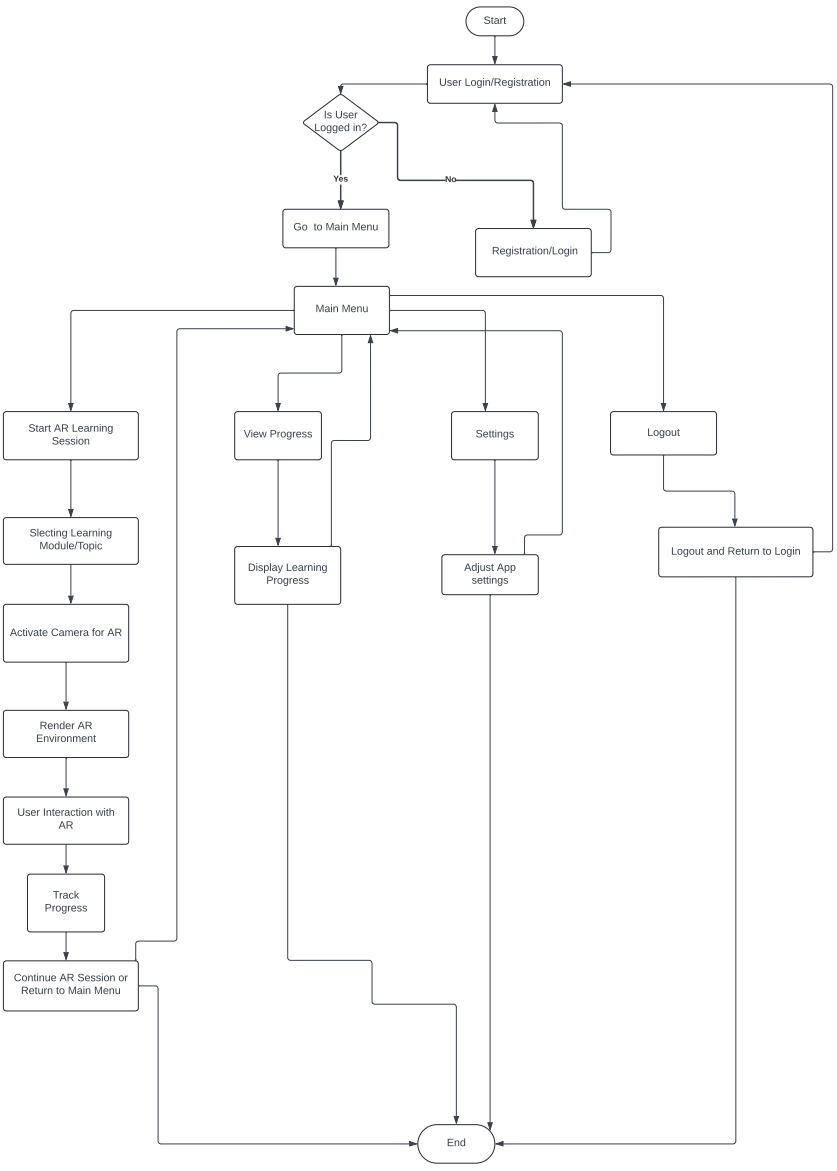

Figure 2: System Flowchart of AR Educational App

The above figure shows the overview of how AR Educational App will function and interact with various components to create an engaging and effective learning environment.

4.1 Algorithm

1. Image Recognition Algorithm

An image recognition algorithm is a computer vision technique that allows a system to identify and process objects, patterns, or features within an image. In augmented reality (AR), image recognition algorithms detect predefined images or objects in the real world and trigger the display of relevant virtual content, such as 3D models or videos.

How It Works:

Step 1: Initialization

Initializes the ARTrackedImageManager which is the manager for tracking 2D images in AR.

Code:

trackedImages = GetComponent<ARTrackedImageManager>();

Step 2: Enable tracking events

Subscribes to the event that notifies when tracked images are **added**, **updated**, or **removed**.

Code:

trackedImages.trackedImagesChanged += OnTrackedImagesChanged;

Step 3: On added (Image detected)

When a known image (marker) is recognized by the camera, it checks for matching prefab and instantiates it **once**.

foreach (var trackedImage in eventArgs.added)

{

// Match reference image name and instantiate corresponding prefab

}

Step 4: On updated

Keeps the object active only when the image is clearly tracked (e.g., not occluded or out of view).

Code: foreach (var trackedImage in eventArgs.updated)

{

// Show/hide based on tracking state

}

Step 5: On disable

removes the event listener when the script is disabled to prevent memory leaks or errors.

Code

trackedImages.trackedImagesChanged -= OnTrackedImagesChanged;

2. Raycasting Algorithm

Raycasting is a technique used in computer graphics and game development to detect objects along a straight path from a point, often the camera or user's input. In AR applications, it helps determine what virtual object the user is interacting with. By casting a virtual ray from the screen into the 3D world, the system can detect which object is hit and respond accordingly—such as displaying information, changing scale, or playing audio. This method enables accurate and interactive experiences in AR environments.

How it Works:

Step 1: User Detection

Detect when the user clicks the left mouse button (simulating a tap in AR)

Code:

if (Input.GetMouseButtonDown(0))

Step2: Create a Ray from the camera to click position

Convert the screen click position to a ray that travels from the camera into the 3D world.

code:

Ray ray = Camera.main.ScreenPointToRay(Input.mousePosition);

Step3: Raycast to detect object

Use the Physics.Raycast method to check if the ray hits any collider in the 3D space.

Code:

if (Physics.Raycast(ray, out hit, 50))

Step4: Check which object was hit (earth or mars)

Examine the tag of the hit object to identify if it's "earth"or"mars".

Code:

if (hit.transform.tag == "earth") { ... }

if (hit.transform.tag == "mars") { ... }

Step5: Dispay info on the UI

Enable the UI canvas, set the text, image, and play corresponding audio based on the object.

Code:

displayCanvas();

displayAndPlayInfo();

Step6: Scale the selected object for visual feedback

Temporarily enlarge the clicked object by 20% to indicate it's selected.

Code:

Vector3 scale = originalScale * 1.2f;

hit.transform.localScale = scale;

Step7: Reset Scale When Clicked Elsewhere

If the user clicks away from the object, reset the object to its original scale.

Code:

hit.transform.localScale = originalScale;

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