A

Project Report on

"Disha: Indoor Navigation using Augmented Reality"

Submitted To

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In Fulfillment of the

Requirement

For the Degree Of

Final Year of B.Tech

COMPUTER SCIENCE AND ENGINEERING

Submitted by

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Submitted at

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Year 2023-24

CERTIFICATE

This is to certify that **Zebaan Mulla (2021000108), Swaroop Chavan (2021000195), Shahin Momin (2021000289), Pallavi Sawanji (2021000640)** have completed the Project Part-II on subject entitled **"Disha: Indoor Navigation using Augmented Reality"**, in the fulfillment of the requirement for the award of Final Year (Computer Science and Engineering) of KIT's College of Engineering, Kolhapur in the academic year 2023-24.

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1. ABSTRACT

This research project explores the use of smartphone-based Augmented Reality (AR) technology for indoor navigation in complex building structures. The study focuses on developing an AR- based framework using the ARcore software development toolkit, incorporating pre-computed paths and fixed background maps to guide users to their destinations. The application offers users a user-friendly interface for precise visual guidance, enhancing efficiency and providing an immersive experience. The framework's flexibility allows users to adapt their destinations during navigation. The research validates the effectiveness of the system through a comprehensive evaluation, including technical, subjective, and demographic data analysis. In summary, this innovative project leverages AR technology to address challenges in navigating intricate buildings, offering practical solutions and contributing to the discourse on technology and spatial navigation in contemporary built environments. We offer an indoor map that expands to 3D capabilities using Augmented Reality, with an increasing focus on commerce and general orientation. Indoor navigation systems integrating augmented reality allow users to locate locations in buildings and gain more knowledge about their surroundings.

2. INTRODUCTION

Indoor Navigation is all about providing flexible guidance to people in chaotic and unfamiliar buildings in universities and resorts. Navigation systems help users easily enter unfamiliar surroundings. The term "navigation" collectively includes the tasks of locating a user's location, planning a feasible route, and guiding the user along the route to a desired destination.

Our system provides smooth localized navigation in large institutions using our navigation system. Indoor navigation is a revolutionary concept that visualizes indoor sites and 3D Modeling. This allows us to walk around universities, large shopping malls, hospitals ,auditoriums, etc. navigation. In terms of complexity, indoor navigation is very different from outdoor navigation. In our indoor navigation, the technology is rather complex as it consists of 3 modules which should be categorized as site mapping, 3D Modeling and user interface design. Augmented Reality (AR) leverages dynamic and accurate 3D maps for real-world experiences. Displaying people, assets and places on a digital map enables solutions such as indoor navigation and indoor positioning. It is an indoor navigation app that can use augmented reality without any restrictions.

The first step in the development of this application is to build a 3D model of the building and its interior where we will deploy this application. We use cellular tools to develop 3D models of buildings. The system needs to know the user's location and it needs to be mapped to a 3D model of the building. A unit that allows the device to detect horizontal and vertical surfaces and planes.

It also includes motion detection, allowing phones to understand and track their position relative to the world. As AR Core continues to improve and expand, it will add more contextual and semantic understanding of people, places, and things. Unity is a free and open-source 3D computer graphics software tool used to create animated films, visual effects, art, 3D printed models, motion graphics, interactive 3D applications, virtual reality and computer games. Unity will naturally import DCC (Digital Content Creation) fbx and obj files. To achieve this, we will install QR codes in all possible destinations in the building, assuming that any destination can be used as a starting point for the user.

Each QR code is linked to a specific graph node, but not all nodes contain a QR code. Using QR codes, the navigation map can identify the user's location and place 3D objects on the smartphone screen. 3D objects are represented by arrows defining the direction to the next point. Once the user scans a QR code, the system will know their current location and prompt them to choose a destination. After the user selects a destination, the user's camera is activated.

2.1 Purpose

The purpose of this Project is to address the challenges faced by modern campus navigation systems, particularly in providing intuitive and high- precision navigation for indoor environments. The focus is on enhancing user experience and overcoming limitations such as reliance on 2D information, network queries, and third-party service platforms.

The proposed solution integrates augmented reality (AR) technology to superimpose computer-generated virtual objects and information onto the real environment. This aims to create a more interactive and user-friendly campus navigation experience.

2.2 Scope

The scope of this project enclose the design and implementation of a mobile campus navigation app that utilizes visual inertial odometry and ARCore- based virtual and real fusion technology. The system's scope includes addressing the shortcomings of existing navigation systems by providing 3D augmented information integrated with real buildings, high-precision navigation in indoor environments, and a rich set of augmented reality content. The focus extends to the use of Unity as the development platform and the incorporation of human-computer interaction functions tailored to different scenarios and user needs. QR codes strategically placed throughout the facility serve dual purposes: they calibrate the user's position for accurate navigation and provide instant access to contextual information about the surroundings. The scope includes the creation of a user-friendly interface with features like dynamic maps, search functionality, and interactive elements to set destinations or explore the environment. This system aims to serve a wide range of users, from shoppers and hospital visitors to museum guests and facility managers, offering an innovative solution that combines technology with practicality to streamline indoor navigation and significantly improve user engagement and satisfaction.

3. REVIEW OF LITERATURE

ARCore and Indoor Navigation

ARCore, provides robust tools for tracking and mapping the real-world environment. It is a fundamental technology for AR-based indoor navigation. Previous research indicates that ARCore enables accurate and real-time tracking of user positions, making it well- suited for indoor navigation systems (Kato & Billinghurst, 2017).

User-Centric Design

User-centred design principles are essential for creating effective indoor navigation applications. Research by Wang and Zhang (2020) emphasizes the importance of intuitive user interfaces and user-centric features that allow for dynamic navigation changes, aligning with the project's motivation for user empowerment and adaptability.

Data Transmission Over the Internet

Several indoor navigation applications require internet connectivity to access real-time updates, cloud-based map data, and user feedback. Researchers stress the need for secure and efficient data transmission, considering privacy and user data protection (Pradhan et al., 2021).

Conclusion

Existing literature indicates that ARCore is a robust technology for real- time tracking and mapping. This technology can offer efficient and adaptable indoor navigation. To ensure the success of such systems, careful consideration of data transmission and user privacy is essential, making them a valuable addition to the development process.

4. SYSTEM ANALYSIS

4.1 Existing System

- GPS (Global Positioning System) relies on satellite signals to determine a user's locate on. However, GPS signals can be severely attenuated or blocked indoors due to the building's structure, resulting in poor accuracy or complete signal loss Additionally , GPS typically has a margin of error ranging from several meters to tens of meters , making it unsuitable for precise indoor positioning.

- BLE Beacons (Bluetooth Low Energy) emit Bluetooth signals that can be used for proximity-based positioning. While BLE beacons can provide better accuracy than GPS indoors, their effectiveness depends on the density and placement of beacons throughout the environment. Coverage gaps, signal interference, and variations in signal strength can affect positioning accuracy. Moreover, BLE beacons primarily offer 2D positioning, which may not capture vertical information accurately in multi-floor buildings.

- Sensor fusion combines data from multiple sensors such as accelerometers, gyroscopes, and magnetometers to improve positioning accuracy. While sensor fusion can enhance accuracy by compensating for individual sensor weaknesses and reducing noise, it still relies on indirect measurements and may struggle to provide precise positioning in complex indoor environments with dynamic conditions.

4.2 Requirements

4.2.1 Functional Requirements

- **AR Wayfinding**

  Displaying real-time navigation cues overlaid on the device's camera feed using AR. Providing directional arrows, path markers, or visual cues to guide users towards their destination.

- **QR Code Recognition**

  Scanning QR codes placed at key points within the indoor environment to determine location and provide context-specific information. Associating QR codes with specific points of interest (POIs) or destinations within the Unity environment.

- **Interactive 3D Map**

  Rendering an interactive 3D map of the indoor environment in Unity. Allowing users to explore the map, view different floors, and interact with POIs. User Registration and Authentication: Users should be able to create accounts and log insecurely. Different user roles (e.g., admin, visitor) with varying privileges.

4.2.2 Non-Functional Requirements

- **Performance**

  Smooth rendering and real-time updating of AR overlays and 3D models to ensure a responsive and immersive user experience. Efficient QR code scanning and processing.

- **Reliability**

  Ensuring accurate positioning and navigation guidance within the indoor environment.

Robust handling of varying lighting conditions and environmental factors that can affect AR performance.

- **Scalability**

  Supporting navigation across different-sized indoor spaces, from small rooms to large buildings.

4.2.3 Usability Requirements

- **User Interface (UI)**

  Design an intuitive and user-friendly interface for navigation controls and information display.
- **Accessibility**

  Ensure the system is accessible to users of varyingtechnological proficiency.
- **Realism**

  Provide an immersive and realistic AR experience that enhances navigation.

4.2.4 Implementation Requirements

- **Unity Development**

  Developing the application using Unity, leveraging AR Foundation for AR functionality and incorporating 3D models for indoor navigation.
- **QR Code Integration**

  Implementing QR code scanning functionality using Unity's QR code scanning libraries or plugins.
- **Data Management**

  Storing and managing indoor map data, POI information, and routing data efficiently within the Unity application.

4.3 Problem Definition

The increasing complexity and scale of modern indoor environments such as shopping malls, hospitals, airports, and museums present significant navigation challenges for visitors, often leading to frustration and inefficiency. Traditional signage and static maps are often insufficient, particularly for first-time visitors or those with limited spatial awareness. The goal of this project is to develop an intuitive and interactive indoor navigation system using augmented reality (AR) with 3D models and QR codes, implemented in Unity software. This system aims to enhance the user experience by providing real-time, step-by-step navigation guidance overlaid on the user's real-world view through their smartphone or AR device. By integrating detailed 3D models of the indoor environment and strategically placed QR codes for accurate positioning and contextual information, the project seeks to address the shortcomings of existing navigation solutions, making it easier for users to find their way efficiently and access relevant information seamlessly.

4.4 System Design

Indoor Navigation Systems is able to display their location on a map. Users should be able to choose their preferred destination on their device. Their devices must be able to direct users where they want. The software should use the camera and 3D animations to guide the user. They should be a minimap for better understanding by the user. Users of indoor navigation systems display their location on a map on their smart device. After selecting a destination or point of interest. The route to the selected destination is displayed on the map.

4.4.1 Flow chart

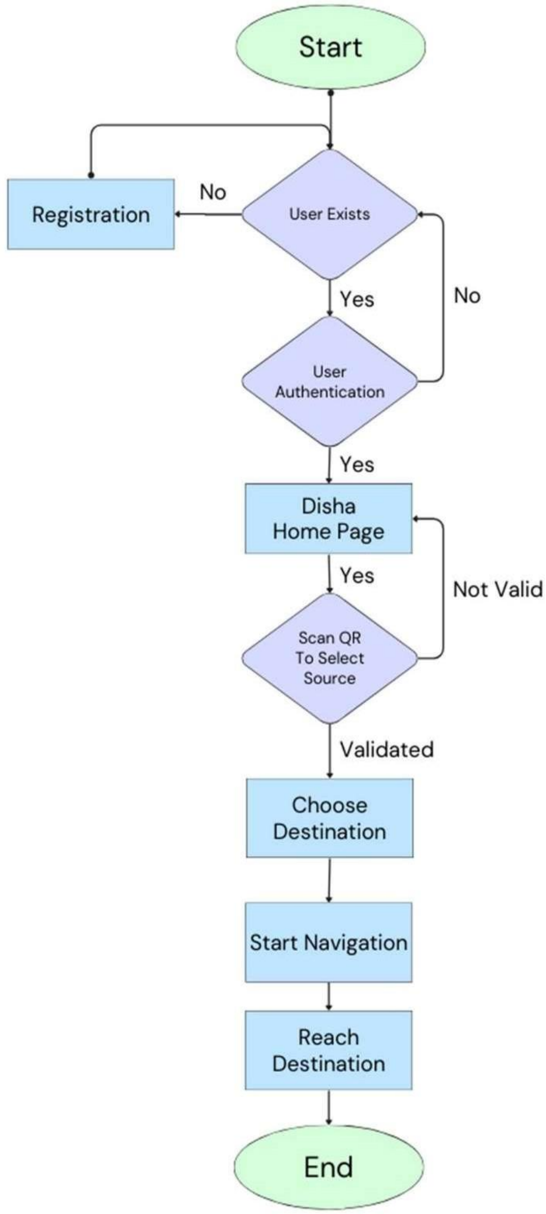

Fig. 4.4.1 Flow Chart Of Application System

4.4.2 Data Flow Diagram

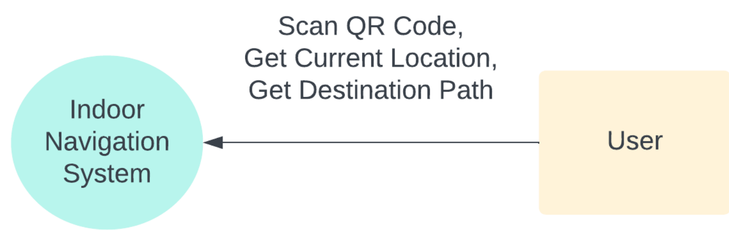

Fig. 4.4.2.1 Level 0 DFD

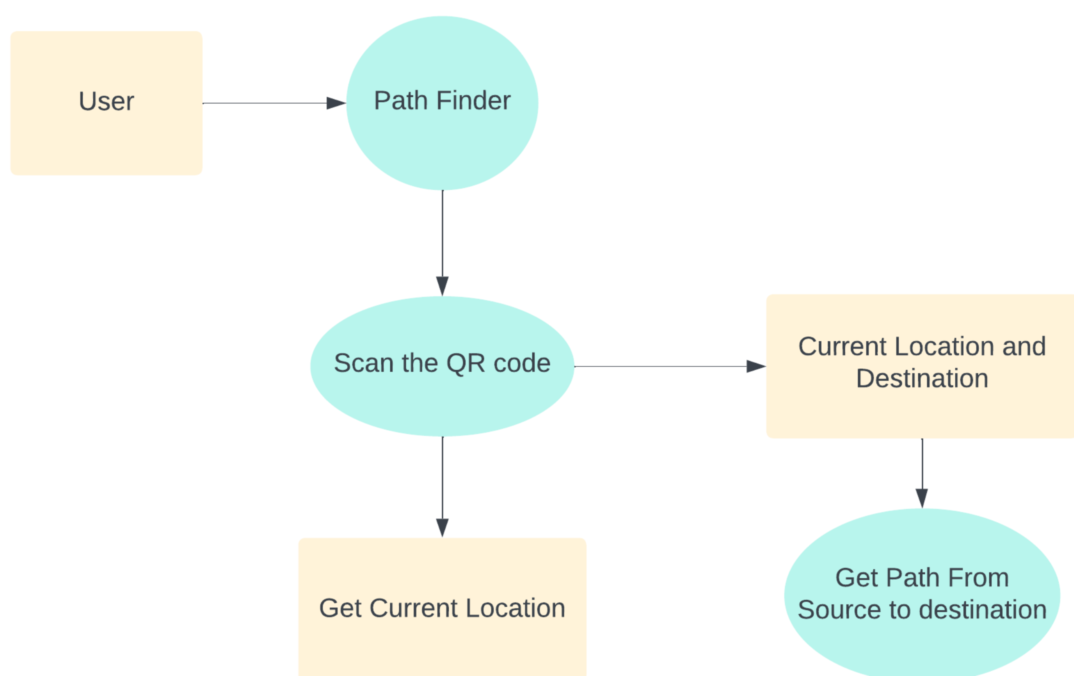

Fig. 4.4.2.2 Level 1 DFD

5. THE OVERALL DESCRIPTIONS

5.1 Product Perspective

- **Feature**

i. Make user familiar with the unknown place

ii. Save time of user for getting current location and searching particular location in college premises.

iii. Reduce paper work that are used for direction purpose in existing system.

- **Target Users**

i. New Students and Faculty.

ii. Visitors, including prospective students and parents.

iii. Event attendees (e.g., conferences, seminars, campus tours).

- **Competitive Edge**

i. Simplifies navigation in large and often confusing campus buildings.

ii. Provides an engaging and modern experience for tech-savvy students.

iii. Enhances campus safety and accessibility.

5.2 User Characteristics

- **Age Range**

Primarily aimed at college students (18-24) and faculty (25-65), but also caters to visitors of all ages.

- **Tech Savviness**

Moderate to high; users are expected to be familiar with Smartphones or AR devices.

- **Needs**

i. Efficient and stress free navigation in a complex campus building.
ii. Quick access to relevant information about their immediate surroundings.
iii. Enhanced campus experience with modern and interactive tools.

- **Behavior**

i. Users Prefer intuitive, easy to easy interfaces.
ii. High engagement with technology that offers clear , practical benefits(e.g. finding a classroom quickly).

User Scenarios

- **New Student**

A freshman uses the AR Campus Navigator to find their classrooms during the first week of classes, scanning QR codes to get additional information about the campus facilities.

- **Visiting Parent**

During orientation, a parent uses the system to navigate the classrooms and find key locations like the auditorium.

- **Event Attendee**

A guest attending a seminar on campus uses AR navigation to locate the specific classrooms.

6. REQUIREMENTS

6.1 Hardware and Software Interface

6.1.1 Hardware Interfaces

- **Android Smartphone**

  Users will need an Android smartphone with ARCore support. This may include devices like Google Pixel, Samsung Galaxy, or other compatible models.

- **Camera**

  A smartphone with a reliable camera is essential for capturing the indoor environment and tracking features. Sufficient Processing Power: The smartphone should have sufficient processing power and memory to handle real-time AR rendering and pathfinding calculations.

Software Interfaces

- **Unity 3D**

  Unity provides a comprehensive development environment with tools and resources for creating interactive 3D applications. Developers can leverage Unity's intuitive interface to design, build, and deploy AR applications for indoor navigation. Unity provides ARCore support through the AR Foundation package.

- **ARCore SDK for Unity**

  ARCore SDK for Unity is a powerful toolset that enables developers to create augmented reality (AR) experiences specifically for Android devices. ARCore provides tools for environmental understanding, including plane detection and feature points detection. Unity developers can leverage these capabilities to identify flat surfaces such as floors, walls, and ceilings within indoor environments.

This information is crucial for placing virtual objects, waypoints, and navigation cues accurately within the AR scene. ARCore's scene understanding capabilities allow Unity developers to analyze the geometry and semantics of the physical environment in real-time. This includes identifying objects, surfaces, and obstacles within the indoor space. By understanding the scene context, developers can optimize navigation paths, avoid obstacles, and provide contextually relevant information to users.

- **AR Foundation**

  AR Foundation is a Unity package that allows for cross-platform AR development, making it essential for ARCore integration. Developers can integrate AR Foundation with Unity's UI system to create intuitive user interfaces for indoor navigation. This includes displaying navigation instructions, route maps, and destination information overlaid onto the AR scene. UI elements can be designed to adapt to different screen sizes and orientations, ensuring a consistent user experience across devices.

- **QR Code Scanning Library**

  i. Choose a suitable QR code scanning library or plugin compatible with Unity.

  ii. Ensure the library supports the target platforms (Android) and can decode QR codes reliably.

- **3D Modeling Software**

  i. Software for creating and editing 3D models (e.g., Blender, Autodesk Maya, or Unity's built-in tools).

  ii. Use tools to design and optimize 3D models for real-time rendering in Unity.

- **NavMesh Integration**

  Unity has so many built-in functionalities which provide ease of use and many more advantages. The NavMesh components are one of the functionalities .This can be used to generate a strong mesh and can be used for pathfinding inside buildings. These NavMesh components are open source. The navigation system will generate augmented reality characters that can be easily placed and moved within the game world using navigation meshes. These navigation meshes are created from scene geometry automatically. As the user moves through the building, there is a chance that he or she will run into obstacles or hindrances in the way of the actual path.So the NavMesh properties will help to identify these obstacles and can provide an alternate path to the runtime by changing the position of these augmented reality objects, like directing arrows.

- **Augmented Reality Path Showing**

  In the end, our indoor navigation app shows the path to take using augmented reality objects (arrows). When the user needs to place a 3D object in the environment where they can move around, they should select the Tracking Type option for rotation and position. If the position option is selected, then it will get the best localization. And 3D objects may not be stable in their position. Hence, they can't be clearly visible. The major goal of this part is to produce an arrow in front of the user that guides them in the direction they need to go after a destination is chosen. There exists a defined mesh surrounding the arrow and every time the blue dot exits the mesh, the previous arrow (AR-object) gets removed and a new one comes in before the user appears at the exact angle. The old arrow can not be seen anymore as the user passes by that region.

7. IMPLEMENTATION

Research about Compatibility of Previous Technology with problem statement

Technology	Description	Strengths	Weaknesses
Wi-Fi Positioning System (WPS)	Utilizes existing Wi-Fi infrastructure to determine the position of a device based on signal strength from multiple access points.	Leverages existing infrastructure, relatively low cost.	Accuracy can be inconsistent, especially across multiple floors; relies on dense Wi-Fi coverage.
Bluetooth Low Energy (BLE) Beacons	Uses Bluetooth beacons placed at fixed locations to triangulate the position of a device based on signal strength and proximity.	High accuracy, relatively easy to deploy.	Requires a dense network of beacons for high accuracy; maintenance can be complex.
Magnetic Positioning	Relies on the unique magnetic field distortions caused by the building structure to determine the position of a device.	Low cost, no additional infrastructure needed.	Accuracy can be affected by environmental changes; less effective in areas with low magnetic variation.
RFID	Uses radio frequency identification tags and readers to determine the position of objects or people within a building.	High accuracy for tagged items, useful for inventory tracking.	Limited range; not suitable for large-scale or multi-floor navigation.
Ultra-Wideband (UWB)	Employs short-range radio waves to determine the precise location of a device based on the time it takes for signals to travel between devices.	Very high accuracy, suitable for complex environments.	High cost; complex setup and maintenance.
Visual Positioning System (VPS)	Uses visual markers and image recognition to determine the position of a device within a building by matching real-time images with a pre-mapped database.	High accuracy, immersive user experience.	Requires extensive setup and maintenance of visual markers; high initial cost.
Dead Reckoning	Combines data from accelerometers, gyroscopes, and other sensors to estimate the position of a device based on its movement from a known starting point.	Does not require external signals, works in signal-deprived areas.	Accumulates errors over time; not reliable for long-term navigation.
Vuforia	An AR platform that uses computer vision technology to recognize and track planar images and simple 3D objects in real-time.	Integrates well with AR applications, supports Unity, robust and reliable.	Can be costly, requires high-quality image markers and good lighting conditions for accuracy.
GPS	Uses satellites to determine the precise location of a device. Effective for outdoor environments but typically ineffective indoors.	Ubiquitous, no additional infrastructure required outdoors.	Ineffective indoors due to signal blockage by walls and ceilings.
Cloud Point Technology	Utilizes 3D point cloud data from LIDAR or photogrammetry to map the indoor environment and navigate within it.	High accuracy, detailed 3D mapping of the environment.	High initial cost, requires specialized equipment and expertise.
3D Model in Unity with AR	Involves creating a detailed 3D model of the building in Unity and integrating AR elements to provide interactive navigation.	High accuracy, immersive and engaging user experience, highly customizable.	Moderate to high initial cost; requires expertise in 3D modeling and AR development.

Table 7.1 Previous Technology

Technology	Accuracy	Scalability	Cost	Maintenance	User Experience	Compatibility with AR	Notes
Wi-Fi Positioning System (WPS)	Moderate	High	Low	Moderate	Moderate	Limited	Utilizes existing Wi-Fi infrastructure; accuracy can be inconsistent across multiple floors.
Bluetooth Low Energy (BLE) Beacons	High	High	Moderate	High	High	Limited	Requires a dense network of beacons; accurate but can be costly and complex to maintain.
Magnetic Positioning	Moderate	High	Low	High	Moderate	Limited	Low cost; affected by environmental changes and low magnetic variation areas.
RFID	High	Low	Moderate	High	Low	None	High accuracy for tagged items; limited range and not suitable for large-scale navigation.
Ultra-Wideband (UWB)	Very High	Moderate	High	Moderate	High	Limited	Very high accuracy; high cost and complex setup and maintenance.
Visual Positioning System (VPS)	High	Moderate	High	High	High	High	High accuracy; requires extensive setup and maintenance of visual markers.
Dead Reckoning	Low	Low	Low	Low	Low	None	Does not require external signals; accumulates errors over time, unreliable for long-term use.
GPS	Low (Indoors)	High	Low	Low	Low (Indoors)	None	Ubiquitous outdoors; ineffective indoors due to signal blockage by walls and ceilings.
Cloud Point Technology	High	High	High	Moderate	High	High	Highly accurate 3D mapping; requires specialized equipment and expertise, high initial cost.
Vuforia	High	High	Moderate	Moderate	High	High	Robust AR platform; integrates well with Unity, requires high-quality image markers.
3D Model in Unity with AR	High	High	Moderate	Moderate	High	High	Highly accurate and immersive; requires expertise in 3D modelling and AR development.

Test Cases for GPS

Test Case ID	Description	Steps	Expected Result	Actual Result	Status
GPS-TC1	GPS Signal Acquisition Indoors	1. Enter the building and proceed to the first floor. 2. Open a GPS-based navigation app. 3. Attempt to acquire a GPS signal.	GPS signal should be acquired.	GPS signal is weak or unavailable.	Fail
GPS-TC2	GPS Accuracy Across Multiple Floors	1. Enter the building and proceed to the second floor. 2. Open a GPS-based navigation app. 3. Check the floor level indicated by the app.	GPS should accurately indicate the floor level.	GPS cannot determine the floor level, showing the same position for different floors.	Fail

Table 7.2 Test Cases for GPS

Test Cases for Cloud Anchor Technology

Test Case ID	Description	Steps	Expected Result	Actual Result	Status
CA-TC1	Cloud Anchor Initialization Indoors	1. Enter the building and proceed to the first floor. 2. Open an AR app using Cloud Anchor technology. 3. Attempt to initialize Cloud Anchors.	Cloud Anchors should initialize successfully.	Initialization fails due to poor network connectivity or insufficient visual features.	Fail
CA-TC2	Cloud Anchor Stability Across Multiple Floors	1. Set up Cloud Anchors on the first floor. 2. Move to the second floor. 3. Attempt to access the same Cloud Anchors.	Cloud Anchors should remain stable and accessible.	Cloud Anchors are unstable or inaccessible from different floors.	Fail

Table 7.3 Test Cases for Cloud Anchor Technology

Test cases for Compatibility and Costing with AR

Test Case ID	Description	Steps	Expected Result	Actual Result	Status
AR-TC2	API Limits and Costs for Large-Scale Deployment	1.Implement a multi-floor navigation system using Google Maps API. 2. Monitor API usage and costs over a month. 3. Compare costs with budget estimates.	API costs should be within budget estimates.	API costs exceed budget estimates due to high usage rates and expensive API calls.	Fail

Table 7.4 Test Cases for Compatibility and Costing with AR

7.1 Module Implementation

- **User Authentication**

  Upon launching the Disha app, users undergo a streamlined authentication process. This initial step ensures authorized access to the navigation features, enhancing security and user privacy.

- **Source Position Identification**

  The app employs QR code scanning technology to pinpoint the user's current location within the college premises. This innovative approach enables precise positioning, facilitating accurate navigation throughout the campus.

- **Destination Selection**

  Users are empowered to select their desired destinations within the college premises through an intuitive interface. This feature provides users with autonomy and convenience, allowing them to navigate to specific locations tailored to their needs.

- **Navigation Initialization**

  Upon selecting a destination, the app initiates the navigation process seamlessly. By leveraging cutting-edge pathfinding algorithms and augmented reality integration, the app calculates the optimal route and overlays intuitive navigation instructions onto the user's real world environment.

- **Real-Time Navigation**

  As users traverse the college premises, the Disha app provides real-time guidance and direction. By continuously tracking the user's position and updating navigation cues in augmented reality, the app ensures a smooth and efficient navigation experience.

- **Destination Arrival**

  Upon reaching the selected destination, users receive instant confirmation and acknowledgment from the app. This final step in the navigation process enhances user satisfaction and provides closure to the navigation journey.

7.2 User Manual

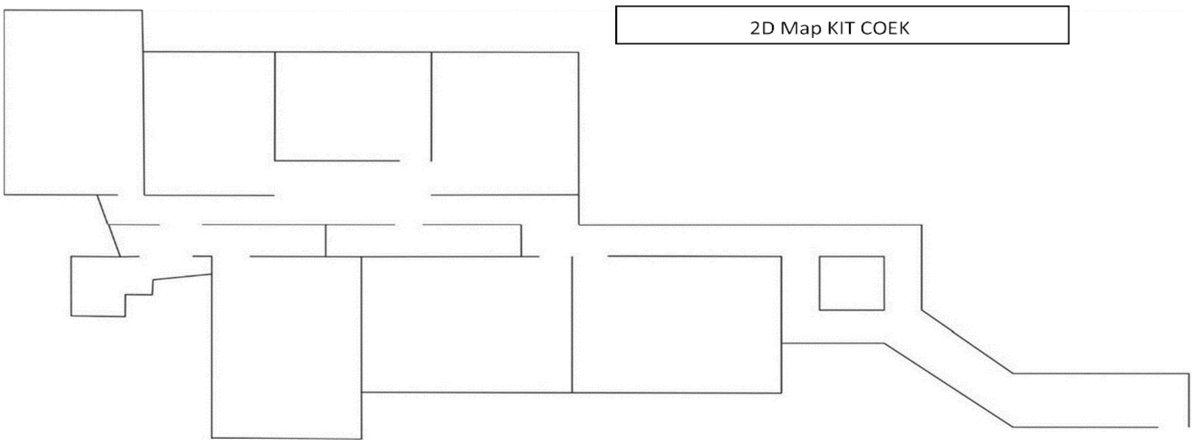

Fig. 7.2.1 2D Map KITCOEK

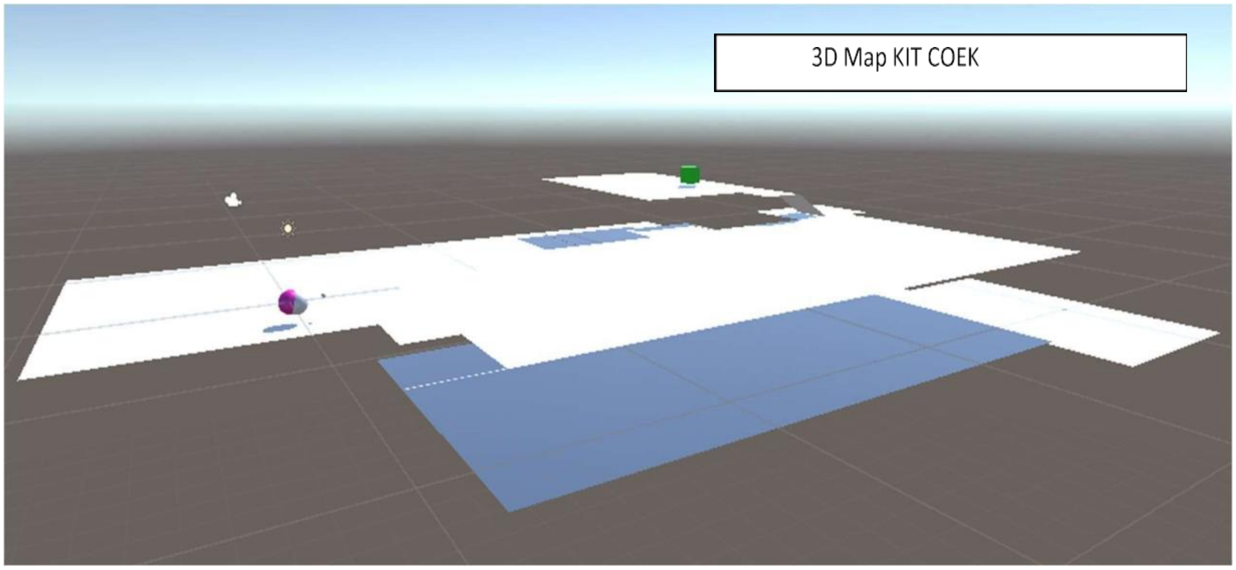

Fig. 7.2.2 3D Map KITCOEK

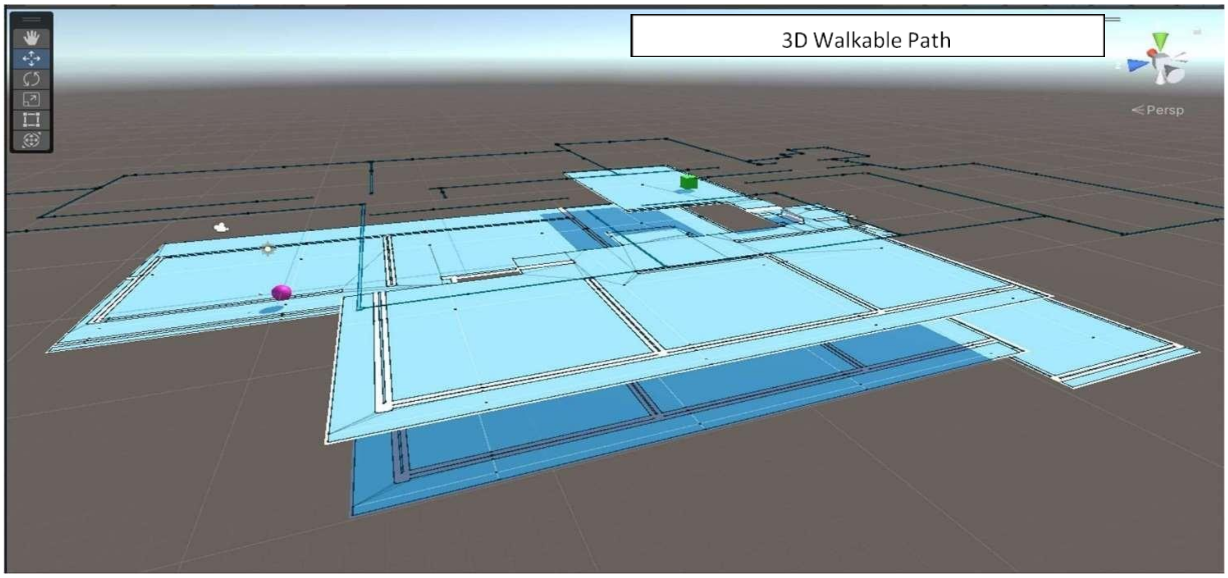

Fig. 7.2.3 3D Walkable Path

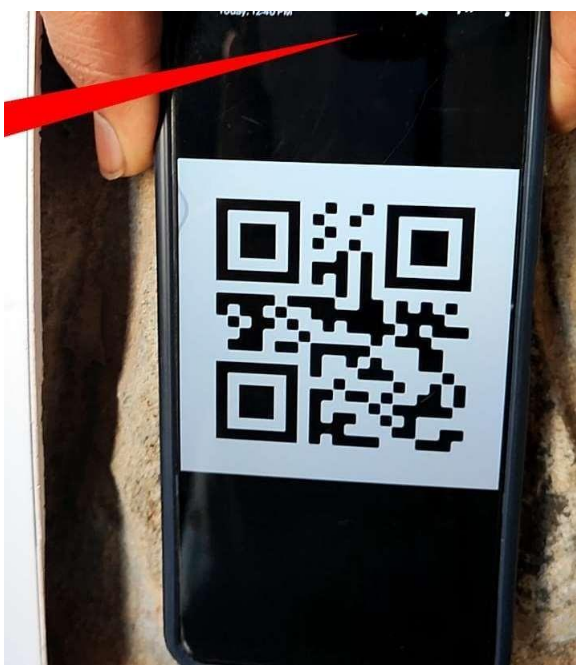

Fig. 7.2.4 QR Code for Classrooms / Labs

Fig. 7.2.5 Floor Navigation 1

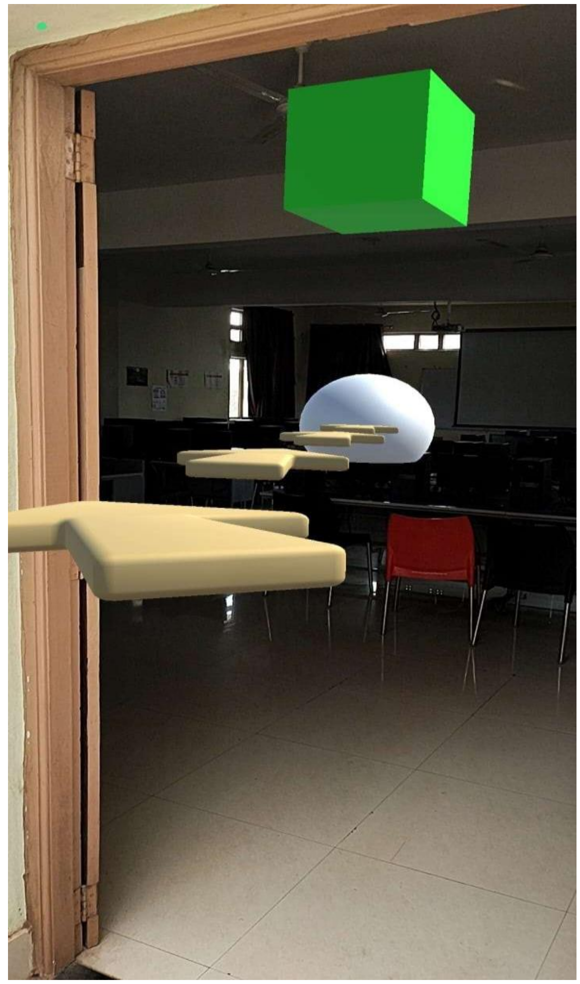

Fig. 7.2.6 Floor Navigation 2

Fig. 7.2.7 Destination Object

8. PROJECT MANAGEMENT

8.1 Process model

In the Iterative model, iterative process starts with a simple implementation of a small set of the software requirements and iteratively enhances the evolving versions until the complete system is implemented and ready to be deployed.

Iterative process starts with a simple implementation of a subset of the software requirements and iteratively enhances the evolving versions until the full system is implemented. At each iteration, design modifications are made and new functional capabilities are added. The basic idea behind this methodis to develop a system through repeated cycles (iterative) and in smaller portions at a time (incremental). he key to a successful use of an iterative software development lifecycle is rigorous validation of requirements, and verification and testing of each version of the software against those requirements within each cycle of the model as the software evolves through successive cycles, tests must be repeated and extended to verify each version of the software.

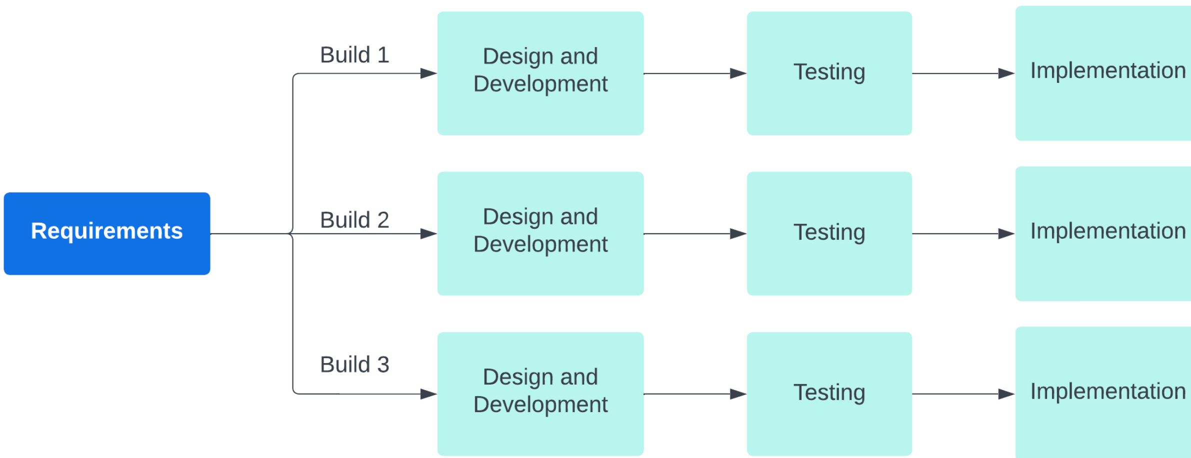

Fig 8.1.1 Iterative model

8.2 Project Timeline

Work Task	Description	Duration
Conceptualization and Planning	• Define project scope, goals, and user requirements. • Research and select appropriate tools and technologies.	01 / 08 / 2023 To 25 /08 / 2023
Asset Preparation	• Gather or create 3D models of the indoor environment (rooms , corridors, landmarks).	27 / 08 / 2023 To 07 / 09 / 2023
Unity Project Setup	• Set up a new Unity project with the appropriate settings for AR development. • Import necessary plugins(AR Foundation , Vuforia).	09 / 09 / 2023 To 23 / 09 / 2023
AR Scene Development	• Build a basic AR scene with a ground plane for placing AR content. • Integrate the 3D model of the indoor space into the AR scene.	24 / 09 / 2023 To 15 / 10 /2023
QR Code Integration	• Implement QR code scanning. • Define QR code locations within the 3D model.	20 /10 /2023 To 30 / 10 / 2023
Navigation Logic	• Develop a navigation system to guide users based on scanned QR codes. • Calculate paths and waypoints dynamically using 3D model data.	01 / 11 /2023 To 15 / 11 / 2023
Implementation	• Project implement in implementation phase	16 / 11 /2023 To 05 / 04 / 2024
Documentation	• Prepare initial report • Prepare Final report	09 / 10 / 2023 12 / 02 / 2024

Table 8.2 Project Timeline

8.3 Feasibility Study

8.3.1 Technical Feasibility

- AR Technology: Evaluate the capabilities and limitations of ARframeworks in Unity (e.g., AR Foundation, Vuforia) for indoornavigation.
- 3D Model Integration: Assess the feasibility of integrating detailed 3Dmodels of indoor environments into the AR application.
- QR Code Recognition: Investigate the accuracy and reliability of QRcode scanning for location detection within an AR context.

8.3.2 User Experience and Usability

- Navigation Accuracy: Consider the precision and reliability of AR-based navigation instructions within indoor spaces.
- Interface Design: Assess the feasibility of creating intuitive userinterfaces for interacting with the AR navigation system.
- User Training: Evaluate the learning curve for users to understand anduse the AR navigation application effectively.

8.3.3 Economic Feasibility

- Development Costs: Estimate the budget required for acquiring software licenses, hardware devices for testing, and hiring skilled developers.
- Time Constraints: Evaluate the project timeline based on development complexity and resource availability.

8.3.4 Operational Feasibility

- Integration with Existing Systems: Determine if the AR navigationsystem can integrate with existing indoor mapping or navigation solutions.
- Maintenance and Support: Assess the feasibility of providing ongoing maintenance and technical support for the AR application post- deployment.

9. TESTING

9.1 Module Name: Navigate to a destination

Test summary/Description:

Test Condition	Test Data	Expected Result	Actual Result	Status of TestCase
Ensure AR Scene Initialization	Launch the application onAndroid	The AR scene should load without errors, detecting the ground plane	AR scene initialize properly in smart phone	Passed
Validate QR Code Scanning Functionality	Use predefined QR codes placed at specific locations	Upon scanning aQR code , the application should recognize the location	QR codes are not recognized accurately , navigation response is not correct	Failed
Validate QR Code Scanning Functionality	Use predefined QR codes placed at specific locations	Upon scanning aQR code , the application should recognize the location	QR codes are recognized accurately , triggering the expected navigation response	Passed
Verify the Accuracy of Navigation	Navigate through area of the indoor environment	Navigation instructions should guide the user accurately	Navigation instructions are clearand lead users to the Correct destination	Passed
Test the responsiveness and functionality	Interact with UI elements during navigation	UI elements should respond promptly(buttons, menus)	UI interaction is smooth	Passed

Test Condition	Test Data	Expected Result	Actual Result	Status of TestCase
Evaluate performance and stability	Test the application on different devices with processing power.	The application should maintain stable performance without crashes or lag.	Performance was not acceptable across different devices with critical issues	Failed
Evaluate performance and stability	Test the application on different devices with processing power.	The application should maintain stable performance without crashes or lag.	Map performance was not stable there were arising object lagging problem	Failed
Evaluate performance and stability	Test the application on different devices with processing power.	The application should maintain stable performance without crashes or lag.	Performance is acceptable across different devices, with no critical issues	Passed
Ensure QR code recognition works under various lighting conditions	Test QR code scanning in different lighting scenarios	The QR codes should be recognized correctly regardless of lighting condition	The QR codes should be recognized correctly	Passed

Table 9.1 Test Cases for Navigate to a destination

10. CONCLUSION

In conclusion, the implementation of indoor navigation using augmented reality with 3D models and QR codes in Unity has proven to be effective and promising. This project successfully demonstrated the potential of AR technology to enhance indoor navigation experiences, providing users with intuitive guidance through digital overlays of 3D models and real-time information accessed via QR codes. The key findings indicate that this approach offers advantages such as improved spatial understanding, interactive wayfinding, and seamless integration with physical environments.

11. REFERENCES

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