# Augmented Reality Based Navigation Assistance for Indoor Environments

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***ABSTRACT***
*Augmented Reality (AR) navigation assistance has emerged as a promising solution for enhancing wayfinding in indoor environments. Unlike traditional GPS-based navigation systems, AR integrates digital information with the physical world to provide users with intuitive, real-time guidance. This paper explores the development and application of AR navigation systems tailored for complex indoor spaces such as shopping malls, airports, hospitals, and university campuses. Leveraging technologies such as visual-inertial odometry, simultaneous localization and mapping (SLAM), and AR overlays, these systems guide users through visually annotated pathways, interactive directions, and contextual information displayed on smart devices or AR glasses. Challenges, including accurate indoor localization, real-time data processing, and user interface design, are addressed through innovative solutions like beacon-based positioning and AI-driven route optimization. Experimental results demonstrate the potential of AR navigation assistance to improve accessibility, reduce cognitive load, and enhance user experience in diverse indoor scenarios. This study underscores the transformative impact of AR in redefining how individuals interact with and navigate indoor environments. Furthermore, the study delves into the potential for AR to improve accessibility for individuals with disabilities, streamline operations in public facilities, and enhance user experiences with personalized and interactive features. This analysis underscores the potential of AR to revolutionize indoor navigation by improving user experience, accessibility, and efficiency.*

## 1-INTRODUCTION

Navigating large indoor environments can be challenging due to their complex layouts and lack of reliable GPS signals. Traditional navigation tools, designed primarily for outdoor use, struggle to provide accurate positioning and directions in such spaces. Augmented Reality (AR) has emerged as a promising solution to address these limitations by merging virtual elements with the physical world to create an interactive navigation experience. AR navigation systems use advanced technologies, including computer vision, artificial intelligence, and localization algorithms, to deliver precise guidance tailored to the unique requirements of indoor environments.

Augmented Reality (AR) has become a transformative technology, bridging the gap between the physical and digital worlds by overlaying computer-generated information on real-world environments. This technology has found a wide array of applications across different sectors, and one of its most promising uses is in indoor navigation. Indoor environments, such as shopping malls, airports, hospitals, museums, and large office buildings, often present significant navigation challenges due to their complexity and size.



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Traditional navigation methods, such as paper maps or static signage, often fall short in helping users navigate these dynamic and intricate spaces.

AR-based navigation systems offer a compelling solution to these challenges by providing users with real-time, context-aware guidance. Through the use of smartphones, tablets, or smart glasses, users can see virtual markers, arrows, or even floor plans overlaid onto their real-world surroundings, guiding them to their destinations. Unlike conventional map-based systems that require users to follow a predetermined path, AR navigation enables a more interactive and dynamic experience. It allows users to receive step-by-step directions, make adjustments as needed, and stay informed about their surroundings in real-time.

In indoor environments, AR technology overcomes the limitations of traditional positioning systems like GPS by utilizing a combination of sensors, cameras, and indoor positioning

systems (IPS) to track a user's location with high accuracy. This enables the system to deliver precise guidance, whether a user is moving through a crowded airport terminal, searching for a specific store in a mall, or trying to find a hospital room in a large medical facility. The AR system continuously adapts to the user's movement, providing directions that are both informative and intuitive.

Furthermore, AR navigation assistance is not only beneficial for general wayfinding but also enhances accessibility for people with disabilities. For individuals with visual or mobility impairments, AR can provide auditory or tactile feedback, making it easier for them to navigate indoor spaces with confidence. By providing real-time information and making complex indoor environments more navigable, AR-powered systems are transforming the way people experience these spaces, offering a seamless blend of technology and real-world interaction.

As AR technology continues to evolve, the potential applications for indoor navigation systems are boundless. Whether for improving customer experience in retail settings, enhancing safety in public buildings, or providing better mobility for individuals with special needs, AR indoor navigation is poised to redefine how we interact with and navigate through our built environment.

## 2 -EXISTING METHODOLOGY

The existing methodology for Augmented Reality (AR) Navigation Assistance for Indoor Environments typically follows a series of established approaches, integrating AR technology with indoor navigation systems. These methodologies combine a variety of technologies like indoor positioning systems (IPS), real-time tracking, computer vision, and pathfinding algorithms. Here's an overview of the existing methodology in this area:

**System Overview**

Augmented Reality Based Indoor Navigation System consists of four modules: indoor positioning, route planning, motion tracking, and AR 3D model placement. At the beginning, the destination selected by the user is sent to the route planning module for determining of a route to the destination. The underneath indoor positioning module continuously updates the user's location based on the received BLE advertisement messages and the associated RSSI . When the user comes to a waypoint, the route planning module sends a message including the expected face orientation and directional indicator to the AR placement module. The AR placement relies on the motion tracking module to obtain the direction and the pitch of the smartphone from the IMU (Inertial Measurement Unit). Based on the collected information, the placement module overlays a 3D arrow model, such as turn left or turn right, on the real-world image.

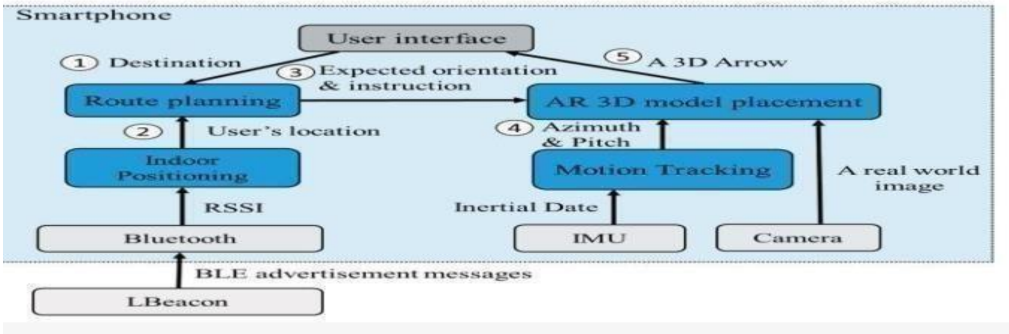


Fig.2.1 System of architecture

Figure 2.2 lists the user interface of the ARBIN App. Frequently asked destinations are shown on the main page figure 2.2a After a user selects a destination on the figure 2.2b, ARBIN determines the user's current location and a route with the shortest distance to the destination. At the beginning, the user is asked to face a specific direction before the navigation service starts figure 2.2c. In other words, the navigation service will not start until the user faces the expected orientation. On the way to the destination, a 3D indicator will be placed in the real-world environment when the use approaches an intersection or a point of interest, such as stairs or elevators figure 2.2d-g. The navigation service stops when the user arrives at the destination. Finally, a message pops up to reminder the user that the navigation service is finished figure 2.2h

**Indoor Positioning Module**

The purpose of the positioning module is to determine the user's location. As Figure 2.3a a shows, Lbeacons are deployed at waypoints. In this work, a waypoint is defined as an intersection, a point of interest, or the middle of a corridor. Each Lbeacon periodically broadcasts its coordinate information to smartphones nearby. From the view point of the user, his or her smartphone continuously receives the coordinate information sent by Lbeacons nearby, while determining how far the smartphone is from the closest Lbeacon. If the distance between the smartphone and a Lbeacon is close enough, for example 3 m, the navigation app provides the user with a directional indicator to guide him or her to the next waypoint. An illustrated example is shown in Figure 2.3b, the route starts from waypoint A and ends at waypoint C. The user first receives a "go straight" command when entering the area of waypoint A, and then a "turn left" command at waypoint B. The coverage size of a waypoint depends on the size of the intersection or the point of interest. The larger the coverage area is, the larger the range of a waypoint is. In our implementation, the coverage size of a waypoint is a 3-m, 5-m, or 7-m radius circle. The key factor for waypoint-based navigation success is accurately determining the distance between the user and the Lbeacons. For this, in our previous work , RSSI distance models stored on the smartphone were adopted to estimate the distance. However, because of the machine cutting error and the characteristics of the RF circuit, the RSSI distance model of each Lbeacon is not identical. To achieve the required positioning accuracy, we constructed a RSSI model for each Lbeacon, but it was time consuming and unscalable.

## 3-SOFTWARE REQUIREMENTS

This project Augmented Reality Assistance for Indoor Navigation, understanding the software requirements is essential for ensuring the system meets user expectations and operates effectively within its intended environment. This chapter outlines the software specifications, tools, and platforms necessary for developing and deploying the application, along with the rationale for selecting these requirements.

In the development of this project, it is critical to ensure that the software requirements align with the technical, functional, and non-functional objectives. Additionally, the identification of the appropriate tools and technologies contributes to minimizing risks, improving development efficiency

**Software Requirements:**

The software requirements for the "Augmented Reality Assistance for Indoor Navigation" project can be broadly categorized into three sections: development tools, platforms, and supporting libraries/frameworks. Each category is crucial to achieving the desired functionality and user experience.

The development tools selected include Android Studio as the core Integrated Development Environment (IDE), offering a comprehensive suite of tools tailored for Android development. Its compatibility with ARCore SDK simplifies the integration of augmented reality functionalities. Git and GitHub are essential for version control and team collaboration, while Visual Studio Code complements Android Studio by supporting external module testing or script editing. Task management tools like Jira or Trello support team coordination, ensuring milestones and deliverables are clearly defined and tracked throughout the development cycle.

The platforms on which the system runs are equally important. The application targets Android OS (minimum version 8.0) to maintain compatibility with ARCore’s advanced features. ARCore is a foundational framework offering capabilities such as environmental understanding, surface tracking, and motion tracking. These features are pivotal in developing a seamless AR experience. Additionally, the app is optimized for mid to high-end Android smartphones

equipped with sufficient RAM, high-quality cameras, and supported sensors like gyroscopes and accelerometers to ensure smooth performance.

To enable robust functionality, a variety of supporting libraries and APIs are integrated. Google Maps API or OpenStreetMap provides interactive indoor maps and real-time positioning. ARCore SDK supports surface detection and 3D object rendering, essential for accurate AR overlays. TensorFlow Lite is considered for implementing AI components such as predictive routing or obstacle recognition. For backend data storage and user session management, Firebase Realtime Database or SQLite is used to maintain persistence, user preferences, and navigation history. The user interface is built using Jetpack Compose or XML layouts, ensuring responsive and accessible UI design.

Beyond core functionalities, other software tools are utilized to enhance reliability and maintainability. Testing frameworks like JUnit and Espresso validate the application's behavior, covering both unit-level and UI testing. Android Virtual Devices (AVDs) or Genymotion emulators enable developers to simulate multiple device scenarios. Performance monitoring is handled through Firebase Performance Monitoring and Android Profiler to detect memory leaks, lag, and rendering issues. Additionally, Firebase Crashlytics and Analytics help in tracking app crashes and gathering usage insights, supporting continuous improvement.

**Development Tools:**

- Integrated Development Environment (IDE): Android Studio is chosen for its robust support for Android app development and seamless integration with AR libraries. It provides powerful debugging tools, a user-friendly interface, and a rich set of plugins to enhance productivity.
- Version Control: Git and GitHub are used for code versioning and collaboration among team members. These tools allow for efficient management of code changes, branching, and merging, ensuring smooth collaboration.
- Code Editor: Visual Studio Code can also be used for editing scripts and testing modules independently, especially for configurations and additional coding needs outside the main IDE.

## 4-AUGMENTED REALITY NAVIGATION ASSISTANCE FOR INDOOR ENVIRONMENTS

In this chapter details the process of translating software requirements into a working system, highlighting the methodologies, tools, and techniques employed during development. This section also elaborates on the structure of the system, its core functionalities, and how the components interact to achieve the project's objectives.


Figure 4.1 Implementation flow

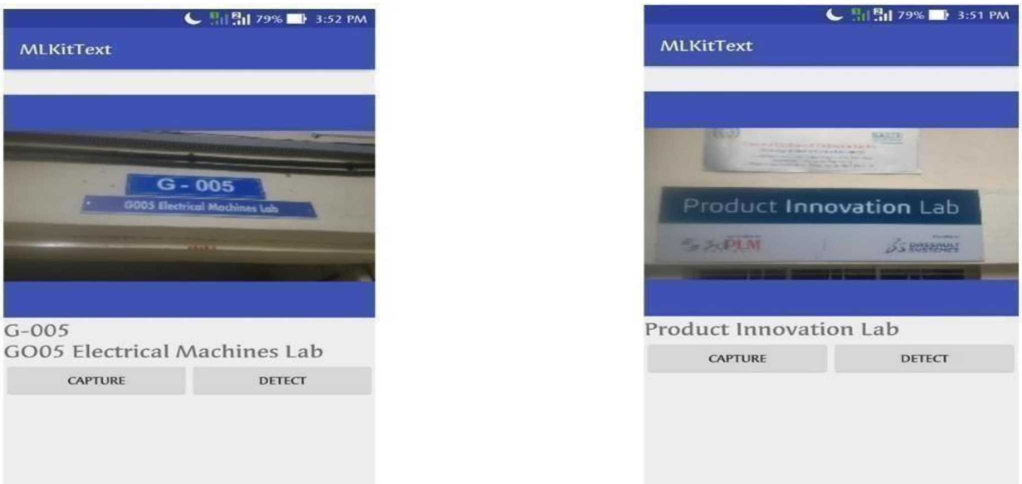
**Source Detection:**

Source Detection here refers to determine the user's current location relative to the intended region. The Admin identifies the prime locations of the navigation area, images of the same are stored in the database. Text recognizer is implemented in backend to detect text from the captured image. The text is stored as a key and corresponding value of its location is set and saved as a key value pair in the database. The user captures an image by smartphone camera of the nearest landmark, it is verified by the application by extracting the text from the image and matching it with the database keys.

Source detection in an indoor navigation system is a critical feature that establishes the user's current position with respect to predefined landmarks in the navigation area. This forms the starting point for route calculation. In the proposed system, the Admin first identifies strategic landmarks—such as hallway labels, entrance gates, reception areas, or signboards—within the indoor environment. Clear and readable images of these key locations are captured and uploaded into the database, along with associated textual data.

Each landmark image is processed using Optical Character Recognition (OCR), which extracts identifying text (e.g., "Block A", "Reception", "Gate 3") and stores it as a key in the database. The corresponding positional coordinates or map node identifiers are saved as the value, forming a key-value pair mapping system.

When the user opens the app and captures a photo of their surrounding landmark, the app automatically invokes the OCR engine (e.g., Google ML Kit's Text Recognition API). The extracted text is matched against the keys in the database. If a valid match is found, the application identifies the user's current location and initiates path planning. This vision-based source detection method is effective in GPS-denied environments and ensures a scalable solution for different types of buildings.




By creating key-value pairs of the location give the following results -

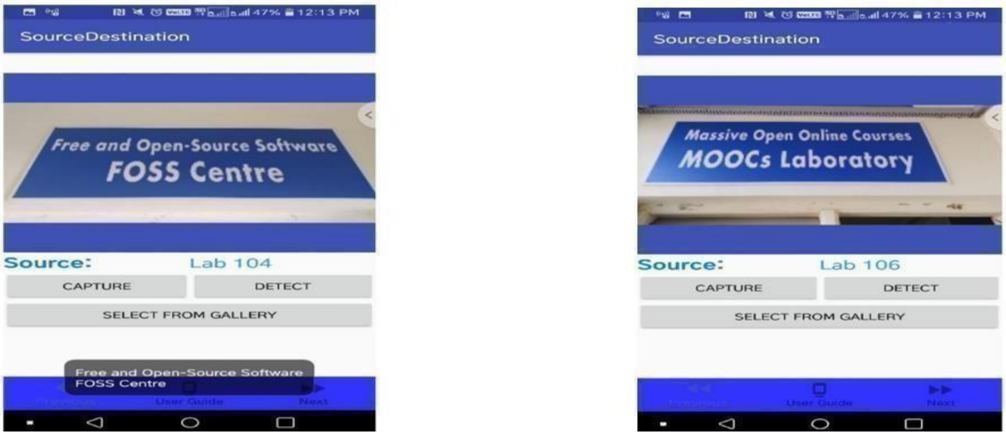



Figure 4.2 Source implementation

**Navigation:**

It is the process or activity of guiding the user to the destination following an appropriate route. Pedometer records the number of steps you have walked and displays them. It is easy to use.

Navigation is the process of directing the user from the identified source to the selected destination using calculated routes and real-time guidance. In the system, a pedometer-based tracking mechanism is implemented, which utilizes the mobile phone's accelerometer and gyroscope sensors to count the number of steps taken by the user.

Upon obtaining the source and destination coordinates, the app computes the shortest path using algorithms like Dijkstra's Algorithm or A*, depending on the map structure. The number of steps between each segment of the path is pre-mapped based on floorplan data. As the user walks, the pedometer compares the number of steps walked against the expected distance between two landmarks, updating the position accordingly.

This method is lightweight, does not rely on Wi-Fi or GPS, and is suitable for multi-floor navigation when combined with floor-level detection (using barometers or QR scanning at staircases or elevators).

**Augmented Reality:**

Augmented reality (AR) is a type of interactive, reality-based display environment that takes the capabilities of computer generated display, sound, text and effects to enhance the user's realworld experience. Augmented reality combines real and computer-based scenes and images to deliver a unified but enhanced view of the world.

Augmented Reality enhances the user's perception by superimposing digital navigation elements—such as directional arrows, labels, and virtual signs—onto the real-world environment captured through the mobile camera. The system uses Google ARCore SDK to provide AR functionalities such as plane detection, 3D anchoring, and environmental understanding.

Once the route is computed, the AR module guides users visually by displaying arrows or virtual markers directly in their camera feed. As the user walks, these overlays update in real-time based on the pedometer input and the system's internal logic. This immersive approach significantly reduces the cognitive load, allowing users to focus on following visual cues rather than interpreting 2D maps.

AR also enhances safety and clarity, especially in complex or unfamiliar buildings. For instance, it can display caution symbols for restricted areas or alerts for nearby amenities.

## 5-PROPOSED SYSTEM ARCHITECTURE

This chapter outlines the architecture of the proposed system for "Augmented Reality Assistance for Indoor Navigation." The architecture is designed to ensure modularity, scalability, and ease of maintenance while integrating cutting-edge AR technologies. The proposed design focuses on providing a seamless navigation experience through effective component interaction and optimized resource management.

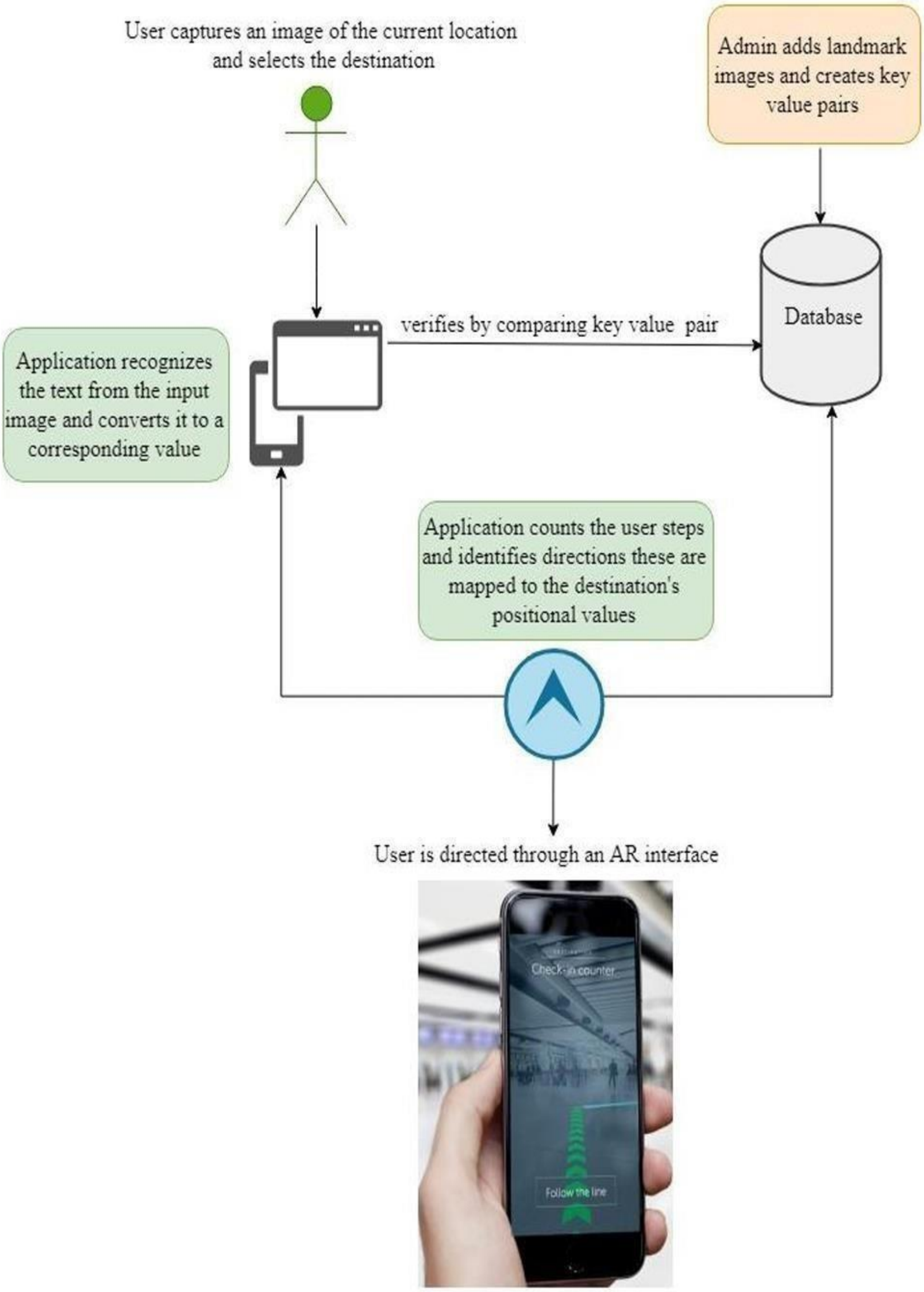



Figure 5.1 Proposed system architecture

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Steps Involved:

**Step 1: Admin Adds Landmark Images**

The process begins with the administrator uploading reference images of key landmarks in the indoor environment—such as entrances, department signs, or corridors. These images act as anchor points for navigation. Each image is assigned a unique textual identifier (key-value pair), which helps map a visual landmark to its corresponding coordinates or zone within the indoor map. These key-value pairs are securely stored in a centralized database that supports fast retrieval and matching during the navigation process.

**Step 2: Source Identification via Image Text Recognition**

When a user launches the app, they are asked to capture an image of the nearest landmark (e.g., a signboard). This image undergoes Optical Character Recognition (OCR) to extract text from the image. The extracted text is compared against the key-value pairs stored in the database. The destination, on the other hand, is selected by the user from a predefined list in the interface. Once the source text matches a key in the database, the app identifies the starting location of the user.

**Step 3: Step Counting and Direction Estimation**

After identifying the source and destination coordinates, the app initiates step counting using the smartphone's accelerometer and gyroscope sensors. Each physical step the user takes is mapped to a coordinate system, allowing the app to track movement indoors, where GPS may not be available. This relative movement is aligned with a predefined navigation path, linking each step to directional instructions towards the destination.

**Step 4: AR-Based Navigation Guidance**

As the user moves, the system uses the device camera and AR overlays to guide them visually. Directional arrows, waypoints, and distance indicators appear in the AR interface, updating dynamically with each step taken. If the user deviates, the app can recalculate the route in real time using AI-based corrections. This ensures that even in complex or multi-turn environments, users can receive intuitive, on-screen directions that blend with the real world.

**Activity diagram:**

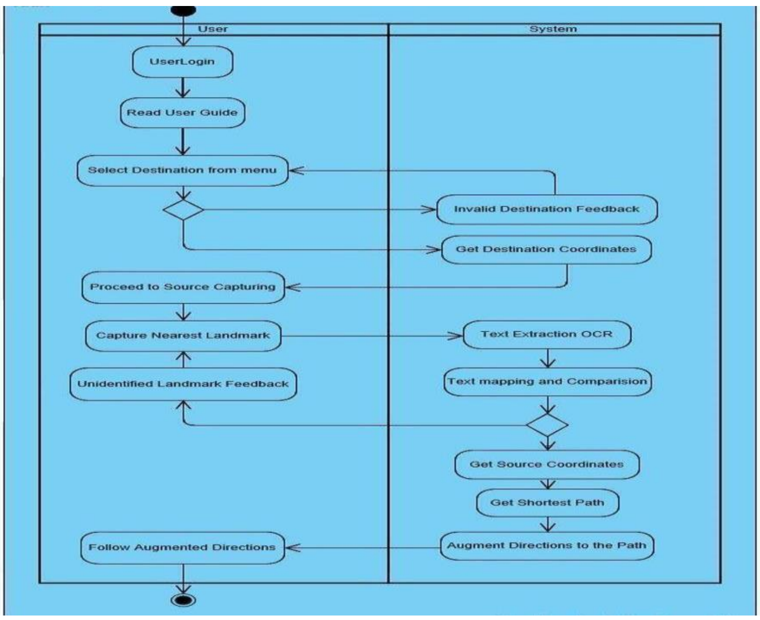


Figure 5.3 Activity diagram

## 6-RESULT AND DISCUSSION

This chapter presents the outcomes of implementing an Augmented Reality (AR) navigation system for indoor environments. The results focus on the system's accuracy, user experience, and real-time performance in guiding users through complex indoor spaces. Comparisons with traditional navigation methods are discussed. The effectiveness of AR overlays in enhancing direction clarity is also analyzed. Finally, user feedback is evaluated to understand the practical usability and limitations of the system.

**Phase-1 Output**

Fig. 6.1: Web Dashboard

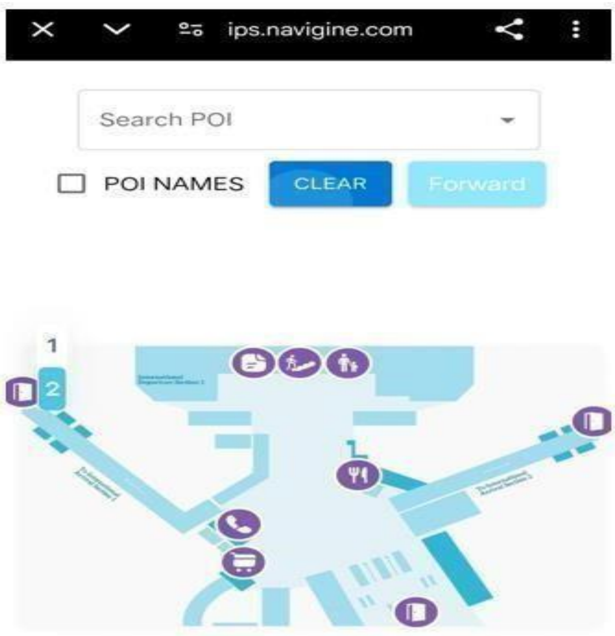


Fig. 2: Map of the Airport

Figure 6.1 shows the Web Dashboard designed for the admin or facility manager. This dashboard allows for managing user data, scanning QR codes, and updating indoor navigation routes. It provides a centralized interface to monitor navigation activity and update points of interest across the indoor environment.

Figure 6.2 displays the Map of the Airport, which serves as the base layer for the AR navigation system. This map is used to identify important locations such as terminals, exits, lounges, and gates. It is linked with QR codes placed at various positions to help users find accurate directions from source to destination through the AR application.

**Phase-2 Output**


Fig. 6.3: Select Data


Fig. 4: Source and Destination

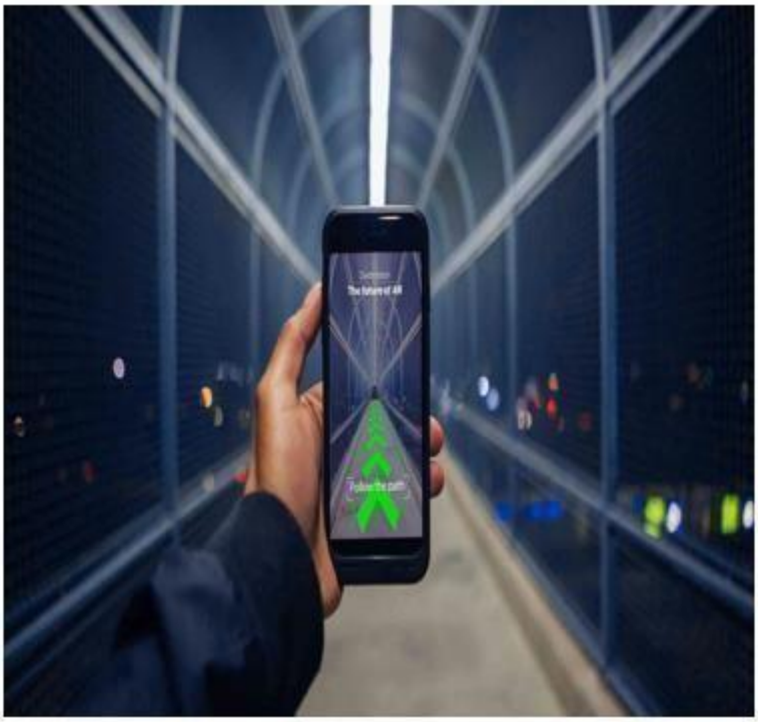


Fig.5: Navigation using Augmented reality

## CONCLUSION

In conclusion, the "Augmented Reality Assistance for Indoor Navigation" project not only addresses a critical need for efficient indoor navigation but also paves the way for innovative applications across industries. With continuous refinement and technological advancements, this system has the potential to become a cornerstone solution in modern indoor navigation, improving accessibility, efficiency, and user satisfaction on a global scale.

The "Augmented Reality Assistance for Indoor Navigation" project serves as a groundbreaking initiative to tackle the complexities of indoor navigation by harnessing the power of augmented reality. It combines an intuitive user interface, efficient backend infrastructure, and seamless AR integration to deliver a system that is not only functional but also highly user-centric. The project's modular architecture enhances scalability and adaptability, ensuring its applicability across diverse sectors such as healthcare, retail, education, and entertainment. Addressing challenges like AR overlay precision, device performance optimization, and varied user requirements, the system demonstrates innovative problem-solving and technological advancement. Looking ahead, the project offers vast potential for enhancement, such as the integration of machine learning for predictive navigation, compatibility with emerging AR hardware like smart glasses, and offline functionality for greater accessibility. Future developments could also include features like voice-guided navigation, real-time notifications, and immersive 3D mapping, broadening its applications. Ultimately, this project not only addresses a critical need but also lays a solid foundation for further advancements, positioning itself as a transformative solution in indoor navigation systems.

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