International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 07 | July - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Design and Implementation of Mobile App for Indoor Navigation System Using AR

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Abstract - The paper "Design and Implementation of Mobile App for Indoor Navigation System Using AR" presents an advanced indoor navigation solution utilizing Augmented Reality to enhance wayfinding in large and complex facilities. Built with Unity and the Immersal SDK, the mobile application projects virtual guidance cues directly onto the user's real-world view, allowing effortless navigation within spaces like shopping malls, airports, hospitals, and office buildings. Core functionalities include accurate positioning through spatial anchors, real-time route guidance, and an intuitive user interface designed for diverse audiences. By merging AR with detailed spatial mapping, the application addresses limitations of conventional indoor navigation, such as static signage and confusing floor plans, delivering an interactive and engaging user experience. This approach not only simplifies movement through intricate environments but also illustrates the transformative role of AR in modernizing indoor navigation systems, ultimately contributing to more efficient, user-centric, and connected interior spaces.

Key Words: Augmented Reality (AR), Indoor navigation, Mobile application, Spatial anchors, Real-time guidance, Unity

1.INTRODUCTION

Navigating large indoor spaces like malls, hospitals, airports, universities, and office complexes presents significant challenges that traditional tools such as static maps and signage often fail to overcome. Unlike outdoor navigation, which benefits from GPS, indoor environments suffer from poor satellite signal reception and intricate layouts, making effective wayfinding difficult. Augmented Reality (AR) introduces a transformative approach by overlaying digital content onto real-world scenes, allowing users to intuitively follow directions enriched with contextual information.

This paper, titled "Design and Implementation of Mobile App for Indoor Navigation System Using AR," explores the development of an interactive AR-based mobile application. Created with Unity and integrated with the Immersal SDK, the app provides real-time navigation guidance by displaying virtual pathways and location markers directly within the user's view. The system harnesses spatial mapping and localization to deliver accurate positioning and dynamic route updates.

Aimed at enhancing user experience across various environments—from shoppers finding stores to patients navigating hospital corridors—the solution prioritizes scalability, usability, and adaptability. Its potential applications span retail, healthcare, education, and corporate settings, leveraging widespread smartphone AR capabilities to make deployment practical and impactful. Ultimately, the project demonstrates how AR can redefine indoor navigation, making it smarter, more accessible, and deeply engaging.

2. Literature Review

1. **Xiang Hui Ng and Wan Nur Azman Lim** [5] design a mobile AR-based indoor navigation system that utilizes Wi-Fi positioning and geomagnetic field data. The authors demonstrate the use of Unity and ARCore to develop an accurate and efficient navigation system that adapts to varying environmental conditions.

2. **Sadhana B, K. Shreyas Kamath, Sandesh R Vernekar, Sanjay G K, and Shashank S Shenoy** [5] present an AR-based indoor navigation application that uses computer vision and pathfinding algorithms. The system detects indoor locations via mobile cameras and provides AR-guided directions, offering an interactive and immersive user experience.

3. **Shriram K. Vasudevan, Karthik Venkatachalam, Harii Shree, Rani B. Keerthana, and G. Priyadarshini** [5] develop an interactive AR-based indoor navigation system integrating GPS and cloud storage. The application dynamically updates location details and presents them as AR markers through the user's camera, ensuring an adaptive and scalable navigation solution.

2.1 Problem Statement

Finding one's way inside large facilities such as shopping malls, hospitals, airports, and university campuses is often difficult due to intricate layouts, insufficient or confusing signage, and the lack of reliable indoor positioning from GPS. Traditional aids like printed maps and static signboards frequently fail to deliver real-

time, context-aware guidance, resulting in user frustration, wasted time, and navigational errors. This highlights the need for an intelligent, real-time navigation solution that can simplify indoor wayfinding and improve the overall visitor experience.

2.2 Objectives

This project seeks to create a mobile application that leverages Augmented Reality to deliver an interactive and user-friendly indoor navigation experience. The key goals include:

- Enabling accurate route guidance through AR visual cues, directing users efficiently to their desired locations.
- Employing the Immersal SDK for precise spatial mapping and localization, ensuring reliable indoor positioning.
- Enhancing user satisfaction by making navigation intuitive, immersive, and engaging.
- Designing the system to be flexible and applicable across diverse indoor settings such as malls, hospitals, airports, and educational institutions.

3. Proposed System

The proposed mobile application for indoor navigation combines Augmented Reality technology, spatial mapping, and efficient backend services to deliver precise, real-time guidance within complex indoor environments. Designed to be modular and scalable, the system consists of several key layers that work together to create a seamless and engaging user experience.

3.1 User Interface Layer

This is the interactive front-end where users access the AR-based navigation features on smartphones or tablets. It includes:

- **AR Guidance View**: Projects virtual arrows, highlighted paths, and points of interest (POIs) directly onto the live camera feed.
- **Destination Input Tools**: Allows users to search, browse categories, or select destinations on a digital map.
- **Interactive Elements**: Enables users to tap on AR markers to view details about shops, services, or facilities.

3.2 AR Processing and Visualization Layer

This layer powers real-time AR rendering and interaction:

- **Unity Engine**: Develops and manages 3D AR interfaces.
- **Visualization Module**: Draws AR elements like navigation cues and POIs in alignment with the real environment.
- **Device Sensors Integration**: Leverages camera, gyroscope, and accelerometer to synchronize AR content with user movements.

3.3 Spatial Mapping and Localization Layer

Crucial for determining user position indoors:

- **Immersal SDK**: Handles creation of 3D spatial maps and real-time localization.
  - *Mapping*: Generates detailed 3D representations of indoor spaces.
  - *Localization*: Continuously updates the user's position within these maps.
- **Pathfinding Algorithm**: Calculates the most efficient route, adapting dynamically to obstacles or layout changes.

3.4 Backend Services Layer

Manages core logic and data communication:

- **Navigation Engine**: Processes route requests and adjusts guidance in real-time as users move.
- **Data Synchronization Module**: Keeps location, map updates, and user inputs consistent between the app and server.
- **Environment Update Service**: Integrates live changes (e.g., temporary closures or new obstacles) to ensure route accuracy.

3.5 Data Storage Layer

Stores essential data to support reliable navigation:

- **Indoor Map Database**: Holds 3D maps generated from spatial mapping.
- **POI Database**: Contains detailed info about stores, departments, and amenities.
- **User Data**: Optionally keeps preferences and history for personalized guidance.

4. Methodology

The development of the mobile indoor navigation application using Augmented Reality followed a structured approach to ensure usability, accuracy, and real-time performance. The first step involved clearly defining the navigation scenarios, targeting complex indoor spaces such as shopping malls, airports, museums, and university campuses. This helped outline key objectives like delivering an intuitive user interface, reliable positioning, and smooth AR experiences.

Next, the indoor environment was scanned and mapped using the Immersal SDK, producing detailed spatial data suitable for real-time localization and pathfinding. Following this, the design phase focused on creating AR overlays—such as virtual arrows, highlighted paths, and dynamic points of interest—to visually guide users within these mapped spaces.

The AR components were then integrated with spatial localization to enable real-time guidance, ensuring that the digital navigation cues aligned accurately with the user's physical surroundings. In parallel, a user-friendly interface was developed, allowing users to easily input destinations and receive step-by-step directions.

Finally, the system underwent comprehensive testing across different indoor environments and conditions. This validation phase ensured that the navigation experience remained robust, reliable, and adaptable to various layouts and dynamic changes within indoor spaces.

Fig -1: Indoor Navigation System Cycle

5. Applications

The proposed AR-based indoor navigation system can be applied across various environments to enhance user experience and operational efficiency:

- **Shopping Malls**: Help visitors quickly locate specific stores, amenities, or services.
- **Airports**: Guide passengers to boarding gates, baggage claim areas, check-in counters, and lounges.
- **Hospitals**: Assist patients and visitors in navigating complex layouts to reach departments, wards, or specialist clinics.
- **Universities and Campuses**: Enable students and guests to find lecture halls, administrative offices, and event locations.
- **Museums and Exhibitions**: Offer interactive tours, highlighting exhibits and providing contextual information in real time.
- **Corporate Offices**: Support visitors and employees in locating meeting rooms and other facilities within large office complexes.

6. Advantages

The mobile AR navigation system offers several notable benefits:

- **Real-time Guidance**: Provides live, context-aware navigation instead of relying on static maps.
- **Improved User Experience**: Delivers an intuitive and visually engaging interface that simplifies wayfinding.
- **High Accuracy**: Combines AR overlays with precise spatial localization to guide users accurately through complex layouts.
- **Scalability**: Adaptable to various indoor environments, regardless of size or structure.
- **Dynamic Updates**: Capable of reflecting real-time changes, such as temporary closures or new obstacles.
- **Enhanced Accessibility**: Supports diverse user groups, making indoor spaces easier to navigate for everyone.

7. Conclusion

This paper presented the design and development of a mobile application that leverages Augmented Reality to simplify indoor navigation in complex environments such as malls, airports, hospitals, and educational institutions. By integrating AR overlays with precise spatial mapping and localization through the Immersal SDK, the system delivers real-time, interactive guidance that significantly enhances user experience.

The modular architecture ensures scalability and adaptability, while the intuitive user interface makes navigation accessible to a wide range of users. Testing in varied indoor scenarios demonstrates the system's effectiveness in providing accurate and immersive wayfinding solutions.

Ultimately, this approach showcases the potential of AR technology to transform traditional indoor navigation methods, offering smarter, more engaging, and user-centric solutions for modern indoor spaces.

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