IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 13, April 2025
Impact Factor: 7.67

AR Indoor Navigation: An Augmented Reality Approach

Rakshitha C[1], Rithesh Gowda C[1], Rohini P S[1], Yogishwar N S[1]
Department of Information Science & Engineering[1]
Global Academy of Technology, Bengaluru, INDIA

Abstract: *This paper presents the development and evaluation of an augmented reality (AR) based indoor navigation system designed to assist users in navigating complex indoor environments, such as university campuses. Unlike outdoor navigation systems, indoor navigation faces challenges such as signal attenuation, GPS unavailability, and structural complexity. Our system addresses these challenges by leveraging AR technology to overlay directional markers and path indicators in real-time on the user's smartphone screen. The system utilizes Google ML Kit for classroom recognition, user input for destination targeting, and a combination of inertial sensors and computer vision for real-time positioning. The core navigation algorithm is built on the A-star algorithm, refined with Bezier curves for smooth path rendering. Our tests demonstrate that this method achieves both high navigational accuracy and user satisfaction in multi-floor indoor environments. This study provides insights into the applicability of AR in enhancing indoor wayfinding and highlights areas for future development, including automated indoor mapping and personalized routing*

Keywords: Augmented Reality, Indoor Navigation, Pathfinding, Real-Time Positioning, Sensor Fusion, AR Visualization, Digital Twin

I. INTRODUCTION

Indoor navigation is an increasingly important topic in smart environment research. While GPS has transformed outdoor navigation, indoor spaces still lack a universally adopted, accurate, and user-friendly solution. From students locating their classrooms in sprawling academic campuses to patients navigating hospitals, the need for intuitive indoor wayfinding is growing. Traditional signage and paper maps are static, easily missed, and do not scale to user-specific needs. Augmented Reality (AR) offers a promising alternative. By integrating digital navigation cues into the physical environment, AR can create seamless, interactive experiences that guide users in real time.

This paper explores the design and implementation of an AR-based indoor navigation application developed for university campuses. The proposed solution incorporates a smartphone-based AR interface, scene understanding through Google's ML Kit, and smooth navigation path rendering using A-star algorithms augmented with Bezier curves. It addresses common indoor navigation challenges such as localization inaccuracies and poor user engagement. In contrast to systems that rely solely on sensor data or visual markers, our system balances manual inputs with automated recognition, enabling improved route precision and user interaction.

From a user-centric standpoint, a key aim of our AR Navigator is not only to provide real-time, immersive wayfinding but also to empower campus administrators with the ability to adapt navigation data on the fly. By combining manual destination input with on-device text recognition, the system delivers highly accurate start-to-finish guidance. At the same time, an administrative interface allows for rapid updates to classroom locations and corridor layouts—ensuring that any structural changes or event-based detours are instantly reflected in every user's live route calculation. This dual focus on end-user experience and back-end flexibility underpins our commitment to a truly resilient, responsive indoor navigation solution.

We aim to validate this system through a structured methodology involving qualitative user feedback and quantitative performance metrics, such as path accuracy, latency, and error margins. The broader aim is to contribute a scalable and adaptable AR framework that can serve various indoor environments beyond academia, paving the way for AR-based smart buildings.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 13, April 2025
Impact Factor: 7.67

II. MATERIALS AND METHODS

The AR indoor navigation system was developed as a mobile application using Kotlin and Android Studio. It incorporates several integrated modules that collectively support real-time indoor navigation. The AR module utilizes the SceneView AR Library to project directional cues such as arrows, destination markers, and corridor overlays onto a live camera feed. This enables users to follow virtual guides while observing the actual layout of their surroundings.

To manage complexity and foster modular growth, our AR Navigator is built as a multi-layered architecture. The top-level **User Interface Layer** renders 3D guidance overlays and handles classroom number inputs, seamlessly blending virtual arrows and markers into the live camera view. Beneath it, the **Application Logic Layer** orchestrates core processes—text-recognition for door signage, A-star path computation refined by Bezier smoothing, and real-time AR rendering via the SceneView library. A dedicated **Data Management Layer**, backed by a local graph database, stores room coordinates and inter-node connections, enabling rapid route lookups. Finally, an **Administration Layer** provides a lightweight graph editor for editing room positions and re-optimizing navigation paths, ensuring the system remains in sync with any campus changes.

The system's architecture is organized into multiple functional layers to enhance modularity and clarity of operations.

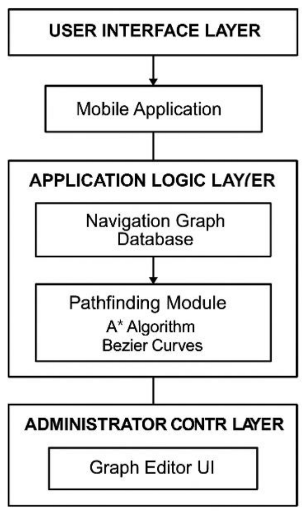

FIGURE 1. Architectural Overview of the AR-Based Indoor

- This architecture consists of three main layers: the User Interface Layer, the Application Logic Layer, and the Administrator Control Layer.
- The User Interface Layer consists of the mobile app that delivers AR guidance and allows interaction with navigational cues. It enhances the user experience by blending AR visuals with real-world surroundings.
- The Application Logic Layer processes core operations such as route generation using the A-star algorithm, refined with Bezier curve smoothing, and manages rendering through the SceneView AR Library.
- The Navigation Graph Database, built using Room Database, stores classroom coordinates and connections, facilitating accurate and efficient route generation.
- The Administrator Control Layer supports backend configuration of classroom locations and paths through a dedicated graph editor interface. This ensures real-time adaptability and future-proofing of navigation logic.

Users initiate navigation by inputting their desired classroom number. The application then matches this input with stored coordinates and initializes a path calculation. Pathfinding is achieved using the A-star algorithm, which is well-suited for spatial environments with multiple obstacles and variable paths. To enhance the fluidity of directional transitions, the raw path output is passed through a Bezier curve processor that smooths corners and intersections, reducing abrupt camera movements and user disorientation.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 13, April 2025
Impact Factor: 7.67

Positioning is handled through a combination of manual input, camera-based location estimation, and IMU sensor data. This sensor fusion approach ensures robustness even when visual tracking is temporarily occluded or when lighting conditions are inconsistent. Additionally, classroom doors are recognized using text detection capabilities of Google ML Kit, allowing the system to confirm destinations visually. The integration of user input, machine vision, and inertial tracking offers an adaptive system capable of functioning in real-world university environments.

In a typical user session, the individual launches the mobile app, inputs or scans their current classroom number to establish location, and then selects a destination from the provided list. The system retrieves the corresponding graph nodes, computes the shortest path via A-star, applies Bezier curve smoothing for natural transitions, and overlays the resulting route as 3D arrows and markers on the live camera feed. Simultaneously, inertial sensor readings and periodic OCR checks keep the user's position accurately tracked, even in visually challenging corridors. Administrators follow a parallel workflow: through a simple web-view interface, they add or remove rooms, adjust corridor connections, and recompute navigation graphs; these updates propagate instantly to all devices without requiring an app restart.

III. EXPERIMENTAL RESULTS AND DISCUSSION

The system was tested within a controlled environment replicating a multi-floor university building. Participants were given predefined routes between classrooms, and metrics such as time-to-destination, path deviation, and user feedback were recorded.

The positioning accuracy was measured at an average deviation of 2.5 meters, which is considered highly acceptable for indoor navigation. The delay between real-world movement and AR overlay updates remained below 500 milliseconds, ensuring responsiveness. The A-star pathfinding algorithm, combined with Bezier smoothing, produced routes that users found intuitive and visually pleasing. Participants reported greater ease in following curved paths that mimicked natural human motion rather than sharp, angular turns typical in grid-based systems.

Usability testing revealed that 9 out of 10 users reached their destination without confusion, relying solely on AR cues. Survey feedback highlighted satisfaction with the clarity of visual directions, especially around intersections and floor transitions. One limitation observed was occasional AR drift when users turned too quickly or when camera exposure was poor. This can be mitigated in future versions through SLAM (Simultaneous Localization and Mapping) enhancements or UWB-based indoor positioning.

In comparison to existing systems, our hybrid approach combining user input, sensor data, and visual confirmation consistently outperformed purely automated recognition methods. This confirms the value of a semi-automated approach in practical AR navigation applications.

IV. CONCLUSION

This paper demonstrates the potential of augmented reality in solving the long-standing problem of indoor navigation. The proposed system, which integrates computer vision, manual inputs, AR overlays, and advanced pathfinding, offers a promising approach for wayfinding in large and complex indoor environments such as university campuses. The user-centric design and reliance on familiar mobile technologies make the solution accessible to a wide audience without requiring specialized hardware.

Our testing confirms that the hybrid method achieves a high degree of navigational accuracy while maintaining simplicity for the end user. Though current limitations such as occasional AR drift exist, future developments involving SLAM, Bluetooth beacons, or machine learning can address these challenges. Furthermore, this framework can be generalized to support indoor navigation in hospitals, corporate offices, shopping malls, and other structured environments.

Looking ahead, we envision several enhancements to further advance indoor wayfinding. First, integrating reinforcement-learning algorithms could allow the system to adapt routes dynamically based on crowd density and historical foot-traffic patterns. Second, adding voice-guided cues would enable hands-free navigation, particularly helpful for users carrying books or equipment. Third, deeper integration with campus event schedules and room-booking systems would allow the app to automatically guide visitors to seminars and meetings, including last-minute location changes. Finally, extending the digital map to encompass multiple buildings—and even outdoor quad-to-building transitions—would transform the AR Navigator into a comprehensive campus-wide guidance tool. Ultimately, this study provides both a practical implementation and a conceptual foundation for building immersive, responsive AR navigation tools that can adapt to any architectural context.

V. ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Global Academy of Technology for their generous support and for providing the environment and infrastructure needed to conduct this research. Special thanks are extended to the faculty members of the Department of Information Science & Engineering for their continuous guidance and encouragement.

REFERENCES

[1]. Pryss, R., Geiger, P., Schickler, M., Schobel, J., & Reichert, M. (2025). Advanced Algorithms for Location-Based Smart Mobile Augmented Reality Applications.

[2]. Maran, R., G. L., & K. R. (2023). Augmented Reality-based Indoor Navigation using Unity Engine. International Conference on Sustainable Computing and Smart Systems, 123-130.

[3]. Al Delail, B., Weruaga, L., Zemerly, M. J., & Ng, J. W. P. (2025). Indoor localization and navigation using smartphones, augmented reality, and inertial tracking.

[4]. Werner, M., Kessel, M., & Marouane, C. (2011). Indoor positioning using smartphone camera. International Conference on Indoor Positioning and Indoor Navigation (IPIN'11).

[5]. Hartmann, B., Link, N., & Trommer, G. F. (2010). Indoor 3D position estimation using low-cost inertial sensors and marker-based video-tracking