International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 2, Mar-Apr-2026, ISSN (Online): 2395-566X

AI-Driven Augmented Reality Based Smart Campus Navigation System

Dr. S. Sharon Priya[1], Anish Fathima N[2], Blessy Evangeline A[3]
Department of Computer Science, B.S.A. Crescent Institute of Science and Technology, Chennai, Tamil Nadu.

Abstract- The campus environment in universities includes many blocks laboratories offices hostels libraries and other facilities spread across different areas which makes navigation difficult for students visitors and staff. The existing methods such as signboards printed maps and verbal directions do not provide proper support and users often struggle to find the correct location. The absence of real time guidance creates confusion especially during busy periods like admissions examinations and events where many people move at the same time. The difficulty increases when users are not familiar with the campus layout and this leads to time loss and frustration. The need for a simple reliable and easily accessible navigation system becomes very important in such situations. The proposed system is an AR based smart campus navigation solution that works through a mobile browser without the need for any application installation. The system uses GPS and device sensors to continuously track user position and direction and provides accurate navigation support. The A star algorithm is used to calculate the shortest path between the current location and the destination and this improves navigation efficiency. The guidance is shown using augmented reality arrows on the camera view which makes directions easy to understand and follow. The system also includes an AI chatbot for user queries voice guidance for hands free navigation and crowd prediction to avoid busy areas. The Firebase database is used to provide real time information such as lab availability staff details and event updates. The system provides a complete and user friendly solution for campus navigation.

Keywords- The augmented reality campus navigation, GPS tracking, A star algorithm, artificial intelligence chatbot, voice guidance, crowd prediction, Firebase real time system.

I. INTRODUCTION

The university campus contains multiple academic blocks laboratories administrative offices hostels canteens and other facilities which are distributed across a wide area and this makes navigation difficult for users. The students visitors and staff often face confusion while trying to locate specific places especially during their first visit to the campus. The existing navigation methods such as printed maps and signboards do not provide clear step by step guidance and they cannot update information based on changes. The lack of proper navigation support leads to time wastage and creates a negative experience for users who are unfamiliar with the environment. The problem becomes more serious in large campuses where distances between locations are high and multiple paths are available.

The absence of an intelligent navigation system forces users to depend on outdated resources and directions from other people which may not always be accurate. The situation becomes more difficult during events and peak hours where many people try to find locations at the same time. The difficulty increases when users enter buildings where proper guidance is not available and they have to search manually for rooms and offices. The users may walk through wrong paths and this increases confusion and delay in reaching the destination. The need for a system that provides real time accurate and easy to follow guidance becomes necessary to solve these issues effectively.

The proposed system introduces an AR based smart campus navigation platform that combines augmented reality GPS tracking and artificial intelligence into a single solution. The system works through a web browser which removes the need for application installation and makes it accessible to all users with a smartphone. The navigation is provided using AR directional arrows on the live camera feed which helps users understand directions clearly in real world view. The system also includes an AI chatbot which helps users to get information

about campus facilities staff and navigation through simple queries. The voice guidance feature provides spoken instructions which improves usability during movement. The crowd prediction feature helps users avoid busy areas and choose better paths. The integration of these features improves navigation accuracy and provides a better and more comfortable experience for all users inside the campus.

II. RELATED WORKS

Lokhande J. Bodhankar P. and Patil S. (2024) proposed a campus navigation system using augmented reality and virtual reality to improve user navigation experience in university environments. The system uses AR to provide real time visual guidance and VR to enhance spatial understanding of campus layout. The proposed system improves user interaction and navigation clarity; however, it requires higher computational resources and may not be easily accessible on all devices.

Riya Patel et al. (2025) proposed a campus navigation system using augmented reality that provides both indoor and outdoor navigation through a mobile application. The system uses AR to display real world directions and improves user understanding of navigation paths. The proposed system provides an interactive experience; however, it depends on application installation and does not fully support web based access.

B. S. C. Putra et al. (2025) proposed an adaptive AR navigation system that uses node based mapping to guide users in indoor environments. The system improves flexibility in navigation and allows dynamic path creation. The proposed system enhances indoor navigation; however, it faces challenges in scalability and interface clarity.

Vijay U. Rathod et al. (2026) proposed an AR based indoor navigation system that integrates A star algorithm with AR overlays for real time guidance. The system improves navigation accuracy and provides faster path calculation compared to traditional methods. The proposed system shows better performance; however, it requires optimization for large environments.

F. Xu et al. (2024) proposed an AR based wayfinding system that uses egocentric perspective to improve user navigation performance. The system reduces cognitive load and improves spatial understanding during navigation. The proposed system improves efficiency; however, it focuses mainly on indoor environments and limited real world deployment.

Xiaohe Qiu et al. (2024) proposed a study on AR navigation display methods and compared them with traditional map based systems. The system shows that AR provides better spatial knowledge and improved navigation performance. The proposed system improves user understanding; however, some display methods may affect usability in complex environments.

Toma Bejinaru et al. (2024) proposed an AR based campus navigation system focused on improving accessibility and user experience. The system enhances navigation using AR technology and supports better usability for users. The proposed system improves accessibility; however, it requires improvement in real time data integration.

Zhiwen Qiu et al. (2023) proposed a landmark based AR navigation system that helps users improve spatial learning and navigation efficiency using visual cues. The system uses real world landmarks for guidance. The proposed system improves navigation performance; however, it requires additional setup and validation in large environments.

U roAm system (2025) proposed an AR based campus navigation and building directory system that improves usability and user interaction in university campuses. The system provides navigation assistance along with building information. The proposed system shows good usability; however, improvements are needed in accuracy and system performance.

N. Rahman et al. (2024) proposed a GPS and augmented reality based navigation system for outdoor environments that provides real time directional guidance. The system improves navigation accuracy in open areas and enhances user experience. The proposed system performs well in outdoor conditions; however, it does not provide complete indoor support and lacks intelligent features such as chatbot and prediction.

III. PROPOSED METHODOLOGY

A. System Architecture

The proposed system architecture is designed as a web based platform that provides AI driven augmented reality navigation for campus environments. The system allows users such as

students visitors faculty and admin to access the application through a mobile browser or web interface. The system connects through the internet and interacts with multiple components including AR navigation pathfinding landmark recognition voice guidance and search functionality. The architecture is designed in a modular way so that each component performs a specific task while maintaining smooth communication between all parts. The system ensures real time processing and provides accurate navigation support to users.

The architecture includes core modules such as real time AR navigation pathfinding and route calculation landmark recognition voice guide instruction live campus status search functionality emergency module and user access control. The system uses Firebase backend services for authentication real time database and storage which helps in managing all campus related data efficiently. The database stores information such as locations staff details lab data event information workshop data and user roles. The system also integrates an AI assistant through API which provides chatbot support and helps users with queries. The overall architecture ensures scalability reliability and easy access without the need for application installation.

Fig. 1. Architecture diagram

B. Module description

Location and Sensor Module

The location and sensor module collects real time GPS data and device orientation to determine the exact position and direction of the user. The module also activates the camera for augmented reality view and processes the data to reduce noise and improve accuracy. The processed data is continuously updated and sent to other modules so that navigation remains accurate and smooth. The module plays an important role in providing reliable input for the system.

AR Navigation and Pathfinding Module

The AR navigation and pathfinding module is responsible for guiding the user from source to destination using augmented reality. The module calculates the shortest path using a graph based approach and updates the route continuously based on user movement. The system displays directional arrows on the live camera view and provides simple instructions such as moving straight or turning left or right. The module also calculates distance and estimated time to reach the destination and updates it in real time. The system detects wrong movement and automatically recalculates the route to ensure correct navigation.

Landmark Recognition Module

The landmark recognition module identifies campus buildings using the device camera and a trained model. The module captures images and processes them to detect important visual features of buildings. The system compares these features with trained data and predicts the building name along with a confidence value. The result is displayed to the user so that they can confirm their location visually. The module improves navigation accuracy especially in situations where GPS signals are weak or confusing.

Live Campus Status and Crowd Prediction Module

The live campus status and crowd prediction module analyzes user movement data and time based patterns to estimate crowd levels in different areas. The system classifies locations into categories such as low medium and high crowd levels and updates this information continuously. The module helps users avoid crowded areas and choose better paths which improves navigation efficiency. The system also integrates live data such as lab availability and event updates which provides useful information to users during navigation.

Voice Guidance and Chatbot Module

The voice guidance and chatbot module improves user interaction by providing both spoken instructions and conversational support. The voice module converts navigation instructions into speech so that users can follow directions

without looking at the screen. The chatbot module allows users to ask questions about campus facilities staff and navigation and provides accurate responses. The integration of these features improves usability and makes the system more user friendly.

Emergency and Search Module

The emergency and search module allows users to quickly find important locations such as medical centers security offices and other facilities. The search functionality helps users locate faculty labs and campus blocks easily through simple queries. The emergency feature provides quick navigation support during urgent situations and improves safety inside the campus. The module ensures that users can access important information quickly without confusion.

User Authentication and Role Based Access Module

The user authentication and role based access module controls access to system features based on user roles such as student visitor faculty and admin. The system verifies user identity and provides access only to permitted features which ensures security and proper usage. The admin module allows management of data such as locations staff details events and workshops. The role based system provides a personalized interface for each user and maintains secure operation of the platform.

IV. IMPLEMENTATION

A. System Development

The system is implemented as a web based application using standard web technologies which allow users to access the platform through a mobile browser without installing any application. The frontend is developed using HTML CSS and JavaScript which provides an interactive interface for navigation and user interaction. The backend services are connected using cloud based platforms which handle data processing and storage. The system is designed to be lightweight and accessible so that it can run smoothly on most smartphones. The implementation focuses on simplicity usability and real time performance for better user experience.

The system integrates multiple components such as navigation logic augmented reality display chatbot support and real time database services. The frontend communicates with backend services through APIs to fetch and update data continuously. The Firebase platform is used for authentication real time database and storage which ensures that all users receive updated information. The implementation ensures proper synchronization between all modules so that the system works efficiently without delay.

B. AR Navigation Implementation

The AR navigation feature is implemented by combining camera access GPS tracking and device orientation sensors. The system captures the live camera feed and overlays directional arrows on the screen to guide the user. The navigation logic calculates the direction and updates the arrow position continuously based on user movement. The system provides simple instructions such as moving straight or turning left or right which makes navigation easy to follow. The implementation ensures that the AR display remains aligned with real world direction.

The system continuously tracks user location and updates the navigation path in real time. The route is recalculated whenever the user deviates from the expected path which ensures accurate guidance. The distance and estimated time to reach the destination are also updated during navigation. The implementation focuses on providing smooth and clear guidance without confusion.

C. Database and Backend Implementation

The database is implemented using Firebase which provides real time data storage and synchronization. The system stores various types of data such as location details staff information lab availability event data and user roles. The database structure is organized in a way that allows quick access and efficient updates. The system ensures that all users receive the latest information without manual refresh.

The backend also handles user authentication and access control which ensures that only authorized users can access specific features. The system verifies user roles and provides access accordingly which improves security. The integration between frontend and backend is maintained through proper API communication which ensures smooth data flow across the system.

D. AI and Chatbot Implementation

The AI chatbot is implemented using an external API which provides conversational support to users. The chatbot processes user queries related to campus navigation facilities and general information and provides appropriate responses. The system maintains context during conversation so that users can ask

follow up questions easily. The implementation improves user interaction and reduces the need for manual search.

The system also integrates intelligent features such as crowd prediction and landmark recognition which enhance navigation accuracy. These features are implemented using trained models and real time data processing. The implementation ensures that these modules work efficiently along with other system components without affecting performance.

E. System Integration

The system integrates all modules such as navigation database AI chatbot voice guidance and user management into a single platform. The integration ensures that all components work together smoothly and provide a unified experience to the user. The data flows between modules in real time which helps in maintaining accuracy and consistency. The system is tested in different scenarios to ensure proper functioning of all features.

The implementation focuses on reliability scalability and ease of use so that the system can be extended in the future. The modular design allows easy updates and improvements without affecting the overall system. The final system provides a complete solution for campus navigation with improved accuracy and user experience.

V. RESULTS AND DISCUSSION

A. Navigation Performance

The system was tested in different campus locations to evaluate navigation accuracy and performance. The system was able to provide correct directions using augmented reality arrows on the camera view which helped users reach their destination easily. The pathfinding approach provided the shortest path and reduced unnecessary movement across the campus. The system continuously updated the route based on user movement and ensured that guidance remained correct even when users changed direction. The overall navigation performance showed improvement compared to traditional methods such as maps and signboards.

The system also showed stable performance during real time tracking using GPS and device sensors. The location updates were processed continuously and the navigation instructions were adjusted based on user position. The system handled small variations in GPS signals and maintained smooth navigation without major errors. The results show that the system can provide reliable navigation support in outdoor campus environments.

B. AR Guidance and User Experience

The augmented reality guidance feature improved the way users followed directions by displaying arrows directly on the camera view. The users were able to understand directions more clearly compared to text or map based instructions. The visual guidance reduced confusion and made navigation more natural and interactive. The system provided simple instructions such as moving straight or turning left or right which made it easy for users to follow without difficulty.

The voice guidance feature also improved user experience by providing spoken instructions during navigation. The users were able to move without continuously looking at the screen which made the system more convenient to use. The chatbot feature allowed users to ask questions and receive instant responses which reduced the effort required to search for information. The combined features improved overall usability and made the system more user friendly.

C. System Efficiency and Data Handling

The system showed efficient performance in handling real time data using the Firebase database. The data such as locations staff details and events were updated and retrieved quickly without delay. The system ensured that users received current information during navigation which improved accuracy. The communication between frontend and backend was smooth and there were no major delays observed during testing.

The system also handled multiple modules such as navigation chatbot and crowd prediction simultaneously without affecting performance. The integration of different components worked properly and maintained system stability. The results show that the system is capable of handling real time operations and providing consistent performance.

VI. FUTURE WORK

The list of future enhancements that could be done with the proposed system includes:

- The integration of indoor navigation support for better guidance inside buildings.

- The addition of real time traffic and movement analysis for route optimization.
- The enhancement of AR visualization for more accurate and stable direction display.
- The integration of user feedback system to improve navigation quality.
- The addition of offline navigation support for areas with no internet connectivity.
- The expansion of the system to support multiple campuses and large scale environments.
- The addition of multi language voice guidance for better accessibility.

VII. CONCLUSION

The proposed system provides an effective solution for campus navigation by combining augmented reality GPS tracking and artificial intelligence into a single platform. The system helps users such as students visitors and staff to find locations easily without confusion. The use of augmented reality improves the way directions are presented and makes navigation simple and easy to understand. The system also includes features such as chatbot voice guidance and crowd prediction which improve usability and user experience.

The implementation of the system shows that it can provide accurate navigation and handle real time data efficiently. The system reduces time wastage and improves overall campus experience compared to traditional methods. The modular design allows easy updates and future improvements. The proposed system can be used as a practical solution for smart campus environments and can be extended further to improve performance and functionality.

REFERENCES

1. Lokhande J., Bodhankar P., and Patil S., “Campus Navigation Using Augmented Reality and Virtual Reality,” International Journal of Advanced Computer Science Applications, vol. 15, no. 4, pp. 112–120, 2024.
2. Patel R., Sharma K., and Verma A., “Augmented Reality Based Campus Navigation System,” International Journal of Innovative Research in Technology, vol. 11, no. 2, pp. 45–50, 2025
3. Putra B. S. C., Nugroho A., and Setiawan D., “Adaptive Augmented Reality Navigation System for Indoor Environments,” Information Journal, vol. 16, no. 6, pp. 1–12, 2025
4. Rathod V. U., Desai P., and Mehta R., “AR Based Indoor Navigation Using A Star Algorithm,” IEEE Access, vol. 14, pp. 1–10, 2026.
5. Xu F., Li Y., and Chen Z., “Egocentric Augmented Reality Navigation System for Improved Wayfinding,” Advanced Engineering Informatics, vol. 58, pp. 101–110, 2024
6. Qiu X., Zhang H., and Liu Y., “Analysis of Augmented Reality Navigation Display Methods,” International Journal of Human Computer Interaction, vol. 40, no. 3, pp. 210–220, 2024.
7. Bejinaru T., Popescu M., and Ionescu A., “Augmented Reality Based Campus Navigation for Improved Accessibility,” Strategica Conference Proceedings, pp. 320–330, 2024.
8. Qiu Z., Wang L., and Sun J., “Landmark Based Augmented Reality Navigation System,” arXiv preprint arXiv:2311.12220, 2023.
9. Uroam System, “AR Based Campus Navigation and Building Directory System,” International Conference on Innovation Computing, pp. 55–60, 2025.
10. Rahman N., Khan S., and Ali M., “GPS and Augmented Reality Based Outdoor Navigation System,” International Journal of Computer Applications, vol. 185, no. 10, pp. 25–30, 2024.