AR Campus Navigation and Information Portal

A Web-Based Augmented Reality Application for Intelligent Campus Navigation and Information Access

ABSTRACT

Large university and college campuses present a persistent navigation challenge for new students, visiting scholars, prospective applicants, and general visitors. The physical complexity of modern campuses—comprising academic blocks, administrative offices, laboratories, libraries, sports facilities, and event venues spread across expansive grounds—makes spatial orientation a nontrivial task for the uninitiated. Conventional navigation aids such as static printed maps, fixed signboards, and institution website directories address this challenge only partially: they are frequently outdated, incapable of providing real-time directional guidance, and entirely unable to adapt to a user's current position and orientation. The AR Campus Navigation and Information Portal is a web-based Augmented Reality application that transforms an ordinary smartphone into an intelligent, real-time campus guide, overlaying contextual virtual labels, directional cues, and informational annotations directly onto the live camera feed, anchored to real-world building positions through GPS geolocation, device orientation sensors, and browser-native APIs. A conversational AI assistant supplements the AR view for open-ended campus queries.

KEYWORDS

Augmented Reality, Campus Navigation, Progressive Web App (PWA), Geolocation, Google Gemini, AR Overlay, React 19, TypeScript, Tailwind CSS, DeviceOrientation API, Campus Information System, Indoor Navigation.

SYNOPSIS

The platform enables any smartphone user to point their device camera at campus buildings and instantly receive overlaid information: building name, estimated distance, cardinal direction, AI-generated descriptions, and navigation cues—all rendered as augmented reality layers atop the physical environment. An interactive campus map provides a conventional 2D fallback view for users who prefer it, while the indoor navigation module delivers step-by-step guidance for complex multi-floor buildings where GPS signals are unreliable. An administrator dashboard allows authorised staff to manage Points of Interest without developer intervention, keeping the knowledge base current in real time. The system follows a strict privacy-first architecture: no user footage, location history, or personal data is ever stored or transmitted.

TECHNOLOGIES

Frontend Framework: React 19 with TypeScript for a strongly typed, component-driven architecture.

Styling: Tailwind CSS — utility-first responsive design system ensuring consistent cross-device appearance.

Application Architecture: Progressive Web App (PWA) — instant browser access with no app store installation required.

Browser APIs: Geolocation API (GPS positioning), MediaDevices API (camera stream), DeviceOrientation API (compass & tilt).

Generative AI: Google Gemini — powers AI-generated building descriptions and the conversational campus query assistant.

AR Rendering: Browser-native overlay engine anchoring virtual labels to real-world GPS coordinates in real time.

PROCEDURE

1. The user opens the Progressive Web App directly in any modern mobile browser such as Chrome or Safari. No application download, app store installation, or account registration is required at any stage, making the platform immediately accessible to first-time visitors and casual users alike.
2. Upon launch, the application requests permission to access the device camera, GPS location, and orientation sensors through the browser's native permission dialogs. These permissions are essential for the core AR functionality and are handled entirely within the browser environment without any external dependencies.
3. Once permissions are granted, the Geolocation API begins capturing real-time GPS coordinates while the DeviceOrientation API continuously reads the device's compass heading and tilt angle. This sensor data is processed locally on the device to determine the user's precise position and the direction they are facing.

4. The system cross-references the user's live GPS coordinates and viewing angle against the stored campus database of buildings and Points of Interest. Structures that fall within the current field of view are identified and selected for AR overlay rendering in the camera feed.
5. Augmented Reality labels are rendered as floating overlays on the live camera feed, displaying each building's name, estimated distance in metres, and cardinal direction. These overlays dynamically reposition and update in real time as the user moves, rotates, or tilts their device, maintaining accurate spatial anchoring at all times.
6. The user may tap on any AR label to expand a detailed information panel powered by Google Gemini, which provides AI-generated contextual descriptions of the selected building including its departments, facilities, and operating hours. The conversational chat assistant is also available for open-ended natural language queries that extend beyond what is visible on screen.
7. For buildings with complex internal layouts or multiple floors, the indoor navigation module activates automatically. It delivers clear, text-based step-by-step directional instructions guiding the user from the entrance to their destination within the building, compensating for GPS signal degradation in enclosed spaces.
8. Authorised administrators access a dedicated management dashboard to add, edit, or remove campus Points of Interest, building descriptions, and scheduled event information in real time. All content updates are immediately reflected in the user-facing AR experience without any redevelopment or redeployment of the application.

WHY IT IS BEST

Zero Installation Friction: Delivered as a PWA, the application is accessible instantly via any mobile browser, removing the app store barrier entirely for casual visitors and prospective students interacting with the platform for the first time.

Privacy-First by Design: No video footage, photographic data, or location history is ever stored, transmitted, or logged at any point during a session. No user account or login is required, ensuring full functionality for every visitor immediately.

Real-Time AR Guidance: Unlike static maps or fixed signboards, AR overlays update live as users move and reorient, providing genuinely adaptive and position-aware spatial guidance tailored to each user's exact location.

AI-Powered Intelligence: Google Gemini delivers contextually rich building descriptions and handles diverse natural language queries without any custom model training, specialised AI infrastructure, or ongoing model maintenance costs.

Universal Accessibility: Runs on any modern smartphone browser with no dependency on proprietary AR platforms, native SDKs, or complex server-side infrastructure, making it inclusive across a wide range of devices.

Low Institutional Barrier: Built entirely on open web standards, the system significantly lowers deployment and maintenance costs, making it a practical and scalable solution for educational institutions of any size.

CONCLUSION

The AR Campus Navigation and Information Portal represents a major advancement in addressing spatial navigation challenges within large, complex educational campuses. It demonstrates that privacy-conscious augmented reality applications can be built and deployed using standard web technologies alone, without native apps, proprietary AR platforms, or complex server infrastructure, establishing a strong case for browser-based AR as a practical solution for real-world spatial applications. The platform integrates AR overlays, real-time GPS geolocation, device orientation sensing, generative AI, and indoor navigation within a single Progressive Web App, delivering a navigation experience that surpasses traditional static tools while remaining accessible to any smartphone user. Its privacy-first architecture and zero-installation delivery model make it ideal for prospective students, external visitors, and first-time users. The administrator dashboard allows updates without ongoing developer involvement, ensuring sustainable long-term deployment. Future enhancements include live event integration, computer vision-based building recognition, multilingual support, and turn-by-turn pedestrian routing with dynamic path recalculation. Bluetooth beacon-based indoor localisation will further improve navigation accuracy within multi-building campuses. Together, these features create a comprehensive, intelligent, and highly accessible campus navigation ecosystem. By combining accessibility, privacy, and advanced AR functionality, the platform sets a new standard for educational navigation tools, demonstrating that sophisticated, real-world AR applications can be delivered effectively entirely through the web. The system provides a seamless experience for both frequent users and one-time visitors, removing traditional barriers to access and establishing browser-based AR as a practical, scalable, and sustainable solution for modern campus navigation.