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uijslictr@gmail.com

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Development of a Smart Campus Navigation System with Real-Time Guidance and Accessibility Features

Agbolade Sunday. J.
Redeemer's University, Ede, Osun-state.
agbolades@run.edu.ng,

Abstract

Navigating your way around a large campus can be difficult, especially for newcomers. This study introduces a Smart Campus Navigation System, a web-based platform designed to make campus travel easier with real-time navigation, QR code indoor guidance, virtual tours, and a user-friendly interface. The system was built using Agile methods, which allowed for ongoing development, regular testing, and user feedback at every stage. ReactJS was used for the frontend, and Django powered the backend. Navigation functionalities were implemented using mapping technologies, including Google Maps API and Leaflet.js. Usability testing took place in real campus settings to assess the system's performance, accessibility, and user satisfaction. Findings show that the system significantly enhances navigation efficiency and overall user experience. Users frequently highlighted its intuitive interface, precise location searches, and smooth navigation via QR codes. The solution effectively addresses typical challenges associated with finding one's way around university campuses. Potential future improvements could involve integrating indoor positioning, adding voice-assisted navigation, and scaling the system for use across various educational institutions.

Keywords: Smart Campus, Navigation System, Agile Development, Web Application, QR Code Navigation, Location-Based Services, Campus Mobility.

1. Introduction

The swift development of location-based technologies has brought major changes to navigation systems in a range of settings, including universities. Today's university campuses typically feature intricate layouts with numerous academic buildings, administrative units, housing facilities, recreation centers, and extensive road networks. As these campuses grow larger and more complex, the need for effective wayfinding has become more critical for students, faculty, and guests alike.

Conventional navigation tools - like paper maps, signage, and fixed digital directories—often fall short when it comes to delivering precise, up-to-date guidance in expansive campus environments. These traditional methods struggle to respond to changing conditions such as temporary roadblocks, construction work, event-driven detours, or emergencies. As a result, individuals often have trouble finding their destinations, leading to wasted time, lower efficiency, and heightened frustration.

Recent developments in smart navigation technologies have introduced innovative solutions capable of delivering real-time, interactive, and context-aware guidance. These systems integrate Global Positioning System (GPS) technology, digital mapping services, Quick Response (QR) codes, mobile computing, and web-based platforms to enhance user navigation experiences. Furthermore, intelligent navigation systems can provide personalized route recommendations, accessibility-aware pathways for individuals with mobility impairments, voice-guided navigation, and virtual tours that improve familiarity with campus environments.

Despite the increasing availability of digital technologies, navigation within large university campuses remains a significant challenge. Many campuses consist of numerous interconnected

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buildings, complex pathways, multiple entry points, and multi-level structures that can be difficult to navigate, particularly for new students, visitors, and temporary staff members. During major institutional events such as matriculation ceremonies, conferences, seminars, and graduation exercises, these navigation challenges become even more pronounced due to increased population density and unfamiliarity with campus layouts.

Furthermore, the absence of a centralized and intelligent navigation platform negatively affects accessibility, operational efficiency, and overall user experience. Visitors may encounter difficulties locating event venues, parking facilities, lecture halls, laboratories, and administrative offices, leading to delays and dissatisfaction. Therefore, there is a need for a smart campus navigation system capable of providing accurate, real-time, and user-friendly navigation services that enhance mobility, reduce navigation-related challenges [8] and improve the overall campus experience for all stakeholders.

2. Related works

2.0 Campus Navigation Systems

A Campus Navigation System is a modern, tech-based solution developed to guide people through the physical spaces of a university. It's particularly helpful in large campuses where finding specific places like lecture halls or offices can be quite challenging. For most users, especially newcomers, relying on traditional options like printed maps or static signposts is often not enough, which is why there's a growing shift towards smarter, more interactive alternatives [6]

2.1 Review of Campus Navigation System Types and Applications

Modern campus navigation systems have evolved into sophisticated, multi-technology platforms catering to various campus users' complex spatial and informational needs. Key categories of navigation systems in academic environments are reviewed here often highlighting diverse design approaches and recent technological foundations thoroughly.

2.1.1 QR Code-Based Navigation Systems

QR (Quick Response) codes provide a cost-effective, low-maintenance solution for delivering localized navigation information. Users can scan codes via smartphone cameras at building entrances corridors or reception areas to get interactive maps or route directions.

Nikoohemat [5] pioneered this approach in the Smart Campus Map work at the Technical University of Munich, providing on-demand navigation services through a mobile web interface using obscure QR codes swiftly. Building on this foundation, Rajagopal and Sharma [1] demonstrated how QR codes improve indoor navigation and reduce reliance on human assistance when integrated with dynamic web applications.

Unique QR codes get generated by this system for each location embedding identifiers that link directly to specific navigation platform pages. QR codes are stuck pretty much everywhere people tend to congregate like entrances of major buildings and fairly busy hallways. Users get redirected instantly upon scanning to corresponding website locations where navigation info and pertinent details become readily available [2].

Easy mobile integration boosts user experience significantly by furnishing rapid access to contextual data without manual searching being required afterwards. Most smartphones inherently possess QR code scanning capabilities thereby supporting universal accessibility sans need for additional applications or so it seems.

QR Code-Based systems offer advantages:

i. Minimal setup and operational costs
ii. No reliance on continuous network connectivity
iii. Compatibility with a vast range of mobile devices

Limitations include manual scanning by users and lack of adaptability to environmental changes such as building renovations or newly closed paths.

2.1.2 GPS-Based Outdoor Navigation Systems

GPS technology stays crucial for navigating outdoor campus spaces pretty effectively nowadays. Smartphones and tablets equipped with GPS can usually pinpoint user locations pretty accurately within 3-5 meters in open air. GPS proves remarkably effective navigating outdoor campus facilities like sprawling sports complexes and lecture halls situated far from administrative buildings.

Also, GPS performance deteriorates in indoor environments or areas with obstructive infrastructure like tunnels or high-rise buildings. [3] noted that satellite signal attenuation limits the viability of GPS in complex-built environments. To resolve this, emphasized using hybrid navigation models that combine GPS for outdoor wayfinding with technologies like QR codes or Wi-Fi-based systems for indoor use. Integration with third party APIs such as Google Maps further enhances the capabilities of GPS navigation systems by Offering users real time navigation and transit alternatives alongside annotated landmarks rapidly.

2.1.3 Wi-Fi and Bluetooth-Based Indoor Navigation Systems

To overcome the indoor limitations of GPS, many institutions have adopted Wi-Fi and Bluetooth Low Energy (BLE) beacon technologies. These systems enable precise indoor positioning through signal triangulation and proximity detection.

i. Wi-Fi Fingerprinting: Relies on the Received Signal Strength Indicator (RSSI) values from multiple access points. A location is estimated by comparing live RSSI data with a pre-recorded signal map.
ii. BLE Beacons: Emit uniquely identifiable Bluetooth signals. When detected by a user's device, they can trigger location-specific actions or navigation instructions.
iii. Sensor Fusion: Combines data from Wi-Fi, BLE, and onboard device sensors (e.g., accelerometers, gyroscopes) to increase positioning accuracy and reduce drift.

Navigine (2025) reported that hybrid systems combining inertial sensors and Wi-Fi data can significantly improve localization accuracy. Classified indoor navigation techniques into three main approaches: fingerprinting, alteration, and proximity sensing**,** each offering varying levels of precision and scalability.

2.1.4 Augmented Reality (AR)-Assisted Navigation Systems

Augmented Reality (AR) technologies overlay digital cues such as directional arrows and labels and route animations onto real-world views captured by mobile device cameras. This immersive, visually guided experience offers a highly intuitive way to navigate complex indoor or unfamiliar spaces.

Despite the benefits, AR systems face practical challenges:

i. Dependence on high-end mobile hardware
ii. High battery consumption
iii. Development and maintenance costs

2.2 Integrating Navigation Technologies

Navigation systems on university campuses that depend on a single technology frequently face limitations, especially in settings that include both large outdoor zones and intricate indoor structures. To address these issues, the proposed solution brings together several navigation technologies to create a reliable, accessible, and user-focused web-based platform specifically designed for campus use.

By merging GPS tracking, QR codes, 360-degree visuals, recorded videos, virtual tours, integration with the Google Maps API, and voice-guided navigation, the system aims to resolve the weaknesses of conventional approaches. This combination ensures smooth, engaging, and inclusive wayfinding experiences throughout both indoor and outdoor campus areas.

2.2.1 GPS and QR Code Integration

The backbone of the outdoor navigation component will be the Global Positioning System (GPS), enabling real-time location tracking and route planning across the university's open spaces. GPS typically offers reliable positioning with an accuracy of 3 to 5 meters in unobstructed environments [3] making it ideal for directing users to primary buildings, outdoor landmarks, and parking areas.

2.2.2 Google Maps API Integration

The system will leverage the Google Maps API to provide real-time geospatial services, including dynamic route plotting, landmark labeling, distance calculations, and estimated travel times. Google Maps offers proven reliability, seamless web integration, and a familiar user interface for most users [7].

2.3. NavSight – Indoor Navigation for the Visually Impaired Using AI and Voice Intelligence

De *et. al.* [8] introduced NavSight, an AI-based indoor navigation system for blind people. NavSight uses AI to infer the user's position from indoor QR codes placed at strategic locations. After scanning through a smartphone app for a QR code, the AI-powered system will calculate the shortest path to the destination. Directions are given to the user in the form of real-time voice directions, and both are available with ease of access.

NavSight stands out for its synching of low-cost QR code technology with intelligent pathfinding and voice directions. The system is particularly beneficial in settings like university campuses and hospitals, where navigation is complex. Its principal benefits—affordability, accessibility, and ease of use- demonstrate how accessible technology can address mobility issues among people with disabilities.

This paper provides valuable information for developing a Campus Navigation System, specifically one accessible to all users, including those with special needs. With similar ideas, such as QR-based locations and voice guidance, the suggested work aims to provide an accessible navigation solution that enhances the user's autonomy and space awareness in a campus setting.

2.3.1. Web-Based Campus Navigation System Using QR Codes: Campus Compass

Patil and Beldar [2] presented Campus Compass, a web-based campus navigation system that uses QR codes to enhance online wayfinding and digital orientation for university users. The system assigns a unique QR code to each central location across campus, such as lecture halls, administrative blocks, and hallways, embedding specific location identifiers that redirect users to detailed map views and relevant content on the Campus Compass platform when scanned via a smartphone. The QR codes are strategically placed in high-traffic areas to maximize visibility and ease of use. Upon scanning, users are instantly redirected to a responsive website interface that provides contextual navigation information about the scanned location. This approach removes the need for dedicated mobile apps and eliminates reliance on external hardware such as GPS or Wi-Fi, making the system lightweight and broadly accessible.

A key strength of Campus Compass lies in its seamless mobile integration, which supports a wide range of smartphone devices without additional software installations. It enhances orientation for first-time visitors and supports scalable deployment with minimal infrastructure requirements. The system's simplicity also reduces operational costs while allowing for modular updates to content as campus layouts evolve.

However, the system does require manual user interaction—users must scan a QR code to receive location-based information, which may not support fully autonomous navigation. Additionally, its reliance on printed or visible QR codes may pose challenges in outdoor areas exposed to environmental wear or vandalism.
Despite these limitations, Campus Compass demonstrates a practical, cost-effective model for universities seeking to improve navigation without the complexity of complete indoor positioning systems.

2.3.2. Smart Campus Navigation System

Neelakantappa *et. al.* [4] proposed an innovative campus navigation system based on a hybrid localization methodology using a blend of GPS, Wi-Fi, and BLE beacons to offer turn-by-turn indoor and outdoor navigation. The system includes a voice-supportive feature that offers end users real-time turn-by-turn voice navigation. It promotes accessibility for visually impaired users or users who prefer to navigate without touching their devices. The navigation app facilitates interaction with an interactive campus map and turn-by-turn voice directions.

The hybrid approach obliterates seamless handover between outdoor GPS-based navigation and indoor BLE-positioning, addressing one of the significant problems in comprehensive campus navigation systems. The system provides efficient and accurate navigation assistance for various campus scenarios using multiple technologies. Voice guidance provides an additional layer of user convenience and accessibility.

However, the system is infrastructure-intensive and requires the placement of multiple BLE beacons across the campus, which may have astronomical costs and maintenance. The cost-effectiveness and scalability of the infrastructure are vital to attaining the case of mass use.

3. Methodology

This research was planned and then subsequently built using a step-by-step approach that informs the understanding of user needs and gathering relevant information and developing a solution that hits the goals effectively. Data was collected quickly online and from users directly about common navigation difficulties faced on campus rather frequently it seems. Gathered information heavily influenced design decisions and system development unfolded accordingly with considerable intricacy over time subsequently. The objectives are deliberated upon alongside various methods tools and frameworks utilized in achieving them effectively.

A Software Development Life Cycle model was chosen for execution and it heavily influenced overall structure and subsequent development processes downstream. Key design elements such as system architecture and entity-relationship diagrams are included alongside use case diagrams and data flow diagrams frequently. Various examples help illustrate somewhat obscurely how disparate system components interact and information flows within such a convoluted setup quite dynamically. Practical and technical steps taken ensured functionality user-friendly and well-structured system overall with considerable effort evidently

3.1.1 Methods of Data Collection

The following approaches were employed to collect both qualitative and quantitative data:

1. Online Survey (Google Form): An online questionnaire with a fixed set of questions was distributed. The survey had multiple-choice and open-ended questions and covered typical navigation issues, most-watched sites, and user preferences regarding map interfaces and features.

2. Informal Conversations and Direct Interviews: Targeted users from specific user groups were briefly interviewed and engaged in informal conversations. This method offered richer information about user behavior, personal experiences navigating the campus, and specific expectations of a digital navigation system.

3.1.2 Description of Data Collected

Data collected sprawled across various categories including user demographics such as student staff or visitor and common entry points on campus. Frequently used routes were examined thoroughly with much scrutiny and detailing challenges people faced locating specific buildings or offices. Preferred navigation aids spanned maps and videos and audio directions amongst other things quite extensively it seems.

i. Desired features in a campus navigation system (e.g., voice prompts, QR code scanning, virtual views)
ii. This data provided a comprehensive overview of user expectations, usability considerations, and improvement areas.

3.2 Method for Design of the Web-based Campus Navigation System

The design process focused on developing a responsive, intuitive, and accessible web interface that caters to the real navigation needs of students, staff, and campus visitors. The system's front end was developed using React JS which ensured structural clarity and responsive layout across various screen sizes. Design decisions were informed by feedback gathered via Google Forms surveys and haphazard conversations with users in various settings quite effectively. Highlighted issues prominently included disorientation finding buildings like lecture halls offices and hostels on sprawling campuses quite frequently. Based on this input, key design features were introduced, including:

i. A search function to locate key campus landmarks.
ii. Embedded Google Maps integration with directional routing.
iii. Support Google Street View to provide users with immersive previews of campus locations.
iv. Indoor guidance using QR codes, enabling users to scan codes placed at building entrances or hallways to receive step-by-step directions or pre-recorded video guidance.
v. Accessibility enhancements include readable font sizes, color contrast, and basic voice assistance features (e.g., click-triggered voice prompts).

This phase ensured the platform would be user-friendly, easy to navigate, and helpful even for first-time visitors or users with accessibility needs.

3.2.1 Frontend Implementation

The system's front end was programmed with React JS, a popular JavaScript library that excels at building light, component-based user interfaces. It is capable of modular design, which allows every feature, such as location search, interactive map display, and QR code scanning interfaces, to be developed as separate components that could be easily maintained or updated. Most users' access system using smartphones or tablets while traversing campus so interface was designed being responsive and mobile-centric inherently. Desktop usage got demoted somewhat awkwardly prioritizing mobility and real time use pretty heavily afterwards.

3.2.2 Backend Development

The backend was developed using Django, a robust Python-based web framework. Django handles:

i. Routing of user requests to appropriate services,

ii. Processing user input or QR code scans,

iii. Delivering location-specific data,

iv. Hosting pre-recorded directional videos or static instructional content,

v. Managing the system's database and user sessions securely.

This robust backend setup ensured seamless interaction between frontend interface and system's core logic with underlying data services remarkably well afterwards.

3.2.3 Mapping and Navigation

Navigation was implemented using the Google Maps JavaScript API. Real-time map display, GPS location determination, and route building between two points on campus were all performed using the API. People could search for specific locations (such as lecture halls, administrative offices, cafeterias, or recreation facilities) and be given optimized pedestrian routes where GPS signals are typically weak or unavailable, supported using QR code-based navigation. These QR codes were strategically placed at key indoor locations such as building entrances, staircases, and hallways. Each QR code was uniquely mapped in the backend to a specific location.

Whenever a user scans a QR code using the camera of their mobile device:

i. The system instantly recognizes the user's current location (no GPS required),

ii. It displays location-specific content such as step-by-step directions, a floor map, or a pre-recorded video explaining how to navigate from that point,

iii. It may also open an information page about that particular building or service.

This method yields a straightforward yet potent fix for navigating indoors ensuring ease of access in convoluted spaces effectively.

3.2.4 Deployment and Modular Design

Deployment happens rapidly and modular design is utilized effectively on a rather mobile-friendly platform hosting a web-based application. Development adheres strictly to modular coding practices allowing radical flexibility and fairly significant scalability options subsequently

3.3 Phases of the SDLC used.

1. **Sprint Planning & Requirements Gathering:** The process started with collecting user needs through questionnaires shared with students, lecturers, and administrative staff. Their responses pointed out key navigation issues—like how hard it was to find certain buildings due to poor signage. From these insights, a prioritized product backlog was created to guide sprint planning.

2. System Design: System architecture and interface behaviors were thoroughly mapped out alongside data flow quite meticulously within various subsystems. React and Django were picked alongside MySQL and Google Maps API for meeting performance goals and some rather crucial functional requirements.

3. Sprint Development: Development proceeded rapidly in short frantic sprints each focusing intensely on a different core module. Major features entailed robust search functionality and quirky route visualization alongside slick QR code integration with multimedia playback capabilities somehow. Frontend handled user interactions and rendered maps meanwhile backend managed data swiftly via various APIs. Modular approach made updates ridiculously easier without affecting whole system somehow.

4. Testing & Feedback: Testing was thoroughly done after each sprint ended ensuring features worked flawlessly as expected normally under usual operating conditions. Actual testers fiddled with tools like search bar and map updates pretty extensively helping us suss out glitches and boost overall user experience dramatically. Feedback from them played a crucial role in refining interface functionality.

3.4 System Design

System design phase laid out structure of Campus Navigation System and it shaped how Campus Navigation System would ultimately function afterwards. Turning user needs into clear models guided how users would interact with platform very effectively and rather smoothly overall. Design priorities centered around simplicity and responsiveness for diverse user bases much throughout development of the product. Tools like UML diagrams and flowcharts were used to map out system behavior and occasionally control logic with precision. Visual models helped clarify system functionality remarkably well and provided solid ground for subsequent development phases effectively.

3.4.1 Design Tools and Diagrams

Various tools and diagrammatic techniques were adopted subsequently to illustrate system functionalities clearly and provide a structured framework:

i. Use Case Diagram: Captures user interactions by searching for a destination, scanning a QR code, and managing location data.

ii. Activity Diagram: Outlines the logical steps from user entry to navigation result.

iii. Sequence Diagram: Describes the step-by-step message flow between the frontend (React), backend (Django), and database (MySQL).

These tools support modular thinking and informed architectural choices, especially in a layered system with multiple integrated services like Google Maps and multimedia.

3.4.2 Use Case Diagram

System functionality caters mainly to two user types: general users like students, staff and visitors and administrators typically. Key use cases include:

i. Entering a destination via search input
ii. Selecting a predefined campus location (e.g., Health Center)
iii. Viewing directions and map overlays
iv. Scanning QR codes for indoor navigation
v. Viewing images or live video walkthroughs
vi. Admin updating building data and route content

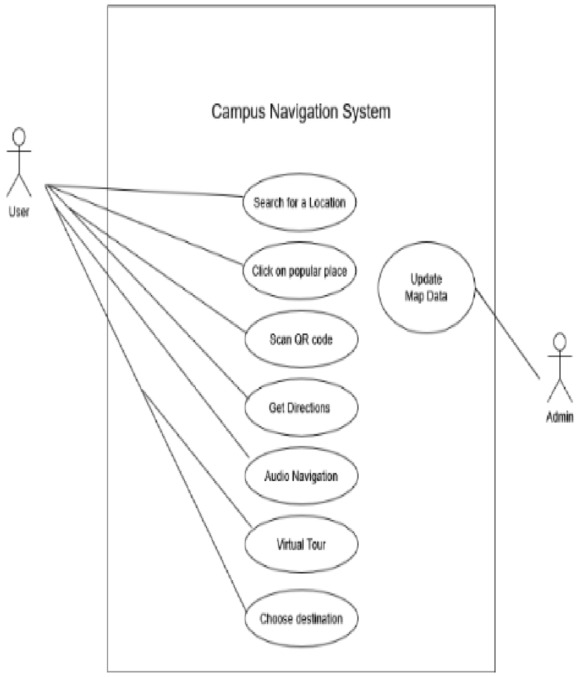

Figure 3.3: Use case diagram

3.4.3 Activity Diagram

The activity diagram describes the workflow of key user actions, such as retrieving a route from one building to another. It includes actions like selecting a location, submitting a request, the system retrieving coordinates, and displaying the map.

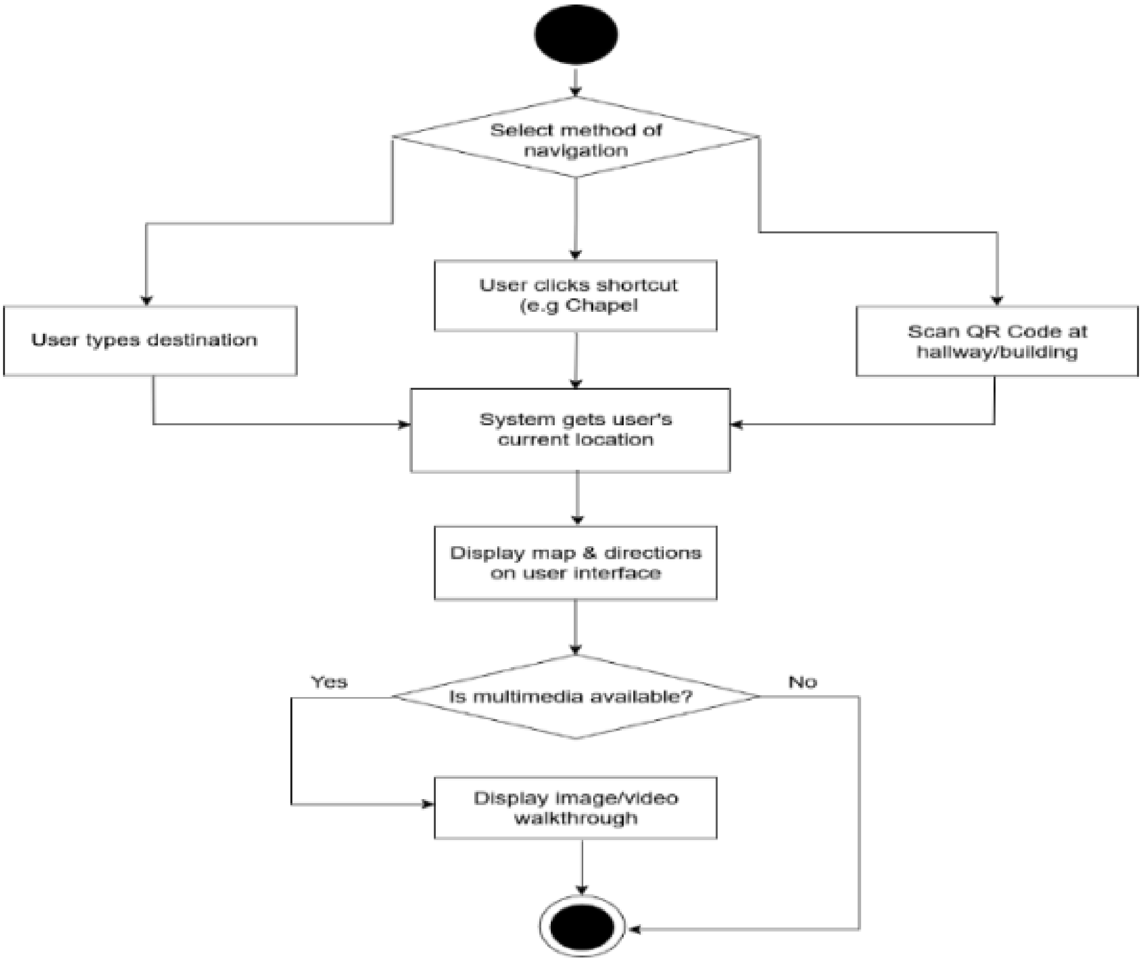

Figure 3.4: Activity diagram

3.5 System Architecture

Campus Navigation System employs somewhat obscurely a rather esoteric three-tier architecture paradigm:

1. Presentation Layer (Client-Side – ReactJS)
2. Application Layer (Server-Side – Django)
3. Data Layer (Database – MySQL)

Modularity promotion in this architecture rather cleverly enhances system scalability pretty significantly and boosts maintainability quite remarkably overall.

3.5.1 Presentation Layer – Frontend

The frontend, built with ReactJS, handles all user interactions and displays the interface across different devices of various sizes. It is designed to be fast, responsive, and easy to use.

Some features include:

i. A search bar function for finding specifics destinations

ii. Shortcut buttons for common or popular locations

iii. Live map display using Google Maps API

iv. Embedded video guides

v. QR code scanning and redirect functionality

Features like keyboard navigation and proper semantic markup were added to support users with various disabilities effectively nowadays.

3.5.2 Application Layer – Backend

Backend development leverages Django thoroughly and handles system logic alongside interactions with external APIs quite effectively nowadays. Responsibilities include:

i. Resolution of location-to-coordinate

ii. Route fetching and computation through Google Maps

iii. Mapping QR code endpoints

iv. Admin control interfaces

v. JSON-based communication with the frontend Interactions with databases and third-party services get forwarded securely via this particular layer usually in a highly controlled manner.

3.5.3 Data Layer – Database

The MySQL database stores structured and unstructured data related to locations, routes, and media content. Its document-based model allows rapid updates and easy schema updates when adding new features. Collections are indexed for fast searching, and relationships between documents (e.g., locations linked to QR codes and media) are maintained through reference fields.

3.5.4 Workflow and Data Flow

Typically, system operation unfolds through several steps like:

1. The user enters the web app
2. Frontend loads map and search interface
3. User selects destination or scans QR code
4. The request is sent to the backend via API
5. Django fetches data from MySQL and/or calls Google Maps API
6. Route and media are returned to the frontend
7. React renders the map, markers, and any multimedia content

3.5.5 Hosting and Deployment Architecture

System gets hosted locally for development purposes first before future implementation of Cloud deployment plans, like:

i. Platform: Heroku, Render, or PythonAnywhere for backend
ii. Static File Hosting: GitHub Pages or AWS S3 for JavaScript/CSS/media files
iii. CI/CD Integration: GitHub Actions for auto-deployment
iv. Reverse Proxy: Nginx to route requests and cache static assets
v. Custom Domain: Set up with institutional branding for public access

3.5.6 Security and Privacy Measures

Standard web security practices were applied rigorously despite sensitive personal data being ostensibly unnecessary for system functionality under normal operating conditions, which are:

i. Input validation and sanitization to prevent injection attacks
ii. HTTPS encryption for all communication
iii. Password hashing and authentication for admin panel access
iv. Future features: OAuth for secure institutional login and Role-Based Access Control (RBAC)

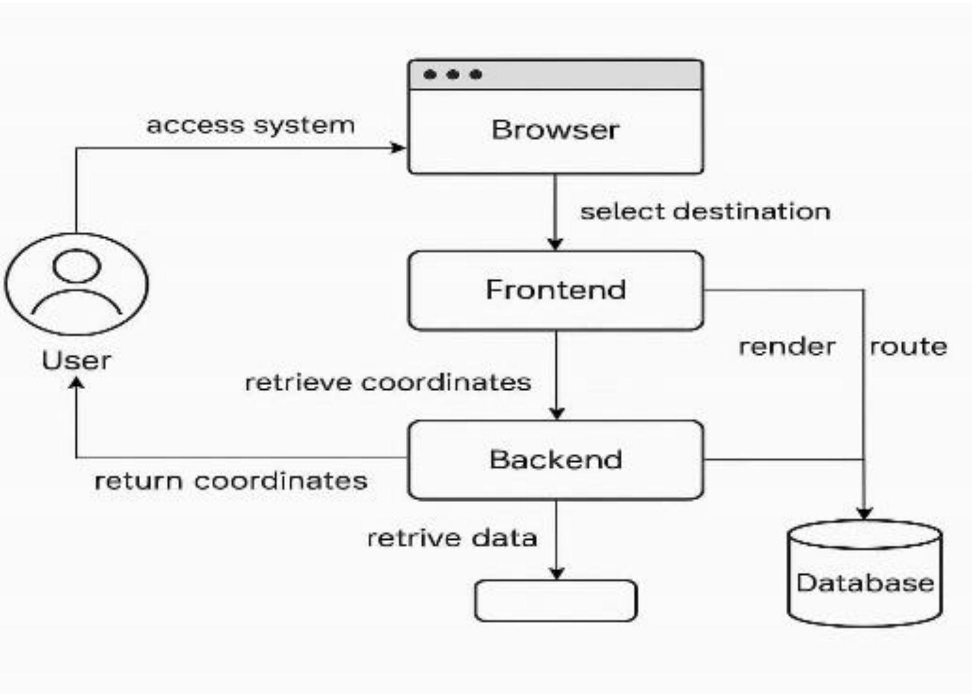

Figure 3.7: Workflow and dataflow diagram

3.8 Performance Evaluation
The developed system is evaluated using the following metrics:

Location Accuracy
[
Accuracy = \frac{Correct\ Locations}{Total\ Locations}
\times 100
]

Response Time
[
Response\ Time = T_r - T_s
]
where:

- (T_r) = Response time
- (T_s) = Request time

System Reliability
[
Reliability =
\frac{Successful\ Operations}
{Total\ Operations}
\times100
]

Tracking Efficiency
[
Efficiency=
\frac{Processed\ GPS\ Records}
{Total\ GPS\ Records}
\times100
]

These metrics are used to determine the effectiveness and reliability of the proposed GPS-integrated software system.

4. Results and Discussions

4.2.1 Home Page

This page is the first page that welcomes the users and provides quick access to the navigation functional elements in the system. It contains a list of popular places on the campus as well as buttons to scan QR codes, buttons to access the virtual tour and also use the map to determine location.

4.2.2 Scan Location Page

Users can scan QR codes placed on buildings around campus. Once scanned, the system displays information about the location, including directions and a video preview (if available).

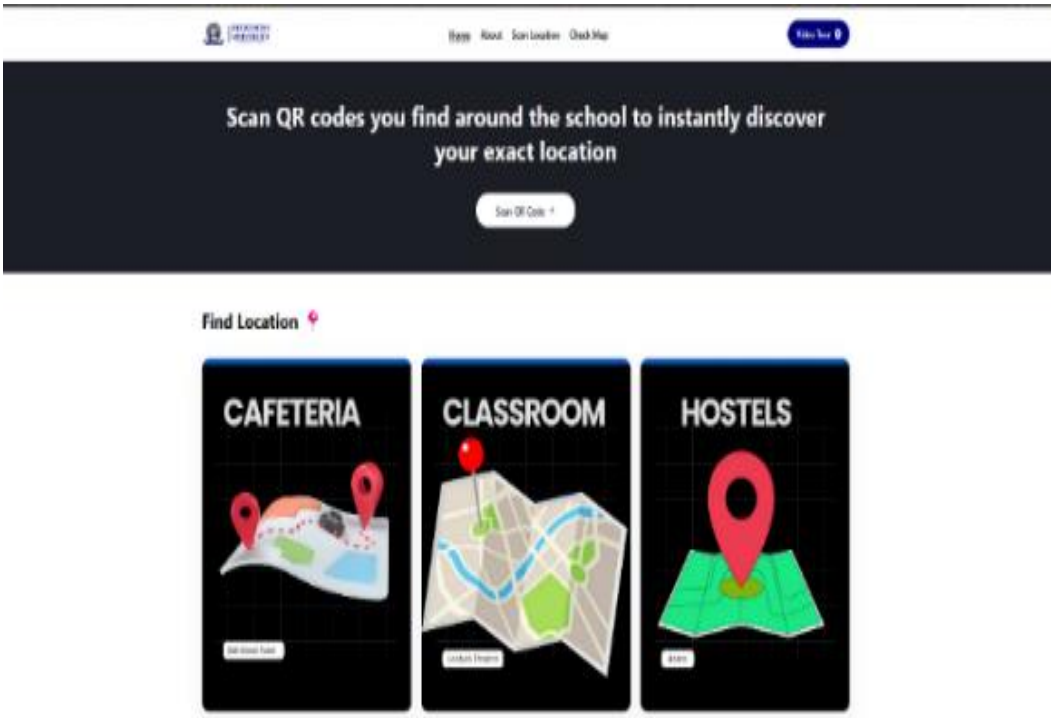

Figure 4.1: The home page

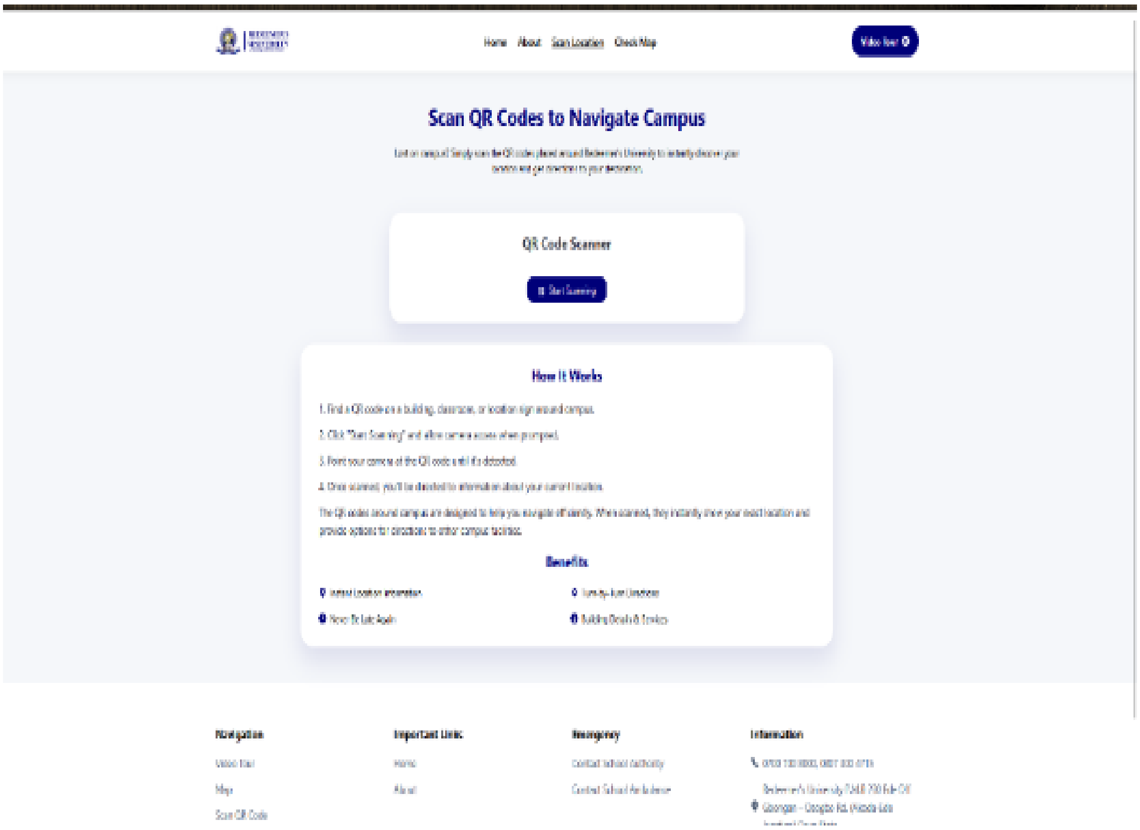

Figure 4.2: The scan location page

Figure 4.3: QR codes for specific locations

4.2.4 Check Map Page

This page provides an interactive map of campus live and in real time on your screen. Users can search locations easily and get walking directions while seeing current positions for navigation purposes effectively.

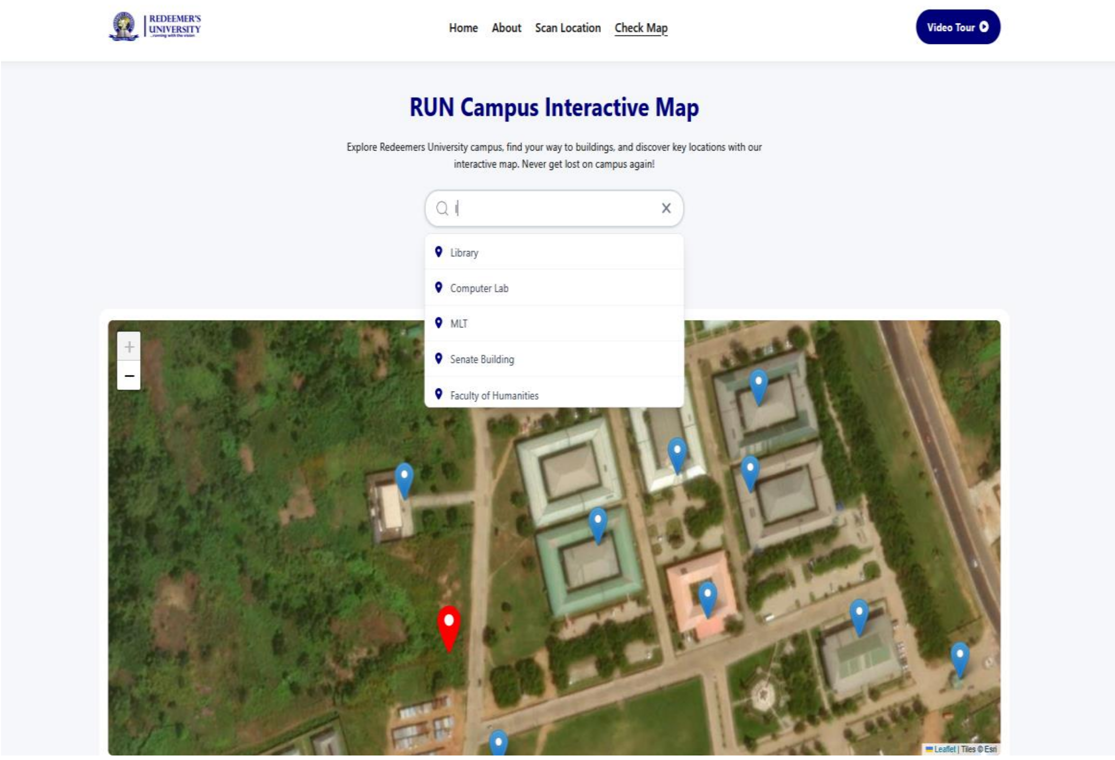

Figure 4.5: The check map page

4.2.5 Virtual Tour Page

A guided tour through campus unfolds on this page via video. Users can view pre-recorded walkthroughs of key spots easily and understand routes landmarks and building layouts rather well afterwards

4.3 Development Environment

Development of Smart Campus Navigation System proceeded within an environment supporting coding alongside real-world simulation quite effectively. System readiness was ensured by thoroughly checking of the functionality and responsiveness before deployment. Software and hardware tools were selected very strategically with great care and much deliberation by experts. Environments played a very important role in ensuring easy integration of components and enabling practical testing across various platforms effectively.

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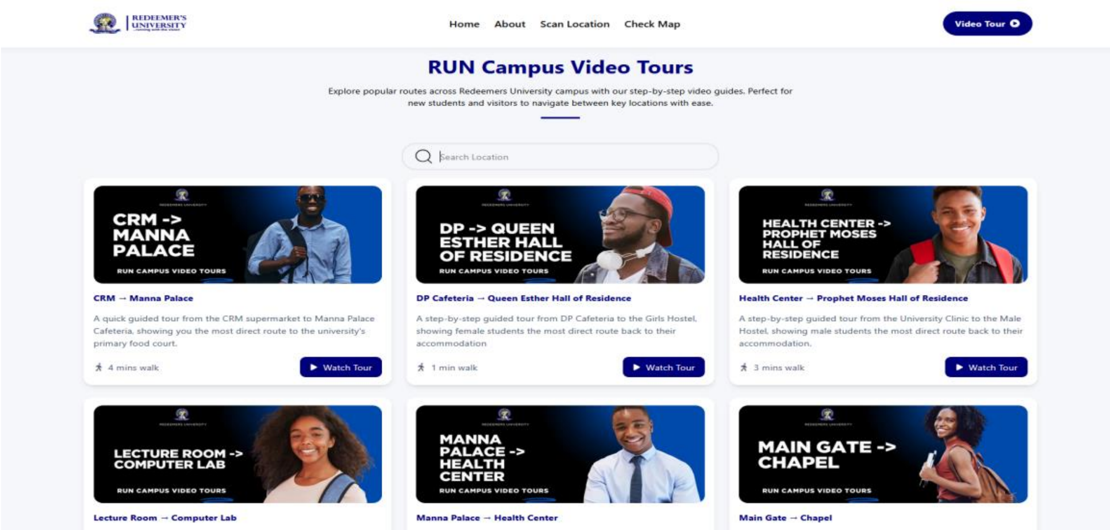

Figure 4.6: Video tour page

4.3.2 API Integration and External Services

Crucial functionality of Smart Campus Navigation System lay in delivering real-time location-based services via integration of various external APIs and some mapping libraries. Services enabled users to interact meaningfully with geospatial features extensively within systems existing framework.

Map Integration

Google Maps API fetched real-time map data rapidly with considerable accuracy and rendered it somehow on screen for user interaction. Users could now view their current position easily search for various destinations within university premises and receive quite detailed walking directions. Familiarity with Google Maps and its reliability helped improve user trust significantly and ease of use was thereby enhanced greatly.

Leaflet Integration

To manage the map interface more efficiently within the ReactJS environment, the system incorporated the Leaflet.js library. The leaflet was particularly suitable for:

i. Highlighting significant campus buildings using interactive markers.

ii. Drawing custom paths based on selected destinations using polyline tools.

iii. Capturing user clicks and touch input for dynamic interaction and route updates.

iv. Allowing map features responded well across mobile phones, tablets, and desktops.

4.4 Development Workflow and Practices

This system components were built in a manner both manageable and scalable aligning with original goals quite thoroughly from inception effectively.

Implementation

Development was carried out in parts. The frontend interface was created using ReactJS, while Django powered the backend operations. Each central feature — including login, map integration, QR code support, feedback submission, and video guidance — was implemented step by step.

Integration and Testing

Key components emerged slowly over time and were coupled together afterwards. React components hooked into backend APIs enabling ridiculously fast interaction with navigation engine pretty much in real-time over multiple channels. Testing occurred subsequently at each central integration hub rather thoroughly.

Final Optimization

Efforts were made before deployment refining system speed and reliability pretty thoroughly. Map loading times got a significant **boost** and little bugs were squashed thoroughly on various devices while QR scanning response was rigorously tested. System functionality and completeness were thoroughly reviewed against initial goals at end of this stage.

4.5 Hosting Infrastructure

A robust hosting infrastructure was needed ensuring users accessed system resources consistently on various devices simultaneously with utmost reliability. Hosting strategy was meticulously crafted bearing reliability heavily in mind alongside stringent security measures and relatively straightforward maintenance protocols.

Security Measures

For protecting user data and building user's trust, the system was designed with a custom domain name, and SSL encryption was implemented. This ensured that all communication between users and the server occur over secure HTTPS connections.

4.6 Usability Testing

Usability testing is a systematic evaluation process aimed at assessing the efficiency, effectiveness, and satisfaction of a system when used by its intended users. For the Smart Campus Navigation System, usability testing was critical to ensure the system meets its goal of facilitating accurate, real-time, and user-friendly navigation within the campus environment.

The testing aimed to answer the following research questions:

i. Can users easily find and navigate to their desired locations on campus using the system?

ii. Is the system responsive and efficient across different devices and network conditions?

iii. Is the system interface intuitive and accessible for users with varying technological proficiency?

iv. How does the system perform under real-world campus conditions, including movement and connectivity fluctuations?

By addressing these questions, usability testing validated the system's alignment with user-centred design principles while identifying areas for refinement before deployment.

5. Conclusion

This work focused on building a campus navigation system for Redeemer's University. The goal was to help people especially new students, visitors, and sometimes staff — find their way around the school without confusion. Let us face it: even those who have been on campus for a while sometimes get lost.

To solve this, a web platform was built. Django handled the backend, while React took care of the front end. These two worked together to give users a smooth and mobile-friendly experience.

The system mainly uses Google Maps for moving around outside. For inside buildings, QR codes were placed in specific locations. When scanned, they show short videos or descriptions to guide the user. You can also search for lecture halls, hostels, offices, or other places and get directions. In short, the system helps reduce confusion, saves time, and gives people a better way to move around campus, especially if they are new.

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