

Smart Campus Path

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Abstract

The Smart Campus Path system provides an intelligent navigation solution for academic institutions by integrating digital mapping with efficient pathfinding techniques. The campus environment is modeled as a graph where key locations such as classrooms, laboratories, and administrative offices are represented as nodes connected through accessible pathways. The A* search algorithm is employed to analyze multiple routes and determine the shortest and most optimal path between a selected source and destination. The application features a user-friendly interface that allows users to choose their starting point and desired location. After processing the request, the system visually displays the computed path on the campus map. This approach enhances accessibility, reduces navigation time, and assists students, staff, and visitors in moving across the campus efficiently without confusion. Additionally, the system can be extended with GPS and Augmented Reality (AR) support for real-time navigation assistance.

Keywords— Smart Campus, A* Algorithm, Campus Navigation, Digital Mapping, Augmented Reality, GPS, Intelligent Pathfinding

INTRODUCTION

Large educational campuses often create navigation challenges for students, staff, and visitors, especially when locating classrooms, laboratories, faculty offices, and event venues. Traditional navigation methods such as printed maps and signboards are static and do not provide real-time assistance. To address these limitations, the Smart Campus Path system is designed as an intelligent navigation solution that integrates digital mapping, GPS-based positioning, and Augmented Reality (AR) guidance. The proposed application provides step-by-step navigation support and enables users to search for locations easily. In addition to navigation, the system can display campus notices, faculty information, and upcoming events, thereby improving communication and accessibility. By centralizing campus information and providing real-time guidance, the system enhances the overall campus experience.

Existing System

Most educational institutions still rely on traditional communication and navigation approaches. Notice boards, printed posters, and static campus maps are commonly used to share information and guide users. These methods are inefficient, as they cannot provide dynamic updates or personalized directions. Campus navigation typically depends on fixed signboards or manually guided directions. These approaches often lead to confusion, particularly for new students and visitors. Furthermore, there is no unified platform to access faculty details, schedules, or event announcements in real time. As a result, users must rely on multiple sources, which increases effort and reduces efficiency.

Problems in Existing System

The current system presents several limitations:

- **Lack of Real-Time Navigation:** Static maps and signboards cannot dynamically guide users to their destinations.
- **Absence of Centralized Information:** Faculty details, classroom locations, and event updates are scattered across different platforms.
- **Time-Consuming Search:** Students and visitors spend significant time locating classrooms, laboratories, and offices.
- **Poor Information Distribution:** Notices and event updates may not reach all users effectively.
- **Limited Accessibility:** New students and visitors face difficulties understanding campus layouts without guided assistance.

Proposed System

The proposed Smart Campus Path system introduces a centralized platform that integrates intelligent navigation, campus notices, faculty directory, and AI-based assistance. The system models the campus as a graph structure and applies the A* pathfinding algorithm to determine the most efficient route between two selected locations.

The application supports both indoor and outdoor navigation using GPS and AR-based visualization. Users can select their starting point and destination, after which the system calculates and displays the optimal path. Additionally, the platform provides instant updates regarding campus announcements, events, and faculty information.

The system is cloud-based, enabling efficient data storage, synchronization, and scalability. This

architecture ensures real-time updates and allows the system to expand easily as campus infrastructure grows. By combining intelligent navigation with centralized communication, the proposed solution improves accessibility, reduces travel time, and enhances the overall campus experience.

REQUIREMENT ANALYSIS

Functional Requirements

The Smart Campus Path system provides several functional features designed to assist students, faculty members, and visitors in navigating the campus efficiently. The system allows users to register by providing essential details such as name, email address, and password. The entered information is validated before account creation, and duplicate email addresses are rejected with an appropriate notification. Once registered, users can log in securely using their credentials. The system authenticates the user data and grants access to the dashboard upon successful verification, while incorrect login details result in an error message.

The application supports real-time campus navigation, enabling users to select a source and destination within the campus. The system calculates the shortest and most efficient route using a pathfinding algorithm and visually displays the path on the campus map. In addition to navigation, the system allows users to view upcoming campus events along with relevant details such as event name, date, time, and location. The faculty directory module provides searchable information about faculty members, including their name, designation, department, and contact details.

An AI-based assistance feature is integrated into the system to answer user queries related to campus facilities and navigation. This intelligent assistant provides guidance and relevant information based on user inputs. The system also includes placement details where students can access recruitment information, company names, and placement statistics. Furthermore, users can view examination schedules and academic timetables, which display subject names, dates, and timings. The system ensures secure logout functionality, allowing users to exit the application safely, after which access to system features is restricted until the user logs in again.

Non-Functional Requirements

The Smart Campus Path system is designed to meet several non-functional requirements to ensure efficiency and usability. The system provides fast performance by delivering real-time navigation and quick responses to user inputs and AI queries. It is scalable and capable of supporting a large number of users simultaneously without affecting performance. The application offers a user-friendly interface that simplifies access to navigation,

campus information, and other services for students, faculty, and visitors.

Reliability is maintained by ensuring accurate navigation routes and consistent availability of event and faculty information. Security mechanisms such as authentication and secure data handling are implemented to protect user accounts and sensitive information. The system is compatible with major mobile platforms and supports integration with technologies such as Augmented Reality for enhanced navigation. Maintainability is ensured through easy updates to campus maps, events, and faculty data without disrupting system functionality. Additionally, accessibility features are considered to support differently-abled users, enabling inclusive access to campus services.

Computational Resource Requirements

The Smart Campus Path system requires both hardware and software resources for efficient operation. The hardware requirements include a processor with at least 2.0 GHz speed, preferably a quad-core processor, a minimum of 8 GB RAM, and at least 512 GB storage capacity. A smartphone equipped with GPS, Bluetooth, and camera support is also required to enable augmented reality-based navigation features.

The software requirements include Python for backend development and KivyMD for frontend design. SQLite is used as the database to store event data, faculty directory details, and notices. The system is designed to run on Windows 10 or later operating systems. Development tools such as Android Studio, Xcode, and Visual Studio Code are used during implementation. These software components collectively support application development, testing, and deployment.

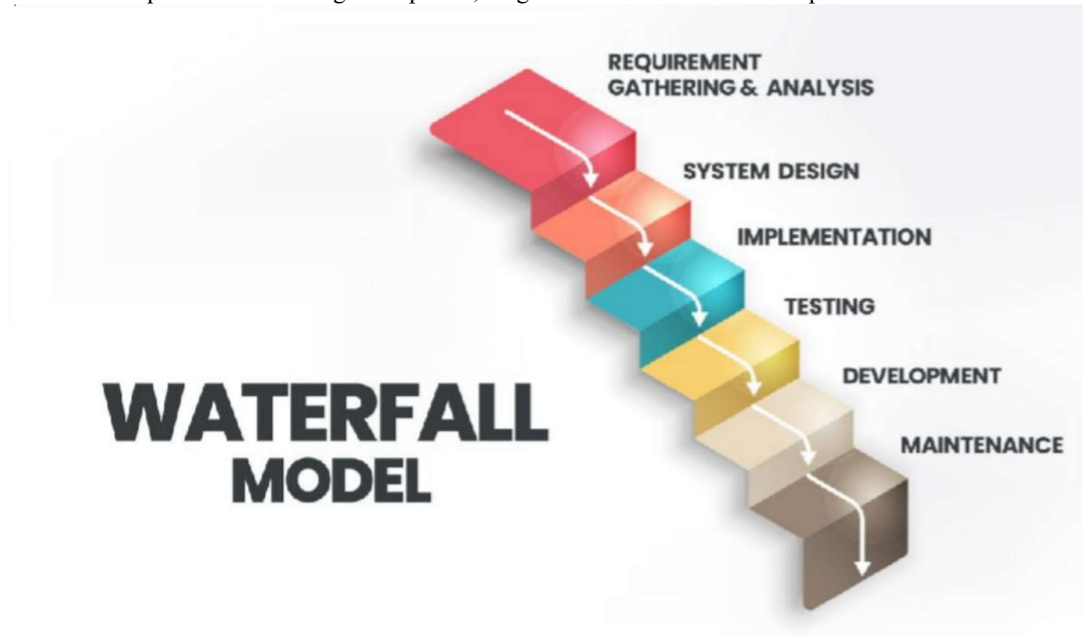
Life Cycle Model

The Smart Campus Path system follows the Waterfall model as the software development life cycle. This model ensures a structured and sequential development process. The requirement analysis phase involves gathering and documenting system requirements such as user authentication, navigation, faculty directory, event management, AI assistance, placement details, and timetable access. In the system design phase, the architecture, database structure, and module interactions are defined. User interface layouts and navigation workflows are also designed during this stage.

During implementation, the system modules are developed according to the design specifications. These modules include login functionality, navigation engine, faculty directory, AI assistant, and event management. After implementation, the testing phase ensures that all modules function correctly. Various tests such as functional testing, navigation accuracy testing, and usability testing are performed to identify and fix errors. Once testing is completed successfully, the system is deployed for

use by students, faculty, and visitors. The maintenance phase involves regular updates, bug

fixes, map updates, and performance improvements to ensure smooth operation.



DESIGN

Architecture

The design of the Smart Campus Path system represents the structure of components and the flow of request processing. The architecture provides a formal representation of the system, allowing better understanding of how different modules interact.

The system architecture is divided into software architecture and technical architecture. The software architecture describes the logical components of the system, including user interface, navigation engine, AI assistant, database, and cloud services. These components work together to process user requests and provide navigation results.

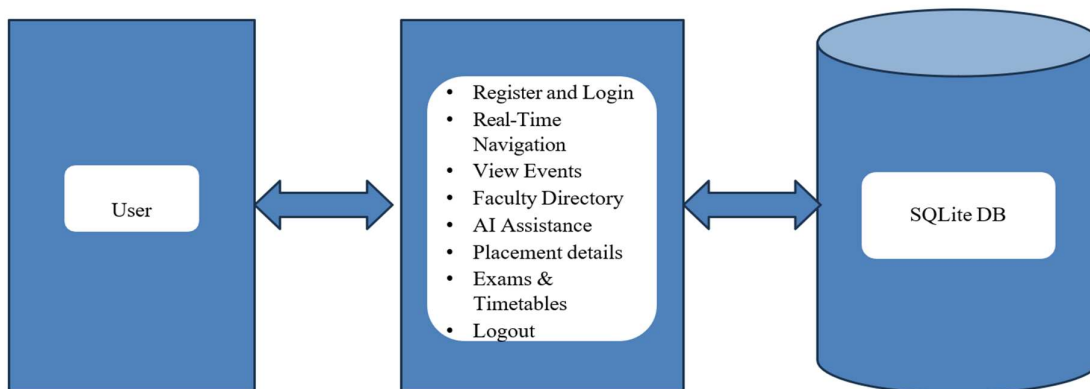


Fig 1 Software Architecture

The technical architecture illustrates the technology stack used for implementation. It includes mobile devices equipped with GPS and camera modules, backend services, database management systems,

and cloud infrastructure. These components communicate with each other to deliver real-time navigation and campus information services

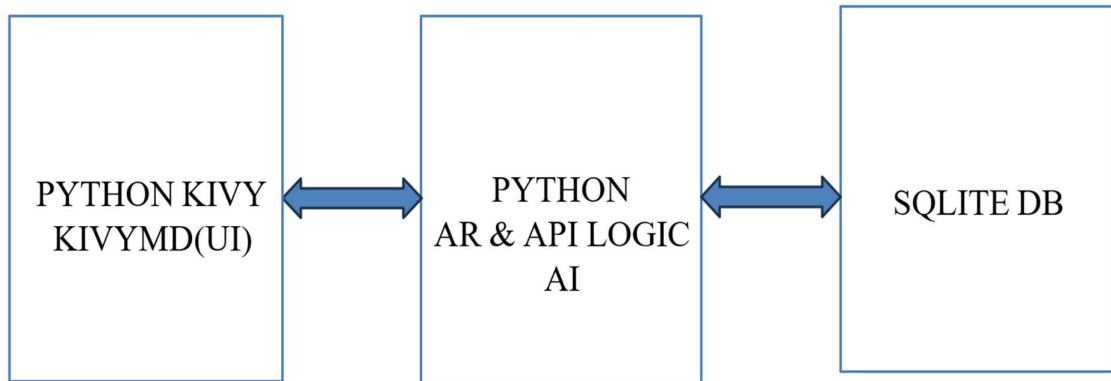


Fig 2 Technical Architecture

UML Diagrams

Unified Modeling Language (UML) is used in the design process to visualize and document the Smart Campus Path system. UML provides a standard method for representing system structure and behavior. It helps in visualizing components, specifying system functionality, constructing system models, and documenting software artifacts. UML diagrams provide both conceptual and physical representations of the system, which improve understanding and communication among developers. Modeling the system using UML helps identify relationships between modules and ensures that the design meets system requirements effectively.

IMPLEMENTATION

Technologies Used

The Smart Campus Path system is implemented using modern technologies to provide efficient campus navigation and information services. Python is used as the primary programming language for developing the core logic of the system. It handles navigation processing, AI assistance, and communication between different modules. The graphical user interface is developed using the Kivy framework, which supports cross-platform mobile application development. To enhance the interface design, KivyMD is used as an extension of Kivy, providing Material Design components such as buttons, navigation drawers, cards, and dialog boxes that improve the overall user experience.

Augmented Reality (AR) technology is incorporated to enhance navigation by overlaying directional guidance on the mobile device camera view, allowing users to visually identify campus buildings and facilities. API integration is used to enable communication between the frontend and backend components, allowing the system to retrieve campus information, event details, and AI-generated responses. Artificial Intelligence is integrated to provide intelligent assistance to users. The AI module responds to user queries related to campus navigation, facilities, and services, thereby

improving accessibility. SQLite is used as the local database for storing user details, faculty information, campus events, placement data, and examination schedules. SQLite is lightweight and well-suited for mobile application environments.

Implementation Steps

The implementation of the Smart Campus Path system follows a structured approach. Initially, the user interface is developed using Kivy and KivyMD. The interface includes screens for login, navigation, campus events, faculty directory, AI assistant, placement details, and examination schedules. After completing the interface, the backend logic is implemented using Python. This includes user authentication, navigation processing, AI query handling, and data management. An SQLite database is integrated to store application data such as user accounts, campus locations, faculty information, and event details. Python scripts are used to connect with the database for retrieving and updating information. The navigation module is then developed using a pathfinding algorithm that calculates the shortest path between selected locations. Users choose their starting point and destination, and the system generates the optimal route.

Navigation Algorithm

The Smart Campus Path system uses the A* pathfinding algorithm to determine the shortest route between two locations. In this approach, campus locations are represented as nodes in a graph, and pathways between them are represented as edges. When the user selects the source and destination, the algorithm evaluates possible routes and calculates the cost of moving between nodes. The algorithm maintains two lists: an open list containing nodes to be evaluated and a closed list containing nodes that have already been processed. The node with the lowest estimated cost is selected and expanded to examine neighboring nodes. This process continues until the destination node is reached. Once the destination is identified, the algorithm traces back the optimal path and displays

the shortest route visually on the campus map interface.

Pseudocode

Pseudocode is used to describe the logical flow of the program in a structured and readable format. It helps developers understand the algorithm before implementing it in a specific programming language. In the Smart Campus Path system, pseudocode is used to represent application initialization, navigation module execution, and the A* pathfinding process. The application begins by configuring the window dimensions and launching the main application class. The navigation module loads campus building data and constructs a graph representation. When the user selects a source and destination, the system calls the pathfinding function. The A* algorithm initializes the open list and assigns cost values to nodes. It repeatedly selects the node with the minimum estimated cost, updates neighbor nodes, and records the path until the destination is reached. Finally, the reconstructed path is displayed as step-by-step navigation instructions on the user interface.

TESTING

Testing is an essential phase in the software development life cycle that ensures the developed system operates correctly and meets specified requirements. The Smart Campus Path system undergoes testing to validate all modules, including user registration, login authentication, real-time navigation, faculty directory, campus events display, AI assistance, placement details, and examination timetable. Each module is evaluated to ensure correct functionality and accurate output. The testing process also verifies that the navigation algorithm correctly identifies the shortest route between campus locations. In addition, testing ensures that the AI assistant responds appropriately to user queries and that data security is maintained. Comprehensive testing improves performance, reliability, usability, and security before system deployment.

Dimensions of Testing

Testing is performed across multiple dimensions to evaluate system quality. The functional dimension ensures that all system features operate according to requirements, including user authentication,

navigation, event viewing, and AI assistance. The performance dimension evaluates response time and efficiency, ensuring quick route generation and fast AI responses. The security dimension verifies protection of user credentials and secure access control. Usability testing ensures that the interface is simple and easy to navigate for students, faculty, and visitors. Reliability testing evaluates consistent system performance and ensures accurate navigation and updated campus information during continuous usage.

Stages of Testing

Testing is conducted in several stages. Unit testing is performed on individual modules such as login authentication, navigation algorithm, and AI assistant to ensure correct functionality. Integration testing verifies that different modules interact properly, such as communication between the navigation module and database. System testing evaluates the entire application to ensure that all modules work together effectively. User Acceptance Testing is conducted by students and faculty members to confirm that the system meets user expectations and is easy to use.

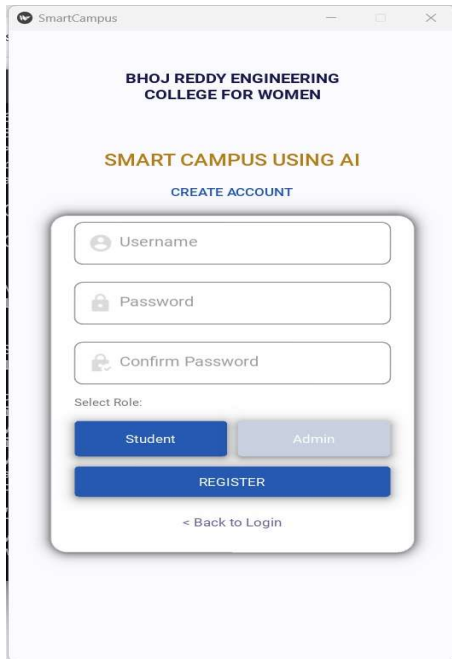
Types of Testing

Black box testing is used to verify system functionality without examining internal code. This testing validates features such as registration, login, navigation selection, and faculty search by comparing expected and actual outputs. White box testing is used to analyze internal logic, including navigation algorithm execution, database queries, and authentication mechanisms. This approach ensures accuracy and efficiency of the system implementation.

Test Cases

Test cases are designed to verify the functionality of different modules. These include login validation, dashboard loading, events section access, examination schedule display, AI chatbot interface, and campus navigation. Each test case compares expected output with actual output to determine system correctness. Successful execution of these test cases confirms that the Smart Campus Path system performs as intended.

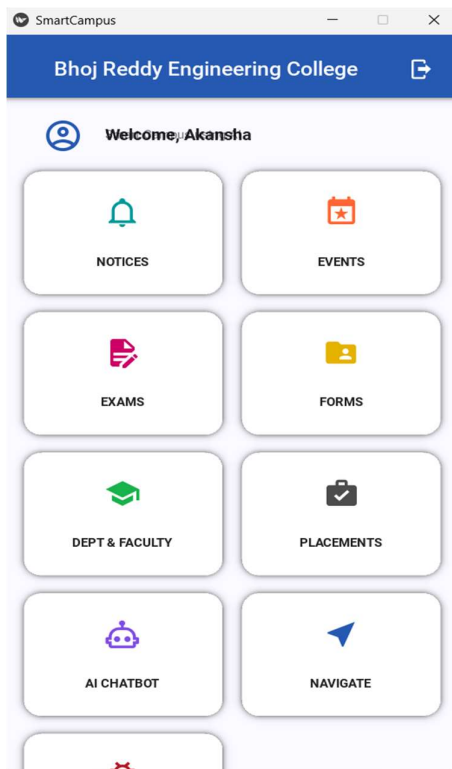
Screenshots



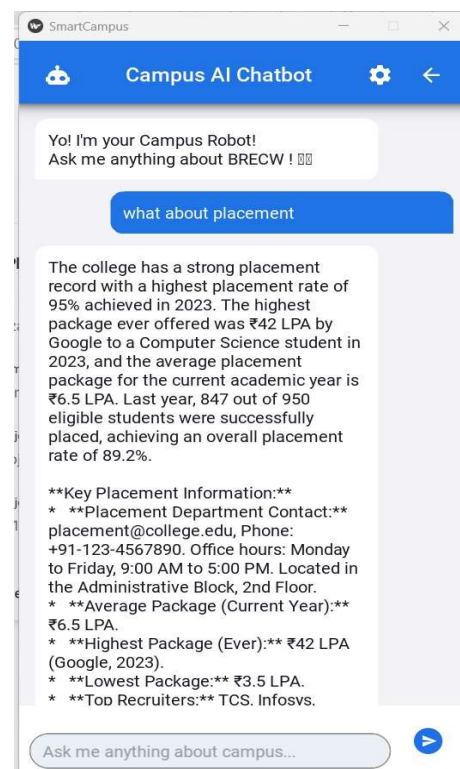
Screenshot 1: User Registration page



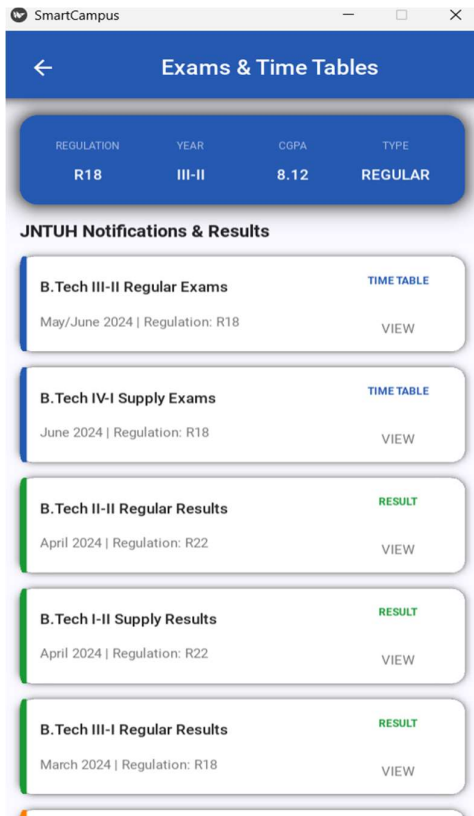
Screenshot 3: AR Navigation Page



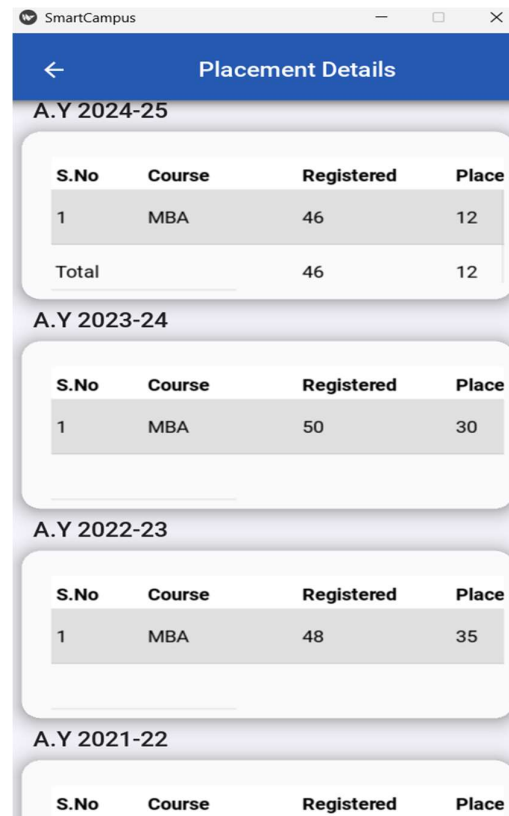
Screenshot 2: Dash Board



Screenshot 4: AI Chat bot



Screenshot 5: Exams & Time table Page



Screenshot 6 : Placements Page

Conclusion

The Smart Campus Path application presents an effective solution for improving navigation and information accessibility within a university campus. Traditional campus management systems depend largely on notice boards, printed posters, and static maps, which do not provide dynamic updates or real-time guidance. These conventional methods often create difficulties for students, staff members, and visitors when locating classrooms, laboratories, faculty offices, and event venues. As campus infrastructure continues to grow, the need for an intelligent and centralized navigation system becomes increasingly important.

The proposed system addresses these challenges by introducing a smart mobile application that integrates modern technologies such as GPS, Augmented Reality, and Artificial Intelligence. The application provides real-time indoor and outdoor navigation, enabling users to reach their destinations through clear and step-by-step directions. In addition to navigation, the system acts as a centralized platform that offers access to faculty directories, campus events, notices, placement information, examination schedules, and other essential services. The integration of an AI-based assistant further enhances user interaction by providing quick responses to campus-related queries.

Overall, the Smart Campus Path system improves campus communication, enhances accessibility, and reduces the time required to locate facilities. By combining intelligent navigation with centralized information services, the application creates a more efficient and user-friendly campus environment. The use of advanced technologies ensures scalability and adaptability, making the system suitable for modern smart campus infrastructure. This solution significantly enhances the overall experience for students, faculty members, and visitors by providing seamless access to campus resources.

Future Scope

The Smart Campus Path system can be further enhanced by incorporating additional advanced features to improve functionality and user experience. Future development may include the integration of Internet of Things (IoT) sensors and smart devices to enable more precise indoor navigation and real-time campus monitoring. Voice assistant support can also be implemented to allow users to navigate the campus using voice commands, thereby improving accessibility and convenience. Advanced analytics can be introduced to analyze crowd density in different campus areas and suggest alternative routes for smoother navigation. The application can also be expanded to support multiple languages, making it accessible to a broader group

of users. Furthermore, the system can be extended to include additional smart campus services such as smart parking management, attendance tracking, and digital identification access. These enhancements would transform the Smart Campus Path application into a comprehensive smart campus management solution, offering improved connectivity and automation across campus facilities.

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