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# INTELLIGENT CAMPUS NAVIGATION ASSISTANT USING SPEECH RECOGNITION, NATURAL LANGUAGE PROCESSING, AND A* ALGORITHM

[1]Rupali R.Jadhav, [2]Mrunal Changdev Wakadkar, [3]Kirti Ashok Satpute, [4]Shruti Dhananjay Nimbalkar

[5]Sneha Bajrang Shelar

[1]Assistant Professor, [2]Student, [3]Student, [4]Student, [5]Studeunt

[1]Computer Engineering,

[1]Zeal College of Engineering and Research, Pune, India

*Abstract:* Navigating large academic campuses can be challenging for students, visitors, and staff due to complex layouts and the lack of intelligent real-time guidance systems. This paper presents the design and implementation of an intelligent campus navigation assistant that integrates speech recognition, natural language processing (NLP), and the A* pathfinding algorithm to provide efficient and user-friendly navigation support. The proposed system enables interaction through both voice and text inputs, allowing seamless and intuitive communication with the assistant. The speech recognition module converts spoken input into text, which is further processed using NLP techniques for intent detection and contextual understanding. Based on the interpreted input, the system is capable of both computing optimal navigation paths using the A* algorithm and handling general user queries related to the campus environment. This integrated approach enhances the system's functionality by combining navigation assistance with intelligent information retrieval.The solution is implemented as a cross-platform application, delivering real-time responses through an intuitive interface. Experimental evaluation demonstrates that the system achieves high accuracy in input interpretation and efficient path computation, improving overall navigation efficiency compared to traditional methods.

***Index Terms*** - Intelligent Virtual Assistant, Campus Navigation, Speech Recognition, Natural Language Processing (NLP), A* Algorithm, Pathfinding

## I. INTRODUCTION

Navigating large and complex campus environments is often a challenging task for students, visitors, and staff, particularly in institutions with multiple buildings, departments, and interconnected pathways. Conventional navigation methods such as static maps, signboards, and manual guidance are often inadequate, leading to confusion, increased time consumption, and reduced accessibility. With the rapid advancement of mobile computing and artificial intelligence, there is a growing demand for intelligent systems capable of providing real-time, interactive, and user-friendly navigation assistance. Recent developments in speech recognition and Natural Language Processing (NLP) have significantly improved human-computer interaction by enabling systems to understand and process user input in a more natural and intuitive manner. These technologies allow users to communicate with systems using voice or text, thereby enhancing usability and accessibility, especially in dynamic

environments. Furthermore, pathfinding algorithms such as the A* algorithm are widely recognized for their efficiency in computing optimal routes in graph-based environments, making them suitable for navigation applications.

In this work, we present the design and implementation of an intelligent campus navigation assistant that integrates speech recognition, NLP, and the A* algorithm to deliver an efficient and interactive navigation solution. The system processes user input through voice or text, interprets the intent using NLP techniques, and computes the shortest path between locations using the A* algorithm. This integrated approach ensures accurate navigation while maintaining a seamless user experience. The proposed system is implemented as a cross-platform application, enabling accessibility across different devices. By combining advanced technologies into a unified framework, the system aims to enhance navigation efficiency and overall user experience within campus environments. Additionally, the proposed solution is scalable and can be adapted to other large-scale environments such as hospitals, airports, and smart city infrastructures.

## II LITERATURE SURVEY

Before starting the development of our project, we studied several existing systems related to campus navigation and information management. We found that many institutions use websites and information portals to provide campus-related information. Some institutions also use navigation applications to help users locate facilities. We reviewed research papers on campus navigation systems and observed that most of them focus only on route guidance. Similarly, information management systems mainly concentrate on storing and displaying information. Very few systems provide both functionalities within a single application.

We also studied cloud-based systems that use Firebase and Firebase databases. These technologies provide efficient data management and real-time synchronization. After reviewing the available solutions, we decided to develop a system that combines navigation and information management features into a single platform. The literature review helped us understand existing approaches and identify the need for a more integrated solution.

## III. PROPOSED SYSTEM

The proposed IVA system is designed to provide navigation assistance and campus information through a single application. The system consists of several modules that work together to deliver the required functionality. The User Authentication Module allows users to securely log into the application using Firebase Authentication. The Navigation Module helps users locate different campus facilities such as classrooms, laboratories, departments, seminar halls, libraries, and administrative offices.

The Information Module provides details regarding various campus facilities and departments. Users can view information without visiting multiple sources. The Event Module displays information about upcoming seminars, workshops, cultural events, and academic activities. We also developed an Administrative Dashboard through which administrators can manage location information, event details, and frequently asked questions. This helps keep the information updated and accurate. The system has been designed with a user-friendly interface so that students and visitors can easily access the required information.

## IV SYSTEM ARCHITECTURE

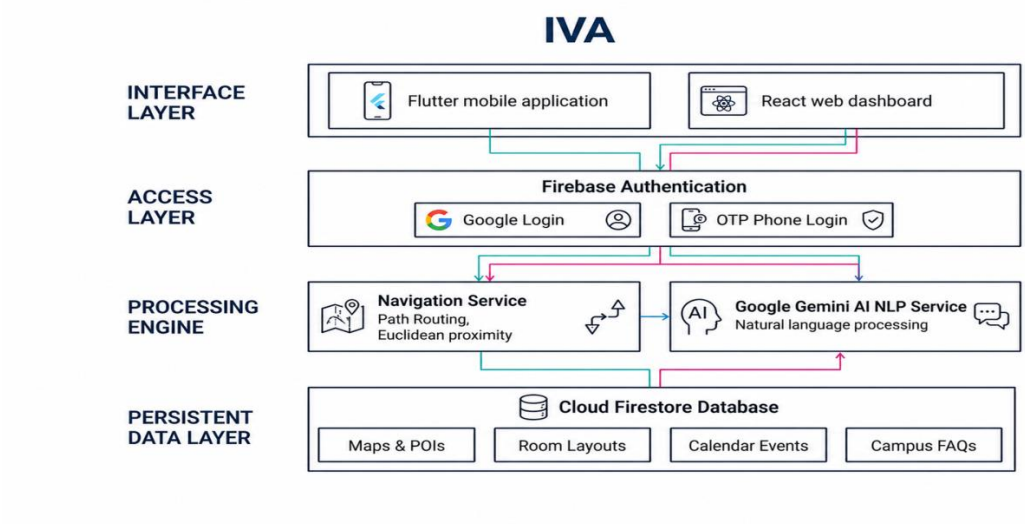


fig. system architecture

The architecture of our Campus Navigation and Information Management System is designed using a layered approach to ensure better organization, scalability, maintainability, and efficient communication between different components of the application. The system is divided into four major layers: Interface Layer, Access Layer, Processing Layer, and Data Layer. Each layer performs specific functions and works together to provide a smooth user experience.

### A. Interface Layer

The Interface Layer is the topmost layer of the system and acts as the communication medium between users and the application. This layer is responsible for presenting information to users and collecting user inputs. In our project, the Interface Layer consists of the Flutter Mobile Application and the Administrative Dashboard. The Flutter application provides an easy-to-use interface through which students, faculty members, and visitors can access various services offered by the system. Users can log in to the application, search for campus locations, view room information, access event details, and browse frequently asked questions. The Administrative Dashboard is designed for administrators who manage the system. Through this dashboard, administrators can add new locations, update room information, manage events, and maintain campus-related data. The dashboard simplifies data management and ensures that users always receive updated information. The main objective of this layer is to provide a user-friendly environment that allows users to interact with the system without requiring technical knowledge.

### B. Access Layer

The Access Layer is responsible for handling authentication, authorization, and security-related operations. Since the application stores important campus information, it is necessary to ensure that only authorized users can access specific resources. In our project, Firebase Authentication is used to verify user credentials and provide secure login functionality. Users can access the system through Google Sign-In or OTP-based authentication. During the login process, Firebase validates user credentials and creates a secure session for the authenticated user. This layer also controls access permissions within the system. Regular users can view navigation details, campus information, and event updates, whereas administrators have additional privileges to manage and update system data through the dashboard. The Access Layer plays a vital role in maintaining data security, preventing unauthorized access, and protecting sensitive information stored within the system.

### C. Processing Layer

The Processing Layer is considered the core component of the system because it handles all business logic and application operations. Whenever a user performs any action within the application, the request is first processed by this layer. For example, when a user searches for a classroom, laboratory, department, or campus facility, the Processing Layer receives the request and determines the required information. It then communicates with the database to retrieve relevant data and sends the response back to the user interface. Similarly, when users access event information or frequently asked questions, the Processing Layer manages the retrieval and presentation of data. The layer is also responsible for handling navigation-related operations such as identifying locations and displaying route information. This layer acts as a bridge between the Interface Layer and the Data Layer. By separating business logic from user interfaces and database operations, the system becomes easier to maintain, debug, and upgrade in the future.

### D. Data Layer

The Data Layer is the foundation of the entire system as it stores all information required for application functionality. In our project, Cloud Firebase is used as the primary database because it provides real-time synchronization, scalability, and secure cloud storage. The database stores various types of information including user details, campus locations, room information, department details, event schedules, and frequently asked questions. Each category of information is organized into separate collections, making data management more efficient. For example, the Locations collection contains details of classrooms, laboratories, seminar halls, libraries, and administrative offices. The Events collection stores information regarding upcoming seminars, workshops, cultural activities, and academic events. Similarly, the FAQ collection contains answers to common questions asked by users. Whenever data is updated through the Administrative Dashboard, the changes are automatically synchronized with the mobile application. This ensures that users always receive accurate and up-to-date information. The Data Layer provides reliable storage, quick data retrieval, and efficient management of campus information.

## V IMPLEMENTATION

The implementation of our project was carried out in different stages. After completing the system design, we started developing the mobile application using Flutter. Our main goal was to create an application that is simple to use and provides easy access to campus navigation and information services.

### A. Mobile Application Development

We developed the mobile application using Flutter because it allows us to build a responsive and user-friendly application from a single codebase. During development, we designed various screens such as Login Page, Home Page, Navigation Page, Information Page, Event Page, FAQ Page, and Profile Page.

We focused on keeping the user interface simple so that students, faculty members, and visitors can use the application without any difficulty. The home page acts as the main screen from where users can access all available services. Proper navigation menus and buttons were provided to improve usability and ensure smooth interaction with the application.

### B. Authentication Module

To provide secure access to the application, we integrated Firebase Authentication. This module verifies user credentials before allowing access to system services.

The application supports Google Sign-In and OTP-based login. When users enter their credentials, the system verifies the information and grants access only after successful authentication. We tested

different login scenarios to ensure that the authentication process works correctly and securely.This module helps protect user information and prevents unauthorized access to the application.

**C. Navigation Module**

One of the main features of our project is the Navigation Module. During development, we collected information about important campus locations such as classrooms, laboratories, seminar halls, departments, libraries, and administrative offices. Whenever a user searches for a location, the system displays the corresponding details. The objective of this module is to help users find campus facilities easily without depending on security staff or other students for directions. While implementing this module, we focused on making the navigation process simple and user-friendly so that users can quickly locate the required destination.

**D. Information Management Module**

We developed the Information Management Module to provide campus-related information through a single platform. This module allows users to access details regarding departments, classrooms, laboratories, faculty offices, and other campus facilities.

Before developing this feature, we observed that students often had to visit different offices or search through multiple sources to obtain information. Through this module, all important information is available within the application itself, making the process faster and more convenient. The information is displayed in an organized format so that users can easily find what they are looking for.

**E. Event Management Module**

The Event Management Module was developed to keep users updated about various activities taking place on campus. Through this feature, users can view information about workshops, seminars, technical events, cultural programs, and other academic activities.

While implementing this module, we ensured that event details such as event name, date, time, venue, and description are displayed clearly. This helps students stay informed about upcoming events and participate in activities of their interest. This feature also reduces the chances of students missing important announcements and event updates.

**F. Administrative Dashboard**

To manage application data efficiently, we developed an Administrative Dashboard. This dashboard allows administrators to maintain and update campus information whenever required. Using the dashboard, administrators can add new locations, update department details, modify classroom information, publish events, and manage frequently asked questions. Any changes made through the dashboard are reflected in the application, ensuring that users always receive updated information. During development, we focused on creating a simple dashboard interface so that administrative tasks can be performed easily without technical complications.

**G. Testing and Validation**

After completing the development of all modules, we performed testing to verify the functionality of the system. Different test cases were executed to check authentication, navigation, information access, event management, and dashboard operations. During testing, we found that users were able to access information successfully and locate campus facilities without difficulty. The login functionality worked correctly, and event information was displayed properly. The results showed that the system performs efficiently and fulfills the objectives defined at the beginning of the project.

## VI RESULTS AND DISCUSSION

After completing the development of the IVA system, we tested all the major features of the application, including user authentication, campus navigation, location search, and information access. The Home Screen successfully provided access to different modules such as Campus Guide, FAQ Help, and Profile. Users were able to navigate between these modules without any difficulty. The Campus Navigation feature displayed the campus map along with important buildings and facilities. Users could search for a destination and view its location on the map. The zoom and navigation controls worked properly and improved map usability. The Route Guidance feature successfully generated routes from the selected starting point to the destination. The system displayed the path and estimated distance, helping users reach their destination more easily. The information management module also functioned correctly by providing access to campus-related information such as facilities, events, and frequently asked questions. Overall, the system performed successfully during testing and achieved the objectives defined at the beginning of the project. The application improved accessibility to campus information and simplified navigation for students, faculty members, and visitors.

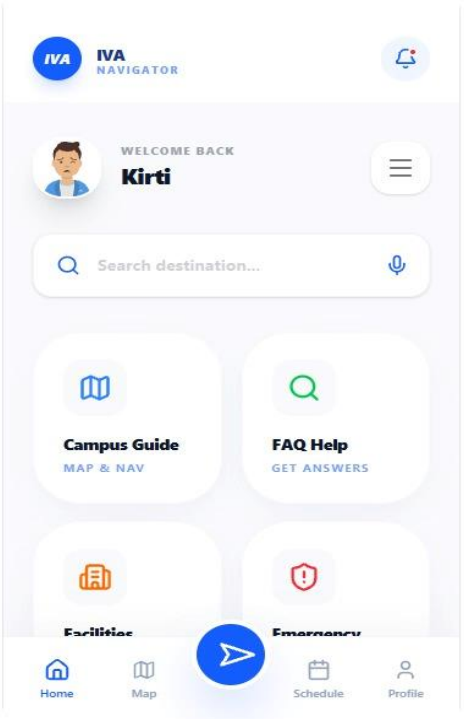


fig. 1 home screen

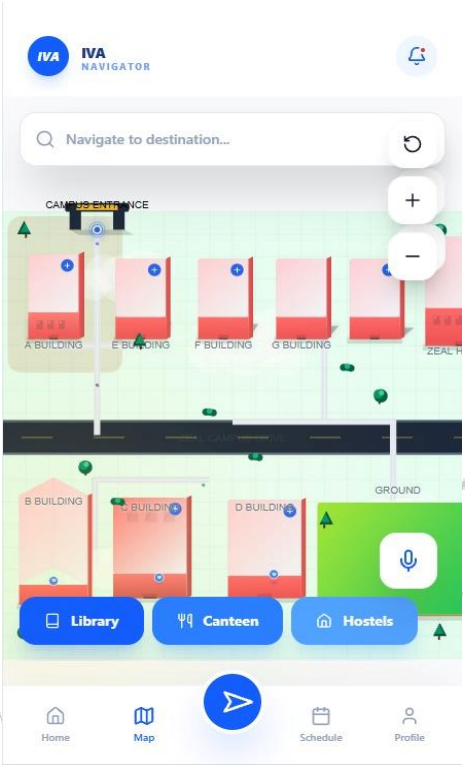


fig. 2 navigation screen

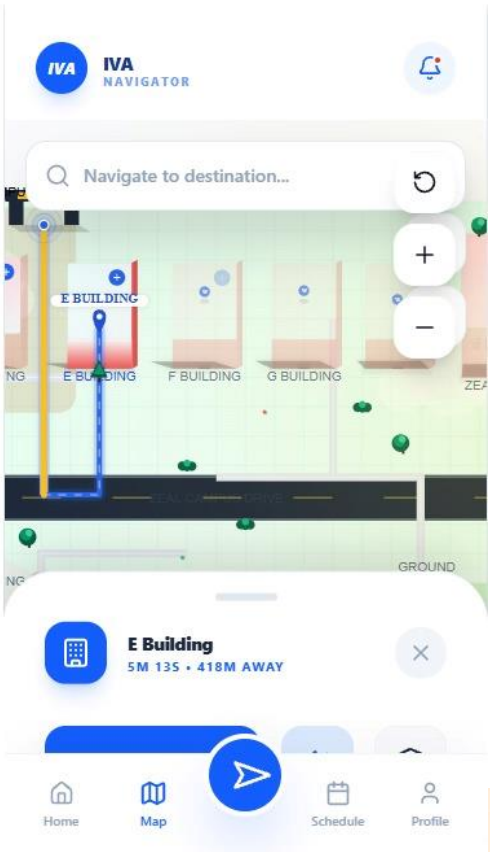


fig. 3 route guidance

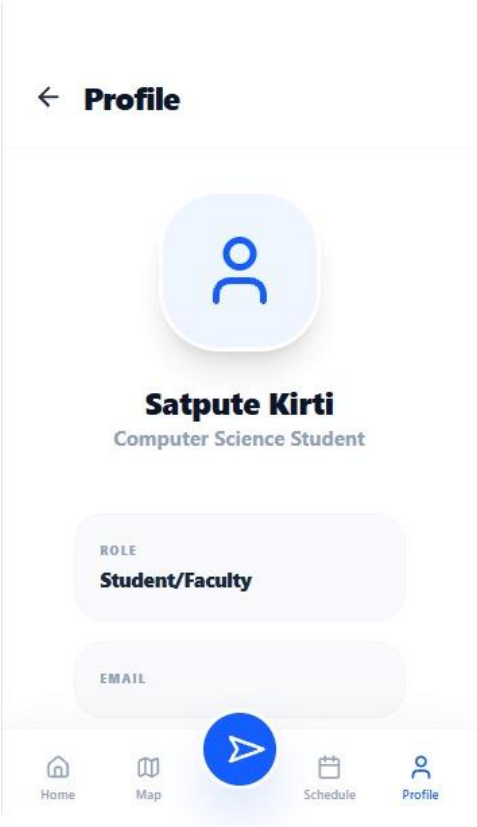


fig. 4 profile page

## VII ADVANTAGES

• Easy to use.

• Centralized information platform.

• Faster information access.

• Secure authentication.

• Reduced dependency on manual guidance.

• Efficient data management.

• Cross-platform support.

• Improved user experience.

## VIII FUTURE SCOPE

Although the current system successfully provides navigation and information management services, several improvements can be implemented in the future. Indoor navigation can be added to provide more accurate location guidance within buildings. QR code-based location identification can also be integrated. Multi-language support can be introduced to improve accessibility for users from different regions. Additional features such as timetable management, attendance monitoring, visitor management, and notification services can further enhance the functionality of the system. These enhancements can contribute toward the development of a complete smart campus solution.

## IX CONCLUSION

In this project, we developed IVA, a Campus Navigation and Information Management System that helps users locate campus facilities and access important information through a single platform. The system was developed using Flutter, Firebase Authentication, Cloud Firebase, and Google Maps services. Throughout the development process, we focused on creating a simple, user-friendly, and efficient solution that addresses common challenges faced by students and visitors. The system successfully provides navigation assistance, event information, room details, and other campus-related information. The project achieved its intended objectives and demonstrated that a centralized platform can significantly improve accessibility and convenience within educational institutions. We believe that the proposed system can be further enhanced and adopted by other institutions seeking to improve campus management and user experience.

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