



CampeX 360 – Virtual Campus Navigation with Club Information Portal

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Abstract—

This paper presents the design and implementation of CampeX 360, a virtual campus navigation system combined with a club information portal. The primary goal of this project is to simplify campus exploration and make it more interactive for users. Students and visitors often face difficulties navigating large campuses or accessing detailed information through traditional maps or static systems. This project aims to address those challenges by providing an immersive and user-friendly solution. For implementation, 360° images of various campus locations were captured and used to create a virtual tour using Marzipano. A web-based application was developed using React for the frontend and Node.js for the backend. Initially, the captured images were processed and optimized to ensure smooth performance, even on slower internet connections. Interactive hotspots were then added to

enable easy navigation between different locations. Additionally, the system was integrated with a backend database to store and manage club-related information, allowing users to access details about campus activities efficiently. User testing was conducted to evaluate the system's usability, and it was observed that users could navigate more easily and access information with minimal confusion. The system is compatible with both mobile and desktop devices, eliminating the need for specialized hardware. Its modular design also allows future enhancements without major changes, making it a scalable and practical solution for modern campuses..

Keywords— Virtual tours, 360-degree panorama, immersive learning, educational technology, web-based applications, resource-constrained systems, interactive navigation



I. INTRODUCTION

Engineering project implementation plays an important role in turning theoretical ideas into real systems that can solve practical problems. In many cases, there is a need for better campus navigation and easy access to information for students, visitors, and other stakeholders. Large campuses usually have multiple buildings, departments, labs, and activity areas, which makes it difficult—especially for new students or visitors—to find specific locations. This problem becomes even more noticeable during admissions, events, or busy academic hours, where people often get confused, waste time, and have a poor overall experience.

Most of the existing solutions have some limitations. Traditional methods like printed maps, brochures, or static websites only provide basic information and are not interactive. They do not give a clear idea of how different places are connected in the campus. Because of this, people often depend on others for directions, which is not always reliable. Some colleges have tried digital solutions like mobile apps or virtual tours, but many of them are either costly, require special hardware, or do not provide a smooth navigation experience.

With improvements in web technologies, virtual tours have become a better option for solving this problem. However, earlier systems still had issues such as limited navigation, low interactivity, poor image quality, or high system requirements. Also, many of these systems did not include useful campus-related information, which reduced their overall usefulness. To address these issues, this project focuses on the design and implementation of CampeX 360: Virtual Campus Navigation with a Club Information Portal. The system uses 360° panoramic images to create a virtual view of the campus. It includes hotspot-based navigation so users can move between locations freely instead of following fixed paths. Along with this, a club information portal is added to provide details about student activities, organizations, and events, making the system more informative and engaging.

The main aim of this project is to develop a simple, interactive, and user-friendly virtual campus

experience using web-based technologies. The system is designed to work on different devices like desktops and smartphones without needing any special hardware or installation. This project mainly contributes by providing a low-cost and scalable solution that combines virtual navigation with useful information. It helps improve user engagement through interactive features, makes the system accessible even for remote users, and reduces the need for manual guidance. Overall, it offers a practical solution for educational institutions looking to improve digital campus interaction.

II. LITERATURE REVIEW

Several studies and systems have been developed in the area of virtual tours and immersive campus navigation, mainly focusing on improving digital accessibility, visualization, and user interaction [1], [7]. Early virtual tour systems were mostly based on static panoramic image techniques, where multiple images were stitched together to form a 360° view of a location. These systems allowed users to explore different environments by moving between predefined viewpoints using simple navigation controls [4].

A. Static Panoramic Image-Based Systems:

The earliest virtual tour systems were developed using stitched panoramic images, where multiple images were combined to create a 360° view of a location [4]. These systems allowed users to explore environments by switching between predefined viewpoints using simple navigation controls. The primary advantage of this approach was its simplicity and low computational requirement, making it easy to implement. However, these systems lacked flexibility and interactivity, as users could only navigate through fixed paths defined by the developer. They did not support dynamic exploration or real-time interaction, which limited user engagement. Additionally, these systems were highly dependent on image quality, and issues such as image distortion, stitching errors, lighting inconsistencies, and resolution loss often affected the overall experience. In crowded or complex environments, these limitations made the system less effective in representing realworld conditions [4].



B. Web-Based Virtual Tour Frameworks:

With the advancement of web technologies, virtual tour systems gradually evolved into web-based applications using frameworks such as Marzipano and Pannellum [7], [13]. These systems made it possible for users to access virtual tours directly through web browsers without needing any additional installations, which improved both accessibility and scalability. Features like interactive controls, zooming, panning, and hotspot-based navigation were introduced, allowing users to move more easily and smoothly between different scenes. These systems also supported cross-platform compatibility, allowing access on desktops, tablets, and mobile devices. In addition, they enabled integration with backend systems for dynamic content delivery. However, despite these improvements, many web-based systems still lacked advanced user interaction features and often depended heavily on well-designed navigation. Poor placement of hotspots, lack of guided navigation, and absence of multimedia support sometimes caused user confusion and reduced engagement. Moreover, performance issues such as slow loading times and lag were observed, especially when handling high-resolution panoramic images or large datasets [6].

C. Interactive Multimedia-Based Systems:

To overcome the limitations of basic virtual tours, researchers introduced interactive multimedia systems that integrate elements such as audio narration, video content, textual descriptions, animations, and guided navigation features [10]. These systems aimed to enhance user engagement by providing not only visual exploration but also contextual information about the environment. Features such as minimaps, clickable information panels, and gamification elements were also incorporated to make navigation more intuitive and engaging. These systems significantly improved usability and user satisfaction, especially in educational and tourism applications [12]. However, the inclusion of multiple multimedia elements increased system complexity and resource requirements. High data usage, increased loading times, and performance degradation were common

issues, particularly in low-bandwidth environments [9]. Additionally, excessive multimedia integration sometimes resulted in cluttered user interfaces, making the system difficult to use and reducing overall efficiency

D. Low-Cost and Smartphone-Based Systems:

Recent research has focused on developing cost-effective virtual tour systems using smartphones and open-source tools [2], [14]. The main idea behind these approaches is to make virtual tour technology more accessible, especially for institutions that have limited resources, by reducing the dependence on expensive equipment and proprietary software. Smartphone-based panoramic capture techniques, combined with lightweight frameworks, make it possible to develop virtual tours quickly and at a lower cost. These systems are generally easy to deploy and can be integrated with existing web platforms without much difficulty. However, they still come with several limitations, such as inconsistent image quality, lower resolution, and less immersive experience compared to high-end systems. Problems like image stitching errors, lighting variations, and the lack of professional equipment can affect the overall visual accuracy of the system [4]. Moreover, these systems often do not include advanced features such as dynamic interaction, scalability, and efficient data management, which limits their use in large-scale implementations [14].

However, despite these improvements, existing systems still face a number of challenges such as restricted navigation flexibility, limited interactivity, high computational requirements, inconsistent performance, and lack of integration with useful contextual information like campus facilities, clubs, and activities [6], [12]. Most systems mainly focus on visualization and fail to provide a complete platform that combines navigation with meaningful user interaction and easy access to relevant information [9].

This project differs from existing work by proposing a cost-effective, web-based virtual campus navigation system that combines immersive 360° visualization with a centralized club information

portal. Unlike traditional systems, the proposed solution offers flexible hotspot-based navigation, improved user interaction, efficient performance optimization, and smooth integration of informative content [7], [13]. The system is designed to be scalable, user-friendly, and suitable for deployment in real-world educational environments, thereby addressing the limitations observed in existing approaches [15].

III. METHODOLOGY

A. System Overview

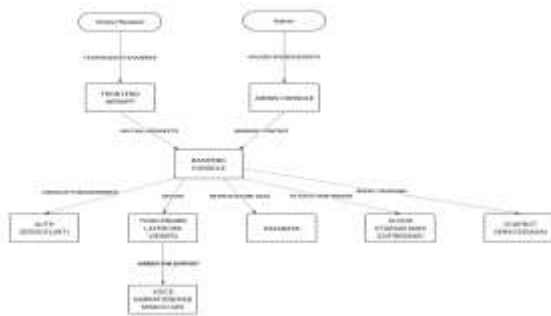


Fig. 1. System Architecture of Campex

The proposed CampeX 360 system follows a client-server architecture that combines multiple modules such as the frontend web application, backend services, virtual tour engine, and cloud-based storage. The system is designed to provide an interactive and scalable virtual campus navigation experience for users, while also making it easy for administrators to manage and update content efficiently.

The overall process starts when a visitor or student opens the frontend web application and submits tour requests or queries. The frontend acts as the main interface, allowing users to explore 360° panoramic views, interact with hotspots, and access information related to the campus. These user actions are then sent as API requests to the backend console for further processing.

On the administrative side, the admin interacts with the system through an admin console, where they can upload new scenes, manage events, and update information related to campus facilities and clubs.

This ensures that the system stays dynamic, relevant, and regularly updated.

The backend console acts as the central processing unit of the system. It takes care of key tasks such as user authentication, data processing, content management, and communication between different modules. It also works along with the authentication service (JWT) to ensure secure user access and proper session handling, which is important for building scalable web-based applications.

For virtual navigation, the backend connects with the tour engine layer (360° viewer), which is responsible for rendering panoramic scenes and enabling hotspot-based navigation. This module creates an immersive experience by allowing users to move smoothly between different campus locations, improving both usability and interaction.

The system also includes a database that stores structured data such as user details, club information, and related metadata. Cloud storage services (AWS S3/Firebase) are used to store and manage large media files like panoramic images efficiently. In addition, a chatbot service (RAG-based system) is integrated into the system to handle user queries and provide intelligent responses, which helps improve user interaction and engagement.

To further enhance the user experience, the system supports voice narration using the Web Speech API, which provides audio guidance throughout the virtual tour. This feature makes the system more accessible and engaging, especially for firsttime users and visitors.

Overall, the system functions in a well-coordinated way where the frontend manages user interaction, the backend takes care of processing and data flow, and supporting services such as cloud storage, authentication, and an AI-based chatbot improve the overall functionality. The final result is a fully integrated, interactive, and scalable virtual campus navigation system that provides both an immersive exploration experience and easy access to useful information.

B.Components Used



360° Panoramic Images: Captured using smartphones or 360° cameras to represent real campus environments in an immersive format. These images provide a realistic visual experience for virtual navigation.

- Hotspots (Interactive Navigation Points): Placed within panoramic scenes to allow users to navigate between different locations. They enable smooth and intuitive movement across the virtual environment.
- Database (MongoDB or Equivalent): Stores structured data such as club details, event information, and other dynamic content. It ensures efficient data retrieval and management.
- Web Server / Hosting Platform: Responsible for deploying the application and handling user requests. It ensures system availability and smooth access over the internet.
- User Interface Components: Includes buttons, panels, and controls for interaction. These elements enhance usability and allow users to easily navigate and access information.

C. Software and Tools used :

The software tools used include React.js, Node.js, Express.js, and Marzipano (or Pannellum). These tools were used for frontend development, backend programming, virtual tour rendering, and system integration, enabling the development of scalable and interactive web-based virtual tour systems .

- React.js: Used for developing a dynamic and responsive user interface. It enables smooth interaction, fast updates without page reloads, and efficient navigation between different components of the system.
- Node.js and Express.js : Used to handle backend logic and API communication. They support efficient data processing, server-side operations, and seamless interaction between frontend and database .
- Marzipano/Pannellum: Used for rendering interactive 360° panoramic scenes. These tools provide smooth navigation, zooming, and hotspot-based transitions within the virtual environment.

- Image Processing Tools: Used for stitching, compression, and optimization of panoramic images. These techniques help reduce image size and improve loading performance while maintaining visual quality

D. Methodology

- Planning and Requirement Analysis: In this phase, the system requirements are identified by understanding what users actually need and what problems exist in current systems. The idea of building an immersive, interactive, and easy-to-use campus navigation system is explored. Functional requirements such as navigation, displaying information, and supporting different devices are defined. At the same time, non-functional aspects like performance, scalability, and usability are also considered.

- System Design: During this stage, the overall system architecture is planned by dividing it into key parts such as the frontend interface, backend services, virtual tour engine, and database. The way data moves between these components is carefully decided to ensure smooth communication. Along with this, decisions are made regarding navigation flow, where hotspots should be placed, and how users will interact with the system.

- Component Selection / Material Preparation: In this step, the required tools and technologies are selected based on the system needs. 360° images of different campus locations are captured and then processed. This processing includes resizing, compressing, and improving image quality so that the system performs efficiently. The virtual tour framework and other development tools are also finalized at this stage.

- Implementation / Development: The development of the system is carried out step by step. First, the virtual tour environment is created by adding panoramic images and setting up scenes. After that, hotspots are introduced and linked to the appropriate scenes for navigation. The frontend is developed using React.js, and backend APIs are built to manage and process data. The club information portal is also

added to provide dynamic content. In the end, all parts are integrated to form a complete working system. • **Testing and Evaluation:** Once the system is developed, it is tested under different conditions to check its performance. Functional testing is done to make sure navigation and data display work correctly. Usability testing is carried out to understand how easy the system is to use and to evaluate the overall user experience

D. PROJECT IMPLEMENTATION

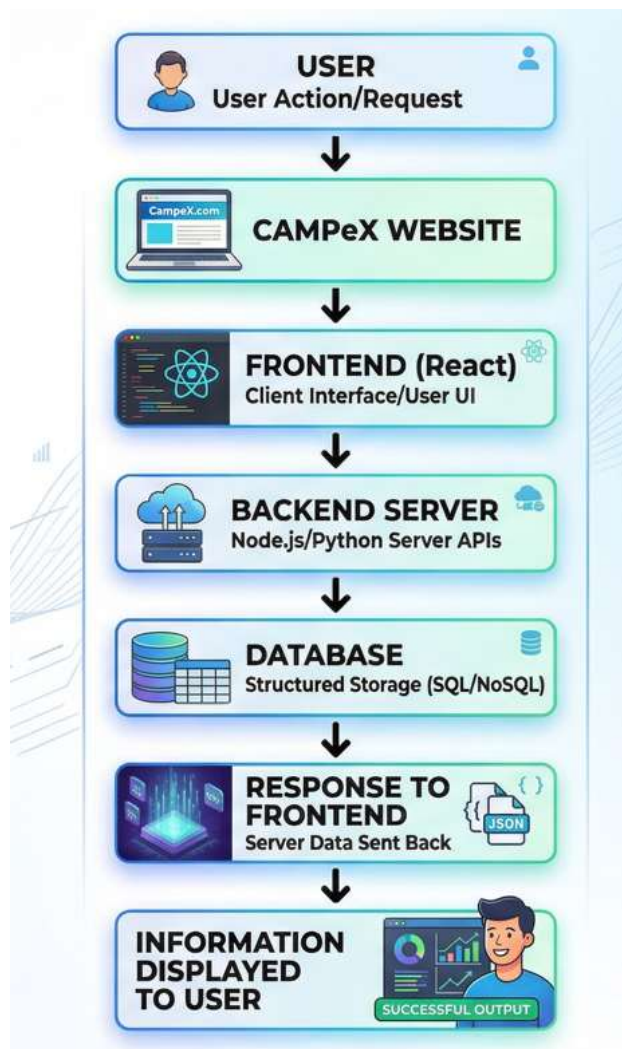


Fig 2: WorkFlow Diagram

The implementation of the project started by identifying key locations around the campus and capturing 360° panoramic images of those areas. These images were taken using a smartphone or a 360° camera to cover places like classrooms, labs, offices, and common areas. After capturing them, the

images were processed using basic editing tools for resizing, compression, and slight enhancement. This was mainly done to reduce file size while still keeping good visual quality, so that the system loads faster and runs smoothly in a web browser. Once the images were ready, they were organized into different scenes to create the virtual tour. After that, the navigation flow between these scenes was set up so that users could move smoothly from one location to another. This made the system easy to use and helped provide a more seamless overall experience.

For the hardware setup, a basic computer system with the required software and a stable internet connection was sufficient. Since the project is web-based, there was no need for any advanced or expensive hardware, which makes it easier to deploy. Simple tools such as a camera for capturing images and a hosting server were enough for the setup. On the software side, React.js was used to build the user interface, while Node.js and Express.js were used for backend development. Tools like Marzipano (or Pannellum) were used to manage the 360° views, and MongoDB was used to store club-related information and other data.

All parts of the system were then connected so that they work together smoothly. The frontend interacts with the virtual tour engine to display scenes and handle user actions like rotating the view, zooming, and clicking on hotspots. When a hotspot is clicked, the next scene loads instantly without refreshing the page, which keeps the navigation smooth. The frontend also communicates with the backend through APIs to fetch club-related information, which is then shown through interactive panels while the user is exploring the campus.

During the implementation, a few challenges came up. Handling large panoramic images was one of the main issues, as it increased loading time and affected performance. This was improved by compressing the images and optimizing their formats. Another issue was maintaining smooth transitions between scenes, which was handled by improving the loading and preloading process. Placing hotspots correctly was also a bit difficult at first, since even small mistakes could affect navigation, so it required careful

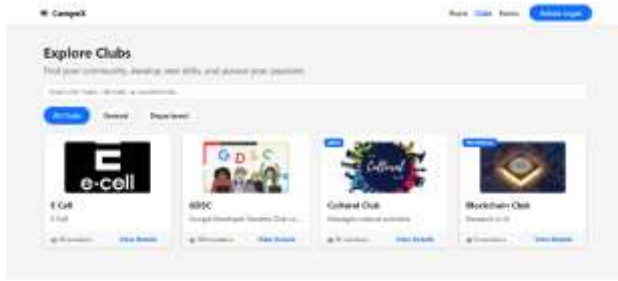


Fig 5: Clubs

The system performed efficiently under normal usage conditions, including moderate internet speed and standard device configurations. It was observed that the system maintained consistent performance across different platforms such as desktops and smartphones. Compared to existing methods such as static websites and basic virtual tours, the implemented project provides advantages such as immersive 360° visualization, flexible navigation, and integration of informational content within a single platform.

However, some limitations were observed, including dependency on internet connectivity for smooth performance, slight delays in loading high-resolution images under low bandwidth conditions, and the need for careful hotspot placement to maintain navigation accuracy. Despite these limitations, the system demonstrates significant improvement in user experience, accessibility, and interactivity compared to traditional approaches.

V. CONCLUSION

This paper presented the implementation of CampeX 360: Virtual Campus Navigation with a Club Information Portal for immersive campus exploration and easy access to information. The system was designed, developed, and tested using 360° panoramic images along with modern web technologies. It helps overcome the limitations of traditional campus navigation methods, which mainly rely on static maps and do not offer much interactivity.

The results show that the system offers an interactive and user-friendly way to explore the campus. Users can move between different locations easily and access the required information without much

difficulty. The hotspot-based navigation helps in smooth transitions between scenes, and the club information portal keeps users updated and connected with campus activities. The system also works well across different devices, so users can explore the campus remotely without needing any special hardware.

The implementation also indicates that combining immersive visuals with dynamic content improves the overall user experience. Methods like image compression and efficient rendering help the system perform better and reduce loading time. In addition, the modular design makes the system flexible, allowing new features to be added later without major changes.

Overall, the proposed system offers a practical and cost-effective solution for digital campus navigation. It improves user experience, reduces the dependency on manual guidance, and makes campus-related information more accessible to students, visitors, and other stakeholders. Because of this, the system can be effectively used in educational institutions for campus navigation, student orientation, virtual tours, and other digital services, contributing to the development of smarter and more interactive campus environments.

In future, this project can be improved by adding AI-based personalized navigation so that users can be guided according to their individual preferences. The use of AR/VR technologies can also make the system more interactive and give users a more engaging way to explore the campus. Along with this, the system can be expanded to include real-time updates of campus events and activities.

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