Virtual Verse: A Web-Based 3D Virtual Campus Exploration System

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ABSTRACT

The growing need for user-friendly and interactive digital spaces has spurred the creation of virtual exploration systems to explore real-world areas. This paper introduces Virtual Verse, a 3D virtual campus exploration platform that works on the web. It offers a simple and immersive way to explore the AVN Institute of Engineering and Technology campus. Using any regular web browser, users can move around and visit campus spots without needing advanced virtual reality gear. The system relies on WebGL-based tools Three.js, to produce detailed 3D visuals and allow smooth interactions. It provides different ways to navigate and includes an AI-powered chatbot with voice features. The system provides immersive and flexible virtual campus experiences to help educational institutions. It improves access and user involvement while supporting digital changes. By doing this, it cuts down on the need to visit in person. It also ensures better interaction and experiences for users working well on various devices and under different network situations.

Keywords: WebGL, Three.js, Virtual Campus, 3D Visualization, AI Chatbot, Progressive Web Application (PWA)

1. INTRODUCTION

The fast growth of digital tech has changed how people use information and interact with spaces. This shift has pushed up the need to develop immersive and interactive virtual systems. In schools and colleges, it's now important to create easy-to-use and interesting platforms to explore campuses. Students, visitors, and others benefit from such tools. Older ways like brochures still photos, or even visits in person often fail to give a full or realistic picture of the campus layout when people are far away. These challenges show why there's a need to build a better digital option to give a more hands-on and easy-to-access experience.

As web graphics technologies like WebGL have advanced, people have become more interested in making 3D applications that run in browsers. These apps allow real-time visuals and interaction without needing special hardware. Tools like Three.js simplify building and sharing detailed 3D environments online. This progress brings new ways to create virtual exploration systems that are affordable and can grow . Still many virtual tour platforms fall short. They often don't offer much interactivity, have clunky navigation, and lack smart

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features to guide users, which makes them less engaging overall.

People using virtual environments need simple ways to move around and clear directions to improve their experience. Many current systems use basic methods for navigation and do not have smart tools to help users while they explore. Also, these systems often do not work across different devices and fail to adjust to mobile platforms, which makes them harder to access. To fix these issues, a complete system is needed to combine interactive navigation smart assistance, and flexibility for different devices in one single platform.

To solve these problems, this study introduces *Virtual Verse*, which is a web tool offering a 3D interactive way to explore the AVN Institute of Engineering and Technology campus. This system lets users move around the campus using controls like arrows for movement first-person navigation, thumbnail-based jumping, and clickable hotspots. Developers used WebGL and Three.js to build it making sure it runs well and responds in a standard web browser.

The system includes an AI chatbot that helps users through both voice and text offering instant support and guidance. It uses tools like text-to-speech, voice instructions, and smart answers to boost usability and keep users interested. The platform works on various devices such as phones, tablets, and computers because of its adaptable user interface. It also uses Progressive Web Application features to make it faster more dependable, and usable even without an internet connection.

The system improves how users explore virtual spaces by offering easy-to-use controls and interactive features. It uses real-time graphics and smart tools to create smooth and fun interactions. Extra functions like a guided tour, a way to give feedback, and better landing page design help make the platform more user-friendly and satisfying.

The key parts of this project include these:

a. A 3D virtual campus exploration tool built with WebGL and Three.js that works through the web
b. Features such as hotspots, arrows, and scene switching that allow users to navigate
c. An AI chatbot added to the system that supports both voice and text communication
d. A platform that is PWA-enabled and adjusts well across devices to improve access and performance

1.1 Overview of the Virtual Verse System

The Virtual Verse system, a 3D virtual campus exploration tool accessible through a web browser, offers users a hands-on way to explore a campus. It creates an interactive and real-time experience that does not require anyone to be present. The system combines 3D visuals instant rendering, and simple navigation tools to make exploring easy and more engaging.

Traditional campus tours have some significant issues such as:

a. Remote access is not available – People have to visit in person to see campus buildings, which is not always practical for prospective students or guests.
b. Poor visuals – Using flat maps or regular images fails to give a true sense of how the campus is laid out or feels in real life.
c. New users struggle to find buildings and key facilities across large

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campuses. Navigation feels confusing and hard to figure out at first.

d. Current systems don't offer real-time help or interactive support when users try to explore the campus.

The Virtual Verse system addresses these issues. It gives users real-time 3D navigation interactive hotspots, and guided exploration tools. This makes moving between locations easier and provides clear detailed information about different parts of the campus.

With virtual campus exploration, users can grasp campus infrastructure better and access it from anywhere at any time. Unlike old systems that rely on static content, which feels less engaging, this system focuses on interactivity to keep users connected and involved.

The addition of voice guidance and location-based details makes the system easier to use. It lets users get directions and learn about places without needing to do it themselves. The platform works on both computers and phones, which makes it accessible and easy to use for more people.

Virtual Verse offers a smart and up-to-date way to explore campuses. It brings together interactivity ease of access, and fast performance.

Key Functionalities of the System

The platform provides live 3D visuals by displaying interactive campus models directly in the web browser using technologies like Three.js and WebGL, allowing users to smoothly navigate different areas with realistic views without requiring additional software. It supports interactive movement through on-screen controls and clickable hotspot arrows, enabling easy transitions between buildings and locations while enhancing user engagement. The system also includes voice assistance and location-based details to guide users and provide information about campus facilities, creating a virtual tour-like experience. Designed for cross-platform use, the application works on both desktops and smartphones, offering touch controls for mobile users and pointer-based navigation for desktop users, ensuring wider accessibility. To maintain better performance and usability, it uses optimized rendering techniques, lightweight 3D models, and efficient resource management to reduce loading time while keeping the interface simple and user-friendly. Additionally, the system features a scalable and expandable design, making it easy to add new locations or functionalities in the future, with potential enhancements such as AR/VR integration, AI-based navigation, and real-time interaction, extending its applications to smart campuses, virtual tours, and educational environments.

2. LITERATURE SURVEY

[1] Sharma et al. (2022) – Web-Based 3D Campus Tour System
This research developed a web-based campus tour using WebGL and Three.js to create interactive 3D environments. Users could explore campus locations through a browser interface. While the system improved accessibility, it suffered from performance issues on low-end devices due to high computational requirements and lack of optimized asset loading techniques.

[2] Kim et al. (2023) – Optimizing 3D Assets Using GLTF/GLB
This study focused on optimizing 3D models using GLTF and GLB formats to reduce file size and improve rendering performance. Although these formats enhanced efficiency compared to traditional formats, large-scale environments still experienced loading

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delays, indicating the need for better asset management strategies.

[3] Lee et al. (2024) – Navigation Techniques in Virtual Environments
This research explored various navigation methods, including pointer-lock controls and free-camera movement. The study found that first-person navigation improves user immersion and interaction. However, performance varied depending on device capability, with low-end systems experiencing lag and reduced responsiveness.

[4] Brown et al. (2023) – Responsive Design for Web-Based 3D Applications
This study emphasized the importance of responsive design frameworks such as Tailwind CSS to ensure compatibility across multiple devices. While responsiveness improved usability, integrating it with complex 3D rendering introduced performance challenges, especially on mobile devices.

[5] Thomas et al. (2025) – Virtual Campus Tours Using 360° Media
This research examined virtual tour systems based on 360-degree images. Although these systems improved accessibility, they lacked real-time interaction and dynamic navigation, limiting users' ability to fully understand spatial layouts.

[6] Patel et al. (2022) – Hotspot-Based Navigation Systems
This study analyzed the use of interactive hotspots for navigation within virtual environments. While hotspots improved user engagement and navigation efficiency, excessive use led to visual clutter and negatively impacted user experience.

[7] Garcia et al. (2023) – Voice-Assisted Navigation Systems
This research introduced voice-guided navigation to improve accessibility. Although it enhanced user experience, issues such as synchronization delays and sensitivity to background noise affected system performance.

[8] Singh et al. (2024) – Cross-Platform Web-Based 3D Systems
This study highlighted challenges in developing cross-platform 3D applications, including hardware limitations and varying input methods. The authors recommended responsive design and optimized controls to ensure consistent performance across devices.

Current virtual exploration systems have made significant progress in terms of visualization and accessibility. However, they still face challenges such as performance limitations, lack of intelligent guidance, and inefficient navigation mechanisms. The proposed *Virtual Verse* system aims to address these gaps by integrating real-time 3D rendering, voice-guided assistance, interactive hotspot navigation, and cross-platform compatibility into a unified and efficient platform.

3.PROPOSED SYSTEM

The proposed system is a Web-Based Virtual Campus Exploration System that integrates 3D visualization, interactive navigation, and voice-assisted guidance to provide a real-time immersive experience of a campus environment. Unlike traditional systems that rely on static images or videos, this system enables users to explore the campus dynamically through multiple interconnected virtual scenes. By combining modern web technologies and computer graphics techniques, the system enhances user engagement, accessibility, and realism.

The system employs 3D rendering techniques using Three.js for visualizing campus infrastructure through detailed GLTF models. Each location, such as the main gate, academic blocks, canteen, library, and administrative offices, is represented as an independent 3D scene.

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These models are dynamically loaded, scaled, and positioned to ensure consistency and smooth transitions between different locations. This approach allows users to experience the campus environment in an interactive and visually rich manner.

To support intuitive navigation, the system incorporates an interactive hotspot-based navigation module. Directional arrows are placed within each scene using sprite objects, enabling users to move between different locations by simply clicking or tapping on them. This navigation is implemented using ray casting techniques to detect user interactions accurately. By guiding users through predefined paths, the system simulates real-world movement across the campus.

For enhanced user interaction, the system integrates a camera control and movement module using Pointer Lock Controls. This allows users to navigate the environment in a first-person perspective. The system supports both desktop and mobile devices by enabling mouse-based controls for desktops and touch-based gesture controls for mobile users. Smooth movement is achieved through velocity-based motion, providing a realistic walking experience within the virtual environment.

A key feature of the system is the voice-guided assistance module, which provides audio descriptions for each location. Using text-to-speech technology, the system delivers real-time voice feedback whenever a new scene is loaded. This not only enhances user engagement but also improves accessibility for users who prefer audio-based guidance.

The system also includes an information display module, where contextual details about each location are presented through a graphical user interface. Users can view descriptions, building information, and other relevant details, making the exploration both informative and interactive.

A significant component of the system is the scene management and hotspot control mechanism. The system ensures that only relevant navigation arrows are displayed for each location by dynamically adding and removing hotspot elements. This prevents overlap, reduces confusion, and improves overall system performance. Additionally, memory management techniques are used to dispose of unused models and resources efficiently.

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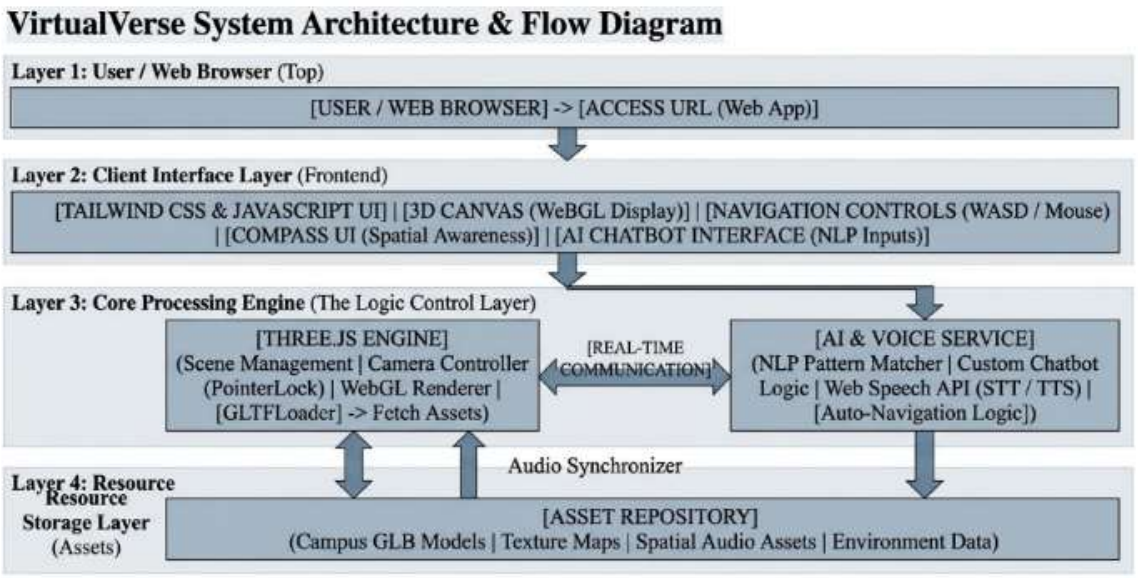

Figure 1: System Flow and Architecture of the VirtualVerse Platform

The diagram illustrates a web-based system architecture designed for real-time virtual campus exploration and interaction. The system is organized into multiple layers, each responsible for specific functionalities that collectively enable an immersive and interactive user experience.

The process begins at the User/Web Browser layer, where the user accesses the application through a web URL. This layer acts as the entry point to the system, allowing users to initiate the virtual tour using any standard web browser without requiring additional software installation.

Once the application is accessed, the request is handled by the Client Interface Layer (Frontend). This layer is responsible for rendering the user interface and managing user interactions. Technologies such as HTML, CSS, and JavaScript are used to build the interface, while Three.js is utilized to display 3D models using WebGL. The frontend also manages navigation controls, including keyboard (WASD), mouse interactions, and touch gestures for mobile devices.

Additionally, features like a compass for spatial awareness and optional chatbot interaction for user queries are integrated into this layer to enhance usability.

The core functionality of the system is handled in the Core Processing Engine (Logic Controller Layer). This layer is divided into two main components: the 3D Engine and the AI & Voice Service. The 3D Engine is responsible for managing 3D scenes, controlling the camera using pointer lock mechanisms, and rendering models through the GLTF loader. It also handles asset management and ensures smooth transitions between different scenes. In parallel, the AI & Voice Service processes user inputs for intelligent interaction, including natural language processing for chatbot responses, speech-to-text (STT) for voice input, and text-to-speech (TTS) for voice-guided feedback. Real-time communication between these components ensures synchronized operation and seamless user experience.

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The system further relies on the Resource Storage Layer (Assets), which stores all required data such as GLB 3D models, textures, spatial audio assets, and environmental data. These resources are dynamically loaded as needed to optimize performance and reduce initial load time. Efficient asset management ensures smooth rendering and interaction without performance degradation.

An important aspect of the system is the audio synchronization mechanism, which connects the processing engine with voice services. This ensures that whenever a new scene is loaded, corresponding voice guidance is generated and played in real time, enhancing user engagement and accessibility.

Overall, the architecture demonstrates a layered approach where user input is captured, processed, and transformed into a visually rich and interactive 3D experience. The integration of real-time rendering, intelligent interaction, and optimized resource management enables efficient and immersive virtual exploration of the campus.

4.RESULTS

Figure 2: Virtual Verse 3D Exploration Interface

Figure 3: Virtual Verse Platform Overview and Institutional Information Interface.

Figure 4: Contact Information and Integrated Campus Map Interface.

Figure 5: Campus Tour Help Interface with Categorized Support Resources.

Figure 6: Integrated User Feedback Modal with Rating System and Text Input.

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Figure 7: Immersive 3D Campus Interface with Navigation Arrows and Location Metadata Overlay.

Figure 8: Integrated Campus Assistant Chatbot and Location Information Overlay.

Figure 9: User Interface for Campus Tour Sharing via Integrated Social Media Plugins.

5. CONCLUSION AND FUTURE WORK

A. Conclusion

The Virtual Verse system presents an effective and innovative solution for virtual campus exploration by integrating 3D visualization, interactive navigation, and voice-assisted guidance within a web-based platform. The system successfully overcomes the limitations of traditional campus tour methods by providing users with an immersive and real-time experience that closely simulates physical navigation.

By leveraging technologies such as Three.js for 3D rendering, GLTF models for efficient asset representation, and intelligent navigation mechanisms using interactive hotspots, the system ensures smooth and intuitive movement across different campus locations. The incorporation of first-person camera controls and multi-device compatibility further enhances user interaction, making the system accessible on both desktop and mobile platforms.

The integration of voice guidance and information display modules adds significant value by improving user engagement and accessibility. Additionally, the layered system architecture ensures efficient processing, optimized resource management, and seamless communication between different components, resulting in a stable and scalable application.

Overall, the proposed system demonstrates how modern web technologies and computer graphics can be effectively combined to create an interactive virtual environment. It serves as a practical solution for institutions to digitally showcase their infrastructure and provides a foundation for future enhancements such as augmented reality integration, advanced AI-based assistance, and real-time multi-user collaboration.

B. Future Scope

Virtual Verse gives users a solid interactive platform, but there's still a lot to improve and explore. Adding support for Virtual Reality (VR) and Augmented Reality (AR) could make the experience much richer and more engaging. Future designs might also include AI-driven virtual assistants to help guide users and answer academic questions.

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Creating mobile apps and adding multi-user features could make exploring the campus together more interactive. Other upgrades like voice-controlled navigation or hosting content on the cloud could improve how scalable and available the system is worldwide. To summarize upcoming efforts aim to turn Virtual Verse into a smarter and accessible platform for virtual exploration.

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