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AI-Based Digital Twin for Smart College with Intelligent Chatbot and 360° Virtual Campus Tour

Snehal Hemant Farkade, Ruchika Dilip Waghade, Khushi Sachin Sakhare, Shravani Suresh Gaygol, Suhani Chandrashekhar Taywade, *Prof. Shital Patil

B. Tech 4th year, Department of Information Technology, Priyadarshini Bhagwati College of Engineering, Nagpur, Maharashtra, India
***Guide,** Department of Information Technology, Priyadarshini Bhagwati College of Engineering, Nagpur, Maharashtra, India*
Emails: [1][snehalfarkade23@gmail.com], [2][waghaderuchika5@gmail.com], [3][khushisakhare816@gmail.com], [4][shravanisgaygol@gmail.com], [5][suhanitaywade0@gmail.com]

ABSTRACT—

This paper presents an AI-based Digital Twin framework for a Smart College that integrates role-based dashboards, an AI/LLM chatbot, structured academic information, and a 360-degree virtual campus tour. The proposed platform provides students, faculty, administrators, and visitors with centralized access to college-related services and information. React.js is used for the frontend, Node.js for backend services, and MongoDB for data management. The AI chatbot is designed to understand natural-language queries and provide relevant responses using AI/LLM capabilities together with structured college or student data. The virtual campus component uses panoramic images and interactive hotspots to provide a visual representation of selected campus locations. The project is currently under development, with the core web modules and AI integration implemented and the 360-degree virtual tour being finalized.

Keywords— Digital Twin, Smart College, Artificial Intelligence, Large Language Model, AI Chatbot, 360° Virtual Tour, React.js, Node.js, MongoDB, Virtual Campus.

1. INTRODUCTION

Digital transformation is changing the way educational institutions manage information, communicate with users, and provide campus services. Traditional college websites generally act as information portals, while students and staff often need to access multiple sources for academic information, notices, attendance, and other services. Visitors may also have difficulty understanding the physical layout of a campus before visiting it.

A Digital Twin can provide a digital representation of a real-world environment or system. In a smart-campus context, research has explored Digital Twins for campus monitoring, environmental information, visualization, and decision support. Our project adopts a practical educational version of this idea by combining a digital representation of the college with smart web services, AI-based assistance, and an interactive 360-degree campus experience.

2. PROBLEM STATEMENT

Existing college websites often focus mainly on displaying static information. Students, faculty, administrators, and visitors have different information needs, but these needs are not always handled through a single integrated platform. Students may need academic information and assistance, faculty may need faculty-related services, administrators require overall management information, and visitors need simple ways to explore the campus.

The project addresses these issues through a centralized Smart College platform with role-based modules, AI assistance, structured information, and a 360-degree virtual campus component.

3. OBJECTIVES

To develop a centralized Smart College web platform.

To provide role-based modules for students, faculty, administrators, and visitors.

To integrate an AI/LLM-based chatbot for natural-language query handling.

To connect AI assistance with structured college or student information where required.

To create an interactive 360-degree virtual representation of selected campus locations.

To use clickable hotspots for navigation between virtual locations.

To improve accessibility, communication, campus exploration, and the overall digital experience.

4. RELATED WORK AND RESEARCH GAP

Previous research demonstrates that Digital Twin technology can be applied to smart campuses for monitoring and management. Zaballos et al. presented a smart-campus Digital Twin for sustainable comfort monitoring. More recent work has investigated campus-scale operational Digital Twins for environmental monitoring and sustainability management. Research has also considered the combination of IoT, advanced communication technologies, and Digital Twins for smart campuses.

Many existing approaches focus on environmental monitoring, facility management, IoT sensing, or sustainability. Our project focuses on a user-facing integration of role-based academic services, AI/LLM assistance, structured information, and an interactive 360-degree virtual campus experience within one platform.

5. PROPOSED SYSTEM

The proposed system consists of four major user-facing roles: Visitor, Student, Faculty/HOD, and Principal/Administrator. Each role receives access to features appropriate to its requirements.

The Student module provides access to student-related information and services such as attendance, marks, syllabus or progress information, notifications, assignments/reminders, and AI assistance. The Faculty/HOD module supports faculty-related academic functions and information. The Principal/Administrator module provides higher-level college information and management-oriented functionality. The Visitor module provides access to the 360-degree virtual campus tour.

The AI chatbot accepts a natural-language query, processes it through the AI/LLM layer, and uses relevant structured college or student data when required to generate a response.

6. SYSTEM ARCHITECTURE

The core web architecture follows: User React.js Frontend → Node.js Backend/API → MongoDB Database. React.js manages the interactive user interface and dashboards. Node.js handles server-side logic, API requests, and communication with the database. MongoDB stores application and structured academic data.

The AI component works alongside this architecture: User Query → AI/LLM → relevant structured college/student data when required → Response. The virtual-tour component follows: Panorama Images → CloudPano Interactive 360° Tour Website Integration.

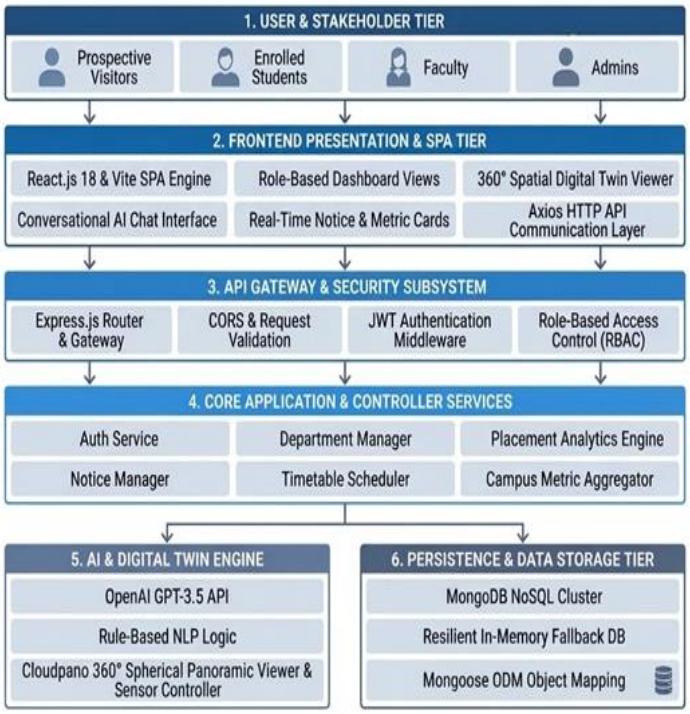


Fig. 1. Block Diagram of AI Digital Twin Smart College Architecture.

7. TECHNOLOGY STACK

React.js: Used to develop reusable and interactive frontend components and role-based dashboards.

Node.js: Used for backend processing, server-side logic, and API communication.

MongoDB: Used for storing and managing application and structured academic data.

AI/LLM: Used for understanding natural-language queries and generating meaningful responses.

CloudPano: Used to build and customize the 360-degree virtual campus experience using panoramic images and interactive hotspots.

Smartphone Panorama Mode: Used during the current image-collection process to capture wide-angle views of campus locations.

8. METHODOLOGY

The development methodology is divided into planning, design, implementation, AI integration, and virtual-tour development. First, project requirements and user roles were identified. Next, the system architecture and technology stack were selected. The Smart College website and role-based modules were then developed. AI/LLM functionality was integrated for intelligent query handling. In parallel, panoramic campus images were collected and organized for the virtual tour.

For the 360-degree tour, campus locations are captured using panorama mode. The images are organized and processed in CloudPano. Interactive hotspots are then added to connect locations and support navigation. Finally, the completed virtual tour is integrated into the Smart College website and tested.

9. SYSTEM MODULES

Visitor Module: Provides an "Explore College" experience through the 360-degree virtual campus tour.

Student Module: Provides personalized access to attendance, marks, syllabus/progress, notifications, assignments/reminders, and AI assistance.

Faculty/HOD Module: Provides faculty-oriented academic information and functions such as notices, attendance, and marks-related operations.

Principal/Administrator Module: Provides overall college information and management-oriented access.

AI Chatbot Module: Accepts natural-language queries and generates relevant responses using AI/LLM capabilities and available structured data.

360° Virtual Campus Module: Provides panoramic views and clickable hotspots that connect different campus locations.

10. AI CHATBOT WORKING

The AI chatbot provides a natural way to interact with college information. The user enters a query in normal language. The system sends the query to the AI/LLM layer, which interprets the request. If structured information is required, the system uses relevant college or student data and generates a response. This is intended to make information retrieval easier than searching through multiple pages manually.

11. 360° VIRTUAL CAMPUS TOUR

The 360-degree virtual campus tour is a major component of the proposed Digital Twin experience. A panoramic image provides a wide-angle view of a campus location. These images are organized and processed in CloudPano to create an interactive virtual environment. Clickable hotspots are placed at relevant locations so users can move from one view to another.

For example, in the IT Department, users can explore the labs, classrooms, and HOD cabin and move between them using clickable hotspots. During the initial stage, the project team used Kuula for the virtual tour. As the project evolved, the team moved to CloudPano because it provided a more suitable workflow for editing and customization.

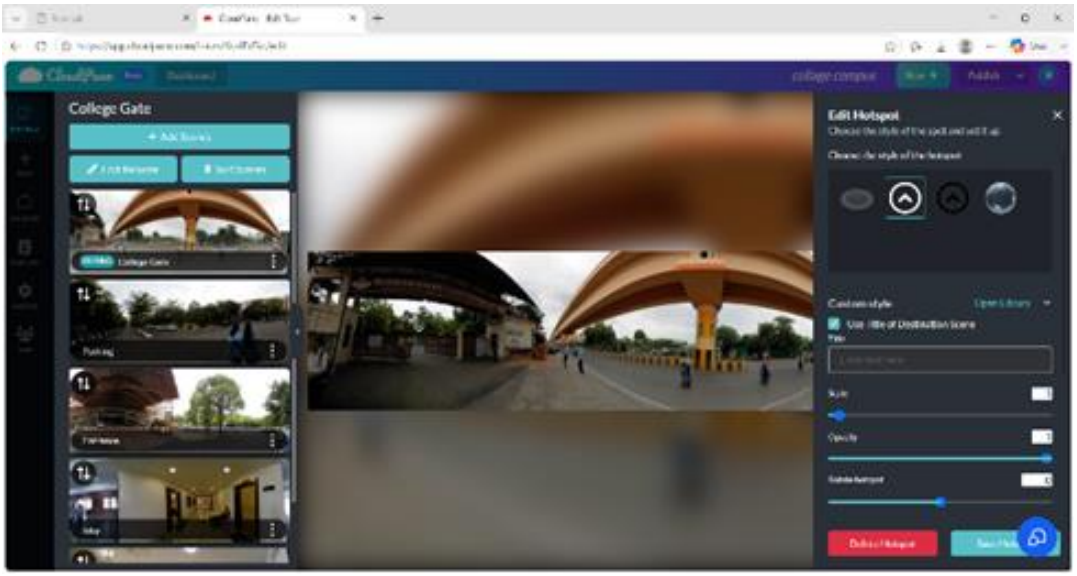


Fig. 2. User Interface of Interactive 360° Virtual Campus Tour with Hotspots

12. IMPLEMENTATION STATUS

Completed or substantially developed: project planning, system design, technology selection, Smart College website development, role-based dashboards/modules, and AI integration.

In progress: panorama image collection, finalization of the 360-degree virtual tour, hotspot integration and testing, website integration, bug fixing, UI/UX improvements, and final deployment.

Because the virtual-tour component is still under development, this paper does not claim final performance results for the complete system.

13. EXPECTED RESULTS

The expected outcome is a unified Smart College platform that reduces the need to access multiple information sources. Role-based dashboards are expected to provide more relevant user experiences, while the AI chatbot is expected to simplify natural-language access to college information. The 360-degree virtual tour is expected to improve campus exploration and navigation for visitors and new students.

A final evaluation of the complete system will be performed after the virtual-tour component and final integration are completed.

14. ADVANTAGES

Centralized access to college-related services and information.

Role-based and personalized user experience.

Natural-language interaction through AI/LLM assistance.

Interactive 360-degree campus exploration.

Hotspot-based navigation between locations.

Modular architecture that can be extended with additional smart-campus services.

15. LIMITATIONS

The current project is primarily a web-based Smart College platform and does not yet implement a complete sensor-driven or real-time physical Digital Twin. The 360-degree tour depends on the quality and coverage of captured panoramic images. AI responses depend on the quality, availability, and correct integration of structured college data. The virtual-tour component is still being finalized.

16. FUTURE SCOPE

Future work can extend the platform with voice-based AI interaction, QR-based campus navigation, IoT sensors, real-time campus monitoring, richer 3D visualization, predictive analytics, and deeper integration with college management systems. With live sensor and operational data, the Digital Twin could be developed into a more comprehensive real-time representation of campus activities and infrastructure.

17. CONCLUSION

This paper presented an AI-based Digital Twin framework for a Smart College that integrates role-based web modules, an AI/LLM chatbot, structured college information, and a 360-degree virtual campus tour. The system is designed to make college services more accessible while providing an interactive representation of the campus. The core web and AI components have been developed, while the 360-degree virtual tour and final integration are ongoing. The proposed approach demonstrates how AI, web technologies, and virtual campus visualization can be combined to create a more connected and future-ready digital campus.

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