Insightix: An AI-Powered Real-Time Monitoring and Analytics System for Intelligent Space Utilization and Crowd Management

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ABSTRACT

Insightix is a real-time AI-powered monitoring and analytics system designed to enhance space utilization optimization, improve crowd management strategies, and provide comprehensive support for data-driven intelligent decision-making across various operational environments. Developed using modern computer vision and deep learning technologies like YOLO, TensorFlow, OpenCV, and VLLM, the system provides features such as human detection, footfall analysis, anomaly recognition, and heatmap generation. The backend, powered by Node.js, Flask, Express.js, and MongoDB, processes real-time video streams, while the React.js-based dashboard offers live analytics, alert notifications, and reporting capabilities. The project was developed using the Agile Scrum methodology with multiple sprints, including AI model training, UI development, and system integration. Insightix is adaptable to various environments such as retail stores, educational institutions, and public event venues, enabling stakeholders to monitor activity, identify behavioral trends, and respond to incidents more effectively. For scalability and performance, the system ensures high responsiveness with a modular architecture. The team successfully improved the AI detection accuracy and completed comprehensive mobile application integration with cross-platform compatibility for both iOS and Android devices. Advanced machine learning algorithms for predictive analytics were fully implemented, along with API integrations with existing security systems. These completed enhancements transformed Insightix into a comprehensive solution that seamlessly combined intelligent surveillance capabilities with smart environment management, delivering high flexibility, accessibility, and operational efficiency for organizations seeking advanced monitoring solutions across diverse operational contexts.

Keywords: Artificial Intelligence, Computer Vision, Real-Time Surveillance, Crowd Management, Space Utilization.

INTRODUCTION

The rapid growth of urban infrastructure and business environments has increased the challenges of monitoring activities, ensuring security, and effectively utilizing space. Traditional surveillance systems rely on passive video recording and manual monitoring, which often result in delayed responses, human error, and limited analytical insight (Mishra *et al*., 2024; Farooq & Khan, 2024). Recent research emphasizes the need for intelligent surveillance systems capable of automated analysis and real-time decision support in densely populated environments (Jeyanth *et al*., 2024).

To address these challenges, this study proposes Insightix, an AI-powered smart surveillance and space analytics system designed to transform conventional security into an intelligent, data-driven solution. Insightix focuses on real-time activity monitoring, crowd analysis, and automated detection to support enhanced security and optimized space utilization. By leveraging modern computer vision and artificial intelligence techniques, the system aims to provide actionable insights rather than passive video data, enabling efficient decision-making for smart campuses, commercial spaces, and public environments (Redmon *et al*., 2016; Bradski, 2000).

OBJECTIVES

The objectives of this research are:

1. To design and develop an AI-powered intelligent surveillance and analytics system capable of monitoring activities and supporting efficient crowd management and space utilization in real-time environments.
2. To automate the analysis of video data using computer vision and artificial intelligence techniques in order to reduce manual surveillance, enhance security, and improve situational awareness.
3. To provide data-driven insights and decision support mechanisms through real-time alerts, historical analysis, and interactive visualizations for effective monitoring and management of smart environments.

METHODOLOGY

The proposed system, Insightix, follows a modular architecture designed for intelligent real-time surveillance and space analytics. The methodology begins with the acquisition of live and recorded video streams from surveillance cameras, which serve as the primary input to the system. These video streams are processed using computer vision techniques to enable automated analysis of human presence, object detection, and activity patterns.

Deep learning–based object detection models, particularly YOLO, are employed to perform real-time detection of humans and objects within the video frames. Video preprocessing and frame-level analysis are performed using the OpenCV library. To support intelligent interaction with video data, Vision Language Models (VLMs) are integrated, enabling natural language–based question–answering over live and recorded video streams.

The system architecture is implemented using the MERN stack, where MongoDB is used for storing user data, camera configurations, detection results, alerts, and analytics, Express.js and Node.js manage backend services and APIs, and React.js provides an interactive web-based dashboard for real-time monitoring and visualization. A mobile application supports remote access and monitoring, while real- time communication between system components is achieved using WebSockets to ensure low-latency data updates.

The overall working of Insightix is represented through the system architecture diagram in Figure **1**, illustrating the flow of data from video acquisition to intelligent analysis, storage, and user interaction.

INSIGHTIX

The system provides a secure user authentication mechanism, allowing authorized users to access the Insightix platform. Upon successful login, users are presented with an interactive dashboard that displays system status, connected cameras, and real-time analytics summaries as shown in Figure **2**.

Insightix stores analytical data for historical review, allowing users to analyze past trends, events, and activity patterns through graphical reports and visual summaries as shown in Figure **3**.

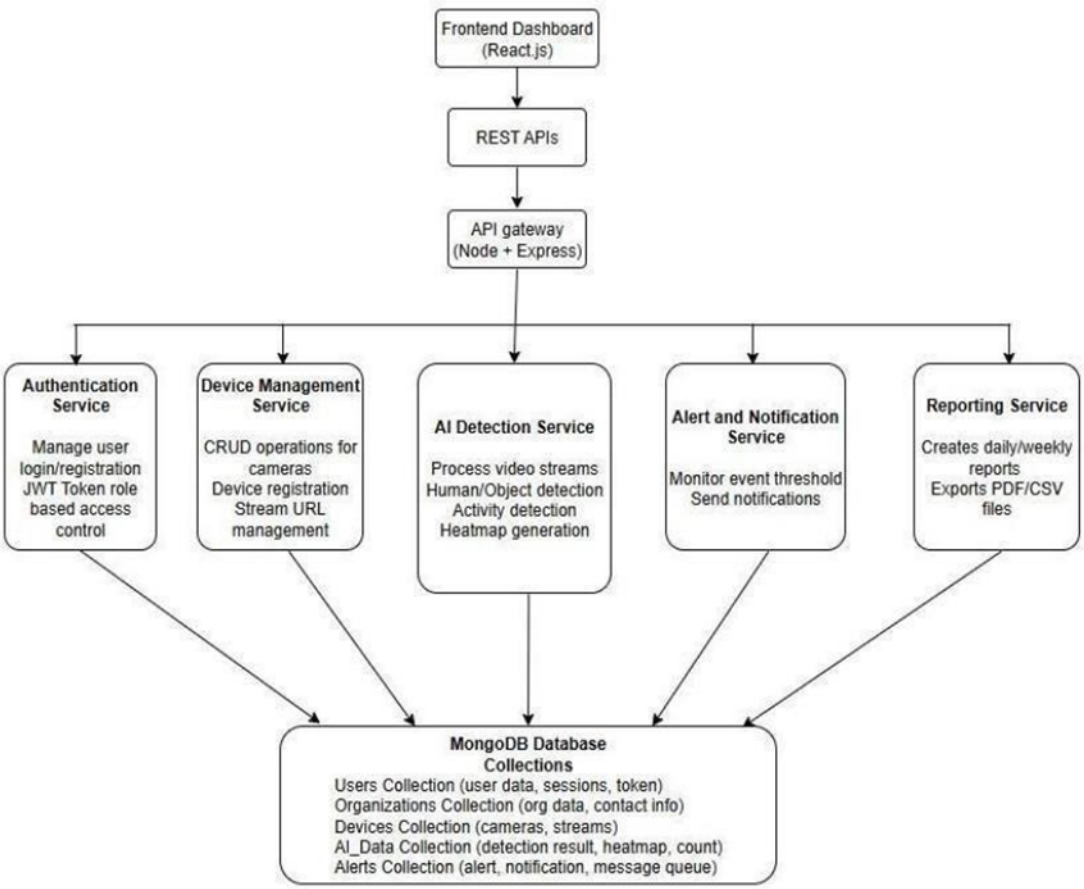

Figure 1. System architecture diagram.

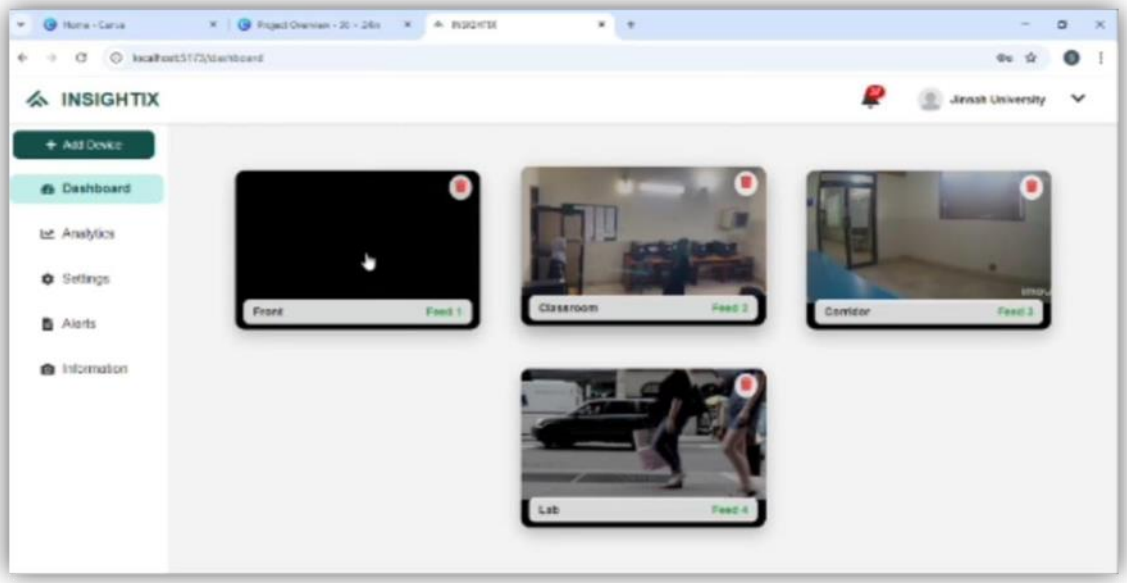

Figure 2. Dashboard home screen.

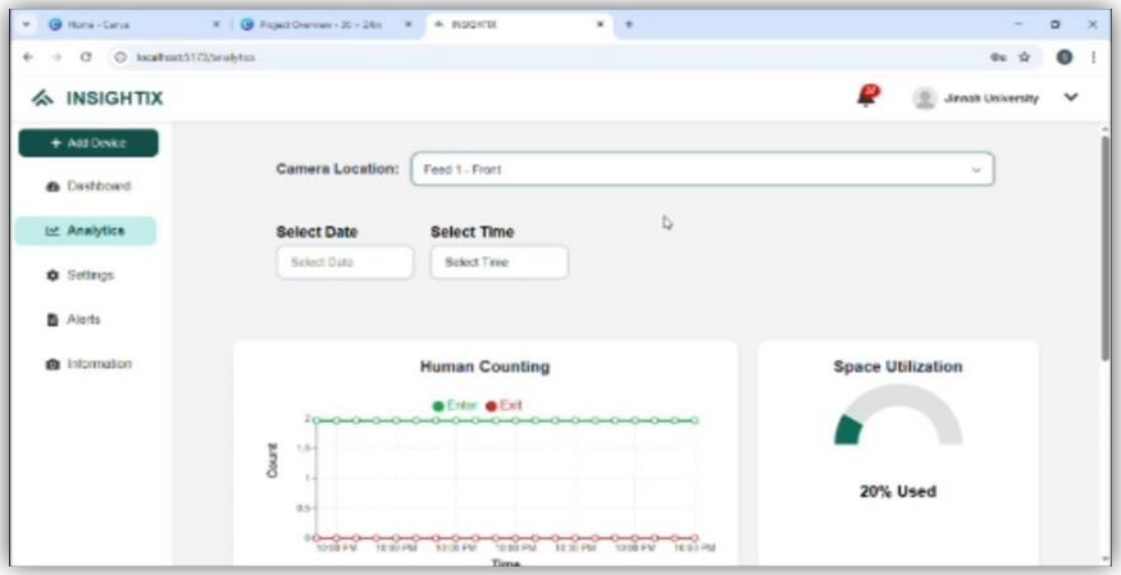

Figure 3. Analytics dashboard.

CONCLUSION

Insightix proves the capability and implementation feasibility of artificial intelligence and computer vision technologies for the evolution of conventional surveillance into intelligent real-time surveillance. With automation capabilities for detection, analysis, alerting, and visualization, the system improves safety and efficiency as well as data-driven decision-making. Future developments might entail cloud-based implementation for massive surveillance setups, the use of IoT sensors for more meaningful context information, and development for more advanced analytics and predictions. Nonetheless, the system presents a sound and versatile platform for the implementation of intelligent surveillance and the management of a smart environment.

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