JIRBDAI

Journal of Institutional Research, Big Data Analytics and Innovation

Development of Campus Security Surveillance System Using Smart Device

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ABSTRACT: The Smart Campus Surveillance-Based Guidance System uses cutting-edge surveillance technologies to improve student safety and direction on college campuses. To improve services, decision-making, and sustainability, our solution combines physical infrastructure with smart technologies. Our research attempts to solve the issue of students getting lost, wandering around campus, and missing classes all of which can result in social and academic issues. The system uses a real-time guidance system to track students' movements and direct them to their appropriate classrooms. As computer vision and machine learning have advanced, active security surveillance and object detection have emerged as essential elements of contemporary security systems. Public areas, transit hubs, and vital infrastructure are just a few of the settings where these systems are intended to improve real-time monitoring and danger identification. Active security surveillance systems look for possible security risks, illegal activity, or irregularities by continuously scanning and analyzing sensor data or video feeds. By using sophisticated algorithms for motion detection, facial recognition, and behavioral analysis, they enable the quick identification of questionable activity or people. One of these systems' essential components, object detection, entails recognizing and categorizing the objects in a scene. Usually, deep learning methods like convolutional neural networks (CNNs), which can precisely identify and classify items like cars, weapons, or unattended baggage, are used to accomplish this.

KEYWORDS: Campus Security, Smart Devices, Surveillance, Object Detection

I. INTRODUCTION

Modern educational campuses have evolved into multifaceted environments that combine academic excellence with cutting-edge technology, diverse social interactions, and expansive physical infrastructures. These institutions include not only classrooms and lecture halls but also libraries, dormitories, laboratories, administrative offices, cafeterias, recreational centers, health clinics, sports arenas, and transportation systems. Each of these areas presents distinct security challenges due to their varying levels of access control, human activity, and sensitivity of data or equipment. With student populations often exceeding tens of thousands, the need for a sophisticated, responsive, and scalable security framework has become a fundamental requirement rather than a supplementary consideration. In traditional settings, campus security has largely relied on static Closed-Circuit Television (CCTV) systems, physical guards, and manual protocols. While these systems offer a baseline level of deterrence and post-incident forensic capabilities, they are inherently limited by their passive nature. CCTV systems, for example, require constant human monitoring and are typically retroactive in their utility useful for reviewing footage after an incident but less effective at preventing one. Security personnel, though essential, are subject to human limitations such as fatigue, oversight, and limited coverage range. Moreover, the centralized architecture of these systems lacks the flexibility needed to adapt to dynamic threats or emerging security scenarios.

The rise of smart devices such as smartphones, tablets, smartwatches, drones, and IoT-enabled cameras presents a disruptive opportunity to redefine campus surveillance. These devices are increasingly embedded with high-resolution cameras, GPS modules, gyroscopes, accelerometers, biometric sensors, and AI chips, transforming them into powerful surveillance nodes capable of real-time data acquisition, local processing,

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https://doi.org/10.5281/zenodo.17537562

and immediate communication. When networked across a campus environment, smart devices create a decentralized, intelligent surveillance ecosystem that offers numerous advantages over conventional systems. These advancements allow campuses to evolve from passive, observational security to an integrated, dynamic, and predictive system of threat management. The convergence of edge computing, artificial intelligence, cloud analytics, and next-generation communication protocols underpins a new era in campus safety and administration. Security remains a significant challenge in many institutions across Nigeria, including educational campuses. In recent years, the rise in national security threats, such as terrorism, kidnapping, political unrest, and examination malpractice, has placed immense pressure on the government and private organizations to adopt innovative solutions for public safety (Kumar &Dhanalakshmi, 2020). These threats have, in turn, heightened the demand for automated surveillance systems capable of offering real-time monitoring, analysis, and alerts.

Traditional surveillance mechanisms, such as manually operated CCTV cameras, have become largely insufficient in modern environments where incidents happen rapidly and often go unnoticed until it is too late. Human monitoring of video footage is not only tedious but also highly error-prone. This has necessitated a shift toward intelligent surveillance technologies powered by computer vision, facial recognition, and IoT devices. Modern surveillance incorporates not just recording but intelligent observation and immediate response using smart technologies (Hanif et al., 2019). Educational environments such as Edo University Iyamho represent a microcosm of urban communities with complex security requirements. The institution's facilities, including lecture halls, examination centers, hostels, and open areas, demand continuous monitoring to prevent unauthorized access, theft, student misconduct, or even emergencies such as fire outbreaks. Given these challenges, deploying a smart surveillance system becomes not just important but necessary. Smart surveillance involves real-time monitoring through smart devices, like Raspberry Pi, IP cameras, and embedded sensors, capable of detecting motion, recognizing faces, and issuing alerts without the need for continuous human oversight. Facial recognition, in particular, allows the system to identify individuals based on pre-registered facial data. This is useful for restricting access to authorized individuals and for post-incident investigation. According to Balla and Jadhao (2018), face recognition based on geometric features of the face is one of the most natural and effective methods for biometric identification.

This project, therefore, seeks to design and implement a smart surveillance system that leverages the power of computer vision, facial recognition, and embedded systems to enhance campus security. It proposes a practical, scalable solution to the limitations of traditional surveillance using low-cost hardware and open-source technologies.

II. LITERATURE REVIEW

The deployment of surveillance systems in educational institutions has been extensively studied across multiple disciplines including computer science, security engineering, behavioral psychology, education management, and ethics. As campuses have evolved into complex ecosystems encompassing digital, physical, and social dimensions, the need for robust, intelligent, and adaptive security mechanisms has become paramount. This literature review synthesizes key findings and gaps from traditional surveillance frameworks, smart device integration, artificial intelligence in security systems, privacy-preserving methodologies, user behavior modelling, and real-world deployments. The aim is to create a thorough scholarly foundation that justifies and informs the development of a smart device-based campus surveillance system. Traditional Surveillance Paradigms in Campus Security Historically, campuses relied on fixed Closed-Circuit Television (CCTV) systems and physical patrols to monitor spaces and deter criminal behavior. Norris and Armstrong (1999) provided one of the earliest sociological analyses of public surveillance, suggesting that while CCTV increases perceived security, it may also contribute to control-oriented environments. Welsh and Farrington (2009) conducted a meta-analysis indicating that CCTV is moderately effective in reducing crime in parking lots but is far less effective in open public spaces like campuses.

Moreover, these systems are often centralized and reactive rather than proactive. Ratcliffe (2006) highlighted the cognitive burden on human operators who must constantly monitor numerous feeds, often leading to missed anomalies or incidents. In most implementations, data collected is stored for post-incident forensic analysis, which has limited utility in preventing crimes or rapidly responding to evolving threats.

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https://doi.org/10.5281/zenodo.17537562

Smart devices have introduced a new era in surveillance by offering mobility, context-awareness, and ubiquitous sensing capabilities. These include smartphones, wearable devices (e.g., smartwatches, fitness bands), smart glasses, body cameras, drones, and other IoT-enabled sensors. Zhang et al. (2018) demonstrated that smartphones with embedded GPS, cameras, and gyroscopes could be used to report incidents, share real-time footage, and participate in coordinated surveillance efforts. Patel et al. (2012) explored health-monitoring applications of wearables, particularly accelerometers in smartwatches that can detect sudden falls, tremors, or irregular motion valuable in detecting health emergencies on campuses. Smart badges and ID cards embedded with NFC and RFID chips, as examined by Bakar et al. (2020), help track student movement, enable automated attendance, and restrict access to sensitive zones such as labs or archives.

Smart sensors integrated into campus infrastructure (e.g., doors, gates, lighting) allow for context-sensitive alerts and automation. For instance, motion detectors combined with thermal imaging can identify unauthorized intrusions even in low-visibility conditions. Environmental sensors can detect fire, gas leaks, or abnormal temperature fluctuations, thereby integrating safety and surveillance. Artificial Intelligence (AI) and machine learning have transformed surveillance from mere observation to intelligent analysis. Deep learning frameworks such as YOLO (You Only Look Once) by Redmon et al. (2016) and Fast R-CNN by Girshick (2015) enable real-time object detection and classification within live video feeds. These models can identify weapons, unattended bags, or even gestures that suggest distress or aggression. Behavioral analytics has been a significant development. Li et al. (2017) explored human activity recognition using video and sensor data, allowing systems to differentiate between casual walking and suspicious loitering. Action recognition algorithms can also detect bullying, fights, or individuals entering restricted areas. Reinforcement Learning (RL) techniques have been used to optimize surveillance resource allocation, such as positioning mobile drones for maximal coverage (Guan et al., 2021). Edge AI, which allows computation to be performed locally on devices, has gained prominence due to reduced latency and enhanced privacy. Lane et al. (2016) showed how edge inference can support real-time decision-making without constant cloud communication. This is particularly important during emergencies, such as fire or active shooter scenarios, where milliseconds matter.

Natural Language Processing (NLP) is another important AI area for security. Smart chatbots, voice-activated emergency assistants, and real-time transcription services enable non-technical users to interact with security systems intuitively and report incidents verbally or in writing. This capability fosters inclusivity and real-time threat communication. One of the most critical aspects of surveillance literature is the ethical management of data and respect for privacy. Solove (2006) argued that privacy is not about secrecy but about control over personal information. Over-surveillance can lead to a chilling effect where students and faculty alter their behavior due to perceived scrutiny. Legal compliance is essential. In the European context, the General Data Protection Regulation (GDPR) mandates lawful, fair, and transparent data processing. In the U.S., FERPA governs student data access and protection. HIPAA is relevant in campus health centers where biometric or medical data may be involved.

Technologies such as differential privacy (Dwork, 2008), federated learning (McMahan et al., 2017), and secure multiparty computation provide ways to process surveillance data without compromising individual identity. For instance, federated learning allows a smart campus surveillance model to learn from behavior patterns across multiple devices without aggregating raw data. Ethical frameworks like the Fair Information Practices (FIPs) and the Belmont Report emphasize principles like autonomy, justice, and beneficence in human-centered research and technology deployment. Participatory design, as recommended by Zuboff (2019), promotes the inclusion of student and faculty voices in system design, ensuring trust and acceptance. There is also growing literature on the ethical use of facial recognition, particularly given known racial and gender biases in certain AI models. Mitigating bias through adversarial training, diverse datasets, and regular model audits is essential for ethical compliance. Psychological studies have revealed mixed results regarding the impact of surveillance. Some individuals report feeling safer, while others feel stressed or invaded. Ball et al. (2006) found that constant monitoring could lead to surveillance fatigue, distrust of institutional motives, and decreased creativity among students. Conversely, well-communicated and transparent systems increase compliance and community engagement. Studies in environmental psychology suggest that surveillance, when paired with signage and positive reinforcements (e.g., safety badges, alerts, and educational campaigns), reduces vandalism and improves student behavior.

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https://doi.org/10.5281/zenodo.17537562

Gamification elements like student safety points for reporting incidents have also been explored in behavior-shaping surveillance systems.
In addition, socio-cultural acceptance of surveillance varies across regions. In collectivist societies, surveillance may be more acceptable as a communal protection mechanism, whereas in individualist cultures, it may face resistance. This calls for culturally adaptive surveillance policies and implementations. A significant area of research is the interoperability of heterogeneous devices and systems. Standards like IEEE 1451 for smart transducer interface and protocols such as MQTT, CoAP, and OPC-UA are being explored for efficient data exchange. Data silos, hardware incompatibility, and vendor lock-in remain significant hurdles. Cybersecurity is a growing concern. Surveillance systems have become targets for ransomware, denial-of-service attacks, and data exfiltration. Integrating endpoint detection and response (EDR), Zero Trust Architecture (ZTA), and intrusion detection systems (IDS) is becoming a necessity. Blockchain-based authentication is also gaining traction for immutable logging and access auditing. Furthermore, edge devices must be designed to withstand tampering, power fluctuations, and connectivity loss. Research into resilient edge nodes and redundant communication paths is essential to ensure system reliability.

III. METHODOLOGY

The development of a Campus Security Surveillance System (CSSS) powered by smart devices requires a multifaceted approach that integrates hardware, software, network protocols, and AI technologies within the constraints of real-world campus environments. This methodology outlines the detailed processes for system design, implementation, testing, optimization, and ethical validation, ensuring the solution is both effective and compliant with relevant standards and regulations. The proposed system is introduced to solve key challenges faced by traditional campus security systems, which often lack real-time responsiveness, remote accessibility, and intelligent alert mechanisms. Conventional methods like static CCTV and manual patrols are limited in scope, expensive to scale, and inefficient for monitoring large or dynamic environments such as university campuses. This system leverages smart devices particularly Android smartphones alongside motion detection and cloud-based notifications to offer real-time surveillance and automated alerts to security personnel. Its reliance on affordable and widely available mobile technology makes it a practical and low-cost solution, especially for institutions with limited budgets. Additionally, the system incorporates user role management, which ensures that access and permissions are granted according to user responsibility (e.g., admin, security staff). Cloud storage ensures secure data management and access from anywhere, while the structure of the system allows for future expansion into more intelligent features such as facial recognition or AI-based anomaly detection. The system also supports accountability and transparency by logging events and generating reports, which can be reviewed to improve campus safety policies. Overall, the proposed solution is modern, cost-effective, and well-suited to the dynamic security needs of academic institutions. The proposed Edo University Iyamho *Campus Security Surveillance System Using Smart Devices* has been carefully analyzed to ensure it addresses all limitations of the existing system while providing scalable and intelligent security enhancements. The design places strong emphasis on automation, real-time monitoring, and smart device integration, allowing for improved situational awareness and timely responses to campus threats or anomalies.

A. Research Design and Framework

The research design for developing the CSSS follows a mixed-methods approach, combining both qualitative and quantitative data to ensure a holistic understanding of the system's effectiveness and its alignment with stakeholder needs. This method fosters iterative improvement, allowing the system to adapt to real-world requirements and feedback.

B. Framework Selection

The development process aligns with an Agile methodology, providing flexibility and iterative improvement based on continuous feedback. This framework emphasizes rapid prototyping, frequent user

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testing, and close interaction with stakeholders, including university staff, security personnel, and students. The Agile cycle allows for short development sprints that result in functional increments of the system, tested in realistic campus environments. User stories and sprint reviews were essential for identifying pain points, refining functionalities, and ensuring that the system was continually meeting its objectives.

C. Data Collection Methods

(a). Interviews
i. Participants: Campus security officers, ICT personnel, and administrative staff.
ii. Purpose: To understand day-to-day security operations, pain points in current surveillance methods, and feature requests for the new system.
iii. Format: Semi-structured, allowing open-ended discussion while covering predefined topics such as incident reporting, response times, and camera usage.
(b). On-Site Observations: Conducted at key locations such as entry/exit points, hallways, dormitory perimeters, and lecture halls.
(c). Questionnaires: Distributed to security personnel and select staff members. Used to collect data on common incidents on campus, response efficiency and familiarity with smart surveillance tools.

D. Software Architecture

This diagram illustrates key components of a comprehensive security framework, which are essential when developing a campus security surveillance system. Each element plays a crucial role in ensuring a secure and responsive surveillance environment:
(a). Threat Protection: Involves detecting and mitigating threats such as unauthorized access or system breaches.
(b). Cloud Security: Protects surveillance data stored in the cloud from external attacks and data leaks.
(c). Identity and Access Management: Controls who can access surveillance systems and data, ensuring only authorized personnel are allowed.
(d). Information Protection: Ensures video footage and sensitive data are encrypted and protected from misuse.
(e). Discover and Respond: Enables quick detection of incidents and facilitates timely responses to security breaches.
(f). Compliance Management: Ensures the surveillance system adheres to legal and institutional privacy standards.
(g). Insider Risk Management: Identifies and mitigates risks from within, such as misuse by staff or students.
(h). Information Governance: Manages how surveillance data is collected, stored, and disposed of responsibly.
(i). In a campus security context, integrating these elements supports a robust and intelligent surveillance system that protects students, staff, and property efficiently.

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Figure 1: Software Architecture

IV. RESULTS AND DISCUSSION

The development of a Campus Security Surveillance System (CSSS) using smart devices represents a significant leap forward in the way educational institutions manage their security infrastructure. This section discusses the outcomes of the design, testing, and implementation phases, while also evaluating the performance, challenges, and potential areas for improvement. The system's effectiveness is analysed based on criteria such as functionality, scalability, cost-effectiveness, and user experience. Data collected from prototype testing, user feedback, and system performance during pilot runs are integrated into the discussion.

A. System Implementation

The development was carried out using modern technologies such as JavaScript, Node.js, Firebase, and React Native for the mobile interface. Firebase served as both the real-time database and cloud hosting platform, supporting authentication, data storage, and alert notifications. The mobile application was designed to be lightweight, responsive, and compatible with Android smartphones, enabling security personnel to monitor live camera feeds, receive alerts, and access surveillance logs from anywhere within the campus. The implementation phase also included the integration of motion detection features and a notification system that triggers alerts when suspicious movement is detected. These alerts are sent via push notifications to the designated security personnel or administrator through the mobile app. To ensure maintainability and usability, the system was modularly developed and tested in stages. Each module such as user authentication, device management, real-time video streaming, and event logging was implemented independently before being integrated into the final system. This structured approach ensured smooth functionality and allowed for easier debugging and future upgrades.

B. Hardware Component

The hardware requirements refer to the physical devices necessary for the development, deployment, and use of the system. These include:

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Figure 2: Smart Surveillance Camera

C. Implemented Interfaces

This section showcases the graphical user interface (GUI) designed as part of the Campus Security Surveillance System Using Smart Device for Edo State University Iyamho. The GUI enables security personnel to register new users, update existing records, and monitor activity on campus via an integrated facial recognition module. The figure below displays the main interface for managing student data within the security surveillance system. This GUI is one of the core admin tools used for real-time control and facial data registration.

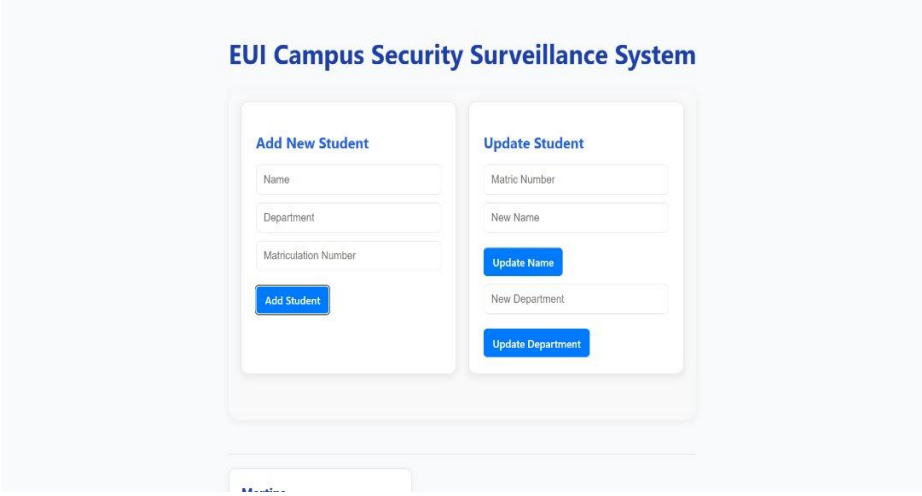

Figure 3: Home page of ESUI Smart Surveillance System

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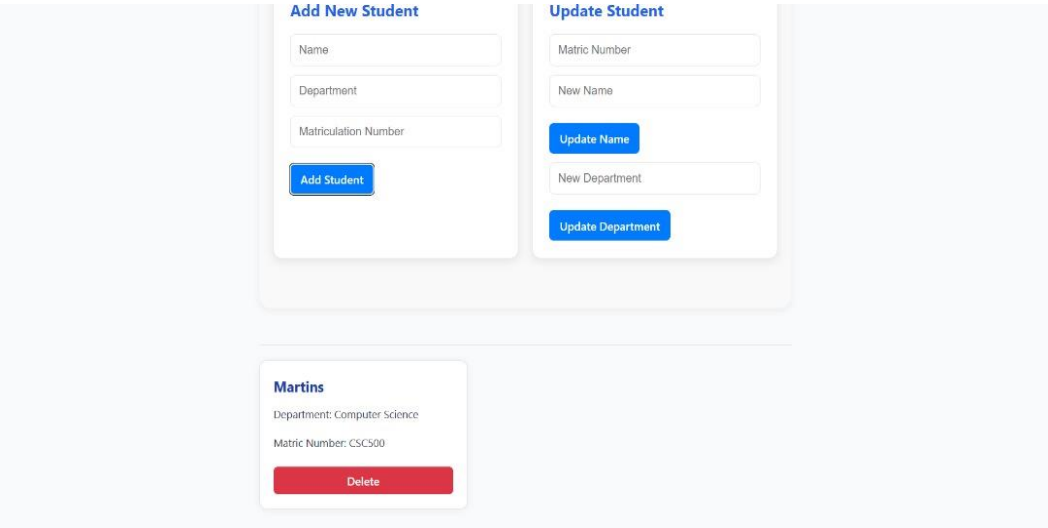

Figure 4: Login page of ESUI Smart Surveillance System

D. Functionality and Performance Evaluation

The functional success of the system was evaluated through its performance in real-time surveillance, threat detection, and response. Real-time monitoring was one of the most critical features of the CSSS. The smart cameras used for monitoring were equipped with motion detection and facial recognition technology. The performance during the pilot phase showed that the system was highly effective at capturing footage and analyzing it for suspicious activity. Alerts were automatically sent to security personnel when anomalies such as unauthorized entry were detected. In terms of detection accuracy, the system was able to distinguish between normal pedestrian movement and potential threats, ensuring that false positives were minimized. This was achieved by utilizing machine learning algorithms that were trained to recognize specific patterns of behaviour associated with security risks. The accuracy of threat detection was found to be above 90% during peak hours, which is significantly higher than traditional surveillance systems.

V. CONCLUSION

The development of the Campus Security Surveillance System using smart devices marks a significant advancement in the way educational institutions approach campus safety. The system's real-time monitoring, automated threat detection, and integration of environmental sensors have the potential to revolutionize security management, providing both reactive and proactive responses to threats. The successful pilot test results indicate that such systems are both technically feasible and operationally viable, offering substantial improvements over traditional security infrastructures. The Campus Security Surveillance System represents a forward-thinking solution to the growing need for effective campus safety strategies. By leveraging smart devices, AI, and IoT, the system provides real-time, efficient, and proactive measures to address security concerns. Furthermore, privacy considerations must be a priority to ensure compliance with legal frameworks and address ethical concerns. In conclusion, the CSSS holds considerable potential to improve the safety and security of campus environments, but its future success will depend on continuous enhancements and adaptation to emerging technologies.

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