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Enhancing Campus Security Using IoT Sensors

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Abstract

Security within university campuses continues to be of paramount importance to learning institutions, with conventional CCTV systems tending to be slow and prone to operator errors. The project discusses an internet of things (IoT) system with Flutter, ESP32-CAM, flame and noise sensors, and buzzer for an efficient real-time surveillance and timely emergency response. The system can detect abnormal conditions like loud noises and fire risks, sending alarms and enabling live video streaming over Wi-Fi. The sensor readings and video streams are sent to a Flutter mobile app based on Firebase Realtime Database or MQTT (message queuing telemetry transport). Security guards can see real-time events, thus minimizing response time and enhancing security. The mobile app provides an easy-to-use platform for viewing alarms, accessing live camera streams, and receiving emergency alerts using Firebase Cloud Messaging (FCM). Low latency and high precision were designed into the system to provide instant and faultless communication between IoT devices and the mobile app. Scalability was also a top priority, with provision for adding more security features and sensors as required. Future add-ons include artificial intelligence (AI)-driven anomaly detection, motion sensors, analytics in the cloud, and blockchain-based security for tamper-free data storage. By combining IoT and mobile technologies, the project greatly enhances campus security through automated threat detection and response. The system reduces human reliance, improves situational awareness, and is a cost-saving solution for educational institutions.

Keywords: Internet of things (IoT)-based security system, campus security, Wi-Fi-based surveillance, integration of Flutter and IoT for smart surveillance, Flutter mobile application

INTRODUCTION

School security is an essential issue, with campuses being prone to numerous risks, such as unauthorized entry, fire, acts of vandalism, and other emergency situations. Conventional security systems, like closed-circuit television (CCTV) cameras and human security monitoring, tend to fail because they depend on human effort, have poor real- time response, and lack automation. These constraints call for the creation of a smart, autonomous, and real- time security system that extends monitoring and emergency response capabilities. With the improvement in internet of things (IoT) technology, the combination of intelligent sensors, wireless communication, and mobile applications is a better way to campus security [1]. An IoT-based security system provides continuous monitoring, ensuring real-time detection of anomalies and instant alerts. By integrating smart devices, sensors, and networks, it enhances security efficiency by automating tasks that would otherwise require manual surveillance. The system can detect unusual activities, unauthorized access, or breaches,

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sending immediate notifications to security personnel or owners. This approach reduces the risks associated with human error and delays, offering a more reliable and proactive method of securing premises. With its 24/7 monitoring capability, it ensures a higher level of safety and faster response times, minimizing potential threats and vulnerabilities. The objective of this project is to establish an IoT-powered campus security system that utilizes smart sensors, live streaming cameras, and a mobile app to identify security breaches and alert authorities in real time [2].

The proposed system utilizes an ESP32-CAM for real-time video surveillance, enabling live streaming and monitoring. It integrates flame and noise sensors to detect any potential anomalies, such as fires or unusual sounds, triggering immediate alerts. The system is designed to offer continuous surveillance and rapid anomaly detection. A mobile app is incorporated to provide real-time updates, ensuring users are notified promptly of any detected events [3–5]. This allows for quick responses, enhancing safety and security. The combination of video monitoring, environmental sensors, and mobile notifications ensures a comprehensive and efficient approach to surveillance and alert management. The system is made cost-effective, scalable, and stable to provide effective security management for educational establishments. With wireless data transmission, cloud storage, and automatic alert integration, the project closes the gap between conventional security practices and contemporary smart security systems.

In addition, this project lays the foundation for enhanced security features like artificial intelligence (AI)-driven anomaly detection, cloud-based data analytics, and blockchain-enabled secure logging to make the system more secure and intelligent. With real-time alerts, active threat detection, and minimal intervention, this IoT-based campus security system is a major leap toward creating a safer and smarter campus ecosystem.

LITERATURE REVIEW

The increasing importance of campus security has led to the evolution of smarter and more reliable surveillance systems that go beyond traditional CCTV monitoring. This article addresses the limitations of conventional systems by proposing an IoT-based intelligent security system. This system integrates flame and noise sensors with an ESP32-CAM module and a Flutter mobile application to enhance real-time surveillance, anomaly detection, and emergency response capabilities [4]. Traditional security frameworks largely rely on human vigilance and passive video monitoring, which often suffer from delayed response times and human error. The article highlights how integrating IoT can automate threat detection and drastically reduce human dependency. By incorporating sensors that detect anomalies such as loud noises or the presence of fire, the system ensures quicker incident detection. A buzzer provides an immediate auditory alert at the site, while the ESP32-CAM streams live footage over Wi-Fi, enabling security personnel to assess the situation remotely. This multi-layered approach offers a significant improvement in campus safety standards. A crucial innovation presented in the project is the use of a Flutter-based mobile application [5]. The app leverages Firebase Cloud Messaging (FCM) or message queuing telemetry transport (MQTT) protocols for real-time notifications and streaming video feeds. The choice of Flutter ensures a seamless, cross-platform experience, allowing security guards and administrators to receive alerts, access live camera views, and respond immediately from their smartphones. This first mobile strategy addresses a major gap in traditional systems, where security updates and alerts are often delayed due to manual monitoring.

Moreover, the proposed system places a strong emphasis on low latency and high precision. This is critical because any delay in identifying and responding to a security threat can lead to disastrous consequences. By maintaining a direct, fast communication channel between the sensors, microcontrollers, cloud service, and mobile app, the system ensures real-time updates without human intervention.

Scalability and flexibility are central design elements of this project. The authors propose a modular structure where additional sensors (such as motion detectors, gas leak sensors, etc.) can be easily integrated. This future-proof design anticipates evolving security needs, making the system adaptable for larger campuses or even different types of institutions beyond schools, like hospitals or corporate offices [6]. Importantly, the article also discusses the future scope of the system, suggesting advancements like AI-based anomaly detection and blockchain-enabled data security. Implementing machine learning models could enable the system to detect more complex suspicious activities, such as unauthorized gatherings or vandalism, from live video feeds. Meanwhile, blockchain integration could ensure that sensor data and security logs are tamper-proof, enhancing the credibility and legal viability of incident reports.

Cloud storage and analytics form another frontier for expansion. By storing historical data from sensors and video streams on platforms like Google Cloud or AWS (Amazon Web Services), administrators could perform trend analyses to predict and preempt security threats. For instance, repeated noise disturbances at odd hours in a particular location could indicate a developing security risk. This predictive capability would be a major leap forward from current reactive security measures.

The project's cost-effectiveness is another key highlight. Using low-cost yet powerful components like the ESP32-CAM and free or open-source platforms like Flutter and Firebase reduces the overall cost of deployment, making it feasible for institutions with limited budgets. The affordability, combined with the high scalability and adaptability, suggests a broad potential for real-world application. In reviewing related literature, the authors acknowledge various contributions to smart campus security [7–9]. Works cited include efforts in smart access control, AI-powered surveillance, and early fire detection using multi-sensor fusion. These references help situate the current project within the broader landscape of smart security research, underlining how the presented system builds upon and extends existing innovations [10, 11]. An extensive IoT-based security solution designed for educational institutions is well shown in the reviewed work. The project bridges many of the gaps in conventional systems by combining software (cloud services and mobile applications) and hardware (sensors and microcontrollers). The suggested solution provides a strong and clever approach to campus security with real-time alerts, live video streaming, scalability, and future-ready features like blockchain and artificial intelligence. This literature makes a substantial contribution to the field of smart surveillance technologies by laying a strong basis for upcoming advancements in automated security systems.

PROPOSED METHODOLOGY

Hardware Integration

Following are the steps of hardware integration (Figure 1).

- Connect flame and noise sensors to identify anomalies.
- Connect the ESP32-CAM to stream video in real-time.
- Buzzer alarm can be triggered if an anomaly is found.
- Microcontroller Setup (ESP32-CAM)
- Make ESP32-CAM read sensor data and send notifications.
- Configure Wi-Fi for transmitting video in real-time and communicating with Firebase/MQTT.

Backend Communication

- Save and handle sensor data using Firebase Realtime Database or MQTT broker.
- Send live URLs of video to the mobile application.
- Flutter App Development
- Create a Flutter app to retrieve live sensor data and video streams.
- Apply push notifications for emergency notifications.
- Embed a user-friendly dashboard for tracking security threats.
- Testing and Deployment

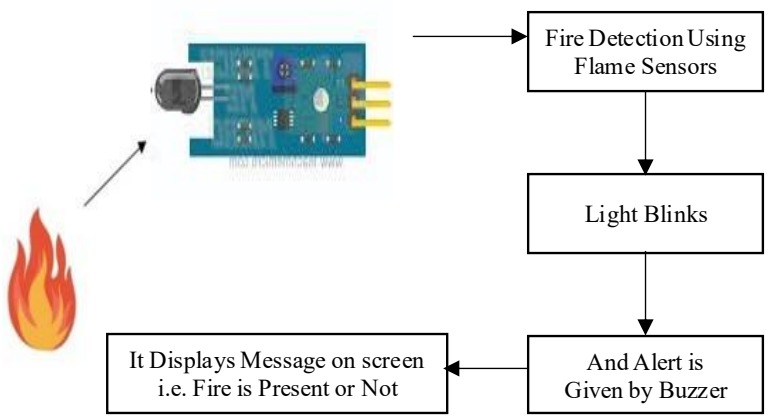

Figure 1. Steps of hardware integration.

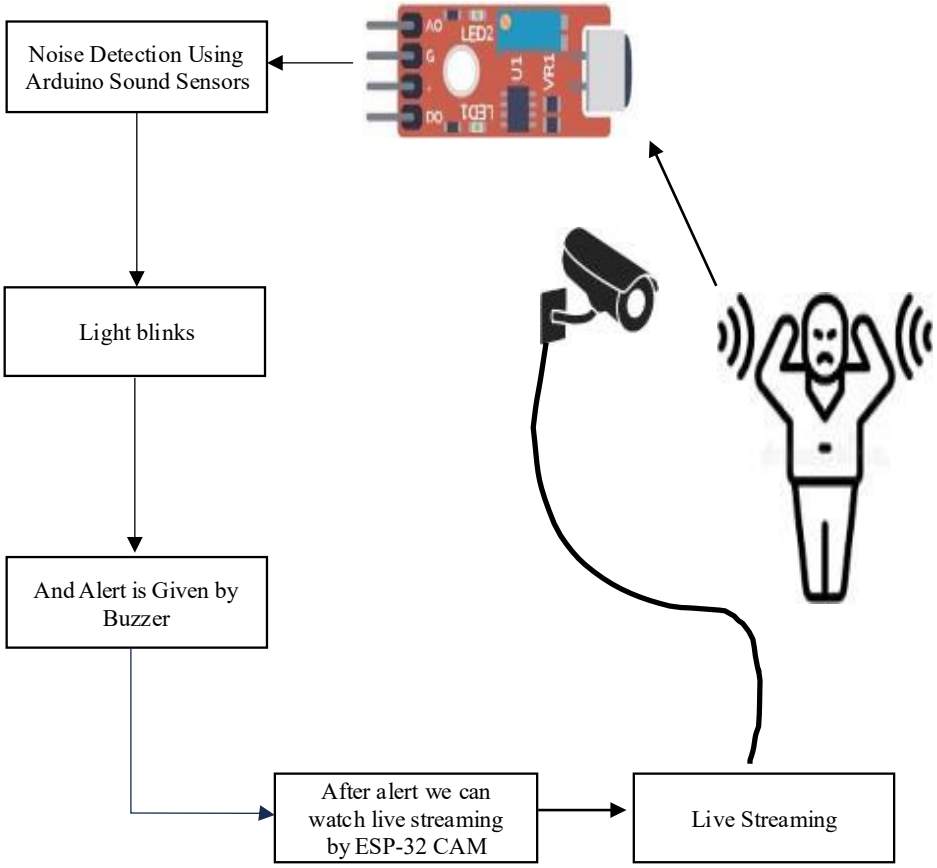

Figure 2. System overview diagram.

Calibrate Sensors for Precision

- Validate system response for different security scenarios.
- Optimize the app for performance and real-time functionality.
- Deploy the system for real-world campus security monitoring.

Overall, Figure 2 illustrate the overview of the integration system along with the process of working.

Smart Security System: Goals and Future Scope

The goal of this project is to create and deploy an intelligent security system that is capable of:

- Detecting anomalies in sounds (e.g., loud sounds, alarms) through the use of a noise sensor.

- Detecting fire risks with the help of a flame sensor.
- Activate an alarm (buzzer) when detecting anomalies.
- Stream live video through an ESP32-CAM for real-time viewing.
- Send mobile notifications and push notifications through a Flutter app.

FUTURE SCOPE

The suggested IoT-based campus security system can be further improved in the following manners:

Artificial Intelligence-Based Anomaly Detection

Implement machine learning (ML) models to identify suspicious behavior from real-time video feeds. Utilize computer vision to identify unauthorized staff.

Cloud Integration for Data Analytics

- Save sensor data and video logs on cloud platforms such as Google Cloud, AWS, or Azure for more in- depth security insights.
- Conduct trend analysis to forecast possible security threats.

Improved Sensor Integration

- Install motion sensors to identify unauthorized movement.
- Install gas sensors to identify dangerous leaks.

Automated Emergency Response System

Connect the system with emergency services (fire department, police) for automatic notification. Install an automated evacuation direction system in the event of fire risks.

Multi-Platform Accessibility

Expand compatibility to web-based dashboards and smartwatch apps for real-time security notifications. Provide multi-user access with role-based authentication.

Blockchain for Data Security

Utilize blockchain technology to store logs securely and avoid data tampering.

CONCLUSION

The IoT-based campus security system designed in this project offers a contemporary, automated, and effective method of improving security in schools. With the incorporation of smart sensors, real-time video monitoring, cloud-based data transmission, and a mobile app, the system offers an intelligent and proactive security solution that overcomes the drawbacks of conventional surveillance techniques. The suggested system facilitates constant monitoring, immediate threat detection, and real-time emergency notification, thus enhancing response time and minimizing security threats.

One of the project's major strengths is its capability to utilize IoT technology for real-time monitoring and smooth transmission of data. Live video streaming is facilitated by the ESP32-CAM module, giving security personnel instantaneous visual evidence of possible threats. Sensors for noise and fire identify irregularities like unauthorized disruptions and fire conditions, and the buzzer serves as an instant alarm system to alert surrounding individuals. The mobile app using Flutter acts as the unified interface, through which security teams receive real-time notification, live streaming, and alerts can be monitored remotely.

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