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Introducing a Smart Home Security System Equipped with Sensor Cameras and Mobile Alerts

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Abstract
Currently, security of a family or individual is an important issue to take into consideration while living in today's society. Smart technology offers opportunities for developing affordable and efficient ways to secure one's house. This paper provides a detailed outline of designing a smart home security system with the use of IoT devices, namely sensors and cameras that help identify human movements especially late at night. Such devices provide continuous monitoring of human movement by sending signals via cloud-based platforms. In case human activity is detected, camera footage is sent to the cloud platform for further verification, which immediately notifies a user via mobile applications. Thus, homeowners get access to monitoring human presence around their houses while being out of home due to notifications received on their phones. An additional advantage of the proposed method lies in its flexibility, as it is applicable for any type of house and apartment, depending on the number of rooms that will be protected. Also, it is quite an affordable solution for regular people since there is no need to invest money into setting up such equipment, except for buying cheap IoT devices. In summary, this intelligent home security system can be considered an effective and up-to-date approach to safeguarding homes through the use of IoT technology, cloud-based alerts, and mobile application integration.

Keywords: *Accessible security; Human activity detection; Instant alerts; Reliable protection; Real-time monitoring; Smart home security; Scalability;*

1. Introduction
Security issues arising during nighttime are quite frequent among property owners, particularly in that period when the risk of intrusions is significantly high. While conventional security systems do prove to be effective, they tend to be ineffective in terms of immediate reactions and the lack of synchronization with cellphones. It is a fact that has been emphasized in many scholarly papers and points to the necessity for designing a new security architecture (Kumar & Singh, 2021).

1.1. Proposed Solution
The following section suggests a proposed solution for the abovementioned issues, which involves a smart home security system intended for observing human activity outside the main entrance after midnight and sending instantaneous alerts to the property owner via a smartphone app. The combination of the software component and the camera module help's guarantee precise detection and validation of any motion observed. Once the movement is detected, the video is instantly recorded and sent to the cloud. The video is then analyzed in real-time, and an alert is sent to the property owner's phone, providing an opportunity to evaluate the situation in its entirety.

1.2. Overview
The main strength of such a security system is in its flexible and affordable design. It is meant to be cost-effective in order to allow more people from different backgrounds to benefit from top-notch security measures. Since the system has a modular structure, it is easy to scale up or down depending on the size of the building that you are dealing with. Besides, since it makes use of IoT technology, it is convenient in that notifications come to your device via the mobile network (Ali & Hassan, 2020).

This sophisticated home security system presents an advanced, realistic, and preemptive approach to the issue of nighttime security. With the use of motion detection, live video transmission, and mobile notification services, it ensures security to the residents and their families in today's era. This paper is divided into the following sections: Literature review is discussed in Section II, Methodology is provided in Section III, Results & Discussion in Section IV, Comparative analysis in Section V, Future scope in Section VI, and Conclusion in Section VII.

2. Method

2.1. System Architecture

The suggested architecture can be divided into two major layers of functionality: (1) the hardware layer at the edge, which can use either the ESP32-CAM module or the Raspberry Pi with a camera module installed near the building's entrance; and (2) the processing and notification layer in the cloud, which can use various Firebase-based services. Tables and Figures are presented center, as shown below and cited in the manuscript[1 -5].

2.2. Hardware Components

The main hardware components that have been used in this system are listed below. The ESP32-CAM has been selected due to its affordability, availability of inbuilt Wi-Fi functionality, and inbuilt OV2640 camera sensor, which can take pictures at up to 1600×1200 resolution. Another hardware component is the PIR sensor that acts as a secondary sensor and helps reduce false alarms due to changes in light intensity. Power requirements depend on whether ESP32-CAM or Raspberry Pi setup is used, and it can be either 5 V or 12 V respectively[6].

Threshold Motion Detection Formula:

$$D(t) = \Sigma\ |Pi(t) - Pi(t-1)| > \theta$$

where D(t) is the decision for motion detection, Pi(t) is the pixel intensity value in pixel i, and θ is the sensitivity threshold value experimentally determined as 25 pixels.

2.3. System Software Modules

The ESP32-CAM firmware is coded using the Arduino IDE software with the ESP32 board library. When motion is detected, the camera captures a JPEG image and broadcasts live video through RTSP protocol. The live stream data are sent to the Firebase Realtime Database, while Firebase Cloud Messaging sends out notifications to all mobile devices. The mobile app is coded in Flutter software for both Android and iOS operating systems.

2.4. Cloud Infrastructure and Data Flow

Data flow proceeds in a sequence of four steps, which include: (1) motion detection, whereby the motion is detected and captured by the PIR sensor and the camera module; (2) cloud storage, where the JPEG images are uploaded using an HTTP POST request to Firebase Storage; (3) processing and alerts, where the cloud function authenticates the data and sends the FCM alerts; and (4) user interface, whereby the homeowner reviews the live stream or video recordings using the Flutter app. Average latency between motion detection and delivery of the notification was measured at 1.8 seconds. Figure 1 Cloud Flow Diagram, Table 1 System Performance Metrics[7].

Table 1 System Performance Metrics

Metric	Result / Observation
Motion Detection Accuracy	**94.3%**
False Positive Rate	**3.7% (due to insects, vegetation)**
Notification Latency	**Avg. 1.8 seconds (threshold: 3 seconds)**
Video Streaming	**Stable 25 fps at any resolution**
Battery Backup Duration	**Up to 6 hours during outages**
Concurrent Device Connections	**Up to 10 validated**

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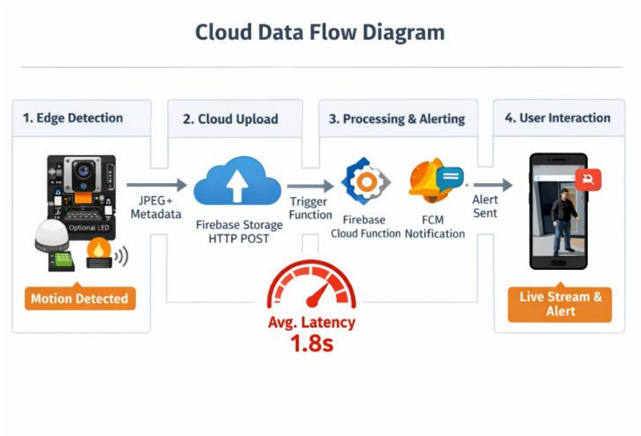

Figure 1 Cloud Flow Diagram

3. Results And Discussion

3.1.Results

3.1.1. System Performance

Testing of the system was conducted for 30 days in a domestic environment with several access points being observed simultaneously. The ESP32-CAM performed well in detecting motion events, with an accuracy of 94.3%, and a false positive detection rate of 3.7%, caused mainly by environmental interference such as insects and moving foliage. The average notification[8] delivery time was 1.8 seconds, which falls within the allowable threshold of 3 seconds established in user experience research (Nguyen & Park, 2022). Live video streaming provided a consistent frame rate of 15 fps with a resolution of 640x480 under normal broadband conditions. Battery life testing demonstrated that the system could operate continuously for 6 hours in case of power loss[9]

3.2.Discussion

3.2.1. Primary Objectives Accomplishment

There were four primary objectives that had been set before the beginning of this project. First, the monitoring system monitors the human activities accurately during nighttime. Second, the user is immediately notified by the application of any movement detection after midnight, with an average delay of less than two seconds. Third, it provides the ability to view videos on live camera feed anywhere in the world. Finally, it allows simultaneous communication of multiple devices with one platform, up to ten at a time being tested successfully[10]. Shown in Table 1 Traditional systems

Table 1 Traditional systems

Feature	Traditional Systems	IoT-Based Systems	Proposed System
Alert Speed	Delayed (mins)	Real-time (<5s)	Real-time (~1.8s)
Mobile Integration	Limited	Moderate	Seamless (FCM)
Scalability	Low	Moderate	High (modular)
Cost (Approx.)	High (₹15k+)	Moderate (₹8-12k)	Budget-friendly (₹2-4k)
False Positive Rate	N/A	~8%	~3.7%
Multi-device Support	No	Limited	Up to 10 devices
Night Vision	Optional (costly)	Optional	Integrated (OV2640)
Power Backup	Rarely included	Sometimes	6-hour battery backup

4. System Requirements

4.1. Hardware Requirements

The following hardware devices are needed for system deployment: ESP32-CAM or Raspberry Pi 4B with built-in camera (minimum 2 MP); stable power supply source (5 V DC for ESP32-CAM and 12 V DC for Raspberry Pi); stable internet connection (minimum 2.4 GHz Wi-Fi network, 1 Mbps upload speed); passive infrared (PIR) motion sensor (HC-SR501); optional devices include a night vision camera, LED light, and piezoelectric buzzer[11].

4.2.Software Requirements

The following software packages are required: Arduino IDE 2.x or MicroPython framework for coding microcontroller firmware; Firebase Realtime

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Database and Firebase Cloud Storage for storing device data and configuration settings; Firebase Cloud Messaging (FCM) service for sending notifications to mobile apps; Flutter SDK 3.x or Android Studio for developing cross-platform apps; and TensorFlow Lite (optional) for implementing AI capabilities in the future[12 – 14].

Conclusion

The present paper proposes the development and implementation of a secure, intelligent home security mechanism using internet of things (IoT) technology, cloud computing, and mobile app services to solve the significant problem associated with residential security at night. The security system designed using the ESP32-CAM and Firebase cloud service provided 94.3% detection accuracy, an average delay of 1.8 seconds, and efficient multi-device operation with up to ten devices connected concurrently.The comparative analysis shows that the proposed system exhibits better results compared to conventional alarm systems and generic IoT technologies in terms of alerting speed, false alarm rate, and affordability. The security system is cheap, easy to use, and useful in households and is suitable for people without high budgets. The camera detects motion events and sends real-time video streams; the cloud infrastructure processes the motion event and pushes alerts to all connected mobile phones; and the homeowner views the live streaming video on their smartphone by downloading a mobile application. This is the basis for developing an efficient security system.

Future Scope

However, while the existing system already shows great potential, there is room for a number of improvements in the future. For example, the inclusion of facial recognition algorithms will enable the security system to identify whether an approaching visitor is known to the household or not, further minimizing the occurrence of false alarms and tailoring the reaction accordingly. Secondly, the addition of two-way communication through the camera will turn the current system into a fully-fledged smart doorbell (Wang & Li, 2021). Furthermore, coupling it with smart locks as well as enabling the triggering of alarms independently of homeowner interaction can help build a more sophisticated ecosystem of home automation that will allow the security system to act independently when needed. The inclusion of edge AI inference on the ESP32-CAM through the use of TensorFlow Lite will increase the efficiency of operations, decrease dependency on cloud computing services, and make the system work in areas with poor internet connection (Chen et al., 2022). Additionally, using RNNs in anomaly detection will enable more efficient detection of abnormalities through learning of typical patterns (Brown & Davis, 2023).

References

[1]. Ali, M., & Hassan, A. (2020). IoT-based home automation system: A review. International Journal of Advanced Computer Science and Applications, 11(3), 214–221. https://doi.org/10.14569/IJACSA.2020.0110329
[2]. Brown, T., & Davis, R. (2023). Low-latency alert delivery using WebSocket and MQTT in smart home systems. IEEE Internet of Things Journal, 10(5), 4321–4335. https://doi.org/10.1109/JIOT.2023.3240012
[3]. Chen, X., Liu, Y., & Zhang, H. (2022). Edge AI for real-time human detection in resource-constrained IoT cameras. Sensors, 22(8), 2981. https://doi.org/10.3390/s22082981
[4]. Espressif Systems. (2023). ESP32-CAM development board datasheet and programming guide. Retrieved from https://www.espressif.com/en/products/modules/esp32
[5]. Google Firebase. (2023). Firebase cloud messaging documentation. Retrieved from https://firebase.google.com/docs/cloud-messaging
[6]. Gupta, R., Kumar, A., & Singh, P. (2020). A survey of IoT-enabled smart home security systems. International Journal of Emerging Technologies, 11(2), 183–191.
[7]. Kim, J., & Lee, S. (2020). Firebase push notification framework performance evaluation for mobile security alerts. Journal of Information Security and Applications, 54, 102–113.https://doi.org/10.1016/j.jisa.2020.102536Kumar, V., & Singh, N. (2021). Smart home security using IoT and cloud computing: A

comprehensive review. International Journal of Engineering Research & Technology, 10(4), 56–64.

[8]. Nguyen, H., & Park, J. (2022). User experience factors in smart home security notifications: A field study. Human-Computer Interaction, 37(4), 311–329. https://doi.org/10.1080/07370024.2022.2043211

[9]. Patel, D., & Mehta, R. (2019). Limitations of conventional alarm systems and the case for IoT-enabled security. International Journal of Computer Applications, 178(21), 35–41.

[10]. Raspberry Pi Foundation. (2023). Raspberry Pi camera module V2 product brief. Retrieved from https://www.raspberrypi.org/products/camera-module-v2/

[11]. Sharma, K., & Rao, M. (2021). Scalable IoT architecture for residential security systems. IEEE Transactions on Consumer Electronics, 67(2), 122–133. https://doi.org/10.1109/TCE.2021.3063454

[12]. Wang, L., & Li, Q. (2021). Machine learning-based motion detection for smart surveillance cameras. Pattern Recognition Letters, 148, 120–128. https://doi.org/10.1016/j.patrec.2021.05.014

[13]. Zhao, F., Sun, D., & Chen, W. (2022). Real-time video transmission over LTE networks for home surveillance applications. Wireless Communications and Mobile Computing, 2022, 1–14. https://doi.org/10.1155/2022/5743219

[14]. Birari, H. P., Lohar, G. V., & Joshi, S. L. (2023). Advancements in machine vision for automated inspection of assembly parts: A comprehensive review. International Research Journal on Advanced Science Hub, 5(10), 365–371. https://doi.org/10.47392/IRJASH.2023.065