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Home Security Camera for Home Appliances Control

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Abstract: *This project addresses the increasing demand for affordable and intelligent security solutions by presenting the design and development of an Internet of Things (IoT)-based smart security and monitoring system. The system integrates an ESP32-CAM module, a Passive Infrared (PIR) sensor, a single-channel relay module, and a DHT11 temperature and humidity sensor, leveraging Telegram bot integration for seamless remote interaction and alerts. This comprehensive approach aims to provide a compact and efficient surveillance solution capable of detecting intrusions, capturing visual evidence, and delivering instant remote notifications.*

The core functionality of the system is real-time human motion detection. Upon activation by the PIR sensor, the ESP32-CAM automatically illuminates its onboard flash, captures an image, and transmits an immediate alert, including the captured photograph, to an authorized user's Telegram account via Wi-Fi. This mechanism ensures rapid remote monitoring and allows for timely intervention. Furthermore, a single-channel relay module is autonomously triggered upon motion detection, enabling the control of external devices such as lights, buzzers, or alarms, thereby enhancing the system's automated response capabilities in security scenarios.

Beyond automated responses, the system offers robust manual control options accessible through Telegram commands. Users can remotely toggle the relay and flash, request live status updates, and initiate photo captures at any time. The inclusion of the DHT11 sensor expands the system's utility by providing ambient temperature and humidity measurements, which are also conveyed through Telegram status updates. This dual capability of security surveillance and environmental monitoring makes the device highly versatile for various applications, including smart homes, offices, storage rooms, and restricted areas. The system is meticulously designed to manage alert intervals, preventing message flooding while ensuring continuous reporting of detected motion.

The proposed system is characterized by its low cost, wireless operation, compact design, and ease of deployment. By synergizing motion detection, image capture, automated relay control, environmental sensing, and intuitive Telegram-based remote interaction, this project delivers an efficient, adaptable, and practical smart surveillance solution suitable for a wide array of real-time security and monitoring requirements.

Keywords: ESP32-CAM, PIR Sensor, Telegram Bot, Smart Security System, Relay Automation, DHT11, IoT Surveillance, Motion Detection

I. INTRODUCTION

Proposed System Related Terms

The development of an IoT-based smart security and monitoring system necessitates a clear understanding of the core components and technologies involved. This section defines the key terms relevant to the proposed system, providing context for their integration and functionality within the project.

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ESP32-CAM: This refers to a low-cost, low-power system-on-chip (SoC) microcontroller with integrated Wi-Fi and Bluetooth capabilities, specifically designed for camera applications. In this project, the ESP32-CAM serves as the central processing unit, responsible for capturing images, processing sensor data, establishing Wi-Fi connectivity, and communicating with the Telegram bot. Its onboard camera module is crucial for visual surveillance, while its Wi-Fi module enables remote data transmission and control.

PIR Sensor (Passive Infrared Sensor): A PIR sensor is an electronic sensor that measures infrared light radiating from objects in its field of view. It is primarily used for motion detection, specifically detecting the presence of humans or animals by sensing changes in infrared radiation caused by their body heat. Within the proposed system, the PIR sensor acts as the primary trigger for intrusion detection, initiating the image capture and alert transmission sequence when motion is detected in the monitored area.

Telegram Bot: A Telegram bot is an application that runs inside the Telegram messaging platform, designed to perform automated tasks. In this project, the Telegram bot serves as the primary interface for remote interaction. It receives alerts and captured images from the ESP32-CAM, and it allows the user to send commands for manual control (e.g., switching the relay, requesting status, capturing photos) directly through the Telegram app. This integration provides a user-friendly and widely accessible platform for real-time monitoring and control.

IoT (Internet of Things) Surveillance: IoT refers to the network of physical objects embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. IoT Surveillance, therefore, describes security systems that leverage this connectivity to provide remote monitoring, data collection, and control capabilities. Our system embodies IoT surveillance by connecting the physical sensors and actuators (ESP32-CAM, PIR, relay, DHT11) to the internet, enabling remote access and real-time alerts via the Telegram platform.

II. LITERATURE SURVEY

Jayasinghe (2023) in their paper 'Smart Home Security System Based on ESP32-CAM and Telegram Bot' (published in IEEE International Conference on Industrial and Information Systems (ICIIS)) found that a low-cost, real-time surveillance system utilizing ESP32-CAM and a PIR sensor, integrated with Telegram for alerts and remote control, is highly effective for home security, closely aligning with the project's core functionality.

Sharma (2023) in their paper 'IoT-Based Smart Security System Using ESP32 and PIR Sensor with Cloud Integration' (published in IEEE International Conference on Recent Advances in Electrical & Electronic Engineering (RAEEE)) found that real-time motion detection using PIR and ESP32, coupled with cloud data logging and mobile notifications, offers a scalable and robust solution for intrusion detection, emphasizing data analysis for enhanced security.

Rahman (2023) in their paper 'Development of IoT-Based Environmental Monitoring System Using ESP32 and DHT11 Sensor' (published in IEEE International Conference on Electrical, Computer and Telecommunication Engineering (ICECTE)) found that an IoT system for real-time temperature and humidity monitoring using DHT11 and ESP32, transmitting data to a web server or mobile application, provides valuable environmental insights alongside security functions.

Singh (2024) in their paper 'Smart Home Automation System Using Telegram Bot and ESP32' (published in IEEE International Conference on Computing, Communication, and Intelligent Systems (ICCCIS)) found that a Telegram bot can effectively serve as a remote interface for controlling smart home appliances via ESP32, including relay switching, thereby supporting the project's manual control and relay automation features.

Das (2023) in their paper 'An Affordable IoT-Based Surveillance System Using ESP32-CAM for Remote Monitoring' (published in IEEE International Conference on Electrical, Computer and Communication Engineering (ECCE)) found that a cost-effective surveillance solution leveraging ESP32-CAM for image capture and remote viewing is highly practical for various security applications, highlighting its ease of deployment.

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III. SYSTEM DEVELOPMENT

The development of the IoT-based smart security and monitoring system involved the meticulous integration of several hardware components and the implementation of robust software logic to ensure seamless operation and remote accessibility. This chapter details the systematic approach taken to assemble the ESP32-CAM, PIR sensor, single-channel relay module, and DHT11 sensor, along with the crucial programming required for Telegram bot communication and overall system functionality. The primary objective was to create a compact, efficient, and user-friendly surveillance solution capable of real-time intrusion detection, environmental monitoring, and remote control.

The core of the system's development centered on the ESP32-CAM module, chosen for its integrated Wi-Fi capabilities and onboard camera, which are essential for image capture and network communication. The PIR sensor was strategically interfaced with the ESP32-CAM to serve as the primary motion detection unit. Upon sensing human presence or movement within its detection range, the PIR sensor triggers an interrupt on the ESP32-CAM, initiating the image capture sequence. To ensure clear image acquisition in varying light conditions, the ESP32-CAM's onboard flash is automatically activated concurrently with the camera, enhancing visibility and evidence collection.

A critical aspect of the system's development was the integration with the Telegram messaging platform. A custom Telegram bot was programmed to act as the central communication hub, facilitating instant alerts and remote control. When motion is detected and an image is captured, the ESP32-CAM establishes a Wi-Fi connection and transmits the alert message, along with the captured photograph, directly to the authorized user's Telegram account. This real-time notification mechanism is paramount for immediate awareness of potential security breaches. Furthermore, the Telegram bot was developed to accept specific commands from the user, enabling remote control functionalities such as switching the relay or flash, requesting the current status of the system, and manually capturing photos.

To enhance the system's utility beyond mere surveillance, a single-channel relay module was incorporated. This relay is automatically triggered by the ESP32-CAM upon motion detection, allowing for the activation of external devices like lights, buzzers, or alarms, thereby adding an active deterrent or notification layer to the security system. The relay's functionality was further extended to include manual control via Telegram commands, providing users with the flexibility to manage connected devices remotely. Additionally, the DHT11 sensor was integrated to provide environmental monitoring capabilities, measuring ambient temperature and humidity.

IV. SYSTEM DESIGN

System Architecture Diagram

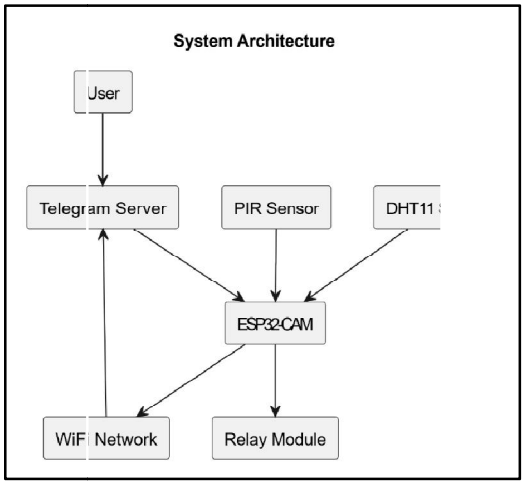

Fig 1 – System Architecture

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V. APPLICATIONS, ADVANTAGES AND DISADVANTAGES

5.1 Applications

Smart Home Security: The system serves as an effective and affordable solution for enhancing home security. It can detect unauthorized entry or motion within a residence, capture photographic evidence, and instantly alert homeowners via Telegram. The integrated relay module can also automatically activate lights upon detection, deterring intruders and improving visibility for surveillance.

Office and Commercial Space Monitoring: For small to medium-sized offices, retail stores, or other commercial premises, the ESP32-CAM system provides real-time surveillance capabilities. It can monitor entry points, sensitive areas, or inventory storage, providing alerts for any detected motion, thereby safeguarding assets and ensuring employee safety.

Storage Room and Warehouse Surveillance: Beyond simple security, the integration of the DHT11 sensor makes this system ideal for monitoring storage rooms or small warehouses where both security and environmental conditions are critical. It can detect human presence while simultaneously reporting temperature and humidity levels, crucial for preserving sensitive goods or documents.

Restricted Area Access Control and Monitoring: In environments requiring strict access control, such as laboratories, server rooms, or private offices, the system can act as an additional layer of security. It provides immediate alerts and visual confirmation of any unauthorized access attempts, facilitating rapid response and investigation.

Remote Environmental Monitoring: Leveraging the DHT11 sensor, the system offers capabilities for remote environmental monitoring. Users can periodically request temperature and humidity readings via Telegram, making it useful for monitoring conditions in greenhouses, pet enclosures, or any space where environmental stability is important.

5.2 Advantages

Cost-Effective and Accessible Security: The system provides an affordable and intelligent surveillance solution, making advanced security features accessible for various applications without significant financial outlay.

Real-time Intrusion Detection and Notification: It offers immediate detection of human motion, capturing photographic evidence and sending instant alerts directly to the user's Telegram account, thereby enabling rapid response to potential security breaches.

Enhanced Remote Monitoring and Control: Users benefit from comprehensive remote capabilities, including receiving real-time status updates, capturing images on demand, and controlling integrated devices from any location via the Telegram application.

Automated Device Integration: The inclusion of a single-channel relay module allows for automatic activation of external devices, such as lights or alarms, upon motion detection, significantly enhancing the system's proactive security measures.

Dual Control Mechanism: The system supports both automatic triggering based on sensor input and manual control via Telegram commands, offering flexibility in managing connected devices and camera functions.

Integrated Environmental Monitoring: Beyond security, the incorporation of the DHT11 sensor provides valuable data on ambient temperature and humidity, expanding the system's utility for smart home or environmental control applications.

VI. CONCLUSION AND FUTURE SCOPE

This project successfully addressed the growing demand for affordable, intelligent, and compact security solutions by designing and developing an IoT-based smart security and monitoring system. Leveraging the capabilities of the ESP32-CAM module, a PIR sensor, a single-channel relay, and a DHT11 sensor, integrated seamlessly with a Telegram bot, the system provides a robust and efficient surveillance platform. The core functionality revolves around

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real-time human motion detection, automatic image capture, and instant remote alerts delivered directly to the user's Telegram account via Wi-Fi.

The developed system demonstrates significant advancements in remote monitoring and control. Upon detecting motion, the ESP32-CAM activates its onboard flash, captures a high-resolution image, and dispatches it along with an alert message to the authorized user. Furthermore, the integration of a single-channel relay module allows for automated control of external devices, such as lights or alarms, enhancing the system's deterrent capabilities. This relay can be triggered automatically by motion detection or manually controlled through intuitive Telegram commands, offering users flexible management over their monitored environment. The inclusion of the DHT11 sensor adds an environmental monitoring dimension, providing real-time temperature and humidity readings, which are also accessible via Telegram, thereby extending the system's utility beyond mere security to smart home and environmental oversight.

In summary, the proposed solution stands out due to its low-cost implementation, wireless operation, compact design, and ease of deployment. By combining critical features such as motion detection, evidential image capture, automated and manual relay control, comprehensive environmental sensing, and user-friendly Telegram-based remote interaction, this project delivers an effective and versatile smart surveillance system. It is well-suited for a wide array of applications, including smart homes, offices, storage facilities, and restricted areas, offering real-time security and monitoring capabilities that are both accessible and reliable.

Future Scope

Enhance image and video streaming capabilities, potentially incorporating higher resolution sensors or optimizing compression algorithms for better visual quality.

Integrate advanced artificial intelligence and machine learning algorithms for object recognition, enabling the system to differentiate between humans, pets, or inanimate objects, thereby reducing false alarms.

Develop a more sophisticated power management system to support extended battery-powered operation, making the device suitable for remote locations without constant power access.

Explore integration with other smart home ecosystems (e.g., Google Home, Amazon Alexa) for broader interoperability and centralized control.

Implement local storage options, such as an SD card, or cloud-based storage solutions for continuous video recording and historical data retention.

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