Intruder Detection and Protection System

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***Abstract*—This paper presents the design and implementation of an Intruder Detection and Protection System utilizing the ESP32-CAM module. The system aims to enhance home security by enabling real-time monitoring and access control. By allowing the homeowner to register known individuals, the system can automatically unlock the door for authorized users while sending alerts with images to the homeowner in case of unauthorized access attempts. This innovative approach leverages computer vision and IoT technology to provide a robust solution for modern home security challenges.**

***Index Terms*—Intruder detection, ESP32-CAM, home security, IoT, access control.**

I. INTRODUCTION

Home security is a significant worry for homeowners, as conventional methods frequently prove insufficient against evolving threats. The fusion of Internet of Things (IoT) and computer vision presents a promising avenue for real-time surveillance and access management. [1] This paper introduces an innovative Intruder Detection and Protection System. This system leverages the ESP32-CAM for real-time facial recognition to identify individuals. Upon detecting unauthorized access, it promptly sends alert notifications to the homeowner. [2] This approach offers a proactive, cost-effective, and intelligent solution to bolster home security and provide timely intervention against potential intrusions.

II. LITERATURE SURVEY

Prior home security research includes motion sensors and standard cameras. Recent progress in facial recognition offers potential for automated access control. [1] This paper expands on existing work by combining facial recognition with IoT for improved security. [2] This integration aims to create a more intelligent and responsive home protection system.

III. METHODOLOGY

A. Components Used

ESP32-CAM: A low-cost camera module with Wi-Fi capabilities.

Relay Module: For controlling the door lock mechanism.

Arduino IDE: For programming the ESP32-CAM.

B. Working Method

The system captures images of the individuals approaching the door.

Registered users are identified through facial recognition.

If a registered user is detected, the door lock is disengaged.

In case of an intruder, an alert message with an image is sent to the homeowner.

IV. SYSTEM DESIGN

At the heart of this system lies the ESP32-CAM, serving as the visual input module, diligently capturing images of its surroundings. These captured images are then fed into the ESP32 microcontroller, which acts as the central processing unit. Here, a sophisticated recognition algorithm analyzes the visual data, making decisions based on pre-defined criteria. Seamless communication is facilitated through a Wi-Fi interface, allowing the system to transmit real-time alerts and notifications to connected devices. The output module comprises a relay, enabling direct control over physical mechanisms such as door locks, and a buzzer, providing immediate audible alerts to nearby individuals. This interconnected architecture allows for autonomous monitoring and response capabilities.

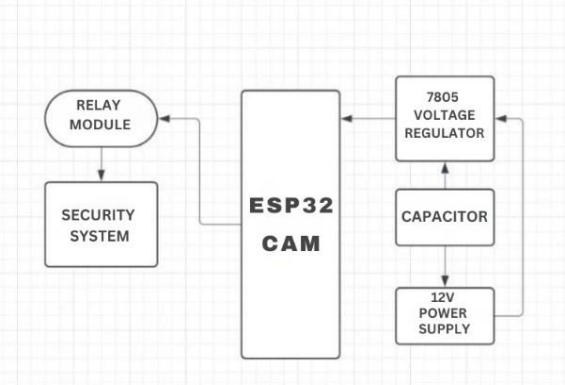

Figure 1: Block diagram of Proposed System

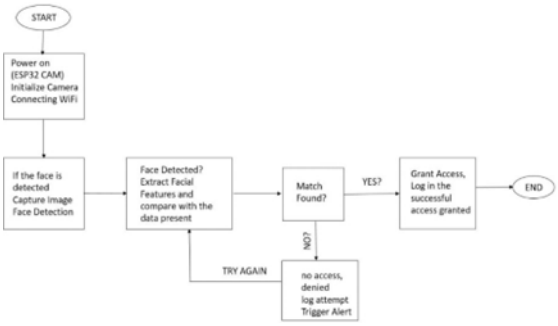

Figure 2: Flow Chart of Proposed System

The system initiates by powering on the ESP32-CAM, initializing the camera, and establishing a Wi-Fi connection. It then continuously checks for face detection. Upon detecting a face, an image is captured, and facial features are extracted and compared against stored data. If a match is found, access is granted, and the successful access is logged before the process ends. If no match is found, access is denied, the failed attempt is logged, an alert is triggered, and the system loops back to try face detection again.

V. IMPLEMENTATION

The process commences with the system booting up, specifically powering on the ESP32-CAM. This crucial first step is followed by the initialization of the camera module, preparing it for image capture. Simultaneously, the system establishes a connection to the local Wi-Fi network, laying the groundwork for subsequent communication and potential remote alerts. Once these initial steps are complete, the system enters a continuous monitoring phase, actively scanning for the presence of a face within its field of view. If a face is detected, the ESP32-CAM captures a still image. Following the image capture, the processing unit springs into action, extracting key facial features from the captured image. These extracted features are then fed into a comparison algorithm, where they are meticulously matched against a pre-existing database of authorized facial data.

VI. ARDUINO IDE AND ESP32 INTEGRATION

The Arduino IDE used in this system is a user-friendly platform for programming microcontrollers like the ESP32, which features built-in Wi-Fi and Bluetooth, making it ideal for IoT applications. To integrate the ESP32 with the Arduino IDE, user must install the IDE, add the ESP32 Board Manager URL, install the ESP32 board package, and select the specific board. Programming involves writing sketches using functions like and uploading code via USB, and utilizing various libraries for enhanced functionality. The Serial Monitor aids in debugging and monitoring application status, facilitating effective development.

VII. ALERT MECHANISM

The intruder detection system's alert mechanism relies on a PIR sensor to detect motion, triggering the ESP32-CAM. Upon detection, the system captures visual data (images or video) and promptly sends real-time alerts to users via mobile apps such as Blynk or messaging platforms like Telegram. To further enhance security, the system can also activate local deterrents like alarms or buzzers, ensuring immediate notification and enabling swift responses to potential intrusions. This multi-layered approach prioritizes timely and effective security alerts.

VIII. SCALABILITY AND MODULARITY

The system is designed with scalability in mind. Additional sensors like motion sensors, environmental sensors and RFID scanner can be integrated without changing the core architecture. Scalability allows the system to expand easily by adding more ESP32-CAM modules or sensors to cover larger areas without significant redesign. The modular structure allows easy

debugging and replacement of faulty components. Also, firmware updates can be made over-the-air using Arduino capabilities.

IX. RESULTS AND DISCUSSION

Testing was conducted in a controlled environment to evaluate the system's performance. The results unequivocally demonstrated the system's ability to accurately identify pre-registered users, seamlessly triggering the door unlocking mechanism. Concurrently, the system exhibited its security capabilities by effectively detecting and flagging unauthorized individuals as intruders, promptly dispatching alerts as designed.

A significant aspect of the evaluation focused on the performance of the integrated facial recognition algorithm. This assessment involved subjecting the algorithm to a range of challenging lighting conditions to simulate real-world variability. The outcomes of these tests were highly encouraging, revealing a consistently high level of accuracy in correctly identifying authorized personnel across different illumination levels. This robustness underscores the algorithm's reliability and suitability for practical deployment. The successful and consistent performance across these critical functionalities confirms the system's potential as a dependable security and access control solution.

Project Model

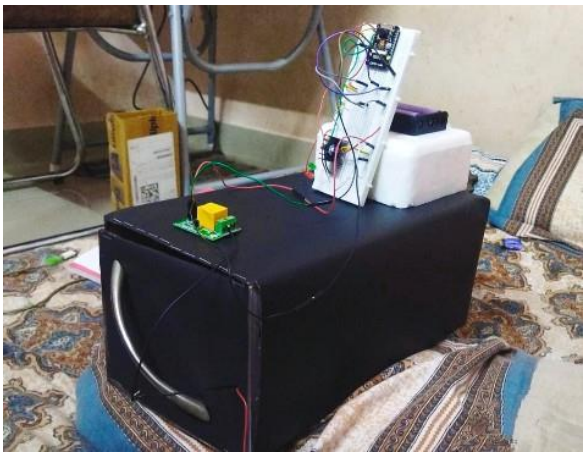

Figure 3: Device Setup

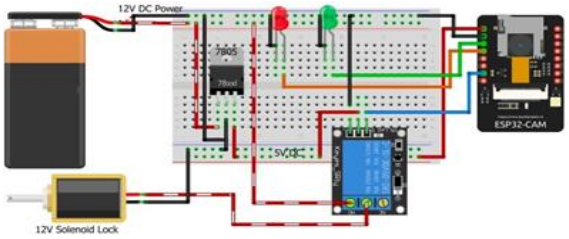

Figure 4: Experimental Simulation

Host Server Simulation

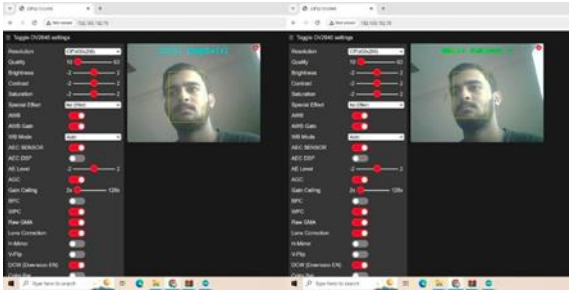

Figure 5: Face Enrollment and Recognition

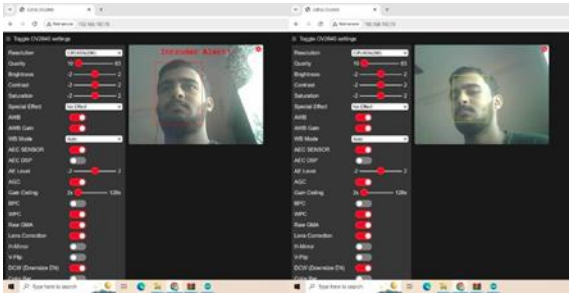

Figure 6: Intruder Alert and Face Detection

X. CONCLUSION

This project aims to develop a face recognition system utilizing the ESP32 CAM module to enhance domestic security. By integrating IOT applications with advanced sensors and a deep neural network (DNN) model, the system effectively performs face detection and recognition while preventing spoofing attempts. This ensures that only authorized individuals can gain access, significantly boosting security measures. The inclusion of Wi-Fi connectivity allows for remote monitoring and control, offering additional convenience and peace of mind for homeowners. The face recognition system not only addresses common security issues but also provides a scalable and user-friendly solution for smart home environments. This project has broad applications, including enhancing security in residential homes, offices, and other private

properties, demonstrating its potential to contribute significantly to the future of smart home technology.

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