Door Unlock System Using Face Recognition

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Abstract: The rising need for enhanced security systems has led to the development of smart door locks utilizing advanced technologies such as face recognition. Traditional locks and keys are susceptible to loss, theft, and unauthorized duplication. In contrast, biometric systems offer a higher level of security by ensuring that only authorized individuals can gain access. This project aims to design and implement a smart door lock system using the ESP32-CAM module for face recognition, providing a robust, secure, and user-friendly solution for home and office security. The system utilizes the ESP32-CAM module for its built-in camera and Wi-Fi capabilities, making it suitable for remote monitoring and control. Programmed using the Arduino IDE and the ESP-WHO library, the project involves setting up the ESP32-CAM, capturing and registering faces, and controlling a relay module for the door lock mechanism. Face recognition is managed via a web server interface for easy user management. The hardware setup includes the ESP32-CAM, an FTDI programmer, a relay module, and a solenoid lock. The system demonstrated high accuracy in identifying registered faces and efficiently controlled the door lock mechanism, with quick response times. The web server interface enabled seamless user management, proving the system's effectiveness and reliability.

Keywords: IDE, Opencv, Face Recognition, relay module and solenoid valve, ESP32 Cam module.

1. INTRODUCTION

Advancements in machine learning and deep learning algorithms have significantly improved facial recognition technology. Early systems depended on basic image processing techniques, which were often inaccurate and susceptible to deception. In contrast, modern systems employ Convolutional Neural Networks (CNNs) and other deep learning architectures to analyze facial features with high precision, enabling them to recognize faces under varying lighting conditions, angles, and changes in appearance, such as glasses or hairstyles. A notable development is the ESP-WHO library by Espressif, which provides an efficient framework for facial recognition on ESP32-based devices. Smart home technologies have transformed security approaches for residential and commercial properties, with facial recognition systems standing out as a crucial innovation. Traditional locks and keys are vulnerable to loss, theft, and unauthorized duplication. Conversely, biometric systems, specifically facial recognition, enhance security by ensuring that only authorized individuals gain access.

This project aims to design and implement a secure door operating system using the ESP32-CAM module for facial recognition. The ESP32-CAM is a cost-effective development board featuring a built-in camera and Wi-Fi capabilities, making it ideal for IoT applications. Its compact size and powerful processing capabilities enable efficient real-time image processing, including facial recognition. By incorporating advanced facial recognition algorithms, the system ensures that only recognized individuals can unlock the door, thus improving security and providing a seamless user experience. The implementation process involves setting up the ESP32-CAM module, programming it using the Arduino IDE, and utilizing the ESP-WHO library for facial recognition. This includes capturing and registering faces, which are then used to control a relay module connected to a door lock mechanism. A web server interface manages the entire system, facilitating easy registration and management of authorized users. The project aims to offer a comprehensive access control solution suitable for both home and office environments. Leveraging the ESP32-CAM and advanced facial recognition technology, this system presents a modern, effective, and user-friendly security approach.

- Develop a facial recognition system that ensures only authorized individuals can access secured areas, reducing the risk of unauthorized entry.
- Implement Convolutional Neural Networks (CNNs) and the ESP-WHO library to achieve high-precision facial recognition, capable of functioning under various conditions and changes in appearance.
- Utilize the ESP32-CAM module for its built-in camera and Wi-Fi features, making it an ideal choice for IoT applications and real-time image processing tasks.
- Design a user-friendly system with a web server interface for easy management, including the registration and deletion of authorized users.

2. PROPOSED SYSTEM

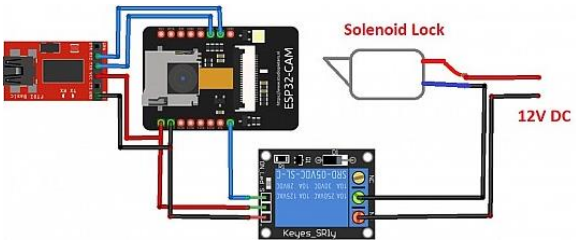

Fig.1: Proposed system

VCC and GND pins of the FTDI board and Relay module are connected to the VCC and GND pins of the ESP32-CAM. This ensures that all components share the same power supply. TX pin of the FTDI board is connected to the RX pin of the ESP32-CAM. RX pin of the FTDI board is connected to the TX pin of the ESP32-CAM. These connections are for serial communication, mainly used for flashing the ESP32-CAM with the program. IN pin of the relay module is connected to IO4 of the ESP32-CAM. This connection allows the ESP32-CAM to control the relay module, switching the solenoid lock on or off. Relay Module is used to switch the solenoid lock. Used to flash the code into the ESP32-CAM as it doesn't have a USB connector. After flashing, the FTDI module is no longer required in the project.

Technical Specification

- ESP32 CAM Module: ESP32-CAM is a low-cost ESP32-based development board with onboard camera, small in size. It is an ideal solution for IoT application, prototypes constructions and DIY projects. The board integrates WiFi, traditional Bluetooth and low power BLE, with 2 high-performance 32-bit LX6 CPUs.

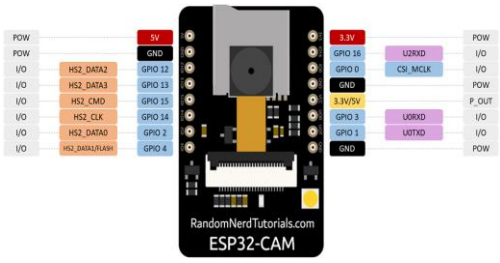

Fig.2: ESP32 cam module

- Solenoid Lock: It is a small metal constructed lock specially designed for keyless entry of cabinets, drawers and lockers. The bolt is 360 degree reversible and with pull ring for manual override. The Electric Solenoid Cabinet Lock is compatible with any access control system or standalone cabinet locking system. It is energy saving, cost efficient, robust, easy to install and suitable for one or multiple cabinet applications.

Fig.3: Solenoid lock

- Relay Module: This 1 channel relay board operates on 5V. Can be used directly to control 240V power appliance from most of the microcontrollers and other control system circuits. Relay has three connections - Common - C, Normally Open-NO, Normally Closed-NC brought out to 3 pin screw terminals which makes it easy to make and remove connections.

Fig.4: Relay Module

3. RESULT AND DISCUSSION

Open the serial monitor in your IDE (like the Arduino IDE) after flashing the code onto your ESP32-CAM. Ensure the baud rate is set to 115200. The ESP32-CAM will display its local IP address in the serial monitor once it connects to your Wi-Fi network. Copy this IP address and enter it into your web browser to access the ESP32-CAM interface.

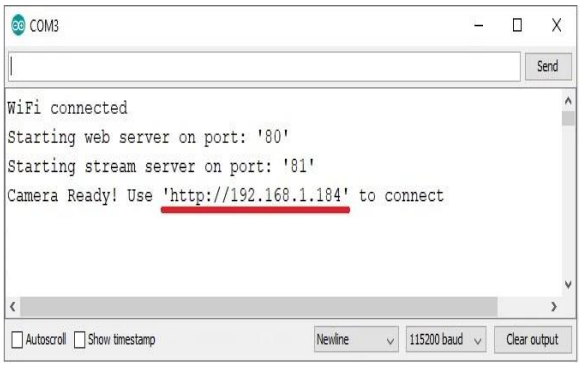

Fig.5: Serial monitor

- Now open the serial monitor to check your local IP.
- Now copy this IP address and enter in the browser to access the esp32 cam.
- Turn on Face Detection and Face Recognition.
- Now click on the Enroll Face button, it will take some time to add your face. once face is added it will identify your face ad subject0 where 0 is the face count, if you will enroll second face then it will identify by subject1.

First, open the serial monitor in your IDE (like the Arduino IDE) after flashing the code onto your ESP32-CAM. Ensure the baud rate is set to 115200. The ESP32-CAM will display its local IP address in the serial monitor once it connects to your Wi-Fi network. Copy this IP address and enter it into your web browser to access the ESP32-CAM interface. In the interface, enable face detection and face recognition. To enroll faces, click the "Enroll Face" button and let the system capture and process your face. Once enrolled, the system will identify your face as subject0, and any additional faces will be identified sequentially (subject1, subject2, etc.). After successful enrollment, the system is ready for use. When the ESP32-CAM detects a recognized face, it sends a signal to the relay, which powers up the solenoid and unlocks the door.

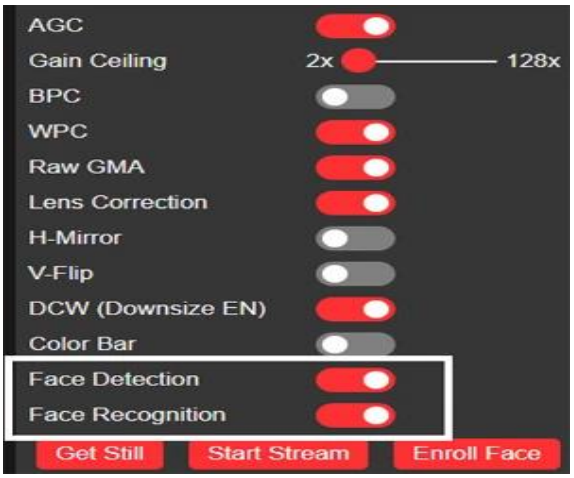

Fig.6: Enroll Face button

4. CONCLUSION

In conclusion, the ESP32-CAM Face Recognition Door Lock System represents a significant advancement in the realm of security and access control. Through the integration of cutting-edge technologies, including the ESP32-CAM module and facial recognition algorithms, this project offers a robust and efficient solution for enhancing the security of door access. The system's ability to accurately identify and authenticate individuals based on facial features not only streamlines the access process but also adds an extra layer of sophistication to traditional door locking mechanisms. The combination of real-time image processing, machine learning, and the versatility of the ESP32-CAM platform ensures a reliable and adaptable solution for various environments. Furthermore, the project's open-source nature encourages collaboration and innovation, allowing developers to further refine and expand its capabilities. The successful implementation of the ESP32-CAM Face Recognition Door Lock System not only addresses security concerns but also showcases the potential of merging IoT devices with artificial intelligence to create intelligent and responsive systems. As technology continues to evolve, projects like this serve as a testament to the transformative power of integrating hardware, software, and machine learning. The ESP32-CAM Face Recognition Door Lock System not only provides a secure access control solution but also paves the way for future advancements in smart home security and automation. In summary, it's important to highlight that the ESP32-

CAM Face Recognition Door Lock System comes with a disclaimer stating that the project team does not take responsibility for any security compromises.

4.1 Advantages

- Enhanced Security: Ensures only authorized individuals can unlock the door.
- Convenience: No need for physical keys or passwords.
- Real-Time Monitoring: Remote access and control via Wi-Fi.
- Cost-Effective: Affordable with the ESP32-CAM module.
- User-Friendly: Easy management through a web server interface.
- Scalable: Easily accommodates multiple users and integrates with smart home systems.
- Open-Source: Encourages collaboration and continuous improvement.

4.2 Applications

- Home Security: Secure residential access.
- Office Access Control: Manage employee and visitor entry.
- Smart Buildings: Integrated with other IoT devices for comprehensive security.
- Sensitive Areas: Access control for restricted zones in labs or data centers.

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