Journal Publication of International Research for Engineering and Management (JOIREM)
Volume: 04 Issue: 7 | July-2026
ISSN (O) 3107-6696

Smart Door Lock System Using Face & Fingerprint Authentication

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Abstract - This paper presents a Smart Door Lock System based on fingerprint and face recognition techniques to enhance security and access control in modern environments. The proposed system utilizes an Android application with an inbuilt fingerprint sensor for fingerprint authentication, while Python OpenCV algorithms are employed for facial recognition. The ESP8266 NodeMCU acts as the central processing and communication unit that receives authentication results from both biometric modules. A relay module interfaced with the ESP8266 controls the electronic door lock powered by a 12V battery supply. The system grants access only when both fingerprint verification and facial recognition are successfully completed, thereby reducing the possibility of unauthorized entry. Unlike conventional lock systems that rely on physical keys or passwords, the proposed approach offers a secure, reliable, and automated access control solution. The developed prototype demonstrates the practical application of IoT and biometric technologies in creating intelligent security systems suitable for homes, offices, laboratories, and other restricted areas.

Keywords: Biometric Authentication, Android Application, Face Recognition, Python OpenCV, ESP8266, Smart Door Lock, Relay Module, IoT Security System.

I. Introduction

In recent years, the need for advanced security mechanisms has increased significantly due to the growing concerns regarding unauthorized access and theft. Traditional lock systems based on mechanical keys are still widely used; however, they suffer from limitations such as key duplication, loss of keys, and lack of monitoring capabilities. Password-based systems also have drawbacks because passwords can be forgotten, shared, or compromised by unauthorized individuals. Therefore, modern security applications increasingly rely on biometric authentication techniques to provide improved protection and user convenience.

Biometric systems identify individuals based on their unique physiological characteristics. Among the various biometric technologies available, fingerprint recognition and facial recognition are commonly adopted because of their accuracy, reliability, and ease of implementation. Fingerprint authentication provides secure identity verification using the distinctive ridge patterns present on human fingers, whereas face recognition identifies users by analyzing facial features through image processing algorithms. The integration of these technologies significantly enhances the overall security of access control systems.

The advancement of embedded systems, IoT technologies, and mobile computing has enabled the development of intelligent security solutions. Modern smartphones equipped with fingerprint sensors can be utilized for secure user authentication through dedicated Android applications. Similarly, computer vision libraries such as OpenCV allow efficient implementation of face recognition systems using standard cameras and Python programming. These technological developments have made biometric security systems more accessible and practical for everyday applications.

The proposed Smart Door Lock System combines fingerprint authentication through an Android application with face recognition using Python OpenCV to establish a dual-layer security mechanism. An ESP8266 NodeMCU serves as the processing and communication unit that controls an electronic door lock through a relay module. The door unlocking operation is performed only when both biometric verifications are successful. This approach improves reliability, minimizes unauthorized access attempts, and provides an efficient security solution suitable for residential and commercial applications.[1][3]

II. Literature Review

Several research articles and existing biometric security systems related to smart door lock automation were studied during the development of this project. Many of the reported systems utilize fingerprint authentication as the primary method of user verification, while others focus on facial recognition techniques for secure access control. Although these systems provide improved protection compared to conventional locking mechanisms, most of them rely on a single biometric feature, which may limit the overall security performance.

Studies involving IoT-based security systems and ESP8266 controllers were reviewed to understand wireless communication, real-time monitoring, and automated control strategies. Existing literature also highlights the importance of mobile applications in enhancing user interaction and providing flexible authentication methods. Android-based biometric applications have demonstrated effective utilization

of inbuilt smartphone fingerprint sensors for secure identity verification.

Research related to face recognition using Python and OpenCV was analyzed to understand image acquisition, feature extraction, and identity matching techniques used in computer vision applications. These systems offer contactless authentication and are increasingly employed in modern surveillance and access control environments. From the literature survey, it was observed that only a limited number of systems combine Android-based fingerprint authentication with OpenCV-based facial recognition within a single framework. Therefore, the proposed Smart Door Lock System integrates both biometric techniques along with ESP8266-based automation and relay-controlled door operation to achieve enhanced security and improved reliability.[2]

III. System Architecture

The proposed Smart Door Lock System is organized into different functional units responsible for biometric authentication and automated door access control. The integration of multiple hardware and software modules ensures secure operation, improved reliability, and efficient user authentication.

A. Fingerprint Recognition Unit

The fingerprint authentication unit consists of an Android application that utilizes the smartphone's built-in fingerprint sensor for identity verification. When a user initiates the authentication process, the application verifies the registered fingerprint data available on the device. Successful authentication generates an approval signal, which is transmitted to the ESP8266 through a wireless communication interface. This method eliminates the requirement for an external fingerprint sensor and enhances user convenience while maintaining a high level of security, reliability, and efficient authentication performance in practical applications.

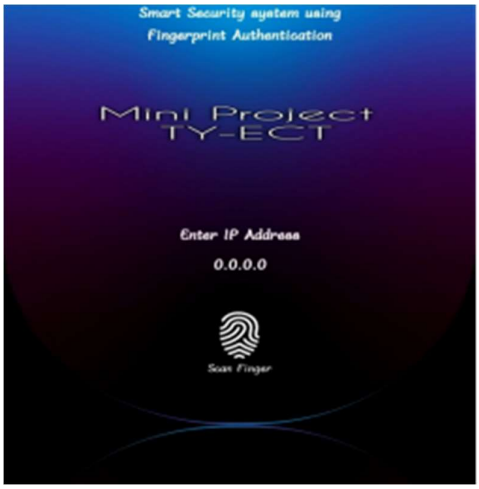

Fig1. Fingerprint Recognition Unit

B. Face Recognition Unit

The face recognition unit employs a camera connected to a computer system running Python OpenCV algorithms. The captured facial image undergoes processing to identify and verify the authorized individual by comparing it with previously stored facial data. OpenCV provides efficient image processing capabilities, enabling accurate and reliable face recognition for smart security applications. This contactless authentication approach further strengthens the access control mechanism of the proposed system.[5]

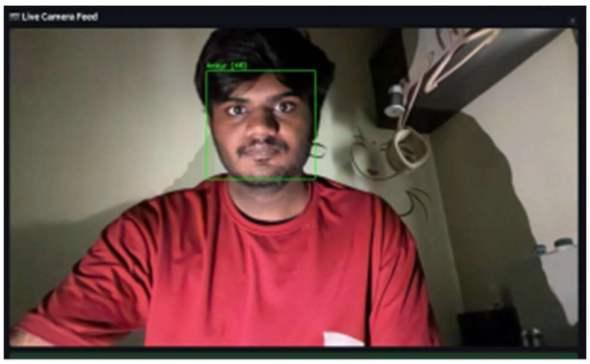

Fig2. Python OpenCV Face Recognition

C. Processing Unit

The ESP8266 NodeMCU functions as the primary processing and communication unit of the system. It receives authentication responses from both the Android application and the face recognition module. Based on predefined security conditions, the controller determines whether access should be granted or denied. The ESP8266 continuously monitors incoming authentication requests and performs decision-making operations to ensure secure door access. Its integrated Wi-Fi capability simplifies communication and supports IoT-based implementation.[8]

D. Actuation Unit

The actuation unit consists of a relay module interfaced with a 12V solenoid door lock powered by a 12V battery supply. The solenoid lock acts as the physical locking mechanism of the system and provides secure door operation through electromagnetic actuation. Based on the authentication results generated by the ESP8266, the relay automatically controls the energization and de-energization of the solenoid lock. When both fingerprint authentication and face recognition are successfully verified, the ESP8266 activates the relay, causing the solenoid lock to retract and unlock the door automatically. In contrast, if either authentication process fails, the relay remains inactive, the solenoid lock stays engaged, and the door continues to remain locked. This automated mechanism ensures dependable operation, improves access control

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efficiency, and contributes to enhanced security and reliability in residential, commercial, and institutional environments.[8]

Fig3. Relay Module And Solonoid Lock

E. User Interface

The user interface of the proposed system consists of an Android application and a Python OpenCV face recognition window for real-time authentication monitoring. The Android application continuously displays important system messages such as **"Place Finger," "Fingerprint Verified," "Scanning Face," "Access Granted,"** and **"Access Denied,"** allowing users to monitor the authentication process easily. The face recognition interface provides a live video feed and displays the recognition status during identity verification. A buzzer can also be integrated into the system to generate warning indications during unauthorized access attempts, thereby improving system safety and reliability. The authentication interfaces help users understand the current operation of the system clearly and enhance overall user interaction. This user interface section makes the proposed system more user-friendly, dependable, and suitable for smart security applications in homes and offices.

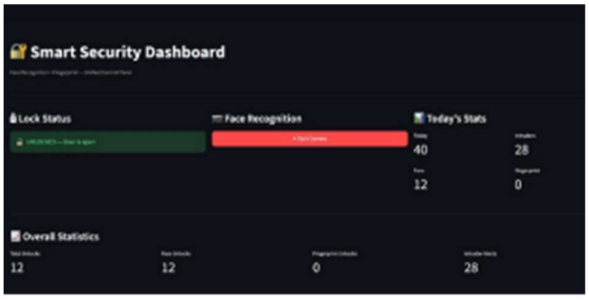

Fig4. User Interface of OpenCV

IV. Methodology

The proposed Smart Door Lock System follows a dual biometric authentication methodology to ensure secure and reliable access control. Initially, the ESP8266 NodeMCU establishes communication with the Android application and the computer system executing the face recognition program. The Android application prompts the user to authenticate using the smartphone's built-in fingerprint sensor. Once the fingerprint is verified successfully, the authentication status is transmitted to the ESP8266 through a wireless interface.

Simultaneously, the camera connected to the computer captures the facial image of the user. The captured image is processed using Python OpenCV algorithms to perform face detection and recognition by comparing the detected facial features with the stored dataset of authorized individuals. The recognition result is then communicated to the ESP8266 controller.

The ESP8266 continuously monitors the authentication responses received from both biometric units. Access is granted only when the fingerprint authentication and face recognition processes are completed successfully. Under this condition, the controller activates the relay module to unlock the electronic door lock. If either of the authentication stages fails, the system denies access and keeps the door in the locked state. This dual verification approach improves security, enhances reliability, and minimizes the possibility of unauthorized entry.[1][2][4][6]

Fig5. System Methodology

V. Implementation

The implementation of the Smart Door Lock System was carried out using IoT and computer vision technologies to develop an efficient biometric access control solution. The hardware configuration consisted of an ESP8266 NodeMCU, relay module, electronic door lock, 12V battery supply, and a computer equipped with a camera. The software components included an Android application for fingerprint authentication and Python OpenCV libraries for face recognition operations.

Initially, the ESP8266 was programmed using the Arduino IDE to establish communication with the authentication modules and control the relay output. The Android application utilized the smartphone's integrated fingerprint sensor to verify the user's identity and transmit the authentication response to the controller. Simultaneously, the Python-based face recognition system captured facial images and processed them using OpenCV algorithms to determine whether the detected individual matched the authorized records.[4]

Upon receiving successful authentication results from both biometric modules, the ESP8266 energized the relay circuit connected to the electronic door lock. The lock was powered using a regulated 12V battery source to ensure stable operation. The entire system was evaluated under different operating conditions to verify the effectiveness of dual authentication, automatic door control, and overall security performance. The developed prototype demonstrated reliable functionality and validated the practical applicability of the proposed smart door lock system for modern security environments.[7][3]

VI. Results & Discussion

1. Fingerprint Authentication
The Android application successfully utilized the smartphone's integrated fingerprint sensor to authenticate registered users. The authentication process provided quick response times and ensured secure verification of authorized individuals.

2. Face Recognition Performance
The Python OpenCV-based face recognition system effectively detected and recognized authorized users under normal operating conditions. The system demonstrated satisfactory accuracy in identifying registered individuals using the stored facial dataset.

3. Automatic Door Control
The ESP8266 NodeMCU successfully processed authentication results received from both biometric modules and controlled the electronic door lock through the relay unit. The door unlocking operation was executed only when both fingerprint and facial authentications were validated successfully.

4. Dual Biometric Security
The integration of fingerprint authentication and face recognition enhanced the overall security of the proposed system. The requirement of dual authentication significantly reduced the possibility of unauthorized access and improved the reliability of the access control mechanism.

5. Smart Security Performance
The complete prototype operated efficiently using the 12V battery-powered locking mechanism and demonstrated stable performance during repeated testing conditions. The developed system provided an effective and practical solution for smart security applications.[7][4]

VII. Future Scope

The proposed Smart Door Lock System can be further enhanced by integrating advanced artificial intelligence and machine learning techniques to improve the accuracy and adaptability of facial recognition algorithms. A dedicated mobile application with additional administrative features can be developed to support remote user management and authentication monitoring.

Future implementations may include cloud-based data storage, real-time notification services, and event logging capabilities for improved security management. The system can also be integrated with smart home ecosystems and voice-controlled assistants to provide enhanced automation and user convenience. Furthermore, the proposed security framework can be deployed in residential buildings, offices, laboratories, and other high-security environments requiring intelligent access control solutions.[3][7]

VIII. Conclusion

The Smart Door Lock System using Android-based fingerprint authentication and Python OpenCV face recognition successfully demonstrates an efficient biometric access control solution. The system effectively combines two independent authentication techniques to establish a secure and reliable mechanism for door access management. The ESP8266 NodeMCU performs the decision-making operation by processing authentication outcomes and controlling the electronic door lock through a relay module.

The developed prototype addresses several limitations associated with conventional lock-and-key systems by introducing intelligent biometric verification methods. The implementation of dual authentication improves protection against unauthorized access while enhancing user convenience and operational efficiency. Overall, proposed system provides a cost-effective, user-friendly, and technologically advanced approach for modern security applications and highlights the significance of integrating IoT and biometric technologies in future smart environments.

IX. References

1. "Smart Door Lock System Using Fingerprint and Face Recognition," International Journal of Engineering Research & Technology (IJERT).)

2. "IoT-Based Smart Security System Using Face Recognition Techniques," IEEE International Conference on Smart Electronics.

3. Vedat Ozan Oner, Developing IoT Projects with ESP8266, Packt Publishing, 2023

4. Adrian Kaehler and Gary Bradski, *Learning OpenCV 4: Computer Vision with Python, O'Reilly Media.

5. Richard Szeliski,Computer Vision: Algorithms and Applications, Springer, 2022

6. https://www.sciencedirect.com/

7. https://www.researchgate.net/

8. https://ieeexplore.ieee.org/