ISSN: 2582 - 6379
Orange Publications
International Journal for Interdisciplinary Sciences and Engineering Applications
IJISEA - An International Peer- Reviewed Journal
2025, Volume 6 Issue 2
www.ijisea.org

Access System for Residential Areas with Face Recognition and Messaging Alerts

S.V.S Jayashyam[1],G. Charan Kumar[2], S. Shaheendra Babu[3], S. Jyothsna Reddy[4], N. Puneeth[5], M. Vishnu Kumar[6]
Associate Professor[1],UG Student[2,3,,4,5,6]
Department of Electronics and Communication Engineering
Sri Venkateswara College of Engineering, Tirupati.

jayashyam.s@svcolleges.edu.in ; charangrande@gmail.com ; babjisalemula@gmail.com ; jyothsnaseviredy@gmail.com ; puneethnarajala@gmail.com ; kumarvishnu20945@gmail.com

ABSTRACT

This paper introduces a truly useful smart access control system, carefully and mindfully designed to improve residential security considerably through facial recognition and immediate, real-time messaging alerts. The system integrates an ESP32 microcontroller, a USB camera, a PIR sensor, an I2C LCD, a buzzer, an L293D motor driver, and a DC motor.These components work together to detect movement, recognize faces, and open or close the gate automatically. When a recognized face is detected, the gate opens automatically, allowing authorized users to enter. If an unrecognized person tries to enter, the system denies access, activates a buzzer, and sends an instant alert via Telegram for immediate action. The system is developed using Arduino IDE, Python, Embedded C, ensuring smooth operation and automation. It reduces the needs for manual security checks and minimizes errors and provides a fast, hands-free, and secure solution.

Key words: ESP32, Face Recognition, Access Control, Sensors, Telegram, IOT, Security System.

Abbreviations:ESP32,Espressif Systems 32-bit Microcontroller, DC, Direct Current, IOT, Internet of Things, RFID, Radio frequency Identification, I2C, Inter-Integrated Circuit, IDE, Integrated Development Environment, PIR, Passive Infrared Sensor.

I.INTRODUCTION

In an era where security threats continue to evolve, modern residential access systems must integrate advanced technologies to ensure enhanced safety and convenience. Innovations such as biometric authentication, IoT-based smart locks, and AI-driven surveillance play a crucial role in strengthening home security, offering real-time monitoring and remote access control for homeowners.

Security in residential areas is essential to prevent unauthorized access,theft,and other threats. Traditional security methods like keys, passwords, and RFID cards are commonly used but have limitations, such as the risk of loss, theft, or unauthorized sharing. The biometric security systems have gained popularity as

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they provide enhanced security. Face recognition is one of the most effective biometric methods because it offers contactless and accurate authentication.

This research proposes a smart access control systemusinganESP32microcontroller,aUSB web camera, and Python-based AI algorithms to recognize faces. APIR sensor detects movement, activating the camera to capture facial data. If the detected face is authorized, the system grants access by activating a DC motor through an L293D motor driver. If the person is unauthorized, a buzzer sounds an alert, and a notification is sent via the ESP32 module to the home owner's mobile device. By integrating real-time face recognition, messaging alerts, and hardware components like an I2C LCD, PIR sensor, and motorized locking system, this project ensures a more secure and efficient access control system for residential areas. By replacing conventional access systems with advanced biometric authentication, this solution enhances security while keeping up with modern technological advancements.

II.RELATED WORK

Security systems have improved over time, moving from simple locks and keys to digital access control methods. Traditional methods like passwords, PIN codes, and RFID cards are still used, but they pose security risks such as theft, loss, or hacking [1]. Biometric security provides better access control by using unique physical features like fingerprints, retina scans, and face recognition, reducing the risk of unauthorized entry [2].

Face recognition is highly effective because it is contactless, fast, and capable of identifying individuals even from a distance or under varying lighting conditions [3]. AI and deep learning have significantly enhanced face recognition accuracy, enabling detection even when a person is at an angle or wearing minor disguises [4].

The ESP32 microcontroller is widely used in smart security systems due to its built-in Wi-Fi, Bluetooth, and low power consumption [5]. PIR sensors detect movement and activate cameras or security systems, making them essential for smart residential access control [6]. USB webcams capture clear images for AI-based face recognition, ensuring accurate verification of individuals [7].

Messaging alerts provide real-time notifications to homeowners about security breaches, allowing immediate action against unauthorized access attempts [8]. Motorized locks, using DC motors and L293D drivers, enable automatic door control, improving both convenience and security [9]. I2C LCD displays show the security status, giving users real-time feedback on access control [10].

AI-powered security systems automate monitoring, reducing human effort and improving response time to threats [11]. While many studies focus on biometric authentication, they often do not integrate real-time alerts and smart locks into a single system [12]. This research combines AI-based face recognition, messaging alerts, and automated locking, enhancing security for residential access control [13].

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III.PROPOSED METHOD

The proposed system introduces a smart access control mechanism for residential areas using face recognition technology, real-time messaging alerts, and IoT integration. Designed to enhance security, it ensures efficient monitoring and seamless access management. The system uses an ESP32 microcontroller as the central processing unit, with a USB camera capturing images for real-time face recognition using Python and OpenCV. Upon successful recognition, access is granted, and a notification is sent to residents and security personnel via a Telegram bot.

In cases of unauthorized access, an alert is triggered, and the captured image is immediately shared. The primary components include an ESP32 microcontroller, USB camera, PIR sensor for motion detection, I2C LCD for status display, and a buzzer for alerts. The face recognition process is executed using a pre-trained model to ensure accurate identification. Real-time alerts are transmitted through the Telegram bot, providing instant notifications to relevant individuals. Additionally, all access attempts are logged for future analysis.

This proposed method enhances security through accurate face recognition, provides real-time monitoring, and reduces reliance on physical keys or access cards. Its user-friendly design, cost-effectiveness, and scalability make it an ideal solution for residential access management. Future enhancements may include multi-factor authentication, AI-based threat detection, and integration with broader smart home ecosystems.

The applications of this system are extensive and adaptable to various environments requiring secure access management. In residential areas, it ensures seamless access for homeowners while providing real-time notifications in case of unauthorized access. In office buildings, the system enhances security by granting entry only to authorized personnel, minimizing the need for physical keys or access cards. Educational institutions can implement this system to efficiently monitor and manage staff, students, and visitors. Industrial facilities can utilize it to regulate employee access to restricted zones, preventing unauthorized entry.

Additionally, healthcare facilities and government offices can benefit from its real-time monitoring and alert capabilities, ensuring the safety of sensitive areas. Its integration with IoT further supports scalability, making it suitable for smart city applications and large-scale infrastructure projects. With the potential for multi-factor authentication and AI-based threat detection, the system offers a robust and reliable security solution across various sectors.

Components Used in the System:

A. ESP32 Microcontroller : The ESP32 acts as the brain of the system. It is responsible for receiving data from sensors, processing information, and controlling other components. It ensures the smooth and efficient functioning of the entire setup.

B. USB Camera : The USB camera captures real-time images of individuals at the entrance. These images are processed using a face recognition algorithm to identify the person attempting access.

C. PIR Sensor (Passive Infrared Sensor) : This sensor detects motion when someone approaches the entrance. It serves as a trigger to activate the camera and initiate the face recognition process.

D. I2C LCD Display : The I2C LCD provides visual feedback to the user by displaying messages such as “Access Granted” or “Access Denied.” It also shows system status information for easy monitoring.

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E. Buzzer : The buzzer generates audio alerts to indicate important events like successful authentication, denied access, or system errors. It enhances the alert mechanism of the system.

F. Power Supply : A stable and reliable power supply ensures uninterrupted operation of the microcontroller, camera, sensors, and other system components.

G. Motor Driver (e.g., L293D) : The motor driver regulates the voltage and current supplied to the DC motor. It converts low-power control signals from the ESP32 into higher-power outputs required to operate the motor.

H. DC Motor : The DC motor performs mechanical actions such as opening doors, rotating the camera, or moving locks. It is controlled via the motor driver to ensure precise movement.

I. Telegram and Email Notification System : The system sends real-time notifications via Telegram and email. In case of unauthorized access attempts, it captures the image and immediately shares it with the homeowner or security personnel for prompt action.

IV.RESULTS & DISCUSSIONS

Figure 2 shows a face recognition-based access control system integrated with a smart phone. The setup includes a webcam for capturing facial images, a microcontroller for processing, and an LCD screen for displaying access status. A motor—likely representing a door lock—is connected to the system. Notifications about access attempts are sent to a mobile app, providing real-time updates and remote control. This setup enhances security for both residential and commercial use.

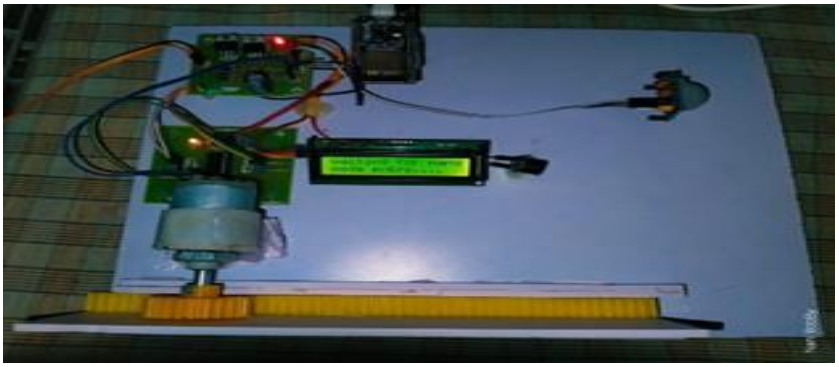

Figure 2: Access system for residential areas with face recognition

The LCD screen displays the message "Movement: 0, No movement," indicating that no motion was detected by the system (Figure 3a). When motion is detected, the screen updates to show "Movement detected," confirming activation of the face recognition process (Figure 3b).

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Figure 3a: When no movement is detected

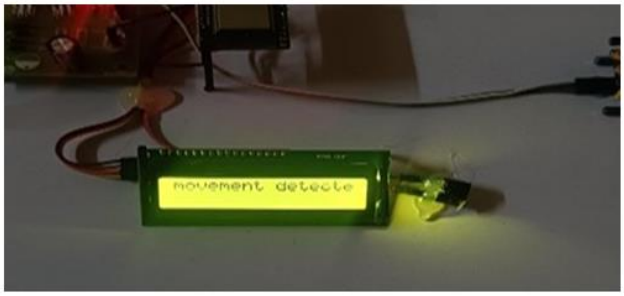

Figure 3b: When movement is detected

Figure 4 illustrates a face recognition system that utilizes a camera and a bot. The bot identifies individuals and displays their names and timestamps upon detection.

Figure 4: Image captured by Telegram bot

The recognized person "Babji" was identified by the system, and the message "Access Granted" was displayed, allowing authorized access (Figures 5a & 5b).

Figure 5a: Registered person

Figure 5b: Access granted

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In another scenario, the system detected a face but could not recognize the individual. It displayed "Person: Unknown, Access Denied," indicating that unauthorized access was successfully blocked (Figures 6a & 6b).

Figure 6a: Shows Unregistered person **Figure 6b: Shows Access denied**

Figure 7 shows the registered persons in the face recognition access system.

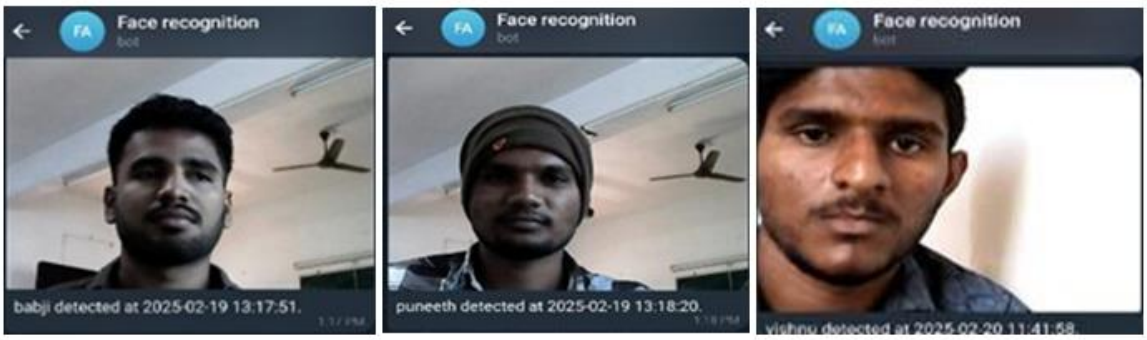

Figure 7: Shows Registered persons

V. CONCLUSIONS

This face recognition-based access system provides a secure and efficient way to control entry into residential areas. It accurately identifies individuals using image processing and grants or denies access based on pre-registered data. The system's automation reduces the need for manual supervision, enhancing both security and convenience. Real-time detection and notification feature further improve reliability.

Future developments could include improving accuracy by using advanced machine learning algorithms to detect faces in various lighting conditions and angles. Additionally, integrating voice recognition and multi-factor authentication would increase security. Connecting the system to smart home devices could offer residents more control over their security. With cloud-based data storage,the system could also enable remote access management. Lastly, expanding its application to commercial and industrial spaces could further enhance safety and convenience in various settings.

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