Smart Door Access System Using Face Recognition

Vaishnavi V. Suryavanshi[1], Diksha D. Kore[2], Tanaya V. Chavan[3]
Project guide- Mr. Chanchal. M. Patil [4]

Padmabhooshan Vasantraodada Patil Institute of Technology,budhgaon, Sangli, Maharashtra

Department of Electronics and Telecommunication
suryavanshivaishnavi10@gmail.com [1], dikshakore111@gmail.com[2], tanayachavan4@gmail.com[3],
cmpatil.etc@pvpitsangli.edu.in[4]

Abstract: Security and access control systems are becoming increasingly important in homes, offices, industries, and public places. Traditional access systems based on keys, passwords, or ID cards have several limitations such as loss, duplication, and unauthorized access. This paper presents the design and implementation of a Smart Door Access System using Face Recognition technology based on OpenCV, Python, and Arduino UNO. The proposed system captures real-time facial images using a webcam and processes them through Haar Cascade classifiers for face detection and recognition. Authorized users are identified by comparing facial features with the stored database, and the door is automatically unlocked using a servo motor controlled by Arduino UNO. If an unauthorized person is detected, the system activates a buzzer alert and generates an email notification. The system provides a low-cost, efficient, and intelligent solution for automated door access and real-time security monitoring. Experimental results demonstrate reliable face recognition performance under different conditions, making the system suitable for smart security applications.

Keywords: Face Recognition, OpenCV, Python, Arduino UNO, Haar Cascade, Smart Security System.

I. INTRODUCTION

With the rapid advancement of automation and artificial intelligence, security systems have become smarter and more efficient. Traditional door security systems mainly rely on passwords, keys, RFID cards, or manual monitoring, which may lead to security risks due to password theft, card duplication, or human error. To overcome these limitations, face recognition technology has emerged as an advanced and reliable method for access control and security applications.

Face recognition is a biometric technology that identifies a person based on unique facial features. It uses computer vision and image processing techniques to detect and recognize human faces from images or live video streams. The increasing use of machine learning, artificial intelligence, and embedded systems has made face recognition systems more accurate, efficient, and suitable for real-time applications.

The Smart Door Access System using Face Recognition is designed to provide secure and automated access control. The system captures live images using a webcam and processes them using OpenCV and Python. Haar Cascade algorithms are used for face detection, while facial recognition techniques compare detected faces with the stored database of authorized users. If a match is found, the Arduino UNO activates the door locking mechanism using a servo motor. In case of unauthorized access, the system activates a buzzer and sends an email alert notification.

This project integrates software and hardware components such as OpenCV, Python, NumPy, Arduino UNO, webcam, servo motor, and buzzer into a single intelligent security system. The system is suitable for applications such as smart homes, offices, laboratories, attendance systems, banks, and restricted areas.

II. LITERATURE REVIEW

Face recognition systems have gained significant attention in recent years due to their applications in security, surveillance, attendance monitoring, and automation systems. Many researchers have developed efficient methods for real-time face detection and recognition using OpenCV, machine learning, and deep learning techniques.

OpenCV-based face recognition systems are widely used because of their simplicity, efficiency, and availability of pre-trained classifiers. Researchers have utilized Haar Cascade classifiers for detecting faces in real-time video streams. The Haar Cascade algorithm, proposed by Viola and Jones, uses machine learning techniques for rapid object detection.

Several studies have focused on improving recognition accuracy under varying lighting conditions, facial expressions, and mask detection scenarios. Deep learning and AI-based approaches have also been integrated into modern face recognition systems to enhance accuracy and real-time performance.

Researchers have also implemented face recognition systems for automated attendance systems, surveillance systems, smart security devices, and restricted access control. These systems reduce manual monitoring and improve operational efficiency.

The literature survey shows that face recognition technology provides a reliable and intelligent approach for automated security systems. However, challenges such as lighting variations, pose changes, and computational requirements still exist, motivating further improvements in smart face recognition systems.

III. PROPOSED DESIGN

The Smart Door Access System is designed to automatically detect and recognize human faces in real time for secure access control. The system continuously captures video frames through a webcam and processes them using OpenCV libraries and Haar Cascade classifiers.

The detected face is compared with the stored face database. If the detected face matches with authorized user data, the system unlocks the door using a servo motor controlled by Arduino UNO. If the face is unknown, the system activates a buzzer alert and sends an email notification to the administrator.

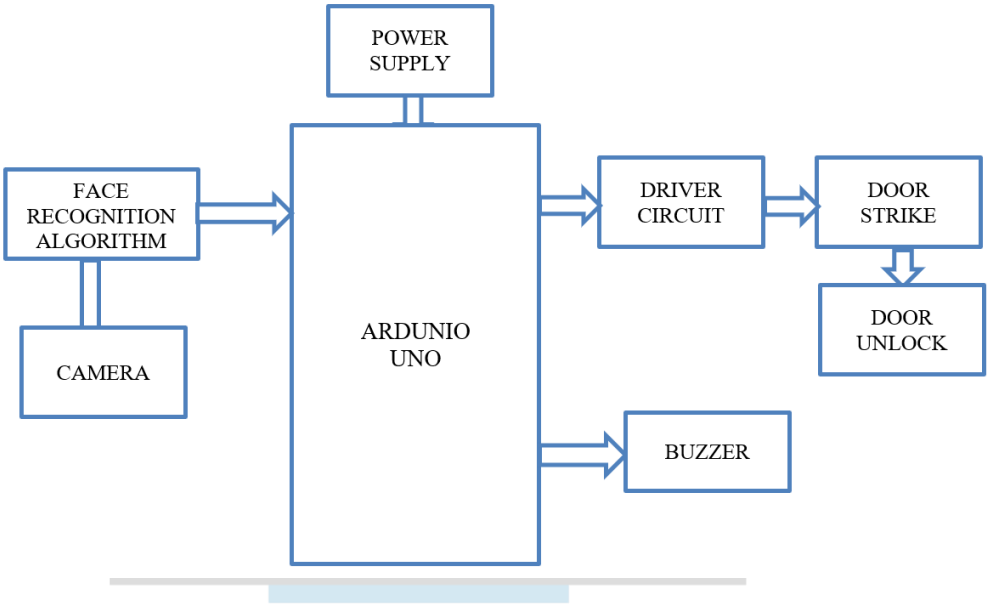


Fig.1 Block Diagram

Working:

The Smart Door Access System using Face Recognition works by automatically identifying authorized users through real-time facial recognition techniques. The system starts functioning when a person stands in front of the webcam installed near the entrance. The webcam continuously captures live video frames and sends them to the computer system for processing. These captured images are converted into grayscale format using OpenCV libraries to improve processing efficiency and detection accuracy.

After image conversion, the Haar Cascade classifier is applied to detect the presence of a human face in the video frame. Once a face is detected, the system extracts important facial features and compares them with the stored face database of authorized users. The comparison process is performed using face recognition algorithms developed in Python.

If the detected face matches with the stored database, the system identifies the person as an authorized user. A signal is then sent from the Python program to the Arduino UNO microcontroller. Arduino UNO activates the servo motor connected to the door locking mechanism, which automatically unlocks the door for a few seconds and then locks it again after entry.

If the detected face does not match with any stored user data, the system identifies the person as unauthorized. In this condition, the Arduino UNO activates a buzzer to generate an alert indication. Simultaneously, the system sends an email notification to the administrator or authorized user regarding the unauthorized access attempt.

The entire process takes place automatically in real time with minimal delay. The integration of OpenCV, Python, Arduino UNO, webcam, servo motor, and buzzer create a smart, secure, and efficient access control system suitable for homes, offices, laboratories, banks, and restricted areas.

Block Diagram Description:

The webcam acts as the input device and captures real-time images. OpenCV and Python process the captured images for face detection and recognition. Arduino UNO acts as the control unit and receives the recognition results from the software. Based on the recognition result, Arduino controls the servo motor for door locking/unlocking and activates the buzzer during unauthorized access.

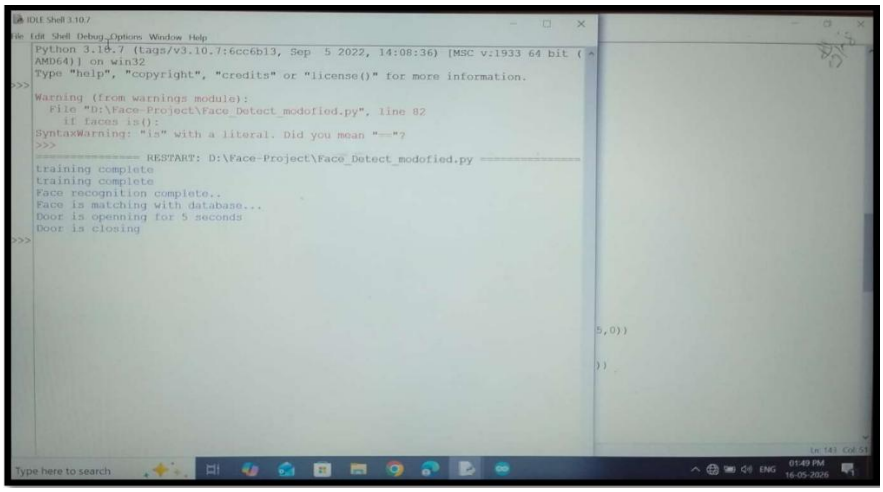
IV. RESULTS & DISCUSSION

The Smart Door Access System successfully performs real-time face detection and recognition. The webcam captures facial images accurately, and OpenCV processes the frames efficiently using Haar Cascade classifiers.

When the detected face matches with the stored database, the servo motor automatically unlocks the door. In case of an unknown face, the buzzer activates and an email notification is generated. The system operates efficiently under normal lighting conditions and demonstrates fast processing speed with minimal delay.

The project successfully integrates image processing, machine learning, and embedded system concepts into a single smart security platform. The results show that the system provides reliable and efficient automated access control.

Fig.2 Results: Unknown Face Detection Email Alert



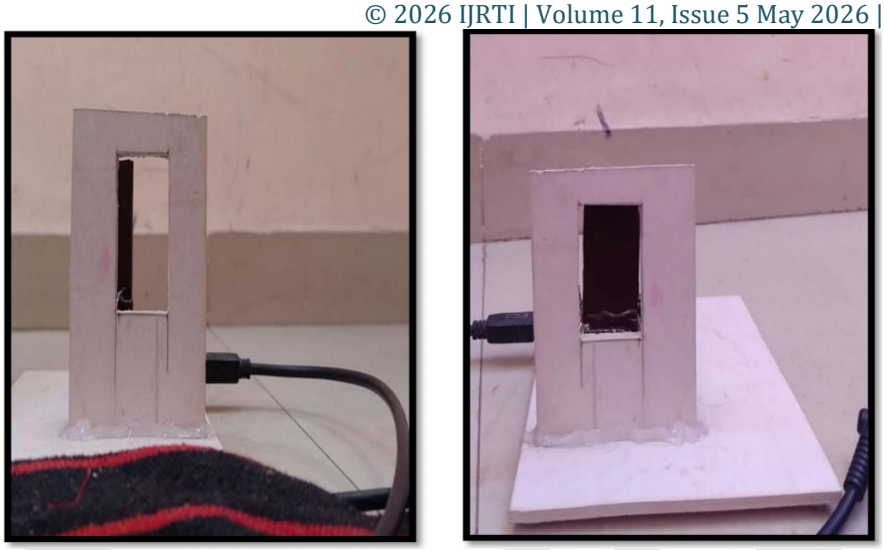


Fig.3 Results: Door Opening and Closing After Successful Authentication

V. ADVANTAGES & DISADVANTAGES

Advantages:

1. Enhanced Security**:** The system provides better security by allowing access only to authorized users through face recognition technology. It reduces the risk of unauthorized entry compared to traditional key or password-based systems.
2. Automated Access Control: The door opening and closing process is fully automatic, reducing the need for manual operation. This improves convenience and saves time in security management.
3. Real-Time Face Recognition: The system can detect and recognize faces instantly using OpenCV and Python. Fast processing enables smooth and efficient real-time monitoring.
4. Reduced Human Effort The project minimizes manual monitoring and attendance checking. It automatically identifies users and controls access without requiring human supervision.
5. Easy Integration: The system can be easily integrated with existing smart security systems, CCTV cameras, and IoT platforms. This makes it suitable for modern smart home and office applications.
6. Alert Notification System: The buzzer and email alert features provide immediate notification during unauthorized access attempts. This improves overall safety and security response.
7. User-Friendly Operation: The system is simple to use and does not require passwords, keys, or ID cards. Users can gain access easily through facial recognition technology.

Limitations:

1. Poor Lighting Conditions: The system performance may decrease in low light or excessive brightness conditions. Improper lighting can affect face detection and recognition accuracy.
2. Face Angle Variations: The system may fail to recognize faces properly if the person is not directly facing the camera. Side angles and unclear facial views can reduce accuracy.
3. High Processing Requirement: Real-time face recognition requires continuous image processing, which may consume more system memory and processing power.

Conclusion:

The Smart Door Access System using Face Recognition successfully demonstrates the implementation of an intelligent and automated security system using OpenCV, Python, and Arduino UNO. The project combines computer vision, image processing, and embedded system technologies to provide secure and efficient door access control. The system is capable of detecting and recognizing human faces in real time and automatically controlling the door locking mechanism for authorized users.

The use of Haar Cascade classifiers and OpenCV libraries enables accurate face detection and fast processing performance. Arduino UNO effectively controls hardware components such as the servo motor and buzzer, making the entire system automated and user friendly. The alert notification feature further improves security by informing users about unauthorized access attempts.

This project reduces manual monitoring effort and provides a reliable, low-cost, and smart security solution suitable for homes, offices, laboratories, banks, and restricted areas. Although the system may face some limitations under poor lighting conditions or different face angles, it still performs efficiently for real-time security applications.

Overall, the project highlights the importance of automation and face recognition technology in modern security systems and provides a strong foundation for future advancements using Artificial Intelligence, IoT, and cloud-based monitoring systems.

Future Scope:

The Smart Door Access System using Face Recognition can be further improved by integrating advanced Artificial Intelligence and Deep Learning techniques to increase recognition accuracy and system performance. Advanced algorithms can help the system recognize faces more efficiently under different lighting conditions, face angles, and facial expressions. Features such as mask detection, emotion recognition, and real-time face tracking can also be added to make the system more intelligent and reliable.

In the future, the system can be integrated with IoT and cloud technologies for remote monitoring and smart access management. Mobile applications can be developed to provide real-time notifications and remote door control through smartphones. Cloud database storage can improve data management and security. The project can also be expanded for applications such as smart homes, offices, industries, banks, attendance systems, and public surveillance systems. Multiple camera support and web-based monitoring systems can further enhance the flexibility and scalability of the security system.

VI. ACKNOWLEDGMENT

We would like to express our sincere gratitude to all those who contributed to the successful completion of our project titled “Smart Door Access System Using Face Recognition.” First and foremost, we extend our heartfelt thanks to our project guide for their invaluable guidance, support, and constructive feedback throughout the course of the project. Their insights and encouragement were instrumental in shaping the development of our system.

We also acknowledge the academic resources, research papers, OpenCV documentation, Arduino references, and online tutorials that provided us with essential knowledge on face recognition technology, image processing, embedded systems, and automation. The support and cooperation received from our department, faculty members, friends, and family members greatly motivated us during the project development process.

This project would not have been possible without the collective support, knowledge sharing, and resources made available throughout our work. Thank you.

VII. REFERENCES

[1] Paul Viola and Michael Jones, “Rapid Object Detection using a Boosted Cascade of Simple Features”, IEEE Conference on Computer Vision and Pattern Recognition, 2001, IEEE publication.

[2] R. Brunelli and T. Poggio, “Face Recognition: Features versus Templates”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 15, No. 10, 1993, IEEE publication.

[3] Gary Bradski and Adrian Kaehler, “Learning OpenCV: Computer Vision with the OpenCV Library”, O’Reilly Media Publication, 2008.

[4] Ahonen, T., Hadid, A., and Pietikainen, M., “Face Recognition with Local Binary Patterns”, European Conference on Computer Vision, 2004, IEEE publication.

[5] Szeliski, Richard, “Computer Vision: Algorithms and Applications”, Springer Publication, 2011.

[6] Arduino Documentation Team, “Arduino UNO Technical Specifications”, Arduino Official Documentation, 2023.

[7] OpenCV Development Team, “Open Source Computer Vision Library”, OpenCV Official Documentation, 2024.

[8] NumPy Developers, “NumPy User Guide and Documentation”, NumPy Official Documentation, 2024.

[9] Jayanth Vadlapati, S. Senthil Velan, and Ewin Varghese, “Face Recognition with Mask Detection using Artificial Intelligence”, International Conference on Intelligent Systems, 2022, IEEE publication.

[10] Musarrat Saberin Nipun, S. M. Shafiul Alam, and M. A. Hossain, “Comparison of Face Detection and Recognition Algorithms for Real-Time Security Applications”, International Journal of Artificial Intelligence Research, 2022.