Face Recognition Based Door Locking System

Akkala Sushank[1], Nalla Rohith[2], Muppidi Raghu[3], Saini Purnachander[4], Sudheer Raja Venishetty[5]

[1,2,3,4] *Student,Department of ECE,Vaagdevi College of Engineering, Warangal, Telangana*

[5] *Faculty, Vaagdevi College of Engineering, Warangal, Telangana*

***Abstract*—Security describes protection of life and property. The main purpose of this system is to provide better security by using face recognition technique. Eigen face algorithm is a basis for face recognition that provides high accuracy and moderate sensitivity to variations in the intensity of light. It is one of the fastest ways to identify faces. This project works in two modes: offline and online. Firstly, the PIR sensor senses the person standing outside the door. Then camera receives instruction to capture image of person standing in front of the door. This captured image is compared to the images stored in the database. The person standing in front of the door will be granted access, if his/her image is recognized. If it's not the authorized person gets a notification via GSM. If the authorized person grants permission, only then the door will open. Or else it will remain closed for further action. This project makes use of Laptop as a processing unit. It uses MATLAB software to carry out the face recognition procedure. The system takes input image by capturing a real time image for online process. For offline process the input image is given manually. In today's world of connectivity and smart devices there is an urgent need to modify our existing day to day objects and make them smart, also it is not the era when we can blindly trust the old and conventional security measures, specifically speaking is our door locks. To change and modernize any object we need to eliminate its existing drawbacks and add extra functionality.**

***Index Terms*—Face Recognition, Door Locking System, Bio- metric Security, Computer Vision, Image Processing, Smart Security, Real-Time Detection, IoT, Access Control.**

I. INTRODUCTION

Developing a face rejection-based door locking system that accurately identifies and rejects unauthorized faces while allow- ing authorized users entry with minimal inconvenience and a high level of security.

Security is at most concern for anyone nowadays, whether

it's data security or security of their own home. With the advancement of technology and the increasing use of IoT, digital door locks have become very common these days. Digital lock doesn't require any physical key but it uses RFID, fingerprint, Face ID, pin, passwords, etc. to control the door lock. In past, we have developed many digital door locks applications using these various technologies. In this tutorial we build a Face ID controlled Digital Door lock system using ESP32-CAM. The AI-Thinker ESP32-CAM module is a low- cost development board with a very small size OV2640 camera and a micro-SD card slot. It has an ESP32 S chip with builtin Wi-Fi and Bluetooth connectivity, with 2 high-performance 32-bit LX6 CPUs, 7- stage pipeline architecture. We have previously explained ESP32-CAM in detail and used it to

build a Wi-Fi door Video doorbell. This time we will use the ESP32-CAM to build a Face Recognition based Door Lock System using a Relay module and Solenoid Lock. In today's digital era, ensuring the safety and security of homes, offices, and restricted areas has become increasingly important. Traditional security systems that rely on keys, access cards, or PIN codes often face challenges such as duplication, loss, or unauthorized access. To overcome these limitations, biometric-based security systems are gaining popularity due to their reliability, accuracy, and user-friend liness. One such advanced approach is a Face Recognition-Based Door Locking System, which uses facial biometrics to verify an individual's identity and grant or deny access accordingly. This system leverages computer vision and machine learning techniques to detect and recognize the face of a person in real-time through a camera installed at the door. Once the face is authenticated against a pre-registered database, the system triggers an electronic lock to open or remain locked. This project aims to design and implement a smart, secure, and contactless access control system that enhances convenience while maintaining high standards of security.

II. SYSTEM DESIGN AND METHODOLOGY

A. Image Acquisition

Image acquisition is the first and foundational step in the face recognition-based door locking system. It involves capturing the facial image of a person who is attempting to gain access through the door. This is typically done using a digital camera or a webcam installed at the entrance.

The camera is configured to operate in real-time, contin- uously monitoring the area near the door. When motion is detected or a person approaches, the camera automatically activates and captures one or more images of the individual's face. The quality and resolution of the captured image play a critical role in the accuracy of the recognition system.

B. Preprocessing

Once the image of the person is captured, it undergoes sev- eral preprocessing steps to enhance its quality and make it suit- able for accurate facial recognition. Common preprocessing operations include resizing the image to a standard dimension, grayscale conversion to reduce computational complexity, and noise reduction using filters to smooth the image and eliminate unnecessary details. These steps help normalize the image

and improve consistency, especially when dealing with varied lighting conditions, camera angles, or facial orientations.

C. Face Detection

After preprocessing, the system uses face detection algo- rithms to identify and isolate the face from the background and other irrelevant areas in the image. Popular algorithms include the Haar Cascade Classifier, which uses machine learning- based object detection, and MTCNN (Multi-task Cascaded Convolutional Neural Networks), which offers more accurate and robust detection in real-time. This step ensures that only the facial region is passed on for further analysis, improving the precision of subsequent stages.

D. Feature Detection

In this stage, distinctive facial features such as the position and shape of the eyes, nose, mouth, and jawline are extracted from the detected face region. These features are used to form a unique digital representation of the face. Various models can be used for this purpose, including traditional methods like LBPH (Local Binary Pattern Histograms) and Eigenfaces, as well as modern deep learning techniques such as Convolutional Neural Networks (CNNs). The accuracy of the recognition system largely depends on how well these features are extracted and represented.

E. Face Matching

The extracted features are then compared with a database of stored facial features belonging to authorized individuals. This comparison can involve distance metrics such as Euclidean distance or cosine similarity to determine the level of match between the input face and stored templates. A predefined threshold value is used to decide whether the face is recog- nized as an authorized user. The closer the match, the higher the confidence in identification.

F. Decision Making

Based on the face matching results, the system makes a decision. If the face matches one in the database, the system sends a signal to a relay module, which activates the electronic door lock, allowing access. If no match is found or if the match confidence is below the threshold, the door remains locked, thereby denying entry. This step ensures that only verified individuals are granted access, enhancing the security and reliability of the entire system.

III. IMPLEMENTATION

The image shows a face recognition-based door locking system powered by an ESP32-CAM module, which is de- signed to enhance home security by allowing access only to recognized individuals.In this setup, the ESP32-CAM, a microcontroller with an integrated camera and Wi-Fi capabil- ities, captures images of faces in front of the device. When someone approaches, the ESP32-CAM activates and scans the face using machine learning or image processing algorithms. The onboard software compares the captured face against a pre-stored dataset of authorized faces. If a match is found,

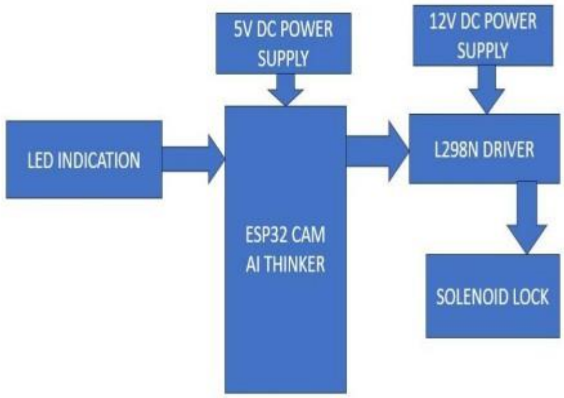

Fig. 1. System Design

a signal is sent to the motor driver module (L298N in this case), which powers a small servo or DC motor connected to the locking mechanism mounted on the vertical frame (likely to control a latch or bolt). This motor either unlocks or keeps the door locked based on the result of face recognition.

The system is powered through a DC jack as shown in the image, and the wiring clearly connects all major components: ESP32-CAM, motor driver, and actuator. The setup is compact and ideal for demonstration or prototyping purposes.Overall, this system automates door access and enhances security by ensuring only recognized individuals can unlock the door, making it a practical application of IoT and AI in smart home technology. The face recognition-based door locking system is an advanced security solution that integrates computer vision, machine learning, and automation to control physical access. Unlike traditional locking systems that rely on keys, cards, or passwords, this system uses biometric authentication, specif- ically facial features, to determine if a person is authorized to enter. This innovation not only enhances security but also adds convenience, as users do not have to carry anything or remember passwords.

The system is often powered by compact microcontrollers like the ESP32- CAM, which combines camera functionality with onboard processing capabilities.The core concept behind this system involves capturing an image of a person's face, analyzing it through a trained recognition model, and then deciding whether to unlock the door. At the heart of the system lies the camera module, typically part of the ESP32- CAM board. When a person approaches the door, the camera captures a live image or video stream. This visual data is then processed either locally on the ESP32-CAM or via an external server or microcontroller, depending on the complexity of the face recognition algorithm being used.

The face detection and recognition process usually involve several stages. First, the camera captures an image and uses face detection algorithms (like Haar cascades or MobileNet) to locate and isolate faces within the frame. Once the face is detected, it is preprocessed (cropped, resized, and sometimes normalized) to ensure consistent recognition accuracy. Then,

using face recognition techniques such as Eigenfaces, LBPH (Local Binary Pattern Histogram), or DNN-based models, the system compares the detected face with the stored database of authorized users. If a match is found with high enough confidence, the system grants access by sending a signal to the locking mechanism. Once a face is successfully recognized, the system proceeds to control the door locking mechanism electronically. This is done using components such as relays, transistors (e.g., 2N2222A), or MOSFETs (e.g., IRF540N) to switch the power to an electronic lock, commonly a solenoid lock. These locks operate on a simple principle: when they receive an electric signal, they either retract or extend a bolt that controls the physical locking of the door.For instance, the ESP32-CAM outputs a digital HIGH signal to the transistor's base or the gate of a MOSFET. This acts as an electronic switch that allows current to flow to the solenoid lock, activating it and unlocking the door for a few seconds. After the delay, the signal goes LOW again, cutting off power to the lock and allowing it to return to the locked position via a built-in spring mechanism. This entire operation is controlled through a predefined program running on the ESP32-CAM or an attached controller. An essential part of the system's effectiveness is timing and user feedback. For user awareness and debugging, LED indicators are commonly used. For example, a green LED might light up when access is granted, while a red LED signals access denied. These indicators are connected to the ESP32-CAM's GPIO pins and reflect the result of the face recognition decision. In more advanced setups, buzzers or even voice prompts can be added to enhance user experience.Powering the system reliably is also critical. Since solenoid locks can draw significant current, a separate power supply (often 12V or 5V DC) is used for the lock, while the ESP32-CAM typically operates at 3.3V. Voltage regulators, level shifters, or logic-level compatible switching circuits are used to ensure safe interaction between components of different voltage levels.Additionally, a reset or override mechanism may be included for emergency cases, allowing manual access in case of system failure. Furthermore, for systems connected to Wi-Fi (which the ESP32-CAM supports), remote access or monitoring features can be added, allowing the homeowner to unlock the door or view the camera feed from a mobile app or web interface.

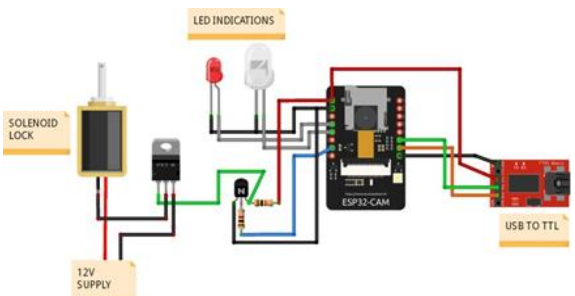

Fig. 2. Circuit Diagram

IV. RESULTS AND DISCUSSION

Face Recognition-Based Door Locking System, designed using IoT and embedded hardware components. The setup includes a compact yet effective demonstration of how facial authentication can be used to control physical access to a secure space like a home or office. At the heart of the system is the ESP32-CAM module, which is clearly visible on the right side of the baseboard. This module includes an inbuilt camera used to capture facial images and perform recognition tasks. It is mounted on a custom PCB (perforated board) for stability and proper wiring. The module is powered via a USB cable, and a red LED indicator on the ESP32-CAM suggests that the device is powered on and possibly active in scanning or waiting for face input. Connected to the ESP32- CAM is a motor driver module, likely based on L298N or a relay, responsible for operating the solenoid lock. The lock is fixed onto a wooden frame that simulates a door structure. This lock is powered by a 12V DC source and is designed to retract the bolt mechanism when a correct face is detected. The wiring between the motor driver and the solenoid is color- coded (red and blue), indicating power and ground connections respectively.

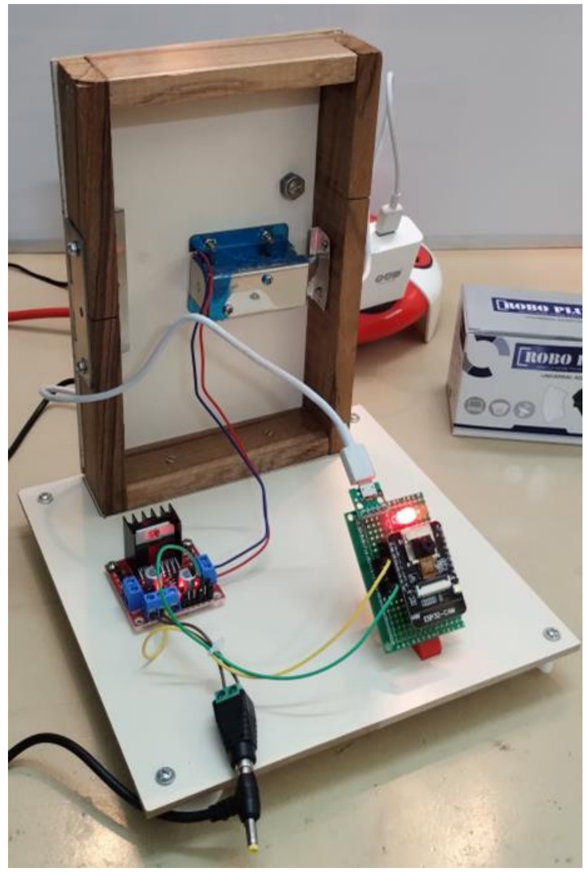

Fig. 3. Output

V. LIMITATIONS

The Face Recognition Based Door Locking System faces several challenges. Environmental factors like poor lighting, inconsistent camera angles, and obstructions (e.g., sunglasses or masks) can impact recognition accuracy. Accuracy issues such as false positives, false negatives, and confusion between identical faces may occur. Hardware limitations, such as low- quality cameras or processing power in embedded systems, can affect performance. Privacy concerns arise from storing and transmitting biometric data, which may be vulnerable to breaches. The system's reliance on the internet and power means that a lack of either can lock out users. Additionally, the system may struggle to adapt to changes in appearance, requiring regular updates. Cost and maintenance are also con- siderations, as high-quality systems remain expensive. Lastly, without anti-spoofing mechanisms, the system is at risk of being bypassed using photos, videos, or advanced spoofing tools.

VI. FUTURE SCOPE

Face Recognition-Based Door Locking System is vast and promising, especially with the rapid advancements in artificial intelligence and IoT technologies. As face recognition be- comes more accurate and faster through the use of deep learn- ing algorithms and enhanced image processing techniques, this system can evolve into a more robust and highly secure access control solution. Integration with cloud computing can allow real-time monitoring, remote access, and storage of face data, enabling users to track and control entry from anywhere in the world. The system can also be enhanced with features like multi-factor authentication, combining facial recognition with voice or fingerprint recognition for heightened security. In smart home ecosystems, it can be seamlessly linked with other smart devices, such as lights, alarms, and surveillance cameras, to create a fully automated and responsive security network. Furthermore, scalability into commercial and industrial sectors
- such as banks, data centers, and government offices
- can provide controlled access to restricted zones. With added AI capabilities, the system could eventually recognize emotions or detect suspicious behavior, adding a predictive layer to security. This innovation holds the potential to revolutionize traditional locking systems and become a cornerstone of modern security infrastructure.

VII. CONCLUSION

The Face Recognition-Based Door Locking System is an in- novative and intelligent security solution designed to enhance access control using facial biometrics. This project utilizes the ESP32-CAM module, which is equipped with a built-in camera for real-time face detection and recognition. The core concept revolves around identifying a person's face and grant- ing access only if the individual is authorized. Once the camera captures an image, it compares the face with stored data, and upon a successful match, a signal is sent to a motor driver module to trigger the electromagnetic lock, thereby unlocking the door. The entire setup ensures contactless operation, which
is particularly beneficial in maintaining hygiene and preventing the spread of germs. The system is not only cost-effective but also easy to implement using components such as the ESP32- CAM, L298N motor driver, solenoid lock, and a basic power supply. It offers a reliable alternative to traditional locks and key-based systems, making it ideal for modern homes, offices, and restricted areas. Furthermore, the project demonstrates a practical application of computer vision, IoT, and embedded systems, providing a robust platform for learning and inno- vation in smart security solutions. The face recognition-based door locking system represents a modern, innovative approach to security and access control. By integrating biometric facial recognition technology with physical locking mechanisms, the system offers a smarter, more secure alternative to traditional methods such as keys, PIN codes, or RFID cards. Unlike these conventional systems, facial recognition offers a contactless and highly personalized form of identification, reducing the risk of unauthorized access due to lost or stolen credentials.At the core of the system lies the ESP32-CAM, a powerful microcontroller with built-in Wi-Fi and camera functionality, enabling image capture and processing. The device performs face recognition by comparing captured images to a stored dataset. Once a match is found, the ESP32-CAM activates a solenoid lock via a MOSFET switch, unlocking the door for the authorized individual.

REFERENCES

[1] Omkar Pawar, Prathamesh Lomkar, Randhir Singh, Vivek Salunke and Prof. D.M. Ujlambkar,. " Door Lock System using Facial Recognition", IJRASET March 2019.

[2] Bours, P., Smeulders, A. (2016). Biometric systems: Privacy and secu- rity issues. IEEE Transactions on Information Forensics and Security, 11(6), 1244-1255. [DOI: 10.1109/TIFS.2016.2568281]

[3] Bello, D., Hassan, A. (2019). Liveness detection in face recognition: Challenges and solutions.

Journal of Visual Communication and Image Representation, 60, 35-47. [DOI: 10.1016/j.jvcir.2019.01.011]

[4] Anwar, A., Alam, M. S. (2019). Real-time face recognition system for access control. Proceedings of the 2019 International Conference on Computer Science and Engineering (ICSE). [DOI: 10.1109/ICSE.2019.00019]

[5] Zhao, W., Chellappa, R., Phillips, P. J., Rosenfeld, A. (2003). Face recognition: A literature survey. ACM Computing Surveys (CSUR), 35(4), 399-458. [DOI: 10.1145/954339.954342]