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Face Recognition Door Lock System Using Raspberry PI

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Abstract: *One of the crucial difficulties we aim to find in computer vision is to recognize items automatically without human interaction in a picture. Face detection may be seen as an issue when the face of human beings is detected in a picture. The initial step towards many face-related technologies, including face recognition or verification, is generally facial detection. Face detection however may be quite beneficial. A biometric identification system besides fingerprint and iris would likely be the most effective use of face recognition. The door lock system in this project consists of Raspberry Pi, camera module, relay module, power input and output, connected to a solenoid lock. It employs the two different facial recognition algorithms to detect the faces and train the model for recognition purpose. The Face Recognition Door Lock System using Raspberry Pi is an intelligent security solution designed to provide contactless, reliable, and automated access control. The system uses a Raspberry Pi as the central processing unit, integrated with a camera module to capture real-time facial images.*

Keywords: Face recognition, raspberry pi, opencv

I. INTRODUCTION

As a result, a better system must be created for more security. People have been employing nonliving objects (such as smart cards, plastic cards, pins, tokens, and keys) for access control and authentication in restricted places for a long time. Consequently, there is a potential that someone will misplace their pins, keys, cards, etc., but if face recognition is employed for the door operating system, there is hope for improved security. The features of a person's face, which include their eyes, nose, and other distinctive features, can reveal a variety of emotions. There are two types of biometrics: behavioral traits and physiological traits (facial features, fingerprints, hand and finger shapes, palms, iris, ears, and voice). (gait, signature and keystroke dynamics). Your behavior may occasionally shift as a result of illness, fear, hunger, etc. Compared to other biometrics, face recognition technology is more secure. Biometrics and faces are frequently combined to identify people. Security personnel have given face recognition a lot of thought as a result of human activity discovered in a variety of security systems, including forensic, airport, face tracking, criminal detection, etc. When compared to other biometric features like palm prints, finger prints, palm prints, etc

II. PROBLEM STATEMENT

Traditional door lock systems such as keys, PINs, or RFID cards are vulnerable to theft, duplication, and unauthorized access. These systems also require physical contact or manual operation, which can be inconvenient and insecure. There is a growing need for a smart, reliable, and contactless security system that can accurately identify authorized individuals and restrict access to unauthorized users. This project aims to design and implement a Face Recognition Door Lock System using Raspberry Pi that uses image processing and machine learning techniques to authenticate individuals in real time and automatically control door access, thereby enhancing security, convenience, and efficiency. Conventional door locking systems that rely on physical keys, passwords, or access cards are prone to loss, duplication, and unauthorized access, reducing overall security. Additionally, these systems require manual interaction and lack real-time user authentication.

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III. METHODOLOGY

The system uses a Raspberry Pi as the main controller with a camera module to capture facial images. The captured image is processed to detect a face using computer vision techniques. The detected face is then compared with a pre-trained database of authorized users using a face recognition algorithm. If a match is found, the Raspberry Pi activates a relay to unlock the door; otherwise, access is denied. The door automatically locks again after a preset time.

1. System Initialization

The Raspberry Pi, camera module, and electronic door lock are powered on and configured to work together. All hardware components and required software libraries are initialized.

2. Image Capture

The camera captures real-time images or video frames of the person standing in front of the door.

3. Face Detection

The captured image is processed to detect the presence of a human face using image processing algorithms, and the face region is isolated for further recognition.

4. Face Recognition

The detected face is compared with the stored facial data of authorized users.

5. Authentication Decision

If the face matches an authorized user, access is granted; otherwise, access is denied.

IV. HARDWARE COMPONENTS

A. Raspberry pi

Raspberry Pi is a series of small, single-board computers (SBCs) that are popular among hobbyists, educators, and developers for a wide range of projects. It was initially developed by the Raspberry Pi Foundation, a UK-based charity organization, with the goal of providing an affordable and accessible platform for learning about computer programming and electronics.

B. USB Camera

A USB web camera, also known as a USB webcam, is a type of digital camera that can be connected to a computer or other device via a USB (Universal Serial Bus) port. It is designed specifically for capturing video and/or still images for use in video conferencing, online streaming, video recording, or other applications that require a camera to be connected to a computer

C. Power Supply

Power Requirements: The Raspberry Pi has specific power requirements, typically 5v (V) DC and a recommended current capacity of at least 2.5 amps (A) for most models. However, the power requirements may vary slightly depending on the specific model of Raspberry Pi andany peripherals connected to it, such as USB devices, displays, or cameras.

D. Solenoid Lock

A solenoid door lock is an electromechanical device that is used to control access to a door by locking or unlocking it using a solenoid, which is an electrically operated coil of wire. Solenoid door locks are commonly used in a variety of applications, including residential, commercial, and industrial settings, and can provide security and access control for doors.

E. Buzzer

In the Face Recognition Door Lock System, a buzzer is used as an audio alert device to indicate the system's status. It sounds when an unauthorized person tries to access, alerting both the user and nearby people. The buzzer can also give a short beep when an authorized user is recognized, confirming that the door is unlocked.

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Fig1. USB camera

Fig2. Raspberry pi

Fig3. Solenoid lock

Fig4.Relay module

Fig5. Buzzer

Fig6.Battery supply

V. CIRCUIT DIAGRAM

The circuit diagram of the Face Recognition Door Lock System using Raspberry Pi shows the interconnection of all hardware components. The Raspberry Pi acts as the main controller, interfacing with a camera module to capture facial images. A relay module is connected to the Raspberry Pi's GPIO pins to control the electronic door lock, allowing it to unlock or lock based on authentication.

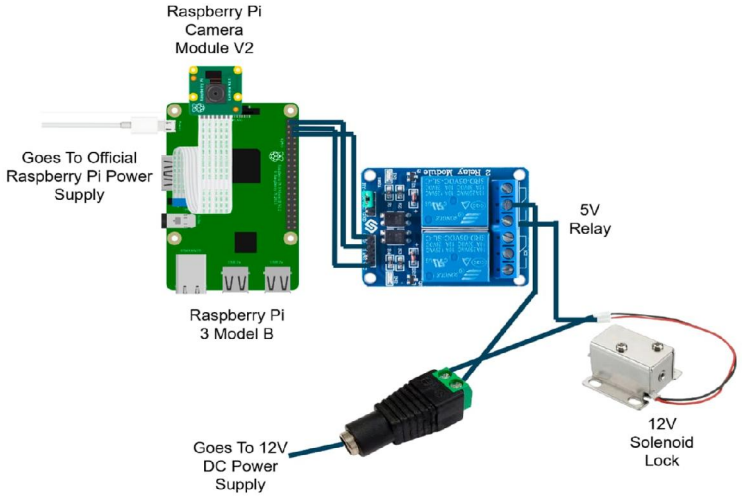

Fig 7. Circute Diagram

VI. CIRCUIT DIAGRAM

Software Implementation

The software implementation of the Face Recognition Door Lock System is responsible for capturing images, detecting and recognizing faces, and controlling the door lock. The system runs on the Raspberry Pi using Python programming language. A face detection algorithm (such as Haar Cascade) is used to locate faces in real-time camera frames.

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Recognized faces are matched against a pre-stored database of authorized users using a face recognition algorithm like LBPH (Local Binary Patterns Histogram) or deep learning models. Based on the recognition result, the Raspberry Pi sends a signal to the relay module to unlock the door for authorized users or triggers the buzzer for unauthorized attempts. Additional software features include logging access attempts and handling system errors. The software integrates hardware control and machine learning algorithms to ensure a secure, automated, and reliable door locking system.

Program flow

The system starts by initializing the Raspberry Pi, camera, relay, and buzzer. It captures real-time images and detects faces using a face detection algorithm. Detected faces are compared with the authorized user database, unlocking the door for recognized faces or triggering the buzzer for unauthorized attempts. The door automatically locks after a preset time, and the system continuously repeats this process.

VI. RESULTS AND DISCUSSION

A. Results

The Face Recognition Door Lock System using Raspberry Pi successfully detects and recognizes authorized users in real time. When a registered face is identified, the door unlocks automatically, and for unrecognized faces, access is denied. The system operates reliably under normal lighting conditions and demonstrates quick response time.Upon successful recognition, the electronic door lock is activated through a relay module, allowing access for a predefined time before automatically relocking. The system effectively prevents unauthorized access by keeping the door locked when an unrecognized face is detected. Test results show good recognition accuracy under normal lighting conditions and acceptable response time, making the system suitable for practical use.

B. Discussion

The system improves security compared to traditional locking methods by eliminating the need for physical keys or passwords. It performs effectively under normal lighting conditions, though accuracy may decrease in poor lighting or with facial changes. Overall, the project proves that a low-cost Raspberry Pi–based system can provide efficient and smart access control for home and office security.The project demonstrates that facial recognition can be effectively integrated with Raspberry Pi for smart security applications. Compared to traditional locking systems, this approach enhances security, convenience, and automation by eliminating the need for physical keys or passwords. The system's performance depends on factors such as lighting conditions, camera quality, and facial variations (such as glasses or facial hair). While the recognition accuracy may reduce under low light or extreme angles, these limitations can be improved by using better cameras or advanced deep learning models. Overall, the results confirm that the proposed system is a cost-effective, reliable, and scalable solution for modern access control systems in homes and offices.

VII. CONCLUSION

In conclusion, The proposed facial recognition door lock system is built, in which an Haar classifier is used for face detection, local binary pattern histogram algorithm for facial recognition, camera to capture the images and raspberry pi for processing these operations. The system allows authorized persons to enter and If the person is not authorized, a photo is sent to the owner's phone so that owner can remotely open or close the door. The system provides a convenient and secure way to control access to buildings and homes, especially in situations where keys or access cards can be easily misplaced or stolen. The use of Raspberry Pi for this application makes the system cost-effective, easy to install, and maintain. The combination of Haar Cascade and Local Binary Pattern Histogram algorithms ensures accurate and reliable face recognition. Overall, the face recognition door lock system using Haar Cascade and Local Binary Pattern Histogram on Raspberry Pi has great potential to revolutionize access control systems and security measures in the future.

The project demonstrates the effective integration of hardware and software components to enhance security and convenience. Although performance may vary under poor lighting or facial changes, the system proves to be a cost-

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effective and reliable approach for modern home and office security. With further improvements, it can be extended for larger-scale and more robust security applications.

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