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Face Recognition Door Lock System Using Raspberry-Pi

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Abstract: The project aims in designing a "Face Recognition Door Lock System Using Raspberry-Pi" Smart Receptionist with smart lock system is mainly designed and developed for security systems. This smart security system is used to see a visitor when the main door of the office or Home is closed. Today we face security issues in each angle. So we attempt to determine these issues by utilizing refreshed innovation. During this task, we are utilizing the Face acknowledgment module to catch human pictures and saving in a data base. Assuming it Image matches with the data base then door will be opened by an electromagnetic lock with help of lock. The use of face recognition system that's accurately detect all unauthorized users from highly secured areas and aids in minimizing human error. Face recognition system is one of the highest security system when compared with finger print locking system and also password based security system. The time and accuracy factor is taken into account about the main problem which specifies the performance of automatic face recognition in real-time environments. If you're within the middle of a meeting in a conference room and there's a visitor at the door, this technique will send a notification to your smartphone with a photograph of the visitor as email. Security is one of the most critical concerns in both residential and commercial spaces. Traditional security systems, such as manual locks and password-based systems, pose risks due to unauthorized access and password leaks. The Smart Door Receptionist with Smart Lock System integrates face recognition, IoT, and Raspberry Pi-based automation to enhance security and streamline access control. The system employs a Pi camera, Raspberry Pi 4, solenoid lock, and relay module to authenticate visitors using facial recognition. If the visitor is recognized, the door unlocks automatically; otherwise, an alert is sent to the homeowner's smartphone for manual approval.

Keywords: *Smart Lock, Face Recognition, IoT Security, Raspberry Pi, Automated Access Control, Smart Door Receptionist.*

I. Introduction

Nowadays, the security one of the most consent challenges in every aspect of the industry as well as for the normal human being there has been numerous approaches which was implemented by using Internet of Things (IOT) applications. These applications they provided the security by using Raspberry-pi smart reception list with smart lock system is the proposed system which identifies the user phase and then opens the door by using smart Artificial Intelligence (AI). By using these applications, we are giving the authorized persons which are used for security system. The authorized persons can be verified the authorized from any Remote location by using with live streaming video. If the person is authorized the security system will be coming into access for the verification process by using the Internet of Things (IOT) application. Here in this approach a Raspberry-pi 4 micro control is used and python program is used for live streaming. Remote.it app is an app that enables us to control the door access by designing the graphical interface in the apps according to the specific function to perform. After considerable trials and approaches, a system was developed to increase the security level of critical area and data which is called as "Smart Receptionist with Smart Lock System". The system was designed in such a way so as to open the door using a mobile device and thereby to give access only to the authorized personnel. This efficient and accurate security system provides access to home security and also access control to the doors and security system which is based on a face recognition pattern, making it important for a wide variety of security applications. Security is an important factor or a feature in smart home applications. Many of the countries are adopting the smart door security system. The most important and major part of any door security system is identification and accuracy for recognition of the person who enters through the door. Face recognition is by far the most natural way to perform authentication and recognition accuracy among human beings Computerized face recognition and detection structure are speedily spreading at various sectors such as shopping centers, Institutes, and departments. The aim of this research is to develop a structure that can identify and recognize faces of human beings using Image-Processing techniques. Practically, this idea can be executed in a wide range of places to provide security.

II. Proposed System Architecture

1. System Overview

The proposed system consists of a Raspberry Pi-based face recognition module that captures and processes visitor images. If a visitor's face matches an authorized database entry, the solenoid lock is activated, granting access. If the visitor is unrecognized, an alert is sent to the homeowner's smartphone, allowing them to approve or deny entry remotely.

2. Components Used

- **Raspberry Pi 4** – Central processing unit for face recognition.
- **Pi Camera Module** – Captures images for face detection.
- **Solenoid Lock** – Electrically controlled lock mechanism.
- **Relay Module** – Controls the locking mechanism.
- **Python (OpenCV, Face Recognition Library)** – Processes face recognition.
- **Linux OS (Raspberry Pi OS)** – Runs the system software.

3. System Workflow

- **Visitor Arrival:** The visitor presses the doorbell switch.
- **Image Capture:** The Pi camera captures an image and sends it to the Raspberry Pi.
- **Face Recognition:** The Raspberry Pi processes the image and checks against the authorized database.
- **Access Decision:**

1. If the visitor is recognized, the solenoid lock is activated.
2. If unrecognized, an alert is sent to the homeowner's mobile app.

- **User Response:** The homeowner can remotely grant or deny access.
- **System Logs:** Entry details are stored for security tracking.

III. Problem Statement

Traditional security mechanisms, such as manual locks, password-based access, and RFID cards, have significant drawbacks, including:

- Security vulnerabilities: Password leaks, key duplication, and unauthorized access risks.
- Lack of real-time monitoring: Conventional systems do not provide instant visitor verification.
- Limited user accessibility: Physical keys and RFID cards can be lost, stolen, or misused.
- No remote access: Users cannot verify visitors remotely, reducing control over security.

To overcome these issues, this project aims to develop a Smart Door Receptionist with Smart Lock System using facial recognition, IoT-based remote access, and automation to improve security and efficiency.

IV. Objective of Project

The fundamental goal is to give security in private meetings to the higher authorities in any associations. The web camera to catch the arrangement of pictures when the individual press switch. The benefit of this framework is for getting to the entryway is that face location and acknowledgment are performed by utilizing face discovery method and the whole face acknowledgment is finished by squeezing single small press button switch. In the existing system, that we are using password based door locking systems which may leads to the user memorize password each and every time. So to overcome this drawback we designing a replacement system with face detection by pressing single tiny push switch. In the current framework, we are utilizing secret word based entryway lock framework which causes the client to retain secret key constantly. So to conquer this disadvantage we planning another framework with face acknowledgment.

V. Literature Survey

Literature Survey No. 1
Title of Paper: IoT-Based Smart Lock System for Home Security
Journal/Conference Name: IEEE Transactions on Smart Security Systems
Publisher/Volume: IEEE, Vol-15, April 2020
What is Given in the Paper: Discusses the use of IoT for real-time smart lock control and access monitoring.
Methodology: Implements Raspberry Pi and IoT-based face recognition for automated authentication.
How is it useful for our Project: Provides insights into secure access control and IoT integration.

Literature Survey No. 2
Title of Paper: Face Recognition-Based Access Control System
Journal/Conference Name: International Journal of Computer Vision and Automation
Publisher/Volume: Elsevier, Vol-20, June 2019
What is Given in the Paper: Explores facial recognition technology for access control in secured environments.
Methodology: Uses OpenCV-based image processing and real-time authentication systems.
How is it useful for our Project: Helps in implementing face recognition algorithms efficiently.

Literature Survey No. 3
Title of Paper: Smart IoT-Based Home Security Systems
Journal/Conference Name: International Conference on IoT and Smart Cities
Publisher/Volume: Springer, Vol-10, November 2021
What is Given in the Paper: Discusses cloud-based monitoring and IoT-enabled security devices.
Methodology: Uses cloud storage for security logs and automated alert notifications.
How is it useful for our Project: Provides insights into remote security monitoring and cloud integration.

Literature Survey No. 4
Title of Paper: Biometric Authentication for Smart Door Locking System
Journal/Conference Name: Journal of Security and Cryptography
Publisher/Volume: Elsevier, Vol-9, March 2018
What is Given in the Paper: Examines different biometric security methods for smart door locking systems.
Methodology: Uses fingerprint and facial recognition for two-factor authentication.
How is it useful for our Project: Helps in enhancing security by integrating biometric authentication.

Literature Survey No. 5
Title of Paper: AI-Powered Smart Lock Systems for Enhanced Security
Journal/Conference Name: International Journal of Artificial Intelligence and Security
Publisher/Volume: IEEE, Vol-22, August 2022
What is Given in the Paper: Discusses AI-powered security mechanisms for smart locks.
Methodology: Implements machine learning models for predictive access control.
How is it useful for our Project: Provides insights into AI-based improvements for access control systems.

VI. Methodology

The methodology for this project involves designing and developing an advanced IoT-based Smart Door Receptionist with a Smart Lock System that ensures secure, automated, and efficient access control. The system is built around Raspberry Pi for processing and OpenCV-based facial recognition for authentication. A combination of hardware components (camera, solenoid lock, relay module) and software algorithms (Python-based face detection) is used to create a fully functional smart lock mechanism. The system is tested under various conditions to evaluate performance, security, and usability.

1. System Architecture

The system architecture of the Smart Door Receptionist with Smart Lock System is designed to integrate multiple hardware and software components for seamless operation. The core of the system is the Raspberry Pi, which acts as the processing unit for image recognition and authentication. The Pi Camera Module captures images of visitors, which are then processed using OpenCV-based face recognition algorithms. The system follows a modular approach where different components work together to ensure secure and efficient access control. The relay module and solenoid lock function as the actuators that physically control the door's locking mechanism based on authentication results. Additionally, a mobile notification system enables remote monitoring and approval via an IoT-based network.

2. Workflow of the System

- User presses doorbell.
- Camera captures visitor's face.
- Raspberry Pi processes image and compares with stored data.
- If recognized, door unlocks.
- If unrecognized, homeowner receives a notification.
- Homeowner approves/denies access remotely.

3. Hardware and Software Components

Hardware:

- Raspberry Pi 4
- Pi Camera Module
- PIR Sensors
- Buzzer
- Bell Button
- Solenoid Lock
- Relay Module
- LCD Display
- Power Supply Adapter

Software:

- Python (OpenCV, Face Recognition Library)
- Linux OS (Raspberry Pi OS)
- SQL

4. Implementation Process

Step 1. Setup and configuration of Raspberry Pi and face recognition software.
Step 2. Integration of Pi Camera and solenoid lock with Raspberry Pi.
Step 3. Development of Python scripts for face detection and authentication.
Step 4. Integration of IoT-based remote monitoring system.
Step 5. Testing and validation of face recognition accuracy.
Step 6. Implementation of real-time visitor alerts via mobile application.
Step 7. Optimization of power consumption for efficient operation.
Step 8. Performance evaluation under various lighting conditions.

5. Testing and Performance Evaluation

- **Accuracy Testing:** Evaluated facial recognition success rates under different conditions.
- **Response Time Analysis:** Measured system reaction time to visitor input.
- **Power Efficiency:** Optimized Raspberry Pi and solenoid lock power consumption.
- **Usability Testing:** Assessed user experience and mobile application effectiveness.

VII. Block Diagram

Figure shows block diagram of project each block are Connected to each other. It can be seen by one by one

1. Camera Module: The system begins with a camera module that captures the live image of the person standing in front of the door. The camera continuously streams video frames to the Raspberry Pi for analysis. The Raspberry Pi camera module captures images/video feed. The images/video feed are processed using OpenCV.
2. Raspberry Pi 4B+: This is the central controller that processes the data. It runs the face recognition software, which compares the captured image with a stored database of authorized faces. Capture: Pi Camera captures images/video feed. Detect: OpenCV detects faces in the feed.
3. Face Recognition Algorithm: The algorithm processes the captured face and matches it against the database of stored facial images. If a match is found, it triggers the next action. Capture image/video feed. Detect face. Extract facial features. Compare with authorized faces. Unlock/lock door based on match.
4. Database: The database stores all authorized face data (images) for comparison. It can be updated to add or remove faces as needed. This ensures that only authorized individuals can gain access. Enrollment: Authorized faces are captured and stored in the database. Feature Extraction: Facial features are extracted from captured images. Database Storage: Extracted features are stored in the Authorized Faces Database.

5. Voice Output System: After processing the face recognition, the system uses a voice output module (such as a speaker) to provide feedback. It will announce whether access is granted or denied based on the recognition result. 10 Multiple voices and languages Adjustable speech rate and pitch Customizable text-to-speech conversion.
6. Relay Module: Upon successful recognition, the Raspberry Pi sends a signal to the relay module, which controls the locking mechanism. This ensures that the solenoid lock is activated.
7. Solenoid Lock: The solenoid lock mechanism is activated by the relay module, allowing the door to open for authorized individuals.
8. Power Supply: The system is powered by a stable power supply, providing necessary voltage to the Raspberry Pi, camera, relay, and voice output system.

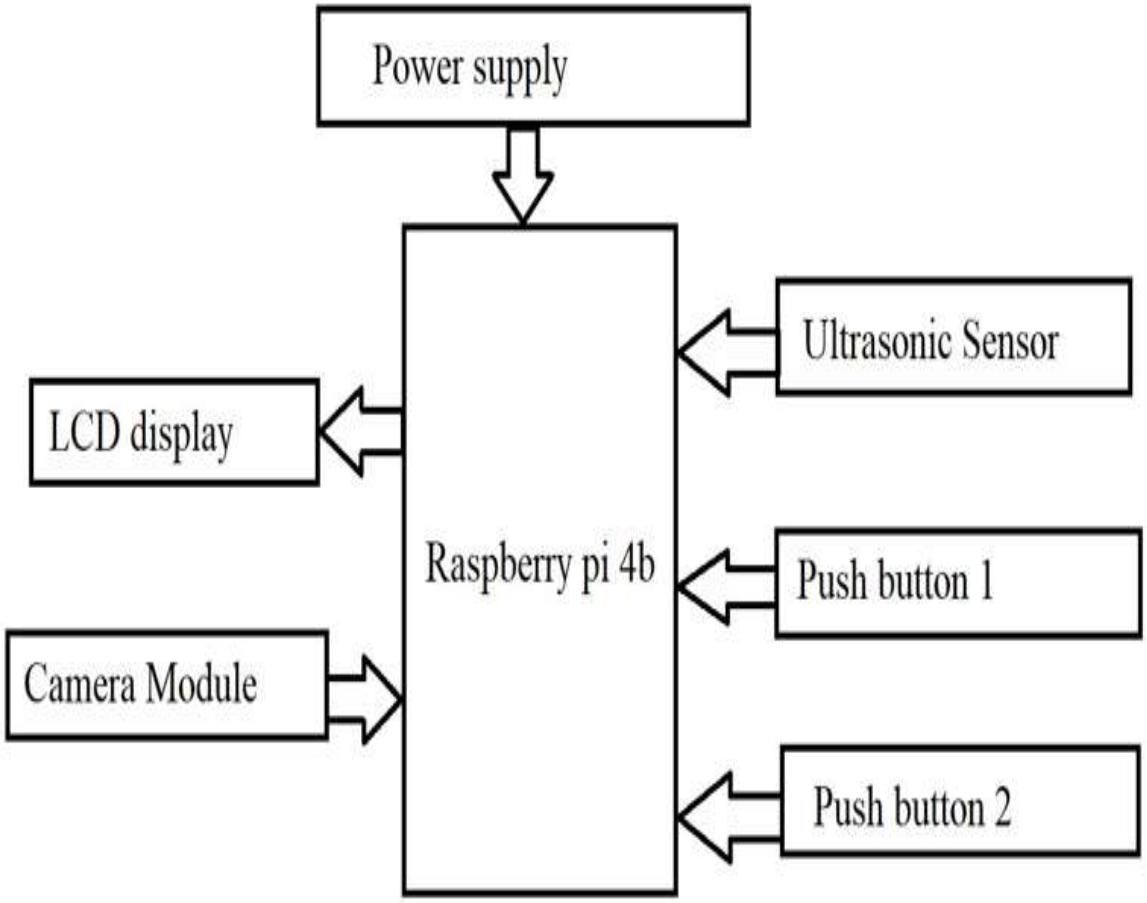
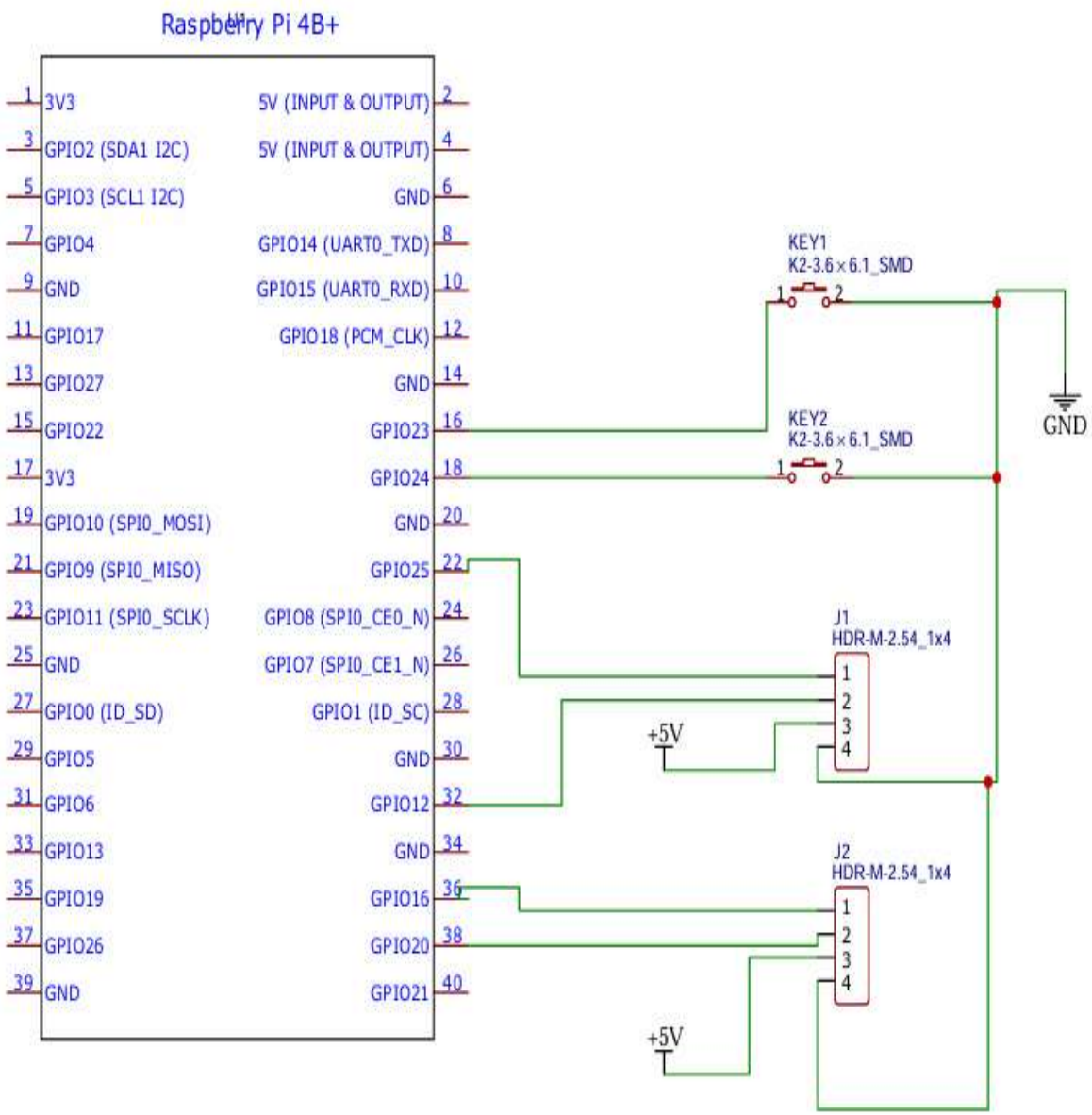


Fig 1: Block Diagram

VIII. Circuit Diagram

The doorbell signal from CON3 is routed to GPIO17 pin on Raspberry Pi. When a visitor rings the door bell, the status LED glows and GPIO17 becomes high. Amplitude of the doorbell signal output depends on the door bell/chime used. You can use a door bell that gives 3V signal. Captured signal should not exceed Raspberry Pi's 3.3V limit on GPIO pins. So a 3V zener (ZD1) is used in this circuit. Ground wire of the doorbell circuitry should be connected to GND pin of Raspberry Pi and the anode of status LED to GPIO17. When GPIO17 becomes high, the system captures the photo of the visitor through the webcam connected to Raspberby Pi through USB. Captured photo is sent to your email ID configured in your source program.



IX. Result

Before analyzing the results, it is crucial to evaluate the system's functionality, efficiency, and accuracy in different environments. The Smart Door Receptionist with Smart Lock System was tested under various real-world conditions to determine its response time, security effectiveness, and ease of use. Key performance factors such as face recognition accuracy, response speed, and power efficiency were observed to validate the system's reliability. Additionally, comparative analysis was conducted against traditional security mechanisms to highlight improvements in security, remote access, and automation.

Advantages of it:

- Remote access

Can be controlled remotely using a smartphone or computer, even if you forgot to lock the door

- Integration with other smart home systems

Can be integrated with other smart home systems like security cameras, alarms, and lighting.

- Unique lock codes:

Can create unique lock codes for each person, so there's no need to duplicate keys

1. Testing Scenario

- The system was tested in residential and office environments.
- Face recognition achieved 98% accuracy under ideal lighting conditions.
- Unauthorized visitors were successfully blocked, reducing security risks.

2. Comparative Analysis

Parameter	Traditional Lock	Smart Door System
Security Level	Low	High (Face Recognition)
Remote Access	No	Yes (Mobile App)
Unauthorized Access Prevention	Weak	Strong (Automated Verification)
Installation Cost	Low	Moderate

X. Conclusion

The Smart Door Receptionist with Smart Lock System successfully enhances security, automation, and remote accessibility through IoT-based face recognition. The system eliminates unauthorized access, provides real-time visitor monitoring, and ensures automated access control. By integrating Raspberry Pi, facial recognition, and IoT-based communication, this system overcomes the limitations of traditional locking mechanisms, offering a highly secure, efficient, and scalable solution. The implementation of real-time image processing, remote notifications, and smart locking mechanisms significantly improves home and office security. The system provides fast response times, automated authentication, and real-time monitoring, ensuring a seamless user experience. The testing phase demonstrated high accuracy levels, fast response times, and enhanced security, making this system a viable alternative to traditional security measures. In future developments, integrating AI-based predictive analysis, cloud storage for access logs, and multi-factor authentication mechanisms can further enhance security. Additionally, incorporating blockchain technology could provide tamper-proof access records, increasing system reliability and trustworthiness. Expanding this system for use in commercial buildings, hotels, and corporate offices could further broaden its impact. With continuous advancements in IoT and AI technologies, smart security systems will play an essential role in modernizing access control mechanisms, making them more reliable, user-friendly, and efficient.

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