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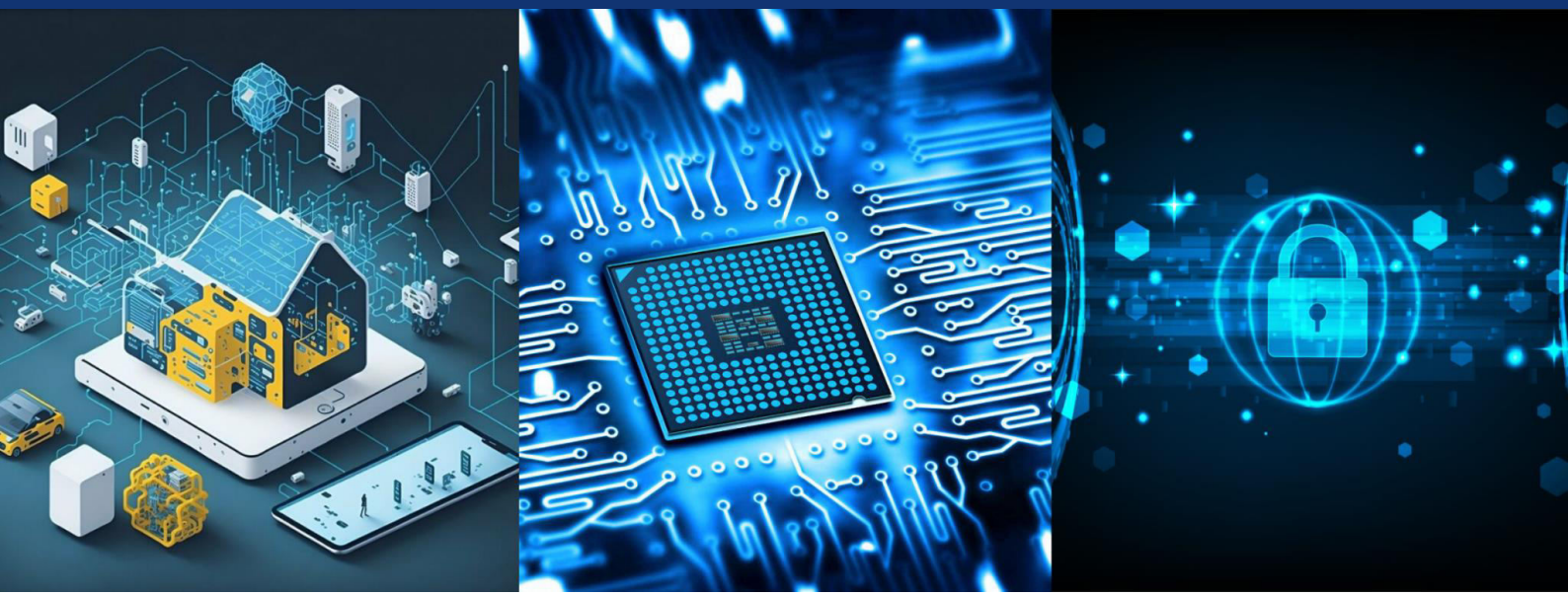

International Journal of Innovative Research in Computer and Communication Engineering

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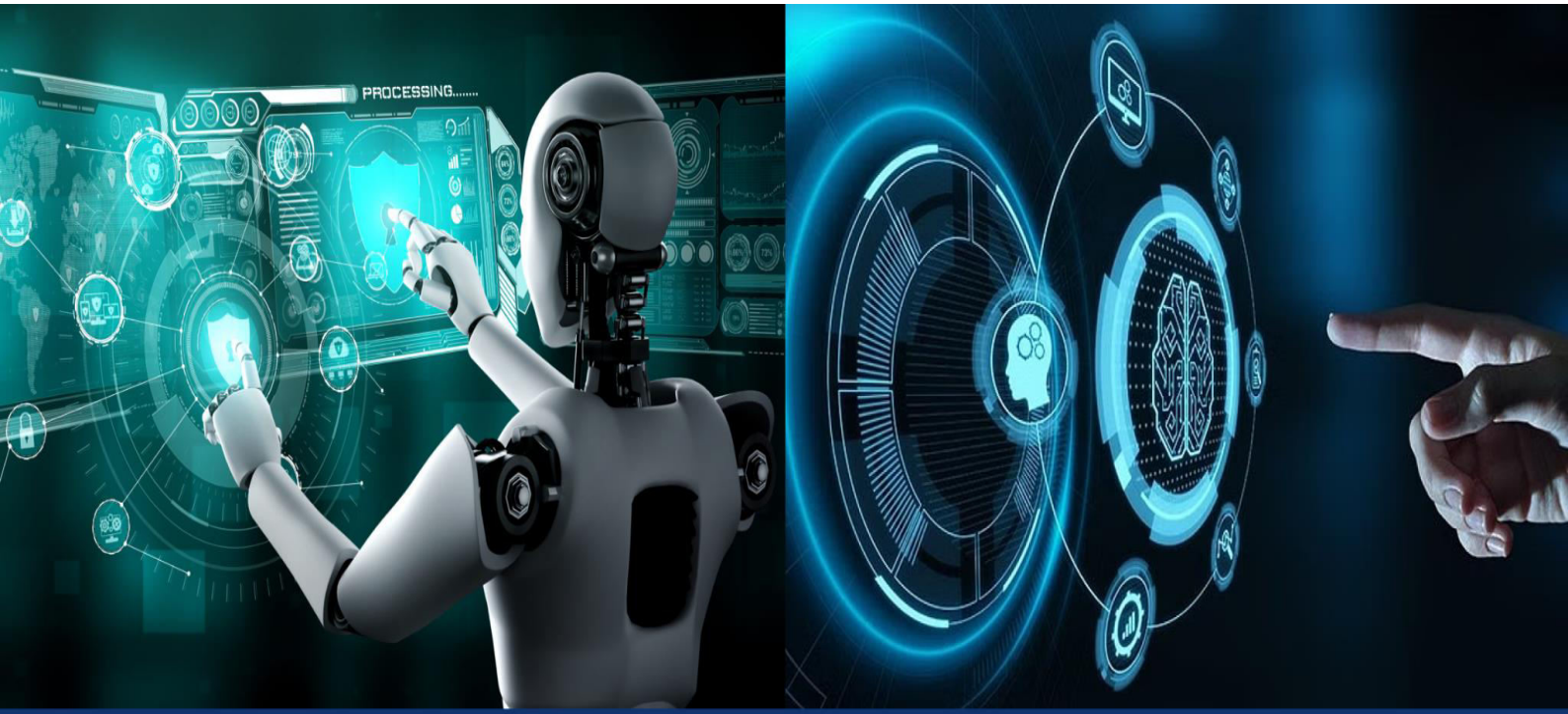

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International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

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Raspberry Pi-Powered Face Detection for Security and Automation

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ABSTRACT: With the rise of IoT-driven smart security systems, traditional access control methods are evolving toward automated, AI-powered solutions. This project, Raspberry Pi-Powered Face Detection for Security and Automation, integrates Raspberry Pi, OpenCV, and IoT to create an intelligent access control system. The system captures real-time video using PiCamera2, processes facial data with AI-based face recognition, and authenticates individuals against a pre-stored database. If an authorized person is detected, the door unlocks automatically using a servo motor/relay, and a confirmation message is displayed on an LCD screen. If an unauthorized person is detected, the system denies access, triggers a buzzer alert, and sends a notification. A PIR sensor ensures that face recognition is only activated when a person is present, optimizing power and processing efficiency. This IoT-enabled security system allows remote monitoring and real-time alerts, making it ideal for applications such as smart homes, offices, and industrial security. The system can be further enhanced with cloud-based authentication, mobile app integration, and remote access logs, making it a cost-effective and scalable solution for next-generation security automation.

KEYWORDS: Face recognition, raspberry pi, opencv.

I. INTRODUCTION

Security breaches due to stolen keys, shared passwords, or unauthorized RFID card duplication pose significant risks in modern security systems. Conventional access control mechanisms can be easily bypassed, necessitating the need for a more secure, contactless, and intelligent authentication method.

Face recognition offers a non-intrusive and highly secure alternative, ensuring access is granted only to registered individuals. This project leverages MobileNet for lightweight yet effective face recognition, making it ideal for real-time applications on Raspberry Pi.

Objectives:

✓ Implement a real-time face detection & recognition system.

✓ Automate door unlocking for authorized users.

✓ Trigger security alerts for unrecognized faces.

✓ Optimize the system for Raspberry Pi's processing constraints.

Related work : A. Traditional Face Recognition Methods

- Haar Cascade Classifier (Viola-Jones Algorithm)
  - Efficient in real-time applications but less effective in poor lighting.
- HOG-based Face Detection
  - Performs well with high-resolution images but requires more computational power.

B. Deep Learning-Based Face Recognition

- FaceNet & DeepFace
  - Highly accurate but requires powerful GPUs, making them unsuitable for Raspberry Pi.
- MobileNet
  - Optimized for edge devices, offering a balance of accuracy and speed.

C. Security & Access Control Systems

- Many existing systems use fingerprint, RFID, or PIN-based authentication, but these can be compromised.

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- Face recognition enhances security by ensuring only authorized individuals can gain access.

This project adopts MobileNet for real-time face recognition, ensuring low latency and high efficiency.

II. BACKGROUND THEORY

Face recognition involves the following core processes:

A. Face Detection

- Utilizes Haar cascade classifiers to identify faces within a frame.

B. Feature Extraction & Classification using MobileNet

- MobileNet extracts facial features and classifies faces into registered or unregistered categories.
- The extracted feature vectors are used to determine access permission.

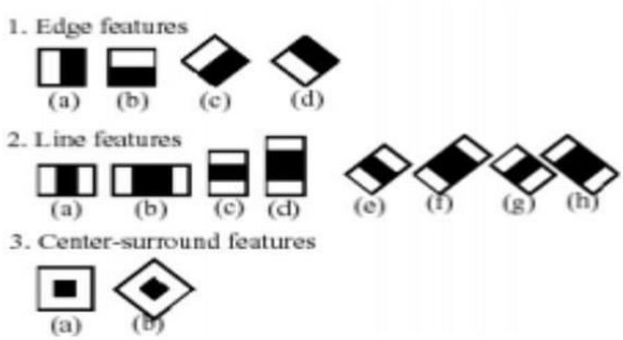

Fig. 2 Common Haar Features

III. SYSTEM BLOCK DIAGRAM

A. Hardware Components

1. **Camera Module** – Captures real-time images.
2. **Raspberry Pi (Model 3/4)** – Processes images and runs the recognition model.
3. **Relay Module & Solenoid Lock** – Controls door access.
4. **Power Supply (9-12V DC)** – Powers the system.

B. Software Components

1. **OpenCV** – Handles face detection.
2. **MobileNet** – Extracts features and classifies the face.

C. Workflow

1. **Capture Image** – The camera detects a face.
2. **Face Detection** – Haar cascades locate the face.
3. **Feature Extraction & Classification** – MobileNet processes the image.
4. **Decision Making:**
   - If **recognized**, unlock the door.
   - If **unrecognized**, trigger a security alert.

1. Image Processing: This process is used for image capture and recognition compared with database images.
2. Embedded System Design: This method is used for the module, which combines hardware, software and many other featured components.
3. GPIO pins give an output of 3.3V only. The solenoid lock needs 9 -12V to operate. So we used an external DC source and relay linked with pi to work the lock. The VCC and GND of the relay module attached to Raspberry Pi pins. Then the signal pin of the relay module is given to the GPIO 26 of Raspberry Pi. On the other side of the relay module, connect.
4. the negative from the external DC source to the negative of the solenoid door lock. Connect the positive from the DC power source to the common of the relay module and then connect normally open from the relay module to positive of the solenoid door lock.

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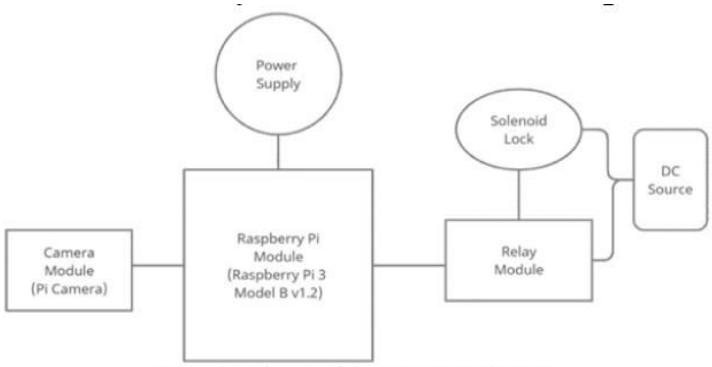
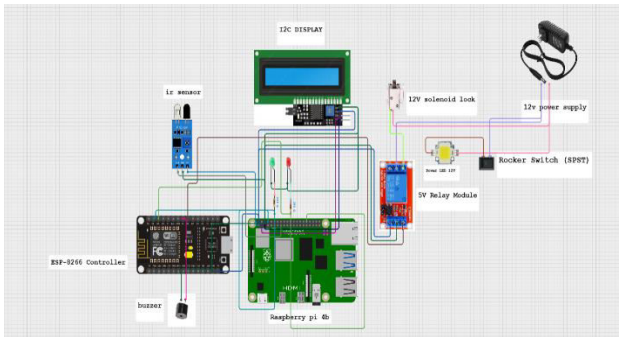


Fig.4 Block layout of the system Raspberry Pi

IV. EXPERIMENTAL PROCEDURE

The project is designed and executed with the help of Raspberry Pi for the door unlocking, which ensures that our homes are safely protected. Raspberry Pi operates the video camera to record images and monitors them. Open CV/ Python Library is developed by using a saved facet database as a given picture of a scene to recognize or check one or more people in the scene. The pictures are then derived and will match photos from the collection. The door opens immediately if the pictures are paired. Otherwise, the door lock stays closed –



Circuit diagram

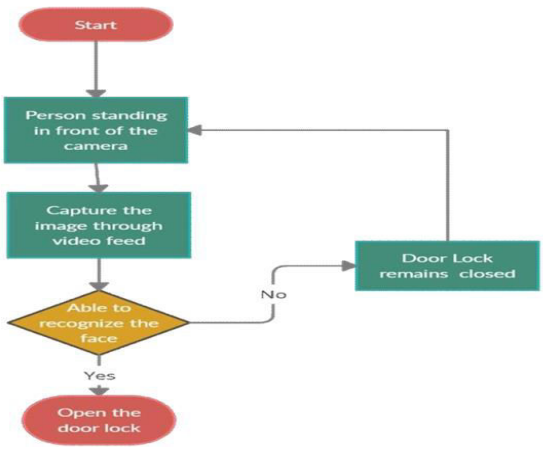


Fig.6 Flow Chart of the process

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A. Data Collection & Preprocessing

- Multiple images per user are captured under different lighting conditions.
- Images are resized and normalized for MobileNet processing.

B. Model Training

- MobileNet is trained using a dataset of registered users.
- The trained model is deployed for real-time face recognition.

C. Real-Time Face Recognition

1. The camera captures an image.
2. Haar cascades detect the face.
3. MobileNet extracts features and classifies the face.
4. If authorized:
   - The door unlocks for 10 seconds.
   - A message is displayed: *Access Granted*.
5. If unauthorized:
   - A security alert notification is triggered.

D. Hardware Implementation

- Raspberry Pi GPIO 26 controls the relay module.
- The relay activates the solenoid lock, granting or denying access.

V. FACE DETECTION AND RECOGNITION IMPLEMENTATION

A. Face Detection Performance

- High accuracy under normal lighting conditions.
- Reduced performance in low-light **environments (~15% decrease).**

Automation Features

Access Control: The system unlocks doors for authorized individuals using a relay and solenoid lock mechanism.
Security Alerts: If an unauthorized face is detected, an alert is sent via email or a mobile app.

VI. RESULTS AND DISCUSSIONS

The system was successfully implemented using Raspberry Pi, OpenCV, and deep learning models for real-time face detection and recognition. The experimental results demonstrate that the system effectively detects and identifies authorized individuals while denying access to unauthorized persons.

During testing, the face detection module using Haar Cascade Classifier accurately detected faces in well-lit conditions. The detection speed was fast due to the lightweight nature of the algorithm. However, in low-light conditions or when the face was partially occluded, the accuracy slightly dropped.

For face recognition, the system processed images using a MobileNet-based feature extractor, which provided high accuracy in identifying known individuals. The recognition was performed by comparing extracted feature embeddings with a stored database of authorized individuals. The system maintained an accuracy rate of approximately 85-90% under normal lighting conditions, but performance slightly decreased when tested under extreme lighting variations or different facial angles.

VII. CONCLUSION

The implemented face recognition system using Raspberry Pi, OpenCV, and deep learning models successfully provides secure and automated access control by detecting and recognizing faces in real time. The use of the Haar Cascade Classifier for face detection ensures fast processing, while MobileNet-based feature extraction enhances recognition accuracy. The system effectively unlocks doors for authorized individuals and denies access to unauthorized persons, making it suitable for smart homes, offices, and industrial security applications. Despite minor challenges in low-light conditions and face occlusions, the system demonstrates high accuracy and efficiency, with potential for future improvements such as infrared-based detection and cloud-based authentication for enhanced security and scalability.

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