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Face authentication for door lock system using IOT

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ABSTRACT: The work presents a smart and secure door access control system using real time face detection and recognition, specifically designed to enhance child safety and support parental awareness. The system allows only authorized individuals such as children or trusted family members to unlock the door automatically upon recognition. When a child is detected, a photo is captured and sent to the parent's email, allowing them to monitor their child's arrival or departure in real time, even if they are busy or away from home. If an unrecognized face is detected, the door remains locked and the image is sent to the parent for security verification. Additionally, a wide angle photo is captured to inform the parent whether the child is alone or accompanied by others. Buzzer tones are used to indicate whether the detected individual is known or unknown, providing an added layer of alert within the home. By combining computer vision, sensor based automation, and email communication, this system delivers a reliable, real time, and intelligent home security solution focused on protecting children and keeping parents informed at all times.

KEYWORDS: Facial Recognition, IoT-Enabled Contactless Detection, Raspberry Pi, Smart Door Lock, Motion Detection.

I. INTRODUCTION

Security is a growing concern in today's world, especially with increasing incidents of unauthorized access, theft, and intrusion. Traditional security systems such as locks and keys, RFID cards, or password-based entry methods are commonly used, but they often lack the intelligence to respond to dynamic security threats. These systems can be easily bypassed, lost, or shared, offering limited protection against unauthorized access. To address these limitations, modern security systems are evolving towards intelligent, automated solutions that can detect, recognize, and respond to threats in real time. One such promising approach is the use of face detection and recognition for secure access control. This technology allows the system to identify individuals based on facial features and make real-time decisions regarding access, alerts, and logging.

To address these concerns, there is a clear need for a smart, automated security solution that not only controls access but also ensures that children remain safe at all times. The proposed system introduces a smart door security solution that integrates face recognition, motion detection, and sensor-based automation to enhance access control with a specific focus on child safety. When a visitor or child approaches the door, motion is detected through sensors, and the system captures the individual's image along with a wide-angle photo to monitor surrounding activity.

If the face is recognized as authorized, the door unlocks automatically, and a confirmation image is sent to the parent's email. For unrecognized individuals, the system triggers a buzzer alert inside the house and sends the captured images to the parent's email. All entry attempts are logged and sent via email for ongoing review and security auditing. In cases where multiple individuals are present even if one is recognized the system still reports the event to ensure full transparency and caution. It improves the level of safety, awareness, ensuring children are protected.

II. LITERATURE REVIEW

Authors Sachin Sharma, Mayank Sharma, et al, have proposed a multi-layered authentication system that combines facial recognition with health monitoring. Leveraging OpenCV and the Haar Cascade algorithm, the system grants access exclusively to authenticated individuals. Additionally, it monitors body temperature and denies entry if abnormal readings are detected, thereby mitigating potential health risks. This approach overcomes the shortcomings of

traditional access control systems by enhancing both security and safety, offering a robust and comprehensive solution for modern security needs across diverse settings [1]. According to Mohd Raza Moghul, Riddhesh Barve, et al, an advanced home security solution has been developed using IoT technology. This system incorporates motion detection and real-time communication to enable secure remote monitoring of visitors. By integrating smart sensors, a Raspberry Pi-based control unit, and cloud-based communication, it eliminates the need for direct contact, offering a more efficient and contactless approach to home security [2]. As per Pooja Bende, Komal Taral, et al, the system captures and analyzes a visitor's facial image using face detection algorithms implemented in Python. The detected image is transmitted to the homeParent's Android application via Wi-Fi for verification. Based on the received image, the Parent can approve or deny access through the app, thereby controlling the door unlocking mechanism remotely [9]. Based on Shweta Malve and Dr. S. S. Morade, et al, when the doorbell is pressed, the system captures an image of the visitor and converts it to grayscale. Using the Haar-Cascade classifier, it detects the face and compares it with a pre-stored database. If a match is found, the visitor's name is announced; otherwise, the image is saved for future reference. This approach enhances security by recognizing familiar visitors and continuously updating the database with new entries [10]. In the words of Onuiké C. B., Amagba S. O, et al, a cost-effective facial recognition system has been designed for security applications using a Raspberry Pi 3 and locally available components. The system integrates microcontrollers, sensors, and Python programming, along with a display screen and buzzer for user interaction. Developed following Dennis and Wixom's prototype methodology, it effectively distinguishes between authorized and unauthorized individuals. While hardware upgrades are recommended to boost performance, proposed future enhancements include voice assistance, integration with police databases, and cloud storage for improved functionality and scalability [5]. In the study conducted by Asif Rahim, Yanru Zhong, et al, the use of deep learning specifically logit-boosted convolutional neural networks (CNNs) was explored for face detection and recognition in IoT-enabled smart homes. Six models were evaluated, combining logistic regression (LR), gradient-boosting classifiers (GBCs), and CNNs, with the LR-HGBC-CNN model demonstrating the highest accuracy across both tasks. The research underscores the potential of deep learning to enhance smart home security and privacy, while also acknowledging key challenges related to generalizability, privacy preserving techniques, and practical deployment. It emphasizes the need for continued research to address these limitations [6]. From the perspective of KH Teoh, RC Ismail, and et al, the system employs Haar Cascade classifiers for face detection and utilizes deep learning techniques for image processing. TensorFlow is used to train the classifier, significantly improving recognition accuracy. The study highlights the effectiveness of deep learning in enhancing facial identification, with experimental results confirming the successful implementation and performance of the system [8]. Michael Kelemen, Ivan Virgala, and et al, argue that ultrasonic sensors are effective for non-contact distance measurement by emitting and receiving sound waves. These sensors operate by calculating the time it takes for an ultrasonic wave to travel to an object and return. Due to the ability of most materials to reflect sound, ultrasonic sensors are versatile and well suited for a wide range of applications. Unlike photoelectric sensors, they are particularly effective in detecting transparent objects, films, and liquids, and their performance remains consistent regardless of the target's color or frequent color variations [13]. As discussed by Kurra Naga Sai, Dr. T.D. Sunil, et al, the study examines mechanical, electronic, and smart lock security systems by analyzing their working mechanisms, strengths, and vulnerabilities. It explores emerging technologies like biometric authentication and smart home integration to enhance overall security. The research also highlights potential threats such as hacking and unauthorized access, aiming to inform the development of more secure and effective access control solutions [3]. Authors Mohan Kumar, Irfan Ahamath M, et al, present the development of an RFID-based door lock system utilizing an Arduino microcontroller to provide keyless and secure access. The system enhances security by eliminating the need for traditional keys and supports remote monitoring via smartphone applications. Proposed future enhancements include the integration of biometric authentication and IoT technology to further strengthen smart home security [4]. As discussed by Oladunjoye John Abiodun and Okwori, et al, an IoT-based security system has been developed for smart homes. The system employs an Arduino Uno microcontroller, ultrasonic sensors, and a GSM module to detect intrusions and send SMS alerts to homeParents, providing an effective solution for home security [11]. The analysis by Amuta E.O., Sobola G.O, et al, focuses on designing a home security system that incorporates PIR sensors alongside a fire detection system using LM35 temperature sensors. It details the development of an integrated security and fire detection solution that combines Passive Infrared Receiver (PIR) sensors and LM35 temperature sensors, all managed through an Arduino Uno microcontroller [14]. According to Yashaswi R, Abdulwahab Ahmed Mohamed Omer, et al, security whether data or home security is a top priority. With technological advancements and the widespread adoption of IoT, digital door locks are becoming increasingly popular. Unlike traditional locks that require physical keys, digital locks use methods such as RFID, fingerprints, Face ID, PINs, and passwords. To maintain security, homeParents usually keep their doors locked at all times, but they may sometimes forget to lock the door or be unsure if it is locked. To address this, the authors

present a smart Wi-Fi door system that offers a convenient and efficient solution for remote door locking and monitoring [12].

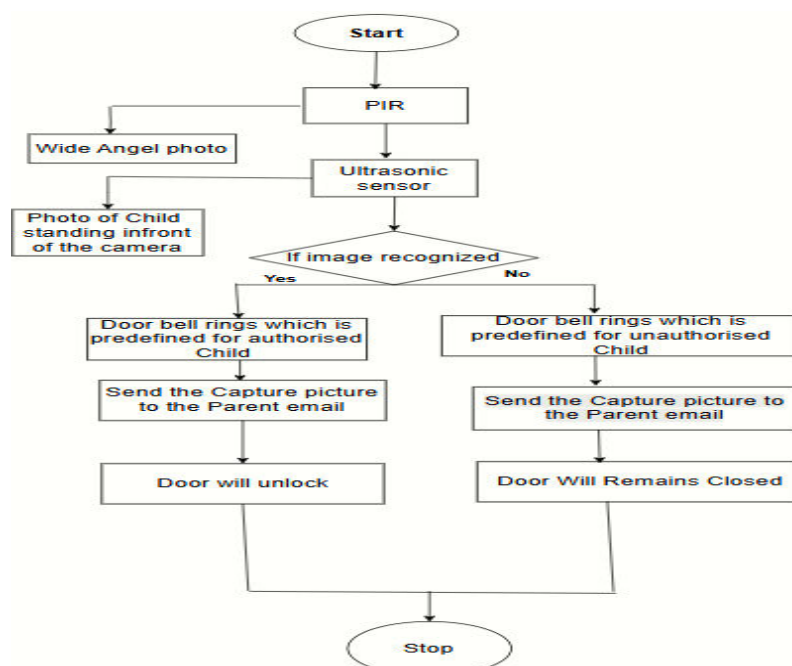
III. OVERVIEW OF SYSTEM

The proposed system is an advanced smart and secure door access control system designed to enhance residential security through the integration of real-time facial recognition, sensor automation, and remote alert capabilities. At the core of the system is a Raspberry Pi microcomputer, which performs high-level processing tasks such as capturing images via a camera module and recognizing faces using Python-based libraries like face recognition and OpenCV. Complementing the Raspberry Pi is an Arduino Uno microcontroller, responsible for interfacing with various sensors and actuators to manage physical system components.

The system utilizes an ultrasonic sensor to detect the proximity of a Child approaching the door by measuring distance changes, and a Passive Infrared (PIR) sensor to detect motion through infrared radiation from the human body. When PIR sensor is triggered, the camera is activated to capture an image or a wide-angle view of the visitor(s). Later when ultrasound sensor is triggered the image of the Child standing in front of camera. The captured face is compared against a pre-stored database of authorized users. If a match is found, the solenoid lock is triggered to open the door, and a confirmation photo along with a wide angle snapshot is sent to the homeParent's email via the smtplib SMTP protocol. In the case of an unrecognized face, the door remains locked, a distinct buzzer is activated to signal unauthorized visitor arrival, and an image of the visitor and wide angle snapshot is sent to the homeParent as an alert.

To ensure real-time decision-making and feedback, separate buzzers indicate whether the visitor is recognized or unknown, providing immediate audible responses. The system is designed to detect multiple individuals in the camera frame, enhancing its reliability in complex scenarios such as group arrivals or suspicious activity. The entire setup runs on a Python-based framework, with additional support from libraries like NumPy, and OS/Time for data handling and system operations. While the system operates on Raspberry Pi OS in deployment, development and testing are performed on a Windows machine for convenience. Overall, this smart door access control system offers a comprehensive, automated, and intelligent solution to modern security challenges by combining facial recognition, sensor input, and remote communication to ensure secure and seamless entry management.

Flow chart



IV. HARDWARE SPECIFICATION

Ultrasonic Sensor

The ultrasonic sensor measures the distance to nearby objects by emitting high-frequency sound waves and detecting their echoes. It is commonly used for proximity detection and helps the system recognize when someone is approaching the door. This triggers other components like the camera or PIR sensor. It's effective in various environments and is crucial for initiating the smart door system before engaging more advanced features like facial recognition.

PIR Sensor

The Passive Infrared (PIR) sensor detects motion by sensing changes in infrared radiation from human bodies. When someone moves within its range, it sends a signal to activate the system. It's an energy-efficient, low-cost way to detect human presence and is often used in security systems. In this setup, it helps trigger the Raspberry Pi to begin facial recognition and alerts the Arduino to prepare other actions.

Raspberry Pi

The Raspberry Pi is a compact microcomputer that handles high-level processing tasks. In this project, it is responsible for facial recognition, comparing live camera input with stored images to verify user identity. It runs Linux and supports languages like Python with OpenCV for image processing. Once identity is confirmed, it communicates with the Arduino to unlock the door, making it the central controller for authentication and system decisions.

Solenoid Lock

A solenoid lock is an electromechanical device that locks or unlocks a door based on an electric signal. When power is applied, the solenoid moves a metal pin to release or secure the lock. In this project, the Arduino activates the solenoid lock when facial recognition confirms an authorized user. It provides a secure, automated locking mechanism without requiring physical keys.

Buzzer

The buzzer provides audible feedback to the user. It is used to signal various states like access granted, denied, or motion detected. Controlled by the Arduino, the buzzer enhances user interaction and serves as a basic alert system. It can also act as an alarm in case of unauthorized attempts, making the system more secure and interactive.

Software specification:**PythonIDE**

A Python Integrated Development Environment (IDE) such as **PyCharm**, **VS Code**, or **Thonny** is used to write, debug, and run the Python code for facial recognition, sensor integration, and system control.

PythonProgrammingLanguage

The core programming language for the project. Python is used due to its simplicity, extensive library support, and compatibility with both Raspberry Pi and OpenCV-based computer vision tasks.

PythonLibraries

Several Python libraries are essential for system functionality:

- `face_recognition`: For face detection and recognition.
- `opencv-python (cv2)`: For video processing and camera interfacing.
- `numpy`: For numerical operations.
- `imutils`: For simplifying OpenCV operations.
- `smtplib`: For sending email alerts (e.g., unauthorized access notifications).
- `os` and `time`: For file handling and execution timing.

WindowsOperatingSystem

Although the system may run on **Raspberry Pi OS** for deployment, development and testing can be performed on a Windows machine. It's also useful for managing the face dataset, testing the code, and sending email alerts.

SMTPLibrary

The **SMTP (Simple Mail Transfer Protocol)** library (via `smtplib`) allows the system to send email notifications in case of unauthorized access or system alerts. It enhances the security aspect by providing remote alerts to the user.

Methodologies:

DataCollection

Face images of authorized users are collected and stored in a designated folder. These images are later encoded and used as reference data during the facial recognition process to verify individuals attempting to access the secured area.

UltrasonicMotionDetection

An ultrasonic sensor is installed near the door to detect the presence of a Child by measuring distance changes. When someone approaches, the sensor triggers the system to activate the camera and prepare for facial recognition, enhancing the responsiveness of the system.

PIRMotionDetection

The Passive Infrared (PIR) sensor detects body heat emitted by humans. When motion is sensed, it helps activate the recognition process. It works in conjunction with the ultrasonic sensor to confirm human presence and reduce false triggers from non-living objects.

SolenoidLock

The solenoid lock is an electromechanical device that remains locked until it receives a signal from the system. When facial recognition confirms an authorized user, the Raspberry Pi or Arduino sends a command to unlock the solenoid, allowing access.

FacialRecognition

The system uses a camera to capture a live image of the visitor and compares it with stored encoded faces using Python libraries. If the face is recognized as authorized, access is granted; otherwise, the system remains locked and may trigger an alert.

Face recognition python library

The **Face Recognition** Python library is a powerful open-source tool used for implementing facial recognition features in various applications. It is built on top of the **dlib** library and utilizes deep learning models, particularly the **ResNet** architecture, to perform accurate face detection, encoding, and comparison. While the library itself provides a simple and user-friendly interface, it internally uses advanced **machine learning algorithms** to analyze facial features and match them with stored data. In the smart door lock system, this library plays a crucial role by capturing a live image, extracting facial features, and comparing them with pre-stored encoded faces to determine whether access should be granted or denied.

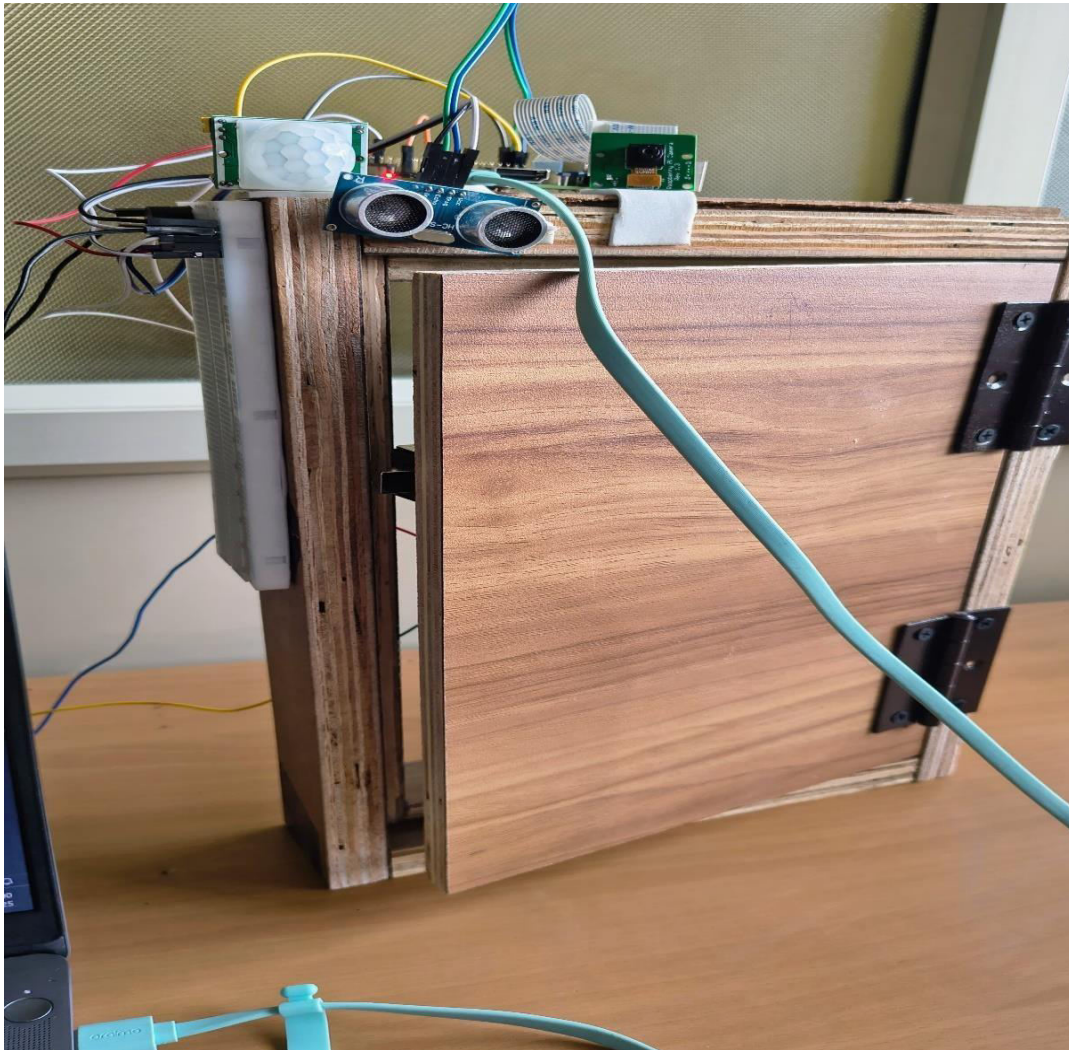
V. RESULTS**Experimental results:**

Fig.1. shows the setup of our proposed system active for authentication

The above Fig.1. shows the initial setup of our proposed system and working mechanisms against the constraints. The initial setup of our system enclosed in a wooden box with metal hinges for support. Various cables are connected to components like sensors and a microcontroller mounted on top. The setup is designed for early-stage testing and development.

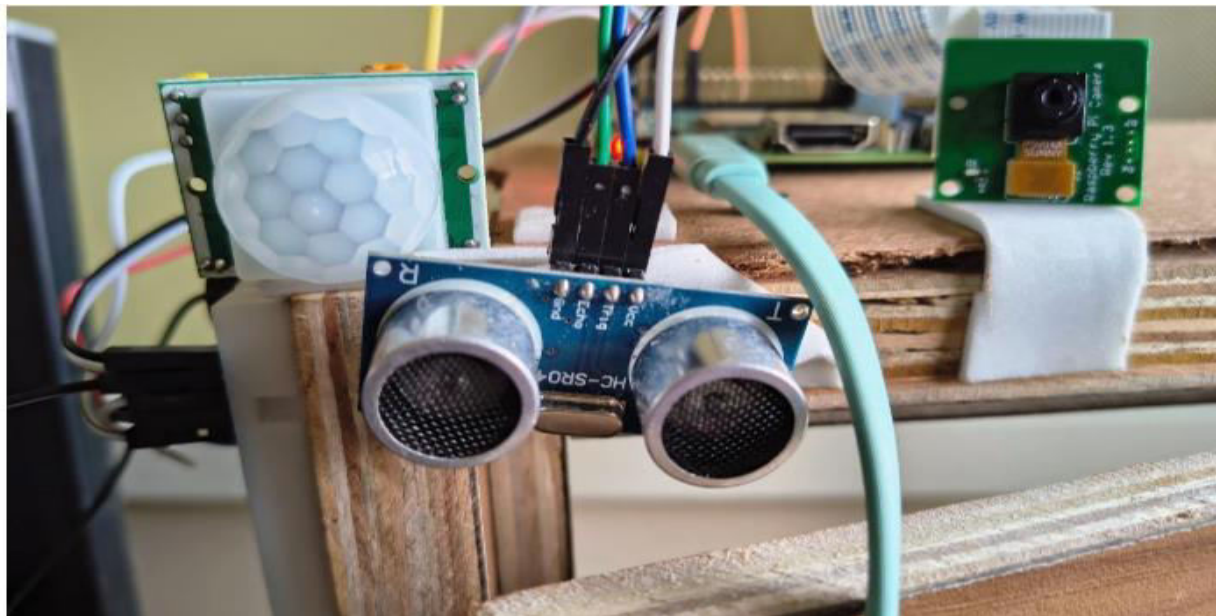


Fig.2. PIR and Ultrasound sensors(HC-SR04) sensors detect the presence of visitors by monitoring temperature change and ultrasonic waves respectively.

The above Fig.2. illustrate the use of PIR and HC-SR04 ultrasonic sensors for detecting the presence of Child. The PIR sensor identifies motion by sensing changes in infrared radiation, typically caused by body heat. Simultaneously, the HC-SR04 sensor emits ultrasonic waves and measures the time taken for the echo to return, detecting movement or obstacles. Together, these sensors provide accurate and reliable presence detection for initiating further system actions.

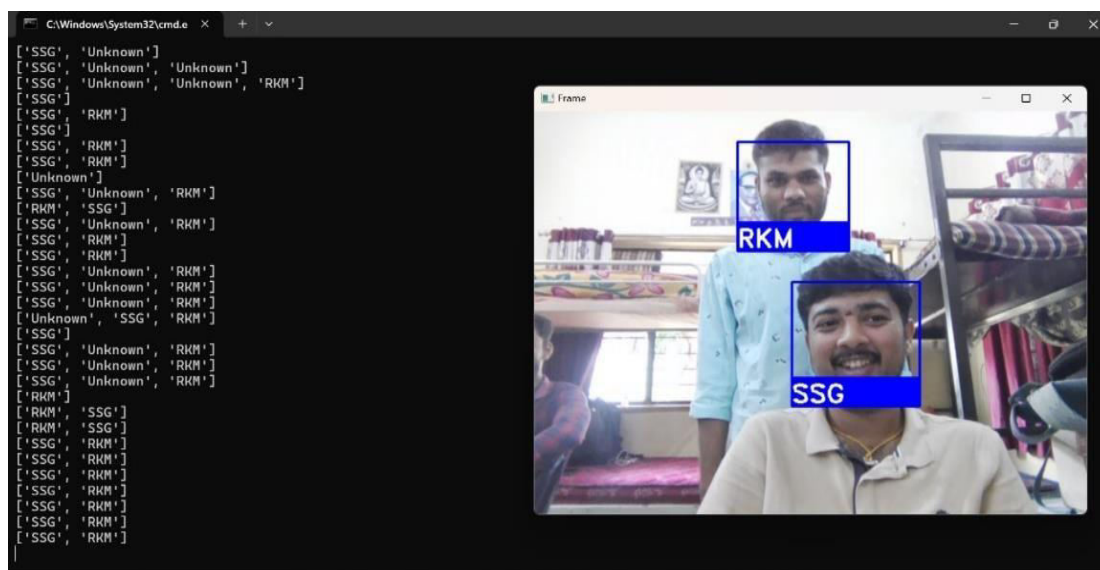


Fig.3. Detecting known Childs

The above Fig.3. demonstrates the successful detection of known individuals using face recognition. The system accurately labels the detected faces as “RKM” and “SSG” in the live video feed. Names are displayed with bounding boxes, indicating proper identification from the database. The console output confirms repeated recognition and differentiation between known and unknown individuals.

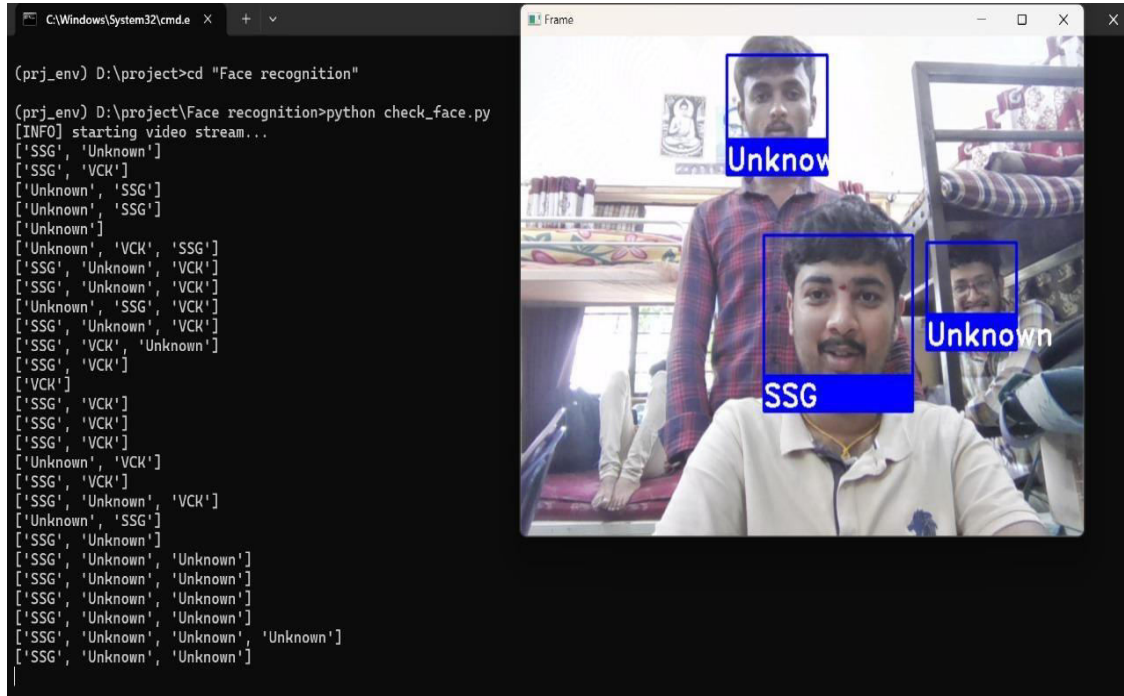


Fig.4. Detecting unknown Childs

The above Figure 8.3 shows the system identifying both known and unknown individuals in a live video stream. The Child labeled "SSG" is recognized, while the other two faces are marked as "Unknown." This demonstrates the system's ability to differentiate between registered and unregistered individuals. The console output also reflects accurate classification of each detected face.

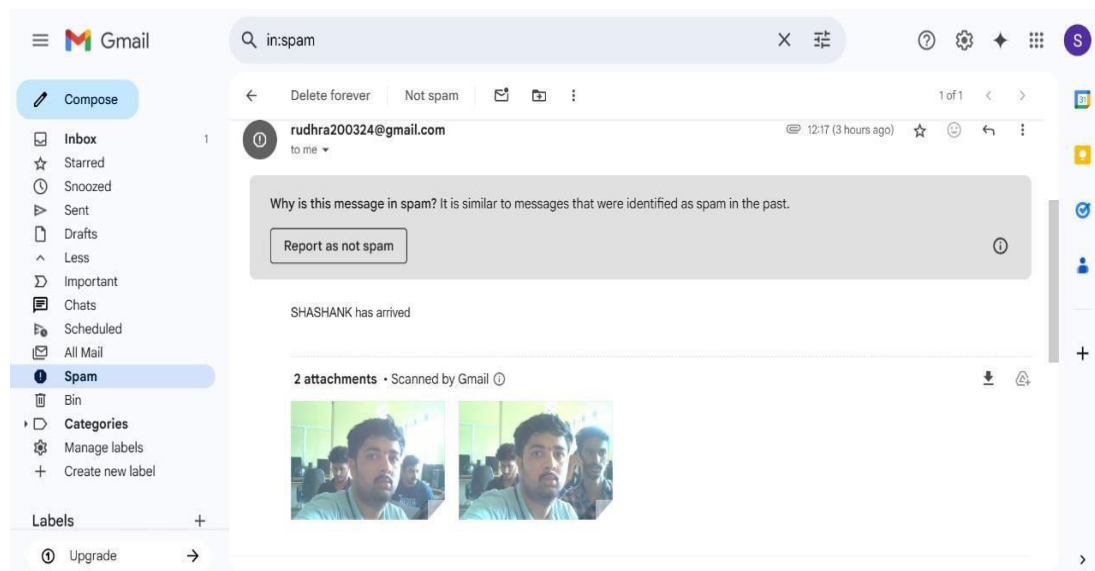


Fig.5. The image of the Child/children is sent to the Parent's email.

The above Fig.5. shows the system is designed to enhance security by capturing images of Child or children detected by the camera. When an unknown face is recognized, the system automatically takes a snapshot of the individual. This

image is then sent to the Parent's email address as an alert or notification. This feature ensures real-time monitoring and immediate awareness of any unrecognized presence.

VI. CONCLUSION

The proposed system is a smart and secure door access control solution integrating real time facial recognition, sensor automation, and remote alerts. A Raspberry Pi performs image capture and face recognition using Python libraries, while an Raspberry Pi controls hardware components like PIR and ultrasonic sensors. When motion and proximity are detected, the camera captures the Child image. If the face matches a stored entry, the solenoid lock opens and an email with photos is sent to the home Parent. If unrecognized, the door remains locked, a buzzer alerts nearby occupants, and images are emailed. The system enhances home security through automation and intelligent decision making.

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