IMPLEMENTATION OF IOT BASED ATTENDANCE MANAGEMENT SYSTEM ON RASPBERRY PI

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MAJOR PROJECT REPORT

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BY

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CERTIFICATE

Date: /06/2025

This is to certify that the project work entitled ***IMPLEMENTATION OF IOT BASED ATTENDANCE MANAGEMENT SYSTEM ON RASPBERRY PI*** *is a Bonafide work carried out by* ***CH. SAI TEJASWINI, G. BHAVITHA, K. MEGHARAJ, D. NIHAL, M. NISHANTH, S. ANU*** *and* ***B. ABHINAYA*** *bearing Roll Nos.* ***21RS1A0427, 21RS1A0424, 21RS1A0435, 21RS1A0418, 21RS1A0438, 21RS1A0456*** *and* ***21RS1A0414*** *in partial fulfillment of the requirements for the degree of* ***BACHELOR OF TECHNOLOGY*** *in* ***ELECTRONICS & COMMUNICATION ENGINEERING*** *by the Jawaharlal Nehru Technological University Hyderabad during the academic year 2024-25.*

The results embodied in this report have not been submitted to any other University or Institution for the award of any degree or diploma.

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ABSTRACT

The implementation of an IoT-based attendance management system using Raspberry Pi leverages facial recognition and fingerprint authentication technologies to enhance efficiency and accuracy. Traditional attendance systems are prone to errors, time consumption, and proxy attendance, making automated systems a vital necessity. This system integrates IoT capabilities to provide a seamless solution for attendance tracking in educational institutions and workplaces. The Raspberry Pi serves as the central processing unit, interfacing with a camera module for face recognition and a fingerprint sensor for biometric verification. Utilizing Python-based libraries and algorithms like OpenCV for face recognition and minutiae-based techniques for fingerprint matching, the system ensures secure and accurate authentication.

This project employs cloud integration for data storage and real-time accessibility, enabling users to manage attendance records remotely. The system ensures high reliability through robust encryption for sensitive data and offers scalability for large-scale applications. Key features include automated attendance marking, real-time notifications, and an intuitive interface for administrators and users. The IoT framework allows for remote monitoring and data analytics, enabling organizations to identify trends and optimize attendance policies. The combination of face and fingerprint recognition not only enhances security but also minimizes fraudulent practices, making it an efficient and user-friendly alternative to traditional attendance systems.

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Introduction

1.1 Introduction

The rapid advancement of technology has significantly transformed various sectors, and one such area where innovation is crucial is attendance management. Traditional attendance systems that rely on paper registers or manual sign-ins are prone to errors, inefficiency, and potential fraud. In educational institutions, workplaces, and other settings, ensuring accurate and secure attendance records has become a challenge. The integration of modern technologies like the Internet of Things (IoT), face recognition, and biometric systems promises a solution to this problem by automating the process, ensuring reliability, and enhancing security.

The IoT-based Attendance Management System is designed to address the limitations of traditional attendance systems by offering a real-time, automated, and efficient solution. Leveraging IoT allows the system to continuously collect and transmit attendance data to a centralized server or cloud platform, enabling real-time tracking and management of attendance records. This automation ensures accuracy and saves time for administrators and individuals alike, reducing the possibility of human error and fraud.

Raspberry Pi, a small and cost-effective computing platform, serves as the backbone of this IoT-based system. Raspberry Pi's versatility allows it to interact seamlessly with various sensors, cameras, and modules, making it an ideal choice for implementing the system. With its processing power and compatibility with numerous software libraries, Raspberry Pi can efficiently handle tasks like face recognition and biometric data collection while maintaining low power consumption and cost.

Face recognition, a biometric technology, is one of the key components of the system. By using advanced algorithms and machine learning techniques, the system can accurately identify individuals based on facial features. This eliminates the need for manual input, providing a seamless and quick way to mark attendance.

1.2 Aim of the Project

The aim of this project is to develop an IoT-based attendance management system using Raspberry Pi that leverages face recognition for automated, accurate, and efficient attendance tracking.

The primary aim of this project is to develop an efficient, secure, and automated attendance management system that addresses the limitations of traditional methods. By utilizing IoT technology, face recognition, and fingerprint sensors, the project aims to create a seamless, error-free, and real-time system for recording and tracking attendance. The objective is to ensure that attendance records are accurate, up-to-date, and easily accessible to administrators, students, or employees without manual intervention, reducing the risk of mistakes, fraud, or unauthorized access.

The objectives of the project are as follows:

1. To develop an automated attendance management system using IoT technology that eliminates the need for manual attendance marking, ensuring accuracy and efficiency in attendance tracking.
2. To integrate face recognition and fingerprint biometric authentication technologies to enhance security, ensuring that only authorized individuals can mark their attendance and preventing fraudulent activities.
3. To design a user-friendly interface that allows for real-time synchronization of attendance data, making it accessible remotely to administrators or authorized personnel for easy monitoring and management.
4. To enable the generation of detailed attendance reports and analytics that can help identify patterns, track trends, and provide insights for better decision-making in educational and organizational settings.
5. To reduce administrative workload by automating the entire attendance process, saving time, reducing errors, and improving the overall reliability and effectiveness of attendance management systems.

1.3 Methodology

The methodology of this IoT-based Attendance Management System using Raspberry Pi, face recognition, and fingerprint sensors involves several key steps to ensure efficient implementation. First, the project begins with selecting the appropriate hardware and software components required for the system. The Raspberry Pi acts as the central processing unit, connecting the biometric sensors (fingerprint scanner and camera for face recognition), and is responsible for executing the necessary algorithms.

In the next step, the system uses the camera to capture the facial image of an individual. The facial recognition process involves processing the image and extracting distinctive features from the face. These features are then compared against a database of stored face profiles using machine learning algorithms. The system uses open-source libraries, such as OpenCV, to train and implement the facial recognition model. The trained model is capable of identifying individuals accurately, and the facial features are stored and matched with

1.4 Significance of the work

The significance of this IoT-based Attendance Management System lies in its ability to automate and streamline the process of tracking attendance, making it more efficient and accurate. Traditional attendance systems, such as paper registers or manual sign-ins, are time-consuming and prone to errors. By implementing an automated system powered by IoT technology, the project significantly reduces human intervention, ensuring that attendance is recorded accurately and efficiently, which is crucial for institutions and organizations where precise attendance data is essential.

The key aspect of the project is the integration of biometric authentication, such as face recognition and fingerprint scanning, which enhances security and reliability. By utilizing these advanced methods, the system minimizes the risks of identity theft, fraud. This makes the system more secure, ensuring that only authorized individuals can mark attendance. This added layer of security is particularly valuable in high-stakes environments such as educational institutions, corporate workplaces, and government organizations.

1.5 Organization of the thesis

This thesis is divided into six chapters including introduction and conclusions. The block diagram, features, pin diagram and other functional units of Raspberry Pi 4B are explained in Chapter 2. The description of various hardware components and the software used in the project is explained in chapter 3 and chapter 4. The schematic diagram, flowchart are discussed in chapter 5.

Chapter 2
Overview of Raspberry Pi

2.1 Introduction

Raspberry Pi is a small, affordable, and versatile single-board computer that has gained widespread popularity among hobbyists, educators, and developers worldwide. Initially introduced in 2012 by the Raspberry Pi Foundation, this compact computer was designed to promote computer science education and help make programming more accessible. With its low price, ease of use, and extensive community support, Raspberry Pi has evolved into a powerful tool for a wide range of applications, from educational projects to industrial uses. Its ability to run a full-fledged operating system like Linux makes it an ideal platform for experimenting with different technologies, including Internet of Things (IoT), robotics, automation, and multimedia systems.

One of the key features of Raspberry Pi is its flexibility in terms of both hardware and software. The board itself consists of a CPU, memory, input/output pins, storage options, and various connectivity ports such as HDMI, USB, Ethernet, and GPIO (General Purpose Input/Output). This allows users to connect different peripherals such as keyboards, mice, displays, cameras, sensors, and actuators, making it suitable for a variety of projects. Raspberry Pi supports multiple operating systems, including Raspberry Pi OS, a Linux-based OS, which provides an environment for running various programming languages and applications, making it an excellent tool for both learning and development.

Raspberry Pi's ability to interface with other hardware components and sensors through the GPIO pins is another reason it has become a staple for DIY and IoT projects. The GPIO pins provide direct access to control and read signals from external devices, enabling users to connect a wide variety of sensors, motors, lights, and other hardware components to the Pi. This is particularly useful for projects involving automation, robotics, and sensing systems, where the Raspberry Pi can act as the central controller for the entire system. By programming these pins using Python or other languages, users can create custom solutions to control external devices in response to various inputs.

2.2 Types of Raspberry Pi

Raspberry Pi comes in several models and versions. Here are the most common types of Raspberry Pi boards:

2.2.1 Raspberry Pi 3 Model B

The Raspberry Pi 3 Model B is a versatile single-board computer that offers a solid balance between performance and affordability, making it an ideal choice for a wide range of applications, from education to DIY projects. Equipped with a 1.2 GHz quad-core ARM Cortex-A53 processor and 1GB of RAM, the Pi 3 Model B provides adequate processing power for many tasks.

2.2.2 Raspberry Pi 3 Model B+

The Raspberry Pi 3 Model B+ is an enhanced version of the Raspberry Pi 3 Model B, offering several improvements in performance and connectivity. It features a 1.4 GHz quad-core ARM Cortex-A53 processor, which provides a slight boost in processing power over its predecessor. This makes it suitable for tasks like running web servers, handling IoT projects, and performing basic multimedia tasks.

2.2.3 Raspberry Pi Zero W

The Raspberry Pi Zero W is a compact and affordable single-board computer that offers a low-cost solution for a variety of projects, particularly in areas where space and power consumption are critical. It features a 1 GHz single-core ARM11 processor and 512MB of RAM, providing sufficient performance for lightweight applications such as simple automation, sensor integration, and embedded systems.

2.2.4 Raspberry Pi 400

The Raspberry Pi 400 is a unique version of the Raspberry Pi, integrated into a compact keyboard, making it a convenient and portable personal computer. It is powered by the same Raspberry Pi 4 Model B hardware, featuring a 1.8 GHz quad-core ARM Cortex-A72 processor, 4GB of RAM, and a suite of connectivity options, including USB 3.0, gigabit Ethernet, Bluetooth 5.0, and dual-band Wi-Fi.

2.2.5 Raspberry Pi Zero

The Raspberry Pi Zero is an ultra-compact and cost-effective version of the Raspberry Pi, designed to be small enough for embedded applications and portable projects. It features a 1 GHz single-core ARM11 processor and 512MB of RAM, offering a basic level of performance suitable for lightweight tasks such as simple automation, sensors, and basic computing.

2.3 Raspberry Pi 4B

The Raspberry Pi 4 Model B is a significantly more powerful and versatile single-board computer that elevated the capabilities of affordable computing for students, hobbyists, and developers. Released in 2019, it features a 1.5 GHz quad-core ARM Cortex-A72 processor and comes with multiple RAM options—2GB, 4GB, or 8GB of LPDDR4 RAM—making it suitable for more demanding tasks, including desktop computing, software development, and multimedia applications. The upgraded processor and memory provide a substantial performance boost compared to previous models, while the support for dual 4K displays via dual micro-HDMI ports expands its use in professional and creative environments.

The Raspberry Pi 4 Model B introduced several advancements in connectivity and performance. It includes USB 3.0 ports for faster data transfer, Gigabit Ethernet for high-speed networking, and improved wireless capabilities with dual-band Wi-Fi and Bluetooth 5.0. Despite these powerful enhancements, it retains the compact and familiar form factor of earlier models, making it ideal for a wide range of applications—from education and IoT projects to media centers and home servers. It supports multiple operating systems, including 32-bit and 64-bit versions of Raspberry Pi OS, Ubuntu, and others. The Raspberry Pi 4 Model B remains one of the most versatile and widely used models in the Raspberry Pi family due to its excellent balance of performance, connectivity, and affordability.

2.3.1 Features of Raspberry Pi 4B

Salient features of Raspberry Pi 4 Model B board:

- **Processor:** 1.5 GHz quad-core ARM Cortex-A72 (64-bit).
- **RAM:** Available in 2GB, 4GB, and 8GB LPDDR4-3200 SDRAM variants.
- **USB Ports:** Two USB 3.0 ports and two USB 2.0 ports for peripherals and high-speed devices.
- **HDMI Ports:** Two micro-HDMI ports, supporting dual displays at up to 4K resolution.
- **GPIO Header:** 40-pin GPIO header for interfacing with sensors and electronic devices.
- **Storage:** MicroSD card slot for operating system and file storage.
- **Operating Systems:** Supports Raspberry Pi OS (32-bit and 64-bit), Ubuntu, and other Linux distributions.

2.3.2 Description of Raspberry Pi 4B

Fig 2.1: Raspberry Pi 4B Board

The Raspberry Pi 4 Model B is a significantly more powerful and versatile single-board computer designed to meet the growing demands of modern computing in educational, hobbyist, and professional environments. Released in 2019, the Pi 4 Model B marks a major upgrade over its predecessors, featuring a 1.5 GHz quad-core ARM Cortex-A72 CPU and multiple RAM options—2GB, 4GB, or 8GB of LPDDR4 memory. This enhanced processing power and memory capacity make it suitable for more demanding applications, including desktop computing, software development, media centers.

2.3.3 Pin Description of Raspberry Pi 4B

The 40-pin GPIO header on the Raspberry Pi 4 Model B retains full compatibility with previous models, including the Raspberry Pi 3 Model B, while supporting more powerful hardware and broader application needs. This header provides a versatile interface for connecting a wide range of peripherals, including sensors, actuators, displays, and communication modules, making it a robust choice for embedded systems, IoT applications, and prototyping.

Power Pins:

These pins provide power outputs and grounding options for connected components.

1. Pin 1 (3.3V): Provides a 3.3V power supply for low-power components like sensors.

2. Pin 2 (5V): Supplies 5V power, ideal for powering external components or devices.

3. Pin 4 (5V): Additional 5V supply pin for peripherals or external modules.

4. Pin 6 (Ground): Ground connection to complete electrical circuits.

5. Pin 9 (Ground): Extra ground pin to ensure stable power delivery.

6. Pin 14 (Ground): Ground pin for additional circuit grounding.

7. Pin 17 (3.3V): Second 3.3V power output for low-voltage electronics.

8. Pin 25 (Ground): Another ground connection point for components.

9. Pin 30 (Ground): Used to maintain electrical stability in larger circuits.

10. Pin 34 (Ground): Offers additional grounding for safer electronics interfacing.

11. Pin 39 (Ground): Final ground pin in the header to support circuit completion.

GPIO Pins (General Purpose Input/Output):

These pins are configurable and can act as either digital inputs or outputs, supporting a wide array of control and monitoring tasks.

1. Pin 3 (GPIO 2 - SDA): I2C Data line, used for I2C communication.

2. Pin 5 (GPIO 3 - SCL): I2C Clock line, synchronizes data transmission over I2C.

3. Pin 7 (GPIO 4): Standard digital I/O pin for general use.

4. Pin 11 (GPIO 17): Commonly used GPIO pin for device control or input monitoring.

5. Pin 13 (GPIO 27): Multipurpose digital I/O pin.

6. Pin 15 (GPIO 22): Used in various applications including signal triggering.

7. Pin 19 (GPIO 10 - MOSI): SPI data output from master to slave device.

8. Pin 21 (GPIO 9 - MISO): SPI data input from slave to master device.

9. Pin 23 (GPIO 11 - SCLK): SPI clock signal output.

10. Pin 29 (GPIO 5): Additional GPIO for input or output tasks.

11. Pin 31 (GPIO 6): General-purpose digital I/O.

12. Pin 33 (GPIO 13): Common GPIO for control and signaling.

13. Pin 35 (GPIO 19): SPI MISO pin, used in high-speed data reception.

14. Pin 37 (GPIO 26): General-purpose digital pin for custom applications.

15. Pin 38 (GPIO 20): Used for output/input functions in control systems.

16. Pin 40 (GPIO 21): Another digital I/O pin for flexible interfacing.

UART Pins (Serial Communication):

UART enables serial communication between the Pi and external devices like GPS modules, serial terminals, or microcontrollers.

1. Pin 8 (GPIO 14 - TXD): UART Transmit pin for sending data.

2. Pin 10 (GPIO 15 - RXD): UART Receive pin for reading data from external devices.

SPI Pins (Serial Peripheral Interface):

These pins support high-speed synchronous serial communication with devices like ADCs, DACs, and displays.

1. Pin 19 (GPIO 10 - MOSI): Master Out Slave In—sends data from Pi to SPI device.

2. Pin 21 (GPIO 9 - MISO): Master In Slave Out—receives data from SPI device.

3. Pin 23 (GPIO 11 - SCLK): Clock signal for SPI data synchronization.

4. Pin 24 (GPIO 8 - CE0): Chip Enable 0—selects the first SPI device.

5. Pin 26 (GPIO 7 - CE1): Chip Enable 1—selects the second SPI device.

I2C Pins (Inter-Integrated Circuit):

I2C allows multiple slave devices to communicate with the Pi using just two lines

1. Pin 3 (GPIO 2 - SDA): Data line for I2C communication.

2. Pin 5 (GPIO 3 - SCL): Clock line for I2C data synchronization.

2.4 Conclusions

In this chapter the history of Raspberry Pi and salient features of different types of Raspberry Pi boards are explained. The architecture of Raspberry Pi 4B board is discussed along with its pin configuration.

Chapter 3
Hardware Description

3.1 Introduction

The hardware description of the IoT-based attendance management system using Raspberry Pi 4 Model B outlines the integration of essential electronic components to deliver a smart, automated, and secure method of recording attendance. This system relies on both facial recognition and fingerprint authentication to accurately identify individuals, ensuring that only authorized users are allowed to mark their presence. Designed to serve educational institutions, offices, and other organizational environments, the system operates efficiently through the collaborative function of its hardware modules.

At the core of the system is the Raspberry Pi 4 Model B, a powerful single-board computer that manages all operations including processing, data storage, and communication between connected peripherals. The Raspberry Pi 4 comes with a quad-core processor and expanded RAM capacity, which makes it capable of running complex facial recognition algorithms and biometric verification programs. Its built-in Wi-Fi enables seamless connectivity to the internet, allowing attendance data to be stored or monitored remotely. This makes it highly suitable for IoT-based applications where real-time access to data is critical.

3.2 Block Diagram

The block diagram represents an IoT-based Attendance Management System using Raspberry Pi. The Raspberry Pi acts as the central processing unit that controls and communicates with all the input and output devices. On the input side, a Power Supply provides the necessary voltage for the Raspberry Pi and connected modules. A Camera Module is connected for facial recognition, allowing the system to identify users visually. A Fingerprint Sensor is also used to capture biometric data for accurate identification. A Switch is used as a manual trigger to start the attendance process or to reset the system when needed.

On the output side, the Raspberry Pi sends signals to a Buzzer, which provides audio feedback indicating a successful or failed authentication. It also interacts with an Attendance Application, which logs and stores attendance data, possibly in a local database. This setup combines both hardware (for sensing and feedback) and software (for data processing and storage), making the system efficient and suitable for secure attendance tracking in places like schools, offices, or labs.

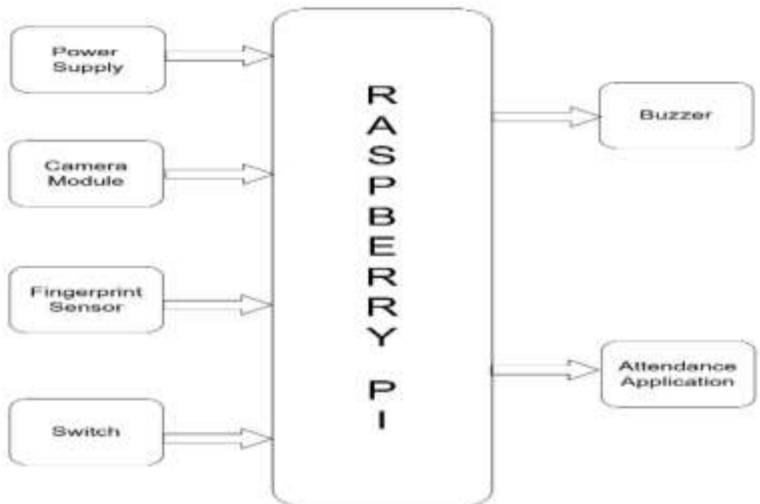

Fig 3.1: Block Diagram of the Project

3.3 Camera

Fig 3.2: Camera

The camera module in the IoT-based attendance management system plays a crucial role in enabling facial recognition functionality. This compact yet powerful device is connected to the Raspberry Pi through the Camera Serial Interface (CSI) port, ensuring seamless communication and high-quality image capture. The camera captures images of users as they approach the system and sends them to the Raspberry Pi for processing. Advanced computer vision algorithms, such as those provided by OpenCV or similar libraries, analyze these images to detect and recognize faces.

This camera module is specifically selected for its compatibility with the Raspberry Pi and its ability to provide real-time image capture. It supports various resolutions and frame rates, making it adaptable to the specific requirements of the system. For example, a higher resolution can improve the accuracy of facial recognition, while an optimal frame rate ensures smooth and timely operation. By enabling contactless attendance marking, the camera enhances user convenience and hygiene, especially in environments where physical contact needs to be minimized.

3.3.1 Features

- **High Resolution:** Captures clear and sharp images for accurate recognition.
- **Compact Design:** Small and lightweight, easily integrates with the Raspberry Pi.
- **Real-Time Capture:** Provides live image feeds for immediate processing.
- **High Frame Rate:** Ensures smooth image capture and processing.
- **Wide Compatibility:** Works seamlessly with Raspberry Pi boards.

3.3.2 Description

The camera module is a critical component in the IoT-based attendance management system, enabling facial recognition to mark attendance efficiently and securely. Designed to interface seamlessly with the Raspberry Pi through the Camera Serial Interface (CSI) port, the module captures high-resolution images of individuals approaching the system. These images are processed by the Raspberry Pi using advanced facial recognition algorithms, ensuring accurate identification. The camera's ability to capture clear images in various lighting conditions enhances its reliability and usability across diverse environments, making it a versatile addition to the system.

3.3.3 Interfacing of Camera with Raspberry Pi

Camera connects via USB to Raspberry Pi. It captures face images for attendance through face recognition.

- Plug camera into Raspberry Pi USB port.
- No GPIO pins needed.
- Enable camera support in settings.
- Use OpenCV to capture and detect faces

Pin Configuration of Camera

Unlike camera modules like the Raspberry Pi Camera Module, which connect through specialized pinouts (e.g., CSI interface), this type of camera connects via a standard **USB interface**.

The general pin configuration for USB:

1. **VCC (Power)**: Provides power to the webcam (usually +5V).
2. **D- (Data Negative)**: Transfers data from the webcam to the Raspberry Pi or computer.
3. **D+ (Data Positive)**: Transfers data from the webcam to the Raspberry Pi or computer.
4. **GND (Ground)**: Completes the electrical circuit.

3.4 Fingerprint Sensor

Fig 3.3: Fingerprint Sensor

The fingerprint sensor is a pivotal component in the IoT-based attendance management system, offering a secure and efficient method for biometric authentication. This sensor captures the unique fingerprint patterns of users and compares them with a pre-stored database to verify identity. Its ability to provide accurate and tamper-proof identification makes it a reliable choice for attendance systems. This biometric sensor operates using advanced pattern-matching algorithms, converting fingerprint data into a digital template for storage and comparison.

The fingerprint sensor eliminates the possibility of fraudulent attendance marking, such as proxy attendance, by relying on unique physical traits that cannot be replicated. This touch-based technology also offers fast response times, making it suitable for high-traffic environments like schools, offices, and industrial settings.

3.4.1 Features

- **Compact Design:** Small and lightweight, easy to integrate into systems.
- **Unique Identification:** Ensures secure and tamper-proof user verification.
- **Durable Build:** Designed for long-term use with robust materials.
- **Energy Efficient:** Consumes minimal power for continuous use.
- **Storage Capability:** Can store and compare multiple fingerprints.

3.4.2 Description

The fingerprint sensor is a vital component in biometric systems, providing a secure and reliable means of identification. This device works by capturing the unique patterns of a person's fingertip and converting them into a digital format. It eliminates traditional methods of attendance tracking, such as manual registers are prone to errors and misuse. By relying on an individual's unique biometric data, the fingerprint sensor offers a modern solution to attendance management.

3.4.3 Interfacing of Fingerprint Sensor with Raspberry Pi

The fingerprint sensor connects via USB using a TTL to USB converter. It is used to scan and verify fingerprints for attendance.

- Connect sensor to USB port using USB-TTL converter.
- No GPIO pins required.
- Use fingerprint library.
- Capture and match fingerprint for authentication.

Pin Configuration of Fingerprint Sensor

The fingerprint sensor module communicates using UART protocol and requires power and serial lines. It has 4 pins which are color-coded for easy identification.

- **GND:** Connects to the ground of Raspberry Pi/Arduino.
- **Rx - Data In:** Receives data from the controller (connect to Tx of Raspberry Pi).
- **Tx - Data Out:** Sends data to the controller (connect to Rx of Raspberry Pi/Arduino).
- **Vin:** Power input pin (connect to 3.3V or 5V depending on module support).

3.5 Buzzer

Fig 3.4: Buzzer

A buzzer is an electromechanical device that produces sound when activated, typically used as an alert or signaling mechanism in various electronic systems. It consists of a diaphragm or membrane that vibrates when an electrical signal is passed through a coil, generating a sound. The sound produced can vary in pitch, tone, and duration depending on the type of buzzer and its design. Buzzers can be either active or passive, with active buzzers generating sound on their own when powered, while passive buzzers require an external signal or oscillator to create sound. Buzzers are commonly found in alarms, notifications, and indicators across various industries, including consumer electronics, automotive systems, and safety devices.

Buzzers are valued for their simplicity, reliability, and low cost, making them a popular choice for both small consumer products and industrial applications. They are especially useful in scenarios where immediate attention is required, such as in fire alarms, doorbells, or warning systems in machinery. Due to their straightforward functionality, buzzers are often used in conjunction with other components like sensors, microcontrollers, and timers to provide feedback or alert users to specific events. The ability to produce sound at different volumes or frequencies also allows for customization, making buzzers a versatile solution for a wide range of signaling and alerting needs.

3.5.1 Features

- **Rated Voltage:** 6V DC
- **Operating Voltage:** 4-8V DC
- **Rated current:** <30mA
- **Sound Type:** Continuous Beep
- **Resonant Frequency:** ~2300 Hz

3.5.2 Description

A buzzer is an audio signaling device that produces sound when electrical power is supplied. In our project, the buzzer acts as a simple yet effective audio indicator that signals the system's operational status. When the attendance mode is activated, the buzzer emits a short beep sound, indicating that the system is ready to scan and authenticate a face or fingerprint. This alert helps users understand that the system is actively functioning and ready to register attendance, eliminating confusion or the need for manual instructions

3.5.3 Interfacing of Buzzer with Raspberry Pi

The buzzer is used to give audio feedback for actions like successful attendance. It is connected to Raspberry Pi GPIO pins.

- Connect positive (+) to GPIO21 (Pin 40).
- Connect negative (–) to GND (Pin 6).
- Control using Python.
- Turn ON buzzer for alerts or confirmation.

Pin Configuration of Buzzer

The pin configuration of a buzzer is typically straightforward as it generally has two pins:

1. Positive Pin (+): Marked with a "+" sign or a longer pin. Connects to the positive terminal of the power source or a control pin (e.g., a microcontroller output).

2. Negative Pin (-): Marked with a "-" sign or a shorter pin. Connects to the ground (GND) of the circuit.

3.6 Light Emitting Diode (LED)

Fig 3.5: LED

A Light Emitting Diode (LED) is a semiconductor device that emits light when an electric current passes through it. In our project, the LED serves as a visual indicator that enhances user interaction with the attendance system. When the system is powered on and ready for operation, the LED glows to indicate standby mode. During the face or fingerprint scanning process, the LED may blink or change state to show that the system is actively processing the input. This gives the user a clear, immediate indication that their presence has been detected and that the system is functioning properly.

The LED also plays a role in confirming different outcomes of the attendance process. A steady or blinking light can be used to signal successful recognition and attendance marking, while the absence of light or a different blinking pattern can indicate failure or an error in recognition. It ensures better communication between the system and its users without the need for complex interfaces.

3.6.1 Features

- **Energy Efficient:** Consumes less power with minimal heat loss.
- **Compact Size:** Small and lightweight design.
- **High Brightness:** Produces intense light output.
- **Low Heat Emission:** Generates minimal heat.
- **Instant Lighting:** Lights up immediately when powered.

3.6.2 Description

An LED (Light Emitting Diode) is a semiconductor device that emits light when current flows through it. Unlike traditional incandescent bulbs, which use a filament to produce light, LEDs generate light through electroluminescence, where electrons recombine with holes in the semiconductor material, releasing energy in the form of photons. LEDs are known for their long lifespan, often lasting 25,000 to 50,000 hours, far surpassing the life expectancy of traditional bulbs.

3.6.3 Interfacing of LED with Raspberry Pi

The LED provides visual feedback for actions like successful scan or error. It is connected to a GPIO pin of the Raspberry Pi.

- Connect LED positive (long leg) to GPIO18 (Pin 12).
- Connect negative leg to GND.
- Use a current-limiting resistor (\~220Ω).
- Control using Python with GPIO.output().

Pin Configuration of LED

The pin configuration of an LED (Light Emitting Diode) is simple, consisting of two pins:
1. Anode (+): The longer pin of the LED. Connects to the positive terminal of the power source or the output pin of a microcontroller.
2. Cathode (-): The shorter pin of the LED. Connects to the negative terminal (GND) of the circuit.

3.7 Switch

Fig 3.6: Switch

A switch is a simple input device used to control the flow of electricity in a circuit. In our project, the switch functions as a manual control to activate or deactivate the attendance mode. When the switch is pressed, it sends a signal to the Raspberry Pi, triggering the system to start face and fingerprint recognition. This allows the system to remain in standby mode when not in use, helping to save power and reduce unnecessary operations.

The switch is connected to a GPIO pin of the Raspberry Pi and is monitored continuously through the code. A simple press can change the system's state, allowing the buzzer and LED to respond accordingly. This manual input method ensures that the attendance system is not running continuously, which can be useful in places like classrooms or offices.

3.7.1 Features

- **Simple Input Device:** Easily interfaces with Raspberry Pi GPIO.
- **Digital Operation:** Works in ON/OFF (1/0) binary mode.
- **Manual Trigger:** Allows users to start a specific function.
- **Low Power Use:** Consumes minimal power for operation.
- **Cost Effective:** Very affordable and widely available.

3.7.2 Description

A switch is a fundamental electronic component used to control the flow of electricity in a circuit by either opening or closing the circuit. In simple terms, a switch acts like a gatekeeper that allows current to flow when it is closed (ON position) and stops the current when it is open (OFF position). Switches come in various forms and sizes, but their primary function remains consistent—to provide manual or automatic control over electrical devices.

3.7.3 Interfacing of Switch with Raspberry Pi

The switch is used to trigger attendance manually or start the scanning process. It is connected to a GPIO pin of the Raspberry Pi.

- Connect one side of switch to GPIO17 (Pin 11).
- Connect the other side to GND (Pin 6).
- Use internal pull-up resistor in code.
- Detect press using Python.

Pin Configuration of Switch

The pin configuration of Switch is simple, consisting of two pins:

Pin 1 – One terminal of the switch (acts as input or output depending on the circuit).

Pin 2 – Second terminal of the switch (completes the circuit when pressed).

3.8 Conclusions

In this chapter different hardware modules involved in the project are discussed is explained.

Chapter 4
Software Tools

4.1 Introduction

In the development of an IoT-based attendance management system using Raspberry Pi with face recognition and a fingerprint sensor, several software tools are essential to create an efficient and reliable solution. At the core of this project is the Raspberry Pi, which runs a Linux-based operating system (like Raspbian) and serves as the primary platform for running various applications and managing peripherals. The first key tool in this setup is the Python programming language, as it offers extensive libraries and support for both hardware integration (GPIO, camera module) and advanced tasks like face recognition and fingerprint processing. Python's simplicity and flexibility make it ideal for rapid development and experimentation.

For face recognition, OpenCV (Open Source Computer Vision Library) is a crucial software tool. It provides a wide array of tools to handle image processing and computer vision tasks. In this project, OpenCV will be used to capture images from the Raspberry Pi camera, detect faces in real-time, and match them against a database of stored facial images. Additionally, libraries like cv2.face.LBPHFaceRecognizer or dlib are used for training the system to recognize different faces and perform accurate identification, ensuring the attendance system operates smoothly and reliably.

For fingerprint recognition, software tools such as the pyfingerprint library are used to interface with the fingerprint sensor. These libraries allow for easy integration with sensors like the R305 or GT-521F52, enabling the system to capture fingerprint data, enroll new fingerprints, and authenticate users. The fingerprint recognition process involves storing biometric data in a database and using it to compare live inputs, providing a backup authentication method when face recognition is not viable or preferred. This ensures multiple layers of security for user identification and attendance tracking.

4.2 Python

Fig 4.1: Python

Python is an open-source, high-level programming language known for its simplicity and readability, making it an ideal choice for beginners as well as experienced developers. Created by Guido van Rossum and first released in 1991, Python emphasizes code readability with its use of indentation instead of curly braces, allowing developers to write clean, concise, and easily maintainable code. Its design philosophy encourages the development of programs that are both functional and easy to understand.

One of the core features of Python is its versatility. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. This makes it adaptable for a wide range of applications, from simple scripts to complex machine learning models. Whether you are building a web application with frameworks like Django or Flask, or conducting scientific research with libraries like NumPy.

4.3 Open CV

Fig 4.2: Open CV

OpenCV (Open Source Computer Vision Library) is an open-source software library designed to provide a wide range of tools for computer vision tasks. It was initially developed by Intel in 1999 and has since become one of the most widely used libraries in the field of image processing and computer vision. OpenCV provides a comprehensive suite of functions for tasks such as image and video analysis, face recognition.

One of the standout features of OpenCV is its versatility and cross-platform nature. The library supports multiple operating systems, including Windows, macOS, and Linux, and is also compatible with mobile platforms such as Android and iOS. OpenCV can be integrated with various programming languages, including C++, Python, Java, and even MATLAB, giving developers the flexibility to use it in their preferred environment. This widespread compatibility makes OpenCV a go-to tool for developers working across different platforms and devices.

4.4 Raspbian OS

Fig 4.3: Raspbian OS

Raspbian OS is the official operating system for the Raspberry Pi, a popular single-board computer designed for both educational and general computing purposes. Based on Debian Linux, Raspbian is tailored specifically for the Raspberry Pi's hardware, ensuring optimal performance and a smooth user experience. It provides a lightweight, user-friendly environment that makes it an ideal choice for beginners and hobbyists looking to explore computing, programming, and hardware projects.

One of the primary features of Raspbian is its compatibility with a wide range of Raspberry Pi models, from the earliest Pi versions to the latest iterations. The operating system is designed to run efficiently on the Pi's relatively low processing power, offering a balanced mix of performance and resource usage. Raspbian includes a variety of essential tools and software to get started with coding, electronics.

4.5 SQLite

Fig 4.4: SQLite

SQLite is a self-contained, serverless, zero-configuration, and transactional SQL database engine. Unlike other relational databases, SQLite does not require a separate server process or system to operate. It is embedded directly into applications, providing a lightweight, easy-to-use solution for managing data. This makes it an ideal choice for applications that need an efficient database.

One of the key features of SQLite is its simplicity and minimal setup. It is a serverless database, meaning it does not run as a separate process. Instead, SQLite integrates directly into the application, and all database files are stored in a single, compact file. This makes it incredibly easy to set up and use, with no installation or configuration required.

4.6 Conclusions

In this chapter, software tools like Python, Open CV, Raspbian OS and SQLite Software are studied.

Chapter 5

Results and Discussion

5.1 Introduction

In this chapter we discuss flowchart of the project, and schematic diagram of setup of the project.

5.2 Schematic diagram

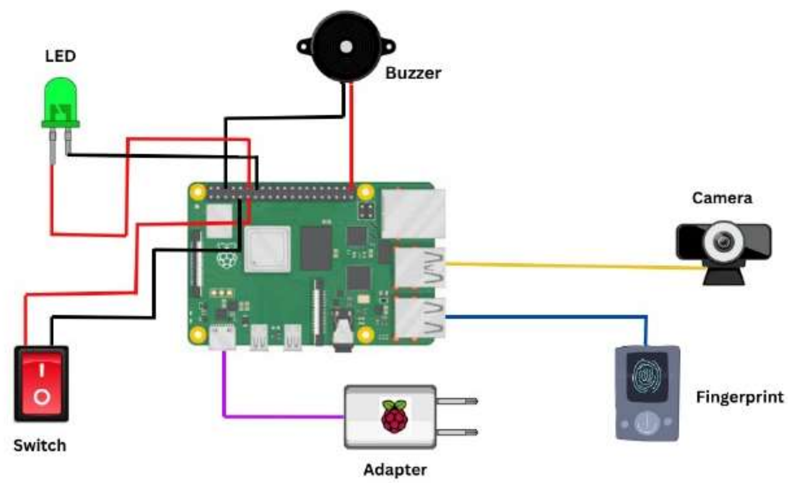

Fig 5.1: Schematic diagram of the project

The schematic diagram illustrates a Raspberry Pi-based biometric system setup incorporating key components for authentication and alert functions. A fingerprint sensor is connected via USB to the Raspberry Pi for identity verification, while a camera module is also connected through USB to capture real-time images or video. An LED and a buzzer are interfaced through GPIO pins to provide visual and audio feedback upon successful or failed authentication. Additionally, a switch is connected to initiate the fingerprint scanning process manually. Power is supplied through an external adapter to the Raspberry Pi, ensuring stable operation. The ground connections from all components are properly tied to the Raspberry Pi's GND pins, ensuring a common reference and smooth functionality.

5.3 Flowchart

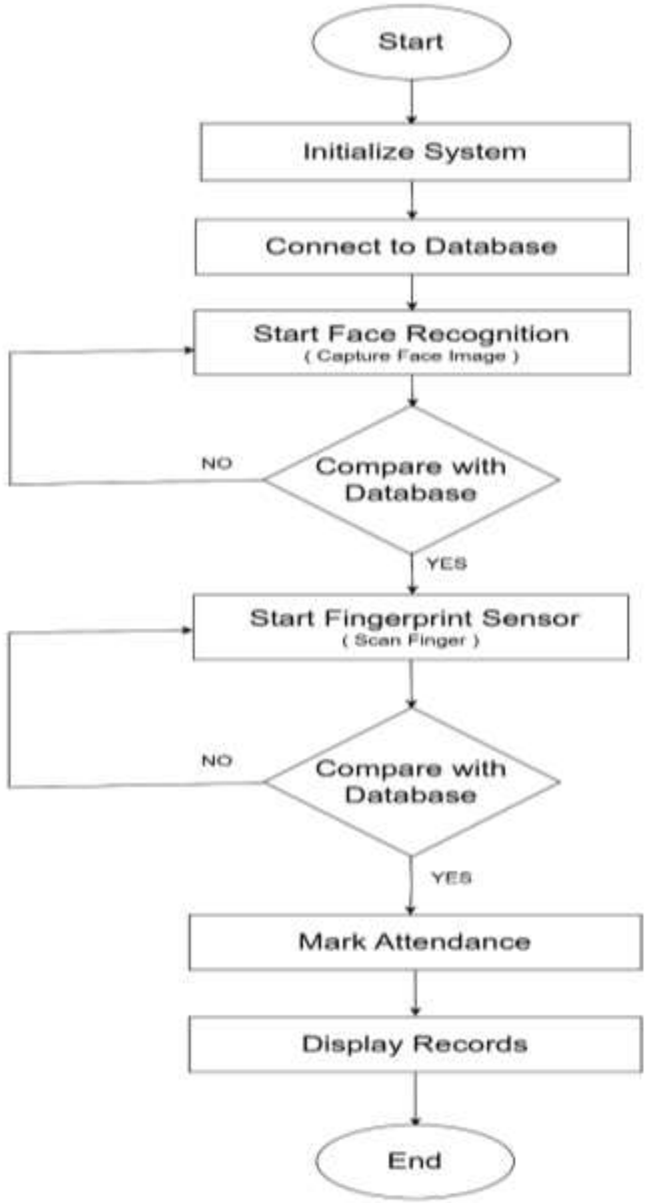

Fig 5.2: Flowchart

The following steps for operating IOT Based Attendance Management System :

1. First Initialize the system by powering Raspberry Pi with 5V Micro USB adapter.

2. Then it communicates with the database for storing attendance.

3. It operates two principle things:

- Face Recognition
- Fingerprint Sensor

4. For Face Recognition:

- Captures a picture, examines the face, and matches it with the database.
- If not stops the process and shows error.
- If matched goes to next step.

5. For fingerprint:

- Scans the finger, checks it, and matches it with the stored fingerprint.

6. If fingerprint is matched:

- Attendance is marked.
- Information is stored and displayed.

7. If it doesn't match:

- It is not marked, and it indicates an error.

5.4 Experimental Setup

The experimental setup shown above illustrates the working model of an IoT-based attendance management system using a Raspberry Pi. The system is equipped with a fingerprint sensor and a camera module to perform dual-mode biometric authentication fingerprint and facial recognition. A Raspberry Pi acts as the central controller, processing inputs from both biometric modules. When a user presses the switch, the Raspberry Pi activates the fingerprint sensor to scan the fingerprint. Simultaneously, the camera module captures the facial image for recognition.

The setup also includes connections to a laptop, which is used to interface with the Raspberry Pi for monitoring logs and accessing the attendance records. The system is powered through an adapter, ensuring stable performance during execution. The attendance data can be stored locally or uploaded to a cloud server, making the system part of the IoT framework.

Fig 5.3: Experimental Setup

5.5 Results

The following figures show the results obtained during this project.

Step – 1: Connect Raspberry Pi, Mobile, Laptop using Advanced IP Scanner.

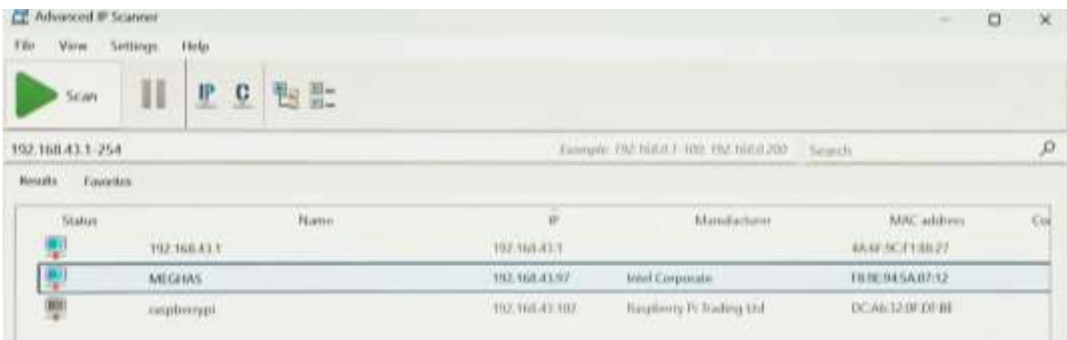

Fig 5.4 : Advanced IP Scanner

Step – 2: Open RealVNC viewer and enter the IP Address of Raspberry Pi.

Fig 5.5 : RealVNC Viewer

Step – 3: Authenticate to VNC Server through username and password.

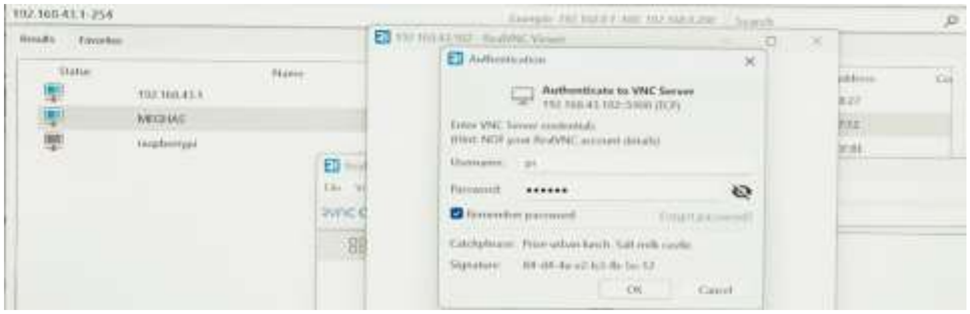

Fig 5.6 : Authentication

Step – 4: Open Database having Roll numbers and copy the re quired Roll numbers.

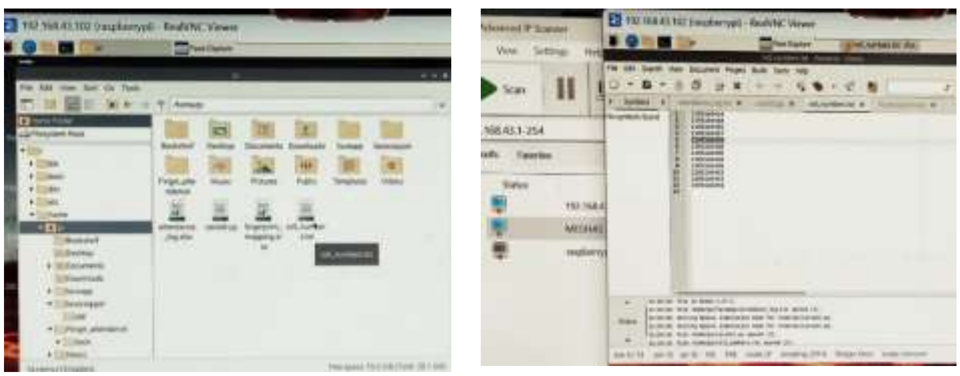

Fig 5.7 : Database

Step – 5: Capture Face using Camera and Fingerprint using Fingerprint Sensor by pasting the copied Roll number.

Fig 5.8 : Face and Fingerprint Verification

Step – 6: After Verification, Roll number Attendance summary will be displayed.

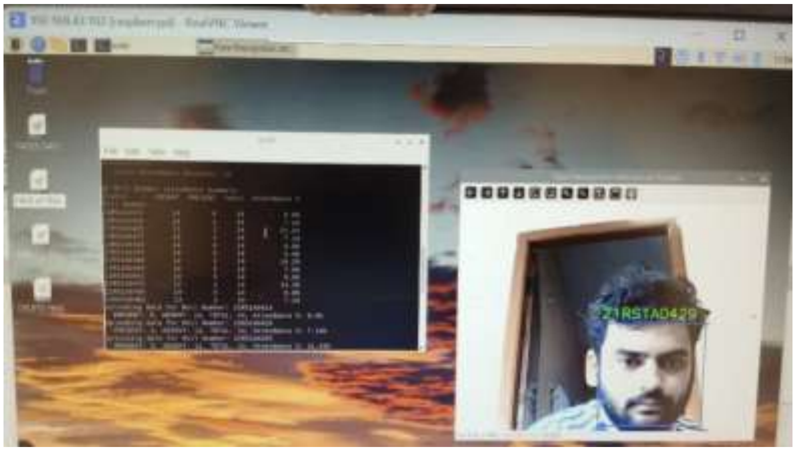

Fig 5.9 : Attendance Displayed

- An App is designed named as ATTENDANCE giving access to both Parents and Faculty.
- The App consists of Spreadsheet having Roll numbers of the students, Total days, Absent, Present, Percentage and also Date and Time.
- The Data in the App can be modified gradually day by day.

S.No	ROLL NUMBER	TOTAL DAYS	ABSENT	PRESENT	PERCENTAGE	DATE TIME
1	21RS1A0414	5	3	2	40.00%	4/29/2025 13:00
2	21RS1A0418	5	2	3	60.00%	4/29/2025 13:00
3	21RS1A0424	5	0	5	100.00%	4/29/2025 13:00
4	21RS1A0426	5	4	1	20.00%	4/29/2025 13:00
5	21RS1A0427	5	0	5	100.00%	4/29/2025 13:00
6	21RS1A0435	5	1	4	80.00%	4/29/2025 13:00
7	21RS1A0438	5	3	2	40.00%	4/29/2025 13:00
8	21RS1A0444	5	5	0	0.00%	4/29/2025 13:00
9	21RS1A0456	5	1	4	80.00%	4/29/2025 13:00
10	21RS1A0461	5	4	1	20.00%	4/29/2025 13:00

Fig 5.10 : Attendance Record

5.6 Conclusions

In this chapter we have seen the schematic diagram, flowchart, experimental setup of the project and their results during various operations.

Chapter 6

Conclusions

The IoT-based attendance management system using Raspberry Pi with face recognition and fingerprint sensor presents an innovative and efficient approach to modernizing traditional attendance methods. This system eliminates the drawbacks of manual attendance, such as time consumption, human error, and proxy marking, by introducing automated biometric identification. The integration of face recognition and fingerprint scanning provides a dual-layer of security, ensuring accurate and reliable authentication of individuals. Raspberry Pi acts as the core processing unit, efficiently handling data from sensors and cameras, while also enabling real-time data storage and transmission over the internet. This compact yet powerful setup offers portability, cost-effectiveness, and ease of implementation. Overall, this project not only showcases the potential of IoT and biometrics in improving administrative tasks but also promotes the use of smart technologies in educational institutions and workplaces for enhanced accuracy, transparency, and operational efficiency.

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