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Attendance Monitoring System Using Raspberry PI

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Abstract: This paper presents the design and implementation of a real-time attendance system using a Raspberry Pi and facial recognition technology, eliminating the need for ID cards. The system automates the attendance process through the integration of embedded hardware and intelligent software, thereby improving accuracy, efficiency, and security. Traditional attendance methods, such as manual roll calls and RFID-based systems, are often time-consuming, prone to human error, and susceptible to proxy attendance. The proposed solution addresses these issues by capturing live images using a Raspberry Pi Zero 2W and webcam, transmitting them over a local Wi-Fi network to a central system, and processing them through the Python face recognition library. The captured images are compared with a pre-stored dataset in a MySQL database, and attendance is recorded automatically via a Node.js backend, with real-time display on a React.js frontend. The system is suitable for educational institutions, offices, and other organizations that require secure, automated attendance tracking. Aligning with the goals of Industry, Innovation, and Infrastructure, this project also emphasizes energy-efficient operation, the use of modern tools, ethical considerations, and the development of practical engineering solutions. The outcome is a robust, real-world applicable embedded system for reliable attendance management.
Keywords: Facial Recognition, Attendance Management System, Embedded Systems, Raspberry Pi Zero 2 W, Computer Vision, Real-Time Monitoring, Internet of Things (IoT), Node.js, React.js, MySQL Database.

1. INTRODUCTION

Attendance tracking is a fundamental part of administrative operations in educational institutions, workplaces, and organizations. Traditional methods such as manual roll calls or RFID-based systems are often inefficient, prone to human error, and susceptible to misuse, such as proxy attendance. With the growth of embedded systems and artificial intelligence, there is a growing shift toward smarter, automated solutions. This project introduces a real-time attendance system using facial recognition and Raspberry Pi, offering a secure, efficient, and modern alternative to conventional methods. This project involves the design and implementation of an automated attendance system that uses facial recognition technology powered by a Raspberry Pi Zero 2W. A webcam captures live images of individuals, which are transmitted over a local Wi-Fi network to a central processing unit. Using the Python face recognition library, the system compares the captured images with a pre-stored dataset in a MySQL database. If a match is found, attendance is marked automatically using a Node.js backend, and the results are displayed in real-time on a React.js frontend. The system eliminates the need for ID cards or manual input, providing a contactless and intelligent solution. The need for this project arises from the drawbacks of existing attendance systems. Manual roll calls are time-consuming and inaccurate, while RFID-based systems can be easily manipulated or misused. There is also a risk of proxy attendance, where someone else marks attendance on behalf of another. In the context of increasing demand for automation, security, and contactless solutions especially post-pandemic this project provides a reliable, efficient, and tamper-proof method of tracking attendance. The primary objective of this project is to develop a real-time, automated attendance system that leverages facial recognition technology to enhance accuracy, security, and efficiency in tracking attendance. By eliminating the need for physical ID cards, manual roll calls, or RFID tags, the system aims to reduce human error, save time, and prevent proxy attendance. Another key goal is to create a user-friendly and energy-efficient solution that integrates embedded hardware with intelligent software, ensuring smooth communication between components.

Furthermore, the project seeks to demonstrate the practical application of modern programming frameworks and embedded systems in solving real-world problems, particularly in educational and professional environments where accurate attendance tracking is critical.

2. LITERATURE SURVEY

[1]Recent advancements in embedded systems, computer vision, and artificial intelligence have significantly improved automated attendance systems. Several researchers have proposed Raspberry Pi–based real-time attendance monitoring solutions integrating face recognition, IoT, and RFID technologies.

[2]Ramadoss, R. et al. (2020) proposed an attendance monitoring system integrating face recognition and RFID using Raspberry Pi, published in International Journal of Creative Research Thoughts. Their hybrid approach improved reliability by combining biometric verification with RFID authentication, reducing proxy attendance issues.

[3]Sharma, S. et al. (2019) developed an automatic attendance system using facial recognition and Raspberry Pi in the International Journal of Advanced Research in Computer Science and Software Engineering. Their system employed OpenCV algorithms for face detection and recognition, demonstrating cost-effectiveness and improved efficiency compared to manual methods.

[4]Similarly, Kumar, P. S. and Rajesh (2020) implemented a real-time face recognition attendance system published in the International Journal of Computer Applications. Their work emphasized optimized image preprocessing techniques to enhance recognition accuracy under varying lighting conditions.

[5]Namrata Bhosale et al. (2018) presented a real-time implementation of a face recognition system on Raspberry Pi in the International Journal of Engineering and Technology. Their research validated the feasibility of deploying computationally intensive vision algorithms on low-power embedded hardware.

[6]An IoT-based automated attendance system using face recognition was introduced by Sravani, M. et al. (2020). Their solution integrated cloud connectivity for centralized monitoring, enabling remote data access and management.

[7]Rahman, M. A. et al. (2020) proposed a facial recognition-based attendance system using Raspberry Pi and OpenCV, presented at the IEEE International Conference on Communication and Electronics Systems. Their approach focused on improving recognition performance through feature extraction techniques and classifier optimization.

[8]In addition, Kumar, L. A. et al. (2021) developed a smart attendance management system using deep learning techniques, presented at the International Conference on Combinatorial and Optimization. Their work highlighted the advantages of convolutional neural networks (CNNs) in enhancing face recognition accuracy.

[9]Recent studies such as Heamalatha, I. et al. (2023) in the IJRASET Journal for Research in Applied Science and Engineering Technology proposed student attendance monitoring and access control using Raspberry Pi, integrating biometric authentication with security mechanisms.

[10]Azmi, F. et al. (2023) introduced a smart management attendance system utilizing advanced computer vision techniques on Raspberry Pi in the International Journal of Innovative Research in Computer Science & Technology. Their study demonstrated improved recognition speed and scalability.

[11]Furthermore, Bin Hamed, R. and Fatnassi (2022) developed a secure attendance system using Raspberry Pi-based face recognition, published in the Journal of Telecommunications and the Digital Economy. Their system emphasized encryption and secure data storage for privacy protection.

[12]The integration of infrared cameras for low-light face detection was explored by Brown, J. and Jones (2022) in the International Journal of Image Processing and Vision Science, addressing limitations of conventional RGB cameras in poorly lit environments.

[13]Additionally, Gupta, A. and Chhabra (2021) proposed an IoT-based smart attendance monitoring system in the International Journal of Engineering Research & Technology, focusing on cloud-based attendance management and real-time data synchronization.

[14]Overall, the reviewed literature demonstrates that Raspberry Pi combined with OpenCV and deep learning techniques provides a cost-effective and scalable solution for automated attendance systems. However, challenges such as illumination variation, spoofing attacks, data privacy, and large-scale deployment remain areas for further research and optimization.

3. PROPOSED SYSTEM

3.1 INTRODUCTION

The proposed system introduces a real-time attendance monitoring system that leverages facial recognition technology to automatically record attendance. Traditional attendance systems often involve manual entry or ID cards, which can be inefficient and prone to inaccuracies or proxy attendance. This project utilizes a Raspberry Pi 2W integrated with an IR Night Vision Camera to capture facial images even in low-light conditions. The images are processed locally using facial recognition algorithms, and attendance data is transmitted wirelessly to a central server via Wi-Fi. The system ensures accurate, contactless, and reliable attendance management for educational institutions, offices, and organizations.

3.2 OBJECTIVE OF THE PROPOSED

- To design and implement a cost-effective and automated attendance system using facial recognition.
- To achieve real-time attendance recording and eliminate manual effort.
- To ensure accuracy and reliability in attendance tracking even under low-light environments using IR night vision.
- To store attendance data securely on a central server through Wi-Fi communication.
- To develop a scalable solution suitable for classrooms, offices, and industries.

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3.3 CONTRIBUTION OF THE PROJECT

- Automation: Eliminates manual marking and reduces human error.
- Low-Light Functionality: IR Night Vision Camera enables detection and recognition in dim environments.
- Compact Design: Raspberry Pi 2W provides a lightweight, portable, and energy-efficient solution.
- Real-Time Data Update: Attendance is updated to the server immediately via Wi-Fi.
- Secure and Reliable: Facial recognition ensures unique identification, preventing proxy attendance.
- Scalability: Can be deployed across multiple rooms or buildings using the same server infrastructure.

3.4 FLOW CHART

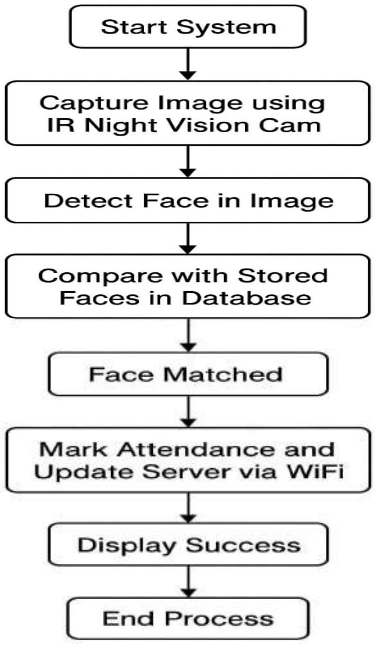

Figure 3.1 Flow Chart for Proposed System

Flow of Operation:

1. The IR Night Vision Camera captures the person's face.
2. The Raspberry Pi 2W processes the image using a facial recognition algorithm.
3. The system compares the detected face with the stored database.
4. If a match is found, attendance is marked automatically.
5. The data is sent to the central server through Wi-Fi.
6. The server stores and updates the attendance record in real time.

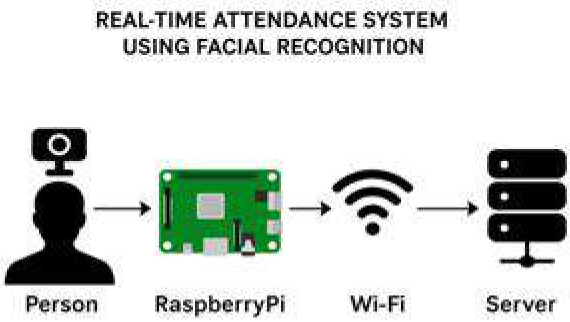

Figure 3.2 Block Diagram for Proposed System

3.5 BLOCK DIAGRAM

Block Diagram Explanation

1.PERSON

Explanation:

- The person (student, employee, or staff member) is the subject whose attendance is to be recorded.
- When the person stands in front of the camera, the system captures a live image or video frame of their face.
- This step replaces traditional methods like signing attendance sheets or using RFID cards.
- The facial image becomes the input for the verification process.
- Since every face has unique features, this ensures accurate and secure identification of each individual.

2. RASPBERRY PI

Explanation:

- The Raspberry Pi acts as the main processing unit of the system.

- It is a small, powerful computer that handles both image processing and communication with the server.
- The connected camera sends the captured facial image to the Raspberry Pi.
- Using facial recognition algorithms, it analyzes and compares facial features with stored templates (either locally or on the server).
- Once the face is recognized, the Raspberry Pi marks the person as “present” and records relevant data such as name, ID, date, and time.
- The Raspberry Pi may also perform preprocessing tasks like:
  - Face detection
  - Image resizing and enhancement
  - Encoding facial features for faster matching
- This makes the system efficient, compact, and cost-effective, ideal for school or office use.

3. WI-FI (WIRELESS COMMUNICATION)

Explanation:

- The Wi-Fi module enables the Raspberry Pi to communicate with the central server.
- Once a person’s attendance is recognized, the Raspberry Pi sends the attendance data (ID, name, timestamp) to the server instantly via Wi-Fi.
- This ensures real-time data transfer without any manual intervention.
- In case of temporary network failure, the Raspberry Pi can store the data locally and upload it once the connection is restored.
- Using Wi-Fi also allows remote monitoring and easy data access from anywhere in the network.

4. SERVER

Explanation:

- The server acts as the central database and management system.
- It receives attendance records from the Raspberry Pi and stores them securely.
- The server maintains a database of registered faces, which helps in verifying the user’s identity.
- It also provides data analytics and reporting features, allowing administrators to:
  - View attendance logs
  - Generate daily, weekly, or monthly attendance reports
  - Track presence and absence patterns
- The server ensures that all attendance data is organized, safe, and accessible in real time.

3.6 OVERALL WORKING PROCESS

1. The person faces the camera for recognition.
2. The Raspberry Pi captures and processes the image.
3. If the person is identified, their attendance is recorded.
4. Attendance details are sent via Wi-Fi to the server.
5. The server updates the attendance database and generates reports.

3.7 ADVANTAGES OF THE PROPOSED SYSTEM

- Automated and contactless — No manual input or ID cards needed.
- Accurate and secure — Uses unique facial features for identification.
- Real-time updating — Attendance is instantly sent to the server.
- Efficient management — Centralized database for easy monitoring and reporting.
- Scalable — Multiple Raspberry Pi devices can be connected to the same server.

4. HARDWARE REQUIREMENT

a) Raspberry Pi 2W

- A compact single-board computer used as the main processing unit.
- Runs facial recognition algorithms and handles data communication.
- Features built-in Wi-Fi and Bluetooth connectivity.
- Low power consumption and cost-effective design.

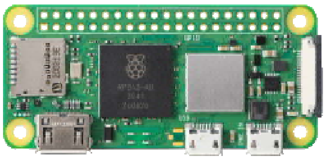

Figure 4.1 Raspberry Pi 2W

b) IR Night Vision Camera

- Captures clear images in both bright and low-light environments.
- Equipped with infrared LEDs for night vision capability.
- Connects directly to the Raspberry Pi via the CSI (Camera Serial Interface) port.
- Ensures reliable image capture regardless of lighting conditions.

Figure 4.2 IR Night Vision Camera

c) Wi-Fi Connectivity

- Enables real-time data transfer between Raspberry Pi and the server.
- Uses built-in Wi-Fi in Raspberry Pi 2W for seamless network communication.

d) Server

- Stores attendance records received from multiple Raspberry Pi units.
- Provides a web-based or database interface for viewing and managing attendance.

e) Power Supply

- 5V DC supply powers the Raspberry Pi and camera module.
- Ensures stable and continuous operation of the system.

Figure 4.3 Power Supply

5. SOFTWARE REQUIREMENT

The real-time attendance system leverages facial recognition technology integrated with embedded hardware to automate attendance tracking. The software components are critical in ensuring the system performs efficiently, accurately, and securely. This section outlines the detailed software requirements, including functional and non-functional specifications, system architecture, and technology stack, which guide the development and deployment of the attendance system.

FUNCTIONAL REQUIREMENT

Functional requirements describe the core operations the software must perform to meet the system's objectives.

1. Face Recognition Module

- Capture live video feed from a Raspberry Pi-connected webcam.
- Detect and recognize faces using the Python face recognition library in real-time.
- Match detected faces with a pre-stored dataset in the MySQL database.
- Support recognition of multiple faces simultaneously in a single frame.

2. Attendance Recording

- Automatically log attendance with a timestamp when a face is successfully recognized.
- Prevent duplicate attendance marking within the same session for individual users.
- Maintain accurate and secure storage of attendance data in the MySQL database.

3. User Management

- Enable administrators to add, update, or delete user profiles, including facial data, via a secure interface.
- Allow bulk import/export of user data for ease of management.

4. Real-Time Monitoring and Reporting

- Provide a React.js-based dashboard for administrators to view live attendance status.
- Display alerts for unidentified individuals attempting to register attendance.
- Generate and export attendance reports in various formats (e.g., CSV, PDF).

NON-FUNCTIONAL REQUIREMENTS

Non-functional requirements specify the quality attributes and constraints of the software.

1. Performance

- Process facial recognition within 1-2 seconds to enable real-time attendance.
- Support simultaneous processing of multiple users without significant performance degradation.

2. Accuracy and Reliability

- Achieve a high accuracy rate (>90%) in face recognition under varying environmental conditions.
- Ensure consistent synchronization between the recognition system and the backend database.

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3. Security

- Secure communication between Raspberry Pi and backend using encrypted local Wi-Fi protocols.
- Implement user authentication and authorization mechanisms for accessing the administrative dashboard.
- Protect stored facial data and attendance records from unauthorized access and breaches.

4. Scalability

- Support an expanding user base and growing attendance data without compromising performance.
- Modular design to facilitate future feature enhancements.

5. Usability

- User-friendly dashboard interface with intuitive controls for administrators.
- Clear error handling and informative messages for troubleshooting and user guidance.

6. Maintainability

- Modular and well-documented code to facilitate updates and debugging.
- Use of standard libraries and frameworks to ensure long-term support and compatibility.

5. RESULTS & DISCUSSION:

5.1 INTRODUCTION

To evaluate the performance and effectiveness of the real-time attendance system using facial recognition, simulations and tests were conducted in a controlled environment. The system's core functionalities, including face detection, recognition accuracy, attendance logging, and real-time data display, were assessed. This section presents the results obtained from the simulation and discusses the system's performance based on these findings.

5.2 SIMULATION SETUP

HARDWARE:

Raspberry Pi Zero 2W: Raspberry Pi Infrared IR Night Vision Surveillance Camera Module (500W) with ribbon cable (720p resolution) Software: Python face recognition library, Node.js backend, React.js frontend, MySQL database. Dataset: Facial images of 30 registered users were used to create the recognition dataset. Testing Environment: Indoor environment with varying lighting conditions, including normal and low-light settings, at distances from 1 to 3 meters between the camera and subjects. Network: Local Wi-Fi network for communication between Raspberry Pi and backend server.

Figure 5.1 Working Sample for the Simulation

DASHBOARD:

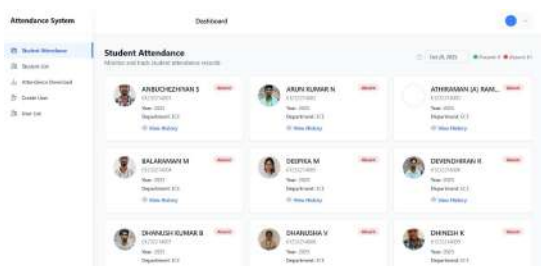

Figure 5.2 Dashboard Student Details

5.3 RESULT

Table 5.1 Face Recognition Accuracy

Test Condition	Number of Face Tested	Correctly Recognized	Recognition Accuracy (%)
Good lighting (2 m)	100	94	94%
Dim lighting (2 m)	100	86	86%
Multiple faces (3 faces per frame)	50	137 (out of 150)	91.3%

Note: Recognition accuracy is calculated as (correct recognitions / total faces) × 100.

ATTENDANCE LOGGING EFFICIENCY

Average time from image capture to attendance logging: 1.5 seconds. Duplicate entries within the same session were effectively prevented.The system handled concurrent recognition of up to 3 faces in a frame without delay.

SYSTEM STABILITY AND USABILITY

- The React.js dashboard updated attendance status in real-time with minimal latency (< 1 second).
- User management functions (add/update/delete) were responsive and error-free.
- No data loss or communication failure was observed during continuous operation for 4 hours.

5.4 DISCUSSION

The inclusion of the Raspberry Pi Infrared IR Night Vision Surveillance Camera Module enabled improved performance in low-light conditions compared to standard webcams. While recognition accuracy remained high (>90%) under good lighting, the IR camera helped achieve better results under dim lighting (86%), mitigating some challenges typically faced by conventional cameras. However, occasional misrecognition under extremely low light suggests that further optimization, such as enhanced IR illumination or preprocessing techniques, could enhance reliability. The IR capability contributes significantly to the system's robustness in various lighting environments, making it suitable for 24/7 deployment in classrooms or offices with fluctuating light conditions. Overall, the simulation confirms that the real-time attendance system meets key software and performance requirements. It delivers accurate face recognition, efficient attendance recording, and real-time monitoring capabilities suitable for practical deployment. Continued development and testing will focus on improving accuracy in challenging conditions and expanding system scalability.

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