

Embedded IoT Face Recognition Attendance System

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Abstract - Attendance in classrooms and workplaces is usually recorded manually, which can be time-consuming and prone to errors such as proxy attendance. To overcome these issues, this project presents a Smart Attendance System based on IoT and embedded technology using face recognition.

The system is built using a Raspberry Pi connected to a camera module, which captures images and detects faces in real time. Once a person is recognized, their attendance is automatically recorded within a defined time period. The data is then stored in Firebase, enabling real-time updates and easy access through a web or mobile dashboard.

The proposed system reduces manual effort, improves accuracy, and provides a faster and more reliable way of managing attendance. It is suitable for use in schools, colleges, and workplaces. Overall, this solution offers a practical approach to modernizing traditional attendance systems using low-cost and efficient technology.

Key Words: Face Recognition, Smart Attendance System, Internet of Things (IoT), Raspberry Pi, Firebase, Real-Time Database, OpenCV, LBPH Algorithm, Haar Cascade Classifier, Embedded System.

1. INTRODUCTION

In educational institutions and workplaces, maintaining attendance is an essential task that helps track participation and discipline. Traditionally, attendance is recorded manually using registers or spreadsheets. Although simple, this method is time-consuming, prone to human error, and can easily be manipulated through proxy attendance. As organizations move towards digital solutions, there is a growing need for a more efficient and reliable attendance management system.

With the advancement of Internet of Things (IoT) and embedded systems, automation has become more accessible and cost-effective. At the same time, face recognition technology has gained popularity as a secure and contactless method of identification. Combining these technologies makes it possible to develop an intelligent system that can automatically mark attendance without requiring manual input.

This project proposes a Smart Attendance System that uses a Raspberry Pi and a camera module to capture and process facial data in real time. The system detects and recognizes individuals using image processing techniques, and once a match is found, attendance is recorded automatically. To ensure real-time access and data synchronization, Firebase is used as a cloud-based database, allowing attendance records to be viewed through a web or mobile interface.

The main objective of this system is to reduce manual effort, improve accuracy, and prevent proxy attendance. It is designed to be simple, cost-effective, and suitable for use in classrooms, offices, and other small-scale environments. By integrating IoT, embedded systems, and face recognition, this project demonstrates a practical approach to modernizing traditional attendance methods.

2. PROBLEM STATEMENT

Traditional attendance systems in schools and workplaces are mostly manual, making them time-consuming and prone to errors such as proxy attendance. Existing automated methods like RFID and fingerprint systems also have limitations, including misuse, hardware dependency, and lack of real-time access.

Therefore, there is a need for a smart, contactless, and reliable attendance system that can automatically identify individuals and record attendance accurately with minimal human intervention. This project addresses these challenges by using face recognition and IoT technology to provide an efficient and secure attendance solution.

3. OBJECTIVES

The main objective of this project is to develop a smart and automated attendance system using face recognition and IoT technologies. The specific objectives are as follows:

- To design and implement a face recognition-based system for automatic attendance marking.
- To integrate a Raspberry Pi with a camera module for real-time image capture and processing.
- To develop a system that records attendance accurately within a defined time period without manual intervention.

- To store and manage attendance data using Firebase for real-time access and synchronization.
- To reduce proxy attendance and improve the reliability of attendance records.
- To create a cost-effective and easy-to-use solution suitable for classrooms and workplaces.

4. LITERATURE SURVEY

Various methods have been developed to automate attendance systems and overcome the limitations of manual processes. RFID-based systems are commonly used due to their simplicity, but they are prone to proxy attendance as cards can be shared. Biometric systems, such as fingerprint recognition, provide better accuracy but require physical contact and additional hardware.

QR code-based systems offer an easy and low-cost solution; however, they depend on user participation and can be misused. More advanced approaches use face recognition technology, which allows contactless and automated attendance marking. These systems typically use techniques like Haar Cascade for detection and LBPH for recognition, but their performance may be affected by lighting conditions.

Based on these observations, there is a need for a reliable, contactless, and real-time attendance system. The proposed system addresses these challenges by integrating face recognition with IoT and cloud-based storage for efficient and automated attendance management.

4.1. Comparison of Existing Attendance Systems:

System	Technology Used	Limitations
RFID Attendance System	RFID Cards	Proxy attendance possible
Fingerprint System	Biometric Sensor	Requires physical contact
QR Code System	QR Scanner	Easy to misuse
Face Recognition System	OpenCV + LBPH	Sensitive to lighting
Proposed System	IoT + Face Recognition	Improved automation

5. PROPOSED SYSTEM

The proposed system is an Embedded IoT-based Face Recognition Attendance System designed to automate the attendance marking process in educational institutions.

The system uses facial recognition technology to identify students and mark attendance automatically without manual intervention.

The system consists of a Raspberry Pi, camera module, OpenCV library, LBPH face recognition algorithm, and Firebase Realtime Database. The camera captures real-time images of students, and the Raspberry Pi processes the captured images for face detection and recognition.

Initially, the system detects faces using the Haar Cascade Classifier. After detection, the LBPH algorithm compares the detected face with the trained dataset stored in the system. If the face matches successfully, the student is identified and attendance is marked automatically.

The attendance details, including student ID, name, date, and time, are stored in the Firebase Realtime Database for real-time access and monitoring. The system also prevents duplicate attendance entries for the same session.

The proposed system reduces manual effort, minimizes proxy attendance, improves accuracy, and provides a fast and efficient attendance management solution using embedded and IoT technologies.

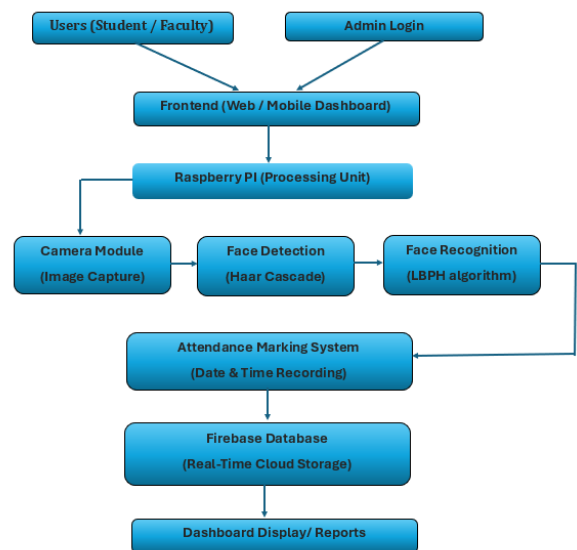


Fig. 1: Proposed System

6. METHODOLOGIES

The proposed system is an Embedded IoT-based Face Recognition Attendance System developed to automate the attendance process. The system uses a camera module to capture real-time images, while the Raspberry Pi acts as the main processing unit.

The captured images are processed using the OpenCV library for face detection and recognition. The Haar Cascade algorithm is used to detect faces, and the LBPH algorithm is

used to recognize registered students by comparing facial features with the stored dataset.

Once a student is recognized successfully, the attendance is marked automatically. The attendance details such as student name, ID, date, and time are stored in the Firebase Realtime Database for real-time access and monitoring.

The system helps reduce manual effort, prevents proxy attendance, and provides an efficient and automated attendance management solution.

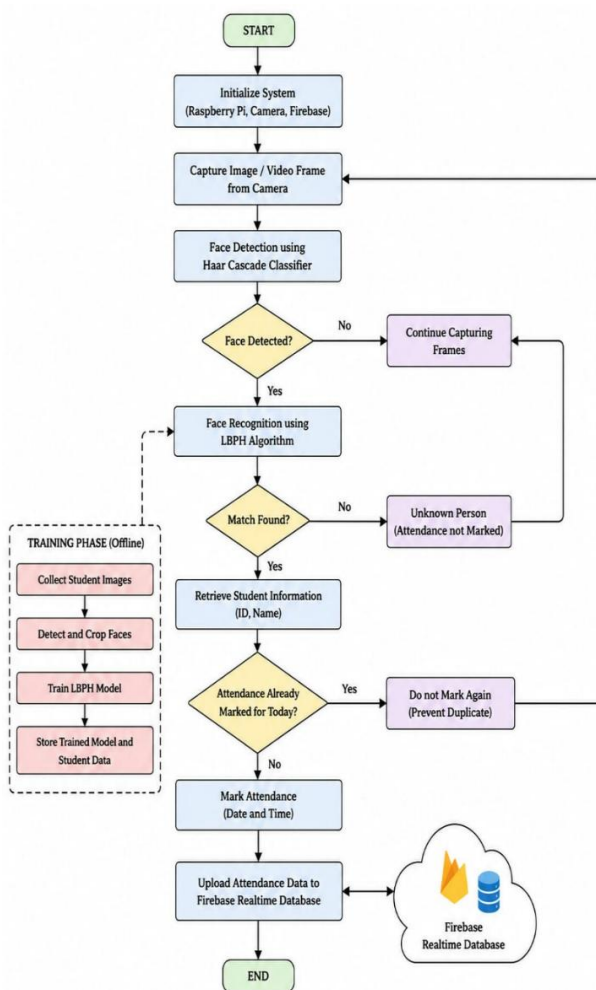


Fig. 2: System Flowchart

7. SYSTEM ARCHITECTURE

The architecture of the proposed Embedded IoT Face Recognition Attendance System consists of hardware and software components that work together to perform automated attendance marking. The main components of the system include a camera module, Raspberry Pi, OpenCV library, face recognition algorithm, and Firebase Realtime Database.

The camera module is used to capture real-time images and video frames of students. These captured images are sent to the Raspberry Pi, which acts as the central processing unit of the system. The Raspberry Pi processes all camera inputs and controls the overall operation of the system.

The OpenCV library is used for image processing, face detection, and face recognition. Initially, the system detects faces from the captured images using the Haar Cascade Classifier. After face detection, the LBPH algorithm compares the detected face with the trained dataset stored in the system to identify the student.

Once the student is recognized successfully, the attendance information such as student ID, name, date, and time is generated automatically. The attendance data is then uploaded to the Firebase Realtime Database through internet connectivity.

Firebase provides real-time cloud storage and allows attendance records to be monitored remotely. The complete system works in an integrated manner to provide secure, automatic, and real-time attendance management.

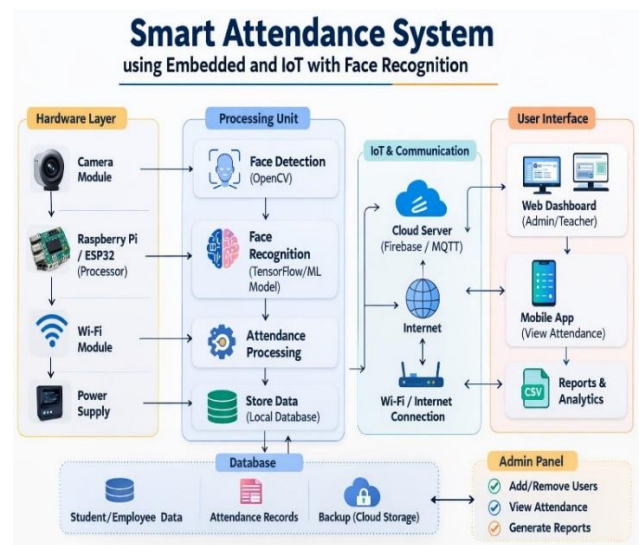


Fig. 3: System Architecture

8. IMPLEMENTATION

The implementation of the proposed Embedded IoT Face Recognition Attendance System was carried out using both hardware and software components. The system was developed using Raspberry Pi as the main processing unit, a camera module for capturing live images, OpenCV library for face detection and recognition, and Firebase Realtime Database for cloud storage.

Initially, student face images were collected and stored as a dataset for training the recognition model. The Haar Cascade Classifier was used for face detection, while the LBPH algorithm was implemented for face recognition. The

trained model was stored in the Raspberry Pi system for real-time identification.

During execution, the camera continuously captures live video frames. The Raspberry Pi processes these frames and detects faces using OpenCV. Once a face is recognized successfully, the system retrieves the corresponding student details and automatically marks attendance.

The attendance information, including student ID, name, date, and time, is uploaded to the Firebase Realtime Database through internet connectivity. The stored attendance records can be monitored remotely in real time.

The complete implementation was tested under different lighting conditions and multiple face samples to improve system accuracy and reliability.

8.1 Hardware setup:

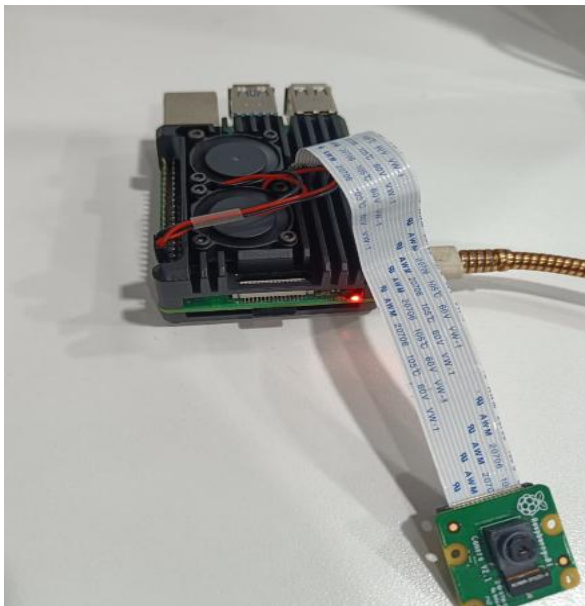


Fig. 4: Hardware setup of proposed attendance system

8.2 Web-Dashboard:

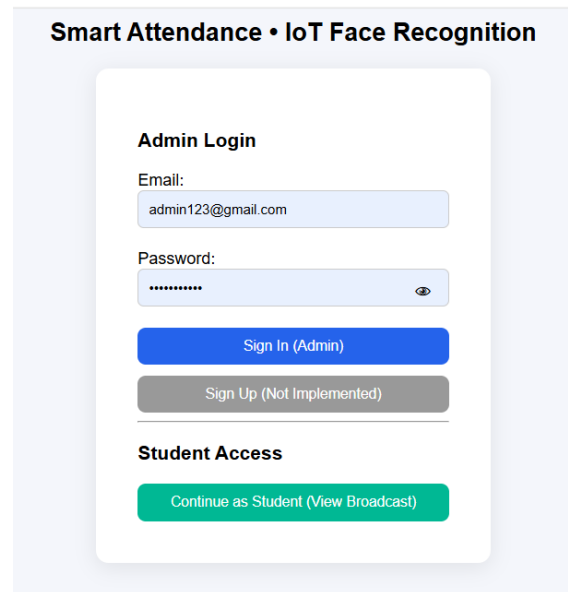


Fig. 5: Admin Login & Student Access

8.3 Authentication for Admin Login (Firebase):

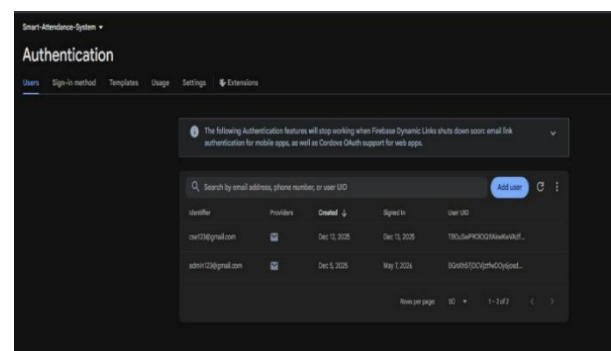


Fig.6: Authentication

8.4 Face Dataset collection:

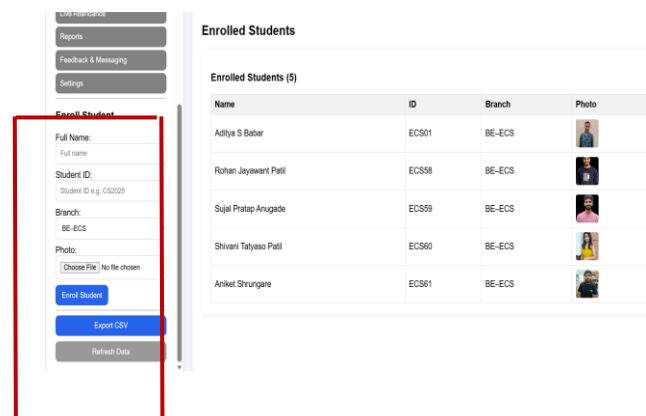


Fig. 7: Enroll Students

8.5 Realtime Database:

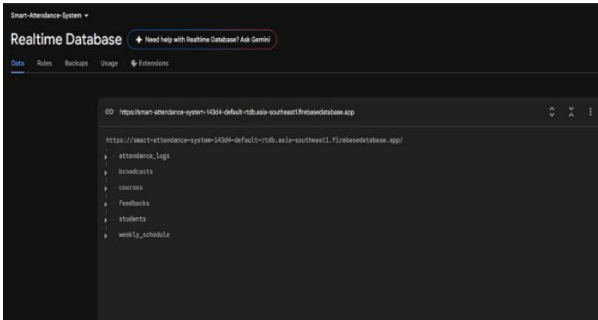


Fig.8: Realtime Database

9.1 Attendance Marked Successfully:

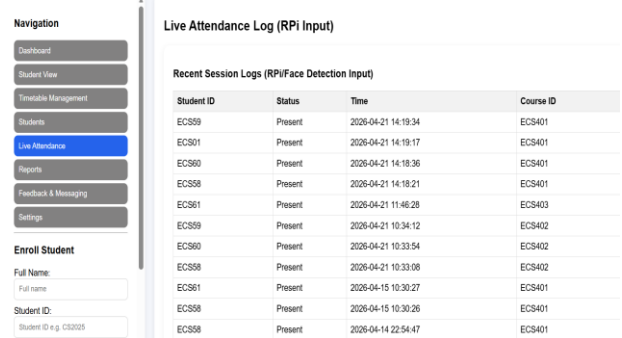


Fig.9: Automated attendance entry generated by the system

9. RESULT AND DISCUSSION

The proposed Embedded IoT Face Recognition Attendance System was implemented and tested successfully using Raspberry Pi, camera module, OpenCV, and Firebase Realtime Database. The system was able to detect and recognize registered student faces in real time and automatically mark attendance with date and time.

During testing, the system accurately identified students whose facial data was stored in the trained dataset. Once recognized, the attendance details were uploaded successfully to the Firebase Realtime Database, allowing real-time monitoring and remote access to attendance records.

The use of Raspberry Pi provided a low-cost and portable embedded solution, while Firebase enabled fast cloud synchronization of attendance data. The system reduced manual effort and minimized the possibility of proxy attendance compared to traditional attendance methods.

The performance of the system depended on factors such as lighting conditions, camera quality, and facial visibility. The system showed better accuracy under proper lighting conditions and clear facial images. However, recognition accuracy decreased slightly in cases of poor lighting, unclear facial orientation, or partially covered faces.

Overall, the proposed system provided an efficient, secure, and automated attendance management solution suitable for educational institutions and IoT-based smart classroom applications.

9.2 Firebase Database Output:

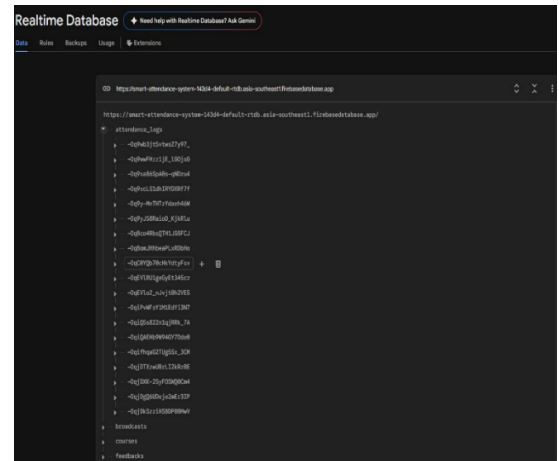


Fig. 10: Attendance records stored in Firebase Realtime Database.

9.3 Monthly Attendance Report:

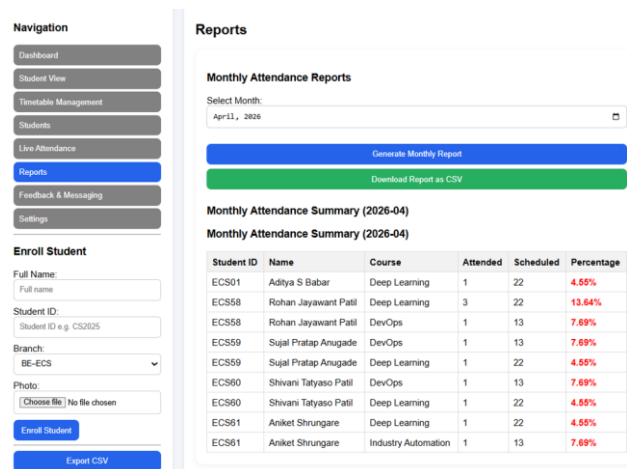


Fig.11. Monthly Attendance Report of Students

9.4. Performance Analysis:

Parameter	Result
Face Recognition Accuracy	92%
Average Recognition Time	1.5 second
Attendance Upload Time	2 second
Performance in Proper Lighting	High Accuracy
Performance in Poor Lighting	Moderate Accuracy

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10. CONCLUSION

The proposed Embedded IoT Face Recognition Attendance System provides an efficient and automated solution for managing student attendance. The system successfully integrates Raspberry Pi, camera module, OpenCV, LBPH face recognition algorithm, and Firebase Realtime Database to perform real-time face recognition and attendance marking.

The system reduces manual effort, minimizes proxy attendance, and improves the accuracy and reliability of attendance management. The use of Firebase enables real-time cloud storage and remote monitoring of attendance records.

The experimental results show that the system performs effectively under proper lighting conditions and is capable of recognizing registered students with good accuracy. The proposed system is cost-effective, user-friendly, and suitable for smart classroom and educational applications.

In future, the system can be enhanced by implementing deep learning techniques, anti-spoofing methods, and mobile application integration to improve security and recognition accuracy.

11. REFERENCES

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