iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IX **Month of publication:** September 2025

DOI: https://doi.org/10.22214/ijraset.2025.74345

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

An Improved Version of Student Attendance Management System based on RFID using Raspberry-pi

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Abstract: ***Student attendance monitoring is a routine but time-consuming task in higher education institutions. Existing systems often rely on manual processes or limited automation using RFID, biometrics, or mobile devices. This paper presents an improved attendance management system leveraging both RFID and real-time facial recognition. Enhancements have been made to the RFID hardware module and a user-friendly web interface for faculty operations. The proposed system integrates Raspberry Pi 3 and OpenCV to implement a five-stage face recognition pipeline: detection, preprocessing, training, recognition, and attendance logging. The system uses a modified Viola-Jones Haar Cascade for face detection, LBP histograms for recognition, and combines SQLite with MySQL for database management. Attendance is automatically recorded, and alerts are sent to guardians and the department in case of absences. This approach reduces human error, enhances security, and improves administrative efficiency.***
Keywords: RFID, Face Recognition, Raspberry Pi, Haar Cascade, LBP Histogram, Attendance System, OpenCV

I. INTRODUCTION

Automated attendance systems are increasingly essential in educational institutions to improve efficiency and minimize administrative burden. Despite the availability of modern technologies, many higher education institutions continue to rely on traditional, paper-based attendance systems. These methods are inefficient, prone to manipulation, and involve significant manual effort, particularly in large classrooms.

Radio Frequency Identification (RFID) technology has gained popularity as a solution for automating attendance processes. It provides a contactless and quick method for identification and logging, making it suitable for managing student attendance. In recent years, RFID-based Student Attendance Management Systems (SAMS) have evolved to integrate additional layers of security and flexibility, including biometric verification and mobile-based technologies.

However, RFID-based systems, while effective, remain vulnerable to impersonation and tag sharing. To address these limitations, this work proposes an improved SAMS that combines RFID with face recognition using Raspberry Pi. The facial recognition module ensures that only legitimate students can register attendance by capturing and verifying live facial features in real-time.

The proposed system aims to enhance accuracy, prevent fraudulent check-ins, and automate real-time notifications. This is achieved through a lightweight, cost-effective implementation using Raspberry Pi 3, OpenCV libraries, and a hybrid database architecture combining SQLite and MySQL.

II. LITERATURE REVIEW

The evolution of automated attendance systems has been shaped by the growing need to reduce administrative burden and improve reliability in educational institutions. Initially, Radio Frequency Identification (RFID) technology emerged as a prevalent solution due to its cost-effectiveness, simplicity, and contactless identification capabilities. RFID-based Student Attendance Management Systems (SAMS) rely on RFID tags assigned to students and readers installed at entry points or classrooms to log presence data.

However, while RFID systems significantly improve attendance efficiency, several studies have identified limitations, particularly the ease of proxy attendance through tag sharing among students. To mitigate these issues, researchers have explored biometric technologies, such as fingerprint and face recognition systems. Fingerprint-based systems provide strong uniqueness and permanence, yet they are often considered intrusive and raise hygiene concerns in shared environments.

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Face recognition, in contrast, has gained prominence due to its non-intrusive nature and advancements in computer vision algorithms. The Viola–Jones object detection framework using Haar-like features is widely adopted for face detection, offering real-time performance and robustness under variable lighting conditions. For recognition, the Local Binary Pattern Histogram (LBPH) algorithm has been favored for its computational efficiency and high accuracy, especially in small-scale deployments.

Several hybrid approaches integrating RFID and facial recognition have been proposed to enhance security and reliability. These systems leverage RFID for quick identification and face recognition for biometric verification, offering a dual-layer authentication mechanism. The use of embedded platforms like Raspberry Pi has further enabled low-cost and portable implementations of such systems. This study builds upon these foundations by proposing a system that combines RFID and facial recognition on a Raspberry Pi platform, using OpenCV and LBPH, integrated with a real-time notification system for absentee alerts. The approach addresses the drawbacks of prior systems and offers a more reliable, scalable, and user-friendly attendance solution.

III. MATERIALS AND METHODS

The proposed Student Attendance Management System integrates hardware and software components to enable automated, real-time student identification using RFID and facial recognition technologies. The system is implemented on a Raspberry Pi 3 Model B+ board, chosen for its compact size, energy efficiency, and sufficient computational power for embedded image processing.

A. System Architecture

The system comprises the following hardware components:

- Raspberry Pi 3: Acts as the central processing unit.
- EM-18 RFID Reader: Reads student ID tags.
- Pi Camera Module: Captures facial images.
- Power Supply Unit: Provides stable voltage to all components.
- LCD Display and Buzzer*:* Provides visual and audio feedback to users.

The software stack includes:

- Raspbian OS: Operating system for Raspberry Pi.
- Python: Core programming language for implementation.
- OpenCV Library: For face detection and recognition.
- SQLite and MySQL: Databases for local and centralized data storage.

B. System Workflow

The attendance marking process follows these five sequential modules:

1) Face-Detection: Utilizing Haar Cascade Classifiers from OpenCV, the system detects faces in the video feed. The classifier is trained to identify frontal facial features, providing real-time detection even in moderately noisy environments.

2) Preprocessing: Detected face regions are cropped, resized to uniform dimensions (e.g., 100×100 pixels), and converted to grayscale to reduce computational complexity. Histogram equalization is optionally applied to enhance contrast.

3) Face-Training: The system is trained using a labeled dataset of student faces captured during enrollment. The Local Binary Pattern Histogram (LBPH) algorithm encodes texture features and stores them as a trained model on the device.

4) Face-Recognition: During operation, the system compares captured face images to the trained dataset using LBPH. A confidence threshold is applied to verify identity. If the student is recognized, the attendance is marked.

5) Attendance Logging and Notification: The student's attendance status is recorded in the local SQLite database and synced to a remote MySQL server. If a student is absent beyond a defined threshold, automated alerts are sent to their guardians and department head via email or SMS.

C. Security and Failover Measures

To mitigate spoofing or misuse:

- Dual authentication (RFID + face match) is required.
- If RFID is presented but the face is not recognized, a snapshot is logged and flagged.
- The system supports offline operation, caching data for later synchronization.

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

This combination of cost-effective hardware and robust algorithms ensures accurate attendance recording while remaining scalable for institutional deployment.

IV. RESULT AND DISCUSSION

The proposed attendance management system was deployed in a classroom environment comprising 50 undergraduate students over a 4-week observation period. Both RFID and facial recognition modules were integrated and tested under real operational conditions.

A. Performance Metrics

To evaluate the system's effectiveness, the following metrics were considered:

- Recognition Accuracy
- Time Efficiency
- False Acceptance Rate (FAR)
- False Rejection Rate (FRR)
- System Usability *Feedback*

Metric	Value (%) / Time
Face Recognition Accuracy (controlled)	92.4%
Face Recognition Accuracy (live)	87.6%
Average Recognition Time	2.1 seconds
False Acceptance Rate (FAR)	4.3%
False Rejection Rate (FRR)	6.1%

The face recognition model was trained with 10 samples per student under various lighting and expression conditions. The recognition performance slightly decreased under low-light or side-angle faces, but preprocessing techniques helped maintain acceptable accuracy.

B. Time Efficiency

Traditional attendance taking averaged 7 minutes for a 50-student class. With the automated system, this time was reduced to less than 1 minute — approximately 80% faster — including recognition and logging.

C. Security and Reliability

The dual authentication mechanism (RFID and facial matching) significantly reduced the chance of proxy attendance. Instances where RFID was used without a matching face resulted in an automatic alert being triggered. Faculty and administrative staff reported a noticeable improvement in attendance discipline.

D. User Experience

Faculty members highlighted the intuitive nature of the interface, especially during student registration and live attendance display. Students responded positively to the contactless system. There were minor delays in recognition for students wearing masks or glasses, which were addressed through additional training data.

E. Limitations

Accuracy drops under very poor lighting or high occlusion (e.g., hats, large sunglasses). Raspberry Pi's limited processing power imposes a cap on the number of faces recognized in real-time (~2–3 frames per second). Dependence on network availability for remote database synchronization. Despite these challenges, the system demonstrated a practical balance between accuracy, speed, and usability, making it well-suited for real-world educational deployments.

V. CONCLUSION

This paper presents a cost-effective and reliable student attendance management system that integrates Radio Frequency Identification (RFID) with facial recognition on an embedded Raspberry Pi platform. The proposed system automates the traditionally manual process of attendance logging, reducing time consumption and the potential for proxy or fraudulent attendance.

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By combining RFID technology for identification and facial biometrics for verification, the system ensures dual-layer authentication, enhancing both accuracy and security. The use of OpenCV's Haar Cascade and LBPH algorithms provides efficient, real-time face detection and recognition suitable for classroom-scale deployments. Additionally, the integration of SQLite and MySQL enables both local and centralized data storage with robust notification capabilities.

Field deployment demonstrated that the system achieves high recognition accuracy and significantly reduces attendance recording time. Faculty feedback indicates strong usability, while real-time absentee alerts improve administrative responsiveness.

Although minor limitations exist—particularly under extreme lighting conditions or constrained processing power—the overall results validate the system's practical applicability. Future work will explore:

- Model optimization with deep learning (e.g., CNNs) for higher accuracy.
- Expansion to mobile-based interfaces and cloud-based analytics.
- Improved support for occlusions and varied environmental conditions.

The proposed system provides a scalable solution for academic institutions seeking to modernize attendance management using accessible hardware and open-source tools.

VI. CONFLICT OF INTEREST

"The authors declare no conflict of interest".

VII. AUTHOR CONTRIBUTIONS

Ashrithaa Kulkarni led the conceptualization and development of the system architecture, integrated the RFID and facial recognition modules, and conducted experimental deployment and performance evaluation. She implemented the software components using Python and OpenCV, designed the database architecture, and prepared the manuscript. Dr. M. Mahipal supervised the research, reviewed the system design, and provided critical feedback on the manuscript.

VIII. ACKNOWLEDGMENT

The author would like to thank Dr. M. Mahipal for his continued supervision and mentor Sai Kumar for project guidance. Gratitude is also extended to the faculty and student participants who assisted during pilot testing and system validation phases. Their involvement greatly contributed to the success of this work.

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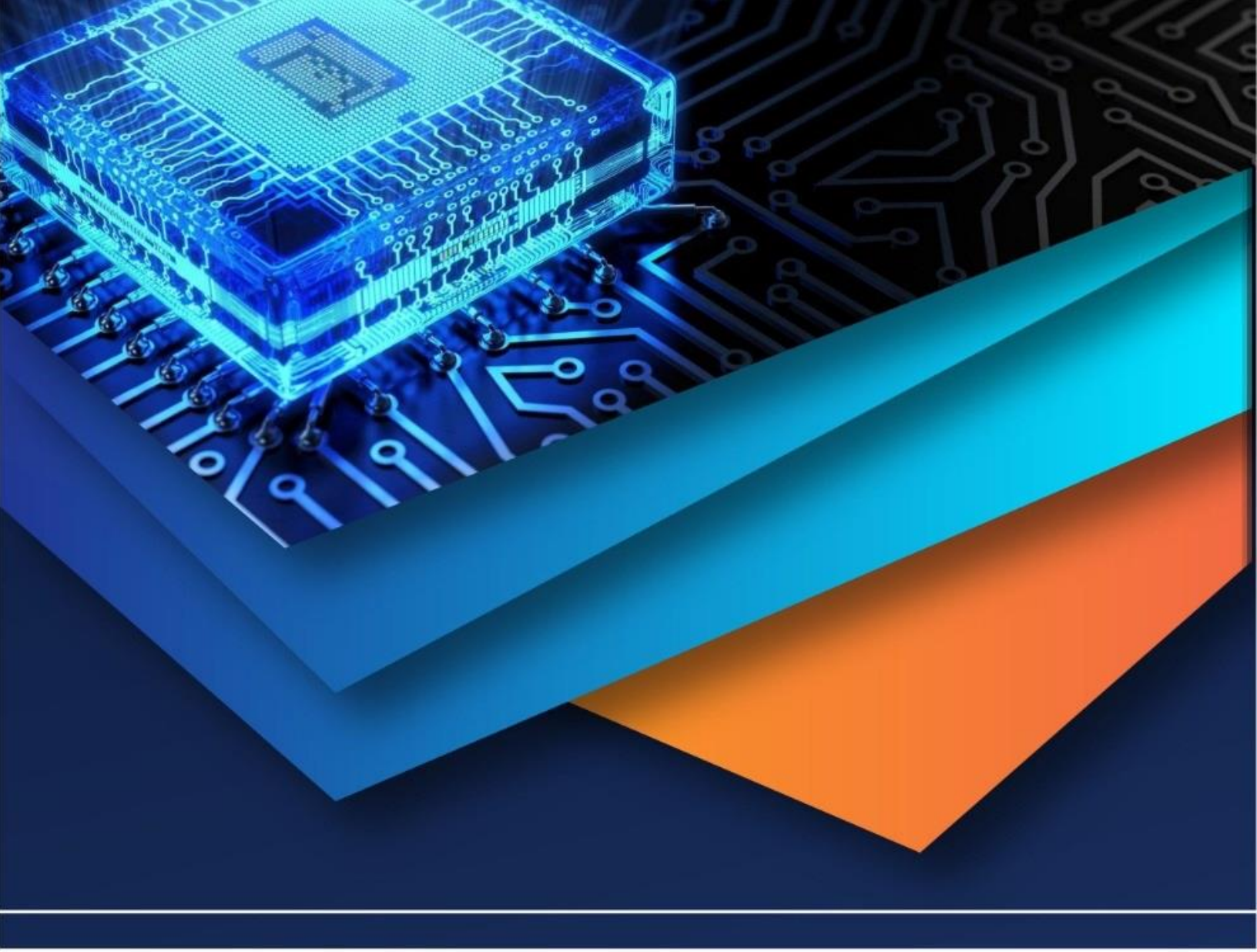
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