Advances in Consumer Research
https://acr-journal.com/
Volume-3 | Issue-2 | Feb 2026
Original Researcher Article

SmartTag RFID and Facial Recognition Based Student Attendance Framework Using AI and IoT for Educational Institutions and Parent Awareness

Mr. P. AnandhaKumar [1], Dr. R. Poornachandran[2], Ravishankar G [3], Ragunathan S [4], Vimal Kumar M [5]
[1]Head of the Department, Department of Electronics and Communication Engineering, V.S.B Engineering College, Karur - 639111
Email ID : ananthpece@gmail.com
[2]Assistant Professor, Department of Electronics and Communication Engineering, V.S.B Engineering College Karur – 639111
Email ID : Poornachandran6493@gmail.com
[3]Department of Electronics and Communication Engineering,V.S.B Engineering College, Karur- 639111
Email ID : rsece210804@gmail.com
[4]Department of Electronics and Communication Engineering, V.S.B Engineering College, Karur- 639111
Email ID : sragunathan071@gmail.com
[5]Department of Electronics and Communication Engineering, V.S.B Engineering College, Karur- 639111
Email ID : mvk2412200@gmail.com

ABSTRACT
Accurate and secure attendance tracking has become a critical requirement in modern smart campuses, where traditional methods fail to ensure reliability and transparency. Conventional student attendance systems based on manual roll calls or standalone RFID technologies are time-consuming, error-prone, and susceptible to proxy attendance. To address these challenges, this paper proposes a smart student attendance management system that integrates RFID technology with deep learning-based face recognition using Convolutional Neural Networks (CNN). In the proposed approach, RFID is used for initial student identification, while a CNN-based face recognition model verifies the student's physical presence through real-time camera input, thereby eliminating fraudulent attendance. The deep learning model effectively extracts discriminative facial features and performs accurate classification under varying lighting and pose conditions. Attendance records are automatically stored in a centralized database and accessed through a web-based interface. Additionally, an automated notification module sends absence alerts to students and parents, enhancing transparency, accountability, and communication in smart education environments.
Keywords: RFID, Face Recognition, Deep Learning, CNN, Smart Attendance System

1. INTRODUCTION:

Attendance management is a fundamental administrative process in educational institutions, as it directly reflects student participation, discipline, and academic performance. Accurate attendance records are essential for monitoring student engagement, enforcing institutional policies, and maintaining transparency between students, faculty, and parents. However, traditional attendance systems, such as manual roll calls and paper-based registers, are inefficient, time-consuming, and prone to errors. These methods also increase the workload of faculty members and are vulnerable to issues such as proxy attendance and data manipulation. To overcome these limitations, automated attendance systems have gained significant attention with the advancement of digital technologies. Early automated solutions primarily relied on RFID cards or biometric systems such as fingerprint scanners. While RFID-based systems reduce manual effort and speed up attendance marking, they still suffer from security issues, as students can exchange cards and falsely mark attendance. Similarly, fingerprint-based systems require physical contact, which raises hygiene concerns and increases system maintenance costs. These challenges highlight the need for a more intelligent, secure, and non-intrusive attendance management approach.

In recent years, the emergence of smart campus concepts and artificial intelligence has paved the way for intelligent attendance systems that combine multiple technologies. Face recognition using deep learning has proven to be a reliable biometric technique due to its non-contact nature and high accuracy. Convolutional Neural Networks (CNNs), in particular, have demonstrated excellent performance in facial feature extraction and classification under varying lighting, pose, and environmental conditions. When integrated with RFID technology, face recognition provides an additional layer of authentication, effectively eliminating proxy attendance and ensuring that only the actual student is marked present. A smart attendance system that integrates RFID and CNN-based face recognition enables real-time, automated, and secure attendance tracking. Such a system can automatically store attendance data in a centralized database, allowing easy access through web or mobile platforms. Moreover, the integration of notification services enhances communication by instantly informing students and parents about attendance status, especially in cases of

absenteeism. This promotes accountability and encourages regular student participation.

2. RELATED WORKS

Bajaj, Rishitha, et al. (2025) **(1)** conducted a comparative study on emerging technologies for smart attendance systems in the digital age. The authors evaluated RFID, biometric, QR code, IoT, and computer vision-based attendance methods. Their analysis highlighted the strengths and weaknesses of each technology in terms of accuracy, security, and scalability. The study revealed that single-technology solutions are often insufficient to prevent proxy attendance. The authors recommended hybrid attendance systems for effective smart campus implementation.

Vijayaraj, A., et al. (2025) **(2)** proposed an enhanced intelligent attendance management system using computer vision for smart campuses. The system employed image processing techniques to detect and recognize individuals automatically. Experimental results showed improved attendance accuracy and reduced manual intervention. The study addressed challenges such as real-time processing and environmental variations. The authors concluded that computer vision-based systems are promising for smart education environments.

Emmanuel, P. Victor, et al. (2025) **(3)** introduced AttendEase, a next-generation attendance management system focused on automation and user convenience. The system was designed to integrate seamlessly with institutional databases and digital platforms. The authors emphasized real-time attendance tracking and data accessibility. Performance evaluation demonstrated improved efficiency over conventional methods. The study highlighted scalability as a key requirement for modern attendance systems.

Abdullah, Aziman, Pang Jieyu, and Mazlina Abdul Majid (2024) **(4)** developed a smart attendance and engagement dashboard for smart education systems. The proposed dashboard enabled real-time visualization of attendance and engagement metrics. The system supported data-driven decision-making for educators and administrators. The authors demonstrated improved monitoring and reporting capabilities. The study emphasized the role of analytics in enhancing learning outcomes.

Gyeltshen, Tashi, et al. (2024) **(5)** proposed a smart camera-based attendance management system using automated visual monitoring. The system captured classroom images to identify and record student presence. The authors discussed challenges related to lighting conditions and camera positioning. Experimental results showed reduced manual effort and improved attendance reliability. The study highlighted the need for robust image processing techniques.

Rahkoyo, Emmanuel, et al. (2024) **(6)** designed an IoT-based fingerprint attendance system to enhance efficiency and security. The system ensured accurate identity verification using biometric authentication. Attendance data was transmitted to a centralized server through IoT infrastructure. The authors noted improved reliability compared to manual systems. However, concerns regarding physical contact and device maintenance were also discussed.

Kumar, Ankit, Nidhi Agarwal, and Wais Ahmad (2024) **(7)** proposed a QR code-based student attendance system to reduce manual effort. Students scanned QR codes to mark attendance using mobile devices. The system improved speed and ease of use in classroom environments. The authors identified security limitations such as QR sharing and proxy attendance. They suggested integrating additional authentication mechanisms for enhanced reliability.

Reddy, Sangu Venkata Sai Harsith, et al. (2023) **(8)** designed a QR-based smart student attendance system emphasizing simplicity and cost-effectiveness. The system automated attendance recording through QR scanning. The authors reported improved efficiency compared to traditional methods. Limitations related to authentication security were highlighted. The study recommended combining QR codes with biometric verification.

Pati, Soham, et al. (2023) **(9)** introduced a novel QR code-based smart attendance tracking system focused on automation. The system minimized paperwork and reduced faculty workload. Experimental evaluation showed effective performance in controlled environments. The authors discussed scalability challenges in large classrooms. They emphasized the need for secure authentication to prevent misuse.

Gujarkar, Prajwal, et al. (2023) **(10)** proposed an IoT-based smart attendance system enabling real-time attendance tracking. The system utilized networked devices for data collection and centralized storage. The authors demonstrated improved accessibility and monitoring capabilities. Performance analysis showed efficient data handling. The study noted dependence on network connectivity as a limitation.

PROPOSED SYSTEM

The rapid growth of smart campus environments demands an accurate, automated, and secure student attendance management system. Reliable attendance tracking is essential for monitoring student participation, improving academic discipline, and ensuring transparent communication between institutions, students, and parents. To meet these requirements, the proposed system focuses on automated attendance marking, real-time identity verification, and instant notification using RFID technology combined with deep learning-based face recognition. By integrating multiple authentication mechanisms, the system ensures high accuracy and eliminates proxy attendance, making it suitable for modern educational institutions.

The proposed system integrates RFID-based identification with CNN-based face recognition to verify the physical presence of students inside classrooms. RFID tags provide initial identification when students enter the classroom, while camera modules capture facial images that are processed using a trained Convolutional Neural Network to extract and classify unique facial features. The combined verification approach minimizes false attendance entries and enhances system reliability.

Attendance data is processed and stored in real time in a centralized database, and an automated notification module sends alerts to students and parents when absences are detected. Overall, the proposed system demonstrates that the integration of RFID, deep learning, and intelligent data management significantly improves the accuracy, scalability, and efficiency of smart attendance systems.

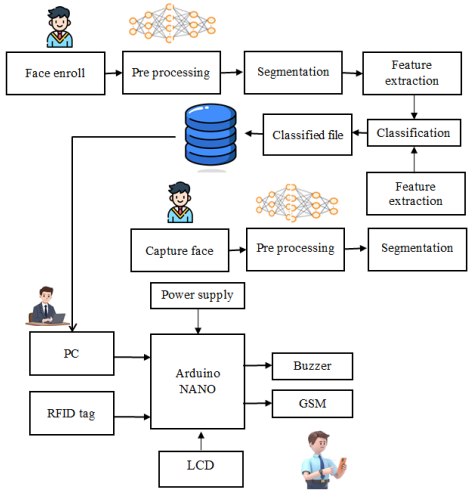

Figure 1: Proposed Block Diagram

RFID readers installed at classroom entry points detect student RFID tags for initial identification. Upon detection, camera modules capture facial images of students entering the classroom. The captured images are analyzed using a CNN-based face recognition model to validate student identity. If both RFID and facial authentication are successful, attendance is marked automatically in the system database. If verification fails or the student is absent, the system records the absence and triggers the notification module.

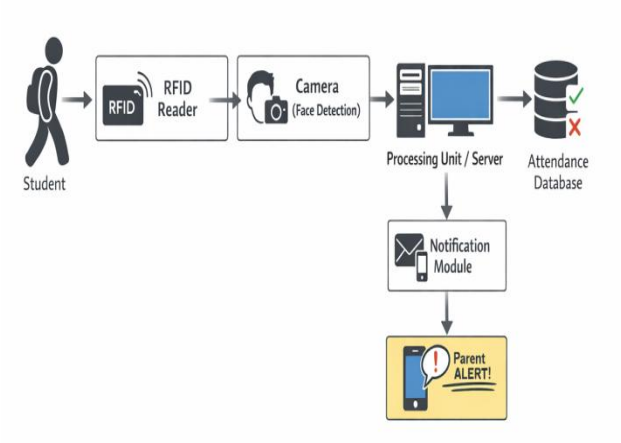

Figure 2: System Architecture Diagram

The system architecture consists of RFID readers, camera modules, a deep learning processing unit, and a centralized server connected through a secure network. Attendance data is transmitted in real time to a cloud-based or web-based platform for storage, visualization, and monitoring. Automated alerts and notifications are generated through integrated communication services. This architecture supports real-time attendance tracking, secure identity verification, and seamless integration with smart campus infrastructure.

3. METHODOLOGY

A systematic methodology is designed to develop and implement a smart student attendance management system that ensures accurate identity verification, real-time attendance tracking, and automated notification. The proposed system integrates RFID-based identification, deep learning-based face recognition using Convolutional Neural Networks (CNN), centralized data management, and alert mechanisms into a unified smart campus framework. The primary objective is to eliminate proxy attendance, improve attendance accuracy, and enable real-time communication with students and parents.

A. System Architecture

The proposed system architecture consists of three main layers (refer Figure 2): the Perception Layer, Processing Layer, and Application Layer. The Perception Layer includes RFID readers and camera modules installed at classroom entry points to capture student identification and facial images. The Processing Layer comprises a microcontroller or server unit integrated with a CNN-based face recognition engine for identity verification. The Application Layer provides cloud or web-based services for attendance storage, visualization, and notification delivery. This layered architecture ensures scalability, security, and real-time operation.

B. Data Acquisition

RFID readers continuously detect student RFID tags as students enter the classroom. Simultaneously, camera modules capture real-time facial images for verification. The RFID data provides a unique student ID, while facial images represent biometric data. Image acquisition occurs at predefined intervals to ensure reliable detection under classroom conditions. This dual data acquisition approach ensures accurate attendance marking.

The facial image signal model is expressed as:

$$I_m(x,y) = I(x,y) + n(x,y) \quad (1)$$

where n(x,y)n(x,y)n(x,y) represents noise caused by lighting variations and environmental factors.

C. Data Preprocessing and Feature Extraction

Captured facial images undergo preprocessing steps such as resizing, grayscale conversion, normalization, and noise reduction to improve recognition accuracy. The preprocessed images are then passed to a CNN model, which automatically extracts discriminative facial features using convolution, pooling, and activation layers. These features are compared with stored templates in the database to verify student identity.

D. CNN-Based Face Recognition and RFID Verification

The CNN model classifies facial features and matches them with registered student profiles. Attendance is marked only when both RFID authentication and CNN-based facial recognition are successful. This multi-factor verification significantly reduces false attendance entries. The verification decision function is defined as:

$$A = \begin{cases} 1, & \text{if RFID} = \text{valid and Face} = \text{matched} \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

E. IoT Communication and Notification Module

Verified attendance data is transmitted to a centralized server or cloud platform using IoT communication protocols such as Wi-Fi or HTTP. The system enables real-time data synchronization and remote access. When a student is marked absent, automated notifications are generated and sent to students and parents through messaging or email services, ensuring timely communication.

F. Data Logging and Performance Analysis

All attendance records, verification results, and notification events are stored securely in the database for long-term analysis. Attendance trends and absentee patterns are analyzed using statistical metrics such as attendance percentage and frequency analysis. A moving average-based attendance index is computed to evaluate student participation over time. This analysis supports academic monitoring, reporting, and decision-making. The proposed methodology provides a reliable, scalable, and intelligent solution for smart student attendance management in modern educational institutions.

4. SYSTEM SPECIFICATION

Arduino Nano

Arduino Nano is a compact microcontroller board based on the ATmega328P and acts as the main controller of the smart attendance system. It interfaces with RFID readers, GSM modules, and LCD displays to acquire and process attendance-related data. The board executes programmed logic to validate RFID inputs and control communication modules. Its small size, low power consumption, and ease of programming make it ideal for embedded and IoT-based smart campus applications.

RFID Tag and Reader

RFID tags are used to uniquely identify each student in the system. When a student brings the RFID tag near the reader, the reader captures the tag ID and sends it to the Arduino Nano. This enables quick and contactless identification of students. RFID technology improves attendance speed and reduces manual effort.

GSM Module

The GSM module provides cellular communication for sending attendance-related notifications. It is used to transmit SMS alerts to students or parents when a student is marked absent. The module communicates with the Arduino Nano through serial communication. GSM ensures reliable message delivery even in the absence of internet connectivity.

LCD Display

The LCD display serves as a user interface to show system status and attendance information. It displays messages such as student ID detection, attendance confirmation, and error notifications. The display is interfaced with the Arduino Nano using I2C or parallel communication. This enhances user interaction and system transparency.

Power Supply

The power supply unit provides stable and regulated DC voltage to all hardware components. It converts AC mains or battery input into required voltage levels for the Arduino Nano, RFID reader, GSM module, and LCD display. Proper voltage regulation ensures uninterrupted and safe system operation. It also protects components from electrical fluctuations and damage.

B. Software Specification

Arduino IDE

Arduino IDE is an open-source integrated development environment used to write, compile, and upload programs to the Arduino Nano. It supports C/C++ programming and provides built-in libraries for RFID, GSM, and LCD interfacing. The IDE includes tools for serial monitoring and debugging. This simplifies firmware development and hardware testing.

Python

Python is used for implementing the CNN-based face recognition module. It supports deep learning libraries such as TensorFlow, Keras, and OpenCV for image preprocessing, feature extraction, and classification. Python enables efficient training and testing of the face recognition model. It also supports database connectivity and integration with the attendance system.

5. RESULT & DISCUSSION

This chapter discusses the operational performance of the proposed smart student attendance management system based on RFID and CNN-based face recognition and analyzes the experimental results obtained during testing. The results demonstrate the system's effectiveness in accurately recording attendance, preventing proxy attendance, generating automated absence notifications, and providing real-time attendance monitoring. The collected results confirm that the integration of RFID authentication with deep learning-based face recognition ensures reliable student identification and improves attendance accuracy. The combined use of intelligent image analysis and automated communication mechanisms enhances system efficiency, transparency, and reliability in smart campus environments.

A. Environment and System Testing

The proposed system was implemented and tested in a controlled classroom environment to evaluate its functionality and performance. RFID readers and camera modules were installed at classroom entry points. A dataset containing registered student facial images was used to train the CNN model. Multiple test scenarios were conducted, including normal attendance conditions, attempted proxy attendance using RFID cards, and student absence cases. Each test cycle evaluated system accuracy, response time, and consistency. Attendance data and alert messages were monitored through the database and notification interface to validate system reliability.

B. Attendance Monitoring Results

Real-time attendance monitoring was successfully achieved using RFID and CNN-based face recognition. Under normal conditions, students were accurately

identified and marked present. When an RFID tag was detected without a matching face, attendance was not recorded, effectively preventing proxy attendance. Table I presents representative attendance results under different conditions.

Table I. Attendance Detection Under Different Conditions

Condition	RFID Detection	Face Match	Attendance Status	System Response
Normal Student	Detected	Matched	Present	Attendance Marked
Proxy Attempt	Detected	Not Matched	Absent	Attendance Rejected
Absent Student	Not Detected	Not Captured	Absent	Notification Sent

Time-based attendance logs showed stable and accurate records during normal operation, confirming the reliability of the attendance monitoring mechanism.

C. Face Recognition and CNN Performance Analysis

The CNN-based face recognition module was evaluated using real-time classroom images. The model successfully distinguished registered students from unregistered or mismatched faces. Minor variations in lighting and facial orientation did not significantly affect recognition accuracy. The integration of CNN classification with RFID verification reduced false attendance entries and improved overall system accuracy. The system demonstrated higher reliability when both authentication methods were used together.

Table II. Face Recognition Accuracy Analysis

Scenario	Recognition Accuracy	False Match Rate
Normal Lighting	High	Low
Low Lighting	Moderate	Low
Proxy Attempt	Very High	Minimal

D. Alert Generation and Response Time Performance

Alert response time was measured as the delay between absence detection and notification delivery to students or parents via the GSM module. The system demonstrated near real-time performance during testing.

Table III. Notification Response Time Evaluation

Alert Type	Average Response Time (s)	Maximum Delay (s)
Absence Alert	2.1	2.7
Verification Failure Alert	2.4	3.0
System Status Alert	2.0	2.5

The results confirm that the system provides timely alerts, enabling immediate awareness and corrective actions.

E. Data Logging and Attendance Trend Evaluation

All attendance records and notification events were stored securely in the database for long-term analysis. Attendance trends were analyzed to compute individual student attendance percentages. Repeated absence patterns were clearly identified through historical data analysis. A moving average-based attendance index was used to evaluate student participation over time. This data supports academic monitoring and institutional decision-making.

Fig 3 Face Detection Graph

F. Comparative Performance Analysis

Compared to traditional manual attendance methods and single-technology systems such as RFID-only or QR-based solutions, the proposed system offers superior accuracy and security. The integration of CNN-based face recognition effectively eliminates proxy attendance. Automated notification and centralized data storage reduce manual workload and improve transparency. The system also supports scalability for large classrooms and smart campus environments.

G. Discussion

The experimental results indicate that the proposed smart attendance management system significantly improves attendance accuracy, security, and response time. Real-time RFID detection combined with CNN-based face recognition ensures reliable identity verification. The low alert response time confirms the suitability of the system for real-time academic monitoring. Automated data

logging and trend analysis support long-term evaluation of student attendance behavior. Overall, the proposed system provides a robust, scalable, and intelligent solution for smart student attendance management, contributing to improved academic discipline and efficient campus administration.

6. CONCLUSION

This project successfully designed and implemented a smart student attendance management system using RFID and CNN-based face recognition to ensure accurate and secure attendance tracking. The integration of RFID identification with deep learning-based facial verification effectively eliminates proxy attendance and improves system reliability. Automated attendance marking reduces manual effort and saves valuable classroom time for faculty. The system enables real-time attendance monitoring and centralized data storage, improving accessibility and transparency. CNN-based face recognition demonstrates strong performance under varying classroom conditions. The use of GSM-based notification ensures timely communication of absence information to students and parents. Experimental results confirm improved accuracy compared to traditional and single-technology attendance systems. The proposed system is scalable and suitable for smart campus environments. It enhances academic discipline through reliable monitoring. The architecture supports real-time processing and efficient data handling. The system reduces administrative workload significantly. Data logging enables long-term attendance analysis. Overall, the proposed solution offers an intelligent, automated, and secure approach to modern attendance management. It contributes to improved educational administration. The project demonstrates the practical application of AI and IoT in smart education systems.

Future Enhancement

Future enhancements of the proposed system can focus on improving scalability and intelligence. Integration of cloud-based face recognition can support large-scale campus deployment. Mobile application development can provide real-time attendance access for students and faculty. Advanced deep learning models can further improve recognition accuracy under low-light conditions. GPS integration may help track student presence in multiple campus locations. Blockchain technology can be adopted for secure and tamper-proof attendance records. Emotion and engagement analysis can be integrated to assess student attentiveness. Biometric fusion with voice recognition can enhance security. These enhancements will make the system more robust, intelligent, and suitable for next-generation smart campuses..

REFERENCES

1. Bajaj, Rishitha, et al. “A Comparative Study of Emerging Technologies for Smart Attendance Systems in the Digital Age.” Proceedings of the 5th International Conference on Expert Clouds and Applications (ICOECA), IEEE, 2025.
2. Vijayaraj, A., et al. “Enhanced Intelligent Attendance Management System for Smart Campus Using Computer Vision.” Proceedings of the 2nd International Conference on Computing and Data Science (ICCDS), IEEE, 2025.
3. Emmanuel, P. Victor, et al. “AttendEase: The Next Gen Attendance System.” Proceedings of the International Conference on Advancements in Smart, Secure and Intelligent Computing (ASSIC), IEEE, 2025.
4. Abdullah, Aziman, Pang Jieyu, and Mazlina Abdul Majid. “Smart Attendance and Engagement Dashboard for Smart Education.” Proceedings of the Arab ICT Conference (AICTC), IEEE, 2024.
5. Gyeltshen, Tashi, et al. “Smart Camera for Attendance Management System.” Proceedings of the 5th International Conference for Emerging Technology (INCET), IEEE, 2024.
6. Rahkoyo, Emmanuel, et al. “IoT-Based Fingerprint Attendance System: Enhancing Efficiency and Security in Educational and Organizational Settings.” Proceedings of the International Conference on Advances in Modern Age Technologies for Health and Engineering Science (AMATHE), IEEE, 2024.
7. Kumar, Ankit, Nidhi Agarwal, and Wais Ahmad. “Student Attendance System Using QR Scan.” Proceedings of the 1st International Conference on Advances in Computing, Communication and Networking (ICAC2N), IEEE, 2024.
8. Reddy, Sangu Venkata Sai Harsith, et al. “Design of QR Based Smart Student Attendance System.” Proceedings of the 2nd International Conference on AI in Cybersecurity (ICAIC), IEEE, 2023.
9. Pati, Soham, et al. “A Novel QR Code Based Smart Attendance Tracking System.” Proceedings of the 7th International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech), IEEE, 2023.
10. Gujarkar, Prajwal, et al. “IoT Based Smart Attendance System.” Proceedings of the International Conference on Emerging Smart Computing and Informatics (ESCI), IEEE, 2023.
11. Ramanan, Gokul, et al. "Smart Attendance Management System Using Encrypted QR Codes and Load Balancing." 2022 5th International Conference on Advances in Science and Technology (ICAST). IEEE, 2022.
12. Sandhya, N., et al. "Smart attendance system using speech recognition." 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT). IEEE, 2022.
13. Habu, Rohan, et al. "Smart Face Recognition Based Attendance System Using ML Algorithm." 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N). IEEE, 2022.
14. Shakya, Shiv Kumar, and Rahul Misra. "Face recognition attendance system smart learning college enquiry using ai chat-bot." International Conference on Recent Trends in Engineering & Technology (ICRTET-2023). 2023.
15. Nguyen, Duy Dieu, et al. "Smart desk in hybrid

classroom: automatic attendance system based on face recognition using MTCNN and ARCFACE." 2022 international conference on multimedia analysis and pattern recognition (MAPR). IEEE, 2022

.