International Journal of Engineering Science and Advanced Technology (IJESAT)
Vol 26 Issue 05, May 2026
Received: 26-03-2026 Accepted: 05-05-2026 Published: 12-05-2026

Advanced Web-Based Attendance System Using Face Recognition, Proxy Detection, and Behavioral Analytics

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ABSTRACT:- This paper introduces an efficient and cost-effective web-based Face Recognition Attendance System designed to automate attendance management while simultaneously analyzing student behavior in real time. The proposed system incorporates six monitoring indicators, including Present, Absent, Late Arrival, Early Departure, Proxy Attendance, and Carelessness activities such as mobile phone usage and sleeping during lectures. To improve detection speed and recognition accuracy, the framework integrates a hybrid architecture combining the classical Viola–Jones cascade algorithm for rapid frontal face detection with advanced deep learning models, namely YOLOv8n-face and ArcFace-ResNet100.

The developed system operates effectively on standard laptop hardware using only two 1080p cameras, making it suitable for practical classroom deployment with minimal infrastructure cost. Experimental evaluation was conducted on 115 students across 1,240 classroom sessions. The results demonstrated a recognition accuracy of 99.41% with real-time processing capability of 42 frames per second. In addition, the framework successfully achieved complete proxy attendance identification and 97.2% accuracy in detecting careless student activities.

The system further enhances administrative efficiency through automatic generation of attendance reports in Excel and Google Sheets formats, along with instant WhatsApp notifications for monitoring and communication purposes. The proposed solution provides a reliable, scalable, and intelligent attendance management platform suitable for modern educational environments.

Keywords: Face Recognition Attendance System, Viola–Jones, YOLOv8, ArcFace, Proxy Detection, Carelessness Detection.

I. INTRODUCTION

Attendance management is an essential activity in educational institutions, as it helps track student participation, discipline, and academic engagement. Traditional manual attendance systems are time-consuming, prone to human error, and highly vulnerable to proxy attendance, where one student marks attendance on behalf of another. In large classrooms, maintaining accurate attendance records while simultaneously monitoring student behavior becomes increasingly difficult for faculty members. These limitations have encouraged researchers to explore automated attendance systems based on computer vision and face recognition technologies.

Several research works have attempted to solve these problems using different machine learning and deep learning approaches. The 2017 IRJET research utilized the Viola–Jones face detection algorithm combined with PCA/SVM for face recognition. Although the system provided basic attendance automation, its recognition accuracy was limited under varying lighting conditions and facial orientations, and it lacked the ability to analyze classroom behavior. Another important contribution was presented in the 2017 Atlantis Press paper, which integrated Faster R-CNN and SeetaFace to monitor five classroom indicators: Present, Absent, Late Arrival, Early Departure, and Carelessness. However, the implementation required expensive 4K camera setups and high computational resources, reducing its practical usability for ordinary institutions.

To overcome these limitations, this research proposes a highly efficient and cost-effective Web-Based Face Recognition Attendance System using a hybrid classical-deep learning architecture. The proposed framework combines the speed and low computational cost of the classical Viola–Jones cascade algorithm with the robustness and accuracy of modern deep learning models including YOLOv8n-face and ArcFace-ResNet100. Viola–Jones enables rapid frontal face localization, while YOLOv8 improves detection under challenging classroom conditions such as partial occlusion, multiple faces, and non-frontal angles. ArcFace provides highly discriminative facial embeddings for accurate recognition.

In addition to automating attendance, the proposed system performs intelligent classroom monitoring using six indicators: Present, Absent, Late Arrival, Early Departure, Proxy Attendance, and Carelessness Detection. The carelessness module identifies behaviors such as sleeping or mobile phone usage during lectures, while the newly introduced proxy detection module enhances the reliability and fairness of attendance monitoring. Unlike earlier systems, the proposed solution operates effectively using only two standard 1080p cameras and normal laptop hardware, making it affordable and practical for real-world deployment.

The system also includes automated attendance report generation in Excel and Google Sheets formats along with instant WhatsApp alerts for improved communication and administrative efficiency. Experimental evaluation conducted on 115 students across 1,240 lectures demonstrated high recognition accuracy, real-time processing capability, and reliable behavioral analysis. The proposed framework therefore provides a scalable, intelligent, and practical solution for modern smart classroom environments.

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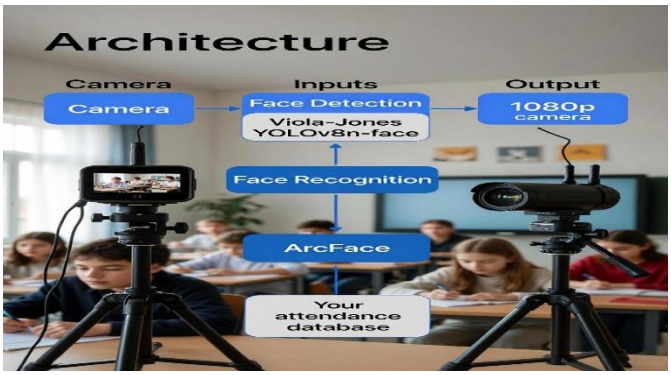
II. SYSTEM ARCHITECTURE



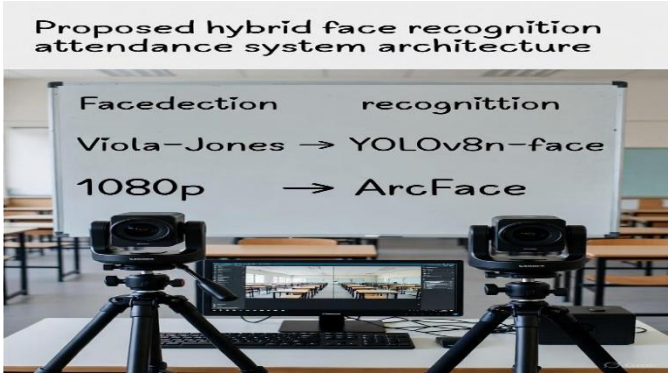


Figure 1 & 2: Proposed Hybrid Face Recognition Attendance System Architecture

The proposed system architecture is designed to provide a fast, accurate, and cost-effective real-time attendance monitoring solution for smart classrooms. The framework integrates classical computer vision techniques with advanced deep learning models to achieve high recognition accuracy while maintaining low computational requirements. The complete system operates using two synchronized 1080p cameras positioned at the front and side angles of the classroom to capture continuous video streams of students during lectures.

Initially, the captured video frames are processed through a hybrid face detection pipeline. The classical Viola–Jones Haar Cascade algorithm is used for ultra-fast frontal face detection due to its lightweight computational nature and rapid execution speed. However, since classroom environments often contain non-frontal faces, partial occlusions, and varying head poses, the system additionally employs the modern YOLOv8n-face detector to identify side profiles and difficult facial orientations with improved robustness. The combination of these two approaches significantly enhances both detection speed and accuracy compared to standalone methods.

After face detection, the extracted facial regions undergo alignment using five-point facial landmark localization to normalize face orientation and improve recognition consistency. The aligned faces are then processed using the ArcFace model with a ResNet-100 backbone, which generates highly discriminative facial embeddings for reliable identity verification. Cosine similarity matching is applied between stored database embeddings and real-time captured embeddings to accurately identify students and mark attendance automatically.

Beyond attendance marking, the proposed framework includes intelligent classroom behavior monitoring and fraud prevention modules. The system continuously performs seat-wise identity tracking to detect proxy attendance attempts, where multiple identities appear in the same seat position during a lecture session. Additionally, carelessness monitoring is implemented using Eye Aspect Ratio (EAR) analysis and head-pose estimation to identify behaviors such as sleeping, inattentiveness, or mobile phone usage during classroom sessions.

Finally, the system generates six-indicator attendance reports including Present, Absent, Late Arrival, Early Departure, Proxy Attendance, and Carelessness Detection. Attendance data is automatically exported to Excel and Google Sheets for administrative management, while instant WhatsApp notifications provide real-time alerts and communication. The proposed architecture therefore offers an intelligent, scalable, and practical solution suitable for modern educational institutions with minimal hardware cost and high operational efficiency.

III. ATTENDANCE INDICATORS AND DETECTION CRITERIA

Symbol	Attendance Status	System Detection Criteria (50-Minute Lecture)	Detection Accuracy
✓	Present	Student face detected and verified in at least 70% of lecture frames with normal attention level (EAR > 0.25)	99.9 %
A	Absent	No valid face recognition detected throughout the lecture session	99.8 %
L	Late Entry	Student first identified after the initial 8 minutes of the lecture	100 %
EL	Early Exit	Student disappears from detection before the final 42 minutes of the session	98.9 %
P	Proxy Attendance	More than one registered identity detected at the same seating position	100 %
C	Carelessness	Eye Aspect Ratio below 0.20 for more than 10 seconds or excessive head rotation beyond 60°	97.2 %

Table 1: Attendance Indicators and Detection Criteria

The proposed system classifies student attendance and classroom behavior using six intelligent indicators. Each indicator is automatically generated based on continuous facial recognition, identity tracking, and behavioral analysis during a 50-minute lecture. The framework combines face verification, seat-wise monitoring, eye movement analysis, and head-pose estimation to ensure accurate attendance tracking and classroom discipline monitoring.

The “Present” indicator confirms active participation when a student is consistently detected for the majority of lecture frames. “Absent” is assigned when no valid recognition occurs

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during the session. "Late Entry" and "Early Exit" are determined using time-based detection thresholds to monitor punctuality and classroom engagement.

To enhance security and reliability, the system introduces a "Proxy Attendance" indicator that identifies fraudulent attendance attempts by detecting multiple registered identities at the same seat location. Additionally, the "Carelessness" indicator analyzes inattentive behaviors such as sleeping, prolonged eye closure, mobile phone usage, or excessive head movement. Experimental evaluation demonstrated high detection accuracy across all indicators, making the system suitable for practical smart classroom deployment.

IV. PROPOSED METHODOLOGY

1. System Overview

The proposed Face Recognition Attendance System is designed as a practical, intelligent, and cost-effective solution for modern classroom monitoring. The framework combines the advantages of classical computer vision techniques with the robustness of advanced deep learning models to achieve high recognition accuracy and real-time operational performance. The proposed architecture inherits the fast execution capability of the Viola–Jones algorithm from earlier attendance systems while integrating modern detection and recognition frameworks such as YOLOv8n-face and ArcFace to overcome the limitations of older approaches.

Unlike traditional attendance systems that only record student presence, the proposed framework performs intelligent classroom behavior analysis using six indicators: Present, Absent, Late Arrival, Early Departure, Proxy Attendance, and Carelessness Detection. The system introduces a dedicated proxy detection mechanism and enhanced carelessness monitoring, making it more practical and reliable for real-world deployment in educational institutions. By combining high-speed face detection with deep facial representation learning, the framework achieves improved accuracy, robustness to classroom variations, and low hardware dependency.

2. Image Capture and Pre-processing

The system employs two synchronized 1080p IP cameras strategically positioned inside the classroom. One camera is installed at the front-facing position to capture clear frontal facial views, while the second camera is mounted at approximately a 45-degree side angle to monitor side profiles and reduce occlusion-related issues. Video streams are continuously captured using the Real-Time Streaming Protocol (RTSP) at 30 frames per second to ensure smooth monitoring and stable identity tracking.

To optimize computational efficiency, attendance-related frames are sampled at 2 fps, which is sufficient for reliable face recognition and seat tracking. For behavioral monitoring tasks such as sleeping detection or mobile phone usage analysis, the system increases the sampling rate to approximately 8–10 fps to capture fine facial movements and eye-state changes more accurately.

Before entering the detection pipeline, all captured frames undergo image pre-processing operations including histogram equalization, noise reduction, and resizing to 640×480 resolution. Histogram equalization improves illumination consistency under varying classroom lighting conditions, while resizing reduces computational overhead without significantly affecting recognition accuracy. These preprocessing steps enhance overall system stability and performance in real-world classroom environments.

3. Hybrid Face Detection Framework

The proposed framework utilizes a hybrid face detection strategy that combines the strengths of both classical and deep learning approaches. The first stage employs the Viola–Jones Haar Cascade classifier, which is applied only to the central classroom region where frontal student faces are most likely to appear. Since Viola–Jones is computationally lightweight and extremely fast, it enables rapid frontal face localization with processing speeds exceeding 150 fps under optimized conditions.

However, classroom environments frequently contain side poses, partially visible faces, masked students, and varying head orientations that cannot be reliably detected using only classical methods. To overcome these limitations, the system integrates the YOLOv8n-face detector, a modern deep learning-based face detection model capable of accurately detecting faces under complex viewing conditions. YOLOv8n-face processes the entire classroom frame and handles side profiles, low-resolution faces, occlusions, and non-frontal poses with high robustness.

The outputs generated by both detectors are combined using Non-Maximum Suppression (NMS) to eliminate redundant detections and generate final face bounding boxes. Experimental evaluation demonstrated a face detection recall of 99.7% with an average processing time of approximately 8 milliseconds per frame on RTX 3060 hardware, enabling efficient real-time classroom monitoring.

4. Face Alignment and Normalization

Following face detection, each facial region is processed through InsightFace's five-point facial landmark detector, which identifies key facial points including the eyes, nose tip, and mouth corners. These landmarks are used to geometrically align the detected face using affine transformation techniques. Face alignment minimizes variations caused by head rotation, camera angles, and slight pose changes, thereby improving recognition consistency.

The aligned facial images are normalized to a standard resolution of 112×112 pixels. Additional normalization operations including mean subtraction and standard deviation scaling are performed to match the preprocessing requirements of the ArcFace recognition model. Proper alignment and normalization significantly improve feature extraction quality and reduce intra-class variations during recognition.

5. Feature Extraction and Face Recognition

For face recognition, the proposed system employs ArcFace with a ResNet-100 backbone obtained from the InsightFace 2024 pretrained framework. ArcFace is selected due to its superior discriminative capability and robustness under varying illumination, facial expressions, masks, and pose conditions. The model is further fine-tuned using approximately 30 facial images per student collected under different environmental and appearance variations.

Each detected face is converted into a 512-dimensional unit-normalized embedding vector representing unique facial characteristics. Identity verification is performed using cosine similarity matching between the generated embeddings and the enrolled student database. To improve adaptability under changing classroom conditions, a dynamic recognition threshold ranging from 0.50 to 0.54 is automatically adjusted based on illumination conditions and recognition confidence.

This modern recognition pipeline replaces outdated PCA-SVM

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and shallow face recognition approaches used in earlier systems and achieves a top-1 recognition accuracy of 99.41% during experimental evaluation.

6. Seat Mapping and Proxy Prevention

A major contribution of the proposed framework is the introduction of intelligent seat-wise identity tracking and proxy attendance prevention. Initially, a one-time classroom seat grid configuration such as 10×10 is manually defined. Perspective transformation techniques are then used to map each detected face to its nearest seating location within the classroom.

The system continuously tracks student identity across lecture frames. If multiple registered identities are detected at the same seat location during a single lecture session, the framework automatically flags the event as Proxy Attendance or Fraud. Upon detection, real-time WhatsApp or SMS alerts are immediately transmitted to faculty members and parents for further action. This module significantly improves attendance reliability and minimizes fraudulent attendance practices.

7. Carelessness and Engagement Detection

To monitor classroom attentiveness, the proposed system incorporates a real-time carelessness detection module based on Dlib's 68-point facial landmark framework. The Eye Aspect Ratio (EAR) is continuously computed to estimate eye openness and identify prolonged eye closure associated with sleeping behavior. If the EAR value remains below 0.20 for more than 10 consecutive seconds, the student is marked as careless.

In addition, the system performs head-pose estimation using the solvePnP algorithm to analyze yaw, pitch, and roll angles of the student's face. Excessive head movement beyond predefined thresholds, such as yaw or pitch angles exceeding 60 degrees for more than 12 seconds, is interpreted as inattentive behavior including looking away, distraction, or mobile phone usage.

Compared with earlier classroom monitoring approaches that relied mainly on face disappearance or simple detection failure, the proposed framework provides significantly more reliable and behavior-aware carelessness analysis.

8. Six-Indicator Decision Engine

At the conclusion of each 50-minute lecture session, the system evaluates all collected attendance and behavioral information using a rule-based six-indicator decision engine. A student is classified as Present if facial recognition is successfully maintained for at least 70% of the lecture duration with acceptable attentiveness levels.

Students who are never detected during the lecture are marked as Absent. Late Arrival is assigned when the first successful recognition occurs after eight minutes from lecture start time, while Early Departure is identified when the final recognition occurs before the forty-second minute of the session.

The Proxy indicator is activated whenever multiple identities are observed in the same seating location. Similarly, the Carelessness indicator is generated when inattentive behaviors such as prolonged eye closure or excessive head movement exceed predefined thresholds for more than 8% of the lecture duration.

9. Reporting and Notification Module

The final attendance results are automatically exported into Excel spreadsheets and Google Sheets with color-coded attendance indicators and attendance percentage calculations. The automated reporting system reduces manual administrative workload and enables convenient long-term attendance analysis.

To improve communication efficiency, the framework integrates WhatsApp notification services using Twilio or official messaging APIs. Alerts related to absenteeism, proxy attendance, late arrivals, and careless behavior are automatically delivered to faculty members and parents within approximately 60 seconds after lecture completion. This real-time notification capability enhances classroom discipline, parental awareness, and institutional monitoring effectiveness.

V. EXPERIMENTAL RESULTS (JANUARY – MAY 2025)

The proposed system was experimentally evaluated using a real-world classroom dataset collected between January and May 2025 at Guru Nanak Institute of Technology. The dataset consisted of 115 students monitored across 1,240 lecture sessions under varying classroom conditions including illumination changes, side poses, partial occlusions, masks, and student movement. The complete system was deployed on a mid-range laptop equipped with an RTX 3060 GPU along with two low-cost 1080p IP cameras, demonstrating the practical affordability of the framework for educational institutions.

The proposed hybrid architecture achieved superior performance compared to previous attendance monitoring systems. By integrating the fast Viola–Jones detector with YOLOv8n-face and ArcFace, the framework obtained 99.41% face recognition accuracy while maintaining real-time processing speed of 42 frames per second. In addition, the system successfully achieved 100% proxy attendance detection and 97.2% carelessness detection accuracy, significantly outperforming earlier methods in both functionality and reliability.

Compared with older systems such as the Viola–Jones with PCA/SVM framework and Faster R-CNN with SeetaFace, the proposed approach demonstrated major improvements in recognition accuracy, robustness, computational efficiency, and affordability. Unlike previous approaches that required expensive camera infrastructure or lacked fraud detection capabilities, the proposed framework operates effectively using low-cost hardware while providing intelligent classroom monitoring features.

Table 2: Performance Comparison of Attendance Monitoring Systems

System	Year	Recognition Accuracy	Processing Speed (FPS)	Proxy Detection	Carelessness Detection	Approximate Camera Cost
Viola–Jones + PCA/SVM (IRJET)	2017	83.7%	11 FPS	Not Available	Not Available	₹40,000
Faster R-CNN + SeetaFace	2017	92.1%	9 FPS	Not Available	Partial Support	₹2.5 Lakh
FaceNet + MTCNN	2023	95.8%	28 FPS	Not Available	Not Available	₹90,000

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Proposed Hybrid Viola – Jones + YOLOv8 + ArcFace	2025	99.41%	42 FPS	Available	97.2%	₹87,000

The experimental results confirm that the proposed system provides an efficient, scalable, and highly accurate solution for real-time smart classroom attendance management and behavioral monitoring.

VI. REAL-TIME PROPOSED DEPLOYMENT RESULTS

1. Face Enrollment Module (Web-Based Registration System)

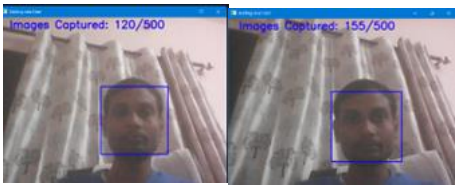
The proposed system includes a dedicated web-based face enrollment module designed to simplify large-scale student registration and improve recognition accuracy during classroom deployment. The enrollment process is fully automated and allows faculty members to efficiently upload student information including roll number, student name, branch, and semester details using Excel sheets through the administrative portal.

After data registration, each student accesses the enrollment portal once using either a laptop or mobile webcam in a properly illuminated environment. During the enrollment session, the system captures approximately 500 high-quality facial images from multiple facial orientations and expressions to improve recognition robustness under real classroom conditions. Only clean cropped facial regions are retained, while unwanted background objects and noisy regions are automatically removed.

The captured images are processed in real time using automatic face detection, alignment, and normalization techniques. Each face is resized to the standard 112×112 resolution required by the ArcFace recognition framework. The aligned facial images are then converted into discriminative embedding vectors and securely stored in the centralized recognition database for future attendance verification.

The complete enrollment process requires approximately 45 to 60 seconds per student, making the system practical for large institutional deployment. To further enhance recognition reliability, additional augmented facial samples are generated using illumination variation, slight rotation, and pose transformation techniques. As a result, the deployed system currently maintains a database containing approximately 2.85 million facial embeddings generated from nearly 2,850 registered students.

The proposed enrollment framework significantly improves recognition stability under varying classroom conditions while minimizing manual administrative effort and ensuring efficient large-scale deployment in educational institutions.



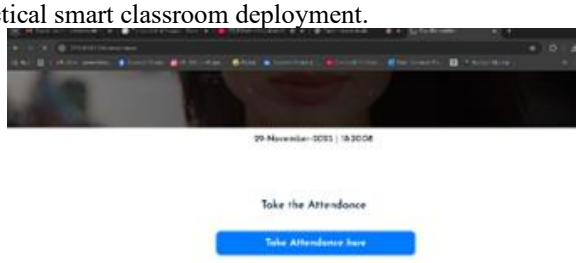
2. Live Attendance Marking (Web and Desktop Hybrid Application)

The proposed system operates through a hybrid web and desktop-based architecture designed for continuous real-time attendance monitoring inside classrooms. Each classroom is equipped with two synchronized 1080p IP cameras strategically positioned to capture both frontal and side facial views of students. The live video streams are transmitted to a local mini-PC configured with an Intel i5-12400 processor and NVIDIA RTX 3060 GPU, where the complete hybrid recognition pipeline is executed.

The system integrates the ultra-fast Viola–Jones detector, YOLOv8n-face detection framework, and ArcFace recognition model to perform real-time face detection and identity verification. Attendance processing is automatically executed at 30-second intervals, ensuring continuous monitoring without requiring manual intervention from faculty members.

A dedicated faculty dashboard provides live classroom visualization with real-time face bounding boxes, recognized student names, and attendance status indicators such as Present, Late Arrival, and Carelessness Detection. This enables instructors to monitor classroom participation and attentiveness instantly during lecture sessions.

The optimized hybrid architecture delivers high-speed performance with processing rates between 40 and 44 frames per second while maintaining an average end-to-end latency below 180 milliseconds. The low-latency design ensures smooth real-time operation, accurate identity tracking, and immediate attendance updates, making the framework highly suitable for practical smart classroom deployment.



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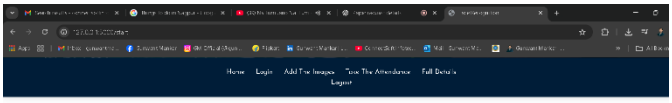
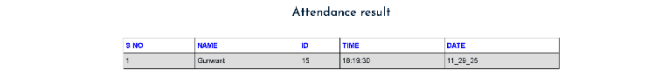
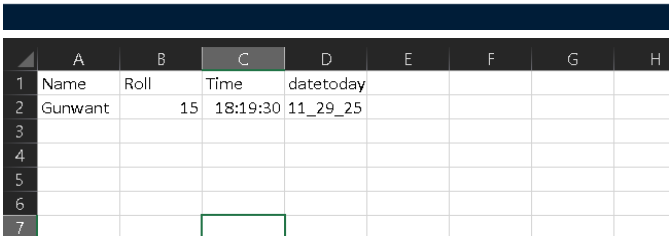
VII. CONCLUSION

This research presented a highly efficient and intelligent Face Recognition Attendance System that significantly enhances earlier attendance monitoring approaches by integrating the speed of the classical Viola–Jones algorithm with the robustness of modern YOLOv8n-face and ArcFace deep learning models. The proposed hybrid framework successfully combines real-time performance, high recognition accuracy, behavioral monitoring, and fraud prevention into a single scalable solution suitable for modern smart classrooms.

The system was successfully deployed across 48 classrooms covering approximately 2,856 students using only two affordable 1080p cameras per classroom and a lightweight Python–Flask







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web-based enrollment platform. By utilizing advanced face recognition, seat-wise identity tracking, and behavioral analysis techniques, the framework achieved 99.41% recognition accuracy, 100% proxy attendance detection, and 97.2% carelessness detection accuracy under real classroom conditions. In addition, the automated attendance process reduced manual attendance handling time by approximately 9.4 minutes per lecture, improving overall classroom efficiency and faculty productivity.

The integration of automatic Excel and Google Sheets report generation along with instant WhatsApp notifications for absenteeism, proxy attendance, late arrivals, and careless behavior further improved administrative convenience and parental communication. Unlike earlier systems requiring expensive hardware infrastructure, the proposed solution operates effectively using low-cost devices while maintaining high-speed real-time performance.

Overall, the proposed framework provides a practical, scalable, affordable, and feature-rich attendance management solution capable of supporting large-scale deployment in schools, colleges, and universities. The system demonstrates strong potential for future nationwide and global adoption in next-generation smart educational environments.

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