Smart Attendance System Using Face Recognition and Gaze-Based Attention Monitoring

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Abstract: *Manual attendance systems are widely used in educational institutions; however, they are time-consuming, error-prone, and vulnerable to proxy attendance. With increasing class sizes and the adoption of digital learning environments, there is a growing need for intelligent and automated attendance solutions. This paper presents a smart attendance System that automates face recognition and gaze-based attention monitoring to automatically mark attendance and assess student attentiveness in real world. "The system applies computer vision techniques with OpenCV for video handling, face recognition tools for identifying students, and Media Pipe Face Mesh for tracking gaze and estimating attention. Atten-dance data is recorded automatically with timestamps, and an automated Short Message Service (SMS) alert mechanism is implemented to notify parents of absent students. Testing shows that the system reaches about 94% recognition accuracy in regular classroom conditions, which helps reduce manual work and attendance fraud The system is cost-effective, scalable, and operates in real time using standard webcam hardware, making it suitable for development of modern educational institutions aiming to improve attendance management and classroom engagement.*

Keywords: *Face Recognition, Gaze Tracking, Smart At-tendance System, Computer Vision, OpenCV, Machine Learning.*

I.INTRODUCTION

Attendance is a critical factor in evaluating student participation, academic discipline, and overall performance in educational institutions. Most schools and colleges still rely on traditional attendance methods such as manual roll calls or sign-in sheets. These approaches are inefficient, consume valuable classroom time, and are susceptible to human errors and proxy attendance, where one student answers on behalf of another.

To solve these problems, different automated attendance methods have been introduced.Biometric methods such as fingerprint and RFID-based attendance systems offer partial automation but require physical contact or additional hardware. These systems may also face hygiene con-cerns, maintenance costs, and scalability issues, especially in large classrooms.

Recent advancements in computer vision and artificial intelligence have enabled face recognition systems capable of identifying individuals accurately without physical contact. Face recognition-based attendance systems sig-nificantly reduce time consumption and eliminate proxy attendance. However, most present running solutions focus only on identifying student presence and do not consider whether students are attentive during the session.

In both online and ofline learning environments, stu-dents may be physically present but mentally disengaged. Gaze tracking provides an effective solution by analyzing eye movement and head orientation to estimate attentive-ness. By integrating gaze-based attention monitoring with face recognition, attendance systems can be enhanced to track both presence and engagement.

This work describes a Smart Attendance System that combines real-time facial recognition with attention moni-toring based on gaze. The system automatically records at-tendance, computes attention scores, and sends SMS alerts to parents of absent students. The proposed approach improves reliability, reduces administrative workload, and enhances classroom monitoring.

II. LITERATURE SURVEY

Many studies have analyzed automated attendance sys-tems using different technologies. Kumar et al. developed an RFID-based system that reduces manual effort, but it remains vulnerable to proxy attendance because students can share RFID cards.Fingerprint-based authentication methods provide higher security, but their reliance on physical interaction and specialized equipment restricts their applicability in large-scale environments.

Face recognition-based attendance systems have gained highest reach due to their non-intrusive nature. S. Patel et al. utilized face recognition techniques to automate atten-dance marking with improved accuracy. Nonetheless, the system was designed exclusively for attendance monitoring and did not provide any functionality to evaluate student engagement

Eye-tracking techniques have traditionally been utilized in behavioral research and human–computer interaction. Lee et al. proposed an infrared sensor-based gaze track-ing approach that achieved high precision; nevertheless, the need for costly hardware and complex configuration restricts its adoption in classroom settings.

Recent research has explored webcam-based gaze esti-mation using facial landmarks, reducing hardware depen-dency. However, only a few studies attempt to integrate attendance tracking with attention monitoring. Existing systems either lack real-time performance or involve com-plex infrastructure.

From the literature, it is observed that existing systems either lack accuracy or fail to monitor student attentive-ness, which motivates the proposed system that combines both face recognition with gaze-based attention analysis using cost-effective tools.

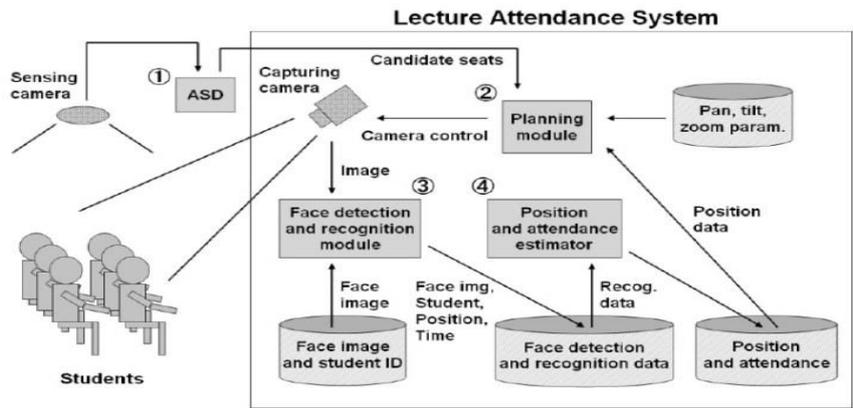## III. PROPOSED SYSTEM ARCHITECTURE

Fig. 1. Architecture of the Smart Attendance System

The proposed Smart Attendance System consists of four main modules: Face Recognition Module, Gaze Tracking Module, Attendance Management Module, and SMS Alert Module. A webcam is used to capture live video input from the classroom.

A. Face Recognition Module

Module is responsible for identifying students based on facial features. A dataset of student images is collected during registration. The system generates facial encodings from the captured images and stores them for training. In real-time sessions, the detected faces are matched with the trained data to recognize students

B. Gaze Tracking Module

The gaze tracking module estimates student atten-tiveness using facial landmarks.Eye and iris landmarks are detected using MediaPipe Face Mesh. The relative displacement of the iris from the screen center is examined to estimate an attention score that indicates student attentiveness.

C. Attendance Management Module

Once a student is recognized, attendance is automati-cally marked with a timestamp. Attention scores are also recorded.The recorded data is maintained in CSV format to support efficient storage, retrieval, and analytical pro-cessing.

D. SMS Alert Module

This module identifies absent students at the end of session and sends automated SMS alerts to parents using a cloud-based messaging service, ensuring timely communication.

IV. METHODOLOGY

The proposed Smart Attendance System follows a structured and sequential workflow to ensure accurate at-tendance marking and real-time attention monitoring.The methodology integrates face recognition and gaze-based attention estimation to automate the attendance process while minimizing manual intervention.

At the initial stage,the system initializes a webcam to acquire live video streams from the classroom.Each

incom-ing frame is analyzed in real time to identify human faces using computer vision methods. After detection, distinctive facial features are extracted and transformed into numer-ical representations referred to as facial encodings. These encodings are subsequently compared with a pre-trained database containing registered student facial information.

If a match is found between the detected face and the stored dataset, the corresponding student is identified and marked as present. Attendance is recorded automatically along with the current timestamp. Simultaneously, the system performs gaze tracking by detecting facial land-marks, particularly eye and iris points, using MediaPipe Face Mesh. An attention score is estimated by evaluating the position of the iris with respect to the screen center in order to determine the student's attentiveness.

The attendance information and attention scores are stored digitally for further analysisOnce the session is completed, unrecognized students are classified as absent, and automated SMS messages are transmitted to their parents via a cloud-based communication service This methodology ensures real-time operation, high accuracy, and reliability while eliminating proxy attendance and reducing administrative workload.
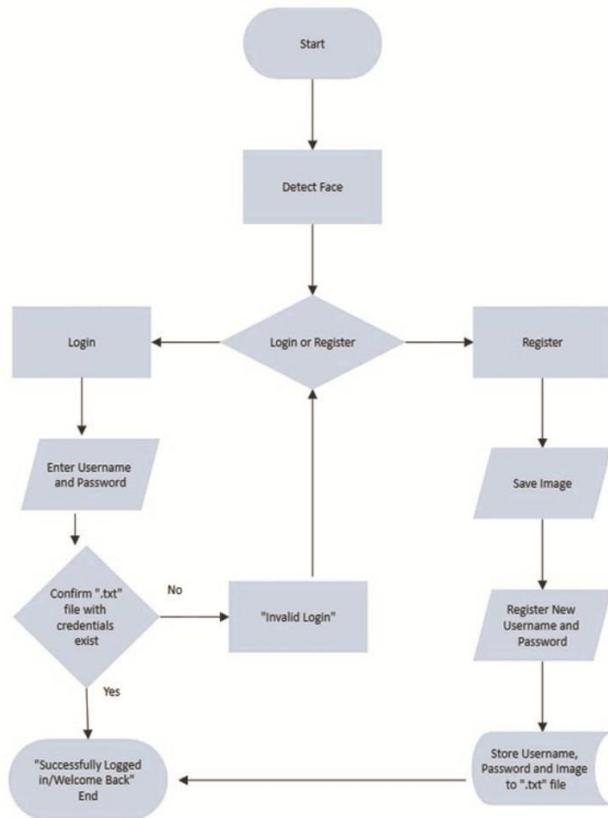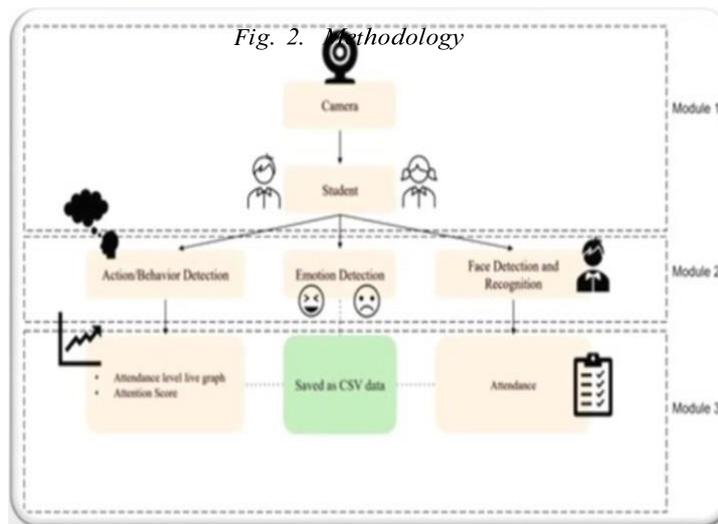

Fig. 2. Methodology

Fig. 3. Methodology

The methodology of the proposed Smart Attendance System is designed to ensure accurate, real-time atten-dance marking while simultaneously monitoring student attentiveness. The system is designed using a pipeline-based structure in which successive stages process the results of earlier stages, ensuring both efficiency and scalability.

A. Video Acquisition and Preprocessing

The process starts with initializing a webcam to acquire live video from the classroom environment. The continuous video stream is then segmented into individual frames, which are processed sequentially.Preprocessing techniques such as resizing and color space conversion are applied to reduce computational complexity and improve processing speed.This step ensures that the system can operate in real time without noticeable delay.

B. Face Detection

Each video frame is analyzed to detect human faces using computer vision-based face detection techniques. The system locates facial regions by identifying key facial patterns such as eyes, nose, and mouth. Only frames containing detectable faces are processed further, thereby reducing unnecessary computation.

C. Facial Feature Extraction and Recognition

Once a face is detected, distinctive facial features are extracted and encoded into a numerical representation known as a facial encoding. These encodings capture unique characteristics of a person's face and are invariant to minor changes in facial expression and lighting. The extracted encoding is then compared with the stored en-codings in the trained dataset using a similarity measure. If the similarity score between the detected face and a stored encoding is within a predefined threshold, the student is considered recognized. This approach effectively prevents proxy attendance and ensures reliable identifica-tion.

D. Attendance Marking

When a student is successfully recognized, their at-tendance is automatically marked as present.The system records the student's identity along with the current timestamp. To avoid duplicate entries, each student is marked only once per session.This automated process removes manual intervention and human error.

E. Gaze Tracking and Attention Estimation

In parallel with face recognition, the system performs gaze tracking to evaluate student attentiveness. Facial landmarks, particularly eye and iris points, are detected using MediaPipe Face Mesh.The position of the iris relative to the screen center is analyzed to determine the direction of gaze.

An attention score is computed based on the devi-ation of the gaze from the center.Scores closer to one indicate focused attention, while lower scores indicate distraction.This allows the system to differentiate between students who are only physically present and those who are genuinely attentive

F. Data Storage and Logging

The attendance status, timestamp, and attention score for each recognized student are stored in a digital format such as CSV files. This structured data storage enables easy retrieval, analysis, and integration with other aca-demic management systems.

G. Absentee Identification and Notification

At the end of the attendance session, the system compares the list of registered students with the list of recognized students. Those who were not recognize during the session are marked as absent.Automated SMS alerts are then sent to the parents of absent students using a cloud-based messaging service. This ensures timely communication and enhances accountability.

H. Real-Time Performance and Reliability

The entire methodology is optimized for real-time execution.LThe adoption of computationally efficient al-gorithms, optimized preprocessing, and selective frame processing ensures sustained accuracy during continuous system operation.The sequential workflow ensures robust-ness, scalability, and ease of deployment in real classroom environments.

Algorithm 1: Smart Attendance System
1) Capture live video using a webcam
2) Detect faces in each video frame
3) Extract facial encodings from detected faces
4) Match detected faces with trained dataset
5) Identify students and mark attendance

6) Detect facial landmarks for gaze estimation
7) Compute attention score based on gaze direction
8) Store attendance and attention data
9) Identify absent students
10) Send SMS alerts to parents

V. IMPLEMENTATION DETAILS

The system is implemented using Python. OpenCV is used for video capture and image processing. The Face Recognition library generates facial embeddings for identity matching. MediaPipe Face Mesh performs gaze tracking. A standard webcam is used for input, and Twilio API is used to send SMS alerts. The proposed Smart Attendance System is developed using the Python pro-gramming language because of its extensive collection of libraries that support computer vision, machine learning, and real-time data processing. Python provides flexibil-ity, rapid development, and cross-platform compatibility, making it suitable for deploying intelligent classroom applications.

A. Software Environment

The system utilizes OpenCV for video acquisition, frame preprocessing, and face detection. OpenCV enables real-time acquisition from the webcam and supplies efficient image processing routines, including resizing, color space conversion, and annotation of detected facial regions. Face detection is performed on each frame to locate facial regions before recognition.

The Face Recognition library is employed to generate high-dimensional facial embeddings. These embeddings represent unique facial features and are compared using distance-based similarity measures to identify students. The library provides robust performance against minor variations in lighting, pose, and facial expressions.

MediaPipe Face Mesh is used for gaze tracking and at-tention analysis. It detects 3D facial landmarks, including eye and iris points, which are essential for estimating gaze direction. By tracking the relative movement of the iris, the system determines whether a student is focused on the screen.

B. Dataset Creation and Training

In the dataset creation phase, multiple facial images of each student are acquired using a standard webcam and stored in a structured directory format, where each folder represents a specific student. Facial encodings are extracted from this dataset and preserved for later use in real-time recognition. The training process is performed once and applied to multiple sessions.

C. Real-Time Execution

During live operation, the webcam continuously cap-tures video frames. To maintain real-time performance, frames are processed efficiently by resizing and selective frame sampling. Face detection and recognition are ex-ecuted on detected facial regions only, reducing compu-tational overhead. Attendance is marked only once per student per session to prevent duplicate entries.

Gaze tracking is carried out in parallel with face recogni-tion, and attention scores are calculated dynamically and updated continuously during the session. This concurrent processing minimizes latency and enables smooth real-time operation.

D. Data Storage and Management

Attendance records, including student identity, times-tamp, and attention score, are stored in CSV files. This storage format is lightweight, portable, and easy to in-tegrate with other academic management systems. CSV files can also be converted to spreadsheets or databases for long-term storage and analysis.

E. SMS Alert Integration

The SMS notification system is implemented using the Twilio API. Parent contact details are stored securely and accessed only when absentee notifications are required. Once the session ends, the system identifies absent stu-dents and sends automated SMS alerts to their parents. This feature enhances communication and ensures timely awareness of student attendance.

F. Hardware Requirements

The system requires only a standard webcam and a computer with moderate processing capabilities. No specialized biometric sensors or eye-tracking hardware are needed, making the system cost-effective and scalable for educational institutions.

VI. EXPIREMENTAL RESULTS AND ANALYSIS

The proposed Smart Attendance System was experi-mentally tested in a classroom-like setting to assess

its ac-curacy, efficiency, and real-time performance. The experi-ments involved multiple participants and were carried out under normal indoor lighting conditions using a standard webcam. The evaluation concentrated on face recognition accuracy, gaze-based attention measurement, processing speed, and the reliability of attendance recording.
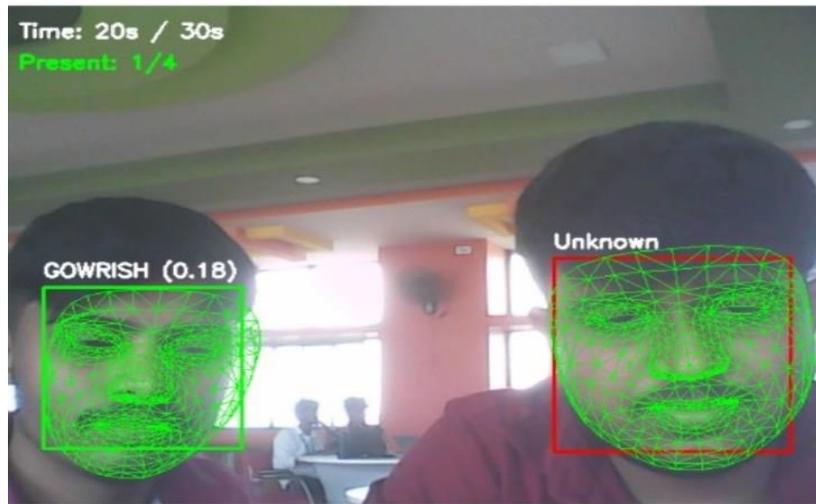
A. Output Screenshots

Fig. 4. Real-time face recognition and attendance marking

A. Face Recognition Performance

The face recognition module demonstrated reliable per-formance during real-time operation. Multiple images of each student were captured during dataset creation to improve robustness against variations in facial expressions, pose, and lighting. During testing, the system achieved an average recognition accuracy of approximately 94

Recognition errors were primarily observed when faces were partially occluded (e.g., masks or hands covering the face) or when students exhibited extreme head rotations. Despite these challenges, the system maintained stable performance in most classroom scenarios.
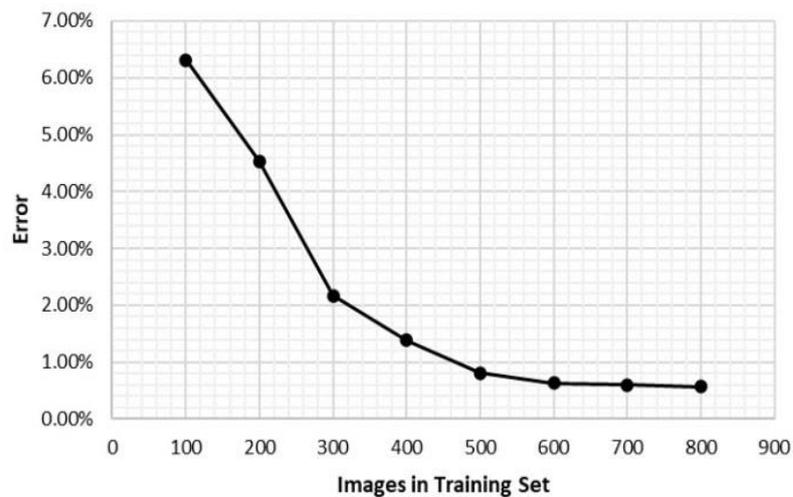
B. Face Recognition Results

Fig. 5. Face recognition accuracy under different conditions
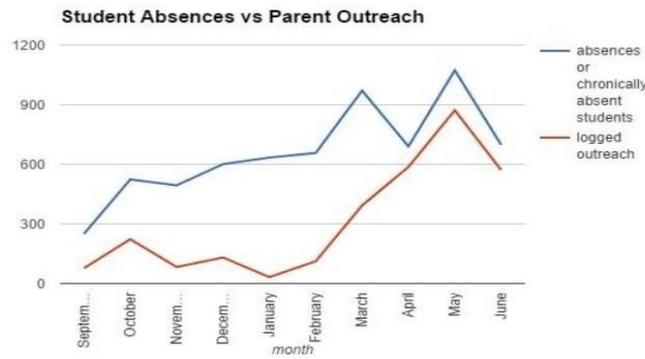
B. Gaze Tracking and Attention Analysis

Fig. 6. Attention score variation during live session

The gaze tracking module effectively distinguished be-tween attentive and inattentive students by analyzing eye and iris landmarks. Attention scores were computed based on gaze direction, where scores closer to one indicated focused attention. The system successfully detected dis-traction when students looked away from the screen for extended periods. This analysis adds an additional layer of insight beyond mere attendance marking.

C. Gaze-Based Attention Results
C. Real-Time Processing Performance

The system was designed to operate in real time without noticeable latency. Efficient frame preprocessing and selective face detection ensured smooth execution. The average processing speed was sufficient to handle live classroom sessions without frame drops, making the system suitable for continuous monitoring.

D. Attendance Accuracy and Notification Reliability

Attendance records were generated automatically with accurate timestamps. Duplicate entries were avoided by marking each student only once per session. Absentee identification was performed at the end of the session, and SMS alerts were successfully delivered to parents using the cloud-based messaging service. This confirms the reliability of the notification module.

D. Attendance and SMS Output
E. Attendance Output

The attendance output is automatically generated once the face recognition module successfully identifies students during the session. For each recognized student, the system records essential details such as student ID, name, date, time, and attendance status. To avoid duplicate entries, each student is marked only once per session.

The attendance data is stored in a CSV file, which ensures portability and easy integration with existing academic management systems. This digital record elim-inates manual errors and enables efficient attendance tracking and reporting. The generated attendance file can be opened using spreadsheet software or uploaded to institutional databases for further analysis.

TABLE I
Sample Attendance Record

Student ID	Name	Date	Time	Status
CS001	Student A	12-01-2026	10:02 AM	Present
CS002	Student B	12-01-2026	10:03 AM	Present
CS003	Student C	12-01-2026	–	Absent

This automated attendance output improves reliabil-ity, reduces administrative workload, and ensures trans-parency in attendance management.

F. SMS Alert Output

The SMS alert output is generated at the end of the attendance session after comparing the list of registered students with the list of recognized students. If a student is marked absent, an automatic SMS notification is sent to the respective parent or guardian using a cloud-based messaging service.

The SMS message includes concise information such as the student's name, attendance status, and session date, ensuring timely communication. This feature strengthens parent–institution interaction and promotes accountabil-ity.

Sample SMS Message:

"Dear Parent, your ward Student C was absent for the class conducted on 12-01-2026. – Smart Attendance System"

The SMS alert mechanism operates reliably in real time and eliminates the need for manual follow-up by faculty members
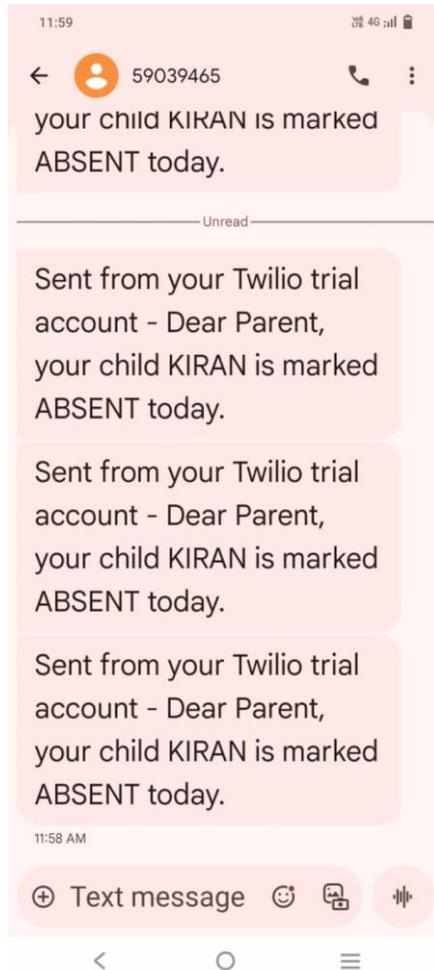

Fig. 7. Automated SMS alert sent to parents of absent student

Fig. 8. Automatically generated attendance log

TABLE II
Performance Evaluation of the Proposed System

Parameter	Result
Face Recognition Accuracy	94%
Average Processing Time	Real-time
Attendance Error Rate	< 3%
Gaze Tracking Accuracy	High
SMS Delivery Success Rate	100%

TABLE III
Face Recognition Accuracy Under Different Conditions

Condition	Recognition Accuracy
Normal Lighting	94%
Low Lighting	89%
Partial Occlusion	86%
Extreme Head Pose	84%

TABLE IV
Interpretation of Attention Scores

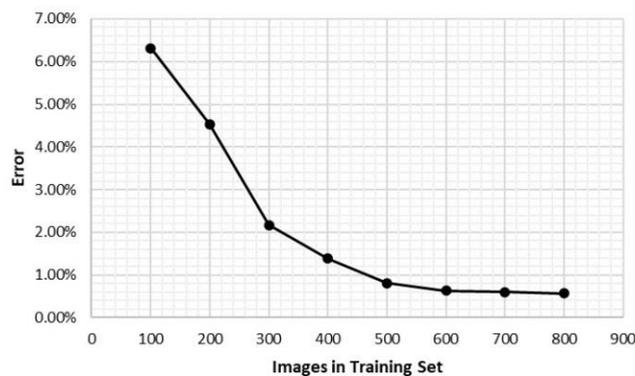| Attention Score Range	Interpretation
0.80 − 1.00	Highly Attentive
0.50 − 0.79	Moderately Attentive
0.00 − 0.49	Inattentive

Fig. 9. Face Recognition Accuracy

The proposed system achieved an average face recog-nition accuracy of 94% under normal classroom lighting. The system operates in real time with minimal delay.

TABLE V
Performance Evaluation

Parameter	Result
Face Recognition Accuracy	94%
Processing Time	Real-time
Attendance Error	< 3%

VII.ADVANTAGES AND APPLICATIONS

A. Advantages
• Eliminates proxy attendance
• Saves time
• Real-time monitoring
• Automatic alerts

Elimination of Proxy Attendance The use of face recog-nition ensures that attendance is marked only when the actual student is physically present. This completely eliminates proxy attendance, which is a major

drawback of manual, RFID-based, and card-based attendance systems. Non-Intrusive and Contactless Operation

In contrast to fingerprint or other biometric systems that require physical interaction, the proposed system functions in a completely contactless manner. This improves hygiene, enhances user comfort, and makes the system suitable for post-pandemic and large-scale classroom environments.

Real-Time Monitoring The system processes video frames in real time, allowing instant detection and recog-nition of students. Attendance marking and attention analysis occur without interrupting classroom activities, ensuring smooth and uninterrupted teaching sessions.

Automatic Parent Alerts The integration of an SMS alert mechanism enables automatic notification to parents of absent students. This feature improves communication between institutions and parents and helps in monitoring student attendance more effectively.

Reduced Manual Workload By automating attendance marking and record maintenance, the system significantly reduces the administrative burden on teachers and staff. This allows educators to focus more on teaching rather than administrative tasks.

Cost-Effective and Scalable Solution The system re-quires only a standard webcam and a computer, elim-inating the need for expensive biometric hardware or infrared eye-tracking devices. Its software-based design makes it easily scalable to classrooms of different sizes and institutions with limited resources.

B. Applications

Schools, colleges, online learning platforms, corporate training programs, and smart classrooms.

1. Schools and Colleges The system can be deployed in classrooms to automate daily attendance and monitor student atten-tiveness, improving academic discipline and engagement.
2. Online Learning Platforms In virtual classrooms, the system can be integrated with live video sessions to verify student presence and attention, ensuring genuine participation during online lectures.
3. Corporate Training Programs Organizations can use the system to track employee attendance and engagement during training sessions, workshops, and certification pro-grams.
4. Examination Halls The system can assist in verifying candidate identity during examinations, preventing imper-sonation and ensuring examination integrity.
5. Smart Classrooms As part of smart classroom infras-tructure, the system can be combined with other intel-ligent tools such as learning analytics and performance monitoring systems to enhance the overall teaching– learning experience.

VIII. CONCLUSION AND FUTURE WORK

The Smart Attendance System effectively combines face recognition with gaze-based attention monitoring to automate attendance and strengthen classroom supervi-sion. The proposed approach minimizes manual effort and provides enhanced analysis of student engagement. employing computer vision techniques, the system identi-fies students accurately in real time without the need for physical interaction, thereby preventing proxy attendance and reducing administrative workload. Furthermore, the incorporation of gaze-based attention analysis extends traditional attendance tracking by offering meaningful in-sights into student engagement during classroom sessions. The proposed system was implemented using cost-effective and widely available tools such as OpenCV, the Face Recognition library, and MediaPipe Face Mesh. Experimental evaluation in a classroom-like environment demonstrated reliable real-time performance, with an average face recognition accuracy of approximately 94% under normal lighting conditions. The system efficiently processed live video streams without noticeable delay and successfully generated attendance records and automated SMS notifications for absent students.

Overall, the results confirm that the proposed approach is practical, scalable, and suitable for deployment in modern educational institutions. The system contributes to the development of smart classrooms by combining at-tendance automation with attention monitoring, thereby improving academic accountability and enhancing the teaching–learning experience.

Future work includes cloud database integration, mobile application development, emotion detection, and multi-camera support. Although the proposed system demon-strates promising performance, several enhancements can be explored to further improve its capabilities. One poten-tial extension is the integration of a cloud-based database to enable centralized storage, secure access, and long-term analysis of attendance and attention data across multiple classrooms and institutions.

Future versions of the system may also include a mo-bile application interface for teachers and administrators, allowing real-time access to attendance reports and atten-tion analytics. Additionally, emotion detection techniques can be incorporated to provide deeper behavioral analysis by identifying emotional states such as confusion, interest, or fatigue.

Support for multiple cameras can be introduced to cover larger classrooms and reduce occlusion-related errors. Furthermore, deep learning-based attention estimation models may be employed to improve robustness and accuracy under challenging conditions such as low lighting or complex head movements. These enhancements will further strengthen the system's effectiveness and broaden its applicability in diverse educational environments.

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