

AI Smart Attendance System Using Face Recognition

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Abstract- Attendance is an essential academic activity, but conventional roll calls and manual records consume classroom time and may introduce recording errors and opportunities for proxy attendance. This paper presents an AI Smart Attendance System using face recognition that automates attendance through real-time camera processing and timetable-based validation. The implemented prototype is developed using Python and Streamlit with OpenCV, the face_recognition library, WebRTC camera streaming, SQLite, Pandas and Matplotlib. The system provides administrator and student authentication, student registration, section management, timetable checking, face-based attendance, multi-frame confirmation, duplicate-attendance prevention, security logging, attendance filtering, analytics and CSV reporting. The face verification workflow is configured to require multiple confirming frames before an attendance record is created. The proposed enhanced architecture extends the prototype with mobile access, GPS/geofencing, separate subject-teacher accounts and an HOD dashboard. Under this architecture, attendance is accepted only when the student's identity, scheduled subject and permitted location satisfy the configured rules. Teachers can monitor attendance for their assigned subjects, while the HOD can obtain department-level visibility across teachers, subjects, sections and students. The paper describes the system architecture, methodology, database design, security controls, implementation status and planned enhancements. Rather than claiming unmeasured accuracy or deployment results, the study identifies the measurable evaluation parameters required for future experimental validation.

Keywords - Artificial Intelligence, Face Recognition, Smart Attendance, Timetable Validation, WebRTC, SQLite, GPS Geofencing, Role-Based Access Control.

I. INTRODUCTION

Attendance management is a routine but important part of academic administration. In a conventional classroom, the teacher may record attendance by calling student names, passing a register, or using a manual signature process. These methods require

repeated human effort and can make it difficult to maintain consistent, searchable records. They can also permit proxy attendance when one student responds or signs on behalf of another. Automated biometric attendance provides an opportunity to reduce these limitations by linking an attendance event to an identifiable student.

Face recognition is particularly suitable for this purpose because it is contactless and can operate through an ordinary camera. A practical attendance system, however, must do more than recognize a face. It must determine whether the recognized student is attending the correct class, whether an attendance record already exists, and whether the event should be accepted by the institution's rules. The supplied implementation addresses these operational requirements through student and administrator login, timetable validation, camera-based recognition, duplicate checking, security logging and attendance analytics. The implementation uses Python, Streamlit, OpenCV, face_recognition, WebRTC, NumPy, Pandas, SQLite and Matplotlib.

The enhanced system proposed in this paper introduces an additional institutional structure. Students use restricted accounts and submit only their own attendance. Subject teachers receive separate accounts with access limited to their assigned subjects and sections. An HOD account provides department-level monitoring. GPS or geofencing is proposed as a second identity-context check so that attendance can be accepted only from an approved college or classroom area. These enhanced modules are presented as proposed extensions rather than as features already implemented in the supplied prototype.

II. PROBLEM STATEMENT AND OBJECTIVES

The system addresses the following problems:

- Time consumed by manual attendance recording.
- Possibility of proxy or impersonated attendance.
- Difficulty in connecting an attendance record to the correct subject and period.
- Limited visibility of attendance records for different institutional roles.
- Repeated manual preparation of attendance summaries and reports.
- The principal objectives are:
- Automate attendance using real-time face recognition.
- Verify the active timetable period before attendance is accepted.
- Restrict students to their own attendance workflow.
- Prevent duplicate attendance records.
- Maintain searchable records, analytics and security logs.
- Extend the system with GPS verification and role-based teacher/HOD dashboards.

III. LITERATURE SURVEY

Automated attendance has been studied using RFID, fingerprint, iris, NFC and face recognition. RFID and NFC systems can simplify identification but depend on physical cards or tags, which may be transferred between students. Fingerprint systems provide biometric identification but require physical contact with a sensor. Iris systems can provide strong biometric discrimination but generally require specialized acquisition hardware. Face recognition offers a contactless alternative and can be performed through cameras already available in many classrooms.

Classical computer-vision approaches include the Viola-Jones object detection framework for rapid face detection and Local Binary Pattern Histogram (LBPH) methods for face description and recognition. [2], [3] More recent approaches use learned facial embeddings and deep neural networks. FaceNet, for example, maps faces into an embedding space in which distance can be used for identity comparison. [4] The choice of recognition method depends on accuracy, computational resources, data quality, illumination, pose and deployment requirements.

The proposed project follows a practical implementation path rather than claiming that one algorithm is universally optimal. The supplied code uses OpenCV and the face_recognition library and performs recognition from a live WebRTC camera stream. The attendance decision is additionally constrained by timetable information and duplicate-record checks. This combination shifts the focus from face recognition alone to an attendance transaction containing identity, subject, period, date, time and evidence.

IV. PROPOSED SYSTEM

The proposed system contains five logical layers: user/client layer, identity and context verification layer, attendance engine, role-based dashboards, and database and reporting layer. In the current prototype, the client and attendance engine are implemented through Streamlit. The camera is accessed through WebRTC, facial processing is performed using OpenCV and face_recognition, and persistent data are maintained using SQLite. The enhanced architecture adds mobile access, GPS verification and separate teacher/HOD authorization.

A. Complete Attendance Ecosystem

The final design is organized around one attendance rule shared by every client: the student may mark attendance only for the student's own account and only for the subject and period permitted by the academic timetable. The website and mobile application are two access channels to the same attendance service. This keeps the system consistent even when a student changes devices.

B. Student Website and Mobile Access

Students can log in through the college website using a browser-enabled camera. The proposed mobile application provides the same attendance workflow on a phone. After login, the student sees the subjects associated with the student's section, selects the currently scheduled subject and starts attendance. The interface does not allow the student to select an unrelated subject or edit an existing attendance record.

C. Subject-Level Attendance

Every attendance transaction is subject-specific. The backend links Student → Section → Subject → Period → Date → Time. When teacher assignment is enabled, Teacher is also linked to the transaction. This structure allows a student to attend one subject

without accidentally creating attendance in another subject and allows reports to be generated independently for every subject.

D. Institutional Roles

The enhanced platform contains Student, Subject Teacher, HOD and Administrator roles. Students submit their own attendance. Subject teachers see only the subjects and sections assigned to them. The HOD can monitor all teachers, subjects, sections and students in the department. The Administrator manages registration, timetable, system configuration, security information and controlled attendance administration.

E. Location and Session Security

GPS/geofencing is an additional validation layer for the mobile and location-aware web workflow. A configurable college or classroom zone can be checked before face verification is completed. A short-lived QR token can optionally be used to launch the active attendance session, but the QR code does not replace face verification. This keeps the QR mechanism as a session-control feature rather than a transferable attendance credential.

V. METHODOLOGY

A. Student Registration

The registration phase creates the identity record required for later recognition. Student information such as name, roll number, class and section is stored in the database, while facial information is associated with the student. The administrator interface in the current implementation provides student registration and editing functions. The registration data form the reference set against which the live camera input is evaluated.

B. Attendance Processing

When a student enters the attendance workflow, the application checks the current section and timetable. If a valid period is available, the camera interface is activated. Frames from the live stream are processed for face detection and recognition. The current configuration requires five confirmation frames within an eight-second confirmation window before a recognition event is treated as sufficiently consistent for attendance processing. A duplicate check prevents

the same student from being recorded repeatedly for the same attendance context.

C. Timetable Validation

Timetable validation connects attendance to an academic period rather than treating attendance as an unrestricted transaction. The current implementation contains teaching periods and break periods and maps subjects to sections and weekdays. This mechanism is important because a valid face match alone should not automatically create attendance for an arbitrary subject or time.

D. GPS / Geofencing Extension

GPS verification is a future enhancement and is not required in the current website-based workflow. The application obtains the device location and compares it with an approved campus or classroom geofence. If location permission is denied, location data are unavailable, or the device is outside the configured area, the attendance request is rejected. If the location is valid, the request proceeds to face verification and timetable validation. The supplied prototype does not currently implement this GPS layer; it is an enhancement for the next version.

E. Role-Based Access

The current prototype provides administrator and student login types. The enhanced architecture adds two institutional roles. A subject teacher can view attendance only for assigned subjects and sections and can generate subject-specific reports. The HOD can monitor teachers, subjects, sections and student attendance across the department. This separation reduces unnecessary access to attendance records and establishes clearer responsibility for attendance management.

F. Subject-Wise Website Attendance

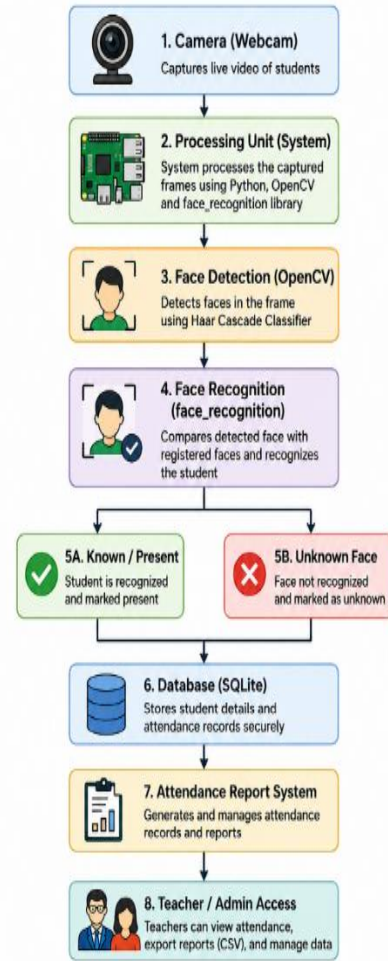
Attendance is subject-specific in the enhanced design. A student can log in through the institutional website or through the proposed mobile application. After authentication, the system displays the subjects available for the student's section and the active timetable context. The student selects the current subject and starts the attendance workflow.

The same rules are applied to both clients: student identity is verified by face recognition, the active period and subject are checked against the timetable, and duplicate attendance is rejected. The mobile phone camera can be used directly through the website; GPS/geofencing remains a future enhancement. The resulting record is associated with Student + Section + Subject + Period + Date + Time and, where enabled, Face Verification + Location Verification.

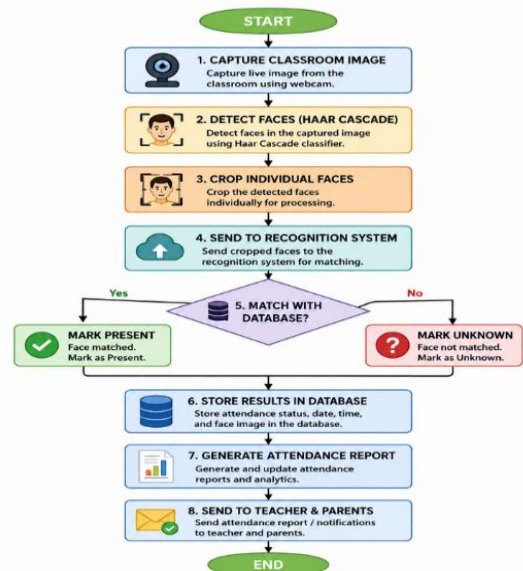
The subject teacher receives a restricted dashboard for the assigned subject and section. The HOD receives department-level visibility. Students cannot edit stored attendance or submit attendance on behalf of another student. The website remains available as an alternative when a native mobile application is not installed.

After The proposed system presents an intelligent and automated attendance management solution using face recognition technology integrated with cloud computing and embedded systems. Based on an extensive literature survey, existing systems were analyzed to identify limitations such as low accuracy, high manual effort, and lack of real-time monitoring. To overcome these issues, an efficient and scalable approach is designed using a combination of image processing, machine learning, and cloud-based services. The system is implemented using a Raspberry Pi 3B+ integrated with a high-resolution webcam, which captures real-time classroom images. The face detection process is performed using the ViolaJones algorithm (Haar Cascade Classifier), which efficiently detects human faces from the captured image. Once faces are detected, the recognition process is carried out using Local Binary Pattern Histogram (LBPH) along with Convolutional Neural Network (CNN)-based cloud recognition through AWS Rekognition for higher accuracy. The methodology is divided into two main phases: Student Registration and Attendance Processing.

A. System Architecture Diagram



B. System Flowchart



C. *Student Registration Process*

The registration process is essential for building the facial database of students. Initially, student details such as name, ID, and class are collected. The system captures multiple images of each student using the camera module. These images are then uploaded to Amazon S3 along with metadata. An AWS Lambda function is automatically triggered upon image upload, which processes the image, extracts facial features, and generates a unique face print. This face print is a mathematical representation of the student's face and is stored in Amazon DynamoDB along with the corresponding student information. This ensures quick and efficient retrieval during attendance marking.

D. *Attendance Processing*

The attendance process begins with capturing a real-time image of the classroom. The system detects all faces present in the image and crops them individually for further processing. These cropped images are sent to AWS Rekognition, which analyzes facial features using deep learning models and compares them with stored face prints in the database. If a match is found, the student is marked as present; otherwise, the face is labeled as unknown. The system automatically generates a list of present and absent students. Teachers are given the option to manually verify and correct attendance records if necessary. The final attendance data is stored securely in the cloud database.

E. *Hardware Requirements*

The system requires minimal and cost-effective hardware components, including:

- Raspberry Pi 3B+sentence.
- Logitech C270 Webcam (8MP)
- Power Supply
- 16GB Micro SD Card
- Monitor (Screen)
- Keyboard and Mouse
- HDMI Cable

F. *Cloud Integration (AWS Services)*

The system leverages multiple AWS services for efficient operation:

- Amazon S3 for image storage
- AWS Rekognition for facial recognition
- AWS Lambda for automated processing
- DynamoDB for storing face prints and student data

This cloud-based architecture ensures scalability, high accuracy, and real-time processing capabilities.

G. *Parent Access and Monitoring Feature (NEW ADDITION)*

A key enhancement of the proposed system is the integration of a Parent Access Module, which improves transparency and student monitoring. In this feature, parents are provided with secure access (via mobile app or web portal) to view their child's attendance records in real time. The system automatically sends notifications to parents regarding their child's attendance status, including daily presence, absence alerts, and overall attendance percentage. This allows parents to track academic participation and take necessary actions in case of irregular attendance. Additionally, periodic reports can be generated and shared with parents via email or mobile notifications, enhancing communication between educational institutions and families.

VI. SOFTWARE IMPLEMENTATION

The prototype is implemented as a Python Streamlit application. OpenCV is used for image-processing operations, while the face_recognition library provides face encoding and comparison functionality. WebRTC provides live browser-based camera streaming from the laptop or mobile device. NumPy supports numerical operations, Pandas supports data handling and reporting, Matplotlib supports analytics visualization, and SQLite provides persistent storage.

- a) Python – application development and control logic.
- b) Streamlit – user interface and dashboard layer.
- c) OpenCV – camera/image processing.
- d) face_recognition – facial encoding and recognition.
- e) WebRTC – live browser camera stream.
- f) SQLite – local relational database.
- g) Pandas – attendance filtering and report generation.
- h) Matplotlib – attendance analytics and visualization.

VII. DATABASE DESIGN AND SECURITY

The current database contains tables for users, students, attendance, security logs and administrator face information. Attendance records contain identity

and academic-context fields such as student name, roll number, class, section, subject, period, date, time and image path. The security-log structure records timestamp, event, roll, section, IP and details. These records provide an audit trail for important system events.

For the enhanced system, the data model should be extended with teacher accounts, HOD accounts, subject-teacher assignments, geofence configuration and location-verification fields. A normalized attendance record can therefore be represented conceptually as: Student + Section + Subject + Teacher + Period + Date + Time + Face Verification + Location Verification. Sensitive biometric and location information should be protected through appropriate access controls, retention rules and secure transmission/storage mechanisms during real deployment.

VIII. ROLE-BASED WORKFLOW

Student: logs in, checks the active subject/period, permits location access, performs face verification and receives attendance confirmation.

Subject Teacher: logs in to the assigned subject account, views present/absent students, filters records by date/period/section and generates reports.

HOD: views department-level attendance across teachers, subjects, sections and students and reviews analytics and audit information.

Administrator: registers students, manages timetable and records, reviews attendance, analytics and security logs.

IX. SECURITY AND ANTI-PROXY MEASURES

The system combines several controls rather than relying on face recognition alone. Face verification links an event to the registered student identity. Timetable checking links the event to an active academic period. Multiple-frame confirmation reduces acceptance based on a single unstable frame, while duplicate checking prevents repeated records. Security logs capture important events such as failed login attempts. In the enhanced design, GPS/geofencing adds a location constraint. Together, these controls are intended to make unauthorized

attendance more difficult, although no biometric system can guarantee complete elimination of spoofing without dedicated liveness and anti-spoofing mechanisms.

X. RESULT AND DISCUSSION

The developed system provides a user-friendly graphical interface using Streamlit, allowing users to efficiently manage attendance through face recognition. The system mainly consists of three modules: student registration, attendance marking, and attendance viewing. In the student registration module, users are required to enter the student's name and roll number and upload a face image. Once the register button is clicked, the image is stored in the dataset folder and the details are saved in the SQLite database. The registered students are displayed in a gallery format with their images resized to a uniform size, ensuring consistency for face recognition. Each student is also provided with a remove option, which allows deletion of both the database record and the corresponding image from the dataset. Additionally, a retrieve student feature is implemented where users can search for a student using their roll number and view their details along with the stored image. This functionality is illustrated in Fig.1, which shows the dataset of registered students and the interface for managing them

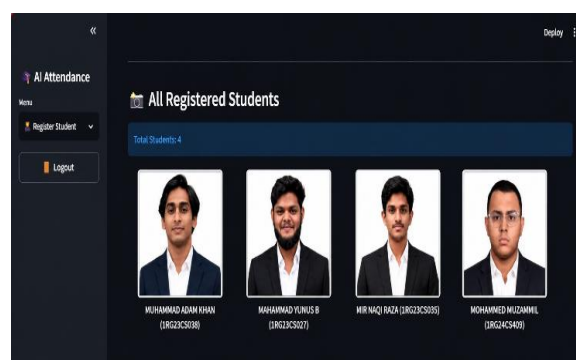


Fig.1. Registered Students Dataset and Gallery View

During the attendance process, the user selects the take attendance option and activates the webcam by clicking the start camera checkbox. The system captures live video frames and detects faces in real-time using the face_recognition library. The detected faces are encoded and compared with the stored dataset images. If a match is found, the system

identifies the student and displays their name on the video frame. If the face is not registered, it remains unrecognized. Once a student is identified, their attendance is automatically recorded along with the current date and time. The system ensures that attendance is marked only once per day for each student, preventing duplicate entries. The real-time face detection and recognition process is shown in Fig.2, where recognized students are highlighted on the screen.

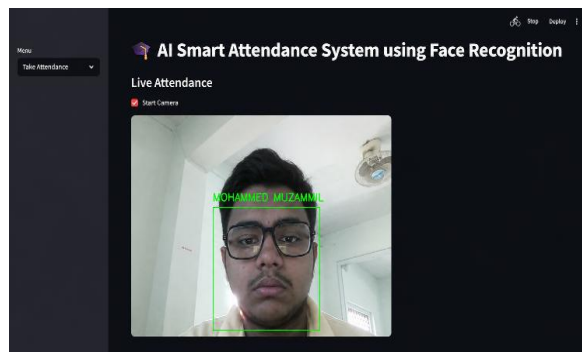


Fig.2. Live Face Recognition for Attendance Marking

The attendance records are stored in the database and can be accessed through the view attendance module. The records are displayed in a structured tabular format containing details such as student name, roll number, date, and time. This allows easy tracking and verification of attendance data. Furthermore, the system provides an option to download the attendance records in CSV format for external use such as reporting or analysis. The attendance table displayed in the interface is shown in Fig.3, which represents the successfully recorded attendance data after the recognition process.

id	name	roll	date	time	image_path
16	MUHAMMAD ADAM KHAN	IRG24CS008	2026-08-22	13:16:13	None
15	MOHAMMED MUZAMMIL	IRG24CS409	2026-08-22	13:14:57	None
14	MANISH GOMBA	IRG24CS030	2026-08-20	11:07:01	None
13	MUHAMMAD YUNUS B	IRG24CS027	2026-08-22	10:49:36	None
12	MUHAMMAD ADAM KHAN	IRG24CS008	2026-08-20	10:38:45	None
11	MIR NAQI RAZA	IRG24CS035	2026-08-20	10:36:42	None
10	MOHAMMED MUZAMMIL	IRG24CS409	2026-08-20	10:36:53	None
9	MUHAMMAD YUNUS B	IRG24CS027	2026-04-10	10:46:57	None
8	MUHAMMAD ADAM KHAN	IRG24CS008	2026-04-10	10:46:47	None
7	MIR NAQI RAZA	IRG24CS035	2026-04-07	09:27:32	None

Fig.3. Attendance Records Displayed in Tabular Format

Overall, the system demonstrates an effective implementation of face recognition technology for automated attendance management. It eliminates the need for manual attendance marking and reduces the chances of proxy attendance. The system is efficient, easy to use, and capable of handling student data effectively. However, its performance depends on factors such as lighting conditions, camera quality, and the availability of clear facial images. Despite these limitations, the system provides a reliable and accurate solution for modern attendance management.

XI. ADVANTAGES

Contactless attendance using the built-in laptop or mobile-phone camera.

Reduced dependence on manual roll calls.

Timetable-based subject and period control.

Multiple-frame confirmation and duplicate prevention.

Searchable attendance records and analytics.

Security logging for important events.

Usable on laptops and mobile phones without requiring a CCTV camera.

XII. LIMITATIONS

Recognition performance may vary with lighting, pose, camera quality and image conditions.

The supplied implementation is a Streamlit/web prototype accessed through a laptop or mobile

browser; a native Android application is not required for the current workflow.

GPS/geofencing is an optional future enhancement and is not implemented in the supplied code.

Separate subject-teacher and HOD roles are proposed extensions; the current login model supports administrator and student roles.

Dedicated liveness/anti-spoofing and large-scale deployment evaluation require further development and testing.

XIII. FUTURE ENHANCEMENT

Future work will focus on converting the student attendance workflow into a mobile application, adding GPS/geofencing, implementing teacher-subject authorization, and introducing an HOD dashboard. The database can be extended for teacher assignments and location audit information. Liveness detection can be incorporated to strengthen protection against presentation attacks. Additional work may investigate cloud deployment, secure remote storage, institutional ERP integration, parent/guardian access, automated notifications and longitudinal attendance analytics. These extensions should be evaluated experimentally before being presented as measured performance improvements.

XIV. CONCLUSION

This paper presents an AI Smart Attendance System using face recognition to automate classroom attendance through a website accessible on a laptop or mobile phone. The implemented prototype uses Python, Streamlit, OpenCV, face_recognition, WebRTC, and SQLite to support student registration, timetable-controlled subject attendance, live camera-based face verification, multi-frame confirmation, duplicate prevention, security logging, attendance records, analytics, and reporting. A student authenticates through the website, the system identifies the student's class and section, verifies the current day, period, and scheduled subject, and activates the built-in laptop or mobile-phone camera. The captured face is compared with the registered face encoding, and multiple frames are confirmed before attendance is accepted. The system then checks for duplicate attendance and records the

student identity, section, subject, period, date, time, and supporting evidence. The student receives an attendance confirmation or rejection message, while authorized administrators can review attendance and security events. As future enhancements, the system can include GPS/geofencing, subject-teacher access, and HOD-level monitoring. The proposed extensions provide a path toward a more complete institutional attendance platform, while future experimental evaluation can measure recognition performance, processing time, usability, and security under real classroom conditions.

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