EduSmart: A Smart Attendance Monitoring System Using Facial Recognition and Geolocation-Based Verification

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***Abstract*—Attendance management is a academically mandatory process in many educational colleges, but techniques such as manual roll calls and paper registers remain inefficient and susceptible to manipulation. Proxy attendance, unauthorized attendance marking continue to be major concerns in large classrooms. Although biometric systems such as fingerprint scanners help reduce impersonation, they require physical contact and cannot ensure that students remain present throughout the entire session. Facial recognition offers a contactless alternative, but without location verification and may still be misuse if students are not present in the classroom. This paper proposes EduSmart, a smart attendance monitoring system that combines AI-based facial recognition with GPS-enabled geofencing. EduSmart records the attendance only when a student is identified successfully and verified to be inside the assigned classroom boundary. Additionally, the system supports randomized location re-verification during the session to reduce the "mark-and-leave" problem where students leave after marking attendance. A role-based access system for students, faculty, and administrators, allowing centralized attendance management, real time monitoring analytics, and transparent reporting. Experimental result shows improved attendance accuracy, reduced fraud attempts, and reduced time overhead compared to traditional methods. EduSmart contributes to smart classroom automation by offering a scalable, reliable, secure approach to monitor attendance.**

***Index Terms*—Smart Attendance, Facial Recognition, GPS Verification, Geofencing, Computer Vision, Anti-Proxy System, EduSmart.**

I. INTRODUCTION

Attendance monitoring is one of the most frequent administrative tasks in educational establishments. It directly shows results in academic eligibility, discipline monitoring, scholarships and student's overall performance evaluation. Despite this importance, many colleges still use traditional attendance tracking methods such as paper-based marking and roll calls. These approaches are very slow and can waste a lot of time in classroom, especially for large groups. In addition, manual systems are easily manipulated such as proxy attendance, marking error, or intentional misreporting.

To address these problems, organizations adopted technology-based attendance marking like RFID cards and fingerprint-based biometrics. RFID systems help seed up the process but still allow identity spoofing if students swap cards. Fingerprint systems offer strong authentication but require physical contact with scanners, which can create delays in large classroom and raise hygiene concerns. Moreover, fingerprint attendance cannot confirm whether the student actually stays inside the classroom after marking attendance.

In recent years, Artificial Intelligence (AI) and Computer Vision have greatly enhanced accuracy of facial detection and recognition systems. Facial recognition offers a contactless and automated way for attendance. However, face recognition cannot solely rely on physical presence because there is a possibility that student might remotely attempt attendance marking using unauthorized devices or manipulated inputs. On another hand, GPS-based attendance systems verify location but fail to confirm identity, and can be compromised easily using fake GPS applications.

Therefore, an effective attendance solution should provide:

- Secure identity verification
- Accurate physical location verification

- Session-level monitoring to ensure continued presence
- Centralized management with role-based access control and reports

To meet these requirements, this paper introduces EduSmart, a smart attendance monitoring system that integrates facial recognition with GPS-based geofencing and periodic randomized re-verification to ensure authenticity.

Related Work: Existing attendance systems can be grouped into three categories: traditional, biometric, and intelligent automated systems.

Manual Attendance: Manual attendance tracking using registers is still widely practiced. It is simple but time consuming and vulnerable to human errors such as absent marking mistakes and inaccurate logs. Moreover, it provides no fraudulent prevention practices.

RFID-Based Attendance Systems: RFID systems provide an RFID tag to every student. By scanning the tag near a reader attendance is marked. Although fast, it suffers from proxy attendance as students can share RFID cards. The system also requires additional hardware installation.

Fingerprint-Based Biometric Systems: Fingerprint authentication improves identity verification significantly. But it is very slow for large classes and require physical contact, which may cause hygiene concerns. Due to improper fingerprint scanning, sensor quality, or skin conditions some students face difficulty.

Face Recognition Attendance Systems: Face recognition systems use cameras to marks attendance by detecting face and matching them with stored data. These systems are contactless and faster but may face problems like poor lighting, face coverings, and spoofing using videos or photos if liveness detection is absent.

GPS-Based Attendance Systems: GPS-based attendance systems verify attendance using specific GPS coordinates. However, they lack identity verification and can be manipulated using location spoofing applications. GPS signals accuracy may not always be reliable.

Research Gap:Based on the review of existing systems, it is confirmed that most existing solutions focus on either location verification or identity verification, but not both together. The propose system combines facial recognition with location verification, to improve reliability and reduce misuse.

II. REVIEW OF LITERATURE

Attendance tracking is important in educational organisations, and various methods have been introduced to reduce manipulation and improve efficiency. Traditional approaches involving roll calls take valuable class time, are prone to errors caused by humans, and increase the possibility of proxy attendance. To overcome the drawbacks, systems researchers have explored smart campus. Guo presented a IoT based smart campus solutions, automation framework designed in order to increase efficiency and security, signifying the growing shift towards digital systems in academic environments.

Biometric technologies have helped in strengthening the authenticity, specially face recognition as it works without physical contact. Raj et al. introduced a face recognition-based attendance model with the help of cloud support and facial encoding for automated attendance. However, facial recognition may get affected by lighting conditions, partial face coverage, and the dataset's quality. Banerjee and Yu discussed advancements in 3D face authentication testing automation but took note of data dependency challenges and scalability.

Verification of physical presence has been studied with GPS-based approaches. Masoud and Zhang enhanced GPS positioning accuracy using reinforcement learning techniques, although such methods need computation and significant training. Gao et al. proposed a crowdsensing-based attendance model designed to maintain low cost and reduce cheating, but interpretability problems were raised. Multimodal solutions have been explored; Anzar et al. integrated deep learning-based facial verification with periodic monitoring for virtual classrooms, though the result was limited in scale

III. HYPOTHESIS

Research Gap: Most current solutions concentrate on either location verification (GPS) or identity verification biometrics, but rarely combine both with continuous monitoring classroom. EduSmart fills this gap by integrating facial recognition with GPS-based

geofencing and includes randomized re-verification to prevent "mark-and-leave" behaviour and proxy.
Problem Statement: Conventional attendance systems face limitations because of the following reasons:
a) Manual attendance consumes valuable session time and is prone to human error.
b) Proxy attendance is difficult to detect and common.
c) Even biometric system cannot confirm whether a student is physically present inside the classroom.
d) GPS-based solutions can be manipulated and do not verify identity.
e) Systems also fail to ensure continued presence after marking attendance.

Therefore, an effective system should:
a) Automatically record attendance
b) Verify student identity securely
c) Confirm physical presence using geofencing
d) Discourage and prevent "mark-and-leave" behaviour

Proposed Solution: EduSmart
EduSmart is an intelligent system that automates attendance tracking using verifies physical presence and facial recognition using geofencing.

Key Features
EduSmart provides:
- Facial recognition for secure student authentication
- GPS-based verification and location capture
- Classroom boundary validation using geofencing
- Random re-verification during lectures to ensure physical presence
- A role-based portal for admin, student, and faculty
- Secure data storage with automated report generation

System Design and Architecture: EduSmart follows a modular architecture for better scalability.
System Modules
1) Student Module
- Scan face to mark attendance
- Allow location permission
- View attendance history
- Receive notifications (optional)

2) Faculty Module
- Start attendance session for a class
- View real-time attendance status
- Generate weekly/monthly reports
- Flag suspicious attendance

3) Admin Module
- Manage users (students and teachers)
- Add/remove datasets
- Configure classroom geofence boundaries
- Manage system permissions and logs

IV. METHODOLOGIES

EduSmart ensures attendance authenticity by using both biometric recognition and location validation.
Face Recognition Technique
EduSmart uses the following steps:
Step 1 Face Detection: The system detects the face in an image frame using computer vision.
Step 2 Feature Extraction: Face embeddings are extracted and converted into a numerical representation.
Step 3 Matching: The embeddings are compared with stored encodings.
Attendance Matching Rule
Match = { 1, if Confidence ≥ Threshold
{ 0, if Confidence < Threshold
Where:
Confidence indicates similarity score
Threshold is minimum acceptable score

Geolocation and Geofencing
The system verifies whether the student is inside the classroom boundary.
Inputs:
- Student Latitude and Longitude
- Classroom Geofence (center + radius)

Geofence Condition
[
Distance (student, classroom) \ leq Radius
]
If inside → location verified.

Randomized Re-Verification
After attendance marking, the system triggers random location checks at intervals (example:every 10–15 minutes).
If a student leaves the boundary, the system can:
- flag them as suspicious

- mark them as “present but left early”
- require re-authentication

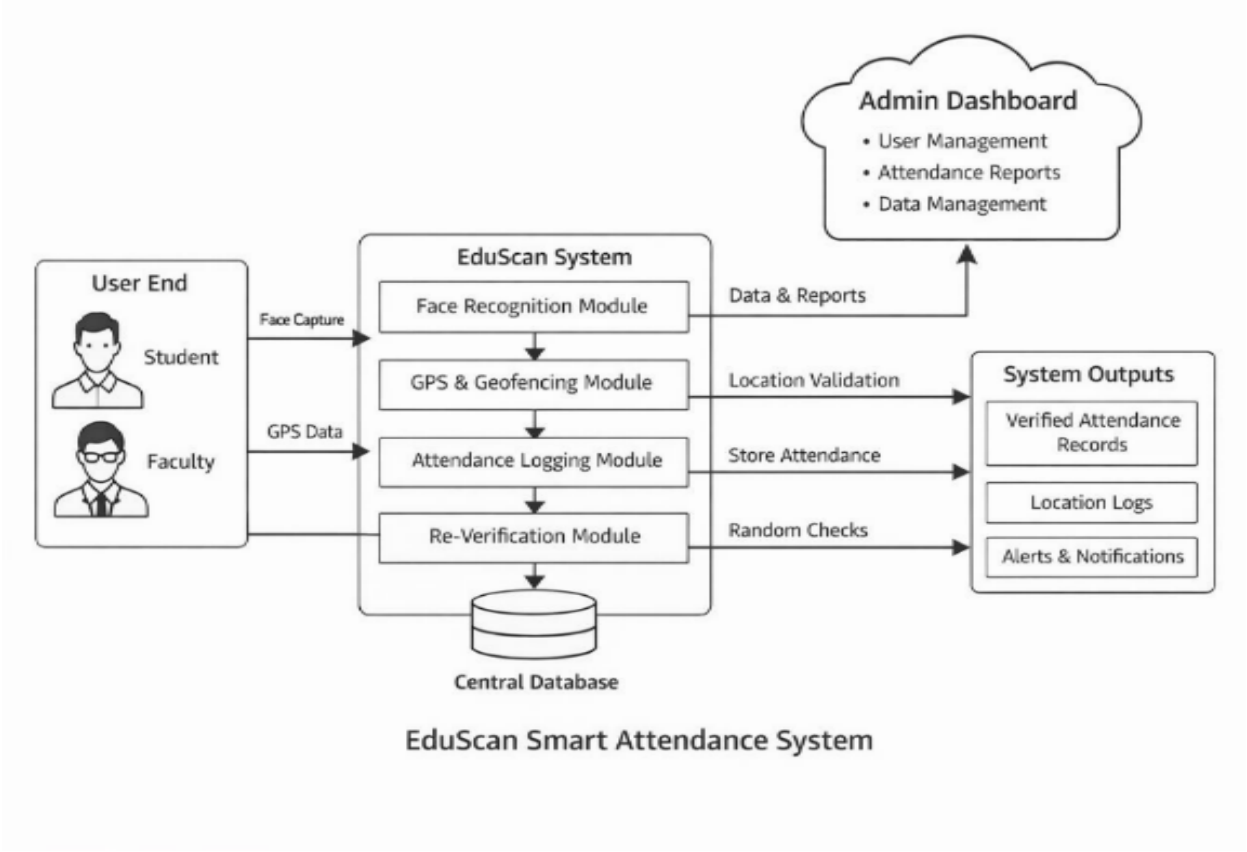
This reduces fake attendance marking.

Implementation Details

Technology Stack

EduSmart can be implemented using:
Frontend: HTML, CSS, JavaScript / React
Backend: Python Flask / Django
AI: OpenCV + Face recognition model
Database: MySQL / MongoDB
Location Services: GPS APIs

Architecture Diagram



V. MATHEMATICAL MODELS

Face Recognition Model

Each face is represented as a 128-dimensional embedding vector.

Let f_s and f_c be the stored and captured face embeddings, respectively. The similarity is computed using Euclidean distance:

$$d = \| f_s - f_c \|_2$$

A match is accepted if:

$$d < \tau$$

where τis a predefined threshold (typically 0.6). This ensures precise identity verification.

Geolocation Verification Model

To validate physical presence, the system calculates the distance between student and the classroom coordinates using the Haversine formula:

$$d = 2R \cdot \arcsin\left(\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\Delta\lambda}{2}\right)}\right)$$

If $d \leq r$(geofence radius), the student is considered present within the classroom boundary.

Random Location Verification Model

To prevent proxies and early exits, the system performs random location checks during the session.

Let $L(t_i) \in \{0,1\}$represents location validity at a time t_i. The verification score is:

$$A = \frac{1}{n}\sum_{i=1}^{n} L(t_i)$$

Attendance remains valid only if all checks pass ($A = 1$).

Final Attendance Decision

The final attendance decision combines all factors:

$$\text{Attendance} = F \times G \times R$$

where:

- F= face verification
- G= initial location validation
- R= random verification

Attendance is marked valid only when all conditions are satisfied.

VI. EXPERIMENTAL RESULTS AND DISCUSSION

Prototype Implementation Status

EduSmart is currently in the development phase and a working prototype has been implemented to validate the feasibility of the proposed approach. The current prototype supports core functionalities like student registration, facial dataset collection, identity verification, GPS based permission handling, and attendance logging. The system is designed to operate in a role-based manner where students can mark their attendance, faculty members can start attendance sessions, and admins can manage user records and datasets.

Module-Wise Functional Testing

To ensure correctness of system, EduSmart was validated with module-wise testing. The facial recognition module was tested to confirm that faces can be detected from live camera input and match them with the stored student dataset. The geolocation module was tested for capturing values of latitude and longitude from the user device and validating location access permissions. Additionally, the database module was tested to verify that attendance entries are stored with proper timestamp, session details, and verification status. The role-based login module was being tested to ensure that students and faculty access only the features permitted.

Preliminary Observations

During initial prototype testing conducted in a controlled environment, EduSmart demonstrated that combining facial recognition with geolocation verification improves the authenticity of attendance marking in comparison to manual systems. Attendance marking is faster and the possibility of proxy attendance is reduced since a student must be successfully recognized by the system. Furthermore, including geofencing ensures that attendance can be marked only when the student is within the configured classroom boundary. The random re-verification feature has been planned as an additional security mechanism to reduce the “mark-and-leave” behavior, where students exit after marking attendance.

Challenges Identified

Some challenges were observed during the early prototype stage. Accuracy of facial recognition might reduce under poor lighting conditions, partial occlusion, or improper alignment of camera. Similarly, GPS-based location verification could show minute deviations indoors due to signal instability and device-based variations. These limitations demonstrate the need for enhanced training datasets,better camera positioning strategies, and improved verification indoors.

VII. DISCUSSION

The current prototype results show that EduSmart is a feasible and scalable solution for smart attendance. The system design ensures improvement in reliability through dual verification (identity and location) while reducing faculty workload by automating logging and reporting. The full system implementation will include optimizing face recognition performance, stronger geolocation validation, continuous classroom presence monitoring provides integration of randomized re-verification.

The EduSmart system uses key performance metrics for evaluation.

Metrics

- Recognition Accuracy
- Attendance marking time
- Location verification success rate
- Fraud detection effectiveness

Observations

- It takes 5–10 minutes per class to track manual attendance.
- Attendance marking time is reduced to nearly 1 minute depending on class size.
- Due to face verification Proxy attempts were reduced.
- Random verification detects students leaving early.

Advantages

EduSmart provides:

- With minimal effort attendance is automated.
- Compared to manual methods it has higher accuracy
- Contactless interface
- Verification of classroom presence
- Reduced proxy attempts
- Centralized dashboards and analytics

Limitations

Although EduSmart performs effectively, it has some limitations:

- Under poor lighting accuracy of face recognition may reduce.
- GPS accuracy may fluctuate indoors.
- Camera access and location permissions are required.
- Risk of fake GPS. (future liveness + anti-spoofing needed).

VIII. PRACTICAL IMPLICATIONS

Conclusion and Future Scope

With the use facial recognition and geofencing verification EduSmart provides secure and automated approach for monitoring attendance. The combination of biometric identity verification and physical location validation ensures reliability and minimizes fraud. EduSmart is suitable for smart classrooms and scalable institutional deployment. Randomized re-verification improves session level presence checking and misuse is prevented.

Future Scope

Can be further improved using:

- Liveness detection (anti-photo spoofing)
- Indoor positioning
- Offline attendance recording and later sync
- Learning management systems and integrating with college ERP.
- Face recognition and mask detection

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