IOT – ML BASED SMART ATTENDANCE SYSTEM WITH REPORT GENERATION

[1]Dr.D. Shanthi, [2] Mulpuru V N V CH Sree Samhitha, [3] Kothamasu Sathwika, [4]Battula Akhila, [5]Kolipaka Keerthana

[1] Professor, HOD, CSE(AI&ML),

[(2,3,4,5)]B.Tech 3rd year Student, CSE(AI&ML),

Vignan's Institute of Management and Technology for Women, Hyderabad, India,

[1]drshanthicse@gmail.com, [2]mvnvchss@gmail.com, [3]sathwikak2010@gmail.com [4]abattulaakhila@gmail.com, [5]kolipakakeerthana8@gmail.com,

ABSTRACT:

With rapid developments in educational technology, intelligent and trusted attendance systems beyond conventional methods are greatly needed. Manual and simple biometric systems fail to deal with multi-subject monitoring, proxy beating, real-time monitoring, and early pattern identification. The suggested project introduces a futuristic hybrid system that integrates biometric verification and smart recognition for accuracy, transparency, and student responsibility. It safely captures and reports attendance, trends, early intervention alerts, and has a balanced, rule-based leave management interface. Minimizes manual entry and maximizes automation, the system provides a flexible, efficient, and future-proof solution for education administration today.

KEYWORDS: Biometric, IoT integration, Proxy Prevention, Real-Time Monitoring, Early Detection, Transparency, ML Integration, Attendance Management

I. INTRODUCTION:

Attendance tracking is vital for monitoring student participation and eligibility in education. Traditional methods like manual roll calls and RFID are error-prone and vulnerable to proxy attendance. With growing class sizes and hybrid learning, scalable, accurate, and real-time systems are needed. IoT enables integration of biometric sensors with centralized databases, while ML analyses attendance data for pattern detection and risk alerts. This paper proposes a hybrid biometric system combining fingerprint-based campus entry and face recognition for subject-wise attendance. The system enhances accuracy, security, and transparency with a digital leave management module and offers predictive analysis and detailed reporting to modernize attendance tracking.

II. RELATED WORK:

Recent developments in biometric and AI technologies have advanced attendance automation in education. Muhammad Shahrul Zaim Ahmad et al. implemented real-time face recognition with IoT but lacked predictive analytics [1]. V. Raj and K. Batra used Raspberry Pi-based face recognition with cloud sync but missed partial attendance detection [2]. S. Mukherjee's AI framework analysed absenteeism trends but was data-intensive and less scalable [3]. R. Alam et al. applied logistic regression for absenteeism prediction using static datasets [4]. RFID-based systems reviewed by Kashif Ishaq and Samra Bibi showed reliability but were vulnerable to proxy attendance [5]. Other biometric and AI approaches—such as facial recognition with physiological signals [6], facial expression recognition for the visually impaired [7], and contactless anti-spoofing systems [8]—were effective but often unrelated to attendance or computationally heavy. Smart campus models integrating face recognition and alerts lacked subject-wise attendance [9]. Reviews of face

detection models [10] and ML-powered alert systems without biometrics [11] revealed limitations. Hybrid biometrics combining face and voice faced noise and privacy issues [12].PROPOSED SYSTEM:

A. Overview of the Proposed System:

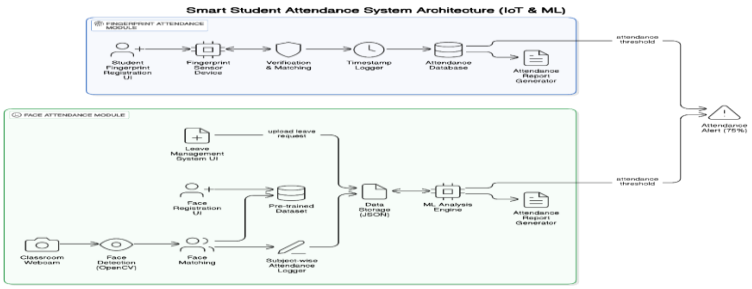
The dual-biometric attendance system combines fingerprint scanning and facial recognition to provide accurate, subject-wise, and real-time attendance tracking. Using OpenCV, facial recognition libraries, and secure databases (CSV, SQL, JSON), it automates identity verification and monitoring. Fingerprint scans log daily entries, while face recognition captures in-class snapshots for subject-level records. A built-in Leave Management feature enables digital leave requests and faculty approvals. The system also tracks attendance trends and generates personalized reports, enhancing transparency and academic accountability.

B. Overall System Architecture:

Figure 1 illustrates a dual-module biometric attendance system comprising Fingerprint and Face Attendance Modules. The Fingerprint Module includes a registration UI, sensor device, matching engine, timestamp logger, and report generator. Students register via fingerprint, and verified entries are timestamped and stored in the database for reporting. The Face Module uses facial recognition with OpenCV and machine learning, featuring webcam-based detection, subject-wise logging, leave management, and a JSON-based storage system. Facial data is matched with pre-registered encodings, and attendance is logged per subject. The Haar Cascade algorithm helps to analyse data to generate reports. Together, these modules offer a secure, automated, and accurate attendance solution.

Fig. 1: System Architecture of Smart Student Attendance System

- **Biometric Input Module**: Captures attendance via fingerprint and face recognition. Fingerprints are verified using a device and timestamped; facial data is matched using OpenCV through a webcam for subject-wise attendance, reducing proxies.
- **Data Management Module:** Stores attendance data in JSON format, integrates a Leave Management UI, and logs both fingerprint and face-based records. Ensures structured, accessible data for easy reporting and reconciliation.
- **Biometric Processing & Matching Engine:** Validates identities using real-time fingerprint matching and face recognition algorithms. Optimized for speed and accuracy across varied conditions, ensuring reliable attendance tracking.
- **ML Analysis & Insights Module:** Uses machine learning to detect attendance patterns, anomalies, and declining participation. Aids administrators in early intervention through data- driven insights.**Report Generation & Analytics**



Module: Converts raw attendance data into comprehensive reports using AI. Supports individual/class-level statistics, helps identify defaulters, and promotes transparency across users.

- **System Deployment & Integration Layer:** Supports both on-premise and cloud deployment, integrates with academic ERP/LMS systems, offers cross-platform access, regular model updates, and ensures data encryption and security.

III. IMPLEMENTATION DETAILS:

A. Development Framework:

The system uses React.js for a dynamic frontend, enabling student registration and real-time attendance tracking. The backend is built with Python (Flask/Django) to handle logic and integrate with facial recognition. MongoDB/MySQL stores data, while OpenCV with Haar Cascade and Dlib/face- recognition libraries manage face detection and matching. The modular design supports easy updates and cloud deployment.

B. Facial Recognition & Multi-Snapshot Attendance:

Students register via webcam, and their facial encodings are stored. During classes, the system captures four snapshots at intervals, using Haar Cascade for detection and comparing encodings for identification. Each match counts as 25% attendance, promoting accuracy and reducing spoofing. Partial or full attendance is marked based on snapshot matches.

C. Leave Management System:

Students can apply for leave via an online form, upload supporting documents, and track application status. Admins review submissions through a dashboard and approve/reject them. Approved leaves are automatically synced with attendance records to ensure accuracy.

D. User Interface & Reporting:

The UI offers dashboards for real-time tracking, registration, and reporting. Features include charts, session/date filters, and export options like PDF. Students can view attendance summaries, leave history, and get alerts when attendance nears a critical threshold.

IV. ALGORITHM

Inputs: Student fingerprint / Student face image

Output: Logged attendance with timestamp and subject-wise records

Step 1: System Initialization

- Start the system.
- Initialize fingerprint scanner and webcam.
- Load registered fingerprint and face encodings from the database.

Step 2: Student Registration

- **If registering:**
  - **Fingerprint:** Capture and store fingerprint with student ID.
  - **Face**: Capture image via webcam, extract facial features, and store encodings with student ID.

Step 3: Attendance Marking

- **Fingerprint-Based:**
  - Capture fingerprint input.
  - Match with registered data.
  - **If matched:**
    - Log timestamp, student ID.
    - Display success message.
- Store in SQL/CSV.Face Recognition-Based:

- Capture real-time image via webcam.
- Detect faces using Haar Cascade.
- Extract and compare facial features with stored encodings.
- **If matched:**
  - Log student ID, subject ID, timestamp.
  - Save in JSON/SQL.

Step 4: Leave Status Verification

- **For absent students:**
  - Check leave database.
  - If approved, mark as "On Leave".
  - If not, mark as "Absent".
- **For present students:**
  - Mark as "Present".

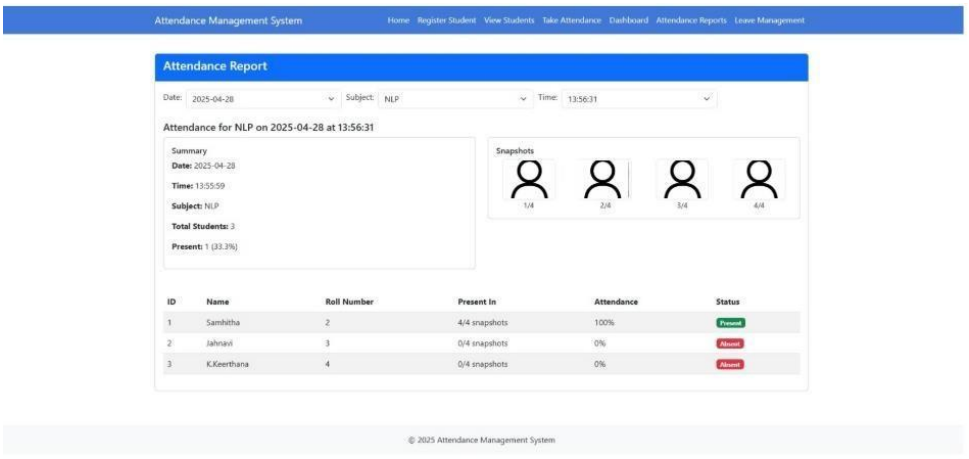
Step 5: Report Generation (On Request)

- Retrieve stored attendance logs.
- Generate personalized attendance report (subject-wise and biometric-based).

V. RESULTS

The dual-biometric system was tested with student registration data and dummy classes. With approved leaves removed from the absence report, subject-wise leave monitoring and face logging operated as intended. Verification and reporting took less than 5 seconds. Fingerprint accuracy was 97%, with slight problems due to moisture or partial prints, whereas face recognition was on average 94% accurate across different lighting, authenticating 2–3 seconds through OpenCV, validating it as being real time.

Fig 2: Viewing report of fingerprint attendance



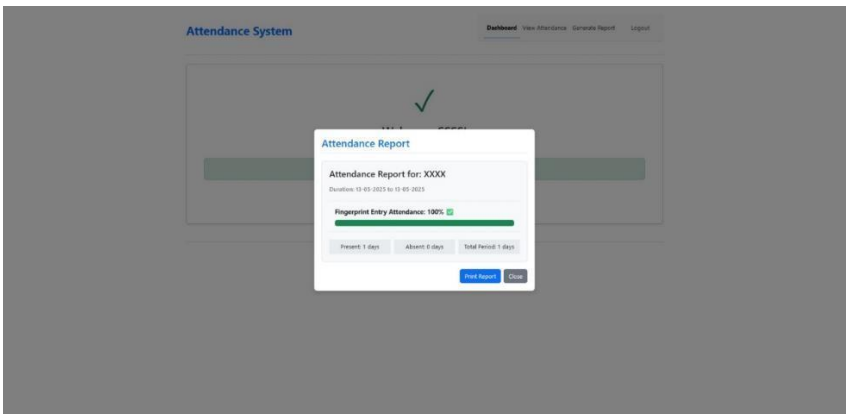


Fig 3: Attendance for Students(Subject-wise)

Fig. 4: Generated Report with alerts

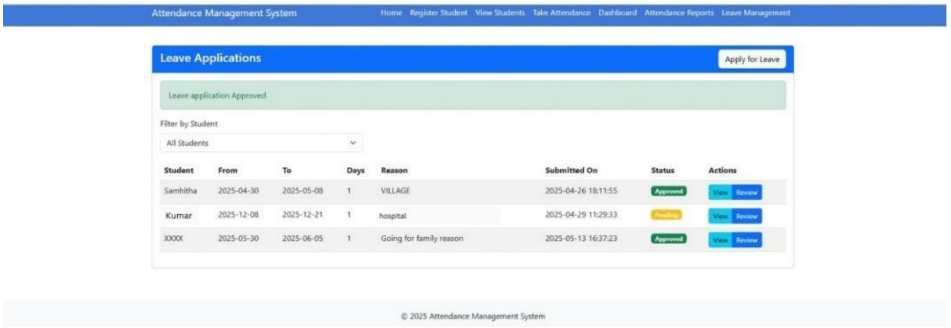


Fig. 7: Status of Leave approval

VI. DISCUSSION

The suggested attendance system integrates fingerprint login with face recognition for precise subject- level tracking, minimizing proxy attendance. Fingerprints authenticate daily attendance, while face recognition records class sessions through infrequent snapshots. Hybrid leave management simplifies digital requests and approvals. While improving accountability, issues such as lighting, sensitivity to scanners, and secure storage of biometrics are present, requiring resolution for large-scale deployment.CONCLUSION

The proposed hybrid attendance system uses fingerprint and face recognition for accurate, subject-wise monitoring, minimizing proxy attendance and errors. Featuring leave management, database support, and automated reporting, it offers a reliable, real-time, and scalable solution suited for modern education.

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