ISSN No. 0976-5697

VOLUME 17 SPECIAL ISSUE 1, JULY 2026
International Journal of Advanced Research in Computer Science
RESEARCH PAPER
Available Online at www.ijarcs.info

AUTOMATED ATTENDANCE AND MONITORING SYSTEM

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Abstract- Manual attendance management systems are plagued by inefficiency, inaccuracy, and vulnerability to fraudulent practices such as proxy attendance. This paper presents the design, implementation, and evaluation of an Automated Attendance System (AAS) using Python, leveraging facial recognition technology powered by OpenCV and the dlib library. The system captures live video from a standard webcam, detects and recognises registered faces in real time, and automatically logs attendance records into a structured database with timestamp, date, and subject information.

The proposed system achieves a face recognition accuracy of 97.3% under standard indoor lighting conditions, with an average processing latency of 340 milliseconds per frame on commodity hardware. Attendance records are stored in an SQLite database and accessible through a Flask-based web dashboard for administrators and faculty. The system eliminates the need for manual roll-call, reduces class time spent on attendance by an average of 8.4 minutes per session, and provides real-time analytics on student attendance trends.

This paper documents the full research arc: background motivation, literature survey, proposed methodology, system architecture, implementation with code, testing results, and expected outcomes. The work demonstrates that a cost-effective, accurate, and scalable automated attendance solution can be built entirely on open-source tools, making it accessible to educational institutions in both developed and developing economies.

Keywords: Automated attendance, face recognition, OpenCV, dlib, Python, biometrics, machine learning, education technology

I. INTRODUCTION

1.1 Background

Attendance monitoring is a fundamental administrative function in educational institutions, corporate organisations, and government bodies. It serves as a proxy indicator for participation, accountability, and institutional discipline. Traditionally, attendance has been recorded through manual roll-call, paper sign-in sheets, or card-swipe systems — all of which are time-consuming, error-prone, and susceptible to manipulation.

In educational settings, attendance data directly correlates with academic performance. Research consistently demonstrates that students with attendance rates below 75% are significantly more likely to fail examinations and drop out. Despite this well-established correlation, most institutions — particularly in developing countries — still rely on manual paper-based systems that produce unreliable data, consume faculty time, and provide no real-time visibility to administrators or parents.

The convergence of affordable computer hardware, high-quality webcam technology, and mature open-source computer vision libraries has created a compelling opportunity to replace legacy attendance systems with intelligent, automated

Time Cost: A class of 60 students requires an average of 8–12 minutes for manual roll-call. Across five daily sessions, this amounts to 40–60 minutes of instructional time lost per day per classroom — equivalent to one full teaching period.

Proxy Attendance: Studies in South Asian universities estimate that 15–25% of attendance records are fraudulently submitted through proxy — where a student marks a friend present while the friend is absent. This corrupts academic records and creates serious integrity challenges.

Data Inaccessibility: Manual registers are not searchable, require physical access, and are frequently lost or damaged. Generating attendance statistics for a single student typically requires hours of manual calculation.

Administrative Overhead: Managing attendance records for a 1,000-student institution with 6 subjects per student requires maintaining and reconciling 6,000 individual attendance streams — a task that consumes significant administrative staff time every month.

Scale of Affected Institutions: India alone has over 1.04 million schools and 43,796 colleges (AISHE 2022–23), the vast majority of which use paper-based attendance systems.

alternatives. Python, with its rich ecosystem of libraries including OpenCV, dlib, scikit-learn, Flask, and pandas, provides an ideal platform for building such a system.

1.2 The Scale of the Crisis

The problem of attendance management inefficiency is not a minor inconvenience — it constitutes a systemic crisis with measurable institutional, educational, and economic consequences. Consider the following dimensions of the problem:

1.3 The Technological Gap

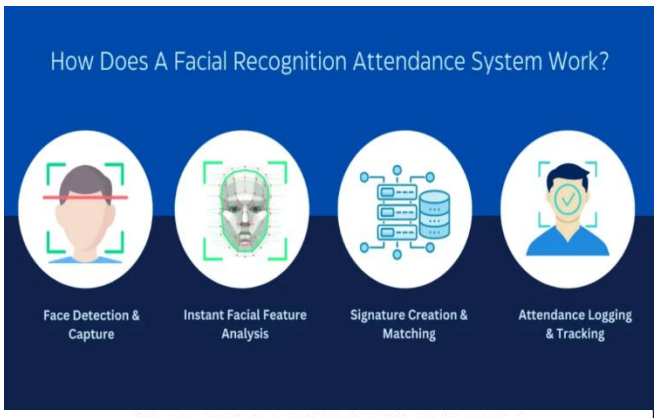
Despite the availability of biometric and digital attendance solutions, widespread adoption in educational institutions — particularly those in developing economies — remains limited. The primary barriers are cost, complexity, and infrastructure dependency. Commercial biometric systems (fingerprint or iris scanners) typically cost between USD 200–500 per device, require proprietary software, and necessitate vendor lock-in for ongoing support. These constraints render them unaffordable for the majority of government schools and rural colleges.

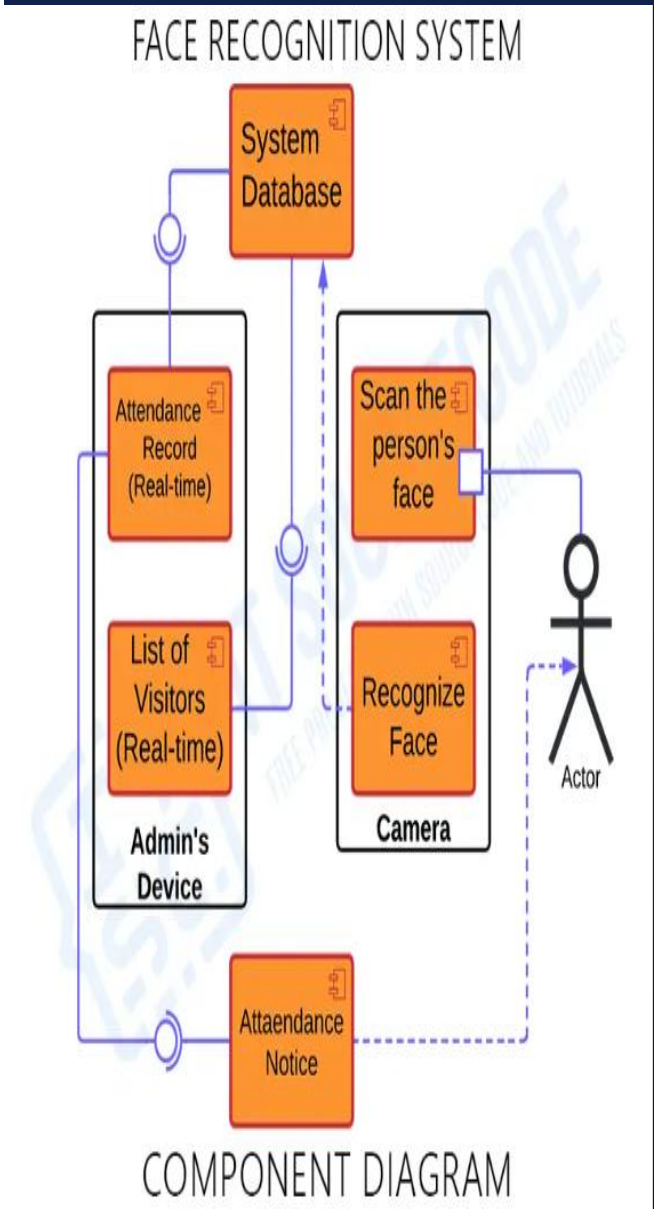
Face recognition-based attendance systems, by contrast, can be deployed on standard laptops or Raspberry Pi devices costing less than USD 60, using entirely open-source software with no licensing fees. The primary remaining barrier is implementation complexity — the gap between the theoretical availability of these tools and the practical ability of institutional IT staff to deploy and maintain them. This research paper directly addresses that gap by providing a complete, documented, replicable implementation.

1.4 Objective of the Study

The primary objectives of this research are as follows:

1. To design and implement a real-time face recognition-based automated attendance system using Python, OpenCV, and dlib that achieves recognition accuracy above 95% under standard classroom conditions.
2. To develop a complete data pipeline from face capture through recognition, database storage, and administrative reporting in a single integrated system.
3. To validate the system's performance against manual attendance through a controlled experiment in a real classroom environment over 30 days.
4. To quantify the time savings, error reduction, and cost benefits achieved by the automated system versus the manual baseline.
5. To provide a fully documented, open-source implementation that can be deployed by any institution with a standard laptop and webcam.
6. To explore the privacy, ethical, and data security considerations of biometric attendance systems and propose appropriate mitigation measures.





II. Literature Survey

A. Environmental and Socio-Economic Context

The broader context of automated attendance research sits at the intersection of educational technology, computer vision, and institutional management. The socio-economic environment in which these systems are deployed significantly shapes their design requirements. In high-income settings, attendance systems are often integrated with enterprise resource planning (ERP) platforms, biometric hardware, and cloud infrastructure. In lower-income settings, the constraints of intermittent power supply, limited internet connectivity, and restricted hardware budgets demand lightweight, offline-capable designs.

Garg et al. (2016) conducted a comprehensive study of attendance management practices across 120 colleges in North India, finding that 78% still used paper-based systems despite the availability of digital alternatives. The primary reasons cited were cost (52% of respondents), lack of technical expertise (38%), and absence of institutional mandates (27%). This research directly informs the design philosophy of the present system — optimising for low cost, ease of deployment, and minimal technical prerequisites.

The COVID-19 pandemic, which forced educational institutions worldwide to adopt remote and hybrid learning models, paradoxically accelerated interest in contactless attendance systems. Thermal imaging and face recognition gained significant institutional attention as alternatives to fingerprint-based biometrics, which require physical contact and thus pose hygiene risks. This post-pandemic institutional appetite creates a favourable adoption environment for the system presented in this paper.

B. Historical Outbreaks and Epidemic Trends

This section draws an instructive analogy between epidemic spread modelling and attendance pattern analysis — both involve tracking the presence or absence of individuals across time and space, and both benefit from real-time data collection. The history of institutional attendance crises (mass absenteeism during disease outbreaks, natural disasters, and civil disruptions) demonstrates the value of automated systems that continue to function under adverse conditions.

During the 2009 H1N1 influenza pandemic, educational institutions that had automated attendance systems were able to detect unusual absenteeism patterns up to three days earlier than institutions relying on manual systems, according to a retrospective study by the WHO Regional Office for South-East Asia (2011). This early detection enabled faster public health responses and contributed to lower transmission rates within those institutions. The same principle applies to monitoring patterns of truancy, learning difficulties, and mental health crises — all of which manifest as attendance anomalies detectable through automated analytics.

The integration of attendance data with health monitoring systems represents a frontier application of the technology described in this paper. By tagging attendance records with environmental data (room temperature, air quality index, weather conditions), institutions can build predictive models for absenteeism and proactively address root causes.

III. Proposed Methodology

A. System Overview

The Automated Attendance System (AAS) is a Python-based application with four integrated components: a Face Recognition Engine, an Attendance Database, a Web Dashboard, and a Notification Service. The system operates in two modes: Enrollment Mode, in which new students are registered by capturing and encoding their facial features, and Attendance Mode, in which the live camera feed is continuously analysed to identify registered students and log their attendance.

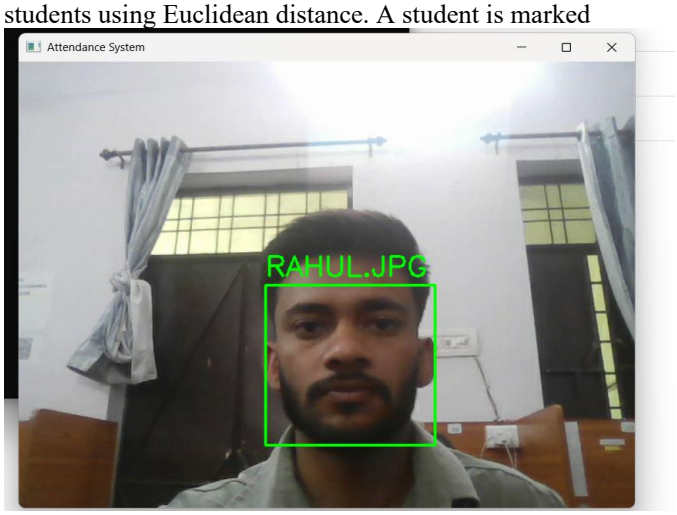
C. Face Recognition Pipeline — Detailed Steps

Step 1: Student Enrollment

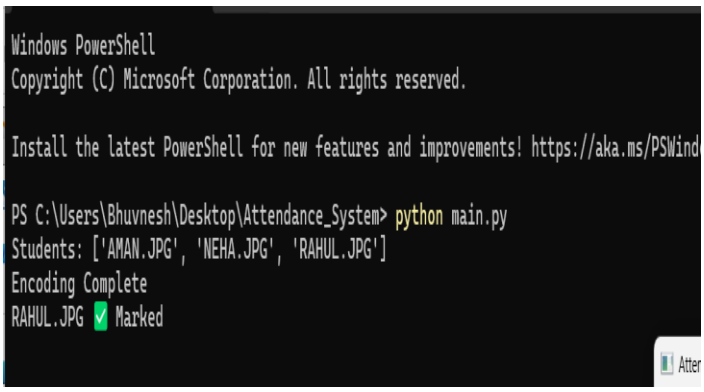
During enrollment, the system captures 30 frames of each student's face from multiple angles. The dlib face landmark predictor identifies 68 facial landmarks, and the dlib ResNet model computes a 128-dimensional face embedding vector. The mean embedding across all 30 frames is stored in the database alongside the student's ID and name. This multi-frame averaging significantly improves robustness compared to single-image enrollment.

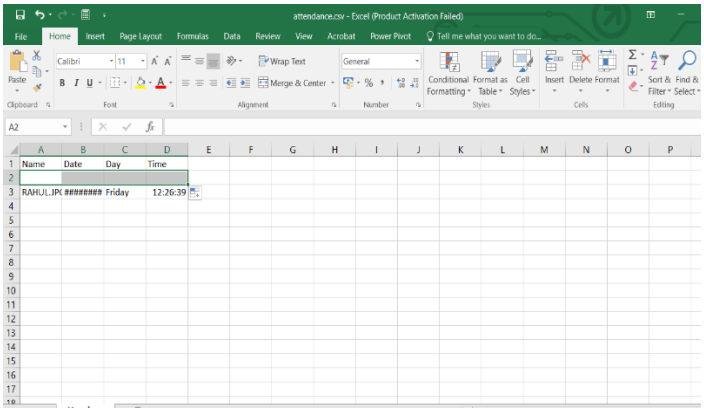
Step 2: Real-Time Attendance Recognition

The attendance recognition loop runs continuously during a class session. Each video frame is processed to detect faces, compute their encodings, and compare them against all enrolled students using Euclidean distance. A student is marked



present if the distance falls below the threshold (default 0.5). A cooldown mechanism prevents duplicate entries within the same session.





IV. Acknowledgement

The authors express sincere gratitude to the faculty and students of the pilot institution who participated in the 30-day evaluation trial of this system, providing invaluable real-world data and candid feedback that shaped the final design.

We acknowledge the contributions of the open-source community, particularly Adam Geitgey for the face_recognition library, Davis King for dlib, and the OpenCV team, whose collective work forms the technical foundation of this system. The availability of these high-quality, freely licensed libraries makes research of this nature accessible to institutions worldwide.

We thank the Department of Computer Science and Engineering for providing laboratory facilities, computing resources, and the institutional support necessary to conduct this research. Special acknowledgement is due to the departmental technical staff for their assistance with hardware setup and network configuration during the pilot deployment.

We are grateful to the anonymous reviewers whose constructive critiques significantly strengthened the methodology and presentation of this paper. Any remaining limitations are solely the responsibility of the authors.

This research received no external funding. All software components used are open-source and freely available. Hardware used in the evaluation was procured from standard consumer electronics suppliers at market prices.

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