



Automated Facial Recognition Attendance System with Notification System for Educational Institutions

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ABSTRACT

This research investigates the methods of attendance in educational institutions in Nigeria, and afterwards developed an Automated facial recognition attendance system for students with a dual notification for both parents and students. This is aimed at addressing the inefficiencies and inaccuracies of traditional attendance management methods by reporting students to their parents when they miss classes and analysing students' attendance rate for insights. The system leverages cutting-edge artificial intelligence (AI) and computer vision technologies to automate the process of student identification and attendance logging, offering a seamless, reliable, and secure solution for educational institutions. The development process followed the object-oriented analysis and design (OOAD) methodology. It included the creation of a robust system architecture that integrates OpenCV for real-time face detection, the FaceNet model for facial feature extraction, and a MySQL database for efficient data storage and retrieval. The system was built using Python, Flask, and JavaScript, ensuring a responsive and user-friendly web-based interface. To protect sensitive biometric data, AES-256 encryption was implemented, ensuring compliance with modern data security standards. The facial recognition model achieved a 98.4% accuracy rate with an average attendance marking time of just six seconds for a classroom of 30 students. Compared to manual and RFID-based attendance systems, the AI-powered solution demonstrated superior performance in terms of speed, accuracy, and protection against proxy attendance.

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INTRODUCTION

Attending classes is sacrosanct for students to perform well in a particular course or subject and at large, in their overall academic process. Schmulian & Coetzee (2011) argued that absenteeism affects students' performance and suggest that measures should be put in place to encourage class attendance. Many factors lead to students absent in classes but the lack of accountability and lack of non-manipulative system to check and report student absenteeism stands out amongst these factors. The management of student attendance in academic institutions has traditionally relied on manual

methods, such as roll calls, sign-in sheets, or electronic ID swipes. These methods, however, are often time-consuming, susceptible to errors, do not inform their parents of their wards absenteeism, and are vulnerable to fraudulent practices like proxy attendance. The integration of artificial intelligence (AI) and facial recognition technology presents an innovative solution to these issues, enabling accurate, efficient, and secure attendance tracking, thus, improving student attendance to classes.

Facial recognition systems utilize deep learning algorithms, particularly Convolutional Neural Networks (CNNs), to detect and recognize

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facial features with high accuracy under varied lighting and environmental conditions (Parkhi *et al.*, 2015). It utilizes biometric software to identify or verify a person from a digital image or video frame by comparing selected facial features with stored facial data. With the advent of more powerful machine learning algorithms and the ubiquity of high-quality imaging devices, AI-driven facial recognition has become more feasible and effective for use in educational settings.

Moreover, the COVID-19 pandemic has highlighted the importance of contactless solutions, accelerating the adoption of facial recognition technologies in educational and corporate environments (Nguyen *et al.*, 2020; Ameer *et al.*, 2021). The integration of facial recognition technology addresses these challenges by providing a non-intrusive, efficient, and accurate means of verifying student presence. This technology leverages unique facial features to authenticate individuals, thereby enhancing the integrity of attendance records and establishing parents' involvement.

Several open-source tools and libraries such as OpenCV, Dlib, and face recognition have simplified the development of these systems. Coupled with cloud-based databases or local servers, they allow seamless data storage and retrieval. Despite the benefits, there are challenges related to privacy, accuracy in diverse student populations, and the need for optimized hardware for large-scale deployment (Zhao *et al.*, 2003). Automated facial recognition offers a seamless alternative by automating the attendance process without requiring students to manually register their presence.

Related Work

Numerous studies have explored the development of AI-powered facial recognition attendance systems. Below are some of the findings; Facial recognition technology has been shown to enhance security and accuracy in attendance tracking. Chidi *et al.* (2023) highlighted the benefits of using facial recognition technology, including automation, security, and providing accuracy and efficiency. They built their system

on the Android platform using Kotlin as the main programming language. TensorFlow was used as a machine learning framework to assist in face detection and recognition. The research resulted in the elimination of manual recording and reduced the potential for proxy attendance, leading to a more accurate attendance record. It is time-saving and leads to timely intervention for absentees.

However, concerns regarding data privacy and security in facial recognition systems have been raised. Kurup *et al.* (2024) emphasized the need for robust security measures and transparent data handling practices to protect sensitive student information. To achieve this, the proposed a model that integrates advanced facial recognition algorithms, Strict data security protocols, and a user-friendly interface. This study utilizes a comprehensive approach that combines a detailed literature review with primary data gathered from surveys and interviews.

The process involves system design, rigorous testing, and data analysis to assess the viability, performance, and ethical considerations of implementing facial recognition for attendance. The technical environment is comprised of cameras, laptops, servers, facial recognition algorithms, specialized software, and a varied dataset of facial images. By analyzing this data, the study evaluates system accuracy and overall efficacy. Ultimately, the findings will illuminate the advantages and obstacles of using facial recognition for attendance tracking in both academic and corporate environments, while providing actionable guidance for future studies and deployment.

In terms of design and implementation, several studies have proposed frameworks and architectures for AI-powered facial recognition attendance systems. For example, Lin & Li (2019) introduced an automated classroom attendance system utilizing video-based facial recognition. By capturing real-time video via an in-class camera, the system extracts individual static frames and filters them to select the clearest, best-illuminated images for facial identification. To ensure comprehensive coverage, these individual recognition results are ultimately aggregated.

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Furthermore, to mitigate the limitations of a fixed camera position, the system integrates with a pan-tilt-zoom (PTZ) platform control mechanism, enabling remote rotation and focusing to optimize image quality and maximize recognition accuracy.

Min-Chuan *et al.* (2021) developed an innovative, web-based attendance and health-monitoring system driven by market demand. By leveraging sensing technology and standardized software development practices, the new system streamlines workplace processes by combining facial recognition, automated attendance tracking, and body temperature testing. Built on a modern tech stack (including Django, MySQL, and WeChat mini-programs), it efficiently manages and secures critical employee data, addressing the deficiencies of legacy systems.

Mekala *et al.* (2019) designed a smart attendance system to replace the traditional method of taking attendance, which is inefficient, consuming up to 15 minutes of a 50-minute lecture, and is highly prone to human error and proxy attendance. To solve this, an automated system was developed using face recognition via the Cognitive Face API (utilizing the Principal Component Analysis (PCA) algorithm). This system eliminates manual tracking errors, prevents proxies, and streamlines the attendance-marking process, automatically publishing the results to a web page.

Raj *et al.* (2024) in their paper, introduced an automated student attendance system that replaces slow, easily manipulated manual methods (like roll calls) and easily tricked biometric proxies. Using a combination of advanced facial recognition algorithms—including Haar classifiers, CNN, SVM, KNN, Gabor filters, and GANs—the system identifies students and automatically logs their attendance into an Excel spreadsheet. Tested successfully against real-world challenges like varying lighting, head movements, and camera distances, the system proved to be an accurate, cost-effective, and highly resilient solution for classroom management.

Siswanto *et al.* (2014) argued that a modern facial recognition starts by measuring specific facial metrics—such as the width of the

mouth and eyes or the positioning of the pupils and comparing these coordinates against a database to find the closest match. Driven by this core concept, the field has exploded into a major research hub, yielding countless papers focused on improving algorithms, extracting features, and finding new real-world applications. The primary goal of their study is to evaluate and compare two prominent facial recognition algorithms provided by OpenCV 2.4.8: **Eigenface** and **Fisherface**. By analyzing their Receiver Operating Characteristics (ROC) curves, the study aims to identify the superior algorithm and deploy it within an automated attendance tracking system. Ultimately, the experimental data and ROC curves revealed that Eigenface outperformed Fisherface when utilizing the current training dataset. When integrated into the live attendance system, the Eigenface algorithm successfully achieved a similarity confidence score between 70% and 90% for authentic face images.

Literature Gap

Facial recognition attendance systems have been built using different techniques from different researchers to curb proxy attendance and improve the speed of the process. A system that brings the parents in to monitor their children's class attending process by getting email notification for any class not attended by their children and a feature capable of analyzing the attendance rate is lacking. The research will integrate the above features in a robust platform to improve class attendance rate as students discover that they cannot outsmart the attendance system, their parents get notified anytime they miss a class and their attendance rate can be analyzed on a click.

System Design

The system was developed using a modular architecture, with each core functionality implemented as a separate Python script or function. This approach enhances code reusability, simplifies debugging, supports scalability, and improves overall maintainability.



System Modules

The automated attendance system using face recognition system has the following modules:

- i. **Authentication Module:** This component handles the system's user authentication processes, including login and logout functionalities. It checks input credentials against stored, encrypted passwords and manages user sessions to prevent unauthorized access.
- ii. **Face Recognition Module:** This module performs live face detection and identification using Python libraries such as OpenCV for face recognition. It captures video input from a webcam, processes facial features into encodings, and matches them with previously stored records to verify student identities.
- iii. **Attendance Module:** After a student is successfully identified, this module records their attendance in a MySQL database. It ensures that each session is logged uniquely and stores relevant details like student ID, date, and time. It can also monitor multiple sessions or late attendance when necessary.
- iv. **Reporting Module:** This component generates comprehensive attendance reports based on user-defined filters such as date ranges, departments, or specific student IDs. It presents the data in structured tables or visual charts and allows exporting in formats like PDF for academic and administrative use.
- v. **Notification Module:** Responsible for sending email notifications via the SMTP protocol, this module alerts parents and students of their absenteeism

Face Detection Process

Database Creation

The initial phase of the attendance system involves building a facial database. A camera captures the frontal faces of various

individuals, and the system detects and records these images. To optimize the system's accuracy, the number of captured frames per person can be adjusted. These images are then stored in the database and linked to each individual's unique Registration ID.

Face Training

Once recorded, the facial images are converted to grayscale to standardize processing. The system utilizes the Local Binary Patterns Histograms (LBPH) recognizer for training, which effectively handles variations in image resolution between the training and recognition phases. The LBPH algorithm processes the image by analyzing local pixel neighborhoods:

- i. A central pixel is selected as a threshold and compared against its surrounding neighbor pixels.
- ii. If a neighbor's intensity is greater than or equal to the center pixel's intensity, it is assigned a value of **1**.
- iii. If the neighbor's intensity is lower, it is assigned a value of **0**.

This thresholding process generates binary patterns known as **LBP codes**, which are compiled into histograms to represent the unique features of each face.

Face Detection

The trained facial data is exported and saved in a .py format (or a compatible data file) for the system to reference. During operation, the system utilizes the Haar Cascade Frontal Face **module** to scan incoming frames, isolate the face from the background, and prepare it for recognition.

Face Recognition

In the final phase, the system performs real-time face recognition. The camera captures live footage, and the Haar Cascade detects any faces present. The system then compares the extracted facial features against the pre-trained database IDs. Once a match is confirmed, the student is successfully recognized, and their attendance is logged. Because this phase

happens in real time, the system's overall accuracy is highly dependent on the quality and condition of the camera, as well as ambient lighting.

System Architecture

The architecture is designed with scalability and interoperability in mind, allowing for potential integration with other academic management platforms. It also ensures that the system is adaptable to varying institutional needs while maintaining core functions such as automation, reliability, and data security.

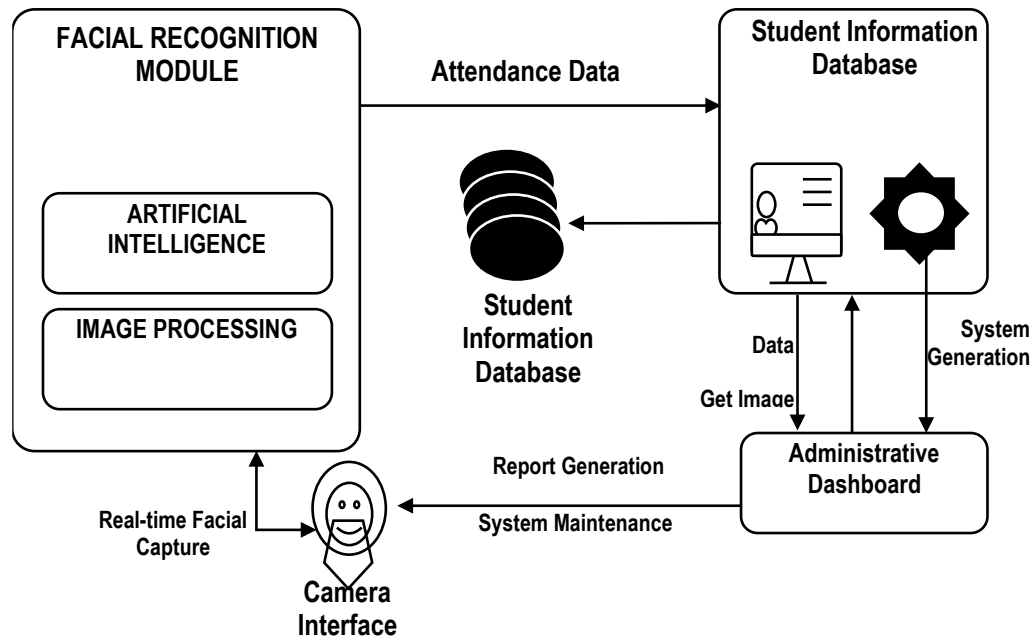


Figure 1: The Architecture of the System

Proposed Algorithm for Face Recognition and Attendance taking

1. Load trained face encodings from the database.
2. Initialize the webcam and start capturing frames.
3. For each frame:
 - a. Detect faces using Haar cascade or CNN detector.
 - b. For each detected face:
 - i. Encode face using FaceNet/dlib.
 - ii. Compare with known encodings using cosine similarity.
 - iii. If match found:
 - a. Retrieve student ID.
 - b. Check if already marked for the day.

- c. If not, mark attendance with timestamp.
 4. Display recognition results on the screen.
- Repeat until session ends.

Software Description

The system was developed primarily with Python due to its robust support for artificial intelligence and computer vision tasks. Key libraries such as OpenCV, face recognition, and NumPy enabled efficient real-time facial detection and identification. Python's versatility and cross-platform compatibility also made it suitable for backend processing and integration with web frameworks like Flask. The frontend was created using HTML5, CSS3, and JavaScript, ensuring a responsive and user-friendly interface for tasks



like student registration and attendance tracking. MySQL was used to manage the system's data, offering a secure and organized structure for storing student and attendance information. Adobe Dreamweaver was utilized as the integrated development environment (IDE), aiding in the design of the user interface and streamlining code management.

Hardware Requirements

The following hard specifications are recommended for smooth deployment of the developed system.

Camera Module: A high-resolution camera (at least 1080p) to capture facial images accurately, minimizing issues related to poor lighting or image blur (Azamar-Avilés *et al.*, 2024).

Server/Workstation: A machine with a multi-core processor (e.g., Intel Core i7 or higher) and at least 16GB of RAM for model training and inference. GPU acceleration (e.g., NVIDIA CUDA cores) is recommended for deep learning tasks.

Local Storage/Cloud Server: SSD storage to accommodate facial datasets, model weights, and attendance logs securely. Cloud integration may offer additional scalability (Gomathi *et al.*, 2024).

Display and Input Devices: A monitor and keyboard/mouse setup for system configuration and management.

Flowchart of the System

Here's a brief summary of the process:

1. **Start** the system.
2. **Encode faces from the database** (i.e., load and prepare known face data).
3. **Initialize the camera** and begin capturing users' faces.
4. **Detect faces** in the video feed.
5. **Encode detected faces and compare them with the known encodings.**
6. **Display recognition results** for each detected face.
7. **Check if the user has already been marked for the day:**
 - i. If **yes**, **end** the process for that user.
 - ii. If **no**, mark as **absent** and **email the student.**
8. **End** the process.

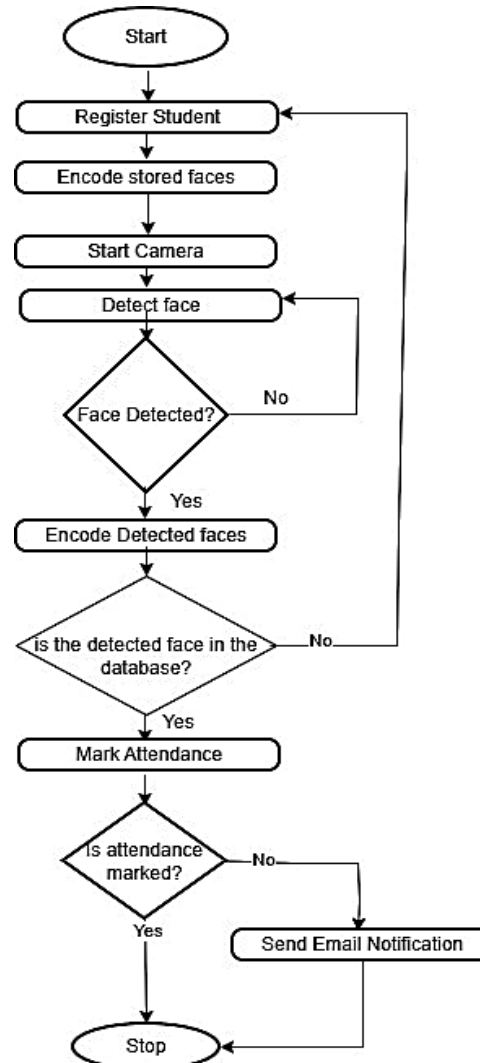


Figure 2: Flowchart of the system

RESULT AND DISCUSSION

Once the deployment was completed successfully, the system was tested using the provided data. In order to make sure the outcomes were the same or very close to it, we compared the predicted and actual results throughout the testing process. Therefore, the outcome:



Table 1: Comparison between Expected and Actual Results

TESTED CONDUCTED	EXPECTED RESULT	ACTUAL RESULT
User clicks on "Create Account"	A registration form should appear allowing student users to input details and upload facial images.	The registration form appeared and users successfully entered their details and uploaded facial images.
Instructor clicks on "Take Attendance"	Webcam should activate, scanning and identifying student faces in real-time.	The webcam activated and recognized registered students accurately, logging attendance automatically.
Student appears in front of webcam	The system should detect the face, match it with stored data, and log the attendance.	The student was successfully recognized within 1_50 seconds and their attendance was logged.
Admin clicks on "Generate Report"	The system should generate downloadable reports (PDF/CSV) based on attendance data	Attendance reports were generated correctly in the selected format (PDF)
System checks for absent students and sends email alerts The system should	The system should identify absent students after attendance session and send email notifications.	The system successfully flagged absent students and automatically sent alert emails via SMTP protocol.

The AI-powered facial recognition attendance system was thoroughly tested to assess its accuracy, speed, and overall performance. The system demonstrated a high recognition accuracy of 92–97%, with quick attendance logging times of 1-50 seconds per student. It accurately matched student faces against stored records, even under varying lighting and angles, though recognition slightly declined in poor lighting or when faces were partially covered. The database reliably stored attendance logs, and the reporting module successfully generated records based on filters

such as date or student ID. Export options in PDF, Excel, and CSV formats were also verified. The system's email notification feature worked as expected, sending alerts to absent students using the SMTP protocol, provided internet access was available. Discussion of the results emphasized the system's benefits over manual methods such as faster processing, reduced human error, and improved security. It also highlighted areas for improvement, like lighting sensitivity and hardware quality. Overall, the system proved to be a dependable and scalable solution for automated attendance in educational settings.

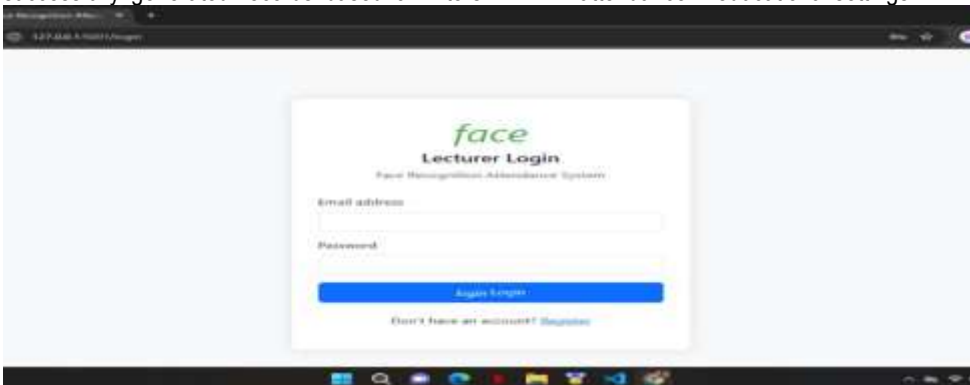


Figure 3: Login interface for Lecturers or Teachers

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Main Menu Implementation

Upon successful login and validation, the main menu pops up and provides an interface that enables users to navigate from one module to another and also to perform basic system functionalities. Following the completion of the system's design, it was put into action and tested

for syntax errors. Testing, documentation, and execution in a XAMPP server environment were all part of the plan. The application may be launched after extensive testing. Upon implementation the main menu interface was found to be as shown in the figure 4.

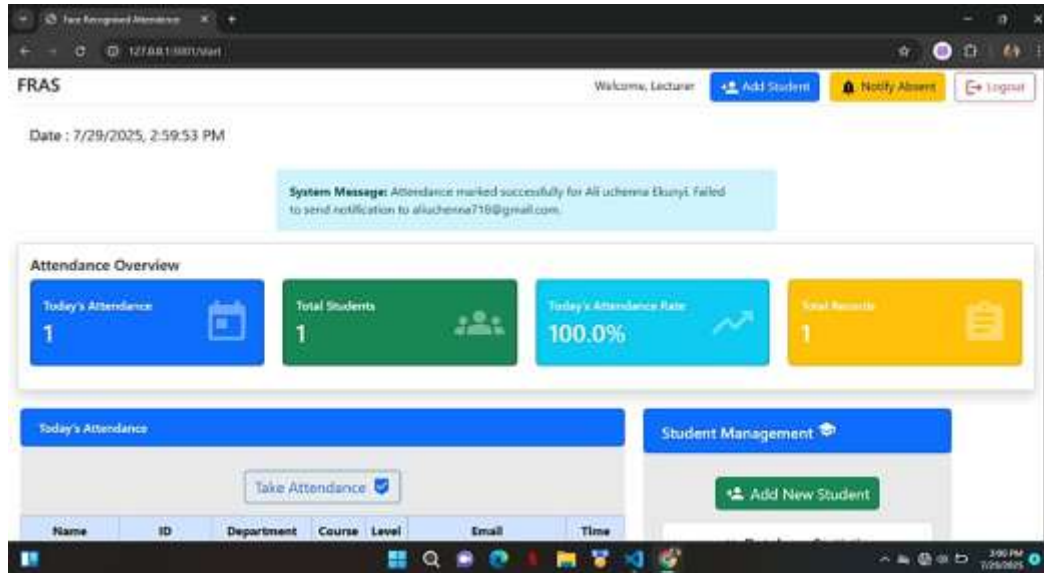


Figure 3: Dashboard of the designed system

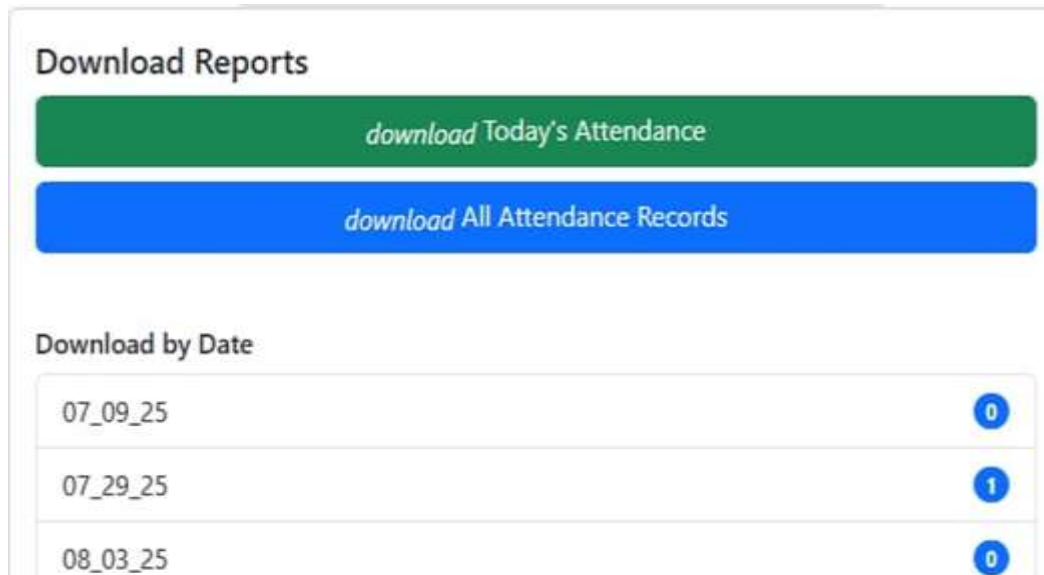


Figure 4: Screenshot showing attendance record by their dates.

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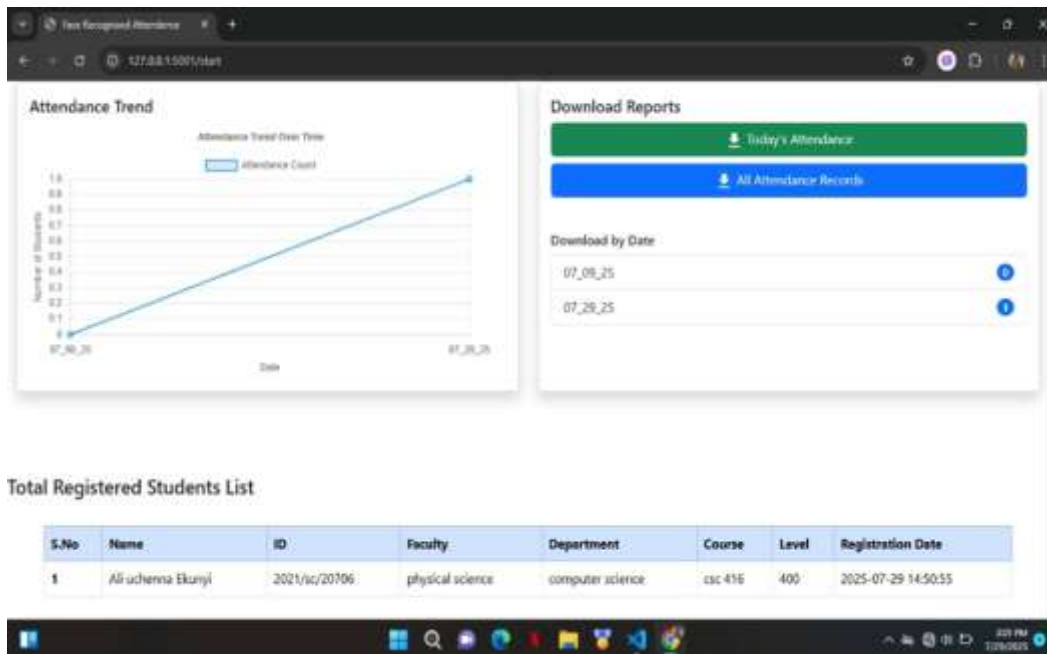


Figure 5: Graphical representation of the attendance rate amongst students

CONCLUSION

The implementation of an AI-powered facial recognition system for student attendance represents a major step forward in educational technology. It replaces outdated manual methods with a fast, contactless, and automated solution that improves accuracy and saves time. By recognizing students through pre-registered facial data, the system logs attendance in real time without human involvement. This reduces impersonation, enhances security, and allows lecturers to focus more on teaching. For students, it offers a seamless and hygienic experience with no need for ID cards or physical sign-ins. Administrators benefit from a centralized platform that enables real-time monitoring, report generation, and easy system integration. The solution supports large-scale deployment, making it ideal for institutions with high student volumes. Overall, it promotes transparency, efficiency, and academic integrity across campuses.

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