Enhancing Attendance Management with Facial Recognition: A Web and Mobile-Based System

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ORIGINAL RESEARCH

Abstract— The development of a facial recognition-based attendance management system is presented in this study. By leveraging facial recognition technology, the system offers a reliable, efficient, and secure alternative to traditional methods such as manual roll calls and paper-based records, which are prone to errors and manipulation. The system employed an Android application to capture students' facial images, which are then processed using advanced Image Processing APIs, including OpenCV and the Python Face Recognition library, to identify and authenticate individuals. The Dlib open-source library which uses a Histogram of Oriented Gradients (HOG) and linear Support Vector Machine (SVM) was used as the face detection model. The system's performance was evaluated using the False Acceptance Rate (FAR) and False Rejection Rate (FRR) metrics. The results indicated a FAR of 0%, ensuring the system effectively blocks illegitimate attendance entries. However, an FRR of approximately 5% was observed, highlighting challenges in accurately identifying legitimate users under varying conditions such as changes in lighting and facial expressions.

Keywords— Attendance Management, False Acceptance Rate (FAR), False Rejection Rate (FRR), OpenCV

1 INTRODUCTION

Traditional methods of attendance management such as paper-based systems, are prone to errors, manipulation, and are labor-intensive, making them inadequate for accurate and secure attendance monitoring Ajayi *et al*. (2024); (Ismail *et al*., 2022; Jha et al., 2023). While traditional attendance management systems rely on manual data entry, cards and biometric scans (Gomes *et al*., 2020), facial recognition utilizes advanced computer vision and machine learning techniques to automate the attendance process (Golasangi *et al*., 2024; Karthick *et al*., 2024).

Despite the success of facial recognition technique in attendance management, some challenges have been identified which include: inaccuracy due to environmental factors like lighting (Kale *et al*., 2024; Vardhan *et al*., 2025), high computational resources leading to inaccessibility, especially in a resource-constrained environment (Osazuwa-Ojo & Elaigwu, 2024), ethical and privacy concerns (Vardhan *et al*., 2025).

This study leverages facial recognition technology to automate the attendance process. This system not only reduces the risk of impersonation and record mismanagement but also enhances the efficiency of attendance tracking by ensuring real-time, accurate data management. The system was implemented on a web- based application, catering for various types of users, including administrators, instructors, and students, with different access levels.

Dang (2023) presented a smart attendance management system based on facial recognition technology. The study utilized an improved FaceNet model based on MobileNetV2 backbone resulting in an optimal model for low-resourced devices. The performance of the system showed an accuracy of 95% detection of faces and a fast inference speed of 25 Frames per second. However, there is need for improvement in the security of the system. Kamil *et al*. (2023) reported a web-based attendance system based on face recognition and face mask detection. A Support Vector Machine (SVM) was trained on face images dataset for recognition. Facial images were preprocessed using the Open-Source Computer Vision. The study recorded an accuracy of 81.8% and 80% accuracy for face mask detection.

In an attempt to mitigate the challenge of face spoofing attacks and portability in face recognition attendance management system, Surantha and Sugijakko (2024) presented a lightweight facial recognition attendance system with liveness detection method. The system was designed to run on a Raspberry Pi, and incorporated a transfer learning method using MobileNetV2 model. The system recorded an improved average processing time of 0.6s and an accuracy of 96% and an F1 Score of 97% for live subjects.

Jha *et al*. (2023) presented a real time attendance management system using the Haar cascade algorithm for facial detection and recognition. Facial features from individuals were extracted from input images and video frames. A confidence score to determine individual identity was calculated using the Local Binary Patterns Histogram (LBPH) algorithm. Authors in (Gode *et al*., 2023) equally employed the LBPH algorithm while

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Section B- ELECTRICAL/COMPUTER ENGINEERING & RELATED SCIENCES

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capturing of faces from a webcam was achieved using the Viola-Jones technique.

A video-based facial recognition attendance system was reported by Chaudhari *et al.* (2023). Facial features were extracted using FaceNet while a multi-task cascaded convolutional neural network (MTCCNN) model was used for the recognition. The system's performance recorded high accuracy even when the images were of low quality. A high accuracy of 94.85% was recorded. Similarly, Al-Amoudi *et al.* (2022) utilized FaceNet and MTCCNN. The system achieved an accuracy of 100% for face detection and 87.03% for face recognition.

Authors in Nguyen-Tat *et al.* (2024) leveraged the power of advanced computing hardware, NVIDIA Jetson Nano integrated into a face recognition-based attendance management system. A raspberry Pi camera and the Haar Cascade classifier were also integrated. An enhanced overall accuracy was recorded.

Kale *et al.* (2024) reported a real-time facial recognition-based attendance marking system using OpenCV's Haar Cascade classifier for face detection and the K-Nearest Neighbours (KNN) algorithm for face recognition. An accuracy of 92% was recorded under optimal lightning conditions and a decrease of 80% under poor lighting conditions. Although a response time of 2 seconds was reported, this speed may not be sufficient in scenarios with a large number of attendees.

In an attempt to address the challenge of high computational resources associated with facial recognition attendance systems, authors in Osazuwa-Ojo and Elaigwu (2024) developed a two-step model authentication approach. A maximum accuracy and precision of 98.7% and 98.82% respectively, was recorded. However, challenges related to computational demands, quality of images, false negatives and scalability were mentioned as its weaknesses.

From the literature reviewed, several techniques have been applied in attendance management systems, however, the balance between the efficiency and security of systems remains an open area for research. This study therefore seeks to improve the efficiency and security of facial recognition-based systems using cost-effective methods.

2 METHODOLOGY

2.1 ATTENDANCE MANAGEMENT SYSTEM ARCHITECTURE

The architecture diagram of the developed system is as shown in Fig. 1. The system is made up of the main Service unit, Image Processing Application Programming Interface (API), web application, and the Android Application.

The Main Service Unit: serves as the system's main hub. It oversees essential functions including subject management, attendance monitoring, and user administration. It communicates directly with the PostgreSQL database. It was developed using Java with Spring Boot technology.

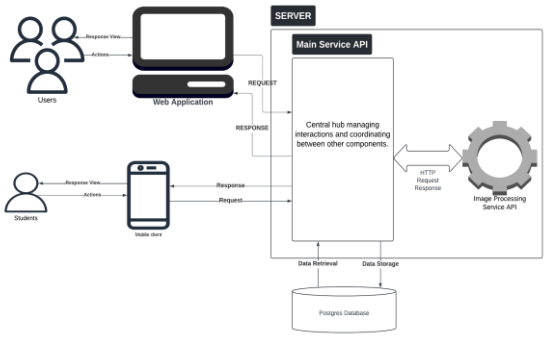


Fig. 1. System Architecture diagram of the facial recognition-based attendance system

The Image Processing API: this unit performs image processing operations. It is used by the main service to analyze images and carry out facial recognition functions. Python with FastAPI and the face_recognition library were used to achieve this.

The Web Application: this web-based tool acts as the system's user interface for controlling several features, it is used to examine records and maintain user accounts. It was developed using JavaScript/TypeScript framework 'React'.

Android Application: allow students to use their mobile devices to record their attendance.

2.2 SYSTEM WORKFLOW

Users may engage with the system through the mobile application and the web application; calls are submitted to the main service API using these applications. The main service API processes the queries, sends appropriate responses, and refreshes the user interface. The main service API as the system's primary processing unit communicates with the database to store, retrieve, and update records. The API uses HTTP requests and responses to interact with other services to carry out operations that may need more processing or integration.

2.3 ALGORITHMS AND FLOW DIAGRAMS

Fig. 2 shows the flowchart of the attendance management process. The developed system used the Python face_recognition library, which is built on deep learning and dlib. The library was used to identify the region of the image that contains a face, perform feature extraction, encode unique facial features into a numerical representation, and then compare the encoded features with those in the database to verify the user's identity. Once a face is recognized, the system automatically logs the attendance of the individual. Attendance is validated only if the recognition confidence exceeds a certain threshold, thereby reducing errors. To secure the system, a password encryption method was used. The system hashes and stores user passwords securely using BCrypt.

3 SYSTEM IMPLEMENTATION

The facial recognition algorithm, mobile application,

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online application, and core service API are all designed as distinct, modular units inside the system. This makes it simpler to int before combining them into the whole.

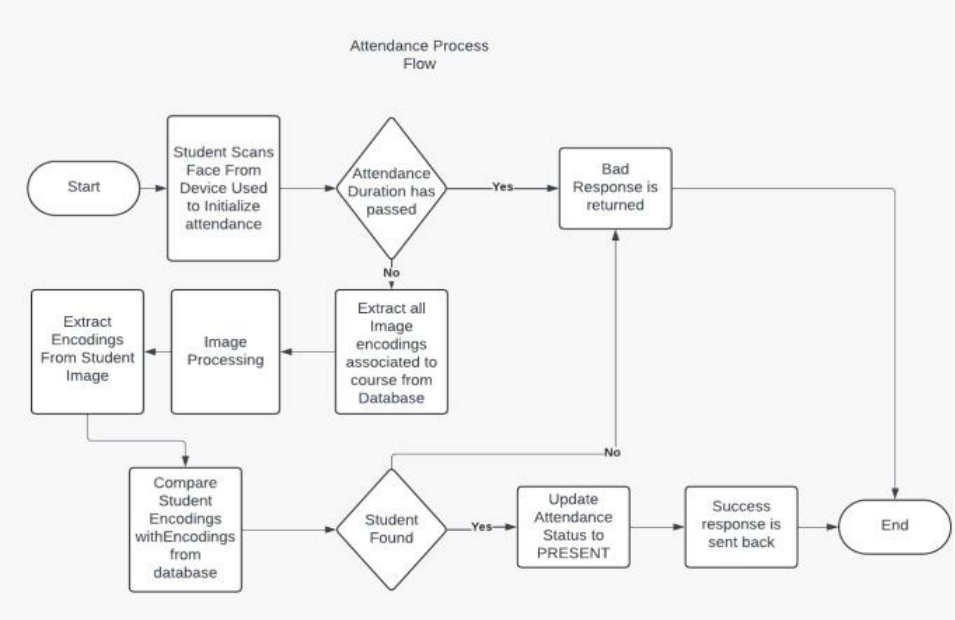


Fig. 2. Flowchart of the Facial Recognition-based Attendance Management System

Face Recognition Algorithm:

The system employed the Python face_recognition library, which is built on deep learning and dlib. This library was used to identify faces in images, encodes their characteristics, and compare saved data to identify individual users. The algorithm identifies the region of the image that contains a face, extracts and encodes unique facial features into a numerical representation, then compares the encoded features with those in the database to verify attendees' identity.

Matching and Validation:

Once a face is recognized, the system automatically logs the attendance of the individual provided the recognition confidence exceed a certain threshold.

Security Algorithms:

The system hashes and stores user passwords securely using BCrypt. This was designed to be computationally costly in order to slow down brute-force assaults, BCrypt is a pass-word-hashing method that uses a salt to prevent rainbow table attacks. To provide safe system access, the system integrates JWT for authentication and authorization.

Database Integration

To manage, store, and retrieve data, the PostgreSQL database was coupled with the primary service API.

Performance Evaluation Metrics

The accuracy and responsiveness of the Application Programming Interface (API) were assessed by calculating the average response time, False Acceptance Rate, and False Rejection Rate as given in equations (1) and (2). These were determined for varied class sizes (i.e. concurrent users) and functionality.

$$\text{FAR} = \frac{Number\ of\ FP}{Number\ of\ FP + Number\ of\ TN} \times 100 \quad (1)$$

$$\text{FRR} = \frac{Number\ of\ FN}{Number\ of\ FN + Number\ of\ TP} \times 100 \quad (2)$$

where: FP = False Positives

TN = True Negatives

FN = False Negatives

TP = True Positives (Jahangir *et al.*, 2021)

4 RESULTS AND DISCUSSION

Fig. 3 shows the developed web application login page to authenticate users. Fig. 4 shows the attendance record page, where lecturers can generate an attendance sheet after inputting fields such as subject and date. The Android application, which allows students to mark attendance from code generated when the lecturer initializes attendance, is shown in Fig. 5.

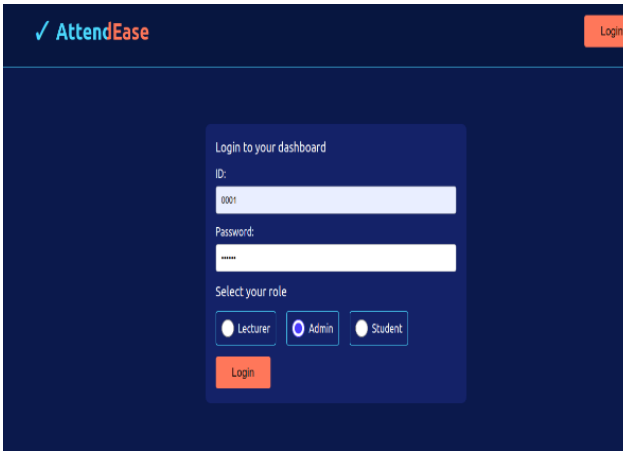


Fig. 3. The developed attendance system login page

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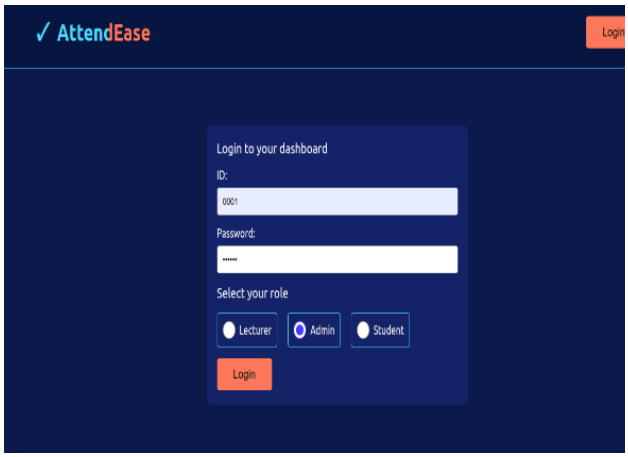


Fig. 4. The developed attendance record page



Fig. 5. The developed Android Attendance Page

4.1 SYSTEM'S RESPONSE TIME

Fig. 6 displays the average response time for the different functions of the system under varying concurrent user request loads. Performance metrics for the photo uploading and login functions were evaluated between 30 and 200 simultaneous users. All tests were carried out with 1 server endpoint with four cores.

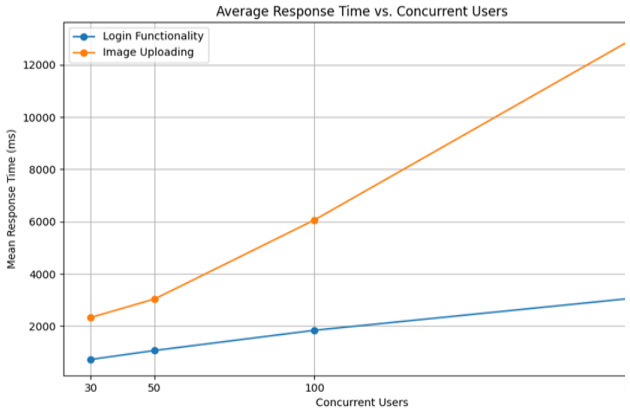


Fig. 6. Graph of System's Average response time versus number of concurrent users

Fig. 6 shows the system can handle modest user loads with high accuracy and response times. Response times and False Rejection Rates, however, become less predictable as the number of users or picture comparisons rises, suggesting areas for possible improvement in resource management and system optimization.

4.2 SYSTEM'S FALSE ACCEPTANCE AND FALSE REJECTION RATE

Table 1 shows the False Acceptance Rate (FAR) and False Rejection Rate (FRR) of the API under varied class sizes using a range of picture encodings for comparison. The result showed that the system exhibits excellent accuracy with smaller class sizes, maintaining a 0% false rejection rate for class sizes up to 200 students.

However, when the class size increases to 300, the FRR rises to 5.3%, indicating that as the number of comparisons grows, the likelihood of incorrect rejections increases. This is because the number of instances of individual images is limited, leading to a higher false rejection rate. The higher the variability in individual images, the better the recognition output.

In assessing the False Acceptance Rate (FAR), every test scenario of the system returned a FAR of 0%, indicating a high level of security and resilience in correctly identifying students without inadvertently allowing undesirable users.

Table 1. False Acceptance and False Rejection Rate of the API

Class Size	Image Encodings to Compare	False rejection Rate (%)	False Acceptance Rate (%)
50	91	0	0
100	169	0	0
200	341	0	0
300	300	5.3	0

5 CONCLUSION

A facial recognition-based attendance management system was developed. The system can be used for real-time attendance marking in any educational institution. The system recorded a FRR of 5.3% for 300 concurrent users and 0% FAR. This indicates that the resilience of the facial recognition system to various ambient conditions needs to be strengthened, and the image processing can also be improved. Detection of students with facial obstructions such as glasses, masks, and poor lighting conditions was not covered. Hence, future research can work on these challenges and also incorporate liveness detection to prevent spoofing attacks.

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