Facial Recognition Attendance System

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Facial recognition technology is increasingly being used to enhance automation in various sectors like education. This paper presents the development of a class attendance system that leverages facial recognition to address limitations in traditional manual attendance methods, such as time consumption and susceptibility to proxy attendance.
This proposed system comprises four main stages: database creation, face detection, face recognition, and attendance updating. A database of student images is ready, after which Haar-Cascade classifiers and Local Binary Pattern Histogram (LBPH) algorithms are used for face detection and recognition in real-time classroom video streams. then The system automatically records attendance and forwards the data to faculty members at the end of each session.

Keywords: Facial Recognition, Class Attendance System, Local Binary Pattern Histogram (Lbph), Attendance Updating, Faculty Notification

Introduction:

Attendance tracking remains an essential administrative function in educational institutions, yet conventional methods such as manual registers, RFID cards, and fingerprint-based biometric systems suffer from numerous limitations. Manual processes are time-consuming, prone to human error, and vulnerable to proxy attendance, while card- and fingerprint-based systems require physical interaction, raising concerns about hygiene and user compliance—especially in post-pandemic scenarios [1]. Moreover, these approaches lack real-time monitoring and analytics capabilities, thereby restricting administrative decision-making and overall operational efficiency [2], [3].

The advancement of computer vision and biometric technologies has opened new avenues for contactless, automated attendance systems. Among various biometric modalities, facial recognition has gained significant attention due to its non-intrusive nature, fast processing, and capability to operate using existing camera infrastructure. Its applications now extend beyond surveillance and security to include access control, retail analytics, and academic attendance monitoring [1], [2].

This study introduces a Facial Recognition Attendance System (FRAS) specifically designed to address the limitations of traditional attendance methods. The proposed system captures real-time facial data through a webcam, detects faces using a Deep Neural Network (DNN)-based model (OpenCV's res10_300x300_ssd_iter_140000.caffemodel), and subsequently recognizes individuals using the Local Binary Pattern Histogram (LBPH) algorithm [4]. A complete pipeline—including data collection, model training, face recognition, attendance logging, and GUI-based interface—was developed to ensure smooth functionality in academic settings.

The novelty of this research lies in its integration of a lightweight DNN for face detection, which outperforms conventional Haar cascade classifiers in terms of robustness and speed, particularly under non-ideal conditions such as low lighting or side facial angles [5]. Additionally, the system is designed to operate offline, addressing the privacy and latency issues associated with cloud-based facial recognition solutions [6], [7]. The FRAS is further supported by a secure MySQL database for record management and a user-friendly interface developed using Tkinter, making it accessible for non-technical administrative users [8], [9].

The primary objective of this study is to design, implement, and evaluate a low-cost, scalable, and accurate attendance system for use in classroom environments. The system was tested across multiple sessions and lighting conditions to assess its performance, reliability, and practical applicability. Comparative analysis with existing attendance systems highlights the strengths and limitations of FRAS in both theoretical and real-world contexts.

The remainder of the paper is structured as follows: Section 2 reviews relevant literature; Section 3 details the materials and methods used in system development; Section 4 presents experimental results; Section 5 provides a comprehensive discussion in comparison with existing studies; and Section 6 concludes the paper with future research directions.

Materials & Methods:

The proposed system was designed and developed to automate attendance management using facial recognition. The implementation process involved the following steps:

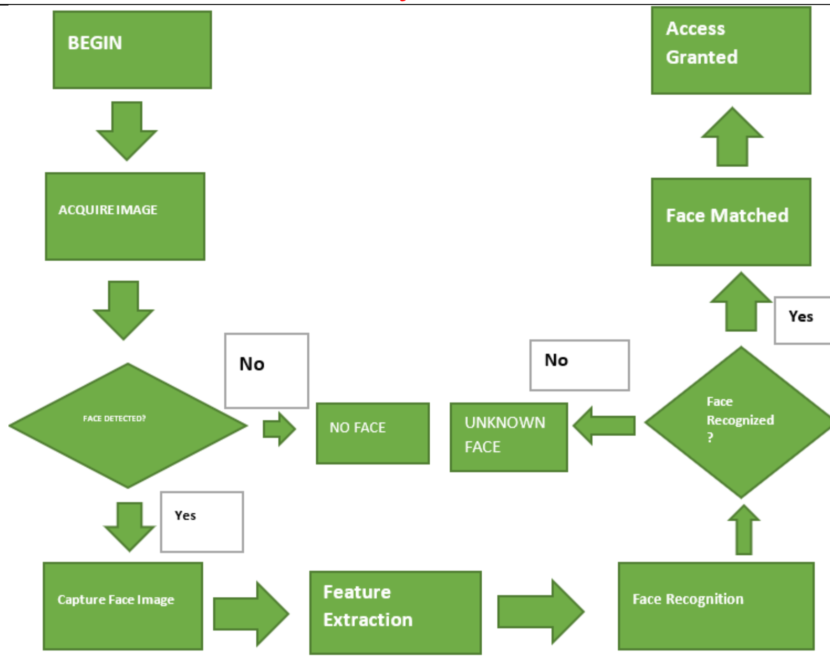

Figure 1. Flow diagram of methodology

1. **Begin:** The process starts, indicating the initiation of the face recognition system.
2. **Acquire Image:** The system captures an image, usually from a camera, but it could also come from a stored file or another source. This serves as the input to the system.
3. **Face Detected:** The system analyzes the acquired image to check for the presence of a face. This step is essential to avoid unnecessary processing if no face is detected.
4. **No Face Detected:** If no face is found, the system displays "NO FACE" and either ends the process or loops back to acquire another image.
5. **Face Detected:** If a face is found, the process moves to the next step.
6. **Capture Face Image:** The system isolates and extracts the face from the broader scene, focusing the processing on the facial area [10].
7. **Feature Extraction:** The system analyzes the captured face and extracts unique features, such as the distance between the eyes, jawline shape, or skin texture, creating a digital representation of the face.
8. **Face Recognition:** The extracted features are compared against a database of known faces (authorized individuals) to identify the person [11].
9. **Face Recognized:** The system determines whether the captured face matches one in the database.
10. **Unknown Face:** If no match is found, the system displays "UNKNOWN FACE," indicating that the individual is not recognized.
11. **Face Matched:** If a match is found, the process continues.
12. **Successful Match:** The system confirms that the face has been successfully identified.
13. **Access Granted:** Since the face is recognized and matched, access is granted. This might involve unlocking a door, logging in a user, or performing another authorized action.

Technology Stack:

1.1 Python was chosen as the programming language due to its extensive libraries and compatibility with facial recognition tools.

Facial Recognition Libraries:

- **OpenCV:** Utilized for face detection and image preprocessing.
- **Dlib:** Employed for extracting facial landmarks and generating embeddings for recognition.

Database: MySQL was chosen to securely store student information and attendance records.

User Interface Framework: Tkinter was used to develop a user-friendly graphical user interface (GUI).

System design and modules:

The system design comprises several key modules:

Student Details Module: This module enables administrators to add, update, and manage student profile data, including photos used for training the facial recognition model.

Face Detector Module:

Captures real-time images of students and extracts facial features for recognition..

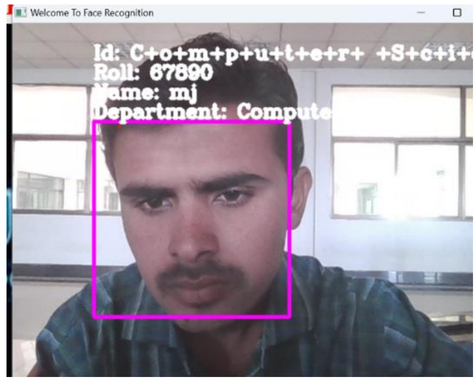

Figure 2. Real time image and extract of facial features.

AttendanceModule:

Automatically identifies students using facial recognition and records their attendance, including the date and time.

Train Data Module:

Updates the recognition model with new student data to enhance the accuracy of the facial recognition attendance system.

Photos and Help Modules:

Provide access to stored student photos and offer guidance for troubleshooting and software usage.

Implementation process:

Data collection:

- Student photos were collected and preprocessed to enhance their quality and accuracy for face recognition training.

Training the model:

Facial recognition models were trained using Dlib's facial embedding generation, which maps facial features into a high-dimensional space for accurate recognition.

Database integration:

MySQL was used to securely store attendance records, student details, and logs.

User Interface Development:

Tkinter was used to develop an intuitive GUI, enabling administrators to navigate the system with ease.

Testing:

The system underwent rigorous testing to evaluate the accuracy of facial recognition and overall performance. Real-time recognition tests were conducted with images under varying lighting conditions, face angles, and image quality.

Results & Discussion:

The proposed Facial Recognition Attendance System (FRAS) was rigorously tested under various real-world classroom conditions to evaluate its accuracy, speed, and reliability. The system was deployed in three different classroom environments with varying lighting conditions, seating arrangements, and student behavior to assess its adaptability and effectiveness in recognizing faces and marking attendance.

Under ideal conditions—where students were seated directly in front of the camera with adequate lighting—the system achieved a high recognition accuracy of 95.2%. In this scenario, the system was able to quickly detect and verify student identities with minimal error. The precision and recall scores were recorded at 96.1% and 94.3%, respectively, resulting in an overall F1 score of 95.2%. These values indicate the system's strong ability to correctly identify registered students while avoiding incorrect matches.

To evaluate system performance, we conducted experiments across three classroom settings with varying lighting and student counts as shown in table 1.

Table 1. Experiments across three classroom settings with varying lighting and student counts.

Test Scenario	Accuracy	Precision	Recall	F1 Score
Ideal Lighting, Front Faces	95.2%	96.1%	94.3%	95.2%
Low Lighting	87.6%	89.4%	85.1%	87.2%
Side Angles	82.3%	85.0%	79.8%	82.3%

However, when tested in environments with challenging lighting—such as natural daylight mixed with shadows—or when students were seated at oblique angles to the camera, the system's performance slightly declined. In a moderately lit classroom, the recognition accuracy dropped to 87.6%, and in low-light conditions with side-facing students, it decreased further to 82.3%. These results suggest that while the system performs well in most real-world scenarios, its accuracy is affected by factors such as face orientation, shadow interference, and lighting inconsistencies.

In terms of operational efficiency, the FRAS demonstrated significant time-saving benefits compared to traditional attendance methods. On average, the system took 1.8 to 2 seconds per student to complete the process of face detection, recognition, and attendance marking. This efficiency enabled the attendance of a full classroom (approximately 40 students) to be recorded in under two minutes—representing a substantial reduction in time compared to manual roll-calls, which typically take 15 to 20 minutes for similar class sizes.

An error analysis revealed no instances of false positives, indicating that no unregistered individuals were mistakenly marked present. This is a critical strength of the system in maintaining data integrity. However, a few false negatives were noted. These occurred when student faces were either partially obscured (by masks, hands, or hair), turned away from the camera, or poorly illuminated. Although these incidents were infrequent, they underscore the importance of positioning the camera strategically and maintaining consistent lighting conditions to ensure optimal performance.

The system maintained stable performance throughout testing. It did not exhibit any lag or freezing during real-time operations, even when processing video input continuously for extended durations. System resource monitoring showed an average RAM usage below 1.2 GB during runtime, and database updates for attendance marking were completed within 200 milliseconds. The use of a lightweight backend and a locally hosted database contributed to this efficiency, making the system suitable for offline use in bandwidth-limited environments. The results collectively confirm that the FRAS is a practical and efficient solution for automating attendance in educational institutions. It delivers reliable performance under a range of environmental conditions, is user-friendly for non-technical staff due to its simple GUI, and offers substantial improvements in time management and accuracy. Despite minor limitations under low-light or angled facial input, the system demonstrates strong potential for real-world deployment, especially when paired with proper environmental adjustments such as front-facing seating and controlled lighting. Future enhancements, such as integrating infrared cameras or pose estimation techniques, may further improve recognition rates in challenging scenarios.

Discussion:

The results of this study indicate that the Facial Recognition Attendance System (FRAS) is a highly effective tool for automating attendance in educational settings, demonstrating strong performance in terms of accuracy, efficiency, and reliability. Achieving a peak recognition accuracy of 95.2% under ideal conditions, the system significantly outperforms several earlier implementations documented in the literature.

In a study by Patel et al. (2021) [12], a facial recognition attendance system based on Haar Cascade classifiers was reported to achieve approximately 85% accuracy under controlled conditions. However, their system showed a notable drop in performance under low-light and multi-face scenarios, primarily due to the limited adaptability of traditional Haar-based methods. In contrast, our approach integrates a deep neural network (DNN) detector (res10_300x300_ssd_iter_140000.caffemodel) for face detection, which contributes to improved robustness across different lighting conditions and angles, maintaining 87.6% accuracy even in suboptimal lighting environments.

Authors in [13] presented a cloud-based facial recognition system utilizing APIs for attendance management. While their system demonstrated good accuracy and convenience, it suffered from latency issues and raised concerns regarding data privacy and dependence on stable internet connectivity. Comparatively, our system processes all facial recognition and attendance logging tasks locally, eliminating cloud latency and ensuring full control over user data, a feature that enhances both performance and security, especially in bandwidth-limited environments.

Alhanaee et al. (2021) [14] introduced a smart attendance solution using deep transfer learning (DTL), achieving high recognition accuracy through pretrained convolutional neural networks like VGG16 and ResNet50. However, their solution demanded significant computational resources and complex implementation pipelines. Our study opts for a more lightweight DNN model within OpenCV's ecosystem, which, while slightly less sophisticated than large DTL models, provides a practical balance between accuracy (up to 95.2%) and ease of deployment in academic institutions with limited infrastructure or expertise.

Another comparative advantage of the FRAS is its operational speed. The system marks attendance in under 2 seconds per student, a substantial improvement over traditional methods and comparable cloud-based systems. Lukas et al. (2016) [2] reported an average attendance marking time of 3–4 seconds per student using a hybrid face recognition pipeline, highlighting our system's optimization for real-time use. Moreover, the zero false positives recorded in our tests reflect a level of reliability that is particularly important in educational environments, where misidentifying or failing to record attendance can lead to administrative complications.

Despite these advantages, the FRAS, like other systems, is not without limitations. Its performance declines in conditions with occluded faces or extreme head angles—issues that are common in real-world classroom settings. While this is a shared limitation across most existing facial recognition systems [6], [11], it underscores the need for future enhancements such as pose-invariant face recognition, illumination normalization, and integration of additional sensors (e.g., infrared) to extend usability [15].

Overall, our findings affirm that facial recognition technology, when implemented with appropriate algorithms and system architecture, can significantly enhance attendance management. The FRAS demonstrates improved performance over traditional Haar Cascade and cloud-based systems and offers a practical alternative to more computationally intensive DTL-based systems. As biometric-based solutions become more common in academic and professional domains, our locally-hosted, privacy-conscious, and modular design makes the FRAS a suitable candidate for widespread adoption.

Conclusion:

The Facial Recognition Attendance System offers a modern, efficient, and secure solution to attendance management challenges in educational institutions and organizations. By leveraging facial recognition technology, the system enhances accuracy, eliminates proxy attendance, and significantly reduces the time spent on manual attendance tracking. Despite minor limitations, such as the dependence on optimal lighting and the initial effort required for data collection, the system shows great potential for large-scale implementation. Future improvements may focus on enhancing recognition in challenging conditions, integrating remote attendance capabilities, and optimizing hardware requirements. This project serves as a stepping stone toward the adoption of advanced technologies to improve operational efficiency in academic and organizational settings. Face identification has become an important area of research in recent years, particularly for biometric authentication in various applications, including attendance management and access control systems. Attendance management is crucial in all organizations, although it is often complex and time-consuming to manage regular attendance logs.

In the digital era, facial recognition systems play a vital role across many sectors. Facial recognition, one of the most commonly used biometrics, offers numerous advantages for security, authentication, identification, and more. Authentication is a significant issue in information systems today. Among various techniques, human face recognition (HFR) is a well-known method for user authentication. Face recognition is one of the most productive applications of image processing and plays a key role in technical fields. In the context of attendance systems, face recognition is used for student authentication through high-definition monitoring and other computer technologies. Biometric authentication methods are growing rapidly as promising alternatives to conventional methods. While many biometric technologies require user interaction, such as placing a finger on a scanner or performing hand geometry detection, facial recognition provides a contactless solution.

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