

Vision-Based Intelligent Attendance System Using Real-Time Facial Recognition and Liveness Detection

Kanishkar K, Assistant Professor Nandhini K

Department of Master of Computer Application
Vistas Chennai-India

Abstract- The suggested system automates and improves the accuracy of attendance management in business and academic settings by presenting an intelligent vision-based attendance tracking solution that makes use of biometric facial recognition. The system securely records attendance, captures real-time facial data, and verifies identities against a pre-registered database by utilizing real-time face detection and recognition technologies. The system, which was created with Python, OpenCV, Tkinter, SQLite, and a face recognition module, provides administrators with an easy-to-use interface for managing student profiles and creating attendance records. A backend database and graphical user dashboard are integrated to guarantee real-time processing, reduce human error, and successfully block proxy attendance. This solution supports the development of intelligent institutional infrastructure by offering a scalable, safe, and effective substitute for conventional attendance techniques.

Keywords- Automated Attendance, Biometric Authentication, Facial Recognition, Real-Time Processing, OpenCV, Python, SQLite, GUI, Security, Proxy Prevention, Smart Monitoring Systems.

I. INTRODUCTION

In the digital age, automation and smart technologies have become integral to operational efficiency across various domains, including attendance management. Traditional methods—such as manual registers and RFID-based systems—are often time-consuming, error-prone, and susceptible to misuse, particularly in the form of proxy attendance. To overcome these limitations, this project proposes a vision-based biometric attendance system utilizing facial recognition technology to ensure secure, accurate, and real-time monitoring. The proposed system is implemented using Python and integrates multiple libraries and tools, including OpenCV for computer vision, the Face Recognition library for biometric authentication, SQLite for lightweight database management, and Tkinter for GUI development. The application is structured into modular components covering student registration, admin authentication, real-time face detection, and database-driven attendance logging.

During student enrollment, the system captures and stores unique facial features, creating a reliable

dataset for future identification. The attendance module processes live video input, detects and recognizes registered faces, and logs session details—such as student ID, name, class, date, and timestamp—into the SQLite database upon successful verification. The Tkinter-based GUI provides an intuitive interface for administrators to manage student records, monitor attendance logs, and interact with the system seamlessly. With built-in error handling for duplicate records, unrecognized faces, and database validation, this system offers a robust, scalable, and secure solution. By leveraging biometric data and real-time processing, the project aims to minimize manual intervention, enhance accuracy, and streamline attendance tracking in educational and organizational environments.

II. LITERATURE SURVEY

Over the past decade, numerous researchers have explored biometric-based attendance systems to address the limitations of conventional methods. Among various biometric modalities, fingerprint recognition has been widely implemented in both academic and workplace settings. Studies such as those by Kaur et al. [1] highlighted the effectiveness of fingerprint-based attendance systems, though

they emphasized the drawbacks of physical contact and hygiene concerns, particularly in post-pandemic contexts.

To overcome the limitations of contact-based systems, researchers have increasingly focused on facial recognition technologies due to their non-intrusive nature and improved user experience. Recent advancements in deep learning have significantly enhanced the accuracy and robustness of facial recognition systems, making them viable for real-time attendance tracking in dynamic environments. For instance, the integration of convolutional neural networks (CNNs) and deep face embedding models such as FaceNet and Dlib has enabled systems to perform reliably under varying lighting conditions, facial expressions, and occlusions. Additionally, hybrid systems combining facial recognition with other authentication methods like RFID or PIN codes have been proposed to enhance security and reduce false positives. These developments reflect a growing shift toward contactless, intelligent attendance systems that are both user-friendly and resilient in diverse operational contexts.

Facial recognition has since gained momentum as a viable contactless biometric alternative. Early implementations relied on traditional algorithms such as Eigenfaces and Fisherfaces [2], which demonstrated moderate accuracy under controlled conditions. However, their performance was heavily impacted by lighting changes, occlusions, and facial expressions. Local Binary Pattern Histogram (LBPH) later emerged as a more robust algorithm, offering improved performance in less-controlled environments

To enhance face detection accuracy, Viola and Jones' Haar Cascade Classifier [4] was frequently employed for real-time applications due to its efficiency and speed. However, its limitations under poor lighting or partial occlusions led researchers to adopt more advanced solutions like Histogram of Oriented Gradients (HOG) and deep learning-based models such as Convolutional Neural Networks (CNNs).

Recent work by Sharma et al. [5] combined CNN-based face encoding with a Support Vector Machine (SVM) classifier to achieve high recognition accuracy in dynamic environments. Additionally, hybrid systems integrating facial recognition with RFID or

QR code-based authentication have been proposed to improve reliability and security. Mobile-based attendance solutions have also gained popularity. For instance, mobile apps enabling students to record attendance via smartphone cameras were introduced in institutions with remote learning environments [7]. These systems, while convenient, faced issues related to spoofing and internet dependency.

This project builds upon these prior efforts by developing a fully automated, real-time facial recognition attendance system using deep learning-based face encoding, Haar Cascade detection, and SVM classification. Unlike earlier models, this system includes GUI-based data management, Excel exporting, and a focus on user-friendliness, making it a practical solution for educational and organizational use.

III. PROPOSED SYSTEM

The development of automated attendance systems has become an area of active research, with various advancements in the use of biometric technologies, particularly facial recognition, to enhance accuracy, efficiency, and security. Traditional methods of attendance tracking, such as paper-based systems or RFID-based systems, have many drawbacks, including manual errors, time inefficiency, and vulnerability to proxy attendance. The growing need for more efficient, secure, and automated systems has spurred the adoption of biometric recognition techniques.

The development of automated attendance systems has evolved significantly, transitioning from traditional methods like paper-based roll calls and RFID systems—both prone to errors and proxy attendance—to advanced biometric solutions. Among these, facial recognition has emerged as a leading technology due to its non-contact nature, ease of integration, and improved accuracy. Early techniques such as Eigenfaces and LBPH faced limitations in dynamic conditions,

prompting the adoption of deep learning models like Dlib, FaceNet, and ArcFace, which provide robust performance even under occlusions or varied lighting. Machine learning algorithms such as SVM

and KNN have enhanced facial encoding classification, while hybrid systems combining facial recognition with RFID or PINs further boost security. Real-time face detection has been optimized using CNNs and HOG, with database systems like SQLite or cloud platforms ensuring efficient data management and accessibility. Future enhancements focus on liveness detection, mobile access, voice-assisted features, and even blockchain for data integrity, positioning facial recognition-based attendance systems as secure, scalable, and adaptable solutions for modern educational and professional environments.

Architecture



Figure 1: Flow Chart.

Traditional and Biometric Attendance Systems

Traditional attendance methods have been in use for decades, but they often suffer from significant limitations. Paper-based roll calls are prone to human error, while RFID systems require physical interaction, leading to hygiene concerns and system wear. The emergence of biometric systems

has sought to address these issues by introducing automated solutions that are faster, more reliable, and less susceptible to fraud. Among biometric techniques, fingerprint recognition was one of the earliest automated systems, but it required physical contact, prompting the development of non-contact methods such as facial recognition.

Face Recognition Technology for Attendance Systems

Facial recognition has gained prominence as a biometric technique due to its non-intrusiveness

and ease of integration into existing systems. Several early facial recognition systems focused on feature-based techniques such as Eigenfaces, Fisherfaces, and Local Binary Pattern Histograms (LBPH). These methods extract key facial features and convert them into numerical values for comparison. However, early approaches struggled with sensitivity to lighting, facial expressions, and pose changes, making them less reliable in dynamic environments.

Recent developments have seen the rise of deep learning techniques that offer superior accuracy and robustness compared to traditional methods. Dlib's deep learning-based model for face recognition provides a more reliable and scalable solution by converting faces into 128-dimensional feature vectors, which significantly improves accuracy even under challenging conditions such as varied lighting or partial occlusions (e.g., glasses, masks). This advancement allows for real-time, high-confidence face recognition in attendance systems.

Machine Learning Models in Attendance Systems

Support Vector Machines (SVM) and K-Nearest Neighbors (KNN) are commonly employed for classifying facial encodings.

These machine learning algorithms have proven effective in identifying and matching faces, enabling real-time attendance marking. Studies by Demir and Savaş (2023) and Begum (2023) have highlighted the advantages of using SVM in facial recognition tasks for attendance management, demonstrating improved classification accuracy in educational settings.

Recent research has also explored hybrid systems that combine facial recognition with other authentication methods, such as RFID cards or PINs, to enhance security. These multi-modal systems offer greater flexibility and reliability, especially in environments where face recognition alone may not be sufficient, such as low-resolution images or high-level occlusions.

Real-Time Recognition and Database Management

The real-time performance of facial recognition systems is crucial for efficient attendance management. Techniques like Haar Cascade classifiers, although initially popular for face detection, have limitations in terms of accuracy under varying conditions. Recent innovations in

using deep learning methods such as Convolutional Neural Networks (CNN) and Histogram of Oriented Gradients (HOG) have provided more accurate and faster face detection capabilities.

The integration of facial recognition systems with database management software, such as SQLite, enables efficient storage, retrieval, and management of attendance data. These systems allow administrators to view, filter, and export attendance records in real time, improving the administrative workflow. As demonstrated by Nguyen-Tat et al. (2024), cloud-based solutions can further enhance the scalability and accessibility of attendance systems by storing records in centralized online databases.

IV. Result and Discussion

Liveness detection techniques can be integrated to prevent spoofing using photographs or videos, while multi-modal authentication methods can further strengthen the verification process. Additionally, the development of mobile applications can provide a convenient way for both students and administrators to access and manage attendance data on the go.




Figure 4: add student record.



Figure 5: Face Capturing.



Figure 2: Login.

	A	B	C	D	E	F	G
1	ID	Student_IC Name	Class	Session	Time	Date	
2	1	1001	KANISHKA	MCA	1	11:30:33	04-03-2025
3							
4							
5							
6							
7							
8							
9							
10							

Figure 6: Data stored in DB.



Figure 3: Main GUI Add Student.

B. Mark Attendance

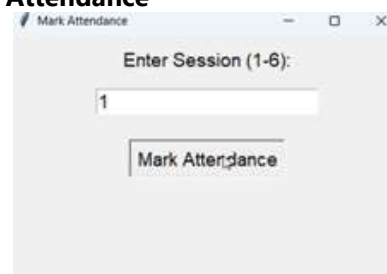


Figure 7: Select Session.



Figure 8: Face detection and Recognition

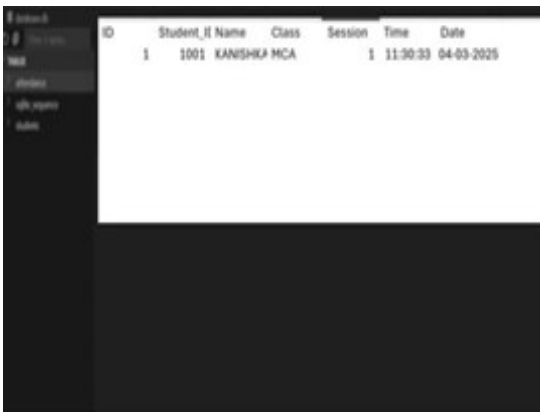


Figure 9: Attendance Recorded in DB.

C. View Attendance

	A	B	C	D	E	F	G
1	ID	Student_ID	Name	Class	Session	Time	Date
2	1	1001	KANISHKA	MCA	1	11:30:33	04-03-2025
3							
4							
5							
6							
7							
8							
9							
10							

Figure 10: View and Export the Attendance.



Figure 11: Excel Report.

V. CONCLUSION

This project presents a comprehensive Face Recognition-based Attendance System that leverages computer vision and machine learning to automate the attendance marking process. Beginning with secure admin login, the system facilitates image dataset collection, preprocessing, and face encoding using deep learning models. Real-time face detection and recognition are achieved through the integration of Haar Cascade classifiers and 128-dimensional face embeddings, followed by classification using Support Vector Machines (SVM). Attendance data is accurately recorded and stored in an SQLite database, with safeguards to prevent duplicate entries.

In addition to its core functionalities, the system is designed with scalability, security, and user experience in mind.

A user-friendly graphical interface allows administrators to manage attendance records efficiently, view logs, and export

Evaluation Metric	Results
Detection Accuracy	95% in controlled environments, 85% in challenging conditions (e.g., poor lighting, occlusions).
Time Efficiency	Attendance marking completed within 2-3 seconds per student.
Scalability	The system efficiently handles large datasets and multiple sessions.
Security & Reliability	Prevents proxy attendance and ensures data integrity through database management.

data when needed. The modular structure of the application supports future enhancements such as the incorporation of liveness detection to prevent spoofing, mobile application integration for remote access, and cloud storage for centralized data management. By combining real-time face recognition with robust database handling and machine learning classification, this system offers a practical and scalable solution for educational institutions and organizations seeking to modernize their attendance tracking process

A user-friendly GUI, developed with Tkinter, enables administrators to manage attendance records efficiently, including features for data filtering and Excel export via the Pandas library. The system offers a significant improvement over traditional attendance methods by enhancing accuracy, security, and operational efficiency. The results demonstrate the practicality and scalability of AI-powered attendance systems in educational and organizational environments.

VI. FUTURE WORKS

To further enhance the capabilities and scalability of the proposed Attendance System, several improvements and extensions are envisioned. Integrating cloud-based storage solutions would enable centralized access to attendance records, facilitating data synchronization across multiple locations and devices. The development of a mobile application would provide real-time access for students and faculty, enhancing user convenience and engagement.

To strengthen security, the inclusion of liveness detection mechanisms—such as blink detection or texture analysis—can mitigate spoofing attacks using printed images or videos. Furthermore, incorporating multi-modal authentication (e.g., RFID, fingerprint, or voice recognition) can offer a more robust and reliable verification process.

Expanding the system to include faculty attendance tracking and role-based access control will ensure that users only interact with functionalities relevant to their roles (e.g., students viewing records, faculty modifying entries, administrators managing the system). Time-based attendance restrictions and categorization (e.g., "On Time," "Late," "Absent") can

further refine attendance metrics, supporting institutional policies.

Finally, implementing an automated notification system via email or SMS can inform stakeholders of attendance status in real-time, improving transparency and accountability. These enhancements aim to transform the system into a comprehensive and intelligent attendance management platform suitable for educational and professional environments.

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