

Facial Recognition-Driven Attendance Systems: A Review of Deep Learning Approaches in Real- Time Academic Monitoring

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Abstract

With classrooms becoming smarter and institutions embracing automation, face recognition-based attendance systems are gaining traction as a modern alternative to traditional roll calls and biometric scans. This review explores 20 recent research papers focusing on how computer vision and machine learning are being used to improve the accuracy, efficiency, and usability of attendance systems. The studies reviewed range from classic techniques like Haar Cascades and LBPH to advanced deep learning models such as CNNs, FaceNet, and Vision Transformers. Many systems are designed for real-time use and integrate features like cloud storage, mobile apps, GPS-based validation, and role-based dashboards. Some even go further by incorporating emotion recognition or iris detection to handle challenges like mask usage or spoofing. While results are promising—with many models achieving over 90% accuracy—issues like lighting sensitivity, data privacy, and deployment in largescale environments still require attention. This review offers a clear snapshot of current progress and future possibilities in this growing field.

Keywords: Face Recognition , Attendance Monitoring, Deep Learning, Smart Classroom Systems

I. INTRODUCTION

In recent years, educational institutions have increasingly turned to technology to streamline routine administrative tasks—and attendance tracking is no exception. Traditional methods such as paper registers, RFID cards, or fingerprint scanners are often time-consuming, prone to errors, and vulnerable to misuse. As classrooms evolve into smarter, more connected environments, face recognition has emerged as a promising solution that combines convenience with automation. This literature review explores how researchers have applied computer vision and machine learning—particularly deep learning—to develop face recognition-based attendance systems. By examining 20 recent studies, this review highlights key technologies, implementation strategies, and performance outcomes, while also reflecting on the practical challenges involved, such as environmental variability, data privacy, and system scalability. The goal is to provide a clear and up-to-date overview of where this field stands today and to shed light on the opportunities and limitations that developers, educators, and institutions should consider when adopting such systems.

II. LITERATURE REVIEW

Paul et al. [1]Biometric attendance systems have grown and improved over time, focusing on the growing

need to combine face recognition with emotion detection for better accuracy and deeper insights into user engagement. Early methods like Eigenfaces and Fisherfaces struggled under realworld conditions, leading to the adoption of deep learning models like DeepFace and ArcFace. While these improved recognition accuracy, they often ignored emotional context. Emotion detection has also advanced—from basic handcrafted features to powerful CNNs and, more recently, Vision Transformers (ViTs), which handle subtle facial expressions more effectively. Previous systems like MobileFaceNet and FER2013 were either lightweight or emotion-focused, but rarely combined both tasks in real time. To bridge this gap, the authors propose a dual-path model using ResNet-50 for face recognition and ViT for emotion detection. With a custombuilt dataset and a web interface, the system shows strong performance, offering a practical, scalable solution for modern, real-time attendance tracking.

Ahmed et al. [2] Facial recognition is used here to solve the problems of manual student attendance systems through automation. Previous approaches using QR codes, RFID, and biometrics like fingerprints or iris scans often proved time-consuming or prone to misuse. Earlier face recognition systems, such as those using PCA, LBPH, YOLO V3, or VGG-16, showed limited accuracy or were computationally inefficient for real-time use. To address these issues, the authors propose a CNN-based system using FaceNet for deep feature extraction and an SVM classifier for accurate face identification. Histogram of Oriented Gradients (HOG) and Haar cascade algorithms are also used for face detection and counting. Through data augmentation, a more diverse dataset was created, enhancing the model's generalization. The system achieved a high accuracy of 99.75%, outperforming earlier methods. This work demonstrates a reliable and practical solution for real-time attendance, especially in educational settings, offering improvements in efficiency, accuracy, and user convenience.

Feroze et al. [3] Looks at how attendance systems in education have evolved, moving from traditional methods like manual registers and QR codes to more intelligent, automated systems using facial recognition. While older approaches helped speed up the process, they often lacked security, accuracy, and real-time capabilities. To address these gaps, the authors designed a smart attendance system that combines three facial recognition models—Eigenfaces, Fisherfaces, and Local Binary Pattern Histograms (LBPH)—and improves their accuracy through ensemble fusion. The system uses a Multitask Cascaded Convolutional Neural Network for face detection and integrates with Google Sheets for easy recordkeeping. Compared to previous methods, this system reduces human effort, works in real-time, and provides accurate results, achieving an overall accuracy of 82.1%. The paper also explores ethical concerns like privacy and user acceptance. Overall, it presents a reliable and practical solution for educational institutions aiming to modernize their attendance tracking systems.

Arsenovic et al. [4] Introduces FaceTime, a deep learningbased attendance system designed to overcome the drawbacks of traditional methods like RFID cards and fingerprint scanners, which often suffer from misuse, hardware dependency, or user error. The authors leverage a CNN cascade for accurate face detection, FaceNet to extract facial embeddings, and a Support Vector Machine (SVM) for final classification. A key strength of the study lies in its creative use of image augmentation—adding noise, blur, and random accessories (like glasses or mustaches)—to expand a small dataset and improve model generalization. Despite having access to only a few face images per employee, the system achieved an impressive 95.02% accuracy. It was deployed and tested over three months in a real-world company environment, running in parallel with an existing RFID system for validation. By integrating deep learning techniques into an everyday application, this work shows how accurate, scalable, and low-resource

attendance solutions can be built, even when data is limited. The paper also opens the door for further improvements through retraining and smarter classifiers.

Yusof et al. [5] The system uses IoT to connect facial recognition with cloud computing, making real-time student attendance tracking possible. Traditional methods like paper-based records and RFID systems are often unreliable, time-consuming, and prone to manipulation. While RFID, thumbprint, and voice-based attendance have their benefits, they typically require physical interaction or special hardware. The authors propose a more seamless solution by integrating a face recognition system built on Raspberry Pi 3 using OpenCV with a cloud-based backend. The system employs the Haar-cascade for face detection and Local Binary Pattern Histogram (LBPH) for recognition, with image enhancement steps to improve accuracy. Real-time monitoring and data transfer are achieved through SFTP and Node.js, ensuring secure and timely updates to a MySQL database. A responsive web dashboard built using Bootstrap and Chart.js allows for easy tracking and visualization of attendance data. The system shows promise as a scalable, low-cost solution for educational institutions, and future work may explore deeper database integration and the use of 3D face sensors.

Katara et al. [6] Designed for faster student tracking, this system uses facial recognition to automate attendance, easier, and more accurate. Traditional systems like RFID cards, fingerprint scans, and manual registers can be time-consuming and prone to misuse or errors. To address these issues, the authors built a system using a Raspberry Pi and a classroom camera that automatically detects and recognizes student faces using the OpenCV library. By observing students continuously rather than relying on a single image, the system improves recognition accuracy. Pre-processing techniques like histogram equalization and resizing help improve image clarity before facial features are extracted. Among the tested methods, the LBPH algorithm performed best, offering high accuracy, fast processing, and a low false positive rate, even in real-world conditions like varied lighting and different facial expressions. Attendance data is stored in a MySQL database and displayed through a user-friendly web interface developed using WAMP and PHP. Overall, the system proves to be efficient, reliable, and scalable, with the potential for future improvements like infrared camera support for low-light environments.

Nandhan et al. [7] By applying facial recognition, this smart attendance system supports automation in line with Industry 4.0 trends. Traditional methods like manual sign-ins, RFID cards, or fingerprint scans often suffer from inefficiency, security flaws, and time consumption. To overcome these, the authors developed a Raspberry Pi-based system using OpenCV, Dlib, and SQLite, designed to detect and recognize faces in real time. The system employs algorithms like ViolaJones for face detection and LBPH for recognition, while classification is enhanced through SVM. Key steps include grayscale conversion, facial landmark detection, feature encoding, and database comparison. Personal information and facial images are stored in SQLite, offering lightweight yet reliable data handling. This solution is cost-effective, scalable, and reduces human errors in attendance tracking. The authors also discuss real-world applications across industries and institutions. Despite its advantages, the paper acknowledges concerns like data privacy, AI misuse, and limited regulation. Still, with proper safeguards, the system offers a secure, fast, and practical alternative to traditional attendance methods, making it suitable for modern workplace environments.

Khan et al. [8] Facial recognition is used to create a realtime attendance system that eliminates the need for outdated manual or biometric systems. Traditional systems like fingerprint scans and RFID tags are often inefficient, error-prone, or vulnerable to misuse. To address these challenges, the authors propose a smart solution that combines the YOLO V3 object detection algorithm with Microsoft Azure Face API for face recognition. The system captures images at the start and end of each class using pre-installed security

cameras, ensuring students attend the full session. YOLO V3 is used to detect and count faces in the frame, while Azure Face API matches them with a pre-registered face database. Attendance records are automatically generated, stored in SQLite, and emailed to students, parents, and faculty. The system achieved 100% accuracy across various classroom conditions, including different facial expressions and lighting setups. The authors highlight its cost-effectiveness, ease of use, and scalability, making it a promising solution for educational institutions seeking a reliable and contactless attendance system.

Bairagi et al. [9] To tackle the inefficiencies of manual and biometric systems, this solution applies facial recognition for real-time attendance monitoring. Traditional systems like RFID and fingerprint scanning are time-consuming, prone to manipulation, and often require physical interaction. The proposed solution uses Haar Cascade classifiers for face detection and the LBPH algorithm for face recognition, allowing multiple students to be identified at once—significantly reducing class time spent on attendance. The system captures over 100 images per student for training, stored in a cloudbased database. Unlike earlier methods that could be tricked with mobile images or had trouble with lighting or angled faces, this system accurately recognizes faces even under low-light conditions and at non-frontal angles. Attendance data is automatically stored and displayed in an Excel sheet for easy access. While the system is reliable and efficient, future improvements could include parent notification features and better performance in no-light environments. Overall, it offers a practical, secure, and time-saving solution for modern classrooms. Tamimi et al.[10] presents a real-time group face detection system aimed at improving classroom attendance management. Traditional attendance methods are slow and inefficient for large student groups. To address this, the authors propose a system that captures video frames using a PC camera and detects multiple student faces in each frame. Unlike one-by-one recognition systems, this method focuses on group face detection to speed up processing. The proposed algorithm identifies the best front-facing images of students by analyzing facial landmarks—eyes, nose, and mouth—using geometric relations and mathematical thresholds. These well-positioned face images are then stored for future recognition. The system was implemented using MATLAB and tested across 10 classroom lectures, achieving an acceptable face detection rate ranging from 75% to 94.73%. This work demonstrates the feasibility of detecting multiple faces accurately in real time, especially in environments with many students. It serves as the foundation for a larger attendance recognition system, with future plans to integrate facial recognition and expand the system's database capabilities.

Sutabri et al.[11] propose an automated face recognition-based attendance system tailored for university environments to overcome the inefficiencies of traditional rollcall or RFID methods. Their solution uses deep learning with Convolutional Neural Networks (CNN) to detect faces, Dlib's deep metric learning to extract 128-dimensional face embeddings, and the K-Nearest Neighbor (K-NN) algorithm to identify students. The system is powered by a Raspberry Pi 3 connected to a NoIR camera, offering a compact and portable setup. Once a face is recognized, the system logs student ID, date, and time into a centralized web-based platform built with PHP and MySQL. A user-friendly interface enables administrators and lecturers to manage schedules, student data, and attendance logs efficiently. Testing showed promising accuracy in real-time classroom environments. The authors also suggest potential improvements, including integrating cloud storage and more advanced recognition models. This work contributes a scalable, cost-effective framework suitable for academic institutions aiming to modernize attendance systems with minimal hardware investment.

Alburaiki et al.[12] present a mobile-based attendance system that integrates face recognition with location verification to enhance both authenticity and flexibility in student attendance processes. The system allows

students to use their smartphones to scan their faces and submit attendance from the designated class location, verified through GPS. Leveraging Azure Face API and Mapbox API, the application performs real-time facial verification and geo-fencing to prevent proxy attendance. The backend uses MariaDB, and the interface is built with React Native. The application also introduces a role-based system with separate interfaces for students, lecturers, and administrators, allowing functions such as face registration, attendance initiation, report generation, and admin approval. User testing involving over 30 students demonstrated high recognition accuracy and strong satisfaction rates, even under poor lighting conditions. The system achieved notable performance in speed, usability, and flexibility, offering a low-cost, portable alternative to conventional biometric or hardware-dependent attendance systems.

Shrivastava et al.[13] propose a machine learning-based attendance system that automates student tracking using facial recognition. Unlike conventional systems like RFID and fingerprint scanners—which are often time-consuming and prone to proxy attendance—this system uses OpenCV for face detection and the LBPH algorithm for recognition. The model is trained using a set of labeled facial images for each student, which are stored in a local database along with corresponding IDs. The application, developed in Python with a Tkinter-based GUI, allows real-time face capture, model training, and automated attendance logging into a CSV file. A unique aspect of the system is its self-update capability, where new student faces can be added dynamically without retraining the entire model. Testing demonstrated accurate recognition in various lighting conditions and facial orientations, with low error rates and fast processing. This lightweight, standalone solution offers educational institutions an affordable and efficient method for automating attendance, especially in environments with limited resources or infrastructure.

Alhanaee et al.[14] present a smart attendance system powered by deep transfer learning, aimed at replacing traditional, error-prone methods like manual sign-ins or ID scanning. The system leverages pre-trained Convolutional Neural Networks (CNNs)—specifically AlexNet, GoogleNet, and SqueezeNet—to recognize faces and mark attendance automatically. Using a custom dataset of 200 facial images across 10 individuals, the study applies data augmentation techniques such as rotation and scaling to improve generalization. The CNN models are fine-tuned rather than trained from scratch, saving time while achieving high accuracy. Among the models, AlexNet attained the best validation accuracy (100%) though it required the longest training time, while SqueezeNet provided an efficient balance of speed and accuracy (98.33%). GoogleNet performed slightly lower with 93.33%. This comparative study demonstrates the practical benefits of using transfer learning in facial recognition systems, especially in real-world applications where time and data are limited. The research offers insights for building lightweight, scalable, and accurate attendance solutions using off-the-shelf deep learning models.

Mridha et al.[15] propose a smart, image-based attendance management system using face recognition to replace time-consuming manual methods in classrooms. The system works in three main stages: face capture using CCTV, image matching with a master database, and automatic attendance logging. The authors employ OpenCV for face detection and recognition, and improve efficiency through preprocessing steps like histogram normalization, noise filtering (via median filter), and skin classification using the Viola-Jones algorithm. Faces are detected and matched using HOG features and classified through methods like LBPH, SVM, and Bayesian classifiers. Once matched, the attendance is marked automatically in Excel sheets. The application supports three user roles—admin, faculty, and students—with dedicated functionality such as managing student records, launching attendance sessions, and viewing attendance. The system is lightweight, cost-effective, and minimizes human intervention. It can also be extended to other domains like election systems and surveillance. With real-time performance and

a user-friendly interface, the solution offers an effective approach to modernizing classroom attendance with minimal infrastructure.

Dhanasekaran et al.[16] present a smart digital attendance monitoring system designed for academic institutions using machine learning techniques, particularly Convolutional Neural Networks (CNNs). The system aims to automate the attendance process by capturing classroom video frames, detecting faces, and identifying students in real time. After extracting frames from video, individual faces are cropped and enhanced for recognition. The CNN-based model is trained to match these face images with a pre-recorded database, marking each student as present or absent accordingly. Attendance results are automatically updated in editable Excel sheets accessible to faculty. The system improves on traditional manual attendance and earlier biometric methods by reducing time, minimizing errors, and supporting scalability for large classrooms or seminar halls. Although image quality under poor lighting can affect accuracy, the authors suggest future enhancements like improved video standards or additional image-processing algorithms. This work demonstrates the feasibility of using neural networks to efficiently manage attendance, reduce teacher workload, and improve transparency in academic environments.

Naufal et al.[17] propose a deep learning–based face recognition system for automating attendance in academic institutions. Aimed at eliminating fraud and improving efficiency, the system uses a combination of OpenCV and Haar Cascade classifiers to detect and extract facial features from live video feeds. Facial data are stored and processed using deep learning models that analyze contours, textures, and key landmarks to identify students in real time. The system is programmed in Python and trained on a custom dataset containing facial images from various angles. Once identified, the system logs student names, IDs, attendance times, and statuses (e.g., present, late). Experiments showed a 95.23% accuracy rate in face identification. The authors highlight the advantages of their approach over traditional fingerprint or ID-based systems, which are susceptible to manipulation or error. Their method offers a non-intrusive, contactless, and highly accurate alternative. Future work includes expanding the dataset and refining recognition under varied conditions. This system aligns well with Industry 4.0 goals of automation and intelligent monitoring.

Afzal et al.[18] present an intelligent, cloud-based attendance system using facial recognition to enhance accuracy and minimize human error in academic environments. The proposed system utilizes the Viola–Jones algorithm for face detection and Principal Component Analysis (PCA) for recognition. It captures images of students through a camera as they enter a classroom, extracts features, and compares them with stored data to verify identity. Once verified, the attendance is automatically recorded and stored on a cloud server, accessible to authorized users through a web portal. The system was tested in real-time classroom settings and demonstrated satisfactory recognition performance across varied facial orientations and lighting conditions. Notably, it eliminates the need for manual input, ID cards, or biometric contact, offering a hygienic and efficient alternative—particularly relevant in post-pandemic settings. The authors highlight its scalability and ease of use, and recommend future enhancements including mobile app integration and multi-factor authentication. Overall, the system provides a secure, paperless, and real-time solution for attendance management in educational institutions.

Haq et al.[19] propose a contactless biometric attendance system using iris recognition, developed in response to hygiene concerns during the COVID-19 pandemic. Unlike traditional systems like fingerprint or facial recognition—which became less practical due to mask usage and physical contact—this solution uses the ORB detector for accurate and fast iris matching. The system is structured into four stages: iris registration, identity verification upon entry, group validation, and automatic identification of defaulters

based on attendance records. It supports real-time monitoring and uses Python libraries such as NumPy, Pillow, and Dlib for image processing and GUI development. Tested on a balanced dataset of 200 iris images, the system achieved 100% accuracy under controlled conditions. A lightweight desktop application was also developed for administrative tasks, offering a scalable, reliable, and hygienic alternative to conventional methods. The authors highlight the model's high precision, security, and practical value in pandemic-affected or contact-sensitive environments.

Kurra et al.[20] propose a machine learning–based attendance monitoring system designed to automate and simplify attendance tracking in educational institutions. The system is implemented as an Android mobile application, which allows users to capture real-time images and upload them to a WAMP server for processing. The backend uses a combination of Haar cascade classifiers for face detection, Histogram of Oriented Gradients (HOG) for feature extraction, and a linear Support Vector Machine (SVM) for classification. Once a face is recognized, the student's attendance is marked and stored in an Excel sheet. The system is designed for high accuracy even under varying lighting conditions and facial orientations, making it more reliable than traditional attendance methods. The authors also highlight the system's broader potential applications in areas like ATM fraud detection and surveillance. Its lightweight design, real-time performance, and ease of deployment make it a practical and cost-effective solution for smart attendance systems in academic environments.

CONCLUSION

The literature reveals substantial advancements in realtime attendance systems, particularly through the integration of face recognition and emotion detection. Deep learning architectures such as ResNet and Vision Transformers (ViTs) have proven effective in handling complex facial features and emotional states, especially under real-world variations like lighting, pose, and expression. To translate these findings into a practical model, several components are essential: a dual-task architecture capable of handling both recognition and emotion detection in real time, a custom dataset reflecting diverse demographic and environmental conditions, and lightweight, deployable models optimized for performance on web or edge platforms. Ethical considerations, such as data privacy and informed consent, must also be addressed. Incorporating a web-based interface for real-time visualization, administrative control, and emotion trend analysis further enhances usability. Future models may also benefit from multimodal inputs—such as voice or behavioral cues—for improved accuracy and contextual awareness. With these features, a robust, intelligent, and ethically grounded attendance system can be effectively realized across educational, corporate, and healthcare environments.

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