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CLASSPIC: AI-POWERED FACE RECOGNITION SYSTEM FOR AUTOMATED ATTENDANCE

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ABSTRACT

Attendance management in educational institutions, particularly those following hour-wise period systems, remains a manually intensive task prone to errors and proxy attendance. This work presents ClassPic, a web-based automated attendance system that leverages deep learning–based face recognition to streamline attendance marking. The system employs SCRFD for face detection and ArcFace for facial feature embedding extraction using the InsightFace framework. Classroom images captured during sessions are processed to detect faces, generate embeddings, and perform identity matching against enrolled student data using cosine similarity with a configurable confidence threshold. Recognized individuals are automatically marked present, and attendance records are maintained in a centralized database. A key contribution of this work is its privacy-conscious design, where raw student images are discarded after embedding generation, and only feature representations are stored. Classroom images are retained temporarily for verification and automatically deleted after a defined duration. To improve reliability, a verification mechanism is incorporated, allowing instructors to review and manually correct attendance results. The system supports role-based access for administrators, teachers, and students, enabling efficient attendance management, monitoring, and transparency. The modular architecture ensures scalability and practical deployment in real-world classroom environments. Experimental evaluation demonstrates that the system effectively reduces manual effort while maintaining reliable recognition performance under typical classroom conditions.

Keywords: Face Recognition, Automated Attendance, Classroom Image Processing, SCRFD, ArcFace, Deep Learning, Cosine Similarity, Real-Time Attendance

1. INTRODUCTION

Attendance management is a fundamental academic activity in educational institutions, serving as a key metric for student engagement, assessment eligibility, and institutional compliance. Traditional attendance methods, such as manual roll calls and paper-based registers, remain widely used despite their inherent inefficiencies. In large classroom environments, particularly those following hour-wise attendance systems, manual processes consume valuable instructional time and are prone to errors, including proxy attendance and data inconsistencies. To address these limitations, many institutions have adopted biometric-based systems such as fingerprint scanners and RFID cards. While these systems introduce partial automation, they suffer from several drawbacks. Fingerprint systems require physical contact and are sensitive to environmental conditions, while RFID cards can be misplaced or misused. Additionally, such systems require sequential interaction by each student, leading to delays and inefficiencies in large classroom settings. The cost of deployment and maintenance further limits their scalability. Recent advancements in artificial intelligence, particularly in deep learning–based computer vision, have enabled significant progress in face recognition technologies. Modern face recognition systems can accurately detect and identify multiple individuals simultaneously from a single image without requiring physical interaction. This non-intrusive and scalable nature makes face recognition a promising solution for automated attendance in classroom environments. Motivated by these developments, this work presents ClassPic, a web-based automated attendance system that utilizes face recognition to streamline attendance marking. The system enables instructors to capture or upload classroom images, which are processed to identify students and automatically record attendance on a per-session basis. A key challenge in deploying such systems is ensuring both accuracy and data privacy. To address this, the proposed approach adopts a privacy-conscious design by avoiding long-term storage of raw facial images and instead relying on feature-based representations. Additionally, a verification mechanism is incorporated, allowing instructors to review and correct attendance results, thereby improving reliability under real-world conditions such as occlusions or lighting variations. The system is designed to support large classroom environments while maintaining scalability, usability, and transparency through role-based access for different users. By integrating deep learning–based face recognition with a web-based platform, this work aims to provide an efficient and practical solution for modern attendance management.

2. LITERATURE SURVEY

Face recognition has been extensively studied over the past few decades, evolving from traditional feature-based methods to modern deep learning–driven approaches. Early techniques relied on handcrafted features such as Principal Component Analysis (PCA)-based Eigenfaces [1] and texture-based approaches such as Local Binary Patterns Histograms (LBPH) [2]. While computationally efficient, these methods were highly sensitive to variations in illumination, pose, and facial expressions, limiting their applicability in real-world environments. The introduction of deep learning, particularly convolutional neural networks (CNNs), significantly advanced the field of face recognition. Several approaches such as DeepFace [3], FaceNet [4], and ArcFace [5] have demonstrated the ability to learn highly discriminative facial representations directly from images. ArcFace further improved performance by introducing an additive angular margin loss, enhancing the separability of learned embeddings. In parallel, efficient face detection models such as SCRFD [6] have been developed to achieve a balance between accuracy and computational efficiency, making them suitable for real-time applications. Building upon these advancements, researchers have explored the application of face recognition in automated attendance systems for educational environments. Kar et al. [7] implemented a real-time attendance system using the LBPH algorithm and live video streams. While effective in controlled settings, the system's accuracy degraded under poor lighting and when students were not directly facing the camera, and it required continuous computational processing. Choudhary and Sharma [8] proposed a web-based system using Haar cascade detection and convolutional neural networks for recognition, enabling automated attendance generation from uploaded images; however, the system lacked mechanisms for verification and error correction. More recent approaches have leveraged deep learning models to improve performance. Singh and Agarwal [9] conducted a comparative analysis of deep learning architectures, demonstrating that ArcFace outperformed other models in terms of accuracy and generalization across varying conditions. Despite these advancements, several limitations persist in existing attendance systems. Many approaches rely on continuous video streams, resulting in high computational overhead and scalability challenges in large classroom environments. Additionally, most systems do not incorporate privacy-conscious data handling practices and store raw facial images for extended periods, raising concerns regarding data security and misuse. Furthermore, existing solutions often lack verification mechanisms, limiting their reliability in real-world scenarios where environmental conditions may affect recognition performance. To address these limitations, this work proposes ClassPic, an image-based automated attendance system that reduces computational complexity while maintaining recognition accuracy. The system adopts a privacy-preserving design by storing only facial embeddings and discarding raw images after processing. A teacher-in-the-loop verification mechanism enables manual review and correction of attendance results, improving system reliability. Additionally, support for multiple enrollment images per student enhances robustness to variations in appearance, making the system suitable for practical deployment in large classroom environments.

3. PROPOSED SYSTEM

The proposed ClassPic system follows a modular three-tier architecture (Fig. 1) consisting of a Presentation Layer, Application Layer, and Data Layer, ensuring scalability, maintainability, and efficient data handling. The system is implemented using the Django web framework with a relational database backend.

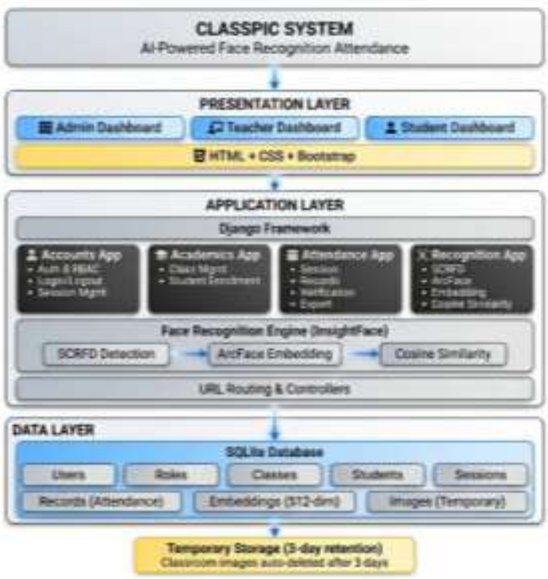

Figure 1. System Architecture

The Presentation Layer provides role-based user interfaces for administrators, teachers, and students, enabling interaction through a web-based platform for operations such as student enrollment, attendance capture, and record viewing. The Application Layer manages the core business logic, including authentication, role-based access control, class and student management, attendance processing, and integration of the face recognition pipeline. The Data Layer is responsible for persistent storage of system entities such as users, roles, classes, student profiles, attendance sessions, and attendance records, while ensuring that only necessary data is retained.

The face recognition pipeline forms the core component of the system and is triggered when classroom images are uploaded.

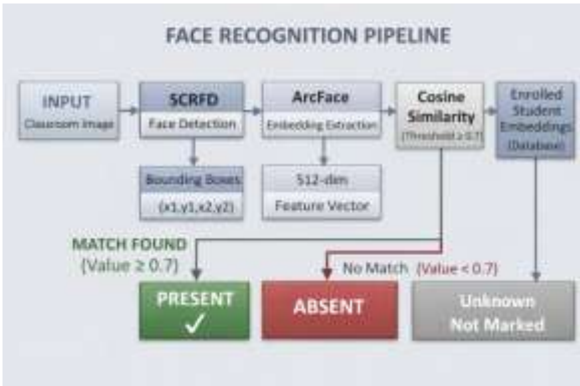

Figure 2. Face Recognition Pipeline

As illustrated in Fig. 2, face detection is performed using the SCRFD model, which efficiently detects multiple faces in a single image while maintaining a balance between accuracy and computational cost. Detected faces are processed to generate feature embeddings using the ArcFace model, which maps facial features into a high-dimensional space for reliable identity representation. These embeddings are compared with pre-enrolled student embeddings using cosine similarity, where a configurable threshold determines valid matches. To improve robustness, multiple enrollment samples are used to generate aggregated embeddings for each student, enabling better handling of variations in pose, lighting, and facial expressions. Recognized students are automatically marked present, while duplicate detections across multiple images are consolidated to ensure accurate attendance records.

The similarity between a detected face and an enrolled student is computed using cosine similarity. Let Es denote the embedding vector of an enrolled student and Ec denote the embedding vector of a detected face. The cosine similarity is defined as:

$$sim(Es, Ec) = (Es \cdot Ec) / (\|Es\| \times \|Ec\|)$$

A match is accepted if:

$$sim(Es, Ec) \geq \tau$$

where τ is a configurable threshold set to 0.7 in this work. To improve robustness against variations in pose, lighting, and facial expressions, multiple enrollment images are used per student. The average embedding for a student is computed as:

$$\bar{E}s = (1/k) \Sigma Es,i$$

where k = 5 enrollment samples per student. This aggregation strategy reduces the impact of poor-quality enrollment images and improves matching reliability.

To enhance system reliability, a teacher-in-the-loop verification mechanism is incorporated. After automated processing, recognition results are presented for review, allowing instructors to validate and correct attendance records before final submission. This approach improves performance under real-world conditions such as occlusions, non-frontal poses, and inconsistent lighting. The system workflow includes student enrollment, attendance processing, and attendance access, ensuring a structured and efficient pipeline from data acquisition to result visualization.

The system adopts a privacy-conscious approach to handling biometric data. During enrollment, raw facial images are processed only for embedding generation and are not stored permanently. Classroom images are retained temporarily for verification purposes and are automatically deleted after a predefined duration. Only feature embeddings and attendance records are stored, significantly reducing the risk of misuse of sensitive data. Role-based access control is implemented to ensure secure system usage, where administrators manage system entities, teachers handle attendance sessions and verification, and students are limited to viewing their own attendance records.

To ensure efficient performance in classroom environments, several optimizations are incorporated, including image resizing, filtering of low-quality detections, parallel processing of multiple images, and in-memory caching of student embeddings. These optimizations reduce processing time and enable the system to operate effectively on standard CPU-based systems without requiring specialized hardware. The overall design ensures that the system remains scalable, efficient, and suitable for real-world deployment in educational institutions.

4. RESULTS AND DISCUSSION

The proposed ClassPic system was evaluated using a custom dataset collected from a real classroom environment consisting of 40 students. For enrollment, 5–7 facial images per student were collected, yielding approximately 200–280 enrollment samples. Classroom images were captured across multiple frames under varying lighting conditions, poses, and occlusions, resulting in over 250 individual recognition instances. All experiments were conducted on a standard CPU-based machine with an Intel Core i5 processor and 16GB RAM, without GPU acceleration. Performance was evaluated in terms of recognition accuracy, reliability, and average processing time per session. The evaluation setup was designed to simulate real-world classroom conditions, ensuring that the system performance reflects practical deployment scenarios rather than controlled laboratory benchmarks.

To ensure student privacy and adhere to ethical research guidelines, raw facial images and detection outputs are not included in this publication. Typical detection outputs include bounding boxes around recognized students and separate indicators for unknown individuals. Instead, the system's efficacy is validated through comprehensive performance metrics. The face detection module demonstrated reliable performance in identifying multiple faces across different seating arrangements.

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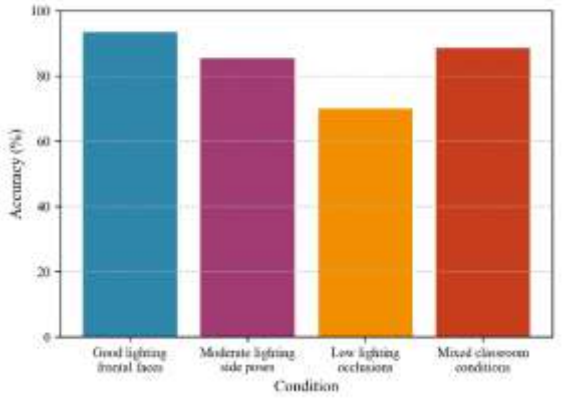

Figure 3. Recognition performance under different classroom conditions.

As shown in Fig. 3, the system performs reliably under favourable conditions, with moderate degradation under challenging scenarios. The system achieved its highest accuracy under frontal and well-lit conditions, while performance degradation in low-light and occluded scenarios highlights the sensitivity of embedding-based recognition to visual quality. The use of multiple classroom images per session improved detection coverage by approximately 10–15% compared to single-image input, particularly under occlusions and side poses. Filtering low-resolution detections improved recognition reliability at the cost of reduced coverage for distant individuals.

The complete attendance process, including face detection, embedding extraction, similarity matching, and verification, required approximately 32 to 45 seconds per session.

Table 1. Computational Latency Analysis (per session)

System Component / Operation	**Time(seconds)**
Face Detection (SCRFD)	4–6
Feature Extraction (ArcFace)	25–30
Matching (Cosine Similarity)	0.5–1
Overhead & I/O	5–8
Total System Latency	**32–45**

While higher than fully real-time systems, this is significantly more efficient than manual attendance methods in large classrooms. Parallel processing and embedding caching contributed to improved computational efficiency and system responsiveness.

The recognition module successfully identified enrolled students using embedding-based matching with cosine similarity. The configurable threshold minimized false positives while maintaining detection sensitivity. The system consolidated duplicate detections across multiple images, preventing duplicate attendance entries, and did not mark unknown individuals as present. Processing multiple classroom images per session improved detection coverage and recognition accuracy by capturing students under varying angles, lighting conditions, and occlusion levels.

From a usability perspective, the system reduces manual effort while maintaining human oversight through the verification mechanism. This balance between automation and manual validation ensures both efficiency and reliability. The web-based interface supports enrollment, attendance marking, and record viewing, enhancing system accessibility.

The system adopts a privacy-conscious design by discarding raw facial images after processing and retaining only feature embeddings. Classroom images are stored temporarily for verification and automatically deleted after a predefined duration, minimizing risks associated with long-term biometric data storage.

Despite its effectiveness, the system has certain limitations. Recognition performance is influenced by image quality, lighting conditions, and facial visibility, and the absence of liveness detection introduces potential vulnerability to spoofing attacks. The system was validated through a controlled experimental study with 40 subjects, and further validation is required for larger-scale deployments. Future work will focus on integrating lightweight liveness detection (e.g., blink or motion analysis), optimizing the pipeline for edge devices such as Raspberry Pi, and evaluating performance across multiple institutions with diverse classroom environments.

Overall, the results demonstrate that the proposed system provides a practical and efficient solution for automated attendance management, significantly reducing manual effort while maintaining reliable recognition performance under real-world classroom conditions.

5. CONCLUSION

This paper presented ClassPic, a web-based automated attendance system that leverages deep learning–based face recognition to address the limitations of traditional manual attendance methods in educational institutions. By integrating efficient face detection and discriminative feature embedding techniques, the system enables reliable identification of students from classroom images while supporting non-intrusive and contactless attendance marking. A key contribution of this work is its privacy-conscious design, where raw facial images are not retained beyond processing, and only feature embeddings are stored. The incorporation of a teacher-in-the-loop verification mechanism further enhances system reliability by allowing manual validation and correction of recognition results before final attendance storage. Experimental evaluation in a real classroom environment demonstrated that the system reduces manual effort, prevents duplicate attendance entries, and operates efficiently on standard CPU-based hardware. The use of multiple classroom images per session further improves detection coverage and recognition reliability under practical conditions.

Despite its effectiveness, the system has certain limitations. Recognition performance is influenced by image quality, lighting conditions, and facial visibility, and the absence of liveness detection introduces potential vulnerability to spoofing attacks. Additionally, evaluation was conducted on a limited dataset, and further validation is required for larger-scale deployments.

The proposed system demonstrates the practical feasibility of deploying deep learning–based face recognition for efficient and scalable attendance management in educational institutions.

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