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Design and Evaluation of a Web-Based Facial Recognition System for Automated Student Attendance

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Abstract: *Manual student attendance is commonly recorded through roll calls, paper registers or spreadsheet-based processes. These approaches require classroom time and may introduce recording errors, delayed reporting and opportunities for proxy attendance. This paper proposes the design and evaluation of a web-based student attendance system that uses facial recognition to assist authorized faculty in recording attendance. The proposed workflow captures a live camera frame or an uploaded classroom image, detects and aligns faces, extracts facial feature representations, compares them with enrolled student templates and records sufficiently confident matches in a centralized database. A browser-based interface provides student registration, class and session management, attendance review and report generation. The design emphasizes a human-review path for uncertain matches, duplicate prevention, secure access and controlled handling of biometric data. The research plan evaluates recognition performance using precision, recall, F1-score, false acceptance rate, false rejection rate, processing time and attendance-recording time. As implementation measurements have not yet been supplied, this paper reports a proposed system and evaluation protocol rather than claiming measured accuracy. The expected contribution is a practical, auditable attendance workflow that can reduce repetitive manual work while retaining faculty oversight and privacy safeguards.*

Keywords: Facial recognition, automated attendance, face detection, face embeddings, web application, computer vision, biometric authentication

I. INTRODUCTION

Attendance is an important administrative activity in schools, colleges and universities. It supports academic monitoring, eligibility checks and institutional reporting. In many classrooms, faculty members call student names or circulate an attendance sheet. Although familiar, manual attendance consumes instructional time and requires later consolidation. A digital attendance application can simplify record storage, but a login, card or one-time code may still be shared with another person.

Facial recognition offers a contactless way to compare a captured face with previously enrolled face templates. Modern systems commonly separate face detection, alignment, feature extraction and identity matching. Deep-learning approaches such as FaceNet represent a face as a compact embedding, allowing similarity to be estimated between two representations [1]. However, real classroom conditions introduce challenges such as varying illumination, head pose, occlusion, camera quality, crowded scenes and look-alike faces.

This study proposes a web-based application in which facial recognition is used as an attendance-assistance mechanism, not as an unquestionable authority. The application records high-confidence matches automatically and sends uncertain or unknown cases to a faculty review queue. This approach is intended to balance automation with accountability.

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1.1 Problem Statement

Manual and conventional digital attendance methods may be time-consuming, difficult to consolidate across classes and vulnerable to proxy attendance. A practical solution is required to capture attendance through a web interface, identify enrolled students from facial images, maintain timestamped records and provide reports. The system must also handle recognition uncertainty, duplicate detections and sensitive biometric information responsibly.

1.2 Motivation and Significance

The project is motivated by the need to reduce routine attendance workload and make attendance records easier to search and analyze. A browser-based architecture can make the system accessible to authorized users without installing a separate desktop application on every device. The project also provides an applied study of computer vision, web development, database design and performance evaluation.

II. LITERATURE REVIEW

Facial recognition research has progressed from handcrafted image descriptors and statistical classifiers to deep neural networks that learn discriminative facial representations. The following studies and methods inform the proposed design.

2.1 Review of Existing Research

Author / Year	Method or focus	Relevance to this project
Schroff et al. (2015) [1]	FaceNet learns compact facial embeddings using a deep convolutional network and triplet-based learning.	Supports embedding-based identity matching rather than direct pixel comparison.
Zhang et al. (2016) [2]	MTCNN jointly performs face detection and facial landmark alignment through cascaded networks.	Provides a reference approach for locating and aligning faces before recognition.
Student attendance review (2023) [3]	A systematic review compares LBPH and CNN-based face-recognition approaches for attendance.	Highlights the trade-off between lightweight traditional methods and deep-learning robustness.
Agustiyar et al. (2026) [4]	Review of attendance recognition methods, trends and research gaps, including multi-face detection and environmental robustness.	Motivates testing under pose, lighting and multi-face classroom conditions.
Real-time face tracking study (2025) [5]	Uses face detection, CNN-based recognition and periodic attendance verification.	Shows the relevance of temporal tracking and presence rules in attendance scenarios.

The reviewed work indicates that a recognition algorithm alone is not sufficient for a dependable attendance application. A complete system also needs enrollment controls, session management, database integrity, duplicate prevention, reporting and procedures for handling uncertain matches. Deep-learning embeddings can improve representation quality, while their practical performance still depends on the quality and diversity of enrollment images and the conditions in which the system is used [1], [3], [4].

2.2 Research Gap

Many prototype studies emphasize recognition accuracy but provide limited detail about end-to-end web workflow, role-based access and correction of attendance records.

Performance can vary with lighting, pose, partial occlusion, camera distance and the number of faces in a frame; these conditions need to be evaluated explicitly.

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A system should distinguish between a confident match and an uncertain result rather than forcing every detected face to an identity.

Biometric data requires clear consent, limited access, secure storage, retention rules and an alternative attendance process.

The proposed work addresses these gaps by combining a web-based attendance workflow with confidence thresholds, faculty review, duplicate checks, performance measurement and privacy-aware data handling.

III. AIM AND OBJECTIVES

Aim:

- To design and evaluate a web-based facial recognition system that assists in recording student attendance accurately and efficiently.
- To study existing manual, digital and facial-recognition-based attendance approaches.
- To design a web application for student enrollment, faculty login, class/session management and attendance reporting.
- To implement a face-processing pipeline consisting of face detection, alignment, feature extraction and similarity-based matching.
- To maintain student records and timestamped attendance entries in a structured database.
- To introduce duplicate prevention and a manual review mechanism for uncertain or unknown detections.
- To evaluate the proposed system using recognition, timing, usability and operational metrics.
- To identify privacy, security and deployment limitations associated with biometric attendance.

IV. PROPOSED SYSTEM

4.1 System Overview

The proposed system follows a client-server architecture. Faculty members access the application through a web browser and select a class, subject and attendance session. A webcam frame or uploaded image is sent to the backend. The backend detects faces, aligns the detected regions and generates facial embeddings using a selected recognition model. Each embedding is compared with enrolled student templates. A match is accepted only when it meets a configurable similarity threshold and session rules. Attendance is saved with a timestamp and source/session information. Low-confidence or ambiguous results are flagged for faculty review.

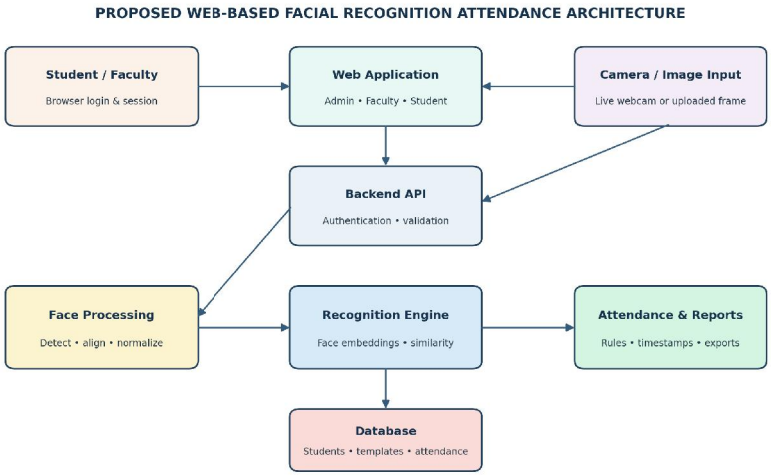


Figure 1. Proposed system architecture.

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4.2 Main Modules

Admin module: manages faculty accounts, departments, classes, subjects and system settings.

Student enrollment module: stores student identifiers and approved enrollment images; generates facial templates for matching.

Faculty module: creates attendance sessions, captures images, reviews uncertain matches and finalizes records.

Face detection and alignment module: locates face regions and normalizes them for consistent feature extraction.

Recognition module: converts face images into embeddings and compares them against enrolled templates using a similarity metric.

Attendance module: applies confidence thresholds, session validity and duplicate checks before recording attendance.

Report module: provides date-wise, subject-wise and student-wise attendance summaries with CSV/PDF export options.

Audit and security module: records important actions, enforces role-based permissions and supports correction history.

4.3 Processing Workflow

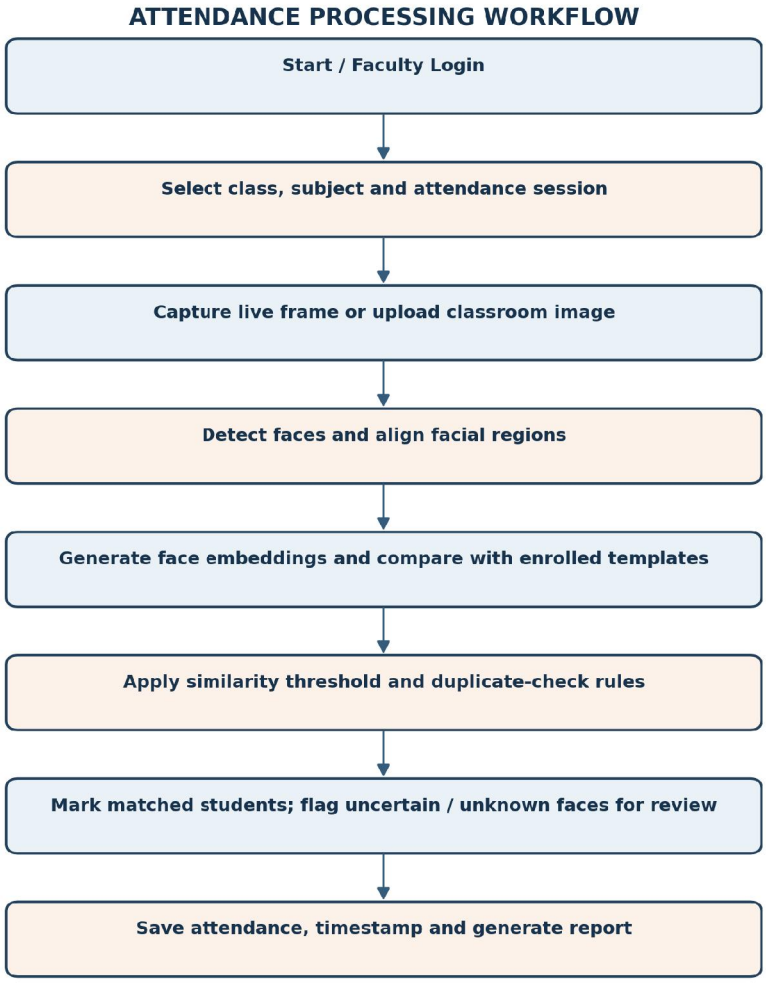


Figure 2. Proposed attendance-processing workflow.

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At enrollment, the institution should obtain appropriate permission and capture multiple representative images under suitable conditions. During attendance, the system detects faces and compares each valid face representation against the enrolled templates. A student should be recorded only once for a given class session. If the best match is below the acceptance threshold, or if two identities have similar scores, the case is marked for manual review instead of being automatically accepted.

4.4 Illustrative Image Pipeline

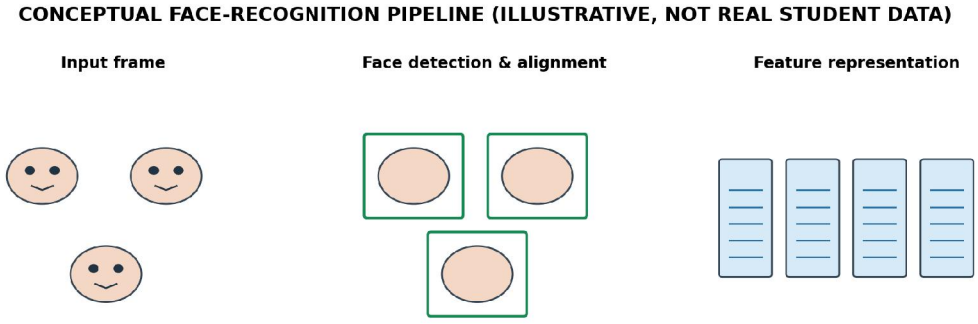


Figure 3. Conceptual illustration of image input, face localization and feature representation. These are schematic illustrations, not photographs or actual student data.

V. METHODOLOGY

5.1 Research Design

The project follows a design-and-evaluation methodology. First, functional and non-functional requirements are identified. Second, the web application, database and recognition pipeline are designed. Third, a prototype is implemented and tested with an approved dataset. Finally, recognition performance, processing time and user workflow are evaluated against predefined criteria.

5.2 Dataset and Image Collection

A controlled institutional dataset is recommended for final evaluation. It should contain multiple images per consenting participant, captured across different sessions and realistic variations in lighting, facial expression, camera distance and head pose. Images should be labelled with a unique student code and separated into enrollment/reference and test sets so that test images are not simply repeated training images. The dataset size, number of identities, image count per identity and capture conditions must be reported in the final implementation paper.

Public face datasets may be used for preliminary model experiments, subject to their licence and permitted use. However, a general public face dataset is not a substitute for institution-specific validation because camera conditions and participant demographics may differ. Do not scrape student photographs from social media or use identifiable images without permission.

5.3 Image Pre-processing

Image resizing and normalization to the input dimensions required by the selected detector and recognition model.

Face detection to identify one or more face regions in the input frame.

Face alignment using landmarks such as eye and nose positions, where supported by the selected detector.

Quality checks for blur, extreme pose, insufficient face size and heavy occlusion.

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5.4 Face Recognition

A deep-learning embedding model such as FaceNet may be used to map each aligned face into a numerical feature vector [1]. Similarity can be computed using Euclidean distance or cosine similarity. The application compares the test embedding with enrolled templates and selects the closest candidate only when the score satisfies a threshold established on validation data. The threshold must not be copied blindly from another dataset: it should be calibrated for the selected model, camera and population.

An alternative lightweight baseline such as Local Binary Patterns Histograms (LBPH) can be implemented for comparison. The final paper should report the selected model version, input size, embedding dimension, threshold-selection procedure and hardware/software environment.

5.5 Web Application and Database

A possible implementation stack is Python with Flask or FastAPI for the backend, HTML/CSS/JavaScript or a frontend framework for the browser interface, OpenCV for image handling, a supported face-detection/embedding library for recognition, and MySQL or PostgreSQL for structured records. The final stack should reflect the actual implementation.

Suggested database entities include Student(student_id, name, class_id, status), FaceTemplate(template_id, student_id, template_reference, created_at), Faculty(faculty_id, username, password_hash, role), AttendanceSession(session_id, class_id, subject_id, faculty_id, start_time, end_time), Attendance(attendance_id, session_id, student_id, status, timestamp, confidence, review_status) and AuditLog(log_id, user_id, action, timestamp). Raw face images should not be retained longer than necessary; where feasible, store protected templates and keep image access tightly restricted.

5.6 Functional Requirements

- Secure login for administrators and faculty members.
- Student registration and controlled face-template enrollment.
- Creation and closure of attendance sessions.
- Live camera capture and/or controlled image upload.
- Face detection, matching and confidence-based decision handling.
- Prevention of duplicate attendance entries within the same session.
- Faculty review and correction of uncertain attendance records.
- Attendance search, summary and export.

5.7 Non-Functional Requirements

- Usability: simple navigation and clear feedback for faculty.
- Performance: acceptable processing time for the expected classroom size.
- Reliability: consistent storage and recovery of attendance records.
- Security: password hashing, role-based access, encrypted communication and audit logs.
- Privacy: informed participation, purpose limitation, restricted access and defined retention.
- Maintainability: modular code, documented APIs and configurable recognition thresholds.

VI. SYSTEM EVALUATION PLAN

Evaluation should be conducted on a held-out test set that was not used to enroll or tune the recognition model. Ground-truth labels should be verified independently. The following metrics are recommended:

Accuracy: proportion of all evaluated decisions that are correct; interpret carefully where the classes are imbalanced.

Precision: proportion of predicted student matches that are correct.

Recall: proportion of actual enrolled-student instances correctly identified.

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F1-score: harmonic mean of precision and recall.
False Acceptance Rate (FAR): rate at which an incorrect identity is accepted.
False Rejection Rate (FRR): rate at which a genuine enrolled student is rejected.
Processing time: average and percentile time to process a frame or image.
Attendance completion time: time required to complete a class session compared with the institution's existing process.
Operational measures: duplicate record rate, uncertain-match rate, manual correction rate and system availability.
Results should be broken down by relevant conditions such as lighting, pose, partial occlusion, group size and camera distance. Report the number of participants, number of images/frames, number of genuine and impostor comparisons, confidence intervals where practical, and the exact threshold used. A single overall accuracy figure is insufficient to demonstrate fairness or robustness.

6.1 Proposed Test Cases

Test case	Expected system behaviour	Evidence to record
Registered student, clear frontal face	Recognize or mark for review based on threshold.	Correct match / confidence / time
Registered student, low illumination	Detect quality issue or recognize if confidence remains valid.	Detection and recognition rate
Partial face occlusion	Avoid forced identity assignment when uncertain.	False match / review rate
Unknown person	Do not create an attendance record for an unknown identity.	False acceptance count
Same student detected more than once	Keep only one attendance record per session.	Duplicate count
Several students in one frame	Process multiple faces and flag ambiguous detections.	Per-face result / processing time
Faculty correction	Record correction with user and timestamp.	Audit log completeness

VII. EXPECTED OUTCOMES

The following are expected outcomes and targets for evaluation, not measured findings:

- A working browser-based prototype supporting student enrollment, faculty login, attendance sessions and reports.
- An integrated face-processing pipeline that detects faces, creates feature representations and compares them with enrolled templates.
- Reduced manual effort for attendance recording in suitable classroom conditions, subject to measured comparison with the existing process.
- Timestamped and searchable attendance records with duplicate prevention and a review process for uncertain matches.
- An evaluation report containing precision, recall, F1-score, FAR, FRR, processing time and performance under varied conditions.
- Identification of practical limitations involving lighting, pose, occlusion, crowded frames, camera placement and biometric privacy.
- No numerical accuracy or time-saving result should be stated as achieved until it has been measured on the completed prototype using a documented test protocol.

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VIII. PRIVACY, SECURITY AND ETHICAL CONSIDERATIONS

Facial templates are sensitive biometric information. Before deployment, the institution should define the purpose of processing, obtain appropriate informed consent or other valid authorization, explain the alternative attendance method, restrict access to authorized personnel and publish a retention/deletion policy. Students should be able to raise a correction request where a recognition error occurs. The system should avoid retaining unnecessary raw images and should protect stored templates using appropriate access controls and encryption. It should not be used for unrelated surveillance or disciplinary profiling. A faculty member must remain responsible for reviewing exceptions and finalizing attendance.

The institution should also assess applicable Indian data-protection requirements and institutional policies before collecting or processing student biometric information. This project paper is not legal advice.

IX. LIMITATIONS

- Recognition performance may decrease with poor lighting, low-resolution cameras, unusual poses, masks or partial occlusion.
- A model trained on external datasets may not generalize equally to the local student population.
- Group-image processing may require additional computation and careful handling of overlapping faces.
- Facial recognition can make mistakes and may be vulnerable to spoofing unless liveness checks are implemented and validated.
- A web-based prototype requires reliable camera access, network connectivity and secure server configuration.
- The proposed evaluation remains incomplete until a working prototype and approved dataset are available.

X. CONCLUSION

This paper has presented the design of a web-based facial recognition system for automated student attendance. The proposed solution combines a browser interface, backend processing, face detection and alignment, embedding-based identity matching, a structured attendance database and reporting tools. Confidence thresholds, duplicate checks and faculty review are included to reduce the risk of incorrect automatic records. The evaluation plan measures both recognition quality and operational efficiency under realistic classroom conditions. The system is expected to reduce repetitive attendance work and improve record accessibility, but its actual effectiveness must be established through controlled testing. Privacy, consent, security and a non-biometric alternative are essential requirements for responsible institutional use.

XI. FUTURE SCOPE

- Add presentation-attack detection and liveness verification, followed by dedicated spoofing tests.
- Improve multi-face tracking across video frames to reduce repeated processing and duplicate detections.
- Provide mobile-friendly faculty access and integration with existing institutional information systems.
- Evaluate model calibration and demographic performance across varied lighting, pose and camera conditions.
- Introduce automated backup, audit dashboards and secure integration with learning-management platforms.

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