Ai Based Attendance System

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***Abstract*—Attendance management is a fundamental administrative task in educational institutions. Conventional methods such as manual roll calls and biometric systems are time-consuming, error-prone, and susceptible to proxy attendance. Moreover, biometric systems raise hygiene and accessibility concerns. With the rapid advancement of artificial intelligence and computer vision, face recognition has emerged as an effective, contactless, and automated solution for attendance management.**

This paper presents the design and partial implementation of an AI-based student attendance system using deep learning-based face recognition techniques. The primary focus of this work is on the registration phase, where facial images of students are collected, processed, and converted into numerical embeddings. Face detection and alignment are performed using the Multi-task Cascaded Convolutional Neural Network (MTCNN), and facial embeddings are generated using the Face Net model. These embeddings are securely stored in Firebase Fire store along with student metadata.

The recognition and attendance marking phase, which involves real-time video processing, face matching, automatic attendance marking, and report generation, is proposed as future work. The proposed system aims to provide a scalable, accurate, and contactless attendance solution suitable for modern educational environments.

***Index Terms*—AI-Based Attendance System, Face Recognition, MTCNN, Face Net, Deep Learning, Firebase Fire store, Computer Vision**

I. INTRODUCTION

Attendance monitoring is an essential requirement in schools, colleges, and universities for tracking student participation and maintaining academic records. Traditional attendance methods such as manual registers are inefficient, especially in large classrooms, and are prone to human error and manipulation. Biometric systems such as fingerprint scanners improve automation but introduce issues related to hygiene, hardware dependency, and user inconvenience.

Face recognition technology offers a promising alternative by enabling contactless and automated attendance marking. Recent advancements in deep learning have significantly improved the accuracy and reliability of face recognition systems. By learning discriminative facial features, deep learning models can recognize individuals even under variations in lighting, pose, and facial expressions.

This project proposes an AI-based student attendance system that leverages deep learning-based face recognition. The current implementation focuses on developing a strong and reliable registration phase, which is the backbone of any face recognition system. A well-designed registration phase ensures higher accuracy and robustness during recognition.

Another important aspect of face recognition-based attendance systems is their ability to adapt to real-world variations such as changes in facial appearance, lighting conditions, and camera angles. These variations often lead to reduced recognition accuracy if not handled during the data preparation stage. Therefore, this work places significant importance on collecting diverse facial images during registration and applying deep learning-based feature extraction techniques. This approach ensures that the system remains robust and reliable when deployed in dynamic classroom environments.

II. CONTEXT AND IMPORTANCE

The digital transformation of education has increased the demand for intelligent and automated systems. With growing class sizes and limited teaching time, manual attendance methods are no longer practical. Automated attendance systems help institutions save time, reduce administrative workload, and maintain accurate records.

Face recognition-based attendance systems are particularly important in the post- pandemic era, where contactless solutions are preferred. Such systems also support smart classroom initiatives by integrating attendance data with digital dashboards and analytics.

The success of any face recognition system depends heavily on the quality of the registration data. Variations in lighting, pose, and facial expressions must be captured during registration to ensure reliable recognition in real-world classroom conditions.

III. RESEARCH OBJECTIVES

The objectives of this research are categorized as follows:

Primary Objectives

- To design an AI-based attendance system using face recognition.
- To implement a robust registration phase using deep learning techniques.
- To securely store facial embeddings in a cloud-based database.

Secondary Objectives

- To collect facial images under different angles and lighting conditions.
- To ensure scalability and security of stored biometric data.
- To propose a complete framework for future recognition and attendance automation.

IV. LITERATURE REVIEW AND RESEARCH GAPS

Early attendance systems relied on manual registers and RFID cards, which were inefficient and vulnerable to misuse. Biometric systems improved automation but introduced new challenges such as hygiene concerns and hardware dependency.

Traditional face recognition techniques such as Eigenfaces and Local Binary Pattern Histogram (LBPH) showed limited accuracy under real-world conditions. Recent deep learning-based models, particularly convolutional neural networks (CNNs), have significantly improved face recognition performance.

Face Net introduced the concept of learning facial embeddings in a high-dimensional space, enabling accurate face matching using distance metrics. MTCNN further improved face detection and alignment by using a cascaded CNN architecture.

Despite these advancements, many existing attendance systems lack:

- Sufficient dataset diversity
- Secure cloud-based storage
- Clear separation between registration and recognition phases

This work addresses these gaps by emphasizing a structured registration pipeline and cloud integration.

Recent studies have also explored hybrid approaches that combine deep learning- based face recognition with cloud-based storage and mobile applications. These systems demonstrate improved scalability and accessibility compared to standalone desktop solutions. However, many such implementations rely heavily on pre-built APIs without clearly documenting the internal working of the registration pipeline. Additionally, limited emphasis is given to dataset preparation strategies, such as capturing facial images under diverse angles and lighting conditions, which are crucial for improving recognition accuracy. This highlights the need for a well- structured registration phase that focuses on data quality, preprocessing, and secure storage, as addressed in the proposed system.

V. PROPOSED SYSTEM OVERVIEW

The proposed system is divided into two major operational phases:

Registration Phase

Recognition and Attendance Marking Phase

This modular architecture ensures flexibility, scalability, and ease of future enhancement. The current work focuses on implementing and validating the registration phase.

The proposed system is designed with a layered and service-oriented architecture, where each module performs a specific task such as face detection, feature extraction, data storage, and attendance management. This modular design simplifies debugging, testing, and future upgrades. Furthermore, the use of cloud-based storage and API- driven communication enables seamless integration with mobile applications and dashboards, making the system suitable for deployment across multiple classrooms and institutions.

VI. WORKING OF THE PROPOSED SYSTEM

6.1. Registration Phase

The registration phase is a one-time process performed for each student. Initially, 13–14 facial images of each student are collected under various conditions, including different angles, head tilts, facial expressions, and lighting environments. This diversity improves the robustness of the system during recognition. Face detection and alignment are performed using MTCNN, which identifies facial landmarks such as eyes, nose, and mouth. Proper alignment minimizes variations caused by pose and orientation.

The aligned facial images are processed using the FaceNet deep learning model, which converts each face into a 128- dimensional numerical embedding. These embeddings uniquely represent each student's facial features. The generated embeddings are stored in Firebase Firestore along with student metadata such as roll number and name. Cloud storage ensures scalability, security, and easy access during recognition.

Capturing facial images from multiple angles and under varying environmental conditions during the registration phase significantly enhances the robustness of the system. Variations such as slight head tilts, half-profile views, and changes in illumination help the deep learning model learn invariant facial features that remain consistent across different classroom scenarios. This diversity in training data reduces false rejections during recognition and improves overall system reliability. Furthermore, preprocessing steps such as face alignment and normalization ensure that irrelevant background information is minimized, allowing the model to focus solely on discriminative facial features

Steps involved:

1. Capture multiple facial images of each student under controlled conditions
2. Detect faces using MTCNN and perform alignment
3. Generate 128-dimensional embeddings using FaceNet
4. Store embeddings along with student metadata in Firebase Fire store

This approach enhances privacy as raw images are not required after embedding generation.

6.2. Recognition and Attendance Marking Phase

In this phase, the teacher opens the attendance application and selects the class. The mobile phone camera records a short video of the classroom.

Using OpenCV, the video is converted into frames. Faces are detected and aligned using MTCNN, and embeddings are generated using FaceNet. These embeddings are compared with stored embeddings using Euclidean distance. If the distance is below a predefined threshold, the student is marked present.

Attendance records are stored automatically, attendance percentages are calculated, and reports can be generated in PDF format using the Report Lab library. Communication between the Android application and the Python backend is handled using REST APIs.

To ensure reliable recognition in real classroom environments, the proposed recognition phase will incorporate threshold-based decision making and frame-level redundancy. Since multiple frames are extracted from the recorded classroom video, a student's presence can be confirmed only when the same identity is detected consistently across several frames. This approach helps in reducing false positives caused by occlusions, motion blur, or temporary face misdetections. Additionally, unrecognized or low-confidence faces can be flagged for manual verification, further improving the reliability of the attendance marking process.

The recognition phase performs real-time attendance marking.

Steps involved:

1 Capture live video using CameraX API
2 Extract frames at regular intervals
3 Detect faces in each frame using MTCNN
4 Generate embeddings using FaceNet
5 Compare embeddings using cosine similarity
6 Apply multi-frame voting to improve decision accuracy
7 Mark attendance and update database
8 The multi-frame voting mechanism aggregates results across multiple frames, reducing false positives and improving reliability.

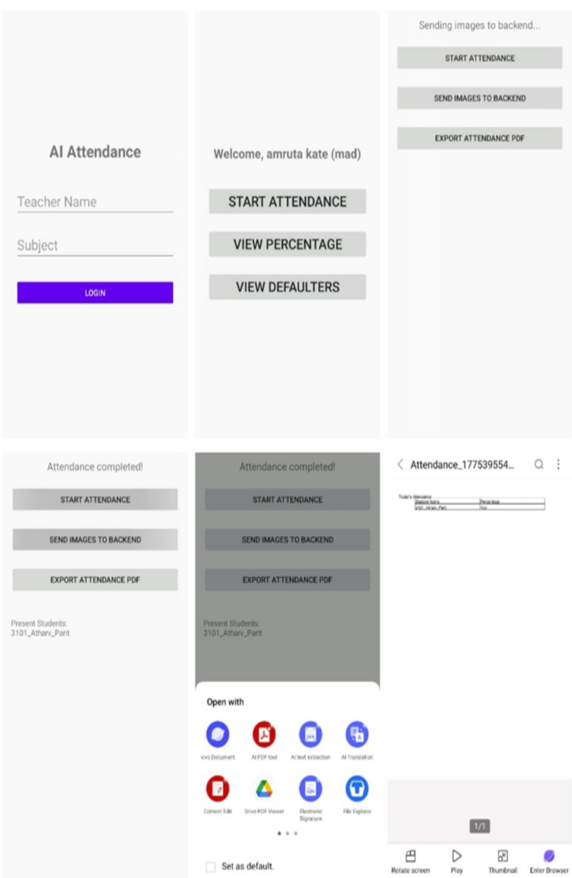
VII. DATASET DESCRIPTION

The dataset consists of facial images collected manually from students. Each student has a dedicated folder containing multiple images. A CSV file maps student details such as roll number and name to their respective folders. The dataset includes variations in pose, lighting, and facial expressions to improve recognition performance.

VIII. KEY TECHNOLOGIES USED

1. Python: -Core programming language
2. MTCNN: - Face detection and alignment
3. FaceNet : - Facial embedding generation
4. TensorFlow: – Deep learning framework
5. OpenCV : – Image and video processing
6. Firebase Firestore : – Cloud database
7. SciPy: – Distance calculation (planned)
8. Report Lab: –Degeneration (planned)
9. Android Studio: –Mobile application development (planned)

IX. RESULT



X. EVALUATION

The system has been partially evaluated through testing of the registration module. The generated embeddings showed high consistency for the same individual across multiple samples.

For comprehensive evaluation, the following metrics will be used:

- Accuracy: Measures overall correctness of recognition
- Precision: Measures correctness of positive identifications
- Recall: Measures ability to detect all actual individuals
- False Acceptance Rate (FAR): Measures incorrect acceptance of unauthorized individuals
- False Rejection Rate (FRR): Measures rejection of authorized individual

Future evaluation will involve real-time classroom testing with multiple students under varying conditions to analyze system performance.

XI. ADVANTAGES

The proposed system offers several advantages:

- Contactless and hygienic attendance system
- Eliminates proxy attendance
- Reduces time required for attendance marking
- Improves accuracy and reliability
- Provides real-time cloud synchronization
- Enables automated analytics and reporting
- Scalable for large institutions

XII. ETHICAL CONSIDERATIONS AND CHALLENGES

The use of biometric systems raises important ethical concerns related to privacy, security, and fairness.

To address these concerns:

- Only facial embeddings are stored instead of raw images
- Secure cloud storage and encryption mechanisms are used
- Role-based access control ensures data protection
- Future integration of liveness detection will prevent spoofing attacks
- Efforts will be made to minimize algorithmic bias through diverse datasets

XIII. CONCLUSION AND FUTURE SCOPE

This paper presents the design and partial implementation of an AI-based student attendance system with a strong emphasis on the registration phase. The system successfully detects faces, generates facial embeddings, and stores them securely in a cloud database. The recognition and attendance marking phase is proposed as future work and will enable real-time attendance automation, report generation, and mobile application integration.

In future implementations, the proposed system can be extended to support real-time classroom monitoring using both mobile phone cameras and fixed classroom cameras. Advanced optimization techniques can be applied to reduce computational overhead and improve real- time performance. The system can also be enhanced by incorporating attendance analytics dashboards, enabling teachers and administrators to visualize attendance trends, identify irregularities, and generate detailed reports. Furthermore, integration with institutional learning management systems (LMS) can allow seamless synchronization of attendance data with academic records. With proper deployment and ethical safeguards, the proposed system has strong potential for real-world adoption in educational institutions.

Declarations

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5. Use of AI Tools: AI tools were used for grammar refinement and structuring
6. Conflict of Interest: No conflict of interest
7. Copyright: All permissions obtained

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