Face Recognition Attendance System

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Abstract— Conventionally, attendance management at educational institutes relies on a manual or partly automatic approach that is not only inefficient but also prone to errors and potential misuse, such as fake attendance. This paper highlights the development of an automated attendance management system that uses deep learning–based face recognition technology to automate attendance recording.

The proposed solution relies on a full-stack approach that incorporates ReactJS on the front-end to build a responsive user interface for the system while the back-end utilizes FastAPI to handle authentication and interactions between the frontend and the relational database used for storing user data, including user roles. DeepFace technology is employed to create an automated pipeline for face recognition, whereby facial images are converted into embeddings before identity matching is performed by calculating cosine similarity between the embeddings.

Access controls are provided to various categories of users based on their roles, thus making it possible for administrators to perform efficient user management, while faculty members are able to mark attendance in class for the enrolled students in real-time. Users are then allowed to access attendance records from dashboards for monitoring purposes.The experimental results show that this system is very effective in reducing manual effort and increasing the accuracy of the attendance system under normal circumstances. However, its effectiveness can be affected by various hardware constraints as well as external factors such as lighting. Overall, the suggested approach provides a very scalable solution for attendance management using AI.

Keywords— ***Face Recognition, Attendance System, Deep Learning, FastAPI, React***

I. INTRODUCTION

1.1 Background

Management and control of attendance records are crucial tasks within educational organizations. Manual methods of taking attendance face many disadvantages such as the following:

1.Wastage of Time: Manual entry of attendance takes about 10-15 minutes per session, resulting in wasted time that could have been used for instructional purposes.

2.Inaccuracy Due to Errors: Errors that might be committed by the human beings who conduct manual processes result in inaccurate information regarding student attendance.

3.Lack of Prevention Against Falsifications: There is a lot of room for falsification using manual systems since attendance records can easily be manipulated in favor of proxy students.

4.Difficult and Lengthy Reporting Processes: The process of managing and preparing reports from manual attendance records is cumbersome and time consuming.

However, to counteract these drawbacks, automation techniques have been applied in the form of biometric technologies such as fingerprint and RFID systems. However, some of the drawbacks associated with these attendance systems include:

5.Scarcity of Scalability: The biometric systems involve personal interaction; hence, scalability is a huge problem in case of bigger classrooms with more people.

6.Time Consuming in Case of Big Numbers: If the number of biometric systems used is not sufficient, the students will have to follow a queue in order to register, leading to inefficiency in terms of time.

7.Lack of Non-Physical Interactions: Some of the biometric systems need direct physical interaction, which is quite difficult to achieve.

Hence, in order to counter these drawbacks, facial recognition systems have proved to be effective.

1.2 Motivation and Significance

The primary motivation for the development of an automated attendance management system is driven by the need for efficiency, accuracy, and dependability in educational institutions. These motivations include the following:

1.Regulatory Requirements: Attendance records are needed in educational institutions to guarantee that students have satisfied the minimum attendance requirements (e.g., 75%).

2.Academic Supervision: Good attendance information may assist in identifying students who attend classes infrequently. It will enable the faculty to offer necessary interventions.

3.Reduced Administrative Tasks: The automation of attendance tracking reduces unnecessary repetitive processes and saves valuable time for faculty and administrative staff.

4.Increased Accuracy and Data Integrity: Human error is minimized in automated attendance systems, and any form of fraudulent behavior like proxy attendance becomes impossible.

5.Immediate Attendance Recording: Digital systems ensure immediate recording and access of attendance records from dashboards by both the faculty and students.

6.Scalability of Attendance Tracking: Automated systems make it possible to process thousands of students' attendance at once without affecting the processing time and labor.

7.Application of Technological Innovations: The use of face recognition technology ensures privacy, contactless attendance, and adherence to current technological trends.

8.Effective Digital Data Management: Data integrity and consistency are maintained using centralized data storage.

1.3 Research Contributions

The proposed system provides the following main contributions:

1.Full-Stack Attendance Management System Development: A full-stack web application was developed to manage attendance. ReactJS and FastAPI were used to develop the frontend and backend, respectively, to facilitate smooth interaction between users and the system.

2.Face Recognition via Deep Learning Models: A deep learning-based pipeline for face recognition using the DeepFace algorithm was integrated into the system. The process involves calculating embeddings of faces using cosine similarity.

3.Real-Time Attendance Capture: Real-time attendance was marked by capturing faces from the webcam stream. Attendance marking can be done in real-time by the faculty member without any further intervention.

4.Multi-User Access with Role-Based Security: Multi-user access was provided to the system. There are three different roles – Admin, Faculty, and Student. Each role has its own permissions to access the system functionalities.

5.Authentication with Password Hashing: JWT-based authentication and password hashing techniques were used to authenticate the users. This approach ensures secure API communication.

6.Database Structure Design: The data were stored in a relational database using SQLite.

7.Dashboard Development: Dashboards were designed for each role. Faculty members were allowed to monitor the attendance record. Students could check their attendance records on the dashboard.

II. Literature Overview

Previous attendance management systems mostly depended on manual procedures or rudimentary automation. The technologies that attempted to improve the system included RFID and fingerprint bio-metrics. Nevertheless, they had flaws such as problems of scaling, physical touch dependence, and the risk of someone else attending on their behalf.8888888

As a result of advances in deep learning and computer vision, face recognition has proven to be a viable method of automatic attendance management. For instance, models **like DeepFace used neural networks to verify an individual's** face and exhibited notable improvement in accuracy in controlled environments. Nonetheless, these models could not cope with changes in lighting conditions, poses, or facial expressions.

Embedding models such as FaceNet provided higher recognition accuracies because they map faces to a feature space for easy comparisons through distances such as cosine similarity. Even better models were developed to handle face recognition challenges in uncontrolled situations.

Even with these improvements, some of the face recognition-based attendance management systems currently in use suffer from the following limitations:

1. Lack of web-based implementation in real time
2. Lack of a user-friendly interface
3. Support for limited role-based access control features
4. Poor integration with advanced backend platforms

These limitations will be mitigated through the integration of deep learning-based face recognition with the full stack web development platform, comprising ReactJS in the front end, FastAPI at the back end, and a reliable database.

III. Methodology

A. ***DATSET*:** The dataset used in the proposed system is a combination of structured data in a relational database together with image data from face recognition.

1.Database Tables:

The following are the main database tables that are involved in the proposed system:

- **Users Table:** Contains users' credentials, users' role (admin, faculty, student), and authentication info.
- **Students Table:** Has student-specific information like the student ID, name, and section of the students.
- **Sections Table:** Contains sections/ classes of students.
- **Attendance Table:**Stores information related to the attendance of the students containing their ID, date of attendance, and whether they attended.

2.Face Images Collection:

- Images of students' faces are collected when they enroll themselves.
- Images of the students are processed using a Deep Learning model to create embeddings.
- Embeddings are created as reference data for recognizing students' faces.

3.Inputs:

Images are collected in real time using the webcam of the computer.

B. ARCHITECTURE

This application is designed based on the three-tier architectural approach:

1. Presentation Layer (Front-end)

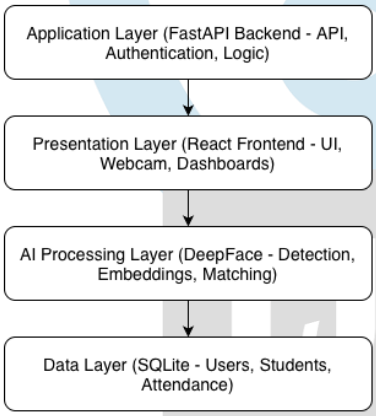
- Designed with ReactJS framework
- Used for logging in and displaying the dashboard interface
- Takes pictures using the user's webcam
- Sends requests to the back-end services

2. Application Layer (Back-end)

- Designed with FastAPI framework
- Manages user authentication through JWT
- Processes attendance requests
- Interacts with face recognition API
- Communicates with the database

3. Database Layer (Database)

- SQLite database
- Holds users' details, students' details, and attendance records



Pipeline of Face Recognition Process:

This technique adopts a face recognition process that employs deep learning technology and follows these steps:

Face Detection: This process involves identifying faces from the captured image using DeepFace technology.

Pre-processing: The detected face is standardized and resized.

Embedding: The detected face is converted to a vector form (embeddings) using a trained FaceNet model.

Similarity Matching: The created embedding is matched with already created embeddings using cosine similarity method.

Decision: If the match passes the defined threshold, then attendance is recorded.

TABLE I. TECHNOLOGY STACK

Component	*Technology*	*Rationale*
Frontend	ReactJS	Develops the UI for the app
Backend	FastAPI (Python)	Deals with the API endpoints and the business logic
Face Recognition	DeepFace (FaceNet)	Creates face embeddings
Similarity Measure	Cosine Similarity	Compares the similarity of faces based on their embeddings
Database	SQLite	Easy-to-manage DB
Authentication	JWT	Authenticates users and API requests
Server	Uvicorn	Hosts the FastAPI application

C. FLOWCHART:

i. Web Application Flowchart:

The suggested system will have a web application with role-based authentication.

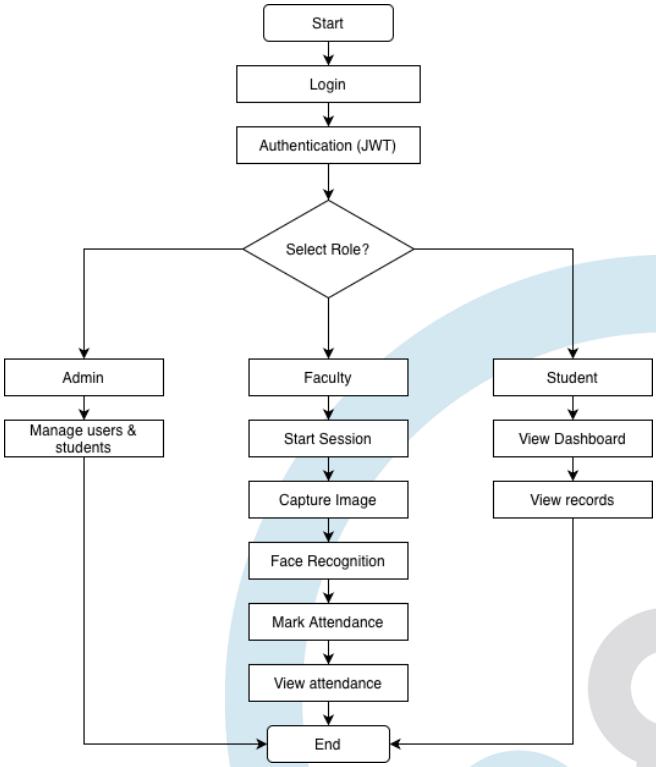
Admin Role: Users management, Students management, Sections management

Faculty Role: Start an attendance session, Records attendance

Student Role: Access dashboard to view attendance

Workflow of application

- User logs in the application using the login form
- User gets authenticated by the system using JWT
- Based on the role, User is redirected to a particular interface
- Faculty begins an attendance session
- Webcam takes picture
- System uses facial recognition technology
- Attendance is recorded



ii. Data Flow Flowchart:

The flowchart provided below showcases the flow of data in the proposed system design

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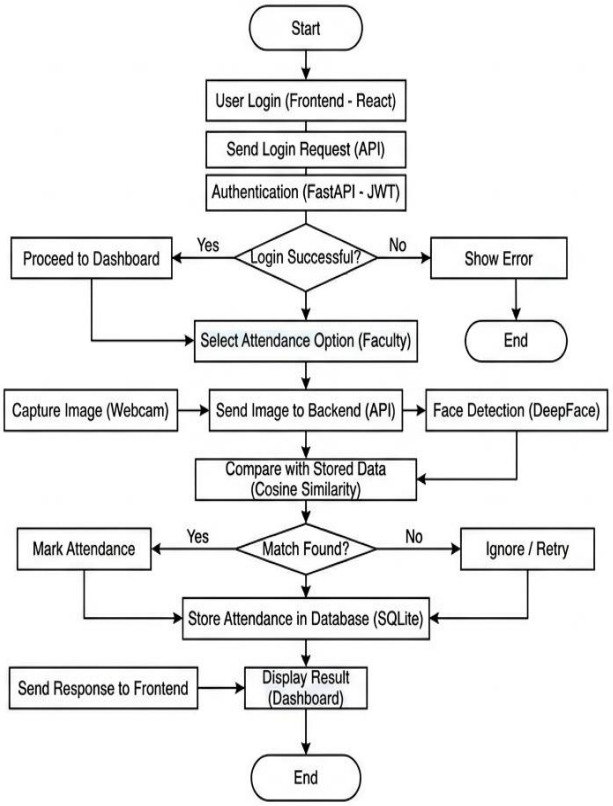

D. RESULTS:

The outcomes of this proposed system include the following:

1. Web Application:

A fully integrated web application has been developed to provide Role-Based Access Control. The current system allows for the following roles to be managed:

- **Admin:** The admin will manage the users, students, and sections within the application.
- **Faculty:** After login by a faculty member, the following features become available to them:

i. Mark Attendance: The faculty member will be taken to an interface to mark the attendance through the use of webcam. This will be done through a facial recognition module on the image captured.

ii. Attendance Records: This feature will allow the faculty members to view the attendance records of students for their sections.

- **Student:** The student can login into the application and check his/her attendance records.

2. Attendance Records

The attendance records will be stored in structured form in the database which will have information about students, dates, and attendance marks.

3. Real-Time Attendance Management

The system provides real-time attendance management using webcam input. It uses a Deep Learning-based facial recognition model to identify students automatically.

4. System Performance

The system demonstrates effective performance under normal conditions:

- Accurate recognition for enrolled students
- Quick processing of attendance data
- Performance dependent on hardware (CPU-based execution)
- Reduced efficiency under poor lighting or unclear images

5. Database Management

All system data is stored in a relational SQLite database, including:

- User authentication data
- Student details
- Attendance records
- This ensures secure storage, efficient data retrieval, and consistency.

5. Observations and Analysis:

Based on system implementation and testing, the following observations were made:

- The system significantly reduces manual effort in attendance marking

- Automated face recognition improves accuracy compared to manual methods
- System performance depends on image quality and environmental conditions

Taking into account the needs of the system, such as real-time processing, efficiency of computation, and simplicity of implementation, the FaceNet model is chosen to be used in the process of recognizing faces (using the DeepFace framework). This solution strikes an ideal balance between accuracy and performance.

Parameter	DeepFace (FaceNet)
Overall Accuracy	High
Low-Light Performance	Moderate
Group Image Handling	Moderate
Occlusion Robustness	Moderate

IV CONCLUSION

This paper presents the design and implementation of an automated attendance management system based on deep learning–based face recognition. The system integrates a full-stack architecture using React for the front-end and FastAPI for the back-end, enabling efficient communication between users and the system. The proposed solution utilizes the DeepFace framework with the FaceNet model to perform face recognition by generating embeddings and matching them using cosine similarity. This approach enables reliable identification of students and supports real-time attendance marking using webcam input. The system successfully reduces manual effort, improves accuracy in attendance tracking, and provides a user-friendly interface with role-based access control for administrators, faculty, and students. Attendance data is securely stored in a structured database, allowing easy retrieval and monitoring. Although the system performs effectively under normal conditions, its performance may vary based on factors such as lighting, image quality, and hardware limitations. Despite these constraints, the results demonstrate that face recognition-based systems are a practical and efficient solution for automated attendance management in educational institutions.

V FUTURE SCOPE

Future enhancements include:

1.Performance Enhancement: Enhance the processing speed of real-time data with the help of GPU processing and advanced face recognition methods.

2.Mobile App Integration: Design a mobile app that facilitates attendance recording and monitoring.

3.Cloud-Based Implementation: Make the solution scalable and centrally accessible by implementing it in the cloud environment.

4.Enhanced Face Recognition Techniques: Use sophisticated algorithms to improve recognition rates even in difficult environments like poor light conditions and obstructions.

5.Anti-Spoofing Techniques: Ensure security by adding anti-spoofing features that prevent the system from being tricked by images or videos.

6.Advanced Analytics: Offer analytics related to attendance statistics and performance metrics.**2. Edge Computing Deployment**: Deploy models on edge devices to reduce CCTV stream bandwidth requirements

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