Real-Time Facial Recognition Attendance System for Smart Classrooms

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Abstract— **Manual attendance marking is a tedious and error-prone task. Problems like proxy attendance and improper record management are common. Frequent hourly attendance makes the task of teachers more difficult. This paper presents a Real-Time Facial Recognition Attendance System for Smart Classrooms. In this system, facial recognition techniques are used to recognize students through images clicked in the class. Teachers log in to the system and capture a classroom image to mark attendance automatically. Faculty attendance is also recorded. This system helps in classifying absent students as hourly absent and alerts subject staff, tutors, and parents accordingly. This system is more efficient and helps in removing proxy attendance through artificial intelligence-based image recognition techniques.**

Keywords— **Absentee Alert, Automated Attendance System, Facial Recognition, Hour-wise Attendance, Image Processing, Parent Notification, Proxy Prevention, Real-Time Monitoring, Smart Classroom, Staff Login.**

I. INTRODUCTION

Managing attendance is an important part of running a school because it helps keep track of student participation, discipline, and academic performance. Teaching staff have always kept track of attendance by hand using registers or spreadsheets. This method is easy to use, but it takes up valuable class time and is prone to problems like mistakes, wrong entries, and proxy attendance. In big classrooms, checking to see if each student is there by hand takes too much time and cuts down on the time that teachers can actually teach.

A. The history of attendance monitoring

Monitoring attendance is an important part of managing academics in schools and colleges. It helps keep track of how many students are participating, keep order, and see how well they are doing in school. Teachers usually keep track of attendance by hand with registers or spreadsheets. This method is easy, but it takes up a lot of class time and makes mistakes more likely. It takes a lot of time and effort to check that each student is in a large classroom. During each class, teachers often spend a few minutes calling out students' names or checking roll numbers.

These tasks that have to be done over and over again take away from the time teachers can actually teach and add to the work load of the administration. Also, manual attendance systems are open to proxy attendance, which means that one student marks attendance for another, which makes the records wrong.

B. Facial recognition as a biometric tool

Biometric identification systems use things like fingerprints, iris patterns, or facial features to tell people apart. Facial recognition has become very popular among these technologies because it doesn't require any special hardware, is easy to use, and doesn't require any contact. Face recognition systems look at unique features of a person's face and turn them into digital representations known as face embeddings or face prints. To find out who someone is, these digital representations are compared to data that is stored in a database. Facial recognition works by using pictures taken by cameras, so it can identify people without having to touch sensors. This feature makes facial recognition especially useful in places like classrooms, where it needs to quickly and accurately detect the presence of many people.

C. Traditional Attendance System Limitations

Several forms of automated attendance systems have been developed using different technologies such as RFID cards, fingerprint readers, and smart cards. While these systems have improved the management of attendance to a certain level, these systems still require students to personally interact with the system. For example, in the case where RFID cards are used, students have to personally swipe their cards or place their fingers on the fingerprint reader. This results in a delay in the recording of attendance when students are many and want to record their attendance at the same time. Besides this, the use of fingerprint readers may also raise hygiene issues that require additional hardware maintenance.

D. Group Image-Based Attendance Recognition

Recent developments in computer vision techniques and machine learning have led to the development of techniques that can recognize multiple faces in a single image.

Instead of asking students to attend one by one, the computer vision technique can be utilized such that a group picture of the entire class can be taken by the camera, and all the students present in the class can be recognized simultaneously from the single image taken by the camera. In this technique, the image of the classroom is taken by the camera, and the face detection techniques are utilized to identify all the students present in the classroom. Each face of the students identified by the face detection techniques is then recognized by the facial recognition techniques, which compare the features of the students' faces with the data stored previously in the database of the system.

E. Motivation for Smart Classroom Attendance Systems

Smart classrooms refer to the utilization of modern technologies to enhance the efficiency of the teaching-learning process. The utilization of automated attendance systems with group image facial recognition is a significant addition to the concept of smart classrooms. It is a quick and effective way to manage student attendance without the need for physical student-teacher interactions. In the proposed attendance system, the camera installed in the classroom captures the image of the students during the lecture session. The system uses the image to detect the faces of the students and then recognize them using the stored images. The attendance is updated instantly in the cloud database along with the date and time stamp. It is an effective way to enhance the efficiency of the academic management system and contribute to the concept of smart classrooms.

II. OBJECTIVES

The main objectives of this research include the creation of an automated attendance system for smart classrooms using the concept of facial recognition. The objectives of the developed system include the elimination of the need for manual attendance recording through the use of computer vision techniques for the identification and detection of student faces from a group image taken inside the classrooms. One of the main objectives is the reduction of the overall time required for attendance recording. Instead of calling each student individually for attendance recording, the system will take a group image of the students inside the classrooms and automatically detect all the students present inside the classrooms. The other main objective is the elimination of proxy attendance problems, which is a common problem with traditional attendance systems. By using the concept of facial recognition, the identification of each student is done through the use of unique facial characteristics.

The other objectives include the integration of the concept of artificial intelligence and machine learning into the developed system for the improvement of accuracy. By using the concept of facial embeddings, the identification of multiple students at the same time is possible from a single image taken inside the classrooms.

III. LITERATURE SURVEY

Facial recognition technology has been extensively studied for the development of an automatic attendance system in educational institutions. Several researchers have proposed systems using computer vision and machine learning techniques for facial recognition. In another research paper, an attendance system was proposed using the Local Binary Pattern Histogram (LBPH) algorithm.In this system, images of students' faces are taken and stored in a dataset. While taking attendance, images of students' faces are taken and compared with the stored images to record attendance automatically. This system works well in controlled environments. However, this system may face some issues in varying light conditions. Although this system works well in recognizing students' faces, in most of the systems, students' faces are recognized individually. In the proposed system, this issue is handled by recognizing the faces of students in a single image. This helps in efficient attendance management in smart classrooms.

Some of the other systems proposed for attendance management using facial recognition techniques are:

1. *Face Recognition Based Attendance System (K. Senthilkumar, R. Suresh, March 2024)* – Images of students in a classroom are taken using a camera. Haar Cascade and LBPH algorithms are used for face detection and face recognition, respectively.

2. *Automated Attendance Monitoring System Using Face Recognition (P. Viola, M. Jones, 2023)* – Faces of students in a classroom image are detected using Viola Jones. The images of students' faces are recognized by comparing the features of the images with the pre-trained dataset.

3. *Real Time Face Recognition Using Deep Learning for Attendance (S. Kumar, A. Sharma, August 2023)* – In this system, images of students' faces in a classroom image are recognized using the CNN model of deep learning.

IV. PROPOSED METHODOLOGY

The proposed system is developed with the aim of automating the attendance recording for the students present in the classrooms using the facial recognition method. The system captures a group image of the students present inside the classrooms and automatically recognizes the students present inside the image. The overall methodology adopted for the proposed system is divided into several stages.

A. Student Registration

The first stage of the overall methodology adopted for the proposed system is student registration. During the student registration stage, the student's name and registration ID are registered with the system database. During the student registration stage itself, the images of each student present inside the classrooms are taken using the camera present inside the mobile device.

B. Face Detection

When the attendance needs to be taken, the system captures a photo of the class using the camera of the device. A face detection process is applied to the image, identifying all the faces present. The face detection module identifies the region of interest for the face.

C. Facial Feature Extraction

After the face detection process, the system extracts the facial features present on the face using a pre-trained machine learning model. A numerical representation of the face, called the facial embedding, is obtained. Facial embeddings are a set of unique numbers that represent the distinguishing features of the face.
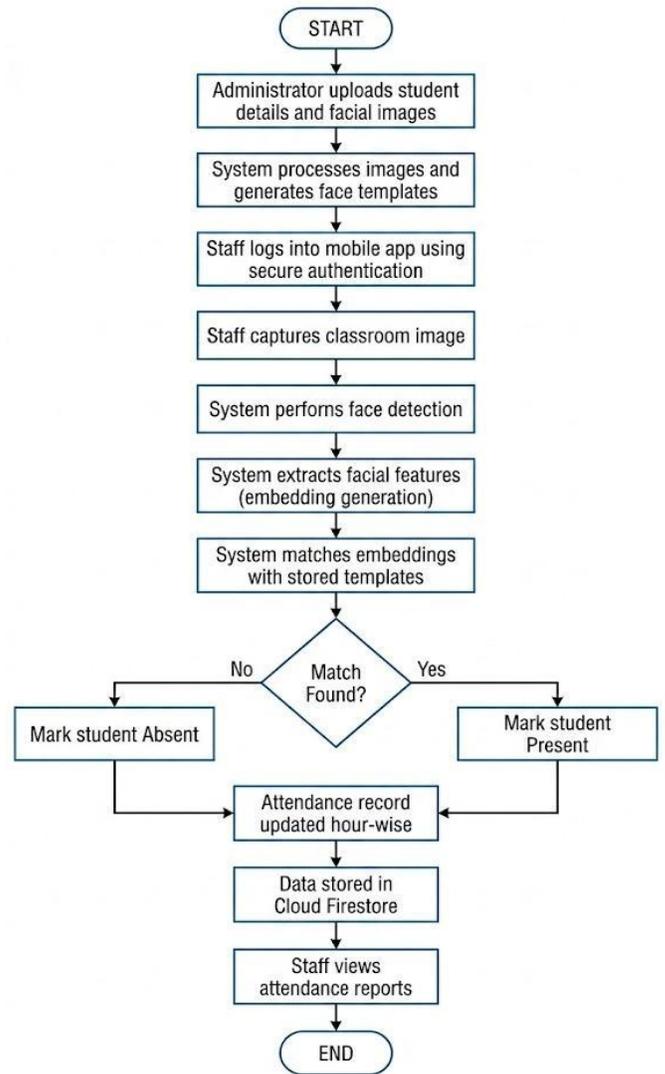

Fig. 1: Block Diagram

D. Face Recognition and Matching

The generated facial embeddings are compared with the stored embeddings in the database. A similarity comparison algorithm calculates the distance between the detected face embedding and the stored embeddings. If the similarity score falls within the predefined threshold, the system identifies the student and confirms their presence in the classroom.

E. Attendance Recording

Once the student is identified, the system records the student's attendance into the database. The information logged includes the student's name, registration number, date, and timestamp. The system is capable of detecting multiple students from a single image taken inside the classroom, hence making the management of attendance a seamless task.

V. System Architecture

The facial recognition attendance system architecture is designed with a multi-layered approach with a mobile app interface, AI processing components, authentication components, and a cloud backend component. It is a four-layer architecture with the Client Layer, AI Processing Layer, Authentication Layer, and Cloud Backend Layer.

A. Client Layer

This is the client layer where the user interacts with the application. It is developed using Flutter and is a cross-platform application. It caters to the needs of the faculty and the administrator. The staff uses the application to take a snap of the class using the camera. The administrator uses the application for other operations such as uploading student images and importing student data. Inside the application, there are several components. For example, there is an image picker component where the staff picks the image of the class. Similarly, there is a file picker component where the administrator picks the student image during the enrollment process. Additionally, there is an Excel component where the administrator imports student data into the application. Finally, the application records the date and time using the internal clock.

B. AI Processing Layer

This is the AI processing layer where the main action occurs. It is the core component where the face recognition is done on the device itself. It uses Google ML Kit for face detection. It is the component where the application is able to detect the presence of multiple faces inside the class image.

Once the faces are detected, the Tensor Flow Lite component extracts the features from the face and converts them into a numerical format referred to as a fingerprint. It is the component where the unique facial characteristics of the student are identified.

C. Authentication Layer

This layer is responsible for the security of the system. It ensures that only authorized individuals are allowed to access the system. For this purpose, we have used Firebase Authentication. The faculty members have to log in to the system using their correct credentials before they are allowed to perform any operation, such as capturing attendance or viewing the data or generating reports. This layer ensures that the system is accessed only by authorized individuals.

D. Cloud Backend Layer

The cloud backend layer is responsible for the storage and management of the app's data. For this purpose, we have used Firebase Cloud Firestore. This acts as the central database for the app. Student profiles, facial templates, class information, and attendance are stored in this database. Once the AI module identifies the students, their attendance is recorded in the cloud. Class information is also stored in this database. Attendance data is also retrieved.
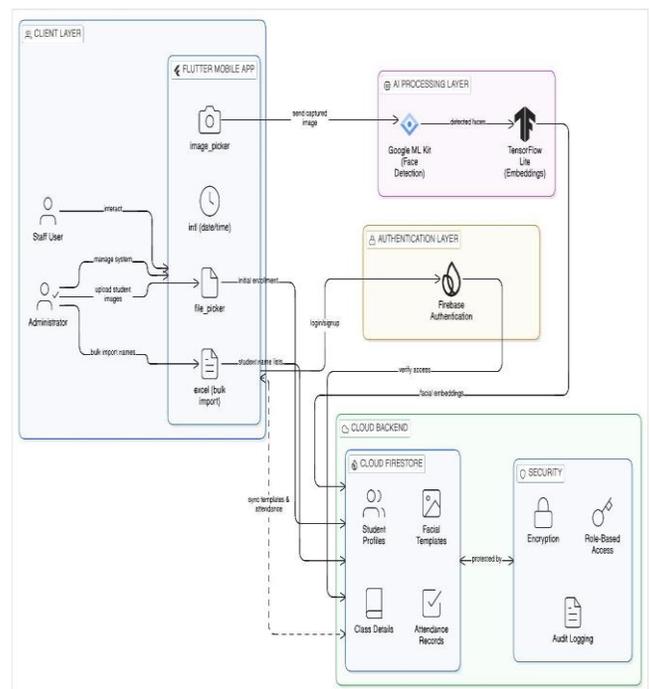

Fig. 2: Architecture Diagram

E. Security Module

The system has been designed with multiple layers to ensure that sensitive information is secure. For example, data at rest is encrypted in the system. Role-based access control is also used to ensure that only authorized users have the ability to perform certain tasks in the system. Auditing is also used to monitor user activity in the system. This is to ensure that attendance management is transparent in the system. In summary, this multi-layered system combines mobile computing, AI, and cloud computing to ensure that a secure automated attendance system is developed that can identify multiple students.

VI. System Implementation

The facial recognition system for attendance tracking is developed in the form of a mobile app that incorporates computer vision and machine learning technologies along with cloud storage. The system is divided into different modules that work in unison to perform the following tasks: student signup, facial recognition, and attendance tracking.

Firebase Cloud Firestore is used to store the data of the students. Each document in the Cloud Firestore contains the registration number, name, and numerical representations of the faces created using the facial recognition model. These numerical representations store unique features of faces in a mathematical format and are used to compare faces while tracking attendance. Cloud Firestore is used to store data securely and in real-time.

Firebase Authentication is used to secure the system. Faculty members are required to enter their credentials to access the system. This adds to the reliability and security of the system.

A. Face Embedding Storage in Database

When a student registers for the application, a picture of the student is taken, and the facial recognition model processes the picture. It converts the picture into a series of numerical values, called face embeddings, which are stored in the Firebase database. These values are the basis for the recognition of students when the attendance is marked.

B. Automated Attendance Marking Interface

The mobile application interface enables the instructor to mark the attendance of the students by using the device's camera. Once the picture of the classroom is taken, the system recognizes the number of faces and compares them with the face embeddings stored previously.

When a match is found, the student is marked present, and the list of students with the status of being present or absent is displayed.

C. Attendance Report Generation

Once the attendance is logged in, the system generates a well-structured attendance report. The information can be easily exported in CSV format, making it convenient to share with others through mobile apps like email and other communication tools.

D. Exporting and Downloading Attendance Data

In addition, the report can be downloaded in an Excel format for further analysis and long-term record-keeping.

VII. Results

The proposed facial recognition attendance system was tested in a classroom environment to evaluate its ability to detect and recognize multiple students from a group image. The system successfully captured classroom images and detected multiple faces simultaneously using the face detection module. Each detected face was processed to extract facial embeddings, which were compared with the stored student embeddings in the database.

Experimental results show that the system is capable of identifying students accurately when their faces are clearly visible in the captured image. Once a face is recognized, the system automatically records the attendance with the corresponding student details, date, and timestamp. The use of facial embeddings improves recognition speed and allows the system to process multiple faces efficiently within a short period of time.

The group image–based attendance approach significantly reduces the time required for attendance marking compared to traditional manual methods. Teachers only need to capture a single classroom image, and the system automatically identifies all present students. This reduces faculty workload and allows more time for teaching activities.

The system also demonstrates the ability to maintain digital attendance records in a structured database. These records can be easily accessed for generating reports, monitoring attendance patterns, and identifying absentee students. Overall, the proposed system provides a reliable and efficient solution for automated attendance management in smart classroom environments.
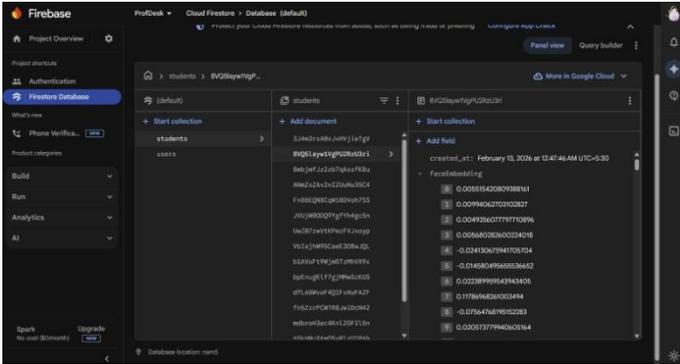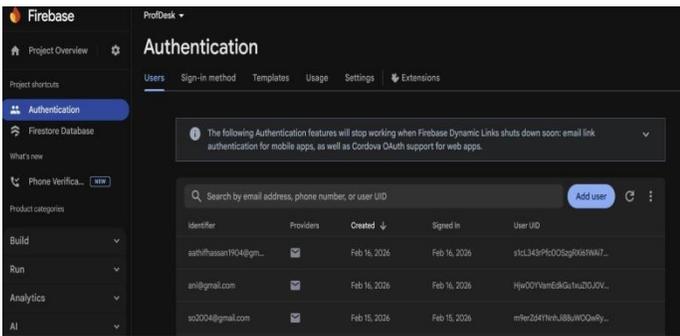
Fig. 3: Firebase Platform
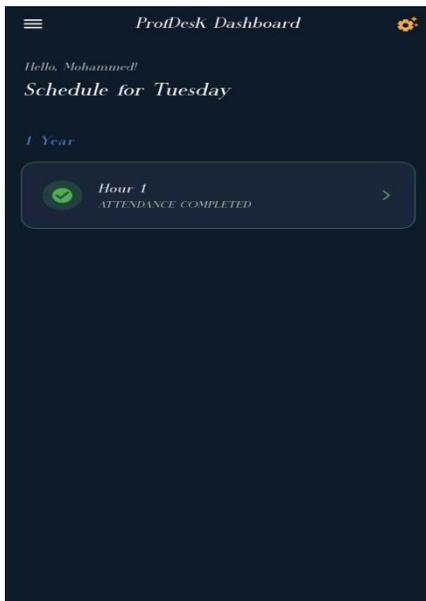

Fig. 4: Firebase Authentication
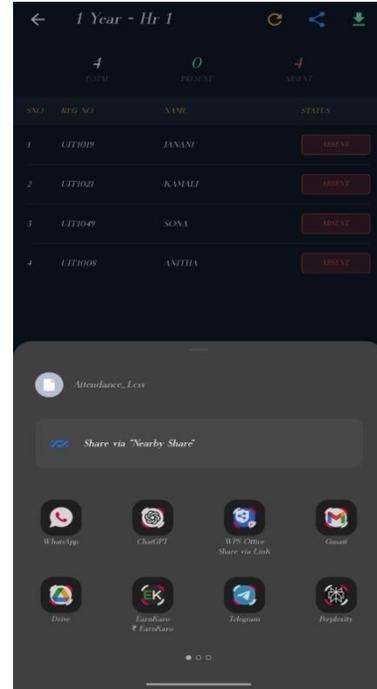

Fig. 5: Attendance Marking

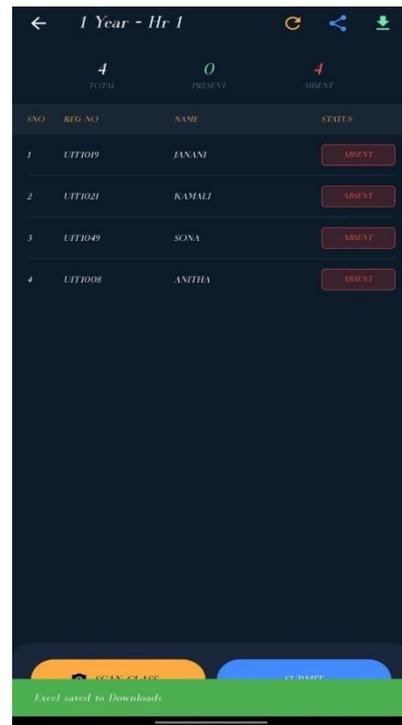Fig. 6: Share the document through Csv file or excel file

Fig. 7: Download as Excel file

VIII. CONCLUSION

The Real-Time Facial Recognition Attendance System provides an efficient and automated solution for managing classroom attendance. The system uses facial recognition technology to identify students from a group classroom image and automatically record their attendance. By integrating computer vision techniques with a cloud-based database, the system eliminates the need for manual attendance marking. The proposed approach significantly reduces the time required for attendance recording and minimizes human errors associated with traditional methods. It also prevents proxy attendance by verifying each student's identity using unique facial features. The system is capable of detecting and recognizing multiple students simultaneously, making it suitable for classroom environments with large numbers of students.

Furthermore, the digital storage of attendance records allows institutions to easily monitor attendance patterns, generate reports, and improve academic management. The integration of artificial intelligence and mobile technology makes the system scalable and adaptable for modern smart classroom environments. Overall, the proposed system demonstrates that facial recognition technology can effectively automate attendance management while improving accuracy, efficiency, and reliability in educational institutions.

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