Real-Time Attendance System Using Face Recognition

Marikannan
Department of Computer Science
Anna University Regional Campus
Coimbatore,Tamilnadu
marikannan6321@gmail.com

Rahul Rathnavel
Department of Computer Science
Anna University Regional Campus
Coimbatore,Tamilnadu
rahulrethnam005@gmail.com

Kabish
Department of Computer Science
Anna University Regional Campus
Coimbatore,Tamilnadu
kabishd74@gmail.com

Abstract-The increasing need for efficient and accurate attendance management in educational institutions has led to the development of automated systems leveraging advanced technologies. This paper presents a real-time attendance system utilizing face recognition technology to streamline the attendance process in classrooms. The system employs a dual-camera setup to ensure complete coverage of students in a classroom of 60x40 ft dimensions. A three-tier verification mechanism ensures student presence throughout the session, effectively addressing challenges such as proxy attendance and early exits. The system features a web-based interface for real-time monitoring, providing staff with the ability to manage records and students with access to their attendance data. Additionally, the system automatically shares daily attendance summaries via Telegram for enhanced communication. The project is built using Python with deep learning frameworks and achieves an accuracy of 98%, offering a robust, scalable, and efficient solution for modern educational environments.

Keywords--Face recognition, attendance automation, real-time monitoring, Flask framework, deep learning, dual-camera setup, educational management.

I. INTRODUCTION

Attendance plays a crucial role in evaluating the academic engagement and participation of students in educational institutions. Traditional attendance methods, such as roll calls or attendance sheets, are labor-intensive, time-consuming, and susceptible to errors like proxy attendance and manual entry mistakes. With the advent of technology, automated systems have become a promising solution to overcome these challenges.

This project introduces a real-time attendance system leveraging face recognition technology. Unlike conventional methods, this system ensures accuracy and efficiency through automation. The dual-camera setup captures the entire classroom from multiple angles, addressing blind spots and providing robust face detection. The system marks attendance three times during a single period, ensuring students remain present throughout. It integrates seamlessly with a user-friendly web interface, allowing staff to modify records and students to view their attendance in real-time. At the end of each day, the system shares attendance data with students via Telegram, making it both efficient and user-centric.

The proposed system offers scalability, adaptability, and integration capabilities, making it a suitable solution for modern educational institutions aiming to modernize their attendance processes.

II. SYSTEM DESIGN AND IMPLEMENTATION

A.Hardware Architecture

The hardware design plays a crucial role in ensuring accurate face recognition across the classroom. A dual-camera setup is employed, consisting of:

- **Front Camera**: Positioned at the front of the classroom, it captures a wide-angle view of the students. This camera ensures that the majority of the student faces are visible during attendance marking.
- **Side Camera**: Installed on the side to complement the front camera's coverage, this ensures no blind spots and can capture side profiles of students.

Both cameras are Logitech C920 Pro HD webcams, which offer Full HD resolution (1080p), a 78-degree field of view, and a frame rate of 30 FPS. These specifications are crucial for providing clear and detailed images under normal classroom lighting, allowing the system to function reliably even in a large room size of 60x40 ft.

B.Software Architecture

The software architecture involves multiple technologies to handle different facets of the system:

- **Backend**: Built with Python and Flask, the backend manages core functionalities such as facial recognition, attendance marking, and data processing. The **face_recognition** library is employed for encoding and matching student facial features against pre-stored encodings.
- **Frontend**: The web interface is developed using HTML, CSS, and Bootstrap. This interface is responsive and allows real-time interaction with the system for both students and staff. It provides options to manage attendance, view live video streams, and navigate attendance data organized by periods.
- **Attendance Data Storage**: The system stores attendance data in CSV files, which makes it portable and easy to manage. Real-time updates are pushed to the frontend using **Socket.IO**, ensuring that the system is dynamic and responsive.
- **Telegram Integration**: At the end of each day, the system automatically compiles attendance data and sends it to students via Telegram. This feature ensures that communication with students remains seamless and automated.

III. METHODOLOGY

A.Face Recognition Workflow

The face recognition-based attendance system operates in two distinct but interconnected phases: the **Training Phase** and the **Detection Phase**. These phases work together to ensure that the system can accurately and continuously identify students and mark their attendance.

1.Training Phase:

The **Training Phase** is the foundational step of the face recognition system. During this phase, the system prepares by capturing and processing the facial images of each student. This is achieved through the following steps:

- **Image Capture**: High-quality images of each student are taken from multiple angles, ensuring that their faces are captured in various lighting conditions and positions. This step is crucial for the robustness of the system, as it helps the model recognize students from different perspectives.
- **Facial Feature Extraction**: Using the **face_recognition** library, the system processes the captured images to extract key facial features. This involves identifying distinctive facial landmarks such as the distance between the eyes, the shape of the nose, the curvature of the jawline, and the positioning of the mouth. These features are unique to each individual and serve as a biometric template for recognition.
- **Encoding Generation**: Based on the extracted features, the system generates **facial encodings**. These encodings are numerical representations of the student's facial features and act as fingerprints for identification. The encodings are highly unique, meaning that even subtle variations in facial appearance (such as slight changes in expression) can still be recognized accurately.
- **Database Storage**: The generated facial encodings are then stored in a secure database. Each student’s encodings are associated with their identity, allowing the system to reference these encodings during the detection phase.

The **Training Phase** is a one-time setup that requires students to be enrolled into the system at the beginning of the course or session. Once completed, the system is ready to begin real-time detection and attendance marking.

2.Detection Phase:

The **Detection Phase** is where the system comes to life during the actual classroom session. In this phase, video feeds from the cameras placed in the classroom are processed in real-time to detect and recognize students. This phase operates as follows:

- **Real-Time Video Capture**: The cameras continuously capture video footage of the classroom during the class session. The video feed is processed frame by frame to identify the presence of faces.
- **Face Detection**: Using computer vision techniques, the system identifies the location of faces in each frame. This step involves detecting faces in the captured video feed and isolating them from the background.

- **Face Matching**: Once faces are detected, the system compares each face against the stored facial encodings from the **Training Phase**. The **face_recognition** library is used to match the detected faces with the stored encodings in the database. If a match is found, the student's identity is confirmed.
- **Attendance Recording**: When a match is found between a detected face and a stored encoding, the system logs the student's attendance. The time and identity of the student are recorded, marking them as present for that particular check.

The **Detection Phase** is continuous, and the system is designed to run throughout the entire class session. It ensures that students are constantly monitored and accurately identified, allowing for the real-time marking of attendance.

B.Attendance Marking Mechanism

To further ensure accuracy and prevent proxy attendance (where someone else marks attendance on behalf of a student), the system employs a **three-tier verification mechanism**. This approach involves checking the attendance of each student three times throughout the class period, ensuring that only students who remain in the classroom are marked present.

1. First Check:

At the beginning of the class or when students enter the classroom, the system performs the first check. Each student's face is identified and verified. If the student is recognized, their attendance is marked for the first time. This step ensures that all students who are present at the start of the class are correctly accounted for.

2.Second Check:

Approximately halfway through the class, the system performs the second check. This ensures that no student has left the classroom early without being recorded as absent. The system once again checks for the presence of each student by comparing the faces detected in the classroom with the stored encodings. Any discrepancies are noted, and students who are absent during this check are marked absent for that period.

3.Third Check:

Before the class ends, a final check is performed to confirm that the students who were marked present at the beginning of the class are still in attendance. This ensures that students who leave before the end of class are not falsely marked as present. If the system detects any student who is absent during this third check, they are marked absent for the session.

Each of these checks is important for ensuring the accuracy of the attendance record. If a student is absent during any one of the three checks, they will not be marked as present for the class, even if they were present at other times. This multi-layered approach greatly reduces the chances of proxy attendance and ensures the reliability of the system.

C.Web Interface Features

The **Web Interface** is an essential component of the system, providing both staff and students with easy access to attendance data, real-time updates, and system management features. The interface is designed to be intuitive and user-friendly, with specific features for different user roles.

1.Staff Features:

For staff members, the web interface offers several important functionalities:

- **Attendance Record Modification**: Staff can access and modify attendance records if necessary. This feature allows for corrections to be made in case of errors, ensuring that the records are always accurate.
- **Attendance Viewing**: Staff can view detailed attendance data, including records for each student, attendance for different periods, and overall attendance trends. This helps educators track student participation and identify any issues related to attendance.
- **Real-Time Video Feed Monitoring**: Staff members have access to live video feeds from the classroom cameras, which they can view through the web interface. This provides additional transparency and allows them to monitor the attendance process in real-time, ensuring that the system is working as expected.

- **Student List Management**: The system allows staff to manage the list of enrolled students, including adding new students or removing those who drop the course. This helps keep the system up to date and ensures that the attendance records are always accurate.

2.Student Features:

Students also have their own access to the web interface, which allows them to track and manage their attendance records:

- **Attendance Tracking**: Students can log into the system to view their real-time attendance status for each class. This feature provides transparency and allows students to stay informed about their attendance.
- **Attendance History**: Students can access their past attendance records, which include details on the dates and periods attended. This can be useful for tracking their overall participation in the course.
- **Real-Time Updates**: The interface updates in real-time, providing students with immediate feedback on their attendance status. They can view any changes in their attendance as soon as they occur.

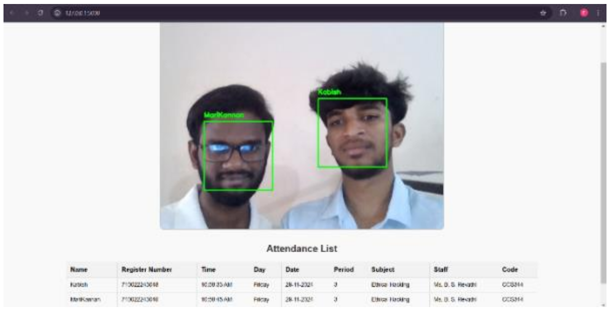
The web interface also features **live video feed monitoring** for both students and staff, offering a clear view of the classroom and ensuring that the system is functioning smoothly. In addition, **period-specific dropdown menus** make it easy for users to navigate between different classes and periods, improving the overall user experience.

Overall, the web interface enhances the functionality and usability of the system by making attendance data accessible and transparent for both staff and students, allowing for better management and accountability.

IV. RESULTS AND EVALUATION

A.Performance Testing

The system was tested in a simulated classroom environment with 60 students. The dual-camera setup provided full coverage, capturing the faces of all students from different angles. The system achieved an **accuracy rate of 98%** in detecting and recognizing faces, ensuring reliable attendance marking. The three-tier verification mechanism was also effective, preventing false positives and ensuring that only present students were marked as such.



Attendance List

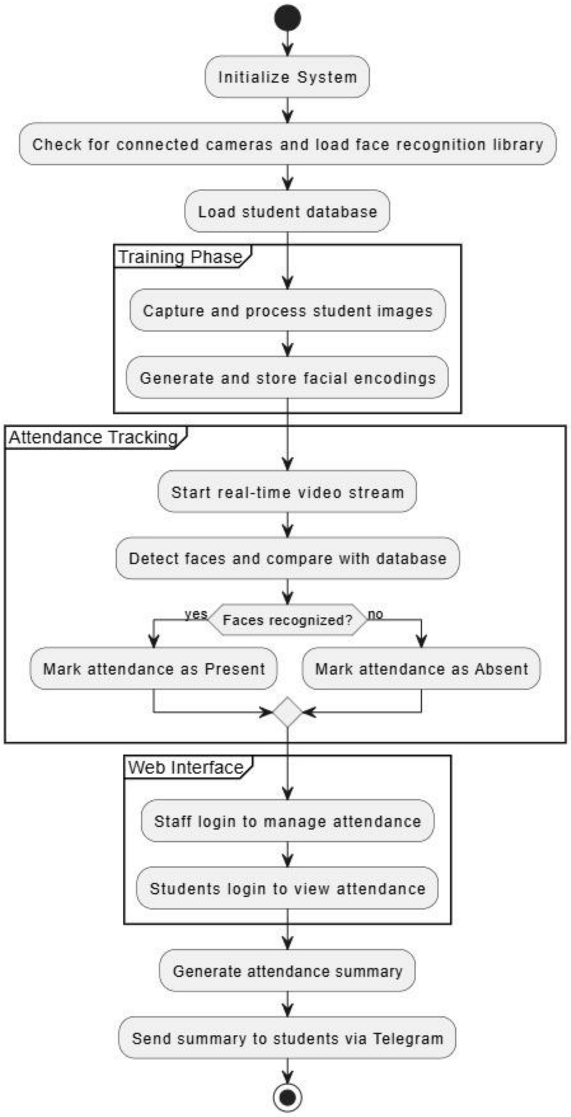
Name	Register Number	Time	Day	Date	Period	Subject	Staff	Code
Kabish	713022243048	10:20:35 AM	Friday	28-11-2024	3	Ethical Hacking	Ms. B. S. Revathi	CCS344
ManiKannan	713022243048	10:20:45 AM	Friday	28-11-2024	3	Ethical Hacking	Ms. B. S. Revathi	CCS344

B.Advantages Over Traditional Methods

Compared to traditional methods of attendance tracking, this system offers numerous advantages:

- **Accuracy**: Face recognition eliminates human errors and proxy attendance, ensuring that only legitimate students are marked present.
- **Efficiency**: The automated system reduces the time spent on attendance recording, freeing up valuable teaching time.
- **Transparency**: Real-time updates allow staff and students to monitor attendance, fostering greater accountability.
- **Scalability**: The system's design is scalable and can be expanded to accommodate larger classrooms or multiple campuses.

V.FLOWCHART


Initialize System
Check for connected cameras and load face recognition library
Load student database
Training Phase
Capture and process student images
Generate and store facial encodings
Attendance Tracking
Start real-time video stream
Detect faces and compare with database
yes
Faces recognized?
no
Mark attendance as Present
Mark attendance as Absent
Web Interface
Staff login to manage attendance
Students login to view attendance
Generate attendance summary
Send summary to students via Telegram

VI. ENHANCEMENTS AND FUTURE SCOPE

A.Advanced Analytics

Future iterations of the system can incorporate **advanced analytics** to analyze attendance trends and student engagement. For example, the system could identify patterns such as frequent absences or late arrivals, providing valuable insights for educators to act upon.

B.Mobile Application

A **mobile application** would improve the accessibility of the system, allowing staff and students to manage and view attendance data from their smartphones. This would be particularly beneficial for institutions with multiple classrooms or campuses, allowing for real-time management on the go.

C.Integration with LMS

The system could be integrated with **Learning Management Systems (LMS)** to provide a more comprehensive view of student progress. Linking attendance with academic performance could streamline administrative processes and allow for better tracking of student development.

D.IoT Enhancements

Integrating **IoT sensors** like motion detectors or environmental sensors could further enhance the system's reliability. These sensors could detect changes in the environment, such as lighting fluctuations or student movements, helping to improve facial recognition accuracy.

E.Scalability Across Institutions

The system's architecture allows for **scalability**, making it suitable for deployment in larger educational institutions with multiple classrooms or campuses. Administrators can manage attendance across multiple classrooms through a centralized platform, reducing administrative overhead and improving operational efficiency.

References

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