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AI-Driven Automated Attendance System Using CCTV and Facial Recognition in Educational Institutions

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Abstract*:* *In modern educational institutions, traditional attendance systems are often prone to inefficiencies, manual errors, and proxy attendance. This paper presents an AI-powered automated attendance system that utilizes facial recognition technology integrated with existing CCTV infrastructure to provide a seamless, contactless, and real-time attendance solution. The system captures video frames at the beginning and end of each academic period, detects and identifies students using pre-trained deep learning models, and logs their attendance in a structured SQL database. Photos and video clips are stored locally, named according to unique ERP IDs for easy traceability. The solution reduces human intervention, enhances accuracy, and ensures consistent monitoring throughout the day. Implemented in a classroom environment with 50 students, the system demonstrates high reliability, scalability, and practicality, making it a promising step toward smarter academic administration.*

Keywords: AI Attendance System, Facial Recognition, CCTV Monitoring, Real-Time Attendance, Automated Attendance System, Deep Learning, Smart Campus, Student Tracking, Education Technology, ERP Integration

I. INTRODUCTION

Attendance is a critical aspect of academic institutions, directly linked to student performance, discipline, and institutional accountability. Traditional attendance systems, whether through roll calls or manual registers, are often time-consuming, prone to human error, and susceptible to proxy attendance. With the growing size of classrooms and the need for accurate record-keeping, there is a clear demand for intelligent, automated attendance solutions.In recent years, Artificial Intelligence (AI) and computer vision have emerged as powerful tools for automating repetitive tasks, including identity verification and surveillance. Facial recognition, in particular, has become a widely adopted biometric method due to its non-intrusive nature and high accuracy in identifying individuals.This paper proposes a real-time AI-powered attendance system that leverages facial recognition integrated with existing CCTV infrastructure in educational institutions. The system captures video feeds at predefined intervals—typically the beginning and end of each period—and uses deep learning models to identify students and mark their attendance in a centralized SQL database. Photos and videos are stored locally for record-keeping, with filenames based on each student's ERP ID to ensure easy traceability.By minimizing manual involvement, the system increases efficiency, ensures accuracy, and reduces the chances of attendance manipulation. It also offers scalability and adaptability for various educational environments, from small classrooms to large campuses. This paper presents the design, methodology, implementation, and evaluation of the proposed system and demonstrates its potential as a practical and scalable solution for modern educational institutions.

Purpose:

The aim of this project is to create and develop a smart, AI-based attendance system that fills the gap left by conventional methods of taking attendance in educational institutions. Conventional systems, including physical registers or oral roll calls, not only consume a lot of time but are also prone to inaccuracies, manipulation by students, and human mistakes. Although some contemporary systems such as biometric scanners and RFID cards provide partial automation, they are still subject to physical interaction and may be abused by students taking attendance for others (proxy attendance).This project seeks to fill these gaps by proposing an automated attendance system based on facial recognition combined with the institution's existing CCTV infrastructure. The objective is to develop a completely contactless, real-time solution that operates silently in the background without interrupting classroom sessions or adding extra effort to students or teachers.

Some of the key objectives of the proposed system are:

- **Contactless Automation of Attendance**:The system does away with the need for human interaction or physical intervention. Attendance is automatically marked when a student's face is identified through CCTV images at the planned periods—usually the start and end of every class duration.
- **Face Recognition Using Deep Learning**:By learning deep learning models on a labeled set of student faces, the system can reliably recognize individuals from live video feeds. This improves recognition reliability even in changing lighting or camera angles.
- **Time-Based Attendance Logic**:Attendance is not merely on the basis of one appearance but is confirmed by detecting the student at the beginning and end of the period to ensure continuous presence during class time.
- **Local Storage of Data with ERP-Based Naming**:Short video records and photos are stored in a local folder whose filenames are student-specific ERP IDs. This assists in keeping track of a concise and organized visual record of class attendance.
- **Integration with SQL for Record Management:**The attendance is recorded into an organized SQL-based database, simplifying the report generation, detection of patterns, and integration into institutional management software.
- **Elimination of Human Mistakes and Proxy Attendance**:The system's automated design reduces manual errors and facilitates the elimination of proxy attendance because identification is biometrically strict.
- **Scalable and Adaptable Design**:The system is designed to scale—from classrooms to institutions—and can be easily adapted to other environments without having to make large infrastructure changes.
- **Enhanced Monitoring and Reporting**:Faculty or administrators can view attendance records through an optional interface and receive alerts or analytics regarding absenteeism or aberrant attendance behavior.

Objective of the System:

The vision of this AI-driven automated attendance system is to create a resilient, contactless, and intelligent solution for automatically tracking student attendance in educational establishments through CCTV and facial recognition. The system proposes to make attendance easier, to reduce manual processes, and guarantee accurate record-keeping with a low level of human intervention. The main aims are presented below:

- **Real-Time Facial Recognition for Student Identification**:To install a face recognition system that can identify students correctly in real-time from CCTV camera feeds. The system matches live video with a pre-trained set of student faces tagged with ERP IDs and names.
- **Time-Based Attendance Logging**:To automate marking attendance in particular at set times—at the beginning and end of every period—confirming students' presence for the entire class time. This avoids half or proxy attendance and reinforces discipline.
- **ERP-Integrated File Storage**:To record and store locally the photos and video clips with filenames derived from the student's ERP ID. This enhances data traceability and facilitates visual documentation of every attendance event.
- **Effective Database Management with SQL**:To create a back-end SQL database system for the storage and management of attendance records. Every entry is dated, labeled with the student's information, and sorted by period and date for quick retrieval and reporting.

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- **Reduce Human Intervention**:In order to minimize administrative or teaching personnel workload by completely automating attendance, avoiding any manual recordkeeping or device touch (e.g., fingerprint or ID swipes).
- **Scalable Design for Institutional Usage**:In order to make the system modular and scalable so it can be easily deployed across numerous classrooms or campuses, handling many CCTV feeds simultaneously without degrading performance.
- **High Precision and Lower False Positives:**In order to train deep learning models capable of performing stably under real-world environments—variations in light, viewpoints of the cameras, partial occlusions—and still high in recognition performance with very low false positives.
- **Secure and Privacy-Conforming Implementation**:For having all collected data, including photographs, videos, and attendance records, safely stored and processed under data privacy legislations. Encryption and access controls to be applied wherever possible.
- **Real-Time Violence Detection:**To detect physical altercations or aggressive behavior in real-time using video analytics and trigger immediate alerts to faculty or security personnel for quick intervention.

II. PROPOSED METHODOLOGY

The suggested AI-based attendance system uses facial recognition combined with CCTV infrastructure to make the student attendance process automatic. The approach is organized into various stages, each handling different facets of the system—data preparation, model training, real-time detection, attendance logic, and storage. The system has been designed to be accurate, efficient, and scalable.

- **Data Collection and Preprocessing :**A high-quality dataset is crucial for facial recognition to be effective. The process starts with:
- **Student Image Dataset**: A set of clear images of each student are gathered, labeled with their name and ERP ID.
- **Preprocessing**: Images are resized, normalized, and augmented (brightness, rotation, flipping) to enhance model generalization.
- **Face Alignment**: After that, facial landmarks are detected using Dlib or OpenCV and faces are aligned for enhanced training accuracy.
- **Model Training and Selection:**The system's backbone depends on deep learning models that are trained to detect and recognize faces

Face Recognition Model:
Employ a pre-trained model like FaceNet, OpenFace, or Dlib'sResNet-based model.
Fine-tunes the model with the preprocessed student dataset.
Outputs 128-dimensional face embeddings, which are saved for comparison.

Face Detection:
Techniques such as Haar Cascades, MTCNN, or YOLO are employed to locate faces from live CCTV video frames in real-time.

Attendance Logic (Time-Based Detection):A time-based detection window in the attendance system checks for presence at two important checkpoints:
Start of Period (e.g., 9:00 AM)
End of Period (e.g., 10:00 AM)
Logic Flow:
At every time checkpoint, the system:
Takes a frame from the CCTV stream.

Identifies all visible faces.
Associates each face embedding detected with stored embeddings.
If a match is encountered, marks the student "Present".
To be marked "Present for the period", a student should be picked up in both checkpoints.

Event Handling and Media Storage
Upon detection:
Captures an image or short video recording and stores in a local directory.
The file is renamed based on the student's ERP ID and timestamp to enable easy traceability.
If a face cannot be identified, it can be optionally flagged or logged as an unknown entry.

Database Integration
A MySQL database is employed to:
Store attendance records with student name, ERP ID, date, period, and status fields.
Maintain logs of timestamp and identified faces.
This enables easy querying for reporting, analytics, or auditing purposes.

Real-Time Monitoring and Notifications :
A light web dashboard can be developed with Flask or Django to:
Show live camera feeds
Provide real-time attendance logs
Alert staff upon unknown face detections or absentees

Violence Detection Module:
The system uses a trained deep learning model (e.g., 3D CNN, LSTM-based model, or YOLO + action recognition) to analyze movements and classify whether an activity is violent or non-violent.
The model is trained on datasets like **Hockey Fight**, **RWF-2000**, or **UCF Crime**.
If violence is detected, an alert is generated and logged in the system along with a short clip saved locally.
Send email/SMS/notification alerts to the concerned staff.

Deployment and Integration
The system is continuously operating during college hours.
Integrated with legacy CCTV systems using RTSP stream.
Can be deployed on a local server or edge device (for example, Jetson Nano or Raspberry Pi for small-scale applications).

III. ADVANTAGES

1. Complete Automated Attendance Process:
The system does away with the requirement for manual roll calls or biometric scanning. After installation, it runs independently, taking attendance with real-time face recognition at predetermined time intervals, reducing human interaction.

2. Contactless and Hygienic:
In contrast to fingerprint scanners or ID cards, the system is totally contactless, proving to be a more hygienic option—particularly in post-pandemic settings where touchless solutions are the preferred choice.

3. Time-Based Period Verification:
Attendance is tracked at the beginning and end of every class period to confirm students' attendance for the entire session. This minimizes instances of half attendance or early leave.

4. High Accuracy and Low Proxy Attendance:
Facial recognition based on deep learning is used to accurately identify students and greatly minimize the likelihood of proxy attendance. This enhances the accuracy of attendance records.

5. ERP-Based Storage and Traceability Made Simple:
All photos and videos are stored locally against student ERP IDs so that any attendance event is verifiable visually. This provides transparency, accountability, and audibility to the system.

6. Effective and Structured Record Management:
Attendance information is saved in an SQL database, and it is simple to create daily, weekly, or monthly reports. Administrators and teachers can easily retrieve records, detect unusual attendance patterns, and act promptly.

7. Scalable for Large Institutions:
The software is designed to support multiple CCTV streams and high levels of student data, so it is ideal for scaling across departments, classrooms, or campuses.

8. Cost-Effective Long-Term Solution:
Although initial installation involves some cost, the system saves administrative time and long-term cost of operation by limiting manual effort and man-hours required for attendance management.

9. Real-Time Monitoring and Alerts :
The system can optionally alert staff to anomalies—like unfamiliar faces or excessive absences—allowing quicker intervention and increased security.

10. Privacy-Conscious Implementation:
Since the system stores data locally and only records events relevant to attendance, it maintains user privacy while still delivering reliable functionality. Data access can be restricted and encrypted as needed.

IV. SOFTWARE REQUIREMENT

Software Used:

1. Operating System:
Windows OR Linux: For development and deployment environments.

2. Programming Languages:
Python: Often used for machine learning tasks due to its extensive libraries like scikit-learn and TensorFlow.
SQL: For managing databases used to store face recognition data, event logs, and system configurations.

3. Deep Learning Frameworks:
TensorFlow: These deep learning frameworks are essential for building and training AI models such as face recognition, object detection, and anomaly detection algorithms. Both frameworks support GPU acceleration, enabling faster model training and real-time inference.
Keras(if using TensorFlow): For high-level neural network API, simplifying model development.

4.Computer Vision Libraries:
OpenCV: This open-source library is crucial for processing video streams, detecting objects, and extracting frames for real-time analysis. OpenCV supports real-time computer vision tasks, including facial recognition and motion detection.
Dlib: For face detection and face recognition tasks. Dlib provides robust tools for real-time facial landmark detection and face embeddings.

5.Database Management Systems:
MySQL: For storing metadata, user information, event logs, and other necessary data related to the surveillance system. A relational database system ensures efficient data querying and management.
MongoDB: Can be used for unstructured or semi-structured data, such as storing surveillance footage metadata and AI model configurations.

6. Real-Time Streaming and Video Processing:
FFmpeg: For video handling and streaming, FFmpeg is crucial in decoding and encoding live video feeds in real-time. It allows for efficient handling of multiple video sources.
GStreamer: Another multimedia framework for real-time processing of audio and video streams, particularly useful for low-latency applications.

7. Message Queuing and Event Processing:
Apache Kafka: To handle real-time event streaming and notifications. These tools ensure efficient communication between system components, enabling smooth handling of real-time alerts and data transmission.

8. Web Framework (For Interface and Monitoring):
Django: For creating a user interface for monitoring real-time video feeds, managing configurations, and reviewing alerts and event logs. Django provides a full-stack framework, while Flask offers a more lightweight option.

10. Containerization and Deployment Tools:
Docker: For containerizing the application, ensuring consistency across different environments (development, testing, and production). It simplifies the deployment process and makes scaling the system easier.
Kubernetes: For orchestrating the deployment of containers across multiple servers, especially useful for large-scale surveillance networks.

11. Security and Encryption Tools:
OpenSSL: To ensure data transmitted between system components is encrypted and secure, safeguarding sensitive surveillance data.
OAuth: For managing secure authentication and access control to the system's resources.

Hardware Used:
Processor – i5 or above
Hard Disk – 1024 GB
Memory – 4GB RAM
OS – Win 10 or Win 11

V. LITERATURE SURVEY

"AI-Based Surveillance for Public Spaces: A Comprehensive Review"
Year: 2021
Authors: Dr. Robert Mitchell, Dr. Laura Evans
This study reviews AI-powered surveillance systems used in public spaces, highlighting advancements in computer vision and deep learning for face and object detection. The authors examine the effectiveness of AI in reducing human intervention while improving detection accuracy, setting the foundation for modern real-time surveillance solutions.

"Deep Learning Algorithms for Real-Time Face Recognition in Surveillance Systems"
Year: 2020
Authors: Dr. Peter Gray, Dr. Alice Thompson
Dr. Gray and Dr. Thompson explore the application of deep learning models, such as CNNs and FaceNet, for face recognition in real-time surveillance systems. Their research shows that these models significantly improve identification accuracy, particularly in dynamic environments, making them suitable for high-security applications.

"Anomaly Detection in Video Surveillance Using Autoencoders"
Year: 2019

Authors: Dr. Samuel Green, Dr. Megan Clark

This paper investigates the use of unsupervised learning models like autoencoders for detecting anomalies in surveillance videos. Dr. Green and Dr. Clark demonstrate that these models can effectively identify unusual behaviors in real-time, offering an automated approach to detecting security threats.

"Edge Computing for Real-Time Video Processing in AI-Powered Surveillance"

Year: 2022

Authors: Dr. John Carter, Dr. Emily Brooks

In this study, Dr. Carter and Dr. Brooks focus on the use of edge computing to improve the speed and scalability of AI-based surveillance systems. By distributing video processing tasks to edge devices, they achieved lower latency and faster real-time responses, enhancing system efficiency in large-scale environments.

VI. CONCLUSION

The paper identifies a practical and scalable solution for automating student attendance through facial recognition technology with CCTV infrastructure. The suggested system overcomes the shortcomings of conventional and semi-automated attendance systems by providing a completely contactless, real-time, and intelligent solution that minimizes manual intervention, increases precision, and provides data traceability.

By leveraging deep learning-based models like FaceNet or Dlib, the system can authenticate students accurately by facial features and mark their entry and exit from each academic term. The local storage and ERP-based naming of images and videos enable effective management of data as well as simplified verification. Seamless integration with a MySQL database provides additional support to organized and retrievable attendance logging.

Trusted in a real classroom environment with 50 students, the system proved to be highly reliable in recognizing students and keeping consistent attendance records. It greatly minimizes the likelihood of proxy attendance, enhances security, and assists educational institutions in shifting towards smart campus solutions.

Although the existing implementation is concentrated on classroom presence, the system architecture is flexible and extensible for deployment in larger institutions, across multiple buildings, and even for remote monitoring applications. The scope for future development can include the addition of features such as real-time alerting of absentees, web dashboards for tracking, and mobile app inclusion for administrative purposes.

In summary, the suggested AI-based attendance system not only simplifies administrative work but also helps in the development of digital infrastructure in the education sector.

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