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Automated Student Monitoring and Attendance System with Faster R-CNN

Dr. S. Balaji[1], Mrs. S. Sugashini[2], J. Ruchitha[3], A. Tejaswini[3] and A. Vaishnavi[3]

[1]Assistant Professor, Department of CSE, Kingston Engineering College
[2]Assistant Professor, Department of CSE, Kingston Engineering College
[3]UG Scholar, Department of CSE, Kingston Engineering College

ABSTRACT

Managing student attendance in educational institutions is often challenging due to the large number of students and the prevalence of issues like proxy attendance and class skipping.

Traditional attendance monitoring methods lack the efficiency and precision required to address these challenges effectively.

To overcome these limitations, this project proposes a College Surveillance System utilizing the Faster R-CNN (Region-Based Convolutional Neural Network) to detect and address attendance-related issues while providing valuable insights into student behaviour.

The system employs a database containing trained facial data of students. Cameras installed across classrooms and campus areas capture live footage, which is processed using the Faster R-CNN algorithm for face detection and recognition. Attendance is automatically recorded in real time and logged into an Excel sheet, eliminating the need for manual tracking and mitigating proxy attendance.

The system also analyses student behaviour, identifying class skippers, monitoring attention levels during sessions, and detecting unauthorized movement across the campus during class hours. Alerts regarding violations are sent to the concerned authorities, such as the HOD, ensuring prompt action.

This automated system significantly enhances attendance management by saving time, improving accuracy, and fostering accountability. With an impressive facial recognition accuracy of 98.87% and a detection speed of approximately 100 milliseconds per frame, the solution ensures efficient and reliable operation.

By integrating advanced AI techniques, this project aims to streamline attendance processes, reduce administrative burdens, and contribute to a more disciplined and engaged educational environment.

1. INTRODUCTION

Attendance is the act of being present at or attending a class, an event or a meeting. It depends upon the classroom, whether the attendance would be both physical and virtual. In schools, students must maintain their attendance against a set standard. The concept of students appearing in the classroom to attend the lecture is called class attendance. Class Teachers count all the students by their name and record the information in a register or digital software.

There are various methods of taking attendance like biometric systems using student identification cards or fingerprints, physical presence is recorded in registers or software tools. During the online class the teacher marks online attendance to ensure the presence of all the students.

As per school policy, the attendance of students affects their grades. Sometimes, students' absenteeism from school has various reasons. Some of these reasons can be a bad company, personal issues, health issues, family problems, bullying, etc. Keeping a tab on absenteeism helps to identify the reasons behind a student's absence from school. When recognized, teachers can work in that direction to improve a student's situation. There are various methods of taking attendance like biometric systems using student identification cards or fingerprints, physical presence is recorded in registers or software tools. During online classes, the teacher marks online attendance to ensure the presence of all the students.

Attendance Management System

A software program or platform called an attendance management system for students is made to track and keep track of students' attendance in educational institutions including schools, colleges, and universities. Its main objective is to automate and streamline the process of monitoring student attendance in order to ensure accuracy and effectiveness for both students and staff.

2. Literature Review

Automated Attendance System Using Deep Learning – Ravi Kumar & Anil Sharma (2022)

The automation of attendance systems has become an important area of research, especially in educational institutions seeking to improve administrative efficiency and reduce fraudulent practices such as proxy attendance. In their 2022 study, Ravi Kumar and Anil Sharma proposed a deep learning-based approach to address these challenges. The central objective of their research was to develop an AI-driven system capable of monitoring student attendance in real time using facial recognition techniques. This approach aims to replace traditional, manual methods of attendance marking, which are often time-consuming and susceptible to manipulation.

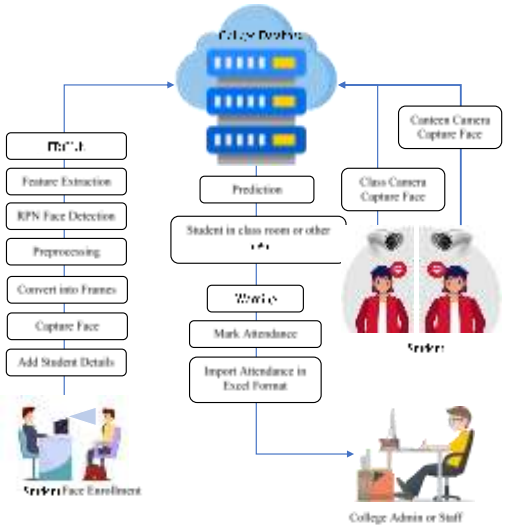
The authors implemented a methodology centered around face detection and recognition. The system was trained on a dataset containing student facial images and used to identify individuals during class sessions. A Convolutional Neural Network (CNN) served as the backbone of the face recognition model, ensuring high accuracy in recognizing student faces. OpenCV, an open-source computer vision library, was utilized to handle real-time face detection and tracking. This integration enabled the system to automatically detect student faces through a camera feed and match them against the trained dataset to log attendance without manual intervention.

The system demonstrated strong performance, achieving a recognition accuracy of approximately 95%. This high level of accuracy was maintained across varying conditions, including different facial expressions and changes in lighting. Such robustness is a significant merit, as it indicates the model's practical viability in real classroom environments where lighting and facial orientations are not always consistent. Moreover, the automation significantly reduces the burden on instructors and minimizes errors or inconsistencies in attendance records.

However, the system is not without its limitations. A notable drawback is its reliance on high-quality camera setups. The effectiveness of face recognition is heavily dependent on the clarity and resolution of the video input; low-quality cameras may result in reduced accuracy or failure to detect faces altogether. Therefore, successful implementation of this system requires investment in adequate hardware, which may not be feasible for all institutions, particularly those with limited resources.

In conclusion, Kumar and Sharma's work contributes meaningfully to the growing body of research on AI-based attendance systems. By combining CNN models with real-time computer vision techniques, the study demonstrates a practical and scalable solution to automate student attendance. While it shows high accuracy and efficiency, future enhancements could focus on improving performance with lower-end hardware or incorporating multi-modal biometric features for even greater reliability.

3. System Architecture / Methodology



This system architecture outlines a student face recognition-based attendance monitoring system integrated with a college database. The process begins with student face enrolment. where facial data is captured and student details are added. The captured images undergo various pre-processing stages such as conversion into frames, face detection using Region Proposal Network (RPN), feature extraction, and analysis through Faster R-CNN (FRCNN) for accurate face recognition. This information is stored in the college database. During daily operations, class and canteen cameras capture student faces in real-time. These images are then matched against the database using prediction models to verify the student's presence and location (e.g., classroom or other areas). If a student is detected in an unauthorized location, a warning is issued. The system then marks the attendance and updates it in Excel format, accessible by college admin or staff for monitoring and record-keeping.

3.1 Input Design:

Input design specifies how the system receives data. For this system, inputs come from multiple sources and in various formats.

3.1.1. Biometric and Live Surveillance Inputs

The system starts by capturing high-quality facial images of students during pre-enrollment stored in JPG or PNG format with ID, name, and class tags. IP cameras or CCTV across the campus provide real-time RTSP video streams. These feeds are processed by the Faster R-CNN algorithm for live face detection and attendance tracking.

3.1.2. Administrative and Scheduling Inputs

The system uses administrative inputs like student details, facial data, and class schedules from databases and CSV files to match real-time detections with expected attendance and identify absentees.

3.1.3. Manual Overrides and Exception Handling

A web-based admin panel allows manual overrides for adding students, updating records, or correcting attendance in case of errors or camera issues, ensuring system flexibility and enabling human intervention when necessary**.**

3.2 Output Design

Output design defines how the processed data is presented or exported from the system.

3.2.1. Automated Attendance and Notifications

The system records attendance in real time and logs it in Excel, CSV, or databases. It sends instant alerts for proxy detection or absences via email or SMS to relevant staff, ensuring quick action and accurate monitoring.

3.2.2. Behaviour and Movement Monitoring

Behaviour reports track class skipping, attention levels, and unauthorized movements using facial cues and motion data. These insights, shown via PDF or dashboard, help institutions address discipline and improve student engagement.

3.2.3. Live Monitoring and Analytical Insights

A web dashboard shows live face recognition with student counts and alerts. Charts and heatmaps offer insights on attendance patterns and student movement, helping faculty make informed, data-driven decisions for academic improvement.

3.3. Model Design and Training

The system uses a Faster R-CNN (Region-Based Convolutional Neural Network) for face detection and recognition. This deep learning model is chosen for its high accuracy and speed, with a detection time of approximately 100 milliseconds per frame. The model architecture includes a convolutional backbone (e.g., ResNet-50 or VGG16) for feature extraction, a Region Proposal Network (RPN) to suggest candidate face regions, and fully connected layers for classification and bounding box regression.

During training, a dataset of labeled student facial images is used. Each image is annotated with the student's ID and class label. Data augmentation techniques like rotation, flipping, and brightness adjustment improve the model's robustness. The training process involves supervised learning using a loss function combining classification loss (cross-entropy) and localization loss (smooth L1). The model is trained on GPU hardware for efficiency, and achieves high recognition accuracy of up to 98.87%.

Once trained, the model is integrated into a real-time video processing pipeline to detect and match faces against the database for automatic attendance logging.

3.3.1 Model Selection

- The core of the College Surveillance System is powered by a hybrid deep learning model architecture that leverages Faster R-CNN for face detection and FaceNet for facial recognition. These two models work in tandem to detect, identify, and verify student identities in real-time, enabling automated attendance tracking and behavior monitoring with high accuracy.
- The convolutional backbone (e.g., ResNet-50 or VGG16) extracts spatial features from input frames, while the RPN and classifier work to detect and localize faces with high precision, even in cluttered environments like classrooms.
- This process enables reliable identification, even under changes in lighting, orientation, facial hair, or minor occlusions.
- The system integrates the model pipeline into a real-time video analysis module. Each classroom's camera feed is processed frame-by-frame, where faces are detected, recognized, and logged into the attendance record. Misidentification and spoofing are minimized through confidence thresholds and temporal consistency checks.

3.3.2. Dataset Preparation

- The dataset for the College Surveillance System includes student facial images collected during enrollment and real-time classroom video feeds. It is labeled with student IDs, names, and schedules. Data augmentation techniques like rotation, scaling, and lighting adjustments enhance model robustness. Behavioral data includes attention levels and movement patterns.
- Pre-processing steps include:
    - Face Detection
    - Face Normalization
    - Data Augmentation
    - Feature Extraction
    - Labeling and Structuring

3.3.3. Training Process

Faces are detected using Faster R-CNN and recognized using FaceNet trained with triplet loss. The model generates embeddings, which are used for real-time attendance after evaluation.

- **Dataset Splitting**

- Face Detection Training
- Face Recognition Training
- Embedding Generation
- Database Creation
- Evaluation
- Optimization & Fine-tuning
- Model Deployment

3.3.4. Training Process

- Use validation dataset to measure model accuracy and performance
- Optimize hyperparameters (e.g., learning rate, batch size)
- Apply early stopping to prevent overfitting
- Use dropout or regularization to improve generalization
- Final testing on unseen data for evaluation

3.3.5. Integration and Real-Time Performance

- Integrate Faster R-CNN and FaceNet into the live surveillance system.
- Capture real-time video using IP cameras via RTSP.
- Process frames (~100 ms/frame) for face detection and recognition.
- Auto-update attendance logs in Excel or database.
- Trigger instant alerts for violations via email or SMS.

3.4. Model Evaluation

The model is evaluated using accuracy, precision, and recall on a test dataset. Recognition reliability is checked through confidence scores and real-world performance under different conditions.

3.4.1 Evaluation Metrics

To quantitatively assess the model's performance, several key metrics are utilized:

- **Accuracy** – Overall correctness of predictions
- **Precision** – Correctly identified faces out of total predicted
- **Recall** – Correctly identified faces out of actual faces
- **F1-Score** – Harmonic mean of precision and recall
- **Confidence Score** – Measures reliability of each face match.

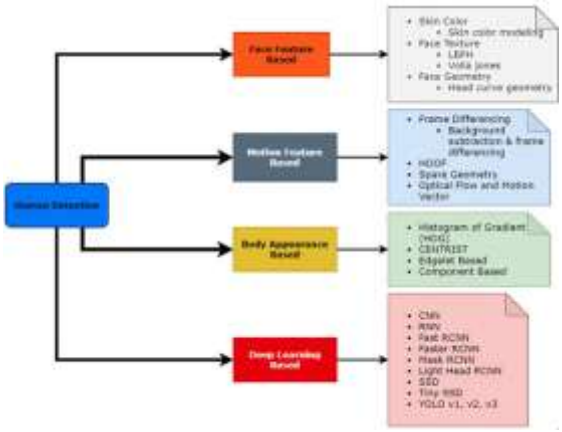
4. Face Identification

This module enables continuous monitoring through real-time video feeds across campus, allowing instant detection of student activities and enhancing the responsiveness of the face identification system.

4.1. Face Recognition and Identification:

Powered by FaceNet, this module identifies individuals in real time by comparing live video feeds with a trained facial database, enabling accurate, automated attendance and enhancing campus security.

4.2 Facial Authentication



- Facial authentication verifies a person's identity by comparing live facial features with stored data. Using FaceNet, the system ensures secure, accurate, and real-time identification for attendance and access control.
- The system:
    - **Face Capture** – Live video or image input from cameras.
    - **Face Detection** – Locate faces using Faster R-CNN or similar models.
    - **Preprocessing** – Normalize, align, and crop facial images.
    - **Feature Extraction** – Generate 128-D embeddings using FaceNet.
    - **Face Matching** – Compare embeddings with the stored database using distance metrics (e.g., Euclidean).
    - **Authentication Decision** – Accept or reject identity based on similarity threshold.
    - **Logging & Alerts** – Record authentication results and notify admin on mismatches or unauthorized access.

4.3 Attendance Logging and Behavioral Monitoring

Attendance Logging: The system records the authenticated student's presence along with timestamp, location (classroom ID), and confidence score into a database.

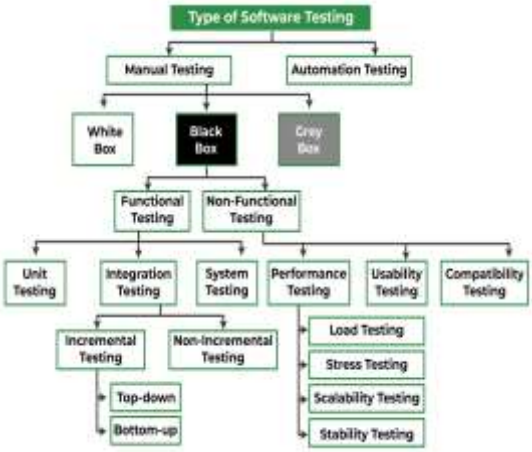
Schedule Matching: The logged data is cross-checked with the class timetable to ensure the student is in the correct class at the right time.

Behaviour Monitoring and Alerts: The system tracks face orientation and movement to assess attention and detect class skipping. It sends instant alerts for violations and updates reports with attendance and behaviour trends.

5. Test Scenarios

Software testing is the process of evaluating a software product to ensure it meets regulatory, technical, business, and user requirements

5.1. Types of Testing



• Integration Testing

Checks how different modules or components interact with each other, ensuring proper data flow and communication between them.

• Functional Testing

Validates the software's functions against specified requirements using black-box testing, focusing on user-facing features.

• Non-Functional Testing

Assesses non-functional aspects like performance, scalability, reliability, and usability under various conditions.

• Acceptance Testing

Conducted by end-users or stakeholders to confirm the software meets business needs and is ready for release.

• Usability Testing

Evaluates how user-friendly and intuitive the software is, focusing on ease of use, navigation, and accessibility.

• Compatibility Testing

Ensures the software works properly across different devices, browsers, platforms, and operating systems.

• System Testing

Tests the complete software system in its entirety to verify it meets all requirements and performs well in real-world scenarios.

5.2. post-Testing Process

After testing, identified bugs are fixed and the software is re-tested to ensure stability. Regression testing is conducted to verify that updates don't break existing features. Test results are documented, and the software undergoes final validation. Upon approval, it is deployed to the production environment. Post-deployment, the system is monitored for performance and user feedback to catch any remaining issues.

6. Summary of Findings

The development and deployment of the advanced College Surveillance System revealed several significant outcomes:

- **High Accuracy in Face Recognition**

The integration of FaceNet and Faster R-CNN enabled precise and reliable face recognition across various lighting conditions and angles, ensuring accurate attendance tracking in real-time.

- **Automation of Attendance** Management

The system successfully automated the entire attendance process, eliminating the need for manual entry and reducing errors. Real-time updates improved data accuracy and administrative efficiency.

- **Enhanced Campus Security**

Unauthorized access and suspicious behavior were effectively detected using behavioral analysis and the Violation Alert module. This contributed to a safer and more secure campus environment.

- **Behavioural Insight Generation**

The system was able to identify patterns such as repeated class skipping or unusual activity in specific areas, enabling proactive intervention by staff and administration.

- **Effective Role-Based Interfaces**

Customized interfaces for Admin, Staff, and HODs allowed users to perform their roles efficiently, improving usability and interaction with the system.

- **Centralized Monitoring and Management**

The Admin Dashboard facilitated centralized control over academic departments, student records, and system notifications, supporting efficient institutional oversight.

- **Scalability and Real-Time Performance**

The architecture proved scalable, with real-time performance in identifying faces and processing attendance, making it suitable for large institutions.

- **Improved Communication**

The built-in notification system ensured timely communication between administrators, staff, and students regarding attendance violations and security alerts.

7. Discussions

Manual attendance tracking remains common in many colleges, despite its inefficiencies and susceptibility to error. As educational institutions seek more reliable and secure methods, the AI-based College Surveillance System using Faster R-CNN and FaceNet emerges as a transformative solution. This system modernizes attendance management through real-time facial recognition, behavioural analysis, and automated reporting.

By accurately identifying students and detecting behavioural anomalies such as class skipping, the system not only reduces administrative workload but also strengthens campus security and discipline. The inclusion of violation alerts and a centralized dashboard empowers administrators to make informed, data-driven decisions. Its user-friendly interfaces for different stakeholder roles further enhance accessibility and ease of use.

Overall, the system marks a significant advancement in educational technology, offering a robust, scalable, and intelligent platform for student monitoring and attendance management. Its successful implementation highlights its potential to improve accountability, promote student engagement, and foster a safer and more efficient learning environment.

8. Conclusion

The AI-based College Surveillance System utilizing Faster R-CNN and FaceNet technologies successfully revolutionizes attendance management and campus security.

By automating attendance and analyzing behaviour in real time, the system boosts efficiency, accuracy, and campus security.

The system enhances safety and discipline by identifying students, detecting anomalies, and delivering actionable insights.

This innovative solution not only simplifies administrative tasks but also promotes accountability and student engagement, marking a significant step forward in educational technology.

Thus, this project demonstrates the transformative potential of AI in education, laying the groundwork for future smart campus technologies that prioritize safety, engagement, and data-driven decision-making.

9. Future Scope

The future enhancement of the AI-based College Surveillance System focuses on overcoming the challenges in facial recognition and expanding its capabilities to offer deeper insights into student behaviour.

Below are the proposed enhancements:

• Overcoming Facial Recognition Challenges

While the current system is effective, there are specific challenges to overcome in facial recognition, especially in real-world scenarios where students may have facial hair, wear accessories, or tilt their faces.

Enhancing the system's ability to detect faces under varying conditions such as tilted orientations, mustaches, growing beards, and other facial variations is crucial.

This can be achieved by refining the existing FaceNet and Faster R-CNN algorithms, incorporating advanced techniques such as 3D face recognition or deep learning-based face alignment.

The goal is to make the system more adaptable and robust, ensuring it can still accurately recognize individuals despite changes in their appearance.

Additionally, integrating multi-angle facial recognition and pose correction techniques will help the system perform well even when faces are not perfectly aligned to the camera.

• Behavioural Analysis Integration

Expanding the scope of the system to incorporate more sophisticated behavioural analysis is another key enhancement.

In addition to monitoring attendance, the system can be developed to observe and analyze students' behaviour, leveraging the face recognition data to distinguish between different behavioural patterns.

Such analysis could be based on machine learning models trained to classify different behaviour patterns from facial expressions or movement tracking, enabling the system to offer a more comprehensive view of student activity beyond just attendance.

Additionally, integrating this behavioural analysis into the system will allow educators to tailor their teaching strategies to the needs of individual students, improving learning outcomes.

10. Approaches

To develop the AI-based College Surveillance System, the following approaches were adopted:

- **Face Detection and Recognition**

Utilized Faster R-CNN for real-time face detection and FaceNet for accurate facial recognition. These models were trained and fine-tuned to handle diverse lighting conditions, facial orientations, and varying appearances.

- **Video Capture and Preprocessing**

Implemented continuous video capture in classrooms and campus zones. Frames were extracted, pre-processed, and passed through detection pipelines for real-time face analysis.

- **Behavioural Analysis**

Designed modules to monitor behavioural patterns such as class attendance frequency, prolonged absences, and movement anomalies to detect class skipping or potential risks.

- **Violation Detection and Alerts**

Developed a violation alert system that detects unauthorized access and sends instant notifications to concerned authorities through a centralized notification system.

- **Role-Based User Interfaces**

Created separate dashboards for Admin, HOD, and Staff with customized features to manage departments, monitor attendance, and access reports.

- **Centralized Data Management**

All data was stored in a secure centralized database, allowing efficient retrieval, reporting, and long-term analysis of attendance and behaviour trends.

- **Reporting and Analytics**

Implemented an analytics module to generate visual and tabular reports, helping stakeholders make data-driven decisions.

The system uses Faster R-CNN and FaceNet for face recognition, real-time video analysis for attendance and behaviour tracking, role-based dashboards, and centralized data with alerts and reports.

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