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INTELLIGENT CLASS MONITORING SYSTEM USING FACENET&OPEN CV

[1]K.S.H. PRASANNA KUMAR, [2]L. SYAMALA DEVI, [3]R. HEMA SUNDAR SAI, [4]M. DHANA LAKSHMI, [5]G. NAGA VENKATESH

[1]ASSISTANT PROFESSOR,[2345] B. TECH, STUDENTS

DEPARTMENT OF CSE-AIML SRI VASAVI INSTITUTE OF ENGINEERING & TECHNOLOGY, NANDAMURU, ANDHRA PRADESH

ABSTRACT

The Intelligent Classroom Monitoring System using FaceNet and OpenCV is an artificial intelligence–driven solution designed to automate attendance tracking and enhance classroom supervision through real-time facial recognition and behavioral analysis. Conventional attendance systems such as manual roll calls, biometric scanners, or RFID-based methods are often inefficient, susceptible to proxy attendance, and limited in monitoring classroom activity. To address these challenges, the proposed system integrates deep learning–based face recognition with computer vision techniques to ensure accurate identification and monitoring of students and faculty members. The system captures live video streams from webcams or IP cameras and processes them using OpenCV for face detection, while FaceNet generates high-dimensional embeddings that uniquely represent each individual. Identity verification is achieved through L2 distance comparison between stored embeddings and detected faces. A randomized attendance capture window is implemented to prevent manipulation and ensure fairness in attendance recording. In addition to attendance automation, the system monitors faculty presence and analyzes classroom behavior through motion detection techniques such as background subtraction and optical flow analysis to identify unusual movement patterns that may indicate classroom disturbances or conflicts. The system architecture includes a web-based dashboard built with modern full-stack technologies that enables administrators to view attendance reports, monitor classroom activities, and receive alerts regarding anomalies. Experimental evaluation indicates that the proposed system achieves recognition accuracy of approximately 92–95% under controlled conditions while maintaining efficient performance on standard hardware. Overall, the system demonstrates the effectiveness of integrating deep learning, computer vision, and web technologies to create a scalable and intelligent classroom monitoring framework that improves institutional management and academic discipline.

Keywords: Intelligent Classroom, Face Recognition, FaceNet, OpenCV, Attendance Automation, Behavioral Analytics, Computer Vision, AI Monitoring System

I INTRODUCTION

The rapid advancement of artificial intelligence and computer vision technologies has significantly transformed various sectors, including education, healthcare, and security systems [1]. Educational institutions increasingly require intelligent systems capable of improving administrative efficiency

while ensuring transparency and accountability within classrooms [2]. Traditional attendance methods such as manual roll calls are time-consuming and prone to human errors, which can affect the reliability of academic records [3]. Furthermore, proxy attendance remains a major concern in many institutions where students may attempt to mark attendance on behalf of absent peers [4]. Earlier automated solutions such as RFID cards were introduced to address these limitations [5]. Biometric fingerprint scanners were also widely adopted for automated attendance tracking [6]. However, these systems still suffer from issues such as device dependency and maintenance costs [7]. Additionally, they are unable to monitor behavioral patterns in classrooms effectively [8]. Recent advancements in deep learning have enabled the development of face recognition systems capable of identifying individuals with high accuracy and minimal human intervention [9]. Computer vision frameworks such as OpenCV provide robust tools for face detection and real-time video analysis [10]. Meanwhile, deep neural network models like FaceNet have demonstrated superior performance in generating discriminative facial embeddings for identity verification [11]. Convolutional neural networks have further improved the accuracy of facial recognition systems in real-world environments [12]. These technological developments have opened new possibilities for intelligent classroom monitoring systems that combine automated attendance with behavioral analytics [13]. Such systems can also improve transparency in academic institutions by maintaining reliable digital attendance records [14]. Additionally, AI-based monitoring solutions reduce the administrative workload on faculty members and institutional staff [15].

In modern smart campus environments, intelligent monitoring systems can contribute to both administrative management and classroom discipline by providing real-time insights into student attendance and faculty presence [16]. Face recognition–based attendance systems offer contactless identification, eliminating the need for physical devices or manual verification processes [17]. Deep learning architectures enable accurate feature extraction from facial images, allowing reliable identification even in dynamic environments such as classrooms [18]. Advanced feature embedding techniques further enhance recognition accuracy even under varying lighting and pose conditions [19]. Moreover, integrating such systems with web technologies enables centralized management and visualization of attendance data through digital dashboards [20]. Cloud-based platforms allow institutions to store and manage attendance records securely and efficiently [21]. Behavioral analysis techniques such as motion detection can further enhance monitoring capabilities [22]. Optical flow estimation methods help detect unusual activity patterns in classroom environments [23]. These features are particularly useful for identifying disturbances, classroom conflicts, or unauthorized gatherings [24]. Intelligent monitoring systems can also assist faculty in maintaining classroom discipline and engagement [25]. With the integration of cloud databases and real-time processing frameworks, educational institutions can store and analyze large volumes of attendance data efficiently [26]. Distributed computing systems further support scalable deployment of AI-based monitoring platforms [27]. Data analytics techniques allow administrators to evaluate attendance trends and student participation patterns [28]. Such insights help institutions improve academic planning and decision-making processes [29]. The combination of artificial intelligence, computer vision, and web-based monitoring

platforms therefore presents a promising approach for creating intelligent classroom management systems that improve efficiency, transparency, and security in academic environments [30].

II LITERATURE SURVEY

Several studies have explored automated attendance systems based on biometric and computer vision technologies [1]. Early research focused on fingerprint-based attendance systems, which provided reliable identification but required physical interaction with scanning devices [2]. These systems improved authentication accuracy compared to manual attendance methods [3]. RFID-based attendance systems were later introduced to enable faster attendance recording through wireless identification tags [4]. Such systems allowed automated identification without direct physical interaction [5]. However, RFID technologies remained vulnerable to misuse when students carried multiple cards or shared identification devices [6]. Researchers therefore began exploring alternative biometric methods for improving reliability and preventing fraudulent attendance marking [7]. With the emergence of computer vision techniques, face recognition–based attendance systems became a promising solution for identifying students from images or video streams [8]. Early implementations used machine learning algorithms for facial pattern recognition in academic environments [9]. Haar cascade classifiers were widely adopted for detecting human faces in classroom monitoring applications [10]. These algorithms enabled real-time face detection in video frames captured by cameras [11]. However, traditional computer vision methods struggled with variations in lighting conditions and facial orientation [12]. Occlusion and partial visibility of faces also reduced the reliability of these earlier approaches [13]. The development of deep learning models significantly improved recognition accuracy by learning complex facial features from large datasets [14]. Convolutional neural networks have been widely used for face recognition due to their ability to automatically extract hierarchical image features [15].

Recent research has increasingly focused on integrating deep learning–based face recognition with intelligent monitoring systems for educational environments [16]. These systems combine automated attendance recording with real-time classroom observation capabilities [17]. The FaceNet model introduced a novel approach for generating high-dimensional embeddings representing unique facial characteristics [18]. These embeddings allow efficient identity verification using distance-based similarity metrics [19]. Studies have demonstrated that FaceNet-based recognition systems achieve high accuracy in real-world scenarios [20]. The model can also perform well with limited training data when combined with transfer learning techniques [21]. Researchers have further investigated behavioral monitoring methods using motion analysis in classroom environments [22]. Motion detection techniques help identify movement patterns among students during lecture sessions [23]. Optical flow algorithms provide detailed information about motion direction and velocity in video frames [24]. Background subtraction techniques such as the MOG2 algorithm are widely used to detect moving objects in surveillance footage [25]. Optical flow algorithms such as Farneback are capable of estimating pixel-level motion between consecutive frames [26]. These algorithms enable systems to detect unusual motion patterns that may indicate disturbances or conflicts in classrooms [27]. Intelligent monitoring systems can therefore automatically identify suspicious or abnormal behavior in real time [28]. Integrating behavioral

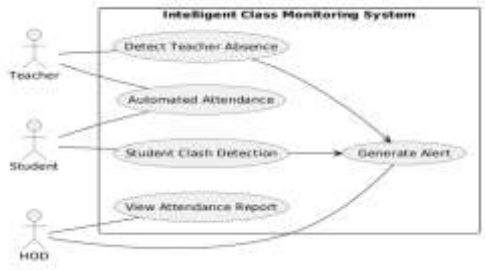
analytics with facial recognition improves the overall reliability of automated classroom monitoring solutions [29]. Combining facial recognition with behavioral analytics therefore provides a comprehensive solution for automated classroom supervision and attendance management [30].

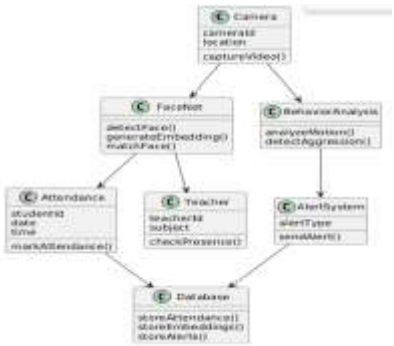
III METHODOLOGY

The proposed intelligent classroom monitoring system integrates computer vision, deep learning, and web technologies to automate attendance tracking and analyze classroom behavior. The system architecture consists of three major components: video acquisition, facial recognition processing, and data management through a web-based platform. Live video streams are captured using webcams or IP cameras installed in classrooms. The captured frames are processed using OpenCV for face detection, where faces are identified and extracted from each frame. Once detected, facial images are passed to the FaceNet deep learning model, which converts them into high-dimensional embeddings representing unique facial features. These embeddings are compared with pre-stored embeddings in the database using L2 distance metrics to determine identity matches. If the distance between two embeddings falls below a predefined threshold, the identity of the individual is confirmed. Attendance is recorded automatically during a randomized two-minute window within each scheduled class period to prevent manipulation and ensure fairness. The recognized attendance data is transmitted to the backend server built with Node.js and Express, where it is processed and stored in a PostgreSQL database. In addition to attendance recording, the system performs behavioral analysis using motion detection algorithms such as background subtraction and optical flow techniques. These algorithms analyze the intensity and movement of objects in video frames to detect abnormal classroom activity. If unusual motion patterns are detected, the system generates alerts and stores the corresponding event logs in the database. The frontend dashboard developed using React allows administrators and faculty members to view attendance reports, monitor classroom activity in real time, and receive notifications regarding faculty absence or classroom disturbances. This integrated methodology ensures efficient attendance management, enhanced monitoring, and improved administrative transparency.

IV SYSTEM DESIGN

The system design of the intelligent classroom monitoring platform follows a modular architecture that integrates artificial intelligence modules with a full-stack web application. The first component of the design is the video acquisition module, which captures real-time video streams from cameras installed inside classrooms. These cameras continuously record frames and transmit them to the processing unit where face detection is performed. OpenCV libraries are used to preprocess the captured frames, detect faces, and crop relevant facial regions. The detected faces are then passed to the FaceNet model, which generates numerical embeddings representing each face. These embeddings are stored in a database during the enrollment phase when students and faculty members register their facial images in the system. During classroom sessions, the embeddings extracted from live video frames are compared with stored embeddings to identify individuals. If a match is detected, the system records the attendance automatically and associates it with the corresponding class schedule. This process eliminates manual attendance marking and reduces the risk of proxy attendance.





The second component of the system design focuses on backend data processing and user interaction through a web-based interface. The backend server is developed using Node.js and Express to manage communication between the AI modules, database, and frontend interface. PostgreSQL is used as the central database to store facial embeddings, attendance records, faculty schedules, and behavioral incident logs. The frontend dashboard built with React provides a user-friendly interface where administrators and faculty members can monitor classroom activity, view attendance statistics, and generate reports. Behavioral analytics modules analyze motion patterns using background subtraction and optical flow techniques to detect unusual activities within classrooms. If abnormal motion levels are detected, alerts are generated and displayed on the dashboard. The system also verifies faculty presence by comparing recognized faculty faces with scheduled lecture times and triggers alerts if prolonged absence is detected. This comprehensive system design ensures seamless integration between AI-based recognition, behavioral analysis, and web-based management tools.

V PROPOSED SYSTEM

The proposed system introduces an intelligent and automated solution for classroom attendance and monitoring by combining face recognition technology with behavioral analysis techniques. Unlike traditional attendance systems that rely on manual verification or physical devices, the proposed approach utilizes deep learning–based facial recognition to identify students and faculty members directly from video streams. The system employs the FaceNet model to generate high-dimensional facial embeddings, which are used to uniquely identify individuals. By comparing these embeddings using L2 distance metrics, the system accurately determines whether the detected face matches a registered user in the database. This approach ensures reliable attendance tracking while eliminating the possibility of proxy attendance. The system also incorporates a randomized attendance capture window within each class session, which prevents students from manipulating the attendance process by appearing briefly in front of the camera.

In addition to attendance automation, the proposed system enhances classroom supervision through behavioral monitoring capabilities. Motion detection algorithms analyze video frames to identify unusual levels of movement that may indicate classroom disturbances or conflicts. Background subtraction methods isolate moving objects, while optical flow techniques evaluate motion direction and intensity. When abnormal

activity patterns are detected, the system generates alerts and logs the corresponding events in the database. The system also monitors faculty presence by verifying whether the assigned instructor is present during scheduled lecture times. If the instructor is absent for an extended period, the system notifies administrators through the dashboard. The integration of AI-based recognition, behavioral analysis, and web-based monitoring tools makes the proposed system a comprehensive smart classroom solution. It improves institutional management, ensures accurate attendance records, and enhances classroom discipline through automated monitoring and real-time data visualization.

VI RESULTS & DISCUSSION

The implementation of the intelligent classroom monitoring system demonstrates significant improvements in attendance management and classroom supervision. Experimental evaluation shows that the FaceNet-based facial recognition module achieves an accuracy of approximately 92–95% under controlled lighting conditions and standard classroom environments. The system successfully detects and recognizes multiple faces from live video streams while maintaining real-time performance. The randomized attendance capture mechanism effectively reduces the possibility of proxy attendance by preventing predictable attendance marking intervals. Behavioral monitoring modules based on background subtraction and optical flow analysis also demonstrate the ability to detect abnormal motion patterns within classrooms. These features allow the system to identify potential disturbances and generate alerts for administrative review. The integration of AI modules with a web-based dashboard provides efficient visualization of attendance records and incident logs. Overall, the results confirm that the proposed system offers a reliable and scalable solution for automated classroom monitoring.

VII CONCLUSION

The intelligent classroom monitoring system presented in this study demonstrates the potential of integrating artificial intelligence, computer vision, and web technologies to improve academic administration and classroom supervision. Traditional attendance methods are often inefficient, prone to manipulation, and incapable of providing insights into classroom behavior. The proposed system addresses these limitations by implementing a deep learning–based face recognition framework using the FaceNet model and OpenCV for real-time video processing. The system automatically identifies students and faculty members from live video streams and records attendance without requiring manual intervention. By using facial embeddings and distance-based matching techniques, the system ensures accurate identity verification and reduces the risk of proxy attendance. In addition to attendance automation, the system incorporates behavioral monitoring modules that analyze motion patterns within classrooms. These modules detect abnormal movement levels that may indicate disturbances or conflicts, thereby enabling timely administrative intervention. The integration of a web-based dashboard further enhances usability by providing real-time access to attendance reports, incident alerts, and classroom monitoring data. Experimental results demonstrate that the system achieves high recognition accuracy while operating efficiently on standard hardware configurations. This makes the proposed approach suitable for practical deployment in educational institutions without requiring expensive infrastructure. Overall, the intelligent classroom monitoring system provides a scalable and efficient solution for modern smart campus environments, improving transparency, accountability, and discipline in academic settings.

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