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AI-Based Student Counting System

[1]Prof. Leena Pimple, [2]Akshavi kalarkar, [3]Samrudhi Somnathe, [4]Roshni Nagrikar, [5]Trupti Shende

[1,2,3,4,5]Department of Computer Engineering, Suryodaya College of Engineering and Technology, Nagpur, Maharashtra, India

[1]sulbhewar.leena@gmail.com, [2]akshavikalarkar123@gmail.com, [3]samrudhisomnathe89@gmail.com, [4]roshninagrikar90@gmail.com, [5]truptishende99@gmail.com

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ABSTRACT

The AI-Based Student Counting System is an intelligent classroom monitoring solution that leverages Artificial Intelligence (AI) and Computer Vision technologies to automatically detect and count students in real time. The system employs state-of-the-art object models, such as YOLO (You Only Look Once), in combination with the open cv library to process video frames, detect human presence, and generate an accurate student count. The collected data can be stored in a centralized database for attendance analysis, classroom occupancy monitoring, and administrative reporting. The system is designed to operate efficiently under varying classroom conditions while minimizing manual intervention. The integration of AI enables real-time monitoring, scalability, and adaptability across classrooms of different sizes. Furthermore, the system can be extended to incorporate advanced features such as facial recognition-based attendance, student tracking, occupancy analytics, cloud-based reporting, and integration with institutional management systems. By reducing administrative workload and improving operational efficiency, the system represents a significant advancement in the application of artificial intelligence within the education sector.

1. INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) and Computer Vision has significantly transformed various sectors, including education. Educational institutions are increasingly adopting intelligent technologies to automate administrative tasks, improve operational efficiency, and enhance the overall learning environment. One such application is the AI-Based Student Counting System, which provides an automated and accurate method for counting students in classrooms, laboratories, seminar halls, and other educational spaces. Traditional student counting methods rely on manual observation or attendance records, which are often time-consuming, labour-intensive, and prone to human errors. These methods become particularly challenging in large classrooms or during events where the number of students changes frequently.

To overcome these limitations, AI-powered computer vision techniques can be employed to detect and count students automatically from live video streams or recorded footage. The proposed AI-Based Student Counting System utilizes advanced object detection algorithms, such as YOLO (You Only Look Once), along with the Open CV library to identify human objects in real time. The system processes video frames captured by a webcam or CCTV camera, detects individual students, and continuously updates the student count with high accuracy. The generated data can be stored in a database and used for classroom occupancy analysis, attendance support, resource planning, and administrative decision-making. Addition to providing accurate student counts, the system contributes to the development of smart classrooms by enabling real-time monitoring and reducing the need for manual intervention. The integration of deep learning techniques ensures efficient performance even in dynamic classroom environments. Furthermore, the system can be extended with features such as facial recognition-based attendance, student tracking, cloud-based analytics, automated report generation, and integration with institutional management systems. As educational institutions continue to embrace digital transformation, AI-driven automation plays a crucial role in improving efficiency, transparency, and resource utilization. The AI-Based Student Counting System represents a practical and scalable solution that enhances classroom management while supporting the broader vision of smart and technology-enabled educational campuses.

2. LITERATURE REVIEW

Artificial Intelligence (AI) and Computer Vision have revolutionized the field of automated surveillance and monitoring by enabling machines to detect, recognize, and analyse objects in real time. In recent years, researchers have developed various intelligent systems for human detection, crowd analysis, occupancy estimation, and attendance management using deep learning techniques. These advancements have provided the foundation for developing automated student counting systems in educational institutions. Early student counting systems primarily relied on manual attendance registers, infrared sensors, RFID cards, or biometric devices. Although these methods improved attendance recording, they required active participation from students and additional hardware infrastructure. Moreover, such systems were unable to provide real-time classroom occupancy information and often suffered from issues such as proxy attendance, equipment failures, and maintenance costs.

With the emergence of deep learning-based object detection algorithms, computer vision has become a more efficient solution for people detection and counting. Models such as YOLO (You Only Look Once), SSD (Single Shot Detector), Faster R-CNN, and Mask R-CNN have demonstrated high accuracy in detecting multiple human objects simultaneously. Among these, YOLO has gained significant popularity due to its high processing speed and ability to perform real-time object detection with excellent accuracy, making it suitable for classroom environments. Several studies have utilized the Open CV library in combination with deep learning models to process live video streams captured from surveillance cameras. These systems detect students by identifying human bodies within each video frame and apply tracking algorithms to avoid duplicate counting. As a result, they provide continuous and accurate estimates of classroom occupancy while minimizing manual intervention. Recent research has also focused on integrating artificial intelligence with educational management systems. AI-powered monitoring solutions not only count students but also support attendance management, classroom utilization analysis, security monitoring, and smart campus administration. Cloud computing and Internet of Things (IoT) technologies further enhance these systems by enabling centralized data storage, remote monitoring, and real-time analytics. Despite significant advancements, existing systems still face challenges such as occlusion, varying lighting conditions, camera angle variations, overlapping students, and complex classroom environments. Continuous improvements in deep learning architectures, image processing techniques, and hardware acceleration have significantly reduced these limitations, resulting in higher detection accuracy and faster processing speeds. Based on the existing literature, it is evident that AI-based student counting systems offer a reliable, scalable, and cost-effective solution for automated classroom monitoring. The proposed system builds upon these advancements by employing modern deep learning techniques and computer vision algorithms to achieve accurate real-time student counting while supporting future enhancements such as facial recognition, cloud-based reporting, and intelligent classroom analytics.

3. RESEARCH GAPS

Although several AI-based human detection and people counting systems have been developed, there are still a number of limitations that affect their performance in real-world classroom environments. Existing studies primarily focus on general crowd counting or surveillance applications rather than classroom-specific

student counting. As a result, several research gaps remain.

A. Limited Accuracy in Crowded Classrooms
Existing systems often struggle to accurately detect and count students when multiple individuals overlap or occlude one another.

B. Sensitivity to Environmental Conditions
Variations in lighting, camera angles, classroom layouts, and background complexity can significantly reduce detection accuracy.

C. Lack of Real-Time Performance
Many existing approaches require high computational resources, making them unsuitable for real-time deployment on low-cost hardware.

D. Duplicate or Missed Counting
In dynamic classroom environments, students entering, leaving, or changing positions may be counted multiple times or missed entirely.

E. Limited Integration with Educational Systems
Most existing solutions focus only on counting people and do not integrate with attendance management systems, classroom analytics, or institutional databases.

F. Privacy and Security Concerns
Many systems rely on facial recognition, raising concerns related to student privacy, data protection, and compliance with institutional policies.

G. Scalability Issues
Existing solutions are often designed for small environments and may not perform efficiently in large classrooms, lecture halls, or auditoriums.

H. Insufficient Classroom Analytics
Current systems generally provide only the total student count without offering detailed occupancy analysis, historical trends, or decision-support reports.

I. Hardware Dependency
Several approaches require specialized sensors or expensive surveillance equipment, increasing deployment and maintenance costs.

J. Need for Intelligent Automation
There is a growing need for AI-powered systems that provide accurate student counting, real-time monitoring, automated report generation, and seamless integration with smart classroom and campus management platforms.

The proposed AI-Based Student Counting System addresses these research gaps by utilizing advanced deep learning-based object detection algorithms to achieve accurate, real-time student counting while providing scalability, improved efficiency, reduced manual intervention, and support for future smart classroom applications.

4. PROPOSED FRAMEWORK

The proposed AI-Based Student Counting System is designed to automatically detect and count students in a classroom using Computer Vision and Deep Learning techniques. The system captures live video through a CCTV camera or webcam installed in the classroom. The video stream is processed frame by frame using the YOLO (You Only Look Once) object detection algorithm to identify students in real time.After detecting students, the system counts the total number of individuals present in each frame. The counting information is then displayed on the monitoring screen and stored in a database for future analysis, attendance tracking, and classroom occupancy monitoring. The system reduces manual effort, improves counting accuracy, and provides real-time monitoring for educational institutions.

The proposed framework consists of the following stages:

A. Video Capture
Capture real-time video using a CCTV camera or webcam.

B. Frame Extraction
Convert the video into individual frames for processing.

C. Image Pre-processing
Resize frames, remove noise, and normalize images to improve detection accuracy.

D. Student Detection
Apply the YOLO deep learning model to detect students in each frame.

E. Student Counting
Count the number of detected students by identifying bounding boxes around each person.

F. Data Storage
Store the counted data along with date and time in a database or CSV file.

G. Result Display
Display the total number of students on the screen in real time.

H. Report Generation
Generate attendance and occupancy reports for teachers and administrators.

5. EVALUATION

A. The following metrics are used to evaluate the system:

Counting Accuracy: Measures how accurately the system counts the number of students.

$$Accuracy(\%) = \left(1 - \frac{|\text{ActualCount} - \text{PredictedCount}|}{\text{Actual Count}}\right) \times 100$$

Precision: Precision measures the proportion of correctly detected students among all detected objects.

$$Precision = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

- TP (True Positive): Correctly detected students
- FP (False Positive): Incorrect detections

Recall: Recall measures the proportion of actual students correctly detected.

$$Precision = \frac{TP}{TP + \text{FN}}$$

FN (False Negative): Students missed by the system

F1-Score: The F1-score provides a balanced measure of Precision and Recall.

$$F1 = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

Processing Time: Measures the time required to process each video frame.

$$Processing\ Time = \frac{\text{Total Processing Time}}{\text{Number of Frames}}$$

Frames Per Second (FPS): FPS indicates the real-time processing capability of the system.

$$FPS = \frac{\text{Number of Processed Frames}}{\text{Total Processing Time}}$$

B. Experimental Results

Table 1: The system was tested in classrooms with different numbers of students.

Test Case	Actual Students	Predicted Students	Accuracy (%)
Classroom 1	20	20	100
Classroom 2	35	34	97.14
Classroom 3	50	49	98.00
Classroom 4	60	59	98.33
Classroom 5	75	74	98.67

Average Accuracy = 98.43%

C. Performance Analysis

The proposed AI-Based Student Counting System demonstrates high counting accuracy under normal classroom conditions. The YOLO-based model successfully detects and counts students in real time while maintaining a high frame processing rate. Minor counting errors occur due to occlusion, overlapping students, poor lighting, or rapid movement. Nevertheless, the system achieves an average counting accuracy of more than 98%, making it suitable for classroom occupancy monitoring and attendance-related applications.

D. Advantages of the Proposed System

- High student counting accuracy (>98%)
- Real-time detection using YOLO
- Fast processing with low latency
- Reduces manual counting effort
- Supports smart classroom automation
- Scalable for different classroom sizes
- Can be integrated with attendance management systems

E. Limitations

- Performance may decrease under poor lighting conditions.
- Heavy occlusion can reduce detection accuracy.
- Multiple overlapping students may lead to missed detections.
- Requires a GPU for optimal real-time performance.
- Camera angle and resolution affect counting accuracy.

CONCLUSION

The AI-Based Student Counting System presented in this study provides an efficient, accurate, and automated solution for monitoring classroom occupancy using Computer Vision and Deep Learning techniques. By utilizing the YOLO object detection algorithm, the system is capable of detecting and counting students in real time from live video streams captured through a CCTV camera or webcam. This approach significantly reduces the need for manual counting, minimizes human error, and improves the overall efficiency of classroom management. The experimental evaluation demonstrates that the proposed system achieves high counting accuracy (approximately 98%) while maintaining real-time performance. The system performs effectively under normal classroom conditions and can be integrated with attendance management systems, smart classroom applications, and occupancy monitoring solutions. Although factors such as occlusion, poor

lighting, and overlapping students may slightly affect detection accuracy, the overall performance remains reliable and suitable for practical deployment. In conclusion, the proposed AI-Based Student Counting System offers a cost-effective, scalable, and intelligent solution for educational institutions. It enhances classroom automation, supports data-driven decision-making, and contributes to the development of smart education environments.

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