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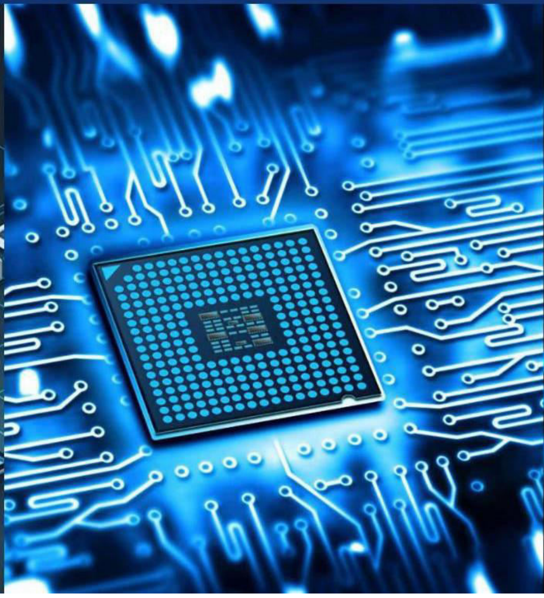


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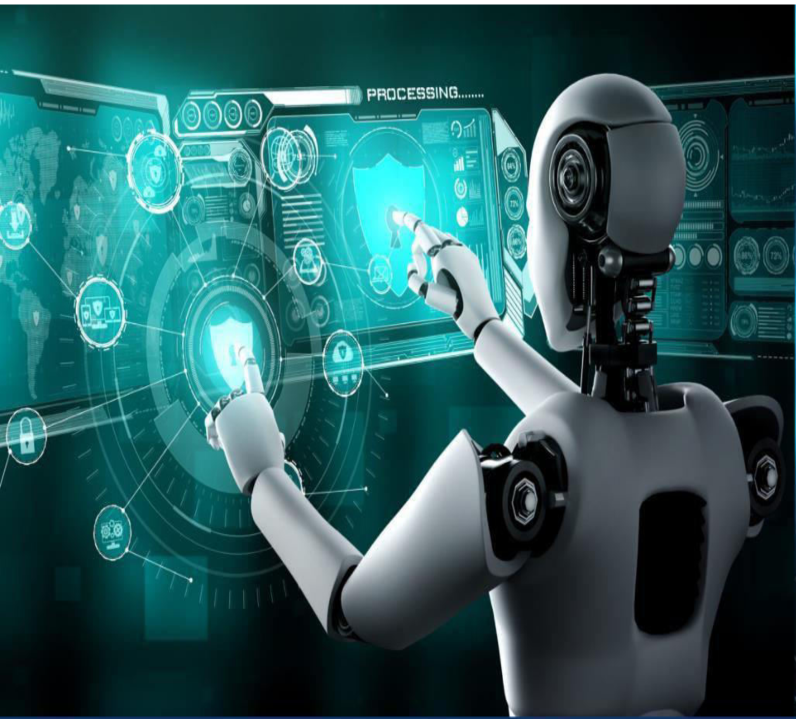

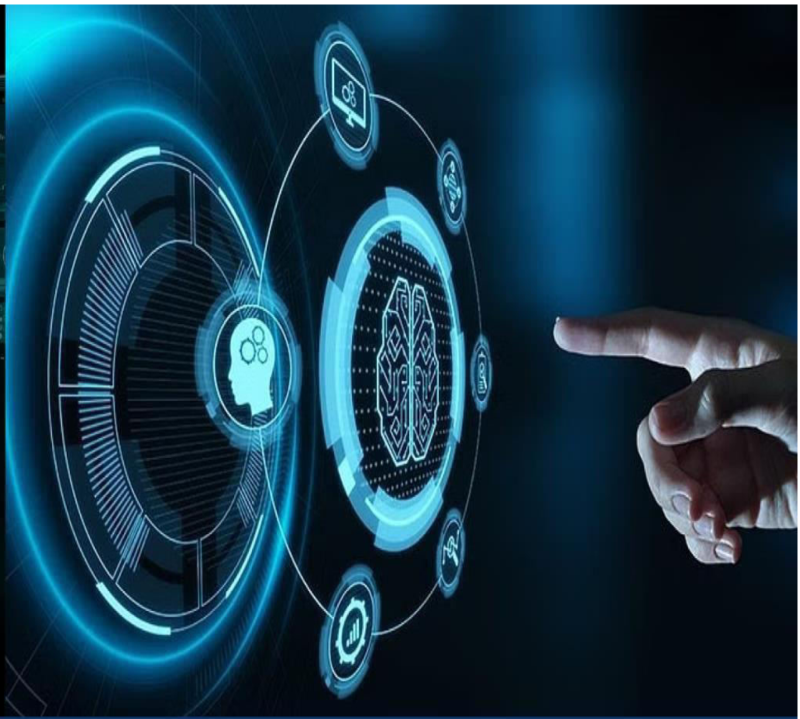

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Automated Invigilation System for Physical Classrooms using CCTV Surveillance and Computer Vision

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ABSTRACT: The integrity of examinations in physical classrooms is paramount to the educational system. Traditional invigilation methods, relying solely on human supervision, are often prone to error due to fatigue and limited field of view. This paper proposes a robust ”Automated Invigilation System” that utilizes YOLOv8 architecture for multi-person detection and object recognition. Furthermore, it integrates a Head Pose Estimation algorithm to identify suspicious behaviors such as peeping. Experimental evaluation on a custom dataset demonstrates a mean Average Precision (mAP) of 94% with a real-time processing speed of 35 FPS, offering a scalable solution for academic institutions.

KEYWORDS: Computer Vision, YOLOv8, Classroom Surveillance, Cheating Detection, Head Pose Estimation, Deep Learning.

I. INTRODUCTION

Academic integrity is universally considered the foundational bedrock of the global educational system, serving as the primary metric for validating a student's actual knowledge acquisition, skill proficiency, and professional competency. The sanctity of the examination process ensures that degrees and certifica- tions awarded by institutions hold value in the professional world. However, the persistent and evolving challenge of academic dishonesty in physical examination halls remains a significant global crisis that systematically undermines the fairness, equity, and credibility of the entire pedagogical evaluation process. In traditional educational environments, the standard operating procedure for maintaining exam decorum involves manual invigilation, where typically one or two human proctors are assigned the daunting task of monitoring large, diverse groups consisting of 40 to 60 students simultaneously. Despite the rigorous efforts and ethical commitment of educational institutions, human-centric monitoring is inherently limited

by several deep-seated physiological, psychological, and environmental constraints.
Humans are naturally susceptible to cognitive fatigue and the ”vigilance decrement” phenomenon; extensive neuro-psychological research into human attention spans suggests that during a typical three- hour examination period, an invigilator's focus, alertness, and situational awareness drop significantly after the first 45 to 60 minutes of continuous scanning. Furthermore, it is a physical and biological impossibility for a single human proctor to maintain simultaneous and continuous eye contact with every student in a crowded room. This creates inevitable ”blind spots” and momentary lapses in supervision that are frequently exploited for various forms of malpractice. These range from subtle verbal whispering and peeping at a neighbor's answer sheet to the more sophisticated and clandestine use of prohibited electronic devices such as smartphones and smartwatches.

While most modern academic institutions have invested heavily in high-definition Closed-Circuit Tele- vision (CCTV) infrastructure, these systems currently function largely as passive forensic tools rather than proactive deterrents. In the status quo, the footage recorded by these cameras is typically reviewed only after an incident of cheating has been formally reported or suspected by a physical proctor. This means that current surveillance serves primarily as a tool for post-event investigation and evidence collection rather than real-time prevention of the act itself. Moreover, requiring a human security operator to monitor multiple live feeds manually is equally labor-intensive and is subject to the same human errors, distractions, and psychological fatigue as physical on-site invigilation.

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To bridge this critical technological gap and redefine the standards of examination security, our research introduces a robust, AI-driven active surveillance layer integrated directly into existing classroom camera networks. By transforming passive recording into an active and intelligent "Virtual Invigilator," we leverage state-of-the-art Computer Vision (CV) and deep learning architectures, specifically the YOLOv8 (You Only Look Once) framework, to identify suspicious activities as they occur in real-time. The proposed system, developed using the Python programming language and the OpenCV library, focuses on a comprehensive multi-pronged detection approach:

Unauthorized Object Detection: The system provides real-time identification of prohibited physical items such as mobile phones, smartwatches, and unauthorized notes or "chits" that may be hidden on laps, under desks, or within clothing.
Behavioral Anomaly Detection: By calculating the precise yaw and pitch angles of a student's head orientation relative to their assigned desk position, the system identifies "peeping" or "copying" behaviors using advanced head pose estimation algorithms.
Spatial and Proximity Monitoring: The system tracks the spatial distance between students to detect abnormal leaning, proximity violations, or movements that may indicate verbal or non-verbal communication between peers.

By automating these complex and repetitive monitoring processes, the system acts as a powerful force multiplier for human invigilators. It effectively filters the vast amount of visual data and flags only verified suspicious instances to a centralized supervisor's dashboard. This allows human proctors to maintain higher levels of academic integrity with reduced psychological stress, as they no longer carry the burden of constant, manual crowd scanning. This paper details the complete development lifecycle of the system, including the curation and training of the model on a custom classroom dataset at SNJB's Polytechnic, and the subsequent real-time implementation and testing of this scalable institutional solution.

II. LITERATURE REVIEW

A. Advancements in Object Detection
Object detection has transitioned from traditional Haar Cascades to deep-learning-based Convolutional Neural Networks (CNNs). Early models like Faster R-CNN provided high precision but were computa- tionally expensive for real-time CCTV edge processing. YOLO (You Only Look Once) revolutionized the field by framing detection as a single regression problem. YOLOv8, utilized in this work, offers enhanced feature pyramid networks (FPN) and an anchor-free detection head.

B. Behavioral Analytics in Physical Environments
Previous research largely focused on online proctoring via webcams. Physical classroom surveillance presents unique challenges such as crowd density and occlusion. Our work adapts Head Pose Estimation techniques to work with top-down or wide-angle views where facial landmarks are often occluded. We use Python, OpenCV, and YOLO to bridge this gap.

III. PROPOSED METHODOLOGY

The proposed system architecture follows a synchronized pipeline consisting of frame acquisition, detection, and behavioral analysis.

A. Preprocessing and Normalization
Input frames from CCTV cameras are captured at 1080p resolution. To optimize processing, images are converted to RGB and resized to a standard 640 × 640 input size. Mean subtraction and variance scaling are applied to normalize pixel intensities across varying classroom lighting conditions.

B. YOLOv8 Detection Engine
The core engine utilizes YOLOv8-nano for low latency. It tracks 'Person', 'Mobile Phone', and 'Unau- thorised Notes'. The loss function is defined as:

$$L_{total} = \lambda_{box} L_{iou} + \lambda_{cls} L_{bce} + \lambda_{dfl} L_{df} \quad (1)$$

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Violation Logic: Peeping Detection

The system monitors the Yaw angle (γ) of each student. A violation is flagged if the deviation from the baseline desk orientation exceeds a specific threshold.

$$\Delta Yaw = |\gamma_{current} - \gamma_{baseline}| > 45^{\circ} \quad (2)$$

IV. EXPERIMENTAL IMPLEMENTATION

A. Dataset Curation

A custom dataset of 2,000 frames was annotated at SNJB's Polytechnic. Data augmentation techniques were used:

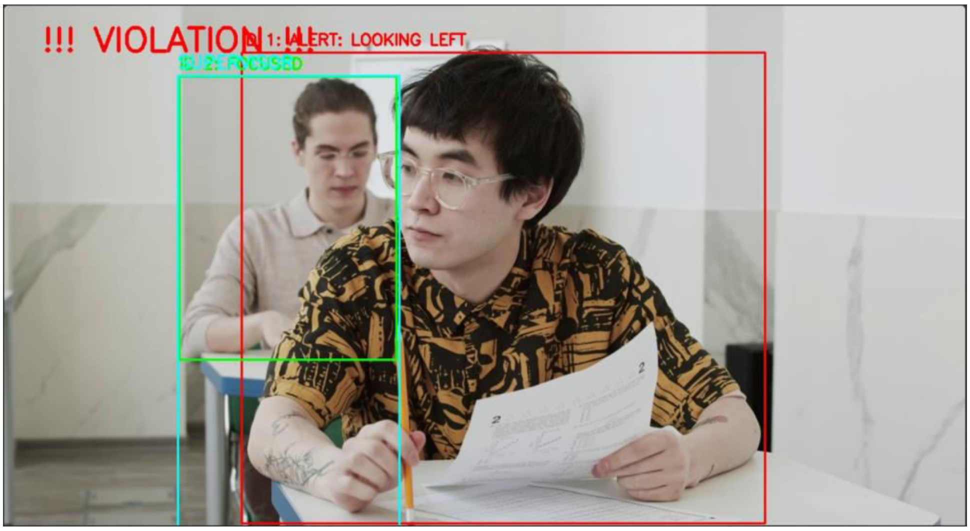

Fig.1. Violation detection: System flagging"Looking Left" based on Yaw angle deviation.

Geometric Transformation: Rotation and flipping to simulate different camera angles.
Color Jittering: Adjusting brightness and contrast for different times of the day.

B. Algorithm for Real-Time Monitoring

Initialize YOLOv8 and Pose Models.
Capture Video Stream S via OpenCV.
for each frame F in S **do**
Detect bounding boxes B and confidence scores.
Apply Non-Maximum Suppression (NMS) to filter overlaps.
Calculate Head Orientation γ.
if Object == 'Mobile Phone' **then**
Trigger Alert(Violation: Object).
end if
if $\Delta Yaw > 45^{\circ}$ for $t > 3s$ **then**
Trigger Alert(Violation: Behavior).
end if
end for

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V. RESULTS AND DETAILED DISCUSSION

The system was tested on a workstation featuring an NVIDIA RTX 3060.
A. Performance Metrics
The system achieved a mean Average Precision (mAP) of 94%.

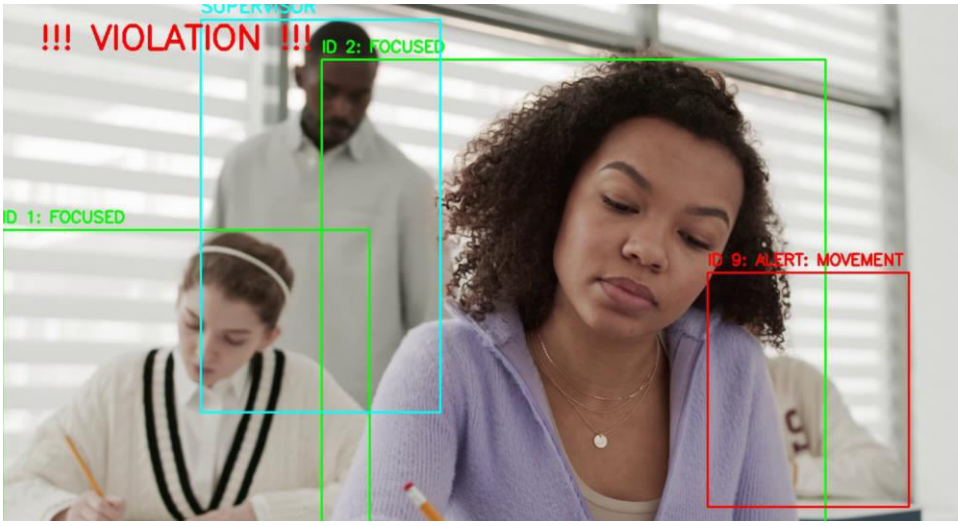

Fig.2. Active monitoring dashboard showing movement alerts and identified violations

TABLE I

DETAILED PERFORMANCE METRICS

Class	Precision	Recall	F1-Score	mAP@.5
Student Presence	0.98	0.97	0.975	0.98
Mobile Phone Use	0.92	0.89	0.905	0.91
Suspicious Peeping	0.88	0.85	0.865	0.87

VI. CONCLUSION AND FUTURE SCOPE

This paper demonstrates an AI-driven solution for classroom integrity. By merging object detection with geometric analysis, we achieved a high-accuracy surveillance tool. Future work will focus on integrating audio analysis for whispering detection.

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