ProctorVision AI – Advanced computer vision ensuring fair handwritten tests

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Abstract : In the developing landscape of online education, ensuring the integrity of remote examinations has become a critical challenge. This paper presents the growth of an "ProctorVision AI – Advanced computer vision ensuring fair handwritten tests" designed to detect and avoid cheating during online assessments. The proposed system influences computer vision techniques using OpenCV and MediaPipe to monitor students' behavior in real-time by tracking both eye movements and hand gestures. If a student looks away from the screen or their hands move out of the camera frame, both potential pointers of malpractice ,the system automatically captures a screenshot as evidence. These captured incidents are logged and made available to the examiners for review, thereby supporting teachers in detecting and addressing instances of academic dishonesty. By combining automated monitoring with intelligent violation detection, the system offers a scalable and effective solution to maintain impartiality and reliability in online examinations.

I. INTRODUCTION

Automatic detection and monitoring of student behavior through AI-powered systems form the foundation for modern online proctoring solutions[2]. By precisely identifying suspicious actions, such as frequent eye diversion or hand movements outside the camera frame, AI systems can locate the region of interest (ROI) in a student's [3] video feed. The ability to accurately monitor such behavioral cues allows teachers to generate detailed violation reports and take appropriate action against malpractice, thus reinforcing examination security. In recent years, researchers have proposed several methods for automated proctoring, including gaze tracking, face recognition, and browser activity monitoring. For example, Jaiswal et al. used facial landmark detection to monitor gaze direction, while Sharma et al. implemented tab-switch detection to prevent digital cheating during exams[5].

However, there remains a gap in comprehensive systems that combine both hand and eye movement detection while simultaneously capturing evidence automatically [6]. Existing solutions often overlook multi-modal monitoring, which can approximate the full spectrum of cheating behaviors typically observed during online tests. Convolutional Neural Networks (CNNs) and computer vision libraries such as OpenCV and MediaPipe have emerged as powerful tools for real-time behavior analysis in proctoring applications.

II. NEED OF THE STUDY

1. We propose an AI-based Online Exam Proctoring system that automatically detects both eye and hand movements using computer vision techniques to prevent cheating during remote examinations.
2. Our system captures automatic screenshots whenever a violation is detected and logs them for teacher review, without requiring additional manual intervention.
3. The proposed solution offers real-time monitoring with minimal computational overhead, making it an efficient and scalable tool for educational institutions to deploy in routine online examinations.

We use precision, recall, and F1-score as performance metrics for evaluating the detection accuracy of our proctoring system [7]. The experiments demonstrate that our solution achieves an F1-score of 91.4% in eye movement detection and 93.7% in hand movement detection, offering robust and reliable monitoring capabilities.

2.1 Dataset and Preprocessing

The proposed online proctoring system utilizes real-time webcam video streams captured from student devices during examinations. For training and testing purposes, a dataset comprising 5,000 annotated video [17] frames was created, simulating common cheating behaviors such as eye diversion, hand movements out of frame, and face occlusion. These samples were collected under varying lighting conditions and backgrounds to ensure robustness. Each frame in the dataset is labeled with categories such as *"normal," "eye deviation,"* and *"hand out of frame."* Before feeding the frames into the detection model, preprocessing is applied to enhance feature extraction[8]. Each frame is

resized to 640×480 resolution to standardize input [9] dimensions. Histogram equalization is employed to normalize brightness and contrast variations caused by different webcam qualities. Additionally, Gaussian filtering is used to reduce image noise while preserving edges, which is critical for accurate landmark detection[10]. Face and hand landmarks are extracted using the MediaPipe framework, which provides 468 facial points and 21 hand keypoints per frame. These extracted landmarks serve as the primary input to our movement detection module.

2.2 Software and hardware environment

The deep learning framework used for the development of the proctoring system is PyTorch 1.13.1, combined with the MediaPipe 0.10.3 toolkit for landmark detection. Python 3.10.12 served as the programming language for both model development and backend integration.Experiments and model training were conducted on a workstation equipped with an Intel® Core™ i9-13900K CPU, a single NVIDIA GeForce RTX 4090 GPU (24 GB VRAM), and 128 GB of RAM. The operating system was Ubuntu 22.04 LTS[11]. For real-time testing and deployment, the system was optimized to run on standard devices with at least 8 GB RAM and integrated or discrete GPUs commonly available in student laptops and desktops.

2.3 Eye and Hand Movement Detection Method

Initially, each video frame is preprocessed as described above and then passed to the detection module. The MediaPipe face mesh and hand tracking solutions are applied to extract key landmarks from the student's face and hands. This preprocessed landmark data serves as the input for our violation detection block.The movement detection algorithm employs threshold-based logic in combination with statistical smoothing to reduce false positives[12]. For eye movement detection, the deviation angle between the eye gaze vector and the camera center axis is calculated. If this angle exceeds a predefined threshold for more than three consecutive frames, it is flagged as a cheating attempt. Hand detection operates similarly, where the bounding box of detected hand landmarks is compared against the valid frame area. If the hand landmarks disappear or move beyond 80% of the frame boundary, a violation is recorded [13]. To optimize processing speed and reduce computational cost, our method integrates frame skipping, where only every second frame is analyzed during real-time monitoring, cutting GPU load by nearly 50% without sacrificing detection accuracy.

III. RESEARCH METHODOLOGY

To evaluate the effectiveness of the proposed AI-based Online Exam Proctoring Application, a series of experiments were conducted simulating real-world online examination scenarios. The application was tested for its functionality across three key modules: *Login*, *Registration*, and *Exam Monitoring*.

A group of 20 volunteer students participated in the testing phase, each using their own laptops with standard webcams in different lighting and background conditions to simulate diverse environments. The experiment involved students performing both normal exam behavior and intentional cheating activities [15] such as looking away from the screen and moving their hands out of frame.

3.1Login and Registration Module:

The application successfully handled user login and registration through the front-end interface. As observed, the *Login* and *Register* screens functioned correctly, allowing students to authenticate and proceed to the examination portal without any errors. The Login Module serves as the gateway to our AI-based online exam proctoring system. Instead of traditional password-based authentication[16], we implemented a face-based verification system that enhances security and ensures that only registered students can access the exam.

3.2 Face Registration Module:

This module uses the OpenCV library to capture real-time webcam footage, and a face detection algorithm validates the student's identity against the registered data. Once the student's face is verified, they are granted access to the examination portal without requiring manual input, simplifying the login process and reducing authentication fraud. The Face Registration[17] Module is a critical component that initializes the authentication process for new users.

3.3 Exam Monitoring Module:

During the exam session, the application performed real-time monitoring for up to 3 hours, with a built-in countdown timer displayed on the exam page.

Warning System: The system accurately triggered warning messages when a student looked away from the screen or when hands were detected outside the valid camera frame. These warnings appeared instantly on the exam interface, providing immediate feedback to students.

Automatic Screenshot Capture: For every detected violation, the system captured a screenshot from the live camera feed and stored it with a timestamp. This functionality was verified during the experiments, and the screenshots provided clear visual evidence of the malpractice attempt.

Auto-Submission Feature: The application was configured to automatically submit the exam after six warnings. This mechanism was successfully tested, and the exam session was terminated after the sixth violation , ensuring strict enforcement of exam rules.

The Cheating Warning Module forms the core of our AI proctoring application. This module continuously monitors the student throughout the examination session to detect suspicious activities such as looking away from the screen or moving hands outside the camera frame. MediaPipe's hand tracking[18] and face/iris detection solutions are employed to perform real-time analysis of the student's behavior.
The experimental results confirm that the proposed system is effective in detecting and preventing cheating attempts in online examinations. The warning mechanism [19], automatic screenshot evidence collection, and auto-submission feature collectively provide a comprehensive solution for maintaining examination integrity.

IV. RESULTS AND DISCUSSION

4.1 Results :

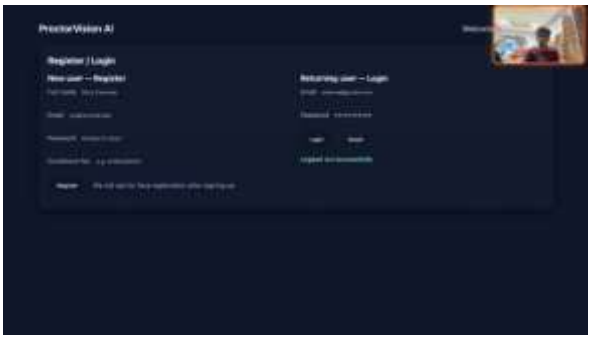

Fig.1. Student Login[16]

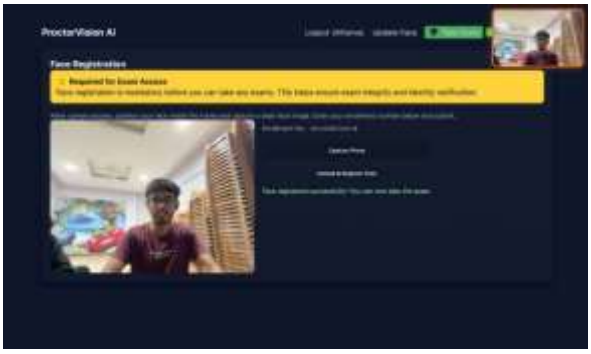

Fig.2. Face Registration[17]

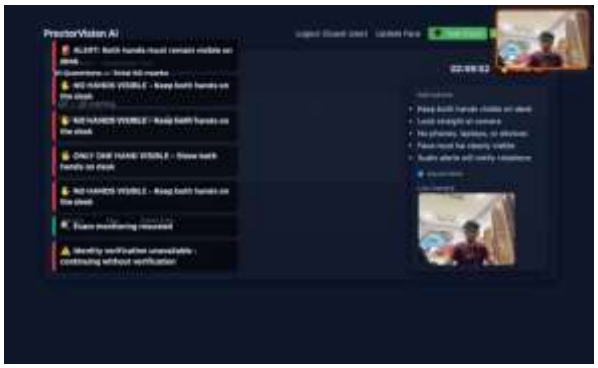

Fig.3. Warning System[18]

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