

Secure On-Screen Activity Tracking and Classification in E-Learning using Machine Learning

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ABSTRACT: In order to preserve academic integrity and guarantee fair exams and online learning, the quick expansion of online education has made efficient proctoring systems necessary. For online tests and e-learning, traditional proctoring techniques like in-person invigilation are impractical. A computer vision-based automated proctoring system is suggested as a solution to this problem. This technology uses sophisticated computer vision algorithms to track and examine how applicants behave during online tests and learning.

The Automated Proctoring System keeps an eye on the test environment in real time by using a webcam and screen recording. The examinee's face, gaze direction, eye movements, body posture, and suspicious activities are all detected and tracked using computer vision algorithms. Unusual patterns of behavior, including repeatedly averting one's gaze from the screen or displaying several faces in the camera frame, are recognized by machine learning models. The examiners receive alerts for more investigation as a result of these irregularities. Through the mitigation of academic dishonesty, such as cheating, impersonation, and unauthorized aids, the suggested system seeks to improve exam security and e-learning. It offers a scalable and non-intrusive way to supervise online tests and e-learning by utilizing computer vision.

I. INTRODUCTION

Strong safeguards to maintain academic integrity during online tests are desperately needed, especially in light of the rise in distant learning and online education. Maintaining a fair testing environment and making sure candidates follow the required examination criteria are two major issues in online exam environments. Because of logistical limitations and privacy issues, traditional in-person proctoring techniques are not practical in online settings. As a result, automated proctoring systems that use computer vision techniques to oversee and manage online tests have gained popularity.

This research suggests an Automated Proctoring System that uses cutting-edge computer vision algorithms to efficiently track and examine how candidates behave during online tests. This system may detect and identify suspicious activities, abnormal gaze patterns, and other behaviors that might point to possible academic dishonesty by utilizing computer vision technologies. The goal is to give educational institutions and online learning environments a non-intrusive, scalable, and effective way to maintain academic integrity.

In this paper, we provide a comprehensive analysis of the Automated Proctoring System, describing the machine learning models used for anomaly detection, the behavior analysis methodology, and the underlying computer vision algorithms. We highlight the system's ability to resolve issues with academic integrity and uphold fairness for all applicants, which eventually helps to establish the legitimacy of online learning. The technical details of the suggested Automated Proctoring System will be covered in detail in the following parts, which will also include the system's design, deployment, and assessment to confirm how well it monitors and upholds the integrity of online tests. To guarantee that the system complies with ethical standards and privacy laws, ethical issues pertaining to data protection and the reduction of false positives will also be covered.

II. LITERATURE SURVEY

Jay Mayekar et al[1]:In this paper, they have proposed and implemented an automated proctoring system using computer vision techniques. The system helps in conducting examinations by fair means and hence, maintains its integrity. This study demonstrates how to avoid cheating in online examinations by employing semi-automated proctoring based on vision and audio capabilities, as well as monitoring several students.

Simon Wenig et al[2]:In this paper, a simulation framework for MMC-based multi terminal HVDC systems is presented. The selected modeling concept offers insight into global arm quantities, considered as essential parameters to investigate transient system controllability. Besides the feature to handle unbalanced voltage conditions in one of the interfaced ac networks, this control approach facilitates active regulation strategies of all converter arm energies to keep the system within a predefined operating area during and subsequent to dynamic events.

Aiman A Turani et al[3]: In this work, they have focused on the limitations and concerns regarding the online proctoring. The two main concerns were test integrity and student performance. Avoiding frauds and cheating attempts within online proctoring sessions without affecting test-taker's performance is considered to be very challenging. We suggested using the 360-degree security camera over the webcam for improving the proctoring process.

AsepHadianSudrajatGanidisastra et al[4]: The evaluation results have shows us that incremental training has a better performance compared to batch training in speed and dataset size. The decrease of training speed and dataset size is not giving a negative influence on the accuracy rate, on the contrary, the proposed method will result in smaller storage space, smaller memory usage, and faster training speed. On the other hand, the face detection method can result in better face recognition accuracy.

SarthakManiar et al[5]:In this paper, we have proposed and implemented an automated proctoring system using computer vision techniques. The system helps in conducting examinations by fair means and hence, maintains its integrity. This study demonstrates how to avoid cheating in online examinations by employing semi-automated proctoring based on vision and audio capabilities, as well as monitoring several students at once. However, if there is a person sitting behind the laptop, the student can communicate with that person by reading the question. This can be catered by having a 360 degree camera monitoring the whole room of the student.

Renuka Devi et al [6]: This paper deals with designing an approach wherein it tries to detect any abnormal behaviors present in the videos. The system first works by detecting all students present in the video. After detecting all the students, it tracks the detected students throughout the course of the video. The features of the tracked students are calculated using HoG feature descriptor and then sent to the K-Nearest Neighbor classifier. The classifier is pre-trained to detect normal or abnormal actions. System is made to be adaptable to lots of different conditions as in, a user can choose the behaviors that they want the system to detect and train the system specifically for that.

YousefAtoum et al.[7]:This paper presents a multimedia analytics system for online exam proctoring, which aims to maintain academic integrity in e-learning. The system is affordable and convenient touse from the test taker's perspective, since it only requireshaving two inexpensive cameras and a microphone. With the captured videos and audio, we extract low-level features from six basic components: user verification, text detection, speech detection, active window detection, gaze estimation, and phone detection.

YusepRosmansyah et al.[8]:In this paper, online learning or e-learning has become increasingly popular and evolved. Many academic institutions use the Learning Management System (LMS) as a medium for delivering e-learning. A vital feature in such a system is the electronic examination (e-exam), where verifying student's authentic competence is a challenge. This paper aims to present countermeasures for impersonation attacks. This research was a more focused effort and a continuation of previously owned one and many others found in works of literature.

The method of protection is presented in the form of an attack-defense tree model. Aditya Nigam et al.[9]: In this paper, online testing is the next wave of adoption after online learning which has seen a significant rise in demand due to the problems posed by the ongoing COVID-19 Pandemic. OPS do not claim to be completely fool proof but are rapidly changing the adoption of online testing from home, a scenario that previously would have been thought to be preposterous amongst the masses.

TejaswiPotluri et al.[10]: The main objective of this paper is to develop a well-rounded automation system that is capable of helping the proctor to monitor the students attending an online examination. Out of the several proposed features of the system, our paper has developed the ability to do multiple person detection, face spoofing, and head pose estimation.

III. PROPOSED SYSTEM

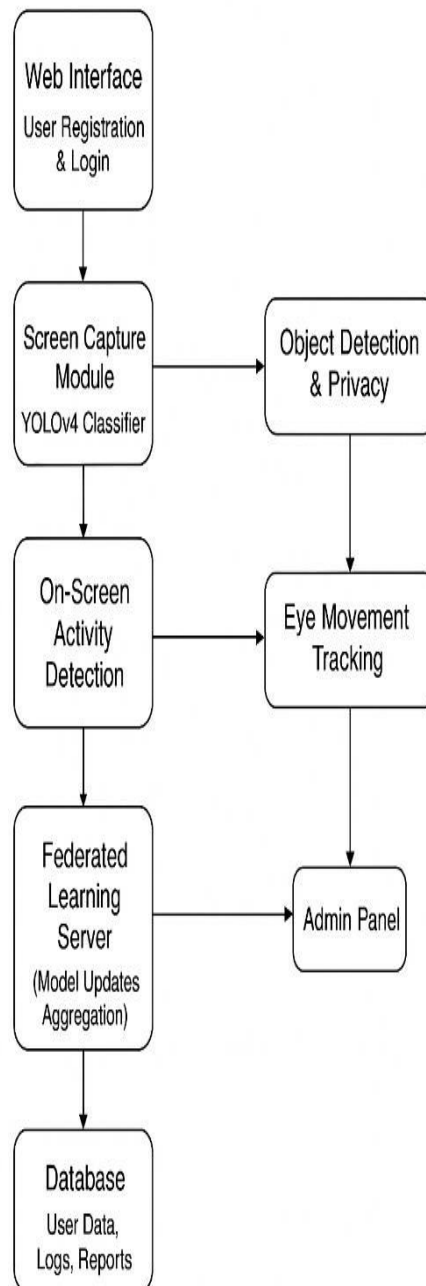


Fig1: Block Diagram

IV. ALGORITHM

A. YOLOv4 Algorithm for Activity Classification

Input: Captured screenshots

Output: Classified label — Educational or Non-Educational

Steps:

1. Load YOLOv4 pre-trained model and configuration files.
2. Preprocess input images (resize, normalize).
3. Perform object detection to identify key regions of interest.
4. Extract features and assign confidence scores for detected objects.
5. Based on contextual object combinations (e.g., notebooks, slides = Educational; chat apps, games = Non-Educational), assign a class label.
6. Store classification results for visualization and analysis.

B. Federated Learning Algorithm for Privacy Preservation

Input: Local training data on user devices

Output: Global optimized model without sharing raw data

Steps:

1. Initialize the global model on the central server.
2. Distribute model parameters to all participating devices.
3. Each client trains the model locally using its own screenshot data.
4. Clients send updated model weights (not data) to the server.
5. The server aggregates updates to refine the global model.
6. Repeat steps 2–5 until convergence is achieved.

This process ensures that sensitive user data never leaves the device, preserving privacy while improving model performance collaboratively.

Mathematical Model

- Input: The process starts with the Global Model (M_{global}) weights from the central server and a set of n clients, each having its own local dataset (D_i).
- Process: Client Download
The central server sends a copy of the current M_{global} weights to a selected subset of clients.
Mathematical operation: Copy weights.
- Process: Local Training
Each client i updates its model weights (M_i) by training on its local dataset (D_i).
The model minimizes a local loss function (L_i) to calculate the local gradient (g_i) over E local epochs.
- Mathematical operation: Gradient Descent (or similar optimization) to find $M_i^t \leftarrow M_i - \eta \cdot g_i$, where η is the learning rate.
- Process: Client Upload
Each client sends its updated local model weights (M_i^t) back to the central server.
- Process: Global Aggregation
The central server aggregates the received local models to update the M_{global} .
The FedAvg formula is applied, which calculates a weighted average of the client models. If all clients are used and have roughly equal data size:
$$M_{\text{global}} \leftarrow \frac{1}{n} \sum_{i=1}^n M_i^t$$

Mathematical operation: Weighted averaging of model parameters.
- Output: The result is a New Global Model (M_{global}) with improved performance. This entire process (Steps 2-5) is repeated for a set number of communication rounds (T).

V. RESULTS AND DISCUSSION

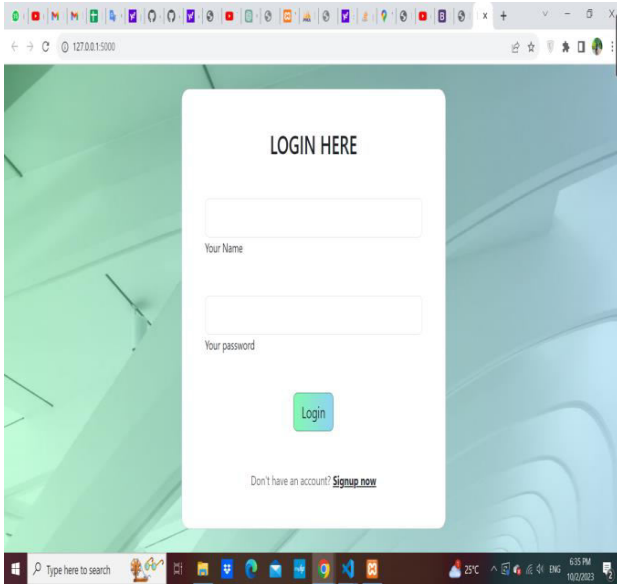


FIG (1)

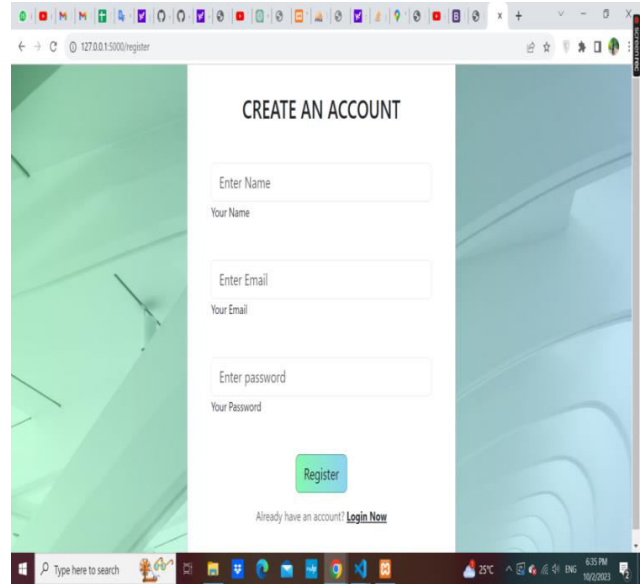


FIG (2)



FIG (3)

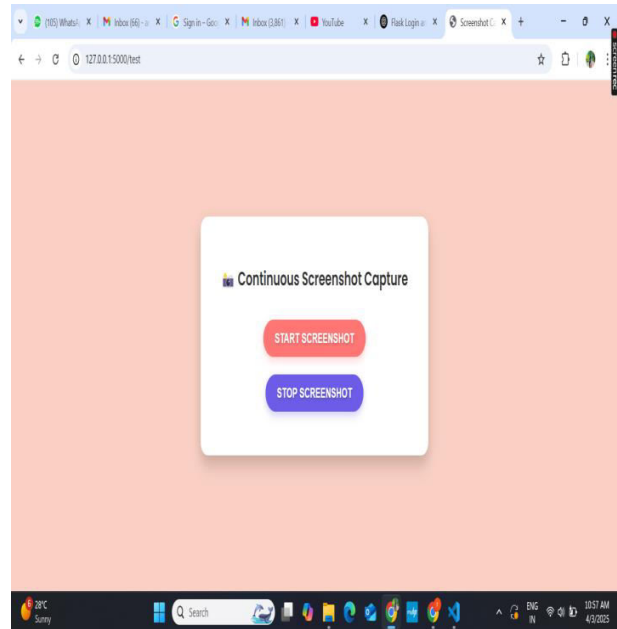


FIG (4)

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