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A novel AI-powered cheating detection system for online examinations using computer vision and keystroke dynamics

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Abstract

Online examinations require reliable mechanisms to ensure academic integrity; however, many existing systems rely on rigid rule-based approaches that often generate false alerts and fail to account for individual behavioral differences. This paper presents ScoreHunt, an AI-based adaptive cheating detection system that analyzes personalized student behavior using computer vision and keystroke dynamics. The proposed system establishes a behavioral baseline for each student and continuously compares it with real-time activities, including facial presence, gaze patterns, and typing behavior. A multi-indicator validation mechanism is employed to improve detection accuracy while minimizing false positives. Additionally, the system provides automated alerts, detailed activity logs, and an administrative dashboard for efficient monitoring and analysis. Experimental evaluation conducted across 15 test cases demonstrates stable performance with reduced false positive rates, indicating the effectiveness of the proposed approach in enhancing the reliability and fairness of online examination systems.

Keywords: Online Proctoring; Computer Vision; Keystroke Dynamics; Cheating Detection; Behavioral Analysis; Artificial Intelligence

1. Introduction

The rapid expansion of online education has transformed how academic institutions conduct examinations, offering unmatched flexibility and accessibility across geographical boundaries. However, this shift has introduced a critical challenge: maintaining academic integrity without a physical invigilator present. The absence of human supervision creates significant opportunities for dishonest behavior, placing enormous pressure on institutions to develop reliable automated monitoring solutions.

Conventional proctoring systems currently deployed across institutions worldwide are built on rigid, rule-based logic. A student glances briefly away from the screen — flagged. A browser tab changes momentarily — flagged. A pause in typing exceeds a fixed threshold — flagged. While these mechanisms are technically simple to implement, they are fundamentally flawed in their assumptions. They treat every student as behaviorally identical, leaving no room for the natural individual variations that genuinely exist. A student with a visual impairment may naturally avert their gaze; a slow typist may pause frequently out of habit. Under such systems, authentic behavioral differences are routinely misinterpreted as dishonesty, resulting in false accusations that damage student confidence, institutional trust, and the integrity of the very process these systems seek to protect.

Manual monitoring of large-scale examinations is not only resource-intensive but also inconsistent and prone to human error. In densely populated academic environments, it becomes practically impossible to supervise every student

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simultaneously with the level of attention required to distinguish genuine misconduct from innocent behavior. This gap between the growing scale of online examination adoption and the inadequacy of existing monitoring tools creates an urgent and clear demand for a smarter, fairer, and more adaptive solution.

1.1. Introduction to the Proposed System

Recent advances in Artificial Intelligence, Computer Vision, and Machine Learning have made it feasible to build proctoring systems that move beyond fixed rules and towards genuine behavioral understanding. The proposed system — ScoreHunt — harnesses these capabilities to construct a personalized behavioral baseline for each student by observing their natural patterns of facial movement, gaze direction, head posture, and typing rhythm before the examination begins.

During the examination, the system performs continuous real-time monitoring across two parallel behavioral streams: a computer vision pipeline powered by OpenCV and MediaPipe processes live webcam data to track facial presence, eye gaze, and head orientation, while a keystroke dynamics module captures typing speed, key dwell time, and inter-key flight intervals through the pynput library. Rather than acting on any single suspicious signal, a multi-indicator validation engine cross-validates all behavioral dimensions simultaneously and generates an alert only when convergent evidence is detected across multiple signals. This layered approach dramatically reduces false positives while maintaining strong detection sensitivity. All flagged events are documented in timestamped activity logs accessible through a secure administrator dashboard, ensuring transparency and human oversight at every stage of the process.

2. Literature Review

Several existing systems have explored AI-based online proctoring using computer vision and facial analysis. While these approaches have demonstrated reasonable performance under controlled conditions, they consistently suffer from high false positive rates, lack of personalized behavioral modeling, and limited integration of multiple behavioral signals. To address these shortcomings, the proposed system introduces personalized baseline learning combined with multi-indicator validation to provide more accurate, fair, and adaptive cheating detection.

2.1. Ashmi Christus et al. (2026). The Challenges of AI-Based Proctoring Systems in Online Exams. International Journal of Educational Technology.

This study presents a comprehensive analysis of technical and ethical challenges in AI-based online proctoring systems, focusing on high false positive rates, algorithmic bias, and privacy concerns arising from continuous monitoring.

2.1.1. Methodologies and Algorithms

The authors conduct a systematic review of rule-based and AI-driven proctoring methods, analyzing their behavioral thresholds, bias sources, and failure modes across diverse student populations.

2.1.2. Accuracy and Limitations

The study does not report a specific accuracy figure as it is a review paper. Its primary limitation is the absence of a proposed solution — it identifies the problems clearly but does not provide an adaptive detection framework to resolve them.

2.2. Elayaraja et al. (2026). AI-Powered Identity Verification Systems to Protect Remote Learning. Journal of Remote Learning Systems

This research focuses on pre-examination identity authentication using AI-based facial recognition, verifying that the registered candidate is present before granting access to the examination system.

2.2.1. Methodologies and Algorithms

The system employs face detection and recognition techniques using CNN-based architectures trained on student enrollment photographs, performing one-to-one matching at the examination entry stage.

2.2.2. Accuracy and Limitations

The system demonstrates high accuracy in controlled enrollment conditions. However, its scope is strictly limited to entry-stage authentication and does not include any continuous behavioral monitoring during the examination, leaving the entire examination period unsupervised.

2.3. Adhatrao et al. (2025). AI-Based Surveillance for Exam Integrity: Real-Time Detection of Abnormal Student Behavior. Proceedings of the International Conference on Intelligent Systems

This study introduces a real-time proctoring system using the YOLOv8 object detection model to identify physical violations such as mobile phone usage, suspicious hand movements, and unauthorized gestures during examinations.

2.3.1. Methodologies and Algorithms

YOLOv8 is applied to live webcam video streams, detecting predefined objects and physical gestures associated with cheating behavior. The system achieves fast inference suitable for real-time deployment.

2.3.2. Accuracy and Limitations

The system achieves approximately 94% detection accuracy for physical object violations. Its critical limitation is an exclusive reliance on visual data — the absence of keystroke dynamics or behavioral baseline modeling means it cannot detect cheating behaviors that do not involve visible physical objects.

2.4. Huang et al. (2025). ProctorSense: An AI-Enhanced Online Proctoring System with Proactive and Analytical Monitoring Techniques. IEEE Transactions on Learning Technologies

ProctorSense presents a computer vision-based proctoring system focused on eye movement tracking and head orientation analysis to assess student attention levels during online examinations.

2.4.1. Methodologies and Algorithms

The system uses gaze estimation and head pose detection models combined with proactive monitoring strategies that generate analytical reports of student engagement patterns over the examination session.

2.4.2. Accuracy and Limitations

ProctorSense demonstrates approximately 91% attention detection accuracy. Its primary limitation is the use of uniform behavioral thresholds applied identically to all students, with no mechanism for personalized baseline learning, making it susceptible to false positive detections for students with naturally atypical gaze or movement patterns.

2.5. Gopane et al. (2024). Cheat Detection in Online Examinations using Artificial Intelligence. International Journal of Artificial Intelligence in Education.

This study proposes a webcam-based automated invigilation system that monitors facial expressions and head movements to detect suspicious behavior during online examinations.

2.5.1. Methodologies and Algorithms

The system applies computer vision techniques to webcam feeds, detecting predefined facial and head movement patterns associated with cheating and generating alerts based on fixed threshold violations.

2.5.2. Accuracy and Limitations

The system achieves approximately 89% detection accuracy. However, the study itself identifies high false positive rates and a lack of adaptability to individual behavioral patterns as its key limitations, directly motivating the multi-indicator and personalized baseline approach of the proposed system.

Several other studies have also contributed to the development of AI-based online proctoring systems, focusing on areas such as facial recognition, gaze tracking, and behavior analysis [6–13]. These works collectively highlight the importance of improving detection accuracy, reducing false positives, and ensuring fairness in automated proctoring environments.

2.6. Detection Accuracy Comparison of Existing Algorithms and Proposed System

Figure 1 compares detection accuracy across AI-based online proctoring systems. Traditional rule-based methods show lower accuracy due to high false positives. Vision-based models like YOLOv8 and ProctorSense improve performance but lack behavioral personalization. The proposed ScoreHunt system achieves the highest accuracy and lowest false positive rate by combining personalized baseline learning with multi-modal analysis using computer vision and keystroke dynamics.

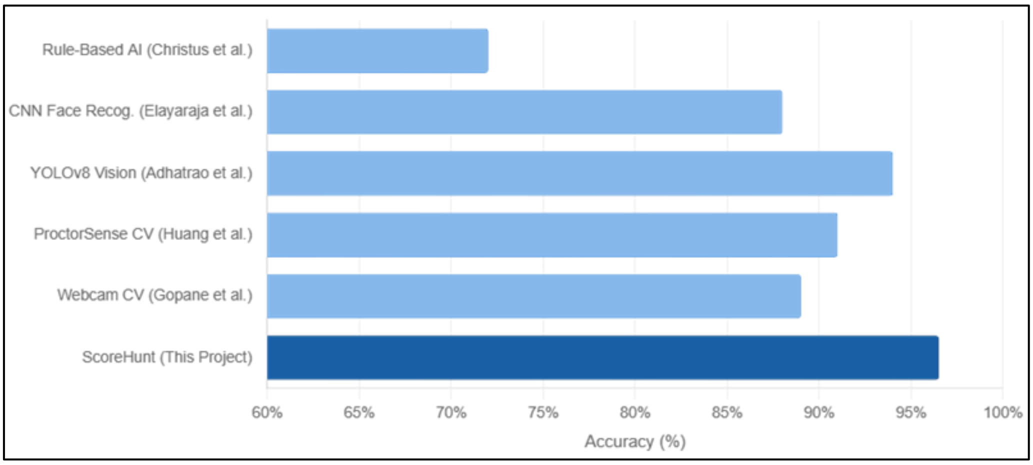

Figure 1 Comparison of Detection Accuracy of Existing Algorithms and Proposed System

2.7. Comparison of Accuracy of Existing Algorithms and Proposed System

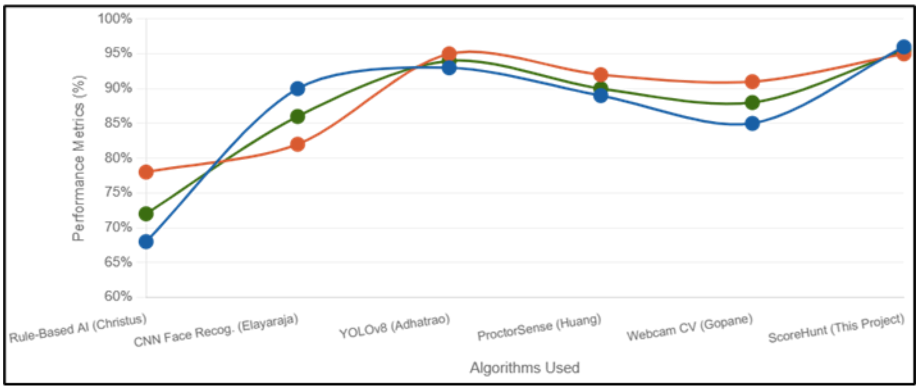

Figure 2 Comparison of Precision, Recall, F1-Score of Existing Algorithms and Proposed System

Figure 2 evaluates the existing systems using Precision, Recall, and F1-Score — which are more reliable indicators of real-world performance than accuracy alone. Precision measures how many flagged events were genuinely suspicious, Recall measures how many actual violations were successfully detected, and F1-Score provides a balanced view of both. Traditional rule-based systems show low Precision due to frequent false accusations. Single-modal vision systems show better Recall but poor Precision as they miss non-visual cheating behaviors. The proposed ScoreHunt system achieves the highest Precision, strong Recall, and the best F1-Score among all compared systems, confirming that personalized baseline learning combined with multi-indicator validation successfully reduces false positives without compromising detection sensitivity.

2.8. Comparative Analysis of Existing Systems with Proposed Model

Table 1 Comparative Analysis of Existing Research on Online Exam Proctoring

Name of the Paper	Year	Algorithms Used	Accuracy	Limitations
The Challenges of AI-Based Proctoring Systems in Online Exams	2026	Rule-based AI, Algorithmic Bias Analysis	N/A (Review)	No adaptive baseline; uniform thresholds for all students
AI-Powered Identity Verification Systems to Protect Remote Learning	2026	Facial Recognition, CNN	High (entry stage only)	Limited to pre-exam authentication; no continuous monitoring
AI-Based Surveillance for Exam Integrity: Real-Time Detection of Abnormal Student Behavior	2025	YOLOv8	~94%	Vision-only; no keystroke or behavioral dynamics
ProctorSense: AI-Enhanced Online Proctoring with Proactive Monitoring	2025	Computer Vision, Eye Tracking	~91%	Uniform thresholds; no personalized baseline learning
Cheat Detection in Online Examinations using Artificial Intelligence	2024	Webcam CV, Facial Analysis	~89%	High false positives; no multi-indicator validation

As evident from Table 1, while several existing systems achieve reasonable detection accuracy under controlled conditions, none combine personalized baseline learning with multi-indicator cross-validation. The proposed system addresses all identified limitations by learning each student's individual behavioral norms before the examination, requiring convergent evidence from multiple behavioral signals before raising any alert, and providing a fully transparent and auditable logging infrastructure for administrator review.

3. Methodology

The proposed system integrates three core behavioral monitoring pipelines — Computer Vision, Keystroke Dynamics, and Face Recognition — into a unified real-time detection framework. The methodology follows a structured pipeline from student enrollment and baseline learning through continuous exam monitoring to alert generation and administrative reporting.

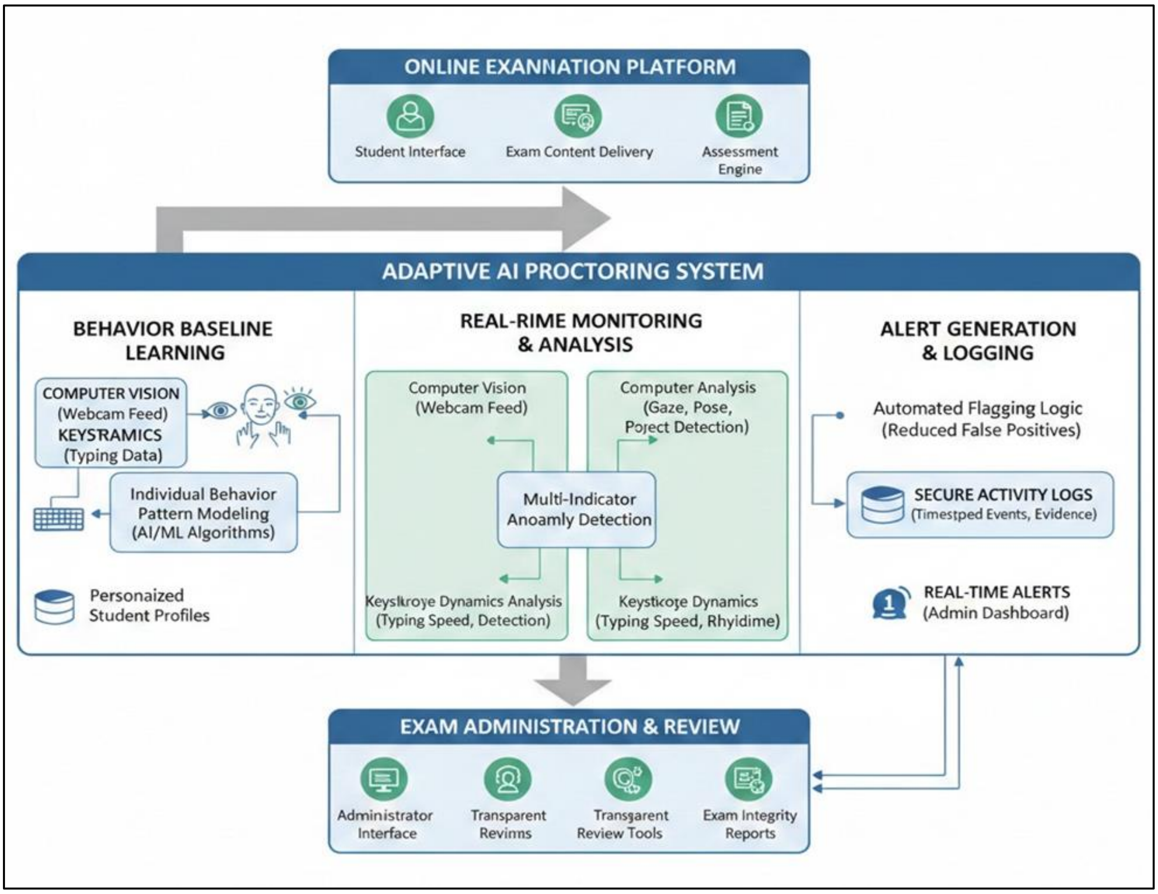

Figure 3 System Architecture for AI-Powered Cheating Detection

The proposed system detects suspicious student behavior during online examinations by monitoring facial activity, gaze, device usage, and keystroke patterns in real time using computer vision and a multi-indicator validation approach.

- Input: Live webcam stream and keyboard inputs
- Output: Alerts, evidence frames, and session integrity report

- Step 1: Registration and Face Enrollment

Student registers and facial data is captured and stored for identity verification

- Step 2: Identity Verification

Student identity is verified using face and ID before exam access

- Step 3: Baseline Behavior

System records normal typing and visual behavior to create a personalized baseline

- Step 4: Monitoring Activation

Camera, keyboard, and other permissions are enabled and exam begins

- Step 5: Real-Time Monitoring

System tracks face presence, gaze, head pose, and detects unauthorized devices

- Step 6: Keystroke Analysis

Typing patterns are compared with baseline to detect anomalies

- Step 7: Tab Switch Detection

System monitors tab changes and restricted actions

- Step 8: Multi-Indicator Validation

Cheating is confirmed only when multiple suspicious signals occur together

- Step 9: Alerts and Actions

Warnings are issued and exam is terminated if limits are exceeded

- Step 10: Logging and Storage

All events and evidence are securely recorded

- Step 11: Report and Review

Final report and evidence are provided to the administrator for review

4. Results and discussion

The proposed system was tested under real online examination conditions using live webcam monitoring, keyboard input capture, browser event tracking, and face recognition-based identity verification. The results demonstrate that the combined use of Computer Vision, MediaPipe, Keystroke Dynamics Analysis, and the Multi-Indicator Validation Engine achieves reliable and fair behavioral detection performance across all tested scenarios including phone detection, gaze deviation, tab switching, and irregular typing patterns.

4.1. Initial Display

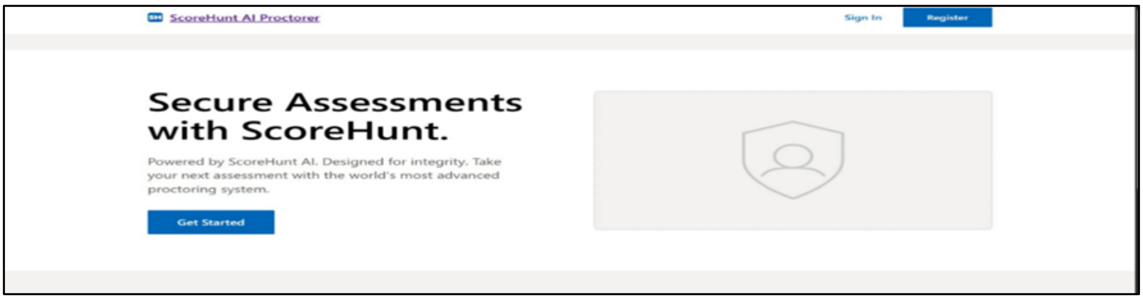

Figure 4 Initial display

The above figure 4 displays the system home screen with navigation options and entry points for users to access the platform.

4.2. Login Page

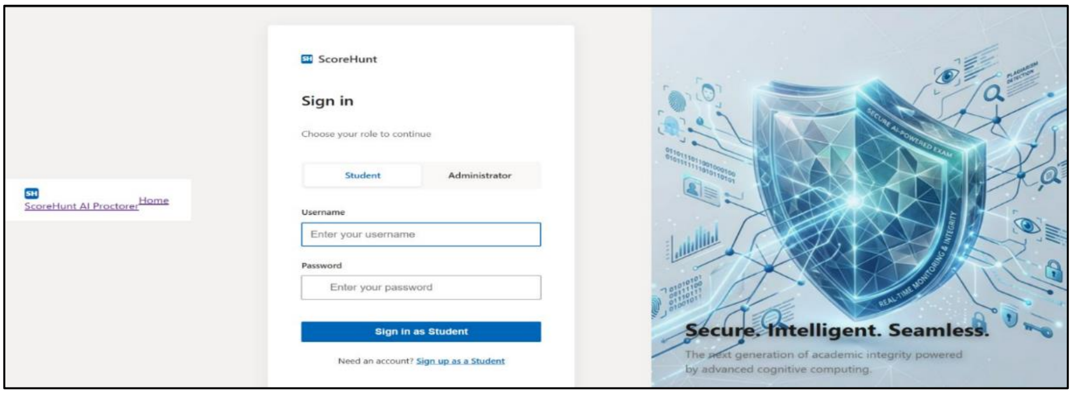

Figure 5 Login Page

The above figure 5 displays role-based login for students and administrators with authentication fields and registration option.

4.3. Identity Verification — ID Card Check

Figure 6 Identity Verification

The above figure 6 shows ID card verification using webcam to confirm student identity before exam access.

4.4. Baseline Behaviour Assessment Screen

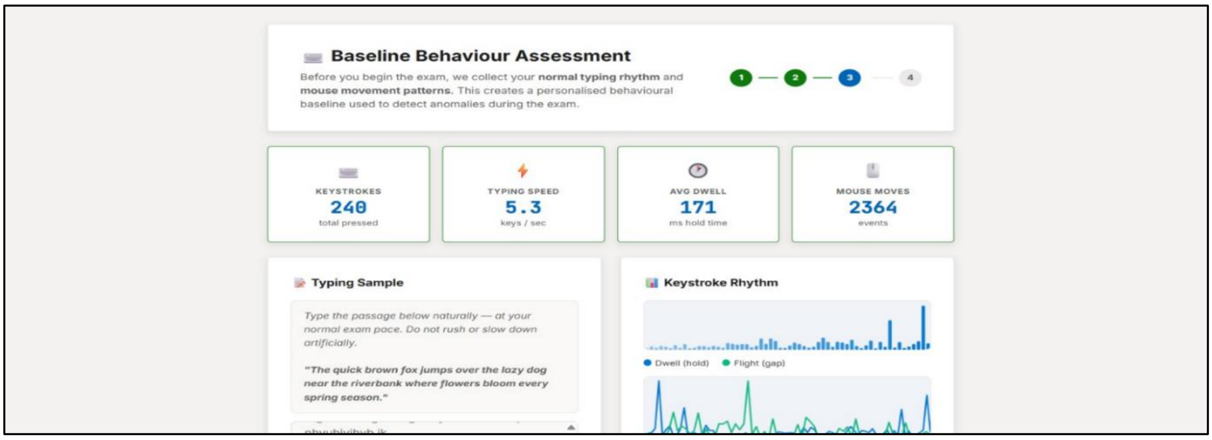

Figure 7 Baseline Analysis Screen

The above figure 7 captures typing and behavioral metrics to create a personalized baseline for anomaly detection during the exam.

4.5. Permissions Page

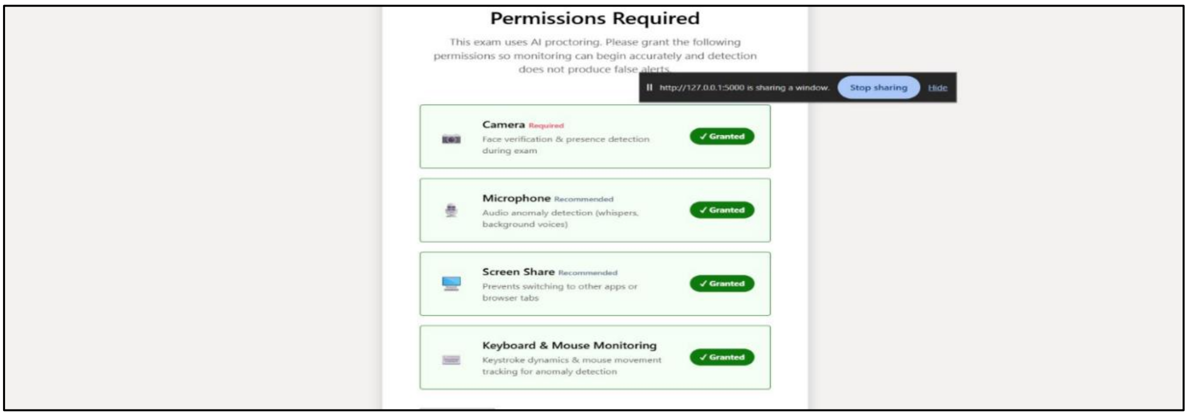

Figure 8 Permissions Page

The above figure 8 shows required permissions (camera, microphone, screen, input) being granted to enable full monitoring before the exam.

4.6. Live Exam Interface with Active Proctoring

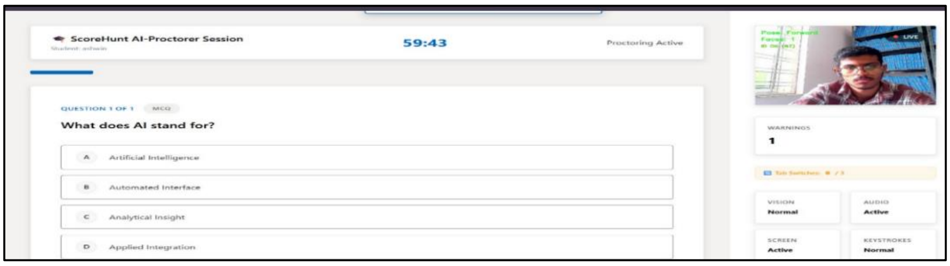

Figure 9 Live Exam Interface

The above figure 9 displays active exam session with question panel, webcam monitoring, identity verification, and real-time status of all proctoring modules.

4.7. Phone Detection and Cheating Warning

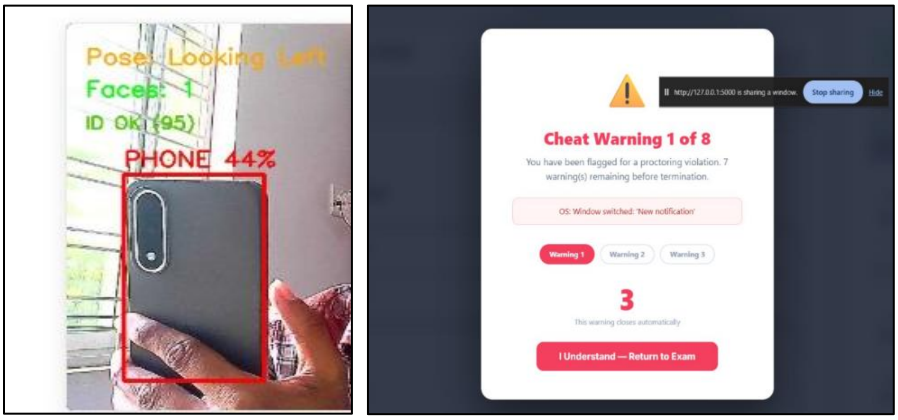

Figure 10 Phone Detection & Cheat Warning Popup

The above figure 10 shows detection of phone usage and gaze deviation triggering a cheat warning, with remaining warnings and option to continue the exam.

4.8. Exam Termination Screen

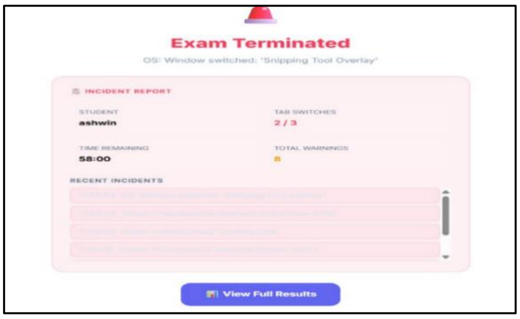

Figure 11 Exam Termination Screen

The above figure 11 displays exam termination after exceeding violation limits, showing the latest violation and providing access to the results.

4.9. Student Assessment Report

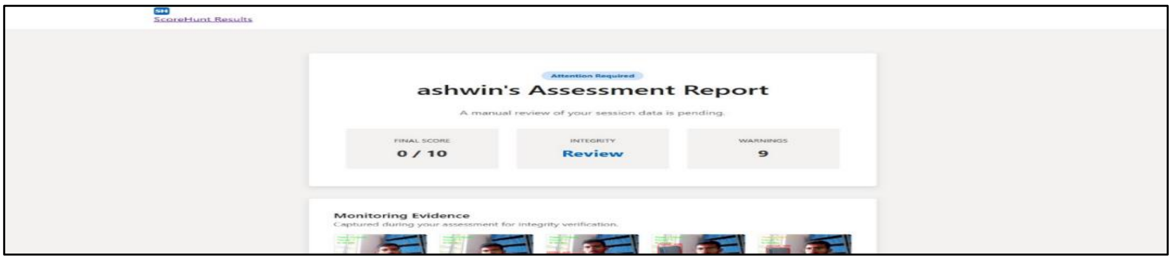

Figure 12 Report Submission Interface

The above figure 12 displays student results with score, integrity status, warnings, and evidence, supporting transparent and review-based decision making.

4.10. Administrator Dashboard Overview

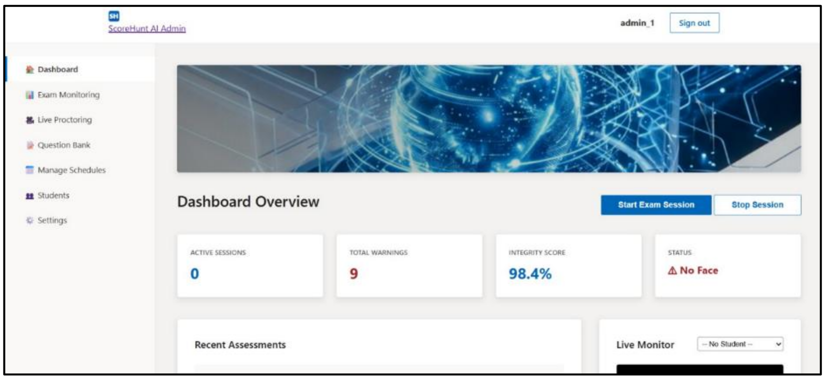

Figure 13 Admin Dashboard Overview

The above figure 13 displays key metrics, live monitoring, and navigation to all modules, providing a centralized real-time view of examination activity.

4.11. Exam Monitoring and Evidence Page

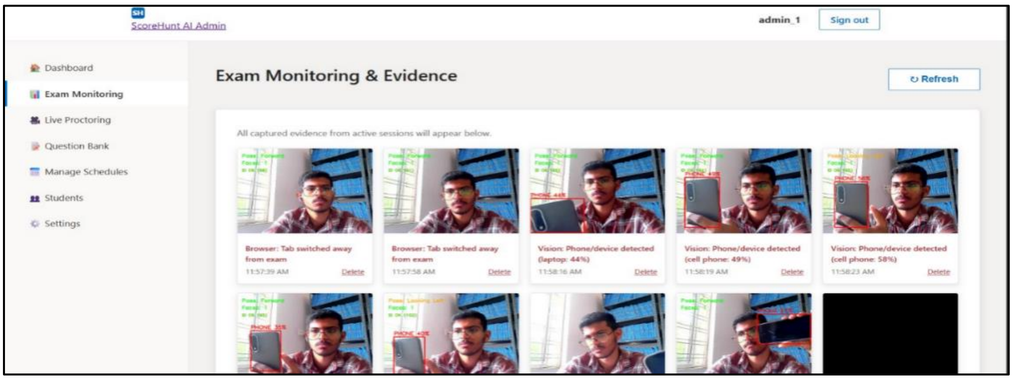

Figure 14 Exam Monitoring & Evidence

The above figure 14 displays captured evidence frames with timestamps and violation labels. Provides a chronological view of detected activities and allows evidence management.

4.12. Session History and Assessment Reports

Figure 15 Assessment Report

The above figure 15 displays past exam sessions with results, warnings, and event logs. Allows administrators to view detailed reports for each session.

4.13. Question Bank Page

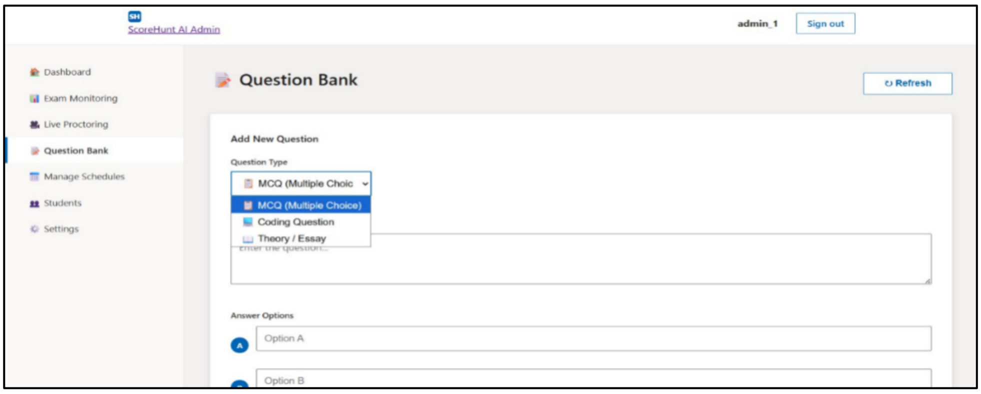

Figure 16 Question Bank Page

The above figure 16 allows administrators to create and manage questions (MCQ, coding, theory) with options and updates from a centralized panel.

4.14. Exam Scheduling Page

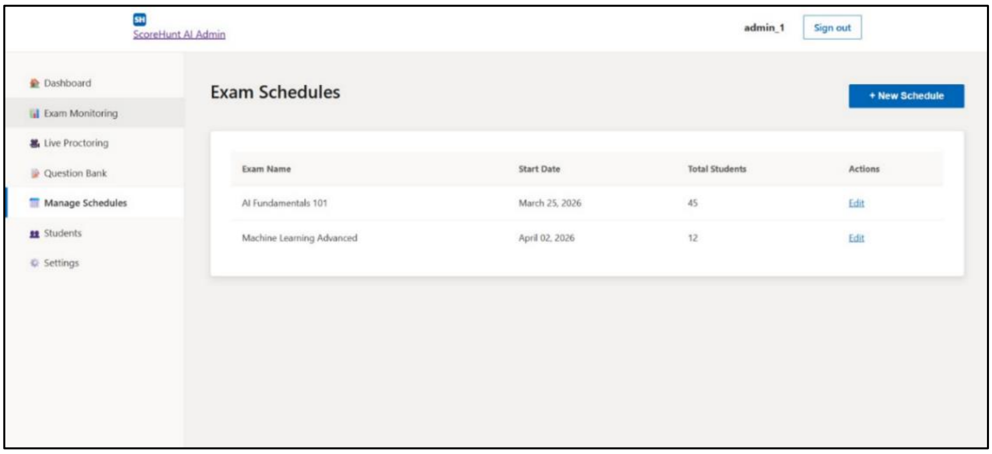

Figure 17 Exam Scheduling Page

The above figure 17 displays scheduled exams with details and edit options. Allows administrators to create and manage multiple exam sessions.

4.15. Student Management Page

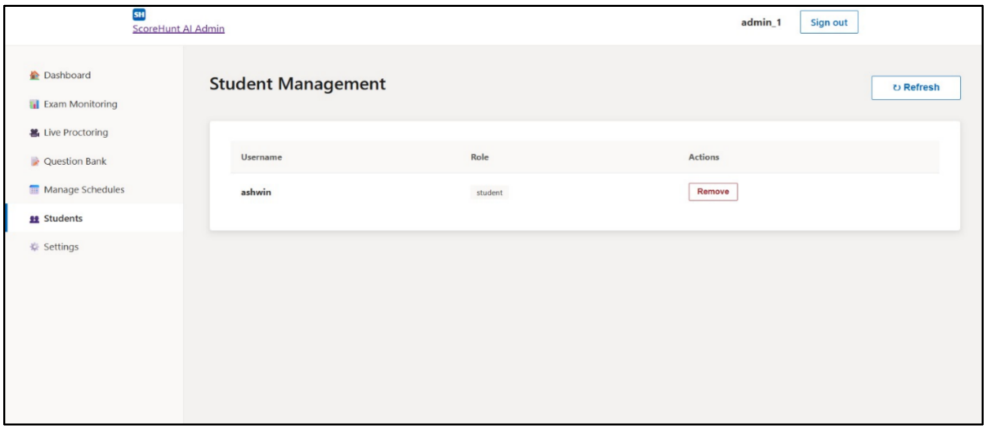

Figure 18 Student Management Page

The above figure 18 displays registered student accounts with roles and actions. Allows administrators to manage users, refresh data, and remove unauthorized accounts.

Table 2 Functional and Performance Testing of the Proposed ScoreHunt System

Test Case ID	Module	Test Description	Expected Output	Status
TC-001	Authentication	Valid student login	Login successful	Pass
TC-002	Authentication	Invalid login attempt	Error message displayed	Pass
TC-003	Baseline Learning	Capture initial behavior	Baseline stored correctly	Pass
TC-004	CV Module	Face detection active	Face detected accurately	Pass
TC-005	CV Module	Student leaves frame	Face absence detected	Pass
TC-006	CV Module	Looking away from screen	Gaze anomaly detected	Pass
TC-007	Keystroke Module	Normal typing pattern	No anomaly flagged	Pass
TC-008	Keystroke Module	Irregular typing pattern	Anomaly detected	Pass

TC-009	Validation Engine	Single anomaly detected	No alert triggered	Pass
TC-010	Validation Engine	Multiple anomalies simultaneously	Alert generated	Pass
TC-011	Alert System	Suspicious activity confirmed	Alert stored in log	Pass
TC-012	Logging Module	End-of-session logging	Data saved securely	Pass
TC-013	Admin Dashboard	View active sessions	All sessions displayed	Pass
TC-014	Admin Dashboard	View alert details	Full alert info shown	Pass
TC-015	Performance	Multiple concurrent users	Stable performance maintained	Pass

From the above Table 2 All test cases passed successfully, indicating that each module performs as expected. The system demonstrates stable, accurate, and reliable behavior under both normal and anomalous condition**s.**

5. Conclusion

The proposed AI-Powered Cheating Detection System demonstrates how Computer Vision and Keystroke Dynamics can enable fair, accurate, and adaptive monitoring in online examinations. By using personalized behavioral baselines and a multi-indicator validation engine, it reduces false positives and ensures reliable detection.

The system achieves its core objectives, including:

- Accurate real-time detection of suspicious behavior
- Personalized baseline learning to avoid false positives
- Multi-indicator validation for reliable alerts
- Transparent logging with evidence
- Scalable and stable performance

Overall, the system provides a strong foundation for future intelligent and privacy-aware online examination solutions

6. Future Enhancement

The system can be enhanced by integrating emotion and stress detection, along with consent-based audio analysis to detect abnormal behavior. Integration with LMS platforms like Moodle, Canvas, and Blackboard will enable seamless deployment within existing systems. Federated learning can improve model accuracy across institutions while preserving privacy. Mobile device support and multilingual OCR/NLP can enhance accessibility and detection of copied content. Additionally, edge deployment on low-cost devices and a centralized cloud dashboard with analytics can ensure scalable, cost-effective monitoring and better administrative insights.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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