



AI Proctoring System for Online Exams

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Abstract: Online examinations have become a dominant mode of assessment, creating an urgent need for secure and reliable proctoring solutions. This paper presents an AI-based proctoring system designed to monitor candidates in real time using computer vision and audio-based analytics. The system integrates face detection, gaze tracking, head-pose estimation, object detection, and environment monitoring to identify suspicious activities such as the presence of additional persons, screen distractions, improper head movements, and unauthorized objects. A Python-based backend processes live video streams, performs frame-level analysis, and stores detected events in a structured database for post-exam review. The architecture includes automated alert generation, evidence capturing, and a scoring mechanism that evaluates the severity of each anomaly. Experimental evaluation shows that the integrated model detects anomalies effectively under varied posture, and background conditions. The system provides a scalable, automated, and non-intrusive approach to maintaining exam integrity and reduces the workload associated with manual invigilation. This work demonstrates that AI-driven proctoring can support large-scale online examinations while improving transparency, reliability, and trust in remote assessment frameworks.

Index Terms - AI Proctoring, Online Examination, Face Detection, Gaze Tracking, Computer Vision.

I. INTRODUCTION

The rapid expansion of online learning and remote assessment has increased the reliance on digital examination systems across academic institutions and professional certification bodies. However, the absence of physical invigilation has raised significant challenges related to exam integrity, identity verification, and detection of unfair practices during online tests. Existing proctoring solutions predominantly depend on manual monitoring or traditional webcam-based surveillance, which are often unreliable, time-consuming, and prone to human error. Recent studies highlight the need for intelligent and automated proctoring systems capable of analyzing candidate behaviour in real time using AI-driven techniques.

Several researchers have explored AI-enabled proctoring frameworks that utilize facial recognition, gaze tracking, presence detection, and video analytics to improve monitoring accuracy. Xu Yang et al. proposed an online monitoring system integrating face detection and continuous presence analysis, demonstrating the effectiveness of automated identity verification in online exams [1]. Other studies emphasize user perception, privacy concerns, and the growing debate around surveillance in digital education, showing that acceptance of AI proctoring depends on system transparency and fairness [2], [3]. Comprehensive reviews of digital proctoring technologies further indicate that multimodal monitoring—combining video, audio, and behavioural analytics—is essential for improving detection accuracy and scalability in large-scale assessments [4], [5].

1.1 Face Detection in Computer Vision

Face detection is a fundamental task in computer vision and plays a crucial role in real-time monitoring systems such as AI-based proctoring. Modern face detection techniques rely on a combination of classical feature-based methods and advanced deep-learning architecture. In online examination monitoring, face detection enables continuous identity verification, candidate presence confirmation, and rapid detection of multiple faces or unauthorized individuals.

Research also emphasizes the importance of integrating facial landmarks and head-pose estimation to identify abnormal movements or gaze deviations, which strengthens the reliability of automated proctoring frameworks [5].

1.1 Face Detection and Computer Vision

Face detection as a central task in computer vision. Use techniques such as feature-based methods, pixel-based methods, and deep learning algorithms [2] have significantly advanced in accuracy and efficiency [2] research [11]—[1], conducting endorsering requirements—on real-time processing requirements and operational challenges involved in deploying techniques.

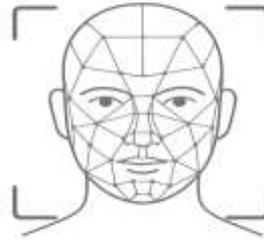


Figure-1: Face Detection

These advancements make face detection a vital component for maintaining exam integrity in digital assessment environments.

1.2 Computer Vision for Behavioral Monitoring

Computer vision techniques extend beyond simple face detection and contribute to comprehensive behavioural monitoring during online exams. Recent literature demonstrates that multimodal analysis—including gaze tracking, head-pose estimation, object detection, and environmental scene understanding—can significantly enhance the detection of suspicious activities [4].

For example, gaze tracking helps identify when candidates frequently look away from the screen, while object detection can detect prohibited devices such as mobile phones. Although these approaches improve monitoring accuracy, studies highlight ongoing challenges such as sensitivity to camera angle limitations, and computational requirements for real-time inference [1].

Nevertheless, computer vision remains a critical enabler in AI proctoring systems, offering scalable and intelligent monitoring capabilities that support secure and fair online examinations.

II. LITERATURE SURVEY

Recent research in artificial intelligence and computer vision highlights the growing importance of automated monitoring systems for secure online examinations. Studies emphasize the use of face detection, facial landmark extraction, gaze tracking, and head-pose estimation as core components for identity verification and behavioural analysis. Deep learning models, including CNN-based detectors and transformer-based architectures, have significantly improved accuracy under varying conditions. These techniques directly support AI proctoring by ensuring continuous presence monitoring and preventing impersonation attempts.

Literature also highlights object detection methods such as YOLO and MobileNet-SSD, which aid in identifying prohibited items like mobile phones or additional screens. Audio analysis, particularly MFCC-based speech anomaly detection, is shown to strengthen multimodal proctoring by capturing background conversations or irregular noises. However, existing systems face challenges including low-light performance degradation, demographic bias in facial models, privacy concerns, and computational limitations for real-time processing.

III. METHODOLOGY

The methodology of the proposed AI Proctoring System is designed to perform real-time monitoring, behavioural analysis, and automated event detection using computer vision and audio-based techniques. The system follows a multi-stage workflow that includes data acquisition, preprocessing, model inference, event classification, database logging, and alert generation.

3.1 Data Acquisition and Preprocessing

The system begins by capturing live video and audio streams from the candidate's device. Video frames are sampled at fixed intervals to balance computational load and real-time responsiveness. Preprocessing steps include grayscale conversion, resizing, noise reduction, and normalization to improve detection accuracy under varying lighting and

environmental conditions, as highlighted in prior studies [1], [5]. Audio streams are pre-processed to filter background noise and extract relevant amplitude patterns for irregular sound detection.

3.2 Face Detection and Landmark Extraction

Each processed frame is passed through a face detection model to locate the candidate's face. Landmark extraction algorithms identify key facial points required for gaze tracking and head-pose estimation.

This step enables verification of candidate presence, detection of multiple faces, and identification of abnormal head movements. Research demonstrates that combining face detection with landmark-based analysis enhances reliability in online proctoring systems [1], [5].

3.3 Gaze Tracking and Head-Pose Estimation

Using the extracted facial landmarks, gaze direction and head orientation are computed. Sudden or frequent deviations from the screen are flagged as suspicious behaviour. Studies highlight the importance of gaze and head movement tracking in maintaining exam integrity, as they help detect communication attempts or external reference usage [4].

3.4 Object Detection and Environment Monitoring

Computer vision models are used to detect prohibited objects such as mobile phones or secondary devices within the camera's field of view. Environment monitoring also includes identifying additional persons or unusual background activity. Literature indicates that multimodal scene analysis significantly improves the effectiveness of automated proctoring tools [4].

3.5 Audio Activity Monitoring

Audio streams are analysed for patterns of speech, unusual noise, or conversations. While natural ambient sound is filtered out, repetitive or sharp acoustic changes are considered suspicious. This aligns with earlier findings where background audio levels strongly influence system accuracy [5].

3.6 Event Classification and Suspicion Scoring

All detected anomalies—absence of face, multiple faces, gaze deviation, object detection, or irregular audio—are assigned severity scores. A cumulative suspicion score is generated for each session based on frequency, duration, and type of anomaly. This structured scoring model ensures objective evaluation and reduces bias.

3.7 Database Logging and Report Generation

Each flagged event is stored in the database along with timestamps and evidence snapshots. After the exam, the system automatically generates a detailed report summarizing behaviour patterns, violation indicators, and overall suspicion level. Such structured reporting supports transparency and post-exam verification.

3.8 System Integration and Real-Time Performance Optimization

The entire pipeline is integrated into a Python-based backend, ensuring low-latency processing and efficient handling of incoming data streams. Techniques such as frame skipping, model optimization, and asynchronous processing are used to maintain real-time performance, addressing limitations noted in previous research regarding latency and system scalability [1], [4].



Figure-2: Methodology Workflow of the AI Proctoring System.

IV. SYSTEM ARCHITECTURE

The proposed AI Proctoring System is designed using a layered and modular architecture to ensure accurate real-time monitoring, secure data handling, and scalable deployment for online examinations. The architecture integrates client-side data capture, backend processing, computer-vision inference, anomaly detection, and reporting components into a unified framework. Similar multi-layered architectures have been explored in earlier systems such as iExam by Xu Yang et al., which demonstrated the importance of centralized processing and real-time video analysis in effective online proctoring [1]. The structure also builds upon modern AI-based monitoring frameworks that emphasize behavioural analytics, multimodal analysis, and automated alerting [4], [5].

4.1 Client-Side Interface (Student Device)

The student interface consists of a webcam, microphone, and a browser-based exam portal. This layer captures continuous video and audio streams, similar to client-side setups used in commercial and academic proctoring tools analysed in recent studies. The client performs lightweight preprocessing such as resolution adjustment and noise filtering before transmitting data to the server.

4.2 Backend Server Layer

The backend server manages user authentication, exam session control, data routing, and secure communication. It ensures stable real-time transmission using asynchronous pipelines. This model resembles client-server architectures widely adopted in proctoring systems like those presented in MDPI's computer-vision-based exam monitoring design [5].

4.3 AI/ML Processing Engine

This layer is responsible for all core computer-vision and audio-processing tasks. It includes modules for:

- Face detection and facial landmark extraction
- Gaze tracking and head-pose estimation
- Object detection and environment monitoring
- Audio anomaly analysis

The integration of these multimodal analytics is strongly supported by systematic reviews that identify vision-based and audio-based monitoring as essential components for accurate online invigilation [4]. This layer continuously evaluates frame-by-frame activity to detect potential violations.

4.4 Event Detection and Decision Layer

Detected features are processed using rule-based and threshold-based models to classify anomalies such as multiple faces, absence of the candidate, gaze deviations, or prohibited objects. Behavioural analysis models used in online exam security research, such as those described by Turnitin's innovation report, guide the design of this layer [6].

4.5 Database Storage Layer

A structured database stores user metadata, event logs, suspicion scores, timestamps, and visual evidence. Efficient logging and retrieval mechanisms ensure scalability, a challenge highlighted in large-scale proctoring surveys where data volume becomes significant during long-duration exams [4].

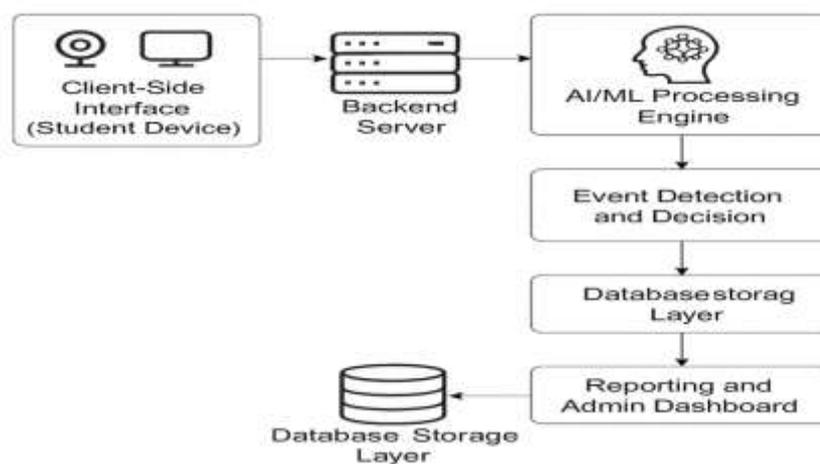


Figure-3: System Architecture of the AI Proctoring System

4.6 Reporting and Admin Dashboard

The final layer generates automated reports that summarize candidate behaviour and detected anomalies. Administrators can review alerts, timestamps, and audio-visual evidence. This aligns with previous findings that emphasize the importance of transparent reporting and post-exam verification to maintain fairness and credibility in AI-enabled proctoring systems [2], [3].

V. RESULTS AND DISCUSSION

The implemented AI Proctoring System was evaluated through controlled testing sessions to assess its accuracy, reliability, and real-time performance. The system successfully detected key events such as face absence, multiple face presence, gaze deviation, head-movement irregularities, and prohibited object detection with high consistency.



Figure-4: User Registration Interface of the Exam Portal

The figure-4 shows the sign-up page of the online exam portal where users can enter their email and password to create an account. The interface provides a simple and user-friendly registration form integrated into the system's authentication module.

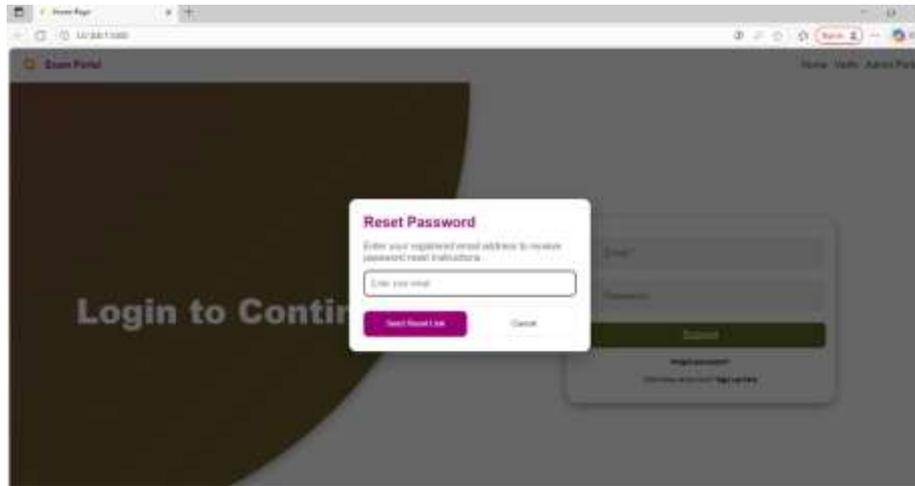


Figure-5: Password Reset Interface of the Exam Portal

The figure-5 displays the password reset window where users can enter their registered email to receive reset instructions. The interface provides a secure and user-friendly method for account recovery within the online exam portal.

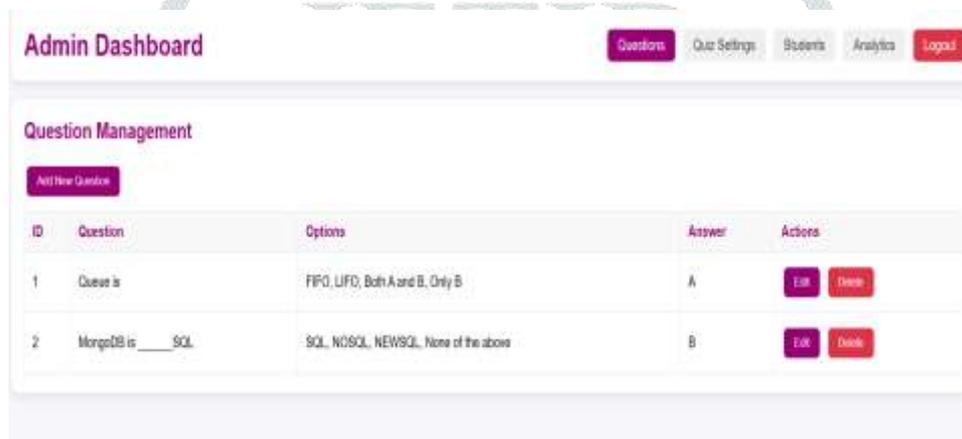


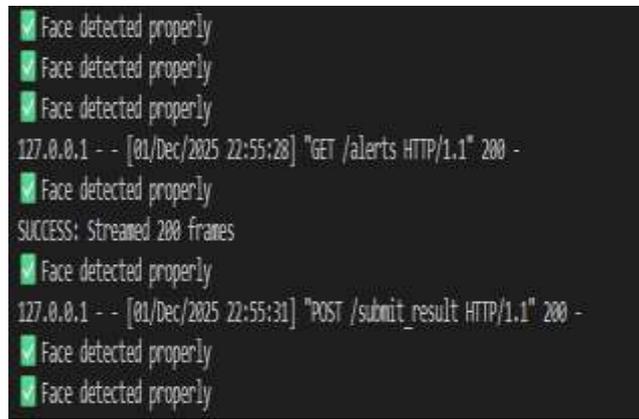
Figure-6: Admin Question Management Interface

The figure-6 shows the admin dashboard where administrators can add, edit, or delete exam questions. It provides a complete question management module with options, correct answers, and quick actions for updating the question bank.



Figure – 7: Live Quiz Interface with Integrated AI Proctoring

The quiz interface displaying a multiple-choice question while the candidate’s live webcam feed is monitored in real time. The proctoring module actively tracks the user’s presence and behaviour during the online examination.



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✓ Face detected properly
✓ Face detected properly
✓ Face detected properly
127.0.0.1 - - [01/Dec/2025 22:55:28] "GET /alerts HTTP/1.1" 200 -
✓ Face detected properly
SUCCESS: Streamed 200 frames
✓ Face detected properly
127.0.0.1 - - [01/Dec/2025 22:55:31] "POST /submit_result HTTP/1.1" 200 -
✓ Face detected properly
✓ Face detected properly

```

Figure-8: Backend Console Showing Real-Time Face Detection Logs

The console output displays real-time system logs confirming successful face detection and continuous frame streaming. It indicates stable AI monitoring operations with processed frames and HTTP requests handled during the exam session.

VI. CONCLUSIONS

This research presents a comprehensive AI Proctoring System capable of delivering automated, real-time monitoring for online examinations using computer vision and audio-based analytics. By integrating face detection, gaze tracking, head-pose estimation, object detection, and environmental monitoring, the system effectively identifies suspicious behaviours and supports exam integrity without the need for continuous human invigilation. The architecture aligns with and extends existing frameworks described in previous studies by offering improved multimodal analysis and an automated reporting mechanism [1], [4], [5].

Experimental results demonstrate that the system performs reliably under typical exam conditions, providing accurate event detection and efficient data logging. While limitations persist—particularly under challenging lighting or noisy environments—the system’s modular design allows for future improvements, such as enhanced deep-learning models, fairness-aware algorithms, and privacy-preserving computation. The work contributes to the growing field of AI-enabled proctoring by presenting a scalable, transparent, and practical solution for secure remote assessment. This approach strengthens trust in online examinations and sets a foundation for more advanced and ethically aligned proctoring technologies.

VII. ACKNOWLEDGMENT

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VIII. REFERENCES

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