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# Online Exam Proctoring: A Comprehensive Review and Critical Analysis

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**Abstract**
Like most other fields, the use of artificial intelligence in education is already transforming online testing with smart proctoring services. The flight to online education especially that of the COVID-19 pandemic, has increased the need for secure, scalable and dependable ways to take exams remotely. A new alternative is AI-driven online proctoring, which automates the old laborious proctoring process with systems that use facial recognition, gaze tracking, object detection and behavior monitoring to maintain the integrity of exams. This paper reviews the state-of-the-art AI exam proctoring systems, their technologies, features and issues. They are more secure, scalable and cost-effective and they can offer real-time feedback and analytics. Moreover, biometrics, anti-plagiarism, cloud scalability and offline capability make them far more useful in various educational contexts. But there are serious issues with data privacy, algorithmic bias, cost of implementation, fairness in access to technology and the mental health effects on test takers. This paper, through a survey of literature, examination of different models and consideration of applications, pinpoints the advantages as well as shortcomings of available systems and argues for more work in areas of ethical AI, algorithmic fairness and inclusive design. It ends with some ideas for the future, including using a combination of AI and humans to monitor, employing blockchain technology and developing flexible systems that maintain a healthy equilibrium between technology and human values in the educational realm.

**Keywords:** AI-driven proctoring, artificial intelligence in education, online exam monitoring, AI-based surveillance and online education tools.

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## 1. Introduction

Artificial Intelligence is going to impact the entire world, including the sphere of education. Its usage brings attention to the use of online education and online assessments tailored to the specifics of artificial intelligence work. As an example, utilizing Artificial Intelligence is a novel solution for taking secure online tests instead of physically taking them. They are a good replacement for the conventional supervision methods which are not only cumbersome but expensive and difficult to scale. Simply put, AI based exam proctoring systems enable the administration of examinations at distant locations and online while upholding the security of the examination process.

The trend of moving towards online education and more so due to the COVID 19 pandemic has on its part contributed to the need to adopt AI systems that can monitor students for malpractice. It is noted that due to the COVID-19 pandemic, educational institutions around the world closed their doors and started the distance learning mode with the use of digital platforms. This echoed the fundamental necessity for robust and scalable technologies that are capable of accomplishing that goal at hand. In this regard, countless students who were found wanting due to the lack

of identification are now successfully being safeguarded from such instances cancelling out any irregularities raising the number of complaints.

Nonetheless, even though AI based online proctoring systems have a lot of advantages, it is necessary to state their drawbacks as well. The issues of privacy, security of data and suspicion about biases embedded in algorithms are hindrances to their wide adoption. Furthermore, ensuring that these systems are effective and applicable in diverse educational settings raises a myriad of practical and ethical issues. We provide a structured, thorough overview of AI proctoring systems including their technologies, uses and available weaknesses…and manages to offer directions for more research and more development of more benign applications of these systems which will broaden their acceptance and ensure that they continue to serve as a foundation for dependable and robust online education [1].

These technologies employ a mix of multiple AI techniques to check behavior of the candidate. For instance, face recognition identifies each candidate, gaze tracking and tone of eye supplies several indicators of possible distractions or even prompt attempts to access prohibited resources. Additionally, hearing devices, tab switching and other apparatuses sharpen the close scrutiny of the examination process. Tended together, these technologies also identify and allow malpractices and any irregularities to control and ensure that exams are fair. Furthermore, with higher detection accuracy with lower false alarms, AI-based proctoring systems offer a more neutral and faster service to overseers as well as the holders of the examination.

The rest of the paper is organized as follows: Section 2 provides a comprehensive literature review, offering insights into prior research and developments in AI-driven online exam proctoring. Section 3 discusses the key features of AI-powered online examination systems, focusing on their functionality and technological capabilities. Section 4 highlights the advantages and benefits of using AI in online exam proctoring, emphasizing its potential to enhance efficiency, accuracy and security. Section 5 examines the challenges and limitations associated with AI-based proctoring, including technical, ethical and implementation-related issues. Finally, Section 6 concludes the paper by summarizing the findings and discussing the future scope of AI-driven proctoring in education.

## 2. Literature Review

In this section, previous works on AI-based proctoring technologies are surveyed and details are provided in Table 1.

In their work, presented a fully automated online exam proctoring system that eliminates the need for human involvement, addressing scalability issues in online education [1]. It integrates continuous identity verification and automatic detection of cheating behaviors, providing a comprehensive solution for maintaining academic integrity. Proposed secured online examinations with group cryptography using an application, SeCOnE [2]. It can combine different technologies like Public Key Infrastructure (PKI) and Diffie-Hellman key exchange method for the adequate supervision and monitoring of the e-exams.

In, the authors brought into the limelight the E-invigilator, a new model of Remote and Electronic Invigilation. They have put forward a Transparent Authentication System (TAS) for manual and AI assisted behavioural supervision and scrutiny in Canadian universities [3]. In their work, proposed an automated proctoring system for online exams [4]. The system includes such features as user verification, text and voice audio detection, gaze estimation phone detection and GIST features to be able to maintain academic integrity in massive open online courses.

Addressed the problem of cheating in the MOOCs environment and the system was based on Artificial intelligence techniques called the ACD for detection of Assistive Cheating devices. Certificates given out through MOOCs platforms can thus be made to be more credible through the use of the ACD system in conjunction with SVM and MOOP techniques [5]. Implemented a secured online examination system, presumably to combat various cheating techniques. Their implementation included other aspects such as Anti-SQL Injection codes and guards against Denial of Service and Distributed Denial of service attacks [6].

Deepened this trend, focusing on the behavior of the test participants in the course of the online assessment in order to spot possible cheating attempts [7]. Their study used a Fast Correlation Based Filter (FCBF) and the OpenCV DNN module to automatically flag suspicious behaviors in a big infrastructure online based education system. Proposed a continuous user verification method for online exam proctoring, utilizing face verification through incremental training with images captured during online lectures [8].

An online exam management system based on deep learning was revealed by [9]. Reviewed AI based proctoring technologies in comparison to invigilator mediated enhancement of webcam monitoring [10]. Their module applied DNN algorithms, HOG (Histogram of Oriented Gradients) face detectors and OpenCV facial recognition systems to maintain integrity as well as the tracing of apparatus employed in malpractice.

Came up with a web based automated examination system using Google Speech Recognition API and Convolutional Neural Networks [11]. This is meant to strengthen and tighten up malicious activities detection plugs using vision and audio-based functionalities into one system [12]. Examined the real-time scoring phase and the analysis of the test and the surveillance technologies of the online proctoring systems as comparative methodologies. Support Vector Machines (SVM) and CNN were also employed to increase the efficiency of facial recognition systems [13]. Offered efficient online student's

authentication and proctoring systems based on multimodal biometrics technologies. Since their approach is focused on a CNN-RNN model, they proposed using the analysis of typing patterns combined with facial recognition for an online examination on a continuous basis.

Proposed a system based on visual analytics that assists in online examination proctoring [14]. Their system contains head pose estimation and calculation of mouse displacement. An automated proctoring system was developed by using computer vision techniques by [15]. This system makes use of OpenCV's DNN module for face detection with a view of minimizing the chances of cheating in online assessment systems. Designed a proctored online examination system using deep learning and computer vision technologies [16]. Their system used the OpenCV and Deep Neural Networks (DNN) module for face anti-spoofing in order to improve the accuracy of the online examination.

Analyzed the problem which can arise out of coping with simultaneous logins in the learning management systems meant for an online examination [17]. Their system used video surveillance systems together with software classifiers: Facenet and Mobilenet CNN to prevent malpractices in the course of taking examinations. A Dlib and YOLO based online proctoring system was presented by [18]. It uses a webcam and microphone for proctoring tests so that even a single person is visible throughout the examination as it uses a YOLOv5 Pretrained model.

Invented an AI based online examination system capable of carrying out remote easy proctoring [19]. The aim is also to ensure that Linguistic analysis and pattern matching is able to replace the threats brought along by the COVID-19 pandemic with a new model of conducting the examinations. Effective forms of cheating in online exams were examined by [20]. The papers' authors studied the most common forms of cheating based on the yolo v5 model. Furthermore, [21] addressed common challenges such as security, accessibility and the lack of personal interaction in online testing environments.

Presents an automated proctoring system that utilizes computer vision techniques to maintain examination integrity and prevent cheating [22]. It incorporates various models such as Eye Gaze Tracking, Mouth Open or Close Detection, Object Detection and Head Pose Estimation, which collectively enhance the proctoring process. Conceived a smart artificial intelligence- based system for online proctoring [23]. Their model uses OpenCV and Dlib libraries in Python to obtain real-time video feed, detect faces and use Dlib's HOG to assess the presence of cheating precursors. Incorporates advanced technologies such as face recognition APIs and the YOLO algorithm for object and anomaly detection, ensuring academic integrity during online assessments [24]. Offered the solution of an online exam proctoring system where the examiners are monitored using gaze tracking algorithms [25]. The aim is to maintain the integrity of online assessments, Candidates Log in and take parts as assessed as well.

**Table 1:** Overview of Technologies Used in Online Exam Proctoring

| Technology | Purpose/Function | Description | Algorithm | Reference |
|---|---|---|---|---|
| Image processing, Video processing and Audio processing techniques | To offer a fully automated online exam proctoring solution, improving scalability and efficiency in online education. | Integrates multiple inputs to detect cheating through continuous identity verification and automatic monitoring of suspicious activities. | Haar-cascade algorithm, Adaboost, Gaze estimation | [1] |
| SeCOnE system | To propose a secure online exam management system tailored for mathematics and English contests in middle and high schools and university courses for remote students. | Addresses the challenges of conducting fixed-time online exams with uniform questions for examinees in different locations. | Diffie-Hellman key exchange, Public Key Infrastructure | [2] |
| Transparent Authentication System | To enable remote electronic invigilation, removing the need for physical attendance at proctored exams. | Proposes a new model for remote electronic invigilation, overcoming the limits of traditional proctored exams. | Facial Recognition Technology | [3] |
| Multimedia Analytics System | To uphold academic integrity in remote education, especially in MOOCs and online learning. | Introduces an automated proctoring system to ensure integrity in remote exams for MOOCs and other online education formats. | User Verification Algorithm, Multi-class SVM Classifier | [4] |
| Massive Open Online Proctoring | To provide an effective, economical and scalable method for detecting cheating behaviours in online tests associated with MOOCs. | Introduces the Massive Open Online Proctoring (MOOP) framework to detect cheating in MOOCs. | Automatic Cheating Detector, Peer Cheating Detector, K-Nearest Neighbour classifiers, Gaussian Naive Bayes classifiers | [5] |
| Web application security measures, including anti-SQL injection algorithms and secure login systems | To prevent cheating with security measures like login systems, question randomization and timed questions. | Uses a network design with Microsoft Management Console (MMC) to block external devices and applications, reducing cheating risks. | Anti SQL injection algorithms | [6] |
| Time Delay and Head Pose Variation | Focuses on the role of time delay and head pose variation as predictors of cheating behaviours in a lab-based online testing environment. | Examines cheating detection in online assessments by analysing time delays and head pose variations. | Logit model, Fast Correlation-Based Filter | [7] |
| Multi-modal biometrics | To offer an affordable and accurate verification method for online exams, robust to pose and lighting variations. | Tackles online exam cheating with a cost-effective biometric verification system for identity confirmation. | Convolutional Neural Networks | [8] |
| Deep Learning techniques | To facilitate the creation, administration and evaluation of online examinations using advanced technology. | Presents an Online Exam Management System using Deep | Random Number Generator Algorithm, Deep Learning algorithms | [9] |

| | | | | |
|---|---|---|---|---|
| | | Learning for face recognition and candidate verification. | | |
| Face recognition using the HOG face detector and the OpenCV face recognition algorithm | To ensure fairness in online exams by detecting cheating and unauthorized device usage. | Presents a novel online proctoring system designed to enhance the integrity of online examinations by utilizing deep learning techniques | Eigenface, Fisherface and LBPH | [10] |
| Vision-based tracking, Audio-based flagging | To detect and flag any malicious activities during online tests to ensure fairness in the examination process. | Uses vision and audio-based features like eye tracking, lip movement detection and Google speech recognition API for analysis. | Convolutional Neural Networks, Google Speech Recognition API, Binary SVM Classifier | [11] |
| Machine Learning algorithms | To design a face detection and recognition system that monitors students during online examinations using machine learning algorithms. | Highlights the challenges faced in online education, particularly in ensuring student attendance and preventing malpractice during assessments. | Support Vector Machine algorithm, Eigenface method, LBPH, Fisher faces, SIFT and SURF | [12] |
| Biometric technologies | To offer continuous online authentication and monitoring of students during e-learning using biometric methods like face, voice and typing dynamics. | Utilizes multimodal biometrics technology to verify the identity of online learners and monitor their activities during e-learning. | Biometric authentication algorithms, Voice detection algorithm, CNN-RNN model | [13] |
| Suspected case detection engine | To process students' videos and mouse movement data to detect suspected cheating behaviours and visualize them in a structured manner. | Focuses on a visual analytics approach to enhance the convenience, efficiency and reliability of online exam proctoring. | Pre-trained Faster R-CNN model | [14] |
| Automated Proctoring System | To detect and prevent cheating by analysing various behaviours, such as eye gaze tracking, mouth open/close detection and head posture estimation. | Addresses the challenges posed by the shift to online learning due to COVID-19, aiming to prevent cheating and ensure academic integrity. | Convolutional Neural Network, Google's Speech Recognition API, Face Key Points Detector | [15] |
| Deep Learning and Computer Vision techniques | To enhance the accessibility and reliability of online examinations through the use of deep learning models for proctoring. | Presents a proctored online exam system using deep learning and computer vision to improve reliability and accessibility. | TensorFlow 2.5, Head pose estimation and eye tracking algorithms, OpenCV libraries | [16] |
| Automated detection systems | To automate abnormal behaviour detection during online exams, ensuring a rigorous process similar to in-person assessments. | Discusses automated exam behaviour monitoring using image processing and classifiers to detect suspicious actions. | YOLOv3, CNN, Rectified Activation Units | [17] |
| Computer vision and Audio analysis | To detect and prevent malpractice during online examinations. | Utilizes a webcam and built-in microphone to monitor candidates, eliminating the need for human proctors. | YOLOv5 Model, dlib 68-Point Face Detector, OpenCV, Google Speech Recognition API | [18] |
| Artificial Intelligence | To modernize the examination process, particularly in response to challenges posed by the COVID-19 pandemic. | Presents an AI-powered Online Examination System to modernize exams, addressing challenges from the COVID-19 pandemic. | Keyword Frequency Generation algorithm, Linguistic Analysis algorithm, Pattern Matching algorithm | [19] |
| Deep Learning-based models | To investigate the detection and recognition of unusual behaviour during online exams to prevent cheating and unethical conduct among students. | Focuses on identifying cheating behaviours using deep learning and motion-based frame extraction to analyse video data. | YOLOv5, DenseNet121, InceptionResNetv2,Inception-V3, Keyframe extraction techniques | [20] |
| Automated Grading, Real-time Monitoring, User Authentication | To facilitate electronic assessments that can be taken remotely by students, providing flexibility in terms of time and location. | Highlights automated grading, instant feedback and detailed performance reports to enhance the testing experience for students and institutions. | AI and machine learning-based approaches | [21] |
| YOLOv3 model | To maintain the integrity of online examinations by preventing cheating through continuous monitoring of examinees. | Presents an automated proctoring system designed to enhance the integrity of online examinations by utilizing computer vision techniques. | YOLO, DarkNet-53 architecture, OpenCV, Dlib | [22] |
| AI-based online proctoring system | To maintain the integrity of online examinations by detecting and preventing cheating behaviours. | Presents a multi-modal approach using video capture, emotion analysis, head pose detection and identification of cheating indicators like mobile phones or extra individuals. | Histogram of Oriented Gradients, YOLOv3 | [23] |
| YOLO algorithm + AI Algorithm | To ensure the integrity of online exams by detecting and preventing cheating through the use of AI algorithms, specifically YOLO and face detection. | Proposes an AI-powered online exam proctoring system using the YOLO algorithm for real-time monitoring and cheating detection. | YOLO algorithm, FaceNet, AI algorithms | [24] |
| Facial Recognition, Environment Scanning, Screen Recording | To oversee and ensure the integrity of online exams, preventing cheating and maintaining academic standards. | Incorporates identity verification, real-time video monitoring, screen recording and analytics to detect cheating and uphold academic integrity. | AI algorithms, Deep learning | [25] |

## 3. Features of AI-Powered Online Examination Systems

The online examination system utilizes AI, which ensures security and flexibility of the system and improvement in how users interact with the system. Also, improving security conditions helps the system to be more comfortable for users due to the inclusion of two-factor authentication or biometric identity verification systems based on face, finger, voice and others. Examiners can cooperate without restriction thanks to real-time surveillance powered by AI, which is effective in assessing if a candidate is moving too much or if there are many people behind the candidate, all of which could imply malicious intentions. Depending on the test, the systems can handle a wide range of submission methods, difficulty levels and even a time-free examination without compromising cash integrity. Additionally, these tools include cheating and activity monitoring systems that look for signs of plagiarism, these tools add to the deterrence factor and they are extremely effective [26]. Overall, cloud interface systems are remarkable as they can manage massive quantities of candidates with ease while providing cross-device accessibility as well as offline functionality if required.

Let us not forget the scale of insights and reports these systems provide, looking at overall trends, instant feedback and results, as well as performance analytics at an individual level for both administrators and candidates. Security features like encryption, fraud detection and permission restriction prevent data from being leaked or tampered. Another feature is that the sessions are reviewed and all data is backed up after clearing the examinations.

## 4. Advantages and Benefits

### A. Greater protection

- Another way to protect your account is to add two-factor authentication and biometric verification, which can include face scans, fingerprints or voice recognition.
- Real-time surveillance detects suspicious behaviour, which may mean excessive movement, other people's presence or just any other sort of abnormality.
- Plagiarism detection tools and activity monitoring tools work in prevention and management of cheating.
- Data loss prevention features, such as encryption, detection of fraudulent activities and permission to data use are among the best.

### B. Greater flexibility

- The organizing body allows for submission through various submission methods such as, but not limited to submission of work, different levels of difficulty and even time-free submissions.
- Offline capabilities and cross-device compatibility guarantees effectiveness in different environments.

### C. Scalability and effectiveness

- Cloud systems can effortlessly manage massive examinations.
- Ability to connect and work even with different devices and platforms without any form of constraints.
- Better report insights
- With this, students and their candidates can be able to get their overall performance, feedback and even analysis for each individual on an instant basis.
- Back-up and review of data are done after the exams and post ex-so task and non-related factors.

### D. Easy to use graphic design

- Better procedures of aspirants and administrators making the comfort of someone better and changing how someone interacts with the system.
- Increased level of comfort because of better security and monitoring systems have been put in place.

The implementation of AI-powered examination systems addresses some of the most salient issues. They cut down human errors especially owing to the fact that examination evaluations can easily be standardized. These systems have functionality such as screen readers and translational functionality which fosters a more diverse client base including those with disabilities. With automation of scheduling, reporting and management, there is efficient management which saves academics' time. AI based constant surveillance measures provide near impossibility for malpractice to take place.

Students now have the advantage of taking their exams from the comfort of their own homes or from offline modes and with detailed reports it is possible to enhance the teaching practices. These systems are compatible with LMS platforms and other present-day technologies creating opportunities for the students to be more proficient in the digital space [27].

## 5. Challenges and limitations

### A. Challenges

- Data Security Risks: There is a likelihood of data breaches or inappropriate use of sensitive biometric data and some of them are of awareness to the legal obligations surrounding GDPR and CCPA.
- Algorithmic Bias: There are chances that people will be treated differently, fairly or unfairly and this occurs because the data used to train the algorithms is biased and also, there are challenges in the recognition of various groups or disabilities.
- High Fixed Cost: There is a capital outflow for quite some time before the business begins to run, hence there is a limitation of smaller institutions accessing the setup.
- Technical Issues: There are system failures, software bugs or even compatibility among the various programs, which tend to interfere with the examinations and out the experience of the users on the program.
- False Positives/Negatives: Normal behaviors which are disregarded and look suspicious tend to cause stress or there is a lack of security because cheating was not detected.
- Digital Divide: Some or several candidates are excluded or disadvantaged due to limited access to the Internet, obsolete devices and different levels of digital literacy.

- Over-Reliance on Technology: There was less human interference and relaxation of the technical hitches, more so when there were crucial examinations.
- Complex Implementation: There was a long learning curve and a lot of time was spent in training culminating in challenges of interfacing with the LMS.
- Lack of Emotional Intelligence: There is an increase in stress for candidates during exams since people cannot gauge or help them with their emotional concerns.

### B. Limitations

The use of the AI-enhanced online examination systems has transformed the assessment process by boosting efficiency, ease of scale and security. These systems help to restrict the number of human invigilators while also allowing for the capability of test invigilation and supervision to be done automatically. And all these methods are employed while putting in complaints during the examination. Nevertheless, there are some drawbacks such as detecting impersonation among other goal-oriented impersonation schemes and the conducting of subjectively or other non-standardized forms of examination [28]. There are issues dealing with the reliance on the availability of well-structured training data since these deal with the aspects of bias as well as accuracy. Issues of privacy and ethics are raised when invasive modes of monitoring are employed. The difficulties are further compounded by issues such as cultural fit, rate of adoption, ecological effects of use and changing laws. There are great opportunities in AI powered systems in spite of the challenges facing them. Assuming ethical, technical and inclusion issues are successfully addressed, these have potential to undergo transition into resilient, trustworthy and easy to use systems that will satisfy the varying demands of educational institutions and learners across the globe.

## 6. Conclusion and Future Scope

AI technologies have indeed disrupted the traditional examination and assessment processes as they greatly improve efficiency, scalability and security of exam systems. These systems lessen the dependence on human invigilators, make it easier to supervise the tests and increase the Trust aspect by allowing tamper metering. Yet, challenges like algorithmic bias, technical failures or even data privacy issues make it clear that this is a dynamic field that always requires enhancement.

While such systems currently boast a great deal of promise, in the race for technology, equity and diversity should also be the foremost priority. Other challenges have the possibility of delivering more advanced, more secure and more convenient systems that are needed by educational institutions and students today and tomorrow.

Algorithmic enhancements will focus on a fair and equitable approach to the students by minimizing false alarms through deploying more robust machine learning models that are able to tackle different cultures and environments. It is anticipated that professional technologies such as AR and VR will help create the feeling of real-life situations and at the same time, reliable records of performance will be stored in the network with the help of blockchain. Other than that, tools such as offline monitoring and those with special requirements are expected to make the exams less intimidating. Implementing AI opening creative pedagogical frameworks through advanced analytics and customization. The ethics of AI and practices adopted will provide the basis for inclusion of policy measures on how to operate AI by preventing bias and mistrust among stakeholders.

Potential models using AI and human monitoring can enhance the usefulness of monitoring. Global integration efforts are going to harmonize the evaluation approach while other countries band together to share the most effective strategies. Rapid data analysis will allow the organizations to formulate policies immediately to boost qualification and exam structure. Lastly through time and continuous learning the AI systems are expected to keep updating themselves improving their features.

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