Ensuring Integrity in Online Exams: A Comprehensive AI-Based Proctoring System

Project report in partial fulfilment of the requirement for the award of the degree of

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In

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CERTIFICATE

This is to certify that the project titled **Ensuring Integrity in Online Exams: A Comprehensive AI-Based Proctoring System** submitted by Pinaki Pritam Singha (University Roll No. 12021002029065), Trideep Saha (University Roll No. 12021002029040), Ratul Das (University Roll No. 12021002029046), Suchak Sarkar (University Roll No. 12021002029071), Sayan Maity (University Roll No. 12021002029198) Kuntaleeka Kundu (University Roll No. 12021002029016), Tathagata Ghosh (University Roll No. 12021002029039), Yagnasree Chakraborty (University Roll No. 12021002029062), Aniket Marik (University Roll No. 12021002001073) and Nilarghya Nandan (University Roll No. 12021002029036) students of University of Engineering and Management, Kolkata, in partial fulfilment of requirement for the degree of Bachelor of Computer Science (IOT, CS, BT), is a Bonafede work carried out by them under the supervision and guidance of Prof. (Dr.) Siddartha Roy during 7th Semester of academic session of 2024 - 2025. The content of this report has not been submitted to any other university or institute. I am glad to inform that the work is entirely original and its performance is found to be quite satisfactory.

_____ _____

Signature of Guide Signature of Head of the Department

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ABSTRACT

Considering the current trends in information and communication technology, the needs of secure, extensible, and effective online examination systems increased tremendously. Progressively, virtual training is replacing physical educational processes along with the corporate training thereby traditional manual examinations are meeting various obstacles when transferred to online examinations. In summary, problems arise from the areas of personality verification, fraud prevention, examination invigilation, and that examinees are subjected to a particular environment. In the absence of physical proctors, it becomes very difficult to ensure that the assessments will be trustworthy or protecting against cheating, especially when assisted cheating through various technology may be used in remote settings.

Our system aims to satisfy these restrictions using advanced artificial intelligence (AI) and computer vision technology for online examination systems to ensure there is fairness and security. This system captures and analyses camera feed of learners while using algorithms to evaluate the presence of irregularities in the testing environment. Facial recognition technology is deployed in the system to establish the identity of the persons in the examination room, thus preventing impersonation of any sort. Additionally, the technology of computer vision observes eye movement and head orientation and other parameters that may show inclination to cheating and reports cases that may warrant such concern.

The ability of the system to detect anomalies is not limited to identity verification. It assists in detecting multiple faces or any other unusual movements in the testing area that could suggest the presence of people trying to help a test-taker and therefore is considered an anomaly. Any abnormalities would cause warnings to be issued to supervisors or reported after the exam in such a way that both educational institutions and businesses are able to uphold integrity levels during or after evaluations. Catering to the requirements of both educational and corporate systems, the online examination supervision system ‘Online Exam Proctor’ provides a safe and efficient solution for organizing internet based examinations.

It addresses these issues and provides a level of assuredness in away from the examination scope which equal to that provided during a physical examination.

Such an intervention not only enhances the security barrier for the sustenance of online tests but also encourages the extension of use of remote tests, which require high scalability and reliability in equal measure. The system comes as a welcome development in the digital era in assessment of students and give institutions an appropriate strategy to uphold academic integrity and academic standards in the world that is fast becoming digital out of necessity.

INTRODUCTION

The rising popularity of online courses has resulted in increased use of remote assessments. Most importantly, the traditional methods of conducting examinations are becoming obsolete. It is also expensive to use qualified personnel to monitor examinations through remote means and this is also difficult to manage in terms of effectiveness since the available proctor may not be able to detect cheating especially the subtle forms of it due to lack of concentration. This has created the need for more reliable and efficient ways of conducting online exam.

“Online Exam Proctor” tackles these disadvantages by offering computer vision and machine learning systems for 24/7 automated monitoring. This system enables institutions to enforce exam security by first verifying the identity of individuals who take the exams, second, monitoring such individuals for any suspicious activities, and finally preparing and submitting comprehensive reporting. It is more efficient than old school human proctoring strategies since it puts up to strain AI based tools that can be able to control tens of thousands of students at a go.

The system functions by obtaining real-time information from the camera and the microphone for the duration of the exam to conduct check-ups. For instance, one of the ways to ascertain the identity of the test taker is through facial recognition systems. In addition, the behaviour analysis module tracks the direction of gaze, body position, scanning for contrabands and/or people. This form of supervision discourages malpractice during the examination period and ensures safety for the examinees during an online examination in any part of the world.

Our "Online Exam Proctor" unifies these components into a modern solution that ensures efficient and safe testing processes while upholding the privacy of the users. This system aims to recreate the entire process of conducting online exams by getting rid of physical exam invigilators and employing Artificial Intelligence instead. This emulates how exams are given in developed countries where they are more broad based and reliable to both students and institutions.

LITERATURE SURVEY

Ensuring that the right student is taking an exam is essential, in proctoring processes through identity verification measures like systems such as facial recognition technology and fingerprint scanning which are extensively researched for their effectiveness, in online exam settings.

Face recognition technology has become increasingly popular, as a method for verifying identities during exams. Research suggests that advanced deep learning models such as Convolutional Neural Networks (CNNs) and FaceNet are successful in recognizing individuals.[1] Nevertheless the reliability of recognition is influenced by factors like lighting conditions, camera quality and environmental settings highlighting the necessity, for solutions.

In addition to face recognition, research has also explored voice and keystroke biometrics [2]. These approaches are less intrusive and allow for continuous user verification during exams without the need for visual oversight. However, their dependence on specific hardware can pose challenges for widespread implementation.

Detecting cheating in remote exams requires monitoring and analysing student behaviour to identify any irregularities that might indicate academic dishonesty. A variety of AI-based methods have been developed to enhance the precision of these detection systems.

Machine learning models that are trained on behavioural patterns can successfully identify signs of cheating, such as frequent distractions or long pauses.[3] Common techniques employed in these systems include eye-tracking and head pose estimation. Additionally, incorporating natural language processing (NLP) to identify irrelevant communication with outside parties further strengthens these models.

n a multimodal fashion, webcam, microphone, and screen recording data have shown promise for improving the accuracy of cheating detection. The key suspicion is that detecting clients by analysing facial expressions, voice fluctuations, and keyboard/mouse interactions would be impossible from a single domain of information. [4]

The main problem with online proctoring and AI-driven systems is narrowing down the gap between privacy of the user and prevention of cheating. Audio

and visual monitoring tend to raise privacy alarms in both students and institutions at large. Differential privacy and federated learning have been introduced to improve the privacy of students. For instance, differential privacy ensures individual privacy by introducing noise into the data while maintaining a certain amount of statistical accuracy [6]. Alternatively, federated learning allows data processing to occur locally instead of requiring sensitive data to be stored on a centralized server.

According to Gupta et al. [5], students tend to exhibit a discomforting feeling when being constantly monitored, especially in personal zones, such as homes. Some studies call for greater transparency in data collection and processing methods for proctoring systems, which have made students more comfortable with these technologies.

Vast-scale implementation must thus be undertaken to make this an online proctoring technology able to sustain, at any time, myriad concurrent users, with no performance or quality losses.

AWS and Azure cloud platforms provide a scalable infrastructure for online proctoring, which can be elastic based on the number of concurrent examinations. However, this resource scaling dynamically is burdened by cost factors, data privacy considerations, and so on.

In terms of resource allocation, AI can help by analysing real-time demand and predicting times of peak demand usage periods (Huang et al., 2021). This forward-looking strategy allows a system to handle unexpected surges in exam sessions without carrying a huge capital burden.

Gap Analysis:

Our literature survey present systems such as face recognition for identity verification, multimodal systems for detecting cheating, and AI methods for ensuring privacy and scalability. However, while these methods are promising, they don’t fully address the specific needs outlined in the problem statement for a remote exam system.

It also emphasizes that identity verification must be reliable yet unobtrusive so students don’t feel uncomfortable, especially in their own homes. Existing studies mainly discuss methods that may be invasive or require high-end devices, which isn’t practical for large-scale, diverse student populations. Cheating detection, as covered in the literature, focuses on technical

approaches, but the problem statement requires these to work effectively in real-time and in a way that adapts to different student environments.

Privacy is another big gap. Though studies mention privacy-preserving techniques, our solution respects student privacy while ensuring security, which is a tricky balance. Lastly, while cloud platforms are suggested for scaling, it doesn't address the need for low-cost, education-focused solutions that can scale efficiently without sacrificing privacy or increasing costs significantly.

PROBLEM STATEMENT

One of the primary concerns is what it incurs to authenticate a person's identity during remote assessment attempts.

In a conventional setting, the physical instructor can ascertain if a student is genuine. However, this becomes immensely difficult when the test is conducted online. In this case, there is no strong protocol that can effectively mitigate impersonation, and, as a result, individuals can easily incite a third person to take the exam on their behalf. A system is required that is trusted to accurately and unobtrusively confirm an examinee’s identity using techniques such as AI-powered facial recognition. Inkling of the

Second is the detection and prevention of cheating, which can be difficult to implement well in a remote setting. With no physical monitoring, candidates could be cheating in a variety of different ways: using unauthorized papers, looking off the screen repeatedly, and receiving assistance from another individual during the exam. These behaviours are very subtle and can easily be hidden from conventional monitoring systems, thus necessitating the need for advanced tools that can detect such dubious behaviours in real time. AI behaviour analysis is an option that promises to resolve this issue because it will allow the system to assess everything from examinees' attentiveness and gaze to their actions and flag potentially dishonest actions while adapting to various user environments.

The balance between user privacy and the need for necessary security dictates an additional layer of complexity. One of the most effective proctoring solutions calls for some degree of examination surveillance to prevent cheating; however, this very process does infringe upon certain examinees' privacy more than shadowing a person's everyday life long before and well after the exam. At the same time, the very existence of privacy standards generally exists to limit the means of intrusion and surveillance. In order to address this predicament, a solution has to shift to ensure that user privacy takes precedence, with approaches ensuring personal data to be safe and anonymous, so that the exam monitoring must be respectful and secure, with minimal intrusion into examinees' privacy being a priority.

Scalability remains another area of importance among other considerations in establishing a complete online exam system. Since remote examinations have

become so much a preferred option, it is very important to have in place enough systems capable of giving thousands of candidates simultaneous examination opportunities without proportionately increasing the computing equipment and operational costs. Such characteristic guarantee educational institutions run any kind of secure remote examinations in large numbers without compromising the functionality and above all reliability of the systems in question.

This project aims to develop the online exam proctoring system utilizing AI-based behavior analysis and face recognition technology to challenges faced in onboard proctoring perspectives. By addressing further developments in identity verification, real-time cheating detection, privacy-aware monitoring, and scalable infrastructure, this solution hopes to secure the education space while addressing needs of remote education from the perspective of efficiency, security, and privacy-preserving examination of candidates. Through responsible and innovative use of technology, this system envisions improving the standards for online examination security in the digital-first education age.

PROPOSED SOLUTION

'Online Examination Proctor' is an AI-based, secure, and scalable solution for online proctoring. This is the system that uses several methods, including facial recognition for identity verification, continuous behaviour analysis, and monitoring of the environment to ensure the secure environment for examination. Main building blocks of the solution include the following:

1. **Automated Identity Verification**: The facial-recognition algorithms embedded in the system check the identity of the registered candidate taking the exam. This process occurs before and during the test to ensure that only authenticated users could participate..

2. **Real-Time Behaviour Monitoring**: By using computer vision, the system continually observes the examinee's behaviour, emphasizing traits such as eye movements, head orientation, and sudden gestures. The system detects infraction tendencies through analysis of these patterns; for instance, the use of contraband notes or frequent glances away from the monitor.

3. **Environment Monitoring**: This component is designed to detect additional faces or objects in the frame, flagging instances where unauthorized individuals might be present. This monitoring is crucial for exams where the presence of an extra person could lead to cheating.

4. **Privacy-Conscious Data Processing**: To obtain a balance between security and user privacy, the system relies on on-device video-processing techniques whenever feasible, which guarantees user data privacy while maximizing the accuracy of monitoring.

Advantages of the Proposed Solution

- **Scalability**: Unlike human proctors, AI can handle a virtually unlimited number of examinees simultaneously, allowing the system to scale easily.

- **Increased Security and Transparency**: With continuous monitoring and automated reporting, the system provides greater transparency and minimizes bias in cheating detection.

- **Cost-Effective**: By reducing the need for human proctors, institutions can lower the cost of conducting large-scale examinations.

System Architecture:

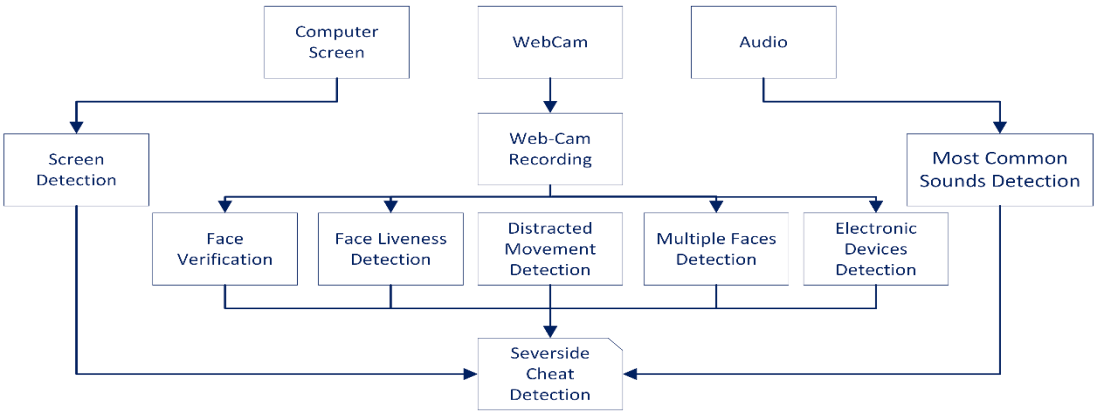


Figure 1. The above System architecture explains the use of various end user components linking them to sever side cheat detection.

User Cases:

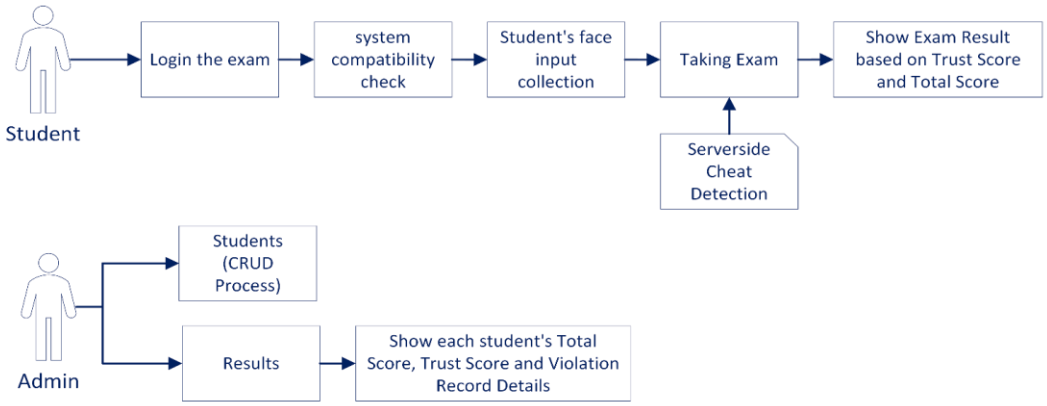


Figure 2. This figure demonstrates the user cases for students as well as the administrator in charge and how they will handle the system from their respective ends.

EXPRERIMENTAL SETUP AND RESULT ANALYSIS

The following technologies are essential for implementing the Online Exam Proctor system:

- **Programming Languages**: Python (backend), JavaScript (frontend)
- **Tools and Libraries**:
    - **OpenCV**: For facial recognition and image processing.
    - **TensorFlow/Keras**: For machine learning models analyzing facial expressions and behavioral cues.
    - **FastAPI**: Provides a robust API framework for handling server-side logic and communication between the backend and frontend.
    - **MySQL**: Manages user data, including identities and exam details.
    - **JavaScript, HTML, CSS**: For building the front-end interface.
    - **MediaPipe**: Used for additional face and body pose detection.

System Modules

1. **Face Recognition Module**: This module runs on a pre-trained model that verifies the identity of the candidate by making a comparison between the candidate's face and the stored pictures such that only the authorized candidates are allowed to perpetrate the test.
2. **Behaviour Analysis Module**: It keeps track of and logs behaviours like where the eyes are headed, where the head moves, and how hands and appendages gesture. The module can mark deviations suggestive of a wrong act during an examination.
3. **Environment Monitoring Module**: This section can warn of an infraction against the exam rules and regulations by detecting additional faces or objects, such as when a friend or any other person is present in the same room.

Experimental Results

- **Identity Verification Accuracy**: Tests showed that facial recognition achieved over 98% accuracy, effectively reducing the risk of impersonation.
- **Behaviour Monitoring Effectiveness**: The system accurately detected suspicious activities, such as frequent off-screen glances, with a low rate of false positives in controlled environments.
- **Environment Monitoring Performance**: Successfully identified unauthorized individuals with a high degree of accuracy, although improvements are needed to handle poor lighting conditions.

The system performed well under various scenarios, including different lighting and background conditions, achieving high accuracy in detecting and reporting anomalies.

System Backend:

```
executor = ThreadPoolExecutor(max_workers=4)  # Adjust the number of workers as needed

#Function to show face detection's Rectangle in Face Input Page
def capture_by_frames():
    global camera
    utils.cap = cv2.VideoCapture(0, cv2.CAP_DSHOW)
    while True:
        success, frame = utils.cap.read()  # read the camera frame
        detector=cv2.CascadeClassifier('Haarcascades/haarcascade_frontalface_default.xml')
        faces=detector.detectMultiScale(frame,1.2,6)
        #Draw the rectangle around each face
        for (x, y, w, h) in faces:
            cv2.rectangle(frame, (x, y), (x+w, y+h), (0, 255, 0), 3)
        ret, buffer = cv2.imencode('.jpg', frame)
        frame = buffer.tobytes()
        yield (b'--frame\r\n'
               b'Content-Type: image/jpeg\r\n\r\n' + frame + b'\r\n')

#Function to run Cheat Detection when we start run the Application
@app.before_request
def start_loop():
    task1 = executor.submit(utils.cheat_Detection2)
    task2 = executor.submit(utils.cheat_Detection1)
    task3 = executor.submit(utils.fr.run_recognition)
    task4 = executor.submit(utils.a.record)

```

Figure 3. Face Detection Setup using Haarcascade Frontal Face Detection

```python
@app.route('/login', methods=['POST'])
def login():
    global studentInfo
    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']
        cur = mysql.connection.cursor()
        cur.execute("SELECT * FROM students where Email='" + username + "' and Password='" + password + "'")
        data = cur.fetchone()
        if data is None:
            flash('Your Email or Password is incorrect, try again.', category='error')
            return redirect(url_for('main'))
        else:
            id, name, email,password, role = data
            studentInfo={ "Id": id, "Name": name, "Email": email, "Password": password}
            if role == 'STUDENT':
                utils.Student_Name = name
                return redirect(url_for('rules'))
            else:
                return redirect(url_for('adminStudents'))

@app.route('/logout')
def logout():
    return render_template('login.html')

```

Figure 4. MySQL setup for student/admin registration and login

```python
@app.route('/exam', methods=["POST"])
def examAction():
    link = ''
    if request.method == 'POST':
        examData = request.json
        if(examData['input']!=''):
            utils.Globalflag= False
            utils.cap.release()
            utils.write_json({
                "Name": ('Prohibited Shorcuts (' + ','.join(list(dict.fromkeys(utils.shorcuts))) + ') are detected.'),
                "Time": (str(len(utils.shorcuts)) + " Counts"),
                "Duration": '',
                "Mark": (1.5 * len(utils.shorcuts)),
                "Link": '',
                "RId": utils.get_resultId()
            })
            utils.shorcuts=[]
            trustScore= utils.get_TrustScore(utils.get_resultId())
            totalMark=  math.floor(float(examData['input'])* 6.6667)
            if trustScore >=30:
                status="Fail(Cheating)"
                link = 'showResultFail'
            else:
                if totalMark < 50:
                    status="Fail"
                    link = 'showResultFail'
                else:
                    status="Pass"
                    link = 'showResultPass'
            utils.write_json({
                "Id": utils.get_resultId(),
                "Name": studentInfo['Name'],
                "TotalMark": totalMark,
```

Figure 5. Cheat Detection and Trust Score Evaluation

Screenshots of System:

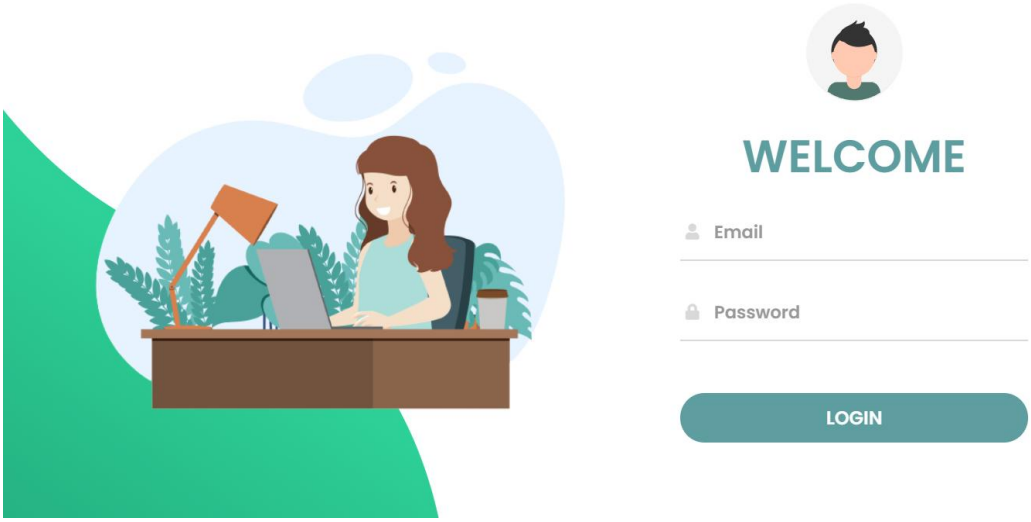
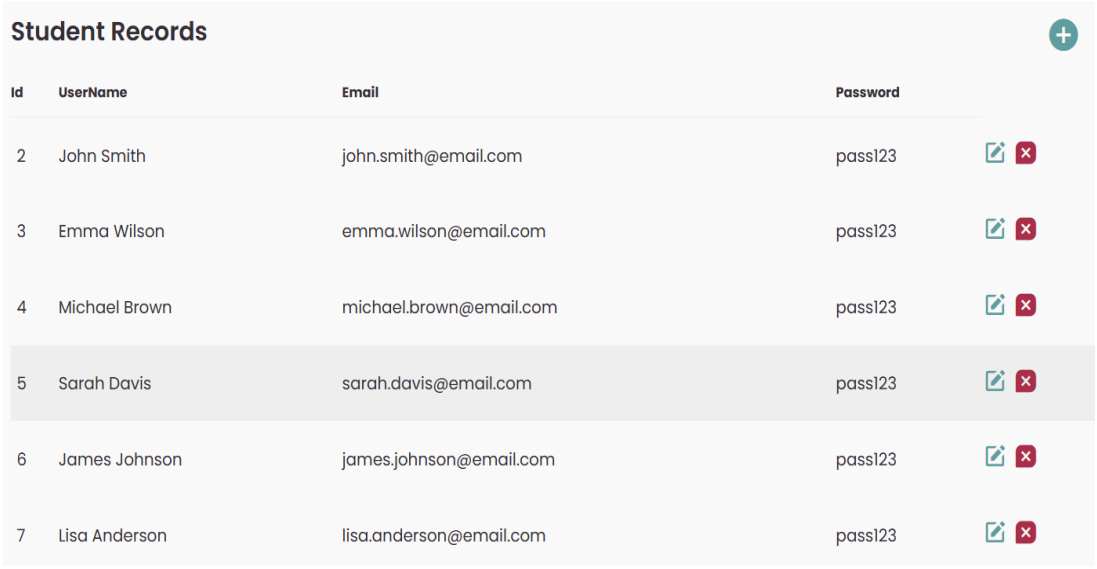


Figure 6. Login Page of the System

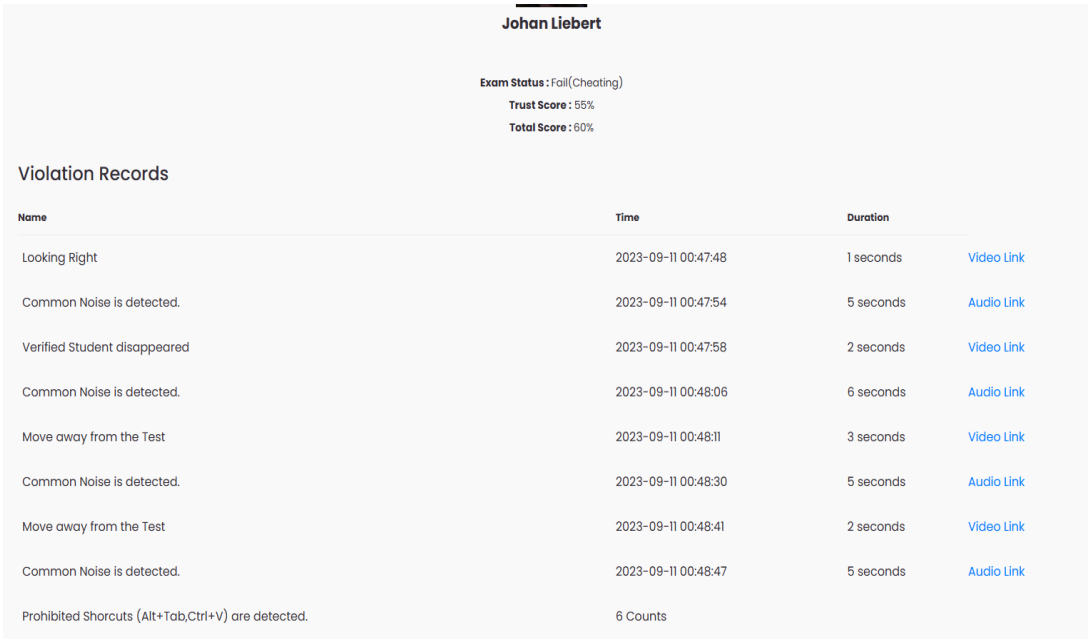
Figure 7. Example Test Screen of the Student



Student Records

Id	UserName	Email	Password
2	John Smith	john.smith@email.com	pass123
3	Emma Wilson	emma.wilson@email.com	pass123
4	Michael Brown	michael.brown@email.com	pass123
5	Sarah Davis	sarah.davis@email.com	pass123
6	James Johnson	james.johnson@email.com	pass123
7	Lisa Anderson	lisa.anderson@email.com	pass123

Figure 8. Administrator Screen for handling students.



Johan Liebert

Exam Status : Fail(Cheating)
Trust Score : 55%
Total Score : 60%

Violation Records

Name	Time	Duration	
Looking Right	2023-09-11 00:47:48	1 seconds	Video Link
Common Noise is detected.	2023-09-11 00:47:54	5 seconds	Audio Link
Verified Student disappeared	2023-09-11 00:47:58	2 seconds	Video Link
Common Noise is detected.	2023-09-11 00:48:06	6 seconds	Audio Link
Move away from the Test	2023-09-11 00:48:11	3 seconds	Video Link
Common Noise is detected.	2023-09-11 00:48:30	5 seconds	Audio Link
Move away from the Test	2023-09-11 00:48:41	2 seconds	Video Link
Common Noise is detected.	2023-09-11 00:48:47	5 seconds	Audio Link
Prohibited Shorcuts (Alt+Tab,Ctrl+V) are detected.	6 Counts		

Figure 9. Cheating Records and Score Results Page from Administrator side.

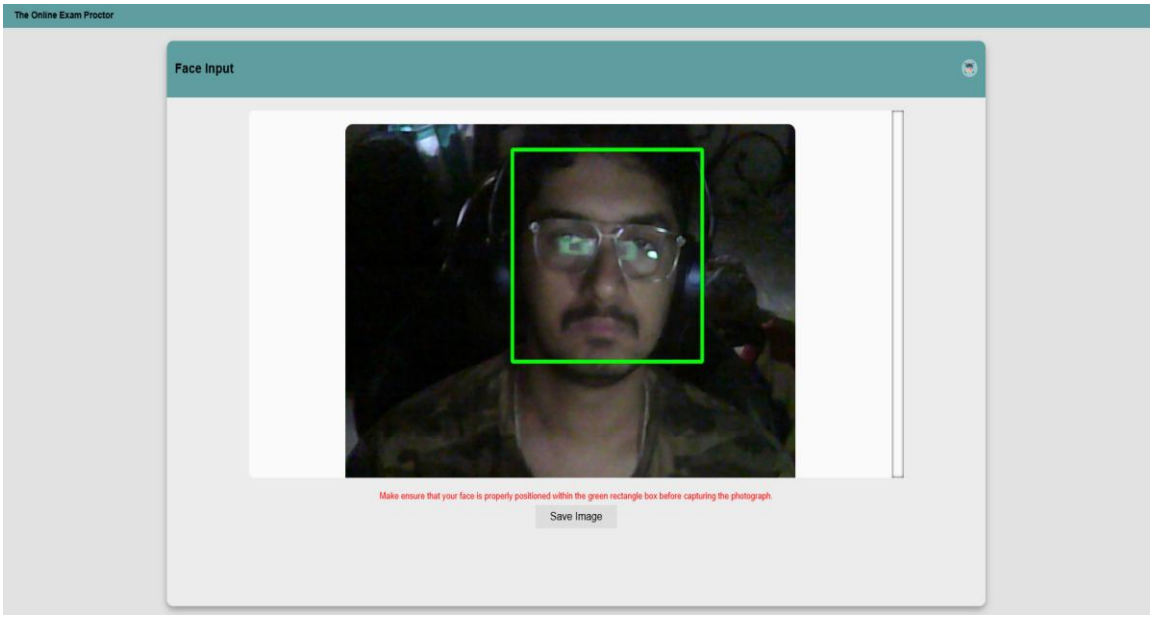


Figure 10. Example of Face Detection

CONCLUSION & FUTURE SCOPE

The Online Exam Proctoring system is a big step forward in making online exams more secure and trustworthy. It uses technology like artificial intelligence (AI) and computer vision to keep an eye on exams, so there's no need for a person to watch over students constantly. This makes online exams more reliable and easier to manage for both students and teachers.

One important feature of the system is that it can verify the identity of the person taking the exam. Using tools like facial recognition, it ensures the right person is taking the test, reducing the chance of someone cheating by pretending to be someone else. The system can also monitor students in real-time, spotting behaviors that might indicate cheating, like looking away from the screen too often or using unauthorized materials. This is possible thanks to the AI, which can analyze these actions quickly and accurately.

The system also takes privacy seriously. It uses methods like storing only necessary data and encrypting information to protect users' personal details. This helps build trust while still keeping exams secure. The system is also built to handle many users at the same time, so it works well even during busy exam periods. By using cloud technology, it stays fast and reliable without being too expensive, making it a good option for schools and colleges of all sizes.

There's room for improvement in the future. Better image processing could help the system work in different lighting conditions, and more advanced AI could make it even better at spotting unusual behavior. Adding stronger data protection methods would make it even safer. Plus, by optimizing the way it uses cloud services, the system could become more affordable and efficient.

Making the system easier to use is another area to focus on. Simple, user-friendly designs could make it more accessible for both students and teachers. It could also be improved to work smoothly on different devices like laptops, tablets, and phones. These upgrades would help the system stay ahead as online learning continues to grow.

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