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Face Recognition for Online Exam Proctoring

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INTRODUCTION

Online proctoring is a technology-driven solution designed to ensure the integrity and security of online exams. With the growing popularity of online learning and remote education, the need for secure online testing has become increasingly important. Online proctoring systems use a combination of software and hardware to monitor and record the behaviour of students during an online exam. The system captures and records various aspects of the student's exam-taking environment, including their desktop activities, webcam feed, and audio feed. Online proctoring systems offer different modes of monitoring, such as live proctoring, automated proctoring, or a hybrid of both. Live proctoring involves a human proctor who monitors the student's activities in real- time, while automated proctoring uses AI algorithms to detect and flag suspicious behaviour. Online proctoring systems typically offer features such as facial recognition, keystroke analysis, browser lockdown, and lockdown browser to ensure a secure and fair testing environment. Online proctoring is an essential tool for conducting secure and reliable online exams and helps to prevent cheating and ensure the validity of the exam results.

Face recognition technology has become integral to the process of online proctoring, particularly in verifying the identity of individuals taking exams remotely. Initially, students register their facial data within the system by providing a set of images or a video capturing their facial features from various angles. During the exam, a webcam captures the student's face in real-time, which is then compared to the registered template using facial recognition algorithms to authenticate their identity. To thwart cheating attempts, anti-spoofing measures may be implemented, such as analyzing facial movements or requiring random actions to confirm liveliness. Throughout the exam, continuous monitoring of the student's face detects suspicious behaviors, triggering alerts for intervention if necessary.

BACKGROUND

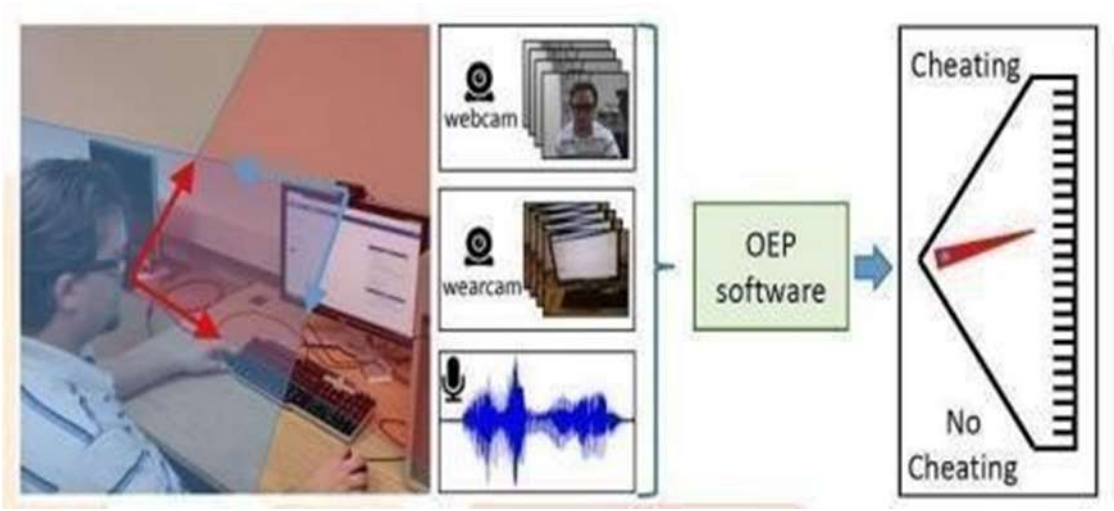

Fig. 1: OEP software records webcam and mic to detect cheating on scale

Background for online proctoring encompasses the evolution of assessment methodologies in response to the digitalization of education. Traditionally, exams were conducted in physical classrooms under the supervision of invigilators. However, with the advent of online learning and remote education, the need for secure and reliable methods of assessment became paramount. Online proctoring emerged as a solution to this challenge, allowing institutions to administer exams remotely while maintaining academic integrity.

The proliferation of internet connectivity, coupled with advancements in technology, paved the way for the adoption of online proctoring. Initially, basic methods such as webcam monitoring and screen recording were employed to oversee online exams. However, as concerns regarding cheating and identity verification grew, more sophisticated approaches were developed. Modern online proctoring solutions leverage a variety of technologies, including artificial intelligence, facial recognition, and biometric authentication, to ensure the integrity of assessments. These systems can detect suspicious behaviour, such as unauthorized use of resources or irregular eye movements, and intervene in real-time to mitigate cheating.

Moreover, online proctoring offers flexibility and convenience for both students and educators, enabling exams to be conducted asynchronously and accommodating diverse learning needs. However, it also raises ethical and privacy considerations, particularly regarding the collection and use of sensitive data.

Overall, the background of online proctoring reflects the intersection of educational needs, technological innovation, and ethical concerns in the digital age. As online learning continues to evolve, so too will the methods of assessment, with online proctoring playing a crucial role in ensuring academic integrity and fostering trust in remote education.

LITERATURE SURVEY

PAPER 1

Title: online exam proctoring system

Authors: Yelkar Anjali & pawar reena vishwas Year: 2022

Description: They explored several recent works and articles and a comparison between generic application development and immersive technology-based application is included. They discussed about more practical approaches that can be taken to enhance the effectiveness of the application.

PAPER 2

Title: AI based proctoring system for online tests Authors: Vandana & Hema GA

Year: 2022

Description: In this project we are going to perform the following in online examination:

Candidate verification and attendance management. Detection of mobile phones nearby to the student and take necessary actions. Perform voice recognition during the online exam to detect malpractice. In online exam, the system will provide a single portal for logging in, accessing question paper, chat window to communicate with examiner and to upload answer sheet using the scanner which is embedded in the portal. Avoiding candidate from opening/accessing any other application during the online exam in the desktop or mobile.

PAPER 3

Title: a systematic review on AI based proctoring system past,present and future Authors: Aditya Nigam & Rithwik Pasrichsa

Year: 2021

Description: There have been giant leaps in the feld of education in the past 1–2 years. Schools and colleges are transitioning online to provide more resources to their

students. The COVID-19 pandemic has provided students more opportunities to learn and improve themselves at their own pace. Online proctoring services (part of assessment) are also on the rise, and AI-based proctoring systems (henceforth called as AIPS) have taken the market by storm.

PAPER 4

Title: On the efficacy of online proctoring system Authors: Laura & Arend Year: 2021

Description: Besides the analysis results provided by Proctorio, we collected several other types of data. First of all, the 30 gradebooks were reviewed by six reviewers (each gradebook by a single reviewer), all of whom were staff members. The reviewers did not know which students had been assigned which role. They noted which fraudulent actions they perceived, and compared their findings against the students' own reports. In reviewing the gradebooks, the reviewers were guided by what the system had indicated as periods of abnormal activities so findings were not completely independent of the automatic detection system.

PROBLEM FORMULATION

One major consideration to be made when designing any software is of the issues which may occur at any stage of execution. For any proctoring software, we must primarily consider two factors where a user may face problems: technological and human response. A major Security factor which can be misused easily is user privacy. Since, user authentication is necessary before allowing the student to attempt the exam; they are required to verify their personal details to the proctor. This can be done by scanning their User Identity Cards like College ID, Aadhar Card etc.

Such documents are often linked to sensitive user details and can be misused easily. The mobile numbers linked can also lead to phishing calls and serious offences like catfishing, harassment and so on. A proctor may end up indulging in immoral activities with the information at hand. Hence, a lot of emphasis must be given to ensuring that any Proctoring Software is robust, secure and ensures privacy of the test-taker. Impersonation by candidates is another security few which needs to be avoided. Since Proctoring Software give us the liberty to attempt any exam at home, this facility can be misused by users as they may make any other person attempt the test using their credentials. User Authentication, therefore, becomes a necessity before permitting anyone to begin with the exam. For ensuring fair assessments, various security measures are applied by Proctoring software.

Research Questions

1. This is the process used for proctoring or supervising the candidates during an online exam. In this process, the candidates are remotely monitored by the supervisors who are located at any other remote location with the help of technology.
2. This process is used to prevent candidates from cheating or carrying out any sort of malpractices during an online exam.
3. Remote Proctoring is the only mechanism which can be used to put a stop to cheating or any malpractice while conducting online exams. As it is developed using the best technology, it helps you to conduct online exams in an absolute cheating- free way

Research objectives

1. User-centered design approach
2. Performance and reliability
3. Use of appropriate technology stack
4. Seamless integration with existing systems
5. Testing for performance and scalability
6. Testing for usability and user experience
7. Testing for security

Research Scope

Educational institutions and corporate organizations across the world had gradually begun the process of adopting online proctoring software over the past decade to conduct remote examinations in a fair manner and ensuring that the candidates gave the exam in a known environment. Due to the COVID-19 Pandemic, it has become the need of the hour to leverage remote proctoring platforms to conduct seamless tests while also ensuring that the candidates do not indulge in malpractices during these online exams. (Remote Proctoring, 2020). There are numerous benefits to any organization when they conduct any assessment via remote proctoring instead of the traditional pen-and-paper based method. Scheduling exams becomes easier as there is no need to set up specific testing centers to conduct examinations. Communication between the examiner and the examinee is more streamlined, hassle-free and faster. Results of the examination can be generated faster and, in some cases, almost instantly. Online examinations also give the organization the liberty to conduct the exam on a massive scale without worrying about maxing out the capacity of the examination

centers. (Arora, 2021). However, a sincere effort needs to be made for developing proctoring technologies to ensure that the level of online examinations is at par with offline examinations in all aspects; be it integrity of marks scored, ensuring candidates do not get involved in wrongdoings etc. Social perception of the masses towards online exams also needs to be changed and they must be made aware of the benefits for the same.

Research Significance

ProctorU is an example of an OPS that uses a microphone and webcam. It is a live proctoring system in which the proctor guides students through the entire process of an online exam, and also monitors them using the webcam. Proctors are required to ensure that no unauthorized materials are present before the start of the exam. They are also required to verify the student's identity by asking them to present their ID cards. Students are required to maintain an uninterrupted audio-visual connection to the proctor throughout the session. (Milone et al., 2017) Kryterion, a widely- used commercial OPS uses an approach very similar to the one used by ProctorU. (Prathish et al., 2016) The AI module of ProctorU, however, isn't highly secure and can be deceived, which is why the company recommends using their hybrid solution to maintain high security. This hybrid solution augments automated proctoring with professionally trained live proctors, who have the ability to interrupt the test and intervene in case they suspect something. (Slusky, 2020). Xproctor, another popular OPS, authenticates students & constantly tracks and monitors them via facial recognition, behavior video streaming, audio and photographic methods.

METHODOLOGY

Experimental setup

1. Data Collection and Preprocessing: Gather diverse facial images and standardize them for factors like lighting and pose.
2. Feature Extraction: Use deep learning (e.g., CNNs) to extract discriminative facial features.

3. Face Representation and Encoding: Encode extracted features into a compact representation suitable for comparison.
4. Database Creation: Build a database of encoded facial templates for authorized users.
5. Online Proctoring Process: Capture real-time facial images during exams, compare against the database, and flag anomalies.
6. Model Evaluation and Optimization: Assess performance metrics, fine-tune parameters, and optimize for robustness.
7. Privacy and Security Considerations: Implement encryption, secure storage, and privacy safeguards for user data.

In this chapter, we introduce the methodology that we use for our work. We will use the case study methodology to investigate in-depth intrusion detection and the machine learning field. This research leads us to explore some possible integration between these two fields. Another reason for selecting this methodology is because we are handling both qualitative and quantitative data.

Algorithm

1. **Procedure**:

The procedure involves selecting facial features based on their importance and training Convolutional Neural Network (CNN) models with varying numbers of features for a specified number of epochs.

Computation | Free Full-Text | Research on the Development of a Proctoring System for Conducting Online Exams in Kazakhstan.

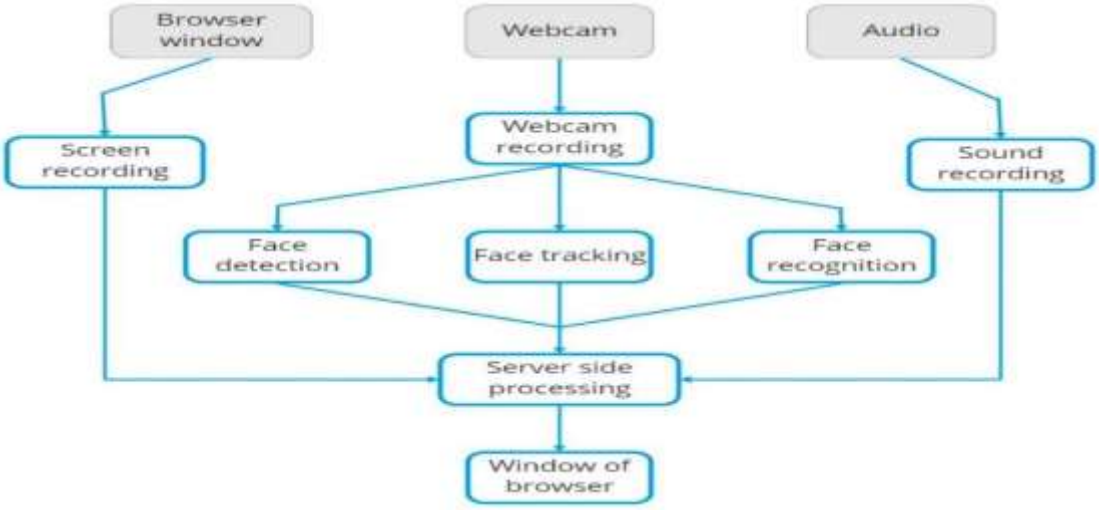

Fig. 2: Flow chart for operating of the Online Proctoring System

2. **Input**:

data: A collection of facial images with corresponding labels (student IDs). num_classes: Number of unique students (labels) in the dataset.

epochs: Number of epochs to train the CNN models.

3. **Output**:

Loss, Accuracy, and the number of epochs trained.

4. **Preprocessing**:

Perform facial detection and alignment to extract standardized facial images. Normalize and preprocess the facial images for training.

5. **Feature Selection and CNN Training**:

    1. Select facial features based on their importance using a feature selection algorithm.
    2. Train CNN models with varying numbers of features for a specified number of epochs as follows:
        - Train a CNN model with 10 features for 10 epochs.
        - Train a CNN model with 20 features for 5 epochs.
        - Train a CNN model with 30 features for 5 epochs.
        - Train a CNN model with 40 features for 5 epochs.
        - Train a CNN model with 50 features for 5 epochs.

6. **Feed Selected Features to CNN**:

For each feature group, feed the selected facial features into the CNN model.

7. **Fit CNN Algorithm**:

Apply the CNN algorithm to the selected feature groups.

8. **Calculate Results:**

Calculate Accuracy and Loss for each CNN model.

9. **Comparison:**

Compare the results to evaluate the performance of CNN models trained with different numbers of features.

Implementation

1. Environment Setup: Choose appropriate programming languages and frameworks (e.g., Python with OpenCV, TensorFlow). Install necessary dependencies.
2. Data Collection and Preprocessing: Gather facial images of authorized users. Standardize images for factors like lighting and pose.
3. Model Development: Develop deep learning models (e.g., CNNs) for feature extraction. Train models to recognize facial features specific to online proctoring.
4. Database Creation: Create a database to store encoded facial templates of authorized users. Implement efficient storage and retrieval mechanisms.
5. Online Proctoring Process: Develop real-time monitoring system to capture webcam feeds during exams. Preprocess images and extract facial features. Compare features against database and flag anomalies.
6. User Interface: Design user-friendly interface for instructors and test-takers. Include features for exam initiation, live monitoring, anomaly review, and result access.
7. Privacy and Security: Implement encryption and secure storage for sensitive data. Adhere to privacy regulations and incorporate privacy features.
8. Testing and Deployment: Conduct extensive testing for performance and reliability. Deploy system in controlled environment and gather user feedback.

Software and Hardware required

Software:

1. Programming Languages and Libraries: Python with OpenCV, TensorFlow, or PyTorch.
2. Face Recognition Algorithms: Deep learning-based (e.g., CNNs) or classical methods (e.g., Eigenfaces).
3. Database Management: SQL or NoSQL databases for storing encoded facial templates.
4. Web Development Tools (Optional): HTML/CSS, Flask, or Django for web-based interfaces.
5. Encryption and Security Tools: Implement encryption techniques for data protection.

Hardware:

1. Webcams: High-quality webcams for capturing facial images.
2. Computing Hardware: CPUs or GPUs for processing face recognition algorithms.
3. Servers or Cloud Services: Hosting the system and databases.
4. Network Infrastructure: Reliable internet connectivity for real-time monitoring.

MODULES

Head Pose

The best way the supervisors use to detect abnormal behavior is the check where the examinee is looking, we use the same concept in this project to detect the direction/angle of the head of the examinee. The major challenge is the computer vision algorithm used to detect the face using the images data as well as the direction of the head, such algorithms usually require large amounts of training data as well as discrete graphic hardware to work properly.

We tackle this problem by using third party open- source algorithms from *MediaPipe* library by google which is designed to work on low end devices with accuracy at par. The *MediaPipe* library provides accurate face landmarks, these face landmarks are then processed by the Perspective-n-Points algorithm implemented with help of an open computer vision library to provide the 3D orientation of the user's head.

Previous Cheat	X axis	Y axis	Audio cheat	Final Cheat Percentage
0	0	0	0	0
0	0	0	1	0.2
0	0	1	0	0.2
0	0	1	1	0.4
0	1	0	0	0.1
0	1	0	1	0.4
0	1	1	0	0.15
0	1	1	1	0.25
1	0	0	0	0
1	0	0	1	0.55
1	0	1	0	0.55
1	0	1	1	0.85
1	1	0	0	0.6
1	1	0	1	0.85
1	1	1	0	0.5
1	1	1	1	0.85

Fig. 3: MatPlot graph detecting the probability of cheating based on variables such as head tilt and audio recognition

Matplot Graph

If the user is looking right or left then the value of x-axis changes. If the user is looking left then it goes to the negative side of zero and if the user looks right then the value goes to the positive side of zero. And similarly, if the user looks up or down then the y- axis value changes. The values of x-axis and y-axis are then passed through an algorithm which checks whether it goes above the threshold then it changes the flag.

Audio Detection

Speech is one of the communication mediums through which one can gain assistance for exams. We assume that the examinee is sitting in a quiet room with no one around. The major challenge in speech detection is false identification, since there might inheritably be some kind of sound in the environment, identifying it as assistance or not-assistance is a major challenge. We have tackled this issue with an audio processing algorithm developed in house. It detects the changes in amplitude of the background noise. It detects frequency of changes of amplitude relative to idle noise value to infer whether the examinee is or his accomplice is talking.

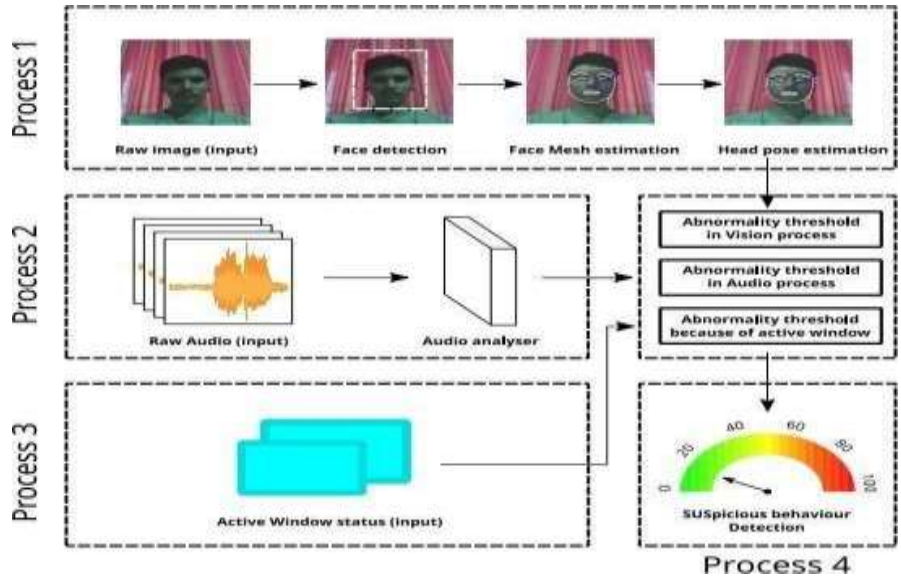

Fig. 4: Three processes. Face detection, audio detection and screen view act simultaneously to detect cheating

RESULTS

Our developed online proctoring system represents a significant advancement in the realm of remote examination supervision. This system has been meticulously crafted to provide a comprehensive solution for monitoring and authenticating students during online exams, thereby upholding the integrity of the assessment process. Leveraging a combination of cutting-edge technologies including facial recognition, screen recording, and behavioral analysis, our system ensures a thorough examination environment where cheating behaviors can be identified and deterred effectively.

Through rigorous testing and validation procedures, we have demonstrated the robustness and reliability of our system in accurately detecting suspicious activities while maintaining user privacy and accessibility. Notably, our system has been designed with a user-friendly interface, making it easy for both administrators and examinee to navigate.

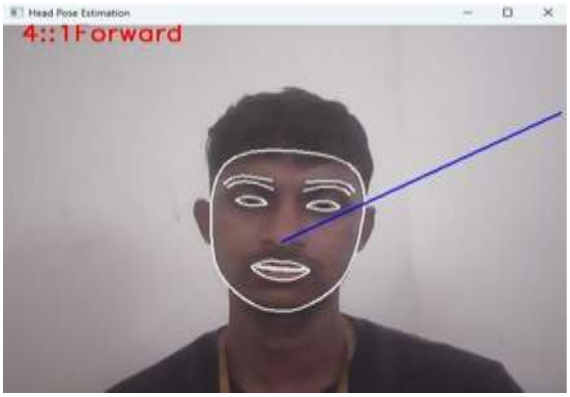

Fig. 5: Head pose algorithm to detect face behaviour detection

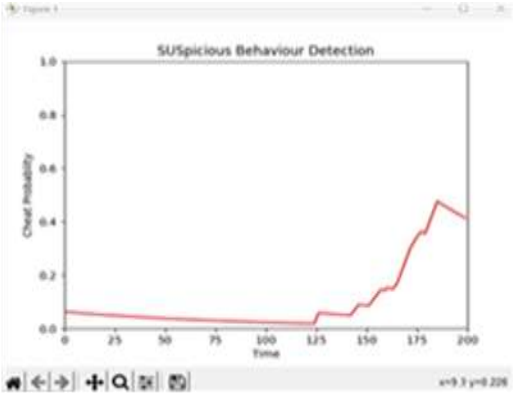

Fig. 6: Graph for detecting suspicious movements

CONCLUSION AND FUTURE ENHANCEMENTS

This system is one of the popular revisited topics due to pandemic and the need for people to conduct online tests. This system aimed to detect whether the user is showing suspicious paper using Video and audio output. During the making of the system, we used various machine learning algorithms for head pose detections and successfully implemented head pose estimation using computer vision as well as speech detection using microphone. We successfully developed a system which can detect suspicious behaviour and it is a light weight, low resource consuming system.

This paper presents a multimedia analytics system for online exam proctoring, which aims to maintain academic integrating e-learning. The system is affordable and convenient to use from the text taker's perspective, since it only requires having two inexpensive cameras and a microphone. With the captured videos and audio, we extract low-level features from six basic components: user verification, text detection, speech detection, active window detection, gaze estimation**.** These features are then processed in a temporal window to acquire high-level features, and then are used for cheat detection.

Future scope

Educational institutions and corporate organizations across the world had gradually begun the process of adopting online proctoring software over the past decade to conduct remote examinations in a fair manner and ensuring that the candidates gave the exam in a known environment. Due to the COVID-19 Pandemic, it has become the need of the hour to leverage remote proctoring platforms to conduct seamless tests while also ensuring that the candidates do not indulge in malpractices during these online exams. (Remote Proctoring, 2020). There are numerous benefits to any organization when they conduct any assessment via remote proctoring instead of the traditional pen-and-paper based method. Scheduling exams becomes easier as there is no need to set up specific testing centers to conduct examinations.

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the exam on a massive scale without worrying about maxing out the capacity of the examination centers. (Arora, 2021).

However, a sincere effort needs to be made for developing proctoring technologies to ensure that the level of online examinations is at par with offline examinations in all aspects; be it integrity of marks scored, ensuring candidates do not get involved in wrongdoings etc. Social perception of the masses towards online exams also needs to be changed and they must be made aware of the benefits for the same. The issues while designing an AI-based proctoring system as discussed by above need to be tackled with the use of existing technologies. Advancement of technologies will no doubt be beneficial for constructing more robust and secure systems but currently, anticipating the growing need for this software; a conscious effort needs to be made to enable existing technologies in mitigating the issues that exist. (Pimple, 2021).

Any proctoring software needs to accurately establish the identity of the person giving the examination. Impersonation is a big threat to the sanctity of the online exams and hence, various methods are being employed to ensure that the designated person is the one giving the examination. Proctoring

software ask every candidate to submit some personal information or proof of identity which is then verified before allowing the candidate to proceed. Certain systems have begun employing biometric authentication via fingerprints through the fingerprint scanner which is now readily available on mobile phones or laptops nowadays.

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