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COMPUTER VISION IN E-LEARNING: ENSURING EXAM INTEGRITY AND LESSON ENGAGEMENT

Abstract. In today's rapidly evolving online education landscape, maintaining the integrity of examinations and ensuring active student engagement is of utmost importance. Global events like the pandemic have spotlighted the urgent need for strong safeguards for online learning platforms. This paper addresses the escalating challenge of academic dishonesty in online exams by proposing an innovative real-time face counting and identity verification system. This research focuses on the development and implementation of a system that leverages Python-based facial recognition tools and cutting-edge computational techniques to accurately detect, count, and verify faces in real-time video streams. By utilizing the OpenCV and face recognition libraries, the system not only ensures that only authorized individuals are present during online exams but also monitors their attention levels, contributing to the enhancement of exam integrity. Through comprehensive testing, this paper demonstrates the system's high accuracy and swift processing, establishing it as a promising solution for real-time monitoring in online examinations and virtual meetings.

Keywords: Facial Recognition, Face Counting, Online Proctoring, E-Learning, Real-Time Video Analysis, Exam Integrity, Convolutional Neural Networks (CNN).

I. Introduction

In educational and professional settings, maintaining exam integrity and lesson engagement is essential. Any exam can contain possibilities for cheating and e-learning is not an exception. According to a survey in [1], online exam cheating was self-reported by a substantial (44.7%) of students in total. Before the COVID-19 pandemic, 29.9% of students reported cheating, but during the pandemic, the percentage increased to 54.7%.

The integrity of online examinations is more than just an academic concern; it underpins the credibility of entire educational institutions. Widespread cheating in online settings can devalue digital certifications and it's essential to combine conventional cheating detection methods with modern digital monitoring and verification techniques to ensure the integrity of assessments in online examinations [2].

As online education surges in all parts of the world, especially post-global shifts like the COVID-19 pandemic and it's here to stay, ensuring authentic assessment becomes essential. Thus, exploring technological solutions, such as real-time focus tracking, is vital to preserving the reputation and efficacy of digital learning platforms.

The research problem concerns the increasing need for effective methods to guarantee the honesty of participants in online exams. Traditional surveillance methods require intensive labor, are potentially intrusive, and are not scalable. An automated real-time solution using video streams could address this challenge.

However, implementing such a solution is not without its challenges. Above all, accurately detecting and analyzing objects in real time through video requires advanced computational techniques [3]. This involves counting and identifying the number of faces in the video frame and detecting someone's focus through slight changes in their eyes and face. This functionality is essential in online exams to verify that only authorized individuals are present and to monitor their attention levels. Furthermore, algorithms that can detect small changes in the ocular and facial features will be required in order to follow a person's focus. For the online exam or meeting to run smoothly, these algorithms must be both accurate and efficient in order to avoid any lag or delay.

In this work, we try to answer the following questions:

- How can Python-based facial recognition tools be effectively utilized to design a system for real-time face counting and identity verification in online exams?
- What are the practical challenges and effectiveness of using these tools for accurate real-time face counting and verification in varied examination settings?

The aim of this research is to develop a system for efficient face counting and identity verification in real-time video streams, enhancing the integrity and effectiveness of online exams and virtual meetings and ensuring accuracy and compatibility across various platforms.

Objectives of the research are:

1. Develop and Test a Face Counting and Verification System: Create a prototype focusing on real-time face counting and identity verification in video streams. This system will utilize Python's face recognition library for its implementation.
2. Optimize Algorithms for Real-Time Processing: Fine-tune the algorithms for face counting and verification to ensure they are accurate and efficient in real time, focusing on minimizing response times and handling potential delays.
3. Evaluate in Controlled Scenarios: Test the system's effectiveness in simulated online exam environments. This includes assessing its reliability and the accuracy of face counting and verification functionalities.

II. Literature review

The transformation of education in the 21st century has shifted learning from classrooms to online platforms. While early instances of computer-assisted education date back to the 1960s with the University of Illinois using interconnected terminals, the real surge in e-learning began in the 1980s. The University of Toronto introduced the first online course in 1984, and by 1989, the University of Phoenix launched the first all-online academic institution, starting the modern era of e-learning [4]. As technology continued to evolve and global connectivity became more pervasive, the importance and reliance on online modes of communication and examination grew exponentially [5]. Today, they are integral to the educational landscape, enabling greater accessibility, flexibility, and opportunities for learners worldwide.

While traditional methods presented limitations, the advancement of technology introduced new opportunities for exam monitoring in online spaces. Early implementations banked on basic motion detection or rudimentary screen activity analysis. However, as the technology matured, more sophisticated solutions arose that utilized a blend of facial recognition, eye-tracking, and behavioral patterns to assess engagement [6]. These systems not only offered a higher accuracy in detecting distractions but also ensured real-time feedback, making it feasible to prompt users immediately [7].

The integration of facial recognition and eye tracking has revolutionized focus detection in online platforms. Facial metrics are powerful indicators of attention, supported by numerous studies [8]. Similarly, eye movements - saccades, fixations, and blink rates—offer insights into a learner's engagement. For instance, increased blink rates may hint at dwindling focus or fatigue. Together, these metrics provide a comprehensive view of focus, shaping the future of attentive online learning.

Yet, the true potential of these metrics is realized when paired with advanced computational methods. In recent years, machine learning (ML), particularly image processing algorithms, has taken center stage in refining and enhancing attention tracking. By training on prepared datasets, ML models can discern patterns and correctly implement drowsiness, head pose, and emotion detectors [9]. The integration of ML enhances the precision of focus detection by adapting to individual learning behaviors. By analyzing vast amounts of data, ML models can identify unique engagement patterns. In [10], the authors concluded that using SVM behaved best and showed an accuracy of 76.4% in classifying student engagement. Sample images are displayed in Figure 1. However, like any evolving technology, the use of ML in attention tracking has had its successes and challenges, which have been explored in the study [11].

Figure 1. Sample photos from the dataset (first line: “Engaged”; second line: “Not Engaged”)

Despite the remarkable advancements in attention tracking, there remain pressing challenges. One of the most significant is the data privacy and ethical concerns. The collection and analysis of facial and eye movement data raise questions about how this information is stored, shared, and utilized, potentially leading to data misuse.

III. Methodology

In this section, we will provide how the dataset will be acquired, the overall design process, and implementation using the Python language.

A quantitative research approach will be employed to evaluate the accuracy of face counting and the rate of face verification. Video data will be sourced from high-resolution web cameras. Each video will be approximately 30 minutes long at 30 frames per second, and examining a frame once in 5 seconds would give a total of about 500 frames per exam.

For the purpose of face detection and counting, we will utilize the OpenCV library coupled with the Python face_recognition library. These libraries provide access to robust methods for real-time face detection. OpenCV will handle frame extraction and initial image processing, while face_recognition will perform the actual face detection and counting within each frame.

Post-face detection, the face_recognition library, which uses Convolutional Neural Networks (CNNs), will facilitate the face verification process. We will leverage the library's built-in models, which are pre-trained on large datasets, to compare detected faces against a database of pre-registered student faces.

A. Design process.

The process starts with a student uploading his/her picture to the system prior to the examination start. The system will use a webcam during the examination process to capture the student and this video stream will be fed to our system. The overall verification system can be seen in Figure 2.

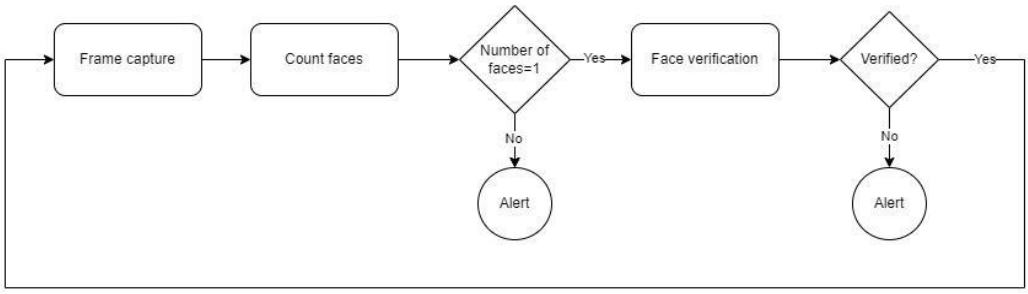


Figure 2. Overall process

B. Implementation

The system starts operating from frame capture, implemented using the OpenCV library. A Python script initiates access to the webcam feed, capturing frames at a rate that balances the need for real-time analysis with computational efficiency. The frames are captured at a resolution that ensures clear visibility of the examinee's face while considering bandwidth constraints, which may be a concern in various network conditions.

Upon frame extraction, the system uses the face_recognition library to detect the presence and count of faces within each frame. Utilizing the library's default CNN-based model, the code counts the number of faces, storing the data for each frame in a time-stamped log.

For frames where exactly one face is detected, the system proceeds with the verification algorithm. The captured face is encoded into a set of measurements and compared against the encoded representations of pre-registered student faces. A match threshold is defined to ensure accuracy while minimizing false negatives.

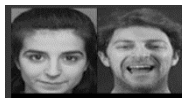
If the face count exceeds one or the verification process fails, the system triggers an alert. The alert mechanism logs the event and, if configured, notifies the exam supervisor. This can be integrated with the institution's examination management system for real-time alerting.

IV. Simulation Results

The testing phase of our facial recognition system was conducted primarily using static images, as opposed to live webcam feeds of real students. The static images were taken from the ORL dataset, and combinations were made to test the face counting. Each image is in grayscale and has dimensions of 92x112.

In Table 1, a small sample of calculations are indicated. It shows that the faces locating feature of face_recognition was able to correctly count the faces in the images and also identify when there is no face in the frame. In total, out of 400 images, 100 different combinations were made, and, in all cases, the correct number of faces was found.

Table 1. Examples of face count results

No	Image	Result
1		5
2		2
3		1
4		0

The facial recognition system was tested with 50 different images of 10 different people (Table 2) featuring subjects under various conditions, such as closed eyes, lateral glances, and wearing glasses. The system successfully verified the subject's identity in all cases, demonstrating a high level of accuracy.

Table 2. Examples of face verification results

No	Frame image	Student image	Verification	Result
1			Verified	Correct
2			Verified	Correct
3			Not verified	Correct
4			Verified	Correct

Table 3. Accuracy and time of experiments.

Experiment	Number of Images	Execution Time (s)	Accuracy (%)
Face Count	100	0.041	100
Face Verification	50	0.043	100

The implementation and testing of the proposed face verification and face counting system have yielded promising results, demonstrating 100% accuracy in both functionalities. The average runtime for each process is approximately 0.04 seconds, underscoring the system's potential for real-time applications, particularly in online exam proctoring (see Table 3). The quick processing time and high accuracy position the system as a viable solution for real-time monitoring without causing significant disruptions or delays in the exam process.

The foremost area for future research will be to rigorously test and enhance the scalability of our face verification and face counting system. Given its potential application in large-scale online examinations, it is crucial to ensure that our system can efficiently handle the load of multiple users simultaneously without any degradation in performance or accuracy. This will involve exploring advanced computational techniques, such as cloud computing resources and algorithm optimization for parallel processing, to support many concurrent exams. Ensuring scalability will address a significant bottleneck for deploying such systems in real-world settings and is essential for maintaining the integrity and smooth operation of online examinations at scale.

VI. Conclusions

This work represents the contribution to the important task of preserving exam integrity and promoting active engagement within the field of online education. With the help of advanced computational approaches and Python-based facial recognition tools, a real-time face counting, and identity verification system has been developed that shows promise in solving these problems. By accurately detecting, counting, and verifying faces in real-time video streams, this system offers a powerful tool to ensure the credibility and efficacy of digital learning platforms. Our study lays the foundation for a comprehensive approach to maintaining exam integrity while monitoring participant attention levels, making it adaptable to diverse educational settings. The primary direction for future research will be centered on conducting a scalability assessment to ensure our system can robustly handle the demands of large-scale online examinations.

Mainly, this work contributes to the ongoing efforts to protect the integrity of online education, by using technology to raise academic honesty and enhance the value of digital certifications, ultimately benefiting educators and learners in the digital age.

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ЭЛЕКТРОНДЫҚ ОҚЫТУДАҒЫ КОМПЬЮТЕРЛІК КӨРУ: ЕМТИХАННЫҢ ТҰТАСТЫҒЫН ЖӘНЕ САБАҚҚА ҚАТЫСУДЫ ҚАМТАМАСЫЗ ЕТУ.

Аңдатпа. Қазіргі онлайн білім берудің қарқынды дамып келе жатқан кезеңінде емтихандардағы тұтастықты сақтау және студенттердің белсенді қатысуын қамтамасыз ету өте маңызды. Пандемия сияқты жаһандық оқиғалар онлайн оқыту платформалары үшін мықты қауіпсіздік шараларының шұғыл қажеттілігіне назар аударды. Бұл мақала нақты уақыттағы беттерді санау және бет-әлпетін куәландыратын инновациялық жүйені ұсына отырып, онлайн емтихандардағы академиялық әділетсіздіктің күшеюін қарастырады. Бұл зерттеу нақты уақыттағы бейне ағымдарында беттерді дәл анықтау, санау және тексеру үшін Python негізіндегі бет-әлпетті тану құралдарын және алдыңғы қатарлы есептеу әдістерін пайдаланатын жүйені әзірлеуге және енгізуге бағытталған. OpenCV және бет-әлпетті тану кітапханаларын қолдану арқылы жүйе онлайн емтихандар кезінде тек уәкілетті тұлғалардың қатысуын қамтамасыз етіп қана қоймайды, сонымен қатар емтихандағы тұтастықты жақсартуға үлес қоса отырып, олардың зейін деңгейін бақылайды. Кешенді тестілеу арқылы бұл мақала жүйенің жоғары дәлдігі мен жылдам өңделуін көрсетеді, оны онлайн емтихандар мен виртуалды жиналыстарда нақты уақыттағы бақылау үшін перспективті шешім ретінде ұсынады.

Түйін сөздер: Бет-әлпетті тану, бетті санау, онлайн-прокторинг, электронды оқыту, нақты уақыттағы бейне талдау, емтихан тұтастығы, конволюционды нейрондық желілер (CNN).

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КОМПЬЮТЕРНОЕ ЗРЕНИЕ В ЭЛЕКТРОННОМ ОБУЧЕНИИ: ОБЕСПЕЧЕНИЕ ЦЕЛОСТНОСТИ ЭКЗАМЕНОВ И ВОВЛЕЧЕННОСТИ В УРОКИ.

Аннотация. В сегодняшнем быстро развивающемся мире онлайн-образования поддержание целостности экзаменов и обеспечение активного участия студентов имеют первостепенное значение. Глобальные события, такие как пандемия, привлекли внимание к острой необходимости в надежных гарантиях для платформ онлайн-обучения. В этой статье рассматривается растущая проблема академической нечестности на онлайн-экзаменах, предлагая инновационную систему подсчета лиц и проверки личности в реальном времени. Это исследование сосредоточено на разработке и внедрении системы, которая использует инструменты распознавания лиц на основе Python и передовые вычислительные методы для точного обнаружения, подсчета и проверки лиц в видеопотоках в реальном времени. Используя библиотеки OpenCV и распознавания лиц, система не только гарантирует присутствие во время онлайн-экзаменов только уполномоченных лиц, но также контролирует уровень их внимания, способствуя повышению честности экзамена. Благодаря всестороннему тестированию этот документ демонстрирует высокую точность и скорость обработки данных системы, что делает ее многообещающим решением для мониторинга в реальном времени на онлайн-экзаменах и виртуальных собраниях.

Ключевые слова: распознавание лиц, подсчет лиц, онлайн-прокторинг, электронное обучение, анализ видео в реальном времени, целостность экзамена, сверточные нейронные сети (CNN).