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Work In Progress: Side-Facing Cameras and Remote Proctoring Integrity

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I'm of Afro-Caribbean descent and spent most of my life raised on the beautiful islands of St. Kitts and Nevis. I am a double Gator at the University of Florida with a B.S. in Computer Science and am currently pursuing a Ph.D. in Human-Center Computing. I aim to conduct research that examines and produces technologies that support learning. This is incredibly important as the pace of technologies often advances without concern for the experiences of people of color.

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Work In Progress: Examining a Side-Facing Camera Arrangement to Increase Remote Proctoring Integrity

Introduction

As post-secondary institutions offer more hybrid and online classes, more students are taking online courses and programs [1]–[3]. These courses are also becoming a more common part of the education of traditional student populations [4]. As such, it is important to address challenges and provide support for secure remote assessments of student content mastery [5].

A major benefit of online learning is the flexibility in time and access [6]. Some remote proctoring services use automated artificial intelligence to provide examinees with flexible test windows [7]. However, instructors view remotely proctored exams as less effective at preventing cheating as they perceive it allows more opportunities to cheat [8], but the use of remote proctoring is growing as online learning proliferates [9]. During COVID-19 we saw a surge in the use of remote proctoring as restrictions were in place that prevented in-person testing [10], [11]. This surge in users, both on the student and faculty end, has highlighted concerns about the application of remote proctoring. One of these concerns is the effect of remote proctoring on students [10], [12]. There is work that indicates this form of assessment increases negative emotions experienced by students such as testing anxiety [10], [12] which may impact students' performance. As such, our goal is to increase the trustworthiness of remote exams while also creating a more comfortable testing environment for students.

Remote proctoring services discourage cheating through the use of technological safeguards [13], [14]. However, these safeguards provide a limited view of the examinee and their environment [15]. To address these limitations, we have introduced the use of a side-facing camera that displays the examinee's head, torso, and arms. This allows us to monitor the student and their environment throughout the entire exam which should make the examinee's testing behaviors more obvious. We believe this expanded view should increase the integrity of the test and the comfortability of students during remotely proctored exams. In Spring 2021, we surveyed three groups of students and found that students who implemented the side-facing camera commented they had no preference for camera orientation. Students also cited difficulty in the setup of the side-facing camera. In the Fall of 2021, we modified our approach to better understand the impact this difficulty has on students. Our follow-up survey had similar results to our previous study where some students do not have a strong preference but still perceived the side-facing camera setup as difficult. We will continue to assess if the side-facing camera arrangement can be easily implemented and the effects this arrangement has on students.

Background

Remote proctoring uses the examinee's computer to allow a proctor to monitor the examinee's video and audio feed through the internet [16], [17]. During the exam, the examinee may be monitored by a human proctor, an artificial intelligence (AI) Proctor, or some mixture of both [10], [15]. While a human proctor may be used, most of the safeguards we will discuss rely on artificial intelligence to ensure secure testing environments. The safeguards used for remotely

proctored exams are to ascertain the examinee's identity [18] and to ensure the examinee will not be able to access unauthorized materials during the exam [16], [19]. At the start of the exam, the examinee will need to complete a check-in that verifies their identity [17], [20] and may also be required to scan the room they are completing the exam in [10]. The room scan gives the proctor/exam issuer a view of the examinee's environment before their exam. During the exam, the proctoring service or exam issuer may utilize a locked-down browser to restrict access to unauthorized computer resources [16]. Additionally, the examinee is also monitored throughout the exam by the AI proctor by utilizing gaze-tracking and head-tracking [21]. If the student displays behaviors the AI proctor determines are consistent with cheating the exam may issue a soft interrupt, which alters the examinee of their behavior, or a hard interrupt that requires that the examinee correct their behavior before continuing their exam [22]. It is important to note that how these services truly carry out these safeguards is unclear as these are safeguarded as proprietary.

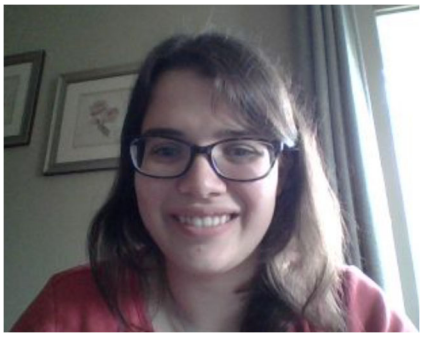

Figure 1. View using front-facing camera.

These proprietary head- and gaze-tacking rely on the orientation of the examinee's front-facing camera (Figure 1). An examinee may be flagged if they look away for too long, if their head is out of frame, or if the AI detects the face of someone else [10], [23]. As remote proctoring has grown, so too has the broad dissemination of circumvention techniques [24], [25]; as a result, remote proctoring services also incorporate proprietary safeguards to prevent direct manipulation of detection measures [16]. The front-facing camera limits the camera view to the examinee's head and shoulders. Because of this limited view, there is no way to detect changes between the room scan and the actual exam. The examinee may have unauthorized material that is unseen during the room scan but accessible during the exam such as in a desk drawer [26], [27]. The discourse online encourages students to imitate the natural eye and head movements to access material undetected. Side-facing cameras may provide a viable solution to these limitations while also increasing the comfortability of students by allowing more natural testing behaviors.

Prior research has investigated the use of environment cameras to monitor the assessment environment [15], [27]. However, these solutions have been implemented using costly specialty devices. Additionally, these studies do not make use of the existing remote proctoring services. By comparison, the side-facing camera arrangement uses a standard web camera. Our prior work identified approaches to integrate external web cameras with existing remote proctoring services [14]. In this arrangement, the camera serves as both an environment and identity camera and allows the proctor to see and monitor the examinee's head, torso, arms, and desk (Figure 2). The wider field of view ensures the integrity of the testing environment. For example, if the examinee reaches out of the camera's view, it can be detected.

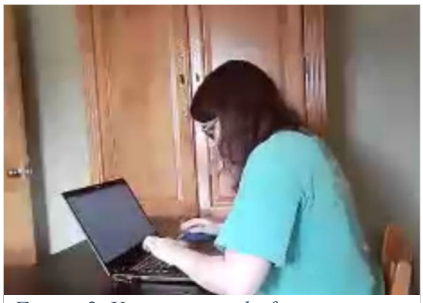

Figure 2. View using side-facing camera.

Methods

In our work, we explore our primary research question: **how do students' perceptions vary between the front-facing and side-view camera arrangements?** We conducted an initial study in Spring 2021 and a follow-up in Fall 2021 to answer

this question. Participants included 268 students from the Discrete Structures class – a required lower-division Computer Science course, 39 students from AI for Games – an upper-division elective Computer Science course, and 25 students from Design Patterns – a lower division elective Computer Science course. In the follow-up study, 12 students participated from Operating Systems – an upper-division required course.

In the Spring of 2021, we conducted a study to understand students' perceptions of front-facing and side-facing camera arrangements. We recruited students from two courses, AI for Computer Games and Discrete Structures. Students received extra credit for participation. The courses were selected as they used different camera arrangements; AI for Computer Games used the side-facing camera, while Discrete Structures used the front-facing camera. Participants were asked to complete the pre-survey which contained demographic questions, free-response questions, and two 7-point Likert questions to assess their preference of camera arrangement and a free-response question asking them to explain their answer (Table 1). After their exam, students were asked to complete a post-survey with similar questions to the pre-survey. The study design and surveys were classified as exempt by the Institutional Review Board (IRB) of the university.

Table 1 Likert questions to gauge student opinion of the camera arrangement.

Q1	Rate your agreement with these statements. - On a remote online assessment, I prefer / think I would prefer a front-facing camera orientation to a side-facing (profile) camera orientation.
Q2	Rate your agreement with these statements. - On a remote online assessment, I prefer / think I would prefer a side-facing (profile) camera orientation to a front-facing camera orientation.

We also provided students with instructions for the side-facing camera arrangement. These instructions asked students to: (i) place the camera approximately 12 inches above the desk, (ii) have the camera in line with their keyboard, (iii) place the camera so that it was an arm's length away, and (iv) place the camera approximately 45-degrees away from their torso. We found that with these instructions, the examinees' hands would be always visible as well as ensuring that the camera would display the examinee's head, torso, hand, and keyboard as seen in the figure to below (Figure 3).

We included the responses from all participants who completed the pre- and post-surveys. We assessed the Likert questions by converting them to numbers (0-7), and we inverted the value of the side-facing preference. We then calculated the mid-point of the front-facing preference and the inverted side-facing preference. A mid-point of 0-4.9 preferred side-facing, 4 was neutral, and 4.1-7 preferred front-facing. We qualitatively coded free responses using the approach described by Auerbach and Silverstein [21]. A second researcher coded 10% of responses to compute inter-rater reliability. The average agreement between coders was Cohen's kappa = 0.5560, which is characterized as ***moderate agreement*** [28]. After analyzing the preliminary results from the pre-surveys, we planned an experiment where we felt we could ascertain more reliable comparisons. Students were recruited from the Design Patterns course and were instructed that they would need an external USB camera as they would be using both the front-facing and side-facing camera arrangements. We randomly assigned

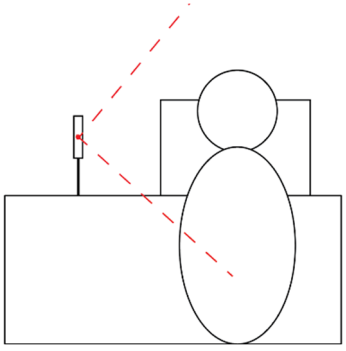

Figure 3. Side camera field of view.

students to use either the front-facing camera arrangement and then side-facing or vice-versa for two consecutive quizzes. We used the same pre- and post-surveys to collect data and the same codebook to qualitatively analyze the results as we did in our initial study.

Figure 4 View from modified front-facing

After analyzing student responses from all three groups, we noted that students who had implemented the side-facing camera arrangement often said it took a lot of time. For our next experiment, we investigated and compared student opinions of the side-facing camera and a modified front-facing camera arrangement. The modified front-facing camera arrangement used an external camera to give an elevated view of the examinee. Students were instructed to place the camera directly behind their computer screen and at least six inches above their direct line of sight. This arrangement of the camera showed the examinee's head, face, torso, and upper arms as seen in the figure to the right (Figure 4). We reasoned that the modified front-facing camera arrangement would present a comparable level of difficulty to set up when compared to the side-facing camera arrangement.

Students from the online section of the Operating Systems class were invited to sign up before their final exam and were then emailed their instructions. Students were randomly assigned to use either the modified front-facing or the side-facing camera arrangement. After their exam, the students were made aware of the instructions available to the other group of students and then asked to complete a post-survey. The post-survey asked demographic questions and Likert questions to record their perceptions and attitudes about their experience. These were similar questions to the three previous student groups and evaluated using the same.

Findings

In our analysis, we qualitatively coded student responses and summarized preferences by course (Figure 5). Across all groups, students were often reported as having a neutral opinion, as such the following focuses on the other codes.

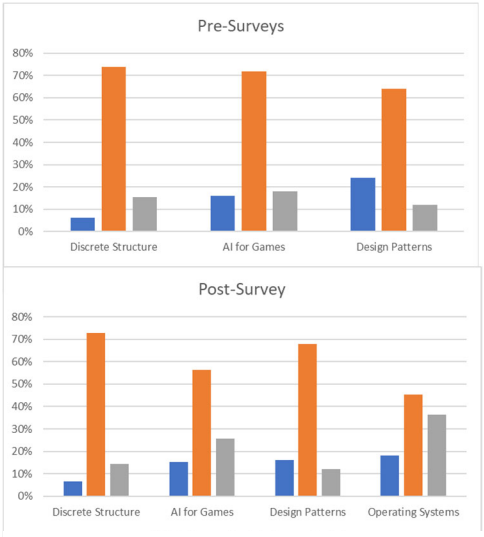

Figure 5 Student preferences by class.

Discrete Structures Group: On the pre-survey, students said they preferred the front-facing option because they had used it previously or because it was easy to use. On the post-survey, these sentiments remained as seen in the table above. One the pre-survey, some students (n=7) also expressed willingness to try the side-facing camera approach. For example, one student said, "I have never experienced a side-facing camera orientation for proctoring so I would prefer what I am already comfortable with as of now. If… it was better then [sic] I would change my mind."

AI for Games Group: AI students were most often concerned about the difficulty needed to set up and use

the side-facing camera, the cost of an external camera, and that the side-facing camera would disrupt testing immersion. On the post-survey, more students said they felt the side-facing camera was better at detecting cheating, and more expressed no opinion or preference about the camera arrangement compared to pre-survey responses. One student stated, "I have no problem… as long as it does not flag me for doing normal things."

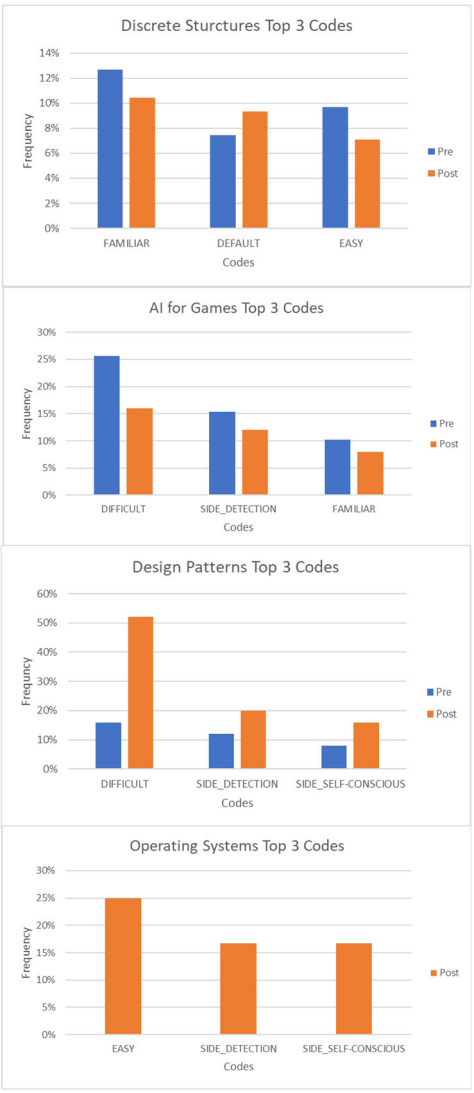

Figure 6 Student code breakdown by class.

Design Patterns Group: Students most frequently said the side-facing camera arrangement seemed difficult on the pre-survey. Some (n=3) also noted the invasiveness of the side-facing camera. Students also expressed that the side-facing camera would be better at detecting cheating which was a sentiment we saw an increase on the post-survey. Additionally, on the post-survey, we saw an increase in responses that expressed difficulty in setting up and using the side-facing camera as well as concerns over how their physical appearance when using the side-facing camera. One student stated, "Using a side-facing camera just added extra steps and things … could go wrong… I might have knocked the camera during the exam."

Operating Systems Group: For our study in Fall 2021, recruited 12 participants. For the Likert questions on camera arrangement preferences, four students rated the front-facing and side-facing camera arrangement equally. The most common codes were for responses coded as having no preference or for preferring the ease of the front-facing camera. Students also commented that the side-facing arrangement provided better cheating detection and testing immersion. In response to how they felt about the ease of use when compared to the camera arrangement the alternate group had, one student stated, "A bit stressful since I had to reorganize furniture ..."

Discussion

The preliminary findings from Spring 2021 continue to shape our work. We used these results to identify potential challenges to deploying side-facing cameras as we aim to create a fair and comfortable testing environment. On the survey, participants in all groups favored the front-facing camera. Students cited diverse reasons for their preferences within the courses.

Lack of familiarity with a side-facing camera arrangement played a significant role in student responses. This was most pronounced in the Discrete Structures class participants, most of whom had never used a side-facing camera. For example, one wrote, "I don't really have a preference besides being used to a front-facing webcam". In other words, some students stated a preference

for the front-facing camera because they had no other experience. In comparison, the participants of the AI for Games class, who were required to use the side-facing camera, less often cited familiarity. This suggests that the Discrete Structures participants may prefer front-facing due to the novelty of the side-facing camera which can present an additional challenge that may add to concerns in remote proctoring such as technical difficulties and test anxiety [10], [23].

Students who used the side-facing camera arrangement frequently noted the difficulty and time required to set up the proctoring environment. One student in the AI for Games class said, “Front facing is slightly more convenient since I don't have to move my camera back and forth between positions, but … it does not really matter to me”. A student in Design Patterns similarly noted, “The side profile takes longer to set up, and it also gives more of a feeling of being watched.” Crucially, the front-facing camera setup required no setup; as our findings showed, challenges in setting up the proctoring environment played a role in student perceptions. To account for this, we crafted the Operating Systems class study to incorporate a setup for the front-facing camera. Participants in this course were also online program students, so even before the pandemic, they were familiar with remote proctoring arrangements; for them, it was not a temporary measure. Likely, as a result, a larger percentage of the participants expressed a neutral or side-facing arrangement preference compared to those in our previous study, and they raised more nuanced concerns. Participants who used the side-facing camera in the Operating Systems class noted that they had physical limitations for setting up the camera such as a lack of space/furniture. For example, one said, “I had to rearrange my desk to make space for the side-facing camera”. In contrast, physical limitations were hardly mentioned with students using the modified front-facing camera arrangement. Some students also specifically mentioned that the transition from the room scan back to the side-facing camera meant they could not ensure the camera orientation was still correct. After the room scan, there was no way for students to validate the angle and positioning of their camera. However, across all groups of students who used the side-facing camera arrangement, many stated that the side-facing camera was better at detecting cheating despite citing difficulties in setup. One student said it was “less convenient and accessible, but… more meaningful in a proctoring environment.” A few students also made comments that support that the side-facing created a more comfortable environment as it allows more natural testing behaviors such as looking down to use scratch paper. One student stated, “With front facing cameras … I'll always move out of the view… which have not affected me in in-person exams.” The responses indicate that even without prompting, many students recognize the promise of side-facing camera arrangement in deterring unethical behavior, which motivates further study.

Future Work and Limitations

Our work lays fertile ground for future research in remote proctoring. However, there are limitations within our work. Other than the Operating Systems group, all the students surveyed were using remote proctoring due to the restrictions set in place due to the COVID-19 pandemic, which likely introduced additional friction into the process. Our sample sizes were also limited in size and scope. Future work will address larger classes and the post-pandemic context. Our future work will also examine how student perceptions vary if the camera setup is provided for students, rather than requiring students to set up the camera themselves. Additionally, while there is the perception that side-facing cameras have a cheating-deterrence effect, future work could explore whether this perception matches up with student behavior in real proctoring settings.

Future efforts may also concentrate on the development of algorithms to detect cheating behavior via side-facing cameras.

Conclusion

As online education becomes more commonplace, so does the need for trustworthy and comfortable remote proctoring. The front-facing camera arrangement limits cheating detection to behavior within the view of the head and shoulders. The side-facing camera expands the view of the camera to capture the examinee's head, torso, hands, and keyboard. This arrangement shows promise in detecting behaviors consistent with cheating. To investigate perceptions of side-facing cameras, we conducted a study where we surveyed four different groups of students to examine their perspectives and views on the side-facing camera when compared to the front-facing camera. Our work so far has supported our hypothesis as students in all groups that tested with the side-facing camera consider it to be better at detecting cheating. However, there are still difficulties in the deployment of the side-facing camera arrangement as it relates to students' ability to set up and maintain the camera arrangement throughout the exam. Students also overall preferred a front-facing camera. Our ongoing work seeks to reduce the difficulties students experience and further delve into what informs students' preferences and perceptions. Our work aims to lay the foundation for a practical and affordable deployment of a remote proctoring arrangement to increase trust in the results of these exams and increase student comfort.

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