JOURNAL OF
EMERGING INVESTIGATORS

Article

Artificial intelligence face-tracking for a semi-virtual reality gaming experience

Oren Pipano[1], Valerie Pipano[2], Monica Higgins[1]
[1] Friends Select School, Philadelphia, Pennsylvania
[2] Offices of Valerie Pipano, Attorney at Law, Philadelphia, Pennsylvania

SUMMARY

Virtual reality (VR) and VR-like experiences are important because they create immersive environments that can enhance learning, training, and community in new ways. We explored the effect of artificial intelligence (AI) face-tracking technology on the immersiveness of video games. AI face-tracking works by tracking horizontal movements of a player's head that allows for rotation of the game point of view based on the player's head position. Virtual reality offers the most immersive gaming experience but is out of reach for many players because of the high cost of VR goggles. We hypothesized that AI face-tracking offers a semi-VR experience at a lower price. To determine if applying AI face-tracking technology increases immersiveness, we conducted two experiments on participants to consider both subjective and objective criteria. For the subjective test, participants played a video game both with and without AI face-tracking and rated each experience. For the objective test, participants played a different video game with a loud sound and flash of light. They were randomly assigned to one group with or without face-tracking. We monitored changes to heart rate with Fitbit devices to approximate the immersiveness the player felt. Players who experienced the "scare" in the game with face-tracking had a higher average increase in heart rate compared to those who played the game without face-tracking. In the subjective survey, we saw that participants felt more immersed with the face-tracking. Our data suggests that AI face-tracking technology increases the immersiveness of gaming and offers a more cost-effective alternative to VR.

INTRODUCTION

Virtual reality (VR) offers great stress relief and social connection for students; however, it is often inaccessible due to its high cost. As of 2024, VR goggles like the Meta Quest 3S and HTC Vive Pro 2 Headset cost approximately $300 to $500 (1). When building a spaceship video game, artificial intelligence (AI) face-tracking technology was applied to give the game a semi-VR feel. This system tracks the horizontal movements of a player's head with a built-in or webcam laptop camera and rotates the game point of view based on the player's face position (2). This system offers a cheaper alternative to goggles because it uses technology often already owned by the user. Most laptops have a built-in cameras and external cameras can be bought for approximately minimum cost of $40 (3).

We tested whether an AI face-tracking system offered a more immersive video gaming experience, as measured by increased average heart rate and user opinion, compared to playing a video game without the AI face-tracking system. We hypothesized that using AI face-tracking technology in video games offers a more immersive experience than a standard video game (4). This hypothesis was based on having played the video game designed with AI face-tracking technology and thinking that it had a semi-VR feel. Heart rate changes can reflect the degree to which a person is absorbed in an experience, the data supports that the heart rate change of those players who used the AI face-tracking technology would be greater than those who did not (5).

To test this hypothesis, we conducted two experiments. The first collected subjective data via a survey from player's playing a game with and without the AI face-tracking system. The second, objective, test looked at player's heart rates during an intense moment in a different video fame and how they differed between playing with or without the AI face-tracking. Both subjective and objective tests are important for a fuller understanding of the subject matter (6). The subjective test showed that participants preferred the immersive experience of a video game using AI face-tracking technology. The heart rate data from the objective test indicated that test participants were more immersed in the gaming experience using this technology. Overall, our data supports the hypothesis that the use of AI face-tracking technology in video games would create a more immersive experience. The results of these experiments could allow video game players who cannot afford VR goggles to still enjoy an immersive gaming experience at home.

RESULTS

To test the hypothesis, we conducted two experiments on each test participant. Test #1 was subjective. Test participants were asked to play the spaceship video game both with the AI face-tracking technology turned on and off. They then completed a survey rating the experience on a scale of 1 to 5 based on a series of subjective criteria including immersiveness and if they wished other games used this feature.

Test #2 measured changes to the heart rate of players via a Fitbit. A new video game was built in which the player used controls to direct themselves through a dark maze. Unknown to the participants, after 60 seconds there was a loud noise and flash of light designed to create a scare and an accompanied increase in heart rate. Each player only played one version (AI face-tracking on or off) that was decided

JOURNAL OF
EMERGING INVESTIGATORS
https://doi.org/10.59720/24-204

randomly. Heart rate data was collected and compared to see if the participants playing the AI face-tracking version of the game had a greater increase in heart rate, indicating that they were more immersed in the game.

In Test #1, 83.3% of the 18 participants experienced greater immersion levels using the AI face-tracking technology (score ≥ 4) **(Figure 1)**. Without AI face-tracking applied, only 11.2% of the 18 participants felt immersed or very immersed in the game (score ≥ 4) **(Figure 2)**. 83.3% of surveyed participants also preferred or strongly preferred having AI face-tracking technology in more games that they played (score ≥ 4) **(Figure 3)**. Only 5.6% would prefer games without this technology (score ≤ 2) **(Figure 3)**. The AI face-tracking technology did not significantly increase the feeling of control in the game. **(Figure 4)**.

In Test #2, participants who played with AI face-tracking had a more volatile heart rate throughout the maze game, indicating a more engaged and immersive experience. When the "scare" occurred in the game with AI Face-Tracking, participants had a significantly higher average increase in heart rate of 10.83 bpm compared with 3.16 bpm among those who played the standard game (*t*-value = 2.647, *p* = 0.05, **Tables 1-2)**.

DISCUSSION

AI face-tracking technology has a positive impact on immersiveness in gaming and may be a more cost-effective alternative to VR. For Test #1, participants subjectively reported higher levels of immersion when using the technology. Without AI face-tracking applied, only 11.2% of participants felt immersed or very immersed in the game. With the technology applied, 83.3% of participants felt immersed or very immersed. 83.3% of surveyed participants also preferred or strongly preferred (score ≥ 4) having AI face-tracking technology in more games that they played. Only 5.6% would prefer games without this technology (score ≤ 2). These percentages demonstrated that subjectively people felt more immersed with the AI face-tracking turned on.

In Test #2, participants who played with AI face-tracking experienced more rapid heart rate changes throughout the game, indicating increased engagement and immersiveness **(Table 2)**. Before the "scare," an average of each participant's heart rate was measured. This period before the scare also allowed participants to become more accustomed to the game. The AI face-tracking group of participants had an average increase in heart rate of 10.83 BPM compared with 3.16 BPM among those who played the standard game when the "scare" occurred. Relying on a previous study that established heart rate as an indicator of immersion, showing the increase in heart rate demonstrates that playing video games with AI Face-Tracking delivers a more immersive gaming experience (6).

Both the objective and subjective tests strongly suggest that the use of AI face-tracking creates a more immersive experience than standard video games. This suggests that it is a possible alternative to virtual reality. The use of this AI face-tracking system only needs a camera to track a user's face, also making it cheaper than most virtual reality goggles (4).

Possible errors could be present in our results from

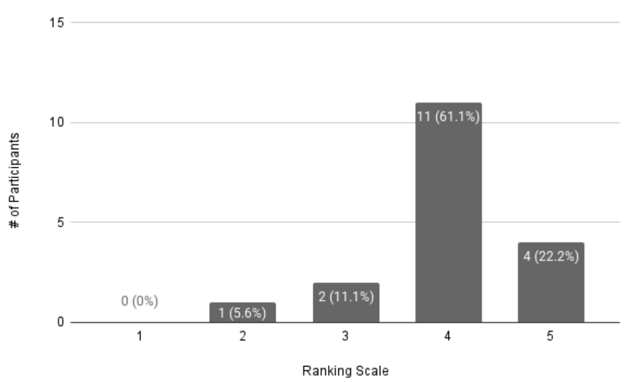

Figure 1: Participant ranking of "immersiveness" with face-tracking following gameplay with and without face-tracking. Levels of immersiveness with face-tracking. Participants were asked to answer this question after first playing the video game with and then without the AI face-tracking system so they would have a basis for comparison. One on the scale represented minimal to no immersion. Five represents high immersion.

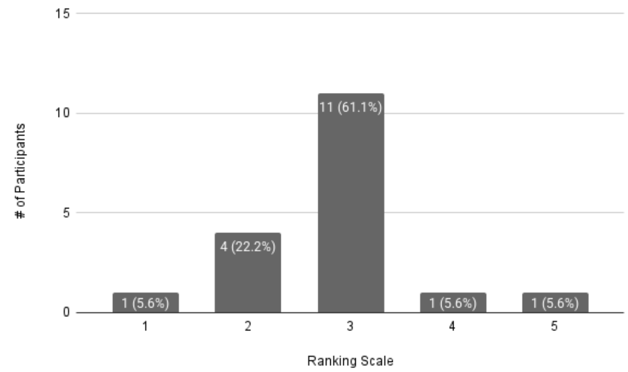

Figure 2: Participant ranking of "immersiveness" without face-tracking following gameplay with and without face-tracking. Shows responses to levels of immersiveness without face-tracking. Participants were asked to answer this question after first playing the video game with and then without the AI face-tracking system so they would have a basis for comparison. One on the scale represented minimal to no immersion. Five represents high immersion.

	Base Heart Rate (BPM)	"Scare" Heart Rate (BPM)	Change in Heart Rate (BPM)
Participant #1	69	70	1
Participant #2	69	70	1
Participant #3	58	59	1
Participant #4	82	89	7
Participant #5	99	103	4
Participant #6	65	70	5
		Average Change (BPM)	**3.17**

Table 1: Change in heart rate without the AI Face-Tracking. Base heart rate in beats per minute (BPM) of the participant without the AI face-tracking. This heart rate was found by taking the average heart rate after the first 59 seconds. This table also shows the "scare" heart rate. Taking the "scare" heart rate and subtracting the base heart rate the table displays the change in heart rate without the AI face-tracking.

JOURNAL OF
EMERGING INVESTIGATORS

https://doi.org/10.59720/24-204

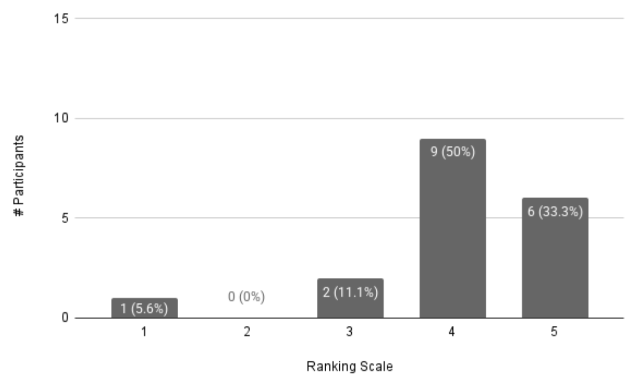

Figure 3: Participant ranking of "desire to play the game" following gameplay with and without face-tracking. Participants were asked to answer this question after playing the video game with and without the AI face-tracking system. One on the scale represents little desire to play other games with face-tracking. Five represents extreme desire to play other games with face-tracking.

human bias in the subjective test or misreading or rounding of the heart rate when tracked by the Fitbit device in the objective test. The relatively small sample size (18 for the subjective test and 12 for the objective test), could also result in error. We consulted a cardiologist, and she recommended additional testing on heart rhythm and heartbeat irregularities might also be informative. However, this testing would require instruments that are not available to us.

Further research may be done to explore other indicators of immersion beyond heart rate that can be used in testing, including recording brain activity and eye tracking. Additional possible areas of research include exploring what other low-cost immersion techniques exist that may be applied to gaming and conduct a comparison to AI face-tracking.

MATERIALS AND METHODS

Participants

This study was approved by a scientific review committee and all participants gave informed consent before participating in any test. As a safety precaution, potential participants were provided a warning in advance of these experiments on the Consent Form and people with a history of epilepsy, nausea or conditions of similar nature were not encouraged to participate. Participants were drawn from peers in school, teachers, neighbors, extended family and friends. It was conducted in Philadelphia, Pennsylvania. A total of 18 people participated. Most, if not all, of the participants were people who have experience playing video games and/or have tried VR technology. Prior to any tests, participants were read the same prepared explanation of the purpose of the experiment and how to play the games.

The majority of participants took part in both tests; however, six participants did not give consent for heart rate tracking and were excluded from Test #2. Participants represented a broad range of ages, gender identities, and races/ethnic groups. For the protection of privacy, no identifiable information was collected or retained for either experiment.

Test #1 (subjective test)

Test participants were asked to play a spaceship video game both with the AI face-tracking technology turned on and off. They then completed a survey that asked participants to rate the experience on a scale of 1 to 5 based on a series of subjective criteria including immersiveness with and without AI face-tracking, if they wished other games used this feature, and if they felt they controlled the spaceship better with face-tracking turned on. These questions were chosen to record the participants' subjective feelings of immersion and enjoyment of the game while the face-tracking was on and off. One on the scale represented minimal to no immersion, little desire to play other games with face-tracking, or little to no effect of the face-tracking on control. Five represented, high immersion, extreme desire to play other games with face-tracking, or high effect of the face-tracking on control. The results of the subjective rankings completed by test participants were analyzed by averaging the percentages provided in the various categories.

Test #2 (objective test)

Participants wore a Fitbit Charge 6 (Cat# GA05195-WW) device that tracked and measured changes to heart rate. For this experiment, a new video game was built in which the player used controls to direct themselves through a dark maze. This game was made with Unity and C# and included the same AI face-tracking technology as the first game. The AI face-tracking technology can be turned on and off. The player only played one version decided randomly. Unknown to the participants, when the game was played for 60 seconds there was a loud noise and flash of light designed to create a scare and an accompanying increase in heart rate. Then the Fitbit's online heart rate graphs were collected and compared to a collected base heart rate data taken before the "scare" to see if the participants playing the AI face-tracking version of the game had a more significant increase in heart rate, indicating that they were more immersed in the game.

The AI face-tracking system can be used on any laptop or computer that has a camera that can see the player's face. It works by running a python script that first turns on the camera, then using OpenCV, detects the player's face (7). The script sends the center coordinates of the face

	Base Heart Rate (BPM)	"Scare: Heart Rate (BPM)	Change in Heart Rate (BPM)
Participant #7	106	119	13
Participant #8	76	80	4
Participant #9	59	62	3
Participant #10	93	114	21
Participant #11	72	84	12
Participant #12	92	104	12
		Average Change (BPM)	**10.83**

Table 2: Change in heart rate with the AI Face-Tracking. Base heart rate in beats per minute (BPM) of the participant with the AI face-tracking. This heart rate was found by taking the average heart rate after the first 59 seconds. This table also shows the "scare" heart rate with the AI face-tracking which is the peak heart rate of the participants 60 seconds after the game was started and when the "scare" was delivered. Taking the "scare" heart rate and subtracting the base heart rate the table displays the change in heart rate with the AI face-tracking.

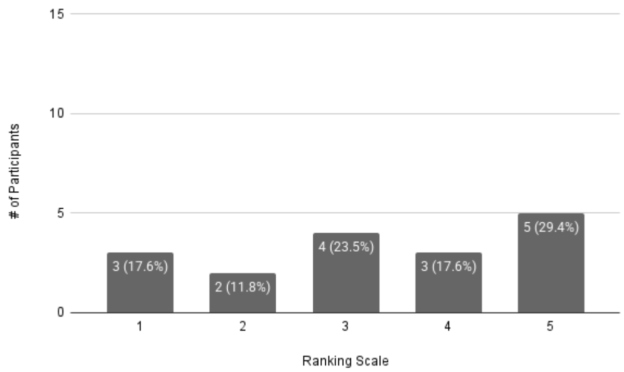

Figure 4: Representation of questionnaire measuring the subjective parameter "feeling that they controlled to" following Test #1 – spaceship gameplay. Participants were asked to answer this question after playing the video game with and without the AI face-tracking system. One on the scale represents little to no effect of the face-tracking on control. Five represents the high effect of the face-tracking on control. One response is missing because a participant decided to end the test early.

into the game software, which was written in Unity C#. The coordinates, relative to the horizontal position of the computer screen equate to local horizontal rotation of the first-person camera of the in-game avatar.

Statistical analysis

Statistical analysis was performed on the results of Test #2. We used a two-sample, two-tailed, *t*-test with a significance level of 0.05. The test was performed in Google sheets.

Received: July 9, 2024
Accepted: December 31, 2024
Published: December 22, 2025

REFERENCES

1. Brewster, Signe. "The Best VR Headset." The New York Times, 11 July 2018, www.nytimes.com/wirecutter/reviews/best-standalone-vr-headset/. Accessed 9 Nov. 2024.
2. Yilihamu, D., *et al*. "A Real-time Face Tracking and Recognition System Based on SeetaFace." *Journal of Physics: Conference Series*, vol. 1673, no. 1, 1 Nov. 2020, https://doi.org/10.1088/1742-6596/1673/1/012043.
3. "NexiGo N60 1080P Webcam with Microphone, Adjustable FOV, Zoom, Software Control & Privacy Cover, USB HD Computer Web Camera, Plug and Play, for Zoom/Skype/Teams, Conferencing and Video Calling." Amazon, www.amazon.com/Microphone-NexiGo-Computer-110-degree-Conferencing/dp/B088TSR6YJ. Accessed 9 Nov. 2024.
4. Pallavicini, F. and Alessandro Pepe. "Comparing Player Experience in Video Games Played in Virtual Reality or on Desktop Displays." *CHI PLAY'19 Extended Abstracts of the Annual Symposium*, https://doi.org/10.1145/3341215.3355736.
5. Stefanidou, C. and Skordoulis, C. "Subjectivity and Objectivity in Science: An Educational Approach." *Advances in Historical Studies*, 3, 183-193, 2014. https://doi.org/10.4236/ahs.2014.34016.
6. Roy, M.J., *et al*. "Heart Rate Response to Fear Conditioning and Virtual Reality in Subthreshold PTSD." *Studies in Health Technology and Informatics*, vol. 191, 2013, pp. 115-9. PMID: 23792855.
7. Radski, G. The OpenCV Library. Dr. Dobb's Journal of Software Tools. 2000.