How horror games featuring eye-tracking mechanics influence player's in-game behavior pattern

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ABSTRACT

Eye-tracking technology has become a major area of interest within the gaming industry, with both players and the market exhibiting a high level of focus on this emerging technology. The aim of this thesis is to explore the impact of incorporating eye-tracking mechanics into horror games on player behavior. To achieve this goal, a 3D horror game was developed with gaze input, and the resulting data was analyzed. The findings suggest that the use of gaze input can significantly impact the player's perception of the game space and the overall effectiveness of the input method. These results offer valuable insights into the potential applications of eye-tracking technology in the design of video games.

Keywords: eye-tracking, gaze-controlled, horror game, game development, immersion

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1. INTRODUCTION

Eye-tracking technology is an innovative addition to the gaming industry, enabling players to control and interact with games using their eye movements. This emerging technology offers a unique way to play games, revolutionizing the gaming landscape. Eye-tracking games allow players to interact with the game solely by using their eyes, controlling the camera, aiming at targets, and selecting options with ease. Such games offer a more immersive and engaging experience, allowing players to become fully immersed in the game world. While eye-tracking technology has been available for some time, it has only recently become more affordable and accessible to the general public, resulting in a rise in eye-tracking games, with new titles being developed and released regularly. To provide a better gaming experience, supplementary equipment such as head-stabilized and remote eye tracking has been invented, in addition to the webcam-based eye tracking used in this research.

This study aims to compare the effect of eye-tracking technology on gameplay, particularly in first-person horror games. To achieve this, we designed a game specifically for playtesting, in which participants used both eye-tracking technology and traditional controls. The game, a simple horror game, was controlled using both a traditional controller and eye-tracking equipment. Two playtest levels, including a tutorial level, were conducted, and we collected participants' responses through surveys and interviews to assess the impact of eye-tracking technology on the game. The objective of this research is to explore the potential benefits and limitations of eye-tracking technology in gaming and to identify its potential for future game development.

2. BACKGROUND

Horror games have been a popular genre in the gaming industry for years, offering players immersive and spine-chilling experiences. However, many horror games rely on traditional scare tactics such as jump scares and gore, which can become predictable and lose their impact over time.

In recent years, eye-tracking technology has emerged as a new way to enhance the horror game experience. Eye-tracking games use specialized cameras to track the movement of the player's eyes and adjust the game accordingly. For example, if the player looks away during a tense moment, the game may respond by changing the environment or triggering a jump scare in a different location. This technology has the potential to create more personalized and immersive experiences for players, making horror games even more frightening and engaging.

Research has shown that eye-tracking technology can indeed enhance the gameplay experience in horror games. A study by researchers at the University of Portsmouth found that eye-tracking technology could be used to increase the level of fear in horror games by customizing the scares based on individual players' eye movements. The study also revealed that

eye-tracking technology could be used to create a more immersive and interactive gameplay experience.

As technology continues to improve, we can expect to see more horror games that incorporate eye-tracking technology to create even more intense and personalized scares. The potential of eye-tracking technology in horror games is exciting, and it will be interesting to see how developers continue to innovate and push the boundaries of this technology in the future. With the integration of eye-tracking technology, horror games could become even more terrifying and thrilling, providing players with a truly unique gaming experience.

2.1 Horror games

The horror game genre is designed to create a frightening and terrorizing experience for players through the use of horror fiction.[1][2] Unlike other video game genres that are primarily defined by their gameplay mechanics, horror games rely on narrative and visual presentation to create a chilling atmosphere. Horror games are typically classified into several genres, including survival horror, action horror, psychological horror, jump scare horror, and reverse horror. Some of the most well-known and acclaimed horror games include Resident Evil and Silent Hill PT. For instance, the latest installment of Resident Evil, Resident Evil Village, sold over 5.7 million units in just one year.[3] These games employ a variety of gameplay mechanics to immerse players in the horror experience, with the aim of evoking fear and terror in the player.

2.2 Eye-tracking

Eye tracking is a technology that enables the measurement of eye position and movement relative to the head. It involves using an eye tracker device to track and record the direction and position of eye movement.[4] This technology has found applications in several fields, including visual system research, psychology, psycholinguistics, marketing, and product design. In addition to these applications, eye tracking can also be used as an input device for human-computer interaction, and for rehabilitation and assistive purposes. For instance, eye tracking technology can be used to control wheelchairs, robotic arms, and prostheses, thereby enabling people with physical disabilities to interact with their environment and carry out daily tasks.

2.3 Eye-trackers

Eye-tracking technology has a long history, with its origins dating back to the late 1800s and early 1900s, when psychologists and neuroscientists began studying eye movements. Early eye-tracking methods involved basic techniques such as measuring the reflection of light from the cornea or using electrodes to detect muscle movements around the eyes.

Today, there are three main methods for measuring eye movements with eye trackers. The first method involves using a contact lens with a specially designed sensor that is attached to the eye.[5] This sensor can detect changes in the shape of the cornea as the eye moves, allowing the tracker to measure the rotations of the eye.The second method uses optical tracking, which does not require direct contact with the eye.[6] This method involves using cameras to track the position and movement of the eye based on changes in light reflection or the pupil's size and shape.The third method involves measuring electric potentials using electrodes placed around the eyes. These electrodes detect changes in the electrical signals generated by the eye muscles as they move, allowing the tracker to measure the direction and speed of eye movements.

These methods have advanced significantly over the years, with modern eye trackers now capable of measuring eye movements with high accuracy and precision. Eye-tracking technology has many practical applications, from scientific research to commercial marketing and product design, and it continues to evolve and improve with new innovations in technology.

2.4 Eye-tracking games

The use of eye-tracking technology in computer gaming has the potential to benefit all players, including those with disabilities. Eye trackers can enhance the gaming experience by providing a more challenging and immersive experience, which can be adjusted in real-time based on the player's gaze behavior.[7] By tracking a player's eye movements, games can offer more personalized and engaging experiences.[8] For example, a game could increase the difficulty level if it detects that a player is getting bored or not paying enough attention, or it could offer hints or clues based on where the player is looking. [9]Eye tracking can also allow players to interact with their environment using only their eyes, such as aiming in a shooter game, selecting options in a menu, or exploring a virtual world. While the mainstream gaming industry may not currently accommodate eye-tracking technology, if benefits were found for all players, mass-market products may become more prevalent. The use of eye tracking in gaming can result in benefits for all players and further improve the design of game environments, while people with disabilities can benefit from increased availability and lower costs of eye trackers.

3. GAME DESIGN RESEARCH METHOD

3.1 Overview

To create an immersive horror experience and investigate the effect of eye-tracking mechanics on player behavior, we developed a 3D horror game where players must escape a ghost island. The game requires players to avoid enemy attacks and collect three keys to escape. The study followed a between-subjects design, with participants randomly assigned to either a control or experimental group. The control group used only a controller as an input method and

had a fixed flashlight at the center of the screen, while the experimental group used both a controller and eye-tracking mechanics to control the direction of the flashlight.

To track participants' eye movements, we utilized a webcam. The objective of our research was to examine how the addition of eye-tracking mechanics impacts a player's in-game behavior pattern. Eye-tracking mechanics allow players to use their gaze to control the direction of the flashlight. Our findings can provide insight into the impact of incorporating eye-tracking mechanics into horror games, and potentially influence the design of future horror games to enhance the player experience.

3.2 Methodology

3.2.1 Participants

We randomly selected 24 students from Northeastern University, 11 of whom were female and 13 were male, aged between 22 and 25, to participate in our study. Participants were divided into two groups: a control group consisting of 12 participants, and an experimental group consisting of 12 participants. Each participant was assigned to play the 3D-horror game.

3.2.2 Procedure

3.2.2.1 Playtesting (Tutorial Level)

The initial playtesting phase involves a tutorial level designed to gauge participants' interest in a 3D horror game with eye-tracking mechanics and help them become familiar with gaze control. The tutorial level is intended to last for two minutes, during which time participants will be given basic instructions on how to control the game. If any participants feel uncomfortable during the playtest, they are free to stop playing at any time.

3.2.2.2 Playtesting (Formal Level)

The second formal level playtest is conducted after the tutorial level playtests, with the aim of testing participants' experience of the game and how eye-tracking mechanics influence their in-game behavior. During this section, each participant will play the same formal level for a maximum of 15 minutes or until they successfully escape from the island. The purpose of this longer playtest is to allow participants to fully immerse themselves in the game and experience how the eye-tracking mechanics affect their gameplay over a longer period of time.

3.2.2.3 Survey

After completing the playtests, participants are asked to complete a survey to provide feedback on their in-game experience. The survey includes a 5-point Likert scale questionnaire, which measures various dimensions of player experience such as positive affect, negative affect, competence, flow, challenge, immersion, and tension. The survey is administered through

Google Forms. Component scores are calculated by taking the average value of their corresponding items.

3.2.2.4 Interview

To gather more qualitative data, participants are invited to take a 15-minute post-play interview after completing the survey. The interview will follow a designed protocol to ask more detailed questions about their experience with the game and their thoughts on the eye-tracking mechanics. As an incentive to participate, all participants will be entered into a lottery to win a $50 Steam gift card at the end of the experiment.

4. GAME DESIGN

4.1 Narrative Design

The game is set in an otherworld where the player assumes the role of an investigator who must collect three target keys to escape back to the real world. Once all three keys are collected, the game concludes with an ending where the player successfully returns to the real world.

4.2 Mechanic Design

The game's core mechanics rely on eye-tracking, specifically the flashlight mechanic, which is crucial not only for in-game exploration but also for enemy combat. Players must use the flashlight carefully and strategically to overcome various challenges throughout the game.

- Eye tracking mechanic (Flashlight):
    - Control: The player can use gaze input to control the flashlight.
    - Features: The flashlight has a limited amount of electricity and will eventually run out of power. To continue using the flashlight, the player must find and pick up spare batteries located throughout the game scene.
    - Enemy-related mechanic:
        - In the game, several shadow monsters are wandering around the towns, and the player needs to use the flashlight to defend against them. Each shadow monster has a specific patrolling route and a unique detection zone. When the player enters the monster's detection zone, the monster will start chasing the player. The conventional weapons are ineffective against the shadow monsters, but the player can temporarily freeze the monsters by shining the flashlight on them. After the monsters freeze, the player can escape and continue with their objective.
        - The towns contain several petrified monsters that are guarded by supernatural forces. These monsters are activated and attack the player if

they are hit by the flashlight too many times. To avoid this, players need to carefully use the flashlight to hit the mystery only when necessary. Otherwise, the monster will remain inactivated and harmless to the player.

4.3 Level Design

The level layout is shown in the following figure.

Figure 1: Basic Level Layout

Map Label	Event Summary	Event Details/Design Logic	Approx. Difficulty (1-10)	Approx. Time
A	Players start the level from here.	Players play the tutorial level and learn the basic gameplay mechanics. Players can get basic information and goals of the level.	3	2:00

B	Players face a crossroad.	Players can turn left and enter the town directly. Players can turn right and they will find a house with an axe (weapon) and a battery (supply) in it.	1	3:00
C	Players enter the town.	The red light is placed in the scene to provide guidance to the players.	1	3:20
D	Players walk through the church.	Three shadow monsters and one petrified monster are placed in this section.	5	4:00
E	Players explore and get the first key.	“Whisper” audio guidance is created as a 3D sound hint to help players locate the first key. Three shadow monsters and one petrified monster are placed in this section.	6	7:00
F	Players use the key to open the gate.	Players move to the next section.	1	8:00
G	Players explore and get the second key.	Three shadow monsters and one petrified monster are placed in this section.	5	9:00
H	Players explore and get the third key.	Three shadow monsters and one petrified monster are placed in this section. Players need to use the flashlight to explore the bungalow.	5	12:00
I	Players explore the “village section”. (optional)	Five shadow monsters and two petrified monsters are placed in this section. Players can get additional weapons and supplies in this section.	8	14:00
J	Players open the gate and escape successfully.	Players collect all three keys and escape from the town by helicopter successfully.	1	15:00

The level layout with light guidance is shown in the following figure.

Figure 2: Level Layout with Lights

5. QUANTITATIVE RESULTS

The results of the game experience questionnaire showed a very positive game experience in both control group and experimental group. For both groups, most notably flow ($M_{Control}$ = 4, $M_{Experimental}$ = 3.58) scored high. As expected, negative affect ($M_{Control}$ = 1.67, $M_{Experimental}$ = 1.75) and tension ($M_{Control}$ = 1.5, $M_{Experimental}$ = 1.67) dimensions scored low, indicating a very pleasant game experience.

Additionally, movement control, flashlight control, and movement accuracy also scored high in both groups. However, after running the t-test, we found that there are three components with p-value less than 0.05, which are flashlight accuracy, shadow monster positive affect, and immersion.

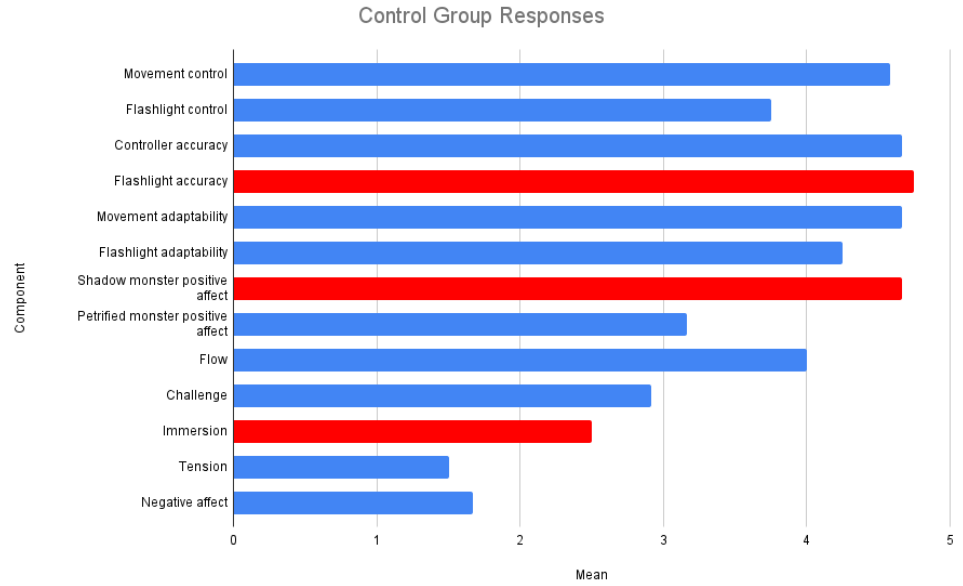

Figure 3: Control Group Survey Responses

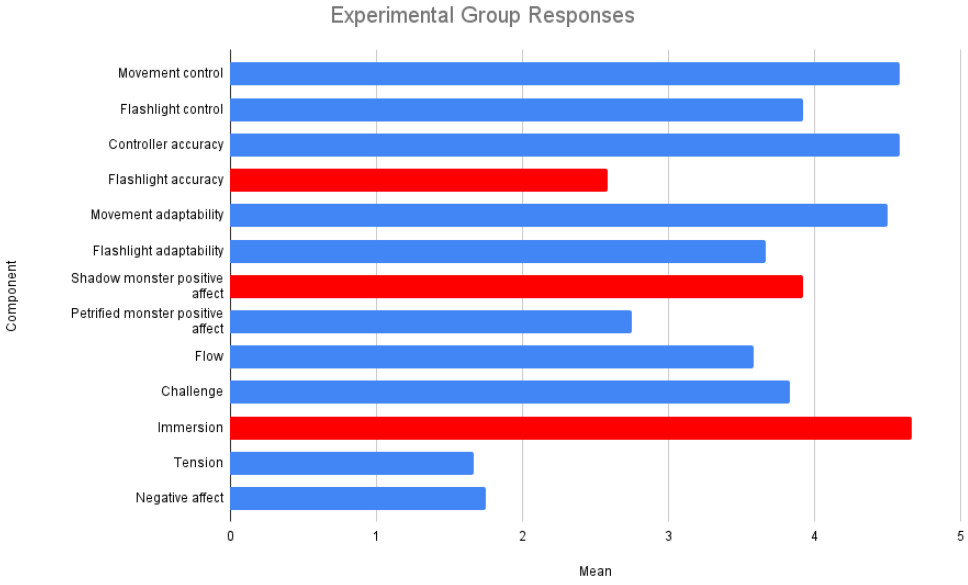

Figure 4: Experimental Group Survey Responses

6. QUALITATIVE RESULTS

6.1 Interaction and Perception Patterns in the Control-group Version

6.1.1 Integrality of Movement and Flashlight

The results indicate that participants in the control group experienced difficulties adapting to shining flashlights on the shadow enemy while in motion. Of the twelve participants, eight reported that it was challenging to adjust both their gaze and the light direction simultaneously while still learning the flashlight mechanic at the start of the game. As an example, A2 stated, "*Sometimes I unintentionally focused on the enemy, when I really just wanted to explore other directions.*"

Moreover, players tended to perceive movement and flashlight as a unified system rather than separate systems. Eight out of the twelve participants mentioned that the flashlight mechanic was intertwined with the main movement mechanic. For instance, A4 explained, "*Since the flashlight is always fixed at the center of the screen, it would only shine in the direction I face. Therefore, I think the flashlight mechanic is part of the movement mechanic.*"

In addition, six out of the twelve participants expressed interest in alternative input methods to control the flashlight. For example, A5 suggested that "*It might be a good idea to separate the flashlight from the movement to provide players with more control and freedom over the flashlight.*"

6.1.2 Linear Space Perception

In the control group, players tended to view the game space as a linear path. Ten out of the twelve participants reported being more inclined to explore the primary path of the level. Three participants (A3, A7, and A8) expressed a desire to avoid potential risks. For example, A3 explained, "*As a horror game, I want to avoid any potential dangers and complete the level as quickly as possible. Therefore, I chose to follow the main path.*"

Additionally, five participants (A1, A4, A6, A9, and A11) indicated that they chose the main path because they did not find any other potential branching paths in the level. For instance, A4 stated, "*The truth is, I did not come across any other branching paths in the level. If I had found them, I would have loved to explore them.*"

6.2 Interaction and Perception Patterns in the Experimental-group Version

All players acknowledged that the flashlight mechanics with gaze input have a significant impact on their player experience.

6.2.1 Inaccuracy of Flashlight Mechanics (Gaze Input)

Out of the twelve players who participated in the experiment, nine of them reported that the flashlight controlled by gaze input was inaccurate, particularly for those with limited game experience (i.e., B6 and B9). For instance, B6 pointed out that "*Although the flashlight had a wide viewable range, it sometimes failed to follow their gaze, which was a little disruptive and required recalibration.*" Meanwhile, B9 suggested that "*fixing the flashlight at the center of the screen might be better than following their gaze.*" These remarks indicate that using a webcam-based eye-tracking system for accurately tracking small, precise movements such as those required for controlling a flashlight in a game may have potential limitations. The participants in the experimental group may have experienced difficulty due to the inherent latency and imprecision of the webcam-based eye-tracking system, resulting in decreased accuracy in controlling the flashlight.

Players with limited controller experience have reported difficulty balancing movement and flashlight control. For example, B8 stated, "Due to my lack of experience with controllers, I had to frequently check the controller. However, this caused my gaze input to become less accurate as my eyes moved between the controller and the screen."

Nevertheless, ten out of twelve players expressed interest in how the game experience could be enhanced if the input device were replaced with an eye tracker that had higher accuracy. For instance, B7 stated, "*Although my overall game experience was great, I wonder if you could substitute the web camera with a more high-resolution device, like an eye tracker. I am really looking forward to playing your game again if you use an eye tracker.*" These comments suggest that players were optimistic about the potential benefits of using more precise eye-tracking technology, and they may be more willing to engage in similar games if the input device were upgraded.

6.2.2 Separability of Movement and Flashlight

The use of gaze as the input method for controlling the flashlight appears to affect how players handle the movement of the flashlight. For instance, ten out of twelve players reported that they could quickly adapt to the movement when using the flashlight with gaze input. As an example, B7 commented, "*I find using gaze input to control the flashlight quite intuitive, and it's easy for me to control the movement when I turn on the flashlight.*" These remarks suggest that using gaze input to control the flashlight may have certain advantages in terms of ease of use and intuitive operation, which may contribute to a more enjoyable game experience.

In addition, nine out of twelve players reported that they appreciated the separation between the control of the flashlight and the control of movement, which gave them more freedom to explore the scene. For example, B11 commented, "*I think you did a great job in separating the control of flashlight from movement. Since it is a horror game, I always need to rotate the camera to make sure if any danger exists nearby, and gaze input helps me to do so easily.*" Players tended to turn on the flashlight to identify points of interest and then adjust the camera to focus on them.

However, in situations where players encountered both types of enemies (shadow monsters and petrified monsters), they tended to fix the flashlight at the center of the screen. This was because players needed to rotate their camera to position themselves appropriately to engage in combat. For example, B2 explained, "*Since I need to defeat the enemies with my weapons, I think it is wise for me to rotate my camera to position the enemies in the center of the screen.*"

6.2.3 Open-space Perception

The game design, particularly the flashlight mechanics, had a significant impact on how players perceived the game space. In the experimental group, where gaze input was used, players tended to view the game space as open rather than linear. As an example, B8 remarked, "*I feel like I can explore the scene freely as I want to. Also, I can choose different paths and routes even though the keys seem to be placed in a specific direction.*"

In addition, players in the experimental group were more likely to explore the entire map, including the "village section" that provided players with a few supplies but did not affect the game's completion. Nine out of twelve participants explored this section. For instance, B4 mentioned, "*The flexibility of the flashlight motivated me to explore the entire map. Whenever I came across something interesting or unusual, I tried to investigate it.*" In contrast, only four out of twelve participants in the control group explored the "village section."

6.2.4 Influence of Gaze Input on Audio Guidance

In the experimental group, some players were unaware of the "whisper" audio guidance. Out of the twelve participants, five did not notice the sound hint for the first key. There were various reasons for this. For instance, participant B3 explained that they were drawn to other points of interest in the game space and did not recognize the whisper guidance. In addition, participant B12 mentioned being fully engrossed in the flashlight mechanic, which caused them to miss the sound hints.

6.3 General Game Usability and Design Problems

Both versions of the game have various usability and game design issues. We will address these concerns in the next iteration based on players' feedback.

6.3.1 Bad Use of Horror Sound Effects

To create a more suspenseful atmosphere, we added several horror sound effects and background music to the game scene. However, several participants in both the control group

(five participants) and experimental group (four participants) reported that their gameplay experience was disrupted by these sound effects. For example, A7 stated, "The game used whispers as audio guidance to help players locate the keys. However, some background music was too loud, making it difficult for me to hear the whispers."

6.3.2 Unclear Lighting Guidance

Spotlights and point lights were strategically placed in the game to guide players towards key locations (i.e., places with keys) or places with supplies (e.g., batteries). However, several participants in both the control group (four participants) and experimental group (five participants) reported that the lighting was not clear, and they did not understand the significance of the different lights. For example, B9 commented, "I noticed that there were lights of different colors in the environment, but I was not sure if the different colors represented different things. Perhaps you could clarify the meaning of the different lights at the beginning of the game."

6.3.3 Petrified Monster is Too Easy

Despite being intended as a challenging enemy, both the control group (nine participants) and experimental group (eight participants) found the petrified monster to be too easy to defeat. As A7 mentioned, "Initially, I thought the petrified monsters would be challenging, but as the game progressed, I found that simply turning off the flashlight made them harmless."

7. DISCUSSION

7.1 Different Eye-tracking Mechanism in Games

Eye-tracking technology has gained increased attention in the gaming industry in recent years[13]. Several studies have investigated the potential benefits of using eye-tracking as a core mechanic in video games [14]. However, there is also interest in exploring the use of eye-tracking as an auxiliary method of play, meaning that players can choose to play the game without eye-tracking devices in another version of the game.

Our project aimed to explore whether the eye-tracking mechanic can improve the player experience [15]. Based on the playtest results, we found that eye-tracking technology has the potential to significantly enhance the gaming experience. However, the cost of implementing this technology can be a barrier to entry for many game developers.

Based on the playtest results, we found that eye-tracking technology has the potential to significantly enhance the gaming experience. However, the cost of implementing this technology can be a barrier to entry for many game developers. As discussed in our paper, using

web-cam-based eye-tracking software are not as accurate as eye-tracking devices, which can actually worsen the player experience.

7.2 Simplify the operation of the Game

One interesting finding from our study is that players using eye-tracking as the view controller in games where players need to handle different types of input can be a good choice. This allows players to focus on other controls while giving control of the camera to the eyes, which is more intuitive. This feature could be particularly useful in driving or flight simulation games where players need to manage multiple operations.

7.3 Explicit Mapping

Compared to traditional controllers, eye-tracking offers a more explicit and intuitive means of controlling the camera, allowing for greater immersion and a more natural gameplay experience.

One of the key advantages of using eye-tracking for camera control is the ability to accurately and precisely target specific objects or areas of interest within the game environment. Traditional controllers, such as joysticks or mouse and keyboard setups, rely on input from the player's hands, which can be imprecise and require more effort to achieve the desired results. Eye-tracking, on the other hand, allows for more direct and precise targeting, as the player simply needs to look at the object or area they wish to focus on.

Furthermore, we found that eye-tracking can increase the immersion of the players. Even if players choose to bypass enemies, they will still inevitably look at them to determine their location, which will activate the enemies. Players reported that this behavior is more instinctual.

We also found that players who used eye-tracking mechanics were more willing to explore the game world. One possible reason for our project is that players using eye-tracking mechanics can explore the game environment more intuitively and immersively. Game designers can use this method to increase game fun and user engagement.

However, there are also some potential drawbacks to using eye-tracking for camera control. One of the main challenges is ensuring that the system is accurate and responsive enough to keep up with fast-paced gameplay. Eye-tracking technology is still relatively new, and there may be some limitations in terms of accuracy and speed that need to be addressed.

8. FUTURE WORK

As eye-tracking technology continues to develop and become more affordable, we can expect to see more innovative uses of eye-tracking mechanics in different types of games. Game developers should continue experimenting with different types of eye-tracking software and find ways to optimize accuracy and performance to create more immersive and engaging gaming experiences for players.

For our project, we plan to improve the game mechanics in the future. Firstly, we will change the game guidance from sound to a spotlight, which makes the game mechanics more coherent with the eye-tracking method. Secondly, we will improve the eye-tracking accuracy by trying different software and conducting playtests with eye-tracking devices instead of webcams.

9. CONCLUSION

In conclusion, while the high cost of implementing eye-tracking technology is a limiting factor for many game developers, our study has shown that using eye-tracking as an auxiliary method of play can significantly enhance the player experience in certain types of games. As eye-tracking technology continues to advance and become more accessible, we believe it will continue to revolutionize the gaming industry.

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