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Building Horror Games with Facial Expression Detection to Enhance Immersion of Gameplay Experience

by

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Abstract

This thesis investigates the use of player real-time emotions to enhance the immersive experience of affecting horror games. Two game experiments were conducted, utilizing real-time facial expression data captured through a webcam. The initial game, SCP-087, triggered horror events based on the player's emotions. An improved version, "The Abandoned Hospital," introduced dynamic difficulty adjustments and incorporated player feedback. The research findings shed light on the relationship between player real-time emotions, dynamic difficulty adjustment, and the immersive horror game experience. Practical implications for designing affecting gaming experiences are discussed.

Chapter 1

Introduction

The horror genre has always captivated gamers throughout time, effortlessly evoking intense emotions and providing a truly immersive experience. With the game industry's expansion, numerous horror games have achieved remarkable success by virtue of their innovative designs and captivating player interactions. Notable titles such as Silent Hill [1], the Biohazard series [2], Amnesia: The Dark Descent [3], and Alone in the Dark [4] have all left an indelible mark, solidifying their place among the most acclaimed horror games of all time.

The horror genre, with its innate ability to evoke player emotions and create immersive gameplay experiences, has become a fertile ground for game designers to experiment with player interaction and enhance the overall gaming experience. Its unique features make it an ideal genre for designers to push the boundaries and explore innovative ways to engage players, ultimately striving to deliver an exceptional gaming experience. We also devoted myself to exploring ways to make a horror game more scary in my previous work [5].

While discussing our movie preferences, especially in the horror genre, we delved into the depths of fear and what truly terrifies us. While certain elements like dimly lit environments, well-timed jump scares, and eerie music tend to scare most people, it became evident that individuals have their own unique set of horror preferences and triggers. Some are deeply disturbed by the enigmatic presence and sudden appearances of vengeful Japanese spirits, while others are frightened by grotesque and macabre creatures with bloody and contorted forms. Dolls and toys can provoke anxiety in some, while clowns evoke spine-chilling sensations in others. Watching various horror game streamers online, I noticed that each person experienced distinct moments of terror, tailored to their specific fears. This sparked my contemplation on the idea of creating a horror game with personalized frights for each player's individual fears. Due to time and resource limitations, I have not been able to fully accomplish this goal yet. However, I am currently working on a prototype that demonstrates how this can be achieved. I plan to present this prototype at the 2023 IEEE Conference on Games [6]. This research is a step toward this ultimate goal.

In order to achieve this, capturing players' real-time emotional reactions during gameplay is essential. This necessitates the implementation of various methods for emotion detection, which can gather data on players' emotional states. Several well-established approaches exist, such as analyzing speech and voice signals, monitoring physiological signals like EEG and ECG, and detecting facial expressions, among others. After careful evaluation, We have opted to utilize camera-based facial expression

detection as the method to accomplish our goal. This decision was primarily motivated by its lightweight nature and practical usability, making it an ideal choice for our intended application.

In addition to real-time emotion detection, We have developed our own experimental horror game called SCP-087. This game revolves around an endless staircase where players descend and encounter various horror thrilling events. This work is also published [7]. It serves as an ideal platform for our research purposes due to its lack of a clear objective in terms of escape or survival. This allows us to incorporate a diverse range of horror events tailored to each player, thus testing their reactions to different triggers and enhancing the game's overall immersion.

Therefore, We designed a new game called "The Abandoned Hospital" to address the feedback and improve the player's experience. In this game, the player is given a clear objective to find a key and escape the hospital, adding a sense of purpose and direction to the gameplay. We also implemented a greater variety of events to keep the player engaged and prevent boredom. These additions aim to enhance the overall immersion and enjoyment of the game for the players.

By analyzing players' emotional responses to various in-game events, We have implemented a dynamic difficulty adjustment system in the game. This system can trigger specific events based on players' emotional states, enhance gameplay and increase immersion. So that the goal that to provide a personalized and engaging experience for each player by adapting the game's difficulty in real-time can be achieved.

Chapter 2

Related Work

2.1 Horror games

Much research on horror games aims to contribute to various fields and explore their unique aspects and effects.

First of all, studies on the psychological and emotional effects of horror games are important to understand player experiences [8]. This includes studies on fear, immersion, presence, and emotional responses elicited by horror game elements such as jump scares, suspenseful atmospheres, and frightening audiovisual cues, which helps this research to set appropriate triggers for game events.

Also, exploring factors that contribute to player engagement and enjoyment in horror games is crucial [9]. This includes investigations into game design elements such as pacing, level of challenge, narrative structures, player agency, and the balance between tension and relief. Understanding what makes horror games compelling and enjoyable for players can inform the design of future experiences.

Besides, one of these researchers Robinson explored the use of biofeedback and physiological responses to enhance the horror game experience [10]. This involves measuring physiological signals such as heart rate, galvanic skin response, and facial expressions to adapt the game in real-time, creating personalized and immersive experiences based on the player's emotional state. These types of research show us the possibility of the combination of the horror game and biofeedback system.

Furthermore, Analyzing player behavior and gameplay patterns in horror games can provide insights into player strategies, decision-making processes, and engagement levels. This includes studies on player exploration, navigation, resource management, and interaction with in-game objects and characters. Understanding player behavior can inform game design decisions and improve the overall experience. [11]

2.2 Bio-signal Detection

Real-time emotion detection in players can be accomplished through various methods, such as monitoring heart rate, breathing rate, skin conductance, analyzing brainwave activity, and detecting facial expressions [12].

Researchers have been investigating the incorporation of real-time player emotions to enhance game design and create more immersive experiences. For instance, Andrew et al. utilized the AFFDEX SDK from Affectiva to adjust difficulty levels in the popular

game Five Nights at Freddy's [13]. Similarly, Nogueira et al. conducted research on biofeedback modulation of affective player experiences in vanishing scares [14]. These studies demonstrate the potential of analyzing real-time player emotions to personalize gameplay and heighten emotional engagement in video games. etc.

These techniques allow for the capture and analysis of physiological and behavioral indicators of emotions, providing valuable insights into the player's emotional state during gameplay. By incorporating real-time emotion detection, game developers can create more dynamic and personalized experiences that adapt to the player's emotions in real-time, enhancing immersion and engagement in video games. Many of these approaches typically involve participants wearing additional devices such as smartwatches, bands, helmets, or finger clippers, which can be inconvenient and disrupt the user experience during gameplay and not common in households. To address this, a camera-based solution can be employed to capture the player's facial expressions and analyze them using algorithms. This method provides a convenient and non-intrusive way to obtain real-time information about the player's current emotions.

2.3 Affecting gameplay

There have been some research studies that have explored the possibility of incorporating real-time human biofeedback of emotions in game design. One notable example is the work of Houzangbe and his colleagues, who successfully enhanced user engagement in virtual reality (VR) horror games through the implementation of biofeedback mechanics. They conducted a study in which they integrated biofeedback sensors into a VR horror game. These sensors measured physiological signals such as heart rate, skin conductance, and facial expressions to detect the player's emotional state during gameplay. The collected data was then used to dynamically adjust the game's intensity and scare factors in real-time [15]; Dekker and Champion have researched utilizing players' biofeedback to dynamically adjust the difficulty of horror games. Their approach emphasizes the use of affordable sensors for measuring biofeedback signals, with the goal of enhancing game performance [16]. Another research related is that of Smith et al. [17], whose experiment is to assess the gameplay experience of a gaze interaction Half-Life 2 game modification. Participants played the game using eye tracking control and rated their experience afterward. These creative works give me much confidence for this research and inspired me in many ways.

Chapter 3

Method

3.1 Game Environment

3.1.1 SCP-087

SCP-087 [18] is a popular horror game developed by Haversine in 2012. It draws inspiration from the fictional Special Containment Procedures Foundation, abbreviated as the SCP Foundation, which is a collaborative project that creates a fictional organization responsible for containing and investigating paranormal phenomena [19].

In SCP-087, players explore a never-ending staircase in a dark and foreboding building. As they descend, they encounter eerie sounds and frightening paranormal occurrences. The game's simple yet suspenseful design lacks specific goals, focusing solely on the continuous exploration of the staircase's depths.

For this study, We use a similar in-house developed game. It features an infinite staircase, from which the player is unable to escape once they enter. The screenshot of the game is shown below as Figure 3.1.

3.1.2 The Abandoned Hospital

After the first experiment of SCP-087, we received valuable feedback regarding the game and The Abandoned Hospital was built. Based on this feedback, we identified areas that needed improvement. These included addressing the excessive repetition of events, extending the duration of events to make the experiment more engaging, adding a clear purpose or objective to the game, and enhancing the map design to make it more interesting. Furthermore, participants suggested introducing diverse Non-Player Characters (NPCs) that can evoke fear in different player archetypes, which could enhance the overall experience of the game. Last, but not least, they suggest improving the accuracy of the facial expression detection.

"The Abandoned Hospital" is a horror survival experience that requires players to navigate through the horror hospital environment in search of a key that unlocks their escape. Throughout their quest, players will encounter various events triggered by their in-game emotions and behaviors. The screenshot of this game is shown as in Figure 3.2.

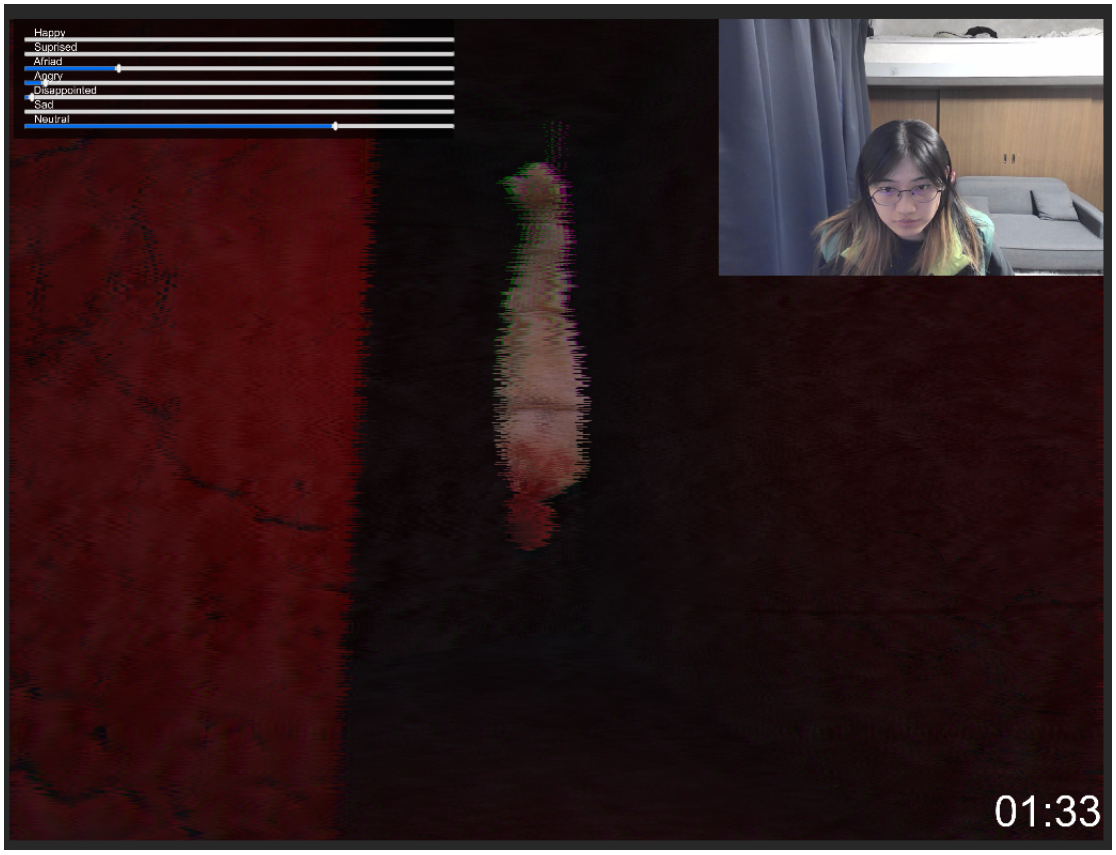

Figure 3.1: SCP-087 with Facial Expression Detection

Figure 3.2: The Abandoned Hospital with Facial Expression Detection

3.2 Game Events

3.2.1 SCP-087

In this game, We designed three levels of events shown in Table 3.2 to provide different levels of feedback to the player in real-time. Level 1 events are designed to be less intense, creating a sense of alertness and encouraging the player to pay attention to changes in the game environment. These events may include footstep sound effects, subtle screen glitches, and distant crying sounds.

Level 2 events, on the other hand, are more intense and designed to shock or scare the player in a short amount of time. These events may include jump scares, vital screen glitches, and sudden, loud sound effects.

Finally, level 3 events are designed to help the player relax and release tension. These events may include making the environment brighter and reducing the frequency of events. By providing different levels of events, We aim to create a more immersive and engaging gameplay experience that responds to the player's emotional state.
Several visual events are depicted in the Figures 3.3.

Table 3.1: Game Events of SCP-087

Event Level	**Feature**	**Events**
Level 1	Less intense, alert, attention	Footstep sound effects, subtle screen glitches, and distant crying sounds
Level 2	Intense, shock, scary	Jump scares, strong screen glitches, and sudden, loud sound effects
Level 3	Calm, relax	Lighten environment, reduce frequency of events

3.2.2 The Abandoned Hospital

This game incorporates a wider range of game events, including those essential to the plot as well as events designed to evoke players' emotions. To create a creepy and dramatic atmosphere, We have included various sound and light effects. Additionally, We have introduced four distinct types of events tailored to different player preferences: the appearance of Japanese movie female ghosts at windows, the presence of a wandering zombie lady, the eerie presence of a clown accompanied by unsettling sounds, and a dark room filled with creepy masks. In this game, similar to the first experiment, We have categorized these events into different levels based on their intended purposes.
Several visual events are depicted in the Figures 3.4and 3.5.

3.3 Facial Expression detection

In this experiment, We employed two distinct approaches to facilitate facial expression recognition in order to monitor and detect the triggers of game events while capturing changes in players' emotions.

Figure 3.3: Visible Events in SCP-087

Table 3.2: Game Events of The Abandoned Hospital

Event Level	**Feature**	**Events**
Level 1	Less intense, alert, attention	Footstep, crying, Wall Scratching sound effects, subtle screen glitches, and chasing by zombie lady or clowns
Level 2	Intense, shock, scary	Hanging deadman sudden drop, Jump scares, ghost appearing window, sudden entry of dark mask room, and sudden loud sound effects
Level 3	Calm, relax	Brighter environment, reduce frequency of events

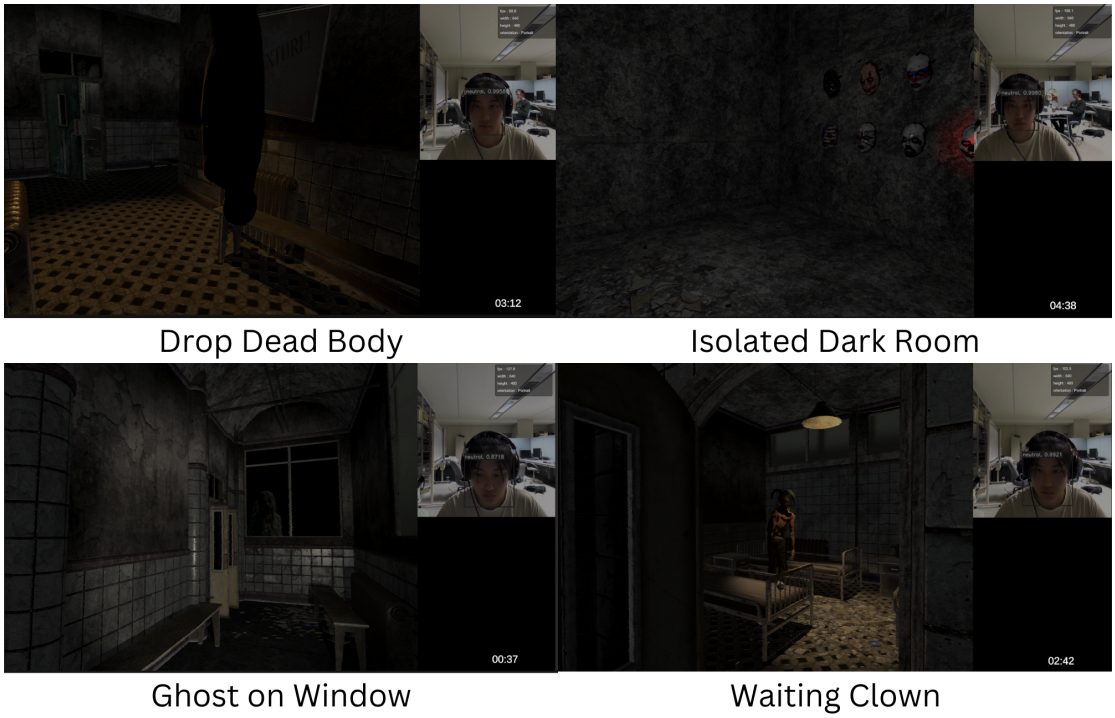

Figure 3.4: Visible Events in The Abandoned Hospital

Figure 3.5: Visible Events in The Abandoned Hospital

3.3.1 SCP-087: MoodMe 4 Emotions Unity Plugin

To detect players' emotions in real-time and track triggers for game events, I employed the MoodMe SDK Unity Plugin [20], which utilizes computer vision and machine learning algorithms to enable real-time facial detection and analysis of emotions.

The MoodMe SDK is capable of detecting a range of emotions, including anger, disgust, fear, happiness, and sadness. Capturing and interpreting facial expressions provides valuable insights into players' emotional states during gameplay.

The potential impact of MoodMe is significant, as it has the power to revolutionize game design and gameplay experiences. With the ability to tailor gameplay to individual emotional responses, game developers can enhance player engagement and create more emotionally captivating experiences.

Though the official website does not explicitly mention the light condition, we have tested the SDK and found that as long as the webcam is capable of capturing the player's facial structure adequately, the SDK works perfectly.

3.3.2 The Abandoned Hospital: OpenCV for Unity

After identifying the limitations of facial expression recognition in detecting subtle expressions during player concentration, We embarked on finding a more effective solution – OpenCV for Unity to fulfill this specific function.

OpenCV for Unity [21] is a powerful computer vision library that integrates the OpenCV (Open Source Computer Vision) framework [22] with the Unity game engine. It provides a wide range of tools and functions for image and video processing. It allows for real-time processing of camera input, enabling tasks such as facial expression detection, Which is one of the optimal choices for this research.

3.4 Emotion Triggers

3.4.1 SCP-087

To capture and utilize the emotions of players as triggers, it is necessary to define the appropriate triggers. As a horror game, We chose to use the MoodMe 4 Bad Emotions asset, which includes the emotions of anger, disgust, fear, and No Emotionity (see this research triggers for game events in table 3.3).

When a player exhibits high levels of anger, We trigger level 1 events to create a sense of tension, or level 3 events to help calm them down. In cases of disgust, if the player becomes too disengaged or bored, We trigger level 2 events to shock them and regain their interest. Similarly, for cases of fear, We use level 3 events to help the player relax and feel calmer.

We also aim to avoid having the player remain in a No Emotion emotional state for too long. If a player remains No Emotion for an extended period of time, We trigger level 1 and level 2 events to make the game more interactive and engaging. By using a range of emotional triggers and event levels, We aim to create a dynamic and immersive gameplay experience that responds to the emotional state of the player.

It's important to note that the emotion values provided by MoodMe are expressed as percentages of the four emotions (Anger, Disgust, Fear, and No Emotion) detected. To determine appropriate thresholds for detecting emotions, We conducted a pretest with

three participants, including one developer, who played the game while recording all emotion values using the MoodMe SDK. This allowed us to establish threshold values for different emotions. All the emotion value would be within 0 - 1. During the pretest, it was observed that when participants played the game without intentionally making facial expressions, but rather naturally revealing their feelings, the values for emotions other than "No Emotion" ranged from 0.05 to 0.32. However, when participants deliberately made facial expressions, the values typically ranged from 0.08 to 0.6. Therefore, a threshold of approximately 0.1 was set for detecting these emotions. Additionally, the No Emotion value exceeded 0.8 in most cases, so We have set 0.8 as the threshold for detecting No Emotionity as well.

Additionally, We have implemented a mechanism in the game that ensures only one event is triggered at a time. This means that once an event is triggered, other events will not be triggered until the current event is fully processed. Furthermore, the timer for event triggers will also be reset after each event has finished, ensuring that events are not triggered too frequently and allowing for a more immersive and balanced gameplay experience.

Table 3.3: Game Triggers of SCP-087

Emotions	**Conditions**	**Triggered events**
Anger	>0.1, for 30 frames	Level 1, 3
Disgust	>0.05, for 10 frames	Level 2
Fear	>0.1, for 30 frames	Level 3
No Emotion	<0.8, for 1000 frames	Level 1, 2

3.4.2 The Abandoned Hospital

We modified the facial expression detection tool and adjusted the triggering parameters to better suit this research needs. The player's most probable emotion is recorded every 15 seconds, and events in the game are triggered based on this recorded emotion.

Using OpenCV, We was able to detect seven different emotions in real-time: Anger, Disgust, Fear, Happiness, No Emotion, Sadness, and Surprise. After careful consideration of how to utilize this data in the context of horror games, We found that emotions such as "Anger" "Disgusted", and "Sadness" may not typically be experienced during gameplay. Therefore, if players do reach these emotions, We aim to provide elements in the game that help calm them down and alleviate any negative feelings.

Emotions such as "Happiness" and "No Emotion" are considered positive emotions that may not align with the desired experience in horror games. Therefore, We utilize these emotions as triggers for events that aim to create a sense of nervousness or shock in the player. By introducing elements that challenge their positive emotions, We aim to enhance the overall suspense and intensity of the gameplay.

When players experience "Fear" emotions, We adopt a random approach to either calm them down or intensify the creepy atmosphere. Since "Fear" is not an extreme emotional state, We aim to strike a balance between releasing their tension and further frightening them. The randomization adds an element of unpredictability to the game, enhancing the overall suspense and keeping players engaged in the experience.

Table 3.4: Game Triggers of The Abandoned Hospital

Emotions	Conditions	Triggered events
Anger	Detected the most in 15 seconds (not including No Emotion and Happiness)	Level 3
Disgust	Detected the most in 15 seconds (not including No Emotion and Happiness)	Level 3
Fear	Detected the most in 15 seconds (not including No Emotion and Happiness)	Level 1, 3
Happiness	Detected the most in 15 seconds (not including No Emotion)	Level 1, 2
No Emotion	Other emotions not detected over 10 times in 15 seconds	Level 1, 2
Sadness	Detected the most in 15 seconds (not including No Emotion and Happiness)	Level 3
Surprised	Detected the most in 15 seconds (not including No Emotion and Happiness)	Level 3

3.5 Dynamic Difficulty Adjustment

3.5.1 SCP-087

In this experiment, the research's main focus was on exploring how biofeedback can enhance the immersive experience of gameplay. We did not specifically aim to set different difficulty levels to make the game more challenging or easier. However, We believe that in horror games, events like levels 1 and 2 already contribute to the overall difficulty of the game.

3.5.2 The Abandoned Hospital

After considering the opinions from the first experiment, We decided to implement a dynamic difficulty adjustment system in the game. We took various factors into account to determine the appropriate level of difficulty for each player. One important factor is the player's emotional stability, as indicated by their rate of emotional change. A higher rate of emotional change suggests a higher level of stress or distraction, while a lower rate indicates a calmer and more focused state. We also consider the player's current emotional state as an additional factor in adjusting the gameplay difficulty. By considering these factors, We aim to create a gameplay experience that is engaging and challenging, while also taking into account the player's emotional well-being.

To enhance the immersive experience of the game, We implemented the following dynamic difficulty adjustments:

Enemy Behavior: The behavior of in-game enemies is dynamically adjusted based on the player's emotional state. If the player's emotions indicate a high level of stress or panic, the enemies' movement will be slowed down. Conversely, if the player's emotions suggest a calm state, the enemies may exhibit more aggressive behavior like moving faster or sprinting, providing a slightly easier gameplay experience.

Player Behavior: To progress in the game, the player must acquire a hand flash-

light. The flickering frequency of the flashlight is determined by the player's emotional change rate, which adds variability and immersion to the gameplay experience. We implemented dynamic adjustments to the player's movement speed and the brightness of the hand flashlight they are holding based on their emotional change rate. If the player's emotional change rate is high, indicating a greater level of emotional fluctuation, their movement speed will increase, allowing them to navigate the game environment more swiftly. Furthermore, the flicking frequency of the hand flashlight will be decreased, so that the player can see the environment a bit clearer. On the other hand, if the player's emotional change rate is low, indicating a more stable emotional state, their movement speed will be decreased, adding a sense of caution and tension to their movements. The flicking frequency of the hand flashlight will be increased, illuminating the surroundings less prominently and providing worse visibility.

Environment Change: We have implemented dynamic changes to the vision brightness and introduced screen glitches that correspond to the player's real-time emotions. Regarding the enemy behavior and player behavior, We have aimed to make the game more accommodating to the player during moments of panic or heightened emotional state. This means that in such situations, the game adjusts to provide a slightly more manageable or less threatening environment. However, when it comes to environmental changes, this research goal is to keep the player alert and on edge. We intentionally introduce elements that push the player to their limits and create a sense of challenge and tension. By dynamically adjusting the vision brightness and incorporating screen glitches, along with carefully designed enemy and player behaviors, We create a game experience that is responsive to the player's emotions. The game's environment becomes darker and the screen glitches intensify as the player's emotional change rate increases.

These dynamic adjustments aim to create a personalized and immersive gameplay experience by adapting the game elements to the player's emotional state in real time. By tailoring the game difficulty to the player's emotions, We provide a more engaging and captivating experience.

3.6 Additional Work – Deep Q Learning

This part of our work will be presented as a Demo paper at the 2023 IEEE Conference on Game. We have proposed a prototype solution to enhance the personalization of emotion feedback in games. While it is still a work in progress, we believe it is a valuable contribution worth mentioning. Our ongoing research aims to explore the potential of using real-time emotion detection and Deep Reinforcement learning to create a more immersive and personalized gameplay experience for players.

3.6.1 Deep Reinforcement Learning

Deep reinforcement learning is a highly effective technique that has demonstrated success in solving complex tasks across various domains, such as game playing [23] [24], robotics, and natural language processing. In the context of our research on horror game AI, the challenge lies in the intricate interaction among the player, the game environment, and the game events. Leveraging deep reinforcement learning, our approach aims to make optimal decisions by considering the current state of the game, the player's ac-

tions, and the impact of game events on the player's emotions. This enables the AI to learn and adapt in order to optimize specific rewards and enhance the overall gameplay experience.

By utilizing deep reinforcement learning, we can create an adaptive game that dynamically responds to the player's emotional state, delivering a highly personalized and immersive experience. The AI's capability to optimize game events and environments based on the player's emotional responses allows for a more intense and engaging gameplay. Moreover, this approach has the potential to automate the game design process, generating and fine-tuning game elements without the need for extensive manual intervention. This automation significantly streamlines the development process, reducing both time and costs while still ensuring a gripping and fear-inducing horror game for players.

3.6.2 Deep Q-Networks (DQN)

Deep Q-Networks (DQN) is a widely used deep reinforcement learning algorithm in video games [25]. It leverages a neural network to approximate the optimal action-value function, which predicts the expected cumulative reward for taking specific actions in given states. In our research, DQN proves suitable for learning the optimal sequence of events to maintain the player's arousal and valence within the desired range. The agent receives the current game state (e.g., player-NPC distance, time elapsed, etc.) and the player's current arousal and valence as inputs to the neural network. The network's output is a set of Q-values for each possible game event, such as jump scares or sound effects. During gameplay, the agent selects the event with the highest Q-value and executes it.

During training, the agent explores the environment by taking random actions, as the game is relatively simple without many constraints. Experiences gained from each action, including game events triggered, time elapsed, player's position, and changes in emotion, are stored in a replay buffer. Periodically, the agent samples from the replay buffer and uses a variant of the Q-learning algorithm to update the neural network weights.

Through this process, the agent maximizes the expected cumulative reward by selecting the optimal sequence of events to regulate the player's arousal and valence, thus providing a more engaging and emotionally impactful gameplay experience.

Chapter 4

Implementation

4.1 Game Building

To develop our two games, I utilized the Unity game engine. The game SCP-087 was constructed using Unity version 2019.4.35f1, while The Abandoned Hospital was built with Unity version 2022.3.2f1.

During the game development process, We incorporated various Unity assets to create the desired environment. These assets included:

1. Environment Asset Pack: This asset pack provided a wide range of pre-designed elements such as buildings, props, and terrain textures to construct the game's environment.

2. Lighting and Effects Asset: We integrated a specialized asset that enhanced the lighting and visual effects in the game, creating a more immersive and atmospheric atmosphere.

3. Many sound effects are also downloaded from different sources to create a creepy and intense environment.

4. Different kinds of character assets are also installed to play the role of nonplayer characters in the game.

By leveraging these Unity assets, We were able to streamline the development process and enhance the overall quality and realism of our games' environments.

- Non-Player Charactor: VileHag – Scary Zombie lady
- Non-Player Charactor: DeadMan – Hanging dead body
- Screen Effect Package: Kino – Glitch Effects

4.2 Facial Expression Detection – MoodMe

During the development of our first game, which involved real-time emotion tracking of players, we needed a network that could be easily integrated into Unity and efficiently perform real-time facial expression recognition. After thorough research, We discovered the MoodMe asset plugin available at the Unity asset store. To install this asset, We simply followed the instructions provided in the Readme file included with the asset.

4.3 Facial Expression Detection – OpenCV

Based on the feedback received after the first experiment, it became apparent that our existing emotional expression detection asset was not achieving the desired level of accuracy. Consequently, We sought out an alternative solution and decided to utilize OpenCV.

To incorporate OpenCV functionality into Unity, We followed the instructions provided by the OpenCV plugin asset. The installation process typically involves the following steps:

Downloading the OpenCV plugin: We obtained the OpenCV plugin asset from Unity Asset Store.

Importing the plugin into Unity: Using the Unity editor, We imported the OpenCV plugin into our project. Imported related package for facial expression recognition.

Configuring the plugin settings: To enable the unsafe code mode, We toggled the necessary compiler flag or setting in our development environment.

Integrating OpenCV functionality: With the plugin successfully installed and configured, We can access and utilize OpenCV functionality within our Unity project.

By adopting OpenCV in our project, We aimed to improve the accuracy and reliability of emotional expression detection, allowing for a more precise analysis of players' facial expressions during gameplay.

4.4 Game System

Firstly, we utilize the "update()" function in C# to continuously monitor players' emotions in real-time during gameplay. The emotion detection system provides values for four different emotions: Anger, Disgust, Fear, and No Emotion. Once the game starts, the emotion detection system is activated, and we keep track of which trigger condition will be activated first. During the occurrence of a game event triggered by a specific emotion, we temporarily pause the detection of other triggers to ensure a seamless and focused experience for the player. After the event has been active for a duration of 5-15 seconds, we resume the detection of emotions to enable the next potential trigger. This process allows us to dynamically adjust the game's events based on the player's emotional state, enhancing the overall immersive experience. Shown as Figure 4.1.

The game SCP-087 source code is pushed on repository:`https://github.com/tuyuanJoy/SCP-087`.

Due to the uploading limitation of large file we can't upload The Abandoned Hospital yet, however, the built game is uploaded at google drive: `https://drive.google.com/file/d/1PKq1peF-Yh5UODpMuEmr5R8xwu98-N7l/view?usp=sharing`.

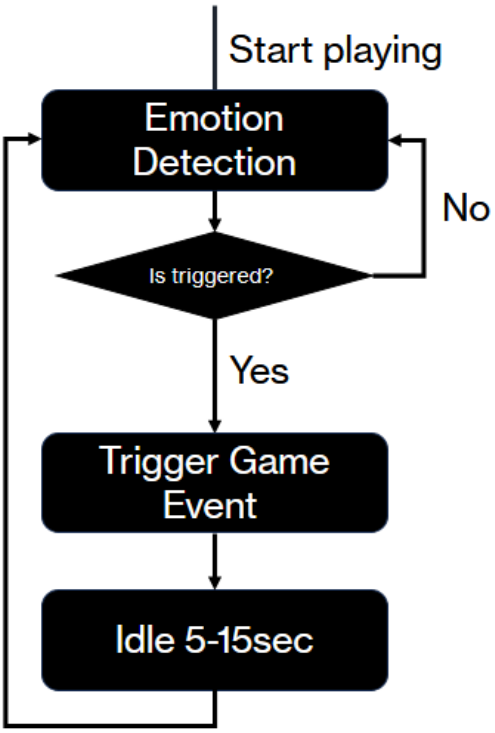

Figure 4.1: Game System

Chapter 5

Experiments

5.1 First Experiment – SCP-087

To evaluate the efficacy of the emotion-based event-triggering system, I conducted an experiment involving two versions of the game. Each gameplay session lasted for three minutes.

In the first version, random events of different intensities were triggered at arbitrary intervals (ranging from 5 to 15 seconds) after the player interacted with a specific object.

In the second version, the game detects and captures the players' real-time emotions, allowing for the triggering of events at varying levels based on their emotional states. We collected continuous emotional data from the participants throughout both versions of the game and administered a questionnaire after the gameplay sessions for their feedback.

5.1.1 Questionnaire

We designed our questionnaire to assess the following aspects:

- Perception of the difference between the two versions of the game
- Awareness of their own emotions triggering the events in the game
- Evaluation of game immersion
- Overall experience of playing the game

We asked participants to provide their opinions and feedback on these aspects to gather valuable insights for our research.

Result of the First Experiment

The experiment involved a total of 17 participants, including ten males and seven females. The participants were kept unaware of the specific versions of the game and were not provided with information about the functioning of the trigger system until after the experiment concluded. The results of the experiment are summarized in the following Table 5.1.

Table 5.1: Experiment Result

Aspect	**Description**	**Result**
Perception of Difference	Noticed difference due to different triggers	29.4%
Perception of Difference	Felt some parts of the game were different	29.4%
Perception of Difference	Total participants who felt a difference	70.6%
Awareness of Own Emotions	Aware of emotions during gameplay	47.1%
Awareness of Own Emotions	Felt emotions triggered game events	41.2%
Awareness of Own Emotions	Participants not paying attention to emotions	52.9%
Evaluation of Game Immersion	Preferred game with emotion triggers	58.8%
Evaluation of Game Immersion	Preferred game with random triggers	35.3%
Evaluation of Game Immersion	Both versions equally immersive	5.9%
Evaluation of Game Immersion	Average score for more immersive version	6/10
Evaluation of Game Immersion	Most common rating for more immersive version	7/10
Emotional Responses	Higher emotional responses in game with emotion triggers	70.6%
Emotional Responses	Higher emotional responses in game with random triggers	23.5%
Emotional Responses	No significant emotional changes in either version	5.9%

During gameplay, we monitored and recorded instances of intense negative emotions, including anger, fear, and disgust, for both versions of the game. Out of the 17 participants, 12 of them exhibited heightened emotional responses when playing the game with emotional triggers. These findings indicate that our game successfully elicited and stimulated players' emotions.

Out of the 17 participants, 12 of them reported perceiving a difference between the two versions of the game. Among those, five participants specifically noted differences in the way events were triggered, while others mentioned variations in the frequency and order of events, among other factors. These findings indicate that the emotion-triggered game had a significant and noticeable impact on the player's perception of the game experience.

Out of the participants, eight reported being aware of their own emotions during gameplay, with seven of them perceiving a connection between their emotions and the triggering of game events. This suggests that the game's integration of emotion triggers may not be fully immersive or seamless, as players are consciously noticing the reliance on their emotions to activate events. Besides, we got feedback that the game's emotion detection system was not able to accurately capture changes in the player's emotions, leading to inaccurate recognition of the emotional triggers. Further refinement and development of the emotion-based event-triggering system could enhance the immersion and integration of emotions into the gameplay experience.

Regarding the evaluation of game immersion, ten participants expressed that the version of the game with emotional triggers provided a more immersive experience, while six participants had the opposite perception. On a scale of 1 to 10, with 1 representing the least immersive and 10 representing the most immersive, the average score given by participants who found the emotion-triggered version more immersive was six, with a mode of 7. Among the ten participants who found the emotion-triggered version more immersive, six of them were not familiar with horror games or movies, whereas the remaining participants had prior exposure to horror-themed media. Conversely, among the six participants who found the randomly-triggered version more immersive, two of them were not familiar with horror games or movies, while the others had prior experience with such media. One participant felt that both versions were equally immersive and also had familiarity with horror games or movies.

In summary, the results of the study indicate that the inclusion of emotional triggers in the game had a notable influence on various aspects of the player experience, including the perception of difference, self-awareness of emotions, evaluation of game immersion, and emotional responses during gameplay. These findings suggest the potential effectiveness of emotion-based event-triggering systems in enhancing the overall player experience in video games. However, it is important to acknowledge that there were some limitations and areas for improvement identified through participant feedback. Specifically, concerns were raised regarding the accuracy of emotion detection and the limited variety of events, leading to some events being repeated multiple times during gameplay. These issues diminished the perceived impressiveness of the game for certain participants. To address these limitations, further advancements in the accuracy of emotion detection and the diversification of event triggers are necessary. Additionally, incorporating a greater range of events and avoiding repetition could enhance the overall effectiveness and appeal of the emotion-based event-triggering system in future implementations. Overall, this study provides valuable insights into the potential of emotion-based event triggers in video games and highlights areas for further research

and development to refine and optimize the player experience.

5.2 Second Experiment – Abandoned Hospital

Based on the lessons learned from the first experiment, we made improvements to our experiment implementation. We recruited 17 participants and created a dark environment with headphones to minimize distractions. It's worth mentioning that seven participants took part in both the "SCP-087" and "The Abandoned Hospital" experiments. We compared the results of new participants and experienced participants, and they were nearly the same. This suggests that the results of this experiment are not significantly biased. They are also asked about the gameplay experience of two different experiments.

For "The Abandoned Hospital experiment", each player was tasked with playing two versions of the game, which involved exploring an abandoned hospital map and finding a key to escape. To maintain consistency, a time limit of five minutes was set, regardless of whether the player found the key. After building the game, we played a quick run and completed it in almost two and a half minutes. We also invited a tester who is new to this game but skilled in horror games, and he spent around four minutes and fourty seconds exploring the game. Based on these observations, we believe that setting a five minutes time limit to explore the map is appropriate. Regarding whether five minutes is sufficient for detecting the player's emotion, we have not found scientific evidence for this yet. However, based on my observations, participants were able to immerse themselves in the game for approximately three and half to four minutes during gameplay.

Then, we recorded the participants' emotional responses throughout both versions of the game and asked them to complete a questionnaire afterward.

5.2.1 Questionnaire

This time we focused the questions on the same aspects as the first experiment:

- Perception of the difference between the two versions of the game
- Evaluation of game immersion
- Awareness of their own emotions triggering the events in the game
- Overall experience of playing the game
- Perception of the Dynamic Difficulty Adjustment

Result of the Second Experiment

Out of the 17 participants, eleven were male and the remaining were female.

Of the total participants, 13 indicated that they perceived clear differences in the triggering of events between the two game versions. The remaining participants acknowledged feeling some differences at times but were unsure about the specific variations. None of the participants reported perceiving no difference. Compared to the first

Table 5.2: Experiment 2 Result

Aspect	**Description**	**Result**
Perception of Difference	Total participants who felt a difference	100%
Perception of Difference	Correctly know which version is with emotional triggers	100%
Perception of Difference	Noticed difference due to different triggers	76.5%
Perception of Difference	Felt some parts of the game were different	23.5%
Awareness of Own Emotions	Aware of emotions during gameplay	64.7%
Awareness of Own Emotions	Felt emotions triggered game events	82.4%
Evaluation of Game Immersion	Preferred game with emotion triggers	76.5%
Evaluation of Game Immersion	Preferred game with random triggers	23.5%
Evaluation of Game Immersion	Average immersion score for the version with Emotion triggers	8.15/10
Evaluation of Game Immersion	Average immersion score for the version without Emotion triggers	6.75/10
Emotional Responses	Higher emotional responses in-game with emotion triggers	88.2%
Emotional Responses	Higher emotional responses in-game with random triggers	11.8%
Perception of DDA	Sense the difficulty difference	64.7%
Perception of DDA	Difficulty Adjustment made the game more immersive	88.2%

experiment, the differences between the versions of the game with emotional triggers and without emotional triggers became more apparent to the players.

All participants (100%) were able to recognize which version of the game utilized an emotional trigger game agent. However, interestingly, four of them expressed the belief that the game without an emotional agent actually made players feel more immersed. And two of them used to play horror game in their daily life. The result, where all players were able to recognize the version of the game with emotional triggers, was unexpected and surpassed initial expectations. Furthermore, a larger number of participants in this experiment perceived the version with emotional triggers as more immersive compared to the first experiment. This finding supports the success of our approach in enhancing game immersion by utilizing players' real-time facial expressions to trigger game events. The remaining four players who believed that the game without emotional triggers was more immersive provided several reasons for their perspective. One reason was that they became overly focused on controlling their facial expressions, detracting from their engagement with the gameplay itself. Additionally, they felt that certain events triggered by emotions occurred abruptly and did not align well with the context or timing of the game, impacting their sense of immersion.

Among the 13 participants who perceived the game with the Emotional Trigger game agent as more immersive, the average immersion rating they assigned to this version was 8.15 out of 10. Conversely, among the four participants who held the opposite belief, the average immersion rating for the game without an agent was 6.75 out of 10. Based on the results, it can be concluded that the version of the game with emotional triggers created a more immersive environment for gameplay. The majority of participants perceived greater immersion and recognized the impact of emotional triggers on their gameplay experience. This supports the effectiveness of using real-time facial expressions to enhance immersion in video games.

There 14 participants noticed that game events are triggered by their emotions without knowing how the game agent works. This result indicates that the integration of real-time emotion triggers in the game system was effectively implemented. Participants recognized the emotional triggers, highlighting the successful incorporation of this feature into the game experience.

Based on the average emotional change rate recorded during gameplay in the two versions, it was observed that 15 out of 17 participants exhibited a higher emotional change rate while playing the game with an emotional game agent. This result demonstrates that our emotional triggers significantly enhance the engagement level of the game.

In summary, out of the eleven participants who sensed a change in difficulty during gameplay, seven of them were confident that the difficulty change was triggered by their own emotions. However, a common question raised by participants was how difficulty is defined in a horror game. The participants recognized that the emotional triggers already made the game more intense and challenging, contributing to the overall difficulty. Thus, the evaluation of difficulty can be considered a part of the perception of difference and immersion in the game. Out of the 14 participants, a majority believed that the dynamic difficulty adjustment implemented in the game contributed to creating a more immersive environment. This suggests that the manipulation of difficulty based on players' emotions enhanced their engagement and overall gameplay experience.

In addition, we gathered feedback from the players regarding their perception of the accuracy of real-time facial emotional expression detection. The average rating

received was 6 out of 10, with a mode of 7 out of 10, indicating a moderate level of satisfaction with the accuracy of the detection system. Furthermore, all 12 participants who took part in the first experiment provided feedback indicating that the OpenCV real-time facial expression recognition was significantly more accurate compared to the initial installation. This improvement in accuracy further enhances the effectiveness of our emotional trigger system in capturing and interpreting players' facial expressions.

Chapter 6

Discussion

Throughout our research journey, we have identified various areas that warrant further improvement and attention. These insights have shed light on potential avenues for enhancing the overall quality and effectiveness of our work. By acknowledging these areas of opportunity, we can dedicate our efforts to addressing them and advancing the field in a meaningful way.

One of the key areas for improvement that we have identified is the lack of personalization in the two games I developed. We recognized that emotional triggers were based on general rules and cases, without taking into account individual preferences and unique triggering events for each player. This raises the question of how we can accurately set the appropriate events and determine the correct triggers for each player. To address this challenge, we propose the use of reinforcement learning as a potential solution. I have a work that will be published at the IEEE Conference on Game later this year [6], where I provide a prototype that addresses this issue using reinforcement learning. By implementing an AI system that can learn and adapt to players' emotional patterns in real time, we can create a personalized gaming experience. As players engage with the game, the AI would continuously analyze their emotional responses and identify the types of events that resonate most effectively with each individual at different stages of gameplay. By leveraging reinforcement learning algorithms, we can dynamically adjust the game's content and triggers to optimize the emotional engagement and immersion of each player. This approach has the potential to enhance the overall gameplay experience by tailoring it to the specific preferences and emotional sensitivities of individual players. Implementing a reinforcement learning-based system would require further research and development, including the collection of extensive player data, algorithm design, and iterative testing. Nonetheless, we believe that this approach holds promise for achieving a higher level of personalization and emotional resonance in future iterations of our games.

Another area of improvement highlighted by participants' feedback pertains to the game-building aspect of our research. One particularly interesting suggestion involves incorporating text content into the game. This suggestion proposes using the webcam recording of the player's face to capture a certain time period of emotional changes. Based on these changes, the game would dynamically generate sentences to evoke a sense of creepiness or unease. For instance, if the player has been smiling for a while and then suddenly stops smiling for a couple of seconds, the text displayed on the screen could change to something like "What's up, why did you stop smiling?" This approach adds an additional layer of immersion by directly responding to the player's emotional

expressions and creating a more interactive and personalized experience. Implementing this suggestion would require integrating facial expression recognition and natural language generation techniques into the game. By leveraging these technologies, we can analyze the player's emotional changes in real time and generate corresponding text responses that align with the game's atmosphere and narrative. This idea opens up new possibilities for engaging players and enhancing their emotional journey within the game. It provides an opportunity to create a more dynamic and responsive gameplay experience that adapts to the player's emotions, further immersing them in the game world.

Additionally, we have discovered that OpenCV offers robust eye-tracking functionality, which presents an exciting opportunity to enhance our game even further. By integrating eye-tracking technology into our game, we can accurately determine where the player is focusing on the screen. This information can be leveraged to strategically position events and elements within the game environment, creating a more immersive and interactive experience. Furthermore, eye-tracking can serve as a valuable sensor for detecting facial expressions and gauging the player's level of concentration. By analyzing the movements and patterns of the player's eyes, we can infer their emotional states and engagement with the game content. This data can then be utilized to dynamically adjust the game's intensity, pacing, and event triggers in real time, tailoring the experience to the player's individual reactions and attention. Integrating eye-tracking functionality into our game not only enhances realism and immersion but also provides valuable insights into the player's behaviors and responses. This enables us to further refine and optimize the gameplay experience, ensuring that it aligns with the player's preferences, emotional engagement, and concentration levels. By combining the power of facial expression recognition, concentration tracking, and eye-tracking technology, we can create a highly immersive and personalized game that responds to the player's emotions, actions, and visual focus. This integration of eye-tracking into our game opens up a world of possibilities for creating captivating and engaging experiences for players.

In conclusion, future work directions for our research include personalizing the emotion-based event triggering in the game using reinforcement learning to adapt to individual emotion patterns, integrating text content based on real-time emotional changes to enhance immersion, and utilizing eye-tracking and concentration detection to position events and assess player engagement. By focusing on these aspects, we aim to improve the game's immersive qualities and extract greater value from real-time facial expression detection and emotional triggers in game design.

Chapter 7

Conclusions

This research has demonstrated the potential of real-time facial expression detection and emotion-based event triggering in enhancing immersion and interactivity in horror games. By incorporating dynamic difficulty adjustment and utilizing real-time facial expression recognition, we aimed to create a more immersive and engaging gameplay experience for players.

The results of our experiments indicate that the inclusion of emotion triggers had a significant impact on most of participants' perception of difference and immersion. Most participants were able to recognize and appreciate the presence of emotional triggers, leading to a immersive experience during gameplay. However, we also identified areas for improvement, such as the accuracy of the emotion detection system and the variety of events triggered.

Through the second experiment, we observed an increased recognition of differences between game versions and a greater preference for the version with emotional triggers. This suggests that the inclusion of diverse events and the improved accuracy of the emotion detection system contributed to a more engaging and immersive gameplay experience.

Overall, this research highlights the potential benefits of utilizing real-time facial expression detection and emotion-based event triggering in horror games. Further advancements in the accuracy and variety of triggers can further enhance the immersive nature of gameplay experiences. Future studies can continue to explore and refine these techniques to create even more captivating and interactive gaming experiences.

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