Master Degree Project

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USING ARTIFICIAL INTELLIGENCE TO CREATE TENSION INDUCING EXPERIENCES IN HORROR GAMES.

Master's degree Project in Informatics
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Abstract

The video game industry is evolving day by day with new technologies being introduced to enhance the player experience. Using Artificial Intelligence (AI) in games can be seen as one of the major areas that many game companies focus on due to the rapid technological development that it has seen in recent years. Even though the application and use of modern AI techniques such as deep learning can be rarely seen in the commercial video game industry in comparison to the area of academic research, we can see that many game developers use AI methodologies to overcome Dynamic Difficulty Adjustment (DDA) and enemy path-finding problems that persist in their games. This paper focuses on looking into how AI can be used in horror games to elevate tension inducing player experiences by researching on the work that has been done with regard to how tension and fear are created in the genre of horror, how to track and identify player emotions in game and finally, coming up with a hypothetical solution that can be used to track player emotions in order to create tension experiences in horror games with the help of AI, together with the physiological responses of the player. The findings of this paper give an idea on the feasibility of the solution system as well as the potential use of physiological responses in commercial video games as well as future work that is to be done to implement and test the solution system proposed in this paper.

Keywords: [AI, Atmospheric Horror Elements, Emotions, Machine Learning, Physiological Responses]

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1. Introduction

With the emergence of new technologies, the video game industry has been able to create and deliver products that have raised the bar when it comes to evoking player emotions and immersing them in game. One of the main areas that researchers as well as game developers have their focus on is how Artificial Intelligence (AI) can be used to enhance player experience in games. According to Pfau, Smeddinck and Malaka (2020) the game industry is still at its infancy when it comes to using AI techniques such as deep learning and reinforcement learning in commercial products in comparison to the other fields where these technologies are used frequently. Even though this is the case, instances of AI being used in games can still be seen. Manipulating enemy and Non-Playable Character (NPC) behaviour, dynamic difficulty adjustment (DDA) and using path-finding techniques on enemies can be considered as some of such examples. The use of AI in horror games is not an alien concept since it has been used in games such as *F.E.A.R* by Monolith Productions (2005) that is more than a decade old. Furthermore, games such as *Alien Isolation* by Creative Assembly (2014) have shown examples of using AI in a manner where the enemy Alien's behaviour is not scripted and is totally random. This randomness can solely increase the tension level of the player since he/she cannot predict where the alien would appear next.

Although there are many instances of using AI in horror games, most of them tend to revolve around manipulating the antagonist or the enemy characters in game or to balance the difficulty. Designers still tend to manually adjust aspects such as sound and lighting triggers that act as key elements when it comes to building up atmospheric horror in a game and the usage of AI to manipulate the atmospheric horror in games are rarely seen. Even though building up atmospheric horror manually has its own advantages, its linear nature can heavily reduce the tension and fear factor that the player would have if the player has to replay certain parts of the game. One can say that another reason for the use of manual adjustment of atmospheric horror elements in a game is not having a way to accurately measure the emotions that the players go through when playing a game. Even though there are various ways to measure player emotions in a lab environment, it is difficult to do so in a casual gaming environment without hindering the player experience. The main objective throughout this paper was to come up with a solution that could be used to overcome the issues that persist with manually generated atmospheric horror elements and create tension inducing, unpredictable experiences according to the fear level of the player.

This paper will give the reader a good understanding about the relationship between human emotions, tension and fear, what horror is, what horror video games are, how horror video games differ from other mainstream media that use horror as entertainment, an in-depth explanation on how the horror games have used AI to create tension and fear in games, what atmospheric horror is and how video games use atmospheric horror to build up tension in games. Furthermore, this paper would give a clear idea of the research question which is, 'the underutilisation of AI techniques to dynamically generate atmospheric horror elements in games' that is addressed through this paper and how this problem can be solved with the help of an AI system that uses physiological responses of the player to dynamically create atmospheric horror elements which can be used to overcome the aforementioned problems. Finally, this paper will also discuss the feasibility of the proposed system with regards to the use of it, in commercial video games.

2. Background

2.1. Emotions

Emotions can be considered as reactions that humans tend to experience in response to certain events or situations. According to the American Psychological Association (APA) Dictionary of Psychology (2014) an emotion is defined as "a complex reaction pattern, involving experiential, behavioural and physiological elements". Tooby and Cosmides (2008 cited in Worthy, Lavigne and Romero, 2020, p.221) define human emotions as rapid information processing systems that help humans to act with minimal thinking. These systems can be said to be one of the reasons as to why we as human beings exist today since these systems aided ancestors of the human race who lived during prehistoric times to survive from predators as well as to hunt and gather resources (Worthy, Lavigne and Romero, 2020). In their work Worthy, Lavigne and Romero (2020) mention that throughout the evolutionary history of mankind, humans have experienced various types of problems which associate with birth, demise, war and seduction and emotions have evolved to help humans in adapting to these problems quickly with minimal cognitive intervention. Without emotions humans would not have the ability to make quick decisions and adapt according to different situations. If not for emotions, humans would have a hard time deciding whether to run or fight back when a threat is present (Worthy, Lavigne and Romero, 2020).

According to the information in the article published by Tyonote (2021) the word emotion originates from the Latin word "Emovere" which means to move, stir, agitate or excite. The article further states that emotions tend to last only for a short period of time and a person who is in an emotional state would do or say things that they would not normally do or say. A specific emotion that an individual would experience can be determined by the circumstances that are responsible for triggering that specific emotion. Darwin (1899) has suggested that the emotional expressions that humans use possess a biological basis and are not just socially learned. Darwin (1899) has further stressed that humans and animals share similar postural expressions when expressing their emotions. One can observe a change in facial expressions when a human or an animal is angry or scared. For example, animals would tend to grind their teeth and frown when they are angry.

2.1.1. Affect, Emotions and Mood

Affect, emotion and mood are considered as terms that are often used interchangeably in everyday language. But in the field of psychology these terms have different meanings. According to Russel and Barrett (2009 cited in Ekkekakis, 2012, p.321) affect is described as "a neurophysiological state that is consciously accessible as a primitive non-reflecting feeling". They further state that affect can be seen as a broader term which covers the characteristics of both mood, and emotions making them subsets of affect. Moods and emotions tend to be a bit similar compared to affect but as for Ekkekakis (2012) these two terms have characteristics that differ from one another. Emotions can be seen as intense feelings that are directed towards something or someone (Ekkekakis, 2012). In other words,

a person can identify the source as to why he/she is feeling a certain emotion. But the same cannot be said when talking about moods. Although a mood can have feelings that are less intense to that of emotions, it is hard to point out why someone is in a specific state of mood (Ekkekakis, 2012). If a person is feeling anxious or depressed it can be due to one or many reasons although the cause for it might not be easily identifiable. Another distinguishable characteristic that can be seen in moods and emotions is that moods tend to last longer than emotions. When a feeling that is associated with emotions tend to last for a certain period of time, it is called a mood (Ekkekakis, 2012).

2.1.2. Key components of emotions

Over the years, medical professionals and psychology experts have suggested that a set of components can be used to describe and assess a specific emotion that an individual is experiencing at a particular moment of time. Many psychology experts including Worthy, Lavigne and Romero (2020) suggest that an emotion can have three main components which are physiological component, behavioural component and cognitive component of emotion. However, according to the definition given by Hockenbury and Hockenbury (1997 cited in Cherry, 2022) in their book "*Discovering psychology*" an emotion is a complex psychological state which consists of three key elements namely, subjective experience, physiological response and behavioural response. When analysing further it is evident that only physiological and behavioural components are common in the list of elements described in both references mentioned above. Hence, for the sake of accuracy, I will be considering all four components mentioned above (physiological response, behavioural response, cognitive response and subjective experience) as key components that can be used to characterise and distinguish a specific emotion that an individual is undergoing at a given point in time.

Subjective Experience: This component can be described as the feelings that a person would have with respect to the emotional state that they are in (Cherry, 2022). Cherry (2022) also mentions that subjective experience of emotions can vary from person to person. For example, two people can experience the same emotion (let's say happiness). But their subjective experience of emotion can have differences. When one person says that he/she is happy, it can mean that the particular person may feel an intense and overwhelming sense of joy whereas to another person the feeling can be a more subdued and mellow sense of contentment. Subjective experience can also be influenced by various factors, such as an individual's personality, past experiences, cultural background and social context. Therefore, emotions can be experienced and expressed differently by different individuals, even when the same emotion is involved.

Physiological Responses: This component refers to the way a person's body responds with regards to emotions that they go through. Some of the key physiological responses that can be seen in a person when he/she is experiencing a certain emotion could include changes in the heart rate, blood pressure, body temperature and breathing rate (Worthy, Lavigne and Romero, 2020). According to Cherry (2022) the sympathetic nervous system is in charge of controlling the body's fight or flight responses and hence is responsible for preparing our body to face a threat or flee from it. The emotion 'fear' can have a direct connection with this since we sense fear when a threat is present (Cherry, 2022).

Furthermore, physiological responses that occur during emotional changes can also include changes in hormone levels, such as the release of adrenaline and cortisol, that can have an influence on a person's energy levels, mood, and physical responses. In their work Worthy, Lavigne and Romero (2020) state that one common misunderstanding that people have with regards to emotions is that emotions must always directly produce an action. While this is regarded as false information, Worthy, Lavigne and Romero (2020) further explain that although emotions prepare the body for action whether a person actually acts on those emotions is influenced by a variety of factors such as the situation that the person might be in, past experiences he/she has had with similar situations and the perceived consequences that one would have to face if they act upon their emotions.

Behavioural Responses: This element can also be recognized as the actual visible expressions that an individual would show when they feel a particular emotion. This could take many different forms ranging from one's facial expressions and body language to social interactions and communication (Worthy, Lavigne and Romero, 2020). For example, when a person is happy, you would see that the person would smile and laugh while interacting with others in a more active manner whereas when someone is angry, they would show negative facial expressions and body language while trying not to engage in social interactions. According to Cherry (2022), Sociocultural norms would also play a role in how people express their emotions. For instance, people in Japan tend to hide expressions of fear or disgust when they are around others whereas in the US, people are more likely to express their negative emotions both alone and in the presence of others. The information provided by the University of West Alabama (2019) regarding a study in the journal of abnormal psychology shows that when participants were exposed to both negative and positive emotional films and were asked to suppress their behavioural responses, the participants tend to show physical effects such as increased heart rate, suggesting that expressing behavioural responses to stimuli that are both positive and negative is better for one's overall health than holding the responses inside.

Cognitive Responses: This component can be described as how humans interpret and emotionally react to different situations and simulations. If you take a scenario as an example where you are a hiker going on a trail and you suddenly see a snake, chances are that your physiological responses would start to take effect putting you into a fight or flight state. But if you find out that the object that you perceived as a snake is just a piece of rope lying around, you would tend to consider the situation as non-threatening, sending signals to your brain to come back to a normal emotional state (Worthy, Lavigne and Romero, 2020). However, the ability that a person has to assess and decide whether a situation is threatening or not, comes with his/her experience, culture and background, meaning that the way different people assess a situation can vary even though they face situations that are similar (Worthy, Lavigne and Romero, 2020).

2.1.3. Universal expressions of emotions

As explained in the previous section, you can say that people tend to express similar physiological reactions while displaying emotions. Additionally it is seen that the ability to generate and understand facial expressions that resemble emotions is a universal human trait (Worthy, Lavigne and Romero, 2020). According to Worthy, Lavigne and Romero (2020) studies conducted on individuals who are blind from birth showed that they were able to generate similar facial expressions that an ordinary person would show (when they are happy, sad, angry etc.) even though they haven't had the chance to observe such expressions in other individuals suggesting that the movement of facial muscles associated with generating emotional expressions is universal and not a result of learned behaviour. Darwin (1899) in his book *Expression of Emotions in Man and Animals* has also stated that the facial expressions of non-human primates such as chimpanzees have a striking resemblance to that of humans.

The study of human emotions can be traced back to as early as the 4th century BC where famous philosophers at the time such as Plato and Aristotle have investigated and discussed the nature and origin of emotions. Aristotle in particular has tried to categorise and identify the range of emotions that are experienced by humans (Cherry, 2021). In his work, he has proposed 14 distinct emotional expressions which are fear, confidence, anger, friendship, calm, enmity, shame, shamelessness, pity, kindness, envy, indignation, emulation and contempt (Cherry, 2021). Cherry (2021) further states that this number has increased drastically by the 20th century. According to Robert Plutchick, who is a professor emeritus at the Albert Einstein College of Medicine, psychologists have put forth more than 90 different definitions of "emotion" in an attempt to accurately describe and differentiate human emotions (Cherry, 2021). However, many psychologists would suggest that the number of basic emotions which are universal to all human beings are far fewer than this and the vast number of emotions that are described by psychologists would fall under these fundamental emotions (Cherry, 2021).

In 1972, with the use of his Facial Action Coding System (FACS) which is a classification model that measures and evaluates the movements of facial muscles and the movement of the eyes and head of an individual, Ekman proposed seven basic emotional expressions that are universal to all human beings. These emotional expressions are namely anger, disgust, contempt, fear, happiness, sadness and surprise (Cherry, 2021). In order to see how facial expressions depicting different emotions relate to different societies and cultures Ekman and Friesen (1972 cited in Worthy, Lavigne and Romero, 2020, pp.227-229) conducted a scientific study with the help of their colleagues from different universities. In this study, they first took pictures of people depicting the seven emotions listed above, showed these pictures to people from different cultures and societies, gave them a list of emotion words and asked them to name the facial expressions depicted in the pictures with the words given. Although the results of the study that was done by Ekman and Friesen (1972 cited in Worthy, Lavigne and Romero, 2020, pp.227-229) concluded that the participants from different cultures matched the pictures to the same emotion words with high accuracy, they also found out that there was a considerable variability in recognition rates across cultures. For example, Ekmand,et al. (1987 cited in Worthy, Lavigne and Romero, 2020, pp.228-229) mentioned that around 95% of participants from the US were more likely to associate a smile with happiness whereas only 69% of the participants from Sumatra made

the same association. Similarly around 86% of participants from the US associated wrinkling of the nose with disgust while only 60% of the participants from Japan made the same connection.

In 2014, a research team at the University of Glasgow followed Ekmand's work on universal emotions in order to find out the universal human emotions based on facial expressions irrespective of sociocultural influences (Cherry, 2021). Their findings showed that some of the universal emotions listed in Ekmand's work drew out the same facial responses. As an example, the same set of facial muscles were used to express the two emotions fear and surprise and hence, might be expressing a single emotion instead of two (Cherry, 2021). From their findings, the researchers were able to conclude that there are four basic emotional expressions that are universal to all human beings irrespective of their background or culture which are happiness, sadness, anger and fear (Cherry, 2021).

2.2. Fear

As one of the seven emotional expressions that are universal to all human beings, fear can be seen as an emotion that is essential for an organism to survive and function since it acts as a protective device that warns us of potential dangers (Akhtar, 2013). According to the definition in Merriam Webster's dictionary (2019), fear can be described as "an unpleasant, often strong emotion caused by anticipation or awareness of danger". Nummenmaa (2020) states that when the sense of fear kicks in, on a person, his/her brain immediately reacts by sending signals that put the body on a flight or fight state, triggering physiological responses in the body. Some of the common responses that a person would tend to experience are the increase in heartbeat, rapid breathing and an increased blood pressure (Newman, 2021). Furthermore, the heart tends to pump more blood to certain muscle groups that would prepare a person for physical actions such as running or jumping (Newman, 2021). Another bodily response that people can sense when they are in fear is the heavy sweating that occurs in one's body. The skin sweats in order to keep the body cool. The body tends to be in this state until the brain receives a signal stating that a threat is not present anymore. This feeling of relief can be rewarding because it signals safety (Nummenmaa, 2020).

Factors that affect fear might change from person to person since humans can be considered as beings that are unique and diverse. A person who is scared of snakes might not feel the same level of fear when seeing a lion or a shark compared to the level of fear that he/she might feel when encountering a snake. Although people may have fears that are unique to each other, it can be clearly seen that all these fears have a connection to things or events that can have a potential danger towards people and has to be avoided. However, when all the fears that people have are categorised and divided into groups, it is visible that all of them belong to one main group which can be called 'The fear of the unknown'. According to Nummenmaa (2020) Fear of the unknown is one of the most fundamental fears in humans and explains a multitude of other fears that people tend to experience in their lives. We tend to fear the dark because we don't know what might be hiding in the shadows, some people tend to fear strangers because they don't know what type of people they are associating with or how they will behave (Nummenmaa, 2020). Fear of the unknown is

utilised well in entertainment, specially in the horror movies and games due to the potential that it has to tap into the primal human instinct of self-preservation and the fear of the unpredictable.

2.2.1. Four Stages of stress when a threat is encountered

According to Butto (2019) the average human tends to go through four stages of stress when a threat is encountered. These four stages are namely Threat, Organization, Flight or fight and Solution. It can be said that these four stages of stress act as a defence mechanism that keeps the player safe from potential dangers (Butto, 2019).

Threat Stage: This is the first stage out of the four stages of stress where the potential danger is initially identified by the person. During this stage the emotional tension of the person rises while the sympathetic and autonomic nervous systems of the person are also activated, resulting in the rise of heart beat as well as the person's blood pressure (Butto, 2019). During this stage, the blood flow to the essential organs that are necessary to handle the threat such as the muscles and the brain, is also increased.

Organisation Stage: During this stage the body collects the necessary energy in order to cope with the threat at hand (Butto, 2019). The blood vessels that carry blood to the essential organs such as the heart, brain, lungs and muscles expand while the breathing rate also increases preparing the body for the next stage which is the flight or fight stage (Butto, 2019).

Flight or Fight Stage: The body has obtained all the necessary energy in order to give the body increased speed and strength in order to either fight the threat or run away from it (Butto, 2019).

Solution Stage: The solution stage or the recovery stage can be considered as the final stage that the human body will experience after successfully facing or avoiding the threat. During this stage, the stress level of the body gradually decreases, and the body returns to a more relaxed state rectifying the incurred damages and refilling the energy reserves that were emptied during the flight or fight stage (Butto, 2019). The immune system also starts its work repairing the damage that the body has incurred during the earlier stages (Butto, 2019).

2.2.2. How fear is translated through media

Even though a person is supposed to sense fear when he/she is in the presence of danger, it can be puzzling as to why these instincts kick in, when watching a horror movie or playing a horror video game while being in a safe environment without the presence of any dangers. According to Nummenmaa (2020) this happens due to the fact that the human mind is hardwired to perceive whatever it senses through the five main sensory organs (eyes, ears, nose, tongue and skin) as genuine and authentic. The amygdala, which is a small almond shaped object that is in our brain is mainly responsible for processing emotions including fear as well as identifying potential threats (Nummenmaa, 2020). The prefrontal cortex on the other hand is responsible for processing information and assessing the threat level informing the brain whether it is necessary to take any action (Nummenmaa, 2020).

These two structures work hand in hand when it comes to detecting and assessing potential threats. However, the amygdala responds to fearful situations in around 120 milliseconds which is much faster than the time that the prefrontal cortex takes to process and evaluate the information in order to assess the threat level. According to Nummenmaa (2020) this can be seen as the main reason as to why people get scared when watching a horror movie or playing a horror game.

Nummenmaa (2020) further states that sources of entertainment such as theatre and movies have a huge effect on people, because of this phenomenon that occurs in the human brain. Due to this reason, artists in the digital entertainment industry can create copies of reality that could trick the human brain into perceiving as real when sensed. Even though forms of media such as movies, theatre and video games mostly use two out of the five senses (seeing and hearing), it's possible to artificially trick those senses into believing something fake as reality. Nowadays, with the emergence of new technologies the practical application of this can be seen at various amusement park rides, where the use of smell and touch are also used to make the experience more realistic. Human imagination also plays a role in enhancing the version of reality that was perceived through our senses. This attribute even lets the human brain perceive unrealistic atmospheres and situations as real, which is why we get scared even when we watch a Sci-fi (Science fiction) horror movie, knowing that the story is based in a fictional environment (Nummenmaa, 2020). The use of suspenseful music, jump scares and other techniques to elicit fear and create a sense of tension and unease also play a part in triggering the fight-or-flight response and causing people to feel scared, even if they know that they are watching a fictional story.

2.2.3. Measuring Fear

Fear in humans can be measured through a variety of methods. These methods can mainly be categorised as physiological and psychological methods. Measuring fear in a person psychologically would involve the use of methods such as interviews and self-report questionnaires. Measuring fear in a person physiologically could be done through the use of electrocardiography (ECG) machines, heart rate monitoring tools, electroencephalograms (EEG s) as well as analysing skin temperature (SKT) data. These are seen as accurate methods to measure fear (Choi, et al., 2015). Although this is the case, measuring fear can be seen as a complicated topic that involves multiple factors. On the psychological level, fear levels experienced by people are subjective and hence can be biassed and hard to compare (Man and Stassen, 2016). When it comes to measuring emotions such as fear physiologically, even though there is an advantage of being able to obtain quantitative results, it is hard to evaluate whether the physiological measurements were caused by fear or due to other factors that weren't taken into consideration (Man and Stassen, 2016). As an example, sweating can happen when someone is experiencing fear but on a hot summer day, it can be hard to say if someone is sweating due to the hot weather or because he/she is experiencing fear (Man and Stassen, 2016).

According to Man and Stassen (2016) although people believed that emotions such as fear were only processed through the amygdala, which is a part of the limbic system in the brain, recent research has shown that other than the amygdala, there is another kind of

circuit like system in the brain which process emotions, meaning that brain waves are created when emotions are being processed. Brain waves can be described as synchronised electrical pulses from neurons that transmit messages to other neurons and the rest of the body (Man and Stassen, 2016). Man and Stassen (2016) further state that there are studies that have been done with the use of an EEG recorder to find out information regarding other parts of the brain that are involved in emotion processing. One such study shows that the right frontal region of the brain is activated when experiencing negative emotions such as fear (Man and Stassen, 2016). Generally these brain waves can be categorised into several bands which are, delta waves (0.5–4 Hz), theta waves (4–8 Hz), alpha waves (8–13 Hz) and beta waves (>13 Hz) (Choi, et al., 2015). The beta wave is considered the fastest among the waves and hence called the fast wave whereas delta waves are considered to be the slowest among the lot and so it is called the slow wave (Choi, et al., 2015). The studies that Putman, et al. (2010 cited in Man and Stassen, 2016) did regarding the connection between emotions and brain waves have shown that the slow wave/fast wave ratio (SW/FW) correlates negatively with fear inducing experiences. A study that was conducted by Choi, et al., (2015) on measuring fear using multi-modal sensors proves this fact further. In their study Choi, et al., (2015) invited 16 participants to watch an experimental horror movie that was created using scary scenes from multiple horror movies. This was done in order to analyse and measure fear through various physiological sensors. From the results that they gathered, it is very clear that the slow wave/fast wave ratio value after watching the horror movie was lower than that of the slow wave/fast wave ratio value that was taken before the participants watched the movie.

In another similar study Man and Stassen (2016) analysed 30 participants in order to examine the relationship between brain waves and emotions using a single sensor EEG headset. In the experiment, they showed the participants three video clips. They were first shown a calm scene of a beach followed by a documentary video. Then they were shown a stressful video with scary clips and finally showed the calm video of a beach again (Man and Stassen, 2016). From the results that were obtained from the test, Man and Stassen (2016) were able to find out that the reactivity of brain waves were high when participants were watching the stressful video compared to the rest of the clips.

Other than the use of EEG devices, another approach that can be used to measure the level of fear is by using facial expressions. With the advancement of AI technology and machine learning, it is now possible to analyse facial expressions of individuals and predict the emotional state that they are in. The study that has been conducted by Babajee, et al.(2020) explores how facial expressions can be used to identify human emotions with the help of machine learning techniques. In this study, Babajee, et al. (2020) have constructed a Convolutional Neural Network (CNN) model that can identify the seven basic human emotions defined by the Facial Action Coding System (FACS) which was proposed by Ekman and Friesen. The CNN model has been trained using a dataset called Face Expression Recognition (FER 2013) which consists of 32,298 images each individually labelled (Babajee, et al., 2020). Babajee et al. (2020) further state that this neural network model has an accuracy of around 79% in predicting the emotional state correctly. However, it is worth to note that the study conducted by Babajee, et al. (2020) have focused mainly on measuring different emotional states, and the measurement of different levels of fear using facial expressions is yet to be studied.

By looking at these studies, it is evident that fear can be measured by analysing brain waves. However, Choi, et al., (2015) suggest that the use of devices such as EEG headsets can cause discomfort in participants since sensors are connected to them. However, the use of facial expressions or the heart rate of a player can be considered as a more practical and cost effective way when it comes to using physiological responses in order to detect and measure fear in individuals even though brainwave signals tend to be more accurate compared to its alternatives mentioned above.

2.3. The Genre of Horror

Nowadays horror can be considered as a genre that is quite popular among the masses. The genre that began reaching people through the means of folklore and literature texts has now expanded to using many forms of multimedia such as movies, theatre, television and video games. The word "horror" originates from a Latin verb meaning "to bristle" or "to shudder" (Author Learning Center, n.d.). According to Scott (2020), horror is a genre of storytelling that has the intention to scare, shock or thrill its audience. Scott (2020) further states that the threat that is depicted in horror can either be a central villain, a monster or a threat that is often reflected by a particular fear that the society is experiencing. Because the fears that are experienced by society change constantly, the genre has been subjected to many changes throughout the years. It can be also said that horror tends to change according to the culture and fears that a society has in a particular time period. A movie like Frankenstein, which was made in the 1930s may not be scary to the present audience because it was targeted at the people who lived in that particular time period and the fears that they had (Norwood, 2019).

The genre of horror mainly consists of four types, namely:

- **Gothic horror:** A subgenre of horror which focuses on the contrast between the natural and unnatural.
- **Supernatural horror:** This sub-genre mainly comprises elements such as spirits, ghosts, gods, demons, or the afterlife.
- **Non-supernatural horror:** This genre typically does not include supernatural elements meaning the events that occur in most of the stories that belong to this category could plausibly occur in real life. The antagonists in these stories tend to be serial killers or deranged individuals who are led to go out on killing sprees.
- **Psychological horror:** A genre that creates distress or dread by simply exposing universal human vulnerabilities or fears.

All horror stories that we read through books and see through movies are built upon one of these sub-genres (Author Learning Center, n.d.).

2.3.1. Horror Games

Horror games can be considered as a genre of video games that are designed to create feelings of fear, panic and anxiety within the player (Yu, 2022). When looking at the various genres that associate with video games, horror can be seen as a genre that has a high chance

of evoking player emotions and immersing them in the experience because of the fear-inducing state that the players are put into. Many horror games tend to limit the player agency by only allowing the player to perform a limited number of actions in the game, which makes the whole experience more realistic compared to many other genres (Griffin, 2019).

Horror games date back to the early 1980s where the main priority of games was to deliver scares rather than telling a story. The first horror game that was released is considered as 'Haunted House' which was released on Atari 2600 consoles in 1981 (Yu, 2022). Even though there were quite a few games released during the 1980s, the titles such as 'Alone in the Dark', 'Resident Evil' and 'Silent Hill' that were released during the 1990s and 2000s are considered as the titles that solidified horror as a genre in the gaming industry.

Even though horror games can be categorised into sub-genres such as survival horror or psychological horror, the overall theme for games are mainly labelled based on their core gameplay elements such as the perspective that the player would see the world (first person view, 3rd person view). Because of this, a developer can take any game and make it into a horror game (Wierzbicki, 2016).

One major thing that makes a horror game great is the clever use of design elements that can keep the player engaged throughout the experience. Many horror game designers tend to use the environmental design, lighting and narrative aspects of the game to build atmospheric horror in the game. Griffin (2019), states that good horror games tend to balance the feelings of fear and relief in the game within the virtual environment which ultimately keep the player immersed and engaged. As for Griffin (2019) balancing these two elements is the key because without the proper balance between those two elements, the player's immersion can break either due to boredom or the game being too intense, which would cause the player to withdraw from the game due to fear or anxiety.

2.3.2. Horror in video games vs other media

When looking at presenting horror through video games in comparison with the other forms of multimedia that is used to present horror, there are a few unique traits that horror in video games have. One such example is how the story in games proceed compared to other forms of media. When we take a movie or a horror novel, the story is always linear and the audience can predict what might happen next whereas in horror video games the story is not always linear, making the decisions that the player make in game have an impact on the story (Gosha, 2015). Since it is not scripted, triggering different events in games can lead the player to different outcomes. Just like the storyline, events that occur in a video game can also be unpredictable (Wierzbicki, 2016). According to Gosha (2015) other forms of media such as movies and theatre, force the audience to form a relationship of some sort with the characters on screen. As adults, we make our own decisions, but movies still insist on making them for us (Gosha, 2015). When you consider most of the horror movies out there, if the main protagonist is facing danger, the audience can safely predict that nothing bad is going to happen because most of the movies never kill off the main protagonist. But we cannot say the same about horror games, because horror games do not care whether you are a protagonist or not and you have to play the game until you reach the end during which,

the character can die multiple times throughout the playtime (Wierzbicki, 2016). The unpredictability level that is involved in games since players do not know how AI reacts in different stages or situations of the game can also increase the fear factor of the player immensely (Wierzbicki, 2016). Gosha (2015) shows a good example regarding this that can be seen in the game *Outlast WhistleBlower* released by Red Barrels (2014). In this survival horror video game, the player cannot fight back and hence has to run and hide under a bed or a locker when they encounter an enemy (Gosha, 2015). Normally, the player can feel safe if he/she hides in a hiding spot. However in the chase scene with Gluskin, who is one of the antagonists in the game, hiding doesn't matter and just when the player starts to feel relieved and safe, Gluskin would drag the player out of the hiding spot terrorising the player (Gosha, 2015). Because of these reasons, the tension level of a player who is playing a horror game can be greater than that of a person who is watching a horror movie (Wierzbicki, 2016). Another major difference that can be seen between video games and other forms of media that are used to present horror is that the latter tends to follow the rules of passive observation whereas games present active interaction (Wierzbicki, 2016). When horror is presented via mediums such as movies or novels, the viewer can skip a fear inducing moment if he/she gets too scared and continue the story after the unnerving part is over. But when it comes to video games the player has to actively take part in the events that are happening, and the player has to play through without having the ability to skip the parts of the game that tend to be scary in order to progress through the story. Wierzbicki (2016) further states that the sense of fear and dread that is created within a player, playing a horror game is much stronger than the sense of dread that is created by other forms of multimedia.

However, one of the downsides that I see in video games is that the replayability in games can reduce the tension level of the player. When you go through a particular fear inducing scene in a movie, you only get to experience it once for the whole duration of the movie. But when it comes to games, the player should somehow manage to clear certain areas in order to progress through. This can include having to play certain areas of the game repeatedly which can hugely decrease the effect of tension and fear that the horror elements in that area would bring to the game.

2.3.3. Atmospheric horror in games

Games tend to use atmospheric horror in order to create a sense of dread and unease in the player. This is mainly achieved through the use of audio, visual and narrative elements that create an eerie and unsettling atmosphere in the game (Horti, 2018). According to Wierzbicki (2016), both horror games and horror movies use a combination of atmospheric horror and jump scares to capture their audiences. While jump scares can be considered as the element that startles the player, atmospheric horror is responsible for building up an eerie atmosphere that would eventually lead up to the jump scare (Wierzbicki, 2016). Horti (2018) who had the chance to interview four top developers in the industry mentions that many successful horror game atmospheres are scenarios that developers and designers imagine in their heads. Horti (2018) further states that developers bring these scenarios to life using various techniques making tense, fear inducing atmospheres in games. In the interviews that were conducted by Horti (2018), he mentions that all the developers emphasised the importance of allowing space for the player's imagination to actively engage

with the game. Ian Miham, who was the art director at Visceral games when they made Dead Space 1 mentions how they deliberately removed enemies and objects from the game during the final stages of development in order to allow the player's imagination to fill the blanks (Horti, 2018). According to Thomas Grip, who is one of the co-founders of Frictional Games, developers exploit the fact that humans tend to expect that things are going to be far worse than how they would actually turn out to be (Horti, 2018). Due to this reason, the frightful scenarios that the player anticipates can be scarier than the actual scenario that they would face (Horti, 2018).

The use of lighting and shadows can heavily influence when creating tense environments in games (Horti, 2018). This is achieved by using flickering lights, having dimly lit areas or areas that are of complete darkness in the game and adjusting the lighting settings according to different situations in the game. Miham explains that creating a tense atmosphere in a game can be done not just by limiting light sources in the environment but also by using lights that only illuminate a small portion of the environment (Horti, 2018). He further states that the use of lighting in this way allows developers to intentionally leave sections between the light sources in the dark, so the players would feel tense entering these dark areas not knowing what to anticipate (Horti, 2018). A good example of the use of lights in this manner can be seen in *Alan Wake* released by Remedy Entertainment (2010). In this game, the developers have cleverly placed light sources that only illuminate a small portion of the environment as a mechanism to guide players through the map as well as to create tension within the players when they enter an area without any source of light. Miham also mentions that providing diverse lighting surfaces is a feature that is seen in good horror games since it makes the whole game environment unpredictable (Horti, 2018).

The use of sound and music is another trait that developers tend to use in order to build up atmospheric horror. Good use of sound and music in a horror game can be as important as having good visuals according to Thomas Grip (Horti, 2018). Grip further states that you can have fairly detailed sounds in a horror game and still frighten players playing it (Horti, 2018). In his article Horti (2018) further explains how sound can be a crucial component in horror games by taking the game *The Nightjar* released by the developer Somethin' Else (2011) as an example. Although this game has no visual elements whatsoever, it is still capable of terrifying players with its clever use of sound design (Horti, 2018). As for Grip, one of the advantages of having good sound design in horror games is the ability to paint a specific and disturbing image in the player's mind about the horrors that lurk in the environment which can be worse than the actual horrors that are visually presented to the player (Horti, 2018). Subtle background sounds like heartbeat sounds and computer beeps can also help build tension in the player (Horti, 2018).

Other than these techniques, developers also use narrative techniques to build up tension within the player. The effective use of environmental storytelling is one of the best ways to create atmospheric horror. If we take an example of a scene with dead bodies and blood all over the place, the player tends to feel terrified while also having the unnerving feeling of what is going to happen next. The fog mechanic used in The Silent Hill franchise creates an atmosphere such that even if the players exactly know where to go they would hesitate to move forward since they aren't quite sure what might lurk in the mist ahead (Matos, 2012). According to Hope who has been involved in developing *Alien Isolation* by Creative Assembly (2014), the team have used game objects that look like body parts of the Xenomorph alien in order to increase the tension of the player while also using visual effects

to obscure the player's view (Horti, 2018). Not being able to clearly see what is ahead of the player can certainly tense up the player because the fear of not knowing what the player would have to face in the coming moments would always keep the player on edge, even in situations where nothing terrifying is bound to happen (Horti, 2018).

2.4. The use of Artificial Intelligence in Horror Games

The use of AI in horror games is not an alien concept since it has been used to create intelligent enemies that can track down players and adapt to different situations depending on how the player acts. One of the earliest examples of using AI in games can be seen in Pac Man where the enemy ghosts are designed to track players using path-finding algorithms (Chan, Chan and Gelowitz, 2015). Many modern games in general, adopt different AI algorithms in games. Finite State Machine, Fuzzy State Machines and Behaviour trees can be named as some of the AI algorithms that are being used in games even to this day (Chan, Chan and Gelowitz, 2015). One might think that using AI in games would be much more advanced to that of now since AI in general has advanced to a point where systems can act and solve problems in a similar fashion to that of humans, but game companies tend to use traditional AI techniques that have been present in the industry for quite some time rather than using advanced techniques to make the AI more intelligent. According to Statt (2019) one of the reasons for this is that adding AI that are intelligent enough to act on their own would behave in ways that would make the game unplayable giving a bad gameplay experience to the player. Imagine a game that cannot be finished by the players because the AI system of the final boss is so intelligent that it can predict player moves hence being unbeatable in the game. Statt (2019) further states that instead of using highly intelligent AI systems in game, developers use multiple systems that intertwine and work together to mimic the game world as realistic as possible. These systems are complex enough to make players think that they are interacting with something intelligent, but predictable and controlled enough to keep the story going without interrupting the core gameplay loop and other game logic. FPS shooters such as the Halo series and *F.E.A.R* developed by Monolith Production (2005) which are known for its use of AI in influential ways back in the day, did not use sophisticated AI systems to mimic the game environment but instead used game systems to trick the players into thinking that they were facing intelligent enemies that act according to their own will (Statt, 2019). For instance, when the player throws a grenade in the game, the enemies tend to shout "grenade", mimicking how a combatant would react in a real battleground. In some of the more recent games, you can see that the enemies try to retreat when fellow enemies are killed, reducing the number of enemy characters left in that specific area.

The main focus that game developers have when it comes to creating video games is to deliver a satisfying gameplay experience to the player and horror games are no exception to this fact. The use of AI elements in games greatly contribute towards achieving this goal. There are two main ways that developers use AI techniques in horror games in order to create truly immersive and terrifying experiences for the player.

2.4.1. The use of Artificial Intelligence (AI) on Non Playable Characters (NPCs)

One effective way of using AI in horror games is to use AI techniques to control the NPCs presence in the game. These characters can vary from friendly characters that help the player to enemy characters that try to catch the player as well as other non playable characters that do not have a particular relevance to the main storyline of the game. These AI systems are mainly responsible for how the NPCs behave and react to different situations that may arise in the game.

Looking at the psychological horror, first-person shooter *F.E.A.R* developed by Monolith Production (2005) which can be considered as one of the earliest horror games to include AI algorithms, it can be seen that the game uses a Finite State Machine (FSM) system and a planning system in order to control enemy AI behaviour. The FSM system is used to give instructions to the enemy AI on how to behave in every situation whereas the planning system is responsible for giving goals to the AI, letting the AI decide on how these goals can be achieved by using the instructions that are available (Orkin, 2006). Even though these techniques are highly efficient when it comes to games that do not require NPCs with complex behaviours, implementing techniques such as FSMs and planning systems on games that consist of NPCs with multiple behavioural states can be complex and hard for the developers. Due to this reason modern games lean towards using behaviour trees to overcome the downsides of the aforementioned design patterns. A behaviour tree can be described as "a tree of hierarchical nodes that control the flow of decision making of an AI entity" (Simpson, 2014). One of the main advantages that this design pattern has in comparison to FSMs is the flexible structure which allows the developers to add new behaviours to the tree making the system much more easy to scale while keeping it simple and easy to understand. One good example of the use of behaviour trees can be seen in *Alien Isolation* by Creative Assembly (2014) which is based on the famous horror movie series Alien.

The design of the main antagonist of this game, which is a Xenomorph alien, has two AI systems which are a behaviour tree and an AI director system (Thompson, 2020). The behaviour tree is solely responsible for the behaviour of the alien AI. This includes tasks that are comparatively simple such as attacking the player to much more complex scenarios such as checking inside lockers and crawl spaces searching for the player and hiding in vents and ambushing the player as well as retreating when the player is using a flamethrower against the alien. According to Thompson (2020), there are around 100 nodes that are present in the behaviour tree AI of the alien and at the top level, there are around 30 nodes that are responsible for selecting the type of behaviour that the AI should execute. At the beginning of the game, some sections of the behaviour tree are locked and these behaviours are unlocked when certain conditions are met as the player progresses through the game which gives the player an impression that the alien is learning and evolving itself as you progress in the game (Thompson, 2020). And since the behaviour of the alien is not scripted, it can be random and unpredictable in the game. This randomness can solely increase the tension level of the players and always keep them on the edge since they cannot predict where the alien would appear next and what it will do in the coming moments.

A more modern example of the use of AI in NPCs can be seen in *The Callisto Protocol* by Striking Distance Studios (2022) which is a 3rd person horror game that has taken its inspiration from the Dead Space series which is considered by many horror game fans as a classic 3rd person survival horror game series that was released in the late 2000s and the early 2010s. According to the information that was collected in an interview that was done with Mark James who is the chief technical officer of Striking Distance Studios, the game has used AI not just to kill, but also to scare the player (Krafton, 2022). This has been achieved by creating the enemy AI systems with the help of behaviour trees as well as a utility AI system which is a design that uses a point system to decide the best decision that the AI should make according to the different scenarios that it faces. One of the examples that Mark mentions in the interview to describe the AI system is how an enemy who is quite far from the player would climb into the vents and hide instead of attacking the player head on. According to him, the AI behaves in this manner in order to get closer to the player so that it can get to a better vantage point to attack the player (Krafton, 2022). In the interview, Mark also mentions how enemies tend to block the attacks of the player if the same type of attack is used again and again forcing the player to use other types of attacks (Krafton, 2022). Just like in *Alien Isolation* by Creative Assembly (2014) the developers of *The Callisto Protocol* by Striking Distance Studios (2022) have also used a behaviour tree with locked sections which can only be unlocked by triggering certain events, leading the player to believe that the AI is slowly learning as the game progresses.

2.4.2. The use of AI to provide a positive gameplay experiences

The main goal that game developers try to achieve when creating a video game is to provide a fun and immersive experience for the players and making sure that the players would return back to play the game without getting frustrated or bored of it, after some time. Most of the games that are being released nowadays use AI to achieve this. Many First Person Shooters (FPS), 2D Platformers and Souls-like games use AI to customise the difficulty of the game according to the skill level of the player so that he/she can experience the game to the fullest, whereas open world games tend to use AI to procedurally generate environments as well as to manage resources so that the game can run at its full capacity all the time (D'Souza, 2023). In addition to the uses mentioned above, horror game developers have the ability to use AI systems for sounds, lighting as well as for the surrounding environment in order to build up tension and fear within the player. When using AI in horror games, developers must make sure to balance the horror elements of the game in a way that the players feel tense and scared but would continue to play despite of that. In order to achieve this balance, game developers use an AI system called “The Director” which is responsible for how other AI systems behave within the game. The AI director is not a methodology, nor does it have a set of rules and guidelines but is rather a concept that developers use in their games. This is due to the fact that the AI requirements in games differ from one another and hence the AI director system has to be created according to the specific requirements of that game.

When you look at how the behaviour tree of the alien AI in *Alien Isolation* by Creative Assembly (2014) behaves, you might think that by having an AI with such capabilities and decision making abilities, alien AI can be too unpredictable and uncontrollable in the game,

resulting in an awful gameplay experience. This is where the AI director comes into play. Even though the alien AI can act on its own, it does not know information on where the player might be on the map. The AI director on the other hand has information regarding the location of the player as well as the alien AI thus dictating when the alien can go and hunt the player (Thompson, 2020). Although the AI director precisely knows the location of the player, it only gives the information of a specific area that the player is in, rather than giving off the coordinates of the player to the enemy AI. This makes sure that the alien AI has to find the player on its own. The AI director uses a measurement called 'the menace gauge' which keeps track of the level of tension that the player is having. This measurement is a predicted value, since the game does not contain ways to measure the tension level that the player would have during run time. The menace gauge does not come by attacking the player but rather by increasing the perceived tension that the player would have, by being in the proximity of the alien (Thompson, 2020). The alien AI has two main behavioural patterns which are known as front-stage and back-stage behaviour. When the front-stage behaviour is triggered, the alien takes a more aggressive approach wandering the corridors and searching for the player. When the back-stage behaviour is triggered, the alien tends to go into the vents allowing the player to wander around the corridors and progress through the storyline of the game. When the menace gauge reaches a certain threshold, the AI director commands the alien AI to trigger the back-stage behaviour, letting the player have some breathing space. When the menace gauge value lowers down, the AI director provides information about the area that the player might be in, commanding him to activate the front-stage behaviour and search for the player (Thompson, 2020). The job done by the AI director on deciding when the alien should show up and try to capture the player or hide in the vents, is the main element that keeps the player from stopping the game due to high tension or the game being unplayable.

Another classic example that can be looked at, when talking about the use of AI in horror games to enhance player experience is the role that is played by the AI director in *Left 4 Dead* (2008) and *Left 4 Dead 2* (2009) developed by Turtle Rock Studios. In this co-op survival horror shooter, the players are stuck in a zombie apocalypse and have to make their way through the remains of destroyed cities while fighting off hordes of zombies. The main goal of the director AI of these games is to manage the pacing of the game. It decides when to put pressure on the players by sending multiple waves of zombies towards them and when to give the players some breathing space (Thompson, 2022). The director AI in the left 4 dead series is merely a Finite State Machine system that mainly takes care of spawning new zombies to the game and choosing which player needs to be targeted. According to Thompson (2022) the AI system has been given the role of choosing a specific player to be targeted at, because it monitors the perceived stress level of each player by monitoring their in-game statuses such as player health, the amount of ammunition that they hold as well as the way they engage in fights. For example, the AI system assumes that a player who has full health plus ammunition and engages from a distance (using a sniper to kill zombies) would have a lesser stress level than a player who fights with hordes of zombies at close range and hence, tends to send more zombies towards the player that is fighting from a distance.

The Finite State Machine (FSM) system that is being used for the AI director has three states

1. **The build up**: The AI tries to increase the stress level of the players by sending zombies to attack different players.

2. **The peak**: The AI tries to maximise the stress levels of the players by increasing the intensity of the enemy waves, sending different zombie types that are stronger than regular zombies.
3. **The cool-down**: Once the players successfully overcome the hordes of zombies that were thrown at them, the AI director gives some breathing space to the players, and waits for some time until it restarts the cycle all over again.

The rate at which the AI director moves through these states is not constant and would highly depend on the pace that the players would play. Furthermore, the AI director also considers whether the player is playing the game as it is intended to be by the developers. Since this is a co-op game, the players are expected to support each other and stick together as a group. The AI system tends to be less punishing and would spawn more resources such as health packs for the players to use, if the players cooperate and support each other. But if a player wanders alone without playing together with the team, the AI system punishes that player by targeting him/her sending hordes of zombies towards the location of that player (Thompson, 2022). Because most of the gameplay elements are handled by the AI director, the players get a unique and positive gameplay experience. The replayability of the game would also increase due to the possibility of experiencing the game in a totally new way.

3. Problem

Even though the use of AI in horror games have advanced in many ways, the AI aspect in most games still tend to revolve around controlling enemy behaviour, resource management and difficulty adjustment in game. The concept of using AI to create atmospheric horror in games seems to be quite new in the game industry and most of the developers still tend to script horror elements in games such as jump scares manually. Although there are situations that can be favourable sometimes, scripting atmospheric horror elements manually into a game can have its own drawbacks.

3.1. The disadvantages, scripting atmospheric horror elements manually

1. **Time Consuming**: When creating atmospheric horror in a game manually, the developers have to look into all the assets and characters that are being used in the game, thoroughly go through the storyline of the game and carefully design the atmospheric horror elements to match the environment and the theme of the game. It usually takes a considerable amount of time for the developers to carefully design the use of horror elements such as sound queues, music and lighting effects to effectively create tense and unsettling experiences for the audience. Furthermore, they have to repeatedly test these horror elements to see if they can scare the audience as intended. Although triple A studios might not have that much of an issue scripting horror elements manually in a short period of time due to resources that they have, a small indie studio with 5-10 developers might have to spend a longer period of time in order to design these elements.

2. **Predictability**: When horror elements are scripted throughout the game, the developers must make sure not to be too predictable since the sound queues or the jump scares that are used in the game being too predictable can reduce the tension level of the player making the game less scary.

3. **Limited Replayability**: Another concern that horror game developers face when creating a game is whether there are enough variations in the game to make a player who has already played the game come back to play and enjoy the experience again. Many single player games that are being built nowadays try to increase the replayability aspect of it by using design tactics such as adding multiple storylines depending on the character that the player would play and adding different endings to the game that would trigger according to the choices that the player makes in the game. However, in a game that has its events heavily scripted, the replayability aspect is drastically reduced. This is clearly relevant for horror games since the player experience in these games

are heavily influenced by the intense moments that are presented to the player. The feeling of fear and tension is taken away from the player, if he/she knows what's going to happen next. As for Roberts (2022) the rise of let's plays and reaction videos, where you-tubers stream themselves playing and reacting to horror games have had an effect particularly on the genre of horror because these type of videos can spoil a good horror game by revealing moments that are intensely frightening to a potentially massive audience. Although reaction videos can help indie studios in terms of exposure, it can also affect the sales since players might not be interested in buying and playing the game after seeing all the jump scares and other important aspects of the game through reaction videos.

3.2. Solution

The main objective of this research was to propose an implementable design that can be used to generate atmospheric horror using AI by analysing the physiological responses of the player in real time during gameplay, by looking into different methods and equipment that can be used to collect physiological data of a person during gameplay, analysing the practicality and feasibility of using them in real time in commercial horror games and observing the feasibility of using Machine Learning (ML) models to recognize emotions (in this particular case, different levels of fear). The proposed system would be a viable solution for the issues that developers face when scripting atmospheric horror elements manually. Furthermore, this would pave the way for developers to save time which in turn can be put into carrying out other important aspects, such as fine tuning, optimising and play-testing the game. Another advantage of the proposed concept is that it can be used in other video game genres by creating ML models that could cater emotional traits, other than fear related ones.

While the games industry has not extensively explored the use of physiological responses to enhance player experiences in video games, there is a vast amount of information related to research work that has been done with regards to this matter. One of the key concepts that come across when looking at these research work is "Affective Gaming". According to Aggag and Revett (2011) the main idea behind this concept is to build a correlation between a player's emotional state and their satisfaction with gameplay by allowing a computer game to effectively detect and adapt to the player's emotional state based on their physiological responses. Affective gaming can be considered as a popular sub-field of biofeedback games which are games that use biosensors as a primary or supplementary means of controlling certain game mechanics rather than conventional input modalities, such as mouse and keyboard (Erb, et al., 2022).

3.3. Previous work done with regard to the usage of player's physiological responses in video games

Nero is a 2D platform game which was developed as a prototype to explore the possibilities of using Affective gaming in the video game industry. In this game, the emotional state of the player is obtained by measuring his/her heart rate (Erb, et al., 2022). The emotional states of the player are divided into four categories, namely relaxed, focused, excited and stressed. In addition to these four emotional states, Erb, et al., (2022) also mentions a base emotional state which is described as the state, represented by the average heart rate that is calibrated before the start of play. The current emotional state of the player is displayed by the body colour of the In game character. Each emotional state consists of a special ability that the player can use when attained. For example the player can jump on breakable objects without falling down when he/she is in the relaxed state, allowing the player to easily navigate through the terrain and push immovable objects when in the excited state (Erb, et al., 2022). In order to succeed, the players must learn to control their emotions so that they can switch from one emotional state to the other in order to overcome different obstacles that are present throughout the levels in Nero.

The research work that has been done by Kalansooriya, Ganepola and Thalagala (2020) explores how background music in racing games can be altered according to the emotions that the player is experiencing during gameplay. For this study the researchers have used EEG signals in order to capture the physiological responses of players. The main reason behind choosing EEG signals as the means of measuring player emotions is because unlike physiological measurement metrics such as facial expressions and body gestures which can be altered sometimes, EEG signals come directly from the human brain, directly reflecting human emotional states that are unaltered (Kalansooriya, Ganepola and Thalagala, 2020).

Although there aren't many examples of commercial video games that use physiological responses of the player real time in game, a few notable cases that creatively inserted this technology into their core mechanic can be seen. Mindlight can be considered as a horror themed experimental serious game that focuses on teaching children between the ages 8-12 on how to cope with anxiety (Schoneveld, et al., 2020). In this game you play as a little boy named Arty who must navigate through his grandmother's scary looking mansion in order to save his grandmother from the evil forces that have possessed her and the house (Schoneveld, et al., 2020). In his grandmother's house, Arty finds a magical glowing hat named Teru which teaches Arty how to control his state of mind and overcome his fears. This magical hat (Teru) has a light attached to it which has the ability to chase away the evil forces and uncover what is present in the darkness when brightly shined. This game mechanic is controlled by an EEG headset that tracks brain waves of the player, which measures in real time, how relaxed the player is. The more relaxed the player, the more bright the light attached to Teru would shine (Schoneveld, et al., 2020).

Nevermind, which is developed by Flying Mollusk (2015) can be considered as a noteworthy example that shows the potential, and the impact a commercial video game that utilises player's physiological responses can have. In this game you play as a Neuro-prober, a therapist of the future. As a neuro-prober, your job is to delve into the psyche of your clients who are experiencing significant psychological distress. Each client represents a

self-contained level whose completion is achieved by finding the root cause for the particular client's distress (Lobel, et al., 2016). In order to do so the player must navigate the client's nightmarish subconscious, solving puzzles and searching for clues (Lobel, et al., 2016). The players can choose to play *Nevermind* as a traditional video game or use biofeedback inputs with the help of a heart rate monitor to have a tenser experience. The player's heart rate that is continuously obtained during gameplay is used to measure the stress level of the player. When the player's stress level increases, the game makes it harder to play by progressively obscuring the screen as well as by making the environment more hostile (Lobel, et al., 2016). The game challenges the player to take control of his/her physiological state as well as mental state in the presence of situations that can arouse negative emotions (Lobel, et al., 2016). A good example of how this is done is shown in one of the levels where the player is stuck in a room, drowning in milk. The milk level rises when the stress level of the player is increased and in order to overcome this situation, the player has to enter a calm state that would reduce his/her stress level which would in turn lower the milk level (Lobel, et al., 2016).

Even though the research work and the commercial video games that I have mentioned above, utilise physiological responses of the player, to manipulate various aspects of game attributes, the player has the ability to control his/her physiological attributes to change a hostile environment into a more safe and calming space. However, the approach that I would be looking at will not give the player the ability to manipulate the environment as he/she wishes. Instead, the goal would be to use the physiological responses to increase the fear and tension level of the player by introducing horror elements that would try to increase the fear level of the player.

4. Research Methodology

The methodology that was used in this research paper was mainly divided into three parts. The first part solely focused on deciding the technologies and devices that will be used for the proposed implementable system. In the second part, a system design that can be implemented in horror games in order to create dynamic atmospheric horror based on the level of fear that the player is experiencing was created. In the final part of the research, several students with a background in game design and a few developers from game studios were interviewed to see what they think about the applicability and practicality of the proposed system design if it is to be implemented commercially.

4.1. A look into the feasible technologies and devices that can be used when implementing the proposed system design

The first step of creating the implementable system was to do a background check on the possible technologies that could be used if the system was to be implemented on a commercial horror video game. This background check was done in order to find out what devices and technologies are suitable to read physiological responses of the player and analyse the level of fear that the player is having at a particular moment. This analysis was divided into two parts.

1. Analysing the applicability and practicality of devices that can be used to measure the level of fear in players.
2. Looking through different Machine Learning models that can be used to train a model to predict the player's level of fear.

4.1.1. Analysing the applicability and practicality of devices that can be used to measure the level of fear in players.

In order to choose the correct device that was to be used in collecting physiological data of the player, a systematic literature review conducted by Navarro, Sundstedt and Garro (2021) was used. This literature review focuses on how different biofeedback interaction methods are used for entertainment purposes in commercial video games between 2008 and 2020 (Navarro, Sundstedt and Garro, 2021). In this literature review the researchers Navarro, Sundstedt and Garro (2021) observes six different biofeedback interaction methods which are Electroencephalography (EEG), Electrocardiography (ECG), Eyetracking (ET), Electro-Dermal Activity (EDA), Electromyography (EMG) and a multi-modal interaction method which is a combination of all five of the aforementioned interaction methods, analysing the strengths and weaknesses each biofeedback interaction method possess with regards to the usability of them in commercial video games. Out of the six interaction methods only EEG, ECG and EDA methods were considered for this particular scenario since only these three methods are commonly known for detecting emotions (in this particular case, fear) through physiological responses.

According to the findings of the systematic literature review, it was found that data obtained through EEG are required to be filtered in order to make interaction techniques functional and responsive. Since the process of doing so would take time, Navarro, Sundstedt and Garro (2021) have come to a conclusion that the use of EEG is not appropriate for interactions that happen in real time. Furthermore Navarro, Sundstedt and Garro (2021) have emphasised that the use of EEG is still not ready to be used in commercial games since most of the EEG interaction techniques are still being developed and tested in controlled environments with dedicated controlled groups. Also setting up EEG devices would take a lot of time and might become irritating for the player to wear them throughout a gameplay session which might hinder his/her overall gameplay experience. Similar to EEG interaction methods, ECG inputs can also face delays due to the gradual increase and decrease in the beat rate that a heart would naturally have, which makes it less suitable for interaction techniques that expect quick changes in its data (Navarro, Sundstedt and Garro, 2021). And since humans can voluntarily manipulate one's heart rate with breathing techniques there is the possibility of players being able to mimic their emotions if ECG interaction methods are used (Navarro, Sundstedt and Garro, 2021). From the results that Navarro, Sundstedt and Garro (2021) were able to obtain when it comes to the use of EDA interaction methods which are also referred to as galvanic skin response (GSR) it is evident that it measures interactions that cover several emotional reactions. However the data obtained by EDA methods highly depend on the environment that the player is in. The player might not be sweating because he/she was facing a tense situation but because due to the high temperature of the room that he/she is in which could lead to having the system respond to false or inaccurate data that can have an effect on the player experience. Although this literature review covers most of the methods that can be used to collect physiological data from the player it has not covered the usability of facial expression recognition (FER) to detect player emotions. However there are many studies that have been done on the use of FER methods to detect emotions in real time video games. One such study, done by Akbar, et al. (2019) to explore how FERs can be used to dynamically balance game difficulty in real time can be said as one such example.

All of the biofeedback interaction methods mentioned above have their advantages and disadvantages. But when it comes to using one in order to analyse data in real time, the chosen interaction method should be able to quickly analyse and evaluate the player's physiological data and since the proposed system is aimed at implementing on commercial video games, the player experience should not be hindered. Furthermore it's best if the player does not have to spend extra money to purchase extra equipment in order to use the emotion detection. By taking all these factors into consideration, it was decided that a FER system is the best match to obtain physiological data.

4.1.2. Looking through different Machine Learning models that can be used to train a model to predict the player's level of fear.

Since it was decided to analyse physiological responses of the player through their facial emotions, it was decided that the best way to do this is by using an image classifier model. The first most important attribute that was considered when looking through different ML models that can be used to measure the fear level of players through their facial expressions was the level of accuracy that each model would have. In order to do so, a literature review that was done by Obaid, Zebaree and Ahmed (2020) on deep learning models on image classification was used. In their work, Obaid, Zabaree and Ahmed (2020)

have analysed thirteen deep learning models in terms of accuracy. All the models have been trained using CIFAR-10 and CIFAR-100 which are two datasets that are used to train ML models. Based on the results obtained by the literature review, Obaid, Zabaree and Ahmed (2020) show that all the 13 models have an accuracy of over 60%. Out of the 13 models which were trained using the CIFAR-10 dataset, the Extreme Neural Architecture Search (XNAS) model has the highest accuracy with a value of 98.4% whereas the Shakedrop model has the highest accuracy when the models are trained using the CIFAR-100 dataset with an accuracy of 87.8%. With the results that were taken by the literature review, it was decided that using an image classifier model such as XNAS or Shakedrop with a high level of accuracy would be ideal.

4.2. Designing the proposed system

Since the main objective of the proposed system was to generate atmospheric horror elements corresponding to the fear level that the player is displaying through his/her physiological responses, the design for the system was created while having this core idea in mind. The proposed system will be identified as Dynamic Horror Generating (DHG) system from this point onwards.

4.2.1. Affective loop theory

The main concept behind the Dynamic Horror Generating (DHG) system is the affective loop theory which is a theoretical framework that describes the interaction between a user and a computer system, particularly in relation to emotional experiences (Kalansooriya, Ganepola and Thalagala, 2020). According to Kalansooriya, Ganepola and Thalagala (2020) this framework consists of three main phases which are

1. **Capturing player reactions through biofeedback:** When the player reacts to a certain event in the game (this can be a certain game mechanic, sound queue or a change in environment in game) this reaction or the change of feeling is captured via bio signals.
2. **Predicting the player emotion using bio signals:** The player feelings that are captured through bio signals are analysed and the emotion that the player is experiencing in that particular moment is predicted.
3. **Adjustment of the game according to the player's emotion:** The game decides on how it is going to react to the current emotional state of the player and make the necessary changes in order to do so.

In the DHG system design, the physiological reactions of the player will be captured using a FER system which will detect the facial expression changes of the player. The data obtained by the FER system will then be analysed in order to determine the level of fear that the player is experiencing at a given time. Finally the data related to the fear level of the player will be sent over to the in game AI system which will trigger in game events corresponding to the fear level of the player.

4.2.2. The four stages of fear

One of the main tasks that needs to be done in order to successfully make this system work is to identify how fear can be measured and categorised into different stages. Although there have been studies done to measure the fear level of an individual, research work that has been done with regards to classifying the perceived fear into different stages is close to none. In order to solve this issue a self defined concept based on Butto's (2019) work to categorise the stages of fear was created. This concept will be called 'The four stages of fear' from this point onwards. The four stages defined in this concept are namely perception, activation, reaction and recovery.

1. **Perception:** This is the first stage of fear which involves perceiving a threat or a danger. When you look at it in the context of a horror game, this could be the instance when a player hears an ominous sound indicating that something frightening is nearby. The player would start to feel scared but still would be curious enough to investigate as to what is behind the ominous noise.
2. **Activation:** This is the second stage of fear which occurs when the player encounters a threat. This can be a sudden jump scare or an enemy noticing and charging towards the player. During the activation phase, the physiological responses such as the increase in heart rate, blood pressure and respiration can be seen in the player.
3. **Reaction:** This is considered as the third stage of fear which involves how the player reacts to the perceived threat. The player would either run away, fight back or stay frozen holding his/her breath until the threat is no longer there. The way players react can vary depending on the situation that the player is in.
4. **Recovery:** This is the final stage of fear which includes the body recovering after reacting to a perceived threat. In a horror game this would be the time period that the player would relax after experiencing a stressful situation. During this phase the heart rate, blood pressure and the respiration would decrease cooling down the body.

In addition to these four stages a baseline state which depicts the neutral emotional state of the player, was introduced. This was done in order to define an emotional state that the system would require to transit to at the beginning of the game. However, after reaching the recovery stage, the players will not return to a neutral emotional state since they are wary of their surroundings and would anticipate jump scares and other horror elements. Due to this reason it is quite possible to say that the players would jump straight into the perception stage after cycling through all the stages of fear mentioned above.

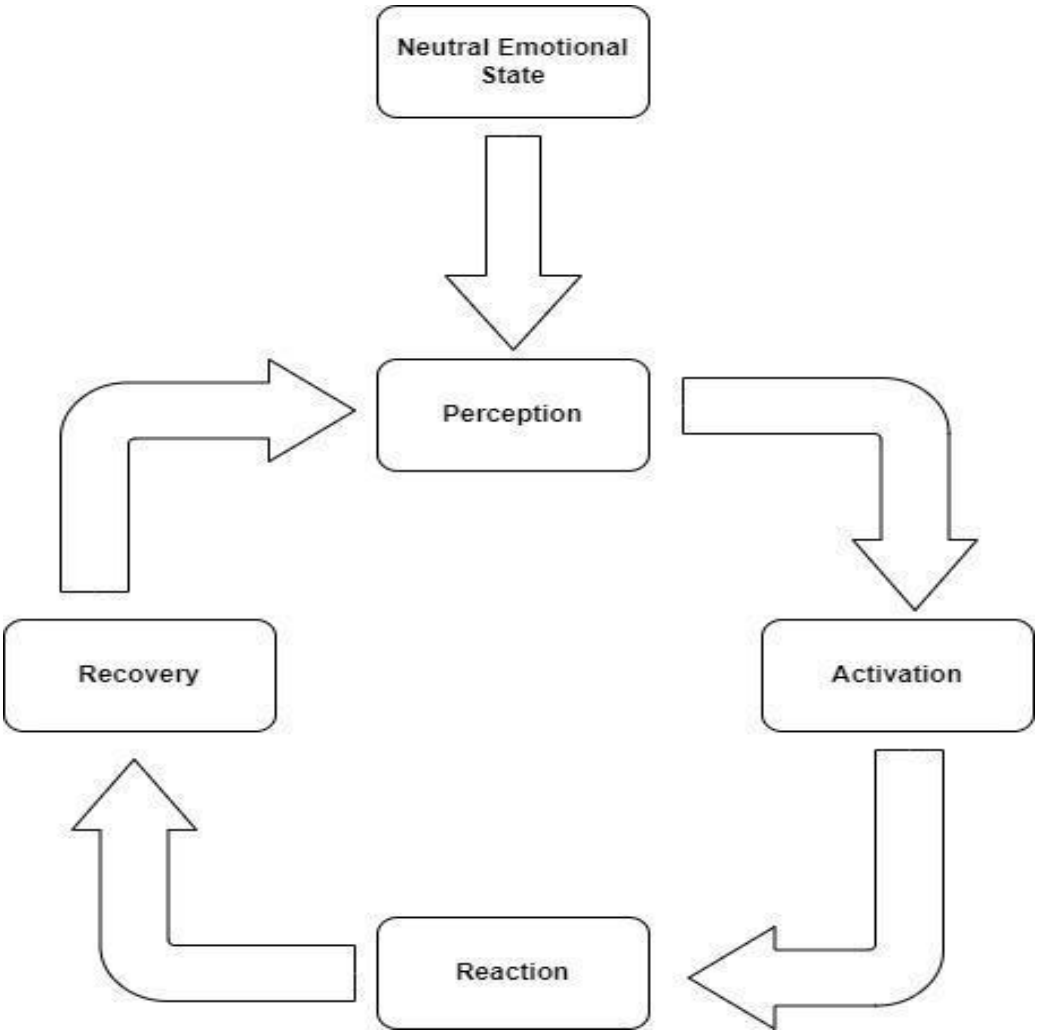

Figure 01: How the four stages of fear would loop through, in the Dynamic Horror Generation (DHG) system

4.2.3. The main components of the system

The design of the DHG system consists of two main components which have been assigned with different duties that they must perform in the system. These components are namely the Facial Expression Recognition (FER) system and the AI system (which will be called as the AI Director from this point onward). A description of these components are given below.

FER System

This system is mainly responsible for analysing the facial expressions that are displayed by the player at runtime and identifying the specific fear level that the player is experiencing at a given moment and providing relevant information to the AI Director of the game. The image classifier model that will be used to analyse the player's facial expressions in the FER system will be trained based on the four stages of fear mentioned above.

AI Director

The AI director of the system is the component that is responsible for analysing the state of fear that the player is currently in, as well as dynamically generating horror elements while keeping track of the current state of fear that the player is in, according to the four stages of fear. The AI director is given access to different props in the game environment such as doors and light bulbs that can be controlled, access to sound cues that can be triggered when needed as well as to various enemy types that can be spawned. However, the AI director can only access the relevant atmospheric horror elements that are available in the area, where the player is currently in.

4.2.4. How the Dynamic Horror Generation (DHG) system works

The DHG system is not always kept active. This is done to make sure that the AI director does not intervene with the game by activating horror elements during cutscenes or areas where the player is not intended to experience fear. When the system is active, it assumes that the player is in a neutral emotional state. The FER system is activated during this stage analysing the facial expressions of the player, predicting the level of fear that the player is experiencing at a given time and continuously sending prediction results to the AI director to decide and generate atmospheric horror elements in game.

The AI director of the DHG system mainly loops around the four stages of fear which are perception, activation, reaction and the recovery state. The main goal of the AI director when the player is in any stage other than the recovery stage is to build enough tension and fear in order to push the player to the next stage of fear. In order to do so the AI director is given a list of different scare tactics that it can use. However the scare tactics that the AI director can use are limited when the DHG system is in the early stages of the loop. This is done in order to prevent the AI director from using scare tactics that are intended to be used at later stages of fear. The scare tactics that are available for the AI director during the early stages would include subtle horror generated through manipulating the surrounding environment eg; flickering of lights, opening and closing of doors/windows and moving game objects in the environment such as furniture. As the system progresses to the latter stages of fear, the intensity of the scare tactics would also increase. The fear level of the player would be at peak level during the reaction stage in which the scare tactics that would be used by the AI director would be highly intense since the player would be chased by enemy characters in the horror game. Once the player reaches the reaction stage the AI director would not switch to the recovery stage until the player avoids all the enemies that are chasing him/her. Once the player has successfully avoided the enemies, the AI director would switch to the recovery stage where the player is given some breathing space. This loop would continue throughout the game.

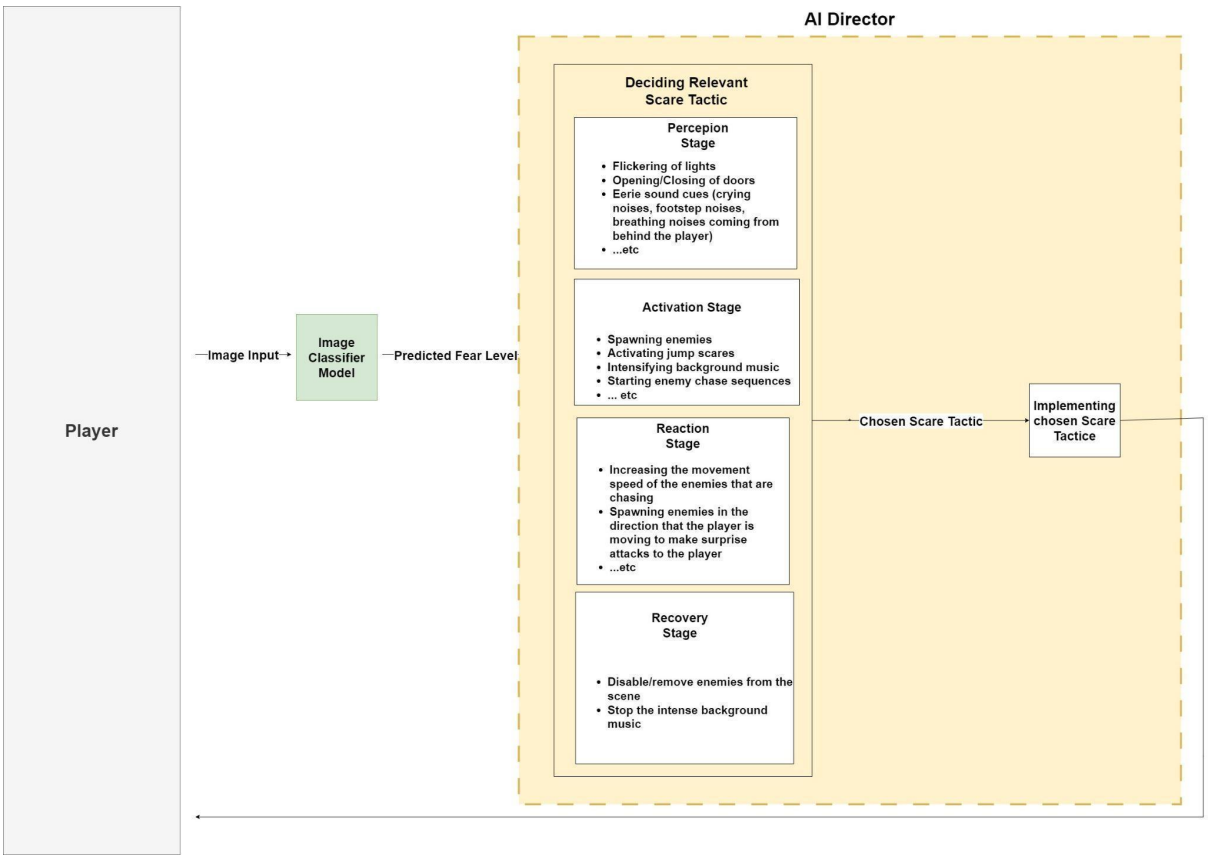

Figure 02: Dynamic Horror Generation (DHG) System

4.2.5. The use of utility AI to generate atmospheric horror elements.

In order to decide the best possible atmospheric horror element that should be used according to different situations that it would face, the AI director will use a utility AI system. Utility AI can be described as an AI system which works by identifying the options available to the AI system and selecting the best one by scoring each option based on the circumstances (Rasmussen, 2016). When looking at this in the context of the DHG system, a particular state of fear can consist of different atmospheric horror generating elements that can impact the fear level of the player in different ways. Instead of triggering these atmospheric horror elements procedurally, or on a random basis, the utility AI system can use other information that are available in the surrounding such as the distance from the particular atmospheric horror element to the player or the amount of time that the player has been in a particular state of fear, to decide which atmospheric horror element is best suited to be triggered at a particular moment. Let's take a practical example to elaborate this more.

Suppose that the player is in the first stage of fear, which is the perception stage and there are three atmospheric horror elements available in the particular area that the player is currently in, for the AI director to choose from; which are

1. Moving a sofa that is in the room, that the player is currently in
2. Opening and closing a door of the room that the player is currently in.
3. Flickering of a light in the environment that the player is currently in.

Let's assume that in this example the main factor that is used to decide on which element to be triggered is the distance between the player and the game object that is used to generate the atmospheric horror element. The score allocated for each element depends on the distance that is there between the player and game object that is used to generate the atmospheric horror element. The shorter the distance, the higher the score would be. Hence, the AI director could go through all the elements and easily decide on which atmospheric horror element should be used in a particular moment based on the scores that are allocated to each one of them.

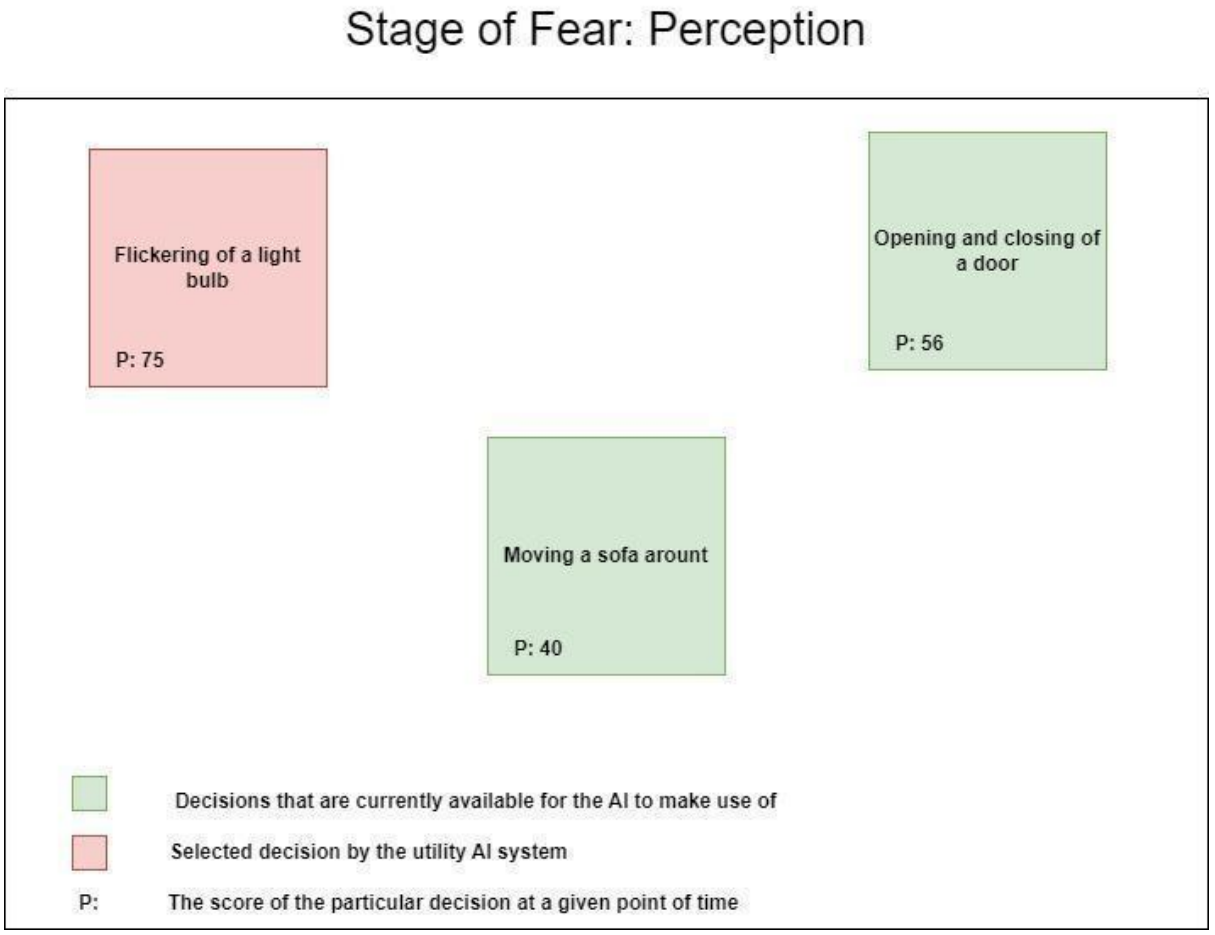

Figure 03: How the Utility AI system is being used by the AI Director in the Dynamic Horror Generation (DHG)system

4.3. Interviews regarding the practicality of the proposed system.

4.3.1. Collection of data

In order to review the Dynamic Horror Generation system with regards to the applicability and usage of it in commercial video games, qualitative data were collected using semi-structured interviews. The use of semi-structured interviews were taken into consideration since the interviewee has the chance to diverge and provide a more in-depth explanation on the key questions that are provided for him/her to answer (Gill, et al., 2008). Furthermore, the interviews were open ended meaning that the possibility to collect rich data would be high since the participants are given the freedom to answer the questions in a more detailed manner.

4.3.2. Participants

Overall 09 participants took part in the interview sessions where seven participants were male and two female. All the participants who took part had a background related to game development either by studying game design and development at the university level or working either part time or full time at a game studio. The main reason to choose participants with a background in game development and design was because all of them had a sound idea about game design, game mechanics, gameplay loops and games user experience and hence were able to provide constructive feedback on the DHG system technology wise as well as user experience wise with regards to how practical this system would be if implemented in commercial games. Out of the 09 participants, 04 were students with past experiences of developing games for game jams, university projects as well as passion projects and the rest of the participants have actively worked in game studios. When looking at the experience levels of the participants who have actively worked in game studios, all of them had at least two years of experience developing video games commercially. Seven Participants mentioned that they have had previous experience working with horror games. It is worth to note that the number of participants who participated was limited due to the fact that most of the individuals who were approached for this study had busy work schedules and had limited availability.

4.3.3. Interview Procedure

The first step that was done before conducting the interviews was to contact all the potential participants who were to participate in the interview sessions. While most of the student participants were contacted and invited for the interview sessions through game development related community groups in platforms such as Discord and Reddit, the majority of the participants who came from a professional background related to game development, were contacted via email. Once the participants confirmed their availability to

participate in the interviews, the interview sessions were scheduled based on their availability. Each interview session lasted around 30-45 minutes. Before starting each interview session, the consent of the participants were taken so that the interview sessions could be recorded. The interview sessions were recorded in order to make sure that none of the qualitative data were lost during the data collection and analysis phase. The interview was started by asking a few demographic questions in order to understand experience and the relationship that the participants had with regards to horror games. Then they were asked about the research problem that was addressed in this paper and the type of solutions that they would come up with in order to solve it. The participants were then introduced to the DHG system and were given an explanation on how the intended system would work if implemented in a commercial video game. They were asked questions related to the practicality of this system if it was to be implemented in the real world environment afterwards. Since the interview questions were semi structured and open ended, the questions regarding the practicality of the system were expanded upon various industry related topics such as current technologies that are used to create commercial video games, user experience and accessibility in order to gain an in-depth understanding on advantages and disadvantages that the DHG system comprises.

4.3.4. Analysis of Data

The information provided by the participants were roughly noted down during the interview sessions and properly analysed later with the help of audio recordings that were recorded during the interview sessions. Before analysing, the collected data were organised by categorising them based off of the opinions that the participants had with regards to the use of manual and dynamic generation of atmospheric horror, opinions on the technologies used in the proposed system design, issues regarding the feasibility of the proposed system design as well as ideas and suggestions made by participants in order to improve the system design. The categorised data were then analysed in hopes of answering the main question behind conducting these interview sessions which is, to see the feasibility of the DHG system design with regards to its use in commercial horror games.

4.3.5. Ethical Consideration

The collection and analysis of data was done in accordance with the approach that was taken by Allmark et al. (2009) in their study. Before commencing the interviews, all the participants were informed about the purpose of conducting the interview sessions as well as how the data collected from the participants will be used in the study. The names of the participants were not used when presenting the information that was provided by them. Each participant was given a number which was used with generic naming convention (eg; Participant 01) in order to distinguish each participant from one another. Participants were given the opportunity to stop the interview at any point if they didn't feel comfortable continuing the interview. Furthermore all the audio recordings that were taken during the interviews were deleted after analysing and collecting the relevant data.

5. Results

In the following chapters, ideas given by participants will be quoted in the following manner. “Participant” will be shortened as P, followed by the number that is used to represent the relevant participant (eg; P01,P02,P03 etc.).

By analysing the data that were collected through interviewing the participants, it was possible to get an in-depth understanding of the view that game developers have about manually scripted atmospheric horror elements in comparison to dynamically adjusting them according to player emotions. While some of the participants agreed that manually scripting atmospheric horror elements to games that follow a more linear approach would work better when it comes to providing the best gameplay experience to the player, all participants agreed that for multiplayer or co-op horror games that are supposed to be replayable, scripting atmospheric horror elements manually would not be the best solution available. One participant stated that games with scripted horror elements would get boring after playing a few times as it is more predictable, while another stated that some manually scripted atmospheric horror elements work well while others do not. However, one participant mentioned how scripting atmospheric horror elements manually, can give the designer a lot more control over the use of atmospheric horror elements in the game as well as being able to predict how a player would act out in a given situation, thus making it easier for them to adjust the game in order to provide a good gameplay experience for the player.

> P04: “I assume that the designer has more control over it(Atmospheric horror elements) and it’s a lot more predictable from the developer’s perspective.”

Some participants pointed out how atmospheric horror elements that are tailored to specific situations can tap into the core fears such as the fear of open/closed spaces and fear of the dark that all humans possess. Another interesting thought that was brought up by one of the participants is how powerful scripted horror sequences have, especially in narrative driven horror games. He mentioned that when it comes to narrative games you need to treat the game as a play where the elements in the game such as the enemies, horror elements and the objects that are present in the environment try to convey a story towards the player in a realistic way. Player perspective can also be seen as an important aspect since if you play as a vulnerable character who cannot fight back, you perceive everything as a threat hence making tailored horror to specific situations structure to trigger different phobias that lie within the player.

> P05: “We as human beings have a set of fears coded into us and the developers tend to deliberately use those fears in games when manually scripting atmospheric horror elements since most of the players would tend to play into one of those fears.”

One of the participants took P.T. which is a playable teaser for the game Silent Hills as a good example to show how the developers have cleverly crafted atmospheric horror elements that tap into the core fears of human beings throughout the hallways that you roam while playing the demo whereas in games like *Slender: The Eight Pages* by Parsec Productions (2012) where everything is auto generated, you cannot tailor the experience to players. Furthermore, another participant mentioned that there are a lot of studies that have

been done on how manually scripted horror elements can be used to effectively scare players stating that the vast availability of resources push developers to use manually scripted horror elements in games instead of trying out dynamic horror generation which is relatively new and less explored.

> P08: “It's not about just putting sound cues or jump scares in the game hoping that the players would get scared.”

The participants also didn’t hesitate to point out the disadvantages of using manually scripted atmospheric horror elements. One such disadvantage of using manually scripted atmospheric horror elements from the developer’s perspective as mentioned by one of the participants was the large amount of time and money that a developer would have to spend in creating and fine tuning the horror elements of the game.

> P09: “It takes too much time to develop, implement and to brainstorm on how to make them (The horror elements) unique.”

Participants also mentioned how developers tend to lose interest in the game during the development phase due to the developers knowing what’s going to happen at a given point of time. One participant mentioned how it was surprising to see that his team thought that their game is not scary enough whereas most of the players who played their game found it terrifying. The amount of content being limited was also highlighted by some of the participants as a disadvantage of using manually scripted atmospheric horror elements. One can say that the use of manually scripted atmospheric horror elements can be a double edged sword since you cannot assure that the created horror elements will scare the player for sure which can be a huge risk specially for games that belong to the genre of horror where players anticipate the thrill of being scared.

The use of AI to dynamically generate atmospheric horror elements on the other hand was appreciated by all the participants stating that AI has advanced quite fast in recent years with the advancement of ML algorithms and even though it is still not perfect, it will eventually make work much easier and time saving for everyone.

> P04: “If Alien Isolation was to be made ten years from now it would probably be done with the help of Machine Learning instead of decision trees.”

However, participants also mentioned that the developers need to consider which aspects of the game need to be dynamic and which ones need to be static in order to give the best experience for the player. Some of the participants also mentioned how AI assists them to make their work easier. They mentioned that they use AI on tasks varying from generating new ideas and concepts that could be used in games to solving coding problems that are encountered on a daily basis. One interesting aspect that can be seen with regards to using AI assistance is how it can give feedback on a different point of view which can be really advantageous if you are an individual developer who doesn’t have a colleague to review your work and provide feedback.

> P08: “Sometimes when I create new scenes I ask Chat GPT to rate the scene and the script from 1-10 and it gives interesting feedback sometimes.”

While all of the participants talked about the advantages dynamically generated horror elements consist of, with regard to the replayability, a key factor that most of them

emphasised was that in order for dynamically generated horror elements to work, the developers have to build the AI system in a way that masks its functionality to the player. In other words, the player should not be able to predict how and when the AI system would use atmospheric horror elements to scare the player. An example that was given to explain the usefulness of unpredictability of the AI system by one of the participants was the Stalker Entity in the game *Receiver 2* by Wolfire Games (2020) which is a kill drone that slowly approaches the player, attacking and killing the player if it is close enough. During the first few encounters with this drone, the player would feel scared and stressed since he/she has not encountered this entity before and does not know what its next move would be, but would eventually get used to the Stalker entity once the player understands its behaviour. The participant also revealed details about a bug in the game where the Stalker Entity would jump in front of the player instead of slowly approaching towards the player, catching the players off guard and scaring them. *Amnesia: The Bunker* by Frictional Games (2023) was also mentioned by participants stating that although it had used dynamically generated atmospheric horror elements really well, it too lacked variation which made it easier for the player to analyse and identify how the AI system behaves.

> P04: "The new Amnesia game has also used a system similar to that of Alien Isolation even though once you start to analyse what the monster in the game can do and cannot do, you don't fear anymore."

The participants also agreed that there are many factors that the developers should focus on such as the player type and play style when creating an AI system to dynamically generate horror elements. They also mentioned the possibility of having a well balanced system if the AI system has access to analyse and predict the stress and fear levels of the player in real time.

> P02: "If there's a way to measure the scare factor or the stress level then it would be ideal to use AI to dynamically generate horror since the AI would be directly responsible for the tension and fear levels of the player and it balances these elements well so that the player does not get frustrated with the game which would disrupt the player flow, affecting player immersion."

Another important tool that developers utilise when creating horror games is the anticipation. The creativity of the human mind plays a huge role when a player is anticipating something to happen. One key factor that was pointed out by participants was to know when the level of anticipation of the player should be broken or increased. In games with manually scripted horror elements, this is decided by the developers since they have control over elements of the game. However, participants pointed out that when it comes to generating atmospheric horror elements dynamically a mechanism to automatically increase or break the anticipation level of the player should be introduced to the game.

> P07: "When it comes to dynamic generation of horror you need a way to trigger elements that arouses anticipation in players and you need to add a method to measure when to break the anticipation or to play with the anticipation level of the player in some dynamic way."

Information on how the player would react to certain atmospheric elements can also be vital when it comes to increasing the fear level of the player dynamically since the information can be used by the system to decide which horror elements work well with the player and use

those specific elements to enhance the player experience by elevating the tension level of the player more.

> P05: "For instance if the player is scared of the fog or snakes and is trying to get away, then AI can be used to generate more of those elements that the player does not like."

When participants were asked about the feasibility and practicality of implementing a system like the DHG system in commercial horror video games, the responses were both positive and negative. While the participants saw the possibility of using it in commercial video games in the foreseeable future, they also stated the issues that might hold it back from being used in commercial games in the present. The issues that were mentioned by the participants are as follows.

1. Accessibility
2. Device accuracy
3. Ethics and user data privacy

5.1. Accessibility

One of the main problems that was brought up by most of the participants regarding the practicality of using a system like this in commercial video games was the availability of the devices that would be used to measure the physiological responses. While using a webcam is more available compared to smart watches and GSR sensors, the entire player base might not have access to it. Players using a laptop to play the game might have access to a camera, but if the player has a built in PC, then he/she would have to buy a camera in order to play the game.

> P03: "You need to either already have a camera or buy one if the game uses facial expression recognition."

The issue here, as one participant pointed out, is that facial recognition as a technology is not commercial in the games industry yet. A solution that was proposed by one of the participants to overcome this issue is to include the external devices that are necessary to play the game with the game. However, this solution too has its own issues. Nowadays, many gamers have got used to purchasing video games digitally and they only have access to the devices that they already have at home.

> P05: "The issue I see mostly is that the amount of people who would go out of their way to buy an extra device just to play a game is far less than the general population. Guitar hero is a good example for this."

In contrast to the point given above, another participant pointed out that the enthusiasm that gamers have, to experience video games in new and different ways, can also motivate them to purchase external devices for games. But this comes with a choice of catering to a selected audience who are willing to take a few extra steps to enjoy games in different ways over the majority of the player base which has a risk of affecting the sales of the game if the

audience aren't attracted. Another solution for this issue that was pointed out during the interviews was to add the capturing of physiological responses as a mode that can be activated by the player. While this solution can be more viable than the previous, the gameplay experience could be drastically different depending on whether the player uses a camera device to capture his/her physiological responses or not. *Nevermind,* developed by Flying Mollusk (2015) can be taken as an example for one such game where the players are given the option to play the game either with or without a device to capture biofeedback inputs.

In addition, participants highlighted the prospect of integrating the DHG system into virtual reality (VR) games, considering that contemporary VR headsets come equipped with built-in sensors and cameras capable of tracking players' facial responses and eye movements. This integration negates the need for players to purchase additional equipment, making it a feasible and user-friendly option.

> P02: "Maybe for VR it is more feasible since there's already a system to track the player's eyes and facial movements."

5.2. Device Accuracy

Another factor that most of the participants emphasised during the interviews was how accurate the facial recognition system would be in predicting different fear levels of players if this system was to be implemented in a commercial video game. The participants gave out many reasons as to why the facial recognition system might have problems when it comes to accurately analysing facial expressions of the players and one common explanation given was how diverse human beings are. The human species comprises a wide range of differences and variations that are influenced by one's ethnicity, genetic inheritance and environmental factors. Hence the behaviour of one's facial muscles can differ when expressing emotions making it hard for the system to accurately analyse and predict the fear level of the player. Furthermore the way people express themselves also varies based on their cultural background and even though a facial recognition system accurately works in identifying basic emotions, it might have problems identifying different stages of a basic fear level, in this case, different stages of fear. Increasing the dataset that is used to train the image classifier model was brought up as a possible solution to overcome this issue but then again it would require a considerable amount of time to collect the necessary data that are required. Analysing a selected set of facial features such as player's eye movement instead of analysing the entire face was also suggested as a way to overcome the issues regarding accuracy that might be present with the current facial recognition system. This can be a better solution. However, it needs to be further researched in order to find connections between the selected features and how they would behave during the four stages of fear.

The way people express themselves in the presence of others vs how they would express themselves when they are alone can also be seen as a key factor that can affect the accuracy of the facial recognition system. When people interact with each other, they often engage in social interactions such as smiling or displaying different facial expressions. But this can be different when an individual is playing a video game alone since he/she might be extremely focused on the game and would display a neutral expression causing issues with regards to the accuracy of the system.

> P06: “For example if someone is being interrogated, it is possible to say whether they are lying or not just by interacting with that person and seeing how their facial expressions change according to different situations. But when someone is playing a game alone, they might be fully focused on playing the game and give out a stone face throughout the gameplay session.”

The use of a heart rate device instead of a camera to measure the physiological responses was also brought up by one participant as a way to overcome the aforementioned issues. However, as explained in the previous chapter, heart rate can be manipulated with the help of proper breathing exercises. The counter argument that was brought up by the participant regarding this was that the chances of a normal person who plays video games knowing about ways to manipulate his/her heart rate would be quite low.

> P08: “You have to be a spy or something like that to fake the heart rate.”

While this is somewhat true, it is hard to ignore the fact that heart rate devices are comparatively less accessible than cameras which provides a good reason not to switch to using heart rate devices to capture physiological responses. Using multiple biofeedback inputs can increase the accuracy level. But this would be hard to achieve with the technological barriers that are currently present.

5.3. Ethics and user data privacy

In today’s society where connecting and sharing information with one another is at fingertips reach, data has become a valuable currency that has become integral to various aspects of one’s life. The value of data has further gone up with the advancement of AI during the recent years and because of this, people tend to prioritise protecting their personal data. Privacy of data related to a person’s face is of high importance since it can be used to impersonate people as well as to spread misinformation damaging one’s reputation if fallen into the wrong hands. The use of facial data in the DHG system can raise concerns for some individuals due to these reasons.

> P02: “it can violate privacy since a system as such will be collecting player information.”

The threat of player data being leaked during gameplay however is less if the system is to be used in single player games since the DHG system will only be analysing the player’s facial information in real time and won’t be storing it in a server but still the threat could persist if the system is being used in online co-op or multiplayer games so tightening the security through means such as encrypting the data should be highly prioritised.

When it comes to ethical matters with regard to the DHG system, one other concern that the participants had was how much authority the AI should be given when it comes to triggering events to scare the player. All the participants agreed that the authority given to the AI system to use the scare tactics should be limited since the main goal of the AI system is to increase the fear level of the player and if it is given access to use the scare tactics at any given time without limits, it could lead the player to have a bad gameplay experience.

> P03: “The AI would have to have some kind of limits on how scary it can be because you don't want to traumatise the players.”

5.4. Suggestions

In addition to pointing out the issues regarding the application of the DHG system in commercial games, participants also made suggestions on how the player experience can be further improved when it comes to using a system like the DHG system in horror games. While dynamically generating horror elements was seen as a way to create unique experiences for players, it was mentioned that the developers might need to manually adjust certain elements in order to provide the best experience to the player.

> P01: “The AI would do a good chunk of the work but you need to manually tweak certain things to provide a perfect experience to the player.”

In order to overcome the problems that are currently present with the use of physiological responses to predict the fear levels of the player, one alternative method that was suggested by some of the participants was the use of in-game data together with the information that can be collected through the input and audio devices that are used to play the game. According to one participant, the sound cues caught through the microphones of players during gameplay can be used to measure the fear level of the player. Even though this data alone might not be enough to predict how scared the player is at a given moment, together with metrics such as the player’s mouse and keyboard data and in-game data such as the time it takes for the player to complete certain levels/chapters of the game, there is a possibility of accomplishing this task. While this is not quite new to the games industry, it has shown success in commercial games that were previously released and participants suggested that similar means can be applied to horror games.

> P04: “A Lot of player data such as player mouse movement or how fast the player moves around can be collected, so it can be used to predict player emotions with the help of machine learning. If this is in the game, you won’t be needing devices to measure physiological responses.”

Allowing the AI to read external information that is available in the device such as the player’s personal information as well as real time information that can be obtained through the device such as the current weather and using that data in the game world in order to immerse the player was also discussed by some participants. Although this concept is interesting, there are legal and ethical boundaries that need to be looked upon when it comes to reading and using personal data of a player in the game.

Participants also mentioned that the same set of scare tactics might not be applicable everywhere and therefore, it is better to include various types of scare tactics to keep the players tense and curious throughout the whole gameplay. Limiting the number of scare tactics that could be used by the AI in particular sections of the game was suggested, since having too many scare tactics can stress the player, disrupting the player flow. Another interesting suggestion that was made by some participants was that this system would be much more effective if it is used together with manually scripted atmospheric horror

elements. An interesting tactic that was proposed by one of the participants to enhance the player experience was to include a fake activation stage to the four stages of fear. The goal of doing this is to make the player aware of his/her surroundings increasing the alertness of the player as well as raising the level of anticipation that the player has. It was also advised to include a mechanism that could delay the transitioning from one stage of fear to another if the player doesn't give the expected responses.

> P07: "The system should know when to stay a little bit when the player doesn't give the expected response. If you can handle that it would be more robust."

When it comes to horror games, scare tactics can be identified as a key component that can decide the success of the game. When creating the DHG system, participants suggested that it would be best to look through different strategies that horror games use in order to scare the player and take inspiration from them when creating scare tactics for different levels of fear. Furthermore one participant suggested creating a prototype horror game that could be used to test the created scare tactics.

Another important aspect that developers must give attention to when creating horror games is to balance the game elements so that the player doesn't get frustrated by the horror elements in the game, making the player quit the game without finishing it. One particular suggestion given by a participant was to reward the player during the recovery stage which would give motivation for the player to continue on playing the game. According to the participant, this doesn't necessarily have to be something that would help the player survive in the game environment such as ammo and health packs. A simple action such as lighting up the environment after a tense event can provide a sense of safety for the player which can encourage him/her to continue on playing.

> P03: "It's better to reward the player in some way since it feeds the brain something positive. This can also be an action that the AI could use in the system."

Although some participants didn't see the practicality of using the DHG system in commercial horror games in the present, due to the lack of technology and accessibility issues, they saw this system as an opportunity to conduct AB testing in order to find the optimal scare tactics that would scare players the most in given sections of the game since it gives a lot more control over to the developer on designing horror elements of the game with the help of the data that is collected through the tests. AB testing is a basic testing method where two or more versions of the same product with slight differences are compared in order to find out which performs better (Gallo, 2017). In the case of using AB testing with the help of the DHG system, the idea is to use the system on testers in order to figure out which scare tactics succeed the most in getting a strong reaction out of the players and then manually scripting those elements into the game. Participants agreed that this can be much more effective when it comes to games that are more linear.

> P04: "If you have a sample size large enough, you can figure out what works and what doesn't so you don't have to deal too much with machine learning elements in the game during play time."

6. Conclusion

Fear is a fundamental human emotion that plays a crucial role when it comes to the survival of mankind which is triggered by perceived threats both real and imaginary. People experience a multitude of fears that evolve and change throughout their lifetime and game developers use different design techniques and methods in order to bring out those fears and provide an immersive experience towards the player. Due to this, many developers and designers who work on horror games tend to lean towards manually scripted horror elements if the games are linear since it is easier for them to tailor the horror experience into triggering the inner fears that players have. However, when it comes to co-op and multiplayer games where the element of replayability is present, it is hard for developers to keep the players interested in the game and the horror experience if the atmospheric horror elements are heavily scripted.

This research mainly revolved around studying the possibilities of providing unique horror experiences to players while preserving the replayability aspect of the game. Measuring the physiological responses that represent underlying human emotions were considered as an efficient way to track the emotional states of players while a self defined concept based on Butto's (2019) work was created in order to determine the player's level of fear and was used to dynamically generate atmospheric horror elements in the game. Although devices that are still being used at the laboratory level are considered as more accurate when it comes to measuring the emotional state of a player through his/her physiological responses, commercial devices such as webcams and smart watches were chosen as the go to devices to measure physiological responses due to the fact that those devices are readily available to the public. Using a camera device such as a webcam to capture the facial movements of the player to predict his/her level of fear with the help of an image classifier that is trained according to the four stages of fear mentioned above was considered as the best approach to measure the physiological responses of players due to its high accessibility compared to devices such as smart watches that can be comparatively expensive.

It was decided that the best way to predict fear levels of players by analysing their facial expressions would be through a trained image classifier model since they are well known to accurately identify human emotions by reading facial responses. However the accuracy of the model solely depends on the size of the data set. The bigger the dataset that is used to train the model, the higher the accuracy rate of the model when predicting. Although image classifier models have been used to predict different emotional states of people, it has never been used to detect different fear levels of people based on their facial responses and there are no standard measurements that can be used to decide which level of fear the person is in. Due to these reasons, gathering data and creating a data set that is large enough for the model to accurately predict the fear levels of players would be a challenging but possible task. The use of a utility AI system to generate dynamic atmospheric horror elements was chosen to be used in the DHG system since the system mainly focuses on overall atmospheric horror of the game. However, this system can be used together with other systems such as behavioural trees that can be used to manage enemy behaviour to enhance the overall gameplay experience.

A system like the Dynamic Horror Generation (DHG) system, which is proposed in this paper can be considered as a good way to overcome the issues related to replayability up to a certain extent providing a unique experience to the player, every time they play.

6.1. Discussion

The results that were collected throughout the span of this study show that even though a system that uses physiological responses of players to dynamically generate atmospheric horror elements looks feasible on paper, there are a number of factors that restrict game developers from using a system like this commercially. Issues relating to accessibility, privacy of data and the lack of technology that is currently being used in the society were seen as some of the barriers that keep the DHG system from being implemented in commercial video games. Other practical issues related to how accurate the image classifier model would be in predicting the fear level of the player and how the system AI used to dynamically generate horror elements could be made in a way that would be hard for the players to predict.

The data also show how most of the developers tend to stick to manually generating atmospheric horror elements in games even though the concepts such as dynamic content generation are being used in games of other genres. One can say that this is due to the fact that developers have control over various elements of the game such as the pacing and the in-game player behaviour. However I think that this is not entirely true since games such as *Left 4 Dead* (2008) developed by Turtle Rock Studios have proven that games with dynamically generated elements too can control the player experience effectively by adapting to the actions and decisions that the player makes, maintaining a high level of tension and engagement throughout the gameplay. This brings out the question as to if horror game developers have inherently gotten used to scripting horror elements manually instead of trying out means of dynamically generating horror elements. This is an interesting area that can be explored in the future.

Even though the technology is not advanced enough for the DHG system to be used in commercial games yet, with the rapid evolution of technology, emergence of concepts such as the meta-verse and the increase in people embracing new immersive technologies such as VR to access and engage in the digital world, it is safe to say that the commercial use of a system as such for games is not far away. But for the time being, the possibility of using in-game data to predict the fear level of players is still present. Furthermore, with the advancement of AI, the use of these technologies have become less complex and far more accessible for game developers. This can be clearly seen through recent games like *Amnesia: The Bunker* by Frictional Games (2023) where the developers have decided on giving an AI brain for the main monster making the game more unique and tense. I firmly believe that AI will be used in a similar fashion to dynamically generate horror elements in the near future.

6.2. Future Work

The DHG system which uses physiological responses of players to dynamically generate atmospheric horror elements presents a potential to revolutionise the Game industry by tailoring unique gameplay experiences towards the play. However, since this system is still in the concept stage, it needs to be implemented and tested in order to assess the success of this system design.

The first step towards implementing the DHG system would be to collect enough data related to facial reactions and create a dataset that is large enough to train the image classifier model to be able to accurately predict the fear level of players. The collection of data would be done by inviting participants to play a section of a horror game where the genuine reactions of the players will be recorded throughout their gameplay session. I personally believe that *Outlast* and *Outlast 2* developed by Red Barrels (2013; 2017) could act as a good stimuli for the play sessions since these games clearly try to loop their gameplay according to the four stages of fear mentioned earlier, making it easier to determine the facial reactions that participants display for each stage of fear. The participants need to be informed about the use of the data collected through the play sessions in order to train the image classifier model and consent should be taken from each participant with regards to this.

The next step after creating the data set would be to build and train the image classifier model that could predict the fear level of players based on their facial responses. It is important to note that the accuracy of the model needs to be at least 90% or higher since an accuracy level lesser than that is considered not reliable enough by industry standards. Training the model is a daunting task due to the long duration of time that is taken for the model to be trained.

As suggested by some of the participants, it is important to figure out the horror elements that would work best with the DHG system. Creating a prototype version of a horror game including all the horror elements that are intended to be included in the DHG system can be an ideal way to figure out which element tends to induce the most tension in players and suit best to be added to the DHG system. Since this prototype will be used as a means to analyse the scare tactics, the horror elements will be scripted manually so that the players can experience all the horror elements that are presented through the game. After creating and testing horror elements through a prototype game, it is possible to create the AI system that triggers horror elements in game and integrate all the components of the DHG system.

Once the system is fully integrated, it is possible to test the system with participants to get an understanding on how the system works in a practical environment, the strengths and weaknesses that the system possess and re-evaluate the practical issues pointed out by the participants who took part in the interview sessions and look at possible measures that could be taken to overcome the aforementioned problems.

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Appendix A - Interview Criteria

Providing a brief introduction to the study and obtaining consent to record the interview

Is it okay to record the Interview?

These interviews are done to evaluate the system design that was proposed to overcome the problems that are faced with manual scripting of atmospheric horror elements in games and to find out how feasible this system design is to be implemented in commercial video games.

Demographic and semi structured questions to understand the background of participants

1. For how long have you been in the games industry?
2. Have you worked in games related to the genre of horror?
    a. If the answer is yes, What are your thoughts on manually scripting atmospheric horror elements in games (is it advantageous / disadvantageous to manually script atmospheric horror in games)
    b. If the answer is no, Do you know the concept of atmospheric horror generation?
        i. If yes, proceed to question 1.a
        ii. If no, explain the concept of atmospheric horror and proceed to question 1.a
3. What are your ideas on dynamically generating atmospheric horror using AI.
4. Do you think that using Physiological responses to measure the player's emotions (fear levels) is applicable in commercial video games?. Are there any other ways that are more feasible to measure emotions in order to dynamically generate atmospheric horror in games?

Present the proposed system design and explain how the system would work if it is to be implemented

Semi Structured questions regarding the feasibility and practicality of the proposed system design

1. How applicable is this system design when it comes to implementing it in commercial horror games?
    a. Applicability of the system w.r.t technology and user experience
    b. What are the advantages of this system with comparison to manual atmospheric horror generation
    c. What are the drawbacks of this system with comparison to manual atmospheric horror generation

2. What are the improvements that can be done to this system to further increase the player experience