Towards the Design of Adaptive Virtual Reality Horror Games: A Model of Players' Fears Using Machine Learning and Player Modeling

Edirlei Soares de Lima
Faculty of Design, Technology and Communication – IADE
Universidade Europeia
Lisbon, Portugal
edirlei.lima@universidadeeuropeia.pt

Bruno M. C. Silva
Instituto de Telecomunicações
Universidade da Beira Interior
Covilhã, Portugal
Faculty of Design, Technology and Communication – IADE
Universidade Europeia
Lisbon, Portugal
bruno.silva@it.ubi.pt

Gabriel Teixeira Galam
Faculty of Engineering
Universidade da Beira Interior
Covilhã, Portugal
gabriel.galam@ubi.pt

***Abstract* — Horror games are designed to induce fear in players. Although fundamental fears, such as the unknown, are inherent to the human being, more specific fears, such as darkness and apparitions, are individual and can vary from person to person. When a game aims at intensifying the fear evoked in individual players, having useful information about the fears of the current player is vital to promote more frightening experiences. This paper explores fear modeling and presents a new method to identify what players fear in a virtual reality horror game. The proposed method uses machine learning and player modeling techniques to create a model of players' fears, which can be used to adapt in-game horror elements to intensify the fear evoked in players. The paper presents the proposed method and evaluates its accuracy and real-time performance in a virtual reality horror game.**

Keywords* — *horror games, virtual reality, player modeling, machine learning

I. Introduction

Fear can be described as an emotion that is experienced in anticipation of dangerous or painful situations [35]. It also represents an important feeling for life itself. Even single-celled organisms react to hostile stimuli in their environment, releasing cascades of processes, resulting in agitated bodies and focused attention [20]. In general, fear occurs when the observer is facing a threat (real or imaginary). According to Damasio [9], the human brain has its own mechanisms to recognize harmful situations or treats, and once they are detected, a change of state occurs in the body as result of the release of adrenaline and dopamine, dilation of the veins and pupils, which serve to prepare the body to flee or to fight against the threat. Damasio [9] calls this state the "primary emotion" of fear. He also describes a "secondary emotion" that is more personal and intimate. Unlike the primary emotion that is innate, the secondary emotion derives from the negative experiences of each individual.

The feeling of threat can also arise from something that is imaginary or not understood. On this subject, Freud wrote a study called "The Uncanny" [13]. Initially, he studied the German word "unheimlich" which has as its main meaning something scary, macabre or sinister. However, this word can also be used as unfamiliar, strangeness at home, or "unhomely". This word contrasts with the term "heimlich", which in this context means familiar, cozy or at home. However, "heimlich" also means secret or clandestine, making it "unhomely" as revealing, or showing what is hidden. Gathering these meanings, Freud puts the strange as something that was familiar to us, but no longer is. Something that was known, and appreciated, but now is different, or even threatening, causing us the feeling of fear. Similar studies on this subject have been conducted by several philosophers and psychologists [13][7][4].

Although fear is usually considered an unpleasant emotion, it can also be used for entertainment purposes. The game industry has been exploring players' fears in horror games for decades. With the advancement of technologies, such as virtual reality, new ways of using horror for entertainment have emerged. Virtual reality, when compared to non-immersive technologies, induces a higher level of emotion on its users [31]. In addition, virtual reality is able to evoke behavioral and emotional responses in players that are similar to those that occur in real situations [15][38], which is useful for serious applications, such as the treatment of anxiety disorders and phobias [28][21], but also for entertainment purposes, were the emotion of fear can be maximized [30]. These characteristics make virtual reality an excellent tool to analyze players' fears.

This paper presents a new method to identify what players fear in a virtual reality horror game. The proposed method uses machine learning and player modeling techniques to create a model of players' fears, which can be used in real time to adapt the content of horror games in order to intensify the fear evoked in players. This paper presents our method and evaluates its accuracy and real-time performance on highly interactive virtual reality environments.

The paper is organized as follows. Section II discusses how fear is explored in games and also describes related work. Section III introduces the proposed model to identify players' fears. Section IV presents a technical evaluation of the proposed model. Section V offers concluding remarks.

II. Fear in Games

In the entertainment industry, the terms "horror" and "terror" are often complementary and understood as equal, but have different definitions. Cavallaro [8] defines terror as the fear that is triggered by unknown entities, while the horror itself is the fear of the visible gore. The famous author Stephen

King also presents a definition for these terms in his book [18], classifying terror as "the best of elements – the feeling of tension before the monster is revealed", while horror is defined as the moment when one sees the creature that causes the terror, provoking a shock in the observer.

The growing number of new horror games and horror films being released every year is a good indicator of the great interest of the general public in this genre. The interest of human beings in horror has been the subject of many studies, such as the one conducted by Carroll [7] during the 90s. According to Carroll, curiosity is the main factor that attracts human attention, especially because the threat (called by him as the "monster") is one of the representations of the unknown, which human beings both fear and are attracted to. Other authors also have tried to understand the human attraction to terror from a biological point of view. Andrade and Cohen [3], did an experiment with a room of students, asking them to rate the degree of negative and positive feelings they felt during the exhibition of three different films (horror, documentary and comedy). In the end of the experiment, it was observed that the moments of more horror were also the most pleasurable moments. This occurs because, as previously mentioned, dopamine is released into the body during times of stress. The high dopamine prepares the body for the threat, but when the brain identifies that the threat is false, the stimulated body feels pleasure. This process makes the person want to repeat the experience and search for more "scary content".

In this context, video games bring new horror possibilities to the entertainment industry. In games, instead of just observers, players can become active actors in a virtual world where they can influence what happens on the screen. In this regard, Perron [32] conducted a study to analyse how survival horror games attract players according to three general characteristics related with player's immersion: (1) presence, which is the impression of being in another world through feelings of immersion and involvement; (2) agency, which represents the power that allows players to take different paths and see the consequences of such actions; and (3) embodiment, which is the personification ability that the player finds with his avatar in the game world. According to Perron, horror games have worlds inherently capable of producing the feeling of presence, as they represent dangerous and scary places, full of sensory stimuli that focus the players' attention, suppressing other external stimuli. Perron also states that agency can naturally emerge in games of the horror genre, since fear is the perfect emotion to incite the player to act as a result of the hypersensitivity state triggered by threatening stimuli. Similarly, horror games also have a close relation with embodiment as they use the horror theme to seamlessly translate the character's feelings to its controller, allowing the player to have the same range of feelings that the avatar has [32].

A. *Horror Elements*

Several techniques to provoke fear in horror games have been developed through the years. Some of them are related to the visual aspects of the environment of the game (e.g. darkness, apparitions, strangeness), others to the narrative itself (e.g. nightmares, isolation, paranoia), and some to the audio of the game (e.g. suspenseful music, unknown sounds and voices). According to Demarque and Lima [10], most of these techniques are inspired by the methods used by cinematographers and film directors to create horror films. In this work, we call these techniques "horror elements", which are elements that bring feelings of horror or terror to the player, either through a real or imagined threat, or by elements that bring discomfort and tension.

As stated by the famous American writer Howard Phillips Lovecraft, "the oldest and strongest emotion of mankind is fear, and the oldest and strongest kind of fear is fear of the unknown" [22]. In accordance with that, the game industry has been exploring the fear of the unknown for decades. Darkness, which hides the unknown, is a central challenge in several survival horror games, from big franchises like Amnesia (Frictional Games) to independent games like Slenderman: Eight pages (Parsec Productions). The fear of the unknown is a fundamental fear of the human being and the elements that derive from it also have similar characteristics [6], such as unknown sounds and voices. The Silent Hill series (Konami) is famous for its use of unknown sounds to provoke fear in players, which includes unknown voices, screams, growls, sirens alerts, and radio bursts – all complemented by the limited visibility caused by the dense fog in outdoors environments and the darkness of hallways and dungeons.

Creatures and apparitions are also present in several games of the horror genre, which can be explained by the theories of Freud [13] and Carroll [7]. As mentioned earlier, Freud's study of "The Uncanny" shows how we fear what is not familiar to us, like ghosts and apparitions, which are horror elements extensively explored by games such as Fatal Frame (Tecmo) and P.T. (Konami). Similarly, creatures represent unfamiliar entities and threats that attract and frighten us at the same time, which is explained by Carroll's study. The use of creatures is also very common in horror games, such as the Resident Evil series (Capcom) and Dead Space series (Frictional Games).

Although fundamental fears, such as the unknown, are inherent to the human being [6], more specific fears, such as darkness and apparitions, are individual and can vary from person to person, depending mainly on personal experiences [9]. According to Lynch and Martins [23], similarities across humans in physiological fear experience exist, however differences among individuals also play an important role when establishing personal fears for specific horror elements. These individual differences can be related with past experiences, such as traumas [33] and phobias [27], or with individual characteristics, such as age [5] and gender [16]. On this subject, Martin [24] presents an extensive review of studies that analyse the psychological responses of individuals to different horror elements.

B. *Analysis of Players' Fears*

In recent years, several works have explored the analysis of fear in games and virtual reality. Lin [21] presents a study that explores players' fright reactions in immersive virtual reality horror games. His work describes the conclusions of a test pilot that involved 145 users playing a virtual reality survival horror game. The main goal was to evaluate the fright reactions and, at the same time, the players coping strategies using Slater's theory of virtual reality and its two dimensions of fear elements: the fear of place illusion (PI) and the plausibility illusion (PSI). According to Slater [34] the PI is the sensation of being in a real place, and PSI is the illusion that a current scenario is actually occurring. Results of Lin [21] work showed that the fear of PSI elements has a greater effect in coping strategies and overall fear. Moreover, this study presents a self-help strategy, consisting in self-talk that is reported as an effective means to cope with emergent dangers or fear situations in virtual reality games. Another interesting conclusion is that males and female players used different coping strategies.

Another interesting study that evaluates emotions and game experience in a virtual environment is presented by Freytag and Wienrich [14]. The authors created a virtual experience specifically to evaluate emotional responses through a game design approach that uses a combination of narrative and objectives. A real experiment was implemented with 8 users that self-reported ratings on emotions and game experience. A relevant contribution of the assessment was that the rating was incorporated in the game and in the narrative in the form of game checkpoints and in-game characters. Results showed that these self-reported ratings had no negative effect on the experience.

The study of immersion and the use of biometric sensors to evaluate emotions and reactions in virtual reality has also gained importance in both research and the game development communities. The use of physiological signals in digital games is a concept already widely explored [1][2][26] and some researchers have started to explore the potential of biofeedback methods to identify emotional moments in games [37]. However, in virtual reality scenarios there are additional challenges related to player movement that creates signal noise. In this context, Otsuka et al. [29] present a promising solution that embedded the physiological measurement in the virtual reality headset. Their proposal uses a light source and a phototransistor sensor to measure photoplethysmography arterial pulse and therefore obtain the heart rate of the player. The collection of players vital signs in real time can be useful for game design proposes and to evaluate the player experience. A promising example of this ecosystem is the game Bring to Light (Red Meat Games, 2018) that automatically adjusts the fear level of the game according to player's heart rate, which is monitored through chest bands available in the market [17].

Different from previous works that try to identify emotional responses using biometric sensors or through user surveys, the present work is based on the hypothesis that players who fear a certain horror element have a similar in-game behavior when playing virtual reality horror games. Therefore, machine learning techniques can be used to find behavioral patterns in past gameplay data, which can be useful to identify what new players' fear, allowing games to adapt their horror content in real time to intensify the fear evoked in players.

III. Identifying Players' Fears in Virtual Reality

Fear is among the six universally experienced emotions identified by the famous psychologist Paul Ekman during the 1970s [12]. Being a basic human emotion, fear also attracted the attention of the computer science research community. With decades of research on the process of identifying human emotions, many different methods for automated emotion recognition have been proposed, including many approaches to identify fear.

Traditional emotion recognition methods usually rely on physiological signals [11], camera images [19], or audio signals [36] to identify certain emotions. However, we argue that these methods are not suitable for games – especially virtual reality games, where the headset obstructs part of the player's face (making it difficult to recognize facial expressions), physiological signals produced by sensors attached to player's body may suffer from noise due to the constant physical movement of the player, and audio signals are rare since players usually do not speak while playing. In addition, these methods require an extra hardware that may not be available to everyone. Therefore, our approach to recognize fear in players relies only on statistical data extracted from the gameplay.

The proposed method to analyze players' fears and to create a computational model to represent this knowledge involves the use of machine learning techniques to ascertain how certain horror elements affect players. Based on the reaction and statistical gameplay data of past players, we aim at predicting what future players fear in a virtual reality game.

A. *Game Prototype*

The game used to test our method is a virtual reality horror game that was developed as part of an undergraduate student project (Fig. 1). The game takes place in a mysterious house where the player assumes the role of an investigator that is following some reports of strange events that are occurring there. After arriving at the house, the player finds four unusual plushies that suddenly disappear, leaving behind just a note asking the player to find them (Fig. 2). The main gameplay loop involves the player's search for clues to uncover the mysteries that surround the plushies and the house.

Fig. 1. Scene of the prototype game: player finds four unusual plushies.

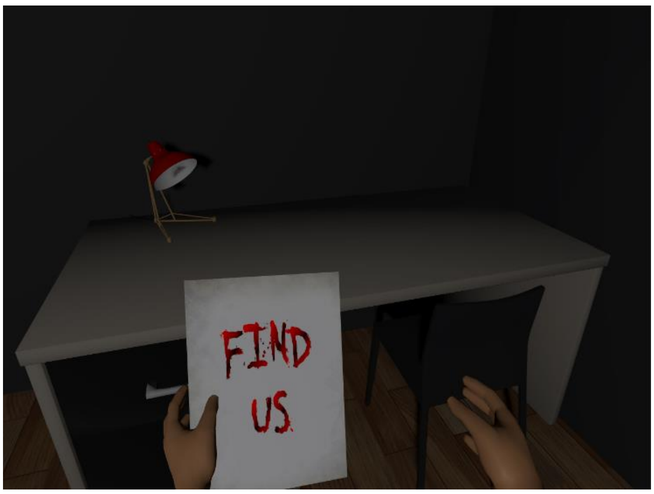

Fig. 2. Scene of the prototype game: player finds the first note left by the plushies.

The game was implemented in Unity[1] using the Oculus Rift Headset and SDK[2]. The head and hand tracking systems (main headset and touch controllers) allow the player to freely walk through the virtual reality environment and interact with objects using his/her hands to grab and push objects.

In terms of horror, the game tries to scare players using traditional horror elements, including darkness, apparitions, and unknown voices/sounds. The darkness is triggered by light sources that turn off mysteriously as a result of certain narrative events, leaving the player in a complete or partial darkness. The apparitions consist of unexpected appearances of ghost-like mannequins and plushies, which are triggered by some narrative events or when the player enters specific areas of the house for the first time. Unknown voices/sounds work like apparitions, but instead a visual appearance, they consist of sound sources that play from specific places of environment without a known cause.

In order to monitor and keep track of player's actions and gameplay statistics, an extra module was added to the game. This module, called Horror Manager, is responsible for collecting all gameplay data that must be provided as input to the fear model (described in the next subsection). The Horror Manager also maintains a state that describes all horror elements that are currently active in the game, which is useful to relate the gameplay statistics with the horror elements experienced by the player when specific fragments of data were collected.

B. *Fear Modeling*

As illustrated in Fig. 3, the proposed fear model is composed of three main components: input, output, and a function. The model's input comprises a set of observations extracted from the gameplay data, which should convey enough information about the player's behavior in response to different horror situations. The model's output represents the set of horror elements that can cause fear in players and can be predicted by the model based on the input observations. The model's function is the core of the model – it maps the input observations into the output horror elements.

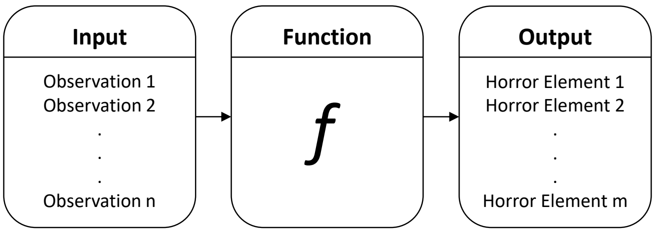

Fig. 3. General fear model.

Given the dynamic aspects of virtual reality games, the fear model must be constantly used to identify and update the horror element that causes more fear in the player, which may change overtime. Therefore, the system must be constantly capturing gameplay data and using it as input to the model. This dynamic process is performed using time windows, which are constant time intervals where the gameplay data is collected and then used to predict the horror elements that can cause more fear in the player. The length of the windows is a crucial variable to determine the accuracy of the model. Too short windows may provide only a limited amount of information about the player's behaviors, but too long windows may fail in capturing transitions and produce blurred data. In order to determine the best length for the time windows, we conducted several tests with window sizes of varying length. The results of these experiments are presented in section IV.

The data used as input to the fear model is composed of a set of statistical features extracted from the gameplay during a time window. Although more features related to specific game mechanics could be included, we selected only general gameplay features that can be found in almost every virtual reality game, which makes the model easily adaptable to other games. The gameplay features used as input to our model are described in Table I, where T is the length of the time window in seconds.

TABLE I. INPUT FEATURES OF THE FEAR MODEL.

ID	Description
F_1	Percentage of time that the player is standing still (in relation to *T*)
F_2	Percentage of time that the player is walking (in relation to *T*)
F_3	Percentage of time that the player is colliding (in relation to *T*)
F_4	Average walking speed
F_5	Standard deviation of the walking speed
F_6	Average rotation speed
F_7	Standard deviation of the rotation speed
F_8	Average position of the right-hand controller on the x-axis
F_9	Average position of the right-hand controller on the y-axis
F_{10}	Average position of the right-hand controller on the z-axis
F_{11}	Standard deviation of the position of right-hand controller on the x-axis
F_{12}	Standard deviation of the position of right-hand controller on the y-axis
F_{13}	Standard deviation of the position of right-hand controller on the z-axis
F_{14}	Average position of the left-hand controller on the x-axis
F_{15}	Average position of the left-hand controller on the y-axis
F_{16}	Average position of the left-hand controller on the z-axis
F_{17}	Standard deviation of the position of left-hand controller on the x-axis
F_{18}	Standard deviation of the position of left-hand controller on the y-axis
F_{19}	Standard deviation of the position of left-hand controller on the z-axis
F_{20}	Average rotation of the player's head on the x-axis
F_{21}	Average rotation of the player's head on the y-axis
F_{22}	Average rotation of the player's head on the z-axis
F_{23}	Standard deviation of the rotation of player's head on the x-axis
F_{24}	Standard deviation of the rotation of player's head on the y-axis
F_{25}	Standard deviation of the rotation of player's head on the z-axis

In terms of output, the model adopts a set of classes that represent the horror elements that can be predicted by the model and used by the game to cause fear. The horror elements were selected based on our research on the main techniques used by horror games to provoke fear in players (section II), of which we selected the elements that were more suitable to the prototype game. Table II describes the four horror elements used as output of our model.

[1] https://unity.com/

[2] https://developer.oculus.com/

TABLE II. OUTPUT CLASSES OF THE FEAR MODEL.

Horror Element	Description
Darkness	Lack of illumination or dimmed lighting conditions created when some or all artificial light sources are turned off.
Apparitions	A remarkable and unexpected appearance of someone or something, such as ghost-like images and inanimate objects.
Unknown Voices	Voices whose source is unknown or originates from specific places, such as walls, rooms, or inanimate objects.
Unknown Sounds	Recognizable or unrecognizable sounds that come from specific places but without a known cause, such as bangs, footsteps, claps, and whistles.

The process of mapping the input data to the output classes is performed by the model's function, which is built with samples extracted from past game sessions in which the player's fears were known, so it can recognize patterns and use them to predict what future players fear. Considering that the output of our model comprises four classes representing different horror elements, the task to build this function can be seen as a multiclass classification problem [25], which is one of the most common machine learning problems. Existing algorithms to handle this type of problem include Artificial Neural Networks, Decision Trees, Support Vector Machines, K-Nearest Neighbors, Naive Bayes, among others.

In the proposed model, we implemented the classification function using an Artificial Neural Network, which was selected after some preliminary experiments conducted in the Weka framework, [3] where the Neural Network classifier produced better results in comparison to all other algorithms available in the framework. For the implementation of the model, we adopted the FANN library, [4] which is an open source library that implements multilayer Neural Networks in C. The model's classification function comprises a single hidden layer Neural Network with 36 neurons in the hidden layer. The Neural Network was trained by an incremental back-propagation learning algorithm using a sigmoidal activation function.

C. Data Collection

Since our method employs a supervised machine learning technique to create the fear model, samples of gameplay sessions need to be captured and annotated with labels describing the horror elements that caused more fear in players during the game.

In order to collect training samples, we invited some participants to play our virtual reality game for the first time. The full procedure to collect training samples comprised three steps. First, participants filled a consent form and a pre-test questionnaire, in which they provided some demographic information, and also indicated what horror games they play and what they usually fear in a horror game. After filling the form and the questionnaire, participants were allowed to freely play our game until they reached the end of the game or until they decided to stop. After playing the game, participants were invited to fill a post-test questionnaire, in which they were asked to rate how much fear they have experienced with each horror element during the game (darkness, apparitions, unknown voices, and unknown sounds). Each horror element was rated in a five-point Likert scale ranging from "not scared at all" (1) through "moderately scared" (3) to "extremely scared" (5).

A total of 18 volunteers participated in the study (15 bachelor's students, 1 master's student, 1 designer, and 1 game developer). All subjects were male, and their ages ranged from 19 to 36 years (mean of 22.2). Nine of them usually play horror games, including Amnesia: The Dark Descent (2010), Resident Evil series (1996-2020), Silent Hill series (1999-2012), Outlast (2013), Dead Space series (2008-2013), and Slender: The Eight Pages (2012). Among the more common aspects that they usually fear in horror games are apparitions/jump scares and the unknown. On average, each game session lasted 10.5 minutes (standard deviation of 2.3 minutes). Fifthteen subjects completed the game and three stopped before reaching the end.

During the game sessions, the system automatically captured all statistical features used by our model (Table II) in six time windows of different lengths (1, 3, 5, 10, 15, and 20 seconds). As previously mentioned, different time windows are being used in order to determine its best length. All sessions combined resulted in a total of 3.15 hours of gameplay data for each time window.

After collecting the data, we performed a preprocessing phase to label the samples and create the final datasets. For the labeling process, we used the players' answers to the post-test questionnaire in order to identify the horror element that caused more fear in each player during the game. Since each player rated every horror element in a five-point Likert scale, the horror element with the highest rate was selected and then used to label all samples collected from the game session of that player. When more than one horror element was rated with the same highest rate, one of them was arbitrarily selected (we had 2 occurrences of this situation). We also ignored samples from players that rated all horror elements with the lowest rate (a total of 2 players). After labeling the samples, we divide them into six datasets (one for each time window). The numbers of samples of the datasets are: (1) time window of 1 seconds – 9507 samples; (2) time window of 3 seconds – 3178 samples; (3) time window of 5 seconds – 1906 samples; (4) time window of 10 seconds – 950 samples; (5) time window of 15 seconds – 631 samples; and (6) time window of 20 seconds – 470 samples.

IV. EVALUATION AND RESULTS

To evaluate the proposed fear model, we performed two tests: (1) a precision test to evaluate the accuracy of the model; and (2) a performance test to evaluate the real-time performance of the Neural Network when predicting what new players fear.

For the precision test, we performed two experiments. The first experiment is a general accuracy test, where we used the six datasets of different time windows to train and test our Neural Network following a 10-fold cross-validation strategy. Although the cross-validation strategy is usually enough to guarantee the generality of a model, it does not ensure that the model has learned what it is intended to. Since our model uses multiple samples of the same player as input, of which all have the same class label, the model could be learning how to

[3] https://www.cs.waikato.ac.nz/ml/weka/
[4] http://leenissen.dk/fann/

identify specific players instead recognizing what they fear. Therefore, to ensure the generality of the proposed model, we performed a second experiment to test the accuracy of the model for new players. For this second experiment, we removed all samples of one player from the training datasets and used them to create testing datasets (one for each time window). Then, the training datasets were used to train our Neural Network and the testing datasets were used to test its accuracy. This process was repeated for all combinations of players in training and testing datasets. Lastly, all results were combined to calculate the average accuracy of the Neural Network for new players. Fig. 4 shows the results of the precision tests.

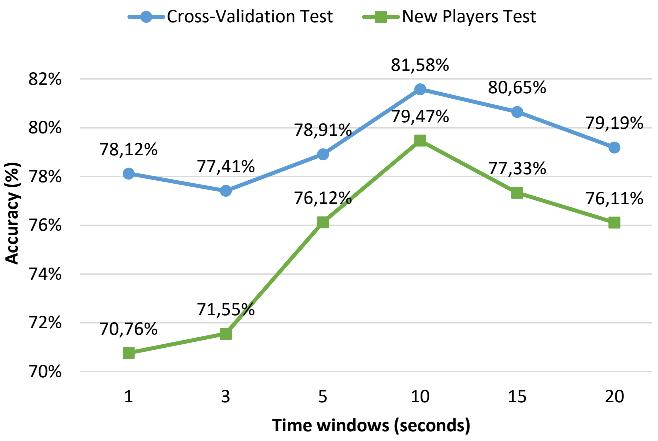

Fig. 4. Accuracy of the proposed model for different time windows (cross-validation test and new players test).

As the results of the precision test indicate, the best length for the time window is 10 seconds, where the general accuracy obtained for the cross-validation test is 81.58% and the average accuracy obtained when classifying new players is 79.47%. Given the similar accuracies obtained in both tests, we can also conclude that the model has learned what it was intended to and is capable of recognizing players' fears.

For the performance evaluation of our model, we tested the prediction of the horror element that causes more fear in the player during a normal gameplay session, wherein a total of 62 predictions were performed (time window of 10 seconds). For each prediction, we computed the time necessary to calculate the input features and to predict what the player fears using the Neural Network. The computer used to run the experiment was an Intel Core i7 2630QM, 2.0 GHZ CPU, 16 GB of RAM using a single core to process the Neural Network. As a result, we got an average time of 3.1 milliseconds (standard deviation of 0.8 milliseconds), which indicates the applicability of the proposed method in highly interactive virtual reality games without noticeable delays.

V. Conclusion Remarks

We presented in this paper a new method to identify what individual players fear in a virtual reality horror game, which combines machine learning and player modeling techniques to create a model of players' fears. The proposed model can be used to adapt the content of horror games in order to intensify the fear evoked in players.

In practice, our method provides game designers with new ways of enhancing the gameplay of virtual reality horror games. However, the actual application of the method requires careful planning and intelligent decisions of when to use the model's knowledge to adapt the horror elements of the game. If the model indicates that the player fears a certain horror element and the game starts to use that element all the time, it may become predictable and less scary over time. Therefore, the inclusion of an intelligent "Horror Manager" module in the game to moderate the use of the horror elements is recommended. In addition, the Horror Manager can also help filtering wrong classifications that occur due to the imperfect accuracy of the model by maintaining all classification results and using the "average horror element" to identify what causes more fear in the current player (considering that around 80% of the classifications are correct, wrong classification will not have a strong impact in the average value). Furthermore, the average horror element is also useful to dynamically handle smooth transitions between horror elements that can occur when the player's fears change over time.

Although the proposed method presented good results in our experiments, some methodological considerations and current limitations of our research work must be pointed out. First, we have relied on a small and homogeneous training dataset created with samples collected mainly from game sessions of young male university students, which serves as an indication that our method is capable of recognizing players' fears, however future work still is needed to validate our method with a larger and more representative dataset, which must take into account a broader range of ethnic and socioeconomic groups. Secondly, the samples of our datasets were labeled using only the information provided by players, which is subject to noise considering that not all players are able to precisely measure their fear levels. Although we did not observe any issues related to this problem in our experiments, it is something to take into consideration when creating larger datasets. Thirdly, since our primary focus was on the technical aspects, we have not yet conducted a rigorous user study to evaluate our method from the player's perspective or analyzed how players react to a game that adapts its content according to their fears, which surely is a mandatory task that will serve as orientation for the next stages of our project.

Apart from the validation of our method with larger datasets and practical user studies, another promising future work that caught our attention is the use of sensors to collect players' biometric data, which can be used to replace the questionnaire where players manually rate their fear levels. The combination of vital signals (e.g. heart rate, temperature, transpiration) with gameplay data can provide more information to the machine learning algorithm, which can result in a more precise identification of the horror elements that cause fear in players.

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