VR-Wizard: Towards an Emotion-Adaptive Experience in VR

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Figure 1: VR-Wizard: A personalized real-time emotion-adaptive Virtual Reality Wizard experience.

ABSTRACT

In this research, we investigate the impact of real-time biofeedback-based emotion adaptive Virtual Reality (VR) environments on the immersiveness, game engagement, and flow state using physiological information such as Electroencephalogram (EEG), Electrodermal Activity (EDA), and Heart Rate Variability (HRV). For this, we designed VR-Wizard, a personalized emotion-adaptive VR game akin to a Harry Potter experience with an objective to collect items in the forbidden forest. The users initially train the system through a calibration process. Next, they explore the forest with adapting environmental factors based on a 'MagicMeter' indicating the user's real-time emotional states. The overall goal is to provide more personalized, immersed, and engaging emotional virtual experiences.

CCS CONCEPTS

• **Human-centered computing** → *Virtual reality*.

KEYWORDS

Emotion Adaptive, Virtual Reality, Physiological Information, EEG, HRV

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1 INTRODUCTION

Neuroscience and psychology research indicates that the experience, actions, and expressions of emotional states influence cognitive processes. This makes the affective and cognitive states subject to frequent changes while interacting with technology. This is especially true for immersive VR Environments which are an extremely powerful tool for providing varied emotional experiences. Understanding and designing interfaces, interactions, and environments based on end-user's emotional responses is a critical challenge but essential from a human-centred computing perspective.

Recognizing emotional states has become more accessible, especially with wearable physiological sensors. These enable us to collect intrinsic, unaltered, and immediate bodily responses essential for accurate emotion analysis. Using physiology-based real-time emotion adaptive VR, we created VR-Wizard, where a user can experience a Harry Potter-themed VR environment in a more immersive and engaging way. The more the user feels unpleasant, their MagicMeter (MM) goes lower, resulting in a magical distortion that disappears when the participant tries to feel positive emotions and increase their MM. This system will allow the user to experience the world of WizardVR and will prompt them to think positive thoughts in unpleasant conditions.

2 RELATED WORK

There has been a lot of research investigating emotion recognition techniques using various physiological modalities such as face expression, voice, text, and Eye-tracking [Marín-Morales et al. 2020]. Much of this research used machine-learning algorithms such as support vector machines and neural networks, to achieve high levels of accuracy in recognizing users' emotional states[Soroush et al. 2017]. However, only few demonstrated real-time applications reflecting emotion back into the VR experience. For example, Dey et. al. [Dey et al. 2018] reported positive influence of heart rate feedback to the collaborators on others' presence, and increased empathy. Bernard et. al. [Bernal and Maes 2017] demonstrated a VR system where user's avatar manipulate their expressiveness based on the user's real-time emotional states. These researches explored the emotions as an indicator but didn't investigate its impact on the overall game experience. In our research, we are interested in exploring these gaps through a personalized emotion-adaptive VR game - VR-Wizard. The main novelty of our research is that is it one of the first examples of an emotionally responsive VR experiences that adapts to the users emotional state in real time and tries to keep the user in given range of emotions.

3 IMPLEMENTATION

The implementation of this system is divided into two stages, 1) Calibration, and 2) VR-Wizard (figure 2). The calibration system trains personalized machine learning based emotion recognition models using EEG, EDA, and HRV signals following AffectivelyVR [Gupta et al. 2020]. The user is shown 3 emotional 360 degree videos in VR while their physiological responses collected at the end asked to rate their perceived emotional states using the Self-Assessment Manikin (SAM) scale [Bradley and Lang 1994]. This process will produce personalized, and accurate models along with a selected feature list that will be used next.

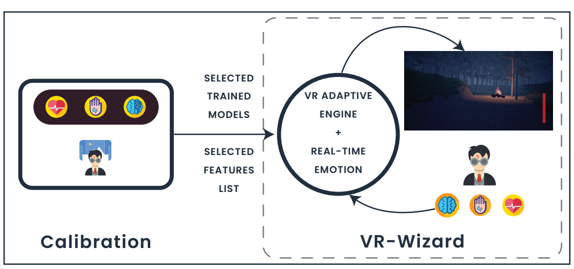

Figure 2: VR-Wizard: System Flow

In the second stage, the VR Adaptive Engine will store the emotion recognition model from the previous stage, and collect physiological data, preprocess, and extract features from every 10 seconds of game activity. The selected features will be used to estimate the emotional state of the user. These emotional states and the confidence level are sent to MM that applies distortion effects to the user's view if the value goes below 30%. We use this threshold in order to prevent the user from experiencing extremely unpleasant emotions. With an objective to keep the environment engaging, we balance the emotional states by manipulating the fog density (FD), fog height (FH), and audio in the VR Environment. Through pilot studies, we observed that users preferred these environmental factors to be directly proportional to the MM values. If MM values increase indicating very pleasant emotional states, the FD, FH, and audio values are increased to make the experience less pleasant. Whereas if the MM values are lower, indicating unpleasant states, these environmental variables are decreased. The MM is invisible to the user, but we display it to the spectators on a separate screen to keep those watching the gameplay entertained.

4 PLANNED USER STUDY

Our hypothesis for this research is that "personalized real-time emotion-adaptive VR-Wizard will enhance the game experience, immersiveness, game engagement and flow state compared to a non-adaptive VR-Wizard game". To evaluate, we plan to conduct a user study with around 50 participants experiencing the adaptive and non-adaptive game in a between experiment design. We will be collecting their EEG, EDA, and HRV physiological signals while they interact with the system. At the end, we will be asking them to rate their experiences on *Player Experience Inventory* [Abeele et al. 2020] for player experience, *Immersive Experience Questionnaire* for immersiveness, *Flow State Scale* for the flow experiences, and *Game Engagement Questionnaire* for engagement.

5 CONCLUSION

In this paper, we present "VR-Wizard", a personalized emotion-adaptive VR game, and a planned user study of the system. Using this system we can examine the effect of a real-time biofeedback loop-based VR adaptation on the users' game experience, engagement, immersiveness, and flow experiences using subjective questionnaire and EEG, EDA, and HRV physiological signals. The results of this study will contribute to research on how to design more personalized, immersive, and engaging emotional virtual experiences and how to measure emotional state in VR using physiological information. In the future we will complete the planned user study and user the lessons learned to plan follow-on studies.

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