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Real-time Anxiety Prediction in Virtual Reality Exposure Therapy

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ABSTRACT

Detection of anxiety patterns in real-time within a virtual reality environment has many uses for medicinal, psychological or entertainment purposes. Virtual reality exposure therapy (VRET) is a therapy method that is quickly rising in popularity, and a built-in way to monitor anxiety levels within VRET applications can contribute to the therapy by providing physiological feedback from the user. This feedback can be used to make meaningful adjustments to context such as increasing exposure levels as user anxiety decreases. For the measurement of physiological signals within Virtual Reality applications, on-body biosensors are generally preferred due to mobility concerns. These biosensors can, however, be susceptible to noise due to movement and it is hard to extract information from a single type of signal. As a countermeasure, this study uses multimodal data and machine learning. The goal of the study is to integrate these signals into a virtual reality experience and accurately assess anxiety levels in real-time by examining patterns across different types of measurements and using a neural network to process information and reduce the effect of noise.

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CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Virtual reality**; • **Computing methodologies** → **Neural networks**.

KEYWORDS

biosensors; biosignals; VRET; VR; anxiety; neural networks; machine learning

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INTRODUCTION

The study sets out to integrate real-time anxiety prediction into Virtual Reality Exposure Therapy (VRET) for better decision-making. VRET is a therapy method that involves gradual exposure to a certain stimulus that the user is uncomfortable with, and couples this exposure with relaxation techniques. There have been many controlled experiments that provide evidence that VRET produces effective and long-lasting results [2]. This study focuses on using wearable physiological sensors to collect information from the user and using a neural network to predict the anxiety level. As mobility is crucial to immersion within Virtual Reality (VR), there can be increased level of noise in the signals from wearable technology due to movement. Pattern detection and the multi-modal system of several different predictors play a key role here in the accuracy of this prediction. The prediction can be used to enhance the experience of the user with better personalisation.

DESIGN

To better accommodate the needs of different types of users, a framework that includes the following will be developed:

- A control interface that displays the anxiety level prediction, current environment and exposure.
- Multiple environments to accommodate users with different types of phobias or anxiety disorders. For example; acrophobia (fear of heights) or claustrophobia (fear of confined spaces).
- Different environments will be developed in a way that defines certain parameters to be adjusted based on the current anxiety level. For example; height for acrophobia or cluster and space for claustrophobia.
- When the anxiety level seems too low at the current exposure level, the exposure could be increased via the control panel and vice versa.

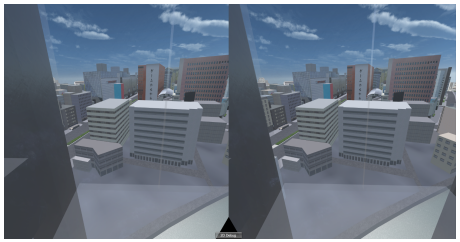


Figure 1: VRET acrophobia scene

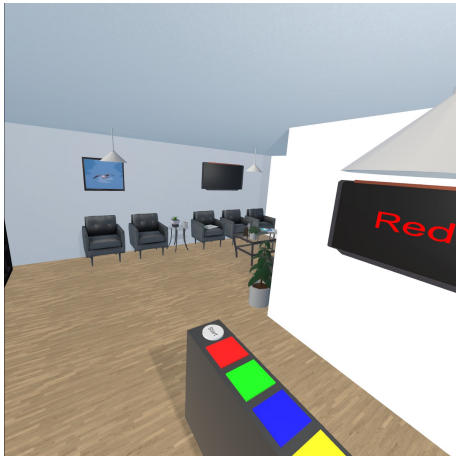


Figure 2: Waiting room scene

PHYSIOLOGICAL SENSORS

There are a number of studies that investigate the accuracy of using physiological signals to detect anxiety with varying results. Systems that are currently the most reliable and accurate are not fit to be used within VR due to mobility limitations. Since mobility within VRET is very important, this study sets out to find the optimal combination of physiological and physical predictors that allow for mobility without compromising greatly on the accuracy.

The most commonly used wearable sensors within VR [1] are the following:

- Electrocardiogram (ECG) for detection of heart rate, heart rate variability and breathing rate and patterns
- Photoplethysmogram (PPG) for detection of pulse rate, pulse rate variability and blood volume pressure
- Electroencephalogram (EEG) for detection of electrical activity in the frontal lobe of the brain
- Galvanic Skin Response (GSR) for the detection of electrical activity in the skin

CURRENT WORK

My current research focus is examining prior work in the area of anxiety prediction using biosensors, and ground-truth detection for anxiety. When we talk about the users' anxiety level, it is important to know the state where the user is not under stress. There are multiple ways to interpret this, for example, users fulfilling mundane tasks or users doing relaxation exercises. I am currently doing a literature analysis to come up with the best solution that would fit my research. Currently, I am in the process of writing a systemic review on the topic of anxiety prediction in VR using physiological signals. The working prototype of the project includes:

- An interface that controls the current scene and exposure.
- A VRET scene for acrophobia that includes five exposure levels (Figure 1).
- A VRET scene for claustrophobia that includes five exposure levels.
- A waiting-room scene for personalisation of the users and stress ground truth determination (Figure 2).
- Physiological signal recording system that simultaneously takes the brain activity, heart rate and skin conductivity level of the user simultaneously and saves it in a database as well as display it on the interface.
- A system that records specific events and notes down the physiological signal information based on this, an example being when the user clicks any button.

FUTURE WORK

By the end of the year, I plan on completing the systematic review of anxiety prediction in VR using physiological signals. I also plan to improve the prototype and come up with a scene that I can use for the classification of anxiety in three states; no anxiety; mild anxiety and severe anxiety. The current planned solution for this involves an emotionally adjusted version of the Stroop Colour-Word Task (SCWT). SCWT is a well-established test for cognitive ability, however, it has been shown to work for anxiety when modified accordingly [3].

In the long term, I plan to use this scene to collect information and train a neural network to predict the anxiety level. This level would then be displayed on the interface instead of the raw values from earlier, which would make it a lot easier to make a decision on the exposure level.

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