The Use of Artificial Intelligence in Interactive Virtual Reality Adaptive Environments with Real-Time Biofeedback Applied to Phobias Psychotherapy

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Abstract: Exposure therapy is a type of psychotherapy where the patient is gradually exposed to a fear situation. Patients may present different degrees of phobia, and the degree of phobia of each patient changes throughout the treatment. The use of Interactive Virtual Reality Adaptive Environments, where the interaction is personalized through real-time biofeedback mechanisms, allows the environment to adapt to the patients and their evolution throughout the treatment. The Artificial Intelligence affective algorithms continuously monitor the patient's behavioral data and physiological responses to adjust the intensity and number of the stimuli. This real-time adaptation aims to personalize and optimize the exposure process, gradually desensitizing patients to their fears.

1 Introduction

Phobias are characterized as irrational fears about situations, creatures, places or objects, affecting around 10% of the world's population at some point in their lives (Garcia, 2017), (Eaton et al., 2018), (Samra and Abdijadid, 2023). These disorders are identified by anxiety and/or fear in certain situations, which pose little or no real danger.

The American Psychiatric Association 2013 recognizes different types of phobias: (1) Agoraphobia - characterized by symptoms of anxiety and panic in situations where the person perceives their environment to be unsafe, with no easy way to escape. These situations may include, for example, going to shopping malls, busy streets, or public transportation; (2) Social Phobia - generally described as social anxiety and causing distress and impaired ability that negatively interferes with the routines of one's daily life. someone. One of the most common is the fear of public speaking; (3) Specific Phobia - consists of an intense fear and anxiety about some specific trigger, such as heights (acrophobia), spiders (arachnophobia), or small, enclosed spaces (claustrophobia).

Apart from pharmacological treatment, the most common form of treatment for phobias is in vivo exposure (Noordik et al., 2010), (Thng et al., 2020). This method consists of confronting the patient for an extended period of time (e.g. 60 minute sessions) with their feared stimulus until the distress subsides. The aim is to change the patient's response to the object or situation that is causing the irrational fear. Gradual and repeated exposure to the anxiogenic source and related thoughts, feelings and sensations can help control the patient's anxiety and fear (Raeder et al., 2020). However, exposure therapy has the negative factor of lack of environment full control, which can lead to negative reactions from the individual being treated.

An innovative strategy to intervene in this problem is the use of Virtual Reality (VR), which consists of a computer-generated environment to simulate the real world through an immersive experience (Bell et al., 2020). VR uses software applications, such as games or simulators, to create a virtual experience in a therapeutic environment, thus making it possible to recreate real everyday situations that cause anxiety in individuals undergoing treatment, in a therapeutically controlled environment (Rimer et al., 2021). Thus, it is possible for the patient to carry out exposure sessions to the feared difficulties/situations, exploring virtual scenarios that trigger emotions, physiological sensations, thoughts, and behaviors similar to real situations in a controlled environment. It is an intervention that enables individuals to find an additional self-regulation, ideal for themselves and their symptomatology, using inhibitory learning, i.e. control of impulsive responses (Albakri et al., 2022), (Reeves et al., 2022).

The literature has shown that VR can be as or more effective as in vivo exposure for the treatment of most in vivo exposure for the treatment of most phobias, with respect to the level of measured anxiety and avoidance (Wechsler et al., 2019). In addition to environmental control, virtual reality also allows for a high degree of confidentiality, since the exposure is done inside a room and there is no risk of potentiating negative reactions, either by the individuals or by possible observers. This intervention also enables the therapist to track the images the individual is viewing, allowing them to understand which specific images more accurately have caused the increases in anxiety and then therapeutically work through the response with the patient.

As there is no standardized protocol for treating phobias, treatment should always be tailored to each person to achieve more robust long-term results (Bergsnev and Sánchez Laws, 2022), (Thng et al., 2020).

The aim of this work is to apply Artificial Intelligence (AI) algorithms in the use of Interactive Virtual Reality Adaptive Environments, that adapt them self to the patients and their evolution throughout the treatment, where the interaction is personalized through real-time biofeedback mechanisms.

2 Methods

The process of building immersive environments is complex and involve a strong technological component and an important human component. The research was conducted using a sociotechnical approach based on Actor-Network Methodology, which focuses on the development of systems whose operation is based on the interaction between human and technological elements. These elements interact with each other during the construction process with the aim of obtaining a controlled system, which reproduces the characteristics necessary for an effective therapeutic exposure. However, this interaction remains and is fundamental throughout the treatment.

The research applies the state-of-the-art VR technology and Artificial Intelligence applications to create realistic and interactive immersive adaptative environments, as user-centered design methodologies involving user feedback and the necessary iterations to ensure the authenticity and effectiveness of the virtual environments.

The development of the algorithms considered the possibility of their use in three different modes of system operation:

- Autonomous Mode Strategy: For use independently by the patient or with the supervision of the therapist.
- Controlled Mode Strategy: For use with therapist monitoring and intervention.
- Real-time Biofeedback Mode Strategy: For use with therapist monitoring and supervision.

3 Results

A biofeedback system collects in real-time unimodal data from skin conductivity, respiratory and heart rate user devices (Figure 1). The system collects also the unimodal data from Headset movements and command buttons. These unimodal data are recorded and graded separately.

The algorithm analyzes the unimodal data collected during exposure from the patient's voluntary reactions, that reflect a conscious response (head movements, use of commands) and involuntary reactions which results from physical reflexes and biological changes (skin conductivity, respiratory and heart rate), and converts it into multimodal data to adapt the environment according to the Biofeedback obtained, readjusting the frequency, intensity and duration of the stimuli generated.

Three operating modes of the system were designed. Each of them has specific characteristics that allow their use in different therapeutic strategies.

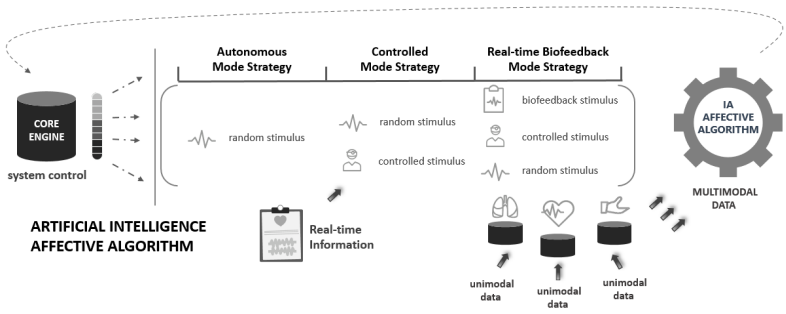

Figure 1: Artificial intelligence affective algorithm for virtual reality biofeedback systems.

3.1 Autonomous Mode Strategy

This mode allows the system to be used individually by the patient. Given its portability, it can also be used at home. The system offers different sections with an increasing degree of difficulty, the user has the autonomy to choose the session they want to carry out. By measuring the user's level of comfort, the system adapts the frequency, duration and intensity of stimuli to their emotional state. Users can repeat the same session as many times as they wish, however, the algorithm generates different sessions with the same degree of difficulty to ensure that repetition is not monotonous or predictable. This mode can also be used under the supervision of the therapist.

3.2 Controlled Mode Strategy

For use with therapist monitoring and intervention, this mode allows full customization of exposure. The therapist, using a tablet, visually monitors what the patient is seeing. Observing the patient's behavior and reactions to stimuli, the therapist can interact with the system, controlling the frequency, intensity and duration of the stimuli.

3.3 Real-time Biofeedback Mode Strategy

In this mode the therapist assumes the role of monitoring and supervision. The system adapts to the user's behavior using the AI algorithm. The AI affective algorithm uses multimodal data to recognize the type and intensity of user emotions during exposition and optimize the experience through the continuous adaptation of stimuli to his own emotional state.

4 Conclusion

The use of VR devices has some limitations as it is a recent technology, consequently users are not yet familiar with how it works and how to resolve minor technical problems that may arise during its use.

To make viable the use of Interactive Virtual Reality Adaptive Environments in Phobias Psychotherapy it was considered the use of AI affective algorithms in different real contexts. The complexity of the algorithms can be adapted to the needs of customizing adaptive immersive environments according to therapeutic objectives, taking into account technological limitations or restrictions on the use of certain devices.

The AI algorithms used guarantee great flexibility in managing the data that indicates user feedback. This feature allows data to be collected independently, which makes it possible to increase or decrease the number of devices and types of data collected according to the portability desired or the degree of accuracy desired. The concept of interactive VR adaptive environment with real-time biofeedback allows its use throughout the entire treatment process. The flexibility adopted in the development and the modular architecture of the AI affective algorithms allows them to be applied in the therapy of different types of phobias.

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