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Analysis and Definition of Data Flows Generated by Bio Stimuli in the Design of Interactive Immersive Environments †

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Abstract: This work focuses on interactivity as one of the essential factors for creating immersive environments, particularly interactivity that generates involuntary responses over which the user does not have conscious control. A dynamic and adaptive model was designed to analyze and define the data flow generated by bio stimuli for the design of interactive immersive environments.

Keywords: mental health and wellness; affective computing; empathy; immersive environments; augmented reality; virtual reality; electroencephalography; biofeedback; affective feedback

1. Introduction

Immersive environments provide impactful experiences that generate different types of emotions. The more immersive the environment, the greater influence it will have on the user's perception of their involvement with that environment, creating a sense of realism and a sense of presence in it. The feeling of immersion is caused by a set of factors. Interactivity is based on the emission of stimuli, which can be of different types, inducing responses by the user. In the process of the interactivity of an immersive system, stimuli intend to trigger responses.

Responses to stimuli can be voluntary, when the user is aware of the response they intend to give and choose to respond to the stimulus in a certain way, or involuntary when the user does not control the response. However, self-control of a person's biological status can be developed with time and experience [1]. This biofeedback process can control physiological factors such as heart rate and brain waves, among others [1].

One of the three core areas of affective computing that provide relevant methods and techniques to affective design is related with emotion sensing and recognition [2]. The concept of affective feedback relates the concepts of affective computing and biofeedback, and its application in immersive environments intends that the use of biofeedback mechanisms in the system will influence the user experience [1].

2. Objectives

The objective of this work is to design a dynamic and adaptive model to analyze and define the data flow generated by bio stimuli for the design of interactive immersive environments.

1. Identify the bio-response inducing stimuli sent by the system.
2. Detect, analyze, and classify the response by the user using biofeedback mechanisms.
3. Convert the obtained values into a scale and relate them to inducing stimuli.
4. Use the values obtained by the biofeedback to redefine the system parameters and emit new stimuli.

3. Methods

Immersive environments are designed to affect the user; exposure causes involuntary reactions, such as changes in the heart and respiratory rate and changes in the electrical brain activity and eye movements. These reactions can be captured in real time by biofeedback devices capable of identifying these changes and measuring their intensity. The real-time data obtained on the user's physiological aspects allows us to determine how the stimuli affect them (Figure 1). On the other hand, when the user receives information in real time about a certain aspect of his physiology, they can determine how their mental changes can influence their state.

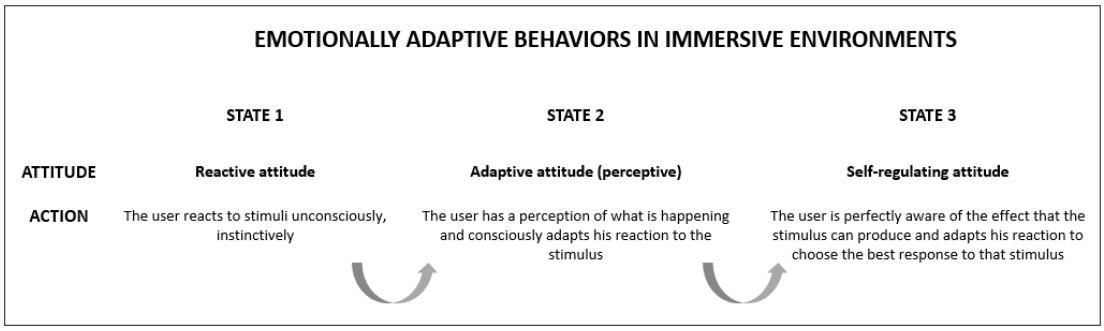

Figure 1. Behavioral change during continuous exposure to stimuli generated in immersive environments.

To optimize the user experience, an emotionally adaptive system continuously adapts its stimulus to the user's emotional state, through the measurement of their emotional data [3]. To incorporate the effects of stimuli on the interactivity process, the system first processes the unimodal data separately and then merges them [4] in order to interpret the user's response and use that response to generate new stimuli.

The perception and externalization of emotions can occur voluntarily and involuntarily. The participant can feel one thing and convey that they felt another. The use of multimodal data increases the reliability of the system by detecting different sources of biological signals [5].

The introduction of biofeedback systems in the design of a simple immersive environment transform it into an Emotionally Adaptive Immersive Environment, where the user experience can be optimized through the continuously adaptation of stimuli to the user emotional state. The quantity and intensity of the stimuli are determined through an adaptive affective algorithm which collects, interprets, and converts the user's physiological data.

To explore the potential of interactivity in immersive environments, the simple stimulus-response model must evolve into a dynamic and adaptive model. This model incorporates a set of cycles between stimuli and responses.

The system emits stimuli that trigger physiological reactions; the data generated by these reactions is sent and interpreted by the algorithm, which identifies the type and intensity of the emotion created by the stimulus. The affective algorithm adapts the system's responsiveness through mapping between the data obtained, considering the type and intensity of the stimuli, with the

appropriate response to each situation, selecting new stimuli to emit and grading the respective intensity.

4. Discussion/Conclusions

Since interactivity is an important factor in the construction of immersive environments, the design of a dynamic and adaptive model to analyze and define the data flow generated by bio stimuli is fundamental for the conceptualization of the system.

The Emotionally Adaptive Immersive Environment through an affective algorithm can use the Not Intentional Mode Strategy (NIMS), based on randomness in the stimulus management process, or the Intentional Mode Strategy (IMS), which automatically generates stimuli according to pre-defined objectives, but it also allows the Controlled Mode Strategy (CMS) through the intervention of a supervisor who controls the system during user exposure to the immersive system.

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