Analysis and Optimization of Brain Behavior in a Virtual Reality Environment

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Abstract. The causes of humans' emotions change are multiple. In order to analyze them, we propose to follow the emotions of an individual in real-time during his interaction with a virtual environment. Then, we propose to intervene on the virtual environment through a neural agent in order to modify and improve the humans' emotional state. Finally, we propose a personal agent, which aims to personalize the environment in order to optimize humans' emotions.

Keywords: Intelligent agent · Virtual reality · Neurofeedback · EEG Emotional intelligence

1 Introduction

The performance of users when interacting with learning systems or other types of programs varies according to their emotional states. Physiological measures of brain activity (EEG) [1] and eye tracking [2] provide better understanding of individual's emotions. Virtual reality helps the user immerse in the environment as if he was in a real one and that way his learning ability and performance will increase [3].

Changes in the virtual environment will cause a change in his emotional state and each modification can have a different impact on the emotional state. The negative emotional states of the user affect his cognitive state, for that, the modification of the emotional states in order to improve them will improve his cognitive state and thus his performance. Therefore, we need to detect the impact of the changes on the user's emotional states. However, sometimes the modification of the virtual environment are not enough to, modify the emotional state of the user. Thus, we need to learn from the link between changes on the virtual environment and changes in emotional states.

Therefore, we have three objectives: (1) Track in real time the emotional states of the user while interacting with the virtual environment in order to analyze his emotional states. (2) Modify the user's emotional states indirectly through the modification of the virtual environment in order to improve the user's emotional state and optimise his performances. (3) Observe the user's emotional reactions after each modification on the virtual environment in order to predict their impact on user's emotional states and thus, personalise the virtual reality environment to each user.

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2 Methodology

In order to achieve our goals, we propose to create a neurofeedback system containing three components: a "Measuring Module" which responds to our first objective, a "Neural Agent" which responds to our second objective and a "Personal Agent" which responds to our third objective. Figure 1 illustrates the architecture of our neurofeedback system.

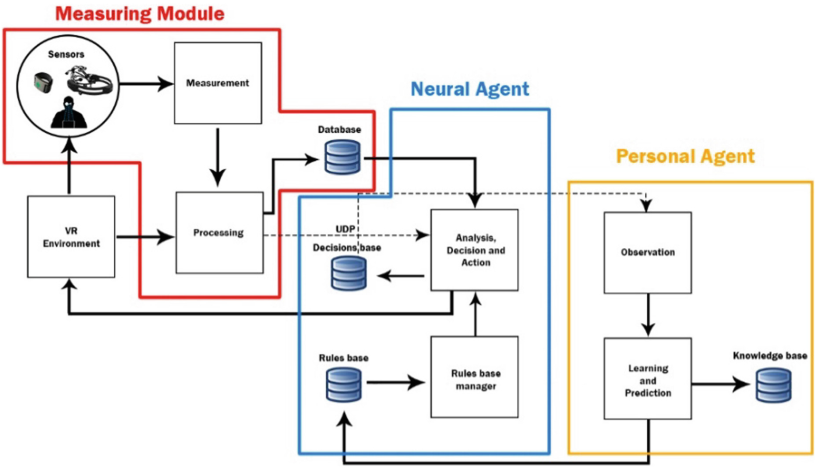

Fig. 1. Architecture of the neurofeedback system

The measurement module receives signals from sensors (EEG, eye tracking, etc.), analyzes them, and extracts the indices of emotional states. Then, this module sends these emotional states in addition to information about the virtual reality environment to the neural agent and stores them in a database for offline analysis.

The neural agent is an intelligent agent that receives the user's emotional states from the measurement module and the information of the virtual environment, then it consults the rules base, which contains intervention rules, to intervene on the virtual environment and modify the emotional state of the user.

The personal agent is a cognitive agent that aims to adapt the virtual environment to the user. It observes the interactions between the users' emotional states and the interventions on the virtual environment. Indeed, the personal agent observes the neural agent's, learns from its interactions with the virtual environment and their impact on the emotional state of the user in order to create new intervention rules and adapt better the environment to the user. This agent runs in parallel with the neural agent to perform the learning and prediction tasks. The heavy learning computing performed by this agent does not affect the real-time execution of the neural agent and the entire neurofeedback system because it does not intervene directly on the virtual environment. The personal agent personalizes the virtual environment by modifying the neural agent's rules base, which will then modify the environment.

3 Preliminary Results

We started by creating the measuring module and for that, we created the measurement component and the processing component in the module. After that, we integrated the Emotiv SDK EEG headset. In order to test this measuring module, we created a physics virtual reality game called “Inertia” which aims to improve the player’s intuitive reasoning. We conducted experiments, involving 20 participants. We used frustration and engagement provided by the measuring module in order to assist the players [4]. Results showed that players’ performance increased when adding assistance strategies.

Then, we created the neural agent and we created “AmbuRun” an adaptable virtual reality game in order to test this agent. We conducted experiments, involving 20 participants, in which the neural agent changes the speed of the game in order to affect excitement and changes the difficulty of the game which affects frustration. Results showed that when the agent adapts the game for the participant by changing speed and difficulty according to his excitement and frustration, it affects the level of his excitement and frustration in the right way [5].

Further work will aim to analyze the effect of each intervention with machine learning techniques to provide the personal agent with deeper adapting capabilities.

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