

An innovative Neurofeedback for children with ADHD using Virtual Reality

V. Delvigne^{1,3}, T. Dutoit¹, L. Ris², H. Wannous³, J.-P. Vandendorre³

¹ISIA Lab, Faculty of Engineering, University of Mons, Mons, Belgium.

²Neuroscience Department Lab, Faculty of Medicine and Pharmacy, University of Mons, Mons, Belgium.

³Institut Mines-Telecom/Telecom Lille, Villeneuve d'Ascq, France.

victor.delvigne@umons.ac.be

Introduction

Attention deficit hyperactivity disorder (ADHD) is the most prevalent neurodevelopmental disease in childhood, it affects between 5 and 7 % of children and is characterized by hyperactivity and/or attention deficit. ADHD diagnosis and assessment can be based on questionnaires, neurophysiological tests or neurophysiological signals^[1]. Three main treatments exist today: medication (Methylphenidate intake), behavioural treatments and neurofeedback. In the context of this work, the attention will focus on the third method: neurofeedback (NF). NF consists of a real-time representation of the brain activity (in an understandable form) to teach how to self-regulate specific functions. For instance, in the case of children suffering from ADHD neurofeedback aims to help the patient to detect the inattention phases and to teach her how to inhibit them in the future (Figure 1).

Methods

The goal is to design a serious game embedded in a virtual reality(VR) environment to provide NF training. It has been proven that VR has a higher ecological validity for neurophysiological assessment ^[2]. Moreover, VR brings more freedom for the environment creation and control with greater safety. The signals considered for neurofeedback will be electroencephalogram signals (EEG) and gaze direction. Recent works addressing NF on these two signals (García-Baos ^[3] et al. with Recogneyes, for the eye-tracking and Bioulac et al.^[4] with Mensia-koala, for EEG) have shown encouraging results on hyperactive children. In that sense, It could be interesting to consider EEG and eye-tracking in VR to identify possible improvements (comp. to a 2D environment). In brief, the goal is to detect the attention state from these signals and to use it to influence the VR environment parameters (e.g. lighting).

Another important aspect considered in this thesis is the use of Machine learning (ML), and especially deep learning, models for the signal classification between attentive vs. inattentive patterns. During the last decade, a lot of ML classifiers have been designed for the classification of EEG rhythms and/or temporal patterns as presented in Lotte et al. 2018 ^[5]. Tan et al. ^[6] performed a ML classification of EEG signals from children with ADHD through VR brain-computer interface but without feedback (i.e. dynamic environment modification).

Results and Discussion

The goal of this thesis is to design a novel neurofeedback method for ADHD children using ML models for signal classification and a VR environment for NF training. The next steps will be: 1) The first deliverable for June 2020: a prototype aiming to create the dataset through a serious game evolving in a VR environment promoting concentration and attention, but also allowing the measurements of several features (physiological signals and cognitive abilities). 2) Dataset creation and ML model development for June 2021: the creation of the dataset employing the first deliverable and development of a ML-based model for attention state classification. 3) The second deliverable for January 2022: a prototype including a feedback loop that will allow the patient to correct his symptoms by herself, by associating game reactivity with real-time physiological signals. Thanks to the multiple collaborations with different faculties (in particular neuroscience departement), a validation of the NF will be made in parallel with the thrid step by specialists.

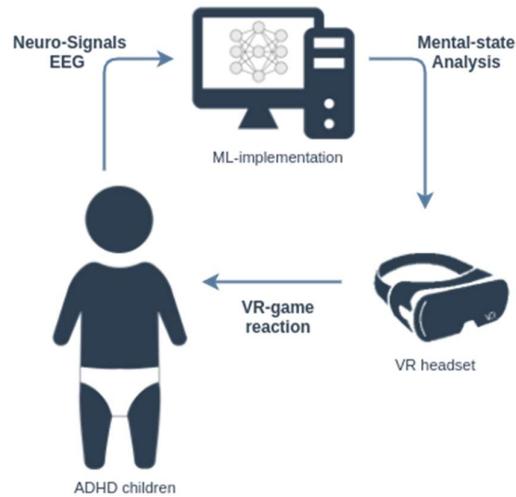


Figure 1 : Overview of neurofeedback for children with ADHD.

1. Signal (EEG) acquisition from the patient.
2. Signal Processing and analysis to deduce the attention state.
3. Game reaction in real-time in the VR environment.

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