Development of a Brain Computer Interface with Virtual Reality Neurofeedback

Project Management and Software Development
for Medical Applications

General Info

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Project Abstract

Mentalab Explore is a wireless mobile biosignal acquisition system with up to 8 ExG (EEG, EMG, EOG) channels and 9 axis movement data (accelerometer, magnetometer and gyroscope). The hardware can be used with various software frameworks i.e. Python, Matlab etc. to develop applications targeting different application solutions. In this project we aim to carry-out a feasibility study. We will develop an interface to provide real time feedback to the subjects via a Virtual Reality (VR) application.

Background and Motivation

Brain computer interface (BCI) based neurofeedback programs aim to provide real time feedback based on ExG (EEG, EOG, EMG) biosignals. While traditional neurofeedback techniques use sound or visual signals, virtual reality based neurofeedback techniques have reported better performance for movement training and classification[1, 2]. VR based neurofeedback has also shown positive results for stroke patients[3] and for phantom limb pain[4]. VR based techniques can provide a better user experience and be coupled with augmented reality (AR) to create engaging and diverse applications.

Student's Tasks Description

For the project the student first needs to develop a machine learning based motor imagery/neurofeedback classifier using the Mentalab Explore device. The classifier would ideally have three classes: left, right and resting state.

The second part would be to connect the classifier with a Unity based VR application to provide real time feedback to the subject.

The project would be realized as a co-development project with Mentalab GmbH. Students can choose to focus in depth only on machine learning or the VR component of the project if necessary.

Technical Prerequisites

These skills are recommended for this project.

- Python/MATLAB programming
- Experience/motivation to work with Unity framework
- Machine learning classification techniques
- Knowledge of signal processing is a plus

References

[1] J. W. Choi, B. H. Kim, S. Huh, and S. Jo, "Observing Actions Through Immersive Virtual Reality Enhances Motor Imagery Training," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 28, no. 7, pp. 1614–1622, Jul. 2020

Please send the completed proposal to ardit.ramadani@tum.de, zl.jiang@tum.de, lennart.bastian@tum.de and tianyu.song@tum.de. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in case of acceptance.

[2] F. Škola, S. Tinková, and F. Liarokapis, "Progressive Training for Motor Imagery Brain-Computer Interfaces Using Gamification and Virtual Reality Embodiment," *Frontiers in Human Neuroscience*, vol. 13, 2019

[3]S. E. Kober, J. L. Reichert, D. Schweiger, C. Neuper, and G. Wood, "Effects of a 3D Virtual Reality Neurofeedback Scenario on User Experience and Performance in Stroke Patients," in *Games and Learning Alliance*, Cham, 2016, pp. 83–94.

[4] Herrador Colmenero, L., Perez Marmol, J. M., Martí-García, C., Querol Zaldivar, M., Tapia Haro, R. M., Castro Sánchez, A. M., & Aguilar-Ferrándiz, M. E. (2018). Effectiveness of mirror therapy, motor imagery, and virtual feedback on phantom limb pain following amputation: A systematic review. *Prosthetics and orthotics international*, *42*(3), 288–298.