Real time neural signal processing and visuo-motor integration: new perspectives for assistive technology

Maria Adelia Albano de Aratanha[1,2], Hougelle Simplício[1,2], Edgard Morya[1,2], Renan Cipriano Moioli[1,2], Fabricio Lima Brasil[1,2]
[1] Edmond and Lily Safra International Institute of Neuroscience of Natal (ELS-IINN)/INCEMAQ
[2] ELS-IINN postgraduate program in neuroengineering

I – Proposers

- Maria Adelia Albano de Aratanha has a B.Sc. in Electrical Engineering, and a Dipl.-Ing in Biomedical Engineering. Works in the field of Brain Machine Interface (BMI) and virtual reality.
- Hougelle Simplício has a MB in Medicine, and a PhD. in Neurology. Has experience on functional neurosurgery and neuromodulation in both clinical and research field, epilepsy and Parkinson's disease.
- Edgard Morya has B.Sc. in Physiotherapy, and a PhD in Human Physiology. Has experience on motor control, rehabilitation, plasticity, learning, EMG, EEG, psychophysics, perception-action, neurophysiology, virtual reality, and eye-tracker.
- Renan Cipriano Moioli has a B.Sc. in Electrical Engineering, a M.Sc. with emphasis on artificial intelligence and robotics, and Ph.D. in Computational Neuroscience and Robotics. Has experience on computational neuroscience, signal processing, information theory and autonomous robotics.
- Fabrício Lima Brasil has a B.Sc. in Electrical Engineering, a M.Sc. in Mechanical Engineering, and a Ph.D. in Neuroscience. Has experiences in the field of brain machine interface (BMI), rehabilitation, EEG, plasticity and brain stimulation techniques.

II – Demo presentation

We are available to present the demo during the full duration of the conference and also during a demo session open to the audience.

III – Demo details

Brain Machine Interface (BMI) systems aim to restore motor activity in patients with motor impairment. Motor disability can result from traumatic injuries to the central or peripheral nervous system or amputation. Also, with increasing life expectancy, more people suffer from conditions that limit their mobility [1] and often their capacity to physically interact with computers, machines and environment is severely impaired [2], hence the relevance of BMI.

A noninvasive BMI uses the electrical brain signal recorded through the subject's scalp. Although the information transfer rates of this type of BMI has been proven sufficient for direct communication, for example in the case of ALS patients, its use to provide intuitive asynchronous control of prosthetic devices requires further development for application in daily situations.

In fact, there is building evidence that the combination of brain waves with other biosignals (e.g. electromyography, electrooculography) might entail many practical solutions to control assistive, noninvasive technology for patients with severe motor impairment [2].

We will demonstrate a real time neural signal processing BMI combined with an immersive virtual environment, in which brain electrical activity will be displayed in real time. More specifically, we will use a head mounted display (HMD) to simulate a 3D avatar mimicking the position and orientation of the user body walking in a virtual environment (VE). The subject's neural signals will be acquired using a wireless electroencephalography (EEG) device with dry electrodes placed on the scalp.

The task consists of four different situations where the subject will: a) passively observe the avatar movements in the VE; b) actively imagine their own movements according to the avatar movements in the VE; c) actively perform the movements based on the VE environment using the HMD; and d) actively perform the movements in the real world (RW) - without the HMD. The innovative aspect of this unique combination of wireless EEG technique and VE is to register brain patterns in standardized situations, where the subject has to observe, imagine, and perform (with and without HMD) the task in the same rhythm of an avatar. This opens new perspectives for unraveling the brain dynamics of walking in healthy and/or motor impaired subjects.

The results will contribute towards a BMI for training of motor impaired patients in a freely walking activity immersed in a virtual scenario, in which subjects will be asked to use executive function, dual tasking, planning, and scanning, to complete the task of controlling an avatar's motor system.

IV – Demo experience

The participants will have the possibility to use both the wireless dry EEG system and HMD in order to perform the proposed tasks. Participants and audience will be able to see the difference in brain functioning between each performed task.

V – Demo technical requirements

- An open 3x3 meters area.
- A monitor/projector to show the audience what the participant using the glasses is seeing (the higher the screen size and quality, the better).
- 5 power outlets, a small table, and two chairs.

VI - References

[1] W.H.O., World report on disability: WorldHealth Organization, 2011.

[2] BRASIL, F.L.; RIBEIRO, P.R.A.; WITKOWSKI, M.; SHIMAN, F.; CIPRIANI, C.; CARROZZA, M. C.; SOEKADAR, S.R. Controlling Assistive Machines in Paralysis Using Brain Waves and Other Biosignals. Advances in Human-Computer Interaction, v. 2013, p. 1-9, 2013.