DOI: 10.3217/978-3-85125-467-9-99

Evaluation of Motion Artifacts on EEG Signals during Exoskeleton Gait.

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Introduction: Brain-Machine Interfaces (BMIs) are currently being applied to enhance rehabilitation strategies by increasing patient's involvement level [1-2]. Most common BMIs work with electroencephalographic (EEG) signals registered from the scalp. Even EEG signals have very good temporal resolution, they have low spatial resolution and signal/noise ratio. When an exoskeleton is used in combination with a BMI for lower limb rehabilitation, the study of how motion artifacts affects EEG signal is a critical point for the correct performance of the final system. The goal of this work is to study these artifacts and how they contaminate the EEG signals.

Material, Methods and Results:
To perform the current study, a recent approach to obtain motion artifacts during walking on EEG signals is used [3]. To do this, users wear a plastic cap to isolate the electrical signals from the scalp. On the cap, a wig coated with conductive gel is located to simulate the conductive surface of the scalp. Finally, the EEG electrodes are located on the wig. The acquisition system use 32 channels over the motor and visual cortex located in the scalp with an elastic cap, AFZ electrode was used as ground with a reference in the right earlobe. Signals are amplified and digitalized using an ActiCHamp commercial amplifier with a sample frequency of 1200 Hz. During the experiments, the users are asked to walk on 4 different conditions: Normal walking registering EEG signals, Normal walking isolating EEG signals, Exoskeleton walking registering EEG signals and Exoskeleton walking isolating EEG signals. Two healthy subjects performed the experiment. On Fig. 1, the spectrum of 30 seconds of data of each condition is shown for electrode CPZ using the welch method. All electrodes present a similar behavior. The exoskeleton used was form by a couple of ankle actuators developed for BioMot Project.

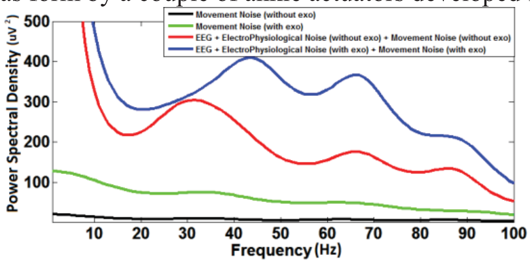

Figure 1. *Spectrum of each experimental condition from electrode CPZ. From the top: Exosqueleton gait registering EEG signals, Normal walking registering EEG signals, Exoskeleton walking isolating EEG signals and Normal walking isolating EEG signals.*

Discussion: Results show the appearance of motion noise affecting all frequencies (being higher the influence on low frequencies). The motion noise during normal walking (black line) is considerably lower than the power of the EEG signals (red line). On the other hand, using the exoskeleton (green line) increase significantly the power of the motion noises, corresponding approximately to the 25% of the EEG signals registered under the same conditions (blue line). The use of the exoskeleton induces extra electromyographic signals that contaminate frequencies from ~40 to ~100Hz (blue line). Power peaks on high frequencies present an unsteady behavior for different users and electrodes.

Significance: This work shows high artifact contribution on EEG signals during exoskeleton gait. This is a critical point on EEG measurements during lower limb rehabilitation based on an exoskeleton. Studies focused on this topic should paid special attention on this reported issue.

Acknowledgements: This research has been funded by the Commission of the European Union under the BioMot project - Smart Wearable Robots with Bioinspired Sensory-Motor Skills (Grant Agreement number IFP7-ICT-2013-10-611695)

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