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A non-invasive EEG-based Brain-Machine Interface for the control of myoelectric prostheses

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Introduction. Decoding brain activity is an ongoing research challenge with implications for the control of upper and lower limb prostheses [1,2]. This study represents a non-invasive Brain-Machine Interface (BMI) to control upper limbs and reports the classification performance of four different grasp movements realized by a myoelectric hand prosthesis (Myobock, Ottobock), modified to be controlled by EEG signals.

Material, Methods and Results. The experimental data were collected in three experimental sessions during which amputee and able-bodied subjects performed different grasp movements under two conditions: Motor Execution (ME) and Motor Imagery (MI). Two different methods based on the combination of the Common Spatial Patterns and Wavelet Decomposition techniques [3] and on an alternative approach using Riemannian Geometry were used to extract the features to be used as inputs to the classification algorithms employed to decode the EEG activity. The prediction performances of the system have also been tested with several combinations of electrodes and compared to the ones obtained by the original set of electrodes. The classification performances obtained by the six decoding algorithms are well above chance levels for all binary classification models with the best results obtained using the Support Vector Machines (SVM). For the four movements, there are almost no differences in terms of classification performance between the MI and ME conditions. In ME the performance of the able-bodied group is superior to the amputee group. Finally, a 2% drop in prediction performance is obtained when reducing the electrodes from 64 to 32 (Fig. 1).

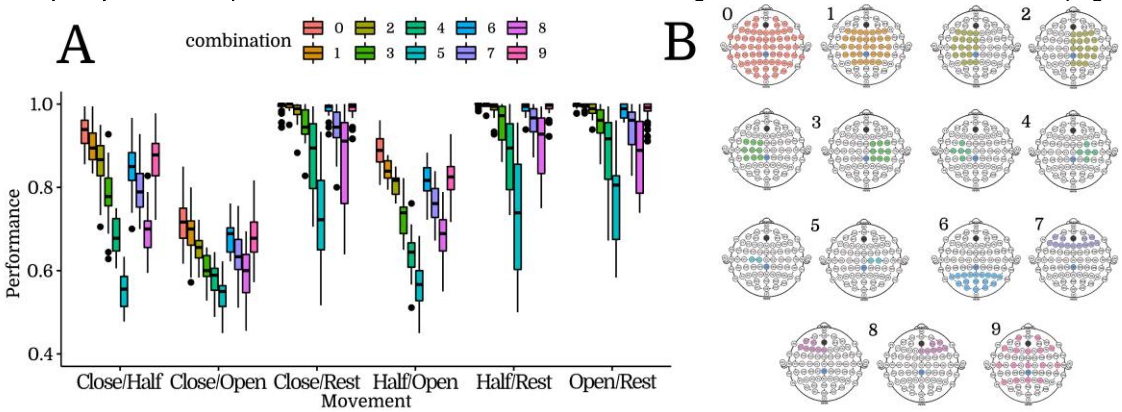

Figure 1 A. Comparison of the performance of the Radial Basis Function SVM for different combination of electrodes and for the six binary classification models. B. Original and nine different set of combinations of electrodes.

Discussion. Even though the EEG signal represents more abstract information about the brain activity compared to the signals obtained by invasive methods our results showed that it can be used to control hand prostheses. The amputee people can perform the movements with similar performance both in ME and MI conditions and the classification performances obtained with different algorithms and feature extraction methods are not significantly different.

Significance. This work gives a proof of concept for the use of a non-invasive BMI system dedicated to the control of prostheses, paving the way for developing a feasible system with a small number of electrodes.

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