Defense Announcement

A Longitudinal BMI Paradigm with a Lower-Limb Exoskeleton & its Induced Cortical Changes

Kevin Nathan

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Committee Chair: Jose L. Contreras-Vidal

Committee Members: Robert G. Grossman
Rose Faghih
David Mayerich
Yingchun Zhang

Brain-machine interfaces (BMIs) have been developed to enable cognitive control of computers and robotic devices. Such technology might potentially lead to restoring movement for persons with motor disabilities allowing them to control robotic prostheses naturally with their mind. However, long-term usage with closed-loop BMI systems has not been thoroughly studied, nor the subsequent changes in the brain induced by cortical plasticity. Eight able-bodied subjects were recruited for a longitudinal BMI training paradigm with the Rex lower-limb exoskeleton. The paradigm consisted of 9 sessions in which users developed their ability to use motor imagery to initiate walking/stopping in the Rex as a Go/NoGo task. The BMI consisted of active EEG with dynamic artifact removal processed through a Localized Fisher Discriminant Analysis dimensionality reduction and a Gaussian Mixture Model classifier on time-lagged delta band amplitudes. BMI decoding varied among the subjects, with at least some achieving significantly above chance classification performance by the end of training. fMRI scans showed contrasts in activation between the Walk and Stop conditions localized in the parietal lobule among other motor-related areas. Offline EEG analysis identified ERPs corresponding to the walk cue, but these may not have been reliably detected by the classifier. The novelty in this study is the extended use of a subject pool continuously for many sessions of BMI training to control a walking exoskeleton, providing insights into how much training subjects may need to achieve reliable classification, what factors separate good BMI operators from poor ones, and what other features may be more relevant in future BMI applications.