Individual and Coordinated Finger Movements Decoding from High-Density EEG and Its Implications in Hand Exoskeleton Control

Qiang Sun, Axel Faes, and Marc Van Hulle

Laboratory for Neuro- and Psychophysiology, Department of Neuroscience, KU Leuven, Leuven, Belgium

Abstract

Introduction. Restoring the hand functionality of paralyzed patients, such as those suffering from stroke, progressive disorders, or even spinal cord injuries, is essential to increase their self-reliance in activities of daily life. As brain-computer interfaces (BCIs) decode brain activity directly, bypassing defective neural pathways, they have been hailed as a solution to restore hand functionality. The BCI-controlled hand exoskeleton, especially the one based on non-invasive EEG recordings, has great potential to improve the finger dexterity of paralyzed individuals and eventually their self-reliance. However, finger movement decoding from EEG is less investigated in literature albeit it's of great importance to realize dexterous exoskeleton control. *Objective*. We aim to investigate the possibility of decoding performed individual and coordinated finger movements from one hand using high-density EEG, and the insights from the study would be used for designing an online hand exoskeleton control system. *Methods*. Four healthy subjects were recruited and asked to perform 8 cue-based finger movements. These movements include 5 individual finger movements, pinch, three-finger pinch, and grasp. We recorded their brain signals during tasks with 62 active electrodes put on the contralateral brain regions of their dominant hand. Their hand activities were also recorded with a data glove. *Results*. Offline results showed that 1) finger movements could be differentiated from each other with power features in the 8-30Hz frequency band after movement onset, but generally coordinated finger movements have the largest distinguishability. For example, the pairwise classification accuracies between grasp and two pinch movements arrived at 80%, while the pairwise classification accuracies between individual fingers were just above the chance level (50%). 2) the movement-related cortical potential (MRCP) in 0.3-3Hz is clear with a stronger decrease starting at -0.5s before the onset of finger movement and rebound after the onset, but its characteristics are subject- and movement-specific. The distinction between each movement in MRCP was insignificant making it difficult to classify, which is different from one literature where the authors show a clear difference between individual finger MRCP patterns. *Conclusion*. The onset of finger movement is possible to be detected with MRCP features and this could be a good solution to solve the latency problem during online hand exoskeleton control. Fine finger movements, i.e., individual ones in this study, are difficult to be distinguished from each other, calling for in-depth feature engineering.