Command of a Virtual Neuroprosthesis-Arm with Noninvasive Field Potentials
by
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Assistive devices, such as motor neuroprostheses, have been developed to help restore function for individuals with tetraplegia. For individuals with severe paralysis, command sources for assistive devices are limited to muscle activity and/or movements of the head and face. These commands can impede eating, talking, and other activities. Incorporating signals from the brain may be a valuable way to augment the command options for complex devices.

The attempted movements of body parts generate characteristic changes in field potentials over brain areas associated with those body parts. These movement-related changes can be recorded from the scalp and used to control an assistive device. Most previous studies using movement-related field potentials as a command source have been focused on the abstract control of computer cursors and not specifically focused on restoring arm and hand function using neuroprostheses.

We developed new spatial filtering techniques to help separate the cortical activities associated with the movement and rest of different body parts. Using these novel spatial filters, we demonstrated that two-dimensional movement of a ‘virtual upper-extremity neuroprosthesis’ can be controlled using electroencephalography (EEG) signals that are modulated by the attempted movement of two body parts which are spread apart in the motor homunculus (i.e., hand and feet).

The attempted movement of the feet and hand was an abstract command strategy using body parts unrelated to the desired device movement. A more natural command strategy of using the attempted movements of arm and hand joints was evaluated as a more intuitive way to control the same joints of the neuroprosthesis. Using a more natural command strategy, we demonstrated that individuals with tetraplegia were able to intuitively control the grasp of a virtual hand using movement-related field potentials associated with hand extension and relaxation. When expanding intuitive control to combinations of the elbow, shoulder, and hand together, our offline analysis showed a reduction in decoding accuracy over abstract command strategies in able-bodied individuals but equivalent or improved accuracy in the tetraplegic participants.

Demonstrating real-time control of a virtual upper-limb neuroprosthesis using EEGs is an important step towards the clinical implementation of brain-controlled motor neuroprostheses.