PRE-CLINICAL APPLICATION OF MUSCLE SYNERGIES FOR ABSTRACT MYOELECTRIC CONTROL

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ABSTRACT

Introduction:

Prosthetics are often controlled by the surface electromyogram (sEMG) of muscles remaining in the limb to which the prosthesis is attached. A major challenge for next-generation prosthetics is to design a proportional control scheme that allows for control of a number of degrees of freedom. Muscle synergies are coordinative structures which act as discrete low-level units typically combined to construct a diverse range of physical movements. In this work we compare use of two channel sEMG against multiple weighted electrodes, representing muscle synergies, in control of an abstract myoelectric user interface (MCI) capable of proportional control.

Method:

sEMG was recorded from the forearm in transradial amputee participants and the upper arm in a participant with a transhumeral congenital deficiency. Participants used isometric muscle contractions to operate a MCI which displayed a cursor on the screen. Users were assessed in their ability to use the MCI under two conditions; using an optimal pair of electrodes and using a weighted combination of eight electrodes representing synergistic muscle output. Muscle synergies were derived using a data driven approach based on Principal Components Analysis (PCA). Cursor position was determined solely by sEMG muscle activation in two simultaneous channels or two simultaneous principal components. Participants began using a four target interface and progressed to eight targets where appropriate. A 1.5 (s) trial was composed of two 750 (ms) periods, the first for movement and the second for holding the cursor in the target. Percent hold score was calculated based on the duration for which the cursor was within, or in contact with, the target during the hold period.

Results:

Overall final trial scores achieved using PCA weighted electrodes were significantly higher than those based on two channel sEMG when using the four target interface. Similarly, cursor path efficiency when using the four target interface was significantly higher for PCA based control than use of sEMG. Final scores for the eight target interface were greater using PCA weighted electrodes however additional data is required before significance testing.

Conclusion:

Initial results demonstrate that amputee participants can learn to use arm and forearm muscle pairs to flexibly control the position of a myoelectric cursor in a 2-D task environment. Data-driven spatial weighting of sensors generally produced more reliable results than a single pair of electrodes. Improved scores maintaining the cursor within target sectors are mirrored in improved cursor path efficiency.