CASE WESTERN RESERVE UNIVERSITY EST. 1826

BIOMEDICAL ENGINEERING

Ph.D. Dissertation Defense

Sears - Room 439
10:00 AM
Friday, January 10th, 2020

"Muscle Synergy-based Functional Electrical Stimulation for the Restoration of Dexterous Hand Function After Paralysis"

by

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Abstract Attached

ABSTRACT

Spinal cord injury at the mid-cervical level leads to loss of upper extremity function and therefore significant dependence on a caregiver for most daily tasks. Technological advancements have enhanced the lives of those with tetraplegia by offering voice-commanded switches controlling virtual assistants, lights, shades, televisions, and bed movements. Further independence has been achieved by restoring hand function to those survivors with retained arm movements through electrical stimulation of paralyzed musculature. The present work is part of a collection of research aims focused on creating more advanced clinical interventions to restore upper extremity function in those with tetraplegia. The investigations included in this dissertation are motivated by creating a stimulation control interface that allows for coordinated control of complex hand function. The main hypothesis for this work is that the time-invariant synergy model can be used to reduce the dimensionality of complex hand movements thus allowing for more naturalistic restored hand function through the modulation of myoelectric control inputs. The results presented here show the feasibility of synergy-based stimulation and propose further investigations to expand the capabilities of restored hand movement through electrical stimulation.

First we showed that the time-invariant synergy model is sufficient for reducing the dimensionality of time-varying complex hand movements to a set of static, coordinated muscle activation patterns. Second, we showed that as few as three synergies can account for the variance in time-varying functional movements on par with previous studies involving less complicated tasks and low dimensional movements. Lastly, we established that these synergy patterns were not only task invariant but common across study participants, laying the groundwork for creating a generalized set of synergy-based stimulation patterns for movement restoration. Additionally, the present dissertation presents a possible method for feasibility testing of synergy-based myoelectric control and discusses future applications of movement restoration with intracortical brain control which offers intuitive, high-dimensional continuous inputs to modulate stimulation patterns.