Abstract

Myoelectric human-machine interfaces (HMI) have been traditionally focused on advanced decoding techniques to decipher neural intent. However the confounding role of the neural adaptation during HMI training with human-in-loop has not been completely understood, which the focus of my current research work is.

First I will present results from two myoelectric decoding algorithms from my past work, 1. Kalman filter based myoelectric controller (and classifier) for terrain-specific control of a powered prosthetic knee: After leg amputation, quality of life depends dramatically on how well amputees can walk with artificial limbs. While artificial limbs have traditionally been passive, recent progress at advanced battery technology and low-weight actuators have made it practical to actuate the joints. To control the motors in these powered prostheses, feedback from a wide range of sensors including the electrical signals produced by muscles (electromyograms, EMGs), and on-board physical sensors were explored. I will present the prosthetic knee as a dynamical system in Kalman filter framework that operates in various regimes of locomotion: up-ramp, down-ramp, and level-walk. The state trajectories of the knee prosthesis as well as their mode of operation could be estimated during level-walk, up-ramp, and down-ramp walking as well as during terrain/regime transitions.

2. Linear discriminant analysis (LDA) based classifier for myoelectrically triggered functional electrical stimulation (FES) assisted walking after partial paralysis: Functional Electrical Stimulation (FES) where a train of electrical current pulses are applied to a nerve or motor point of a muscle in order to produce functional movement. FES may assist activities of daily living like walking, in stroke survivors and spinal cord injured (SCI) subjects. Although foot switches may work well in triggering FES, a more natural command source like electromyogram (EMG) from ankle plantarflexor and dorsiflexor muscles may facilitate re-learning of normative muscle activation patterns and may have therapeutic benefits. It is possible to utilize EMG from partially paralyzed muscles to drive FES to assist over-ground ambulation. A LDA based myoelectric decoder will be presented that could trigger FES of lower limbs in real-time for FES-assisted overground ambulation in two incomplete SCI subjects However, pathological muscles required substantial training where the mapping from the command source to the actuator (i.e. electrically stimulated muscles) had to be consolidated through regular use.

The critical finding from the clinical study on myoelectrically controlled FES was that the performance of the 'constant' linear classifier improved with month-long training for the partially paralyzed muscles involved with the task. Once that prosthetic mapping was consolidated, it was retained, readily recalled and resistant to interference and the user should be able to drive it without conscious effort. Therefore an enhanced understanding of neuroplasticity mechanisms associated with HMI-based training is necessary for designing successful long-term rehabilitative strategies.