Mechanical Engineering Doctoral Defense

On Enhancing Myoelectric Interfaces by Exploiting Motor Learning and Flexible Muscle Synergies

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abstract

Myoelectric control is filled with potential to significantly change human-robot interaction. Humans desire compliant robots to safely interact in dynamic environments associated with daily activities. As surface electromyography non-invasively measures limb motion intent and correlates with joint stiffness during co-contractions, it has been identified as a candidate for naturally controlling such robots. However, state-of-the-art myoelectric interfaces have struggled to achieve both enhanced functionality and long-term reliability. As demands in myoelectric interfaces trend toward simultaneous and proportional control of compliant robots, multi-muscle coordinations, or synergies, play a larger role in the success of the control scheme. This dissertation presents a framework enhancing the utility of myoelectric interfaces by exploiting motor skill learning and muscle synergies for reliable long-term simultaneous and proportional control of multifunctional compliant robots. The framework employs human-embedded controllers, allowing users to learn efficient control through the refinement of unique muscle synergies while interacting with the device. The myoelectric interface is learned as a new motor skill specific to the controller, providing long-term performance enhancements without requiring any retraining or recalibration of the system. The controller operates both motion and stiffness simultaneously in a natural interface for compliant human-robot interaction. The framework is validated through a series of experiments characterizing motor learning properties and demonstrating control capabilities not seen previously in the literature. The results validate the approach as a viable option to remove the trade-off between functionality and reliability that have hindered state-of-the-art myoelectric interfaces. Thus, the framework contributes to the expansion and enhancement of myoelectric controlled applications beyond commonly perceived anthropomorphic and “intuitive control” constraints and into more advanced robotic systems suited for everyday tasks.

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