Mechanical Engineering Doctoral Defense

Active and Passive Precision Grip Responses to Unexpected Perturbations

School for Engineering of Matter, Transport and Energy

Michael De Gregorio, M.S.

Advisor: Dr. Veronica J. Santos

abstract

The development of advanced, anthropomorphic artificial hands aims to provide upper extremity amputees with improved functionality for activities of daily living. However, many state-of-the-art hands have a large number of degrees of freedom that can be challenging to control in an intuitive manner. Automated grip responses could be built into artificial hands in order to enhance grasp stability and reduce the cognitive burden on the user. To this end, three studies were conducted to understand how human hands respond, passively and actively, to unexpected perturbations of a grasped object along and about different axes relative to the hand. The first study investigated the effect of magnitude, direction, and axis of rotation on precision grip responses to unexpected rotational perturbations of a grasped object. A robust "catch-up response" (a rapid, pulse-like increase in grip force rate previously reported only for translational perturbations) was observed whose strength scaled with the axis of rotation. Using two haptic robots, we then investigated the effects of grip surface friction, axis, and direction of perturbation on precision grip responses for unexpected translational and rotational perturbations for three different hand-centric axes. A robust catch-up response was observed for all axes and directions for both translational and rotational perturbations. Grip surface friction had no effect on the stereotypical catch-up response. Finally, we characterized the passive properties of the precision grip-object system via robot-imposed impulse perturbations. The hand-centric axis associated with the greatest translational stiffness was different than that for torsional stiffness. This work expands our understanding of the passive and active features of precision grip, a hallmark of human dexterous manipulation. Biological insights such as these could be used to enhance the functionality of artificial hands and the quality of life for upper extremity amputees.

July 19, 2013; 8:00 AM; ERC 490