Biologically Inspired Control of a Dexterous Artificial Hand Through Study of the Human Hand

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Abstract--Traditional motion planning methods for dexterous anthropomorphic robotic manipulators are computationally expensive and require one or more control inputs for each degree of freedom (DOF). Additionally, there are no provisions for anthropomorphic manipulators to move and react to the environment in a physiologically expected manner. As such, the realization of a highly anthropomorphic dexterous prosthetic hand is not currently feasible. Even though the physical appearance of newer prosthetic hands is similar to human hands, the dexterity, motions, reactions, and control interface are unnatural and limited in versatility.

An important focal point of this presentation is to describe approaches to overcome these shortcomings to spur the evolution of more sophisticated prosthetic hands. The methods described in this presentation will incorporate modeled human hand motion planning and reactions implemented within robust nonlinear control algorithms for a dexterous artificial hand. This will simultaneously ensure overall system stability and anthropomorphic motions. Computationally inexpensive grasp primitives and finger joint synergies will be presented to enable the operators of the hand to perform complex tasks like catching different shaped objects and unscrewing/screwing different sized objects with a single control input. Results will be presented both from amputee and nonamputee test subjects who use electromyogram signals to control the dexterous artificial hand.

Another new concept discussed in this presentation is that of variable feedback configuration control. With this concept, different feedback configurations analogous to electrical synapses in the human peripheral nervous system are presented to produce anthropomorphic reactions to the environment. The appropriate feedback configurations are shown to depend not only upon the task to be performed, but also upon the type of grasp selected to complete the task.