The Department of Mechanical Engineering/College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar

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Lecture Title: Dimensionality Reduction in Control and Coordination of the Human Hand

Friday, July 16, 2010, 2PM, Room 173 Engineering Building

Abstract

The human hand has a large number of mechanical degrees of freedom (DoF), which offers tremendous flexibility to perform skilled finger movements. Such flexibility makes the control of the hand very challenging. Nevertheless, the central nervous system (CNS) seems to handle the complexity and high dimensionality in movement control with amazing ease and absence of effort. Researchers have been confronted by the high DoF control problems when attempting to understand physiology behind the movements. These problems have been addressed by different theories on dimensionality reduction, many of which converge at an endeavor of extracting synergies. Though named the same, synergies have different meanings. In many contexts, synergies are common (shared) spatiotemporal patterns in muscle activities or movement kinematics/dynamics. These patterns can be used as primitives or building blocks, by combining which one can formulate complete movements.

This talk introduces a method for extracting kinematic synergies from joint-angular-velocity profiles of hand movements. Decomposition of a limited set of synergies from numerous movements is a complex optimization problem. This optimization problem can be solved following two steps. The first step is to extract waveforms of synergies from rapid movement tasks using singular value decomposition. A bank of template functions is then created from shifted versions of the extracted synergies. The second step is to find weights and onset times of the synergies based on l_1-minimization, which can be efficiently solved by linear programming. Synergies have received increased attention in the fields of robotics, human-computer interface, telesurgery, and rehabilitation. Improved performance and new computational model to decompose synergies presented here might enable them to be appropriate for real time applications.

Biography

Zhi-Hong Mao is an assistant professor in the Department of Electrical and Computer Engineering and the Department of Bioengineering at the University of Pittsburgh, Pittsburgh, PA. He received the dual B.S. degrees in automatic control and mathematics and the M.Eng. degree in intelligent control and pattern recognition from Tsinghua University, Beijing, China, in 1995 and 1998, respectively, the S.M. degree in aeronautics and astronautics from Massachusetts Institute of Technology (MIT), Cambridge, in 2000, and the Ph.D. degree in electrical and medical engineering from the Harvard-MIT Division of Health Sciences and Technology, Cambridge, in 2005. His research interests include neural control, human centered control, and networked control systems. He was a recipient of the NSF CAREER Award in 2010.

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