MAE Seminar Series

Robotic Beating Heart Surgery: Design of Next Generation Robotic Telesurgical Systems

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Abstract

Use of intelligent robotic tools promises an alternative and superior way of performing off-pump coronary artery bypass graft (CABG) surgery. In the robotic-assisted surgical paradigm proposed, the conventional surgical tools are replaced with robotic instruments which are under direct control of the surgeon through teleoperation. The robotic tools actively cancel the relative motion between the surgical instruments and the point-of-interest on the beating heart, in contrast to traditional off-pump CABG where the heart is passively constrained to dampen the beating motion. As a result, the surgeon operates on the heart as if it were stationary. We call the proposed algorithm "Active Relative Motion Cancelling" (ARMC) to emphasize the active cancellation.

In this talk, I will introduce the current state of our research on development of robotic tools for off-pump CABG surgery. I will first present the model-based intelligent ARMC algorithm we have developed to achieve effective motion cancellation. The developed algorithm relies on the quasi-periodic nature of the heart motion, using feed-forward predictive motion control with estimation of heart motion. The developed model-based algorithm employs biological signals, such as electrocardiogram (ECG), in estimation of heart motion, and also uses this for integrated arrhythmia detection and handling to provide safety during the operation. The algorithm was implemented and tested on a realistic 3 degrees-of-freedom robotic test-bed system, with root-mean-square tracking errors (305 um) more than 5.5 times better than the best results reported in the literature.

Following the description of the ARMC algorithm, I will also introduce our work on the other aspects of the problem, including, mechanism design, sensing algorithms and sensor system development, and development of an underlying quantitative design framework for the design of robotic telesurgical systems.

Speaker Biography

M. Cenk Cavusoglu received the B.S. degree in Electrical and Electronic Engineering from the Middle East Technical University, Ankara, Turkey, in 1995, and the M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California (UC), Berkeley, in 1997 and 2000, respectively. He was a Postdoctoral Researcher and Lecturer at the Department of Electrical Engineering and Computer Sciences, UC Berkeley, from 2000 to 2002. In 2002, he started as a faculty member at the Department of Electrical Engineering and Computer Science at Case Western Reserve University, Cleveland, OH, where he is currently an Associate Professor. Dr. Cavusoglu is an Associate Editor of the IEEE Transactions on Robotics.

Dr. Cavusoglu's research involves applications of robotics and control engineering to biomedical and biologically-inspired engineered systems. Specifically, his research interests include robotics, systems and control theory, and human-machine interfaces, with emphasis on Medical Robotics, Haptics, Virtual Environments, Surgical Simulation, and Bio-System Modeling and Simulation.

110 Knox Hall
Thursday, March 19th, 2009
3:30 pm – 4:30 pm

Please contact Dr. Venkat Krovi (vkrovi@buffalo.edu) for additional information