Complementary Perception and Situational Awareness in Robotic Surgery: Modeling, Control and Sensing

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Emerging surgical paradigms such as natural orifice surgery and minimally invasive surgery in deep surgical sites present new challenges to surgeons and engineers. These new challenges stem from the limitations of surgeon’s sensing, perception and incomplete situational awareness. To overcome these challenges, a new class of intelligent surgical robots has been developed at the speaker’s lab. These robots range from continuum robots with force sensing and contact detection capabilities to elastomeric electrode arrays capable of traversing anatomical passageways in the inner ear. Within the context of these surgical applications, we will focus on our efforts in modeling, designing and controlling intelligent surgical robots capable of sensing the environment and using the sensed information for task execution assistance. The talk will describe recent results on the design and control of continuum robots capable of performing contact detection and localization of contact. A modeling approach for compliant motion control of continuum robots will be presented along with clinical motivation from the area of minimally invasive surgery of the upper airways, cochlear implant surgery, trans-urethral resection of bladder tumors, and OCT-guided retinal micro-surgery.

Bio: Dr. Nabil Simaan received his Ph.D. in mechanical engineering from the Technion—Israel Institute of Technology, in 2002. His Masters and Ph.D. research focused on the design, synthesis, and singularity analysis of parallel robots for medical applications, stiffness synthesis and modulation for parallel robots with actuation and kinematic redundancies. His graduate advisor was Dr. Moshe Shoham. In 2003, he was a Postdoctoral Research Scientist at Johns Hopkins University National Science Foundation (NSF) Engineering Research Center for Computer-Integrated Surgical Systems and Technology (ERC-CISST), where he focused on minimally invasive robotic assistance in confined spaces. In 2005, he joined Columbia University, New York, NY, as an Assistant Professor of mechanical engineering and the Director of the Advanced Robotics and Mechanisms Applications (ARMA) Laboratory. In 2009 he received the NSF Career award for young investigators to design new algorithms and robots for safe interaction with the anatomy. In 2010 he joined Vanderbilt University as an Associate Professor and was promoted to the rank of a Professor in 2017. He is a Senior Member of the IEEE. He served as an Editor for IEEE International Conference on Robotics and Automation (ICRA) (2013-2015), Associate Editor for IEEE Transactions on Robotics (TRO) (2012-2016), Editorial board member of Robotics, Area Chair for Robotics Science and Systems (2014, 2015), Associate Editor for ASME JMR (2018-2021) and Corresponding Co-Chair for the IEEE Technical Committee on Surgical Robotics.