The Chinese University of Hong Kong
Department of Biomedical Engineering

Optical Imaging/Sensing Meets Robotics for Precision Medicine

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Abstract

Population aging and the growing burden of chronic disease are driving demand for diagnostic and therapeutic tools that are faster, safer, and more reliable. Optical imaging and sensing are increasingly central to precision medicine because they enable minimally invasive procedures, improve diagnostic accuracy, support continuous monitoring, and reduce recovery time and risk versus conventional approaches. This talk highlights recent advances in optical imaging and sensing for microsurgery and precision diagnostics, with a focus on optical coherence tomography (OCT) and confocal microscopy. OCT provides noninvasive, high-resolution cross-sectional tissue imaging, and its integration with biomedical robotics can enhance visualization and surgical precision. In ophthalmic microsurgery, OCT-guided robotic systems deliver real-time intraoperative feedback, motion stabilization, and accurate manipulation of delicate retinal structures. The talk also presents a confocal endomicroscopy platform using a thin polyimide film, a piezoelectric tube actuator, and phase-offset Lissajous scanning. Finite element analysis and experiments were used to optimize film dimensions, enabling effective frequency separation and a wide field of view under low driving voltages. In vivo rodent gastrointestinal imaging demonstrates its potential for real-time endomicroscopy. Finally, we introduce an epidural needle integrating an optical interferometry-based fiber force sensor for force-aware guidance. Paired with a piezoelectric actuator-driven robotic insertion mechanism, the system supports controlled advancement and improved procedural safety without reliance on inconsistent loss-of-resistance methods or ionizing fluoroscopy.

Biography

Dr. Cheol Song is an Associate Professor and Vice Department Chair in the Department of Robotics and Mechatronics Engineering at Daegu Gyeongbuk Institute of Science and Technology (DGIST), Republic of Korea. He received the Ph.D. and M.S. degrees in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST), following a B.S. degree in Mechanical Engineering from Sogang University. Prior to his faculty appointment, he completed postdoctoral training at the Department of Electrical and Computer Engineering, Johns Hopkins University, and at KAIST's Information & Electronics Research Institute. His research interests span biomedical robotics, artificial intelligence endoscopy, intelligent bio-opto-mechatronics, optomechatronic biomedical devices, and mixed reality human–robot interaction. Dr. Song has published in venues including IEEE/ASME Transactions on Mechatronics, Biomedical Optics Express, and major IEEE robotics conferences (e.g., ICRA, IROS), with recent works addressing topics such as endomicroscopy scanning mechanisms, OCT-guided injection systems, and sensor-fusion interfaces for mixed/virtual reality. He is professionally affiliated with IEEE, OSA, SPIE, MICCAI, and multiple Korean academic societies in robotics and biomedical engineering.

***** ALL ARE WELCOME *****

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