The Chinese University of Hong Kong
Department of Biomedical Engineering

Computational microscopy for high-throughput, multi-dimensional biomedical imaging

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Abstract

High-resolution, high-throughput imaging of large multicellular biological structures remains a fundamental challenge in microscopy. In this talk, I will present several innovative imaging platforms developed in our laboratory that address this challenge through advanced 2.5D and 3D imaging of biological specimens. The first platform, the E2E-BPF microscope, enables large-area, high-resolution imaging without the need for serial refocusing. This strategy integrates a physics-informed, deep-learning–based design of a binary phase filter with a deconvolution neural network to generate high-resolution, high-contrast images over an extended depth range. The E2E-BPF prototype achieves a 15.5-fold increase in depth of field compared to conventional microscopes and demonstrates high-throughput performance across a wide variety of cellular and tissue samples. I will then introduce reference-free polarization-sensitive intensity diffraction tomography (PS-IDT), a technique designed to reconstruct three-dimensional anisotropy distributions in multiple-scattering specimens. By illuminating 3D anisotropic objects with circularly polarized plane waves from multiple angles, PS-IDT encodes structural information into two-dimensional intensity measurements. Using a vectorial multi-slice beam propagation model combined with gradient-based optimization, this method reconstructs detailed 3D anisotropy maps, as demonstrated with specimens including potato starch granules and tardigrades. Together, these advanced imaging platforms offer transformative potential for rapid image-based diagnostics, optical vision, and metrology, opening new avenues for discovery in biological and materials science research.

Biography

Chulmin Joo obtained S.M. and Ph.D. degrees in mechanical engineering from Massachusetts Institute of Technology, USA, in 2003 and 2008, respectively. Prior to joining Yonsei University, he worked as a lead engineer at GE Global Research, USA, involving and leading research programs for the development of various optical imaging devices. His primary research interests lie in the development and application of novel optical instrumentation and computational imaging technologies to address challenges and applications in diverse fields such as biology, medicine, optical metrology, and beyond. He strives to integrate fundamental understanding of optical imaging and computational technologies with the insights and needs from clinicians, biologists, and industry. He is a senior member of Optica (formerly Optical Society America) and has been a program committee member of Optica Imaging Systems and Applications since 2017. He served as the program and general chairs of Optica Imaging Systems and Applications (2020, 2021), and is serving an Associate Editor of Advanced Imaging and Current Optics and Photonics, and as a member of Academic Editorial Board of PLoS One.

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

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