

The Chinese University of Hong Kong Department of Biomedical Engineering



Graduate Seminar - PhD Oral Defence

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Date : 23 September 2022 (Friday)Time : 9:00 am (Hong Kong time)

Zoom Link: https://cuhk.zoom.us/j/9179080993?pwd=RDVodFBrTkdjSXIvdTJBUjY4TUIzZz09

Meeting ID : 917 908 0993

Password : 160410

Title: Development of High-speed Optical Diffraction Tomography for Label-free Cell Dynamics Tracking and Large-scale Single-cell Phenotyping

Over the past several decades, several advanced light microscopy techniques have been developed that have enabled many breakthroughs in biology and medicine. Optical diffraction tomography (ODT), as a recently developed label-free optical imaging technique, maps the three-dimensional (3D) refractive index (RI) distribution of a semi-transparent specimen. In the cells, the measured RI distribution is proportional to the concentration of organic molecules. For cutting-edge biomedical applications involving high throughput cell imaging and/or cell dynamics observation, current angle-scanning ODT methods are inapplicable as they require multiple measurements (around 50 or more) that limit their 3D imaging speed and throughput. Therefore, my thesis is focused on developing high-speed and highthroughput ODT techniques. In the first development, we invented High-speed Angle-multiplexing ODT (HSAM-ODT), which is based on implementing digital micromirror devices (DMDs) for fast illumination angle scanning and multiplexing and a high-speed camera for acquiring interferograms. HSAM-ODT achieves a 3D imaging speed of over 615 volumes/second using 13 interferograms which is over 10 times faster than current 3D imaging techniques. To further push the imaging speed, we developed Singleframe Label-free Cell Tomography (SILACT), which is based on HSAM-ODT and a trained deep neural network model to reconstruct a 3D RI map from one angle-multiplexed interferogram. SILACT has realized a full-field 3D imaging speed of over 12,500 volumes/second, and subsequently achieved an unprecedented cell imaging throughput of over 20,000 cells/second by flowing cells in microfluidics. With our high-speed ODT systems, we demonstrated several important applications, including characterizing 3D microstructures printed by two-photon photopolymerization (TPP), tracking the 3D motions of individual human sperm cells that are fast swimming, and characterizing the mechanical properties of cells. Finally, we propose to standardize image assessment in ODT by designing a set of quantitative metrics to evaluate the RI tomograms, including signal-to-noise ratio (SNR), contrast-tonoise ratio (CNR), and structure distinguishability (SD). Our metrics can be used to guide the optimization of the ODT technique for live-cell imaging experiments.