Speckle diffraction tomography for mapping nanoscale topographic features in thick tissues

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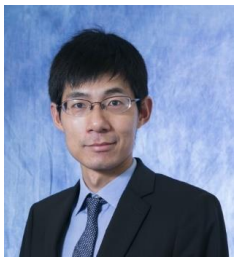
Optical diffraction tomography (ODT) has been applied to quantifying the morphological features of microscopic specimens by solving their three-dimensional (3D) refractive-index distributions. Due to its high resolution and label-free nature, ODT has recently shown promising applications in tomographic imaging of living cells and intracellular organelles. However, resolving 3D morphological features in thick specimens remains a significant challenge for ODT and label-free imaging. We report a new speckle diffraction tomography (SDT) approach that can image thick biological specimens with around 0.5 μm transverse resolution and around 1 μm axial resolution in a reflection geometry. In SDT, multiple-scattering background is rejected through spatiotemporal gating provided by dynamic speckle-field interferometry, while depth-resolved refractive index maps are reconstructed by developing a comprehensive inverse-scattering model that also considers specimen-induced aberrations. Benefiting from the high-resolution and full-field quantitative imaging capabilities of SDT, we successfully imaged red blood cells and quantified their membrane fluctuations behind a turbid medium with a thickness of 2.8 scattering mean-free paths. Most importantly, we performed volumetric imaging of cornea inside an ex vivo rat eye and quantified its optical properties, including the mapping of nanoscale topographic features of Dua's and Descemet's membranes that had not been previously visualized without dissection.



Short Bio:

Renjie Zhou is an Associate Professor of the Department of Biomedical Engineering and Assistant Dean (Research) of the Faculty of Engineering at CUHK, where he directs the Laser Metrology and Biomedicine Laboratory (LAMB). He received a PhD degree in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign in 2014 and undertook postdoctoral training at MIT before

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