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High-speed 3D Fluorescence Microscopy with Digital Adaptive Optics

Observing large-scale three-dimensional subcellular dynamics in vivo at high spatiotemporal resolution has long been a pursuit for biology. However, both the signal-to-noise ratio and resolution degradation in multicellular organisms pose great challenges. In this talk, I will discuss our recent work in in vivo aberration-free 3D fluorescence imaging at millisecond scale by scanning light-field microscopy with digital adaptive optics. Specifically, we propose scanning light-field microscopy to achieve diffraction-limited 3D synthetic aperture for incoherent conditions, which facilitates high-speed aberration correction for every pixel in post-processing. Various fast subcellular processes are observed, including mitochondrial dynamics in cultured neurons, membrane dynamics in zebrafish embryos, and calcium propagations in cardiac cells, human cerebral organoids, and Drosophila larval neurons, enabling simultaneous in vivo studies of morphological and functional dynamics in 3D.

Biography

Born in 1964, Qionghai Dai is a Professor in Tsinghua University, and the director of the Institute of Brain and Cognitive Sciences at Tsinghua University (THUIBCS). Qionghai's research centers on the interdisciplinary study of Brain Engineering and the next-generation Artificial Intelligence. He has built up various multi-scale multi-dimensional computational imaging instruments, aiming for the simultaneous multi-scale observation of dynamic structures spanning from organelles, cells, tissue, and organs. By developing advanced imaging techniques for the simultaneous recording of millions of neurons, he tries to understand the structures and mechanisms of entire neural circuits on various tasks at single-cell level, which can provide theoretical supports for next-generation neuromorphic computing algorithms (including expression, transform, and rules), as a new pathway from Brain Science to Artificial Intelligence.