HIGH-CONTRAST, SYNCHRONOUS VOLUMETRIC IMAGING WITH SELECTIVE VOLUME ILLUMINATION MICROSCOPY

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Abstracts
Light-field fluorescence microscopy uniquely provides fast, synchronous volumetric imaging by capturing an extended volume in one snapshot, without needing to acquire a series of optical sections [1-3]. However, light-field microscopy often suffers from low-contrast due to the background signal generated by its wide-field illumination strategy. Taking inspiration from Selective Plane Illumination Microscopy (SPIM; also known as light-sheet microscopy), which achieves low-background and high-contrast imaging by illuminating only the optical plane of interest, we reasoned that we could enhance the contrast of light-field microscopy by illuminating only the volume of interest. We thus created light-field-based Selective Volume Illumination Microscopy (SVIM), where illumination is confined to only the region of interest, removing the background generated from the extraneous sample volume. SVIM reduces background, increases contrast, enhances the effective resolution, and produces an overall higher-quality reconstruction of the sample, while preserving the synchronous volumetric imaging capability of light-field microscopy. We demonstrate the capabilities of SVIM by capturing cellular-resolution 3D movies of flowing bacteria in seawater as they colonize their squid symbiotic partner, as well as of the beating heart and brain-wide neural activity in larval zebrafish. These applications demonstrate the breadth of imaging applications that we envision SVIM will enable, in capturing tissue-scale 3D dynamic biological systems at single-cell resolution, with high contrast and fast volumetric rates (up to camera-limited rate of ~ 100 volumes s^{-1} or more), to reveal the underlying biology.

References:
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