3D FOURIER PTYCHOGRAPHY IN SCATTERING MEDIA

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Abstract:
Objects embedded in scattering media are difficult to image due to aberrations introduced by the sample. Imaging these samples in 3D is even more challenging, since 3D methods often rely on focusing a beam within the aberrating media, as in confocal microscopy, or require a weakly scattering object, as in diffraction tomography. We show that these limitations can be overcome in biological tissue phantoms by using 3D Fourier ptychographic microscopy (FPM) with a forward model that includes multiple scattering. FPM uses illumination coding to reconstruct high resolution images across a wide field of view using a low-NA objective lens [1]. FPM has been extended to 3D using a multi-slice model, which accounts for forward multiple scattering inside the object [2]. In 3D FPM, illumination angle calibration is critical to image quality, so we calibrate our angles of illumination directly from the captured data using an image processing algorithm [3] to account for distortions by scattering media.

We present 3D refractive index reconstructions of a human brain capillary model [4]. In this model, human cells are co-cultured on an agarose lumen to form a human-like capillary. The lumens range from $127 - 500\ \mu m$ in diameter and are embedded within a 5 x 5 x 10 mm block of agarose. Given the rough surface of the agarose and the thickness of the media, it is difficult to obtain decent 3D images of this object using conventional methods, such as confocal microscopy. Preliminary experiments show our capability to image these objects with a test lumen of diameter $127\ \mu m$ filled with $9 - 13\ \mu m$ diameter beads and agarose gel with $0.5\ \mu m$ lateral resolution and $8.1\ \mu m$ axial resolution.

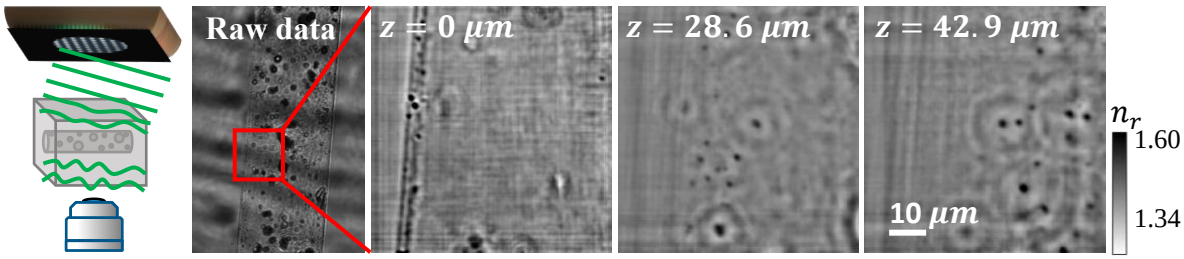

Figure 1: Reconstructed refractive index of a bead-filled lumen embedded in agarose.

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