Aberration Correction for 3D Phase Microscopy

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Abstract:

Intensity-only optical diffraction tomography (I-ODT) enables reconstruction of 3D refractive index distributions of biological samples from non-interferometric images captured with varying illumination angles [1,2]. Unfortunately, large numerical-aperture microscope objectives contain significant optical aberrations that can create severe image artifacts, preventing high-resolution 3D refractive-index I-ODT reconstructions. Here, we improve the inverse algorithm in [2] to model the optical aberration in the image formation process using a single pupil function parameterized by Zernike polynomials, while keeping the experimental setup the same. We then develop a joint estimation scheme to update both the pupil function and 3D refractive index distribution simultaneously. In Fig. 1, we show significant improvement in 3D resolution after more accurately modelling the imaging process. With a numerical aperture of 1.45, we report the highest resolution ever achieved in I-ODT, moving closer toward isotropic resolution in all three dimensions.

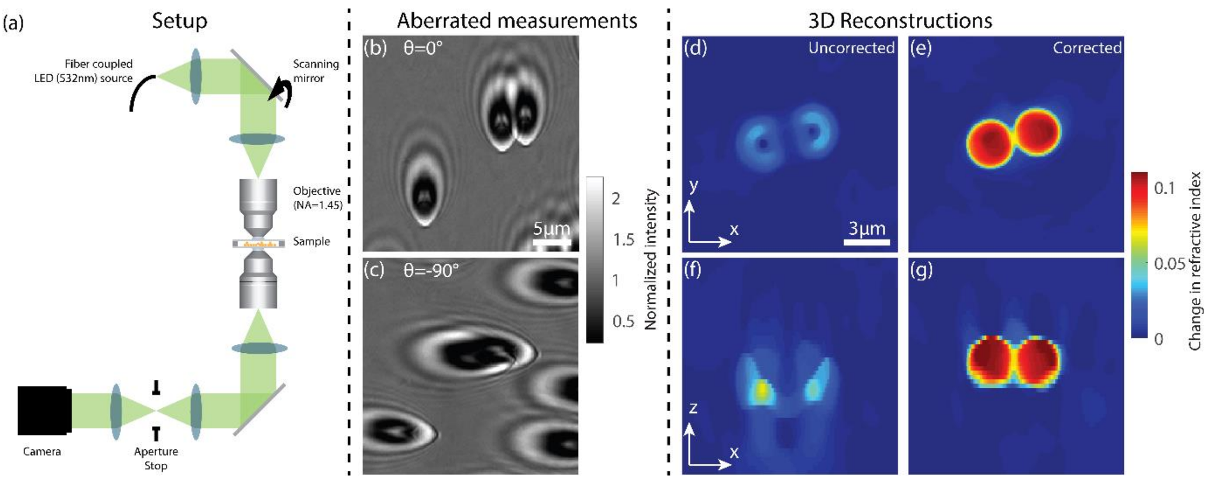

Figure 1: (a) Experimental setup of the 3D phase contrast microscope, with an objective NA of 1.45. (b)-(c) shows aberrated measurements under oblique plane wave illuminations on 3μm polystyrene microspheres. (d)-(g) Lateral and axial cross sections of cross sections without and with proposed aberration correction.

References:

[1] A Matlock, L Tian Biomedical Optics Express 10 (12), 6432-6448
[2] S Chowdhury, M Chen, R Eckert, D Ren, F Wu, N Repina, L Waller Optica 6 (9), 1211-1219