MULTI-CONJUGATE ADAPTIVE OPTICS FOR BIOMEDICAL MICROSCOPY

Jiahe Cui[1], Karen Hampson[1], Matthew Wincott[1], Richard Lane[1], Syed Hussain[1], Kaustubh Banerjee[2], Pouya Rajaeipour[2], Hans Zappe[2], Çağlar Ataman[2], Martin Booth[1]
[1]Department of Engineering Science, University of Oxford, UK
[2]Department of Microsystems Engineering, Freiburg University, Germany
Email: jiahe.cui@eng.ox.ac.uk

KEY WORDS: Multi-conjugate, adaptive optics, confocal microscopy.

Adaptive optics (AO) in microscopy is usually performed by placing a corrective device, usually a deformable mirror (DM) or a spatial light modulator, in a conjugate pupil plane to correct for phase aberrations. This can be referred to as pupil AO. This approach proves effective when the aberrations are spatially invariant, thus the same pattern of correction can be applied to all points within a certain field of view (FOV). However, it has been demonstrated both theoretically and experimentally that limitations occur with field dependent aberrations over an extended FOV [1]. A better solution would be to place the corrective device at a plane conjugate to that where aberrations are most dominant, namely conjugate AO [2, 3], or better still, to use dual or multiple corrective devices for correcting different layers, ultimately leading to multi-conjugate AO (MCAO).

Here we present a multi-conjugate adaptive optics system for field dependent aberration correction using a sensor-based optimisation method in a confocal microscope. A custom Shack-Hartmann wavefront sensor (SHWS) is incorporated consisting of an EMCCD and a 400-segment lenslet array. A 140-actuator electrostatic membrane DM is used in a conjugate pupil plane, with a custom 37-actuator electrostatic transmissive programmable phase plate placed conjugate to the sample. The whole FOV is split into 5 sections in a "+" formation, and 2 sections are used for demonstration. Results from our system suggest that it is experimentally feasible for MCAO to improve the image quality in biomedical imaging.

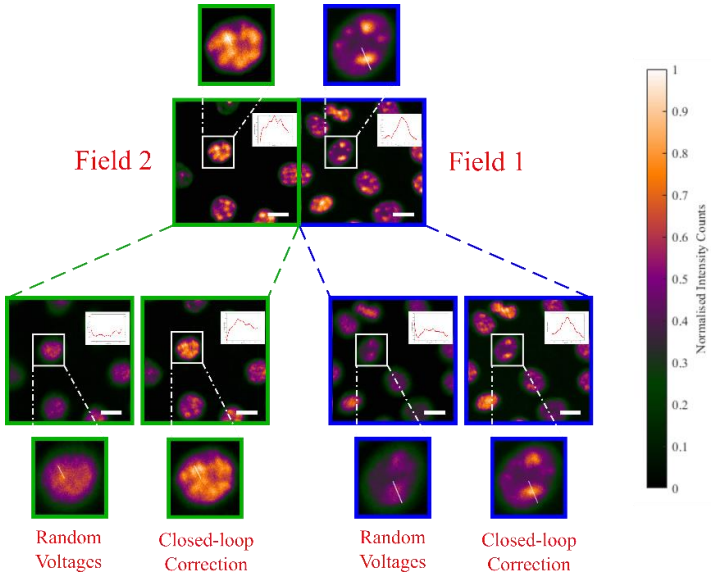

Figure 1: MCAO correction using HeLa cells labelled with Alexa Fluor 594. Scale bar:20 μm.

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