Adaptive Optics for Biological Light Microscopy at Durham

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Background

In this talk we give an overview of the adaptive optics (AO) platform developed at Durham for bringing both closed loop and 'sensor-less' optimization based techniques to biological microscopy. The use of AO can deliver a wide range of benefits to microscopy, from auto-tuning system alignment on a regular basis to correcting for sample induced aberrations. Of particular interest is the use of AO as an enabling technology when transforming various non-linear and sub-diffraction microscope technologies into beam scanning instruments.

Sensor-less Optimization Techniques

Sensor-less optimization based techniques use a time sequential approach to eliminating aberration by exploring the effect on image quality of a range of corrective wavefronts. This approach represents the simplest optical design, a useful consideration when integrating into a facility class instruments. We present an example of results obtained using image-based optimization on a commercial beam scanning confocal microscope. When using AO with fluorescence microscopy it is essential to minimize the level of fluorescence illumination used, as the fluorescence process causes irreversible damage to biological samples. We will present our investigations into various methodologies to reduce the use of fluorescence during optimization, such as guided searches and brightfield based image optimization.

Closed Loop Adaptive Optics

Closed loop AO uses a wavefront sensor to determine spatial information about wavefront aberration allowing much faster correction than optimization-based approaches. However, the reliable generation of guide stars within arbitrary samples presents a series of challenges compared to astronomical adaptive optics. We will discuss our progress in this area.