A UNIVERSAL FRAMEWORK FOR MICROSCOPE ADAPTIVE OPTICS

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Adaptive optics (AO), has been introduced into microscopes in order to overcome the problems caused by specimen-induced wavefront aberrations, restoring image quality. This is particularly important when focusing deep into tissue where the cumulative effect of focusing through the refractive index structure of the specimen causes significant wavefront distortion. Adaptive optics has been demonstrated in a range of microscope modalities including conventional widefield microscopes as well as laser scanning systems with various applications in biomedical imaging and other areas [1]. Adaptive microscopy has most recently been developed for super-resolution microscopes – or nanoscopes – which enable resolutions smaller than the diffraction limit of light. A range of recent advances in this field are now benefitting applications in cell biology, neuroscience and other areas [2].

Despite these numerous technological advances, AO is still seen as a challenge in microscopy and is still confined to relatively ambitious research projects. However, it has the potential to become more commonplace, if the technology can be made more accessible.

One problem is that current advances are being made through development of bespoke AO solutions to individual imaging tasks. However, the diversity of microscopy methods means that individual solutions are often not translatable to other systems. For example, a method developed for two-photon microscopy will not necessarily be useable in a wide-field microscope.

We are therefore creating theoretical and practical frameworks that tie together AO concepts and provide a suite of scientific tools with broad application. In this presentation, we will describe these advances and the tools that have been developed for wider use. These tools include universal, adaptable schemes for image-based sensorless adaptive optics that have broad application across different microscopy modalities. Further developments include operating protocols, hardware designs and software algorithms that will support next generation AO microscope systems.

Dissemination of these tools will equip researchers in many areas to adopt AO technology to improve the capabilities of optical microscopes, particularly for biomedical applications [3].

[1] M. J. Booth, “Adaptive optical microscopy: the ongoing quest for the perfect image”, Light Science Applications, **3**, e165 (2014).

[2] N. Ji, "Adaptive optical fluorescence microscopy", Nature Methods **14**, 372-380 (2017).

[3] https://aomicroscopy.org/