REMOTE-FOCUSSING FOR VOLUMETRIC IMAGING IN A CONTACTLESS AND LABEL-FREE NEUROSURGICAL MICROSCOPE

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Visual guidance at the cellular level during neurosurgical procedures is essential for enabling maximal tumour resection with minimal damage to adjacent brain tissue. However, most conventional surgical microscopes are not optimised for visualisation of individual cells. Modern endoscopic probes provide high spatial resolution, but the need for direct tissue contact makes it susceptible to erythrocyte contamination [1]. Label-free imaging is highly desirable to eliminate complexities from fluorophore uptake and toxicity, injection timings, dose constraints, etc. Meanwhile, direct perception of depth information is important for understanding complex relationships of neuroanatomical structures in the peripheral environment [2]. There are many ways to achieve volumetric imaging. Remote-focussing (RF) using a dynamic device, such as a deformable mirror (DM), is one of these methods that can permit fast, inertia-free axial refocussing by reshaping of the DM membrane [3].

Here we present our developments upon a compact and contactless reflectance confocal neurosurgical microscope [4] by integrating a DM and a custom Shack-Hartmann wavefront sensor (SHWS). A lateral resolution of <1.2 μm and axial resolution of <5.8 μm was maintained from our previous work, as well as an effective working distance of 20 mm for non-invasive imaging. Calibration of the DM actuator voltages required for RF at different depths was enabled by a closed-loop sensor-based adaptive optics scheme. Axial refocussing via the deformable mirror was achieved for a 150 μm depth range without noticeable decrease in image quality. Wavefront analysis was performed and RF was demonstrated for volumetric stacks 90 μm deep in frozen mouse calvaria (Fig.1).

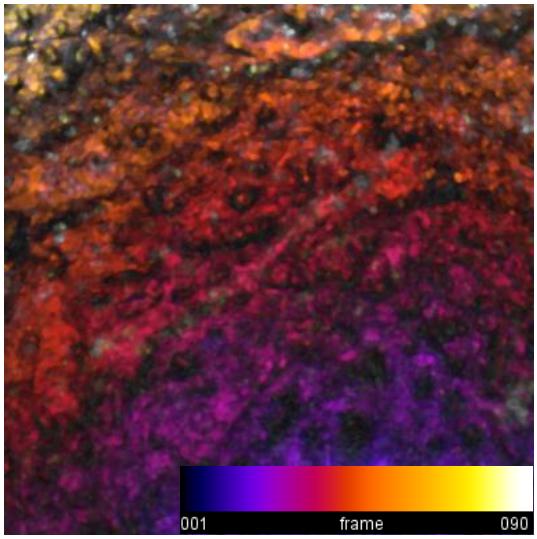

Fig.1. Full colour projection for 90-μm deep RF stack images in frozen mouse calvaria.

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