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Seeing anywhere in the brain through 100mm thin glass fibre

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Light-based in-vivo brain imaging relies on the transportation of light through highly scattering tissues over long distances. As scattering gradually reduces imaging contrast and resolution, it becomes challenging to visualize structures at greater depths, even when using multiphoton techniques. To overcome this limitation, minimally invasive endo-microscopy techniques have been developed that typically use graded-index rod lenses. However, a recently proposed alternative involves the exploitation of holographic control of light transport through multimode optical fibres [1], which promises superior imaging performance with less traumatic application [2]. Following the review of the fundamental and technological bases, the talk will introduce a 110 μm thin laser-scanning endo-microscope, which enables volumetric imaging of the entire depth of the mouse brain in vivo [3]. The system is equipped with multi-wavelength detection and three-dimensional random-access options, and it has a lateral resolution of less than 1 μm. Various modes of its application will be presented including the observations of fluorescently labelled neurons, their processes, and blood vessels. Finally, the use of the instrument for monitoring calcium signalling and measurements of blood flow in individual vessels at high speeds will be discussed.

References

[1] T. Čižmár, and K. Dholakia. "Exploiting multimode waveguides for pure fibre-based imaging." Nature communications 3.1 (2012): 1027.
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[3] M. Stibůrek, et al., 110μm thin endo-microscope for deep-brain in-vivo observations of neuronal connectivity, activity and blood flow dynamics. Nature Communications, (in print, 2023).