Ultrathin Endoscopy Probe for Simultaneous Photoacoustic and Fluorescence Microscopy

Tianrui Zhao, Sebastien Ourselin, Tom Vercauteren, and Wenfeng Xia
School of Biomedical Engineering and Imaging Sciences, King's College London
4th Floor, Lambeth Wing St Thomas' Hospital, London SE1 7EH, United Kingdom

Abstract—

Background, Motivation and Objective: Photoacoustic imaging (PAI) is an emerging biomedical imaging modality capable of distinguishing spectroscopic signatures of tissues by encoding rich optical contrast into ultrasound signals. It promises to be applicable in many preclinical and clinical applications [1, 2]. In the past decade, various minimally invasive photoacoustic imaging systems have been studied to extend PAI applications to examining deep internal tissues [3]. While more attention was paid to the development of side-viewing photoacoustic endoscopes, forward-viewing photoacoustic probes, which are more suitable for some surgical and interventional applications, were relatively less exploited [3].

Statement of Contribution/Methods: In this work, we developed a highly miniaturized, high-speed, duel-modal photoacoustic and fluorescence probe based on a multimode optical fibre. The light transmission through the fibre was characterized with a high-speed RVITM algorithm [4] using a digital micromirrors device (DMD). After characterization, raster-scanning a focused light beam over the distal end of the fibre was performed for high-speed microscopic imaging using the DMD. The same ns-pulsed light source was used for both photoacoustic and fluorescence signal excitation. A focused ultrasound transducer was employed to detect photoacoustic signals, and the excited fluorescence light was collected by the same optical fibre and received by a photodetector. Both the photoacoustic and fluorescence signals were then digitized and transferred to a PC for processing and display.

Results/Discussion: Figure 1 shows imaging results from a phantom comprising a carbon fibre and fluorescence beads. The size of the optical focus through the multimode fibre was measured to be ∼1.5 μm and led to a spatial resolution of ∼1.7 μm. With the DMD running at 23 kHz, it took ∼1.7 s for the acquisition of each image frame with 40000 pixels. In the future, an all-optical forward-viewing probe will be developed with ultrasound detection via a fibre-optic Fabry-Perot ultrasound sensor. The potential of this ultra-thin probe for guiding minimally invasive procedures will be exploited.

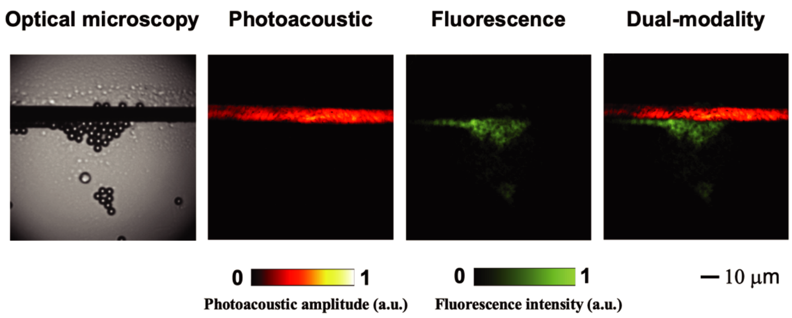

Figure 1: Photoacoustic and fluorescence imaging of a phantom comprising carbon fibre and fluorescenec beads. Scale bar: 10 μm.

REFERENCES

1. Beard, P., *Interface Focus*, Vol. 1, No. 4, 602–631, 2011.
2. Wang, L. V. and Song Hu, *Science*, Vol. 335, No. 6075, 1458–1462, 2012.
3. Zhao, T., et al., *Photoacoustics*, Vol. 16, 100146, 2019.
4. Zhao, T., et al., *Optics Letters*, Vol. 46, No. 5, 1165–1168, 2021.