Full-field optical coherence tomography through digital holography

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Optical coherence tomography (OCT) enables the measurement of the structural information of diffuse samples such as tissue in a non-invasive and label-free way, by retrieving a depth-resolved signal from the back-scattered part of the excitation light. In its original implementation, classically denoted as time-domain OCT, a three-dimensional scanning is required to retrieve an x-y image of the signal emitted by the back-scatterers at a certain depth z, with the signal being extracted from the interference pattern in depth.

Several approaches were developed to reduce the scanning requirements and improve the acquisition speed. On one hand, Fourier-domain OCT enables the recording of the whole depth information through the recording of a spectrally-resolved interferogram [2]. In parallel, full-field temporal OCT has been proposed, where the detector is replaced by a 2D camera, enabling the acquisition of the tomogram directly through a scan in depth by recording the interference patterns in parallel [1]. This approach reduces the scanning requirement to one dimension, but at the cost of a more complex setup. Furthermore, it also still requires a fine (sub-wavelength) scanning in depth, which potentially prevents high-speed imaging. On the other hand, the full-field illumination makes it more suitable for recording from deep sections by avoiding tight focus in the excitation.

We present early results of a full-field OCT implementation where the signal retrieval is based on off-axis holography. The scanning speed can be significantly improved due to the ability of recovering both amplitude and phase from the spatially-modulated interferogram. Furthermore, this approach enables rapid monitoring at a chosen depth without any scanning, and the acquisition of the complex field makes it possible to employ numerical methods to improve the signal quality, such as through digital refocusing [3], or by compensating for optical aberrations.

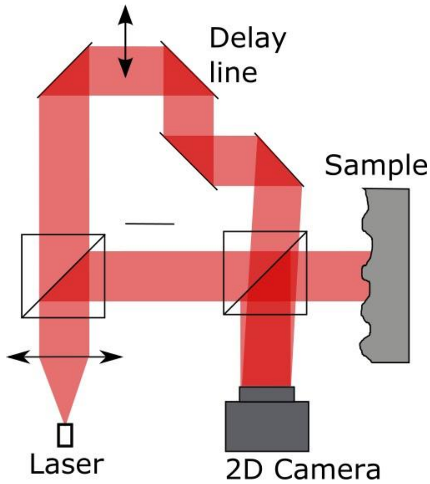

Figure 1. Optical schematic of the measurement principle of OCT with off-axis recording.

Acknowledgements The authors acknowledge support from the Photonics Center, Osaka University, under the ACORE program, MEXT Photonics Advanced Research Center Program, the World Premier International Research Center Initiative Funding Program and from the Grant-in Aid for Scientific Research (no #15K17473).

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