Pilnojo lauko optinė koherentinė tomografija ir jos taikymai

Full-field optical coherence tomography and its applications

Egidijus Auksorius
Institut Langevin, ESPCI ParisTech, PSL Research University, CNRS UMR 7587, 1 rue Jussieu, 75005 Paris, France
egidijus.auksorius@espci.fr

Optical coherence tomography (OCT) has become an established tool in biomedical imaging. Standard OCT is a fast point-scanning interferometric technique capable of *in vivo* visualization of tissue architecture. Detection can be parallelized by employing a camera and an imaging Michelson/Linnik interferometer to enable fast *en face* image acquisition deep in tissue. Furthermore, utilization of an inexpensive and spatially incoherent light source, such as an LED, can eliminate the cross-talk between pixels in the image. This technique, known as "full-field optical coherence tomography" (FF-OCT), is cost-effective, simple and achieves quick *en face* imaging that is challenging with a standard scanning OCT systems. FF-OCT is useful in a range of applications that require high resolution and/or *en face* imaging. For example, thanks to its high isotropic resolution (< 1 μm in 3D), it can be used in applications that normally require the preparation of histology slides, such as in studying the enteric nervous system [1], for example. On the other hand, spatial resolution can be traded-off for a larger field-of-view (>1 cm^2) that is necessary in, for example, subsurface fingerprint imaging [2].

Images of subsurface fingerprints are of great interest in biometrics since they can contain more details than the surface fingerprints and, most importantly, be largely free of imaging artifacts caused by damage, moisture or dirt on the surface. Thanks to the recent appearance of silicon cameras with high frame rate (~1 kHz) and high full well capacity (2 Me^-), specifically designed for FF-OCT, a sensor can be built that is capable of detecting tissue reflectivity that is smaller than 10^{-10} in just 0.1 s [3]. Such FF-OCT sensor allowed acquisition of high quality subsurface fingerprints, and subsequently, identification of individuals with high accuracy (with the equal error rate < 1 %) from a single finger [3]. Fig. 1 shows an example of such a subsurface fingerprint that contains sweat ducts and a fingerprint pattern from which a person can be identified.

Dark-field detection can be implemented in the FF-OCT configuration [4] to increase the sensor's performance in terms of the signal-to-noise ration (SNR) or acquisition time. Dark-field detection can reject spurious signal, such as specular reflections from a sample and other optical elements, that effectively allows a more efficient use of camera's detection bandwidth. Since some of the genuine signal is also rejected in the process, a brighter light source or a configuration that utilizes the limited light budget more efficiently is needed. A particular configuration that involves an asymmetric interferometer with a 10:90 beamsplitter allows theoretical near ×4 increase in the detected signal. Another way to increase SNR is to use a light sources with a longer coherence length (>100 μm), such as a VCSEL array, which effectively integrates the signal from a thicker tissue slice.

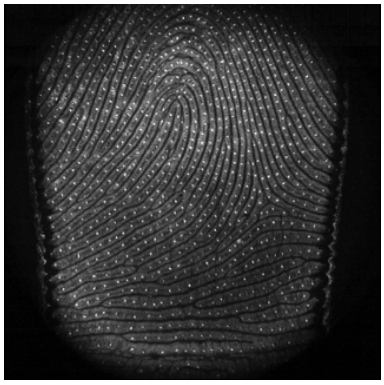

Fig. 1 Fingerprint as imaged with FF-OCT 100 to 200 μm below the finger surface. The white dots are sweat ducts and the black lines correspond to valleys of the surface fingerprint

The developed instrument could be used in a number of other *en face* deep-tissue imaging applications thanks to its high sensitivity and speed. Naturally, it could be used for imaging various skin conditions, such as cancer and other dermatological diseases. We are currently also using it for passive elastography experiments that can map the stiffness of biological tissues.

Keywords: Optical coherence tomography, Medical and biological imaging, Biophotonics, Fingerprints.

References

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