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Optical Coherence Tomography and Scanning Laser Ophthalmoscopy: approaches to dual-channel retinal tissue imaging

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Abstract: We report a Talbot bands-based optical coherence tomography (OCT) system capable of producing longitudinal B-scan OCT images and *en-face* scanning laser ophthalmoscopy (SLO) images of the human retina *in-vivo*, with various degrees of simultaneity.

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Due to a higher sensitivity and speed than their time domain (TD) counterpart, spectral domain (SD) methods dominate the OCT technology of eye imaging [1]. The SD-OCT methods produce fast A-scans, which are used to create real time cross-section (B-scan) images.

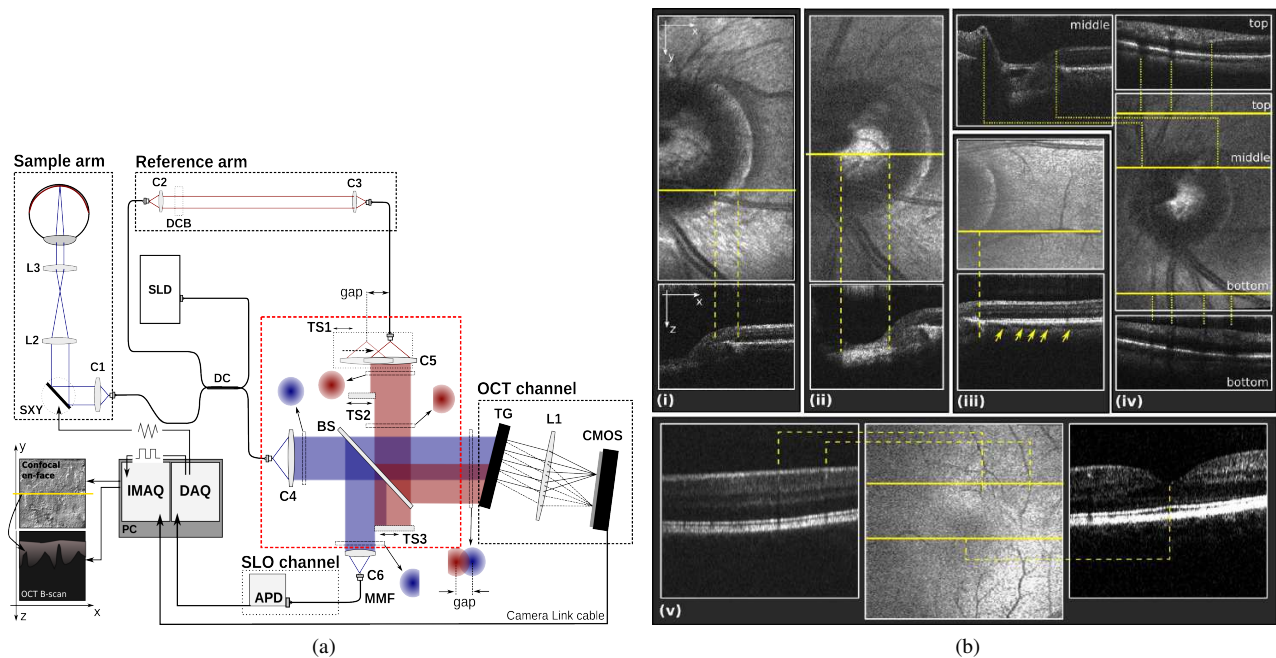


Fig. 1: (a) Schematic representation of the set-up devised, and (b) some of the results obtained with it: images of the retina of a volunteer taken from the two channels, yielding an *en-face* SLO image (top) and a B-scan OCT image (bottom), with a correspondence of features between the two being emphasized.

For several reasons, an *en-face* image is also required when imaging the retina in the human eye. These reasons may include the guidance of the OCT examination, or even the correction of motion artifacts created by imaging *in-vivo*

tissues with a low degree of fixation. SD-OCT methods allow the creation of such images, however when scanning over the two orthogonal directions it is inevitable to obtain a full volumetric image, which will have to be post-processed, the image being then displayed static to the user.

Several other techniques are available to generate an *en-face* image without resorting to a SD-OCT based method, which show the interest for presenting such images alongside the SD-OCT investigation delivering B-scans, with a good pixel-to-pixel correspondence between the two frames.

Our method [2] involves a SD-OCT system (schematically described in Fig. 1a) whose spectrometer system has been modified to take advantage of Talbot bands [3]: the degree of overlapping between the two beams returning from the interferometer on their way to the diffractive medium can be controlled and employed to shift the SD-OCT sensitivity profile maximum away from the interferometer's alignment point. This implementation involves a beam-splitter *BS* to couple the two beams, and by placing a specially-devised filter over the beam path that would not otherwise be used, one is capable of spatially separate the two components, therefore isolating the optical power returning from the sample and directing it to a highly-sensitive detector, forming a confocal image which is acquired in tandem and with the same interface optics as the OCT image. Given that the system in question is used to image human retinal tissue, the confocal channel will yield images similar to the ones produced by a scanning laser ophthalmoscope (SLO). The two frames are then acquired: an *en-face* SLO image and a depth profile (B-scan OCT), whose lateral position can be controlled by means of a cursor overlaid on the SLO frame.

With adequate acquisition and control systems in place, it is then possible to acquire these two frames with varying degrees of simultaneity and pixel-to-pixel correspondence. The constraints present are purely related to the speeds of acquisition and scanning provided by current technology: the fastest CMOS camera in near-IR available is capable of performing up to 312,500 spectral reads per second [4] and current galvo-scanner technology (preferred over faster scanning techniques, such as resonant scanners, to implement some of the operating modes described in [2]) cannot exceed a scanning rate of 1 kHz. One is capable of true simultaneity in terms of image acquisition *and* refresh if the transversal range is sacrificed; conversely, if larger transversal ranges are desired the two channels will have to be read sequentially.

Figure 1b features some of the results obtained with the system described. In all pairs of frames the retina from the same volunteer is being imaged in different regions, with varying lateral sizes (from 2.6 to 5 mm). The Talbot bands allow for an improvement of the OCT channel sensitivity at larger depths (measured up to 6 dB), thus reducing the occurrence of mirror terms by reducing the need to place the sample very close to the alignment point of the interferometer.

With this method it is then possible to achieve simultaneous imaging of the two channels within the hardware-related constraints. This will allow the clinician to have more information when performing an investigative analysis, as one can guide the OCT-based depth profiling using a "bird's eye" view provided by the SLO imagery.

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