Design of a system for anterior and posterior segment imaging based on swept-source optical coherence tomography integrated into an instrument for autonomous evaluation of the visual function

A. Rodríguez-Aramendía[1,2], F. Díaz-Doutón[2], J. Pujol[2,3], J.L. Güell[1], I. Grulkowski[4]

1) Instituto de Microcirugía Ocular (IMO). Barcelona
2) Centro de Desarrollo de Sensores, Instrumentación y Sistemas (CD6), Universitat Politècnica de Catalunya. Terrassa, Barcelona.
3) Davalor Research Center (dRC), Universitat Politècnica de Catalunya. Terrassa, Barcelona.
4) Nicolaus Copernicus University. Torun, Poland.

Abstract: In this work we present the design of a swept-source optical coherence tomography (SS-OCT) system optimized for both anterior and posterior segment imaging and such that can be integrated into an instrument for autonomous evaluation of the visual function, developed by our group in previous works. We envision the combined system to provide a complete examination of the patient's visual system, joining both functional and morphological information.

Optical coherence tomography technique has proved to be a powerful tool in ophthalmology, providing very detailed visualization of the ocular morphology with high axial resolution and penetration depth. In this work we present the design of a SS-OCT system that can be used for both anterior segment and retinal imaging. Additionally the design of the system is able to be integrated with an instrument previously developed by our group that performs an objective, automatized, comprehensive assessment of the visual function of a patient while he/she is interacting with a 3D virtual reality environment.

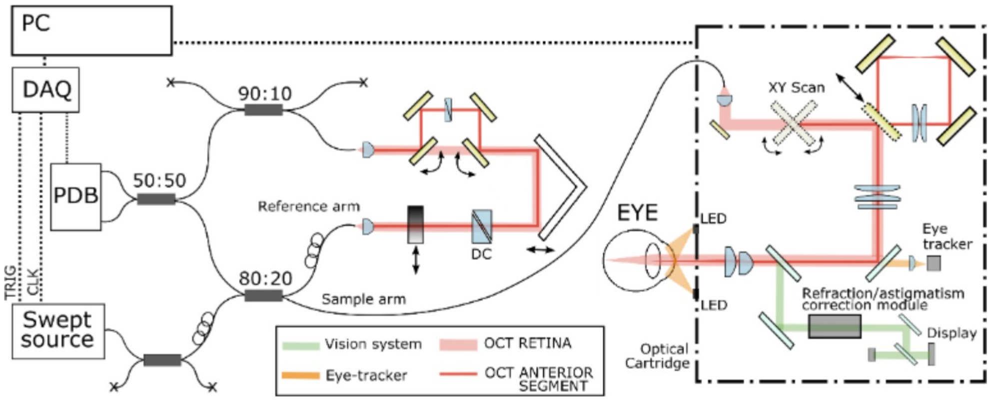

Figure 1- Scheme of the design of the SS-OCT for both anterior segment and retinal imaging integrated into the instrument that performs the autonomous evaluation of the visual function.

The designed optical module features a multichannel configuration: the compact SS-OCT system (working at 1050 nm), an eye-tracker system (working at 900 nm) and a vision channel (working in the visible range), thanks to which the patient can visualize the abovementioned 3D scenes while his/her eye movements are monitored. The SS-OCT utilizes a short cavity swept laser with a 100 nm wide spectrum centered at 1050 nm, a 50 kHz sweep rate and a 16 mm coherence length. The all-in-fiber interferometer permits the formation of the spectral interferogram between both sample and reference arm, which is further digitized at a rate of 1 GS/s. These arms have been developed using a dual-path dual-focus configuration [1] [2] such that it is possible to switch fast and reliably from anterior to posterior segment imaging. In the anterior segment modality, the design looks towards a longer depth of focus, so that an axial image depth range of 15 mm is achieved and an area of 13 mm x 13 mm can be scanned with a lateral resolution of 43 µm. In the retinal imaging modality the lateral resolution is 10 µm within a scan area of 6 mm x 6 mm. The axial resolution of the system is about 8 µm. The high speed performance of the system allows for investigation of dynamic ocular processes, making it a very complete tool that, once implemented, will be tested on healthy and pathological eyes.

References

[1] Nankivil, D., Waterman, G., LaRocca, F., Keller, B., Kuo, A., Izatt, J. A. "Handheld, rapidly switchable, anterior/posterior segment swept source optical coherence tomography probe", Biomed. Opt. Express 6(11) 4516 (2015).
[2] Grulkowski, I., Manzanera, S., Cwiklinski, L., Sobczuk, F., Karnowski, K., & Artal, P. "Swept source optical coherence tomography and tunable lens technology for comprehensive imaging and biometry of the whole eye", Optica 5 52 (2018).