Eye and Heart Synchronisation: Development of Time-Resolved Optical Coherence Tomography with Electrocardiographic Coupling

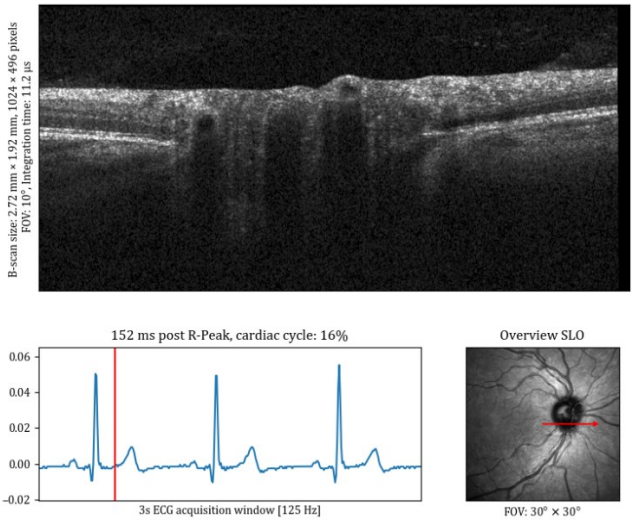

Figure 1: Time-resolved optical coherence tomography (OCT) with synchronised retinal and electrocardiographic data acquisition. (Image: P. Valmaggia).

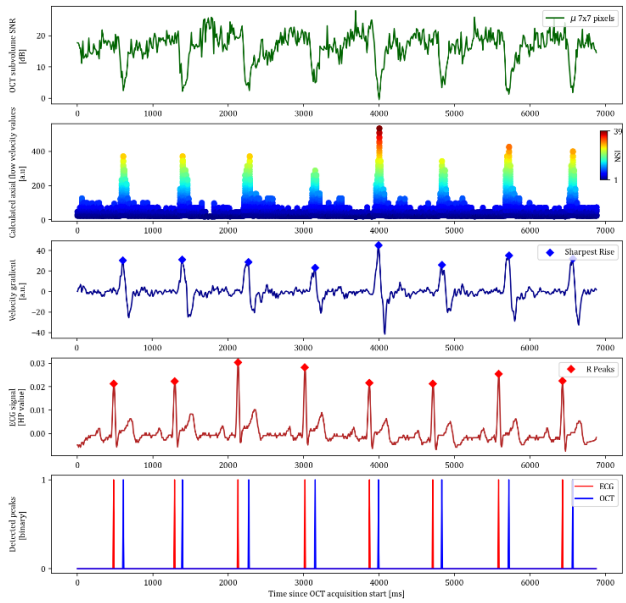

Figure 2: Heart-retina time analysis based on electrocardiographic R-peaks and pulse arrival calculated by the retinal blood flow profiles (Image: P. Valmaggia).

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Optical coherence tomography (OCT) is a non-invasive imaging technique that can provide depth-resolved images of the retina with a micrometre resolution. In clinical settings, the images are static, which does not allow for the visualisation of changes over time.

To overcome this, we developed methods to generate time-resolved OCT images, enabling the visualisation of blood flow dynamics in the eye. We estimated retinal blood flow profiles based on quantitative fringe washout analysis, allowing us to analyse the intravascular blood flow dynamics in vessels close to the optic nerve head. Additionally, we built a coupler to synchronously acquire OCT and electrocardiogram (ECG) data. This approach enabled the calculation of the blood flow propagation from the heart toward the eye. This time is presented as the heart-retina time (HRT) and proposed as a potential biomarker for cardiovascular health. Using classical computer vision techniques and deep learning algorithms, this research further aimed to automate the segmentation of blood vessels and pigmented choroidal lesions, previously unexplored entities of automation in OCT data.

Overall, this research has explored novel dynamic, quantitative, and automated analyses of OCT data. We introduced methods to visualise retinal blood flow dynamics, to calculate the heart-retina time and to segment retinal structures and tumours automatically.

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References:

[1] Valmaggia P, et al. Feasibility of Automated Segmentation of Pigmented Choroidal Lesions in OCT Data With Deep Learning. *TVST* 2022.

[2] Valmaggia P, et al. Time-Resolved Dynamic Optical Coherence Tomography for Retinal Blood Flow Analysis. *IOVS* 2024.

[3] Valmaggia P, et al. Heart-retina time analysis using electrocardiogram-coupled time-resolved dynamic optical coherence tomography. *medRxiv*. 2024 (Manuscript under review)