Quantifying Myopic Changes with OCT

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Deeper insight into dynamic changes of retinal and ocular microstructures during natural eye growth can support the development of new preventive treatments for myopia. In the scope of this thesis, a commercial optical coherence tomography system (OCT) was extended with second wavelength band at 1075nm which allows for detailed imaging of layers beneath the retinal pigment epithelium (RPE) such as the choroid (CH) and the sclera.

Motivation

Myopia is a long known but wide-spread disorder characterized by an imbalance of optical power and axial eye length. Causes are found in genetic predisposition and altered behavior, such as increased near-work. Optical coherence tomography, with its ability to acquire fast, in vivo retinal cross-sectional images, is an almost ideal detection method to characterize dynamic ocular changes.

Method

To benefit from the sophisticated eye-tracking device of the commercial system, synchronized frame acquisition has been implemented. In corporation with the manufacturer (Heidelberg Engineering) hard- and software synchronization between the individual components was developed. Real-time protocol communication allows for scan parameter and mode exchange. For patient specific correction of axial blur, a dispersion finder has been implemented for high speed processing on a GPU (graphic processing unit). It evaluates an entropy based sharpness measure on a region of interest and uses grid search to optimize dispersion.

Multi-frame averaging is used to increase signal to noise ratio (SNR) in the OCT-scans. This requires precise correction of motion distortion between consecutive frames. An intensity-based registration frame-work has been implemented to correct for similarity- and affine motion models. The optimization is based on a variation of a steepest descent method combined with an image pyramid for multi-resolution registration. An additional phase correlation based initialization is used to further reduce failure rate.

Results

System synchronization has been shown on several patient examinations and reduces handling complexity which allows to use the system for extensive clinical trials. Evaluation of the registration method by different sharpness measures (entropy, image acutance) showed good performance for similarity models. Registration quality is underlined by the high resolution of the averaged scan in Fig. 1. a) with dispersion corrected for up to the 6th order. The indicated region of interest is shown without correction of the dispersive spreading in b) and for correction up to 6th order in c). Increasing dispersion order (e.g. from 2 to 6) showed better separation of adjacent peaks (e.g. Bruch's membrane (BM) and choriocapillaris (CC) from the retinal pigment epithelium (RPE)). Registration for a 1024×500 pixel frame computes in 0.5s on a standard machine (CPU-i5-2400).

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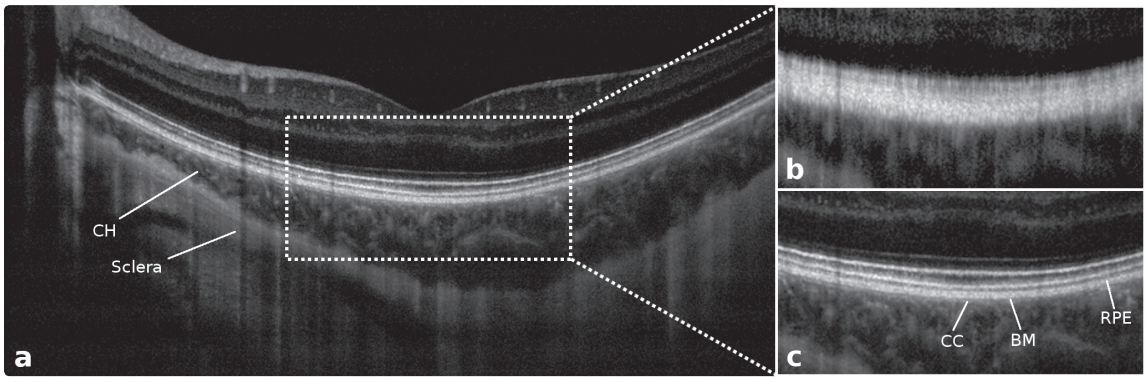

Fig. 1: 1075nm OCT-scan with synchronized acquisition, dispersion finder and image averaging (100 frames).