Statistical Retinal OCT Appearance Models

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Purpose

To generate a noise and motion artifact free synthetic Optical Coherence Tomography (OCT) data set as a standardized ground truth against which image processing algorithms can be tested and validated.

Methods

More than 20.000 OCT scans of over 1000 patients retrieved from the Vienna Reading Center (VRC) database were used as a basis for the generation of the synthetic data set. The scans were grouped by vendor (Spectralis OCT, Heidelberg Engineering and Cirrus HD-OCT, Carl Zeiss Meditec) and for each scan the internal limiting membrane (ILM) and retinal pigment epithelium (RPE) segmentation of the device specific software where extracted. The thickness profile (i.e. distance between ILM and RPE) was calculated and regions with missing or implausible thickness values were excluded automatically. After estimating the foveal position, the polar coordinates relative to the macular center were calculated for each A-scan. By grouping spatially close A-scans with same thickness values, an appearance model for each position and thickness was estimated (Fig. 2). A mathematical model of the thickness map was constructed (Fig. 1) and used to select corresponding A-scans out of the appearance model. The A-scans of the final synthetic volume were interpolated using a weighted circular neighborhood in order to avoid artifacts introduced due to the spatial grouping of the source A-scans.

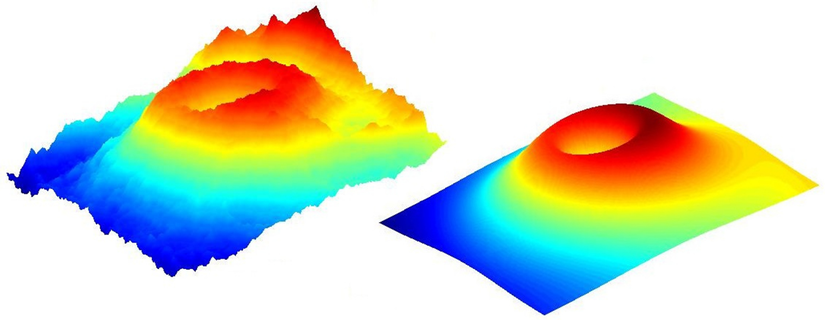

Fig. 1 left: thickness map of mildly pathologic eye, right: mathematical model of the thickness map

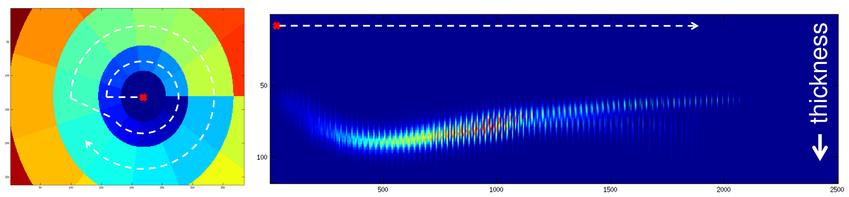

Fig. 2 left: bins in fovea centered polar coordinate system, right: number of samples in appearance model

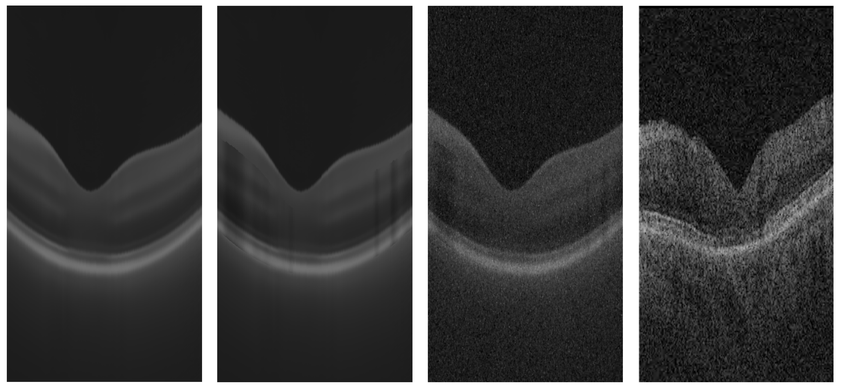

Fig. 3 left to right: noise free synthetic, with vessel shadows, with noise, real OCT

Results

The method yields a synthetic, noise and motion artifact free representation of healthy OCT scans. It enables generation of multiple OCT volumes of varying scan geometries and positions relative to the macula. After adding synthetic speckle noise[1], vessel shadows[2] and motion artefacts (Fig. 3) a realistic volume is derived.

Conclusion

- Synthetic OCT volumes can be used for parameter exploration during algorithm development …
- … and as a ground truth for different classes of image processing methods such as denoising, segmentation or motion correction algorithms.
- By generating OCT volumes based on different OCT devices using the same scan parameters, cross-device comparison of the repeatability of image processing algorithms is feasible.
- We are currently implementing the method for additional OCT devices and improving the appearance of vessel shadows.

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[2] Staal, J., Abràmoff, M.D., Niemeijer, M., Max A, V., van Ginneken, B.: *Ridgebased vessel segmentation in color images of the retina.* IEEE Transactions on Medical Imaging 23(4) (April 2004) 501-509

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