Computerized image analysis for ophthalmologic applications

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Background

- Glaucoma is the second leading cause of blindness worldwide.
- Open angle glaucoma affects 1-2% of the population above 40 years of age in Europe. The prevalence increases with increasing age.
- As yet, there is no cure for glaucoma. Instead, modern glaucoma management focuses on decreasing the rate of disease progression.
Glaucoma treatment

- The current standard method for follow-up of glaucoma is visual inspection of the visual field.
- Low precision, subjective
Optical coherence tomography

- Optic coherence tomography (OCT) is a noninvasive technique that measures time lapse for light conductance into different depths of the eye and back.
- Using OCT, we can capture tomographic 3D images of the eye of a living human, with micrometer resolution.
Optical coherence tomography
Optical coherence tomography

2D frontal projection of 3D data
Aim

- The aim of this project is to investigate the possibility of using OCT images for clinical follow-up of glaucoma progression.
- We are developing automatic and semi-automatic image analysis methods for measurement of morphometric variables relevant to diagnosing alterations of the nerve fiber layer in the optic nerve head in OCT images.
- These estimates will complement visual inspection for early detection, diagnosis and treatment guidance.
Interesting measurement: PIMD

**P**igment **I**nner limit of ret**i**na **M**inimal **D**istance

- The central limit of the pigment epithelium and the surface of the inner limit of the retina are relatively easy to identify in OCT images.

- The shortest distance between these boundaries reflects the nerve fiber layer thickness. Therefore, measurement of this distance is interesting for follow-up of glaucoma.
Step 1: Locating the inner limit of the retina

- Apply a low pass filter.
Locating the inner limit of the retina

- For every column, find the first voxel whose (filtered) intensity exceeds a given threshold.
3D visualization of the resulting surface
Step 2: Manual delineation of ONH pigment epithelium central limit (OPCL)

- Approximately circular structure.
Manual delineation of ONH pigment epithelium central limit (OPCL)

- We have developed a software tool for manually tracing the OPCL, by marking the location in a few slices (resampled to polar coordinates).
PIMD Measurements

- Once the central limit of the pigment epithelium and the surface of the inner limit of the retina have been delineated it is straightforward to calculate, for each point along the curve representing the central limit of the pigment epithelium, the distance to the closest point on the surface pigment epithelium, i.e., the PIMD.
Empirical evaluation

- Subjects were recruited among patients at the glaucoma unit, ophthalmology clinic, Gävle sjukhus.

- Inclusion criteria:
  - Older than 40 years of age.
  - Presence of early to moderate stage glaucoma.
Empirical evaluation

- So far, we have acquired measurements from 19 subjects; 13 women and 6 men.
- For each subject, the OCT imaging procedure was repeated six times.
- PIMD was measured from all images using the proposed method. For each image, the measurement was repeated three times to estimated variations in the manual steps of the measurement procedure.
Repeated OPCL delineation, one image
PIMD results, one subject
Conclusions

- Preliminary results of the empirical evaluation indicate that the proposed approach can measure PIMD with sufficient precision for follow-up of glaucoma.

- Empirical evaluation is still ongoing.
Fully automatic algorithm

- To make the whole process automatic, we want to delineate the OPCL automatically.
Fully automatic algorithm

- Calculate derivative along Z-axis. Truncate negative values to 0.
Fully automatic algorithm

- Erode segmentation of the inner limit of the retina to mask away the surface.
Fully automatic algorithm

- Sum voxel values along Z-axis
- Segment by thresholding
Next steps

- Finalize empirical study with 30 subjects.
- Statistical analysis of sources of variation.
- Finalize automated method for delineating OPCL. Evaluate using manual method as ground thruth.
Project output

• During 2015, the project was presented at
  – Medicinteknikdagarna, Uppsala
  – Svenska ögonläkarföreningens årsmöte, Göteborg
  – EVER Congress (European Association for Vision and Eye Research), Nice, France. (*Travel award for best section abstract*)

• During 2016, two extended abstracts have been presented at the SPIE conference on Opthalmic Technologies, San Francisco.

• A journal publication is under preparation.
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