Quality Assessment and Enhancement Method for high-resolution Fourier-Domain OCT Imaging of Retina Laser Lesions

P. Steiner[1A,2], D. Ernst[2], Ch. Meier[2], J.H. Kowal[1A,1B]

[A]ARTORG Center Ophthalmic Technologies, [B]Department of Ophthalmology,

[2]OptoLab, Berne University of Applied Sciences, Biel, Switzerland

HuCE OptoLab

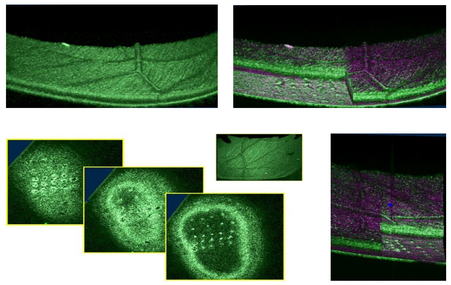
UNIVERSITÄT BERN

ARTORG CENTER BIOMEDICAL ENGINEERING RESEARCH

PURPOSE

Since its first appearance in 1991, OCT has proved to be a very useful and important imaging modality for non-invasive and high resolution mapping of biological structures and tissues. The proliferation of the technique to a growing field of applications also increases the need for automatic OCT image assessment and enhancement.

One of those applications, the employment of OCT for the monitoring of laser lesions caused by the Selective Retina Therapy (SRT) is currently under investigation. For this application, the best possible image quality as well as an automated assessment of the OCT image and the laser damage are needed.



OCT images of SRT lesions in dissected ex-vivo porcine retina

METHODS

Maximum-Likelihood Deconvolution

Due to the fact that the axial PSF is known in OCT systems, an axial deconvolution algorithm can be used for image and resolution enhancement. One of the well established algorithms is the Maximum-Likelihood deconvolution which works especially well with structured PSFs:

- Estimate „original“ image **s** and calculate intermediate image
- *Compare intermediate image to recorded image, make correction vector*
- *Normalize and back-project vector to object space*
- *Update estimation of „original“ image*

$$\hat{g}_{(k)}(x) = h(x) \otimes \hat{s}_{(k)}(x)$$

$$\hat{d}_{(k)}(x) = \frac{g(x)}{\hat{g}_{(k)}(x)}$$

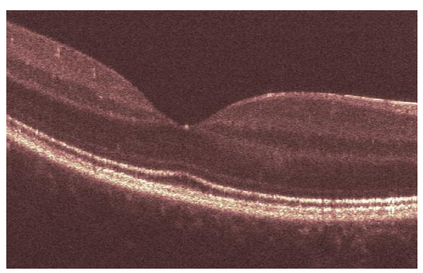
$$r_{(k)}(x) = \frac{1}{H(0)} \cdot h(-x) \otimes \hat{d}_{(k)}(x)$$

$$\hat{g}_{(k)}(x) = h(x) \otimes \hat{s}_{(k)}(x)$$

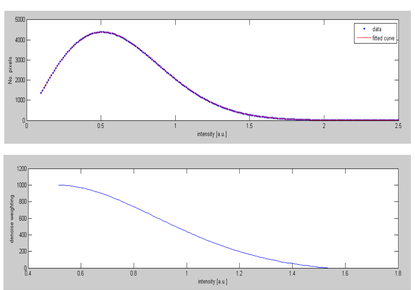
$$\hat{s}_{(k+1)}(x) = \hat{s}_{(k)}(x) \cdot r_{(k)}(x)$$

Histogram-based assessment and enhancement methods

Well adjusted OCT systems can be expected to be shot-noise limited. After Fourier-Transform, the noise will be present as a Rayleigh distribution in the histogram of an OCT scan. With a curve fit, parameters such as the noise intensity distribution, the noise mean and the noise border intensity value can be extracted. This information can be used for denoising and the computation of quality assessment values.



OCT image of retinal layers (acquired with self-designed system, left) and the corresponding histogram with the Rayleigh curve fit and noise intensity distribution (right). Only the lowest part of the histogram containing the noise information is shown.



RESULTS

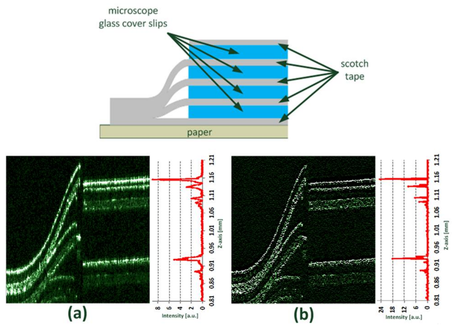
The proposed algorithms were applied to scans of artificial samples consisting of scotch tape and glass cover slips, retinal scans from healthy volunteers and on scans from a sponge cake. Furthermore, with the key numbers extracted from the algorithms, a set of image quality parameters were computed:

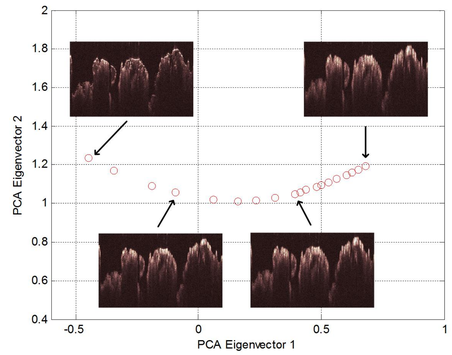
Image SNR: $ISNR = 20 \cdot \log\left(\frac{histogram_{99\%}}{noise_{mean}}\right)$

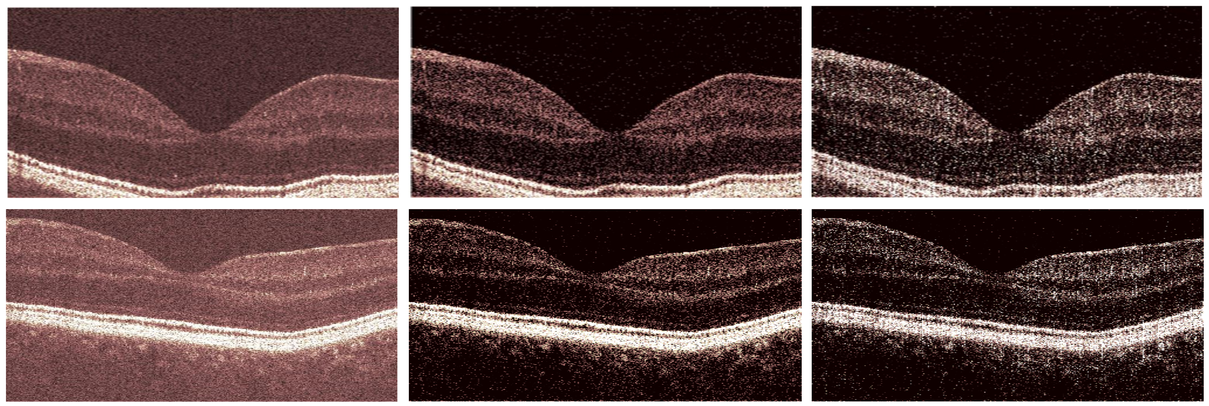
Signal band ratio: $SBWR = \frac{peakValue_{Signalband}}{noiseValue_{border}}$

Mean signal SNR: $MSSNR = avg\left[20 \cdot \log\left(\frac{I_{pixel=signal}}{noise_{mean}}\right)\right]$

Information carrying pixel: $ICP = 100 \cdot \left(\frac{pixel_{signal}}{pixel_{total}}\right)$







OCT image of retinal layers (left) with denoising by inverse rayleigh weighting (middle) and after Maximum-Likelihood deconvolution (right). Color table and dynamic range are identical for all images.

CONCLUSION

The presented work depicts the preliminary stage of the application of image enhancement and analysis algorithms to OCT scans against the background of SRT therapy monitoring through FD-OCT. The algorithms need to be tested and evaluated on a larger set of scans. The described algorithms only work on data represented with at least 12bit. Nevertheless, the results prove to be a promising starting point for further developments in this field.

The authors would like to thank the Dr. Werner Jackstaedt foundation in Wuppertal, Germany, for the generous financial support of this ongoing study

Contact: patrick.steiner@artorg.unibe.ch

Commercial Relationships: **None**