# Optical Investigation of Skin Morphology and Anatomy

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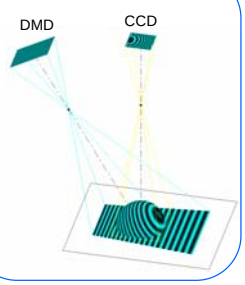
## Motivation

This project investigates skin anatomy and physiology by three optical, non-invasive techniques:
**Fringe projection topography** mainly for the investigation of tissue topography
**Parallel laser Doppler blood flow imaging** for the investigation of tissue micro circulation , and
**Optical Coherence Tomography (OCT)** assessing the anatomy and tissue morphology
The different methods are compared and contrasted with respect to their ability to analyse the microstructure of healthy human skin.

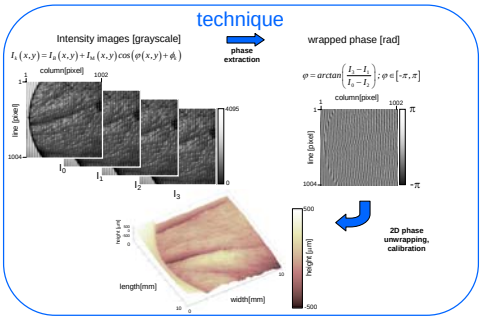
## Fringe projection topography

Projection of illumination beams of appropriate periodic intensity distribution. A single image, of the projected patterns, distorted by the shape of the surfaces, encodes the object heights.

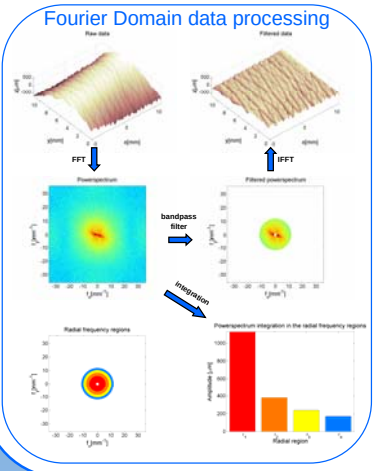
### setup




### technique




### Fourier Domain data processing

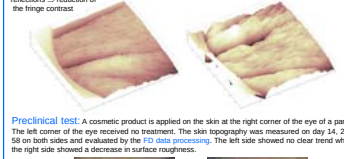



### results

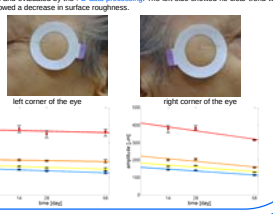
Comparison of in vivo measurements on the skin with print data

in vivo
- in-vivo topographies show more details than prints: transversal / lateral resolution ~20µm
- pores and hairs introduce artefacts(phase jumps)
- volunteer movements are inevitable ⇒ artefacts
- transparency of the skin introduces multiple reflections ⇒ reduction of the fringe contrast

print
- the prints smoothes all details below 50µm
- the prints show no hair artefacts
- air bubble formation ⇒ artefacts
- moistening of the skin influences morphology



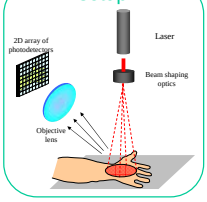
**Preclinical test:** A cosmetic product is applied on the skin at the right corner of the eye of a panellist. The left corner of the eye received no treatment. The skin topography was measured on day 14, 28 and 58 on both sides and evaluated by the FD data processing. The left side showed no clear trend whereas the right side showed a decrease in surface roughness.



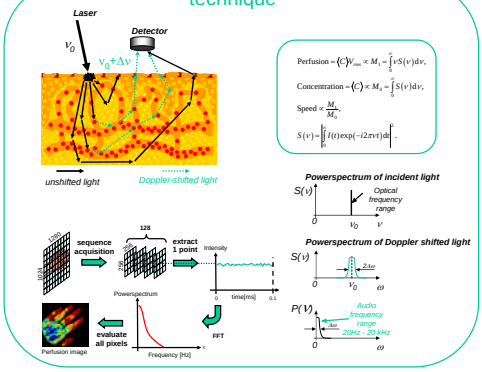

## Laser Doppler blood flow imaging

Tissue is illuminated by laser light. Some of the photons are scattered by moving blood cells and undergo a frequency shift due to Doppler effect. The analysis of the spectrum of the intensity fluctuation yields the information about concentration and speed of the moving blood cells.

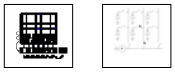
### setup




### technique



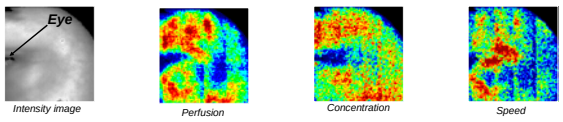

### CMOS technology



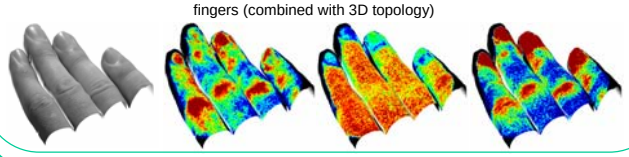

**CCD:** Successive pixel addressing
**CMOS:** Random pixel addressing

### LDI results

corner of the eye



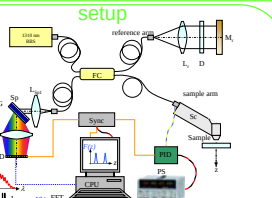

fingers (combined with 3D topology)



## Optical Coherence Tomography

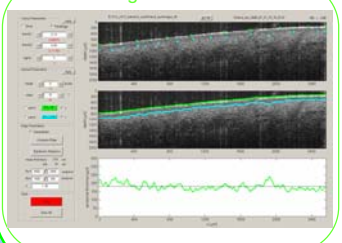
OCT is a non-invasive imaging technique used to visualize subsurface structure in biological tissues. Employing light at 1300nm one penetrates strongly scattering tissue such as skin down to 2mm. In Fourier Domain OCT (FD-OCT) a 1D depth scan is deduced directly by Fourier transform of a spectral interference signal. The lateral dimensions are obtained by mechanical scanning. With a current speed of 18.000 spectra per second one tomogram of 1000 lines takes only 55ms.

### setup

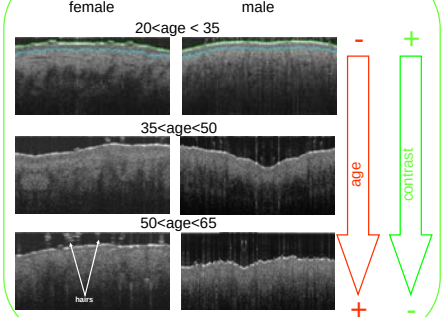



set-up FDOCT system with BBS: broad band source, FC: fibre coupler 50% / 50%, reference arm with collimation lens Lr dispersion compensation D and reference mirror Mr, Sc: handheld XY-scanning system, Sp: spectrometer with collimation lens LSp1 transmission grating G, lens LSp2 and linescan CCD, Sync: synchronization unit, CPU: central processing unit, PID: feedback control and power stage for motors and PS: power supply.

### edge detection

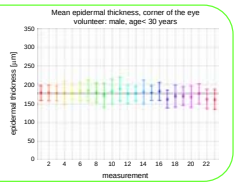


### results



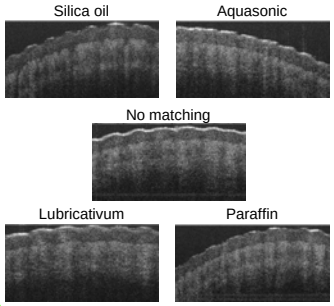

### evaluation

A stack of 23 tomograms (skin corner of the eye, volunteer: male, age <30 years) is evaluated with the edge detection program (Matlab)
- calibration of the image
- initialization by manually given control points
- automatic edge detection
- computation of the epidermal thickness,
- representation of epidermal thickness mean value and standard deviation




### Index matching*

* for suppression of surface reflection




Best results with Silica oil and Paraffin

The epidermal thickness was investigated for serving as indicator of skin health and skin status. A first study shows a tendency for the region of interest at the eye corner that only less than 20% of the volunteers' OCT images have sufficient contrast to extract the epidermal junction independent of gender but depending on age.

## Summary

✓ A clinical study was performed on 19 volunteers including fringe projection and Laser Doppler perfusion imaging. The FP allowed to measure the effect of cosmetics.

✓ The LDI data gave no significant difference for treated and untreated skin.

✓ OCT yields depth resolved skin structure. The epidermal thickness in the eye corner region as skin status parameter seem only to be evaluable in <20% of volunteers.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## Reference


Michaely R., Serov A., Jacquot P., Lasser T., *Laser Doppler blood-flow imaging combined with topographical imaging of the sample*, Proc. SPIE Vol. 6081, p. 54-61, Multimodal Biomedical Imaging, Azar F. S., Metaxas D. N., 02.2006.