BIOPHOTONICS – EXERCISE 4: LASER SPECKLE IMAGING

1 General Information

Please prepare the task until the deadline provided in the slides. Please upload your solution via Digicampus. Make sure that the following requirements are met:

- Hand in the experiment protocol as PDF
- The experiments and tasks, as well as results should be comprehensible from the protocol without having to consult this task assignment!
- List your sources!
- For communication and control of the infrared cameras it is recommended to use the PyPylon or IDS peak library.
- All source code must be available and executable for us (this implies that you specify the required packages; in addition, you have to provide necessary data and/or give advises if paths have to be adjusted; in order to do so, you should provide a reasonable README file).

Submission: submission deadline is 02.02.2025, 23:59.
Experiment recordings take place at Room F1 111 (Eichleitnerstraße 30).
Please ask in case of any doubts regarding the contents or the forma procedure.

2 Background on the exercise

Laser Speckle Imaging (LSI) is a technique to measure the perfusion and blood flow in the skin using changes in the reflective pattern (speckle pattern) of a laser beam. Hereby the reflective pattern's stability is dependent on the movement of particles, i.e. in the blood stream. Therefor a high variability in the speckle pattern correlates with a high perfusion of the tissue.
The applications include cardiovascular research, monitoring in dermatology and even neurology or neurosurgery.
In this exercise you will conduct a small-scale experiment: You will define the study protocol, implement data acquisition, processing and evaluation. You will learn how to control cameras and retrieve images using the Pylon or IDS peak library and how to process the recorded data with OpenCV.

3 Task(s)

Before recording an LSI sequence on skin perfusion inform yourselves about the requirements of such an experiment and create procedure instructions for your 'patient'.

The experiment should include a baseline recording, a stimulation to increase the skin perfusion, and a suitable procedure to record and evaluate the changes provoked through the stimulation, e.g. by comparing the contrast of two regions of interest (ROI). Each recording sequence should also be long enough to evaluate different time intervals in between 100 ms and 30,000 ms.

(1) Present your experiment procedure and expected outcome.

(2) Present the configured camera parameters.

Implement a python script to configure the camera and to record one sequence. Then record the LSI sequences following your experiment procedure. For validation, also record reference measurements with the software provided by moor instruments.

(3) Show the first frame of every sequence and mark the stimulated and reference ROI.

Research calculation formula for the creation of an LSCI representation. For the following tasks, at least one calculation should incorporate temporal contrast.

(4) Present and explain your LSCI calculation.

Calculate the LSCI representation of your **baseline sequence** and think of a suitable visualization.

(5) Show the LSCI visualization of the baseline sequence.

(6) Vary the temporal filtering of your LSCI calculation and compare them to the result of (5).

(7) Visually compare your LSCI image with the result from moor's software.

For the following tasks, calculate LSCI images of the **follow up recordings**.

(8) Show the calculated LSCI images for all sequences.

(9) Define a measure of perfusion, which can be calculated from the pixels in each ROI

(10) Evaluate the perfusion of the stimulated skin area and compare it to your reference ROI

(11) Compare your results to the results from moor's software.

4 References (and recommended reading)

[1] Simon Erdmann, Flora Weissgerber, Élise Colin Koeniguer, and Xavier Orlik, "Dynamic speckle imaging of human skin vasculature with a high-speed camera," Opt. Express 30, 11923-11943 (2022)
[2] LSCI device 'moor instruments FLPI-2' specification: https://www.moor.co.uk/de-de/products/imaging/laser-speckle-contrast-imager/
[3] Basler AG camera 'Basler acA2040-120um' documentation: https://docs.baslerweb.com/aca2040-120um
[4] PyPylon library: https://github.com/basler/pypylon/tree/master
[5] IDS camera 'GV-5240CP-NIR-GL Rev.2.2' documentation: https://en.ids-imaging.com/store/gv-5240cp-rev-2-2.html
[6] IDS peak library: https://pypi.org/project/ids-peak/
[7] OpenCV library: https://opencv.org/