PROJECT DESCRIPTION

Project goals

- To develop a machine learning based approach for numerical increasing the quality of optical coherence tomography (OCT) and optical coherence microscopy (OCM) images.
- To develop a machine learning approach for quantitative analysis of structural and functional OCT and OCM for applications in biology and medical diagnostics.
- To develop algorithms that efficiently combine information from multimodal optical devices (OCT, OCM, eye-trackers, laser ophthalmoscopes and other).
- To conduct experiments with human subjects in clinical environment.

Outline

The first research objective of the doctoral project will be to develop methods for increasing the quality of optical coherence tomography (OCT), optical coherence angiography images (OCTA), optical coherence microscopy (OCM), scanning laser ophthalmoscopy (SLO) and others. The methods will include noise reduction, speckle removal, various image registration and compounding approaches and will be combined with numerical phase optimization. It is expected that these goals will be achieved by employing deep learning methods. Deep learning has played very important role in the image processing over the past few years including image classification [1], image recognition [2], image denoising [3] and image super resolution [4].

The remaining goals will be achieved by developing data and image processing algorithms that will exploit the combination of methods from step one and the potential of the multimodal optical device comprised of the ultrafast retinal eye tracking module (FET – FreezEye Tracker), OCT/OCTA imager, and the scanning laser ophthalmoscope (SLO). The eye-tracker device developed recently in our laboratory allows for fast and accurate quantification of retinal motion and can be used for offline and online image stabilization during in-vivo retinal imaging. It is expected that the full potential of the device will be achieved with dedicated algorithms for multimodal data merging developed in this project. For example, OCT images with low noise level are usually obtained by averaging several OCT images that are repeatedly acquired at the same position, but due to eye movement during OCT data acquisition, the acquired OCT images cannot be captured from exactly the same place. Eye-tracking devices reduce this problem, but motion artifacts may still appear and some key information in the averaged OCT images could be lost. It is a serious problem of OCT/A data acquisition for unstable patients, especially with neurodegenerative diseases like Parkinson. In order to recover high quality OCTA images, it is necessary to propose effective methods for simultaneous image stabilization and quality enhancement.

The project will be carried out alongside a larger multidisciplinary team consisted of physicists, engineers, mathematicians and software developers that is currently developing the retinal tracker for image stabilization purposes.

The framework of the PhD project will follow the project goals and start with systematic organization of the state-of-the-art knowledge in the field of image processing with the use of deep learning, followed by development of numerical method and finished by their implementation and tests in the clinical environment.

Literature:

1. A. Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet classification with deep convolutional neural networks," in International Conference on Neural Information Processing Systems, 1097–1105 (2012),
2. K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in Proceedings of IEEE Conference on Computer Vision and Pattern Recognition , 770–778 (2016),
3. Devalla, S.K et al., "A Deep Learning Approach to Denoise Optical Coherence Tomography Images of the Optic Nerve Head, Scientific

Reports 9 (2019),
4. C. Dong, C. C. Loy, K. He, and X. Tang, “Image super-resolution using deep convolutional networks,” IEEE Trans. Pattern Anal. Mach. Intell. 38(2), 295–307 (2016).

The PhD candidate will have an opportunity to strengthen qualifications in a great choice of scientific and engineering topics, according to her or his scientific interests:

- machine learning in biomedical imagining,
- biomedical data and image analysis methods,
- advanced programming (GPU),
- development of data acquisition software,
- computer control of imaging devices.

Initial requirements:

- basics in computer programming (preferably Python, LabView, Matlab, C++, C#).