Tytuł projektu

Wizualizacja i analiza ilościowa systemów naczyniowych w obrazowaniu oka za pomocą koherencyjnej tomografii optycznej.

Project title

Visualization and quantitative analysis of vascular networks in OCT imaging of the eye.

Dyscyplina /Area of science

Nauki fizyczne, informatyka / Physical sciences, informatics

PROJECT DESCRIPTION

Project goals

- To develop image processing methods for de-noising of the OCTA and Doppler OCT images.
- To develop methods for co-registration of three-dimensional OCTA data sets with eye-motion induced distortions.
- To develop segmentation and visualization methods of the vascular networks in the 3D OCTA data, and quantitative analysis of their features**.**

Outline

Doppler Optical Coherence Tomography (Doppler OCT) and OCT Angiography (OCTA) are interferometric imaging techniques which enable visualization and measurement of the blood flow in the vascular networks *in vivo*. Several experimental and data processing methods have been developed to enable detection of the blood flow in the vessels of the human eye [1-6]. A great majority of these techniques is used for the analysis of the retinal circulatory system with the goal to aid the diagnosis of eye diseases presenting with a vascular component, i.e. affecting the structure and functioning of the vascular systems. So far, the research efforts have been focused on the improvement of the experimental techniques to provide more accurate data, and on development of basic image processing methods attempting automatic segmentation of the vessels. The goal is to introduce metrics characterizing the retinal circulatory systems in ways which could be useful in the ophthalmic diagnostics [7]. Recently, new OCT imaging methods have been developed enabling imaging of the vessels of the choroid [8, 9], which is a highly perfused vascular system abutting the retina. Perhaps of the greatest interest is the possibility to image the intricate meshwork of capillary vessels of the choroid (choriocapillaris) [10, 11] since no other *in vivo* imaging method can provide information about their structure and function. Hence, a new area for research has opened promising development of new methods with direct application in ophthalmic diagnostics.

The goal of this doctoral project is to develop methods for visualization of the retinal and choroidal vasculature and their quantitative analysis in the OCT data obtained in the healthy and disease affected eyes. The key problem will be to develop methods for segmentation of the vascular systems in noisy data and visualization of the segmented vascular networks in a way which will highlight the parameters of interest in the diagnosis. Further development of the project will include search for metrics which can potentially identify disease development, progression or severity. Of great scientific interest will be modeling of the blood flow through the segmented vascular networks with the information about blood flow direction and velocity obtained from the Doppler OCT. The data necessary for the development of the project will be collected in the healthy and disease affected eyes with research-grade spectral-domain and swept-source OCT systems.

Work plan

1. The PhD candidate will learn the theoretical and experimental basics of the OCT technique to understand how OCT images are created and what are the characteristics which set OCT images apart from images obtained with other medical imaging techniques. The candidate will also study existing methods of OCT angiography and Doppler OCT image analysis and search for new approaches of OCT images analysis.
2. The PhD candidate will be solving several problems inherent to the OCT technique, including development of methods for the de-noising of OCTA and Doppler OCT images [12] and co-registration of sets of three-dimensional data affected by eye-motion introduced distortions. Classic image analysis methods will be tested for the effectiveness in the segmentation of vessels in OCTA images while the candidate will research the possibility to utilize artificial neural networks to perform similar tasks.
3. The PhD candidate will implement vascular segmentation methods and perform their tests in a set of data obtained from the human subjects. Methods for three-dimensional visualization of the segmented vascular networks and quantitative analysis of their features will be developed. Depending on the advancement of the project, the PhD candidate will also have an opportunity to initialize research on modeling of the blood flow in the segmented vascular networks.

Literature

1. S. Makita, et al., Opt. Express 14(17), 7821-7840 (2006).
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6. R. F. Spaide, et al. Progress in Retinal and Eye Research 641-55 (2018).
7. Zhongdi Chu, et al., J. Biomed. Opt. 21(6), 066008 (2016),
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9. R. Poddar, et al., J. Biomed. Opt. 22(10), 1–14 (2017).
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11. J. V. Migacz, et al., Biomed. Opt. Express 10, 50-65 (2019).
12. M. Chlebiej, et al., Biomed. Opt. Express 10, 1013-1031 (2019).

Required initial knowledge and skills of the PhD candidate

- ➔ Well-developed skills in C/C++ programming,
- ➔ Familiarity with basic computer graphics algorithms,
- ➔ Familiarity with basic digital image processing algorithms,
- ➔ Experience in analysis of volumetric data sets will be an asset.

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