Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences

Subject

Arterial spin labeling, diffuse correlation spectroscopy, time resolved near infrared spectroscopy - study on methodology of the brain cortex perfusion assessment

Supervisors, contact, place of research

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Project Description

The Near infrared spectroscopy (NIRS) technique allows to assess the tissue oxygenation by analysis of attenuation of light penetrating in the tissue at several wavelengths. Utilization of spectral properties of the oxy- and deoxyhemoglobin leads to assessment of changes in the tissue oxygenation. Most advanced approach to NIRS technique – time domain NIRS (TD-NIRS) is based on emission of ultra-short (picosecond) light pulses and evaluation of pulse broadening during its propagation through the investigated tissue. Application of this technique allows for depth-resolved evaluation of changes of oxygenation and perfusion in the tissue [1].

DCS is based on similar physical principles as NIRS and advantages such as noninvasiveness due to its ability to penetrate tissues by low power light but it provides a direct measure of so-called blood flow index (BFI)[2]. In practice, the intensity autocorrelation function is measured in the distance of about 3 cm from source to detector. Fast decay of the autocorrelation function indicates fast blood flow under the fiberoptic probe, while slow decay reflects slow or impaired blood flow.

In opposite to TD-NIRS, which is already applied for numerous clinical and non-clinical application, time-domain DCS (TD-DCS) is, so far, tested only in laboratories and ways of measurement and algorithms of analysis of the signals are still under development. Nevertheless, the clinical application of this method leads to important information about brain cortex perfusion separated from extracerebral contamination. Research in the planned two-year project will concern, among other things, development of measurement methodology and analysis of data obtained with this method and comparison with the reference modality which is ASL-MRI (magnetic MRI technique)[3]. The main scientific **hypothesis** for the proposed project are:

- Depth discrimination and the ability to separate changes of blood flow in deep tissue layers from superficial ones could be achieved.
- Monitoring and calibration of optical techniques by simultaneous arterial spin labeling MRI (ASL-MRI) measurements is feasible.
- Assessment and increase of the sensitivity of DCS and TD-DCS methods to deep blood flow could be achieved by utilizing a priori knowledge taken from the flow simulations and ASL-MRI scans.

During realization of the project, we plan to carry out the measurement campaigns on 3D printed phantoms of the tissue with precisely defined and controlled flow inside. In second part of the project the study on the healthy subjects, team members, will be performed, during delicate stimulations that change slightly the blood flow (i.e. hyperventilation or motor cortex stimulation). Optical measurements on phantoms and studies on healthy group will be carry out inside the MRI scanner using non-magnetic fibers and optodes.

Bibliography

1. Kacprzak, M., P. Sawosz, W. Weigl, D. Milej, A. Gerega, and A. Liebert, *Frequency analysis of oscillations in cerebral hemodynamics measured by time domain near infrared spectroscopy.* Biomed Opt Express, 2019. **10**(2): p. 761-771.
2. Durduran, T. and A.G. Yodh, *Diffuse correlation spectroscopy for non-invasive, micro-vascular cerebral blood flow measurement.* Neuroimage, 2014. **85 Pt 1**: p. 51-63.
3. Hales, P.W., F. d'Arco, J. Cooper, J. Pfeuffer, D. Hargrave, K. Mankad, and C. Clark, *Arterial spin labelling and diffusion-weighted imaging in paediatric brain tumours.* Neuroimage Clin, 2019. **22**: p. 101696.

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