Doctoral School of Information and Biomedical Technologies
Polish Academy of Sciences (TIB PAN)

SUBJECT:

Superimposing multi-frequency measurements into a distribution of time of flight of photons

SUPERVISOR:

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DESCRIPTION:

Goal: To develop a method of superimposing multi-frequency measurements into a distribution of time of flight of photons, following the conclusion drawn in [1] where existence of the multi-frequency domain (MFD) method is recognized. Finally, to test if the distributions of time of flight of photons (DTOF) as measured in the MFD can be applied to in-vivo measurements on humans.

The MFD method introduces principles of a new measurement technique where a MFD instrument becomes an equivalent of a time-resolved (TR) time-correlated single photon counting set-up. The MFD will open a path to new research where the affordable TR instruments can be expanded to a high-density time-resolved diffuse optical tomography. Furthermore, MFD will be applicable in biomedical optics clinical applications [2] where absorption and scatter parameters or improved depth discrimination are beneficial or required. This includes non-invasive optical biopsy, optical mammography, functional brain imaging, monitoring therapy and rehabilitation of stroke patients, monitoring of brain condition of traumatic brain injury patients or intraoperative brain oxygenation monitoring [3].

The idea of the MFD can be compared to a mechanism of delivering a broadband Internet. Carrier waves at many frequencies (VHF-UHF radio frequency range) will be superimposed together to power a laser diode. Frequencies will mix in the heterodyne manner creating beating frequencies detectable at acoustic frequency range (single kHz).

Work description: This work regards basic research on development of the MFD method and proof-of-concept prototype. This will require a multi-disciplinary effort including theory, software and hardware research finalized with in-vivo tests on healthy human volunteers.

You can expect to learn biomedical optics and biomedical engineering basics; develop and construct new optoelectronic hardware, methods, algorithms, software, etc.; carry out measurements in-vivo on humans; write peer-reviewed research publications; write PhD thesis based on the research.

BIBLIOGRAPHY:

[1] S. Wojtkiewicz, T. Durduran, and H. Dehghani, "Time-resolved near infrared light propagation using frequency domain superposition," Biomedical optics express **9**, 41-54 (2018).

[2] W. Weigl, D. Milej, D. Janusek, S. Wojtkiewicz, P. Sawosz, M. Kacprzak, A. Gerega, R. Maniewski, and A. Liebert, "Application of optical methods in the monitoring of traumatic brain injury: A review," Journal of cerebral blood flow and metabolism : official journal of the International Society of Cerebral Blood Flow and Metabolism **36**, 1825-1843 (2016).

[3] A. Rajaram, D. Milej, M. Suwalski, L. C. M. Yip, L. R. Guo, M. W. A. Chu, J. Chui, M. Diop, J. M. Murkin, and K. St Lawrence, "Optical monitoring of cerebral perfusion and metabolism in adults during cardiac surgery with cardiopulmonary bypass," Biomedical optics express **11**, 5967-5981 (2020).