

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

SUBJECT:

'Imaging with the speed of light' - a CCD camera working in the multi-frequency domain providing picosecond temporal resolution.

SUPERVISOR:

Supervisor: Prof. dr hab. inż. Adam Liebert

Auxiliary supervisor: dr inż. Stanislaw Wojtkiewicz (swojtkiewicz@ibib.waw.pl)

Laboratory for Biomedical Optics, IBIB PAN, Ks. Trojdena 4, 02-109 Warszawa

DESCRIPTION:

Goal: To develop a method of real-time 'imaging with the speed of light' utilizing a CCD camera working in the multi-frequency domain providing picosecond temporal resolution. The aim is to answer a question if a CCD camera of ≥ 1000 frames per second rate used in the multi-frequency domain (MFD) is capable of tracking/imaging a laser beam dispersion on objects at pico-second temporal resolution.

The MFD method is based on superimposing multi-frequency measurements into a distribution of time of flight of photons, following the conclusion drawn in [1] where existence of the MFD method is recognized. The MFD can be used in any area where knowledge of the time of light travel can be beneficial e.g. laser guidance (military, civil engineering, robot vision), surface capture (LIDAR, cartography, autonomous vehicles), 3D objects tracking (entertainment, gaming, surface capture).

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 the CCD camera sampling at single kHz framerate.

The state-of-the-art laboratory system of imaging with the speed of light can capture frames at 0.1 ps intervals [2], two orders of magnitude faster than the MFD camera. Such ultra-fast imaging use pico/femto seconds short laser pulses and time-gated intensified CCD cameras correlated with the pulse trigger. In comparison, the MFD methodology is applicable to the current flagship smartphones hardware.

Work description: This work regards basic research on development of the MFD method and proof-of-concept prototype of the CCD camera working in the MFD regime. This will require a multi-disciplinary effort including theory, software and hardware research.

You can expect to learn biomedical optics and biomedical engineering basics; develop and construct new optoelectronic hardware, methods, algorithms, software, etc.; 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] J. Liang, L. Zhu, and L. V. Wang, "Single-shot real-time femtosecond imaging of temporal focusing," *Light: Science & Applications* **7**, 42 (2018).