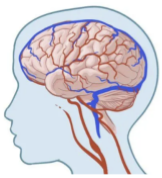
PARALLEL INTERFEROMETRIC NEAR-INFRARED SPECTROSCOPY (πNIRS) FOR NONINVASIVE MONITORING OF THE CEREBRAL BLOOD FLOW IN HUMANS *IN VIVO*

Cerebral blood flow (CBF) uses about 15% of the cardiac output to deliver nutrients to the brain (oxygen and glucose) and remove metabolic by-products. Therefore, any deviations in the CBF can hamper the brain metabolism and cause significant brain damage or disease, including traumatic brain injury, ischemic stroke, or Alzheimer's disease. Hence, noninvasive monitoring of cerebral blood flow and brain function is invaluable in clinics to treat brain dysfunctions.



Cerebral blood flow is critically important to maintain proper brain function by supplying the brain with the necessary oxygen and energy substrates

Functional magnetic resonance imaging (fMRI) provides state-of-the-art CBF monitoring. fMRI monitors local CBF changes as a proxy of neuronal activity to study the human brain in vivo. Though fMRI offers high-resolution images of the blood flow changes in the brain, it is expensive, cannot be used continuously, and is susceptible to the subject's motion, which makes fMRI challenging to acquire in young children.

The brain can be continuously and noninvasively monitored using optical methods. Brain oxygenation can be estimated using functional near-infrared spectroscopy (fNIRS), while the blood flow can be qualitatively monitored using diffuse correlation spectroscopy (DCS), but their most widely adopted versions rely on continuous wavelength (CW) lasers, **precluding absolute measures**. Absolute measures are possible in time-domain DCS (TD-DCS) and interferometric near-infrared spectroscopy (iNIRS). However, both methods use single-channel light detection, making them too slow to detect rapid changes in the blood flow that could be linked to neural activation.

In this project, we intend to solve those problems by investigating parallel, multi-channel detection to measure cerebral blood flow in the human brain *in vivo*.

To achieve this goal, we aim to parallelize the iNIRS system. The collected optical signals will be recorded using a two-dimensional camera operating at ultra-high speed frame rates (~1 MHz). Each pixel in the recorded image sequence will effectively act as an individual iNIRS detection channel. By processing signals from each channel and then combining them, we achieve similar information as in iNIRS but orders of magnitude faster than conventional iNIRS.

Thus, we can sense the rapid blood flow changes, which could be linked to neural activation. Based on our knowledge, this will be the fastest optical system for measuring cerebral blood flow in humans *in vivo*.

So, this research project will enable rapid, noninvasive cerebral blood monitoring systems in humans in vivo. Continuous and noninvasive blood flow monitoring could help to treat major brain diseases. Moreover, rapid cerebral blood flow sensing will take us closer to developing the noninvasive brain-computer interface (BCI), which could help people with disabilities.

Finally, our project will strengthen traditions of Polish development in diffusive optics.

Our research will complement the development of the time-resolved diffuse optics in Poland.

This project aims to develop a fast optical system for noninvasive continuous cerebral blood flow monitoring in humans in vivo.

Our results will enable continuous cerebral blood flow monitoring at the bedside, helping to treat significant brain diseases and support people with disabilities.