Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Full time from April 2026 (it can start part time from February 2026)
Presentation date to be chosen: end of July or beginning of September 2026

Note: The main Master Thesis supervisor has to be a professor of the Master in Photonics program. One co-supervisor (internal or external) can be defined. Main Supervisor is responsible for the subject of the proposal and has to give continuous support to the student (research development, Report writing and presentation preparation). For external proposals a co-supervisor from the Master program and a collaboration agreement with UPC are needed.
You can find all information about the Master Thesis process in our webpage.

Laboratory: Medical Optics
Institution: ICFO – The institute of photonic science
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: Advanced computational methods for cerebral blood flow monitoring with optical techniques
Name and affiliation of the master thesis supervisor: Turgut Durduran, ICFO-The institute of photonic sciences
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Keywords:
Biophotonics, diffuse optics, speckle contrast optical spectroscopy, optical signal processing, data quality assessment, neuroscience, physiological monitoring

1. **Summary of the subject (maximum 1 page):**

The brain consumes 20% of the total body's oxygen supply, although it represents only about 2% of the total body weight. Its high oxygen consumption is an significant indicator of its high metabolic rate. Oxygen molecules are delivered to the tissue through microvessels that reach all the tiny regions of the brain. Oxygen is transported in the form of oxyhemoglobin, which is distributed according to the needs of each brain region. In other words, areas that require more oxygen are supplied with more oxygenated blood. The mechanisms responsible for blood distribution can increase or decrease cerebral blood flow by dilating (vasodilation) or constricting (vasoconstriction) the microvessel, respectively. As a result, pathological conditions that affects blood perfusion can instigate to severe tissue damage at anatomical and/or functional level. For instance, in paediatrics, abnormal development of the heart and/or the blood vessels during pregnancy is associated with cognitive impairments (e.g. language, memory, attention…) that can lead to poor academic performance and, essentially, impact cognitive abilities on a daily basis.

Understanding the fundaments of the mechanisms behind blood perfusion can help to characterize the way in which neuronal and non-neuronal factors, such as malformations in cerebral and extracerebral structures or abnormalities in physiological parameters (e.g., arterial pressure), affect brain hemodynamic and their subsequent impact on brain function. To study these mechanisms, optical techniques are particularly suitable since enable continuous and non-invasive monitoring of hemodynamic. In particular, diffuse correlation spectroscopy (DCS) that measures blood flow changes at the microvascular level with higher sensitivity to brain tissue as compared to other optical methods. However, DCS is also sensitive to artifacts or 'noise' that can mitigate the true physiological response. These include optical artifacts, such as changes in probe–scalp coupling, ambient light interference, or signal contamination from extracerebral tissues, and physiological artifacts, such as motion-induced perturbations, or spontaneous fluctuations in systemic parameters (e.g., blood pressure, heart rate, and CO_2 levels).

In this regard, the core objective of this master project is to analyse and characterize the most persistent artifacts found in clinical and non-clinical optical signals acquired using DCS. The work will involve the development of algorithms in Matlab and/or Python, assessment of data quality, data processing and interpretation (e.g. artifact identification, physiological/neuroscience interpretation), and the extraction of relevant features linked to meaningful parameters for clinical and/or neurodevelopment studies. The ultimate goal is to enhance the interpretability of DCS data acquired in realistic clinical and non-clinical environments.

The student will contribute significantly to the development of new data analysis pipelines aimed at improving data quality and exploring the optical features in parallel with neurodevelopmental and/or clinical parameters, as well as studying the correlation between them. The student may also participate in measurements conducted in the hospital and/or Babylab, gaining hands-on experience with optical technologies in multidisciplinary environment. This will provide a unique experience opportunity to collaborate with researchers from diverse scientific backgrounds.

The project will be primarily carried out within ICFO's Medical Optics group, which is a multidisciplinary research team with extensive experience in the development of cutting-edge optical devices, in collaboration with hospitals and research centres all around the world.

2. **Objectives (maximum 1 page):**

The main objective of this project is to develop a processing pipeline for the detection of artifacts in optical data recorded from clinical and non-clinical signals acquired using DCS. The student is expected to gain an understanding of the fundamental physics behind the technique and to actively contribute to the development and implementation of the new analysis pipelines.

Specific objectives:

- To understand the fundamental physical principles underlying functional DCS (fDCS) and other relevant physiological concepts (e.g., neurovascular coupling).
- To design, implement, and validate algorithms for data-quality assessment and artifact detection in order to improve data interpretability and reliability.

Additional information (if needed):

* Required skills:

- Background in physics, photonics, biomedical engineering or a related discipline.
- Basic programming experience in Python or MATLAB.

- Interest in applying photonic technologies to biomedical and clinical problems.
- Ability to work in a multidisciplinary environment.