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:
Signal analysis and machine learning methods for global hemodynamic monitoring by means of optical blood flow characterization.

Name and affiliation of the master thesis supervisor: Turgut Durduran, ICFO-The institute of photonic sciences
Name and affiliation of the co-supervisor (if any): Marta Zanoletti, ICFO-The institute of photonic sciences
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Keywords:
Biophotonics, diffuse optics, speckle contrast optical spectroscopy, optical signal processing, physiological monitoring, machine learning, data quality assessment.

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

Maintaining adequate tissue oxygenation is essential to sustain cellular metabolism and prevent organ failure. In acute care and intensive settings, clinicians continuously face the challenge of optimizing cardiovascular function to ensure sufficient tissue perfusion. Decisions such as fluid administration, vasoactive drug delivery, or mechanical support depend on how the circulatory system responds in real time, Yet, existing monitoring tools are often invasive, intermittent or insufficiently precise, creating a critical gap between early intervention and accurate hemodynamic guidance.

Optical methods are promising tools that can provide continuous, non-invasive assessment of microvascular blood flow, which serves as a sensitive marker of circulatory status. Among these, Speckle Contrast Optical Spectroscopy (SCOS) has emerged as a next-generation diffuse optics technique capable of measuring tissue blood flow by analysing laser speckle fluctuations, offering compact, robust and low-cost. This makes SCOS particularly suited for use in dynamic and challenging settings such as emergency rooms and intensive care units (ICUs).
This master thesis will focus on the analysis and characterization of optical signals acquired with SCOS during physiological and clinically relevant manoeuvres. The work will include developing algorithms for pre-processing and data quality control, extracting features that reflect microvascular dynamics and responses to hemodynamic interventions such as fluid administration, and applying exploratory data-driven techniques to identify consistent patterns in the signals. The aim is to improve the interpretability and reliability of optical perfusion measurements in realistic clinical conditions.

The student will be responsible for implementing and evaluating data-analysis pipelines, improving data quality, and exploring relationships between optical features and clinical parameters.
The student may also participate in data collection within a hospital ICU, gaining first-hand experience in biomedical research, clinical collaboration and the translation of photonic technologies into healthcare environments.
The work will significantly contribute to the broader goal of advancing non-invasive optical monitoring technologies and supporting their integration into real clinical practice.

The project will be carried out at ICFO's Medical Optics group, a multidisciplinary research environment at the interface of photonics, biomedical engineering and data science in close collaboration with clinical partners. It will be done in close collaboration with Dr Jaume Mesquida of Hospital Parc Tauli who is an expert in clinical and physiological aspects of this research and its future translational applications.

2. Objectives (maximum 1 page):

The main objective of this project is to develop and apply signals and machine learning methods for the characterization of optical blood-flow signals acquired using SCOS. The student will contribute to the design of computational tools that improve signal quality, extract physiological information and support the integration of optical monitoring in clinical environment.

Specific objectives:

- **Understanding and characterize SCOS signals:** Review the physical principles of SCOS and analyze the variability of optical blood flow signals recorded across different physiological and clinical states.
- **Develop and validate processing pipelines:** Design, implement and validate algorithms for signal preprocessing, artefact removal, normalization, and data-quality assessment to ensure robust performance in clinical settings like the ICU.
- **Extract and interpret physiological features:** Identify features that describe microvascular dynamics and responses to hemodynamic interventions (e.g. fluid administration).
- **Explore data modelling:** apply machine learning methods (unsupervised or semi-supervised) to discover patterns and correlations within the optical data that may reflect underlying hemodynamic states.
- **Contribute to experimental data collection:** when possible, participate in hospital-based data acquisition sessions to gain hands-on experience with instrumentation setup, measurement protocols and data handling.

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.