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:
Measurement standards and performance validation of diffuse optical monitoring techniques in neurocritical care patients

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, physiological monitoring, data quality assessment.

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

Continuous monitoring of cerebral blood flow and oxygenation is critical in neurocritical care, yet traditional methods have significant limitations. Diffuse optical (DO) techniques offer promising non-invasive alternatives, but their clinical adoption requires rigorous validation and standardization. A key challenge is understanding how heterogeneous superficial skin optical properties influence measurement accuracy across diverse patient populations.

This project will be conducted at ICFO's Medical Optics group in close collaboration with Vall d'Hebron Institut de Recerca. This partnership provides access to clinical expertise, patient cohorts, and a translational research framework essential for advancing optical monitoring technologies from laboratory to clinical implementation.

The research utilizes a hybrid optical device previously developed at ICFO that combines two complementary near-infrared techniques: time-domain diffuse optical spectroscopy (TD-DOS/TRS) and diffuse correlation spectroscopy (DCS). TRS quantifies tissue oxygenation and total hemoglobin concentration by measuring absorption and scattering of near-infrared photons as they traverse deep tissue, while DCS measures microvascular blood flow by analyzing laser speckle fluctuations induced by red blood cell movement. Together, these techniques provide complementary physiological information about hemodynamics, oxygen transport, and metabolism.

The project addresses a critical gap in measurement standardization by examining how superficial skin optical properties systematically influence DCS and TRS signals. The student will work at the intersection of photonics and medicine, analyzing real clinical data from patients at Vall d'Hebron Hospital to establish measurement standards for these techniques. The student may also participate in clinical data collection, gaining hands-on experience with research protocols, patient interactions, and the translation of photonic technologies into healthcare settings.

Clinical data was collected for two distinct patient populations with neurological conditions: adults with idiopathic normal pressure hydrocephalus (iNPH) and infants with apparently arrested hydrocephalus (AAH) and/or craniosynostosis. The student will process optical signals, compare different skin characterization approaches, and perform statistical analyses to identify correlations between skin properties and measurement signals.

Establishing how patient-specific skin properties affect optical measurements is essential for developing robust calibration methods and ensuring measurement accuracy across diverse populations. Understanding these relationships will enable more accurate monitoring and facilitate development of personalized correction algorithms. This standardization work will support clinical studies and provide the evidence base necessary for integrating these emerging neurocritical care technologies into clinical practice, ultimately advancing the broader clinical translation of diffuse optical technologies.

2. Objectives (maximum 1 page):

The primary goal of this project is to establish measurement standards and validate the performance of diffuse optical monitoring techniques in neurocritical care by characterizing how tissue optical properties influence measurement accuracy across diverse patient populations.

Specific Objectives:

1. Characterize the performance of diffuse optical techniques in neurocritical care: Investigate how skin optical properties systematically affect measurement signals from both time-resolved spectroscopy (TRS) and diffuse correlation spectroscopy (DCS) modalities.

- Analyze how variations in skin optical properties affect signals from both TRS and DCS modalities
- Identify systematic relationships between tissue characteristics and measurement parameters across the patient cohort

2. Compare and validate sensors for measuring superficial skin optical properties: Compare two distinct approaches for assessing tissue optical properties: classification scale and quantitative optical sensors.

- Assess the correlation between each characterization method and actual optical measurement variability
- Determine which approach provides more clinically relevant information for correcting or interpreting optical signals

3. Establish Standardized Clinical Protocols: Propose best practices for optical measurements accounting for tissue property variations, including recommendations for sensor selection for tissue characterization, and potential correction factors or calibration approaches to improve measurement accuracy across diverse populations.

Training and Skills Development: The student will develop expertise in biomedical optics, near-infrared spectroscopy, and data analysis algorithms. When possible, participation in hospital-based measurements will provide hands-on experience with clinical research protocols.

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.
  - Strong motivation and curiosity are as important as technical background.