Open Internship / Master's Thesis Project

Embedded Control for Next-Generation Neurosurgical Polarimetric Imaging

Neuro Robotics Group at the ARTORG Center for Biomedical Engineering Research & the Department of Neurosurgery

University of Bern & University Hospital Bern

The **HORAO project** develops an intelligent surgical microscope based on polarization imaging to support real-time, label-free differentiation between healthy brain tissue and tumour tissue during neurosurgery. The team consists of researchers from the **Department of Neurosurgery at Inselspital** and the **Neuro Robotics Group** at the **ARTORG Center** for biomedical engineering research at the University of Bern.

Project background: Our interdisciplinary team is developing polarization-based imaging technology for real-time, label-free, and non-contact assessment of brain tissue during surgery. The new platform combines high-speed cameras, polarization control, image processing, and robotic assistance. The current system supports real-time image acquisition and visualization, while ex vivo studies have demonstrated the potential of polarimetric imaging for quantitative brain-tissue characterization [1, 2]. However, its control and synchronization architecture was not designed for compact, fully integrated, and robot-assisted operation. We are now developing new strategies for intraoperative optical assessment of brain tissue, focusing on acquisition speed, measurement fidelity, and surgical integration. Your project will be part of the next-generation instrumentation platform for intraoperative polarization-based imaging currently being developed at Inselspital and the University of Bern.

Project Aim: The objective of this project is to develop the embedded-control and synchronized-acquisition architecture of the instrument. You will systematically investigate how the allocation of timing and control functions between a microcontroller and a Linux-based acquisition computer, together with the selection of communication and triggering strategies, affects synchronization accuracy, latency, timing jitter, dropped frames, and long-term acquisition stability. You will quantitatively compare alternative configurations to identify the architecture that best balances deterministic timing, reliability, modularity, and acquisition speed. Based on these findings, the selected architecture will be integrated with the image-processing pipeline and robotic workflow.

Materials and Methods: The project will develop and validate an integrated acquisition and hardware-control framework for the imaging system. Acquisition routines will be implemented in Python and/or C/C++, together with a microcontroller-based timing system coordinating the high-speed cameras, triggering electronics, illumination, and other optical subsystems. Suitable hardware interfaces and communication protocols will be implemented and evaluated to enable deterministic synchronization across instrument components. System performance will be quantitatively characterized in terms of latency, timing jitter, dropped frames, and long-term acquisition stability. The control framework will be interfaced with the image-processing pipeline and robotic workflows, and the complete acquisition sequence will be validated using calibrated samples and selected biological specimens. Software modules, hardware interfaces, and diagnostic procedures will be documented to support reproducibility, troubleshooting, and subsequent system development.

Your profile: Master's students in biomedical engineering, embedded systems, electrical or computer engineering, mechatronics, robotics, applied physics, or a related discipline. Experience with Python and/or C/C++, Linux, microcontrollers, digital electronics, camera SDKs, Ethernet communication, hardware triggering, ROS2, or real-time systems is advantageous. Candidates are not expected to have experience in all these areas; If you have a strong background in one or more of them and an interest in developing complementary skills you are encouraged to apply.

Supervisors:
Dr. Omar Rodríguez-Núñez
Prof. Dr. Manuela Eugster

Institutions:
Department of Neurosurgery, Inselspital Bern
ARTORG Center for Biomedical Research, University of Bern

References:

[1] É. Gros, O. Rodríguez-Núñez, L. Felger, et al., 'Characterization of polarimetric properties in various brain tumor types using wide-field imaging Mueller polarimetry,' IEEE TMI, vol. 43, no. 12, pp. 4120--4132, 2024.

[2] C. Hahne, I. Diaz, O. Rodríguez-Núñez, et al., 'Polarimetric feature analysis of matrices for brain tumor image segmentation,' Optics Express, vol. 33, pp. 43379--43392, 2025.

Start date: Upon agreement.
Workplace: HORAO Lab at the Neurosurgery Department & ARTORG Center (Murtenstrasse 50) on the InselSpital Campus.

Apply for this project by sending your CV, diplomas and course transcripts to omar.rodrigueznunez@insel.ch.

UNIVERSITY OF BERN

ARTORG CENTER
BIOMEDICAL ENGINEERING RESEARCH