Open Internship / Master's Thesis Project

Automated Zoom and Autofocus for Robotic Neurosurgical 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: Intraoperative optical imaging must maintain stable image quality despite changes in working distance, magnification, field of view, tissue geometry, and robotic viewpoint. Our interdisciplinary team is developing a real-time, label-free, and non-contact polarization-based imaging platform for intraoperative tissue analysis combining 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. We are now developing a more compact, robust, and automated system. You will work with an existing imaging platform and motorized optical components to achieve fast and repeatable autofocus while preserving the conditions required for polarimetric measurements.

Project Aim: The objective of this project is to design, develop, and validate an automated motorized zoom and autofocus module for the next-generation imaging system. You will systematically investigate how the choice of autofocus metric and search strategy, together with changes in magnification, working distance, and robotic viewpoint, affects focusing accuracy, convergence time, repeatability, and polarimetric image stability. Alternative approaches will be quantitatively compared to identify suitable operating strategies for robust imaging under changing acquisition conditions. You will combine optical design, motor control, image-based autofocus, and optomechanical optimization. The module will be integrated with the polarization state generator, polarization state analyzer, image-acquisition pipeline, and robotic workflow.

Materials and Methods: The project will begin by defining the optical, mechanical, and control requirements of the module and characterizing the available motorized zoom and focus components. Linux-based software interfaces will then be developed to coordinate motor control with image acquisition. Different autofocus metrics and search strategies will be implemented and systematically compared under changes in magnification, working distance, and robotic viewpoint. The relationships between motor position, magnification, field of view, focus, and working distance will be experimentally calibrated. Optical modelling using Zemax OpticStudio or comparable tools may support the optimization of the imaging configuration, with guidance provided as needed. Performance will be quantitatively evaluated in terms of focusing accuracy, convergence time, repeatability, and polarimetric image stability. Finally, the complete module will be validated using reference targets, optical phantoms, and selected biological specimens.

Expected outcomes: The project is expected to deliver a functional motor-control interface, a calibrated zoom and focus model, a quantitative comparison of autofocus approaches under changing imaging conditions, an automated autofocus algorithm, optomechanical design recommendations, and an experimental demonstration of the integrated module.

Your profile: Master's students in biomedical engineering, optical engineering, photonics, 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

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.

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