Master thesis proposal

Design and development of a partial Mueller matrix macroscope for visualization of brain tissue

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Background. During neurooncological surgery a clear visualization and differentiation of healthy and diseased tissue is essential for radical resection and preservation of neurological functions. However, even with modern surgical microscopes it is still difficult for surgeons to distinguish healthy brain tissue from tumor tissue. Instead of focusing on detection of the tumor, the HORAO project aims to visualize the brain's microarchitecture, during brain tumor surgery, since the absence of fibers would imply tumor tissue. Our experimental studies of brain specimens with polarized light have already demonstrated the wide-field imaging Mueller polarimetry (IMP) as a promising technique for tissue discrimination and in-plane brain fiber tracking in an interventional setup, based on maps of depolarization, linear retardance and azimuth of the optical axis. Our current system uses the Mueller matrix (MM) for describing the interaction of polarized light with biomedical samples, the tissue characterization requires 16 intensity measurements to obtain the MM and data post-processing decomposition algorithms for the extraction of the polarimetric parameters.

It has been showed that in the case of the reduced form of the Mueller matrix yields results very close to those obtained with more complex decomposition algorithms applied to a complete Mueller matrix. Which could simplify the measurement system and address the crucial goal of the HORAO project to integrate the IMP into the in vivo neurosurgical workflow.

Aim. For this master theses project, you will design the new partial polarimetric imaging system by targeting a simplified and real-time acquisition instrument. You will built and carry out the proof of concept of the new instrument using brain specimens. Finally, you will validate the partial polarimeter comparing results extracted from other IMP

Materials and Methods. Your biggest challenge will be the optical design and develop the polarization state generator (PSG), and the synchronization with the polarization state analyzer (PSA). You will learn how to calibrate and optimize polarimetric instruments efficiently using several methods.

You will acquire and increase your knowledge in optical design, polarimetry, optoelectronics, and programming. You will have the opportunity to work in the HORAO Lab on Inselspital campus, in close collaboration with experts in Optical Instrumentation, Images Processing, Neurosurgeons and Neuropathologists

Proposed duration: 6 months

Applicant profile: Master's student with focus in physics/photonics/biomedical engineering.

Required skills and interests: Knowledge in electronics, optics, and interest in biomedical applications. Hands on working experience preferable and programming.

For more information, please contact Omar Rodríguez (omar.rodrigueznunez@insel.ch) or David Hasler (david.hasler@insel.ch).