MULTIMODAL ALIGNMENT OF POLARIMETRIC AND HISTOLOGICAL IMAGES FOR BRAIN TISSUE CHARACTERIZATION

Éléa Gros,*[1] Omar Rodríguez-Núñez,[2] Stefano Moriconi,[3] Richard McKinley,[3] Ekkehard Hewer,[4] Théotim Lucas,[5] Erik Vassella,[1] Christopher Hahne,[3] Philippe Schucht,[2] Tatiana Novikova,[5] Theoni Maragkou[1]

[1] *University of Bern, Institute of Tissue Medicine and Pathology, 3008 Bern, Switzerland*
[2] *Bern University Hospital, Inselspital, Department of Neurosurgery, 3010 Bern, Switzerland*
[3] *Bern University Hospital, University Institute of Diagnostic and Interventional Neuroradiology, Support Center for Advanced Neuroimaging (SCAN), 3010 Bern, Switzerland*
[4] *Lausanne University Hospital, Institute of Pathology, 1011 Lausanne, Switzerland*
[5] *Ecole Polytechnique, IP Paris, CNRS, LPICM, 91120 Palaiseau, France*
* elearomy.gros@unibe.ch

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Imaging Mueller polarimetry has demonstrated strong potential for label-free characterization of brain tissue microstructure, particularly in distinguishing neoplastic from healthy tissue. However, algorithm development and validation remain hindered by the scarcity of annotated datasets containing both tumor core and surrounding non-neoplastic regions, especially in neurosurgical samples. To overcome this limitation, we developed a multimodal imaging pipeline based on autopsy-derived formalin-fixed whole-brain sections, which include tumor, infiltration zones, and healthy tissue.

An image reconstruction pipeline was developed to assemble whole-brain section polarimetric images from a series of overlapping tiles, acquired in reflection mode. These polarimetric tiles are aligned to a macroscopic reference image using feature-based matching and non-rigid deformation. To provide histological ground truth, we reconstructed high-resolution maps from fragmented H&E-stained sections and co-registered them to the same reference. Additional stainings, such as LFB-PAS and neurofilament, were aligned to the H&E stainings and to the reference image.

The resulting datasets offer spatial correspondence across modalities and support the generation of detailed ground truth maps for training and evaluating segmentation models. While this work is validated on healthy tissue, the framework is designed to scale toward annotated tumor-border datasets. This opens new possibilities for machine learning-based delineation of tumor margins and enhances the translational potential of MPI in neurosurgical guidance.

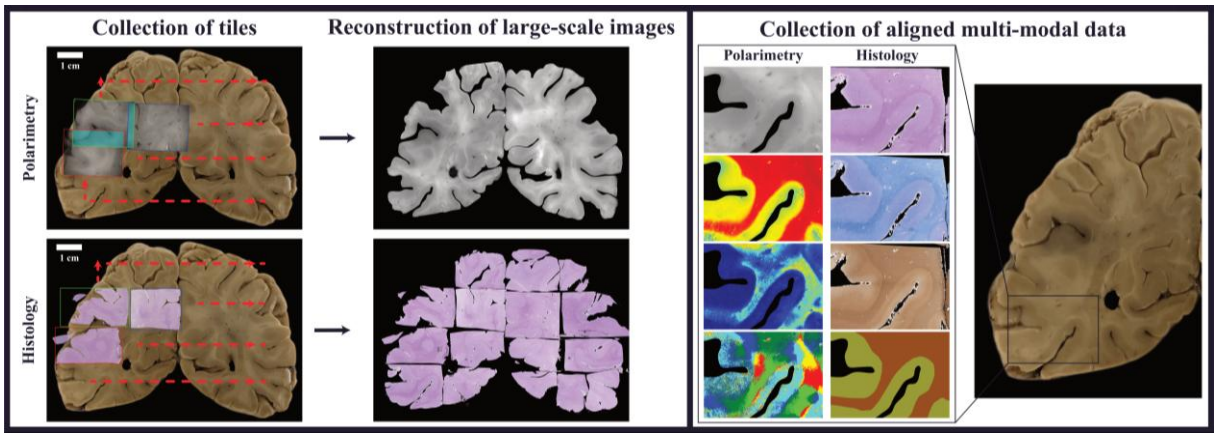

Fig. 1: Graphical abstract of the image reconstruction pipeline. Polarimetric and histological tiles were reconstructed in parrallel, yielding a collection of spatially aligned multi-modal data.