Evolution of Polarimetric Properties of Brain Tissue With Time Following Formalin Fixation

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Keywords: brain tissue, polarimetry, formalin fixation, image segmentation, shrinkage

Gliomas are often highly infiltrative brain tumors whose borders are difficult to detect during neurosurgery. The combination of Imaging Mueller Polarimetry (IMP) and Machine Learning (ML) appears as a promising technique that could be used to identify the fiber tracts in white matter, and hence differentiate healthy from neoplastic tissue in real time during neurosurgery.
In this study, we assessed the changes in polarimetric properties of brain tissue after formalin fixation (FF). This parameter is crucial for succeeding in the transfer of ML models from fixed tissue, commonly used to create large datasets for training ML algorithms, to fresh tissue, the final application domain.
The results showed that depolarization increased in gray matter and remained constant in white matter, while linear retardance decreased similarly in both tissue types. Importantly, the contrast between white and gray matter remained preserved, and fiber tracking was still feasible after FF revealing similar results as for fresh tissue. The width of the uncertainty region, in which the segmentation ground truth is ambiguous, was also estimated between grey and white matter, indicating that tissue shrinkage caused by FF had no effect on the width of the uncertainty region.
The presence of similar polarimetric properties in both fresh and fixed brain tissues suggests a high potential for transfer learning.

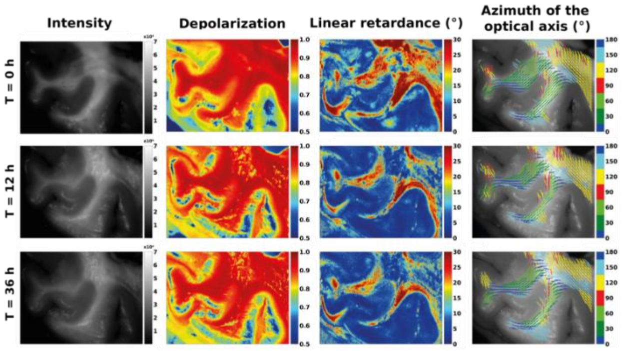

Fig. 1: Polarimetric maps calculated from the experimental MM images of coronal sections of pig brains at different fixation time points (0 hrs, +12 hrs and+36 hrs). The gray-scale reflected intensity images (1st column) and the polarimetric maps of depolarization (2nd column), linear retardance (3rd column) and azimuth of the optical axis (4th column) are represented as well. Similar polarimetric properties can be observed.

[1]. Gros, Romain, et al. "Effects of formalin fixation on polarimetric properties of brain tissue: fresh or fixed?." *Neurophotonics* 10.2 (2023): 025009-025009.