Towards Multispectral Wide-Field Imaging Mueller Polarimetry for Intraoperative Brain Tumor Visualization

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Incomplete surgical resection of gliomas remains a major clinical challenge due to the poor intraoperative visibility of tumor margins [1, 2]. The HORAO project addresses this limitation by developing a wide-field imaging Mueller polarimetry system that leverages the optical properties of brain tissue, where healthy white matter exhibits strong linear birefringence and tumor-infiltrated tissue shows reduced retardance and increased depolarization [1, 3]. The wavelength-dependent nature of tissue optical properties necessitates multispectral capabilities, as demonstrated by the improved classification accuracy and structural insights afforded by multi-wavelength analysis [4].

This work presents the instrumental and software upgrades required to extend the system to RGB-based multispectral polarimetry. A spectral characterization of Liquid Crystal Variable Retarders (LCVRs) was performed, identifying 500–700 nm as the optimal operating range for stable polarization control. A Python-based graphical interface was developed to unify the control of the LCVRs, RGB polarimetric cameras, and a motorized calibration slider, streamlining the calibration workflow [5]. The detection system was upgraded with dual RGB Division-of-Focal-Plane polarimetric cameras, enabling snapshot acquisition of 12 data channels (3 colors × 4 polarization angles) [6,7]. A comparative analysis of illumination strategies demonstrated that discrete RGB LEDs provide superior optical power efficiency and temporal stability compared to filtered broadband sources, particularly in reflection-mode imaging.

These developments establish the instrumental and software foundation for high-speed, spectrally resolved polarimetric imaging system and represent a critical step toward enabling real-time, intraoperative guidance in neurosurgery. The full implementation and clinical integration of the multispectral system will be pursued in future work.

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