CHARACTERIZING BIOLOGICAL SAMPLES THROUGH POLARIZATION-BASED METHODS

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Mueller-Stokes based methods have emerged as powerful tools for enhancing tissue imaging and supporting AI-based classification of biological structures and pathologies. Mueller polarimetry is particularly well-suited for studying depolarizing samples—such as biological tissues—thanks to its ability to capture the complete polarimetric response of a sample. Biological tissues exhibit three main polarimetric properties: dichroism, retardance, and depolarization, which vary depending on tissue type and condition. Among sample polarimetric features, depolarization has proven to be especially suitable for studying biological tissues. In fact, depolarizing observables can significantly enhance image contrast, surpassing what intensity-based methods can achieve.

In this article, we present some of the latest results obtained in this context by the Optics Group at the Universitat Autònoma de Barcelona (UAB), with particular attention to depolarization metrics such as the Indices of Polarimetric Purity (IPP) and certain coefficients derived from the Arrow decomposition. Both are extracted from the Mueller matrix and offer deep insight into depolarization behavior. The IPP quantifies how different polarization states are affected by a sample, distinguishing between isotropic and anisotropic depolarization. The Arrow decomposition, based on singular value analysis, reveals structural features linked to depolarization mechanisms.

These observables not only provide physically interpretable information but also enable the creation of targeted polarimetric filters that enhance specific structural features while minimizing fully depolarizing content that masks meaningful physical insights. Their practical impact is illustrated in Fig. 1, which shows a transverse section of cattle left ventricle. Fig. 1(a) presents the original intensity image, where structural details are barely visible. In Fig. 1(b), the same sample is visualized using the P1 channel (from the IPP), revealing subtle contrasts. Finally, Fig. 1(c) shows the result of applying a polarimetric filter based on depolarization characteristics, which significantly improves the visibility of internal tissue structures and highlights the potential of these techniques for biomedical imaging.

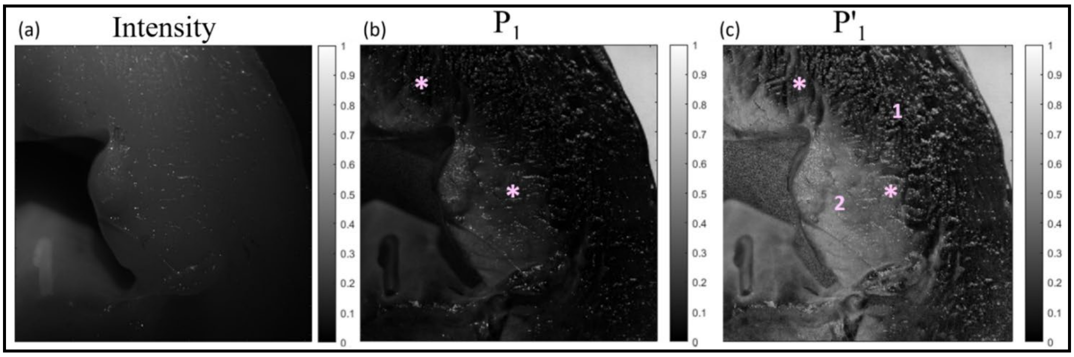

Fig. 1: Comparison between (a) intensity and P1 observable, (b) before and (c) after applying an isotropic depolarization filter on a cattle left ventricle section. (1) marks myocardial tissue; (2) subendocardial tissue. Pink asterisks indicate their boundary. Image adapted from [1].

[1]. M. Canabal-Carbia et al., Proc. SPIE **13322**, 1332202 (2025).