Advanced Polarization Imaging Techniques for Microstructural Validation of Diffusion MRI

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Background
Magnetic resonance imaging (MRI) is a non-invasive method to image organs, tissue, or skeletal systems deep within the body. A primary challenge with MRI is that a large amount of mathematical modeling is required to generate the resulting images. As a result, there is a strong need for robust validation techniques for MRI imaging. In particular, diffusion MRI is gaining popularity as an imaging technique in which physiological mechanisms are determined by the mobility of water within the body. A primary challenge with MRI is that a method to image organs, tissue, or skeletal systems deep within the body.

Methods
- Five ferret brains were imaged using diffusion MRI given similarity to human physiology.
- For each brain, three regions with different microscale features were imaged using a custom Nikon polarimeter.
- Polarimetric data is then processed to output the Mueller matrices through MATLAB.
- Quantification is then conducted by using the Mueller Matrices to identify depolarization, diattenuation and retardance (Fig. 3-4).

Objective
Our overarching goal is to develop robust validation techniques for diffusion MRI scans using polarization imaging.

Motivation
Polarization imaging is an optical technique that probes microstructural features and shows promise for diffusion MRI validation. A polarimeter will use monochromatic light that passes through polarizing plates, creating a polarized beam that rotates as it passes through a given sample (Fig. 2-3). By doing this it can measure polarization effects such as depolarization, retardation, and diattenuation, which are linked to tissue microstructure and orientation.

Conclusion
Preliminary results suggest that the polarization parameters extracted from the imaging system correlate with microstructural features (Fig 6-7). Next steps are to compare quantitative values between complex Mueller polarimeter to conventional polarized light imaging methods, and to correlate to diffusion MRI data to assess suitability for validation. We also are examining the use of polarization imaging when applied to samples of human brain tissue.

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References