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Robust optimization of diffusion-weighted MRI protocols used for fiber reconstruction

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Abstract. Diffusion-weighted imaging (DWI) is a magnetic resonance imaging (MRI) technique that employs diffusion-encoding gradients to sensitize the signal to the diffusion of water molecules. DWI allows the noninvasive and quantitative probing of opaque structures such as fibrous soft tissues. Model-based DWI post-processing algorithms, such as diffusion tensor imaging (DTI), solve an inverse problem to estimate from a series of DWI data a set of model parameters representing the diffusion process and the environment of the water molecules. DWI models connect the model parameters (e.g., fiber orientations for fibrous soft tissues) with the experimental parameters (e.g., strengths and directions of the 3-D diffusion-encoding gradients). For spinal cord injuries and skeletal muscle characterization, the fiber orientations within the imaged region can be approximately known *a priori* using localizer images. Then, we propose and implement a model-based robust optimization framework for two axisymmetric diffusion models, producing robust DWI protocols with respect to the approximate knowledge of the fiber orientations within the images, thereby reducing the uncertainty in the parameter estimates caused by experimental noise. Our goal is to improve the yield of quantitative DWI diagnostics used in clinical and preclinical trials by minimizing the experimental uncertainty.