Parameter Estimation Analysis of Diffusion-Weighted MRI Protocols Used for Soft Tissue Fiber Reconstruction

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Abstract

Quantitative biomedical image analysis often leads to inverse problems in the sense that biophysically relevant parameters are being estimated from a series of images when imaging techniques and engineering disciplines are integrated into the image post-processing. Magnetic Resonance Imaging (MRI) can thus be used in combination with solid mechanics (e.g., measurements of Young's modulus in soft tissues) and transport phenomena (e.g., measurements of diffusion characteristics in liquids and soft tissues). In the study of brain development and diseases, diffusion-weighted MRI can provide the distribution and orientations of neuron bundles inside elementary volumes, as well as estimates of the diffusion characteristics within brain compartments (axons, extra-axonal medium). Several models exist to recover these physiologically relevant parameters, and more are being developed. However, the mathematics of the inverse problems themselves has not been systematically investigated yet. The proper computation and analysis of the sensitivity coefficients for the estimated parameters can help reveal which models are promising and which need to be either discarded or revised, and design optimal experimental protocols.

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