JOHNS HOPKINS
BIOMEDICAL ENGINEERING

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Likelihood Analysis of Diffusion Weighted MRI

Bennett Landman, MS
Ph.D. Candidate
Department of Biomedical Engineering
Johns Hopkins University

Abstract: Diffusion weighted magnetic resonance imaging (MRI) provides unique insight into in vivo tissue structure through contrasts sensitive to the directional diffusion of water. Voxel-wise modeling of the diffusion process has been widely applied to characterize cytoarchitectural changes related to white matter damage in the brain and spinal cord. For investigation of brains, diffusion tensor imaging (DTI) is widely used in research and is being adopted in the clinic, while q-space imaging is emerging as a valuable source for biomarkers in the spinal cord. Clinical imaging studies typically suffer from low signal-to-noise ratios, and consequently, computed model parameters tend to systematically diverge from their true values (increased bias in addition to increased variability), which leads to artifactual changes that confound clinically significant ones. To address these concerns, we present a maximum likelihood approach for estimating tensors from DTI data that specifically addresses the joint likelihood of all observations given a tensor model. We generalize this approach and demonstrate a robust M-estimator for q-space MRI. Finally, we present a simple, yet efficient, method for estimating spatially varying noise fields from clinical diffusion weighted MRI. These methods improve the reliability of diffusion models and increase tissue contrast. In turn, they enable more detailed exploration of the tissue structure than prior approaches and may allow acquisitions at higher spatial resolution.

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