Diffusion Propagator Imaging by Model-driven Regularization

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Abstract: Diffusion-weighted magnetic resonance imaging is able to non-invasively visualize the fibrous structure of the human brain white matter. The robust and accurate estimation of the ensemble average diffusion propagator (EAP), based on diffusion-sensitized magnetic resonance images, is an important preprocessing step for tractography algorithms or any other derived statistical analysis. In this work, we propose a new regularization strategy for EAP estimation that bridges the gap between model-based and model-free approaches. The idea is to use a Gaussian prior density which is especially designed for the diffusion signal in the human brain. Therefore, we propose to compute covariance statistics over a family of functions that are typical for human brain white matter. As the considered functions and the physically observed EAPs are usually smooth and local the Gauss-Laguerre basis system is used for realization. With this methodology it is possible to estimate the whole 3D EAP from a single q-shell measurement. In comparison to usual extrapolation strategies our approach is linear in the measured signal which makes it more robust to noise and partial volume effects. We will show this in synthetic and in-vivo experiments.