The 3d space varying coefficient model and its influence on diffusion tensor estimation and fiber tractography

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One major benefit from magnetic resonance diffusion tensor imaging (DTI) is the in vivo identification of neural fiber trajectories within the human brain. The standard processing cascade from raw data to reconstructed fibers involves manifold steps that may lead to uncontrolled error accumulation. Aiming at a unified framework for diffusion tensor estimation, regularization and interpolation a space varying coefficient model (SVCM) was developed on the basis of penalized B-splines. The use of multiple 3d space varying coefficient surfaces and the large dimensions of realistic datasets represent however severe challenges for the implementation in R (R Development Core Team, 2007). These shortcomings concerning computational time and storage allocation could be overcome by exploiting matrix sparsity and efficient model approximation. Superiority of the B-spline based SVCM to the standard approach of sequential data processing was demonstrable from simulation studies in terms of the precision and accuracy of the individual tensor elements. The integration with a probabilistic fiber tractography algorithm and application on real brain data revealed that the unified approach is at least equivalent to the serial application of voxelwise estimation, smoothing and interpolation. From the error analysis using boxplots and visual inspection the conclusion was drawn that both the standard approach and the B-spline based SVCM may suffer from low local adaptivity. Improved results are expected from replacing the B-spline basis functions with wavelet basis functions (on-going research). Regarding the qualitative evaluation of fiber tracts, the smoothing rate appears to be most important for admissable fiber reconstruction.