Resolution-Dependent Differences in Fiber Tracking and Quantification

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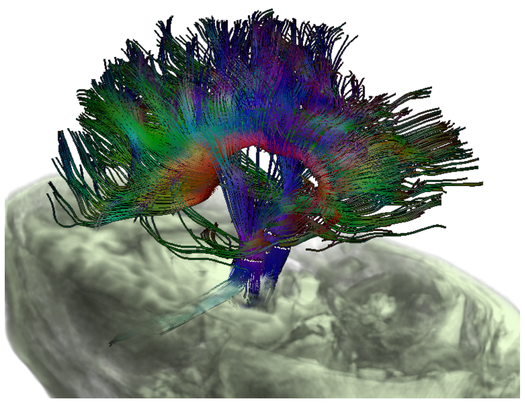
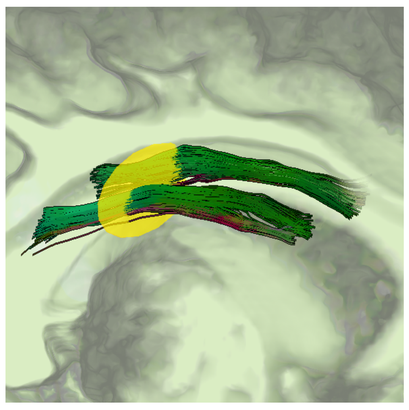
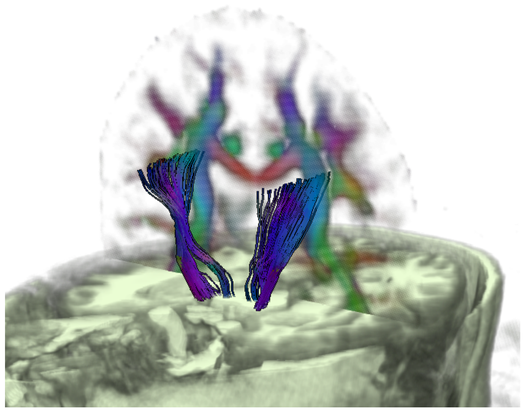

Fiber tracking result


Part of cingulum


Part of pyramidal tracts

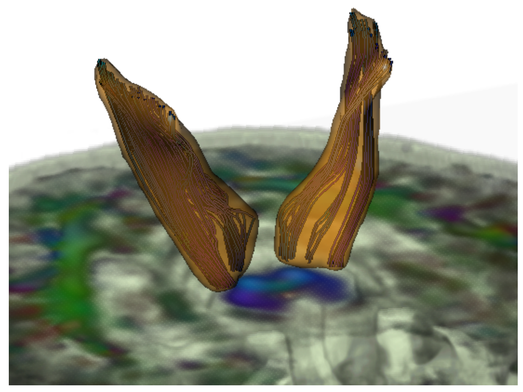

Sheath enclosing pyramidal tracts

Fig. 1: The image resolution of a DTI data set influences quantitative DTI measurements. We demonstrate this by quantifying DTI parameters along fiber bundles and by measuring the volume of their sheath. For quantification, we extract parts of the cingulum as well as parts of the pyramidal tracts.

Abstract

We demonstrate how fiber tracking [1] and quantification [2] of DTI parameters depend on the resolution of the underlying DTI data. For measuring the resulting differences, we propose a novel algorithm that allows for an automatic quantification of MR DTI parameters along arbitrarily oriented fiber bundles as well as an approach for quickly measuring the volume of the sheath enclosing a bundle.

Methods

Fiber acquisition: DTI data sets were acquired at four different image resolutions (Tab. 1). Using a deflection-based tracking algorithm and spectral fiber clustering (Fig. 2) [4], we reconstructed parts of the cingulum as well as parts of the pyramidal tracts for all data sets.

Quantification along fiber tracts: For a given fiber bundle, reference planes were determined as functions of the local curvature (Fig. 3). For each plane, a mean FA value was computed by averaging the FA values in the points of the fibers closest to the plane [3].

Volume of sheath: The sheath of a fiber bundle can be computed by a neighboring cells algorithm which is based on the well-known marching cubes technique where an image volume is scanned by discretizing it into cells.

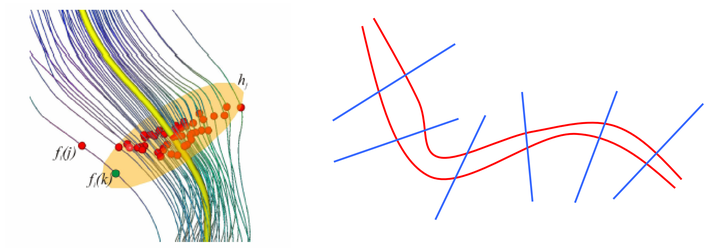


Fig. 3: Reference planes are determined along a bundle as functions of the local curvature.

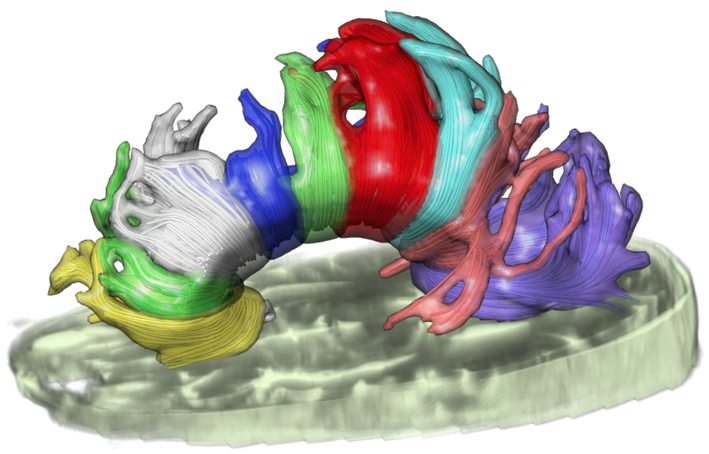


Fig. 2: Example for spectral fiber clustering [4]. It can be used for a robust extraction of fiber bundles at different image resolutions.

Results

Parameters like average FA, the volume of the sheath, or the number of fibers depend on the resolution (Fig. 4). The variability also depends on the fiber bundle (Tab. 1).

In high resolution data sets, FA is remarkably higher in the cingulum but not in the pyramidal tracts. This is due to the fact that FA values at a certain position of the cingulum are much more inhomogeneous compared to the pyramidal tract.

When lowering resolution, the volume of the sheath changes more for the pyramidal tract. This is due to the fact that bundles in isotropic surroundings are assessed too large whereas fibers in inhomogeneous areas are not tracked at borders.

Conclusions

Our initial experiments have shown that resolution-dependent differences in fiber tracking and quantification are differently pronounced in different fiber bundles. Thus, it should be examined whether our technique could be used to model the uncertainty associated with a certain image resolution and with the surrounding tissue of a certain fiber bundle. Moreover, our technique may support the decision which resolution should be used when acquiring MR-DTI images.

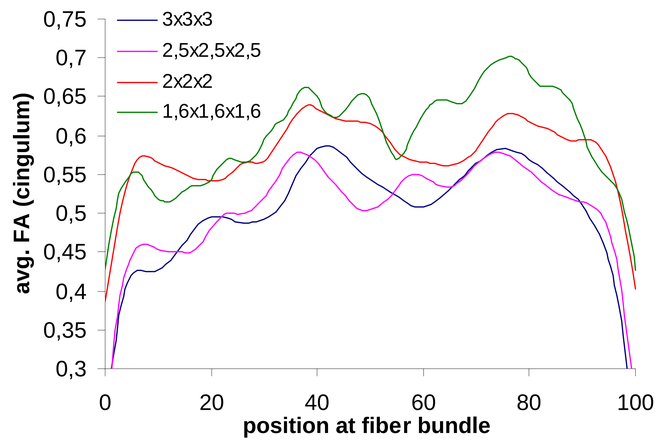


Fig. 4: FA along cingulum at different resolutions.

Resolution (mm^3)	Volume per voxel (mm^3)	Acquisition time (min.)	# Fibers (cg/pyt)	Average FA (cg/pyt)	Volume of sheath (cg/pyt)
1.6×1.6×1.6	4.096	16	484 / 442	0.600 / 0.602	5680 / 16,840
2×2×2	8	12	472 / 442	0.576 / 0.600	5680 / 19,376
2.5×2.5×2.5	15.625	10	454 / 384	0.503 / 0.588	5248 / 16,416
3×3×3	27	8	392 / 546	0.498 / 0.588	5064 / 21,648

Tab. 1: Number of fibers, average FA, and volume of the sheath are shown for different resolutions of the DTI data for the cingulum (cg) and the pyramidal tract (pyt).

References

[1] S. Mori et al., Ann Neurol. 1999, 45:265–269
[2] M. Niethammer et al., MICCAI 2006, 252–259
[3] J. Klein et al, Proc. BVM, 2007, 272–276
[4] J. Klein et al., Proc. SPIE, 2007, to appear.