SUPER-RESOLUTION MULTI-FASCICLE IMAGING REVEALS THE PRESENCE OF BOTH RADIAL AND TANGENTIAL DIFFUSION IN THE MATURE CORTEX USING A CLINICAL SCANNER

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PURPOSE.

- Radial diffusion has been reported at early stages in cortical development
- Previous studies: diffusion tensor imaging, an over-simplified model
- McNab et al²: while mostly radial diffusion persists, tangential diffusion may exist in very particular cortex areas.

ACQUISITION. Orthogonal thick-slices acquisitions, high in-plane resolution

+ For each orientation, pair of b=0 with opposite phase encoding directions, Geometric & intensity distortion compensation for each DW image

Gradient encoding scheme: Cube and Sphere (CUSP)

- Projection of a two-shell HARDI
- Gradient orientations maximally separated
- Timings parameters Δ and δ defined by the inner-shell
- High b-values up to 3 binomial
- Low echo time (TE)

Image multiple non-zero b-values with high SNR

Necessary to estimate a mixture of tensors

Reconstruction = Compute the inverse problem:
Reconstruction at 1x1x1mm³
(Number of HR voxels to estimate matches the number of LR observations)

Forward Model:

\[ y_k = D_k B_k M_k x + \epsilon_k \]

Residual error

Unknown HR Volume

MULTI-FASCICLE MODEL ESTIMATION

Fractions of occupancy

Signal arising from unrestricted diffusion

Signal arising from each fascicle

+ Estimation of the number of fascicles at each voxel: minimization of the generalization error

(Scherrer et al, 2012A)

RESULTS

STG: Superior Temporal Gyrus

MTG: Middle Temporal Gyrus

PRG: Precentral Gyrus

DISCUSSION

Super-resolution reconstruction from anisotropic images

- Reduces the scanner burden, achieves higher SNR.
- Reconstruction with an image generative model
- Does sample higher-frequencies in k-space

⇒ In contrast to Tract-Density Imaging, the imaged resolution is increased

Quantitative super-resolution approach

We demonstrate that, in the mature cortex, both radial and tangential diffusion can be observed using a clinical scanner.

Future work: using multi-slice (multi-band) acquisitions: 15min acquisition?

Impact of missing the corners of k-space during the SRR?