Diffusion MRI: Tools and Applications

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Diffusion Weighted Imaging

Diffusion Sensitizing Gradients
Diffusion Weighted Imaging

\[ S_i = S_0 e^{-b\hat{g}_i^T D\hat{g}_i} \]

(Stejskal and Tanner 1965, Basser 1994)
Diffusion Tensor Imaging

\[ S_i = S_0 e^{-b \hat{g}^T D \hat{g}_i} \]

\[
D = \begin{bmatrix}
D_{xx} & D_{xy} & D_{xz} \\
D_{yx} & D_{yy} & D_{yz} \\
D_{zx} & D_{zy} & D_{zz}
\end{bmatrix}
\]
DTI Analysis

- Algorithms
- Tools
- Applications
NA-MIC DTI Algorithms

- DWI Filtering
- DTI Resampling
- DTI Segmentation
- DTI Registration
- Fiber Tract Clustering
- Fiber Tract Statistics
- Group Analysis

Images courtesy of NA-MIC Algorithms Core
Clinical Application: Neurosurgical Planning

• Incision and trajectory planning to preserve function

• 3D Visualization of tumor mass effect on white matter structures

Images courtesy of Lauren O’Donnell, PhD and Alex Golby, MD
Virtual Probing

- Movable seed point
- Interactive probing of peritumoral fiber bundles
- fMRI display in context with structural and DTI volumes

Slide courtesy of Ron Kikinis, MD and Jean-Jacques Lemaire, MD, PhD
Clinical Application: Autism Research

• A key diagnostic feature of autism is impairment in communication
• DTI analysis of the arcuate facisculus showed that white matter microstructure is affected in autism

Population-based Analysis

- Non-rigid registration of a population to a common coordinate system
- Comparison of tensor features and fiber tract geometry
- Clinical Application: Neurodevelopment

Images courtesy of Guido Gerig, PhD

DTI Tractography Validation

- Pilot study on the quantitative evaluation of DTI tractography algorithms in the absence of ground truth
- Cross-comparison of different tractography approaches on five white matter fascicles
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