Diffusion Imaging Processing

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We have a fair amount of knowledge about anatomy – function correlation of the cortex. We have various types of atlases showing which cortical regions are involved in which brain functions. For the creation and usage of the maps, surface sulcal patters have played important roles as anatomical landmarks. Compared to the cortical mapping, white matter mapping has been a challenging target, because we do not have visual clues in the white matter equivalent to the sulcal patterns; it is difficult to identify a specific white matter area. For example, the vast areas of the white matter look rather homogeneous in T1 and T2-weighted images. Even in histology samples, it is not straightforward to visualize convoluted anatomy of the white matter.

This situation has changed since the introduction of diffusion imaging and diffusion tensor imaging (DTI) in '90s. [1-3] In DTI, translational motion of water molecules is measured along multiple orientations and the results are fitted to a simple 6-parameter tensor model. Although this inevitably leads to oversimplification of the underlying neuroanatomy, it can provide us with unique anatomical contrasts of the white matter, such as approximate orientations of axonal tracts within each pixel, which is not accessible by any other imaging modalities. It has been also shown that trajectories of prominent white tracts can be three-dimensionally reconstructed based on DTI results. There is a possibility that we can create an entirely new anatomical map of the white matter, which is an essential first step toward the understanding of white matter anatomy – function correlation.

In this presentation, the basic principles of DTI data processing and analysis will be explained. Emphasis will be placed on how different types of image contrasts can be generated, what type of neural architectures can be visualized, and how they can be correlated with classical anatomical definitions. Various approaches to use the results for applications studies will also be demonstrated.

References:

1. Le Bihan, D., et al., *MR imaging of intravoxel incoherent motions: application to diffusion and perfusion in neurologic disorders.* Radiology, 1986. **161**: p. 401-407.
2. Moseley, M.E., et al., *Diffusion-weighted MR imaging of anisotropic water diffusion in cat central nervous system.* Radiology, 1990. **176**: p. 439-445.
3. Basser, P.J., J. Mattiello, and D. LeBihan, *Estimation of the effective self-diffusion tensor from the NMR spin echo.* J. Magn. Reson. B, 1994. **103**: p. 247-254.