Acquisition and Reconstruction Methods for *in-vivo* Diffusion Tensor Magnetic Resonance Imaging

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Diffusion Tensor Magnetic Resonance Imaging (DTI) allows one to map the anisotropic water diffusion in biological tissue on a per-pixel basis. Over the last 15 years this technique has become the backbone of many neuroimaging experiments because DTI offers us a unique way to interrogate the integrity and orientation of brain white matter. Clinically, this can be used to track brain fibers around tumors, measure other biophysical parameters along such tracts, or just determine changes due to a pathological or congenital abnormality that would be otherwise occult on conventional structural MRI.

Despite its great potential and developmental strides, thus far, DTI is notoriously SNR-starved and very sensitive to motion. On top of spatial encoding, the encoding of the diffusion tensors (and especially its higher order variants) is rather time consuming and hence motion sensitive. Altogether, the complexity of the acquisition and reconstruction process in DTI warrants advanced algorithms to improve data veracity and throughput.

With a growing understanding of the peculiarities of DTI, investigators have focused on improving the properties of DTI by addressing issues with the Rice-Nakagami noise distribution of magnitude MR data, introducing non-linear reconstruction algorithms to reconstruct the diffusion tensor elements directly from the MR k-space data, co-registratering tensor data, and leveraging methods for sparse data acquisition and reconstruction. Above all, however, there is an increased awareness that the widely used assumption that k-space information is the Fourier transform of an image is a mere idealization, which is hard to meet in practice given likelihood of encoding inconsistencies to due to patient motion (pose and image phase changes, altered gradient direction exposure, altered susceptibility fields) and system imperfections (gradient non-linearities, magnet shim, noise figures). The objective of this presentation will be to briefly review the fundamental concept of DTI, discuss the aforementioned challenges, and then delve into potential solutions to address those.