Computational anatomy of cerebral white matter

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One of the basic principles underlying modern neuroscience is that of connectional specificity; that is, neurons in different regions of the brain do not form connections randomly but rather in a manner that facilitates the processing of information among regions with related functions. Until recently the white-matter pathways connecting neurons in differrent brain regions could only be studied invasively. The advent of diffusion-weighted magnetic resonance imaging (DW-MRI) has opened the way to the in vivo, non-invasive study of these pathways and to many exciting applications but it has also given rise to a host of technical challenges.

In this talk I will give an overview of the computational problems related to the analysis of DW-MRI data and the methods that are being developed in our lab to address some of these problems. These include a Bayesian framework for reconstructing white-matter tracts that incorporates prior information on anatomical context to obviate the need for manual intervention present in many existing tractography algorithms; an elastic registration method that aligns tracts from different subjects accurately by extracting geometrical information from a surface based morph of the cortex and diffusing it into the white matter; and our initial efforts to probe structural and functional brain connectivity jointly by integrating diffusion and functional MRI data.