ISMRM 2009
Sunrise Session "Quantitative Neuro-anatomical and functional image assessment"

Thursday Course Lecture:
Recent progress on image registration and its applications

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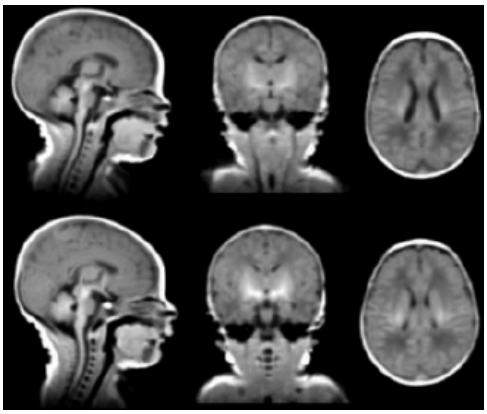
Nonlinear registration of volumetric images has become one of the most important methodologies in medical image analysis. Building of population-specific atlases, mapping of images to a common template space, automatic segmentation via the use of segmented templates, or integration of multiple image modalities are just a few of the many widely used applications. While there is still rapid progress on new methodological developments of registration tools, successful use of such technology requires understanding of some basics in order to optimally apply such tools, to avoid eventual pitfalls, and to explore new potential uses that would answer specific new research questions. As in many other scientific areas, there is no notion of a best tool that fits all purposes. Users need to choose the appropriate methodology given a specific task, which requires understanding of fundamental methodological principles and differences.

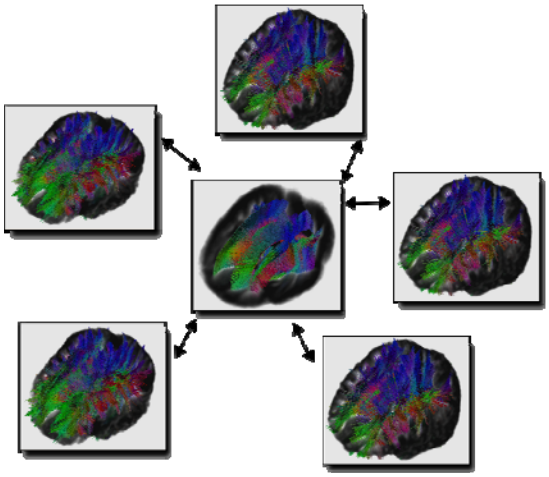


Groupwise atlas construction for the identification of neuroanatomical changes associated with preterm birth

This course will introduce the current state-of-the-art of image registration technology, discuss important conceptual differences between various algorithms and their parameter settings, and illustrate its use with the example of challenging clinical applications. In particular, we will introduce important fundamental aspects such as transformation properties (diffeomorphism, regularization, invertibility, smoothness), image similarity metrics (mutual information, normalized cross-correlation), and information derived from the deformation fields (metrics such as the deformation and strain tensor or differential operators such Jacobian, curl or divergence). We will then continue with the extension of pairwise registrations to registration of large sets of images. By introducing the general notion of averaging in terms of images rather than numbers, we will show how a registration of a population of images towards a template, which by definition is biased, can be replaced by creating the average image given a population, a procedure called unbiased atlas building. Applications of such computational anatomy tools in cross-sectional and longitudinal studies will be discussed. We will also cover new technical

challenges arising from longitudinal imaging studies, e.g. studies of the growth trajectory of the early developing brain, the neurodegeneration pattern of the aging brain, or in general monitoring disease progress.

The discussions of methodological aspects will be illustrated, among others, by recent clinical applications of automatic atlas-based segmentation, modeling of the aging brain via extension of atlas-building to regression, and population-based analysis of white matter fiber tracts via building of DTI tensor atlases.



Building of DTI Population Atlas