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Conférence Analyse d'Images
16h30 – 17h15

Variational, geometric and statistical methods for modeling brain anatomy and function

We survey the recent activities of the Odyssee Laboratory in the area of the application of mathematics to the design of models for studying brain anatomy and function. We start with the problem of reconstructing sources in MEG and EEG and discuss the variational approach we have developed for solving these inverse problems.

This motivates the need for geometric models of the head. We present a method for automatically and accurately extracting surface meshes of several tissues of the head from anatomical MR images. Anatomical connectivity can be extracted from Diffusion Tensor Magnetic Resonance Images but, in the current state of the technology, it must be preceded by a robust estimation and regularization stage. We discuss our work based on variational principles and show how the results can be used to track fibers in the white matter as geodesics in some Riemannian

space. We then go to the statistical modeling of fMRI signals from the viewpoint of their decomposition in a pseudo-deterministic and stochastic part which we then use to perform clustering of voxels in a way that is inspired by the theory of Support Vector Machines and in a way that is grounded in information theory. Multimodal image matching is discussed next in the framework of image statistics and Partial Differential Equations with an eye on registering fMRI to the anatomy. The paper ends with a discussion of a new theory of random shapes that may prove useful in building anatomical and functional atlases.

Keywords: MEG, EEG, fMRI, DT-MRI, Maxwell equations, inverse problems, segmentation, level sets, Riemannian spaces, Partial Differential Equations, Brownian motion, Diffusion tensor, Lie groups, Eikonal equation, tractography, mutual information, information theory, Kernel PCA, Information Bottleneck, retinotopy, Laplace- Beltrami operator, shape topologies, Hausdorff distance, mean shape, covariance of shapes.

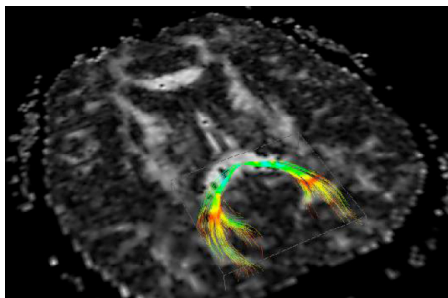


Figure 1: Inferred geodesics in the splenium of the corpus callosum (red: low anisotropy - blue: high anisotropy)

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