Master Internship Position 2020

Anatomical priors and diffusion multi-compartment models for brain white matter tractography

Supervisors: Olivier Commowick, Unité/Projet Empenn, Inria (Olivier.Commowick@inria.fr)

Location: Unité/Projet Empenn, IRISA, Campus de Beaulieu, 35042 Rennes Cedex, France
https://team.inria.fr/empenn

Duration: 5 to 6 months, start around March 2020

Context

Diffusion MR imaging allows the advanced study of brain microstructure and the extraction of the nervous system brain fibers. From a set of diffusion weighted acquisitions, the first step estimates a model of diffusion, which characterizes the different diffusion properties of water in a voxel, and thus indirectly the brain white matter microstructure. A large number of models have been proposed for this modeling, including diffusion compartment models [1] allowing to correctly depict fiber crossings. Such models bring great promises for the better understanding of brain pathologies and the study of brain connections through so-called tractography algorithms [2].

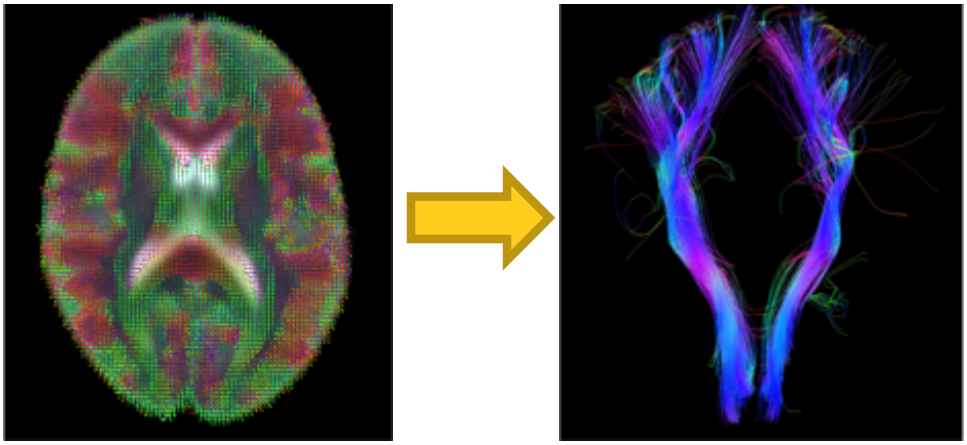

Figure 2. Tractography of the cortico-spinal fibers.

These algorithms however still lack reliability, especially due to the presence of false positives in their results [3] which need to be manually filtered out to obtain anatomically meaningful fibers. In addition, the specificities of diffusion compartment models are not really exploited and could bring a better reconstruction of fibers as well. We have studied in the past ways to incorporate such knowledge in tractography algorithms but without fully exploiting their potential. Moreover, some recent databases provide now validated reference tracts [6] that could help in the tractography task.

Internship objectives

In this context, we are looking for an intern to explore multi-compartment tractography methods exploiting anatomical knowledge to obtain realistic fiber bundles. After a review of the current literature on the topics of tractography and diffusion MRI, the intern will focus on developing new methods using both anatomical priors and multi-fiber information coming from the individual compartments of the model. Validation of the methods will be carried out with respect to simulations of fiber bundles as well as real datasets. The intern will apply the developed methods to test datasets obtained in research protocols on several diseases. This will validate the usability of the methods on clinical data and help evaluate the impact of pathologies on brain fibers.

From a methodological point of view, this internship will focus on the following domains:

- Diffusion MRI and diffusion modeling
- Tractography and anatomical priors

Location

This internship will take place at Inria/IRISA, UMR CNRS 6074, among the Empenn U1228 research team. The work will be conducted in close link with the MRI experimental platform at Neurinfo (http://www.neurinfo.org).

Requirements: C++, Matlab, strong knowledge of applied mathematics: signal and/or image processing, some knowledge of MRI acquisition techniques.

References

[1] E. Panagiotaki, T. Schneider, B. Siow, M. G. Hall, M. F. Lythgoe and D. C. Alexander. Compartment models of the diffusion MR signal in brain white matter: a taxonomy and comparison. NeuroImage, vol. 59, no. 3, pages 2241–54, 2012.
[2] B. Jeurissen, M. Descoteaux, S. Mori and A. Leemans. Diffusion MRI fiber tractography of the brain. NMR in biomedicine, vol 32, no. 4, pages e3785, 2019.
[3] K. H. Maier-Hein, P. F. Neher et al. The challenge of mapping the human connectome based on diffusion tractography. Nature communications, vol. 8, no. 1349, 2017.
[4] A. Stamm, O. Commowick, A. Menafoglio, S. Warfield. A Bayes Hilbert Space for Compartment Model Computing in Diffusion MRI. MICCAI proceedings, pages 72-80, 2018.
[5] A. Stamm, O. Commowick, C. Barillot, P. Pérez. Adaptive Multi-modal Particle Filtering for Probabilistic White Matter Tractography. IPMI proceedings, pages 594-606, 2013.
[6] J. Wasserthal, P. Neher, K. H. Maier-Hein. TractSeg - Fast and accurate white matter tract segmentation. Neuroimage, vol. 183, pages 239-253, 2018.