Post-doctoral position 2020

Tractography and connectivity analysis from advanced diffusion MRI for early depression diagnosis and characterization

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Duration: 20 months, from october 2020.

Net income: from 2100 € / month depending on experience

Context

Psychiatric diseases, among which depression is major one, are still not fully understood. The exact mechanisms and brain modifications related to those diseases are especially complex to explain. Recent research advances have shown major changes but the connectivity alteration remains to be explained. Advanced MRI techniques including multi-shell diffusion imaging have shown a great potential to highlight subtle changes of microstructure in the brain [1]. We are therefore looking at how these advanced MRI techniques may allow a better definition of the brain change patterns in major fiber bundles that are related to classical pathways involved in depression.

The Empenn research team is currently involved with the Rennes university hospital EA4712 in a multi-site project lead by Inserm U1000 in Paris, France. The goal of this project is to evaluate how the brains differ between healthy subjects and patients suffering from drug resistant and non-drug resistant depression. In turn the long-term goal of this study will be to evaluate from early imaging how young patients suffering from depression may be susceptible to become drug resistant. To do so, advanced MRI acquisitions are being performed both In Paris and in Rennes with advanced diffusion, and soon relaxometry data from which myelin information will also be extracted.

Scientific objectives

The major scientific objective for this post-doctoral position will be to develop and evaluate new methodologies to quantify microstructure changes along major fiber tracts of the brain using advanced diffusion models [2] from diffusion MRI. To do so, the post-doctoral fellow will first evaluate methodologies to extract reliable brain fibers from diffusion MRI data as this is a major problem identified in the literature [3]. Then he will propose new methods to compare brain fiber tracts, their associated microstructure information and brain connectivity inferred from those tracts. For these tasks, the post-doctoral fellow will build on previous works from the team on those topics [4,5] as well as a literature review [6].

The post-doctoral researcher will then apply the developed tools to the databases acquired among the project. This includes the IMAGEN database acquired in Paris with over 100 patients each with advanced multi-shell diffusion MRI; the local databases from Rennes on depression that also include

advanced diffusion MRI (CUSP sequence [7]). From all this data, he will develop pipelines to analyze the data and evaluate the interest of diffusion MRI in depression early diagnosis.

In terms of methodology, the following domains will be covered in this post-doctoral position:

- Advanced multi-shell diffusion MRI (multi-compartment models)
- Fiber tractography from multi-compartment models
- Analysis of fiber tracts and associated microstructure information
- Connectivity analysis in controls and patients suffering from depression
- Statistical comparison between groups of patients and/or controls

Location

The recruited person will work at Inria/IRISA, UMR CNRS 6074, among the Empenn U1228 team. The work will be in close link with the research MRI platform Neurinfo (http://www.neurinfo.org) and clinicians working on depression at EA4712. Collaboration with the Inserm U1000 group in Paris will also be involved in this project.

Keywords: diffusion MRI, tractography, depression, fiber-based analysis

Requirements: This position will require strong knowledge both in applied mathematics (optimization, representations in Riemannian manifolds, statistics…) and in advanced image processing (tractography, tract-based analysis…). A PhD defended close to one of those domains will therefore be required. A good knowledge of computer science aspects is also mandatory, especially in object-oriented programming (C++), Python and Matlab.

References

[1] F. Sepehrband, K. Clark et al. Brain tissue compartment density estimated using diffusion-weighted MRI yields tissue parameters consistent with histology. Human Brain Mapping, 36(9):3687-702. 2015.
[2] E. Panagiotaki, T. Schneider, et al. Compartment models of the diffusion MR signal in brain white matter: a taxonomy and comparison. NeuroImage, vol. 59, no. 3, pages 2241–54, 2012.
[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] M. Mani, S. Kurtek et al. A comprehensive riemannian framework for the analysis of white matter fiber tracts. IEEE ISBI, 2010.
[5] R. Hédouin. Diffusion MRI processing for multi-comportment characterization of brain pathology. PhD thesis. 2017.
[6] D. Raffelt, J.D. Tournier et al., 2017. Investigating white matter fibre density and morphology using fixel-based analysis. Neuroimage 144 (Part A), 58–73.
[7] B. Scherrer, S.K. Warfield. Parametric representation of multiple white matter fascicles from cube and sphere diffusion MRI. Plos One. 2012.