

Subject-Specific Representation of Cortical Structure and Function

Research theme: machine learning, brain imaging, domain-specific languages.

Keywords: regression, brain MRI, neuroanatomy.

Duration & salary: 4 to 6 months, between 500 € and 800 € monthly

Research teams: Parietal (INRIA Saclay) and NeuroSpin (CEA)

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Application: Interested candidate should send CV and motivation letter

Context:

A fundamental challenge in computational neuroanatomy and the understanding of the human brain is the representation of neuroanatomy and function beyond spatial matching. Formalising the neuroanatomical concepts that define brain regions in terms of anatomy, tissue structure and function across subjects is currently limited to quashing individual variability into a common template space. However, there is ample evidence that individual variability escapes such template space transforms [1, 2]. Specifically, recent studies have shown that shape- or anatomy-based alignment, even when carried out through sophisticated diffeomorphic deformations procedures, does not solve the issue [see e.g. 3].

In this internship, we propose to take an alternative way to represent neuroanatomy: to formalise the rules identifying brain areas instead of their geometric properties. This work is a follow up of a similar formalisation already performed on the human brain's white matter [4].

Proposed work:

We will generalise common models based on functional MRI activation and tissue characteristics to identify brain regions [3, 5] and set the grounds for a generalized abstraction of these through a domain-specific language. We expect that this generalization will enable us to capture population as well as individual variability. Furthermore, we will be able to define an explicit formalization of brain areas that will generate an anatomo-functional correspondence across subjects.

Required skills:

The successful candidate will be interested in applications of theoretical computer science, machine learning and in the understanding of human neuroanatomy. Knowledge of scientific computing in Python (Numpy, Scipy) is encouraged. All the work will be done in Python based on the Nilearn (<http://nilearn.github.io>) and tract-querier (<http://tract-querier.readthedocs.io>) libraries.

References

- [1] Karl Zilles and Katrin Amunts. Individual variability is not noise. *TRENDS in Cognitive Sciences*, 2013.
- [2] Evelina Fedorenko, Michael K Behr, and Nancy Kanwisher. Functional specificity for high-level linguistic processing in the human brain. *Proc. Natl. Acad. Sci. U.S.A.*, 2011.
- [3] Matthew F Glasser, Timothy S Coalson, Emma C. Robinson, Carl D Hacker, John Harwell, Essa Yacoub, Kamil Ugurbil, Jesper Andersson, Christian F. Beckmann, Mark Jenkinson, Stephen M Smith, and David C. Van Essen. A multi-modal parcellation of human cerebral cortex. *Nature*, 2016.
- [4] Demian Wassermann, Nikos Makris, Yogesh Rathi, Martha Shenton, Ron Kikinis, Marek Kubicki, and Carl-Fredrik Westin. The white matter query language: a novel approach for describing human white matter anatomy. *Brain Structure and Function*, 2016.
- [5] Deanna M. Barch, Gregory C Burgess, Michael P Harms, Steven E Petersen, Bradley L Schlaggar, Maurizio Corbetta, Matthew F Glasser, Sandra Curtiss, Sachin Dixit, Cindy Feldt, Dan Nolan, Edward Bryant, Tucker Hartley, Owen Footer, James M Bjork, Russell A. Poldrack, Stephen M Smith, Heidi Johansen Berg, Abraham Z Snyder, David C. Van Essen, and WU-Minn HCP Consortium. Function in the human connectome: task-fMRI and individual differences in behavior. *NIImg*, 2013.