

The Aramis team at the Brain Institute is recruiting a PhD student

PhD thesis: Segmentation and generative modeling of brain imaging data in multiple sclerosis

General information

Workplace: **Brain Institute, ARAMIS Team, Pitié Salpêtrière Hospital, 47 Bd. de l'hôpital, 75013 Paris**

Name of the scientific supervisor: **Olivier Colliot (olivier.colliot@sorbonne-universite.fr)**

Mission

Multiple sclerosis (MS) is the most common cause of neurological disability in young adults and thus represents a major public health issue with about 100,000 patients in France and 2 million worldwide. In order to optimize treatments, it is essential to be able to measure and track brain alterations in MS patients. To that purpose, neuroimaging plays a central role due to its ability to characterize different types of structural and functional alterations.

The aim of this project is to design new deep learning approaches for segmentation and generative modeling of brain images in order to derive new biomarkers of MS. The project may start as a Master internship.

We first propose to focus on the design of a deep neural network to segment the choroid plexus (CP) from MRI data. The CP is the structure of the brain that produces the cerebrospinal fluid. In multiple sclerosis, there is evidence that its neuroprotective functions are altered and that abnormal patterns of the CP can be related to disease progression. In particular, we will investigate whether models that make use of multiple MRI sequences are advantageous over those using a single image. We will also assess the impact of different data augmentation methods on the performance. We will aim to relate CP characteristics to disease progression of the patients.

We then propose the following research leads. A first axis is devoted to the improvement and extension of segmentation tools by introducing GANs. We will aim to improve the developed CP segmentation and to consider other relevant structures such as T2-FLAIR hyperintense lesions. The second axis concerns the development of generative models that could generate maps of active lesions and simultaneously synthesize PET images from multimodal MRI scans. This would build

upon our recent work in which we proposed new approach, called Sketcher-Refiner Generative Adversarial Networks (sr-GAN), that allows to synthesize myelin PET data from multimodal MRI (Wei et al, 2019). In the present PhD, we will aim to: 1) work on active lesions rather than demyelination; 2) generate maps of active lesions and not only PET images.

- Wei W, Poirion E, Bodini B, Durrleman S, Ayache N, Stankoff B, and Colliot O. Predicting PET-derived demyelination from multimodal MRI using sketcher-refiner adversarial training for multiple sclerosis. *Medical Image Analysis*. 2019 Dec;58:101546. doi: 10.1016/j.media.2019.101546. Epub 2019 Aug 24.
- Burgos N, Bottani S, Faouzi J, Thibeau-Sutre E, and Colliot O. Deep learning for brain disorders: from data processing to disease treatment. *Brief Bioinform*. 2020 Dec 15:bbaa310. doi: 10.1093/bib/bbaa310. Online ahead of print

Activities

- Develop research in the field of deep learning for brain imaging
- Write scientific articles for publication in international journals and conference proceedings
- Present results at international conferences
- Contribute to the implementation and dissemination of open source software

Working context

You will work within the ARAMIS lab (www.aramislab.fr) at the Paris Brain Institute. The institute is ideally located at the heart of the Pitié-Salpêtrière hospital, downtown Paris.

The ARAMIS lab, which is also part of Inria (the French National Institute for Research in Computer Science and Applied Mathematics), is dedicated to the development of new computational approaches for the analysis of large neuroimaging and clinical data sets. With about 35 people, the lab has a multidisciplinary composition, bringing together researchers in machine learning and statistics and medical doctors (neurologists, neuroradiologists).

The project is done as part of a collaboration between the ARAMIS Lab (Olivier Colliot, machine learning), the team of Bruno Stankoff at the Paris Brain Institute which has a strong expertise on neuroimaging of multiple sclerosis and the Epione team (Nicholas Ayache) at Inria Sophia-Antipolis.

We have access to a supercomputer with 1044 nVIDIA V100 GPU.

Additional information

Desired skills

- Master or engineering degree with a specialization in machine learning
- Good programming skills in Python
- Knowledge in digital image processing and medical imaging
- Good writing skills
- Good relational and communication skills

Contact

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