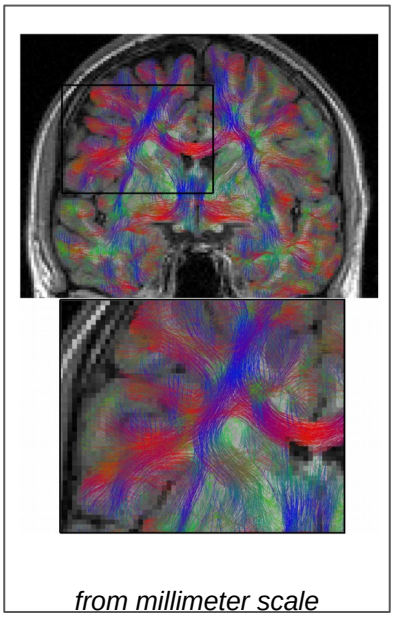
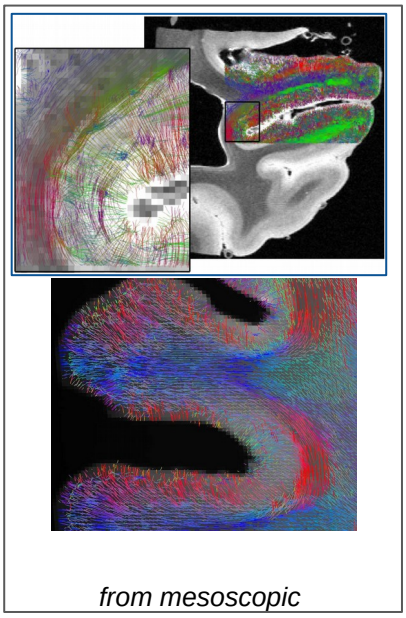
1-Year High Performance Computing M/F Post-doc dedicated to Extreme Scale Brain Analytics at NeuroSpin/BAOBAB

AIDAS2

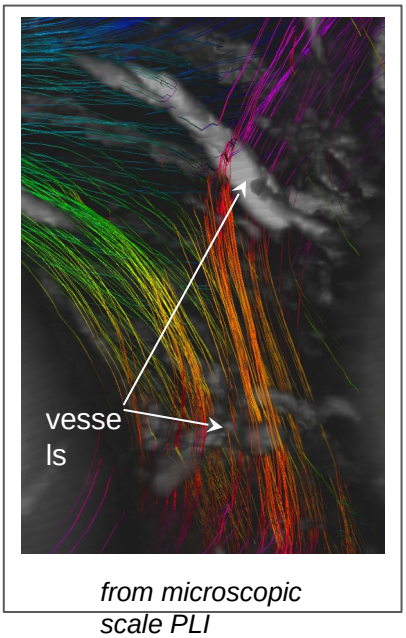
March, 3rd, 2020



from millimeter scale dMRI



from mesoscopic scale dMRI



from microscopic scale PLI

1. Description of the position

NeuroSpin's research teams have been developing magnetic resonance imaging methods to characterize the human brain connectivity and to probe its microstructure for over a decade. Modeling the human connectome is one of the major challenge of neuroscience and rely on a fine modeling of brain networks from both functional and anatomical point of views.
Diffusion Magnetic Resonance Imaging (MRI) is the only available tool to map the connections in vivo within the human brain, and was proben to be useful to map the major white matter bundles. However, due to its limited spatial and angular resolutions (aroung 1mm and 30 degrees using conventional MRI scanners), it remains hard to have access to the fine sub-cortical connectivity, thus limiting the impact of connectomics.
In order to go beyond these limitations, two partners of the European Human Brain Project, the NeuroSpin/BAOBAB (Frédédric Joliot Life Sciences Institute, Fundamental Research Division, Commissariat à l'Energie Atomique (CEA)) team and the INM1/Fiber Architecture Group (Institute of Neurocience and Medicine 1, Forchungszentrum Jülich, FZJ), have scanned human brain ex vivo, providing access to massive MRI dataset and massive 3D Polarized Light Imaging (3D-PLI) dataset of unprecedented resolutions (100um for MRI and 1.3um for 3D-PLI).

The available diffusion MRI and 3D-PLI dataset provides access to a plethora of anatomical details,

allowing to go down to the scale of individual connections (axonal fibers). However, due to their huge size amounting for hundreds of terabytes of data, current software available in the community cannot be used anymore to process the data, which requires to develop novel methods based on High Performance Computing (HPC) and exploiting the supercomputing infrastructures of CEA and FZJ.
The global inference of the structural brain connectivity from difusion MRI or 3D-PLI, also called tractography, is an ill-posed problem that relies on the construction of a global model from the local microstructural information (such as the angular profile or the angular dispersion of the connections) provided by diffusion MRI or 3D-PLI. Most current methods use streamlining methods to reconstruct individual connections independently from the other connections, which yields lots of false positives. The NeruroSpin partner has developed a novel approach relying on a Markovian framework able to find a global solution to the problem using a competitive construction of the entire set of brain connections and making use of further anatomical and microstructural constraints to avoid and discard false positives.

In the frame of the joint CEA/FZH AIDAS2 institute, the NeuroSpin/BAOBAB partner will develop in collaboration with the FZH/INM1 partner a novel HPC version of the global spin-glass tractography able to deal with massive dataset, and will then proceed with the construction of a unique mesoscopic/microscopic atlas of the human brain connectivity using the massive diffusion MRI & 3D PLI dataset acquired in the frame of the European Human Brain Project flagship.
This utra-high resolution atlas of the structural connectivity should bring to the community the missing piece of the brain puzzle that would allow to propose a model of the human brain connectome.

The main mission of the post-doctoral position is to develop the global spin-glass tractography HPC platform and to apply it to the mesoscopic diffusion MRI and microscopic 3D-PLI dataset acquired by the French and German partners in the frame of the Human Brain Project.
To this aim, the Post-doc will :
- design the architecure of the object-oriented C++ code that will manage the I/O of distributed diffusion MRI and 3D-PLI data and perform the optimization of the spin-glass based Markov random field corresponding to the aforementioned global approach,
- write the corresponding I/O, global tractographies libraries using advanced HPC frameworks (Kokkos, …) to address both GPU-based or CPU-based supercomputers,
- develop a web-service in the frame of the ICEI/FENIX infrastructure to make the tool publicly available to the community,
- develop an interactive 3D visualization framework able to render the spin-glasses and connections under construction,
- write the associated documentation and participate to the writing of scientific communications,
-interact regularly with the INM1/Fiber Architecture Group to codesign the software with the 3D-PLI experts.

The Post-doc (m/f) will work in direct contact with the physicists, IT and image processing experts fof the NeuroSpin/BAOBAB research unit.

2. Research environment

NeuroSpin is an international brain imaging research center located on the campus of the University Paris-Saclay (http://joliot.cea.fr/drf/joliot/Pages/Entites_de_recherche/NeuroSpin.aspx). NeuroSpin's goal is to push the limits of ultra- high field (UHF) MRI/MRS and MEG/EEG brain imaging to elucidate the structure and functioning of the healthy and sick brain at all ages.
Combining the strengths of multiple institutions including the CEA, Inserm, INRIA

and CNRS, NeuroSpin is led by Stanislas Dehaene, Member of the French Academy of Sciences. It brings together 180 researchers in three main areas: MRI and neuroinformatics research (UNIRS, C Poupon, UNATI, Jean- François Mangin, and PARIETAL, B Thirion), cognitive neuroimaging (UNICOG, Stanislas Dehaene) and clinical and translational imaging (UNIACT, Lucie Hertz-Pannier).

NeuroSpin is equipped with two state-of-the-art 3T and 7T whole body MRI scans and 3 preclinical MRI scans at 7T, 11.7T and 17T. A world- first 11.7T whole body system is being installed. MEG systems with 306 channels, EEG with 256 channels are also available. A clinical facility allows research protocols to be conducted with human volunteers of all ages (patients and healthy controls), with 8 day- beds, examination rooms, a nursing facility, a fake scanner. A preclinical installation (rodents and primates), and platforms for electronics, mechanics, chemistry, histology and cell culture, complete the installation.

NeuroSpin teams develop advanced software tools for structural image processing (BrainVisa), functional data analysis (Nipy, Nilearn), diffusion imaging (Ginkgo), M/EEG analysis (MNE). A 150 terabytes data archiving system, a large local IT cluster and access to the CEA's new supercomputer are available. Neurospin's environment finally benefits from the new NeuroPSI building, dedicated to fundamental neurosciences, inaugurated in 2019.

3. Position profile

- Engineering degree and a PhD thesis in informatics and/or image processing.
- Strong experience in software development:
  - ◦ proficiency of object-oriented software architecture
  - ◦ proficiency in high-performance computing (HPC)
  - ◦ proficiency in C++ and Python languages
  - ◦ proficiency of versioning tools (Git, ...)
  - ◦ proficiency of technologies for the development of web-services
- Experience in neuroimaging and neuroscience:
  - ◦ diffusion MRI and tractography methods
  - ◦ structural human brain connectome
- Ability to interact with the various communities present at NeuroSpin (methodologists, biologists, clinicians, etc.)
- Fluency in oral and written English.
- Autonomy and a taste for teamwork

Applications must include

- A complete CV
- A letter of motivation

Requests should be addressed to:

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