Inserm UMR 1253 «Imaging & Brain »
Team 3 - Imaging, Biomarkers and Therapy

PhD position: Development of a Multiscale MRI atlas of the human brainstem.

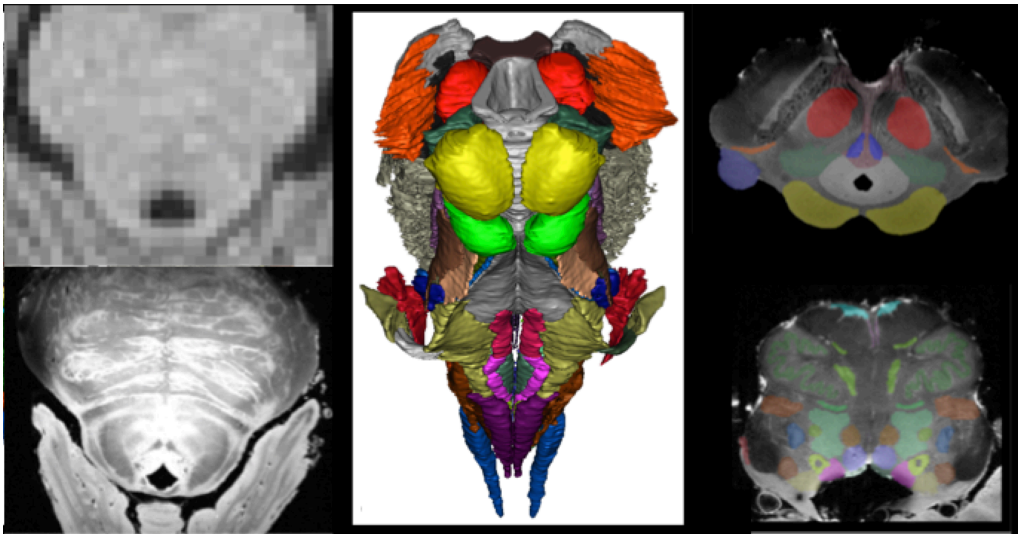
Supervisors: Prof Christophe Destrieux and Frédéric Andersson

Dates: Oct. 2018 – Sept. 2021 in Tours, France

Salary is according to standard French regulations (± 17.000€, net/year).

Keywords: MRI, ultra high-field MRI, high resolution, medical imaging, muli-scale imaging, brainstem, atlas, image registration, image segmentation

Summary : The aim of the project is to establish a multiscale atlas of the human brainstem. This atlas will first be built from ultra high field (11,7T) MRI *ex vivo* images. It then will be applied to *in vivo* MRI images in order to obtain an automatic segmentation of brainstem structures in routine clinical condition (3T).



Context

The brainstem contains multiple grey (cranial nerves, proper and reticular nuclei) and white matter structures (association and projection tracts). Its *in vivo* exploration, using clinical 1.5 or 3T MRI (Magnetic Resonance Imaging) scanners, is limited by the spatial resolution and contrast. Indeed, it only permits a global exploration of the brainstem, but cannot distinguish fine components. However, some of the latter become visible using preclinical scanner and anatomical specimens. This method increases the resulting spatial resolution and contrast, thanks to the high strength of the magnetic field and gradients used to explore diffusion, but also to potentially unlimited scanning time and absence of physiological noise.

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Long-term aim

To build a multimodal atlas of the human brainstem from *ex vivo* ultra high filed MRI, and to use it to automatically segment *in vivo* images obtained at lower resolution.

Contributions & work program

1) **High resolution anatomical probabilistic atlas of the human brainstem.** 8 anatomical specimens are being scanned on a preclinical 11.7T scanner in Neurospin: T2 (spatial resolution 100-300µm isotropic) and diffusion weighted (350µm isotropic) images. The PhD student will use a protocol we previously develop to manually segment 71 grey matter structures of the brainstem (about 800 slices per specimen). The segmented data will be used to compute a probabilistic atlas, which will be able to automatically segment new anatomical specimens obtained at the same resolution. For validation, a jack-knifing leave one out procedure will be used to check the similarity between automated and manual segmentations.

2) **Application of the high-resolution atlas to *in vivo* MRI.** The high resolution *ex vivo* atlas will be used to automatically segment grey structures of the brainstem in *in vivo* images. This will imply to limit the segmentation to a subpart of *in vivo* images (namely the brainstem) and to use data having very different contrast and spatial resolution (*in vivo* images *versus ex vivo* atlas).

3) **Validation of the automated segmentation of *in vivo* images.** No direct manual segmentation of *in vivo* images will be possible since most of the studied structures won't be visible on this dataset obtained at a millimetric resolution on a 3T scanner. In other words, no ground truth will be available *in vivo* to validate the developed automated atlas. For this purpose, we will use subjects from the ANR Fibratlas project, which collects *in* and *ex vivo* MRI data for the same subjects. The ultra-high field MRI-scanner used for *ex vivo* acquisitions will provide high contrast and resolution, allowing a manual segmentation. At least 3 *in/ex vivo* datasets should be available until the beginning of this PhD: brainstem structures will be automatically segmented in *in vivo* images (segmentation to be validated) and manually in *ex vivo* images (used as a ground truth). Both segmentations will then be compared to validate the automated method.

Spin-off. The proposed atlas will have academic (automated segmentation of cohorts, for instance for morphometric analysis or the definition of reproducible regions of interest) and clinical applications (definition of targets for deep brain stimulation using clinical images where these targets are not visible).

Feasibility & host structure

The 8 anatomical specimens which will be used for building the atlas are being scanned in the frame of a partnership with Neurospin, one of the leader laboratories in the field of ultra high field *ex vivo* imaging. MRI data used for steps #2 and #3 will be obtained from the Fibratlas ANR project. The anatomical rules and method for segmentation of the brainstem were defined during a master of science thesis. The host laboratory (Inserm U1253 "Imaging & Brain") includes experts in the field of Neuroanatomy and imaging process. Among other contributions, our laboratory has developed an automated atlas of the human cortex widely distributed in the community (C Destrieux, Neuroimage, 2010).

Contributions & work program

We are looking for highly motivated candidates to work in a research environment with Engineering or Master degree. The candidates should have a background in image processing, image registration and programming skills (Matlab, R, …). Experience using neuroimaging softwares will be a plus (SPM, FSL, FreeSurfer, AFNI, ITKsnap, …). Anatomical skills and knowledge would be appreciated but are not mandatory and will be acquired during his/her PhD.

Application

Send a cover letter, CV, copy of diplomas including grades obtained and two letters of recommendation to Christophe Destrieux and Frédéric Andersson (christophe.destrieux@univ-tours.fr ; frederic.andersson@univ-tours.fr) before 4th September 2018.

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