MASTER Internship

Joint estimation of neuronal activation and basal metabolism from functional Arterial Spin Labeling

Supervision: Pierre Maurel, Unité/Projet Visages Inserm/Inria, IRISA (pierre.maurel@irisa.fr)
Isabelle Corouge, Unité/Projet VisAGeS Inserm/Inria, IRISA (isabelle.corouge@irisa.fr)
Christian Barillot, Unité/Projet VisAGeS Inserm/Inria, IRISA (christian.barillot@irisa.fr)

Location: Unité/Projet VisAGeS, IRISA, Campus de Beaulieu, 35042 Rennes Cedex, France, https://www.irisa.fr/visages

Duration: 4 to 6 months

Keywords: Image processing, Statistical detection, Source Decomposition, Modeling Brain Activity, Brain imaging, Applications to Functional MRI and Arterial Spin Labeling,

Context

Functional arterial spin labeling (fASL) has recently proven to be a suitable tool for mapping neuronal activity changes induced by a task or a stimulation. fASL uses the magnetically labeled blood as an endogenous tracer (Detre, et al. 1992) and allows non invasive imaging and measurement of the local perfusion variations induced by neuronal activation. The advantage of fASL is that it potentially reflects not only the vascular component of the vascular coupling but also the basal metabolic activity of the brain. Hence, fASL can be potentially a more direct biomarker of neuronal activity than the standard BOLD fMRI. The BOLD signal is in fact multifactorial, resulting from complex interactions between simultaneous variations in cerebral blood flow, cerebral blood volume and cerebral metabolic rate of oxygen. This specificity of fASL theoretically leads to higher intra-individual reproducibility and a more accurate spatial localization of neuronal activity, which is essential for longitudinal clinical studies. In a recent study in Rennes, spatial accuracy of fASL in detecting motor neuronal activation in the primary hand area was demonstrated to be significantly higher than for BOLD fMRI, with higher specificity, and positive and negative predictive (Raoult, et al. 2011).

However, because of low intrinsic signal-to-noise ratio (SNR), as well as lack of expertise and automatic post-processing tools, the use of fASL remains confidential. The low SNR can partially be compensated by acquiring a high number of activated images. But multiple averages and consequently long acquisition sequence time remain required to obtain sufficient SNR increase. Thus, most of the fASL protocols proposed in the literature are not really effective on the daily clinical practice.

The objective of this internship is therefore to provide new computational algorithms allowing to reduce the sequence duration of fASL, as well as joint estimation of functional activation and basal perfusion.

Internship focus

The internship work will make use of already existing functional paradigms. It will then be dedicated to adapt two different image processing workflows, one based on the use of the general linear model (Mumford, 2006) and one based on source decomposition approaches. The objective will be to adapt these methods to fASL signals and to exhibit their respective capabilities to jointly estimate the relevant activation signal as well as the basal perfusion signal in a single fASL protocol. At term, these

results will be used as a reference to quantify functional and vascular deviance for patients with abnormal hemodynamics (e.g. stroke) or perfusion characteristic (e.g. dementia, tumors, epilepsy).

Location of the Internship

This internship will be located at INRIA Rennes (both at the INRIA center and the Neurinfo MRI platform at the university Hospital).

Requirements: Matlab, C/C++, good knowledge in image processing and statistics.

References

1. Detre JA, Leigh JS, Williams DS, Koretsky AP. 1992. Perfusion imaging. Magn Reson Med 23(1):37-45.
2. Ances BM, Leontiev O, Perthen JE, Liang C, Lansing AE, Buxton RB. 2008. Regional differences in the coupling of cerebral blood flow and oxygen metabolism changes in response to activation: implications for BOLD-fMRI. Neuroimage 39(4):1510-21.
3. Mumford JA, Hernandez-Garcia L, Lee GR, Nichols TE. Estimation efficiency and statistical power in arterial spin labelling fMRI. NeuroImage 2006;33(1):103–14
4. Jan Petr, Jean-Christophe Ferré, Hélène Raoult, Elise Bannier, Jean-Yves Gauvrit, Christian Barillot. Human Brain Mapping, Wiley-Blackwell, 2014, pp.1179-89 Template-based approach for detecting motor task activation-related hyperperfusion in pulsed ASL data
5. Hélène Raoult, Jan Petr, Elise Bannier, Aymeric Stamm, Jean-Yves Gauvrit, Christian Barillot, Jean-Christophe Ferré, Arterial spin labeling for motor activation mapping at 3T with a 32-channel coil: Reproducibility and spatial accuracy in comparison with BOLD fMRI, NeuroImage, Volume 58, Issue 1, 1 September 2011, Pages 157-167

Figure 1: principles of perfusion imaging with Arterial Spin Labeling

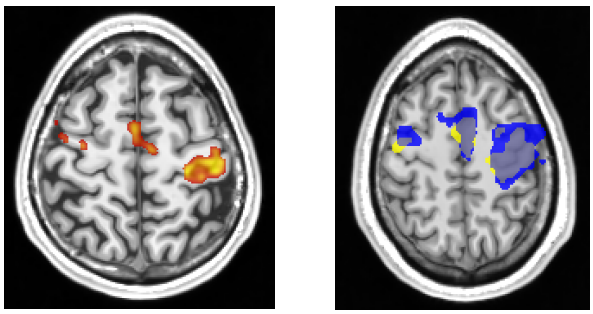

Figure 2: **Left: Motor activation of the right hand obtained from fASL data. Right: Example of an individual functional map of fASL (yellow) and BOLD fMRI (blue) and overlapping activation area (grey). From Raoult et al. 2011.**