# PhD Proposal 2017

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| **School: Ecole Centrale de Marseille** | |
| **Laboratory: Institut des Neurosciences de la Timone** | **Web site: http://www.int.univ-amu.fr** |
| **Team: Methods and Computational Anatomy (http://www.meca-brain.org)** | **Head of the team: Olivier Coulon** |
| **Supervisor: Olivier Coulon** | **Email: olivier.coulon@univ-amu.fr** |
| **Collaboration with other partner during this PhD:**<br>**In France:** | **In China:** |

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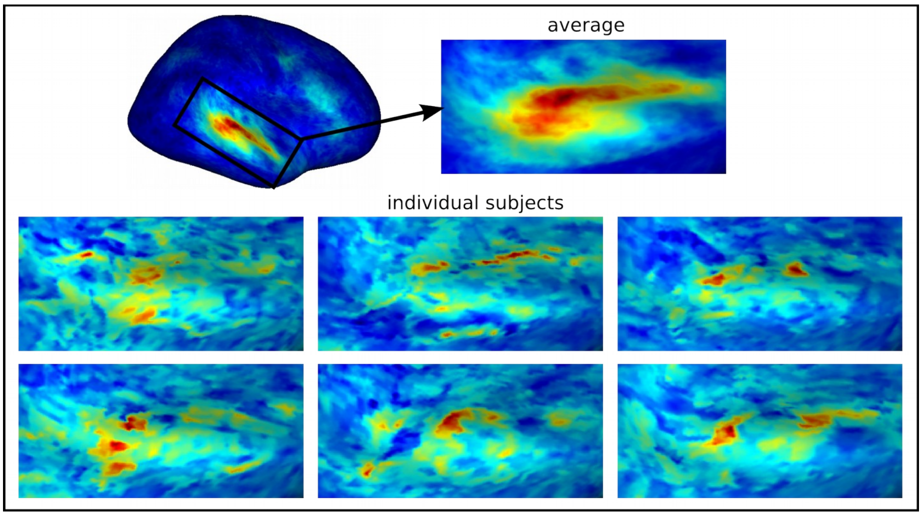
| **Title: Cross-modal learning using high-level neuroimaging descriptors.** |
| **Scientific field: Computer science** |
| **Key words: Image processing, Machine learning, Computational neuroimaging, MRI** |

**Details for the subject:**

Background, Context:

Magnetic Resonance Imaging (MRI) offers a unique set of techniques to explore the architecture of the central nervous system: anatomical MRI (aMRI) allows studying the morphology of the brain, diffusion MRI (dMRI) estimating the structural connections that link distant brain regions and functional MRI (fMRI) mapping brain activation patterns induced by the behavior of the subject. In this thesis, we aim at combining the information provided by these three modalities to precisely establish the cognitive architecture involved in voice perception, as studied by Pascal Belin's team at INT [1,2]. More specifically, we will study whether the between-subject variability observed in one scan type, such as illustrated in the figure below with the patterns of activation recorded using fMRI and displayed onto an inflated cortical surface, can be explained by the other scans, by addressing two methodological questions: 1) the extraction of high-level image descriptors and representations; 2) the design of machine learning models and methods to quantify cross-modal relationships.




Research subject, work plan:

In order to establish correspondences between the three modalities, a proper representation must be inferred for each of them. Our team has already established such high-level representations for aMRI [3] and fMRI [4]. However, the inference of structural connectivity from dMRI remains challenging and we are currently developing dedicated acquisition protocols and data pre-processing algorithms to solve this problem. The first stage of this thesis will complement this work by developing methods aimed at characterizing 1) local connectivity of the cortex in a predefined area in order to build a graphical representation of the different components of this area, the difficulty being to accurately depict U-shaped short fiber bundles that define such connectivity 2) long range connectivity profiles of a given point or region, as a connectivity-based feature associated to this region, the difficulty being to estimate reliable profiles for points that are on the walls of gyri.

Once these descriptors will have been extracted, we will design inter-subject learning models adapted to their associated representations in order to study the links between modalities. Inter-subject learning is a supervised learning setting that consists in training a model on labelled data recorded in a given set of participants. The accuracy of the predictions produced by the model on data recorded in new subjects allows assessing its validity for the entire population from which the participants are drawn. This setting is vastly under-used in neuroimaging, but recent studies have demonstrated its potential in providing ground-breaking results [4, 5]. Preliminary studies in our team have demonstrated the validity of model proposed in [5] to study the relationships between fMRI and dMRI in the voice processing system. We here aim at pushing this line of work by 1) framing the cross-modal inter-subject learning question as a multi-source learning problem, 2) defining methods that directly exploit the high-level descriptors previously identified and 3) applying these models to further study the links between dMRI, aMRI and fMRI (thus following-up a recent study where we have shown the existence of anatomo-functional correspondences in the superior temporal sulcus, the region of the brain where voice-sensitive activations occur [6].)

This inter-disciplinary project asks for a PhD candidate with a high-level expertise in computer science (in particular image processing and machine learning) and an interest for neuroscientific applications (without the necessity for previous knowledge). A large amount of high quality data will be made available to the student, with both images acquired by our team and images made available publicly to the scientific community such as provided by the Human Connectome Project.

Supervisors:

- Olivier Coulon (Institut de Neurosciences de la Timone, INT; Laboratoire des Sciences de l'Information et des Systèmes, LSIS)
- Pascal Belin (Institut de Neurosciences de la Timone, INT)
- Sylvain Takerkart (Institut de Neurosciences de la Timone, INT).

References :

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