Offer #2024-08000

Doctorant F/H Fast Optimal Transport for the Encoding and Decoding of Brain Activity across species

The offer description below is in French

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Inria Saclay-Île-de-France Research Centre was established in 2008. It has developed as part of the Saclay site in partnership with **Paris-Saclay University** and with the **Institut Polytechnique de Paris** .

The centre has 40 project teams, 32 of which operate jointly with Paris-Saclay University and the Institut Polytechnique de Paris; Its activities occupy over 600 people, scientists and research and innovation support staff, including 44 different nationalities.

Context

Porjet CEA Brain and Repair.

L' objectif est de mettre au point des méthodes nouvelles de décodage de l'activité cérébrale.

Des déplacements réguliers sont prévus pour ce poste ? Non.

Assignment

The availability of millimeter or sub-millimeter anatomical or functional brain images has opened new horizons
to neuroscience, namely that of mapping cognition in the human brain and detecting markers of diseases.
Yet this endeavor has stumbled on the roadblock of inter-individual variability: two different brains may differ at the scale of centimeters in shape, folding pattern, and functional responses. The problem is further
complicated by the fact that functional images are noisy, due to imaging limitations and behavioral differences
across individuals that cannot be easily overcome. The status quo of the field is thus to rely on anatomy-based
inter-individual alignment that approximately matches the outline of the brain [1] as well as its large-scale
cortical folding patterns [2]. This loses much of the original individual detail and blurs the functional information that can be measured in brain regions (see Figure 1).
In order to improve upon the current situation, a number of challenges have to be addressed: (i) There exists
no functional brain template, which renders current cortical matching method blind to function. This is unfortunate, since functional information is arguably the most accessible marker to identify cortical regions
and their boundaries [3]. (ii) When comparing two brains – coming from individuals or from a template – it is unclear what regularity should be imposed on the matching [4]. While the common use is to impose diffeomorphicity [1], such a constrain may be counterproductive, given the frequent observation that brain
regions vary across individuals in their fine-grained functional organization [3, 5]. (iii) Beyond the problem of
aligning human brains, it is an even greater challenge to systematically compare functional brain organization
in two different species, such as humans and macaques [6, 7]. Such inter-species comparisons introduce a
more extreme form of variability in the correspondence model. A forthcoming challenge is to compare the
units of a human brain with those of an artificial network trained to perform a similar task [8, 9]. Finding such a mapping results in a so-called encoding model or a decoding model, owing to the model directionality.

Main activities

Following [17], we use the Wasserstein distance between source and target functional signals – consisting of
contrast maps acquired with fMRI – to compute brain alignments. We have already contributed two notable
extensions of this framework [18]: (i) a Gromov-Wasserstein (GW) term to preserve global anatomical structure – this term introduces an anatomical penalization against improbably distant anatomical matches,
yet without imposing diffeomorphic regularity – as well as (ii) an unbalanced correspondence that allows mappings from one brain to another to be incomplete, for instance because some functional areas are larger
in some individuals than in others, or may simply be absent. This is particularly needed to address inter-species mapping. We have already shown that this Unbalanced GW (UGW) approach successfully addresses
the challenging case of different cortical meshes, and that derived brain activity templates are sharper than
those obtained with standard anatomical alignment approaches [18]. With the present proposal, we propose
to leverage it to address further challenges:
Inter-species mapping We consider UGW as a principled way to perform systematic inter-species (human-
macaque) mapping, provided that there exist some correspondence in the contrasts measured in the indi-
viduals of both species. We want to extend the approach in [19] and provide a thorough validation of this mapping.
Decoding-based validation the classification of brain states or decoding, when performed across individ-uals, provides the most credible metric to measure the gain brought by inter-individual alignment. Indeed,
across-individuals generalization of brain state classification is generally hampered by inter-individual vari-
ability, but is likely to improve after alignment. We want to assess such gain using high-resolution data and
a large array of decoding problems [14].
High-dimensional encoding and decoding Current AI architectures provide high-dimensional feature spaces representing the characteristics of stimuli in some standardized tasks (object recognition, language
understanding). We want to assess whether UGW enhance this bidirectional (encoding/decoding) mapping,
and whether it allows to better reconstruct stimuli across individuals, when it is coupled with generative models [20]. As a motivating neuroscience questions, we would like to understand the competition of semantic
versus traditional level vision to fit brain activity along the ventral, and possibly dorsal streams.

Skills

Compétences techniques et niveau requis : Expert en neuroimagerie en machine learning, en transport optimal et en développement Python.

Langues : English

Compétences relationnelles : Travail en équipe

Compétences additionnelles appréciées : -

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

1st et 2nd year : 2 100 euros brut /mois

3st year : 2 190 euros brut / mois

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine
- **Town/city :** Palaiseau
- **Inria Center :** Centre Inria de Saclay

- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-09-30

Contacts

- **Inria Team :** MIND
- **PhD Supervisor :**
  Thirion Bertrand / Bertrand.Thirion@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

The successful candidate will be interested in applications of machine learning and in the understanding of hu-
man cognition. Note that the work will take place in a multi-disciplinary environment (physics, neuroscience,
computer science, modeling, psychology).
Prior experience on deep model is a major asset, as it makes it easier for the candidate to understand the concepts and tools involved. Knowledge of scientific computing in Python (Numpy, Scipy, Torch) is required.
All the work will be done in Python based on standard machine learning libraries and the Nilearn library for neuroimaging aspects. The candidate will benefit from the numerous development of the MIND and Unicog team for computational facilities and expertise in the various domains involved (machine learning,
optimization, statistics, neuroscience, psychology).

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.