Offre n°2024-08000

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

Type de contrat : CDD

Niveau de diplôme exigé : Bac + 5 ou équivalent

Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

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.

Contexte et atouts du poste

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.

Mission confiée

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.

Principales activités

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.

Compétences

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 : -

Avantages

- 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

Rémunération

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

3st year : 2 190 euros brut / mois

Informations générales

- **Thème/Domaine :** Neurosciences et médecine numériques
- **Ville :** Palaiseau
- **Centre Inria :** Centre Inria de Saclay

- **Date de prise de fonction souhaitée :**2024-10-01
- **Durée de contrat :**3 ans
- **Date limite pour postuler :**2024-09-30

Contacts

- **Équipe Inria :** MIND
- **Directeur de thèse :**
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A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

L'essentiel pour réussir

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).

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Sécurité défense :
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.