A propos du centre ou de la direction fonctionnelle

Located at the heart of the main national research and higher education cluster, member of the Université Paris Saclay, a major actor in the French Investments for the Future Programme (Idex, LabEx, IRT, EquipeX) and partner of the main establishments present on the plateau, the centre is particularly active in three major areas: data and knowledge, security, safety and reliability; modelling, simulation and optimisation (with priority given to energy).

The 450 researchers and engineers from Inria and its partners who work in the research centre's 28 teams, the 60 research support staff members, the high-level equipment at their disposal (image walls, high-performance computing clusters, sensor networks), and the privileged relationships with prestigious industrial partners, all make Inria Saclay Île-de-France a key research centre in the local landscape and one that is oriented towards Europe and the world.

Is regular travel foreseen for this post?

Regular travel foreseen to conferences and visits to institutes around the world.

Mission confiée

Assignment:

Sensing microstructural characteristics of human brain tissue with clinical MRI scanners has been an area of heated debate in the diffusion MRI (dMRI) community [1]-[3]. We have recently presented evidence that, if we focus on the cortex, specifically in the insula and anterior cingulate cortex (ACC), the unique characteristics of the cellular populations in these gyrri allow us to use clinical-grade scanners to sense the presence of Von Economo neurons (VENs) and link their presence to cognitive function [4]. VENs, uniquely localized in the insula and ACC, are large neurons and their particular size is what enables their quantification through dMRI. However, the inverse problem relating microstructural characteristics to microstructural configurations is plagued by indeterminacies [5]. Furthermore, required dMRI imaging protocols to invert such models are extremely demanding in terms of acquisition time and gradient strength. These combined difficulties point to a lack of computational tools to expand microstructural studies on the mammalian cortex to a wider variety of neuronal populations and cortical areas.

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We propose a project that pushes on a thriving axis of dMRI for microstructure quantification by focusing on the cortex, rather than the heretofore much studied white matter areas. Our main goal is to hedge and deepen our recent advancements in microstructure quantification through likelihood-free inference (LFI) [6], [7] to bypass model indeterminacy issues; gain precision; and increase the specificity of current links between cognition, development, pathology and cytoarchitecture.

Likelihood-free inference is a recent tool combining Bayesian analysis and Deep Learning for probabilistic model inversion [8]. As opposed to other approaches, LFI-based algorithms yield estimations of model parameters along with a full posterior distribution over the parameter space. This enables model inversion results encompassing indicators linking dMRI data with confidence intervals, along with the estimation of higher moments of the posterior distribution. An excellent characteristic of our LFI-based approach is to pinpoint cortical areas where a proposed microstructural model and the data harmonize together to provide an accurate model inversion. Consequently, LFI-based models provide enriched parameter estimations which also indicate which microstructural parameters, such as neuronal soma size or neurite density, can be confidently used in a specific dataset to link cytoarchitecture with cognition and pathology. In this PhD project, we will push forward our current advances in LFI-based cytoarchitecture quantification for dMRI. In particular, we will explore the design of summary statistic networks for LFI and simulation-based inference through the use of hierarchical modelling of cytoarchitecture-induced diffusion MRI signals. Harnessing our collaborations with the Institut Pasteur in Paris (cf. B. Tzourio) and St. Bartholomew Medical School (cf. V Menon) we will apply our advancements to the analysis of mammalian brain development in ferrets and cognitive function modelling in adolescents.

We foresee the following challenges in this project:

1) Design and production of a forward probabilistic model of brain tissue cytoarchitecture which can articulate with LFI algorithms and pushes precision beyond what we have achieved through simple geometrical models;
2) Conceive LFI techniques to invert designed probabilistic models and develop a non-linear-based model linking estimated parameter posteriors with development and cognition;

Contexte et atouts du poste

Within the framework of a partnership (you can choose between)

not applicable.

L'essentiel pour réussir

- Good skills in computer science, mathematics, physics and or physics,
- Teamwork preference.
- Vocation for cross-disciplinary research.
- Essential qualities in order to fulfill this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen.
- Passionate about innovation, with expertise in Python development and strong influencing skills. A master thesis on[4]. VENs, uniquely localized in the insula and ACC, are large neurons and their particular size is what enables their quantification through dMRI. However, the inverse problem relating microstructural characteristics to microstructural configurations is plagued by indeterminacies [5]. Furthermore, required dMRI imaging protocols to invert such models are extremely demanding in terms of acquisition time and gradient strength. These combined difficulties point to a lack of computational tools to expand microstructural studies on the mammalian cortex to a wider variety of neuronal populations and cortical areas.

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Informations générales

- Thème/Domaine : Neurosciences et médecine numériques
- Ville : Palaiseau
- Centre Inria : CRI Saclay - Île-de-France
- Date de prise de fonction souhaitée : 2022-10-01
- Durée de contrat : 2 ans
- Date limite pour postuler : 2022-09-22

Contacts

- Equipe Inria : PARITEL
- Directeur de thèse : Wassermann Demian / demian.wassermann@inria.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 200 équipes-projets agissent, en général communes avec des partenaires académiques, impliquent plus de 3800 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 quinzaine 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 180 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.

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 défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du contrat.

Politique de recrutement :

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

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.
3) Widen the applicability of our cytoarchitecture-detection methods to more general dMRI acquisitions and open access databases such as the Adolescent Brain Cognitive Development.

We have assembled a team that is capable of overcoming the aforementioned challenges. The Parietal team (http://team.inria.fr/parietal) from INRIA (http://www.inria.fr) and Neurospin which has a provable experience in developing and applying machine learning models to dMRI and linking dMRI with cognition and pathology; the team of applied and theoretical neuroanatomy from Institut Pasteur (https://neuroanatomy.github.io) which has extensive experience in animal model studies for the study of mammalian neuroanatomy [9], [10]; and the Stanford Cognitive and Systems Neuroscience Laboratory, USA (http://med.stanford.edu/scsnl.html) with an outstanding track record in imaging-based cognitive analysis.

Steering/Management:

The person recruited will be in charge of performing research and development in the frontier of neuroscience, machine learning, and computer sciences.

Principales activités

Main activities :

- Basic and applied research in neuroscience and knowledge representation
- High-quality coding within a quality/assured framework
- Inter-disciplinary research

Compétences

Technical skills and level required: Discrete mathematics, numerical model implementations, data analytics. Python programming and knowledge in biology will be appreciated

Languages: Excellent English conversational and written skills

Relational skills: Good interpersonal abilities and Problem-solving/Reasoning/Creativity

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 (after 6 months of employment) 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 and 2nd year: 1982 euros/Month
3rd year: 2,085 euros/Month