HR EXCELLENCE IN RESEARCH

2023-06169 - Post-Doctoral Research Visit F/M “Decoding Transformers”: Analyze Transformers for Brain Language Decoding and Encoding (IDP 2023)

Contract type : Fixed-term contract
Level of qualifications required : PhD or equivalent
Fonction : Post-Doctoral Research Visit

About the research centre or Inria department

The Inria center at the University of Bordeaux is one of the nine Inria centers in France and has about twenty research teams.. The Inria centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative SMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute...

Context

Keywords
Brain encoding/decoding; Transformers; Language; Computational Neuroscience; fMRI/MEG/EEG brain data

Advisors
Xavier Hinaut & Gaël Jobard
This work will be co-supervised with Gaël Jobard also at the Institute for Neurodegenerative diseases (Institut des Maladies Neurodégénératives – IMN –, Pellegrin Hospital Campus, Bordeaux).

Contact deadline:
Please contact Xavier HINAUT by email (firstname.lastname@inria.fr) for questions before May 3rd 2023.

Assignment

The development of new mechanistic models of brain activity can help to better understand how the brain works. This is particularly true for language, where a better understanding of the cognitive mechanisms involved could lead to improved treatments for developmental language disorders in children and to improved rehabilitation methods for brain injuries that lead to aphasia. The development of theoretical models for the neural dynamics underlying brain functions, including learning, is essential to (1) better understand the general functioning of the brain and (2) explore new paths that are not accessible using purely experimental (neurobiological) methods.

In this project we will consider various imaging methods with different spatial and temporal resolutions: Functional Magnetic Resonance Imaging (fMRI, high spatial resolution), ElectroEncephalography (EEG, high temporal resolution), MagnetoEncephalography (MEG, high temporal resolution, and better spatial resolution than EEG), as well as ECoG (ElectroCorticoGraphy, similar to EEG but less noisy as it is directly on the surface of the cortex and covers a reduced area of the brain).

The number and quality of brain imaging datasets available in open source is increasing rapidly in recent years [Li et al., 2021, Nastase et al., 2021, Gwilliams et al., 2022]. This is a great opportunity for modellers who do not usually have easy access to such data, and also an opportunity to compare different algorithms on the same data, in order to make the research more robust and reproducible.

Main activities

The long term objective is to obtain both mechanistic models that are explanatory and produce good predictions of brain imaging data. At the moment we have mechanistic models that are not very predictive (e.g. based on Reservoir Computing) and predictive models that are not very explanatory (e.g. Transfomers). The objective is to obtain the best of both worlds

in order to provide some answers to our question by identifying the mechanisms necessary for language processing, while improving the predictive capacities of mechanistic models. To this end, this research project aims to understand the mechanisms that allow Transformers to predict brain activity. In the long term, this project also aims to build models that are more biologically plausible than Transformers by using their components that best predict brain activity, and by introducing constraints derived from our knowledge of cognitive and brain functions.

The objective of this project is divided into different sub-objectives: 1. to identify the components of the Transformer architecture that best predict the activity obtained by different imaging techniques (MRI, EEG, ECog, MEG) on linguistic tasks. 2. to identify which types of models fail to predict brain activity in a meaningful way, in order to derive a "set of neural computations" needed for the prediction of brain activity.

The majority of the analyses will be based on publicly available data. Some analyses will be based on data already acquired by Gaël Jobard. Because language models such as Transformers evolve rapidly, we will adapt the mechanisms sought and data analysed according to the advances of language models. For example, it seems that new multimodal models (e.g. taking into account images and language simultaneously) will be available soon. In such case, we will exploit these models and also analyse corpora containing images. Indeed, this may allow us to get closer to human representations that are multimodal in nature, while mitigating the "symbol grounding problem" [Harnad, 1990] that applies to purely linguistic models such as ChatGPT.

The hired postdoc will collaborate with other PhD students in the team. If time permits, in parallel to the data analysis, the postdoc will set up an experimental protocol in fMRI with the experimental

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine
  Statistics (Big data) (BAP E)
- **Town/city :** Talence
- **Inria Center :** Centre Inria de l'université de Bordeaux
- **Starting date :** 2023-10-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2023-05-14

Contacts

- **Inria Team :** MNEMOSYNE
- **Recruiter :**
  Hinaut Xavier / xavier.hinaut@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

Instruction to apply

Thank you to send:
- CV
- Cover letter
- Support letters (mandatory)
- List of publication

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.

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.

means available to Gaël Jobard.

References

[Caucheteux et al., 2023] Caucheteux, C., Gramfort, A., and King, J.-R. (2023). Evidence of a predictive coding hierarchy in the human brain listening to speech. Nature Human Behaviour, 7(3) :430–441.

[Gwilliams et al., 2022] Gwilliams, L., Flick, G., Marantz, A., Pylkkanen, L., Poeppel, D., and King, J.-R. (2022). Meg-masc : a high-quality magneto-encephalography dataset for evaluating natural speech processing. arXiv preprint arXiv :2208.11488.

[Harnad, 1990] Harnad, S. (1990). The symbol grounding problem. Physica D : Nonlinear Phenomena, 42(1-3) :335–346.

[Li et al., 2021] Li, J., Bhattasali, S., Zhang, S., Franzluebbers, B., Luh, W.-M., Spreng, R. N., Brennan, J. R., Yang, Y., Pallier, C., and Hale, J. (2021). Le petit prince : A multilingual fmri corpus using ecological stimuli. Biorxiv, pages 2021–10.

[Nastase et al., 2021] Nastase, S. A., Liu, Y.-F., Hillman, H., Zadbood, A., Hasenfratz, L., Keshavarzian, N., Chen, J., Honey, C. J., Yeshurun, Y., Regev, M., et al. (2021). Narra- tives : fmri data for evaluating models of naturalistic language comprehension. bioRxiv, pages 2020–12.

[Pedrelli and Hinaut, 2022] Pedrelli, L. and Hinaut, X. (2022). Hierarchical-task reservoir for online semantic analysis from continuous speech. IEEE Transactions on Neural Net- works and Learning Systems, 33(6) :2654–2663.

Skills

- Good background in computational neuroscience, computer science, physics and/or mathematics;
- A strong interest for neuroscience, linguistics and the physiological processes underlying learning;
- Python programming with experience with scientific libraries Numpy/Scipy (or similar programming language: matlab, etc.);
- Experience in machine learning or data mining;
- Experience in neural imaging data;
- Independence and ability to manage a project;
- Good English reading/speaking skills.

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 partial 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

2746€ / grossly per month (before taxes)