# Offre n°2020-02754

# PhD Position F/M Doctorant F/H GRAAACE: GRAph neurAl network for brAin Connectivity Exploration

*Le descriptif de l'offre ci-dessous est en Anglais*

**Type de contrat :** CDD

**Niveau de diplôme exigé :** Bac + 5 ou équivalent

**Fonction :** Doctorant

## A propos du centre ou de la direction fonctionnelle

Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

## Contexte et atouts du poste

**Proposal description:**

Graphs are nowadays a common mathematical formalism used in various domains where the notion of network is significant, such as Genetics, Sociology, Ecology and Neurosciences to cite a few. In particular, in Neurosciences, graph representation allows to describe brain connectivity both at a structural and a functional level. Indeed, each node of the graph represents one brain region and edges describe functional or anatomical connections between these regions. Brain connectivity networks may capture both spatial and temporal information characterizing the brain mechanisms. This formalism allows to quantitatively describe heathy and abnormal brain states. Indeed, it is possible to associate macro descriptors, using topological features of the networks or subnetworks, to specify brain alterations. However, global descriptors currently used may be misleading: no global differences may be detected from however different graphs.

Graph neural networks is an emerging topic in data mining where the graph modelling allows the use of common mathematical tools from graph theory in combination with deep learning. Based on these tools, several studies have been proposed to classify the graphs, extract nodes charateristics, predict edges... (Wu et al. 2020 for a review) The main goal of these studies is to extract common patterns from different observed graphs in order to understand specific features.

## Mission confiée

The objective of this thesis is to derive mathematical properties of classical graph neural networks methodologies in order to capture specificity of brain networks. Using open access datasets, such as those provided by the Human Connectome project, we may extract the brain networks (e.g. default network) of hundreds of healthy controls. The first step consists in extending the new paradigm of graph neural network to scale for large mass of data in order to incorporate hundreds of healthy control networks. This will allow to learn an average network embedding capturing the interindividual variability under healthy conditions defining an healthy signature. The advantage of the construction of such a representative graph is to facilitate its interpretation in neurosciences. Mathematical foundations of the extraction of a representative graph for a large group of subject will be studied carefully.

In a second step, we will compare brain altered network embedding from patients under different conditions. The objective is to reveal which nodes and edges of the graphs are representative of brain alterations and define specific pathological signatures relevant for

neurosciences.

A third step will consist in developing new tools to combine a good estimation of brain connectivity graphs with a high accuracy for classification. Generative models may also be simulated to test and infer the action of a given disease on brain connectivity networks. The signatures can be also informative about the nodes and connections that are sensitive and vulnerable to attack. We will then focus on adversarial studies where the classification results can be fooled by the insertion at different steps of the convolutional network construction or use of specific perturbations. The long-term objective is to improve our understanding of the brain mechanisms implicated in dysfunction and possibly refine the nosology of brain diseases.

**Environment:** We offer a stimulating research environment gathering experts in Neurosciences & Neuroimaging and experts in Advanced Statistical and Machine Learning methods. A PhD position will be available in the context of the Grenoble 3AI project (@MIAI https://miai.univ-grenoble-alpes.fr/).

**Key words:** Machine learning; Multidimensional data; Brain networks

**Supervision / contact:** GIN-team « Functional neuroimaging and brain perfusion» : Michel Dojat (michel.dojat@inserm.fr) et Inria-team Statify (sophie.achard@inria.fr)

**Location**: Grenoble Neurosciences Intitute : https://neurosciences.univ-grenoble-alpes.fr & Inria Montbonnot : https://www.inria.fr/en/teams/mistis

**Starting date:** Autumn 2020

**How to apply**: Send an email directly to the supervisors with your CV. Applications will be accepted up to the 30st of June. The final decision will be given by the beginning of July.

**References:**

Wu et al. 2020 A Comprehensive Survey on Graph Neural Networks, IEEE Transactions on Neural Networks and Learning Systems, 1 – 21, 10.1109/TNNLS.2020.2978386

## Avantages

Subsidised catering service
Partially-reimbursed public transport
Social security
Paid leave
Flexible working hours
Sports facilities

## Rémunération

**1st and 2nd year :** 1 982 euros brut /month

**3rd year :** 2 085 euros brut / month

## Informations générales

- **Thème/Domaine :** Optimisation, apprentissage et méthodes statistiques
  Statistiques (Big data) (BAP E)
- **Ville :** Montbonnot
- **Centre Inria :** Centre Inria de l'Université Grenoble Alpes
- **Date de prise de fonction souhaitée :** 2020-10-05
- **Durée de contrat :** 3 ans
- **Date limite pour postuler :** 2020-08-31

## Contacts

- **Équipe Inria :** STATIFY

- **Directeur de thèse :**
  Achard Sophie / sophie.achard@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 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.

**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.