PHD POSITION IN COMPUTER SCIENCE / NEUROANATOMY / DEEP MEARNING
(LIFAT TOURS – INRAE NOUZILLY)

Title: Graph Neural Networks for morphofunctional analysis and comparison of brain structures

Supervisors

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- *En collaboration avec l'équipe iBrain, INSERM (C. Destrieux, F. Anderson)*

Description

Nowadays, the development of brain imaging methods generates a considerable amount of morphological and functional data. However, their exploration and comparison over time for an individual (development and aging), between individuals (variability within the species), and even more so between different species have been done only partially. We propose to model these data in the form of graphs, then to use recent approaches of artificial intelligence to better analyze them.

This approach has already been initiated by a multidisciplinary consortium of researchers in neuroanatomy, biology and computer science as well as neurosurgeons during the Regional projects NeuroGéo and Neuro2Co (LIFAT, INRAE, INSERM). It led to the creation of SILA3D, a software platform (in free access) allowing the representation of anatomo-functional data in the form of graphs thanks to an interactive semantic segmentation of images [1, 2].

In this context, the proposed thesis aims to create new algorithms for anatomical and functional analysis and comparison of brain structures using recent deep neural networks techniques dedicated to graphs (GNN, geometric deep learning ...).

The general objectives of this thesis are:

- To specify different strategies for modeling the brain data as graphs. For this, morphological and functional data from different imaging modalities, including structural MRI and tractography, will be combined using different approaches to be defined. The PhD student will use two datasets already acquired: a) ex vivo high field MRI of the human brainstem (iBrain and NeuroSpin) [5, 10]; b) in vivo MRI of growing lambs (PRC and PIXANIM) [8].

- To Investigate differences between individuals (human brainstem variability) and over time (monitoring lamb brain development from birth to adulthood [7,8,9]). The PhD student will propose several graph comparison methods exploiting recent advances in Deep Learning on Graphs (GNN) [3, 4, 11].

The scientific challenges associated with these objectives are (1) to develop new graph-based deep learning methods for the detection and classification of particular substructures in an encephalon (semi-supervised classification of nodes) [3, 11]; (2) to develop new graph-based deep learning methods for the comparison, discrimination, and classification of encephalon (supervised or unsupervised classification of graphs) [4,11].

Throughout the doctoral project, the student will implement a participative design approach including all the participants in order to ensure constant multidisciplinary exchanges throughout the work and to guarantee the achievement of innovative and operational results.

Qualifications

Candidates must have an MSc or engineering degree in a field related to computer science or applied mathematics, with strong programming skills (in particular with deep learning frameworks). Experience with medical image analysis or brain analysis will be a plus. Candidates are expected to have abilities to write scientific reports and communicate research results at conferences in English.

Information and application

Applications should include the following documents in electronic format: i) A short motivation letter stating why you are interested in this project, ii) A detailed CV describing your past education and research background related to the position. iii) The transcripts for master degrees. iv) The contact information for references (do not include the reference letters with your applications as we will only ask for the reference letters for short-listed candidates).

Please send your application package to jean-yves.ramel@univ-tours.fr and elodie.chaillou@inrae.fr

A first selection will occur and then interviews will be proposed between April and the end of May.

The position will start in October 2022 with a salary of 1975 euros gross/month (legal amount for doctoral contracts in France) and will be located in Tours, France. Ideally located in the heart of France (Loire Valley), one hour from Paris and 2.5 hours away from the Atlantic Ocean, Tours is a lively and dynamic city.

References

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[11] Rozemberczki B, Scherer P, He Y, Panagopoulos G, Astefanoaei M, Kiss O, Beres F, Collignon N, Sarkar R. (2021) PyTorch Geometric Temporal: Spatiotemporal Signal Processing with Neural Machine Learning Models. arXiv preprint arXiv:2104.07788