PhD proposal

Self supervised learning for anomaly detection in medical neuroimaging

Scientific context

The vast majority of deep learning architectures for medical image analysis are based on supervised models requiring the collection of large datasets of annotated examples. Building such annotated datasets, which requires skilled medical experts, is time consuming and hardly achievable, especially for some specific tasks, including the detection of small and subtle lesions that are sometimes impossible to visually detect and thus manually outline. This critical aspect significantly impairs performances of supervised models and hampers their deployment in clinical neuroimaging applications, especially for brain pathologies that require the detection of small size lesions (e.g. multiple sclerosis, microbleeds) or subtle structural or morphological changes (e.g. Parkinson disease).

Objective and research program

To solve this challenging issue, the objective of this thesis is to develop and evaluate deep **self-supervised detection and segmentation approaches** whose training does not require any fine semantic annotations of the anomalies localization. Presently, we have developed anomaly detection methods based on mixture models [Arnaud 18] and deep statistical unsupervised learning model [Alaverdyan 20]. Additionally, we have recently compared different auto-encoder architectures for the detection of early forms of Parkinson's disease [Muñoz Ramírez 21], [Muñoz Ramírez 22].
During the PhD thesis, new methodological research axes will be considered based on the prolific literature in this field. We will explore different categories of self-supervised methods, including : novel *unsupervised auto-encoder based anomaly detection models* leveraging on the recent developments in visual transformers blocks (ViT) or vector quantized variational autoencoders (VQ-VAE), scalability of *Gaussian mixture models* as well as *weakly supervised models* based on scarce annotations.
In a first step, we will focus on Parkinson disease and micro hemorrhage imaging data and fuse different MR modalities.

Environment: We offer a stimulating research environment gathering experts in Image processing, Neurosciences & Neuroimaging, Advanced Statistical and Machine Learning methods.
The successful candidate will have access to performant computing resources (internal GPU clusters or CNRS Jean Zay supercomputer) and imaging databases such as the PPMI database (https://www.ppmi-info.org/accessdata-specimens/download-data) for Parkinson disease and the WMH database (https://wmh.isi.uu.nl/) for white matter hyperintensities (WMH) of presumed vascular origin.

The PhD position is granted by the “Défi IA” program sponsored by la Région Auvergne Rhône-Alpes.

Key words: Machine learning, Deep Learning; Multidimensional data, Segmentation, Neuroimaging, Self-supervised learning, Anomaly detection, Unsupervised representation learning

Supervision / contact: The PhD candidate will be co-supervised by:

- GIN - team «Functional neuroimaging and brain perfusion»: Michel Dojat (michel.dojat@inserm.fr),
- CREATIS - team Myriad : Carole Lartizien (carole.lartizien@creatis.insa-lyon.fr)
- INRIA - team Statify: Florence Forbes (Florence.forbes@inria.fr)

Location: Grenoble Neurosciences Institute: https://neurosciences.univ-grenoble-alpes.fr & CREATIS - Villeurbanne: https://www.creatis.insa-lyon.fr/. Time sharing in the two laboratories will be discussed with the selected candidates.

Starting date: Autumn 2022

How to apply: Send an email directly to the supervisors with your CV and persons to contact. Interviews of the selected applicants will be done on an ongoing basis. Applications will be accepted up to the 30st of June.

References

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Alaverdyan Z, Jung J, Bouet R, Lartizien C (2020). Regularized siamese neural network for unsupervised outlier detection on brain multiparametric magnetic resonance imaging: Application to epilepsy lesion screening. Medical Image Analysis. 60:101618

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Arnaud A, Forbes F, Steele R, Lemasson B, Barbier E. Bayesian mixtures of multiple scale distributions. Working paper