ARAMIS LAB
Paris Brain Institute (ICM)
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PhD thesis

Deep learning for assisting clinical decisions in brain imaging: trustworthy validation and benchmarking

Keywords: deep learning, brain imaging, neurological disorders, experimental machine learning, validation, statistics

The topic

Deep learning-based analysis of brain imaging data holds great promises for assisting clinical decision in brain disorders (e.g. Alzheimer's disease, Parkinson's disease…). This is a very active research field with many papers published each year (Colliot, 2023). However, the real medical impact in terms of translation to patient care has been so far limited. Experimental results presented in research papers are most often inadequate for answering two key questions for clinical translation: i) do we have solid guarantees on the performance of the proposed approach?; ii) among different deep learning approaches, do we have strong evidence to select the one which performs best? There are several underlying reasons: i) irreproducible research procedures and results; ii) inadequate experimental set-ups which don't account for the specificities of brain imaging; iii) biased validation procedures; iv) inadequate or lack of inferential statistics.

Our team has been a pioneer and has produced highly-cited work on reproducible and trustworthy evaluation of machine learning for computer-aided diagnosis of Alzheimer's disease (e.g. Samper-Gonzalez et al, 2018; Wen, Thibeau-Sutre et al, 2020). In particular, we have unveiled biased validation procedures, proposed frameworks to avoid them, performed large-scale benchmarks and created an Open Source software platform for reproducible deep learning in brain imaging, ClinicaDL (https://clinicadl.readthedocs.io/en/latest/). However, important questions remain unanswered including integration of inferential statistics into the framework, generalization across different disorders, accounting for dependent data (e.g. patient/scanner/hospital hierarchical data structure), and generalization across datasets.

Building upon these efforts, this PhD project aims at obtaining a general methodological and experimental framework for trustworthy and reproducible validation and benchmarking of deep learning methods in brain imaging and performing large-scale experiments. Specific objectives are as follows:

- enrich the framework with more advanced deep learning models, more tasks and more datasets
- better account for specificities of brain imaging (multiple acquisitions over time, multiple scanners, multiple hospitals, multiple datasets, multiple disorders)
- propose an adequate inferential statistics framework for both model validation and model comparison
- perform benchmarking experiments across deep learning (and also standard machine learning) models, tasks, diseases and datasets to create a new standard for the community

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- demonstrate the importance of accounting for brain imaging specificities when evaluating models
- implement the approaches in open-source software, in particular ClinicaDL (https://clinicadl.readthedocs.io/) so that they can benefit the entire scientific community

References

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- Samper-González J, Burgos N, Bottani S, Fontanella S, Lu P, Marcoux A, Routier A, Guillon J, Bacci M, Wen J, Bertrand A, Bertin H, Habert M-O, Durrleman S, Evgeniou T, and Colliot O, Reproducible evaluation of classification methods in Alzheimer's disease: Framework and application to MRI and PET data, *NeuroImage*, 183:504–521, 2018. https://inria.hal.science/hal-01858384v2/file/AD_ML_manuscript_postprint.pdf

A vibrant scientific, technological, clinical and ethical environment

You will work within the ARAMIS lab (www.aramislab.fr) at the Paris Brain Institute (http://www.icm-institute.org), one of the world top research institutes for neurosciences. The institute is ideally located at the heart of the Pitié-Salpêtrière hospital, downtown Paris.

The ARAMIS lab, which is also part of Inria (the French National Institute for Research in Computer Science and Applied Mathematics), is dedicated to the development of new machine learning and statistical approaches for the analysis of large neuroimaging and clinical data sets.

This PhD is funded as part of the Paris Artificial Intelligence Research Institute (PRAIRIE - https://prairie-institute.fr/). O. Colliot holds a research Chair within the PRAIRIE institute. Within the PRAIRIE Institute, the PhD candidate will have access to a rich scientific environment covering all aspects of AI, including many seminars, workshops and gatherings for PhD candidates and postdocs.

To perform large scale experiments, the PhD candidate will have access to the Jean Zay supercomputing infrastructure which comprises about 2,000 V100 GPUs and about 400 latest generation A100 GPUs.

The PhD candidate will be interacting frequently with other PhD students as well as with engineers working on the ClinicaDL software platform. In particular, the PhD candidate will receive the help of engineers for data management and implementation.

Finally, this project is part of a large-scale collaboration on validation of AI algorithms in medical imaging conducted with the German Cancer Research Center at Heidelberg and at the Soda Team at Inria Saclay.

Your profile

- Master or engineering degree with a specialization in machine learning
- Excellent background in machine learning

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- Excellent programming skills in Python
- Strong interest for experimental aspects of machine learning
- Good background in statistics
- Knowledge of the specificities of computer vision and medical image processing would be a plus
- Good writing skills
- Good relational and communication skills
- Ability to collaborate efficiently with other team members

Starting date

- The starting date is flexible (the target is around October 2024).

Contact

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