PhD in AI and medical imaging (Bordeaux: 2024-2027)
An AI Assembly for the Prediction of Neurological Diseases

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Funding:	National Grant (2300€ gross / month) – National project HoliBrain
Laboratory:	Computer Science Research Laboratory of Bordeaux (LaBRI) University of Bordeaux, Talence's campus
Team:	Image and Sound (25 permanents, 25 PhD students)
Teaching:	Teaching opportunities during the thesis
Collaboration:	Institute of Neurodegenerative Diseases (IMN): Dr. Vincent Planche Polytechnic University of Valencia (Spain): Pr. José Manjon

Context

Magnetic Resonance Imaging (MRI) plays a pivotal role in the detection of pathologies, the study of brain organization, and clinical research. Every day, a vast amount of data is generated, and this number is continuously growing, making manual analysis approaches impractical. Consequently, the development of reliable, robust, and rapid techniques for the detection of neurological pathologies becomes a significant area in medical imaging. In this project, the goal is to develop a new generation of Artificial Intelligence (AI) methods capable of automatically detecting neurological diseases, thereby assisting clinicians in their differential diagnosis (see Figure 1).

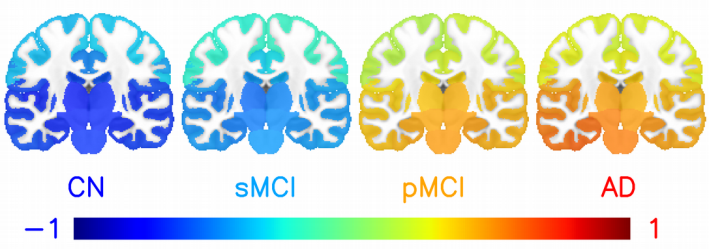

Figure 1: G*rading* maps on different population groups [3].
(CN=Cognitive Normal, s/pMCI= Stable/Progressive Mild Cognitive Impairment, AD =Alzheimer's Disease).

Objectives

The main goal of this thesis is to overcome methodological obstacles in AI that limit effective prediction of pathologies from MRI brain images using deep learning-based methods. This thesis will progress through several stages and intermediate objectives:

1) The first objective is to develop new pathology detection methods by addressing the current limitations of deep learning (DL) in medical imaging. DL is a rapidly growing field in computer vision, thanks to its many successes. However, the results achieved by DL in assisting with the early diagnosis of neurological diseases are still quite limited [1]. In this project, the candidate will therefore propose a new generation of methods capable of overcoming these limitations for diagnostic aid. Indeed, the complexity of the problem and the scarcity of available training data challenge the effectiveness of DL methods [2].

To address this issue, we have recently developed methods based on an assembly of artificial intelligences [3], and *transformers* [4], applied to MRI images in the form of 3D volumes. The initial results show an improvement in classification quality compared to state-of-the-art methods. Many questions remain open in this very promising new research avenue. What is the optimal organization of this large number of AIs? How can they be made to communicate effectively? How can their learning be improved by using unlabeled data through semi-supervised learning? The candidate will explore these various questions and propose solutions tailored to the addressed problem.

2) The second objective will focus on the development of specific tools for studying dementias: frontotemporal dementia (FTD), dementia with Lewy bodies (DLB), and Alzheimer's disease (AD). These diseases affect over 50 million people worldwide. For AD alone, the associated global cost is estimated at 605 billion dollars. The candidate will work closely with our collaborators at the Bordeaux University Hospital and the Institute of Neurodegenerative Diseases, thus gaining access to experts in these pathologies. By developing methods for earlier and more accurate diagnoses, this project aims to improve patient care, provide better treatment, and thereby reduce associated costs. Therefore, our project could play a significant role in the transition towards P4 medicine (predictive, personalized, preventive, and participatory): the proactive medicine of the next decade.

Environment/Collaborations

This PhD project is part of the National project HoliBrain (2024-2029), which has already secured funding with the goal of developing holistic (multi-scale) brain analysis methods. The PhD candidate's salary and activities, including research stays, conference participation, summer schools, scientific publication, etc., will be covered by the project.

The candidate will join a consortium comprising international experts in AI, medical imaging, neurological diseases, and neuroscience. They will benefit from the resources of the Laboratoire Bordelais de Recherche en Informatique, including GPU servers and computing platforms. The candidate will also work closely with clinicians and neuroscientists involved in the project. Additionally, the project includes a longstanding collaboration with the Polytechnic University of Valencia (Spain), where a research stay during the PhD is possible.

Moreover, the tools developed by the candidate may be integrated into our volBrain platform (http://volbrain.net), which offers a free, open-access service to the scientific community. With over 10,000 users worldwide and having processed over 500,000 MRIs, it stands as one of the largest databases globally. Today, it has become one of the most recognized international platforms in its field. This unique environment will give international visibility to the PhD work.

Required profile

The candidate (holding an engineering degree from a prestigious school or a Master's degree) must have a strong foundation in deep learning/machine learning. They should also possess skills in image processing and programming. Proficiency in Python, Keras, PyTorch, and TensorFlow is highly recommended. A good level of English in reading/writing is also a key element. An interest in medical imaging is a plus.

To apply, please send a package containing your CV, a cover letter, transcripts (M1+M2 or Engineering School), a list of your publications (if available), contact information for 2 references who can vouch for your skills, and any document that might strengthen your application.

References

[1] Wen, Junhao, et al. "Convolutional Neural Networks for Classification of Alzheimer's Disease: Overview and Reproducible Evaluation." arXiv preprint arXiv:1904.07773 (2019).
[2] Huo, Yuankai, et al. "3D whole brain segmentation using spatially localized atlas network tiles." NeuroImage 194 (2019): 105-119.
[3] Nguyen, Huy-Dung, Michaël Clément, Boris Mansencal, and Pierrick Coupé. "Towards better interpretable and generalizable AD detection using collective artificial intelligence." Computerized Medical Imaging and Graphics 104 (2023): 102171.
[4] Nguyen, Huy-Dung, Michaël Clément, Boris Mansencal, and Pierrick Coupé. "3D Transformer based on deformable patch location for differential diagnosis between Alzheimer's disease and Frontotemporal dementia." In International Workshop on Machine Learning in Medical Imaging, pp. 53-63. Cham: Springer Nature Switzerland, 2023.
[5] J. V. Manjon and P. Coupé. volBrain: an online MRI brain volumetry system. Frontiers in Neuroinformatics, 30:10, 2016