Machine learning for differential diagnosis of neurodegenerative diseases from multimodal data

Contract type: Public service-fixed-term contract
Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

Context
This project is proposed within the ARAMIS project-team. ARAMIS is a joint research team between Inria (Paris research center), CNRS, Inserm and UPMC within the Brain and Spinal Cord Institute (ICM). The ICM is a recently created neuroscience research center within Pitié-Salpêtrière hospital in Paris. It gathers over 700 researchers covering the full spectrum of neuroscience. ARAMIS is the methodological research team of the ICM. It is a multidisciplinary research team gathering computer scientists and medical doctors. The team develops cutting-edge machine learning and image analysis approaches for multimodal medical data (neuroimaging, clinical, genetic data), in order to create new tools for diagnosis, prognosis and monitoring of brain disorders. The team has close collaborations with several clinical teams of the ICM and the Pitié-Salpêtrière hospital to apply these methods to the study of neurodegenerative diseases including Alzheimer’s disease, fronto-temporal dementia and Parkinson’s disease. The team has a very strong network of international collaborations and in particular currently participates or coordinates two large-scale European projects funded under Horizon 2020 and two US-French grants co-funded by NIH (USA), NSF (USA) and ANR (France).

Assignment
Neurodegenerative dementias are a major public health problem. They currently affect over 40 million people worldwide and this number is expected to double every twenty years. Dementia can be due to various neurodegenerative diseases including Alzheimer’s disease, fronto-temporal lobar degeneration, dementia with Lewy bodies, primary progressive aphasias and cortico-basal degeneration. These diseases have different pathophysiological mechanisms and different evolution profiles. Being able to differentiate between neurodegenerative diseases (a task known as differential diagnosis) is therefore essential for optimal clinical care of patients as well as for effective design of clinical trials.

In the past years, machine and statistical learning approaches have been designed to assist diagnosis of neurodegenerative diseases. The majority of these works are dedicated to the automatic classification of patients with a given disease (very often Alzheimer’s disease) with respect to healthy controls. In particular, the ARAMIS team has introduced new classification approaches that achieve high accuracies for differentiating between patients with Alzheimer’s disease and controls (Cuignet et al, 2013; Samper-Gonzalez et al, 2017) as well as for differentiating between some pairs of neurodegenerative diseases (Morin et al, in Revision). However, such approaches are not sufficient for differentiating between several diseases because: i) their accuracy is too low for some types of neurodegenerative diseases; ii) they are designed for two-class classification problems.

The aim of this PhD project is to design and validate a machine learning approach for the differential diagnosis of neurodegenerative diseases from multimodal data. The first objective of the project will be to develop approaches that can handle multiple and unbalanced diagnostic classes. We will then aim to extend this to situations where two diagnoses can co-exist in the same patient (mixed disease). The second main objective will be to adequately integrate multiple types of data (imaging, fluid biomarker, clinical and genetic data). Indeed, while most existing approaches rely on neuroimaging data (most often MRI), this information is not sufficient for accurate differentiation between multiple diseases. We will in particular aim at developing approaches that can adequately model non-additive interactions between the different types of data.

To develop and validate the approach, we will use different multimodal datasets including publicly available datasets and local datasets of the ICM and the Pitié-Salpêtrière hospital.

References
Main activities
- Design of machine learning methods for differential diagnosis
- Implementation of corresponding software prototype
- Validation on clinical research datasets
- Writing of scientific publications
- Scientific presentations at international conferences and internal seminars

Skills
- Knowledge of medical image analysis
- Knowledge on machine learning algorithms
- Good programming skills, preferably in Python

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport

Remuneration
Gross Salary per month: 1 982 € the first 2 years and 2 085 € the last year