Inria

Offer #2023-06881

INTERNSHIP Scalable unsupervised subtle anomaly detection from longitudinal MR imaging data: Application to Parkinson's disease

Contract type : Internship agreement

Level of qualifications required : Master's or equivalent

Fonction : Internship Research

Level of experience : From 3 to 5 years

Context

Context:

Anomaly detection in medical imaging is a challenging task in contexts where abnormalities are not annotated and difficult to detect even for experts. This problem can be addressed through unsupervised anomaly detection (UAD) methods, which identify features that do not match with a reference model of normal profiles. In the context of Parkinson's disease and newly diagnosed patients, the detection task is all the more challenging as abnormalities may be subtle and hardly visible in structural MR brain scans. Some preliminary work [Oudoumanessah et al 2023] has shown that structural abnormalities could be detected from MR image data in a way that is consistent with the disease progression, as accounted by the Hoehn and Yahr scale [Hoehn & Yahr 1998].

Assignment

The goal of this project is to further improve the reliability of the detection by leveraging additional information coming from longitudinal data. Longitudinal data [Hedeker & Gibbons 2006] consist in the repeated observations of patients over time. In practice, we expect to analyse image data at a few different times corresponding to successive visits of patients. Their analysis informs us on the progression of the disease through the evolution of abnormalities, both in size, numbers, or locations. More specifically, when applied to anomaly detection, the expectation is the confirmation of uncertain detections or the discovery of new ones, not visible at early stages.

Modelling longitudinal data presents different types of challenges. First are the methodological challenges related to the design of relevant models to handle all the data and disease's characteristics in order to answer the statistical and medical questions. These modelling difficulties cannot be separated from challenges arising from data with very different modalities and time dependencies, in particular involving different acquisition time-sets and different scales of patient screening, resulting on possibly partially missing data [Couronne et al 2019].

Raphael Couronne, Marie Vidailhet, Jean-Christophe Corvol, Stephane Lehericy, and Stanley Durleman. Learning disease progression models with longitudinal data and missing values. In ISBI 2019 - International Symposium on Biomedical Imaging, Venice, Italy, April 2019.

Donald Hedeker and Robert D. Gibbons. Longitudinal data analysis. John Wiley & Sons, Inc, New Jersey, 2006.

Hoehn, M. and Yahr, M. D. Parkinsonism: onset, progression, and mortality, Neurology 1998.

Kendall, A and Gal, Y. What Uncertainties Do We Need in Bayesian Deep Learning for Computer Vision? NeurIPS 2017.

Oudoumanessah G, Lartizien C, Dojat M, Forbes F, Frugal unsupervised detection of subtle abnormalities in medical imaging, in: Greenspan H, Madabhushi A, Mousavi P, Salcudean S, James Duncan J, Syeda-Mahmood T, R T (Eds.) Miccai, Springer-Verlag AG Swizerland, Vancouver (Ca), 2023, pp. 411-421.

Marek S. Chowdhury, A. Siderowf, et al., "The parkinson's progression markers initiative (ppmi) - establishing a pd biomarker cohort," Annals of Clinical and Translational Neurology, p. 1460–1477, 2018

Main activities

Directions of research:

As a first direction of research, we propose to consider the modalities used in our previous work [Oudoumanessah et al 2023] and investigate the extension of the model and inference technique therein to multiple time data. A first idea would be to use analysis and results at previous times to inform analysis at subsequent times using a Bayesian approach as a way to incorporate information from one time to another.

As a second direction of research, we will focus on accounting for possibly missing time sampling point, considering that the sample size of patients having performed all required analysis at regular time intervals, is often quite small. This task will aim at reporting on the uncertainties associated to the individual prediction in this case. The performances, strengths and weaknesses of two approaches will be compared. The first one will consist in making Bayesian predictions from the model already developed. The second will consist in exploring a Bayesian Deep learning approach [Kendal & Gal, 2017].

Skills

Hard skills:
-Applied mathematics, probability theory.
-Data analytics, learning and more specifically

-Statistical and deep learning, Longitudinal analysis, Clustering, Mixture distributions, Online EM algorithm, Biomarkers.

- Programming (Python or equivalent).
- Fluent in English or in French

Soft skills:
-Strong communication skills.
-Rigor in problem analysis, and formulation.
-Autonomy, enthousiasm.
-Curiosity, ability to propose ideas

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods
  Statistics (Big data) (BAP E)
- **Town/city :** Montbonnot
- **Inria Center :** Centre Inria de l'Université Grenoble Alpes
- **Starting date :** 2024-03-01
- **Duration of contract :** 5 months
- **Deadline to apply :** 2024-05-23

Contacts

- **Inria Team :** STATIFY
- **Recruiter :**
  Forbes Florence / florence.forbes@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

The topic of this proposal requires backgorund in in statistical learning and big longitudinal data and skills in computer science, applied mathematics, interest for statistics applied to medical data.

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Instruction to apply

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is

granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.