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

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].

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].

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: 2024-02-29

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