Proposition de stage de M2 en statistique:
Project title: "Statistical networks for functional data with applications to brain networks based on neuroimaging data"

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Project background: Many modern applications such as medical image analysis and genetics produce complicated data structures, where the sampling units are vectors of functions rather than numbers or vectors. As a result, functional data analysis (FDA) techniques have been vigorously developed over the past decade or so, aiming to deal with the statistical treatment of samples of random functions. A statistical tool in FDA that is gaining increasing attention in recent years is *functional graphical modeling*, where the central goal is to investigate the interdependence structure among multivariate functional data. In general, a functional graphical model is composed of nodes and edges, where the nodes correspond to functions and the edges represent dependence between the functions (nodes). These models have been used recently in neuroscience research, where the goal is to explore the network structure of the brain based neuroimaging data collected by electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Brain functional network connectivity reveals intrinsic functional architecture of the brain. Studies have shown that brain connectivity network alters under different pathological conditions, and such alterations are associated with cognitive and behavioral functions, and hold crucial insights of pathologies of neurological disorders.

Project: Nearly all existing functional graphical models in the literature only study independent functional data. However, as technology advances, heterogeneous and repeated functional data are becoming increasingly available, for example fMRI data that are observed repeatedly on the same subject at different situations or fMRI data recorded from different sub-populations. The purpose of this MSc internship project is to develop and apply new or existing methodologies at the interface of functional data analysis (FDA) and graphical models to investigate the inter-dependence structure of large-scale, heterogenous and dependent functional data. Then, computational algorithms will be proposed to estimate the graph. The methods will be evaluated by simulation studies and they will be applied to real-world neuroimaging data (functional MRI and EEG) to characterize connections between the regions of the brain.

Main duties and responsibilities: The successful candidate will be responsible for i) the application of new and existing statistical methodologies from graphical models and FDA; ii) for the development and the application of algorithms to solve penalized optimization problems iii) for testing and validating the methods through simulation studies iv) for the collection, preprocessing and the statistical analysis of real-world functional MRI (fMRI) data or EEG to investigate connectivity patterns in human brain networks.

Qualifications: Applications are welcomed from students in their final year of study (Bac+5) with a strong background in mathematical statistics. Advanced skills in programming with R and/or Python and some experience with the applications on real data sets are also required. The student should have a motivation and interest in working with neuroimaging data. Having experience working with functional MRI neuroimaging or EEG data sets would be considered an advantage. Good communication skills in oral and written English are required.

Information about CREST and ENSAI: France's top graduate school for statistics and data science, ENSAI has made a name for itself in Europe and beyond thanks to the quality of the education and the research. ENSAI is home to part of the CREST research laboratory, a mixed research unit of the CNRS attached to the Group of National Schools in Economics and Statistics (GENES) and Ecole polytechnique in Paris. CREST is a multidisciplinary research center for Economics, Statistics, and Sociology. It is located in both Saclay (ENSAE Paris and Polytechnique) and Ker Lann (ENSAI). The majority of the CREST lab at ENSAI is made up of Statisticians who are bolstered by Economics researchers and Computer Science researchers specialized in Machine Learning. Research in statistics covers a wide range of research areas related to statistical modeling. ENSAI's reputation as a leader

in the field is the result of this high-level scientific and operational expertise that we have cultivated since the founding of the school in 1996. More information about us can be found on our website http://ensai.fr/en/.

Location and period:

- The master student will be supervised by Eftychia Solea at CREST Lab, at ENSAI in Rennes.

- Duration: up to 6 months. The internship could start as soon as February 2022.

Funding:

- The internship is funded by the Dispositif Allocation D'Installation Scientifique of Rennes, Metropoles.

- The rule of the French minimal monthly wage for internship will be applied.

Contact: Please send your application (CV, academic transcripts and cover letter stating the motivation) to Eftychia Solea (eftychia.solea@ensai.fr). **Deadline of applications: December, 31st.**