Machine learning for the study of EEG data recorded during general anesthesia

Supervisors

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Keywords classification, Wasserstein distance, signal processing, EEG data, anesthesia, ...

Our laboratory This internship will take place at the Centre Borelli (ENS Paris Saclay/Université Paris Saclay, CNRS, Université de Paris, SSA, INSERM). The Borelli Center is a multidisciplinary research unit focusing on all applications of mathematics, neuroscience and biomedical research. It brings together multidisciplinary teams of mathematicians and experts in medicine, physics, mechanics, biology, and engineering, to conduct research actions motivated by real data and use cases from science and industry. It offers courses of excellence in applied mathematics, neurosciences, ergonomy and bioengineering on promising themes with high technological and societal stakes.

The societal stakes are considerable and offer many opportunities to the student who will choose this project in the field of the interface of engineering sciences, computer science, new technologies and medicine, ... In case of success, the internship may be the subject not only of scientific publications but also of a valorization project.

Environement The trainee will have the opportunity to be fully integrated into an interdisciplinary team of clinical anesthesiologists, mathematicians, neuro-scientists, statistical modelers and computer scientists. The internship will take place at ENS Paris Saclay (Gif sur Yvette) and Université de Paris (Paris). The trainee will attend weekly seminars of the MLMDA team. The duration of the internship is between 4 and 6 months and the trainee will be paid according to the standard internship wage (around 600 euros per month).

Motivation General Anesthesia (GA) is a drug-induced, reversible condition with three commonly accepted goals: lack of experience of surgery, nociceptive blockade and immobility for the needs of surgery. In 2010, 11.3 millions of anesthesia procedures were performed in France. However, despite numerous progresses in the understanding of GA mechanisms, some questions remain unanswered like the precise mechanisms of awakening after a GA, the long term effects of anesthesia or the common pathway of all anesthetics. The aim of this project is to use electroencephalogram (EEG) signatures and machine learning tools in order to better understand the phenomena involved during awakening from GA. In particular, the goal of our study is to precisely quantify GA recovery in order to further investigate its nature and time course, which remains debated. GA recovery is often considered as a passive process : as the anesthetics are eliminated, the reactivation of the neuronal circuits affected by GA would simply mirror their deactivation. But is it true ? Could we find some traces of GA in the EEG of patients, even several hours after they woke up ?

Objectives We have continuously recorded the EEG signals of 30 patients under GA with a 32-channel EEG device, from 1 hour before their sedation up to 3 hours after their awaking (when it is generally assumed that the recovery period is over). The objectives of this internship is to develop machine learning tools to analyze this database, in order to investigate whether or not GA effects were still visible in the EEG activity 3 hours after awaking. Since GA is mostly characterized by the appearance of spatially coherent frontal alpha-oscillations [1], several adapted machine learning tools can be investigated

1. Use adequate measures of fit (such as normalized Euclidean distance, or Wasserstein distance) to derive a classifier for EEG frames in the frequency domain [2]. The main idea here is to see the frequency patterns as discrete probability distributions that can be compared and classified. The task can be seen from two different yet linked points of view : attempt to classify and/or cluster the frequency signatures before and after awaking to figure out the similarities or conduct statistical tests to test for significant differences.

2. Thanks to filtering, recover the alpha-band energy as a function of time, and study this trajectory with tools derived from supervised statistical signal processing such as change point detection [3], feature extraction and selection [4] or prediction algorithms [5].

Preliminary planning

1. State of the art for the study of EEG in the context of GA + common tools for analysis (spectrograms, time-frequency analysis. . .) : 1 month

2. Review and implementation of standard distances and divergences for the classification/comparison of discrete probability distributions. Tests on real data and first conclusions on the database : 2 months

3. Study of the alpha-band energy in the time domain : change point detection and sliding feature extraction for the characterization as homogeneous regimes. Study of the symmetry of the GA trajectory (sedation/awaking) : 2 months

4. Publication of the results and redaction of the master thesis : 1 month

Références

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