Master internship on

Machine learning of EEG signals and videos

in the context of epilepsy research

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Context: Epilepsy is a severe neurological condition concerning approximately 50 million people worldwide. It is characterized spontaneously recurring seizures, and has a variety of symptoms ranging from abnormal sensations to generalized convulsion. Electroencephalography (EEG) is the most relevant measure for understanding the origin of the epileptic seizures [4], but the detailed analysis of the EEG activity is difficult. Several states can be characterized: inter-ictal (intervals far away from seizures), pre-ictal (intervals of several minutes preceding a seizure), ictal (during a seizure). Recording videos of behaving animals as well their EEG is useful in order to observe the animals and evaluate the severity of the seizure. However, visual analysis of long-term videos and/or EEG recordings is error-prone.

In this project, two interns will be hired. A biologist intern, hosted at the Institut de Pharmacologie Moléculaire et Cellulaire (IPMC), will record the EEG and videos on epileptic mice [5]. The machine learning intern will be based at Inria (both labs are close by in Sophia Antipolis), and will develop algorithms to detect epileptic activity in EEG signals and videos [1,2,3] :

- For the EEG signals, it is important to detect different typologies of spike discharges (via the density of the spikes, and the shape of the spikes). For this, a Dictionary Learning approach will be used [1,2,3], in order to automatically identify signal components which recurr in the data, while accounting for shape variability.

- For the video analysis, the goal will be to improve a python code which is already present in the biology lab. The analysis of simultaneous EEG recordings can provide labels for the video-based classification of seizures. Several methods of seizure detection from videos will be compared, including deep convolutional networks.

Relevant publications from Inria and IPMC :

[1] Papageorgakis, C., Hitziger, S. and Papadopoulo, T. Dictionary Learning for Multidimensional Data. Proceedings of GRETSI 2017, Sep 2017, Juan-Les-Pins, France.

[2] Hitziger, S., Clerc, M., Gramfort, A., Saillet, S., Bénar, C. and Papadopoulo, T. Jitter-adaptive dictionary learning - application to multi-trial neuroelectric signals. arXiv preprint:1301.3611, (2013)

[3] Hitziger, S., Clerc, M., Saillet, S., Bénar, C. & Papadopoulo, T. Adaptive Waveform Learning: A Framework for Modeling Variability in Neurophysiological Signals. IEEE Transactions on Signal Processing, 65(16):4324--4338, (2017).

[4] Mantegazza M. and Cestele S. et al. (2017). Pathophysiological mechanisms of migraine and epilepsy: similarities and differences. Neurosci Lett

[5] Hedrich U.B. *et al.* (2014). Impaired Action Potential Initiation in GABAergic Interneurons Causes Hyperexcitable Networks in an Epileptic Mouse Model Carrying a Human NaV1.1 Mutation. J Neurosci