3iA Côte d'Azur
Interdisciplinary Institute for Artificial Intelligence

Ph.D. research topic

- Title of the proposed topic: **Estimating the learning process of the brain**
- Research axis of the 3IA: (Axis 3) AI for computational biology and Bio-inspired AI
- **Supervisor (name, affiliation, email): Patricia Reynaud-Bouret, LJAD, Patricia.Reynaud-Bouret@univ-cotedazur.fr**
- Potential co-supervisor (name, affiliation): Luc Lehéricy, LJAD
- The laboratory and/or research group: LJAD, Probability and Statistics team

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Apply by sending an email directly to the supervisor.
The application will include:

- Letter of recommendation of the supervisor indicated above
- Curriculum vitæ.
- Motivation letter
- Academic transcripts of a master's degree(s) or equivalent.
- At least, one letter of recommendation.
- Internship report, if possible.

- Description of the topic:

The aim of the project is to quantitatively understand the mechanisms that take place during learning. The first part of the project consists in fitting classic learning algorithms like reinforcement learning [1], or less classic learning algorithms [2], on real behavioral data. These models will next be adapted to take advantage of recorded neuronal activity to improve prediction.

Bounds inspired by regret analysis and bandit problems [3] will be used to prove convergence of the algorithms, the aim being to identify the most discriminant features between models in order to find the best fit.

Estimation for these reinforcement learning models is challenging since the succession of failure and success through the trials can be seen as a (partially observed) Markov chain in transient phase (the learning part), the length of the transient phase depending on the parameters themselves which therefore impacts the quality of their estimation.

To assess the relevance of these models, we have access to neuronal and behavioral data recorded on rodent during a spatial memorization task thanks to the Computabrain interdisciplinary project

http://univ-cotedazur.fr/en/idex/projet-structurant/neuromod/projects/computabrain/

Note that during learning phases, the neuronal activity is of course not stationary and depending on the task, this learning phase can be so short that it can be almost impossible to estimate any feature without having a meaningful model.

Therefore, another task in the project would be to build a new model, inspired by [4,5] for the evolution of the neuronal activity in close collaboration with mathematicians, statisticians, computer scientists and neurobiologists.

Interested candidates with a PhD thesis in probability or statistics should send a CV and a motivation letter to Patricia.Reynaud-Bouret@univ-cotedazur.fr.

References

[1] R.S. Sutton and A.G. Barto *Reinforcement Learning: An Introduction.* MIT Press. 2018

[2] A. Muzy *Exploiting activity for the modeling and simulation of dynamics and learning processes in hierarchical (neurocognitive) systems"* IEEE Magazine of Computing in Science & Engineering (CISE), vol. 21, no. 1, pp. 84-93. 2019

[3] S. Bubeck and N. Cesa-Bianchi *Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems.* Foundations and Trends in Machine Learning, Vol. 5, No. 1, 1–122. 2012

[4] G. Ost and P. Reynaud-Bouret *Sparse space-time models: concentration inequalities and Lasso*, Annales de l'IHP, Probabilités et Statistiques, to appear. 2019.

[5] R. Lambert, C. Tuleau-Malot, T. Bessaih, V. Rivoirard, Y. Bouret, N. Leresche, P. Reynaud-Bouret *Reconstructing the functional connectivity of multiple spike trains using Hawkes models*, Journal of Neuroscience Methods, 297, 9-21, 2018.