Subject: Towards a mathematical understanding of neural networks through mean-field analysis

Supervisor: Arnaud Guillin

Laboratory: Laboratoire Mathématiques Blaise Pascal

Email and phone: arnaud.guillin@uca.fr, 0473407090

Co-advisor(s): Manon Michel (LMBP)

Abstract (up to 10 lines):

If deep neural networks have proved their efficiency in a number of real applications (game of Go, image analysis,…), we are far from understanding the mathematical reasons behind this success. Recently a mean field analysis has been introduced to get a new perspective on these algorithms. We will pursue this direction and make links with statistical physics to hopefully gain a profound understanding of these new statistical learning tools.

Skills: Mathematics, Probability, Statistics, Statistical learning, R, Python

Keywords: Deep neural networks, statistical learning, mean field analysis.

Description (up to 1 page):

The recent developments of Machine Learning algorithms have been marked by popular successes, in particular coming from neural networks and their deep implementation. However such successes are still poorly rigorously justified and the rich behavior of deep neural nets is yet to be characterized by a well-understood mathematical framework. In this thesis, we propose to work

towards such formalism by use of a mean field analysis. First developed for spin systems and then applied in the 80s to shallow neural nets by physicists, the mean field approach is the object of a recent renewed interest in mathematics for such problems, thanks to its simplification power. However, this simplification comes with limitations which need to be precisely analysed. Eventually, the mean-field approach allows to draw natural bridges with statistical physics, namely the spin-glass community, which will be also investigated further.

References (recent):

"Mean field analysis of neural networks: A central limit theorem", Konstantinos Spiliopoulos, Justin Sirignano, Stochastic Processes and their Applications , Volume 130, Issue 3, March 2020, pp. 1820-1852.
Deep Neural Networks Motivated by Partial Differential Equations, Lars Ruthotto, Eldad Haber. Arxiv 2019.
 "Mean field analysis of neural networks: a law of large numbers", Konstantinos Siliopoulos, Justin Sirignano, 2019, *SIAM Journal on Applied Mathematics*, *to appear*.

Explorations on high dimensional landscapes, G. Ben Arous, L. Sagun, V. Ugur Guney, and Yann Le Cun International Conference on learning representations, ICLR 2015

Références (up to ½ page):

How to candidate?
Contact the supervisor