Basic Course 11: Advanced statistical methods

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Overview. This course is organized as follows: 8 academic lessons, joint with 3 numerical labs with Python. Each slot lasts 3 hours.

The first part (5 slots) deals with Bayesian statistics, asymptotic behavior of Bayesian estimators and connections with decision theory. The second part of the course (6 slots) consists in introducing stochastic algorithms to deal with simulation, estimation and optimization problems.

The validation of the course is done by an individual homework and a group lab report for the first part and by an individual homework and two group lab reports for the second one.

Part 1: Bayesian Statistics

- **Slots 1 to 4:** introduction and motivation of Bayesian statistics, information theory, prior and posterior distributions, asymptotic behavior of Bayesian estimators, connections with decision theory, Bayesian testing procedures.
- **Slot 5 (Lab):** Bayesian linear regression and Gaussian regularization

Bibliography:

1. C. P. Robert, *Le Choix Bayésien*, Springer-Verlag, 2006
2. A. W. van der Vaart, *Asymptotic statistics*, Cambridge University Press, 1998.

Part 2: Stochastic Algorithms

- **Slots 1 to 3:** introduction and motivation of stochastic algorithms, simulation problems, Monte Carlo method by Markov chains, Metropolis–Hastings algorithm, Gibbs sampling.
- **Slot 4 (Lab):** Ising model and Monte Carlo method by Markov chains
- **Slot 5:** Simulated annealing, Stochastic gradient descent.
- **Slot 6 (Lab):** Logistic regression and stochastic optimization

Bibliography:

1. B. Bercu and D. Chafaï, *Modélisation stochastique et simulation*, Éditions Dunod, 2007
2. M. Duflo, *Algorithmes stochastiques*, Springer Mathématiques et Applications, 1996.
3. C. P. Robert and G. Casella, *Monte Carlo Statistical Methods*, Springer Texts in Statistics, 2004.