Fundusze Europejskie Wiedza Edukacja Rozwój

Unia Europejska Europejski Fundusz Społeczny

Lectures on statistical aspects of Data Science.

MARKOV CHAIN MONTE CARLO ALGORITHMS

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16-27 March 2020.

Description: **Markov chain Monte Carlo** (**MCMC**) methods comprise a class of algorithms for sampling from a probability distribution. By constructing a Markov chain that has the desired distribution as its equilibrium distribution, one can obtain a sample of the desired distribution by recording states from the chain. MCMC methods are primarily used for calculating numerical approximations of multi-dimensional integrals, for example in Bayesian statistics, computational physics, computational biology and computational linguistics.

In Bayesian statistics, the recent development of MCMC methods has made it possible to compute large hierarchical models that require integrations over hundreds to thousands of unknown parameters.

This course will lead the students through the basic concepts of MCMC methods and will give a chance for a hands on experience with modern and efficient MCMC algorithms.

Course Outline

Markov chain Monte Carlo (MCMC) algorithms are one of the most dynamic areas of research in modern statistics and are key to Bayesian inference. The recent trends in statistical modeling that focus on big models and big data render Markov chain Monte Carlo more challenging and motivate new exciting developments. This course will introduce and present the theory, methodology and practice of Markov chain Monte Carlo comprising the following indicative list of topics:

- Main concepts of Bayesian modelling and inference; uncertainty quantification; exploring the posterior distribution: the need for Markov chain Monte Carlo and related tools.
- The classical Monte Carlo computational method and its validity via probabilistic limit theorems.
- Markov chains, stationary distributions, reversibility and the Metropolis algorithm.
- Markov chain Monte Carlo, the toolbox of algorithms: Metropolis-Hastings, the Gibbs sampler, Metropolis adjusted Langevin Algorithm (MALA), Hamiltonian Monte Carlo (HMC), the slice sampler, hybrid algorithms.
- Markov chain Monte Carlo and related algorithms for multimodal distributions.
- Validity of Markov chain Monte Carlo: limit theorems, theoretical properties and practical implications.
- Optimal scaling and the adaptive Metropolis algorithm.
- Adaptive MCMC - theoretical background.
- Adapting the Gibbs Sampler.
- Adaptive MCMC for variable selection problems.
- Adapting increasingly rarely Markov chain Monte Carlo (AirMCMC).
- Markov chain Monte Carlo and Intractable Likelihoods.
- Pseudo-marginal MCMC.
- Approximate Bayesian Computation (ABC) and ABC-MCMC.
- Continuous time MCMC: the Zig-Zag.

The course will be illustrated with Bayesian inference examples and will be accessible to students with varied backgrounds. The students will be encouraged to familiarize themselves with R (or an equivalent programming language), implement some of the discussed algorithms and perform simulations.