Advanced Topics in Systems, Control and Learning 1 (048715)

Monte Carlo Methods for Computation and Optimization

Prof. Nahum Shimkin

Wednesday, 16:30-18:30, Room 352

Prerequisites: Random Signals (044202), or a similar basic course on random processes.

Outline: Monte Carlo simulation methods are extensively used in science and engineering for numerically solving complex computation and optimization problems. These methods essentially rely on repeated draws of basic random samples, which are then processed and averaged to obtain the quantities of interest.

In this introductory course we present the core techniques of the field, from independent sampling to Markov chain Monte Carlo (MCMC) methods, along with selected applications.

Topics:
1. Introduction: MC methods and applications
2. Random variate generation
3. Variance reduction techniques, I
4. Variance reduction techniques, II: Rejection and Importance Sampling
5. Sequential Monte Carlo, Particle Filtering
6. Markov-Chain Monte Carlo: Metropolis-Hasting, Gibbs sampling
7. Markov-Chain Monte Carlo: convergence rates
8. Stochastic system simulation
9. Sensitivity estimation
10. Monte Carlo optimization, the Cross-Entropy method
11. Monte-Carlo planning: Random tree-search algorithms.
12. Additional topics (time permitting): perfect sampling, quasi Monte-Carlo, counting and splitting methods.

Textbooks:
1. R. Rubinstein and D. Koese, Simulation and the Monte Carlo Method, Wiley, 2008.
2. C. Robert and G. Casella, Monte Carlo Statistical Methods, 2nd ed., Springer, 2005.
3. S. Asmussen and P. Glynn, Stochastic Simulation, Springer, 2007.
4. J. Liu, Monte Carlo Strategies in Scientific Computing, Springer, 2008.

GRADING: 50% Homework, 30% Seminary paper/class presentation, 20% exam.