STAT 608: Monte Carlo methods in Statistics

Fall 2021

Basic information. Lecture Time: 11:30–1 PM TTh, USB 4151
Instructor: Long Nguyen, xuanlong@umich.edu, WH 461, office hours: by appointment
Teaching Assistant: Rayleigh Lei, rayleigh@umich.edu, office hours: tba

Course description. This course is an introduction to Monte Carlo sampling and integration methods that arise in statistics. Course topics include: basic Monte Carlo methods (random number generators, variance reduction techniques, importance sampling and its generalizations), an introduction to Markov chains and Markov Chain Monte Carlo and mixing time properties (Metropolis-Hastings and Gibbs samplers, data-augmentation techniques, convergence diagnostics). Optional topics include: sequential Monte Carlo, Hamiltonian Monte Carlo, advanced computational methods (approximate Bayesian computation, variational inference) for complex statistical models such as latent variable and hierarchical or nonparametric Bayesian models.

Textbook. I will draw from following texts and other relevant research papers.

- Jun Liu, Monte Carlo strategies in scientific computing, Springer, 2008.
- David Levin, Yuval Peres and Elizabeth Wilmer, Markov chains and mixing times, AMS, 2008.
- Sean Meyn and Richard Tweedie, Markov chains and stochastic stability, Cambridge Univ Press, 2009.

We will use Canvas class page for announcements, resources and assignments.

Tentative topics.

- Motivations and problems
- Rejection sampling, variable reduction, importance sampling and weighted methods
- Sequential Monte Carlo methods
- General conditional sampling
- Hybrid Monte Carlo methods
- Introduction to Markov Chain Monte Carlo methods:
  - Metropolis, Metropolis-Hasting, Gibbs samplers
  - Analysis of MCMC mixing times: coupling, path coupling, upper and lower bounds
  - Markov chains in uncountable state spaces: irreducibility, pseudo-atoms, small sets, stability structures and convergence
- Applications in context of hierarchical modeling and nonparametric Bayesian statistics

Evaluation. Students will be asked to scribe some lecture notes. There is a final project which consists of implementation, evaluation and analysis of Monte Carlo algorithms and an oral presentation.