STA 7828 Markov Chain Monte Carlo Methods in Statistical Inference
Fall 2019

Instructor Hani Doss—222 Griffin-Floyd; Office Hours: MWF 8th period, i.e. 3:00–3:50 pm (if you come to see me, please do so before 3:30 pm); email: `doss@stat.ufl.edu` (do not ask questions regarding the course material by email); phone: 352-273-2991.

Course Description Monte Carlo methods are increasingly used in many scientific areas, including statistical physics (where they originated), Bayesian and frequentist statistical inference, and image reconstruction. The basic idea is to carry out a simulation to estimate quantities of interest that cannot be computed analytically. This course will begin with a brief discussion of some standard Monte Carlo schemes, before moving to Monte Carlo methods based on Markov chains.

Consider the situation where there is a distribution π on some space, and we are interested in estimating π or $\int f\,d\pi$ where f is some function, but π is analytically intractable. Markov chain Monte Carlo proceeds as follows. We set up a Markov chain with the property that its transition function has π as its stationary distribution. Then we run a chain $X_1, X_2, \dots$ with this transition function. If the Markov chain converges to its stationary distribution (i.e. for large n, the distribution of X_n is approximately π), then by running the chain long enough, we can obtain a sample from π. This sample can be used to estimate π or some feature of it such as $\int f\,d\pi$.

In this course I will explain the method in detail, describe the main implementations, and discuss some classes of problems in statistics, primarily in Bayesian inference, where it has had success. The method is not fool-proof. I will talk about some of the mathematical results pertaining to convergence issues, and also discuss some practical convergence diagnostics.

Prerequisites STA 6466-7 (Probability Theory I and II) and STA 7346 (Statistical Inference I). You also need to be familiar with the statistical computing language R. This is a course intended primarily for Ph.D. students in the Statistics Department. Students who are not in the Statistics Department and wish to take this course can do so if they have a strong background in statistics, and they should talk to me first. I will not assume you know anything about Markov chains.

Grading Your final course grade will be based on the four components below, with the stated weights:

Exam 1:	Wednesday October 2, 8:20 pm, room TBA. Note the evening time slot.	25%
Exam 2:	Wednesday November 6, 8:20 pm, room TBA. Note the evening time slot.	25%
Final:	Thursday December 12, 12:30pm–2:30pm. Comprehensive, but with emphasis on material covered after Exam 2.	30%
HW:	There will be about 8 homeworks assigned during the semester.	20%

Some of the homework assignments will be of a theoretical nature, and some will involve computer implementation of the methods we discuss on specific data sets.

Course Policies Homework must be turned in at the beginning of the lecture on the due date. Late homework will not be accepted. The solutions to the homework assignments must be entirely your own (this applies also to R code).

Course Web Page `http://www.stat.ufl.edu/~doss/Courses/mcmc`

A username and password are needed to enter the Homeworks page; they will be given out in class.

Topics

- Issues in practical implementation of Bayesian statistics
- Illustrative example: censored data
- Basic Monte Carlo methods
- General idea of Markov chain Monte Carlo
- The Gibbs sampler (general properties; application to latent variable models, including hierarchical Bayesian models and censored data models; application to high-dimensional problems)
- Rao-Blackwellization and variants thereof
- Convergence diagnostics
- Application of the Gibbs sampler to nonparametric Bayes problems
- The Metropolis-Hastings algorithm (general properties; application to Ising model; random walk chains and independence chains; adaptive rejection Metropolis sampling)
- Hamiltonian Monte Carlo
- Theory of convergence (ergodic theorems and central limit theorems)
- There will be one additional in-depth application of MCMC to some nontrivial problem in statistics, which is likely to be Bayesian variable selection in regression.