STATS 225: Bayesian Analysis

Department of Statistics, UCI

Objective

The objective of this course is to explore Bayesian statistical methods and discuss their applications in real life problems (beyond what has been covered in STATS 205). Students are expected to have strong background in statistics, probability, and computational methods. Further, they need to be comfortable with at least one programming language. By the end of this course, students would learn how to formulate a scientific question by constructing a Bayesian model, and perform Bayesian statistical inference to answer that question. Although the focus of this course is on Bayesian methodology, throughout this course, students would be also exposed to some theoretical aspects of Bayesian inference (more details are provided in our theory courses). They would also learn several advanced computational techniques (beyond what has been covered in STATS 230), and use these techniques for Bayesian analysis of real data.

Instructor

Babak Shahbaba, 2224 Donald Bren Hall

Class location and hours

DBH 1423, MW 11:00-12:20

Office hours

Wednesdays 2PM to 3PM

Evaluation

There are 4 assignments (10% each), one project (30%), and a final exam (30%). **You should learn about ACADEMIC HONESTY POLICIES before you start the class**: `http://honesty.uci.edu/students.html`.

Syllabus

- **A quick review of rigorous probability**: probability measure space; expectation; convergence; distribution; conditional probability; Bayes' theorem
- **A quick review of introductory Bayesian analysis**: prior; likelihood; posterior; conjugacy; simple Bayesian models: binomial model; normal model; Poisson model; multinomial model
- **Approximation methods**: Laplace's method; variational Bayes
- **Sampling methods**: general Monte Carlo framework; importance sampling; rejection sampling; Metropolis algorithm; Gibss sampler; slice sampling; Langevin dynamics; Hamiltonian dynamics
- **Decision theory**: utility; loss; posterior risk; formal Bayes rule; classical decision theory; risk function; Bayes rule
- **Bayesian models**: Hierarchical Bayesian models; linear regression; logistic regression; Poisson regression; multinomial logistic regression.
- **Bayesian nonparametrics**: Gaussian process for regression and classification; Dirichlet process mixtures for density estimation and clustering

References

Main textbooks

I am using my own course notes, but these books are great references for this course. Choose one (or more) that matches your background. Meet me if you need help.

- "Bayesian Data Analysis," by A. Gelman, J.B. Carlin, H.S. Stern, and D.B. Rubin.
- "Bayesian Ideas and Data Analysis: An Introduction for Scientists and Statisticians," by R. Christensen, W. O. Johnson, A. J. Branscum, and T. E. Hanson.
- "A First Course in Machine Learning," by Simon Rogers and Mark Girolami.
- "A First Course in Bayesian Statistical Methods," by Peter Hoff.

Other relevant references

- "A First Look at Rigorous Probability Theory," by J. Rosenthal
- "Probabilistic Inference using Markov Chain Monte Carlo Methods," by R.M. Neal (available online)
- "Data Analysis Using Regression and Multilevel/Hierarchical Models," by A. Gelman and J. Hill

- "Bayesian Theory," by J.M. Bernardo and A.F.M. Smith
- "Monte Carlo Strategies in Scientific Computing," by J.S. Liu
- "Information Theory, Inference, and Learning Algorithms," by D. MacKay
- "Theory of Statistics," by M.J. Schervish
- "Applied Statistical Inference," by L. Held and D.S. Bove