STATS 225: Bayesian Analysis

UCI, Winter 2010

Objective

The objective of this course is to explore Bayesian statistical methods, and discuss their application in real life problems. Students would learn how to formulate a scientific question by constructing a Bayesian model, and perform Bayesian statistical inference to answer that question. Throughout this course, students would be exposed to the theory of Bayesian inference. They would also learn several computational techniques, such as Markov Chain Mote Carlo (MCMC) algorithms, and use these techniques for Bayesian analysis of real data.

Instructor

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Syllabus

- **A quick review of rigorous probability**: probability measure space; expectation; convergence; distribution; conditional probability; Bayes' theorem.
- **Bayesian inference**: prior; likelihood; posterior; posterior predictive distribution; Bayesian hypothesis testing and model evaluation.
- **Decision theory**: utility; loss; posterior risk; formal Bayes rule; classical decision theory; risk function; Bayes rule.
- **Some simple Bayesian models**: informative and noninformative priors; conjugacy; binomial model; normal model; Poisson model.
- **Markov chain process**: random walk; discrete space Markov chains; convergence; general space Markov chains;
- **Monte Carlo methods**: general Monte Carlo framework; importance sampling; rejection sampling.
- **Markov chain Monte Carlo sampling**: Metropolis algorithm; Gibss sampler; Slice sampling; Hamiltonian dynamics.

- **Bayesian regression and classification models**: linear regression; logistic regression; Poisson regression; multinomial logistic regression.
- **A brief preview of some advanced topics**: Gaussian process for regression and classification, and Dirichlet process mixtures for density estimation and clustering

References

Main textbook

- "Bayesian Data Analysis," by A. Gelman, J.B. Carlin, H.S. Stern, and D.B. Rubin.

Other interesting 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.