PHP2530: Bayesian Statistical Methods
Fall 2013
Mon, Wed 9:00 – 10:20
121 South Main St. Rm 241

Instructor Information

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Office Hours

Mon, Wed 10:30-11:30 pm and by appointment

Recommended Text

Gelman, A., Carlin, J.B., Stern, H.S., and Rubin, D.B. (2004). *Bayesian Data Analysis (2nd Edition)*. Chapman and Hall/CRC.

Objectives

The Bayesian approach to statistics differs in a number of ways from the classical or "frequentist" approach, including the ability for Bayesians to flexibly incorporate prior knowledge/experience in data analyses. Modern advances in computing have allowed many complicated models, which are difficult to analyze using conventional frequentist methods, to be straightforwardly analyzed using Bayesian methodology. The Bayesian paradigm for data analysis can be described as consisting of four main steps: constructing probability models for data given parameters, computing posterior distributions of parameters, exploring posterior distributions, and checking/improving models. This course exposes students to the Bayesian approach and its conceptual underpinnings. Basic Bayesian models are introduced at the beginning, and then more complicated hierarchical and mixture models are described, many of which have important applications in a variety of fields.

Prerequisites

Some prior exposure to statistical inference will be extremely useful for this class. If you are concerned that you do not have a sufficient background for this class, please see the instructor.

Computational Requirements

The free BUGS (Bayesian inference Using Gibbs Sampling) software and R software will be used in assignments and classes for fitting Bayesian models. In addition, students will be required to write their own code (such as simulations, sampling, Markov Chain Monte Carlo) in one other programming language of their choice (R, Matlab, Fortran, C++, etc.). Students who do not have

prior experience with such programming languages are strongly encouraged to gain some working knowledge of one early in the semester, independent of the class. Computational proficiency is essential for modern Bayesian analysis and will be stressed during the course.

Course requirements and grades

- Class participation (10%)
- Homework (40%) - *there will be 5-6 homework assignments.*
- Final project and presentation (50%). The final project will be either an application of material learned in the course to a problem or a dataset, or a methodological investigation/improvement of existing methods.

Course Outline

PART I: Fundamentals of Bayesian Inference (4 weeks)
Week 1: Introduction, the Bayesian paradigm
Week 2: Perspectives on probability, univariate and multi-parameter models
Week 3: Likelihood Principle, prior selection, decision theory
Week 4: Exchangeability, hierarchical models, Bayesian inference
PART II: Bayesian Computation & Modeling (5 weeks)
Week 5: Quadrature, importance sampling
Week 6: Model selection, hypothesis testing, Bayes factor
Week 7: EM and its extensions
Week 8: Gibbs sampling, MCMC
Week 9: MCMC continued and diagnostics
PART III: Applications of Bayesian Inference (5 weeks)
Week 10: Regression models, data collection, randomization, ignorability
Week 11: Causal inference framework, missing data formulation
Week 12: Principal stratification & compliance
Week 13: Spatial data modeling
Week 14: Meta Analysis and Clinical Trials

Additional Bibliography

- Berger J. (1985) Statistical Decision Theory and Bayesian Analysis (2nd Edition). Springer Verlag
- Box, G.E.P., Tiao, G.C. (1973) Bayesian Inference in Statistical Analysis, Addison-Wesley.
- Albert J. (2007) Bayesian Computation with R. Springer.
- Robert C. and Casella G. (1999) Monte Carlo Statistical Methods. Springer Verlag.
- Gelman A., Hill J. (2007) Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press.
- Carlin B, Louis T (2008) Bayes and empirical Bayes methods for data analysis, Chapman & Hall/ CRC.
- Selected articles.