Bayesian Statistics

Level: STAT 6740
Instructor: Dr. Mevin Hooten
Time: Tues/Thurs 1:30-3:00 PM
Location: ENGR 304
Recommended Text:

- Bayesian Data Analysis (Second Edition), Chapman & Hall, 2004, Andrew Gelman, John B. Carlin, Hal S. Stern, and Donald B. Rubin
- Bayesian Core: A practical approach to Computational Bayesian Statistics, Springer, 2007, Jean-Michel Marin and Christian P. Robert
- Bayesian Computation with R, Springer, 2007, Jim Albert

Computation: R Statistical Computing Environment. We will make use of R for course assignments, portions of exams, and the semester project. Prior familiarity with R is required and will be necessary for success in this course.

Prerequisites: STAT 5710. Other extremely useful courses include: computer programming, multivariate statistics, statistical modeling (regression, ANOVA).

Software: We will make use of the statistical computing software R for course assignments, portions of exams, and the semester project. Prior familiarity with R is required and will be necessary for success in this course.

Overview: This course will be predominantly lecture-based (i.e., without a formal lab component), however, the majority of work required will be of an applied nature with mostly computational homework. Students will be required to demonstrate their analytical comprehension of the subject through various homework exercises and in-class examinations. A semester project will be required that includes the development and implementation of a Bayesian model in the presence of a real dataset and motivating scientific question (ideally pertaining to your own research interests).

Tentative Grading: 2 exams worth 20% each, semester project worth 20%, and homework worth 40%. The semester project should utilize data and methods from your own area of interest and should be typed, double-spaced, and no more than 10 pages. Also, you will be required to give a short presentation (10 mins) of your project on the date of the final exam (attendance mandatory).

Topics:

1. Introduction:
    a. Review of useful probability concepts
        i. Univariate Distributions
        ii. Multivariate Distributions
        iii. Conditional Probability
    b. Review of useful statistical modeling concepts
        i. Likelihood Principle and Methods

    ii. Linear Models
  c. Introduction to the R computing environment
2. Bayesian Fundamentals:
  a. Frequency vs. Probability
  b. Uncertainty
  c. Conditional Model Specification
  d. Random Parameters
  e. Prior Distributions
    i. Conjugacy
    ii. Informative
    iii. Vague
    iv. Non-informative
  f. Single Parameter Models
  g. Point and Interval Estimation
  h. Computation
    i. Monte Carlo Sampling
    ii. Slice Sampling
    iii. Rejection Sampling
3. Hierarchical Modeling
  a. Mixed vs. Hierarchical Models
  b. Advanced Computation
    i. MCMC
      1. Gibbs Sampling
      2. Metropolis-Hastings
    ii. Importance Sampling
  c. Linear Models
    i. Uncorrelated errors
      1. Multiple Linear Regression
    ii. Correlated errors
      1. Spatial Models
      2. Time-Series Models
  d. Generalized Linear Models
    i. Logit/Probit Regression
    ii. Poisson Regression