Statistics 520: Statistical Methods III

Fall 2016

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Lectures: MWF 1:10-2:00 Snedecor 3121

Lecture Notes: Available for purchase at Copy Works on Welch Ave.

Grading: There will be assignments, one or two in-class exams, and either a take-home exam or project. Points will be determined as these are developed, but you can expect that roughly 75% of the class grade will be from exams/project and 25% from assignments

Topic Outline

1. **Statistical Modeling**
   - 1.1. Scientific and Statistical Abstraction
   - 1.2. The Building Blocks of Models
   - 1.3. The Impact of Objectives on Model Formulation

2. **Generalized Linear Models**
   - 2.1. Random and Systematic Model Components
   - 2.2. Likelihood Analysis
   - 2.3. Deviance and Model Assessment

3. **Additive Error Models**
   - 3.1. Constant Variance Models
   - 3.2. Models with Known Variance Parameters
   - 3.3. Modes with Unknown Variance Parameters
   - 3.4. Transform Both Sides Models
   - 3.5. Least Squares Estimation and Inference
   - 3.6. Pseudolikelihood Estimation and Inference
   - 3.7. Likelihood Estimation and Inference

3.8. Model Assessment

4. Monte Carlo, Bootstrap and Cross-Validation
- 4.1. Monte Carlo Approximations
- 4.2. Parametric Bootstrap and Bootstrap Intervals
- 4.3. Cross-Validation

5. Basic Concepts In Bayesian Analysis
- 5.1. Data Models, Priors and Posteriors
- 5.2. Inference from the Posterior Distribution
- 5.3. Estimation
- 5.4. Model Assessment

6. Prior Distributions
- 6.1. Types of Prior Distributions
- 6.2. Constructing Joint Priors
- 6.3. Choosing Parameter Values for Priors

7. Simulating Posterior Distributions
- 7.1. Basic Simulation Principles
- 7.2. Inference from Simulated Posteriors
- 7.3. Simulation of Un-normalized Distributions
- 7.4. Metropolis-Hastings and Gibbs Sampling Algorithms
- 7.5. Monitoring Convergence of Markov Chain Samplers

8. Introduction to Hierarchical Models
- 8.1. Basic Mixture Models
- 8.2. Hierarchical Models as Mixtures
- 8.3. Hierarchical Models and Multi-Stage Prior Distributions
- 8.4. Full Conditional Posteriors for Use with Gibbs Sampling
- 8.5. Metropolis Within Gibbs Algorithms

9. Additional Examples/Case Studies

Disability Statement

Iowa State University complies with the American with Disabilities Act and Section 504 of the Rehabilitation Act. Any student who may require an accommodation under such provisions should contact the instructor as soon as possible and no later than the end of the first week of class or as soon as you become aware. No retroactive accommodations will be provided in this class. Please make sure that Disability Resources staff members send a SAAR form verifying the disability and specifying the accommodation needed. The Disability Resources office is located on the main floor of the Student Services Building, Room 1076, 515 294-7220.

Learning Outcomes

A student that successfully completes this course should be capable of approaching the analysis of moderately complex scientific problems using several statistical approaches. The student will be capable of formulating a probabilistic model for the analysis of observed data by defining appropriate random variables, assigning distributions, identifying suitable parameters and functions of parameters to be the object of inference, and conducting a coherent set of estimation and inferential procedures following the principles of likelihood and/or Bayesian philosophy.

Online Course Content

Statistics 520 is being offered as an online course this Fall. The lectures given in Snedecor 3121 will be captured and posted. We hope to set up a time for Yixiao, our TA, to hold office hours online. Both distance and on-campus students will have access to these resources. If you are a distance student, you will need to arrange for a proctor for the exams. The exact logistics will be worked out near the beginning of the semester in terms of mode of delivery of exams, etc. Distance students will email assignments in after scanning them (or preparing answers in something that can be saved in a pdf format).

Course Web Page

The course web page will be on Blackboard. All assignments will be posted on Blackboard and Announcements will be used to notify you that an assignment has been posted. We will try to standardize due dates to the degree possible to help distance students, but sometimes it turns out that an assignment causes more difficulty than I originally planned and we need to extend the amount of time given to work on it, so we all need to remain flexible to some degree. We will work out whatever logistical difficulties may arise.

Computing

I will assume that you are using R to complete assignments in this course. I have had students successfully complete the course using Matlab and that, or anything else you want to use is ok with me, but the computing functions I provide will be R code. You will need to write fairly simple functions to compute various pieces needed by more general algorithms, such as writing a function to compute a log-likelihood and its derivatives for use with a generic optimization function. Additional notes on computation that will not necessarily be discussed in lecture will be posted on the course web page.