Applied Bayesian Analysis for the Social Sciences

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Course Description

This course introduces the basic theoretical and applied principles of Bayesian statistical analysis in a manner geared toward students in the social sciences. The Bayesian paradigm is particularly useful for the type of data that social scientists encounter given its recognition of the mobility of population parameters, its ability to incorporate information from prior research, and its ability to update estimates as new data are observed. The course will begin with a discussion of the strengths of the Bayesian approach for social science data and the philosophical differences between Bayesian and frequentist analyses. Next, the course will cover the theoretical underpinnings of Bayesian modeling and provide a brief introduction to the primary estimation algorithms. The bulk of the course will focus on estimating and interpreting Bayesian models from an applied perspective. Students will be introduced to the Bayesian forms of the standard statistical models taught in regression and MLE courses (i.e., normal, logit/probit, Poisson, etc.) as well as a variety of measurement and multilevel models. This course assumes a solid understanding of the linear model and matrix algebra and some exposure to models with limited dependent variables. The course will rely heavily on R and WinBUGS for estimation. Prior experience with these software packages is preferred but not assumed.

Note: Although this course will cover some of the basics of MCMC and the Gibbs Sampler (among other sampling algorithms), application/interpretation will be the primary focus. For this reason, students already familiar with the basics of Bayesian modeling using WinBUGS, MCMCpack, JAGS or some other software may find the Bayesian course offered in the second session more appropriate.

APPLE CAVEAT. I am not a Mac user. WinBUGS does run on Mac with the appropriate ‘make your Mac run Windows’ software, but can be a bit buggy. JAGS is Mac friendly software and is nearly identical to BUGS. We will offer special Mac-friendly lab sessions and support both JAGS and WinBUGS. JAGS code for all models encountered in this course and other Mac-specific code and examples are on Johannes’ course website, http://spot.colorado.edu/~joka5204/bayes2013.html.
Books

The main texts for the course are:


For those of you unfamiliar with R, I strongly recommend:


Software

This course will rely mostly on R and WinBUGS, but will also use Stata for some applications. I strongly encourage you to install R and WinBUGS on your computers before class begins. The labs will have all necessary software as well. Both are available on line at no cost:

- [www.cran.r-project.org](http://www.cran.r-project.org)
- [www.mrc-bsu.ca.ac.uk/bugs](http://www.mrc-bsu.ca.ac.uk/bugs)

Both websites have links to documentation/user manuals for both programs and both are easily installable following the directions available on the websites. Although R and WinBUGS are not as user-friendly as many programs you may be used to (SPSS and Stata), they both use a similar language and are much more user friendly than the alternatives. That is to say, there is a learning curve for these programs, but you need not have any computer programming background to learn them rather easily—just patience and desire.

See Johannes’ website for more information on JAGS.

Homework

Homework exercises will be assigned in class conditional on how far we get—we will have a ‘no child left behind’ policy. There will be between 1 and 2 assignments per week. These will be mostly computer-based with the exception of the first assignment.
Course Content
(May be modified depending on how the course progresses)

Day 1
Introduction, Background, and Basics of Bayesian Inference

Readings:
- Gill–Chapter 1

Day 2
Review of the Generalized Linear Model

Day 3
Review of Probability
Combining Priors and Likelihoods

Readings:
- Gill–Chapter 2

Day 4
Priors

Readings:
- Gill–Chapter 5 (3rd edition: 4)

**HW 1 assigned:** Prior and posterior distributions.

Day 5
Sampling Methods and Introduction to WinBUGS/JAGS

Readings:
- Gill–Chapters 8 – 9 (3rd edition: 9 – 10)
Day 6
Convergence Diagnostics

Readings:


*HW 2 assigned:* Getting familiar with WinBUGS/JAGS.

Day 7
The Normal Distribution and more on Priors

Readings:

- Gill—Chapter 3

Day 8
The Bayesian Linear Model

Readings:

- Gill–Chapter 4 (3rd edition: 5)

*HW 3 assigned:* Linear model.

Day 9
Missing Data

Readings:


*HW 4 assigned:* Debugging BUGS/JAGS code.
Day 10
Dichotomous Variable Models

HW 5 assigned: Logistic regression model.

Day 11
Measurement and IRT Models

Readings:


HW 6 assigned: Factor model.

Day 12
Measurement Models and Identification

Readings:


Day 13
Ordered and Categorical Outcomes

Readings:


HW 7 assigned: Ordered and multinomial logit model.

Day 14
Model Checking and Summarizing Posterior Distributions

Readings:

- Gill–Chapters 6 – 7


Day 15

Introduction to Multilevel Models

Readings:

- Gelman and Hill–Chapter 16.

Day 16

More on Multilevel Models/TSCS

Readings:

- Gelman and Hill–Chapters 17 – 18

*HW 8 assigned:* Multilevel model.

Day 17

Multilevel Models continued:

discrete level 1 outcomes

Readings:

- Gelman and Hill–Chapters 15 and 17.
Day 18

Wrap-up and Discussion of Bayes versus Frequentist.

Readings: