Class Website: Dropbox Link & Listserv

Course Outline:

This course covers the theoretical and applied foundations of Bayesian statistical analysis at a level that goes beyond the introductory course at ICPSR. Knowledge of basic Bayesian statistics (such as that obtained from the Introduction to Applied Bayesian Modeling for the Social Sciences workshop) is assumed. First, we will discuss model checking, model assessment, and model comparison, with an emphasis on computational approaches. Second, the course will cover Bayesian stochastic simulation (Markov chain Monte Carlo) in depth with an orientation towards deriving important properties of the Gibbs sampler and the Metropolis Hastings algorithms. Extensions and hybrids will be discussed. The third and fourth modules will focus on applications of Bayesian statistics in social science data analysis. The topics include Bayesian Hierarchical models for cross-sections and panel data, factor analysis models, and Instrumental Variable Models. Throughout the workshop, estimation with modern programming software (R, JAGS, and a little Stan) will be emphasized.

Readings:

Recommended textbook:


All other readings will be available on the course website.
Week I: Introduction & MCMC (Menninga)

Monday: Introductions

- Introductions
- Recommended: start tomorrow’s reading.

Tuesday: Why Bayes? & Quick Overview of Bayesian Logic

- Why Bayes?
- What is Bayes?
- Essential Reading:
  - Gill (2014) Chapters 1-5
- Recommended Reading:
  - Buckley, J. (2004) “Simple Bayesian Inference for Qualitative Political Research” Political Analysis

Wednesday: Posterior Prediction & Assessing Model Quality

- Posterior Predictive Distributions
- Global & Local Sensitivity Analysis
- Global & Local Robustness
- Comparing Data to the Posterior Predictive Distribution
- Model Selection
- Model Expansion
- Essential Reading:
  - Gill (2014) Chapter 6
- Recommended Reading:
Thursday: Model Comparison & Bayesian Hypothesis Testing

- Posterior Probability Comparison
- Cross-Validation
- Bayes Factors
- AIC, BIC, DIC
- Software Issues
- Replication Bayes Factors
- Essential Reading:
  - Gill (2014) Chapter 7
- Recommended Reading:
  - Gelman et al. (2014) “Understanding predictive information criteria for Bayesian models” *Statistical Computing*


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**Friday: Introduction to Simulation Based Inference**

- Classical Numerical Integration
- Rejection Sampling
- Importance Sampling
- Mode finding and the EM Algorithm
- What are Markov Chains?
- Properties of Markov Chains
- The Ergodic Theorem
- Essential Reading:
  - Gill (2014) Chapter 9

- Recommended Reading:
Week II: MCMC & Special Topics (Menninga)

Monday: MCMC Algorithms & Convergence Diagnostics

- The Gibbs Sampler
- The Metropolis-Hastings Algorithm
- The Hit-and-Run Algorithm
- RJ MCMC
- Hamiltonian MCMC
- Visual & Empirical Convergence Diagnostics

Essential Reading:
- Gill (2014) Chapter 10 & 14

Recommended Reading:

Tuesday: Bayesian Change Point Analysis

- Essential Reading:
  - Gill (2014) Brief Example p. 346
• Recommended Reading:
  – Western & Kleykamp. (2004). “A Bayesian Change Point Model for Historical Time Series Analysis” Political Analysis

Wednesday: Topic Modeling & Bayes

• Recommended Reading:

Thursday: Dynamic Latent Space Models

• Recommended Reading:
  – Hoff & Ward. (2004). “Modeling Dependencies in International Relations Networks” Political Analysis
– Sewell & Chen. (2016). “Latent Space Approaches to Community Detection in Dynamic Networks” *Bayesian Analysis*

**Friday: Bayesian Decision Theory**

– Essential Reading:
  * Gill (2014) Chapter 8
– Recommended Readings:

**Week III: (Stegmueller)**

**Monday: The Linear Model and Extensions**

1. Bayesian linear model
2. Robust regression via t-errors
3. Bayesian tobit model
4. Diagnostics, model comparison, and prediction
5. Conjugate and nonconjugate priors

**Tuesday: Models for Binary & Count Outcomes**

1. Bayesian estimation of Probit models via latent data augmentation
2. Bayesian estimation of Logit models
3. Bayesian estimation of Poisson and negative binomial models
4. Dealing with complete separation in binary data models
5. Diagnostics via latent Bayesian residuals
6. Model comparison
7. Prediction and effective graphical presentation

**Wednesday: Discrete Choice Models I: Ordered Outcomes**
1. Bayesian estimation of ordered choice models
2. Priors and sampling strategies for latent variable cutpoints
3. Diagnostics and model comparison
4. Prediction, interpretation, and effective graphical presentation

**Thursday: Discrete Choice Models II: Unordered Outcomes**
1. Multinomial and Conditional Logit Models: Principles and Bayesian estimation
2. Identification problems in discrete choice models
3. Multinomial Probit Models: Principles and various Bayesian estimation strategies
4. Understanding prior choices
5. Prediction, interpretation, and effective graphical presentation

**Friday: Seemingly Unrelated Regression / Multivariate Outcomes**
1. The Bayesian Seemingly Unrelated Regression Model: Priors and Estimation
2. Multivariate Probit Model: Identification and Estimation
3. Discuss anything left over from previous sessions; Questions
Week IV: (Stegmueller)

Monday: Hierarchical/Multilevel Models
1. The Bayesian Hierarchical Linear Model
2. Hierarchical Logit/Probit Models
3. Understanding and choosing variance component priors
4. Advantages of Bayesian vs. Frequentist hierarchical models
5. ‘Mr.P’: Multilevel regression and post-stratification

Tuesday: Bayesian Models for Panel and TSCS Data
1. Heterogeneity in units via random effects models: priors and estimation
2. Heterogeneity in effects via random coefficient models: priors and estimation
3. Correlated random effects
4. Serially correlated residuals
5. Change point models

Wednesday: Latent Factor Models
1. Bayesian factor analysis for multivariate normal data
2. Ideal-point / item-response theory models
3. Identification issues in IRT models
4. IRT models with covariates
5. Bayesian factor analysis for continuous-discrete data

Thursday: Bayesian Instrumental Variable Models
1. The classical instrumental variables estimator
2. Bayesian instrumental variable model: priors and estimation
3. Advantages of Bayesian IV in the presence of weak instruments
4. Robust Bayesian IV via flexible error distributions

Friday: Final topic to round off the course. Depending on participants’ preferences, either
- Bayesian thinking in causal inference, or
- Bayesian nonparametrics