Introduction to Bayesian Statistical Modeling

A SHORT COURSE FOR RESEARCH PROFESSIONALS, FACULTY, AND GRADUATE STUDENTS

Dates:	June 24-26, 2013 (Monday AM – Wednesday PM)
Instructor:	Dr. Roy Levy, Arizona State University
Location:	Benjamin Banneker Room, Stamp Student Union University of Maryland, College Park, MD 20742

Bayesian Statistical Modeling

Bayesian approaches to statistical modeling and inference are characterized by treating all entities (observed variables, model parameters, missing data, etc.) as random variables characterized by distributions. In a Bayesian analysis, all unknown entities are assigned prior distributions that represent our thinking prior to observing the data. Once values for the data are observed, Bayes' theorem is employed to update the prior distributions, yielding posterior distributions. Posterior distributions constitute the solution to the analysis and can be summarized using point or interval summaries and interpreted via probability-based reasoning. This approach to modeling departs, both practically and philosophically, from traditional frequentist methods that constitute the majority of statistical training. Importantly, adopting a Bayesian approach allows an analyst to accomplish statistical and inferential goals that cannot be attained by, or pose considerable challenges to, conventional frequentist approaches, and recent computational advances now allow researchers access to this wider class of models. Examples of such modeling complexities include dynamically updating beliefs based on the arrival of data over time (e.g., revising a medical diagnosis based on test results), incorporating prior beliefs about the modeled phenomena, modeling highly dependent multivariate systems with multiple sources of uncertainty (e.g., weather forecasting), estimating scores on latent variables (e.g., factor scores, latent class membership), dealing with nonlinearities in parameters (e.g., mediation effects in longitudinal data, interactions of latent variables), and analyzing datasets with small sample sizes. Indeed, a number of sophisticated analyses in frequentist approaches are, in fact, explicitly Bayesian or approximations to Bayesian analyses (e.g., multiple imputation for missing data, multilevel modeling of clustered observations). Even in simple modeling situations, a Bayesian approach allows for probability-based reasoning that is more natural and extensible than the inferential machinery of frequentist approaches. Bayesian statistical modeling and inference is an attractive alternative to frequentist approaches in that a Bayesian perspective offers a coherent approach to statistical modeling, including building and fitting models with complex features, interpreting results, making inferences, and representing uncertainty.

Scope of Workshop

This three-day course is intended as both a theoretical and practical introduction to Bayesian statistical modeling. An understanding of Bayesian statistical modeling will be developed by relating it to participants' existing knowledge of traditional frequentist approaches. It is assumed that participants have expertise with frequentist approaches to statistics (e.g., hypothesis testing, confidence intervals, least-squares and likelihood estimation) in contexts up through multivariate statistical analysis (e.g., multiple regression, MAN(C)OVA, the general linear model for multiple outcomes, logistic or probit modeling for discrete outcomes). Although not required, a participant's experience in this workshop will be enhanced by additional prior coursework or experience with advanced modeling techniques such as factor analysis, item response theory, structural equation modeling, and multilevel modeling, and/or by familiarity with the basics of probability theory (e.g., joint, marginal, and conditional distributions, independence). No prior experience with Bayesian statistical modeling is required. The philosophical underpinnings and departures from conventional frequentist interpretations of probability will be explained. This in turn will motivate the development of Bayesian statistical modeling.

To introduce Bayesian principles in familiar contexts we will begin with simple binomial and univariate normal models, then move to regression, and then give examples of more complex models including factor analysis, item response models, structural equation models, and Bayesian networks. Along the way, we will cover aspects of modeling including model construction, graphical representations of models, Markov chain Monte Carlo (MCMC) estimation, evaluating hypotheses and data-model fit, model comparisons, and modeling in the presence of missing data. Although Bayesian statistical modeling has proven advantageous in many disciplines, the examples used in presentations draw primarily from social science research, including the fields of education and assessment. Examples will be accompanied by input and output using the WinBUGS and Netica software packages. Throughout the course participants will be able to practice exercises using WinBUGS and Netica; *participants are strongly encouraged to bring their own laptop PCs to perform these exercises*. (Participants will be instructed on how to download free versions of WinBUGS and Netica prior to the course.)

About the Instructor

Dr. Roy Levy is an Associate Professor of Measurement and Statistical Analysis in the T. Denny Sanford School of Social and Family Dynamics at Arizona State University, where he teaches coursework in Bayesian statistical modeling. His research has appeared in such journals as Structural Equation Modeling: A Multidisciplinary Journal, British Journal of Mathematical and Statistical Psychology, Multivariate Behavioral Research, Applied Psychological Measurement, Journal of Educational and Behavioral Statistics, Sociological Methods and Research, Educational and Psychological Measurement, and Journal of Probability and Statistics. He is a past chair of the structural equation modeling special interest group of the American Educational Research Association, has served on the editorial boards of several journals, and was a 2010 recipient of the Presidential Early Career Award for Scientists and Engineers by the President of the United States. Dr. Levy holds a B.A. in Philosophy, an M.A. in Measurement, Statistics and Evaluation, and a Ph.D. in Measurement, Statistics and Evaluation from the University of Maryland.

Workshop Information

Dates:	June 24-26, 2013 (Monday – Wednesday)	
Time:	Continental Breakfast:	8:30 AM – 9:00 AM
	Morning session:	9:00 AM – 12:30 PM
	Lunch (on your own):	12:30 PM – 1:30 PM
	Afternoon session:	1:30 PM – 5:00 PM
Location:	Benjamin Banneker Room, Stamp Student Union University of Maryland, College Park, MD 20742	

Registration, Fees, and Location

E-mail or fax registration:	Mr. Antonio Araneta, *aaraneta@umd.edu* EDMS Seminar and Training Center 3304 Benjamin Building University of Maryland College Park, MD 20742 Phone: 301.405.1659 Fax: 301.405.2891
Registration Fee:	$595 ($395 for full-time students). This includes course materials and continental breakfasts. Participants are responsible for lunches, dinners, lodging, and parking.
About the Location:	For general University visitor information, see http://www.umd.edu/.