AMS 241: Bayesian Nonparametric Methods
Winter 2009

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Lectures: Tuesday, Thursday 10-11:45am (Social Sciences II 137)
Office hours: Monday 2-3pm; Thursday 12-1pm (or by appointment)

Course description: Bayesian methods are central to the application of modern statistical modeling in a wide variety of fields. Bayesian nonparametric methods increase the flexibility and utility of Bayesian models, and are becoming increasingly popular in recent years.
This course will offer, at a graduate level, a survey of the theory, methods and applications of Bayesian nonparametrics. Some elements of the theoretical construction of nonparametric priors will be introduced. However, emphasis will be placed on modeling approaches, implementation for inference and prediction using Markov chain Monte Carlo (MCMC) methods, and applications.
Prior probability models for spaces of (random) distributions and functions that will be covered include Dirichlet processes, mixtures of Dirichlet processes, Pólya trees, nonparametric mixtures (in particular, Dirichlet process mixture models), Neutral to the right processes, Gaussian processes, Gamma processes, Beta processes, and dependent Dirichlet processes.
We will discuss applications of Bayesian nonparametric modeling in areas that include categorical data analysis, density estimation, nonparametric regression, spatial statistics, and survival analysis.

Background: Knowledge of Bayesian theory, modeling, and computing (at the level of AMS 207) will be assumed.

Grading: The course grade will be based on homework assignments and a project. (There will be no exams.) The homework assignments will involve data analyses using nonparametric priors and associated MCMC methods for inference and prediction. A typical project will consist of expository review of a specific part of the literature, and may include illustration of related Bayesian nonparametric models with relevant data sets/case studies. A written report on the project will be required. Moreover, there will be in-class project presentations (likely, during the last week of the quarter).

References: There is no textbook. Books on Bayesian nonparametrics include:

• Dey, D., Müller, P., and Sinha, D. (Editors) (1998). *Practical Nonparametric and Semiparametric Bayesian Statistics*, New York: Springer.
• Ghosh, J.K., and Ramamoorthi, R.V. (2003). *Bayesian Nonparametrics*, New York: Springer.

Review papers include:

1. Ferguson, T.S., Phadia, E.G., and Tiwari, R.C. (1992). "Bayesian Nonparametric Inference," in *Current Issues in Statistical Inference: Essays in Honor of D. Basu*, eds. M. Gosh and D. Basu, Institute of Mathematical Statistics, pp. 127–150.
2. Gelfand, A.E. (1999). "Approaches for Semiparametric Bayesian Regression," in *Asymptotics, Nonparametrics and Time Series*, ed. Subir Ghosh, New York: Marcel Dekker, Inc., pp. 615–638.
3. Hanson, T., Branscum, A., and Johnson, W. (2005). "Bayesian nonparametric modeling and data analysis: An introduction," in *Handbook of Statistics, volume 25: Bayesian Thinking, Modeling and Computation*, eds. D.K. Dey and C.R. Rao, Amsterdam: Elsevier, pp. 245–278.
4. Hjort, N.L. (1996). "Bayesian Approaches to Non- and Semiparametric Density Estimation," in *Bayesian Statistics 5, Proceedings of the Fifth Valencia International Meeting*, eds. J.M. Bernardo, J.O. Berger, A.P. Dawid and A.F.M. Smith, Oxford: Oxford Clarendon Press, pp. 223–253.
5. MacEachern, S.N., and Müller, P. (2000). "Efficient MCMC Schemes for Robust Model Extensions Using Encompassing Dirichlet Process Mixture Models," in *Robust Bayesian Analysis*, eds. F. Ruggeri and D. Rios-Insua, New York: Springer, pp. 295–316.
6. Müller, P., and Quintana, F.A. (2004). "Nonparametric Bayesian Data Analysis," *Statistical Science*, 19, 95–110.
7. Sinha, D., and Dey, D.K. (1997). "Semiparametric Bayesian analysis of survival data," *Journal of the American Statistical Association*, 92, 1195–1212.
8. Walker, S.G., Damien, P., Laud, P.W., and Smith, A.F.M. (1999). "Bayesian Nonparametric Inference for Random Distributions and Related Functions" (with discussion), *Journal of the Royal Statistical Society*, Ser. B, 61, 485–527.