AMS 241: Bayesian Nonparametric Methods
Fall 2015

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Lectures: Tuesday, Thursday 10–11:45 am (Cowell Acad 222)
Office hours: Wednesday 2–3 pm (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 have become 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.

The Bayesian nonparametrics literature comprises by now a large collection of prior probability models for spaces of (random) distributions and functions, including: Dirichlet processes; Dirichlet process mixture models; Pólya trees; Stick-breaking priors for general nonparametric mixtures; Species sampling models; Product partition models; Normalized random measures with independent increments; Neutral to the right processes; Gamma and extended gamma processes; Beta processes; dependent Dirichlet processes; and Gaussian process priors for nonparametric regression.

We will study some of these prior models and discuss applications of Bayesian nonparametrics 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 206B and AMS 207) will be assumed.

Grading: The course grade will be based on homework assignments and a project. Some of the homework problems 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. For the project presentations, we will likely use the day and time assigned by the registrar for the final exam: Monday December 7, 8-11 am.

References: There is no textbook. The course material is taken from books and several papers covering theory, methods, and applications of Bayesian nonparametrics. Some of the material is included in notes that will be made available during the quarter through the course website.

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.

• Hjort, N.L., Holmes, C., Müller, P. and Walker, S.G. (Editors) (2010). *Bayesian Nonparametrics*, Cambridge University Press.

Some of the chapters of the Hjort et al. (2010) edited volume provide reviews of certain topics from the theory and methods of Bayesian nonparametrics. Additional review papers include:

• 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.

• Müller, P. and Quintana, F.A. (2004). "Nonparametric Bayesian data analysis," *Statistical Science*, 19, 95–110.

• 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.

• Müller, P. and Mitra, R. (2013). "Bayesian nonparametric inference – why and how" (with discussion), *Bayesian Analysis*, 8, 269–360.