Statistics 610: Bayesian Statistics Syllabus and Schedule (Fall 2019)

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Course Summary: Bayesian analysis methods provide ways for researchers to learn from data while also potentially incorporating other knowledge. (See: https://bayesian.org/what-is-bayesian-analysis/) In this course, students will learn how to construct Bayesian models to relate data to scientific questions, to fit such models fitting using statistical programs (R and STAN), to interpret model results, and to check model assumptions. Specific methods covered will include Bayesian linear and logistic regression, as well as hierarchical (regression) models. Additional topics (spline regression models and spatial models) will be discussed as time allows. The class also includes discussion of selected papers from the literature that serve as case studies, as well as a project in which students carry out Bayesian modeling, estimation, and inference for a real data set.

Prerequisites: An introductory class in mathematical statistics such as STAT 515 & 516 (and a willingness to be comfortable with the mathematical language of probability), experience with R, and experience with regression modelling. I will try to support *anyone* who wants to take the course, but it might be very difficult for someone who does not satisfy the above. Buyer beware! The mathematical level of the course will be approximately at the level of Hoff (2010): A first course in Bayesian statistical methods, which is available online from the UMass Library.

Requirements (and grading):

- (40%) Problem Sets / Computing Assignments: Most Fridays will be devoted to in-class computing / problem set work – the assignments will be posted on Thurs evening. (Not the first Friday though.) Those assignments will be due in class the following Friday.
- 2. (15%) In class midterm exam (to be scheduled approximately the end of October).
- 3. (5%) Short quizzes about distributions and definitions. (You will need to know the pdfs, parameters, and moments for common distributions. Handouts will be given. Statistics is like learning a language, and this is the vocabulary.)
- 4. (40%) Project (in groups of 1-3). Details given in October. Deliverables are a short write up and a presentation. I'll give some suggestions in Oct. (You're welcome to come up with your own project idea too. Please feel free to talk to me about this!)

Course Objectives: At the end of the course, students are expected to be able:

- 1. To apply Bayes rule to derive a posterior distribution or a full conditional distribution for selected problems (i.e. for which closed-form solutions exist)
- 2. To describe a model and method mathematically and precisely.
- 3. To fit a variety of Bayesian models to data with software, including hierarchical regression models.
- 4. To interpret Bayesian model output, including estimates of regression coefficients and other model parameters and perform inference.
- 5. To use and interpret the output of diagnostic tools for checking performance of sampling methods.
- 6. To check goodness of model fits/model performance and compare different model fits.
- 7. To learn about / practice learning about statistical methods from reading.

Resources: (books - all are available online from the UMass Library)

Selected readings for the main material will be assigned from (in alphabetical order)

- 1. Gelman, Carlin, Stern, Dunson, Ventari and Rubin (2013). Bayesian Data Analysis (Third Edition).
- 2. Gelman and Hill (2006). Data Analysis Using Regression and Multilevel/Hierarchical Models.
- 3. Hoff (2010). A first course in Bayesian statistical methods (primary source)
- 4. Lesaffre and A.B. Lawson (2012). Statistics in Practice: Bayesian Biostatistics.
- 5. Lyle D and Broemeling (2014). Bayesian methods in epidemiology.

Additional material for specific methods and applications/case studies (in the form of research papers and reports) will be made available as the course progresses.

Tentative Course Schedule:

Sept 4	Introduction – please read Ch 1 in Hoff & Ch 1 in Gelman et al.
Sept 6	Less than formal introduction – please read Ch 1 in Hoff & Ch 1 in Gelman et al.
Sept 9	Probability and exchangeability – please read Chapter 2 in Hoff
Sept 11	Probability and exchangeability – please read Chapter 2 in Hoff
Sept 13	Quiz 1 & Computing & work on problems in class
Sept 16	One parameter Models: likelihood, prior, posterior, predictive, conjugacy – Ch 3 in Hoff
Sept 18	One parameter Models: likelihood, prior, posterior, predictive, conjugacy – Ch 3 in Hoff
Sept 20	Quiz 2 & Computing & work on problems in class
Sept 23	One parameter Models: likelihood, prior, posterior, predictive, conjugacy – Ch 3 in Hoff
Sept 25	Monte Carlo approximation – Ch 4 in Hoff
Sept 27	Quiz 3 & Computing & work on problems in class
Sept 30	Normal model – Ch 5 in Hoff
Oct 2	Normal model – Ch 5 in Hoff
Oct 4	Quiz 4 & Computing & work on problems in class
Oct 7	Gibbs sampling – Ch 6 in Hoff
Oct 9	Gibbs sampling – Ch 6 in Hoff
Oct 11	Quiz 5 & Computing & work on problems in class
Oct 15	Mulitvariate normal – Ch 7 in Hoff
Oct 16	Mulitvariate normal – Ch 7 in Hoff
Oct 18	Computing & work on problems in class
Oct 21	Hierarchical models – Ch 8 in Hoff
Oct 23	Hierarchical models – Ch 8 in Hoff
Oct 25	Computing & work on problems in class
Oct 28	In class midterm
Oct 30	No class
Nov 1	Computing & work on problems in class – project proposal due.
Nov 4	Linear regression – Ch 9-11 in Hoff
Nov 6	Generalized linear models (w/ hierarchy) – Ch 9-11 in Hoff

- Nov 8 Computing & work on problems in class
- Nov 13 Generalized linear models (w/ hierarchy) Ch 9-11 in Hoff
- Nov 15 Computing & work on problems in class
- Nov 18 Nonparametric and spatial modeling
- Nov 20 Nonparametric and spatial modeling
- Nov 22 Computing & work on problems in class
- Dec 2 Presentations
- Dec 4 Presentations
- Dec 6 Presentations
- Dec 9 Presentations
- Dec 11 Presentations