Syllabus for ST440/ST540
Applied Bayesian Analysis
Spring 2018

Course:

Lecture: MW 1:30–2:45, 1216 SAS Hall
Course website: www4.stat.ncsu.edu/~reich/ABA

Instructor: Brian Reich

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Office Hours: MW 2:45–3:45

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Office Hours: TuTh 2-3

Prerequisites for ST440: ST 422 and ST 430.

Prerequisites for ST540: ST 501 or ST 512 or ST 514 or ST 515 or ST 516 or ST 517.


Computing: The primary computing language will be R, which is freely available at http://www.r-project.org/. We will also use JAGS, which is freely available at http://sourceforge.net/projects/mcmc-jags/files/.

Grading: Final grade will be based on:

Final Semester Score = (HW + 3M1 + 3M2 + 3F)/10,
where HW is the homework average, M1 and M2 are the midterm scores, and F is the final exam (all out of 100).
Homework: There will be roughly weekly homework assignments. Problems and due dates will be posted on the course webpage. Unexcused late homework will be discounted by 50%.

Exams: The midterms are tentatively scheduled for Feb 19 and April 9. The mid-term exams will be open book, open notes, and may include a take-home portion. The final exam will be held on April 30 from 1-4 in 1216 SAS Hall. The final exam for 540 will be an independent group research project; the final exam for 440 will be a take-home data analysis challenge. Any conflicts with the scheduled exam dates must be submitted in writing to the instructor well in advance. The final exam grade can replace a university-excused missing exam grade. Unexcused missing exams, or inadequate notice of missing an exam will result in a grade of 0 for the exam.

Course objectives:

1. Summarize the relative strengths of Bayesian and frequentist methods.
2. Derive the posterior distribution for one-parameter models with conjugate priors.
3. Use Markov Chain Monte Carlo (MCMC) via JAGS to simulate from the posterior.
4. Effectively summarize a posterior using tables and graphics.
5. Compare models using cross-validation and goodness-of-fit diagnostics.

Policy on Academic Integrity: The University policy on academic integrity is spelled out in Appendix L of the NCSU Code of Student Conduct. For a more details see the NCSU Office of Student Conduct website http://www.ncsu.edu/student_conduct/. For this course group work on homework is encouraged. However copying someone else’s work and calling them your own is plagiarism, so the work you turn in should be your own.

Students with Disabilities: Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students (DSS), 1900 Student Health Center, CB 7509, 515-7653.
**Central concepts:**

<table>
<thead>
<tr>
<th>Section</th>
<th>Key concepts</th>
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<tbody>
<tr>
<td>(1) Introduction</td>
<td>Parameters; likelihood; sampling distributions; subjective probabilities; priors; posteriors</td>
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<tr>
<td>(2) Computing with R</td>
<td>Data structures and manipulation; simulation; graphics; loops; functions</td>
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<tr>
<td>(3) Probability</td>
<td>Mass and density functions; simulation in R; joint, conditional and marginal distributions; Bayes rule; Bayesian learning; conjugate priors</td>
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<td>(4) One-parameter models</td>
<td>Estimating a proportion, rate, normal mean and normal variance; conjugate priors; simulation in R and JAGS; shrinkage and prior sensitivity</td>
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<td>(5) Multi-parameter models</td>
<td>One-sample t-test; Marginal posteriors; Monte Carlo sampling</td>
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<tr>
<td>(6) Markov Chain Monte Carlo</td>
<td>Gibbs sampling; Metropolis sampling; JAGS; convergence diagnostics; summarizing the posterior</td>
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<td>(7) Linear models</td>
<td>Prior distributions; predictions; missing data; generalized linear models</td>
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<td>(8) Hierarchical models</td>
<td>Random effects; mixed models</td>
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<td>(9) Model checking</td>
<td>Bayes factors; Deviance information criteria; predictive model checks</td>
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<tr>
<td>(10) Frequentist properties</td>
<td>Bias/variance trade-off; Bayesian central limit theorem</td>
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A week-by-week schedule of the lecture content is available on the course web page.