[Syllabus] STAT 388/488 - Applied Bayesian Statistics

INSTRUCTOR

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COURSE DESCRIPTION

"Classical" statistics, encapsulating well-known methods such as t-tests, ANOVA, etc. are from the frequentist school of statistical thought. The basic idea of frequentist statistics is that the world is described by parameters that are *fixed* and *unknown*. Since these parameters are *unknown*, we do not know their exact values. Since they are *fixed*, however, we cannot discuss them in probabilistic terms. Probabilistic reasoning can only be applied to random variables—and parameters are not random, in the eyes of a frequentist. The Bayesian says, "Who cares?!"

It turns out that we can use probabilities not only to express the chance that something will occur, but we can also use them to express the extent to which we believe something, and all the math still works. The frequentist can only apply probabilities to the act of repeating an experiment, while the Bayesian can apply probabilities directly to their knowledge of the world.

Bayesian statistics are rippling through everything from physics to cancer research, ecology to psychology, law to politics, even sports analytics. Enthusiasts say they are allowing scientists to solve problems that would have been considered impossible just 20 years ago. It is proving especially useful in approaching complex problems, such as in the search for the crashed Air France Flight 447 in 2011.

Data gathering is frequently expensive compared with data analysis. It is sensible then that hard-won data be inspected from many different viewpoints. In the selection of viewpoints, Bayesian methods allow greater emphasis to be given to scientific interest and less to mathematical convenience. This course is designed to provide an introduction to fundamental conceptual, computational, and practical methods of Bayesian data analysis.

LEARNING OUTCOMES

After completing this course, the student will be able to

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) methods to sample from a posterior.
4. Effectively summarize a posterior using tables and graphics.
5. Compare models using various goodness-of-fit diagnostics.

COURSE INFO

Time & Location: TR 1:00pm–2:15pm, IES 111
Course materials: http://math.luc.edu/~ebalderama/bayes
Grades, assignments turn-in, announcements, etc.: https://sakai.luc.edu

PREREQUISITE

STAT 203 or STAT 335 or STAT 304 or instructor consent;
STAT 308 or 408, and experience with R strongly recommended (although not required).

REQUIRED TEXT

Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (2014) *Bayesian Data Analysis*, Third Edition. Chapman & Hall/CRC.
ISBN: 978-1-439-84095-5.

Suggested Texts

Hoff, P. D. (2009) *A First Course in Bayesian Statistical Methods.* Springer.
ISBN: 978-0-387-92299-7

Kruschke, J. K. (2014) *Doing Bayesian Data Analysis*, Second Edition. Elsevier Academic Press.
ISBN: 978-0-124-05888-0.

McElreath, R. (2016) *Statistical Rethinking.* Chapman & Hall/CRC Press.
ISBN: 978-1-482-25344-3.

Computing

1. This course will primarily use **R**, and is freely available from https://www.r-project.org
2. (recommended) Download the user interface **R-Studio**, free from https://www.rstudio.com
3. (recommended) Use **markdown**, **knitr**, or LaTeX for assignments.
4. We will also use **Stan**, which is freely available from http://mc-stan.org/

Tentative Schedule

Week 01 - Intro to Bayesian Statistics
Week 02 - Probability
Week 03 - One-parameter models
Week 04 - Multi-parameter models
Week 05 - MCMC - Gibbs Sampling
Week 06 - MCMC - Metropolis Algorithm
Week 07 - **Mid-Semester Break**
Week 08 - Priors and Convergence Diagnostics
Week 09 - Generalized linear models
Week 10 - Hierarchical models
Week 11 - Hierarchical models
Week 12 - Model checking
Week 13 - **Thanksgiving Break**
Week 14 - Additional topics
Week 15 - Additional topics

Grading

The final course grade will be based on four major grading components:

30% — **H**omework
30% — **M**idterm Exams
30% — **F**inal Exam/Project
10% — **O**ther (Quizzes, Participation, etc.)

Grading Scale

A 93%, A- 90%, B+ 87%, B 83%, B- 80%, C+ 77%, C 73%, C- 70%, D+ 67%, D 60%

Course Policies

Attendance

Attendance is expected. It is a vital part of the class and should be considered with the highest regard. Excessive absences will be interpreted as a lack of serious academic effort. You are solely responsible for missed handouts or announcements made during lecture. If you cannot attend a particular lecture, make sure that you stay informed regarding the information provided during that lecture. Please note: It is your responsibility to drop the course. Even if you stop coming to class, I still may not drop you!

Exams

Make-up exams will be given only in case of a legitimate, documented excuse. If for some reason you are not able to take a particular exam at the scheduled time, you are required to inform me in advance.

Homework

Homework must be clearly written and organized with your full name and chapter/assignment number(s) at the top. I reserve the right to not grade your homework if I can't read it. ABSOLUTELY NO LATE HOMEWORK WILL BE ACCEPTED.

Academic Integrity

All work in this course must be completed in a manner consistent with the accepted standards of academic integrity. In particular, cheating will result in disciplinary action, including the instructor assigning the grade of "**F**" and notification of the appropriate Dean. Cheating includes, but not limited to, copying someone else's work or allowing another student to copy your work, plagiarizing someone's work or letting someone plagiarize your work and/or others, using unauthorized references, collaborating with another student, giving out answers or receiving answers, etc. The Code of Academic Integrity will be enforced in all areas of the course. More information regarding the relevant policies and procedures, including information about your rights and responsibilities as a student, is available at
http://www.luc.edu/academics/catalog/undergrad/reg.shtml.

Special Accommodations

The Americans with Disabilities Act requires that reasonable accommodations be provided for students with disabilities or other special needs. Students who would like accommodations at the University need to contact the Coordinator of Services for Students with Disabilities. For more information, please visitwww.luc.edu/sswd/.

DISCLAIMER

Any information contained in this syllabus is subject to change in accordance with the instructor's professional best judgment, within the parameters of the official catalogue-description of the course. This and prior syllabi in no way should be imagined to constrain the instructors' choices of course-materials, assignments, activities, grading-scales, topics, or policies for the current or subsequent offerings of the course.