**September 22, 2019**

**Bayesian Statistical Inference and Modeling**

**Edps 590BAY**

**Fall 2019**

**Instructor**: Carolyn J. Anderson

Office rm 236C Education Building

Office hours: Tuesday 1:00-3:00pm

**Meetings**: Mon/Wed 10:00-11:30am, rm 22 Education Building

**Overview**: Bayesian methods have become more prevalent in statistics including inference, prediction, up-dating probabilities as more data become available, and fitting complex models. A Bayesian approach solves many problems that are difficult under a traditional frequentist approach. In classical and Bayesian statistics, a specific or single value for population parameters are fixed but unknown. It is the values of these parameters, whether a single proportion or coefficients of a complex model, that are interesting. Classical and Bayesian statistics differ in terms of interpretation of the concept of probability and inferential summaries. In classical statistics, probability is defined in terms of long run frequencies; whereas, in Bayesian statistics probability is a degree of belief. In the latter, inference is based on an estimated probability distributions of possible values of the unknown quantities. The probability distributions are based on prior beliefs and data.

This seminar will cover the basics of Bayesian inference and using Bayesian methods for fitting increasingly complex models. The specific topics beyond foundational concepts and procedures will be determined based on student’s interests and needs. This will be an active and collaborative learning course where material will be presented by the instructor or students and in class exercises worked out in small groups.

**Prerequisite**: At least one statistics course beyond Psych 506/507 or Edps 581/582 and consent of the instructor.

**Textbook**: You can use either

Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., & Rubin, D.B. (2013) *Bayesian Data Analysis, 3rd Edition*. Capman & Hall/CRC. ISBN-13: 978-1439840955.

Or

Kruschke, J. (2014).  Doing Bayesian Data Analysis: A tutorial with R, JAGS, and Stan.  2nd Edition. ISBN-13: 978-0124058880.

The former is ``the reference’’ on the subject and is more mathematical. The latter has a higher words/math ratio than the former and you can get an online version for free (to those associated with the University) by going to the UofI library and search for it.

**Evaluation**: 30% participation, 30% assignments (including reading), 40% course project (presentation). The range of projects is very board.

**Computing**: We will use R for computation, especially JAGS and rStan. You should to bring a laptop to course meetings.

**Course web-site**: Should be available <http://education.illinois.edu/faculty-pages/cja/edpsy-590ca> . Besides course information and materials, there are links to multilevel web-sites. This site is open access.

**Questions and feedback:** This term we will be using Piazza for class discussion outside of lectures. The system is highly catered to getting you help fast and efficiently from classmates and myself. This will also be used for students to subject materials for the presentations and will only be available to other students in the class.

I will enter the e-mail addresses of all those who were registered as of September 5. You should receive a note and you just need to activate your account.

Find our class page at: <https://piazza.com/illinois/fall2019/edps587/home>

If you have any problems or feedback for the developers, email [team@piazza.com](mailto:team@piazza.com).

**Illness**: If you are sick, do **NOT** come to lecture, the instructor’s office hours, or the Tas office hours. If you need to turn in homework, you can either give it to a fellow student (preferred) or send it in electronically (to both the TA and instructor).

**Fair Use/Plagiarism Policy**: Please see go to the following link for policy on academic integrity: [http://education.illinois.edu/edpsy/about/academic-integrity](https://webmail.illinois.edu/owa/redir.aspx?SURL=e1APeWO7lwIDRGnqfhP973lGQCDnCn417Z531quHL_ush-RzoKHSCGgAdAB0AHAAOgAvAC8AZQBkAHUAYwBhAHQAaQBvAG4ALgBpAGwAbABpAG4AbwBpAHMALgBlAGQAdQAvAGUAZABwAHMAeQAvAGEAYgBvAHUAdAAvAGEAYwBhAGQAZQBtAGkAYwAtAGkAbgB0AGUAZwByAGkAdAB5AA..&URL=http%3a%2f%2feducation.illinois.edu%2fedpsy%2fabout%2facademic-integrity) The definition as spelled out in this document is

**“**The definition of plagiarism is straightforward: Presenting someone else’s words, materials, manner of expression, or ideas as your own. This means that even if another person agrees to let you present his or her content as if it were yours, it is still plagiarism. Plagiarism does **not** require intent: it can be intentional or unintentional.”

I take this very seriously.

**Emergencies:** Review <http://police.illinois.edu/emergency-preparedness/>

In an emergency in this building, we’ll have three choices: **RUN** (get out), **HIDE** (find a safe place to stay inside), or **FIGHT** (with anything available to increase our odds for survival).

First, take a few minutes this week and learn the different ways to leave this building (exits are to the North, South and two to the West). If there’s ever a fire alarm or something like that, you’ll know how to get out, and you’ll be able to help others get out too.

Second, if there’s severe weather and leaving isn’t a good option, go to a low level, in the Education building the east side of the basement (away from windows).

If there’s a security threat, such as an active shooter, **RUN** out of the building if we can do it

safely or **HIDE** by finding a safe place where the threat cannot see us. We will lock or

barricade the door and we will be as quiet as possible, which includes placing our cell phones on

silent. We will not leave our area of safety until we receive an Illini-Alert that advises us it is safe to do so. If we cannot run out of the building safely or we cannot find a place to hide, we must be prepared to fight with anything we have available in order to survive.

**Remember, RUN away or HIDE if you can, FIGHT if you have no other option.**

Finally, if you sign up for emergency text messages at [emergency.illinois.edu](http://emergency.illinois.edu/), you’ll receive information from the police and administration during these types of situations.

If you have any questions, go to [police.illinois.edu](http://police.illinois.edu/), or call [217-333-1216](tel:%20217-333-1216)

**Tentative Course Schedule and Topics (a work in progress)**:

Need to put in the following:

* Model evaluation
* Hypothesis testing

**Reading**

**Topic Gelman et al. Kruschke**

Introduction & Brief History of Bayesian Statistics ch 1 ch 1 & 2

* What is Bayes Theorem? onlinelibrary.wiley.com/doi/pdf/10.1002/wics.1293
* Why Bayesian analysis?
* Basic Steps
* A little Example
* History
* In class practice: R basics
* Assignment #1: Up-date R and RStudio to most recent version

Beliefs and Probabilities ch1 ch 4

* Requirements of a system of beliefs
* Types of distributions: marginal & conditional
* Expected values
* In class practice: Conditional probabilities and more R
* Assignment #2: Work with conditional probabilities

One Parameter Model: Inference for a Proportion and the Beta-Binomial ch 1 ch 5 & 6

* Priors, likelihood & posterior distributions in action
* Credible intervals
* High density intervals
* Posterior predictive checks
* Examples:
  + Heights of US presidential candidates
  + 2018 General Social Survey Data (attitude toward abortion)
  + Trump approval ratings
* In class practice:
  + 2018 General Social Survey Data (GUNLAW: Favor or oppose permits?)
* Assignment #3:
  + Inference for proportion (GSS OWNGUN: Have gun in your home?)

Count: Poisson-Gamma (probably skip) ch 1

* Example: GSS number of children respondent has (2 cases)
* Posterior predictive checks
* Predicting new (next) observations
* In class practice: pick one, maybe another GSS

Two Parameter Model: Mean and Variance and the Normal Model

* For mean when variance is known (analytic method)
* For unknown mean & variance
* Monte Carlo sampling
* Example: You get what you pay for
* Assignment #4:

Linear Regression Models

* Markov Chains
* Metropolis-Hastings
* Gibbs sampler (& jags)
* Variable selection
* Example: You get what you pay for
* Assignment #5:

Stan

* The Hamiltonian Sampler
* The Stan language
* Example: Mean and Variance
* Example: Linear Regression (you get what you pay for)
* Assignment #6: mean and variance using rStan

Generalized linear models

* The brms package
* Examples: lots of possibilities from 589

Mixed effects models (i.e. multilevel)

* Hyperparameters
* A natural
* Perhaps location scale models

Topics of Student’s choice

Student Project Presentations

References:

Depaoli, S., & van de Schoot, R. (2017). Improving transparency and replication in Bayesian statistics: The WAMBS-checklist. *Psychological Methods*, 2, 240361.

Hoff, P.D. (2009). *A First Course in Bayesian Statistical Methods*. Springer. e-ISBN 978-387-92407-6.

Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., & Rubin, D.B. (2013) *Bayesian Data Analysis, 3rd Edition*. Capman & Hall/CRC. ISBN-13: 978-1439840955.

Kruschke, J. (2014).  *Doing Bayesian Data Analysis: A tutorial with R, JAGS, and Stan*.  2nd Edition. ISBN-13: 978-0124058880.

Leonard, T.H. (2014). A personal history of Bayesian statistics. *WIREs Computational Statisics*, 6: 80-115. doi:10.1002/wics.1293. Retrieved from <https://onlinelibrary.wiley.com/doi/pdf/10.1002/wics.1293>.

McElreath, R.M. (2016). *Statistical Rethinking: A Bayesian Course with Examples in R and Stan*. Boco Raton, FL, CRC/Taylor \& Francis.