CENTER FOR TEACHING EXCELLENCE

JANUX

Bayesian Statistics: An Advancing Introduction

16 units – each unit a week's work.
The following are the contents of the course divided into chapters of the book ***Doing Bayesian Data Analysis . by John Kruschke.***
The course is structured around the above book but will be embellished with more theoretical content as needed.
The book can be obtained from the library :
http://www.sciencedirect.com/science/book/9780124058880

Topics: This is divided into three parts

From the book:

> "Part I The basics: models, probability, Bayes' rule and r: Introduction: credibility, models, and parameters; The R programming language; What is this stuff called probability?; Bayes' rule
>
> Part II All the fundamentals applied to inferring a binomial probability: Inferring a binomial probability via exact mathematical analysis; Markov chain Monte Carlo; JAGS; Hierarchical models; Model comparison and hierarchical modeling; Null hypothesis significance testing; Bayesian approaches to testing a point ("Null") hypothesis; Goals, power, and sample size; Stan
>
> Part III The generalized linear model: Overview of the generalized linear model; Metric-predicted variable on one or two groups; Metric predicted variable with one metric predictor; Metric predicted variable with multiple metric predictors; Metric predicted variable with one nominal predictor; Metric predicted variable with multiple nominal predictors; Dichotomous predicted variable; Nominal predicted variable; Ordinal predicted variable; Count predicted variable; Tools in the trunk"

Part 1: The Basics: Models, Probability, Bayes' Rule and R

Unit 1 Chapter 1, 2 Credibility, Models, and Parameters,

- Derivation of Bayes' rule
- Re-allocation of probability
- The steps of Bayesian data analysis
- Classical use of Bayes' rule
    - Testing – false positives etc
    - Definitions of prior, likelihood, evidence and posterior

Unit 2 Chapter 3 The R language

- Get the software
- Variables types
- Loading data
- Functions
- Plots

Unit 3 Chapter 4 Probability distributions.

- Tables from categorical variables
- Conditional probability
- Review discrete distributions (7 of them)
- Expectation
    - Mean

    - Variance
- Review continuous distributions (5 of them)

Unit 4 Chapter 5 Bayes' Rule
- Bayes' rule and its derivation
- Complete example with estimating Bias on a coin
- The Bayes' box
- R function for making the Bayes' box

Part 2: Inference to a Binomial probability

Unit 5 Chapter 6: Beta distribution used as prior
- Conjugate
- Mathematical development
- R code.

Unit 6 Chapter 7 Markov Chain Monte Carlo
- Use Stewart and Stewart Article
- Tactile construction
- R functions to carry out simulation

Unit 7 Chapter 8: JAGS and R2Jags
- OpenBUGS and creating models graphically
- Making JAGS run remotely
- Continuous example
- Sampling from the prior

Unit 8 Chapter 9: Hierarchical Models
- Single coin from a single mint
- Multiple coins from a single mint
- Shrinkage

Unit 9 Chapter 10: Model Comparison and the Hierarchical model
- General formula and Bayes factor
- Two factories of coins
- Solution by MCMC
- Prediction
- Model complexity accounted for
- Sensitivity to prior

Unit 10 Chapter 11: NULL Hypothesis Testing
- Prior Knowledge
- Confidence Interval and HDI
- Multiple Comparisons
- What a sampling distribution is good for.

Unit 11 Chapter 12: Bayesian Approaches to Testing Point Null
- The estimation approach
- Model comparison approach
- Relations of parameter estimation and model comparison

Unit 12 Chapter 13: Goals, Power, and Sample size

- Computing power and sample size
- Sequential testing

NB : we skip chapter 14 on STAN

Part 3: The generalized Linear Model (GLM)

Unit 13 Chapters 15,18: Overview of the generalized model

- Variable types
- Parts of the GLM
- Exponential family
- Formal expression of GLM
- Multiple Linear Regression
- Multiplicative interaction of metric predictors
- Shrinkage of regression coefficients
- Variable selection

Unit 14 19: Metric Predicted variables on one and two groups

- Describing multiple groups of metric data
- Traditional analysis of variance
- Hierarchical Bayesian approach
- Including a metric predictor
- Heterogenous variances and robustness against outliers