

COURSE SYLLABUS

BAYESIAN DATA ANALYSIS

- Instructor:** József Fiser, Associate Professor
Department of Cognitive Science
Central European University
- Term:** Winter, 2016/17
- Course level:** PhD (2 credits for grade)
- Pre-requisites:**
- E-learning site:**
- Office hours:** Tuesday 13:30 – 15:10 Oktober 6 utca 7. Room 103

Course Description

This course will provide an introduction to practical methods for making inferences from data using probabilistic models for observed and missing data. This approach is an alternative to frequentist statistics, the presently dominant inference technique in sciences, and it supports a common-sense interpretation of statistical conclusions by using probabilities explicitly to quantify uncertainty of inferences. The course will introduce Bayesian inference starting from first principles using basic probability and statistics, elementary calculus and linear algebra. We will progress by first discussing the fundamental Bayesian principle of treating all unknowns as random variables, and by introducing the basic concepts (e. g. conjugate, noninformative priors) and the standard probability models (normal, binomial, Poisson) through some examples. Next, we will discuss multi-parameter problems, and large-sample asymptotic results leading to normal approximations to posterior distributions. We will continue with hierarchical models, model construction and checking, sensitivity analysis and model comparison. We will conclude the course with explicitly contrasting frequentist and Bayesian treatment of null hypothesis testing and Bayesian formulation of classical statistical tests. Students in the course will get familiar with the software packages R and JAGS, which will allow them to fit complex Bayesian models with minimal programming expertise. Familiarity with Matlab or C++ programming is required.

Learning Outcomes

- Getting acquainted with probabilistic thinking and interpretations of data
- Understanding the logic of Bayesian data analysis
- Gaining a basic knowledge about R, RStudio and JAGS
- Being able to perform Bayesian analyses on your own data

Course Requirements

The final grade will be determined roughly by the following weighting:

- Assignments: 50%
- Homeworks: 40%
- Class participation: 10%

Required Materials:

- Kruschke, J.K. (2014). *Doing Bayesian data analysis: A tutorial with R, JAGS and Stan 2nd ed.* Academic Press (**KR**)
- Calculator (cheap - adds, subtracts, multiplies, divides)
- Computer (PC or Mac)

COURSE SCHEDULE

Week	Date	Topic/Reading done <u>before</u> class	Assignment Due	Homework Due
1	Jan. 10	Introduction and Probability KR Ch 4		
2	Jan. 17	Introduction to R KR Ch 3	Install R, RStudio and JAGS	HW 1: Ex 2.1, 2.2, 4.3, 4.6
3	Jan. 24	Bayes rule; Inferences with binomials KR Ch 5-6		HW 2: Ex 4.1 - 4.6
4	Jan. 31	MCMC methods KR Ch 7		HW 3: Ex 5.1 - 5.4, 6.1, 6.2, 6.4, 6.5
5	Febr. 7	Introduction to JAGS KR Ch 8	Assignment #1: R	HW 4: Ex 7.1, 7.2, 7.3
6	Febr. 14	Hierarchical models KR Ch 9		HW 5: Ex 8.1 - 8.4
7	Febr. 21	Model comparison KR Ch 10		HW 6: Ex 9.1 - 9.3
8	Febr. 28	Frequentist and Bayesian Null hypothesis significance test KR Ch 11-12		HW 7: Ex 10.1 -10.3
9	Marc. 7	Goals, Power and sample size KR Ch 13	Assignment #2: JAGS	HW 8: Ex 11.1 - 11.3, 12.1, 12.2
10	Marc. 14	The Generalized Linear Model KR Ch 15		HW 9: Ex 13.2, 13.3, 13.4
11	Marc. 21	t-test for a single mean KR Ch 16		HW 10: Ex 15.1
12	Marc. 28	Linear Regression KR Ch 17		HW 11: Ex 16.1, 16.2
			Assignment #3: Data modeling	