COURSE SYLLABUS

BAYESIAN DATA ANALYSIS

Instructor: József Fiser, Professor
Department of Cognitive Science
Central European University

Term: Winter, 2020/21
Course level: PhD (2 credits for grade)
Pre-requisites:
E-learning site: **http://ceulearning.ceu.hu/**
Time and place: Tuesday 13:30 – 15:10 Online

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 use the software packages R and JAGS, which will allow them to fit complex Bayesian models with minimal programming expertise. Familiarity with R, 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)
- Laptop (PC or Mac)

COURSE SCHEDULE

Week	Date	Topic/Reading done ***before*** class	Assignment Due	Homework Due
1	Jan. 12	Introduction and Probability KR Ch 4		
2	Jan. 19	Bayes rule; Inferences with binomials KR Ch 5-6	**Install R, RStudio and JAGS**	**HW 1: Ex 2.1, 2.2. 4.1, 4.2, 4.4, 4.6**
3	Jan. 26	MCMC methods KR Ch 7		**HW 2: Ex 5.1 - 5.4, 6.1, 6.2, 6.4, 6.5**
4	Febr. 2	Introduction to JAGS KR Ch 8	**Assignment #1: R**	**HW 3: Ex 7.1, 7.2, 7.3**
5	Febr. 9	Hierarchical models KR Ch 9		**HW 4: Ex 8.1 - 8.4**
6	Febr. 16	Model comparison KR Ch 10		**HW 5: Ex 9.1 - 9.3**
7	Febr. 23	Frequentist and Bayesian Null hypothesis significance test KR Ch 11-12		**HW 6: Ex 10.1 -10.3**
8	Marc. 2	Goals, Power and sample size KR Ch 13	**Assignment #2: JAGS**	**HW 7: Ex 11.1 - 11.3, 12.1, 12.2**
9	Marc. 9	The Generalized Linear Model KR Ch 15		**HW 8: Ex 13.2, 13.3, 13.4**
10	Marc. 16	t-test for a single mean KR Ch 16		**HW 9: Ex 15.1**
11	Marc. 23	Linear Regression KR Ch 17		**HW 10: Ex 16.1, 16.2**
12	Marc. 30	One-way ANOVA KR Ch 19		**HW 11: Ex 17.1, 17.2**
	Apr. X		**Assignment #3: Data modeling**	