**Course Syllabus**

**Title:** Probabilistic modeling: From perception to sequential decisions

**Instructors:** Constantin Rothkopf, Visiting Professor  
 József Fiser, Associate Professor

**Term:** Winter, 2017/18

**Course level:** PhD (2 credits for grade)

**Pre-requisites:** Basic knowledge of JAGS, probabilistic computation

**E-learning site:** [**http://ceulearning.ceu.hu/**](http://ceulearning.ceu.hu/)

**Time and place:** Thursday, 10:30 – 12:10, Dept. CogSci, Oktober 6 utca 7, Room 103

**Course Description:** This course is an introduction to probabilistic modeling of human behavior.  The sequence of topics starts with the formalization of decisions in classical detection paradigms. From there, we will look at the formalization of perception as inference of latent causes given sensory measurements. To handle more complex interactions of different sensory measurements and different latent causes, we will investigate cue combination, explaining away, and causal inference problems. From there, we will introduce the topic of how to take decisions in a principled way based on inferences, leading to Bayesian decision theory. Finally, we will show how sequential decision making, which builds an all previous topics, introduces a new level of complexity through the need to do planning and we will arrive at the classic exploration-exploitation dilemma. To develop computational intuitions and understand the material, we will use JAGS, a software tool that allows carrying out statistical inference on fairly complex models through MCMC.

**Learning Outcomes:**

* Getting acquainted with probabilistic modeling of perception and perceptual decision making
* Understanding the link between perceptual experimental literature and computational modeling
* Understanding probabilistic computational models through explorations with MCMC simulation software JAGS
* Gaining experience in how to read and present various scientific materials

**Course Requirements:**

The course is graded and the final grade will be determined roughly by the following weighting based of three components.

-  Homeworks: 80%

-  Class preparation: 10%

-  Class participation: 10%

-  Class preparation: each student needs to read the assigned paper for each class (before the class!).  This does not have to be a deep thorough reading (although that is the best), however, it must be sufficient to be familiar with the topic covered in the paper.  Having said that, reading of the course material is essential component of the course, and keeping up with the readings will be expected.  To facilitate this, each student has to submit (before the class by E-learning Dropbox) and also bring to class a copy of a max half-a-page summary sheet.  On this sheet, four items need to be presented in an itemized manner: a) one-two sentences about the gist of the paper, b) a single idea/result/methodological trick that was the most interesting, c) the list of topics, notions, equations that the student did not understand or did not agree with, d) at least one question that s/he wants to clarify based on the study that defines the next step in the research.  During the class students will be asked to present their summary and the question, which will be discussed in class. Students will be expected to reach and present an answer to their question by the end of the class.

- Class participation: This is a small, seminar-style course with the goal of understanding each topics in depth.  It is essential that the class formed a coherent view on the covered topics by the end of the semester.  To achieve this, we expect a highly interactive and critical discussing during classes. Passive absorbance of presented information is not highly valued.

- Homeworks: Homeworks will have to be submitted before the beginning of each class.

**Required Materials:**  All course material, PDFs of the reading and codes will be provided

**Course Schedule:**

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| Week | Date | Topic | Paper | Homework due |
| 1 | 21.09. | Refresher: probabilistic graphical models, inference, JAGS & BUGS | Krushke Chap. 8 |  |
| 2 | 28.09. | Model of human perceptual detection experiments | Lee & Wagemakers Chp. 11.1 | Modeling decision proportions |
| 3 | 05.10. | Hierarchical model of human perceptual detection experiments | Lee & Wagemakers Chp. 11.2 | Posterior predictive: what do you expect given the model? |
| 4 | 12.10. | The power of generative models | Peters, Ma, Shams (2016) | Non-Gaussian distributions for N and S+N |
| 5 | 19.10. | Cue integration: likelihood and prior | Weiss, Simoncelli, Adelson (2002) | Testing different priors -> non linear inference |
| 6 | 26.10. | Cue integration: factored likelihood | Ernst & Banks (2002) | Testing different likelihoods -> nonlinear inference |
| 7 | 02.11. | Explaining away in perception | Neupärtl, Hoppe, Rothkopf (2017) | Comparing by hand calculation vs. JAGS simulation of the sprinkler example |
| 8 | 09.11. | Causal inference | Körding , Beierholm, Ma, Quartz, Tenenbaum, Shams (2007) | Reusing code from Class 6 to implement model of causal inference |
| 9 | 16.11. | Posterior, cost functions, decisions | Murphy,  Chap. 5.7 (2012) | Applying cost function to posteriors from HW 4 & 5 |
| 10 | 23.11. | Decisions and ballistic movements | Trommershäuser, Maloney, Landy (2003) | Implementing model from the paper |
| 11 | 30.11. | Sequential decisions I | Pessiglione, Seymour, Flandin, Dolan, Frith (2006) | Implementing model from the paper |
| 12 | 07.12. | Sequential decisions II | Hoppe & Rothkopf (2017) | Planning one vs. two actions |