

CS506 Cognitive Modeling

Credits: 2-0-2-3

Approval: Approved in 3rd Senate

Students intended for: 3rd, 4th year B. Tech. CSE/M.S. SCEE/Ph.D. SCEE, H&SS

Elective or Core: Elective

Prerequisite: Consent of the faculty member

Semester: Odd or Even

Course objective:

The objective of this course is to scientifically explain the basic cognitive processes of perception, thinking, problem solving, decision making, and moving in the environment and how these processes interact. But how does one explain these cognitive processes? The answer is by developing and testing computational models of cognitive processes. Models of cognitive processes are appearing in different fields of study like human factors, clinical psychology, cognitive neuroscience, agent-based modeling, and economics etc. This course provides students an elementary introduction to the basic methods used to develop and test computational models of cognition. It answers many of the questions one faces when developing cognitive models: What makes a cognitive model different from a statistical model? How does one develop a cognitive model? How can one qualitatively and quantitatively determine the parameters of a cognitive model? And, how do we compare performance of different models? This course provides concrete answers to these questions using examples and laboratory exercises. It provides a presentation of psychological, mathematical, statistical, and computational methods used in different areas of cognitive modeling. Students taking this course would understand detailed examples of these methods in a variety of modeling areas that include recognition, categorization, decision making, and learning.

Evaluation:

- Final exam
- Announced Quizzes
- Surprise Quizzes
- Lab Assignments (to be started in the lab and finished offline; there would be a grading component for in-lab work this component would be separate from out-of-lab work)

Course content:

- Introduction to Cognitive Modeling: What are cognitive models? Advantages of cognitive models, Practical uses of cognitive models, The steps involved in cognitive modeling
Lab: Install and becoming familiar with cognitive modeling software tools (Excel and/or Matlab) on your computer
- Qualitative Model Comparisons: Category learning experiment, Two models of category learning, Qualitative comparisons of Models
Lab: Simulate qualitative model comparison using the Exemplar model in Matlab or Excel
- Basic Parameter Estimation Techniques: Linear and Nonlinear parameter estimation, Retention Experiment and Model, Aggregate modeling versus individual modeling, Objective function and searching for optimal parameters
- Application to Choice and Response Time Measures (Signal detection task; Dynamic signal detection model; parameter estimation; goodness of fit; lack of fit tests)
Lab: Simulate parameter estimation using the Retention model in Matlab or Excel. Also, simulate parameter estimation using the Wiener Diffusion Model in Matlab or Excel

- Quantitative model comparisons: Maximum likelihood estimation, Bechara's Simulated Gambling Task (BSGT), Three Cognitive Models on BSGT, Parameter estimation, Quantitative model comparisons using AIC and BIC, Cross-validation and Generalization

Lab: Create models on BSGT in Matlab or Excel; Simulate parameter estimation on BSGT in Matlab or Excel

- Connectionist versus Rational Approaches: (Rational) Instance-based Learning (Instances; K-nearest neighbor learning; Case-based reasoning; Similarity; Activation), (Connectionist) Neural Networks(neural networks, Rescorla-wagner/delta rule, Multi-layer feed forward networks, Discuss the relative theoretical merits of either approach

Lab: Create and simulate a cognitive model for each of the connectionist and the rational approaches.

Textbooks:

J. Busemeyer & A. Diederich. *Cognitive Modeling*. 2009. Sage Publications, Inc. [BD]

S. Farrel & S. Stephan Lewandowsky. *Computational Modeling in Cognition: Principles and Practice*. 2010. Sage Publications, Inc. [FL]

Reference Books:

R. Sun. *Cognition and Multi-Agent Interaction*. 2006. Cambridge University Press. [RS]

Konar. *Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain*. 1999. CRC Press; 1 edition [AK]

T. Mitchell. *Machine Learning*. 1997. McGraw-Hill Science. [TM]

B. Hahn. *Essential Matlab for Engineers and Scientists* (4th Edition). 2009. Academic Press [BH]

Articles

Certain articles from JSTOR: I will hand out photocopies during the semester.

Software

Matlab and Palisade Decisions Tools (the instructor will provide the CD for these software tools)