PSYCH 734 / CES 734 FALL 2016

Computational models of learning and memory

Instructor: Sue Becker
TA: Kiret Dhindsa

This course will cover some of the most influential computational models of learning and memory, and the application of these models to understanding how the brain learns and encodes information, the analysis of neuroscientific data, the design of brain-computer interfaces, as well as general data analysis with machine learning. Students must have some computer programming experience (in any programming language), and be comfortable writing programs that include loops, variables and procedures/functions. Assignments will be done using Matlab (Octave is acceptable if the student can ensure the code can be run in Matlab).

Evaluation will be based on 3 small programming assignments (due every 2nd week for the first 6 weeks), presenting and leading the discussion of 1 research paper, participation in paper discussions, and one major project involving the application of one of the learning models discussed in the course to the classification of EEG data for a brain-controlled interface application.

SCHEDULE

Thursdays 11:30-2:20
Location: TBA
The course will run for 12 weeks.
Sept 15: First class.
Dec 8: Last class.
No class on Sept 29

COURSE OUTLINE

Weeks 1-2: Overview, and simple Hebbian learning models
- LTP, STDP, competitive learning, Hebbian pattern associators

Weeks 3-4: Associative memory models continued
- Hopfield networks
- Boltzmann machines as brain models
- Applications of Boltzmann machines to deep learning for data modelling

Week 5-6: Reinforcement learning models
- simple reinforcement learning rules
- TD-learning: the temporal difference learning algorithm
- applications to understanding the brain
- predicting fMRI responses from the TD learning rule

Weeks 7-9: Supervised learning models

- the delta rule
- back-propagation learning
- stacked auto-encoders for deep learning
- MVPA: applications of back-propagation learning to pattern classification of fMRI signals

Weeks 10-12: Decoding the brain (Kiret's section)

- Neural Networks as machine learning tools for data analysis
- Clustering and classifying data using neural networks
- Application of computational learning models to neuroscientific data: EEG (ECoG and fMRI given time and student interest)
- signal preprocessing and feature extraction
- artefact detection
- signal classification
- Brain-computer interfaces using EEG

READINGS

- Selected papers, TBA

(will include a mix of computational brain models and neural networks applied to neuroscientific data analysis and brain-computer interfacing)