

Harvey Mudd College
Computer Science 152
Neural Networks
Fall 2010

Trailer: Can a computer be taught to read words aloud, recognize faces, perform a medical diagnosis, drive a car, play a game, balance a pole, predict physical phenomena? The answer to all of these is yes. All these applications and others have been demonstrated using varieties of the computational model known as "neural networks", the subject of this course.

The course will develop the theory of a number of neural network models. Participants will exercise the theory through both pre-developed computer programs and ones of their own design.

Catalog Description: Modeling, simulation, and analysis of artificial neural networks. Relationship to biological neural networks. Design and optimization of discrete and continuous neural networks. Backpropagation, and other gradient descent methods. Hopfield and Boltzmann networks. Unsupervised learning. Self-organizing feature maps. Applications chosen from function approximation, signal processing, control, computer graphics, pattern recognition, time-series analysis. Relationship to fuzzy logic, genetic algorithms, and artificial life.

Meets: Tu Th 2:45-4:00, 1285 Parsons

Instructor: Prof. Keller, 1253 Olin, x18483, keller at cs hmc edu, AIM: MuddProf

Prerequisites: CS 60 (Principles of Computer Science) and Mathematics 12 (Multi-variate Calculus and Linear Algebra), or permission of the instructor.

Text: Simon Haykin, [Neural Networks and Learning Machines, Third Edition](#), Hardcover: 936 pages, Prentice Hall (November 28, 2008) ISBN-13: 978-0131471399

Course Requirements and Grading:

There will be some homework, mostly programming assignments, but no exams. The assignments will constitute about 40% of your grade. 40% of your grade is from a substantial final project involving either creation of a working neural network application or a research paper. The grade on the project will be determined by the comprehensiveness and degree to which you explored competing approaches. The projects will be presented orally. 10% of your grade will be based on a preliminary presentation you make, ideally on material related to your project. Finally, 10% will be based on general participation, which

includes attendance.

CS 152 Topic Outline (Approximate Draft) [Reading in the Haykin book is in brackets; additional reading will be indicated as needed]:

Week 1:

- Biological motivation [Introduction]
- Historical overview
- Perceptrons [chapter 1]
- Perceptron convergence theorem

Week 2:

- Least Mean Square (LMS) algorithm [chapter 3]
 - Adalines
 - Adaptive filtering
- Multi-Layer Perceptrons (MLP), Backpropagation [chapter 4]

Week 3: Backpropagation performance optimization [chapter 4]

- Conjugate gradient
- Newton's method
- Levenberg-Marquardt
- Quickprop
- Resilient backpropagation (RPROP)

Week 4: Hebbian Learning

- Associative Memory
- Hebb rule
- Pseudoinverse rule
- Instar/Outstar rules

Week 5: Kernel Methods and Radial basis function networks [chapter 5]

Week 6: Support Vector Machines (SVMs) [chapter 6]

Week 7: Principal-Components Analysis (PCA) [chapter 8]

Week 8: Self-Organizing Maps (SOM) [chapter 9]

- Learning vector quantization (LVQ)
- Counterpropagation networks (CPN)
- Hamming network

Week 9: Independent-Components Analysis (ICA) [chapter 10]

Week 10: Boltzmann Machines and Deep-Belief Nets [chapter 11]

Week 11: Temporal Difference Method [chapter 12]

Week 12: Hopfield Nets [chapter 13]

- Bi-directional associative memory (BAM)

Week 13: Recurrent Networks [chapter 15]

- Time series
- Backpropagation through time
- Real-time recurrent learning
- Control applications
- Finite Impulse Response (FIR) MLP
- Temporal difference Method

Weeks 14-15: Final Presentations by Students

Might be fit in Somewhere

- Adaptive resonance theory (ART)
- Fuzzy logic
- Evolutionary computation
- Artificial life