

SYLLABUS FOR:
TECHNIQUES IN COMPUTATIONAL NEUROSCIENCE

Physiology 317, Part II, Neural Networks

Instructor: T. Anastasio

The second half of the course will consist of seven segments, each with one classroom session (Mondays) and one computer lab (Wednesdays). Each classroom session will consist of a lecture by the instructor on a neural-network modeling paradigm, followed by discussion of the neurobiological implications of the paradigm. A homework assignment will be given in class each Monday, and help in completing it will be provided in the computer lab that Wednesday. The completed assignment must be submitted to the TA during the computer lab on the following Wednesday. Students are expected to submit their homeworks on time.

Topics to be covered and readings are listed below. Articles that provide a focus for discussion of the neurobiological implications of neural network models are marked with an asterisk. Copies of discussion articles have been placed on reserve in the Granger Engineering Library. Also listed are recommended textbooks for further, optional reading.

I. Lateral Inhibition

Ratliff K, Knight BW, Graham W (1969) On tuning and amplification by lateral inhibition. *Proc Natl Acad Sci* 62:723-730

Didday RL (1976) A model of visuomotor mechanisms in the frog optic tectum. *Math Biosci* 30:169-180

* Coombs S, Mogdans J, Halstead M, Montgomery J (1998) Transformations of peripheral inputs by the first-order lateral line brainstem nucleus. *J Comp Physiol A* 182: 609-626

II. Self-Organizing Feature Maps

Malsburg CH von der (1973) Self-organization of orientation sensitive cells in the striate cortex. *Kybernetik* 14:85-100

Kohonen T (1982) Self-organized formation of topologically correct feature maps. *Biol Cybern* 43:59-69

* Obermayer K, Ritter H, Schulten K (1990) A principle for the formation of the spatial structure of cortical feature maps. *Proc Natl Acad Sci* 87:8345-8349

III. Hopfield Networks

Hopfield JJ (1982) Neural networks and physical systems with emergent collective abilities. *Proc Natl Acad Sci* 79:2554-2558

Hopfield JJ (1984) Neurons with graded response have collective properties like those of two-state neurons. *Proc Natl Acad Sci* 81:3088-3092

* Rolls ET (1989) Functions of neuronal networks in the hippocampus and neocortex in memory. In: Byrne JH, Berry WO (Eds) *Neural models of plasticity: experimental and theoretical approaches*. Academic Press, San Diego, pp 240-265

IV. Back-Propagation

- Rumelhart DE, Hinton GE, Williams RJ (1986) Learning internal representations by error propagation. In: Rumelhart DE, McClelland JL, PDP Research Group (Eds) Parallel distributed processing: explorations in the microstructure of cognition: vol 1: foundations. MIT Press, Cambridge, pp 318-362
- Anastasio TJ, Robinson DA (1989) the distributed representation of vestibulo-oculomotor signals by brain-stem neurons. Biol Cybern 61:79-88
- * Zipser D, Anderson RA (1988) A back-propagation programmed network that simulates response properties of a subset of posterior parietal neurons. Nature 331:679-684

V. Genetic Algorithms

- Holland JH (1992) Adaptation in natural and artificial systems. MIP Press, Cambridge, ch 1
- Happel BL, Murre JMJ (1994) Design and evolution of modular neural network architectures. Neural Networks, 7:985-1004
- * Schaffer JD, Caruana RA, Eshelman LJ (1990) Using genetic search to exploit the emergent behavior of neural networks. Physica D 42:244-248

VI. Temporal Difference Learning

- Sutton RS (1988) Learning to predict by the methods of temporal differences. Machine Learning 3:9-44
- Barto AG (1995) Adaptive critics and the basal ganglia. In: Houk JC, Davis JL, Beiser DG (Eds) Models of information processing in the basal ganglia. The MIT Press, Cambridge, ;; 215-232
- * Montague PR, Dayan P, Sejnowski TJ (1996) A framework for mesencephalic dopamine systems based on predictive Hebbian learning. J Neurosci 16:1936-1947

VII. Recurrent Back-Propagation

- Williams RJ, Zipser D (1989) A learning algorithm for continually running fully recurrent neural networks. Neural Comp 1:270-280
- Anastasio TJ (1991) Neural network models of velocity storage in the horizontal vestibulo-ocular reflex. Biol Cybern 64:187-196
- * Zipser D (1991) Recurrent network model of the neural mechanisms of short-term active memory. Neural Comp 3:179-193

Suggested Textbooks

- Beal R, Jackson T (1990) Neural computing: an introduction. Institute of Physics Publishing, Bristol, UK
- Churchland PS, Sejnowski TJ (1992) The computational brain. MIT Press, Cambridge
- Haykin S (1999) Neural networks: a comprehensive foundation. second edition. Prentice Hall, Upper Saddle River