Artificial Neural Networks

Eötvös Loránd University, Budapest, Hungary, 2005 – 2007 Fall, Spring
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The goal of this course is to provide a brief introduction to the theory of artificial neural networks (ANN) and their applications. We review the history of ANN research, cover basic neural network architectures and learning algorithms, and discuss applications in image processing, speech processing, pattern recognition, computer vision, and computational neuroscience. This course has both graduate and undergraduate versions for students in computer science, mathematics, physics, and engineering.

Feedforward neural networks

Questions about representation: Hilbert's 13th problem, Kolmogorov theorem, Sprecher theorem.
Approximation power: Hornik's theorem, Blum-Li theorem, SgnNet2 is uniformly dense in L_2 spaces.
Perceptron: binary classifier, the perceptron algorithm and its convergence.
Multilayer perceptron: the backpropagation algorithm.

Statistical physics

Hopfield-networks: binary and continuous networks, applications, convergence of Hopfield networks, capacity, Lyapunov function, Hopfield networks and the traveling salesman problem.
Boltzmann machines: maximum likelihood estimation of Boltzmann machines, applications.

Linear networks

Neural principle component analysis.
Neural independent component analysis.

Self-organizing and topological networks

Self-organizing maps: Kohonen's SOM algorithm.
Local linear embedding. Isomap. Local tangent space alignment. Multidimensional scaling.
Nonlinear principal component analysis.

Recurrent neural networks

Discrete time recurrent neural networks. Backpropagation through time. Real-time recurrent learning.
Recurrent neural network teaching with extended Kalman-filtering.
Echo state networks: dynamical reservoir, damped dynamics, ESN training.
Neural Kalman-filter.

Computational neuroscience

Modeling the Entorhinal-hippocampal (EC-HC) loop.
Primary visual cortex (V1). Edge detector cells. Independent component analysis.