

ICS 435 Machine Learning Fundamentals

15 week syllabus, two lectures per week. Lecture numbers indicated in bold font on the left.

1 Introductory Lecture: Introduction to machine learning and computational neuroscience/neuroinformatics.

2-3 Basic maths skills: review of important mathematical methods, such as differential equations, linear algebra, calculus of variations, probability theory - specifics depend on student needs.

4-5 Basic neuroscience:

- Neurons, Synapses.
- Information processing and adaptation in the nervous system.

6-8 From real neurons to artificial neurons:

- Realistic biophysical model: Hodgkin-Huxley model.
- Simplifications
 - * Morris-Leccar model.
 - * Integrate-and-fire model
 - * Threshold units.

9-10 Mathematical models of learning:

- Hebbian learning.
- Spike-timing dependent plasticity.

11 From biophysics to machine learning algorithms: the Perceptron algorithm - theory and implementation.

12-15 Feed-forward artificial neural networks:

- Theory and implementation.
- Selected applications to contemporary problems. Subject areas are listed below - specifics are adjusted to student interests.

16-20 Support Vector Machines (SVMs):

- Introduction to support vector learning.
- Selected applications of SVMs. Subject areas are listed below - specifics are adjusted to student interests.

21-25 Recurrent Neural networks:

- Hopfield network.
- Simple recurrent networks.
- Selected applications of recurrent networks, including associative memory and content-addressable memory (CAM).

26-30 Unsupervised learning:

- Undergraduate level introduction to cluster analysis: concepts and different types of clustering algorithms.
- K-means and vector quantization.
- Applications: image segmentation, data mining, and other areas (see below) - specifics are adjusted to student interests.

Application subject areas include: robotics, computer vision, speech recognition, time series analysis, renewable energies, mathematical finance, geology, medical imaging, and bioinformatics. Students are allowed to add subjects.