Machine learning from a physicists point of view

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1 Introduction (1 lecture)

Learning and adaptation: some biological motivation for machine learning, and some selected modern history of the subject's origins. Overview (non-technical).

2 Energetics of information processing (4 lectures)

2.1 Thermodynamic foundations (2 lectures)

- Equilibrium thermodynamics applied to information processing
  - Quick review of some basics
  - Second law limits information processing efficiency
  - Szillard's discussion of Maxwell's demon
  - Landauer's argument
- Information processing out of equilibrium
  - Introduction to some far-from-equilibrium ("stochastic") thermodynamics basics

2.2 Measurement and Information (2 lectures)

- Energetics of measurement and data representation
- From physics to information theory
  - From maximal work potential to channel capacity
  - From minimum effort to rate-distortion theory
  - Keeping maximal work potential at minimal effort: the Information Bottleneck method

3 From information processing to machine learning (4 lectures)

3.1 Information and unsupervised learning (2 lectures)

- Unsupervised learning

  - Challenges of unsupervised learning and cluster analysis
  - Some approaches
  - Using rate-distortion theory for clustering
  - Unsolved problems

- Information Bottleneck approach to clustering and cluster analysis
  - Information Bottleneck method
  - IB Clustering
  - IB cluster analysis
  - Open problems

3.2 Regression and classification (2 lectures)

- Bayesian Inference
  - Data fitting and Chi-Square
  - Regularization
  - Occams Razor and model comaprison
- Introduction to statistical learning theory and kernel machines
  - Classification and neural nets
  - Regularization
  - Support Vector machines
  - Structural risk minimization
  - Kernels

4 Closing (1 lecture)

Overview of advanced and recent machine learning methods (light on the technicalities).