

What is Learning Theory?

Machine Learning
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Outline

- Overview of learning theory
- Results of two example analyses
 - Perceptron mistake bound
 - Generalization bound

Science of Machine Learning Research

- Mix of mathematical science and experimental science
- Experimental: cross-validation, held-out testing, deployment
- Mathematical: theorems and proofs
- Strongest contributions combine both styles of science

Questions We Can Ask

- Under what assumptions can we guarantee some behavior of some learning algorithm?
- What is the computational complexity of some algorithm?
- What is the sample complexity required to fit some model?
- How many mistakes will an online learner make?
- How well will a learned model generalize when trained on a finite sample?

Core Topics in Learning Theory

- Design and analysis of learning algorithms and their generalization ability
- Statistical and computational complexity of learning
- Optimization models and algorithms for learning
- Unsupervised, semi-supervised learning, and clustering
- Online learning

(the first few topics from the COLT 2015 call for papers)

Analysis 1: Perceptron

[Novikoff, 1962]

- In an **online learning** setting, where we receive an infinite stream of labeled examples
- If the data is generated to be linearly separable with fixed margin ρ
- And all data examples have bounded norm no greater than r
- The total number of mistakes the perceptron will make is r^2/ρ^2

See Mohri & Rostamizadeh for a thorough survey of perceptron analyses

<http://www.cs.nyu.edu/~mohri/pub/pmb.pdf>

Analysis 2: Generalization Error

