

# Statistical Machine Learning from Data

## Introduction to Machine Learning

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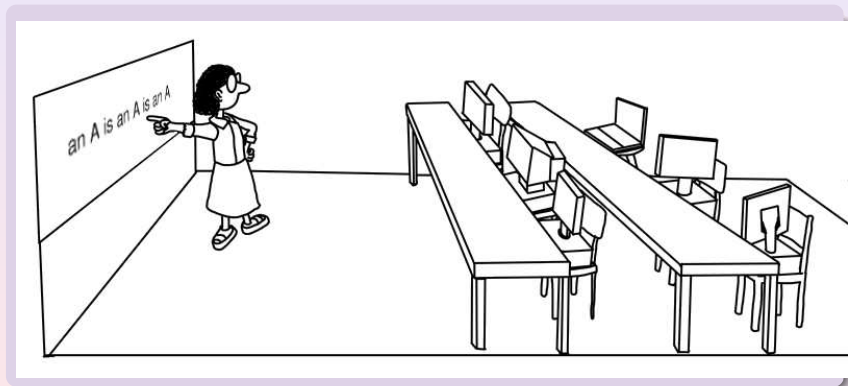


November 30, 2005

- 1 What is Machine Learning?
- 2 Types of Problems and Situations
- 3 Content of the Course
- 4 Documentation

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# What is Machine Learning? (Graphical View)

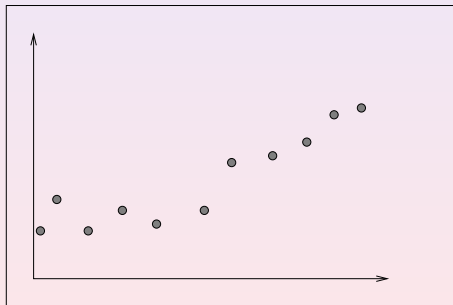


# What is Machine Learning?

- Learning is an essential human property
- Learning means **changing** in order to be **better** (according to a given **criterion**) when a similar situation arrives
- Learning **IS NOT** learning by heart
- Any computer can learn by heart, the difficulty is to **generalize** a behavior to a novel situation

# Why Learning is Difficult?

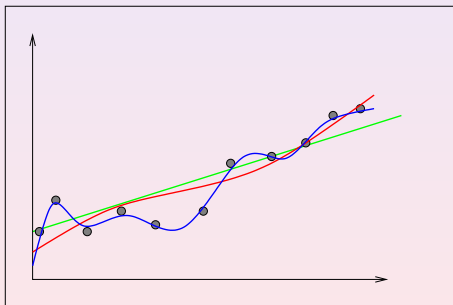
- Given a **finite** amount of training data, you have to derive a **relation** for an **infinite** domain
- In fact, there is an infinite number of such **relations**



- How should we draw the relation?

## Why Learning is Difficult? (2)

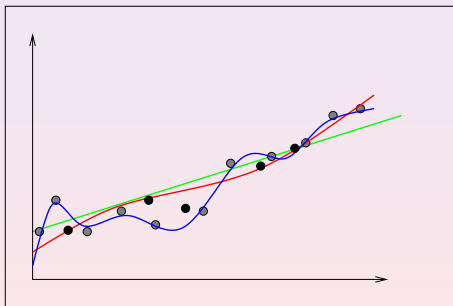
- Given a **finite** amount of training data, you have to derive a **relation** for an **infinite** domain
- In fact, there is an infinite number of such **relations**



- Which relation is the most appropriate?

## Why Learning is Difficult? (3)

- Given a **finite** amount of training data, you have to derive a **relation** for an **infinite** domain
- In fact, there is an infinite number of such **relations**



- ... the hidden test points...

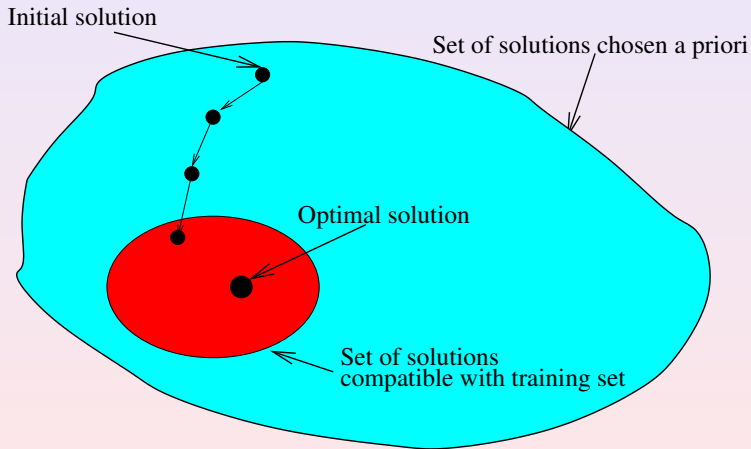


# Occam's Razor's Principle

- William of **Occam**: Monk living in the 14th century
- **Principle of Parsimony**:  
One should not increase, beyond what is necessary,  
the number of entities required to explain anything
- When **many** solutions are available for a given problem, we should select the **simplest** one
- But what do we mean by **simple**?
- We will use **prior knowledge** of the problem to solve to define what is a simple solution

*Example of a prior: **smoothness***

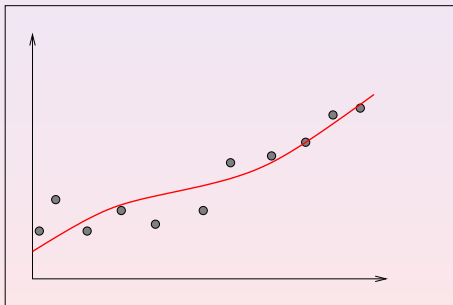
# Learning as a Search Problem



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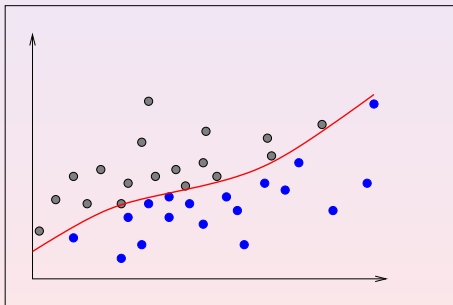
# Types of Problems

- There are 3 kinds of problems:
  - regression



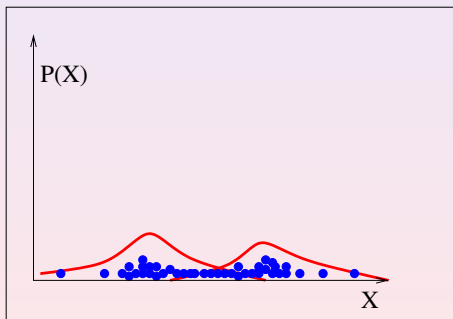
# Types of Problems

- There are 3 kinds of problems:
  - regression, **classification**



# Types of Problems

- There are 3 kinds of problems:
  - regression, classification, **density estimation**



# Types of Learning

## Supervised learning:

- The training data contains the desired behavior
- (desired class, outcome, etc)

## Reinforcement learning:

- The training data contains partial targets
- (for instance, simply whether the machine did well or not).

## Unsupervised learning:

- The training data is raw, no class or target is given
- There is often a hidden goal in that task (compression, maximum likelihood, etc)

# Applications

- Vision Processing
  - Face detection/verification
  - Handwritten recognition
- Speech Processing
  - Phoneme/Word/Sentence/Person recognition
- Others
  - Indexing: google, text mining, information retrieval
  - Finance: asset prediction, portfolio and risk management
  - Telecom: traffic prediction
  - Data mining: make use of huge datasets kept by large corporations
  - Games: Backgammon, go
  - Control: robots
- ... and plenty of others of course!



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# Content of the Course

- Theoretical Issues
  - What are the **theoretical foundations** for statistical learning?
  - How can we **measure** the expected performance of a model?
- Modeling Issues
  - Models specialized for classification, regression, distributions, sequences, images, etc
  - For each model, we need to devise a **training algorithm**
- Others
  - Other **practical issues**, such as feature selection, parameter sharing, etc.
- Laboratories
  - About one third of the course will be through practical laboratories, using the **python** programming language

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# Journals and Conferences

- Journals:
  - Journal of Machine Learning Research
  - Neural Computation
  - IEEE Transactions on Neural Networks
  - IEEE Transactions on Pattern Analysis and Machine Intelligence
- Conferences:
  - NIPS: Neural Information Processing Systems
  - COLT: Computational Learning Theory
  - ICML: International Conference on Machine Learning

## Books and Lecture Notes

- Books:
  - C. Bishop. Neural Networks for Pattern Recognition, 1995.
  - V. Vapnik. The Nature of Statistical Learning Theory, 1995.
  - T. Hastie, R. Tibshirani, J. Friedman. The elements of Statistical Learning, 2001.
  - B. Schölkopf, A. J. Smola. Learning with Kernels, 2002.
- Other lecture notes: (some are in french...)
  - Bengio, Y.: <http://www.iro.umontreal.ca/~pift6266/A03/>
  - Keggl, B.: <http://www.iro.umontreal.ca/~kegl/ift6266/>
  - Jordan, M.:  
<http://www.cs.berkeley.edu/~jordan/courses/281A-fall04/>
  - LeCun, Y.:  
<http://www.cs.nyu.edu/~yann/2005f-G22-2565-001/>

## Electronic Resources

- Search engines:
  - NIPS online: <http://nips.djvuzone.org>
  - Citeseer: <http://citeseer.ist.psu.edu/>
  - Google scholar: <http://scholar.google.com/>
- Machine learning libraries:
  - Torch: <http://www.Torch.ch>
  - Lush: <http://lush.sf.net>