Queen Mary
University of London

EECS708: Machine Learning

Introduction to Machine Learning Module

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Outline

Course Logistics

Examples of Machine Learning problems

A rough categorization of Machine Learning problems

What will cover in this module

Course Format

- 12 weeks, 2 (+1 occasionally) hours of lectures per week
- 2 coursework assignments organised in 6 lab sessions of 2 hrs each as follows:
  - 2hrs lab sessions for part 1 of assignment X
  - 2hrs lab sessions for part 2 of assignment X
- Assesment: 60% final exam, 40% coursework

Feedback

- Feedback on assessments:
  - Written, collective feedback with the common mistakes
  - Online lecture session with Tas
- Forum Q/A
- Questions during the interactive lecture session
  - Questions to be posed on the chat channel
- Feedback to me (lecture/labs/demonstrators/+++)
  - By email, msteams appointment

Recommended texts

- Kevin Murphy. Machine Learning. A probabilistic perspective. MIT Press. http://www.cs.ubc.ca/~murphyk/MLbook/
  [Main book for the module]
- D. Barber: Bayesian Reasoning and Machine Learning
  [Comprehensive, a bit advanced, free online pdf]

- Duda, Hart and Stork: Pattern Classification (2001)
  [Good, comprehensive]
- Bishop: Pattern Recognition and Machine Learning (2006)
  [Good and reasonably affordable.]
- Barber (2002). [Thorough coverage of Probability, RVs, etc.]

Machine Learning

- Use of “intelligent” techniques for analysis and processing of signals and data.

Applications include:

- Autonomous vehicles
- Speech recognition
- Medical diagnosis
- Search engines (google search, google image search)
- News grouping, Ad placement
- Netflix recommendations
- Spam Filtering
- Stock market prediction

A Few Quotes

- “A breakthrough in machine learning would be worth ten Microsofts” (Bill Gates, Chairman, Microsoft)
- “Machine learning is the next Internet” (Tony Tether, former director, DARPA)
- “Machine learning is the hot new thing” (John Hennessy, President, Stanford)
- “Machine learning is going to result in a real revolution” (Greg Papadopoulos, former CTO, Sun)

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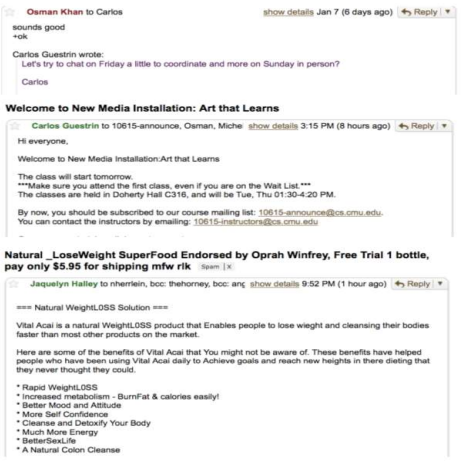
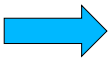
Machine Learning by examples

Classification

Spam Filtering





Spam/no spam

Face detection

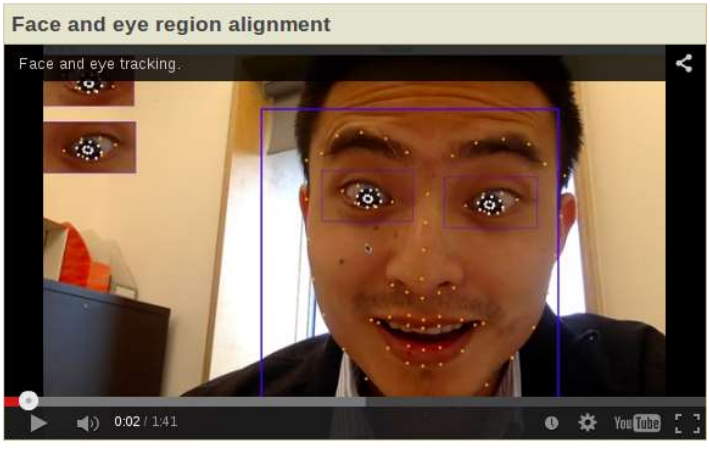
Example training images
for each orientation

Machine Learning by examples

Regression

Stock market prediction

Facial landmark localisation



https://www.youtube.com/watch?v=ONnobin5GBs

Machine Learning by examples

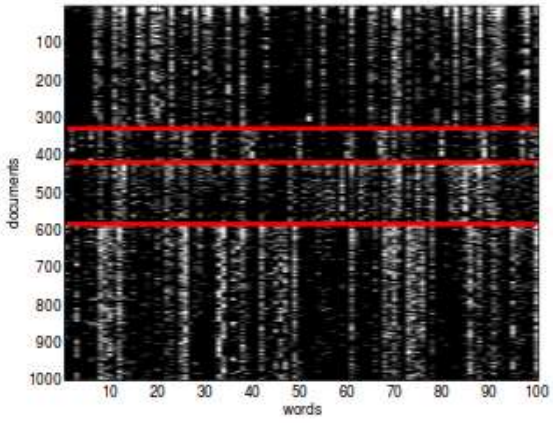
Clustering

Clustering Images

Clustering images

[Goldberger et al.]

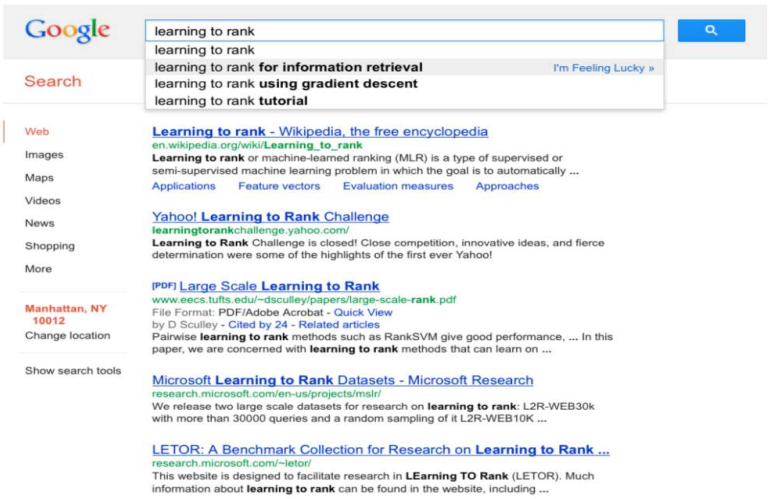
Clustering documents



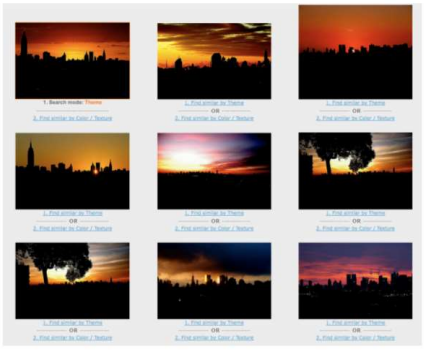
Machine Learning by examples

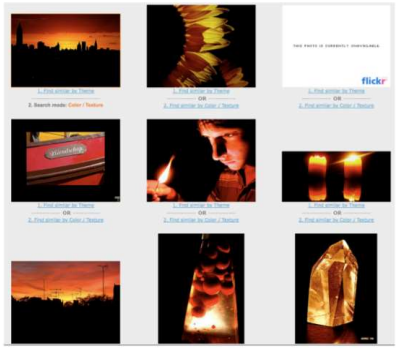
Ranking

Text-based search



Visual search – find similar images





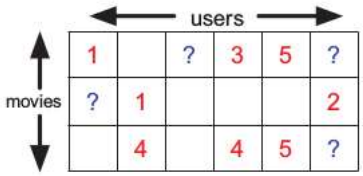
http://www.tiltomo.com/

Machine Learning by examples

Recommendation

Recommendation

Recommendation systems



Netflix competition (www.netflixprize.com)

Machine learning competition with $1m prize

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Types of Learning Problems

- Supervised Learning
  Regression, Classification
- Unsupervised Learning
  Clustering
- Reinforcement Learning
  Policy learning

Supervised Learning: learn a prediction function

Learning a function f when the target is known for the training data.

Given $\{(x_i, y_i)\}\text{^}N_{\{i=1\}}$, $x_i \in \mathrm{X}, y_i \in Y$

Learn $f: X \to Y$

House price prediction [R]

Stock market prediction [R]

Categorizing (Classification).

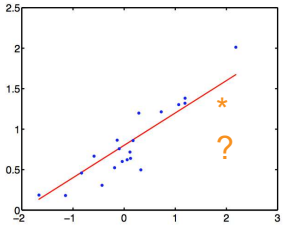
Supervised Learning (regression)

Learn to predict the price of a house (target y) given the size of the house (features x)

Assume an unknown continuous function y=f(x)

Given examples (x_i,y_i), which may be noisy

Learn f(x), to enable prediction of y* given new point x*. It should generalise well to new x*



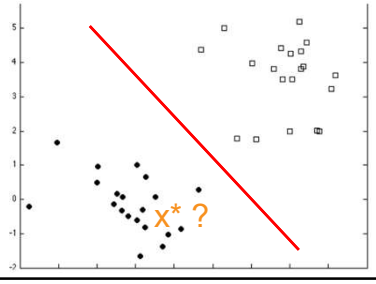
Supervised Learning (classification)

Learn to predict the whether a tumour of a given size and "sharpness" (features x) is malignant or not (target y, squares/circles)

Assume an partition of the feature space: y=f(x)

Given examples (x_i,y_i), which may be noisy

Learn f(x), to enable prediction of y* given new point x*. It should generalise well to new x*



Unsupervised Learning

Categorise these LEGO bricks into groups

Can you write an algorithm to explain how you grouped them?

No explicit target was given.

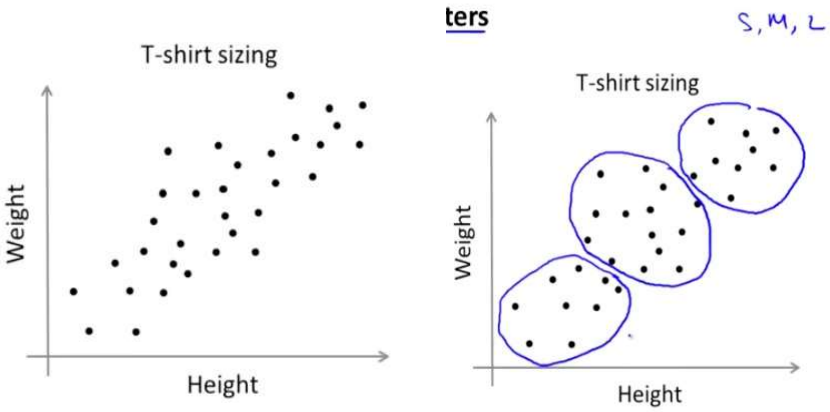
Reduce dimensions

Compress data

Visual Hierarchies

Unsupervised Learning (clustering)

Given the height and circumference (features) of the general population, group them into three (3) clusters so as to design S, M, L size T-shirts.



Reinforcement Learning

- LEGO example. Choose 2 blocks one after the other, and I'll tell you how well you've done.
- A kind of denuded supervised learning where you just have a hotter/colder signal, not the complete right answer. Its as if I give you an exam and a mark, but never the model answers. At least there is more guidance than with unsupervised learning.

Reinforcement Learning

Given the outcome (reward) of previous checkers games, learn the move (action) you should make given a checkerboard configuration (state).

Other ways for Classifying Machine Learning Methods

Parametric Methods: Learn a low dimensional set of parameters, e.g. weights in a neural network, throwing away the training data points.

Non-parametric: Keeps the training data points throughout, e.g. k-nearest neighbor methods.

Think of the whole of ML like this

Feature Engineering/Design: Pre-process the data based on domain specific/expert knowledge.

Model: Choose a machine to make the prediction using these features.

Cost Function: Write an equation that describes how well or badly your model is doing.

Minimize cost function: Write an algorithm to minimize/maximize your cost function, preferably provably so.

Generalization: Check that you have not overfitted or underfitted the data.

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Techniques

- Probability and Random Variables
- Regression (Linear, non Linear, Multivariate)
- Classification I (Linear, non Linear, regularisation)
- Classification II (Decision Trees, Naïve bayes, metrics)
- Neural Networks

- Clustering (k-means, hierarchical)
- Density Estimation (parametric distributions)
- Dimensionality reduction

- Deep Learning, convolutional NN
- Ensembles

Summary

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