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Machine Learning

Lecture. 1.

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What is Machine Learning?

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- Machine learning is concerned with the development of techniques which allow computers to "learn". More specifically, machine learning is a method for creating computer programs by the analysis of data sets.

What is Machine Learning?

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- Machine learning overlaps heavily with statistics, since both fields study the analysis of data, but unlike statistics, machine learning is concerned with the algorithmic complexity of computational implementations. Many inference problems turn out to be NP-hard, so part of machine learning research is the development of tractable approximate inference algorithms.

What is Machine Learning?

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- Machine learning has a wide spectrum of applications including search engines, medical diagnosis, detecting credit card fraud, stock market analysis, classifying DNA sequences, speech and handwriting recognition, game playing and robot locomotion to name a few.

Why do Machine Learning?

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- Many interesting CS related problems can be tackled with ML - two slides further on
- It's a whole lot of fun.... hmmmmm

Who does Machine Learning?

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- Researchers & practitioners from diverse backgrounds contributing to development of the discipline

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- Statistics - Multivariate Statistics, Bayesian Statistics, Statistical Pattern Recognition

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- Engineering - Control Theory and Adaptive methods

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- Engineering - Control Theory and Adaptive methods
- Psychology - Cognitive science and theories of learning

Problems for ML?

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- Bioinformatics

Problems for ML?

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- Bioinformatics
- Predicting the interaction of genes within an organism

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- Predicting the interaction of genes within an organism
- Inferring gene & protein network structures

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- Bioinformatics
- Predicting the interaction of genes within an organism
- Inferring gene & protein network structures
- Predicting protein function from sequence

Problems for ML?

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- Computer Vision & Graphics

Problems for ML?

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- Computer Vision & Graphics
- Image reconstruction from degraded images

Problems for ML?

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- Image reconstruction from degraded images
- Object detection and localisation

Problems for ML?

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- Computer Vision & Graphics
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- Visual tracking

Problems for ML?

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- Networked Systems Measurement & Control

Problems for ML?

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- Networked Systems Measurement & Control
- Autonomic network management systems

Problems for ML?

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- Networked Systems Measurement & Control
- Autonomic network management systems
- Detecting network level packet patterns

Problems for ML?

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- Networked Systems Measurement & Control
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- Detecting network level packet patterns
- Intrusion detection systems

Problems for ML?

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- Human Computer Interaction

Problems for ML?

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- Human Computer Interaction
- Speech recognition

Problems for ML?

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- Human Computer Interaction
- Speech recognition
- System control via auditory feedback

Problems for ML?

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- Human Computer Interaction
- Speech recognition
- System control via auditory feedback
- Gesture recognition

Problems for ML?

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- Information Retrieval

Problems for ML?

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- Information Retrieval
- New topic identification in news feeds

Problems for ML?

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- Information Retrieval
- New topic identification in news feeds
- Language Models for *ad hoc* retrieval

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- Information Retrieval
- New topic identification in news feeds
- Language Models for *ad hoc* retrieval
- Image & video retrieval

Problems for ML?

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- Software Engineering & Technology

Problems for ML?

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- Software Engineering & Technology
- Compilers that learn to optimise (Edinburgh)

Problems for ML?

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- Automatic classification of software behaviour

Problems for ML?

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- Enough I think?

Course Overview

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- Supervised Learning

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- Will focus on probabilistic learning of functions from data

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- Graphical models

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- Introduce classification methods both probabilistic & non-probabilistic
- Unsupervised Learning
- Introduce methods of density estimation, generative modeling & clustering
- Graphical models
- Numerous applications

Supervised Learning

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- Introduce flexible linear models based on Least-Squares estimation

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- Study the effect that model complexity has on generalisation ability

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- Learn flexible linear models within the probabilistic inferential framework

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- Introduce the Bayesian inferential method for flexible linear models

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- Study probabilistic methods for classification based on conditional density estimates and flexible nonlinear models, introduce approximate Bayesian methods

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- Study non-probabilistic classification methods based on maximum margin machines, Support-Vector Machines and the good old K-Nearest neighbours

Unsupervised Learning

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- Generative models, Semi-parametric density estimation, EM-algorithm

Unsupervised Learning

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- Generative models, Semi-parametric density estimation, EM-algorithm
- Non-parametric density estimation, Parzen windows, RSDE

Unsupervised Learning

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- Clustering methods - Spectral & Model based clustering (lots of fun)

Unsupervised Learning

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- Generative models, Semi-parametric density estimation, EM-algorithm
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- Clustering methods - Spectral & Model based clustering (lots of fun)
- Introduce sub-space methods such as PCA & ICA

Unsupervised Learning

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- Generative models, Semi-parametric density estimation, EM-algorithm
- Non-parametric density estimation, Parzen windows, RSDE
- Clustering methods - Spectral & Model based clustering (lots of fun)
- Introduce sub-space methods such as PCA & ICA
- Brief introduction to Graphical Models & applications

Focus of Course

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- Students not encouraged to blindly adopt off-the-shelf *Machine Learning Packages* for applications

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- Focus on basic principles underlying many Machine Learning methods

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- Students capable of making intelligent decisions about what methods (if any) would be appropriate for specific problems

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- Understanding of core issues associated with particular problems

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- Focus on basic principles underlying many Machine Learning methods
- Students capable of making intelligent decisions about what methods (if any) would be appropriate for specific problems
- Understanding of core issues associated with particular problems
- Possibly develop own methods for specific applications

Structure of Course

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- Two lectures each week, lecture notes posted on course website

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- Laboratory & Tutorial session on Friday afternoon

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- Matlab environment being used - rapid implementation of methods and algorithms - many requiring a couple of lines of code - allows students to focus on study of issues surrounding performance of ML methods - rather than implementation issues

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- Matlab environment being used - rapid implementation of methods and algorithms - many requiring a couple of lines of code - allows students to focus on study of issues surrounding performance of ML methods - rather than implementation issues
- Students strongly advised to attend all lectures & laboratories and to keep up with material as delivered

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- Module Website

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- http://www.dcs.gla.ac.uk/ giro-lami/Machine_Learning_Module_2006/index.htm

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- Lecture notes, Laboratory sheets, Tutorial sheets, snippets of Matlab for each lecture session

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- Links to some useful resources for the module

Assessment

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- Practical Assignment 20% total marks

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- Assignment issued Monday 30th January, to be handed NO LATER THAN Friday 17th March

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- Enjoy.....