Machine Learning, Machine Learning (extended)

1 – Introduction

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Outline

- What is machine learning?
- Applications
- Aims
- Learning outcomes
- Assessment
- Relevant texts
- Plagiarism
- Basics of machine learning
- What is the learning problem?
- Classes of learning
- Common terminology

What is machine learning?

- Algorithms (i.e. computational methods) that enable computers to learn from examples

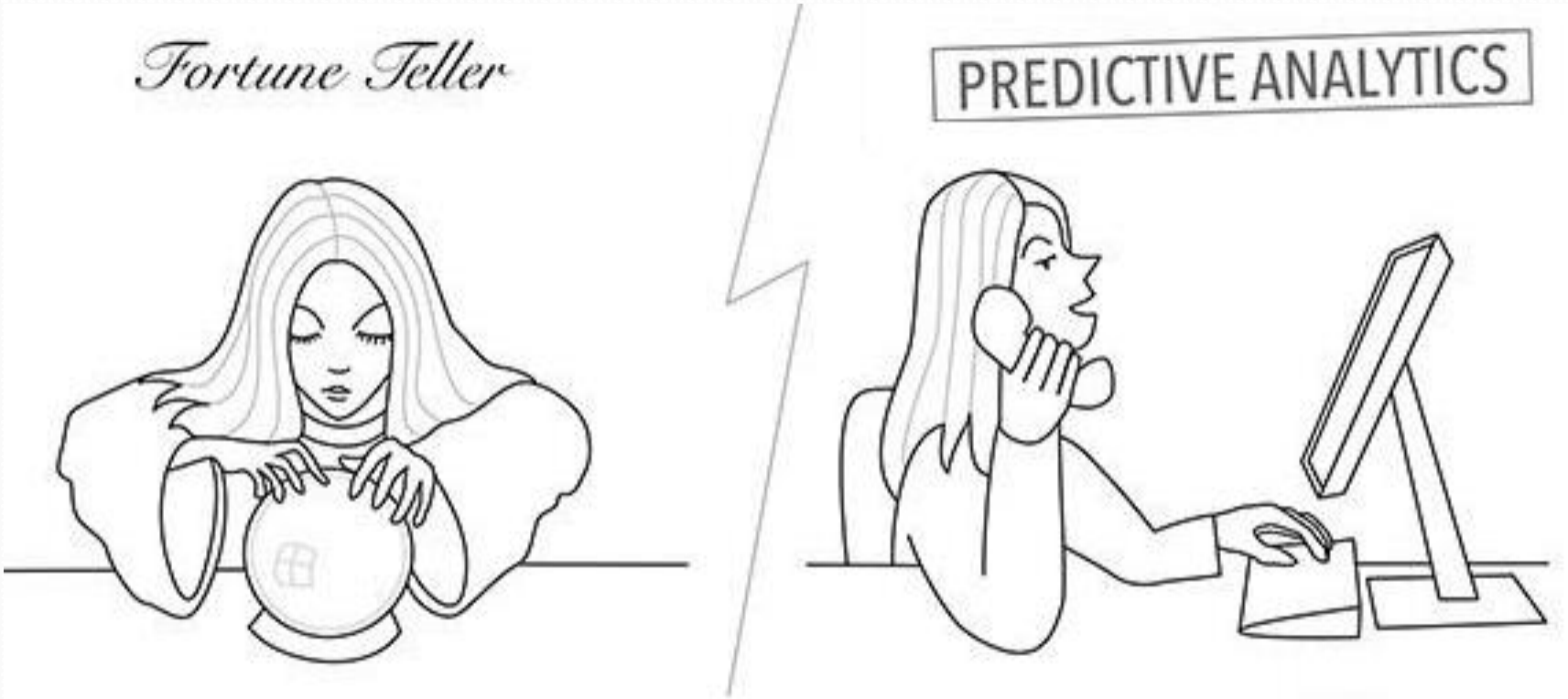
- Algorithms learn from example observations of objects
  - Speech?
  - Image?
  - Health symptoms?
  - Stock prices?
  - Personal choices?
  - Gene characteristics?

What is machine learning?

Given example observations of objects:

- Can we find similar objects?
- Can we make predictions about objects?
- Can we learn something about the objects?
- Can we group the objects?

What is machine learning?



"Why the change? Well, I could see where the future was going..."

Machine learning

- Myriad of algorithms
- Hard to use
  - Often the algorithm parameters need to be tuned
- Important to understand them
- We will discuss a very small selection of algorithms..
  - ..but covering variety

Applications

- Speech recognition
- Computer vision
- Robot control
- Text or document classification (spam)
- Language translation
- Natural language processing
- Recommender systems
- Personal software assistant
- Image understanding
- Disease diagnosis
- Driverless cars (autonomous vehicles)
- Game playing (e.g. chess, go, backgammon)

……

ML in industry

- Companies with lots of data for which traditional models don't exist:
  - Google (in almost everything)
  - Microsoft (e.g. personal assistant)
  - Amazon (e.g. recommendation system)
  - Facebook (e.g. friends suggestion, face tagging)
  - Uber (e.g. driverless navigation)

Aims

1. Introduce the basic concepts and terminology of machine learning
2. Give an overview of the main approaches to machine learning
3. Show similarities and differences between different approaches
4. Present basic principles for the classification of approaches to machine learning
5. Give practical experience of applying machine learning algorithms to classification and data analysis problems
6. (ML extended only) Develop skills of literature surveying and critical thinking in an area of machine learning

Learning outcomes

On successful completion, the student should be able to:

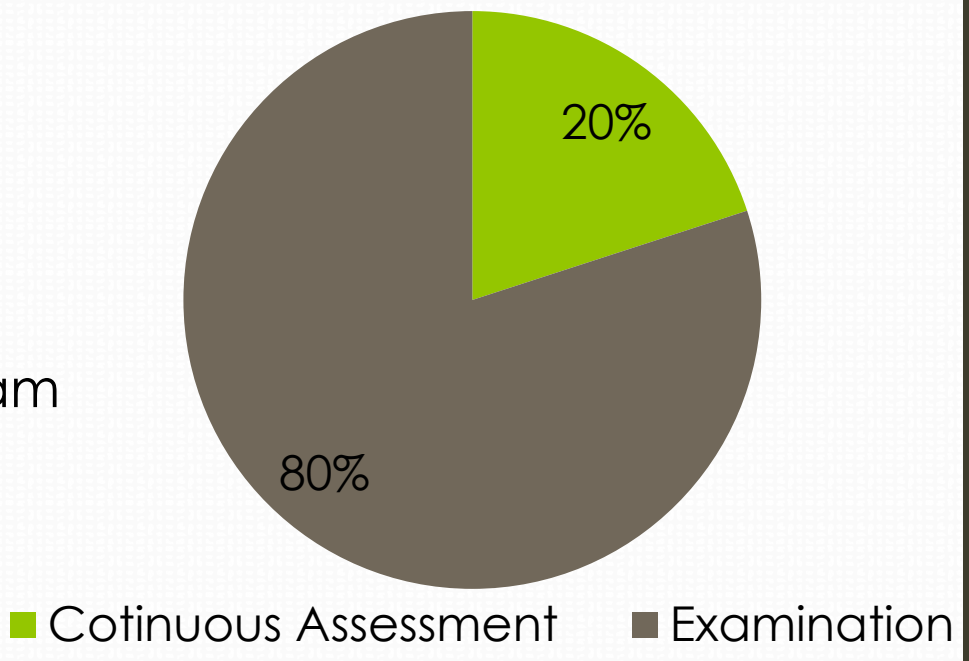
1. Demonstrate a knowledge and understanding of the main approaches to machine learning
2. Demonstrate the ability to apply the main approaches to unseen examples
3. Demonstrate an understanding of the differences, advantages and problems of the main approaches in machine learning
4. Demonstrate an understanding of the main limitations of current approaches to machine learning, and be able to discuss possible extensions to overcome these limitations
5. Demonstrate a practical understanding of the use of machine learning algorithms
6. (ML extended only) Survey and discuss the research literature in one subfield of machine learning

Module focus

- Understanding the fundamental principles
  - Common algorithms
  - Common pitfalls
  - Common practical sense (for ML)
  - Categories of algorithms
- NOT a module on ML software packages

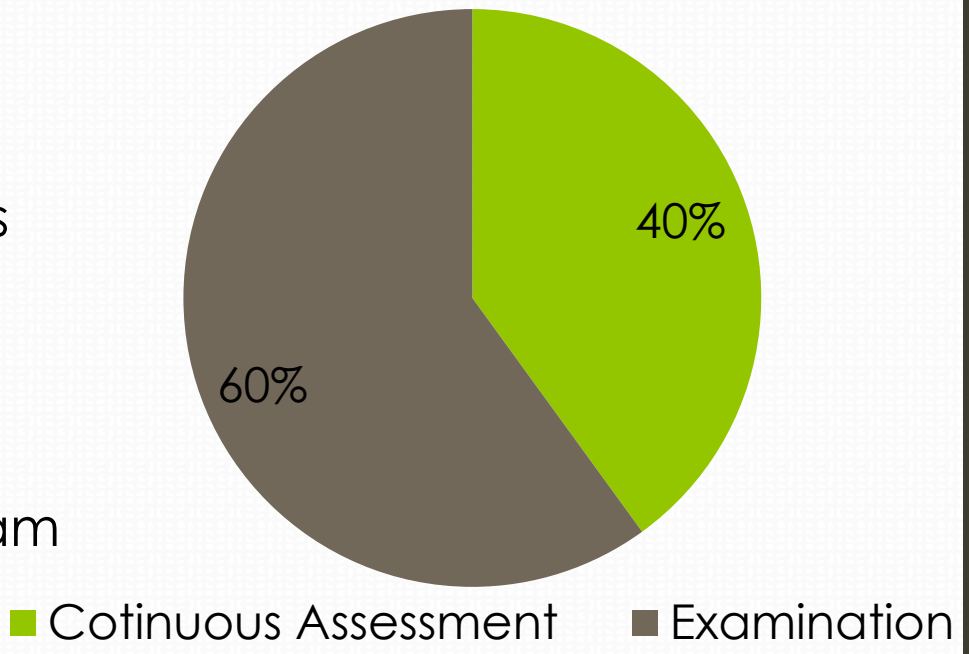
Assessment: machine learning

- Continuous assessment (20%)
  - Class test (15%)
  - Home test (5%)
- Examination (80%)
  - 90 minutes written exam
  - Closed-book and closed-notes exam



Assessment: machine learning (extended)

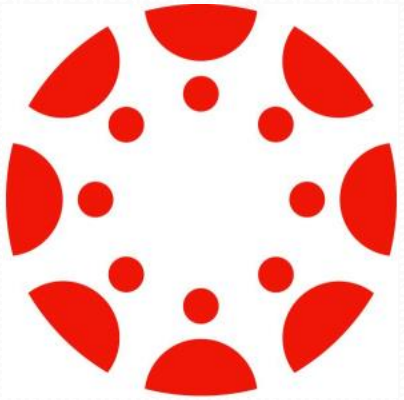
- Continuous assessment (40%)
  - Class test (15%)
  - Home test (5%)
  - Computer based tests (20%)
- Examination (60%)
  - 90 minutes written exam
  - Closed-book and closed-notes exam



Assessment schedule (tentative)

Week	Test (ML)	Test (ML extended) + including Test (ML)
1		
2		Computer based test 1 given
3		
4		Computer based test 1 due
5	Home test given	Computer based test 2 given
6		
7		Computer based test 2 due
8	Home test due	Computer based test 3 given
9	Class test due	
10		Computer based test 3 due
11		

Module website

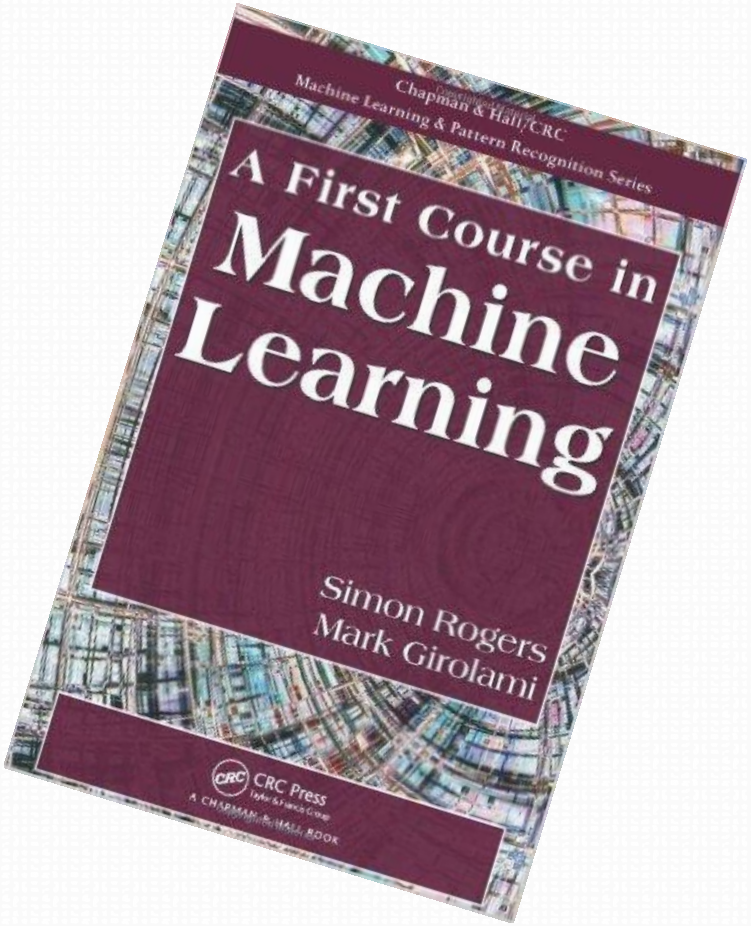


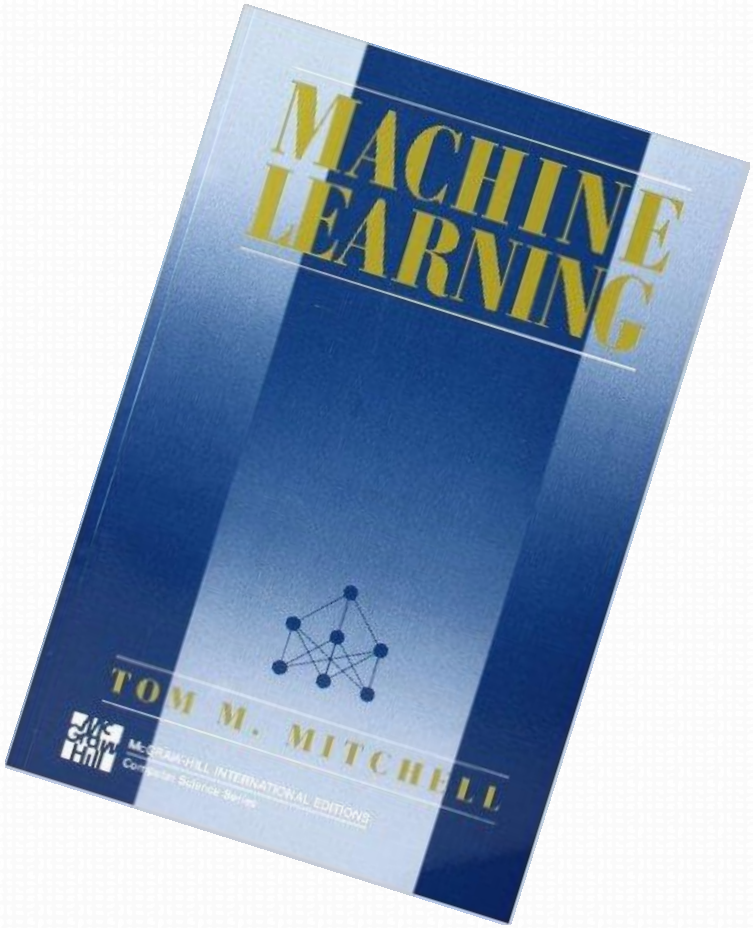
- Module Canvas page
  - https://canvas.bham.ac.uk/courses/21807
- Lecture slides will be uploaded weekly
- Announcements/discussions
- Home exercise submission
- Computer based test submission (ML extended only)

Office hours

- Tuesday 9.30am-11am
- Location: LG06d (lower ground floor)

Relevant texts





Plagiarism

- https://intranet.birmingham.ac.uk/as/studentservices/conduct/plagiarism/index.aspx
- https://intranet.birmingham.ac.uk/as/studentservices/conduct/plagiarism/guidance-students.aspx
- http://www.birmingham.ac.uk/Documents/university/legal/plagiarism.pdf

Pre-requisites

- Mathematical techniques for computer science (or equivalent)
- Introduction to AI (or equivalent)
- Math refresher material is available on Canvas
  - Linear algebra
  - Probability theory

Math refreshers

- Linear Algebra
  - Canvas (https://canvas.bham.ac.uk/files/3224546/download?download_frd=1)
  - A First Course in Machine Learning (section 1.3)
- Probability theory
  - Canvas (https://canvas.bham.ac.uk/files/3224547/download?download_frd=1)
  - A First Course in Machine Learning (sections 2.2 to 2.6)

MATLAB Tutorials

- MATLAB basics (vectors, matrices, loops, plotting, etc)
  - http://www.cyclismo.org/tutorial/matlab/
  - http://users.rowan.edu/~shreek/networks1/matlabintro.html
- MATLAB primer (by Mathworks)
  - http://au.mathworks.com/help/pdf_doc/matlab/getstart.pdf

Basics of machine learning

What is the learning problem?

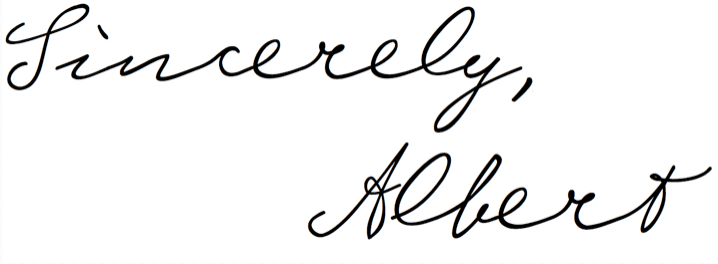
- Ability to improve *performance* (or to make accurate predictions) through *experience* to perform a *task*
  - Improve at task T, with respect to performance measure P, based on experience E
- Task?
- Performance measure?
- Experience?

What is the learning problem?

- Learning to play checkers
- Task T?
- Performance measure P?
- Experience E?

What is the learning problem?

- Learning to recognize handwritten words
- Task T?



- Performance measure P?
- Experience E?

What is the learning problem?

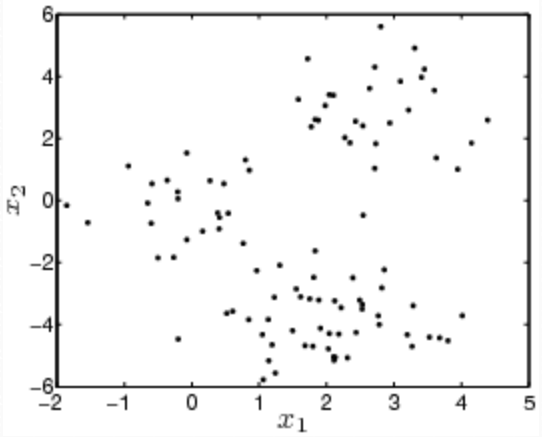
- Learning to recognize faces
- Task T?
- Performance measure P?
- Experience E?

What is the learning problem?

- Learning to drive autonomously
- Task T?
- Performance measure P?
- Experience E?

What is the learning problem?

- Learning to find clusters in data
- Task T?
- Performance measure P?
- Experience E?



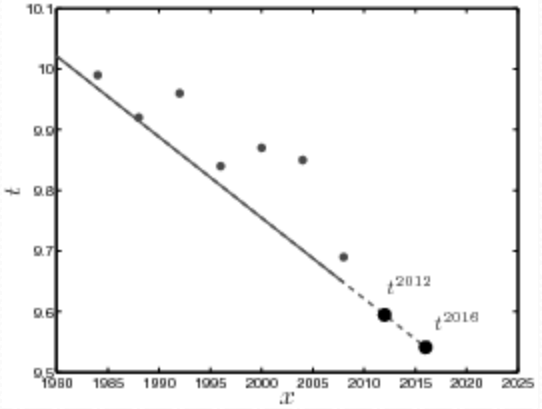
What is the learning problem?

- Learning to interpret image scene
- Task T?

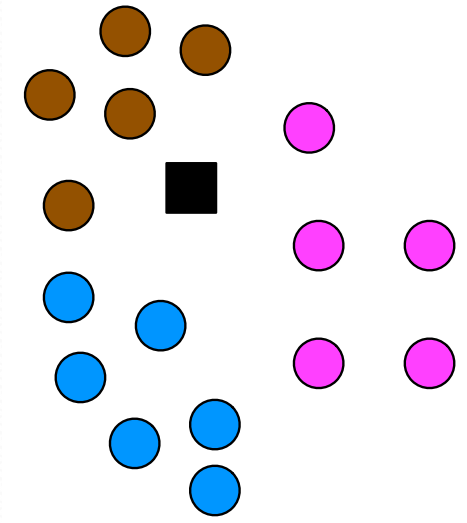
- Performance measure P?
- Experience E?

Classes of learning

- Regression: learning a continuous function from a set of past examples
  - Predict a real value target for a future example
  - e.g. predict winning time in Olympic race

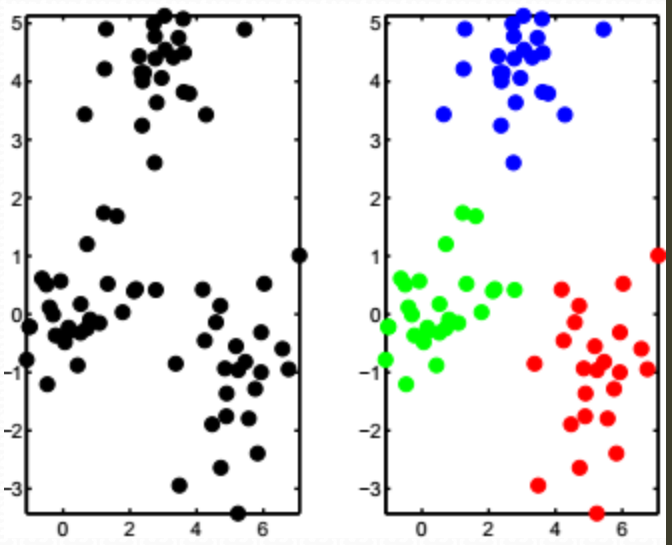


- Classification: Learning a function that can separate past examples of different types from one another
  - Assign a discrete target label/type for a future example
  - e.g. document classification

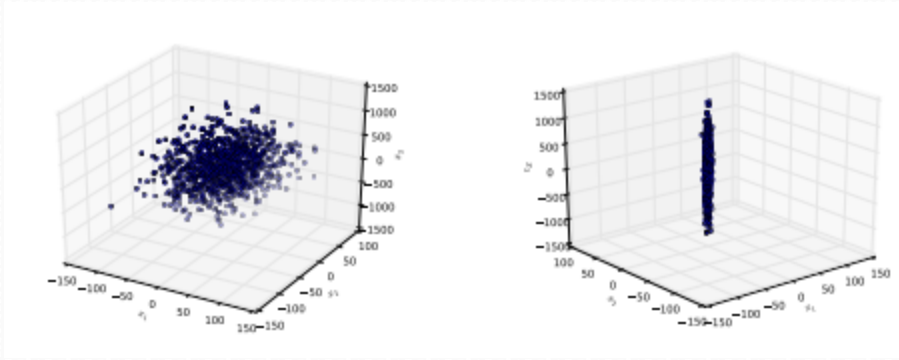


Classes of learning

- Clustering: partition examples into groups, each group having similar examples
  - e.g. brain regions with similar activation



- Dimensionality reduction: transform high-dimensional data into a lower-dimensional preserving representation
  - e.g. reducing unnecessary attributes



Training experience

- Direct or indirect feedback may be available
  - Chess game move
  - Digit recognition
  - Face recognition
- With or without a teacher
  - Examples (i.e. experience) with or without target labels
- Is the training experience representative of the performance goal?
  - How well the training examples distribution represent the true examples distribution?

Forms of machine learning

- *Supervised learning*: learner receives set of labelled examples (i.e. direct feedback) in order to learn to classify unseen examples
  - Classification, regression
- *Unsupervised learning*: learner receives set of unlabelled examples (i.e. no teacher) in order to learn to categorize unseen examples
  - Clustering
- *Dimensionality reduction*: transform high-dimensional data into a lower-dimensional preserving representation

Forms of machine learning

- *Semi-supervised learning*: learner receives set of labelled and unlabelled examples to learn predict unseen examples

- *Reinforcement learning*: learner actively interacts with the environment and receives a short-term reward for each action. The objective is to maximize long-term reward over a course of actions and iterations.

ML research questions

- How much training data is sufficient?
- What algorithms exist for learning general target functions from specific training examples?
- Can we transfer what is learned from one task to improve learning in other related tasks?
- What is the relationship between different learning algorithms, and which should be used when?

ML research questions

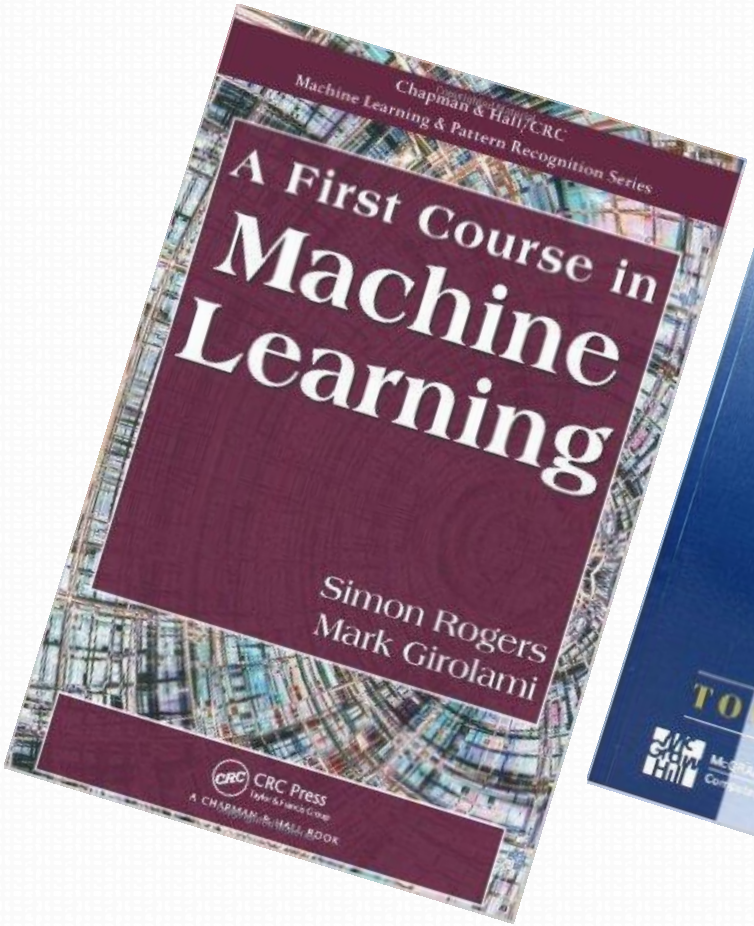
- Can we build never ending learners?
- Can machine learning theories and algorithms help explain human learning?
- Can we design programming language containing machine learning primitives?

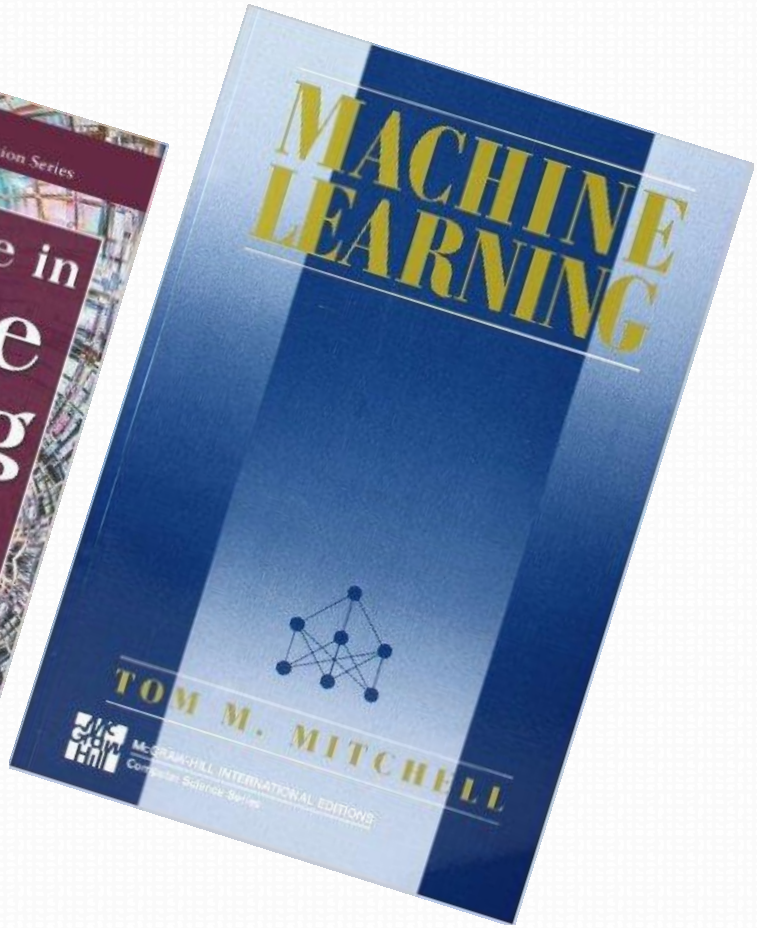
Common terminology

- Examples: items of data used for learning or evaluation
- Features: attributes associated to an example
- Labels: values or categories assigned to examples
- Performance: measure of prediction accuracy of an algorithm
- Task: a prediction activity that the algorithm needs to learn
- Experience: past examples which can be used in learning
- Training: learning to predict from examples
- Testing: predicting previously unseen examples

Common terminology

- Cross validation: distribute data into k-folds to train and evaluate algorithm performance
- Training samples: examples used to train algorithm
- Validation samples: examples used to tune algorithm parameters
- Test samples: examples used to evaluate algorithm
- Loss function: performance (loss) measure function
- Learner function/model: a function or model that is learnt to predict labels from features
- Hypothesis set: set of functions mapping features to labels





Author's material (Simon Rogers)

- Ata Kaban's material from previous years

Thank You