Inf2b Learning and Data
Lecture 1: Introduction to Learning and Data

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http://www.inf.ed.ac.uk/teaching/courses/inf2b/
https://piazza.com/ed.ac.uk/spring2019/infr08009inf2blearning
Office hours: Wednesdays at 14:00-15:00 in IF-3.04

Jan-Mar 2019
Welcome to Inf2b!

Inf2b: Algorithms, Data Structures (ADS), and Learning

Today’s Schedule:

1. Course structure
2. What is (machine) learning? (and why should you care?)
3. Administrative stuff
   - How to do well
4. Setting up a learning problem (time allowing)
Course structure

http://www.inf.ed.ac.uk/teaching/courses/inf2b/

Equal split into two threads:

- **Algorithms and Data Structures** – **KK** (Kyriakos Kalorkoti)
  Design and analysis of correct, efficient and elegant data structures and algorithms.

- **Learning** – **Hiroshi**
  Building models that describe a data set and can make predictions about new data

Constituents:

- 30 lectures (including review) - Tuesdays, Thursdays, Fridays
- Tutorials (starting in week 2)
- Drop-in labs for Learning (Mon, Tue 11:10-13:00)
- 2 assessed assignments (with drop-in labs)
  
  **CW1 (ADS):** 07/Feb. – 25/Feb. (Part 1), 08/Mar. (Part 2)
  **CW2 (Learning):** 12/Mar. – 05/Apr.
Drop-in labs for Learning

- Mondays and Tuesdays 11:10-13:00 in AT-6.06
  Starting in Week 2. Both sessions are the same.
- Worksheets available from the course webpage
- Purposes of lab sessions
  - Assistance in understanding basic algorithms and techniques of machine learning and data analysis
  - Assistance in programming with Matlab
  - Assistance in working on the 2nd assignment (CW2)
- Practice on machine learning using Matlab
  - Work on toy problems for the topics taught in the course
- Demonstrator: Ioannis Chalkiadakis (Mondays), Caesar Zhang (Tuesdays)
Face detection

How would you detect a face?

How does album software tag your friends?

(R. Vaillant, C. Monrocq and Y. LeCun, 1994)

http://demo.pittpatt.com/
Viola–Jones Face detection (2001)

- Face detector consists of linear combination of 'weak' classifiers that utilise five types of primitive features.
- The detector is trained on a training data set of a large number of positive and negative samples.
- Scan the input image with a sub-window (24 x 24 pixels) to detect a face.

Taken from: https://ahprojects.com/cvdazzle/
A nice demo: http://vimeo.com/12774628
Hiding from the machines (cameras)

The Viola-Jones face detector is fast, but has some drawbacks.

Taken from: https://ahprojects.com/cvdazzle/
Applications of machine learning

Within informatics:

- **Vision**: as we’ve seen. (eg1, eg2)
- **Graphics**: increasingly data driven
- **AI & Natural Language Processing (NLP)**: text search/summarisation, speech recognition/synthesis, e.g. IBM Watson
- **Robotics**: vision, planning, control, . . .
- **Compilers**: learning how to optimise and beyond: data analysis across the sciences

Every day:

- Adverts / recommendations all over the web ··· Big Data
- Speech recognition and synthesis (e.g. Siri, Echo), Machine Translation, . . . with self-driving cars
Fit numbers in a program to data (i.e. train machines on data)
More robust than hand-fitted rules
Can’t approach humans at some tasks (e.g., vision)
Machines make better predictions in many other cases
Private study

- ~2 hours private study per lecture *in addition to tutorials & assignments*
- No required textbook for Inf2b. There are notes and slides. See those for recommended books.
- Importance of maths skills (especially algebra). Why should you remember and get familiar with maths formulas for machine learning?
  - Good understanding of the ideas
  - Guessing reasonable output of the model
  - Identifying/spotting the problems (bugs) with the system implemented
- Importance of programming practice [with Matlab or Python] (attend the drop-in labs!)
Warning: Inf2b is NOT an easy course

Inf2b requires a solid maths background:
- Linear Algebra
- Calculus
- Probability

Independent learning (self-directed learning) is essential.
See the following page regarding differences between secondary-school and university in terms of learning style and what is expected from you as a student.

https://www.birmingham.ac.uk/accessibility/transcripts/school-uni-differences.aspx

For exam preparation, use not only notes, but also slides and tutorial sheets. NB: slides are not just the summaries of notes.
Useful webpage to check your maths:
http://www.mathsisfun.com/algebra

- Laws of exponents (Exponent rules)
  e.g. \( x^m x^n = x^{m+n} \), \((x^m)^n = x^{mn}\)

- Log and exponential
  e.g. \( \log(x^n y^m) = n \log x + m \log y \), \( e^{\ln x} = x \)

- Quadratic equations and their solutions
  e.g. \( ax^2 + bx + c = 0 \), \( x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \)

- Vectors \( \mathbf{v} = (v_1, v_2, \ldots, v_D)^T \)
  - Notation: column/row vectors, transpose
  - Addition and subtraction eg. \( \mathbf{u} + \mathbf{v} \)
  - Dot product (inner product) \( \mathbf{u} \cdot \mathbf{v} = \mathbf{u}^T \mathbf{v} \)

- Equation of a straight line, linear equations
Matrices

\[ A = (a_{ij}), \quad A_{ij} = a_{ij} \]

- Addition, subtraction \( A + B, \ A - B \)
- Multiplication \( (AB)_{ij} = \sum_{k=1}^{d} a_{ik} b_{kj} \)
- Transpose \( (ABC)^T = C^T B^T A^T \)

Determinant \( |A| \)

Inverse \( A^{-1}A = AA^{-1} = I \)

Eigenvalues and eigenvectors

Vector spaces, subspaces, linear independence, basis and dimension, rank and nullity

Linear transformations \( y = Ax \)

NB: See Section 4 of Learning Note No. 1 for the notation we use.
Two hours study this week?

- **Start to familiarise yourself with** MATLAB (or OCTAVE)
  Introductory worksheet on the course website
  Many others at the end of a web search

- **Learn Matlab** try the lab sheets for the 1st lab this week.

- **Love Python?** Learn NumPy+SciPy+Matplotlib
  (instead, or as well)

- **Vital skills:**
  - add, average, multiply vectors and matrices
  - plot data stored in vectors
  - save/read data to/from files
Have a look at the lecture note and slides in advance to the lecture.

Have questions prepared to ask.

Laptops, tablets, phones are not allowed to use during lectures unless permitted.

NB: lectures will be recorded, and videos will be published in a few days after the lecture.
Classification of oranges and lemons
A two-dimensional space

Represent each sample as a point \((w, h)\) in a 2D space
Pixel image to a feature vector

Turn each cell (pixel) into a number (somehow, see notes)
Unravel into a column vector, a feature vector
⇒ represented digit as point in 64D

\[ x = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_{64} \end{pmatrix} \]

\[ x_i \in \{0, \ldots, 127\} \text{ or } x_i \in \{0, 1\} \]

http://alex.seewald.at/digits/
Image data as a point in a vector space

\[ \mathbf{x} = (2, 6, 5)^T \]
Euclidean distance

Distance between 2D vectors: \( u = (u_1, u_2)^T \) and \( v = (v_1, v_2)^T \)

\[
r_2(u, v) = \sqrt{(u_1 - v_1)^2 + (u_2 - v_2)^2}
\]

Distance between \( D \)-dimensional vectors: \( u = (u_1, \ldots, u_D)^T \) and \( v = (v_1, \ldots, v_D)^T \)

\[
r_2(u, v) = \sqrt{\sum_{k=1}^{D} (u_k - v_k)^2}
\]

Measures similarities between feature vectors
i.e., similarities between digits, movies, sounds, galaxies, \ldots
Question

Have high-resolution scans of digits.

How many pixels should be sample?

What are pros and cons of:

$2 \times 2$, $4 \times 4$, $16 \times 16$, or $100 \times 100$?
Example of image resolutions

Accountability
Exercises in the lecture note 1

- Try the exercises in the lecture note 1.
- No solutions will be published.
- In case you’re not sure if your answers are correct.
  - Discuss them with your classmates
  - Use the Inf2b-Learning discussion board on Piazza
Summary

- Self-study both ADS and Learning everyday.

- Drop-in labs for Learning starts in Week 2 (21st, 22nd Jan at 11:10)
  Try the worksheet before the lab.

- Tutorial starts in Week 2.

- Discussion forum for “Learning” in Piazza

- Office hours: Wednesdays at 14:00-15:00 (TBC) in IF-3.04