Welcome to Inf2b - 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/](http://www.inf.ed.ac.uk/teaching/courses/inf2b/)
- 15+1 lectures (including review) - Tuesdays, Fridays
- Tutorials (starting in week 4)
- Drop-in labs for Learning (Tuesdays 11:10-13:00, Wednesdays 13:10-15:00)
- 1 assessed assignment (with drop-in labs)
  - CW1: 06/Mar. – 03/Apr.

Inf2b - Learning

Lecture 1: Introduction to Learning and Data

Hiroshi Shimodaira

(Credit: Iain Murray and Steve Renals)

Centre for Speech Technology Research (CSTR)
School of Informatics
University of Edinburgh

http://www.inf.ed.ac.uk/teaching/courses/inf2b/
http://piazza.com/ed.ac.uk/spring2020/inf2b08028
Office hours: Wednesdays at 14:00-15:00 in IF-3.04

Jan-Mar 2020

Drop-in labs for Learning

- Tuesdays 11:10-13:00, Wednesdays 13:10-15:00 in AT-6.06

Starting in Week 2. Both session 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 assignment (CW1)
- Practice on machine learning using Matlab
- Work on toy problems for the topics taught in the course
- Demonstrator: Teodora Georgescu (Tuesdays), Riccardo Fiorista (Wednesdays)

Face detection

How would you detect a face?

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

http://demo.pittpatt.com/

How does album software tag your friends?

Taken from: [https://ahprojects.com/cvdazzle/](https://ahprojects.com/cvdazzle/)

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/](https://ahprojects.com/cvdazzle/)

A nice demo: [http://vimeo.com/12774628](http://vimeo.com/12774628)

Intro summary

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

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
- Discounts in Tescos [http://www.mightbe.co.uk/discovery/big-data-woo.html](http://www.mightbe.co.uk/discovery/big-data-woo.html)
- Speech recognition and synthesis (e.g. Siri, Echo), Machine Translation, … with self-driving cars

Applications of machine learning

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Hiding from the machines (cameras)

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

Taken from: [https://ahprojects.com/cvdazzle/](https://ahprojects.com/cvdazzle/)
### Maths skills

Useful webpage to check your maths:

http://www.mathsisfun.com/algebra

- **Laws of exponents** (Exponent rules)
  - $x^m x^n = x^{m+n}$
  - $(x^m)^n = x^{mn}$

- **Log and exponential**
  - $e^{\log x} = x$, $e^{ln x} = x$

- **Quadratic equations and their solutions**
  - $ax^2 + bx + c = 0$, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

- **Vectors** $v = (v_1, v_2, \ldots, v_n)^T$
  - Notation: column/row vectors, transpose
  - Addition and subtraction: $u + v$
  - Dot product (inner product): $u \cdot v = u^T v$

- **Equation of a straight line, linear equations**

### 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

### Classroom

- **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.

### Maths skills (cont.)

- **Matrices** $A = (a_{ij})$, $A^T = (a_{ji})$
  - 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: $A^{-1} A = A A^{-1} = I$
  - 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.

### 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!)

### 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**

\[ x = (x_1, x_2, \ldots, x_{64})^T \]  

or \( x_i \in \{0, \ldots, 127\} \) or \( x_i \in \{0, 1\} \)

http://alex.seewald.at/digits/

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**Image data as a point in a vector space**

- **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, . . .

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**Question**

Have high-resolution scans of digits.

How many pixels should be sample?

What are pros and cons of:

- 2 × 2, 4 × 4, 16 × 16, or 100 × 100?

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**Example of image resolutions**

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**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

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**Summary**

- Self-study everyday.
- Drop-in labs for Learning starts in Week 2 (21st, 22nd Jan.)
  - Try the worksheet before the lab.
- Tutorial starts in Week 4.
- Discussion forum in Piazza
- Office hours: Wednesdays at 14:00-15:00 (TBC) in IF-3.04