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/
https://piazza.com/ed.ac.uk/spring2020/infr08028
Office hours: Wednesdays at 14:00-15:00 in IF-3.04

Jan-Mar 2020

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/

- 15+1 lectures (including review) - Tuesdays, Fridays
- Tutorials (starting in week 4)
- Drop-in labs for Learning (Tue 11:10-13:00, Wed 13:10-15:00)
- 1 assessed assignment (with drop-in labs)
  CW1 : 06/Mar. – 03/Apr.

Drop-in labs for Learning

- Tuesdays 11:10-13:00, Wednesdays 13:10-15:00 in AT-6.06 Starting in Week 2. Both sessoins 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 (Tuedays), Riccardo Fiorista (Wednesdays)

Face detection

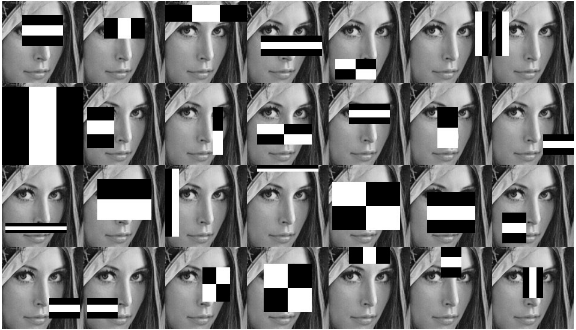
How would you detect a face?

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

How does album software tag your friends?

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

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

Attendance monitoring

- Attendance monitoring with Top Hat
  - Informatics 2B - Learning
  - Join code: **322890**

Private study

- $\sim$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!)

Private study *(cont.)*

- 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.

Maths skills

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

Maths skills (cont.)

- Matrices $A = (a_{ij})\,,\ A_{ij} = a_{ij}$
  - 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 $\mathbf{y} = A\mathbf{x}$

NB: See Section 4 of Learning Note No. 1 for the notation we use.

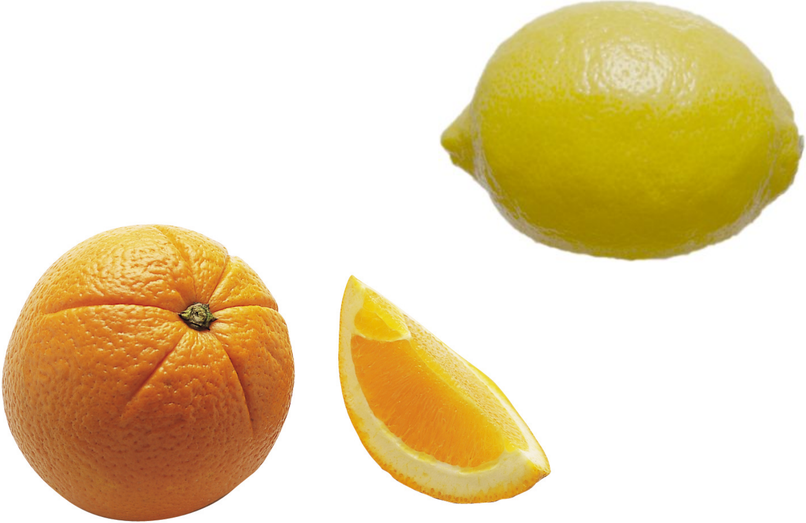
Two hours study this week?

- **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

Classroom

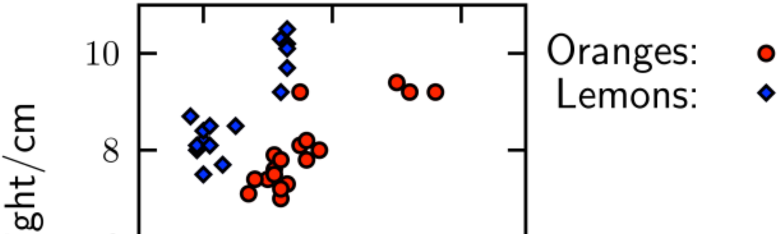
- Have a look at the lecture note and slides in advance to the lecture.
- Have questions prepared to ask.

Classification of oranges and lemons



A two-dimensional space

Represent each sample as a point (w, h) in a 2D space



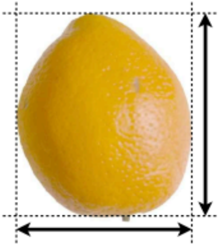
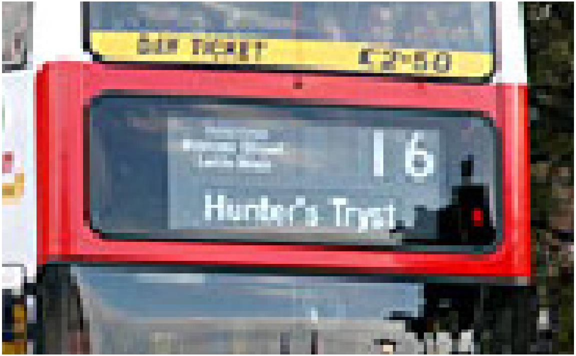
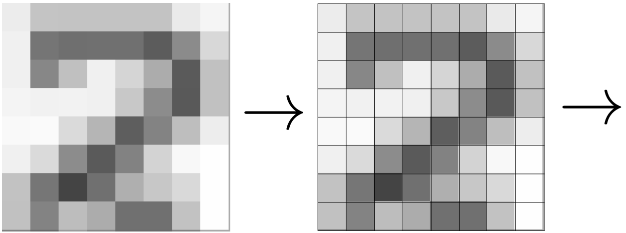


Photo image – pixels



Pixel image to a feature vector



$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_{64} \end{pmatrix}$$

Turn each cell (pixel) into a number (somehow, see notes)

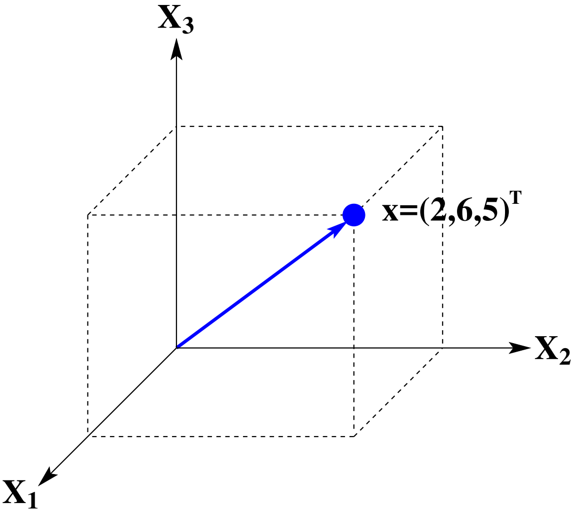
Unravel into a column vector, a **feature vector**

$\Rightarrow$ represented digit as point in $64D$

$$\mathbf{x} = (x_1, x_2, \ldots, x_{64})^T, \quad x_i \in \{0, \ldots, 127\} \text{ or } x_i \in \{0, 1\}$$

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

Image data as a point in a vector space



Euclidean distance

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

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

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

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

Measures similarities between feature vectors

i.e., similarities between digits, movies, sounds, galaxies, ...

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?

Example of image resolutions

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 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