Introduction & Linear Regression

CS4061 / CS5014 Machine Learning

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Based on previous material by
Simon Rogers & Ke Yuan

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- **Data Science** ...but it is *used* by data scientists
- **Statistics** ...but it uses lots of related maths

Machine learning *is*...

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- no human engineering of rules
- machine analyses data, discovers patterns, makes deductions

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- Can we make **predictions** about objects?
  - *e.g.* predict one attribute given others
  - *e.g.* predict future given past
- Can we **group** the objects?

Algorithms

- Machine Learning can be thought of as an ever-growing set of algorithms
- Important to understand how they work!

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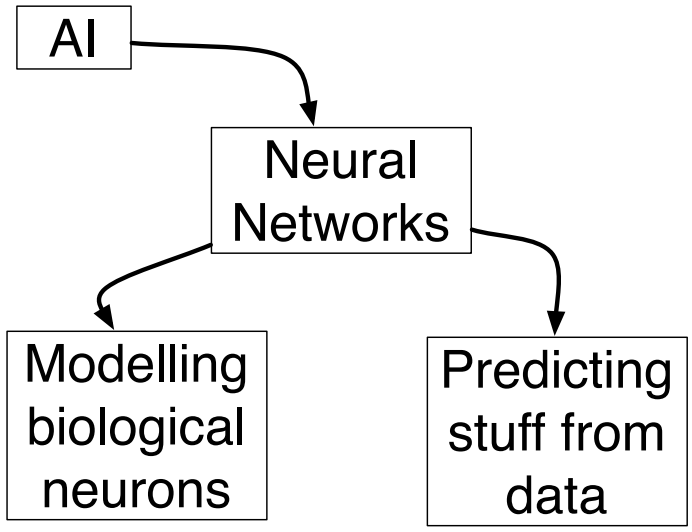

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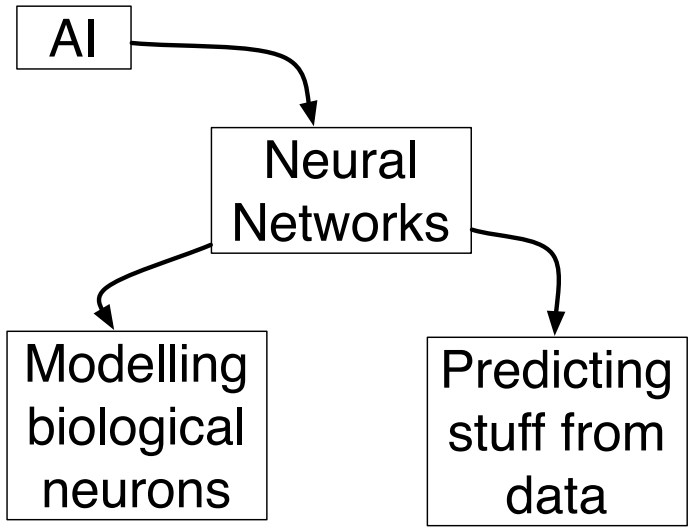


- **1990-2010**: SVMs, Bayesian methods, random forests
- **2012-now**: deep neural networks

Self-driving cars

include video in pptx from
https://blogs.nvidia.com/wp-content/uploads/2019/10/Panoptic-Segmentation_Video-Trimmed.mp4; credit nvidia

- ML is used by Tesla, Waymo, etc. for perception
- convert raw sensor data to actionable information

Recommender systems

- ML is used by Amazon, Spotify, etc. for recommendations
- can't write down a traditional equation that describes what I like
- ...but we can look for **patterns** in what I (and others) buy

Autocorrect

- ML is used by Google, Microsoft, Apple, etc. for autocorrect
- dictionary + similarity rule = brittle
- better: learn what people type, and what they correct it to

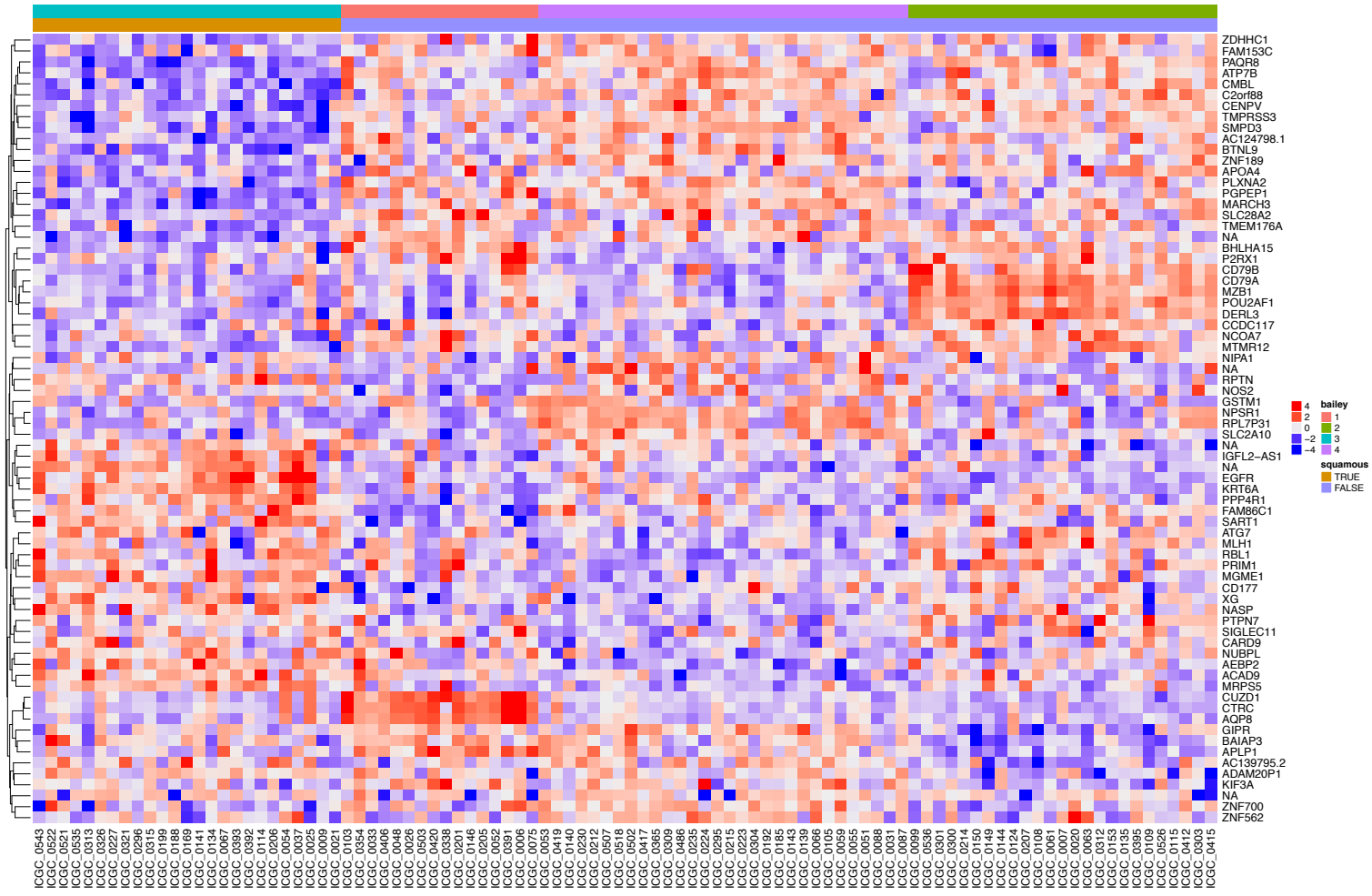
Some examples within SoCS

Information retrieval

- Search
- Topic identification in news feeds
- Language Models for prediction and retreival
- Image & video retrieval and annotation

Some examples within SoCS

Bioinformatics



Some examples within SoCS

3D from a single image

include pmh birds animation here

Some examples within SoCS

Robotic grasping of cloth

include
https://ieeexplore.ieee.org/mediastore_new/IEEE/content/media/7083369/9750005/9808118/duan4-3186747-large.gif

We'll cover...

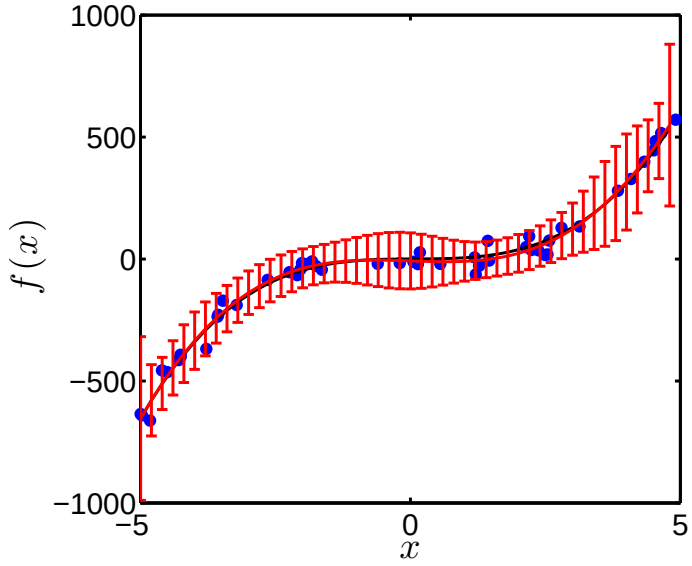
Supervised Learning

Unsupervised Learning

Supervised Learning

Regression

Learning a continuous function from a set of examples.



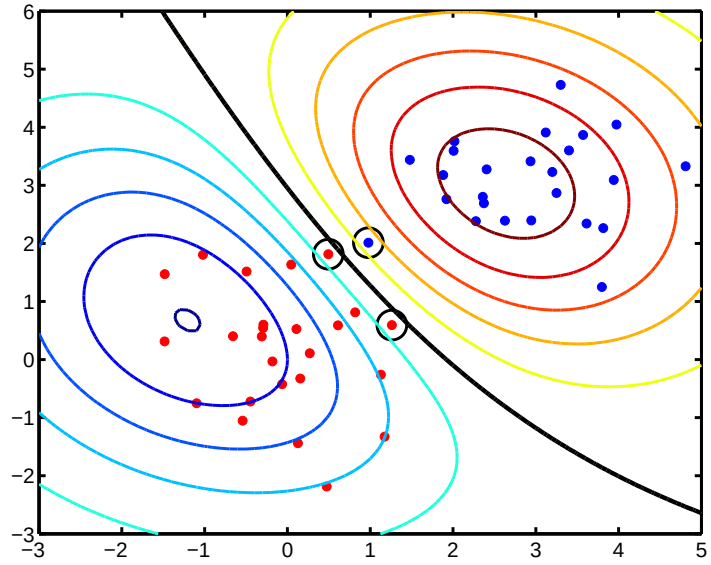
Example

Predicting stock prices (x might be time or some other variable of interest)

Supervised Learning

Classification

Learning a rule that can separate objects of different types from one another.



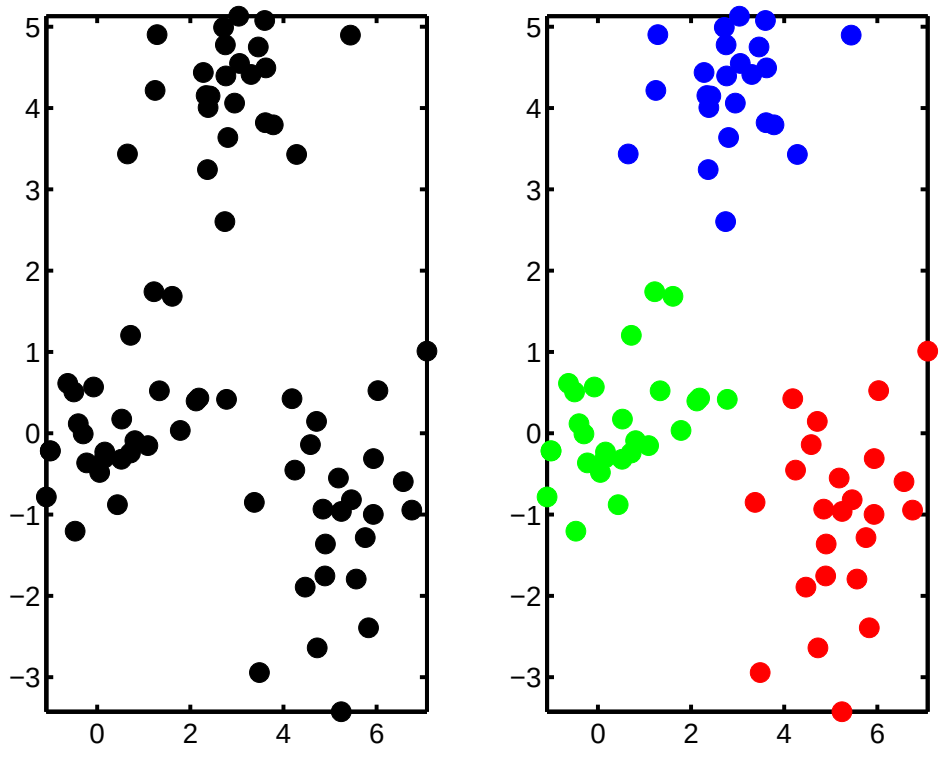
Examples

Disease diagnosis, spam email detection, detecting cats in photos

Unsupervised Learning

Clustering

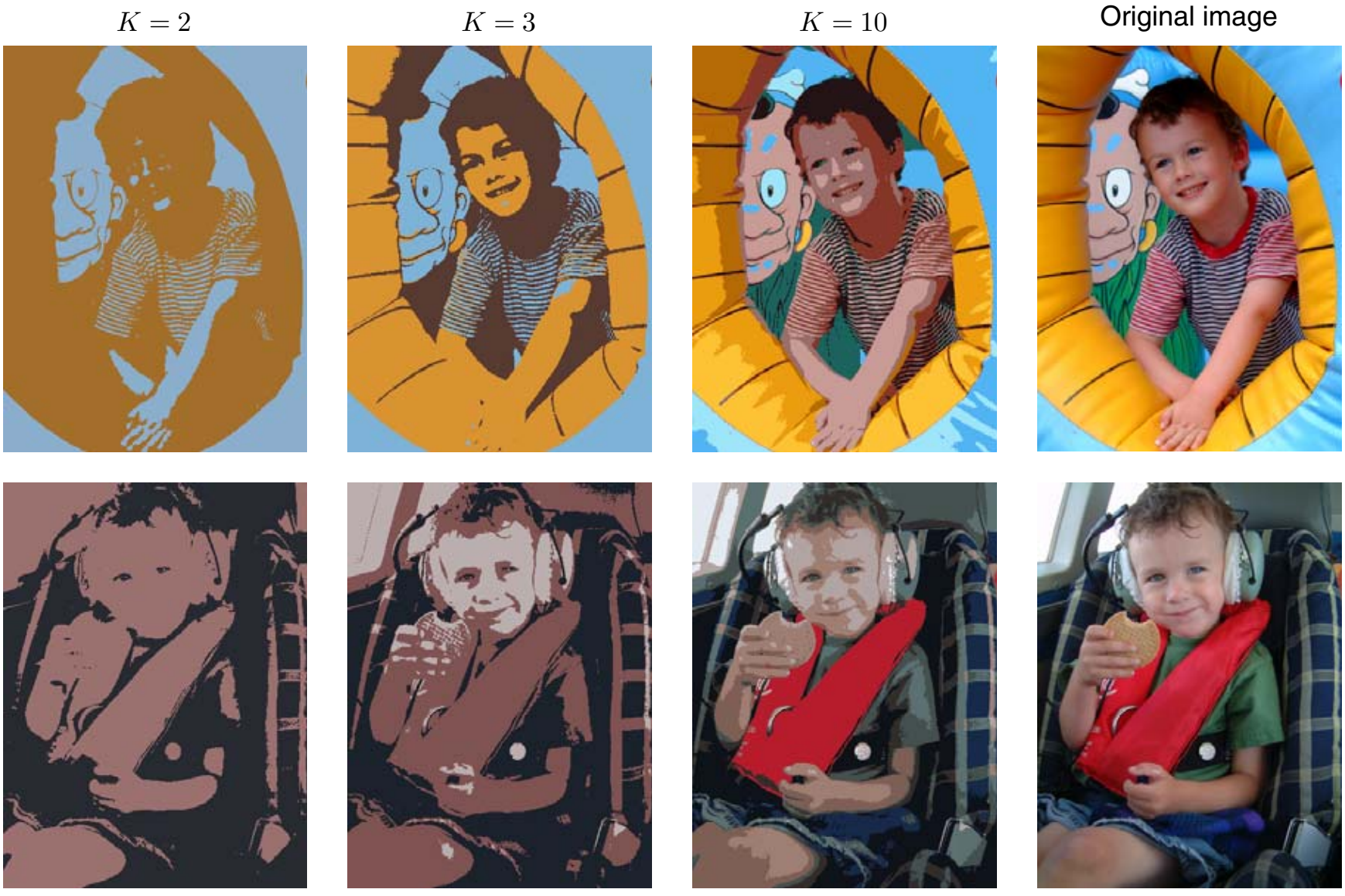
Finding groups of similar objects.



Examples

People with similar ‘taste’, genes with similar function.

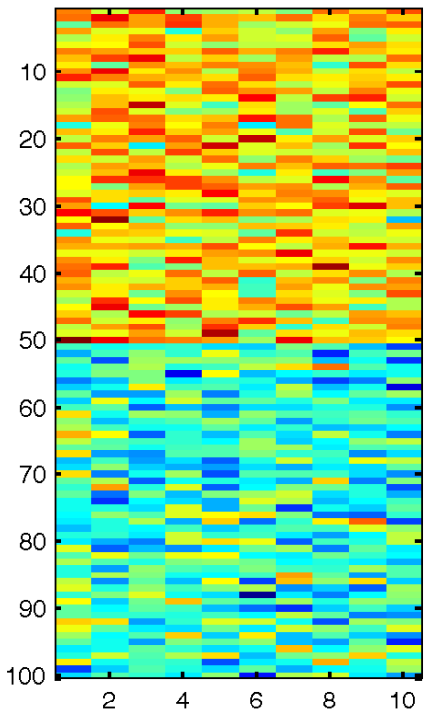
Clustering Example

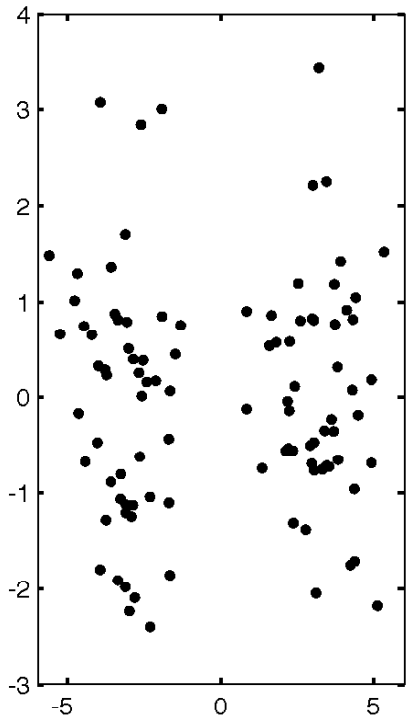


Unsupervised Learning

Projection

Reducing the number of variables – e.g. from 10 to 2.

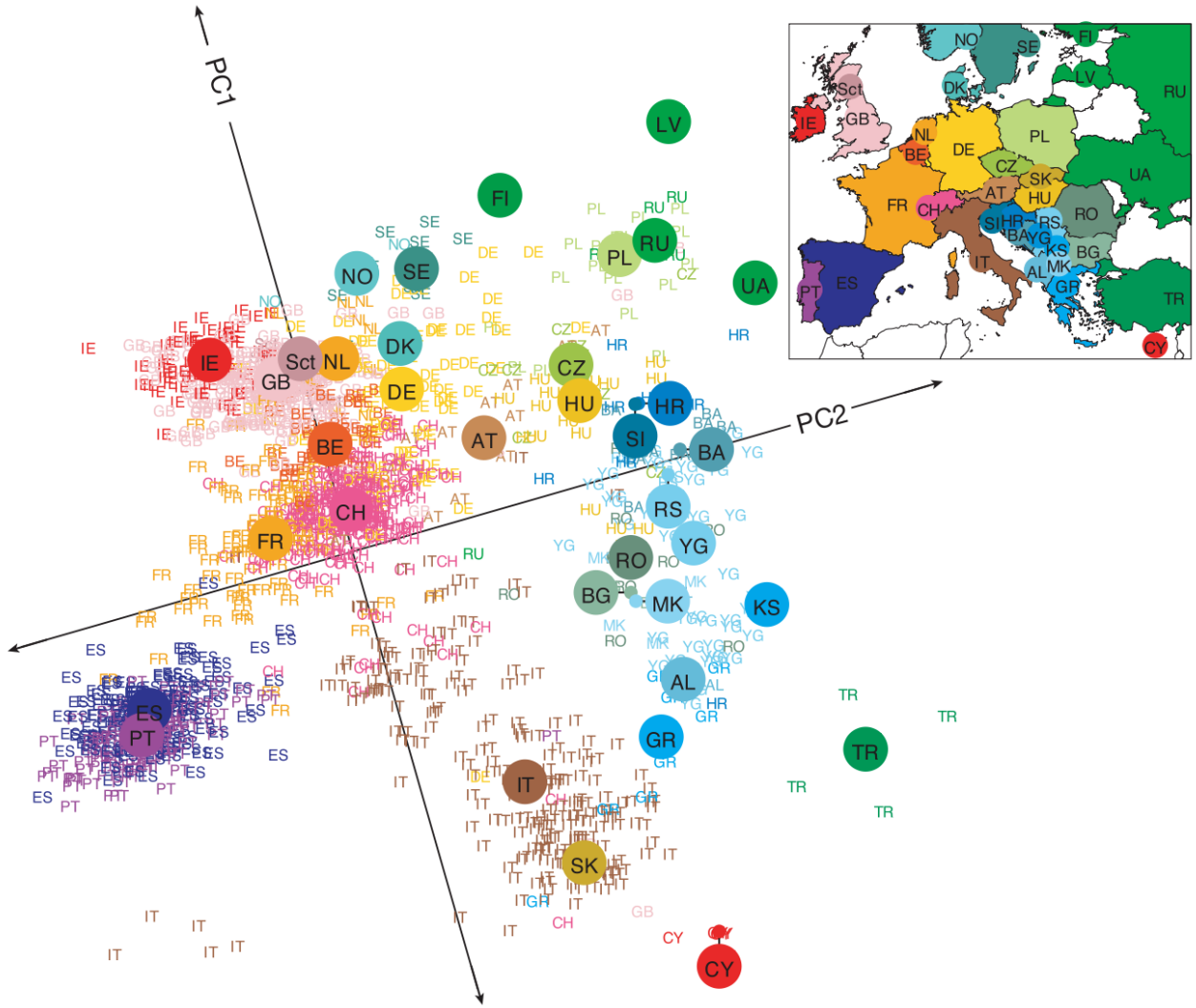




Examples

Visualising complex data

Novembre et al. (2008) — doi:10.1038/nature07331



We *won't* cover...

Reinforcement Learning

Deep Learning

Maths

If things like this look completely alien to you...

$$f(x) \quad \sum_{i=1}^{N} x_i \quad \prod_{j=1}^{P} f(y_j) \quad \frac{\partial f(x)}{\partial x} \quad (t - wx)^2 \quad y^{-2/5} \quad \log(x)$$

...then look up the suggested reading on Moodle

Maths

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad \mathbf{A} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \quad y = \mathbf{x}^T \mathbf{w}$$

They'll be explained but you still need to make sure you're comfortable with them

We'll also need some probability: random variables, probabilities, density functions, integration, conditioning,...

$$P(X = x) \quad p(x) \quad \int xp(x)dx \quad p(\mathbf{t}|\mathbf{X}, \mathbf{w}, \sigma^2)$$

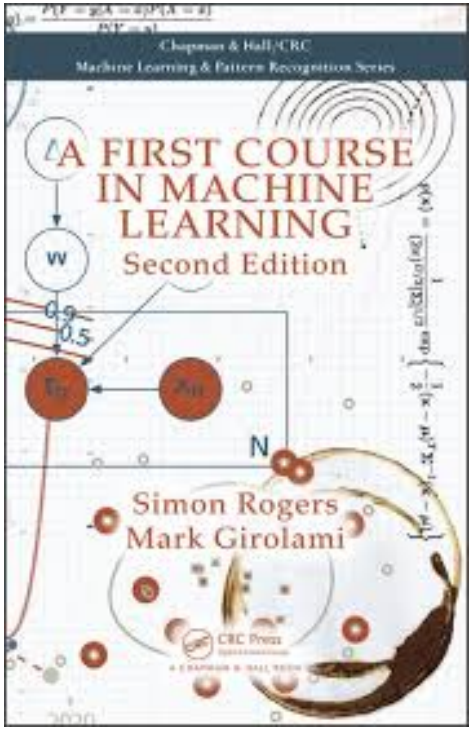
They'll be explained – ensure that you are happy dealing with them.

Coding

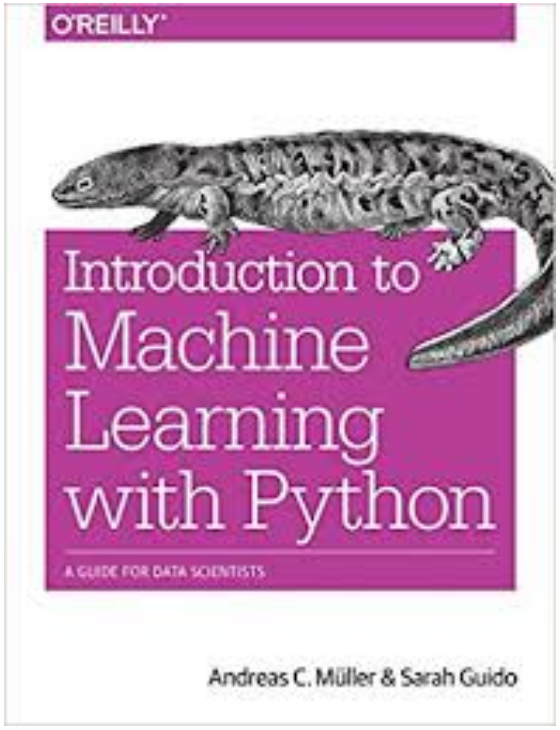
- Practicals are in Python (Numpy, SciPy, scikit-learn, Jupyter)
- Self-learning materials on Moodle (Guides and references section)

Books

Theory



Practice



Also:

- Chris Bishop: *Pattern Recognition and Machine Learning*
- Kevin Murphy: *Machine Learning: A Probabilistic Perspective*