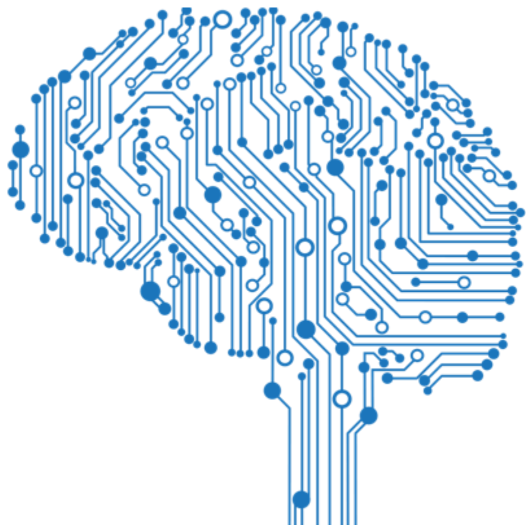
Introduction to Machine Learning

From raw data to predictive models



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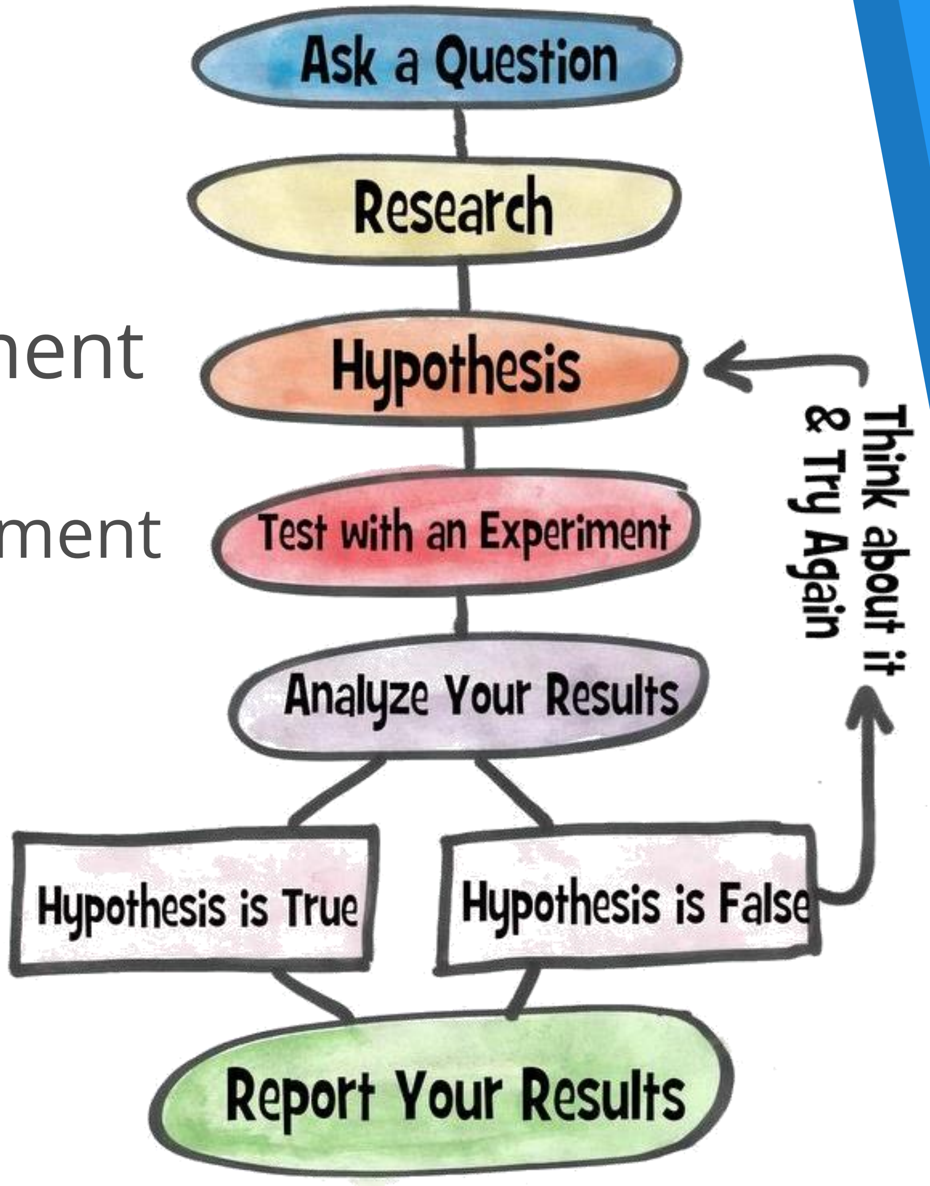
The Scientific Method

How to work with data…
the right way

The Scientific Method Steps

- Ask a question
- Do a research
- Form a hypothesis
- Test the hypothesis with an experiment
  - Experiment works ⇒ Analyze the data
  - Experiment doesn't work ⇒ Fix experiment
- Results align with hypothesis ⇒ OK
- Results don't align with hypothesis ⇒ new question, new hypothesis
- Communicate the results



OSEMN Model

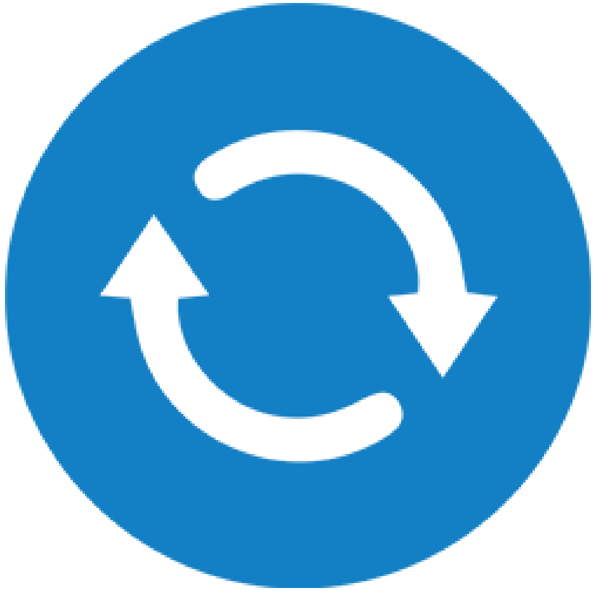
- Some guidelines on the process to extract meaningful information from data
  - Very similar to the scientific method
  - Can be viewed as a sequential process
    - Or just as some guidelines on how to do research
  - Read as "awesome"

1. **O**btain data
2. **S**crub data
3. **E**xplore data
4. **M**odel data
5. i**N**terpret the results

Applied Machine Learning Process

- This allows us to do our job faster and more reliably

1. Problem definition
   - Make sure the problem is well-defined and that you're solving the right problem
2. Data analysis
   - Get familiar with the available data
3. Data preparation
   - Get the data ready for modelling
4. Algorithm evaluation
   - Test and compare algorithms
5. Result improvement
   - Use results to create better models (e.g. fine-tuning, ensembles)
6. Result presentation
   - describe the problem and solution to non-specialists



Machine Learning

Fundamental concepts

Machine Learning

- We described a general process
  - We didn't explain ML in detail
- *"A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."* – Tom Mitchell, Carnegie Mellon University
- More simply, **making computers learn from data**
  - And observing them getting better and better
  - Results: computers do things that they weren't explicitly told
- The field is vast (and expanding)
  - There are many sub-fields, variations and algorithms
  - ... but the basis is still the same

Types of Machine Learning Algorithms

- **Supervised learning**
  - We train the program on previously known (labelled) data
  - After training, we expect it to make predictions on new data
  - Examples: regression, classification
- **Unsupervised learning**
  - We leave the program to find patterns in data
  - Examples: clustering analysis, dimensionality reduction
- **Reinforcement learning**
  - A form of unsupervised learning
  - The program learns continuously
  - Examples: learning to play a game by observing other players, learning to drive a car

Algorithms by Task

- **Statistical algorithms**
- **Regression** – predicting a continuous variable
- **Classification** – predicting class labels
- **Clustering** – finding compact groups of data points
- **Dimensionality reduction** – simplifying the input data
- **Recommendation** – suggest items for users
- **Optimization** – minimize / maximize a target function
- **Testing and improvement algorithms** – helper algorithms to select, fine-tune and optimize other ML algorithms
- … and more :)

Environment Setup

Download and install all tools

Anaconda

- You can install the Python interpreter and all libraries manually
  - Hard, boring and repetitive work
  - Error-prone
- Easy solution: platforms like **Anaconda**
  - Provide everything you need to get started with Python for science: interpreter, packages (720+), package manager, IDE
- Download from https://www.continuum.io/downloads
  - Current version (March 2018): Anaconda 5.1
  - Choose your platform (Windows, Linux, or MacOS)
  - Download the **Python 3.6** version
  - Follow the installer

Python Tools for Visual Studio (Optional)

- You can use the built-in IDE called **Spyder**
  - You can even use Notepad if that's your thing
- If you want to use another IDE, you have to configure it to work with Python
  - Syntax highlighting, autocomplete, etc.
- If you're using Visual Studio
  - Python Tools
  - https://www.visualstudio.com/vs/python/
- Visual Studio Code
  - If you prefer something lightweight, Visual Studio Code is a good alternative
  - https://code.visualstudio.com/docs/languages/python

Jupyter Notebook

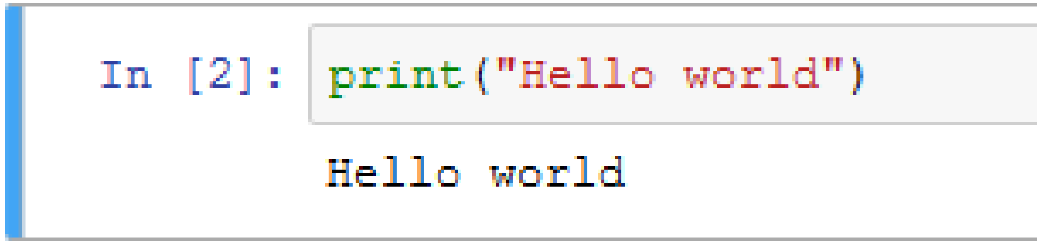
- A very nice and clean way to document your research
- Included in Anaconda
- Can create documents that contain live code, equations, visualizations and explanatory text
  - HTML / CSS / JavaScript
  - Markdown
  - $\LaTeX$
  - Python
- Start – use the Anaconda shortcut
  - ...or type into the Command Prompt

```
jupyter notebook
```

How to Use Jupyter

- Create a new notebook
  - New > Python 3
- Every piece of text or code is in a cell
  - Text cells just contain text or Markdown

  - Code cells contain code (obviously)
  - Code can be executed
  - Jupyter "remembers" the code



- Execute cell: **`Ctrl + Enter`**
  - Or use the menus

Getting and Preparing Data

Preparing raw data for modelling

Common Libraries

- In Python, we use libraries to perform common operations
- `scikit-learn` – machine learning models
- `pandas` – working with data
  - Reading, tidying, cleaning, preparation
- `numpy` and `scipy` – numerical and scientific libraries
  - Contain a ton of useful functions for performing research
- `matplotlib` – plotting and data visualization
- There are many more we'd like to use but these are the most commonly used ones

Getting Data

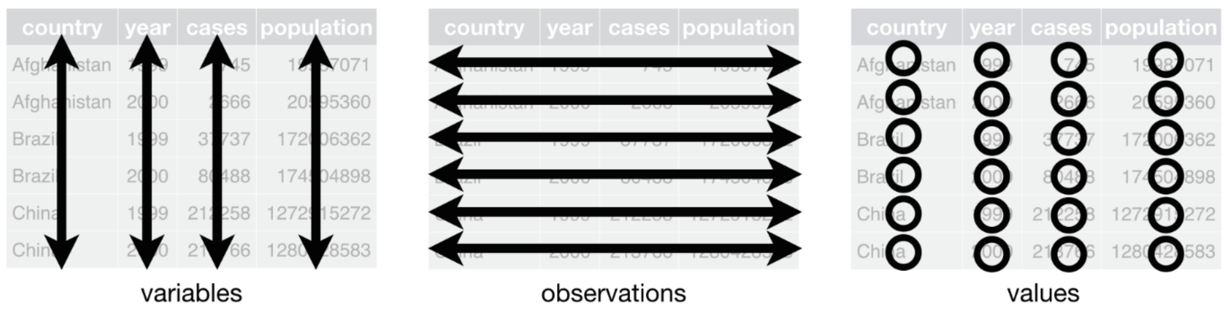
- Import pandas in your notebook or script
  - We usually give it an alias to make code shorter

```
import pandas as pd
```

- Read a dataset (table with data)

```
dataset = pd.read_table(...)
```

  - The method contains a lot of options
  - We can also read from other (non-local) sources
- Transform the data to make analysis easier
  - Tidy up the data
    - Attributes in columns
    - Observations in rows
    - Adding a new record = adding a single, complete row



Preparing Data

- Make other transformations as needed
  - Incorporate many datasets
  - Filter rows and columns
  - Group and aggregate values (e.g. sums by group)
  - Transform columns (e.g. apply a function to all values)
    - Change data types
    - Alter the distributions (e.g. `log`, `minmax`)
    - Calculate new columns (e.g. sum of two columns)
- All of these transformations are commonly used and have their own methods within pandas
  - 10 Minutes to pandas
  - Pandas Cheat Sheet
  - Full docs

Exploring Data

- Running an ML model is a small part of the process
  - Before that, we have to get to know our data
- **Exploratory data analysis (EDA)**
  - "Playing around" with the data, looking for interesting features, distributions, correlations, causal relationships, etc. using "mind power"

- An important part of EDA is creating graphs
  - We use `matplotlib` for this
  - Histograms and boxplots – to represent distributions
  - Line and bar charts – to represent relationships and allow comparisons
  - Scatterplots – to represent correlation
  - … and many others, depending on the case
    - We can even create our own charts if we need that

Example: Getting and Exploring Data

- Passengers on the Titanic
  - Dataset provided in the additional materials: `titanic.csv`
  - Dataset info
- Read the data (using pandas)
- Tidy up and clean the data
  - While also exploring the information
  - No "hard and fast" rules – you've got to use intuition
  - **Usual workflow:** start by inspecting variables and data types, move to single-variable distributions, then try to find relationships between two or more variables; transform the data if needed
  - Deal with missing values and outliers, normalize the data if needed

Example: Preparing Data for Modelling

- Most models require two additional steps
  - Convert categorical variables into indicator variables

    ```
    dataset = pd.get_dummies(dataset)
    ```

  - Normalize values if needed (e.g. scale all variables from 0 to 1 using minmax scaling, or use Z-scores)
- Perform other model-specific transformations
  - E.g. your model may not work well with highly imbalanced data (when you look for anomalies)
- If possible, prepare several versions of the dataset with different transformations to see whether a transformation affects model performance negatively
- **Describe and document the entire process!**

Example: AzureML

- In this course, we'll be using Python code to run and evaluate models
  - We'll create a nice, structured pipeline
  - But there are other solutions
- Microsoft AzureML Studio: https://studio.azureml.net/
  - Good for a demo if you're not experienced in coding
  - Pros
    - Free to try
    - Easy, visual representation of the workflow
    - Has many predefined modules; can also execute Python code
    - Runs on the cloud – no need to throttle your machine
  - Cons
    - Hides away or obscures some important implementation details
    - Running on the cloud is too expensive sometimes

Summary

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Questions?