MESS 2019

It begins.

Schedule

Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Python	Classical Linear Models	Random Forests	Deep Learning	Machine Learning Frameworks
	Basics of Neural Networks 1			Talks
SKIING				
ObsPy	Basics of Neural Networks 2		RNN	
	Support Vector Machines		Generative Networks	

Organizational Things

(Heiner)

AI,
Machine Learning,
Deep Learning,
…

Much of the following is inspired by fancy slides from Jason Mayes:

https://goo.gl/5Wd2vy

Artificial Intelligence

Artificial intelligence (AI) is the science of making things smart. It can be defined as

“Human intelligence exhibited by machines”

Basically a broad term for getting computers to perform human tasks.

We are not there yet

- Only works for a few, well defined things. And usually each model does only exactly one thing!
- Machines can do things like speech synthesis or object recognition at near human level.
- But none of the algorithms is actually smart – they have just been fitted to a ton of data. (And they are easy to trick).
- Some people call this **narrow AI**.
- Nonetheless very useful for many tasks.

Machine Learning

One definition is

“An approach to achieve artificial intelligence through systems that can learn from experience to find patterns in sets of data.”

Thus a computer it taught to perform a certain task not by hard-coding rules but by recognizing patterns, e.g. fancy ways of fitting data.

Difference to normal coding

Write a computer program
with **explicit rules** to follow

```
if email contains V!agrå
  then mark is-spam;
if email contains …
if email contains …
```

Traditional Programming

Write a computer program
to **learn from examples**

```
try to classify some emails;
change self to reduce errors;
repeat;
```

Machine Learning Programming

$$\text{Input} \longrightarrow f(x) \longrightarrow \text{Output}$$

Input $\longrightarrow$ f(x) $\longrightarrow$ Output

Handwritten Function

$$\text{Input} \longrightarrow f(x) \longrightarrow \text{Output}$$

Machine Learning Model

Features

- A term that will be used a lot.
- Describes some interesting attributes of our data. Algorithms are oftentimes only trained on these attributes.

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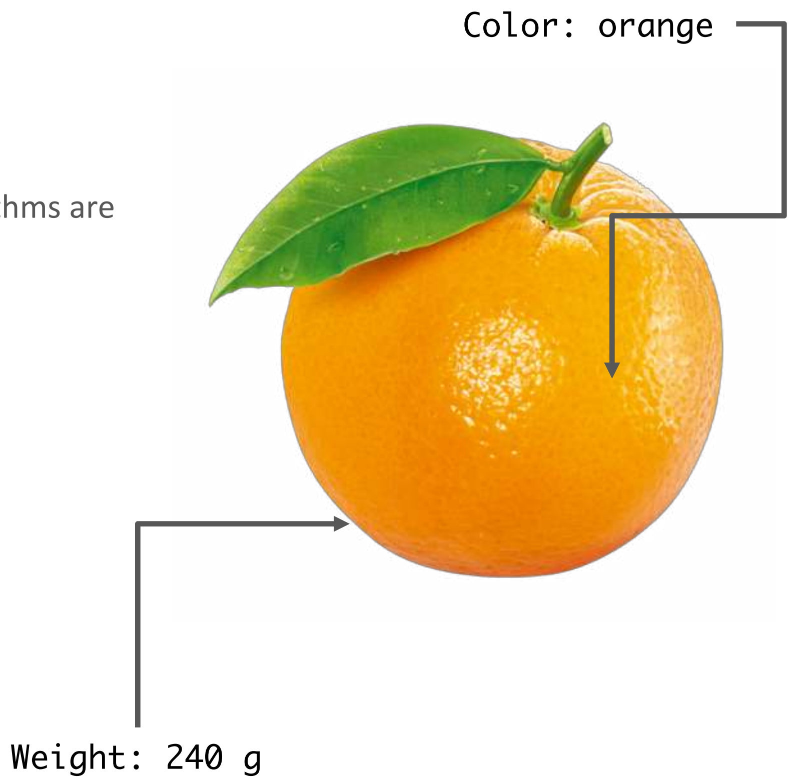

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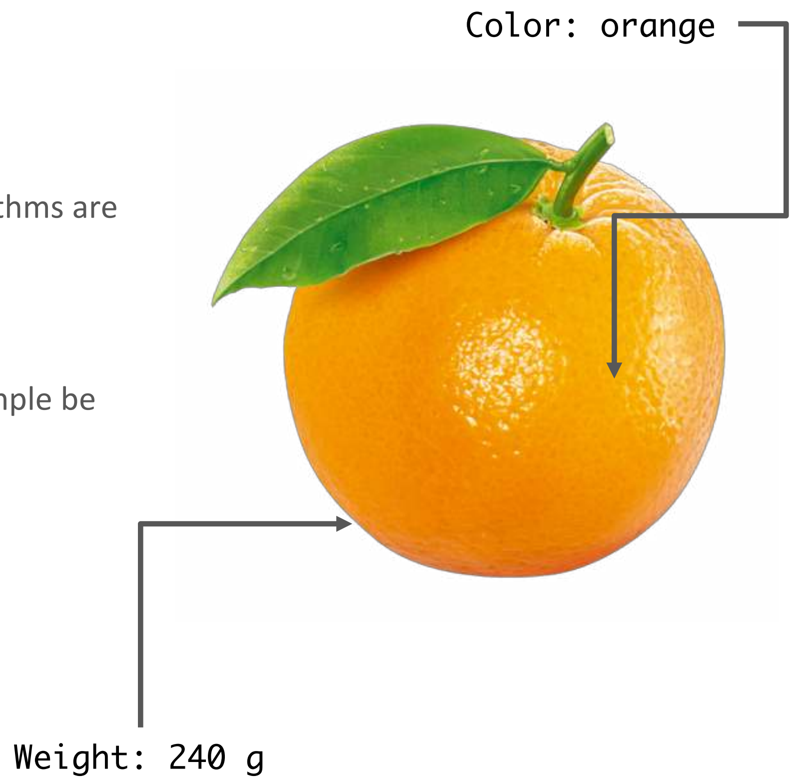
- In seismology the features of a waveform might for example be the maximum amplitude, the total energy, ...



Deep Learning

- Just a certain type of machine learning algorithm.
- Large neural networks.
- Has produced some spectacular results in the last maybe 7 years.

- A classical issue in non-deep learning is that one has to carefully extract features from the data before even launching the machine learning algorithm.
- One promise of deep learning is to get rid of that so called “feature engineering”.

- Largely enabled by increases in the amounts of data as well as computational power/techniques.

Predictive Power

By and large a ML system cannot predict things it does not know about and thus has not seen during training.

A ML system oftentimes can generalize to unseen examples but they must, in some domain, be similar to the training data.

“Catastrophic failures” where a ML grossly miss-performs can always be found.

Another problem are for example rare events for self-driving cars.

Styles of Machine Learning

Supervised Learning

- A system has labelled training data, e.g. there is known ground truth data and the ML system tries to learn the underlying mechanism mapping input to output.
- Classification and regression problems are typical examples.
- A lot of the recent and spectacular examples use supervised learning.
- Also the focus of this workshop.

Unsupervised Learning

- A system has unlabeled training data and must try to find some structure in it.
- The classical example are clustering problems.
- Other examples are anomaly detection, blind signal separation, generative algorithms, …

Reinforcement Learning

- Learn by trial-and-error through reward and punishment.
- A simple example is to train an algorithm to play a game. It randomly plays the game millions of times and gets rewarded for better runs and punished for worse. Thus over time it learns to play the game.
- Works really well for games which have a simple score count.
- Another way is to let the system play against itself and reward the better version. Used e.g. for go and chess playing.
- Also used for resource management, traffic light control, robotics, bidding and advertising, …

I'm not aware of any applications in seismology.

ML Output Types

Common ML Output Types

Regression

Predict numerical values
(e.g. price of house, magnitude of earthquake…)

Classification

Assign a pre-determined label
(e.g. earthquake/noise, damaging/non-damaging, …)

Clustering

Find the most similar other examples
(e.g. matched filters, event clustering, …)

Sequence Prediction

What comes next?
(e.g. find the next 10 samples in a time series)

Sticky Notes System

We realize that the level of the lectures and tutorials is rarely exactly right for anyone. Please let us know if we go too fast or too slow.

Let’s get it started!