Machine Learning

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Learning

‘Learning is the process of acquiring new, or modifying existing, knowledge, behaviors, skills, values, or preferences’

Wikipedia: Learning

‘a relatively permanent change in behavior due to past experience’

Psychology: The Science of Mind and Behaviour 6th Edition

Machine Learning

A very broad term encompassing a variety of algorithms based on statistical techniques

The basic goal: Get a computer to perform tasks in place of a human in an automated fashion

Typically involving very large data sets that humans can’t hope to fully explore

Supervised Machine Learning

Train a computer to recognise/predict things

Training requires examples of these things

Assess how accurate your algorithm has classified these things

Apply your algorithm to unseen things so the computer can identify them for you

Supervised Machine Learning

What is training?

Associating data (features) with specific things (classes)

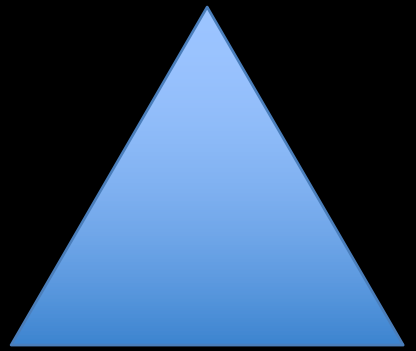
Classes	Features
Animals	Number of legs?
Vehicles	Number of wheels?
Instruments	Shape/Number of strings/Sound?

Supervised Machine Learning

What is training?

This is a square

This is a triangle



Supervised Machine Learning

What is training?

So 4 sides = square, and 3 sides = triangle?

This is a square

This is a triangle

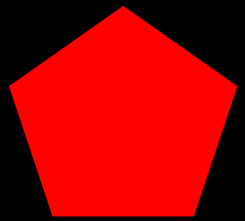
Supervised Machine Learning

What is training?

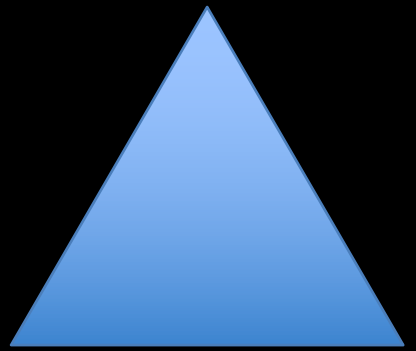
So 4 sides = square, and 3 sides = triangle?

Then what is this?

This is a square



This is a triangle



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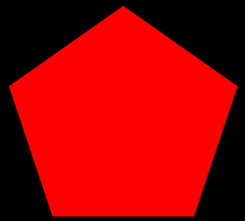
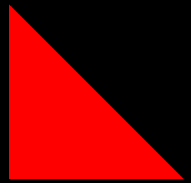
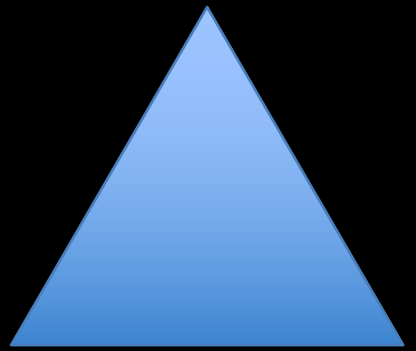


But you can still identify this?



This is a triangle



Supervised Machine Learning

What is training?

4 wheels = car, and 2 wheels = bike?

This is a car

This is a bike

Supervised Machine Learning

What is training?

4 wheels = car, and 2 wheels = bike?

so these are…?

This is a car

This is a bike

Supervised Machine Learning

I’ve shown images for clarity, but these examples are not image recognition

You have to extract the features you think best separate the classes

Supervised Machine Learning

What features describe these animals?

This is a dog

Credit: Benn Jordan

This is a cat

Credit: Rachael Ainsworth

Supervised Machine Learning

What features describe these animals?

This is a dog

Credit: Benn Jordan

So what is this?

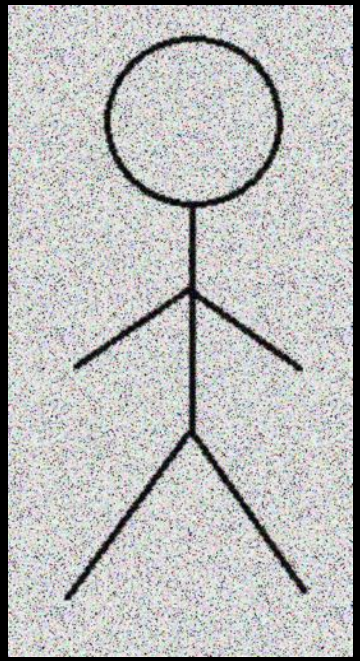
Credit @MeCookieMonster

This is a cat

Credit: Rachael Ainsworth

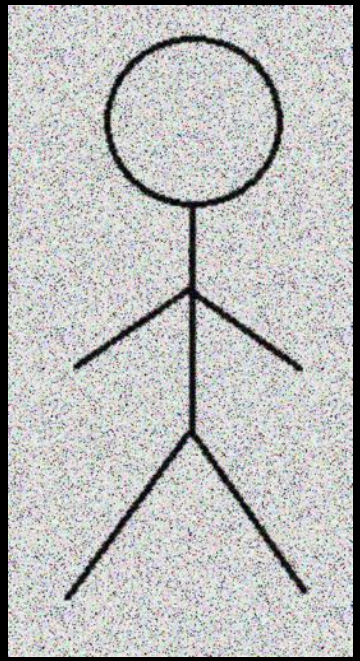
Supervised Machine Learning

What features describe a particular illness?



One of these patients is ill

Is it possible to tell which?
And why?



Supervised Machine Learning

So what data do you need? Typically hundreds of samples with labels

1. Training data (known labels, building the model)
~50%

2. Validation data (known labels, verifying the model & prevent over fitting)
~20%

3. Testing data (known labels, but don't show the algorithm, then assess accuracy)
~30%

4. Can then apply the algorithm to new data (unknown labels)

Supervised Machine Learning

Your favourite type of music?

Your preferred shopping brands?

Natural disaster warnings?

Fake news?

Doctored videos?

Email spam?

The price of a house in 10 years?

A star with a habitable planet in orbit?

Supervised Machine Learning

You need to obtain enough features to describe your desired classes

Domain expertise is important in being able to select good features

You need enough examples of the classes to be sure your features can distinguish them

The best features can be complex and time consuming to obtain

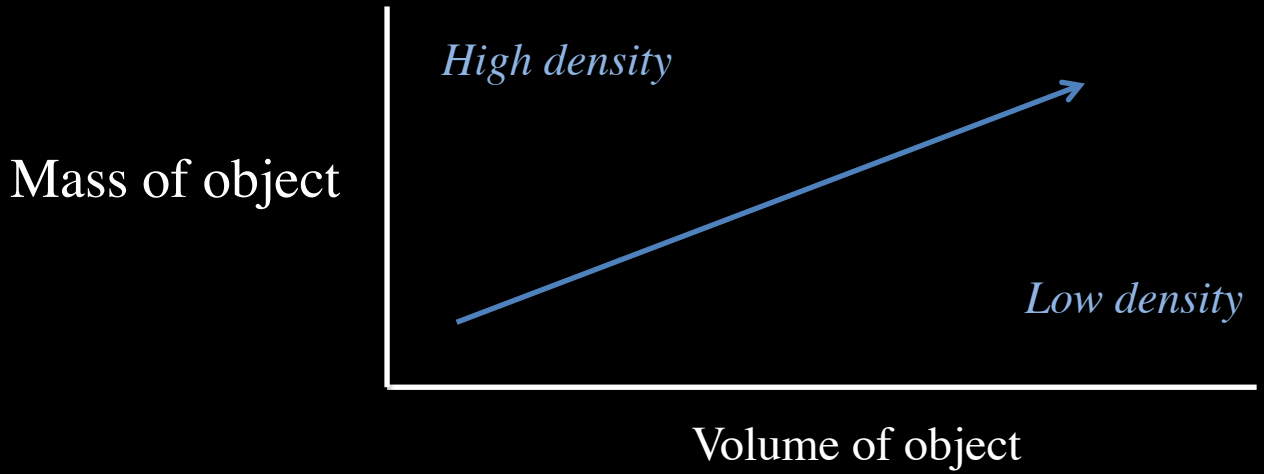
Practically, how can you obtain these features for a large data set?

Unsupervised Machine Learning

You have no information about the classes, you only have features

Clustering techniques can reveal classes

A very simple example: Plot two features against each other



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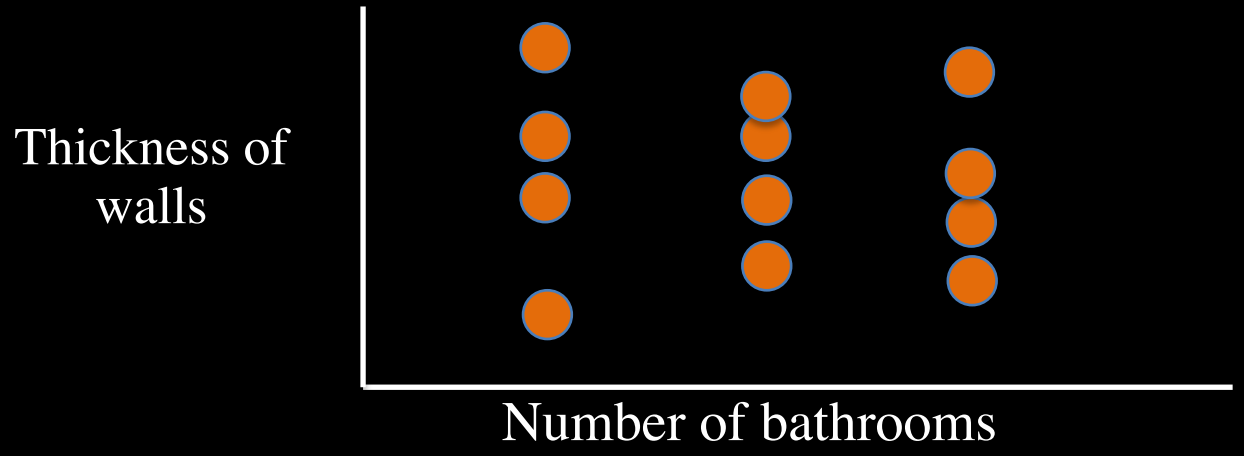

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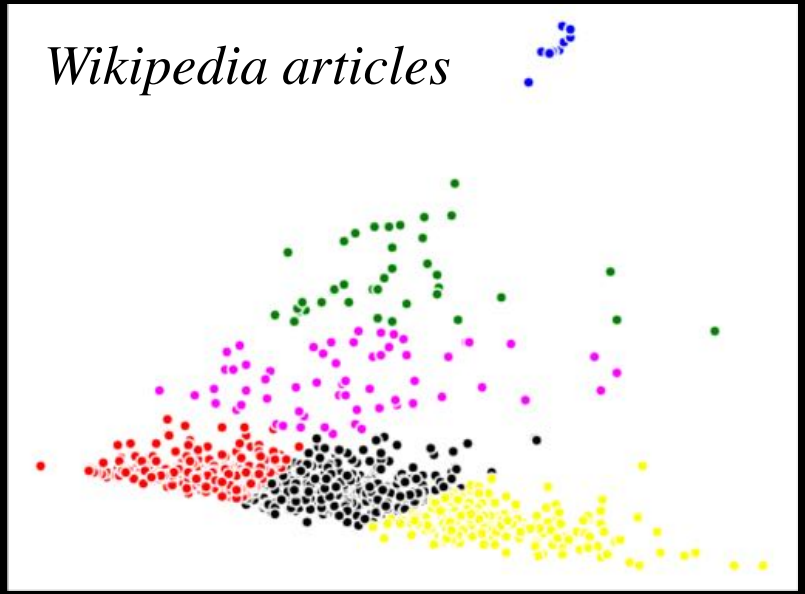
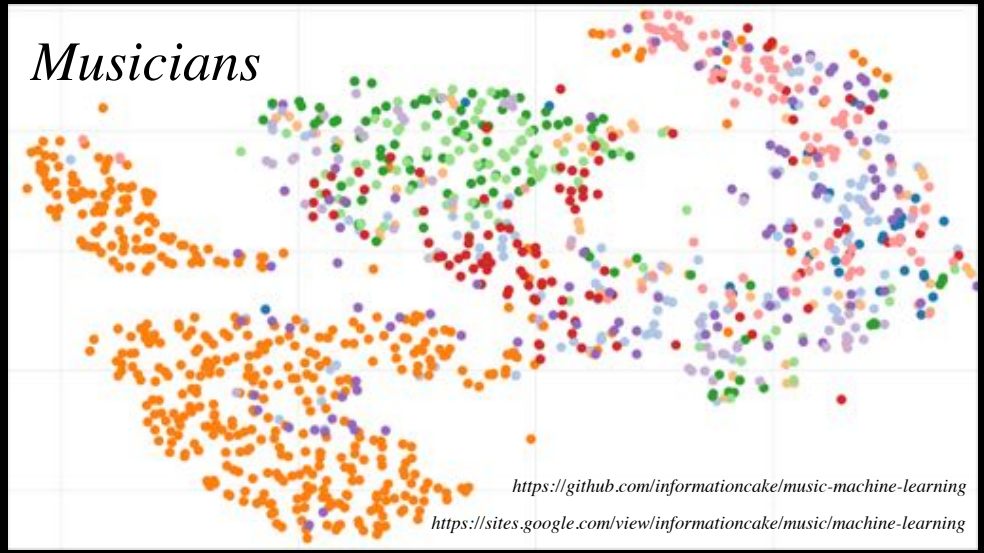
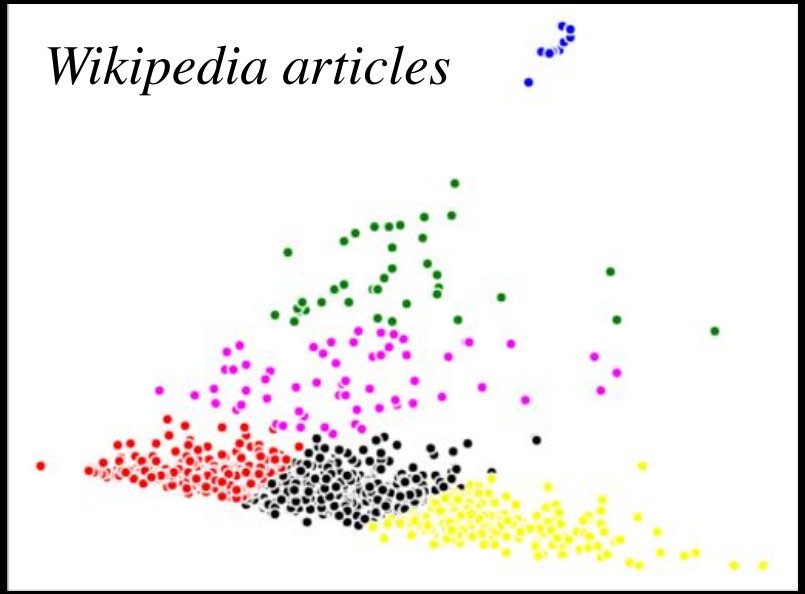




Unsupervised

Natural Language Processing



black

film
village
game
population
county
census
series
2006
class
province

green

de
coordinates
municipality
province
french
river
island
house
population
village

red

species
football
genus
league
season
team
described
cup
club
player

yellow

she
station
county
administrative
village
church
film
east
father
radio

blue

album
band
song
records
music
songs
single
studio
recorded
albums

magenta

served
minister
government
party
election
law
bridge
professor
company
college

Performance Metrics

Accuracy

Precision

Recall

F1 score

Benign tumors don't invade surrounding tissue

Malignant tumors can invade surrounding tissue

Example: 100 tumors, either malignant or benign, accuracy 91%

True Positive (TP): • Reality: Malignant • ML model predicted: Malignant • **Number of TP results: 1**	**False Positive (FP):** • Reality: Benign • ML model predicted: Malignant • **Number of FP results: 1**
False Negative (FN): • Reality: Malignant • ML model predicted: Benign • **Number of FN results: 8**	**True Negative (TN):** • Reality: Benign • ML model predicted: Benign • **Number of TN results: 90**

$$\text{Accuracy} = \frac{\text{Number of correct predictions (91)}}{\text{Total number of predictions (100)}}$$

Always predicting benign tumors would achieve the exact same accuracy!

https://developers.google.com/machine-learning/crash-course/classification/accuracy

True Positives (TPs): 1	False Positives (FPs): 1
False Negatives (FNs): 8	True Negatives (TNs): 90

What proportion of positive identifications were actually correct?

$$\text{Precision} = \frac{\text{True Positives (1)}}{\text{True Positives (1) + False Positives (1)}} = 0.5$$

When it predicts a tumor is malignant, it is correct 50% of the time

$$\text{Recall} = \frac{\text{True Positives (1)}}{\text{True Positives (1) + False Negatives (8)}} = 0.11$$

It correctly identifies 11% of all malignant tumors

https://developers.google.com/machine-learning/crash-course/classification/precision-and-recall

True Positives (TPs): 1	False Positives (FPs): 1
False Negatives (FNs): 8	True Negatives (TNs): 90

Accuracy = 0.9

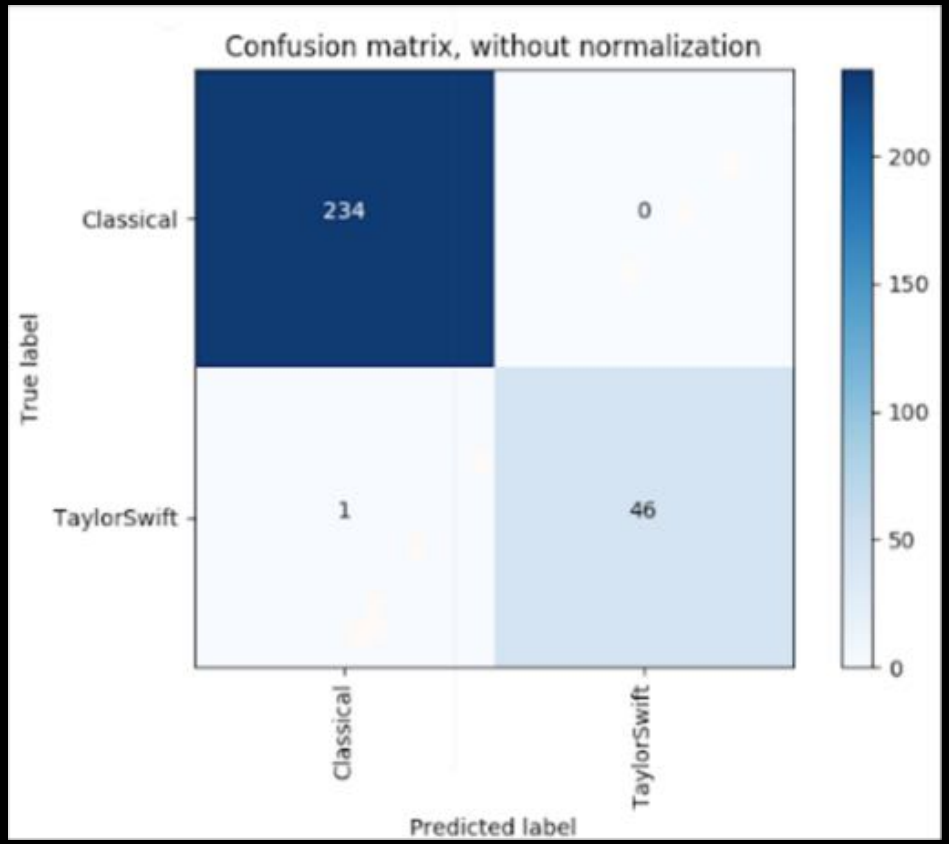
Precision = 0.5

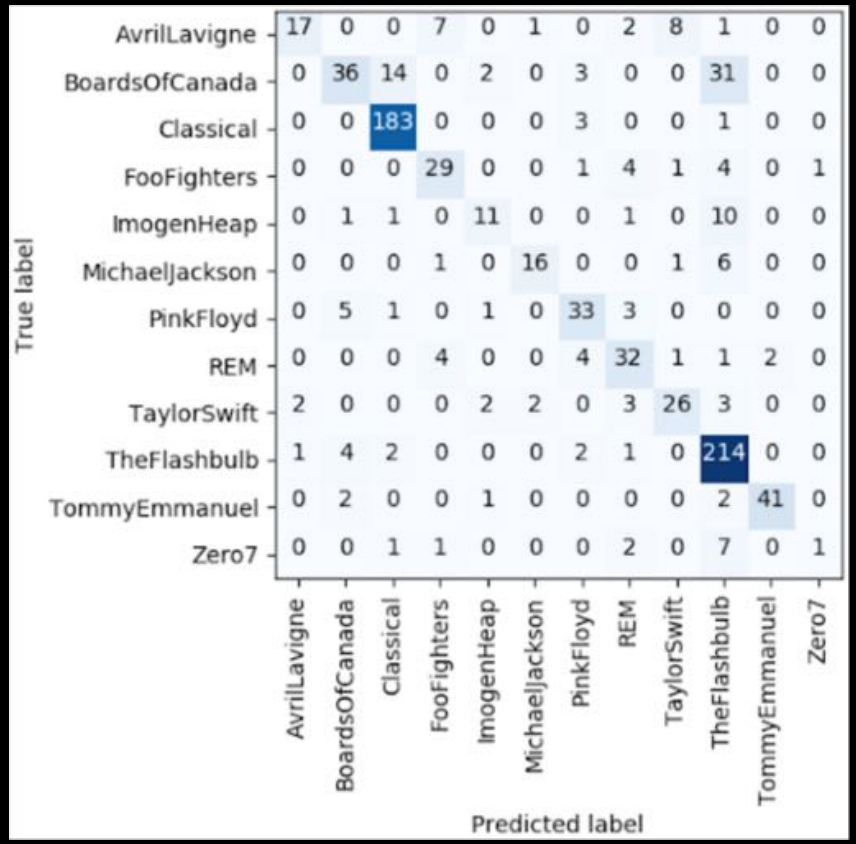
Recall = 0.11

F1 score = harmonic mean of precision and recall = 0.18

Tends towards the smallest element of the list

A Confusion Matrix is an easy way to visualise a classifiers strengths and weaknesses





Machine Learning

Supervised – making a connection between features and classes

Unsupervised – providing features, but have no prior information about classes

Domain expertise is essential - are you providing good features? Are your class choices appropriate/practical?

Algorithm expertise is essential – are the features practical to obtain? Are the results reliable? Why? Why not?