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Fundamentals of Machine Learning

Introduction

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Sessions

Week 1:	Week 2:	Week 3:	Week 4:
Introduction	Supervised Learning	Neural Networks	Reinforcement Learning

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Data

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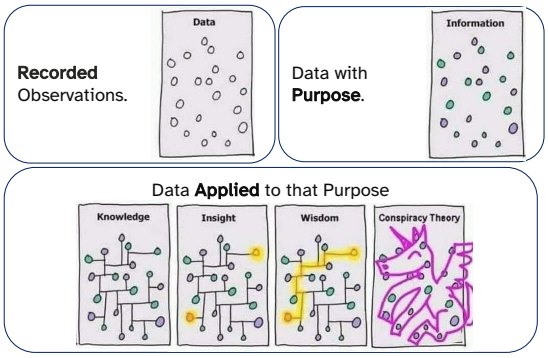

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Machine Learning as a Tool

- It can be good to think of machine learning as a tool, using parts of other fields to solve real-world issues based on data.
- We may want to find patterns:
  - Detect anomalies or outliers
  - Cluster groups of similar things
  - Identify relationships between things
  - Apply a label to an observation
- These identified patterns are only useful if they allow us to then do something, we want actionable insights.

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Machine Learning as a Tool

- A common example is to predict whether email is spam or not.
- Let's say that I've seen numerous emails over the last few years which tell me I can "make money quick" in some form or another. Those emails have turned out to be spam.
- My friends and colleagues send me genuine, non-spam emails, and they don't contain any mention of making money quick.

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Machine Learning as a Tool

- We could create a **rule** that says:

  IF subject contains “make money quick”

  then the email is spam, otherwise it is not.
- Given a new email, we **apply our rule** and **predict** whether it should be labelled as spam or not.
- We **classify** it’s **label** from the set of possible labels

  {spam, non-spam}
- Based on something we observed (the subject content).

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Machine Learning as a Tool

- However, it is quite weak rule, easy to bypass and pontentially could get it wrong (misclassify).
- If I can spot that trend as a human, then what is the point of throwing machine learning at it?
- Instead we often want to find patterns/insights which humans could not find easily:
  - Complex patterns
  - Massive amounts of data

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Data

- Dataum
  - “A single piece of information”
  - “A item of data”
  - “A single recorded observation”
- A dataum is often an observation or measurement of something, recording information about that thing
- A collection of multiple observations can form from data

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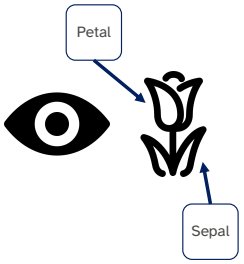
Data

- Suppose we observe a flower
- What could we measure/record about that flower?

- Colour/ Number of petals
- Length/ Width of petals
- Length/ Width of sepals



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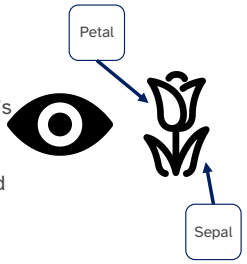
Data

- Why might we want to?
- Well perhaps we have a hypothesis that we might be able to tell what the flower's **species** is by these measurements.
- Similar to our example example, we might want to predict the species based on our data, so that if we see a new flower, we can **classify it**



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Data

- Our one observation becomes a single data point:
  - Colour: Black
  - Number of petals: 3
  - Length of petal: 1.5cm
  - Width of petal: 2cm
  - Length of speal: 0.7cm
  - Width of sepal: 0.3cm
  - Species: Black rose

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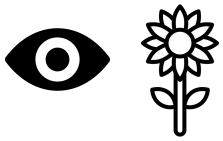
Data

- Our one observation becomes a single data point:
  - Colour: Yellow
  - Number of petals: 12
  - Length of petal: 13cm
  - Width of petal: 2cm
  - Length of speal: 3.5cm
  - Width of sepal: 2cm
  - Species: Sunflower



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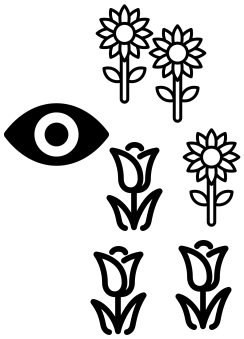
Data

- If we then look at a lot of flowers, lots of observations perhaps we can create a large dataset on which we can apply our machine learning methods
- Maybe there are some trends in that data we collected which can help us solve our task



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Data

- Data comes in a variety of shapes, sizes and types.
- We may collect numerical data, text data, images…
- We may collect pieces of information about a single observation. E.g. Name, age, address …
- We may collect tens, thousands, or even millions of data points

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Data Types

Categorical

Nominal
- No order

Examples:
- Eye colour
- Postcode
- Star sign

Ordinal
- Ordered

Examples:
- Race position
- Ratings
- Degree level

Numerical

Discrete
- Countable

Examples:
- Class size
- Cars owned
- Fake teeth

Continuous
- Measurable

Examples:
- Salary
- Height
- Time

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Dataset

Features

Sepal Length	Sepal Width	Petal Length	Petal Width	Species
5.1	5.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
7.0	3.2	4.7	1.4	versicolor
6.4	3.2	4.7	1.4	versicolor
6.3	3.3	6.0	2.5	virginica
5.8	2.7	5.1	1.9	virginica

- **Samples**
- **Instances**
- **Data Points**

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Machine Learning: Motivation

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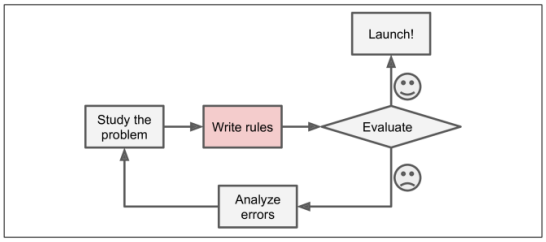
Traditional Approach



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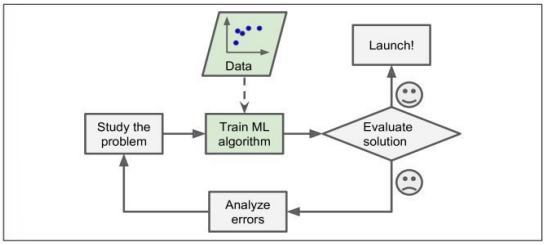
Machine Learning Approach



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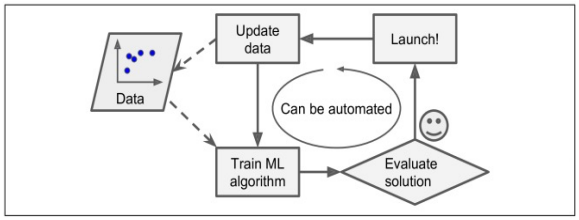
Automated Learning



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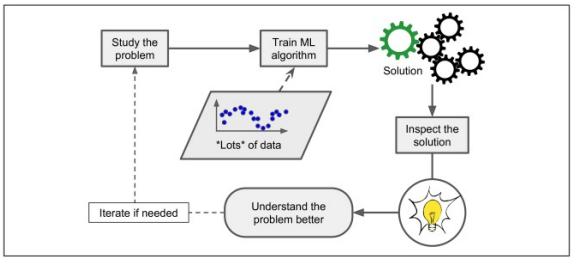
Learning from Learning



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Machine Learning: Types

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Distinguishing Criteria

Three criteria to separate machine learning algorithms:

- Human involvement during training
  The machine learning *paradigm*
- When data is used to learn.
  Batch vs *Online* learning
- How data is used to learn
  Model-based vs *Instance-based* learning.

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Learning Paradigms

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

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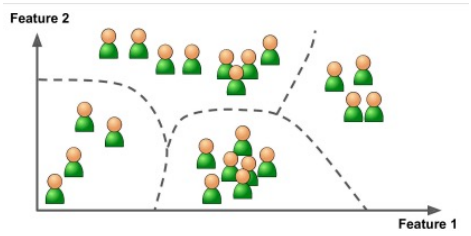
Unsupervised Learning



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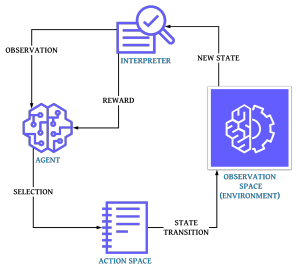
Reinforcement Learning



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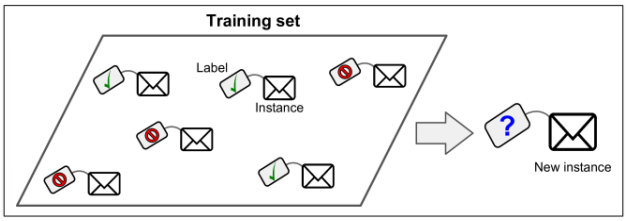
Supervised Learning: Classification



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Supervised Learning: Regression

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Supervised Learning: Training and Evaluation