Introduction to Machine Learning

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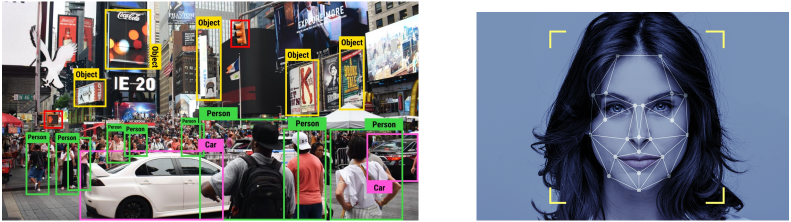
What is Machine Learning?

- Arthur Samuel (1959). Machine learning is a “Field of study that gives computers the ability to learn without being explicitly programmed”.
- Tom Mitchell (1998). “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E”.

Some applications - Image recognition



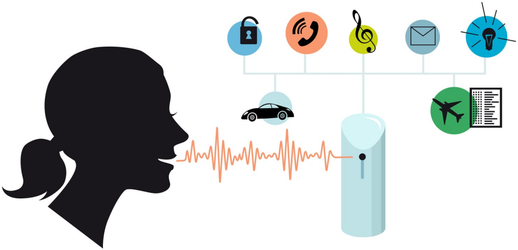
(a)

(b)

Two examples of image recognition.
(a) Labelling different entities in a given image.
(b) Face recognition (as in our smartphones).

Some applications - Speech and voice recognition

Speech recognition involves recording words using a recording device. The audio is then converted into a set of words stored digitally within the device or program. Instead, the purpose of voice recognition is to identify the person who is speaking.



(c)

(d)

(c) A general idea of speech recognition.

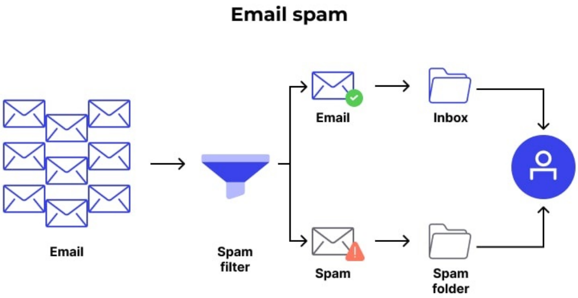
(d) Google's voice assistant provide individualized responses (e.g. calendar updates or reminders) only to the users who trained the assistant to recognize their voices.

Some applications - Self-driving cars

Using e.g. image recognition, companies are building self-driving cars increasingly efficient.

Some applications - Email spam filtering

Task: determine if a given email is spam or not.



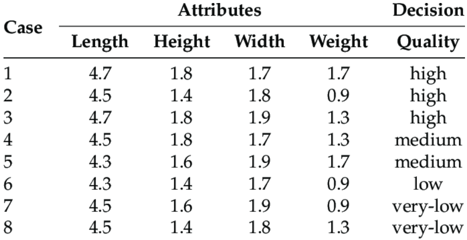
Some applications - Learning how to play games

”AlphaGo is the first computer program to defeat a professional human Go player, the first to defeat a Go world champion, and is arguably the strongest Go player in history.”
More info: https://www.deepmind.com/research/highlighted-research/alphago

Data

A **sample** (or example) is a collection of **attributes** (or features) that have been quantitatively measured from some object or event that we want the ML system to process.

A **dataset** is a collection of many samples.

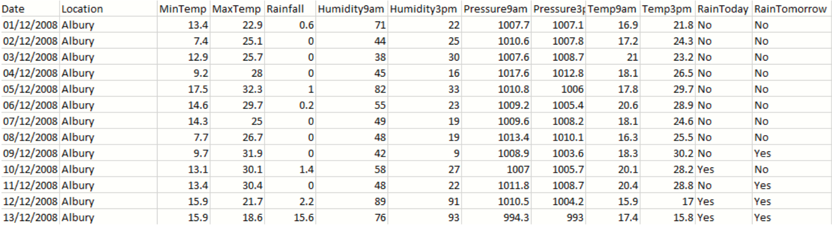


Case	Attributes				Decision
	Length	Height	Width	Weight	Quality
1	4.7	1.8	1.7	1.7	high
2	4.5	1.4	1.8	0.9	high
3	4.7	1.8	1.9	1.3	high
4	4.5	1.8	1.7	1.3	medium
5	4.3	1.6	1.9	1.7	medium
6	4.3	1.4	1.7	0.9	low
7	4.5	1.6	1.9	0.9	very-low
8	4.5	1.4	1.8	1.3	very-low

We will see two types of attributes

- Continuous attributes (real numbers).
- Categorical (or discrete) attributes (integers).

Data - Attributes



Date	Location	MinTemp	MaxTemp	Rainfall	Humidity9am	Humidity3pm	Pressure9am	Pressure3p	Temp9am	Temp3pm	RainToday	RainTomorrow
01/12/2008	Albury	13.4	22.9	0.6	71	22	1007.7	1007.1	16.9	21.8	No	No
02/12/2008	Albury	7.4	25.1	0	44	25	1010.6	1007.8	17.2	24.3	No	No
03/12/2008	Albury	12.9	25.7	0	38	30	1007.6	1008.7	21	23.2	No	No
04/12/2008	Albury	9.2	28	0	45	16	1017.6	1012.8	18.1	26.5	No	No
05/12/2008	Albury	17.5	32.3	1	82	33	1010.8	1006	17.8	29.7	No	No
06/12/2008	Albury	14.6	29.7	0.2	55	23	1009.2	1005.4	20.6	28.9	No	No
07/12/2008	Albury	14.3	25	0	49	19	1009.6	1008.2	18.1	24.6	No	No
08/12/2008	Albury	7.7	26.7	0	48	19	1013.4	1010.1	16.3	25.5	No	No
09/12/2008	Albury	9.7	31.9	0	42	9	1008.9	1003.6	18.3	30.2	No	Yes
10/12/2008	Albury	13.1	30.1	1.4	58	27	1007	1005.7	20.1	28.2	Yes	No
11/12/2008	Albury	13.4	30.4	0	48	22	1011.8	1008.7	20.4	28.8	No	Yes
12/12/2008	Albury	15.9	21.7	2.2	89	91	1010.5	1004.2	15.9	17	Yes	Yes
13/12/2008	Albury	15.9	18.6	15.6	76	93	994.3	993	17.4	15.8	Yes	Yes

⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮ ⋮

Figure: "MinTemp" is an example of continuous attribute, while "RainToday" is an example of categorical attribute (Yes = 1, No = 0).

Data - Preprocessing

Preprocessing: prepare and manipulate data to make them suitable for the model.
Why Preprocessing:

- **Data cleaning**. Identifying and correcting inconsistencies in the data.
- **Data transformation**. Converting the data into a suitable format
- **Data reduction**. Reducing the size of the dataset preserving as much as you can the important information
- **Data Normalization**. Scaling the data to a common range (usually between 0 and 1 or -1 and 1).

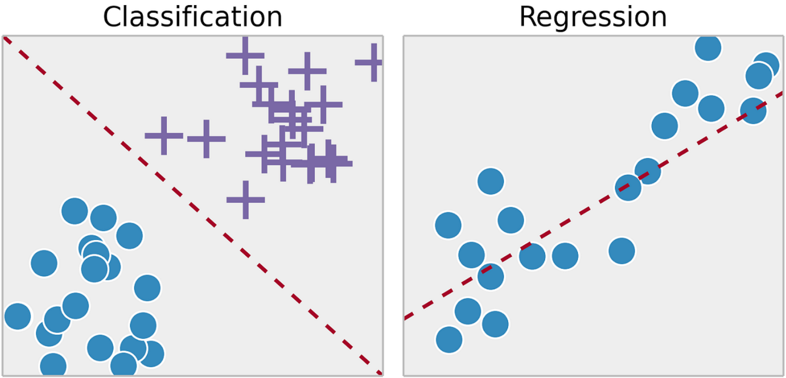
Tasks - Supervised Learning

The task is the purpose of the application.

Supervised learning consitutes of task where the dataset contains features, but each example is also associated with a **target** (also called label).
The term supervised learning originates from the view of the target being provided by an instructor or teacher who shows the ML system what to do.
Two type of supervised learning problems:

- **Regression**. Predict results within a continuous output.
  Example: Predict the price of an house given its size.
- **Classification**. Predict which categories/classes the input belongs to (categorical data).
  Example: Given an email, predict if it is spam or not (*binary classification*)

Supervised Learning - an example



Tasks- Unsupervised Learning

Unsupervised learning tasks experience a dataset containing many features, then learn useful properties of the structure of this dataset (**unlabeled data**). In other terms, we have to derive structure and different relationships from data.

Examples:

- Take a collection of essays and find a way to automatically group them based on word frequency, sequence length, page counts etc.
- Recommender systems. Automatically provide suggestions for an item that is most pertinent to a particular user.

Unsupervised Learning - an example

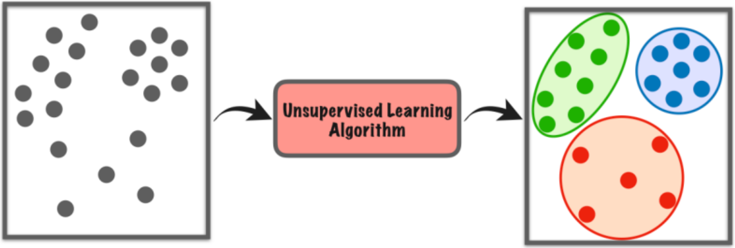


Figure: A clustering example.

Model

A **model** is an abstract representation of a system using mathematical concepts. In the present context, the model operates on data to solve the task.

Hypotheses: a candidate model for the task.
Hypotheses space: the class of hypotheses that the learning algorithm (see later) can produce.

No free lunch theorem (idea): no machine learning algorithm is universally any better than any other.

Learning algorithm

A machine learning algorithm, in brief **learning algorithm**, is an algorithm that is able to learn from data.

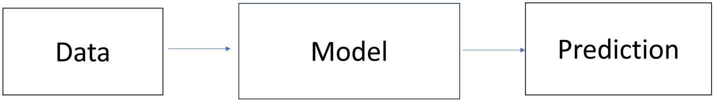
Based on: data, task and model.

To evaluate the abilities of a learning algorithm, we must design a quantitative measure of its performance. Usually this performance measure P is specific to the task being carried out by the system.

The performance measure is called *cost function* (or *loss function*).

Example: a performance measure for the classification tasks is the **accuracy**. Accuracy is just the proportion of examples for which the model produces the correct output.

ML road map



Data

Model

Prediction

-How much data?
- Should I *pre-process* my data?
-Is the data *balanced*?

-What is the *task*?
-Which *learning algorithm* will I use?
-How to *validate my model?*

What is the performance on
unseen data?