Class
Artificial Intelligence

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Course evaluation criteria

Third time's a charm

30%	Final project	Project Code			50%
		Project document			30%
		Project presentation			20%
70%	Theoretical course	33%	1st term	Test	70%
				1st project	30%
		33%	2nd term	Test	30%
				2nd project	70%
		34%	Final term	Test	100%

The road so far

- **Uninformed Search Strategies**
  - Have no clue about how close a state is to the goal(s)
  - The search order does not depend on the nature of the solution
- **Informed (Heuristic) Search Strategies**
  - Uses domain-specific hints about the location of goals
  - The hints come in the form of a heuristic function
- **Local search algorithms and Optimisation Problems**
  - The path to the goal does not matter, so do not worry about paths at all
  - Operate using a single current state (rather than multiple paths) and generally move only to neighbours of that state

Somewhere down the road

- Game theory
- Monte Carlo tree search
- Constrain satisfaction problems
- Logical agents
- First-order logic
- Planning
- Ontologies
- Uncertain knowledge and reasoning
- Multiagent decision making

Now

Machine Learning

Machine Learning

- An agent is learning if it improves its performance after making observations about the world

- When the agent is a computer, we call it machine learning:
  - Observes some data
  - Builds a model based on the data
  - Uses the model as both a hypothesis about the world and a piece of software that can solve problems

Machine Learning

- Why would we want a machine to learn?
- Why not just program it the right way to begin with?

Taken from
https://www.ecured.cu/Clarividencia

Taken from
https://www.momtastic.com/babies/newborns/101560-do-babies-recognize-themselves-in-the-mirror/

Machine Learning

Components of an agent	Learning process example
A direct mapping from conditions on the current state to actions	Every time the driver brakes, the agent might learn a condition-action rule for when to brake
A means to infer relevant properties of the world from the percept sequence	By seeing many camera images that it is told contain buses, it can learn to recognize them
Information about the way the world evolves and about the results of possible actions the agent can take	By trying actions and observing the results, for example, braking hard on a wet road, it can learn the effects of its actions
Utility information indicating the desirability of world states	When it receives complaints from passengers who have been thoroughly shaken up during the trip, it can learn a useful component of its overall utility function
Action-value information indicating the desirability of actions	
Goals that describe the most desirable states	
A problem generator, critic, and learning element that enable the system to improve	

Taken from https://www.researchgate.net/figure/View-from-inside-an-artificial-Moral-Agent-ie-a-Tesla-self-driving-car-7_fig2_324546836

Machine Learning

- Induction = Going from a specific set of observations to a general rule

- If the sun rose every day in the past, we induce that the sun will come up tomorrow

- Induction ≠ Deduction
  - The inductive conclusions may be incorrect, whereas deductive conclusions are guaranteed to be correct if the premises are correct

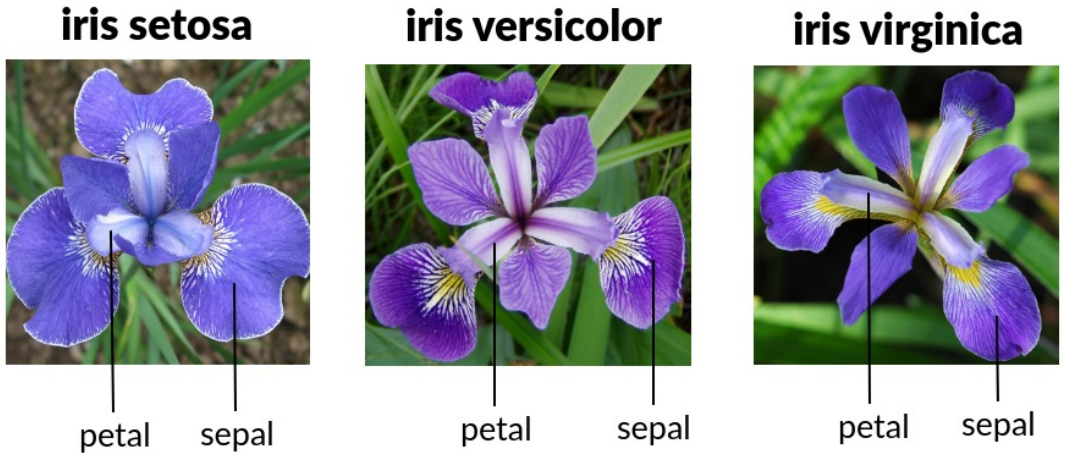
Machine Learning

- Types of input can be of any kind of data structure, including atomic and relational

- A common of input type is a factored representation => A vector of attribute values

Machine Learning

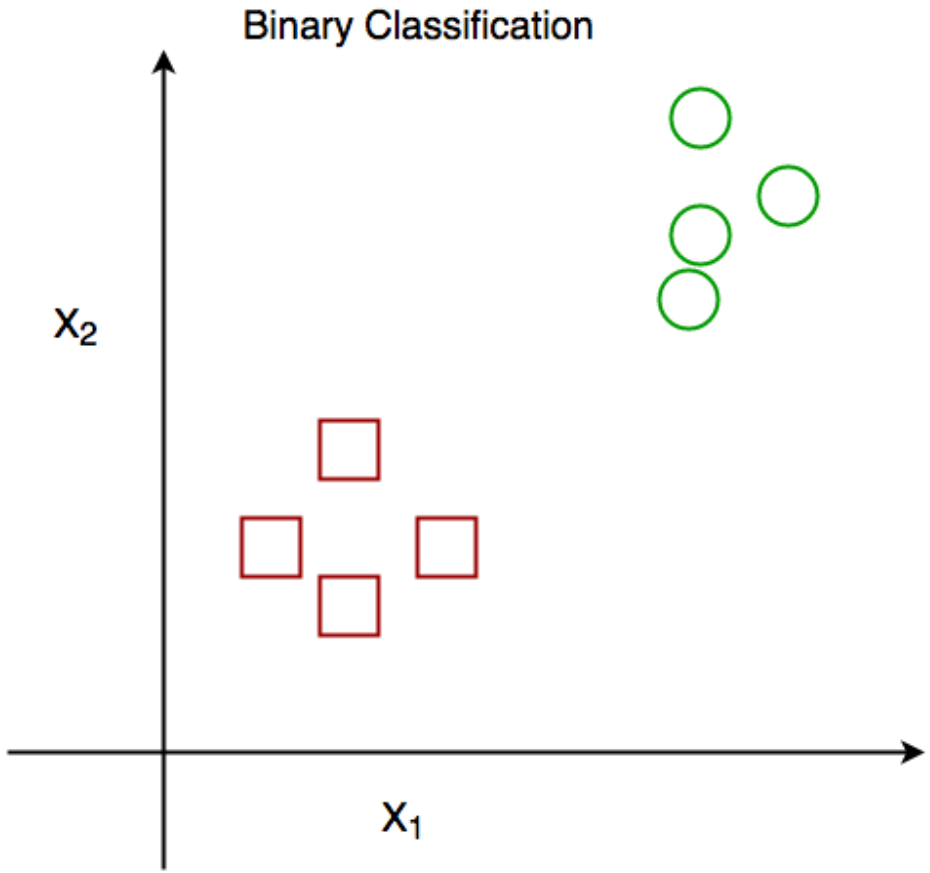
- We can address two types of problems:
  - **Classification**
    - Output is one of a finite set of values such as sunny/cloudy/rainy or true/false



Taken from https://www.analyticsvidhya.com/blog/2022/06/iris-flowers-classification-using-machine-learning/

Machine Learning

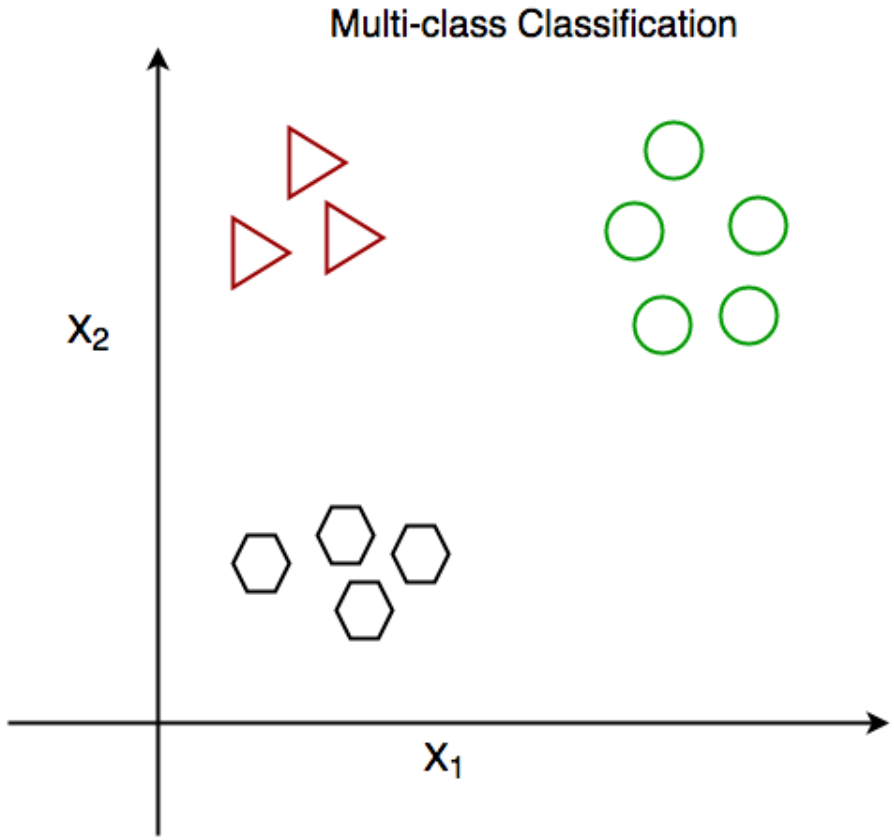
- **Classification**
  - Binary Classification



Taken from https://www.geeksforgeeks.org/getting-started-with-classification/

Machine Learning

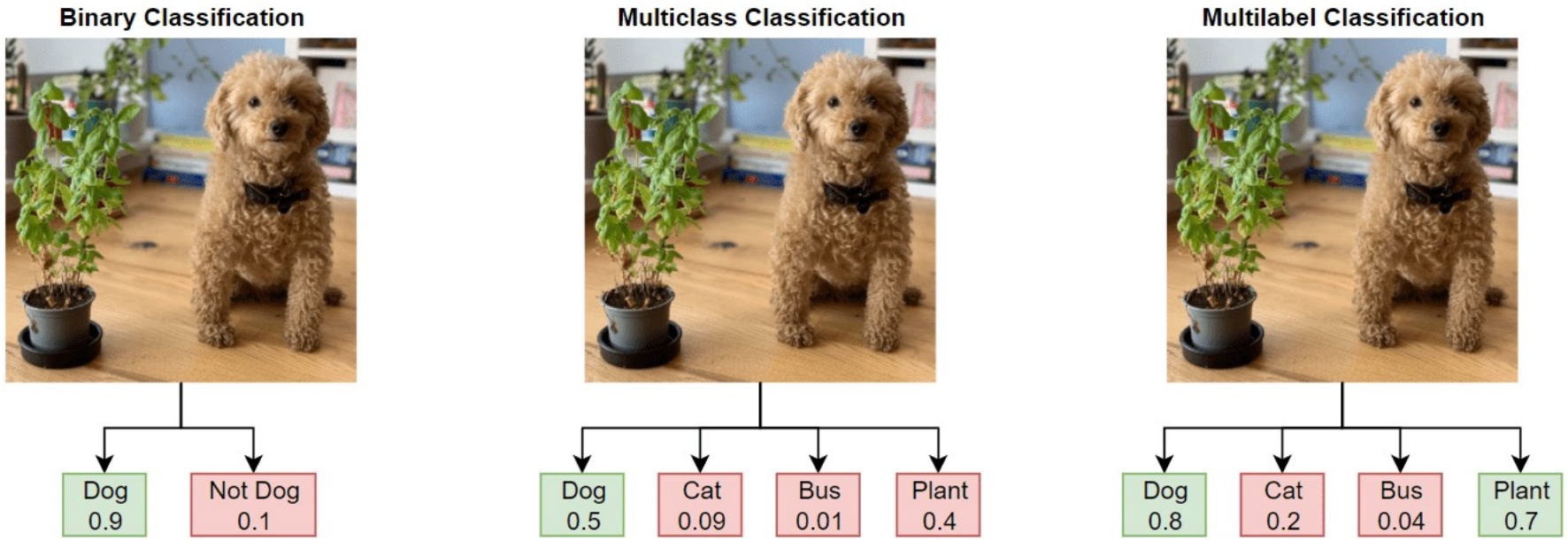
- **Classification**
  - Multi-Class Classification



Taken from https://www.geeksforgeeks.org/getting-started-with-classification/

Machine Learning

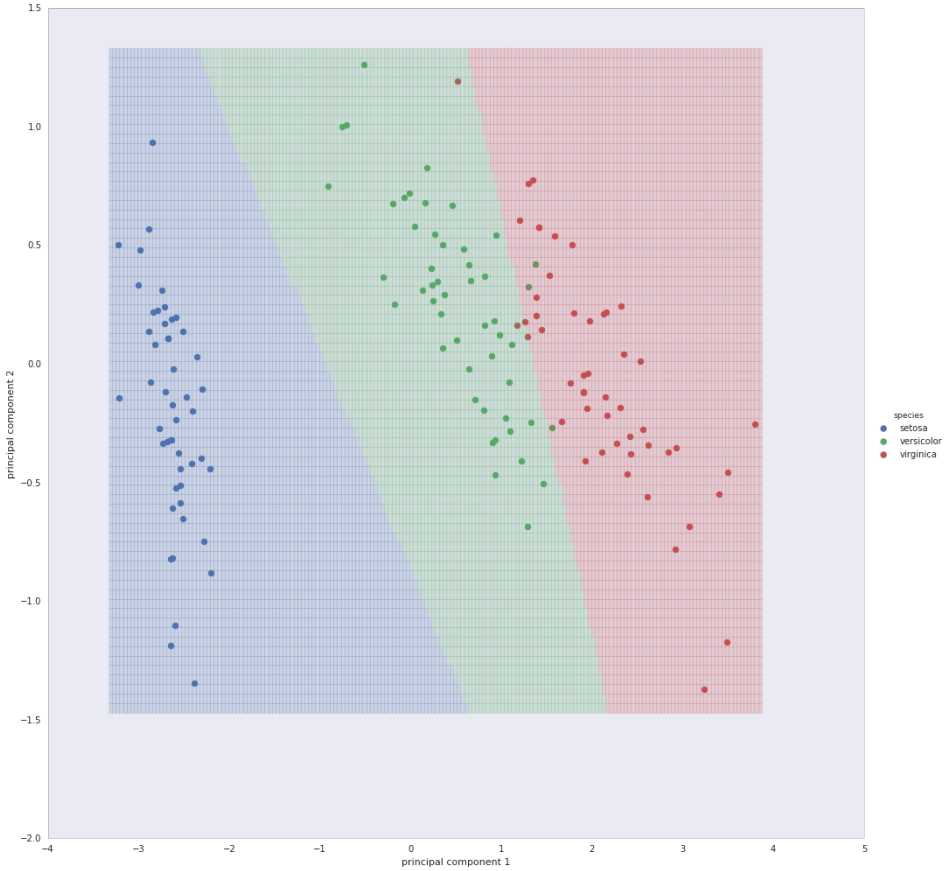
- **Classification**
  - Multi-Label Classification



Taken from https://la.mathworks.com/help/deeplearning/ug/multilabel-image-classification-using-deep-learning.html

Machine Learning

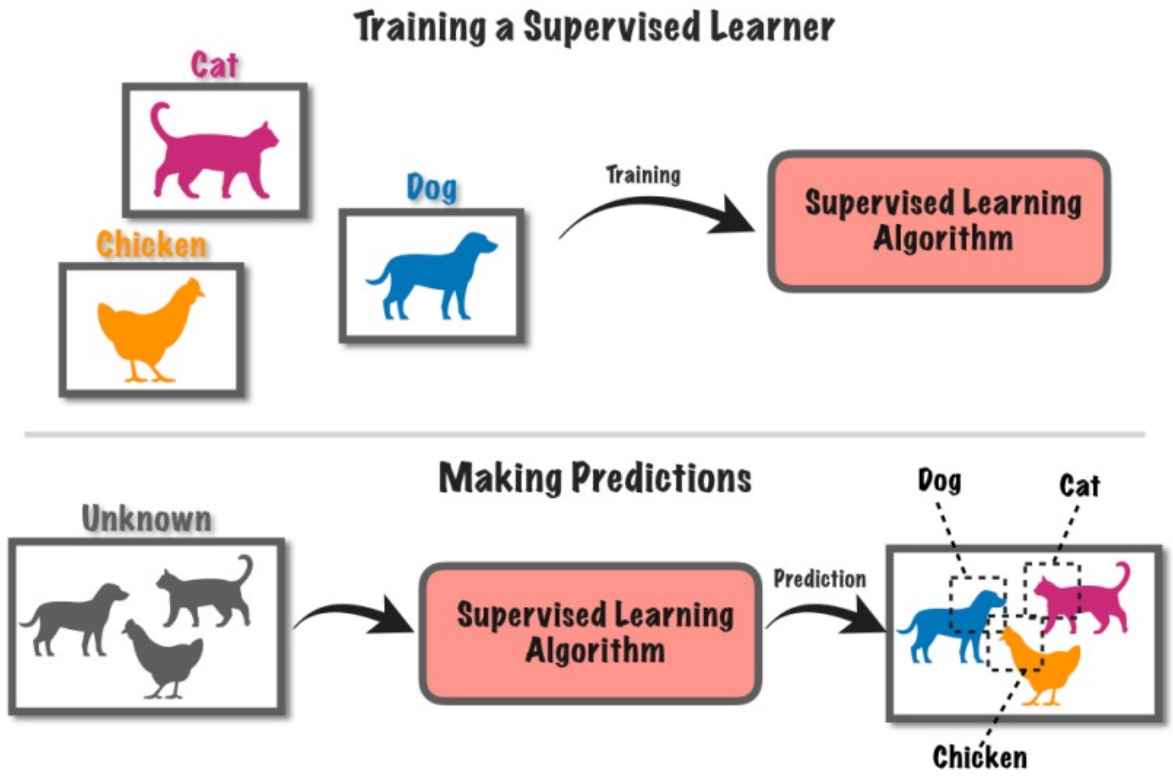
- We can address two types of problems:
  - **Regression**
    - Output is a number such as tomorrow's temperature, measured either as an integer or a real number



Taken from http://gavinln.github.io/blog-site/post/scikit-logistic_reg-iris/

Machine Learning

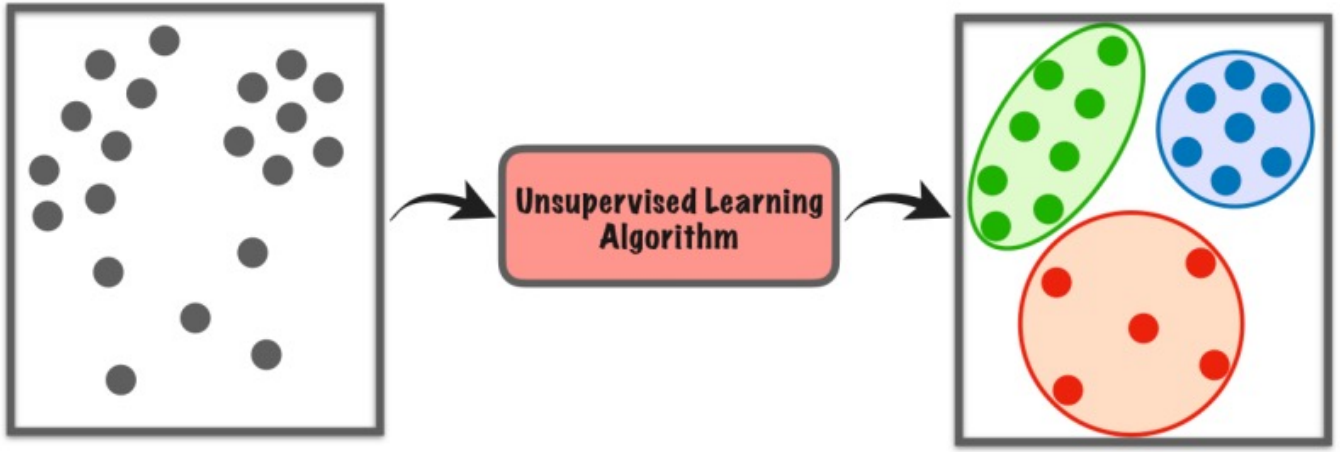
- Three main types of learning:
  - **Supervised learning**
    - The agent observes input-output pairs and learns a function that maps from input to output



Taken from https://towardsdatascience.com/supervised-vs-unsupervised-learning-in-2-minutes-72dad148f242

Machine Learning

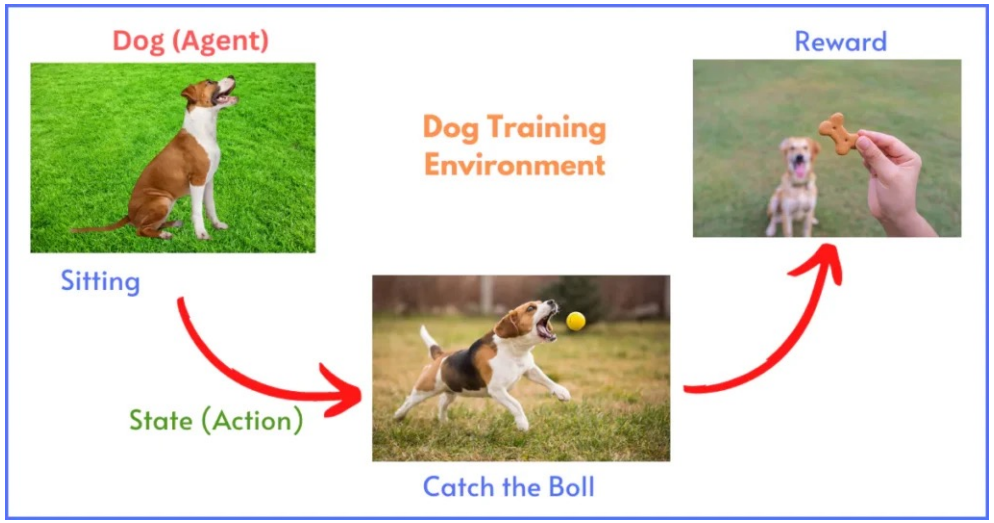
- Three main types of learning:
  - **Unsupervised learning**
    - The agent learns patterns in the input without any explicit feedback



Taken from https://towardsdatascience.com/supervised-vs-unsupervised-learning-in-2-minutes-72dad148f242

Machine Learning

- Three main types of learning:
  - **Reinforcement learning**
    - The agent learns from a series of reinforcements: rewards and punishments



Taken from https://thinkinfi.com/what-is-reinforcement-learning-in-machine-learning/

Machine Learning

Supervised learning

Supervised learning

- More formally, the task of supervised learning is this:

Given a **training set** of N example input–output pairs

$$(x_1, y_1), (x_2, y_2), \ldots (x_N, y_N)\,,$$

Training set

where each pair was generated by an unknown function $y = f(x)$, discover a function h that approximates the true function f.

The function is called a **hypothesis** about the world

Supervised learning

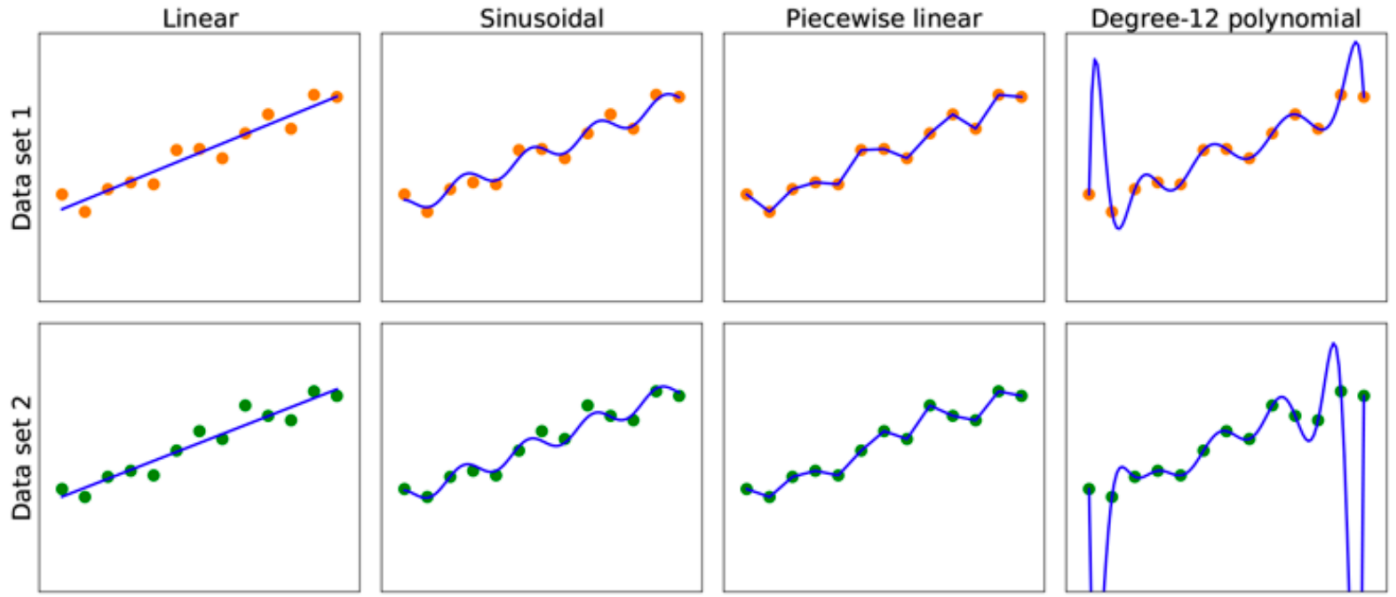
COLUMN 1: Straight lines; functions of the form $h(x) = w_1 x + w_0$. There is no line that would be a consistent hypothesis for the data points.

COLUMN 2: Sinusoidal functions of the form $h(x) = w_1 x + \sin(w_0 x)$. This choice is not quite consistent, but fits both data sets very well.

COLUMN 3: Piecewise-linear functions where each line segment connects the dots from one data point to the next. These functions are always consistent.

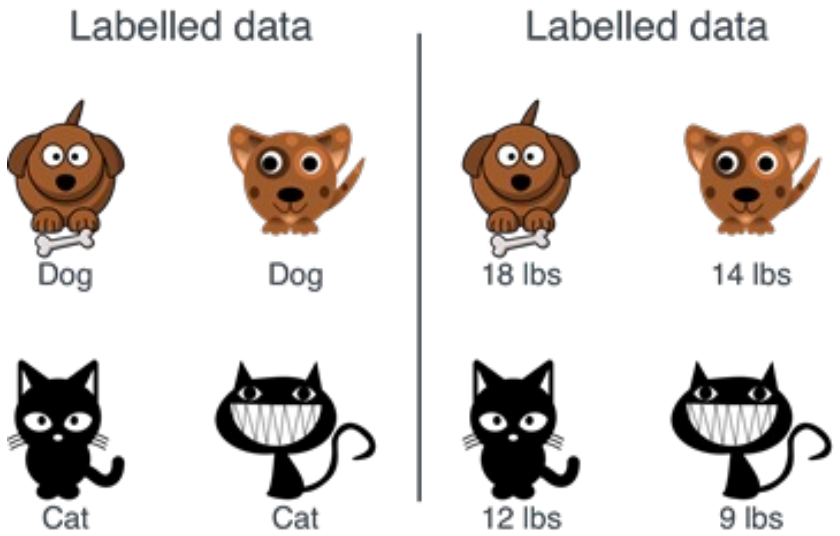
COLUMN 4: Degree-12 polynomials, $h(x) = \sum_{i=0}^{12} w_i x^i$. These are consistent: we can always get a degree-12 polynomial to perfectly fit 13 distinct points. But just because the hypothesis is consistent does not mean it is a good guess.

- About the hypothesis



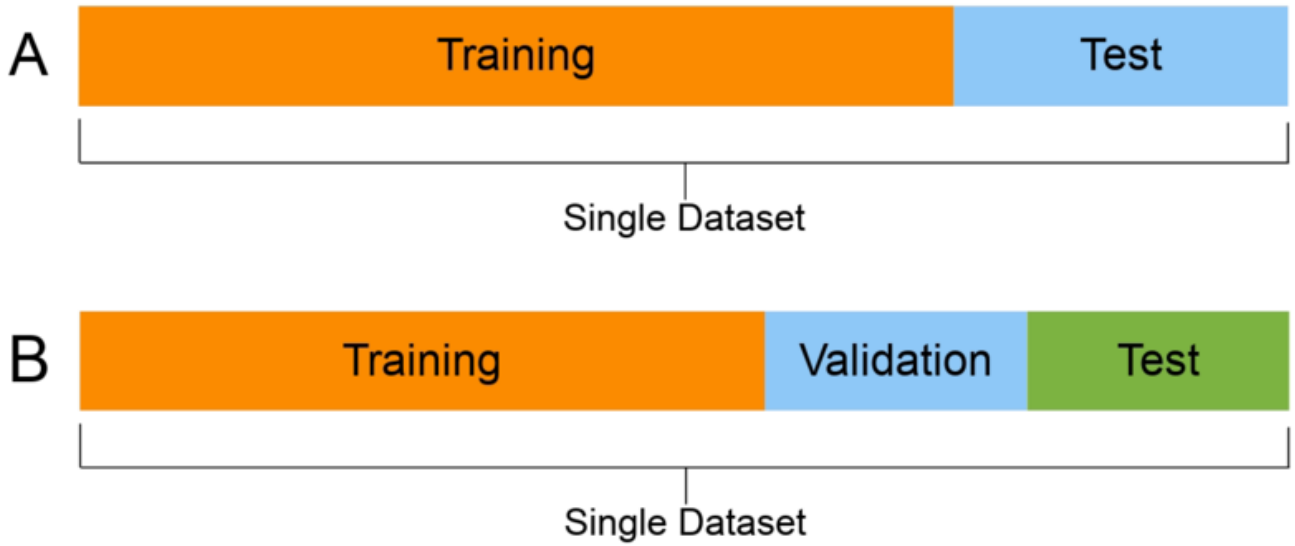
Supervised learning

- About the data



Ground truth

Taken from https://livebook.manning.com/book/grokking-machine-learning/2-1-what-is-the-difference-between-labelled-and-unlabelled-data-/v-4/

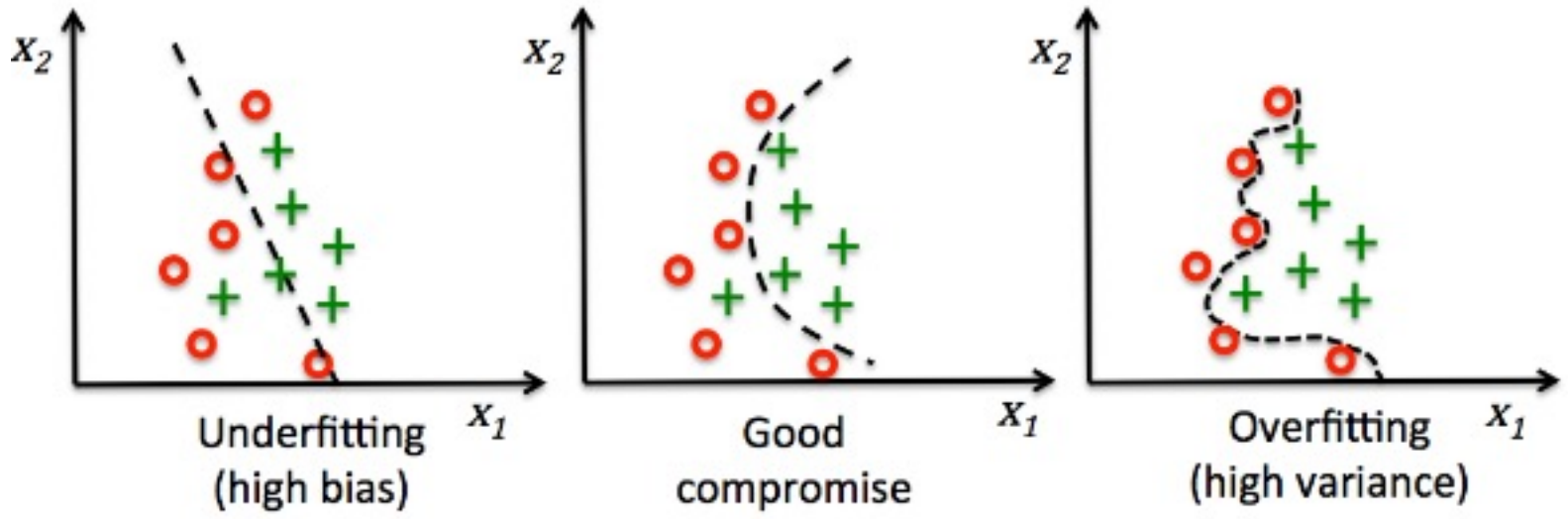


Taken from https://commons.wikimedia.org/wiki/File:ML_dataset_training_validation_test_sets.png

Supervised learning

- The hypothesis generalizes well if it accurately predicts the outputs of the test set

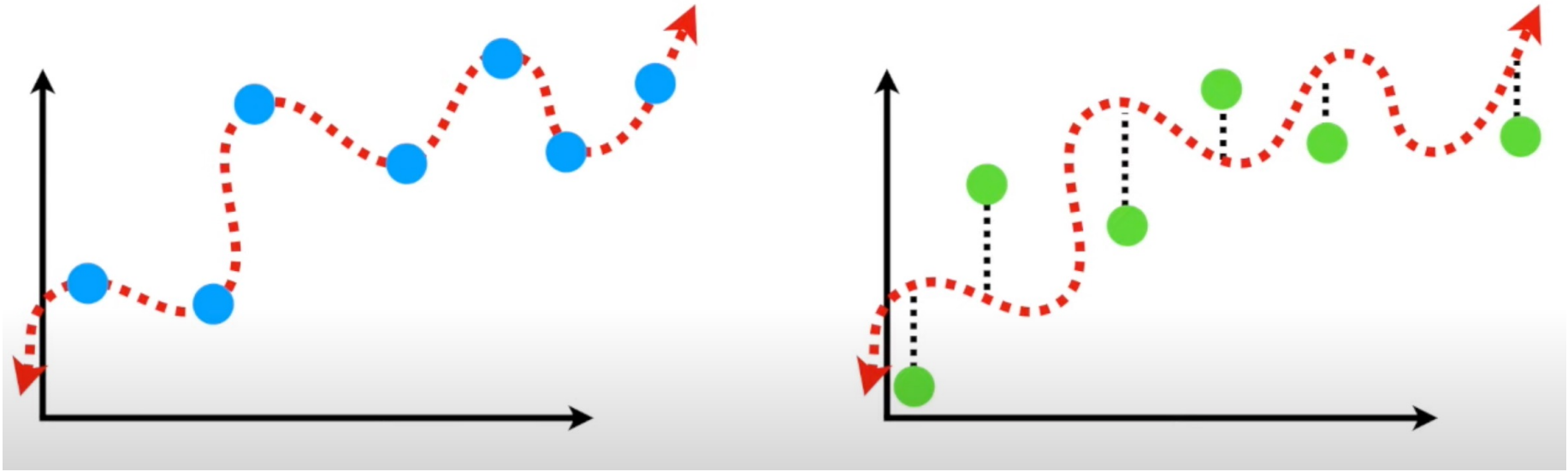
- Bias (loosely) is the tendency of a predictive hypothesis to deviate from the expected value when averaged over different training sets



Taken from https://www.kdnuggets.com/2019/07/bias-machine-learning-bad.html

Supervised learning

- Variance is the amount of change in the hypothesis due to fluctuation in the training data.



Taken from https://www.youtube.com/watch?v=EuBBz3bI-aA

Machine Learning

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Supervised learning

Practice Weka