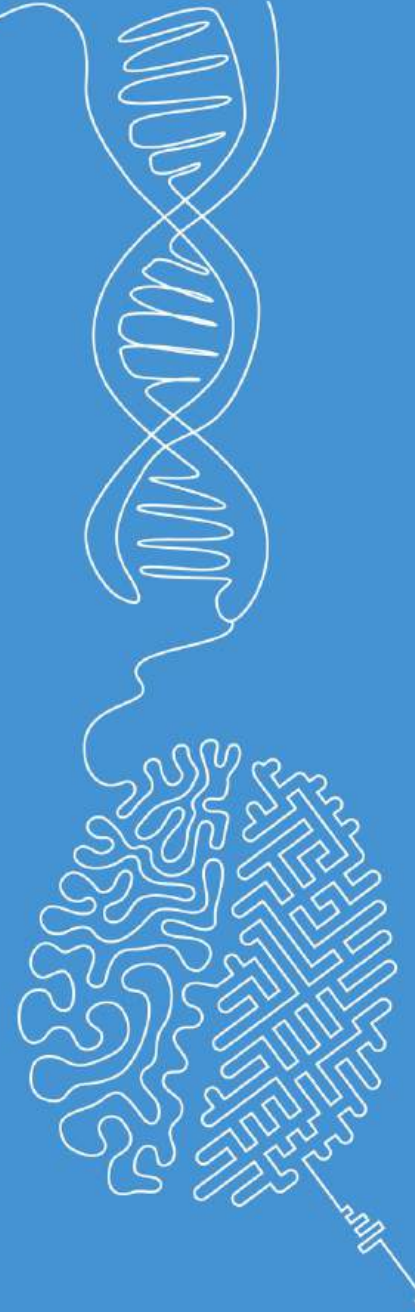


Introduction

Machine Learning

Norman Juchler



Learning objectives

- ML impacts many aspects of our lives!
- ML / AI: Definition and differentiation
- The basic structure of a ML model
- Different ML paradigms

Introduction

What is artificial intelligence?

ML/AI are changing everything

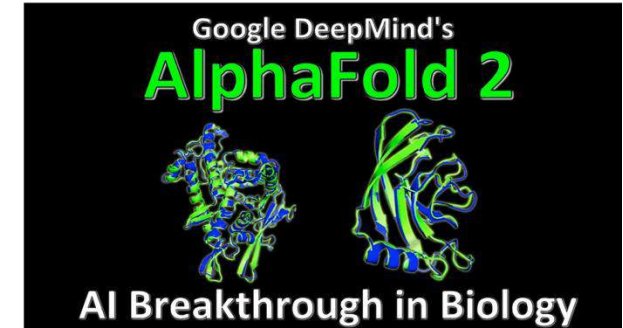
Recommender Systems



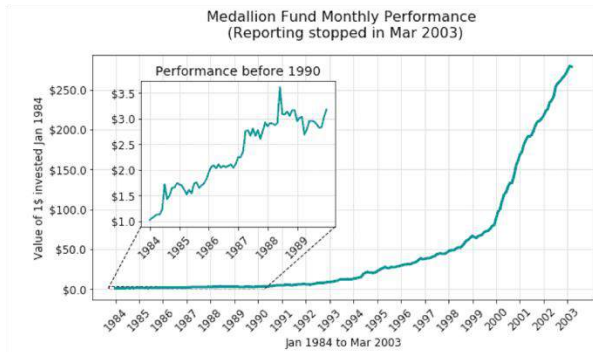
Beating Humans at GO



Predicting protein structure



Automated Trading



Language Translation

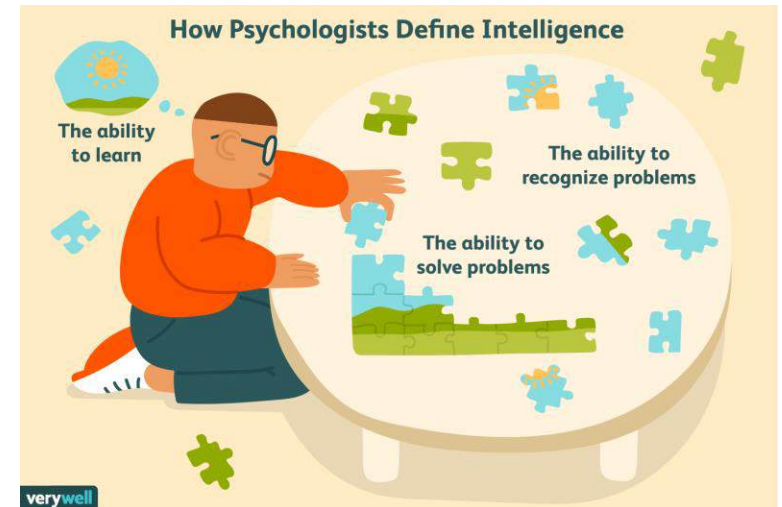


Self-driving Cars



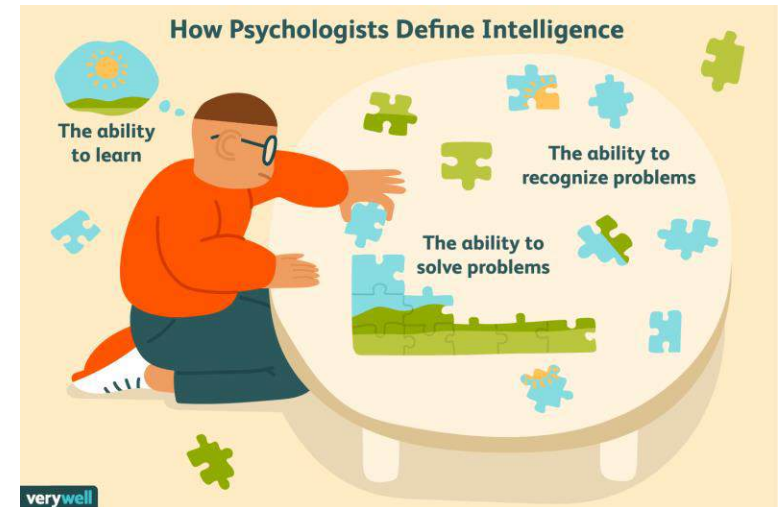
What is intelligence?

- The word intelligence derives from *intelligere*, Latin for: to comprehend or perceive
- Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn from experience, and to apply knowledge to manipulate one's environment. ([Source](#))
- Intelligence in psychology: Ability to... ([Source](#))
 - ...learn from experience: Acquisition, retention, and use of knowledge is an important component of intelligence.
 - ...recognize problems: To use knowledge, people first must identify the problems it might address.
 - ...solve problems: People must then use what they have learned to come up with solutions to problems.



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- Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn from experience, and to apply knowledge to manipulate one's environment. ([Source](#))
- Intelligence in psychology:
 - Memorization
 - Pattern recognition
 - Generalization



What is artificial intelligence?

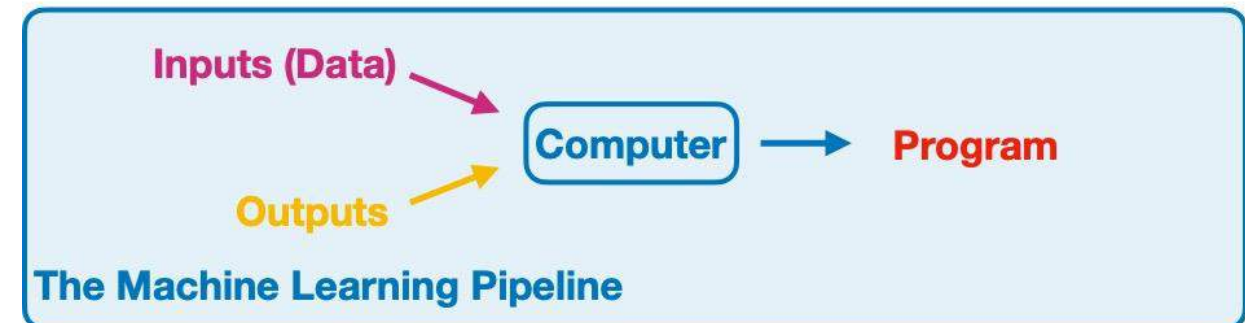
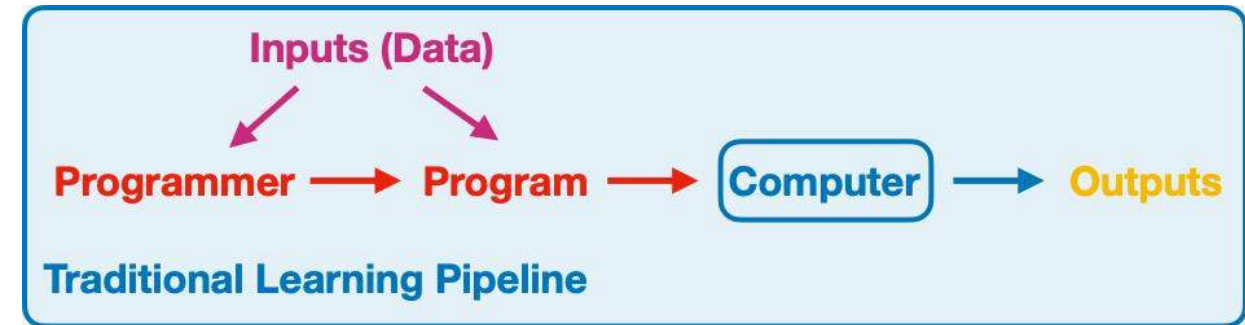


Machine learning is the field of study that gives computers the ability to learn without being explicitly programmed.

Arthur L. Samuel, AI pioneer, 1959

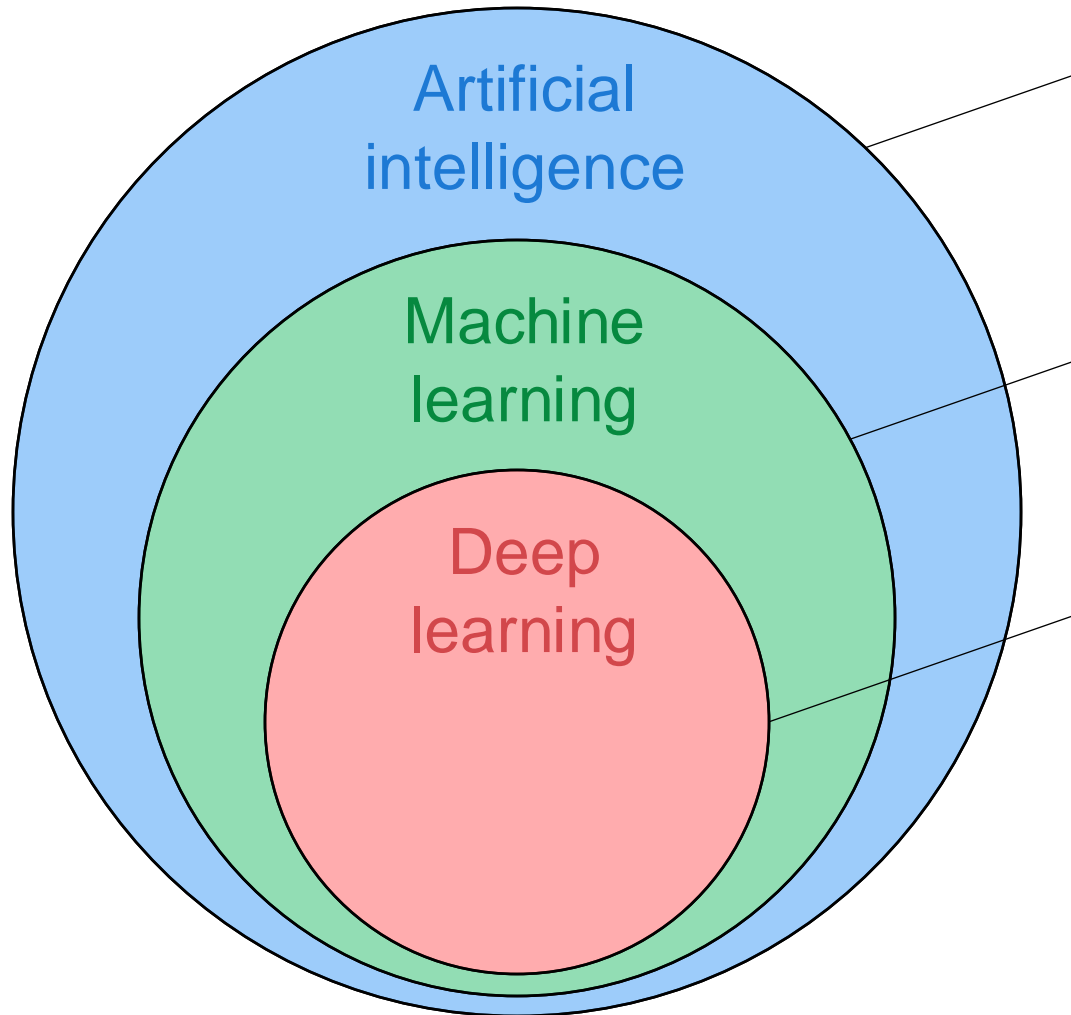
Software 2.0

- Machine learning enables a new paradigm in software development.
- Software 1.0: Rules and logic to make predictions, given the data, are explicitly programmed.
- Software 2.0: Developers create or curate datasets and train models to make decisions, predictions, or optimizations.



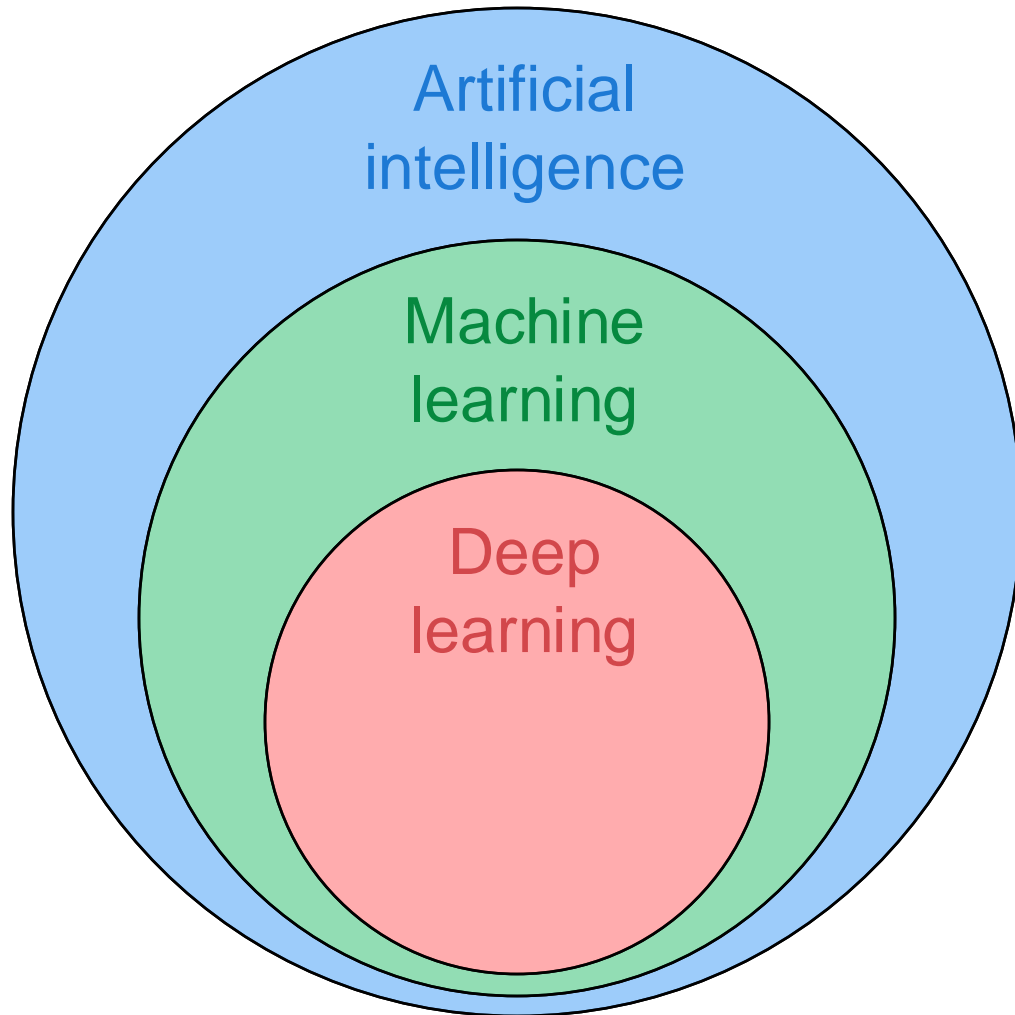
If you want to know more about it:
Article about Software 2.0 (by Andrej Karpathy): [Link](#)

What is artificial intelligence?



- Techniques to enable computer systems to imitate intelligent human behavior.
 - Goal: Solve tasks humans are good at, like sensing, reasoning, acting, adapting...
- Subset of AI techniques which use statistical methods to enable machines to learn and improve from experience
- Application of machine learning based on algorithms with brain-like logical structure called artificial neural networks.

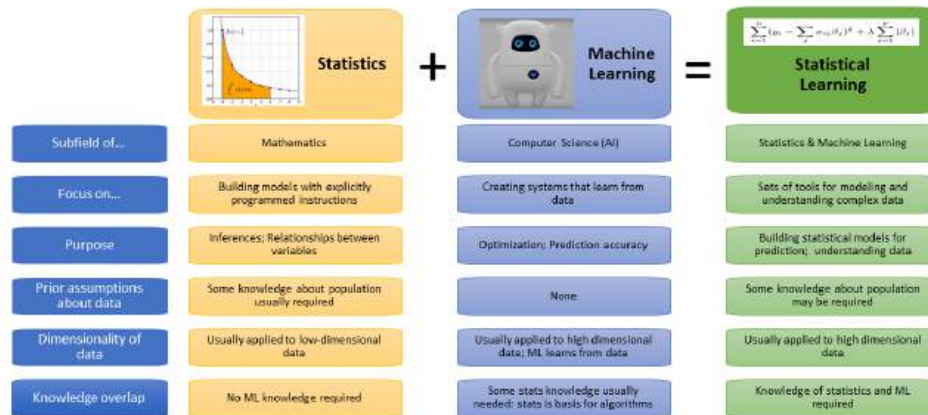
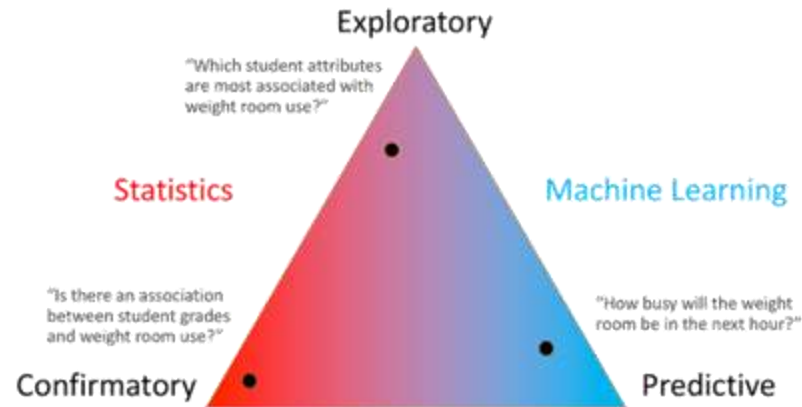
What is artificial intelligence?



Distinctions:

- **Statistics \neq machine learning**
 - ML: the focus is on prediction
 - Statistics: focus is on inference
 - ML theory and algorithms rely on statistics and probability theory
 - ML often makes fewer formal assumptions about data
- **Machine learning \neq statistical learning**
 - The terms are often used interchangeably, but have slightly different meanings
 - SL: includes the formulation of stochastic models for the data generating processes
 - SL: besides the use for prediction, the focus is also on formally understanding the data

What is artificial intelligence?



Musio Image: Aikawipic [CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>)]

Distinctions:

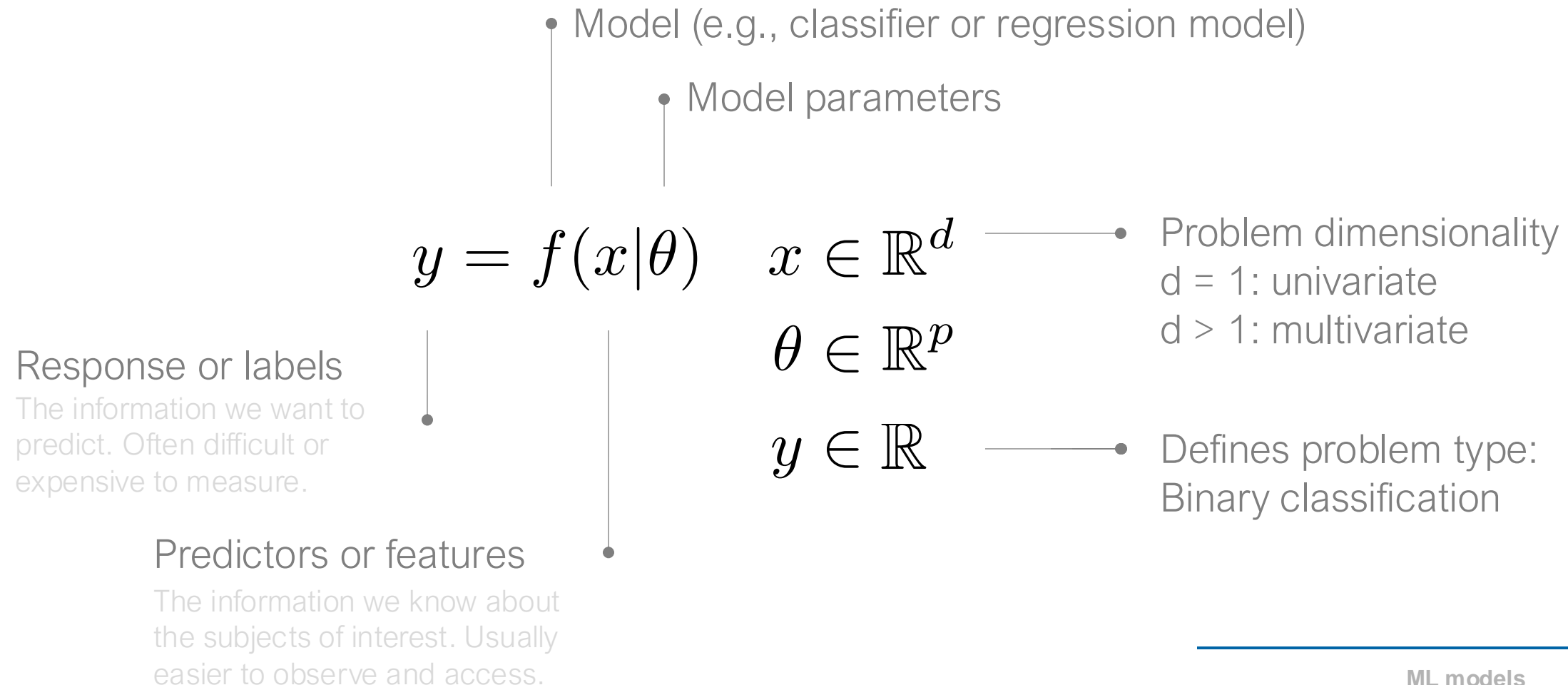
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Source: stats.stackexchange.com

**So what is a machine learning
model?**

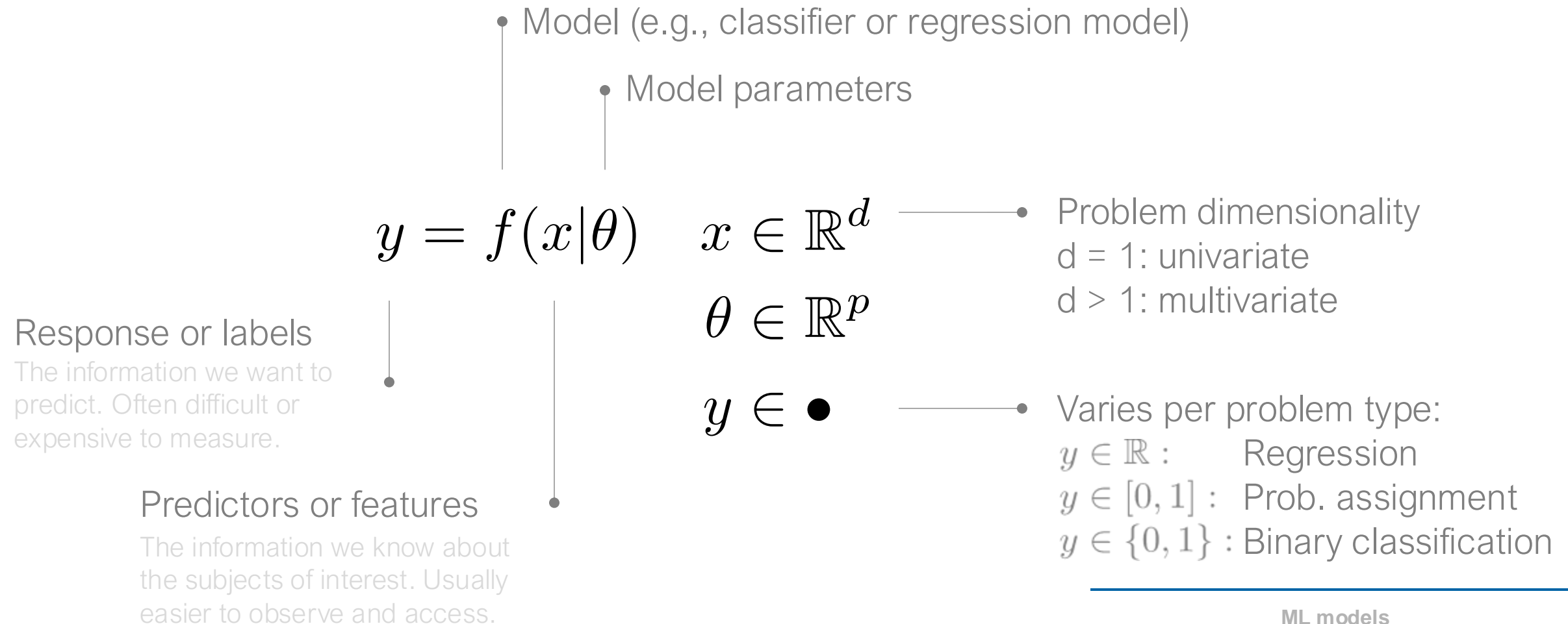
Formal introduction

- In ML, a **model** is a mathematical representation, function or algorithm that defines the relationship between input data and the desired output.



Formal introduction

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Example: Linear regression

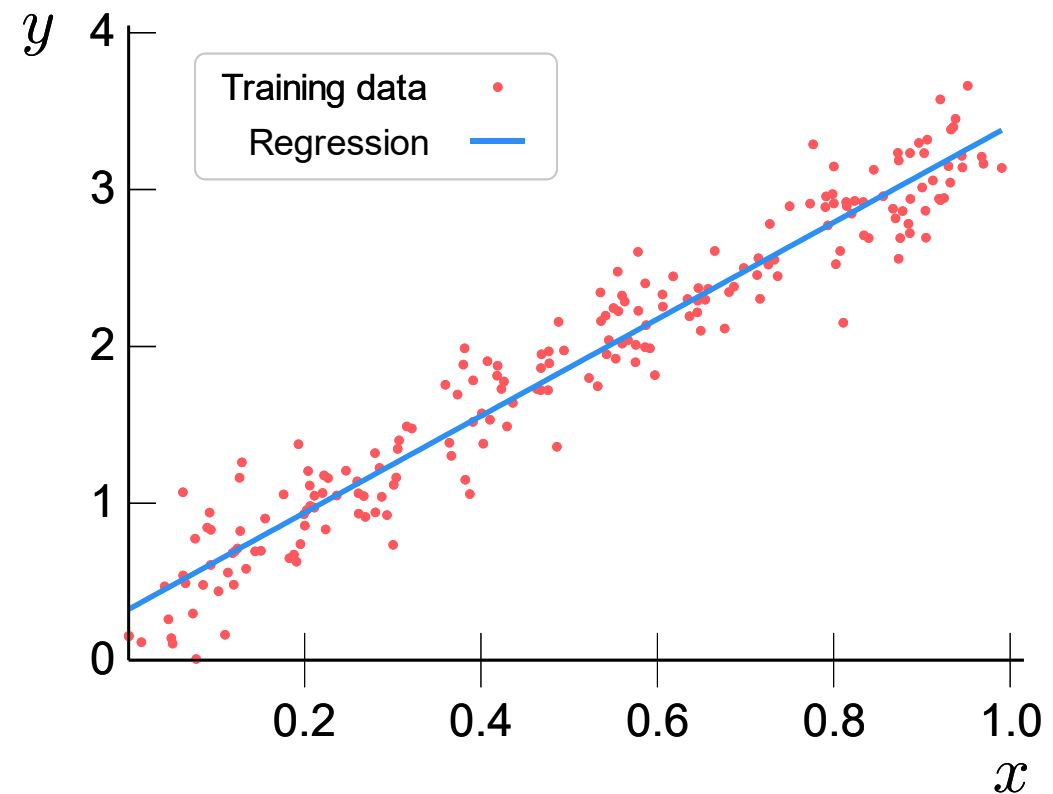
- **Available data:**

- x : Amount of chocolate consumed (observable)
- y : Reported happiness (difficult to measure)

- **Aim:** Develop a model to predict a person's happiness once we know their chocolate consumption.

- **Assumption:** The relation is linear!

- Model: $y = f(x|\theta) = mx + q$
- Model parameter: $\theta = (m, q)$



Model training

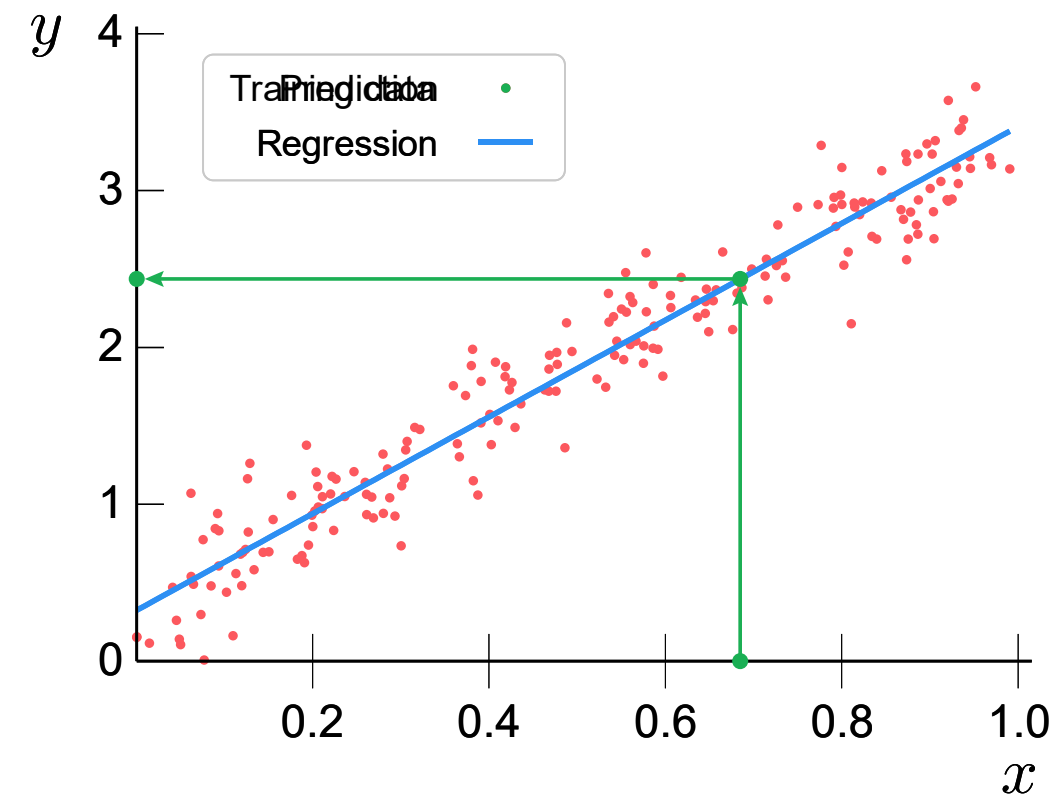
- The model is trained using data to learn patterns or correlations, enabling it to make predictions, classifications, or decisions when provided with new, unseen data.
- During training, learning happens!
- More formally, training refers to the process of finding optimal model parameters (or model weights) θ^* , given some training data.
- ...optimal with respect to what?
 - We will require an optimality criterion, and performance measures to assess the quality of prediction



Adobe Stock / AI generated

Example: Linear regression

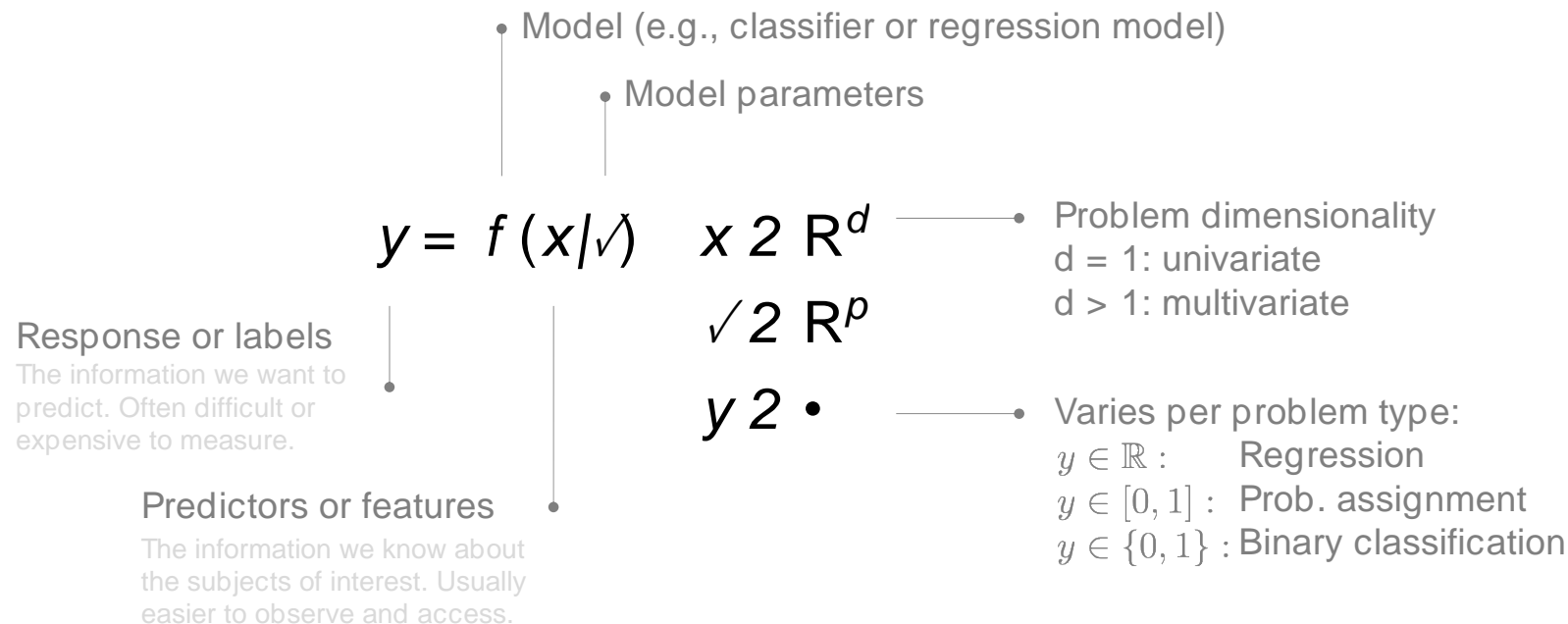
- The basic ML lifecycle
 - Training phase (find optimal model parameters)
 - Testing phase (check model performance)
 - Deployment (utilize the model for predictions)



How would you do it?

Task:

- Choose three different real-world machine learning problems.
- For each of the problems, describe what x and y mean in words.
- Can you say something about f and θ ?



How to use a machine learning model?

$$f(X) = \textit{prediction}$$

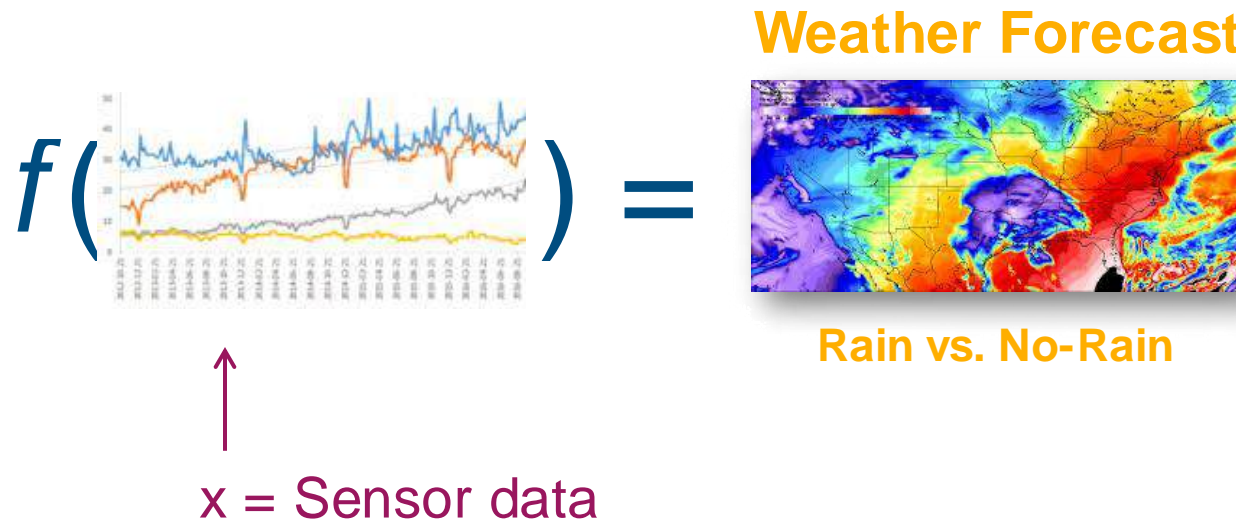
How to use a machine learning model?

$x = \text{X-ray image}$

$f(\text{X-ray image}) = \begin{cases} \text{COVID} & \checkmark \\ \text{Healthy} & \times \end{cases}$



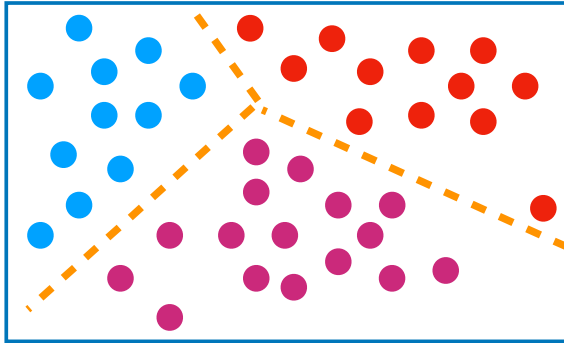
How to use a machine learning model?



Machine learning paradigms

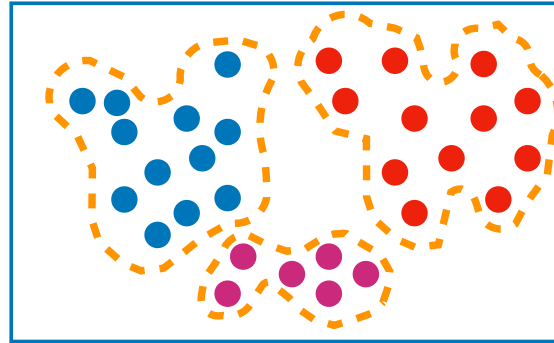
Machine learning paradigms

Supervised Learning



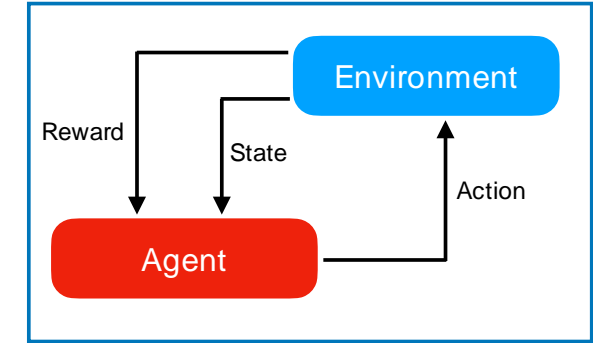
$$\{x_i \in \mathbb{R}^d, y_i \in \mathbb{R}\}_{i=1}^n$$

Unsupervised Learning






$$\{x_i \in \mathbb{R}^d\}_{i=1}^n$$

Reinforcement Learning



Supervised Learning



x_i :   
 y_i : panda lion dog

Unsupervised Learning



x_i : 

Reinforcement Learning



Agent: Kid
 Environment: Neighbourhood street