Hahn Schickard

Visions to Products

What is Artificial intelligence, Machine Learning and Deep Learning?

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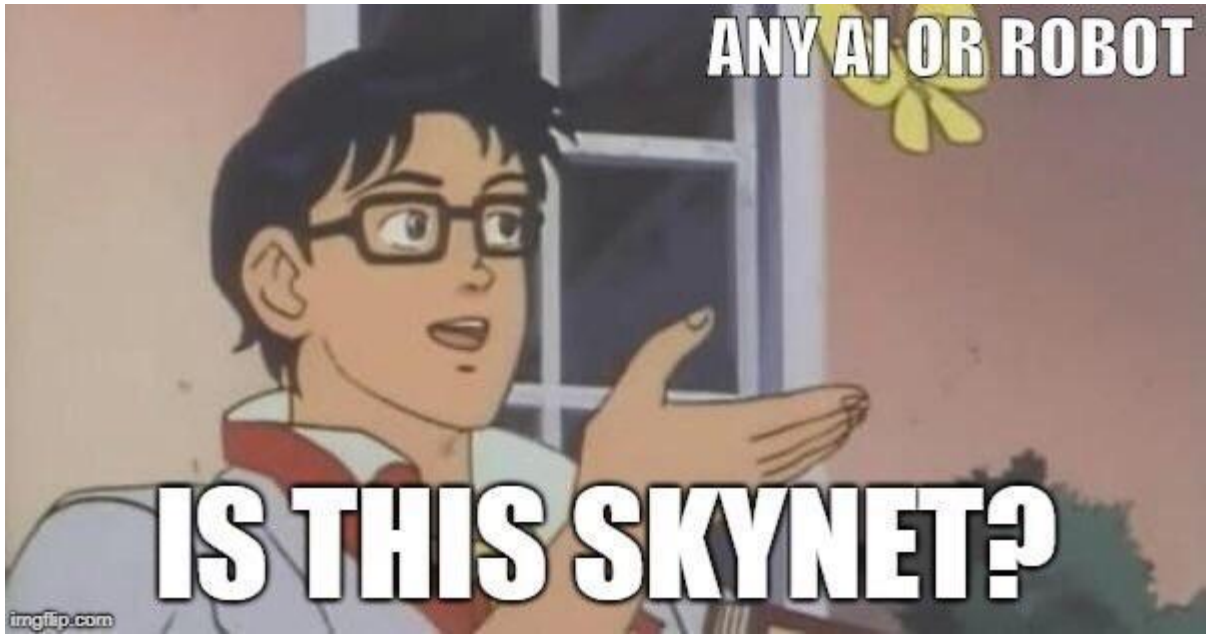
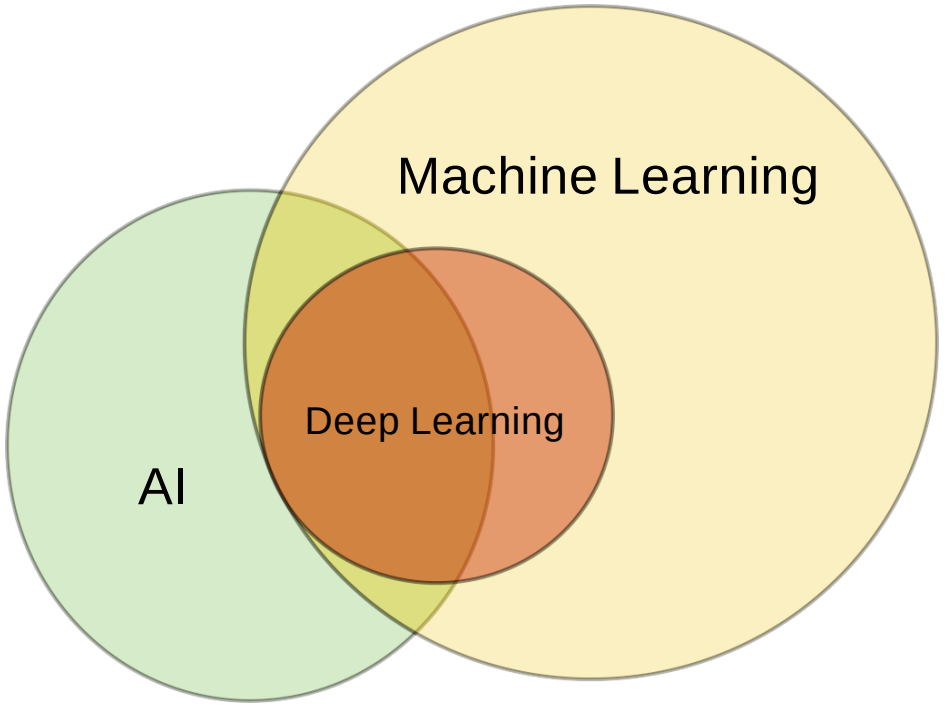
This Session:

- Introduction
- What is Machine Learning?
- Examples
- How Machine Learning works?
- Machine Learning concepts



The Connection Between Fields

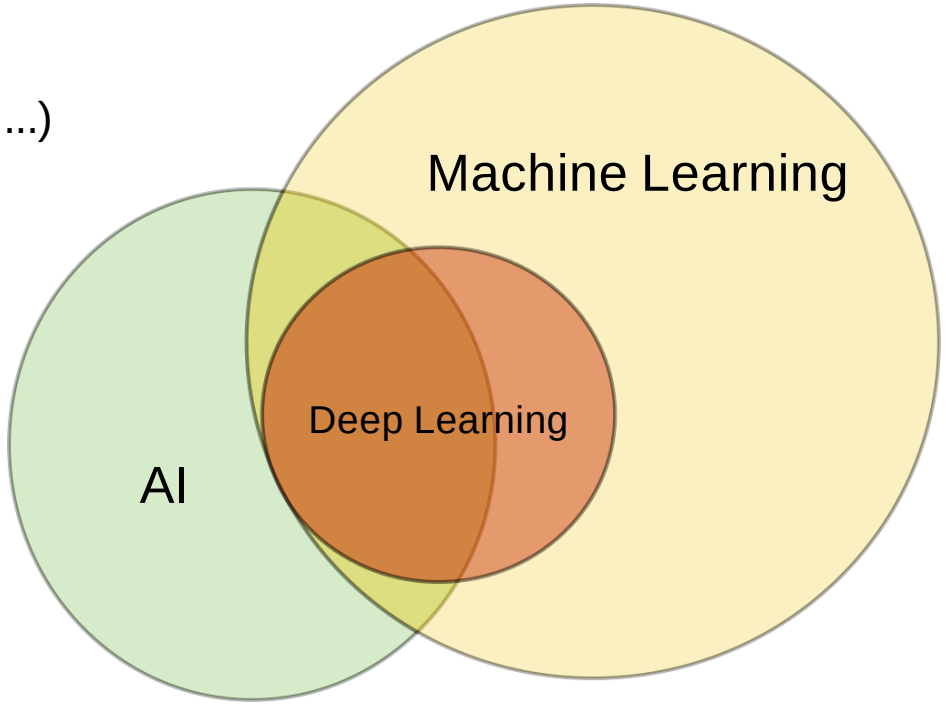


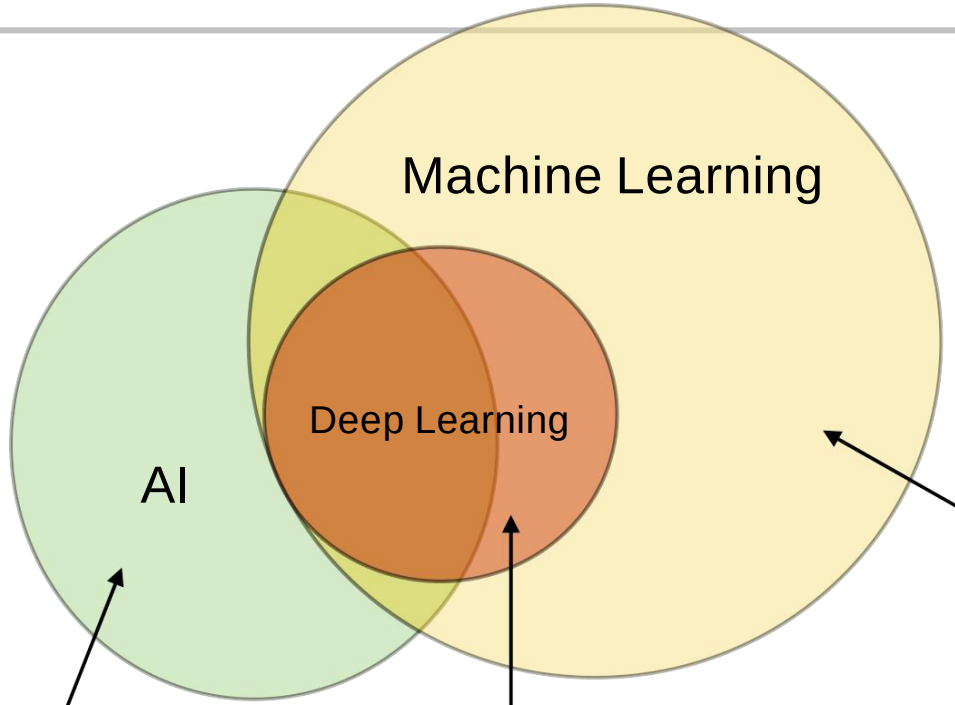
The Connection Between Fields

Artificial Intelligence (AI):
orig. subfield of computer science, solving tasks humans are good at (natural language, speech, image recognition, ...)

Artificial General Intelligence (AGI):
multi-purpose AI mimicking human intelligence across tasks

Narrow AI:
solving "a" task (playing a game, driving a car, ...)

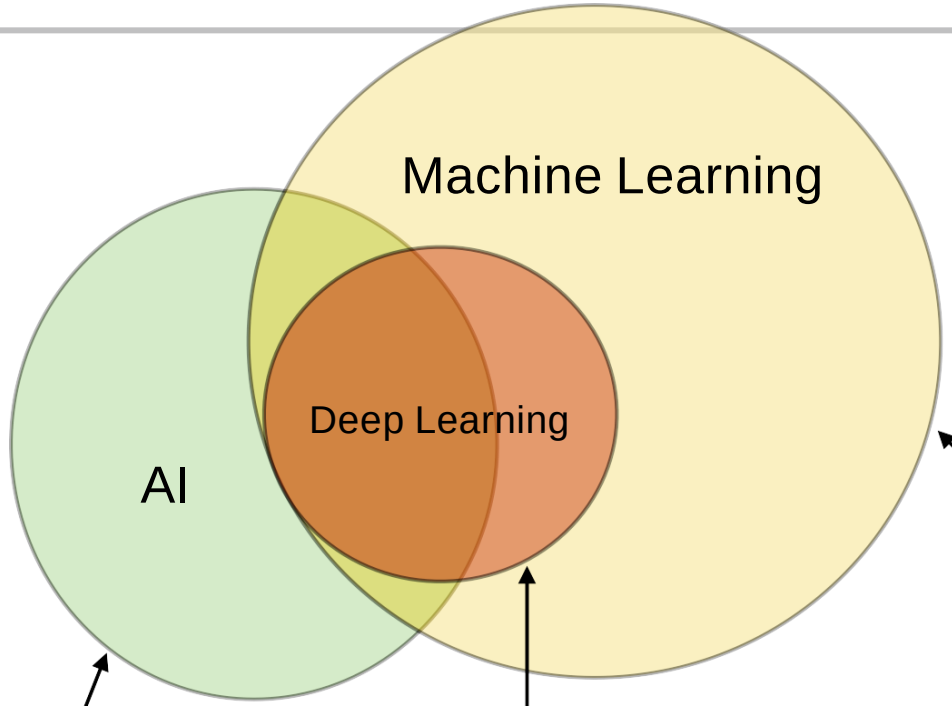




E.g., symbolic expression, logic rules / "handcrafted" nested if-else programming statements ...

Main focus of the course

E.g.,
generalized linear models, tree-based methods, "shallow" networks, SVM, nearest neighbors, ...



= a non-biological system
that is intelligent
through rules

= algorithms that parameterize multi-layers
neural networks that then learn
representations of data with multiple layers
of abstraction

= algorithms that learn
models/representations/
rules automatically
from data/examples

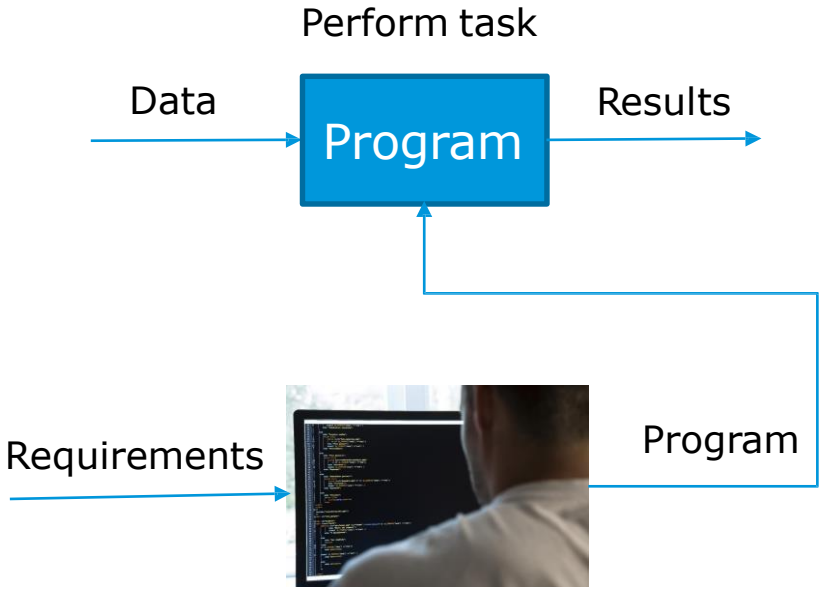
What's Machine Learning?

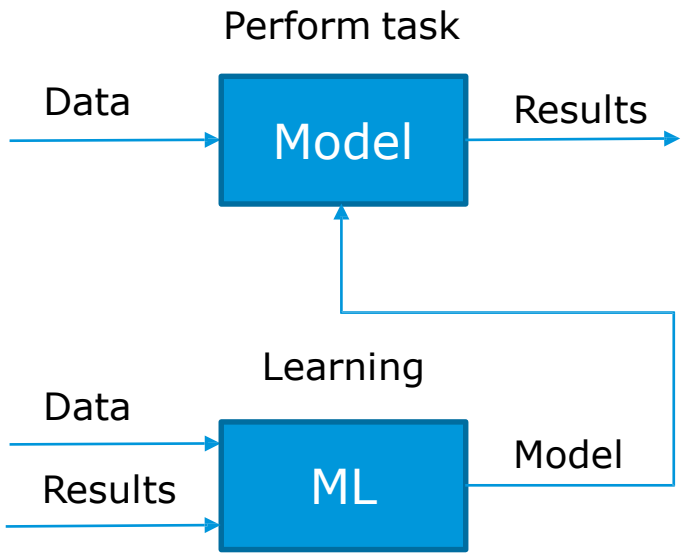
- **The science (and art) of programming computers so that they can learn from data [Aurélien Géron, 2017]**

- "The field of study that gives computers the ability to learn without being explicitly programmed" [Artur Samuel, 1959]

- "A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E" [Tom Mitchell, 1997]

How is Machine Learning different from programming



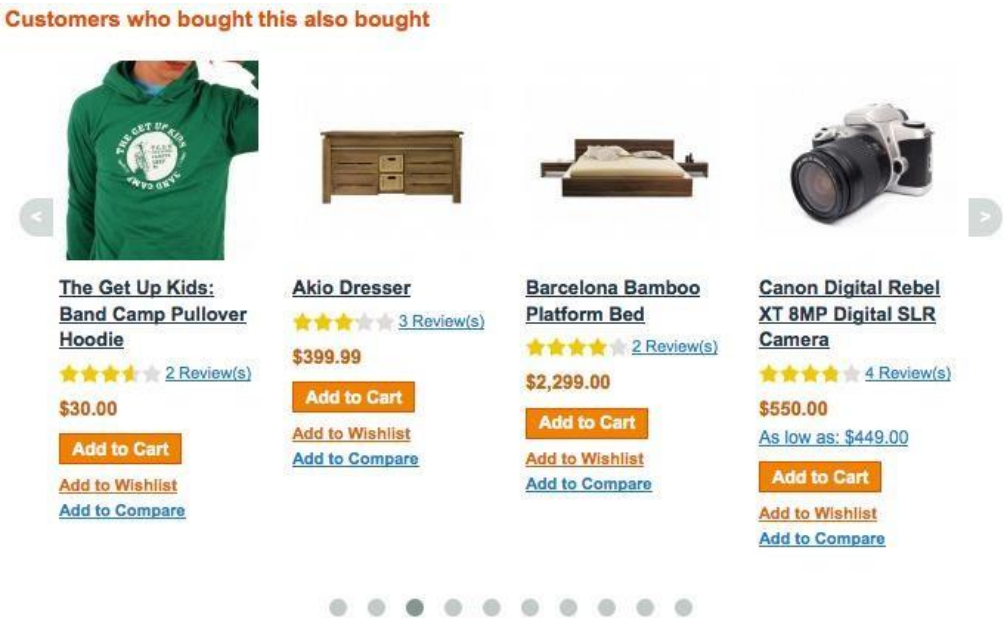


Only for some tasks

Which tasks can Machine Learning perform?

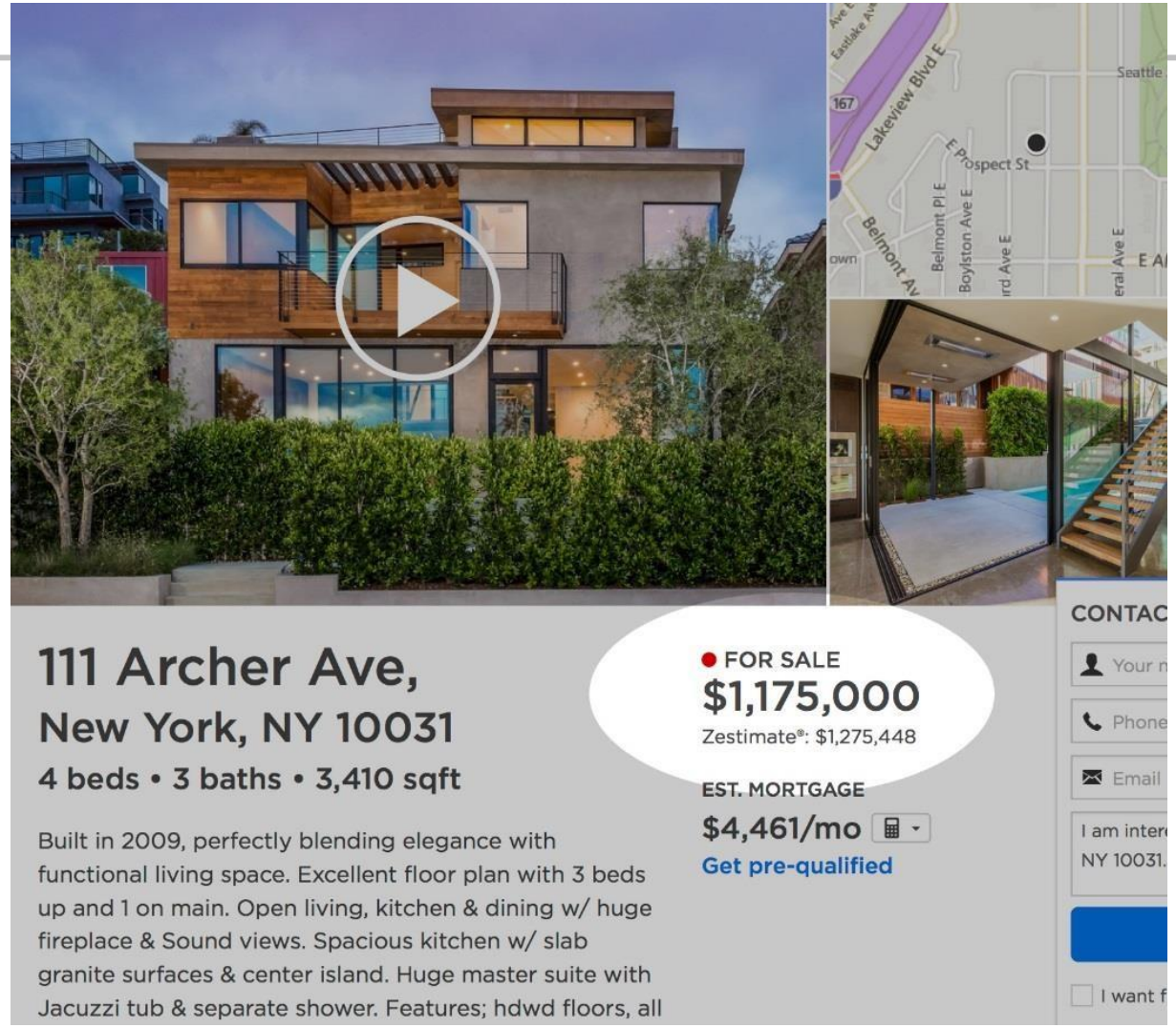
- Let’s see some examples

Spam Filter



Recommendation Engine

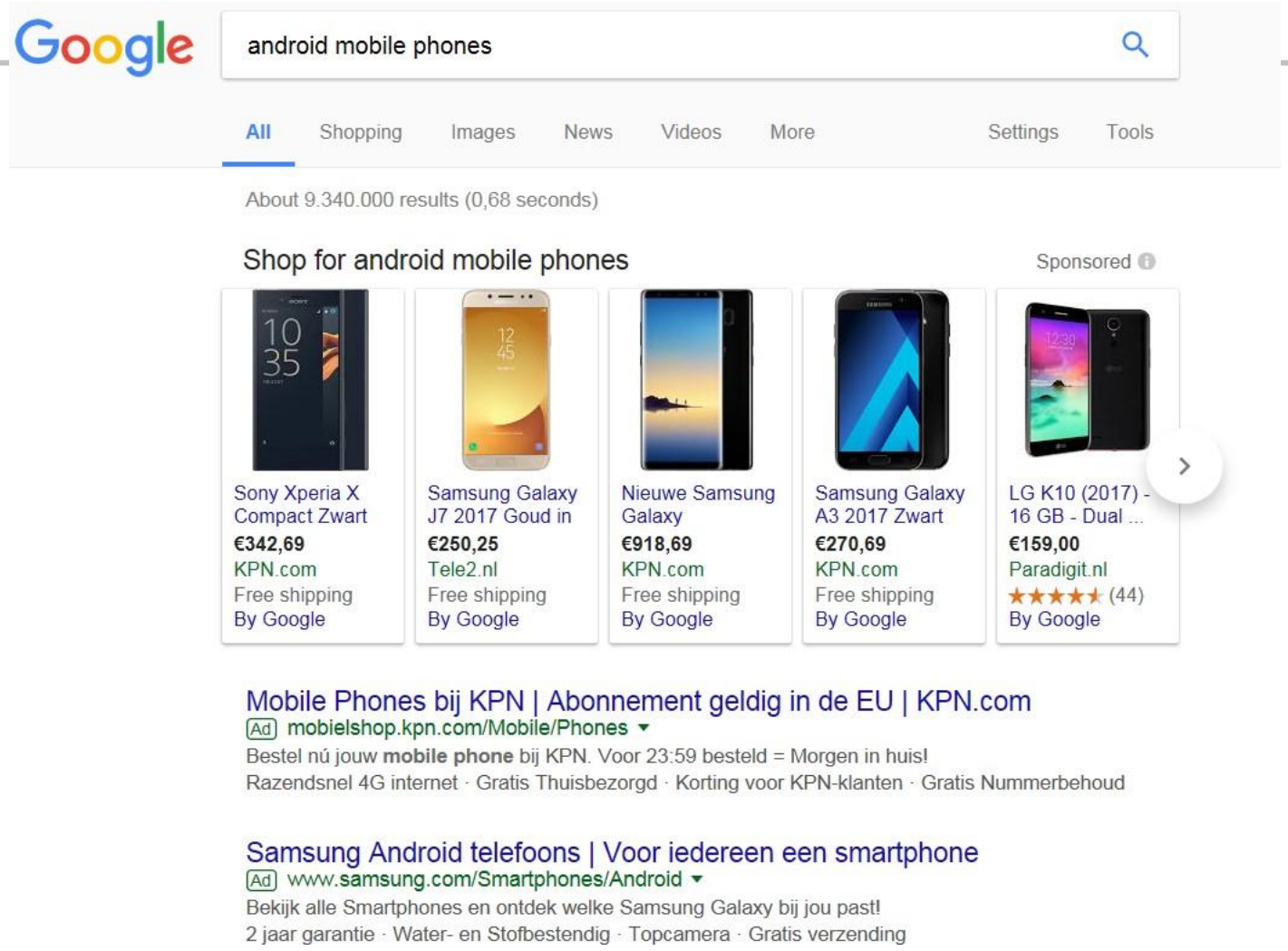
Which tasks can Machine Learning perform?



Real Estate

Predict at which price a property will be sold

Which tasks can Machine Learning perform?



Advertising

Predict which ads you are more likely to click on

Which tasks can Machine Learning perform?

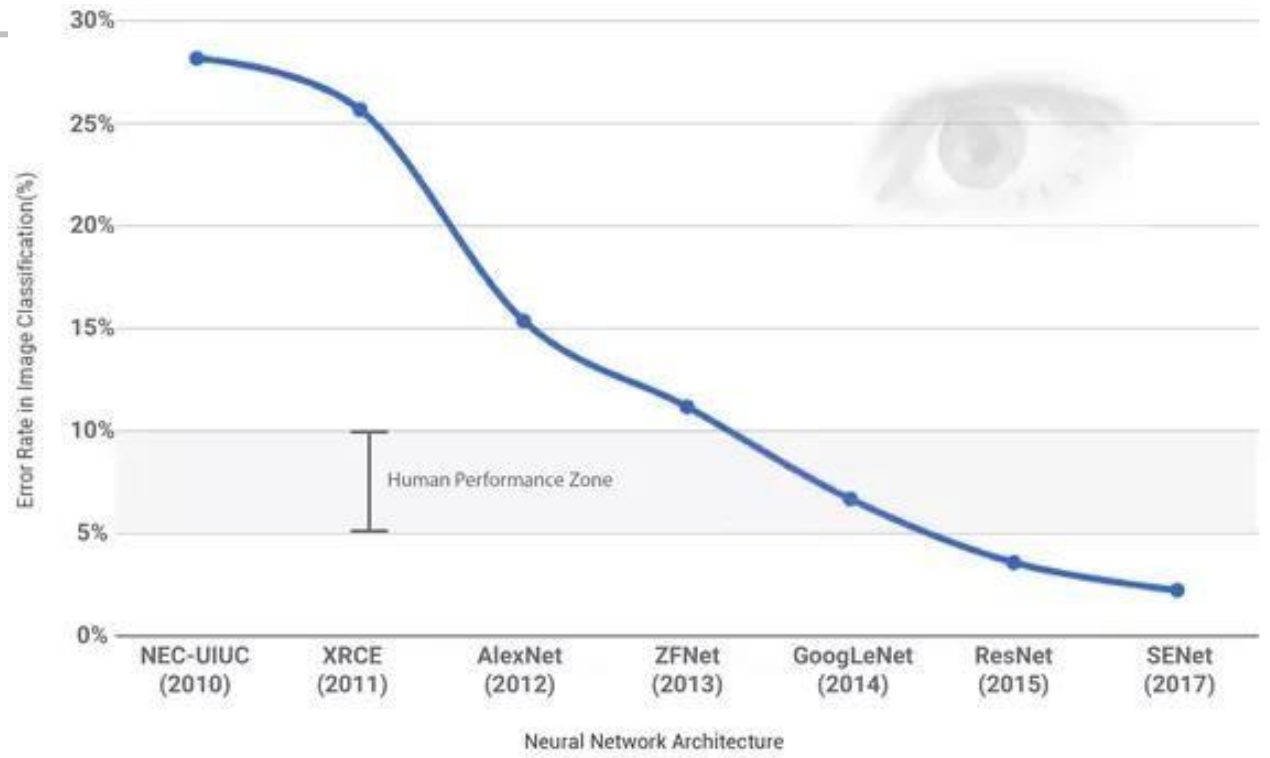
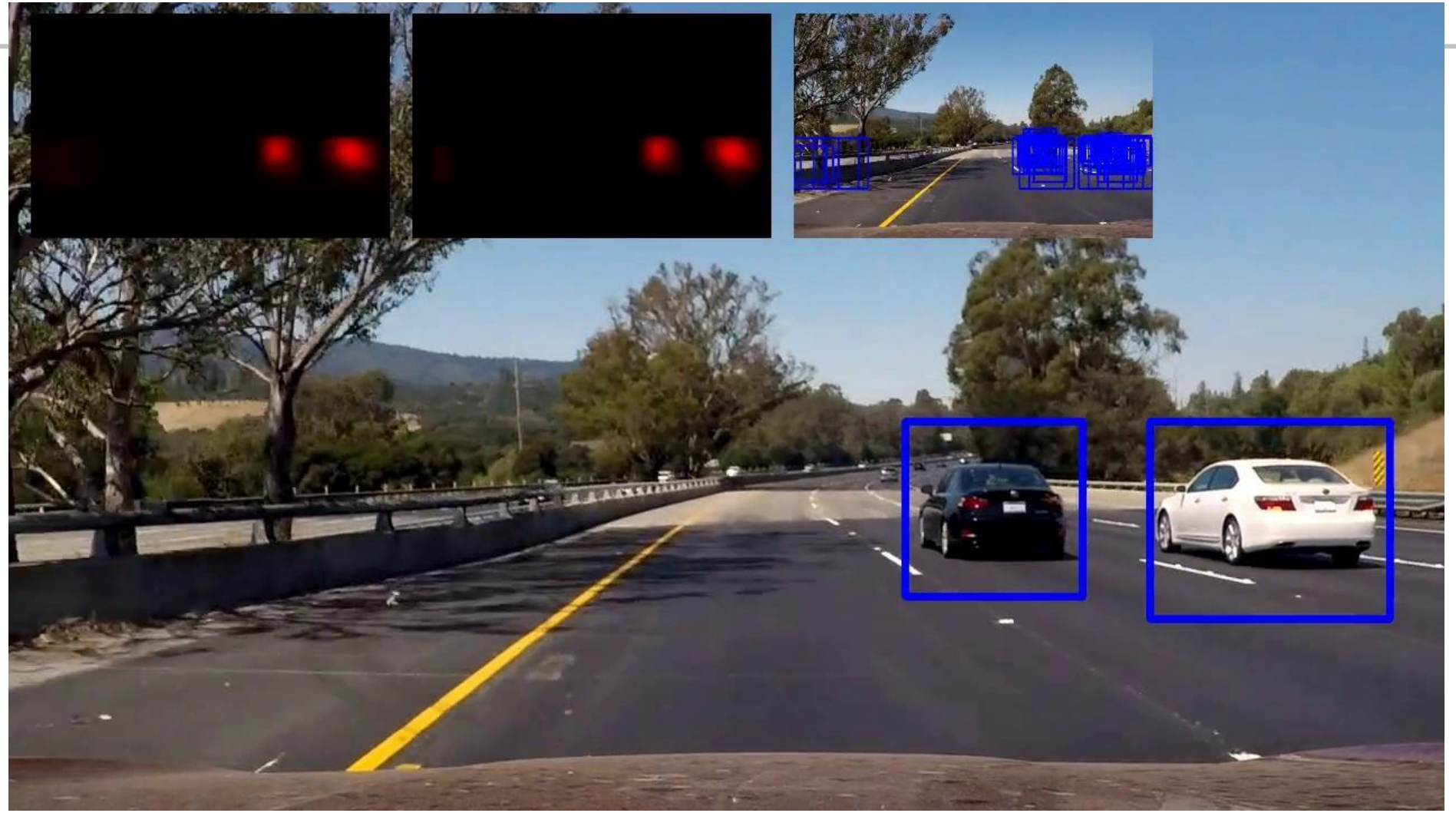


Image Classification

Which tasks can Machine Learning perform?



Self-driving cars

Which tasks can Machine Learning perform?

Speech Recognition
& Synthesis

Which tasks can Machine Learning perform?

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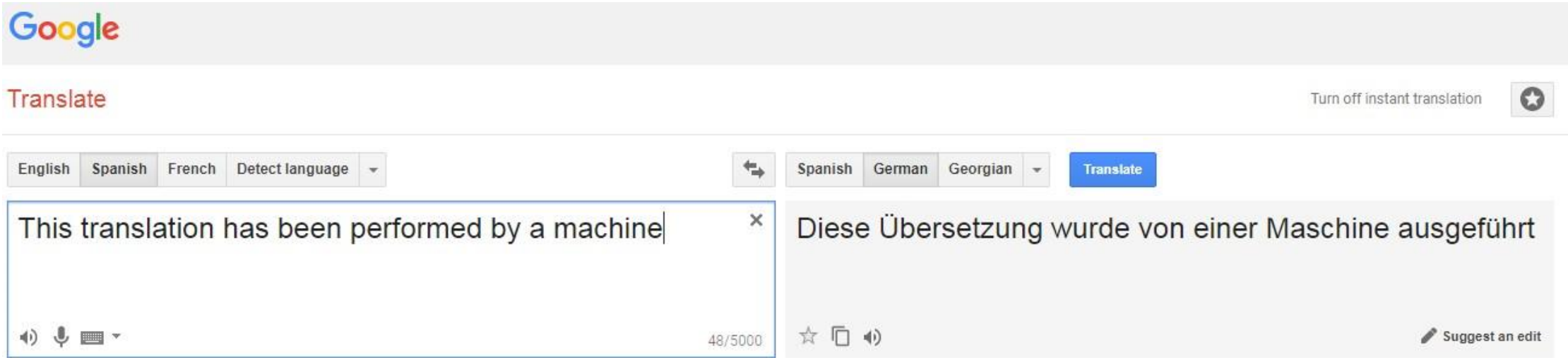
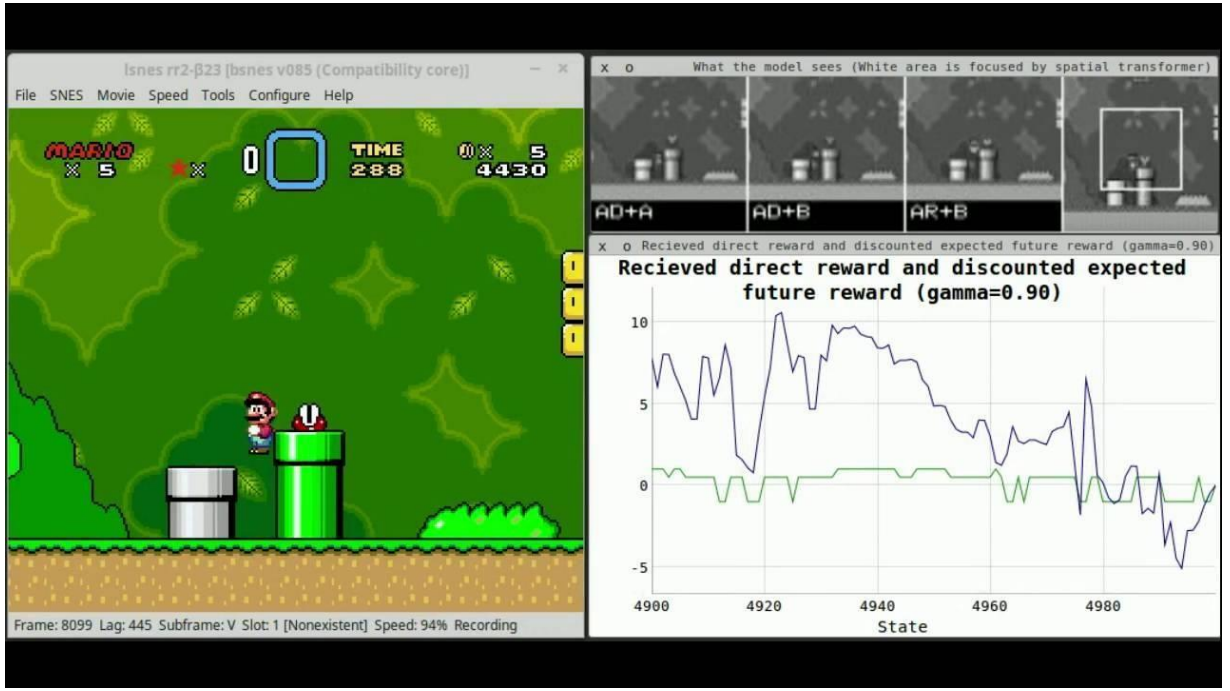
Language Translation

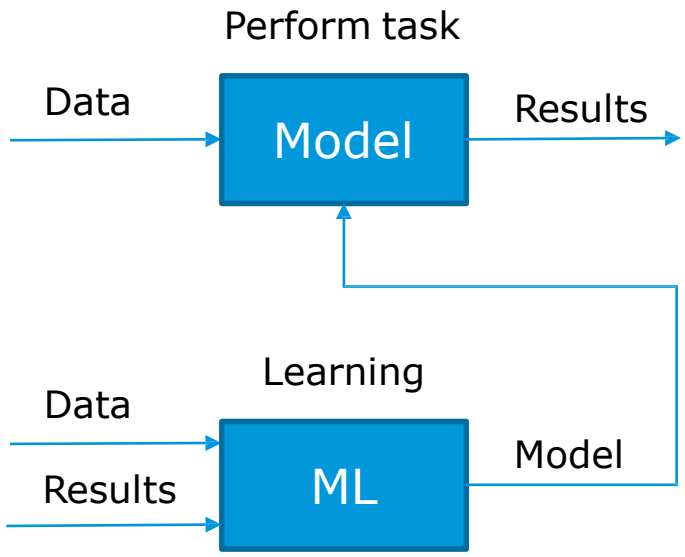


Which tasks can Machine Learning perform?

Playing Games

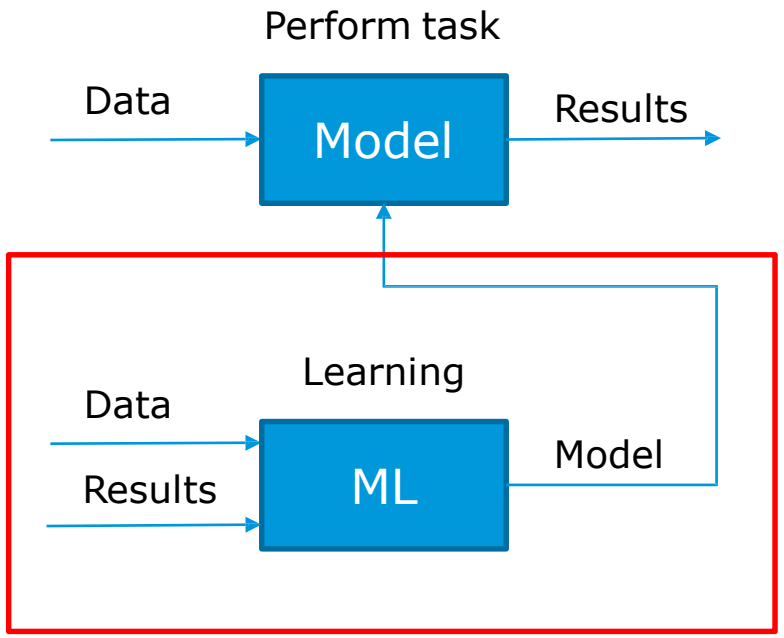


Considerations on using Machine Learning



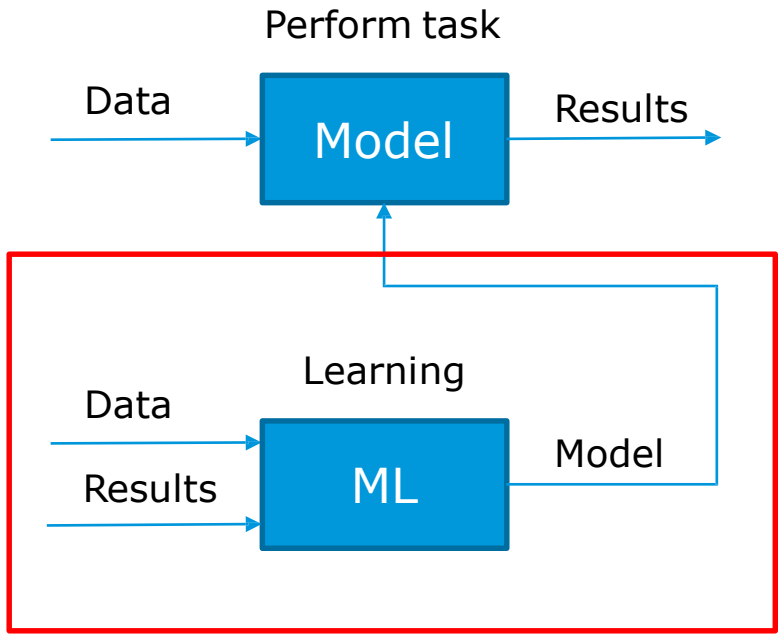
- There must be a pattern in the input – output relationship (lottery winning numbers cannot be predicted with ML)
- There must be enough data to discover this pattern
- It's difficult to formulate a mathematical expression (otherwise we will just use this formula instead)

How Machine Learning Learns?



- Different Machine Learning techniques for different kinds of tasks
- Learning is finding which model's parameters represent best the input – output mapping

How Machine Learning Learns?



- **Linear Regression example:**
  - Model: f(x) = mx + b
  - Model's parameters: m, b
  - Parameter values: m=1, b=0
- Learning is finding which values of 'm' and 'b' fit the data best (e.g. minimizes the prediction error)

Type of learning

Depending on the level of supervision …

- Supervised
- Unsupervised
- Semi-supervised
- Reinforcement Learning

Supervised Learning

- Labeled data
- Direct feedback
- Predict outcome/future

Unsupervised Learning

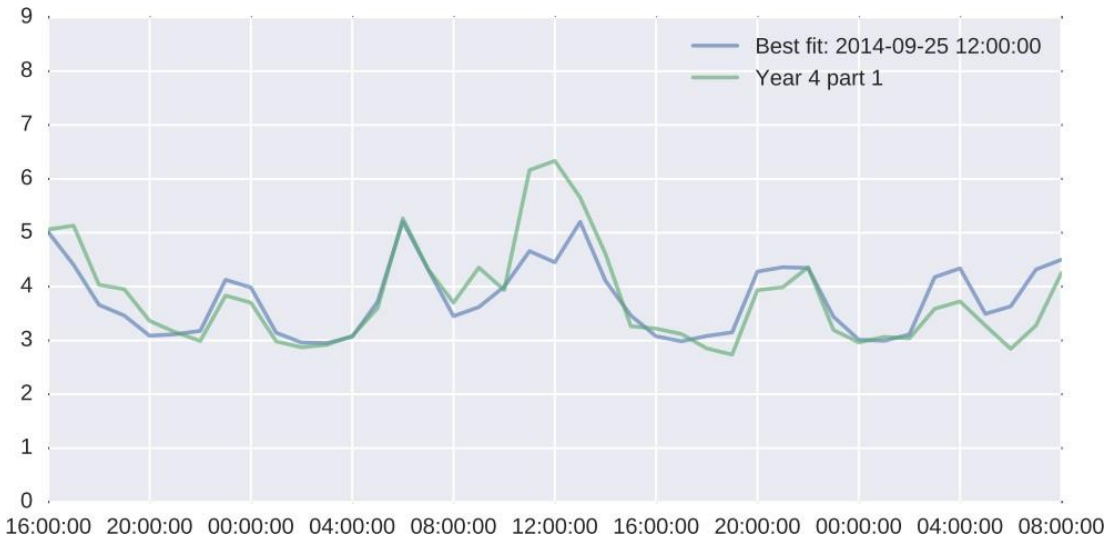
- No labels/targets
- No feedback
- Find hidden structure in data

Reinforcement Learning

- Decision process
- Reward system
- Learn series of actions

Types of Learning

- Supervised
  - Supervision: we can tell for every case what the correct answer was
  - Example: predict the thermal power consumption



Focus
Predict the future

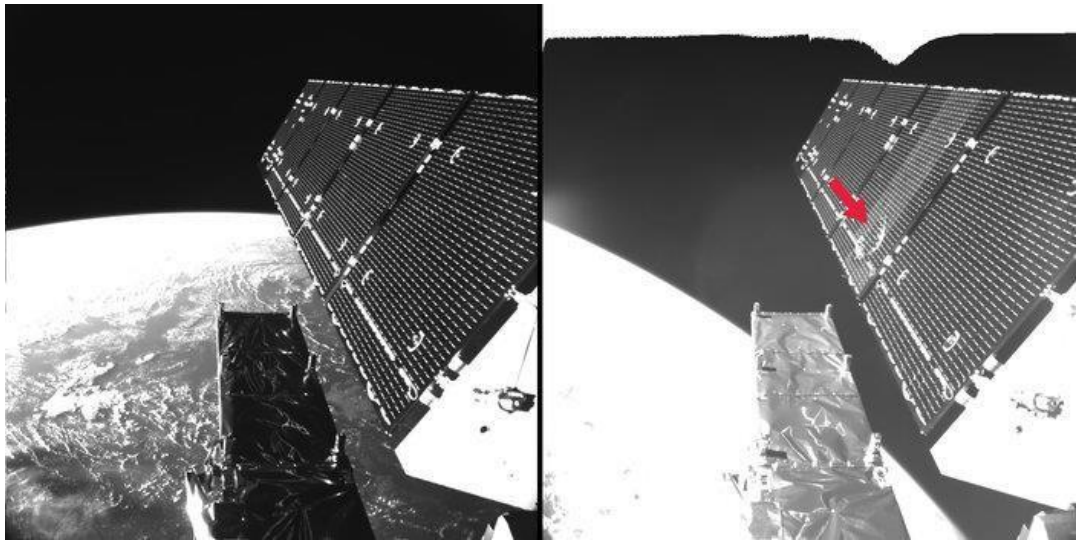
Types of Learning

- Unsupervised
  - Supervision: there is no right answer, we are looking for insights
  - Example: market basket analysis for supermarkets

Focus
Understand the past

Types of Learning

- Semi-supervised
  - Supervision: we can tell the correct output for a limited number of cases
  - Example: characterize what a particle impact looks like in TM



Focus
Understand the past

Sentinel-1A: particle impact on August 23th 2016

Types of Learning

- Reinforcement Learning
  - Supervision: we only know the final outcome, but not intermediate steps
  - Example: playing Go

Focus
Find which is the next action most likely to lead to the desired outcome

Types of Learning

- The type of learning with most industrial applications is

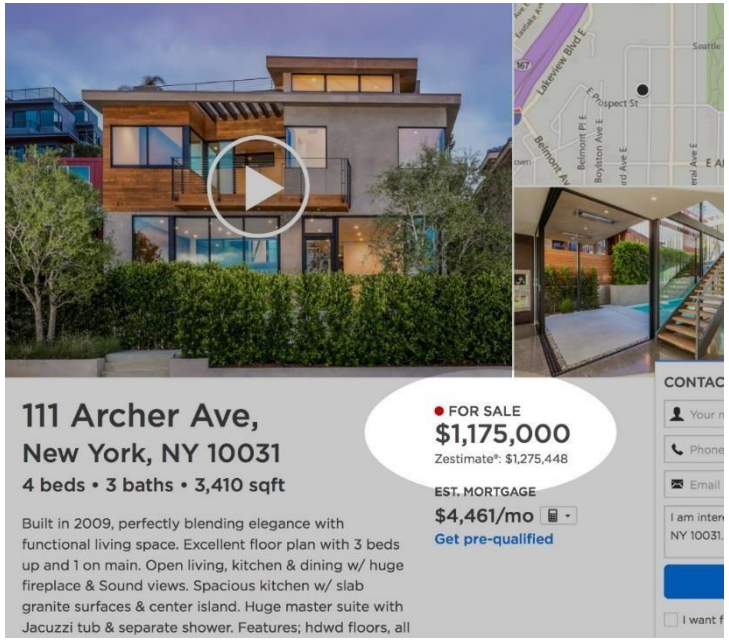
Supervised Learning

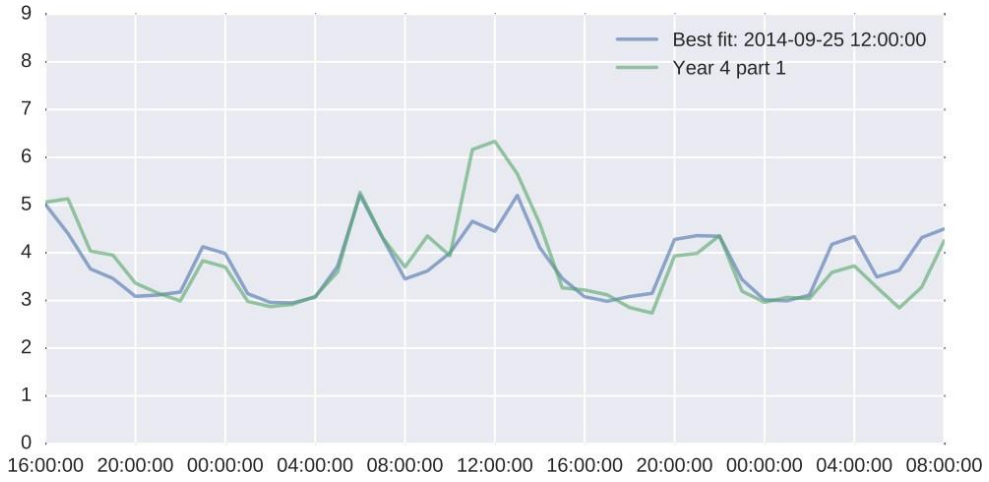
(Predictive Analytics)

- Depending of what kind of data is predicted we can talk about:
  - Regression
  - Classification

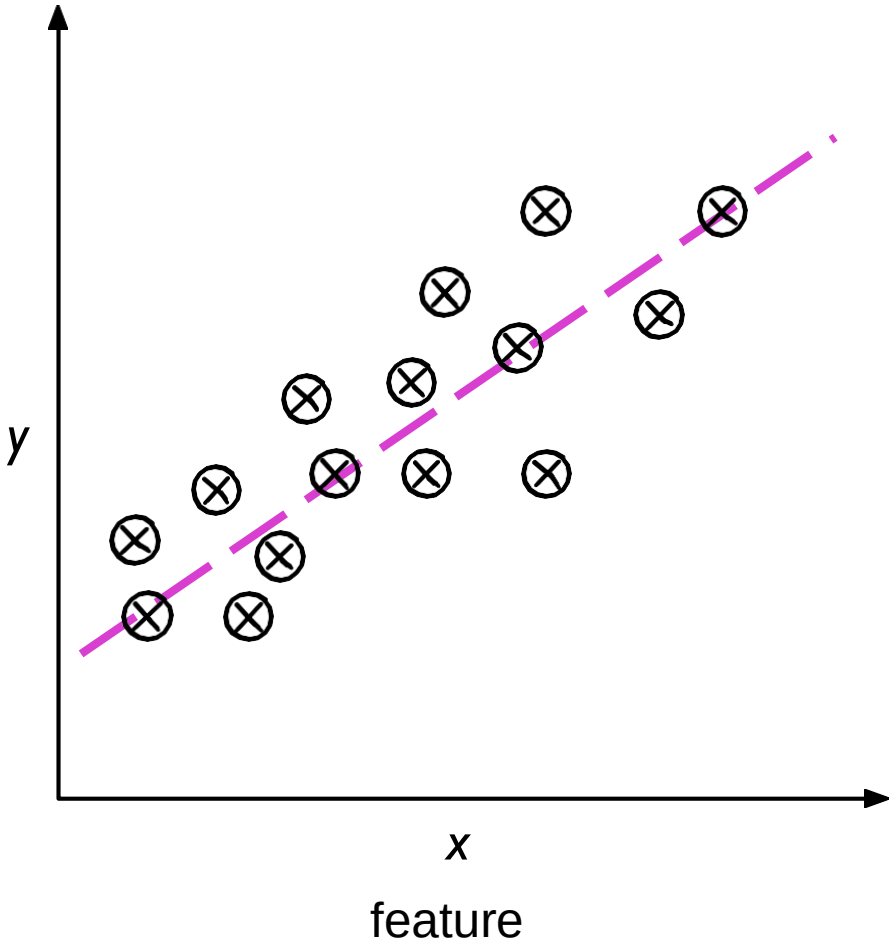
Regression

- Predict real numbers





Regression



Artificial Intelligence

$$\hat{y} = \boldsymbol{w}^\top \boldsymbol{x} + b$$

Classification

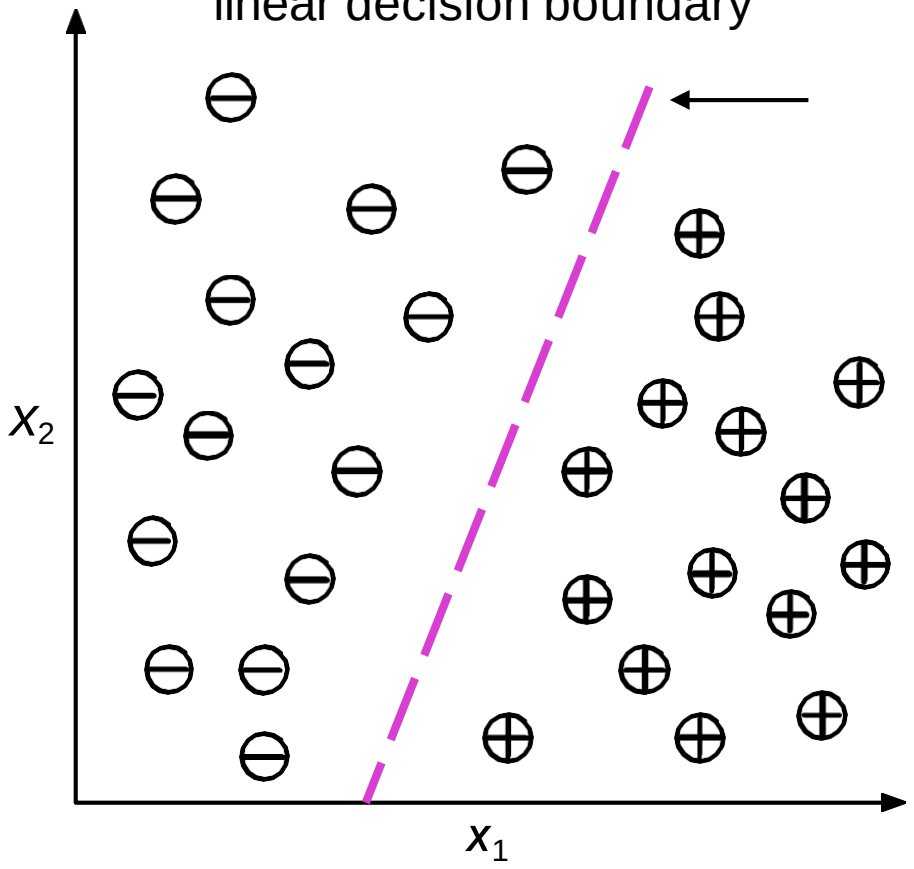
- Predict which option out of a limited set of possibilities

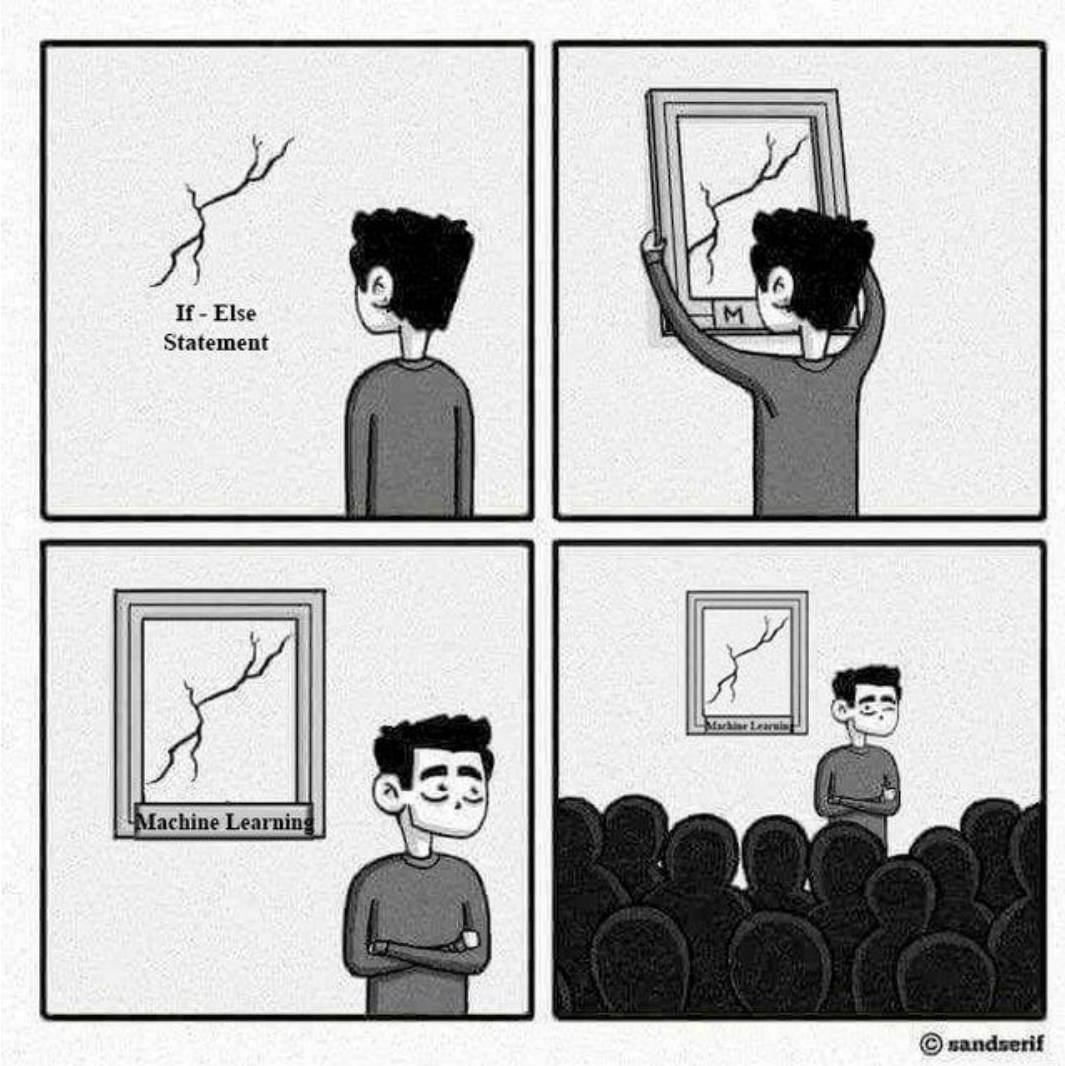
Spam Filter

What’s in the picture

Classification

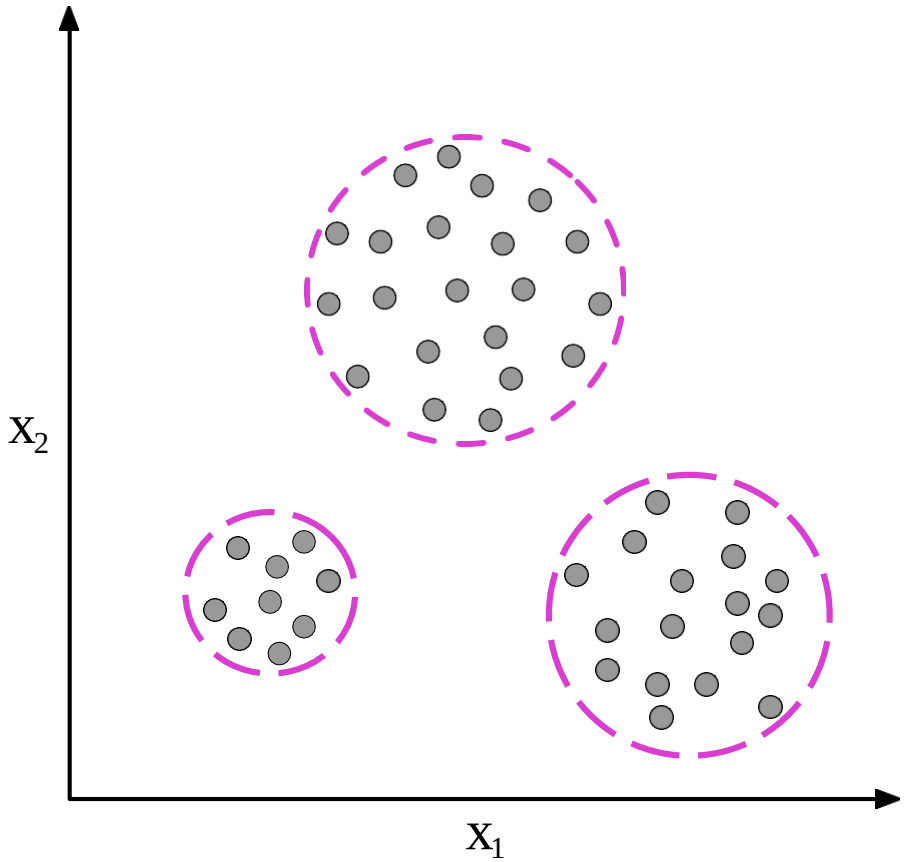
Binary classification example with
two *features* ("independent" variables, predictors)
linear decision boundary





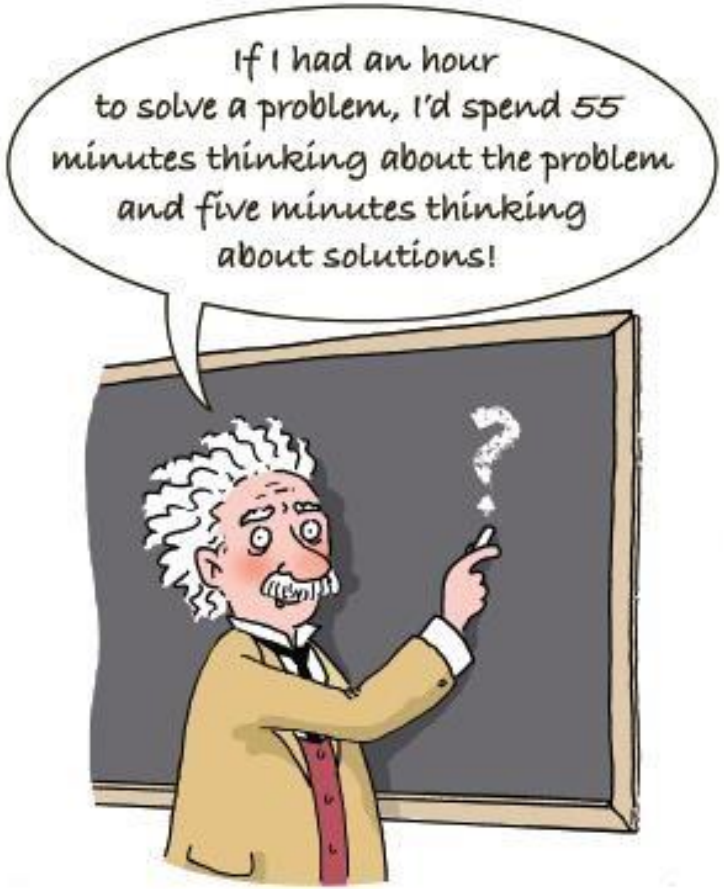
Unsupervised Learning: Clustering

Assigning group memberships to unlabelled examples (instances, data points)



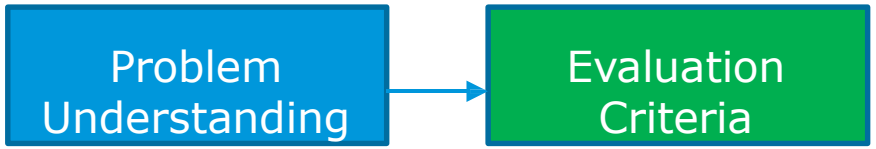
Machine Learning Workflow

Problem Understanding



Machine Learning Workflow

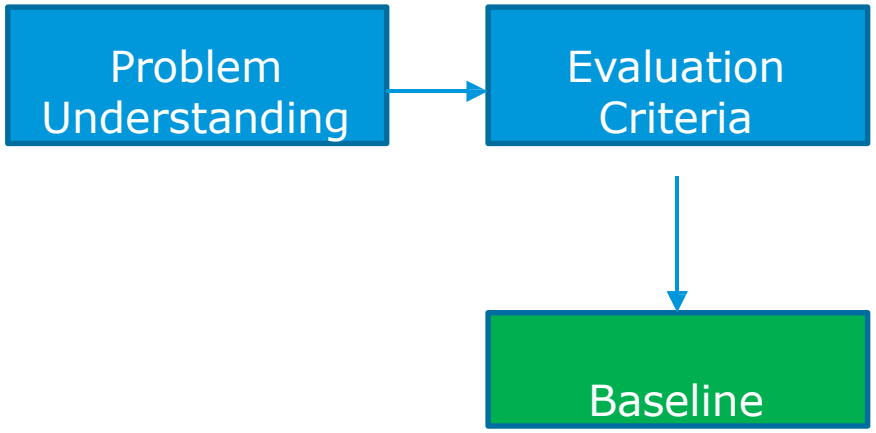
- How will we measure how good the model is performing?
- Do we know already at what point it would be enough?



Machine Learning Workflow

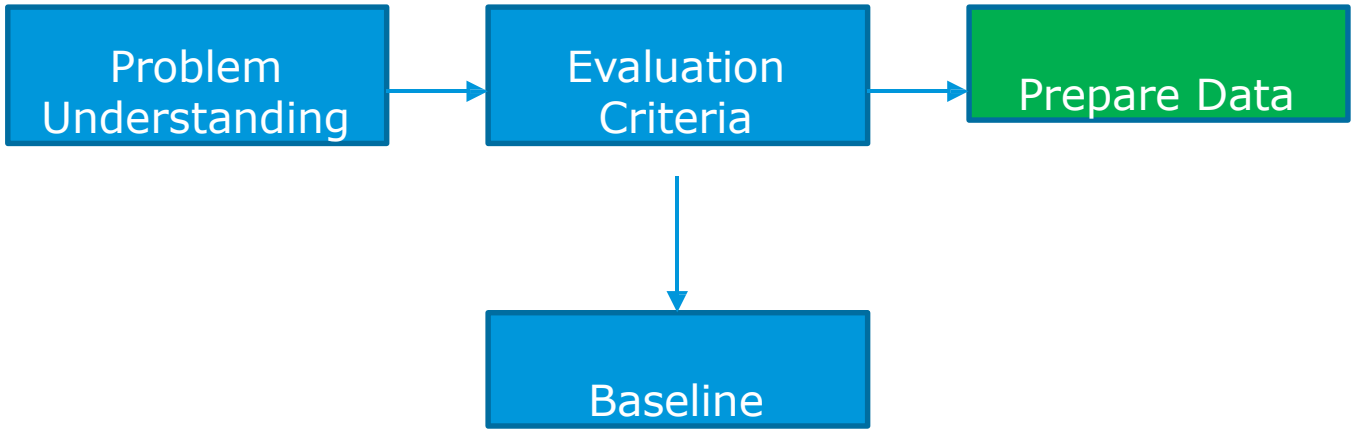
- How the current approach is performing against the evaluation criteria? Define a simple baseline if there is none (e.g. mean value)

- This will allow us to quantify how much Machine Learning helps and if it is worthwhile compared to simpler solutions



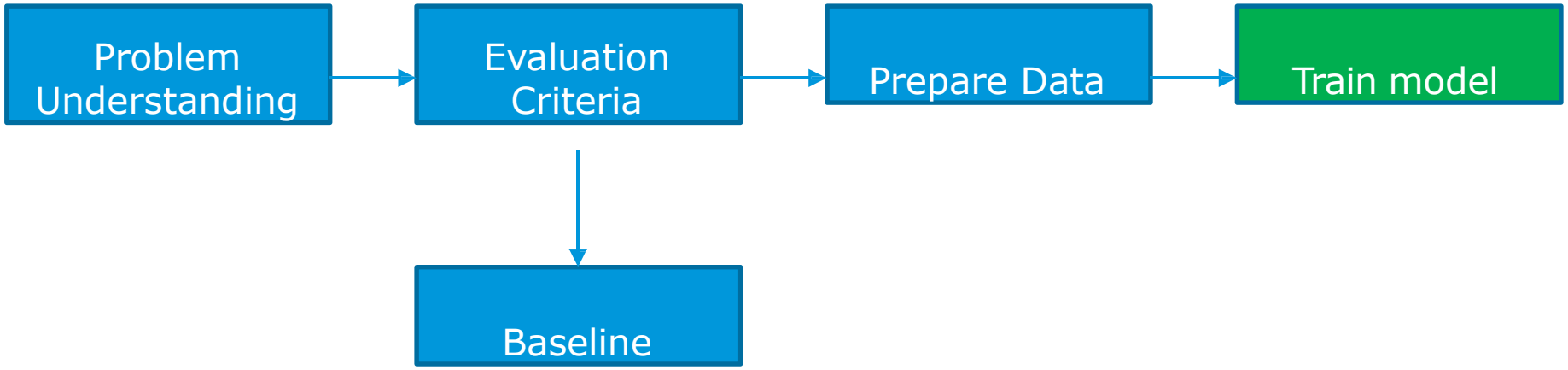
Machine Learning Workflow

- “Enough” data in the sense that it’s representative of the behaviour the model needs to learn
- Features: data transformations that encode your knowledge



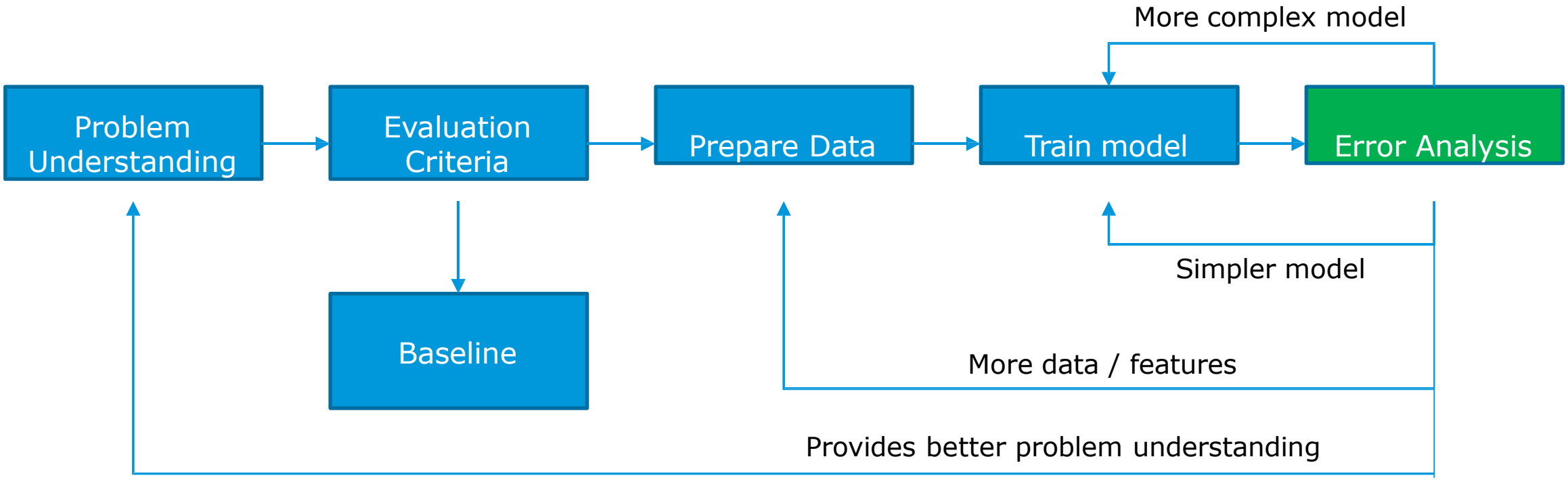
Machine Learning Workflow

- Use data / features to tune the parameters that optimize the evaluation criteria (e.g. minimise error)



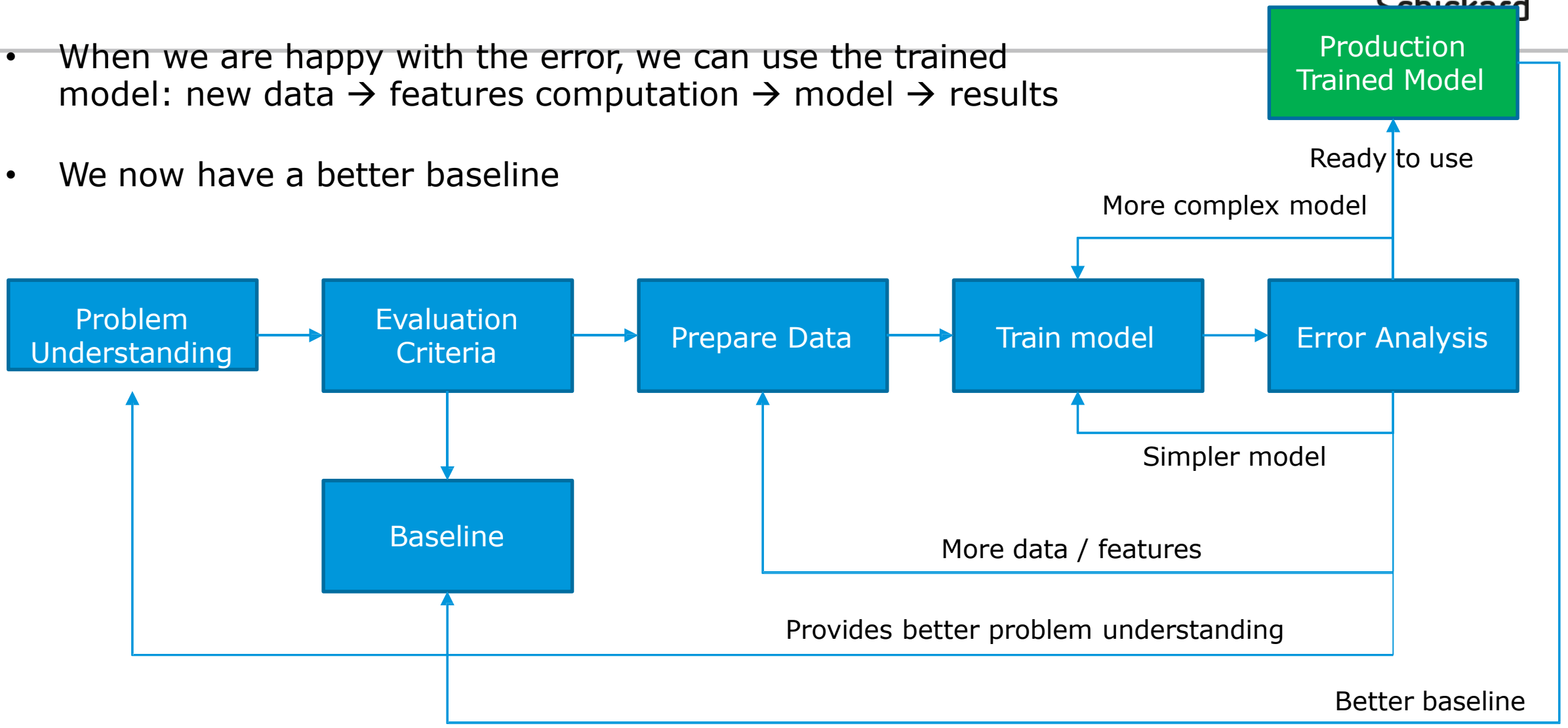
Machine Learning Workflow

- Understand what the model is doing: where is it right / wrong

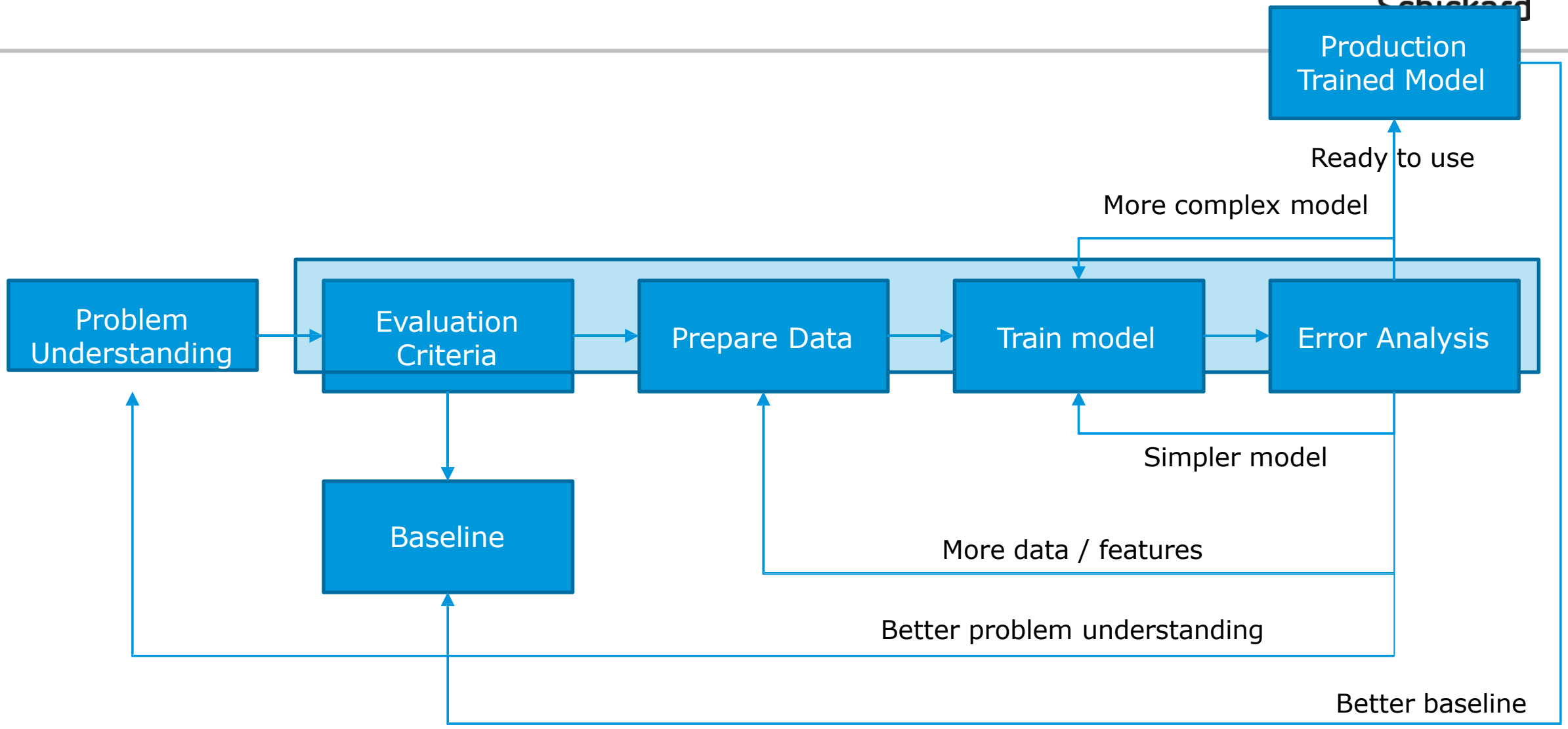


Machine Learning Workflow

- When we are happy with the error, we can use the trained model: new data → features computation → model → results
- We now have a better baseline



Machine Learning Workflow



Questions:

What is Artificial intelligence, Machine learning and deep learning.

Where do we use AI already?

Explain: Supervised, Unsupervised, Semi-supervised, Reinforcement Learning

Explain: Regression, Classification