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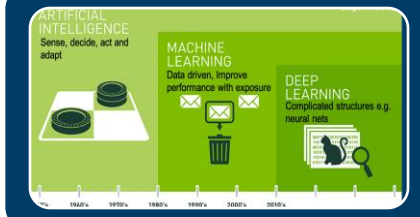
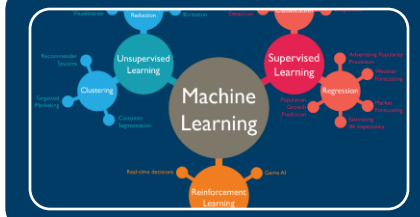
INTRODUCTION TO MACHINE LEARNING - KEY CONCEPTS AND TERMINOLOGY

Milan De Cauwer – SINTEF Digital – Norway, Oslo

Outline

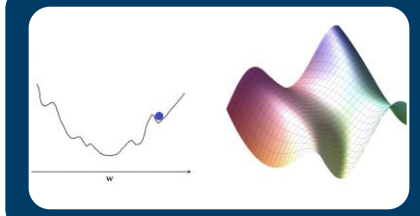


Discussion on Machine Learning and AI



Machine Learning – A definition

- Supervised learning
- Unsupervised learning
- Reinforcement learning



Concepts in machine learning

- Data – Features, labels, instance, dataset and data splitting
- Models – Training and inference
- Bias and variance trade-off

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Who am I?

Milan
SINTEF Digital

- Research scientist at SINTEF Digital, Norway
  - SINTEF is one of Europe's largest independent research organisations
  - Applied research in collaboration with industry

Building and construction
Climate and environment
Digitalisation
Food and agriculture
Health and medicine
Materials
Microsystems and nanotechnology
Ocean space
Renewable energy
Society and security
Sustainable production
Transport and mobility

- My research interests
  - Applications of **Machine Learning** for modeling and solving **combinatorial problems**

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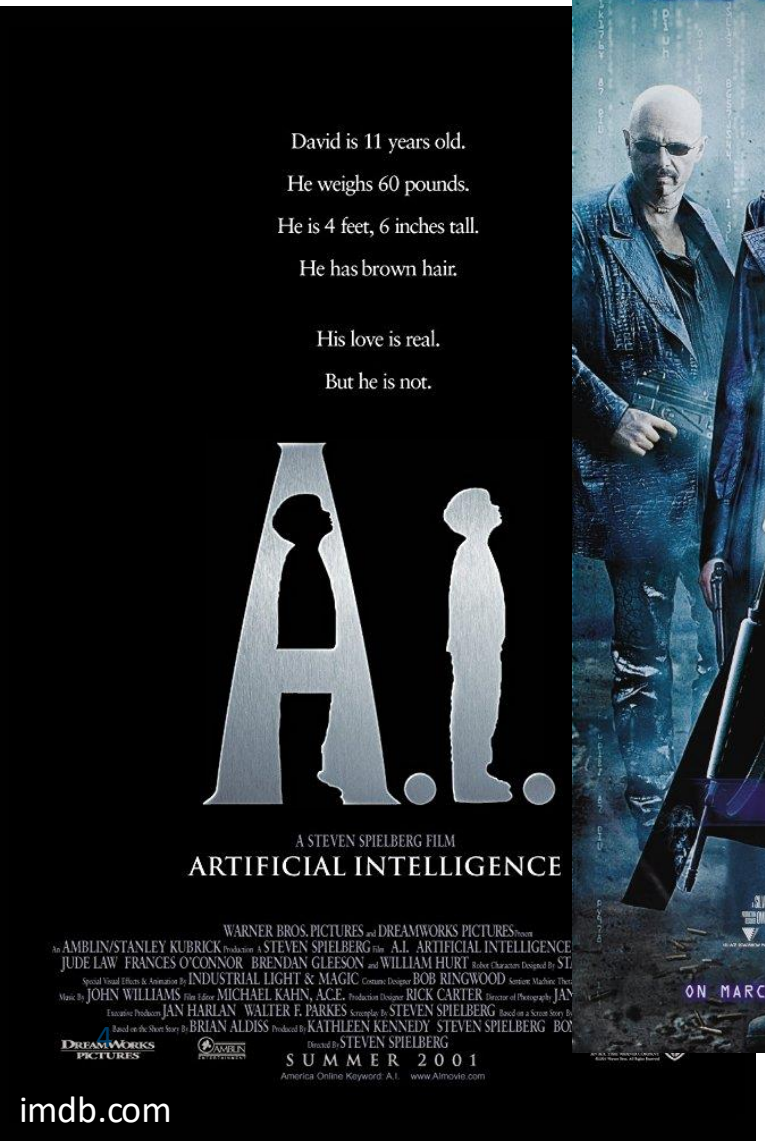
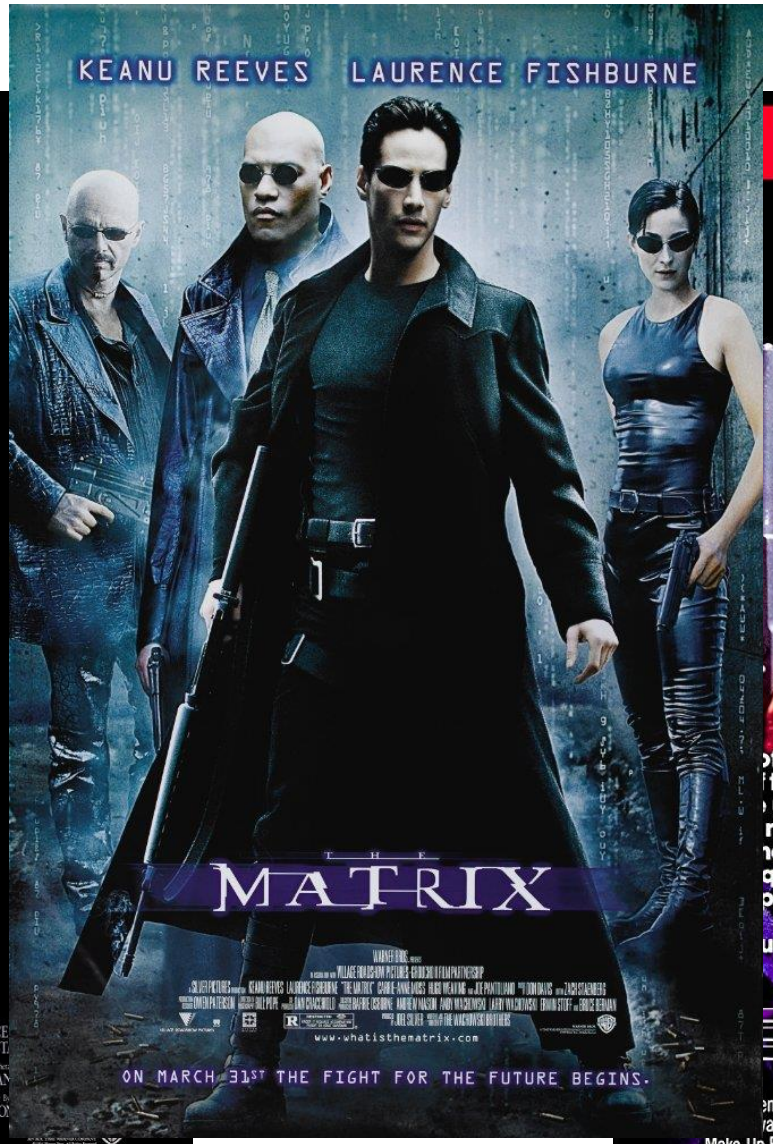
AI in pop culture





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Examples of AI in daily life

Search engines

Filters

Media suggestions

Assistants

Online shopping

Examples of AI in daily life – ChatGPT (Large language models)

Search engines

Filters

Media suggestions

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Online shopping

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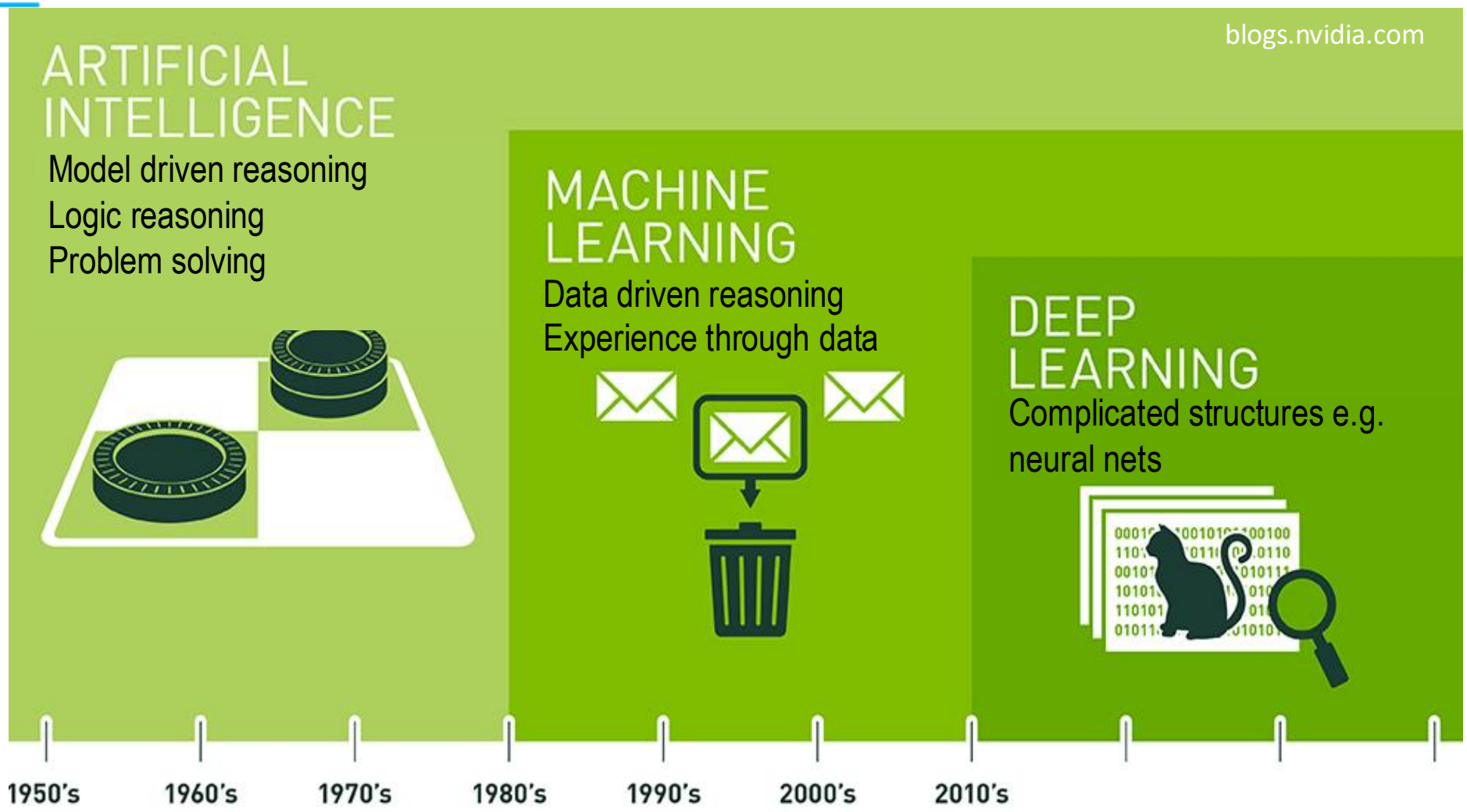
AI - Machine learning – Deep learning



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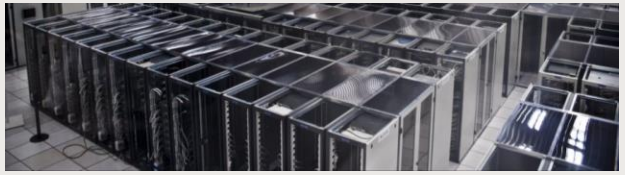
Why now?

Three paradigm shifts at once

Data

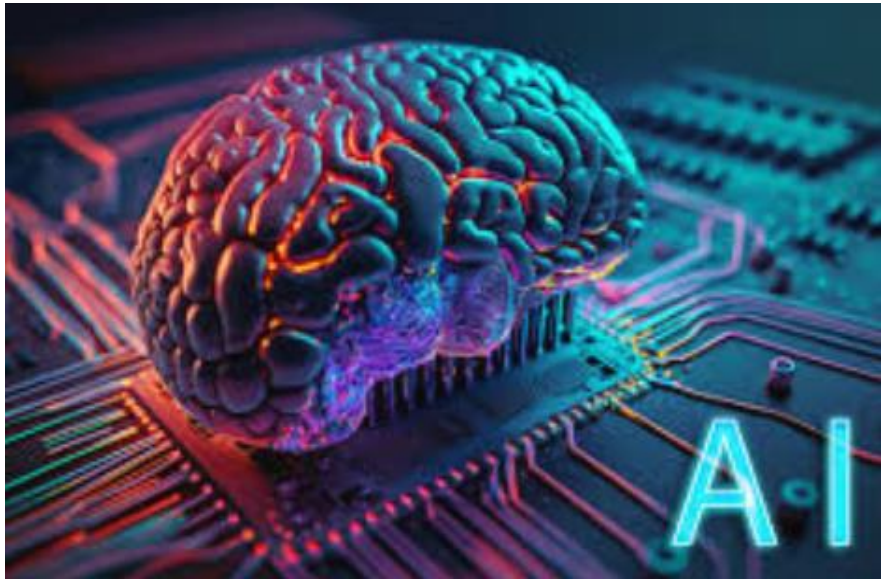
Technology

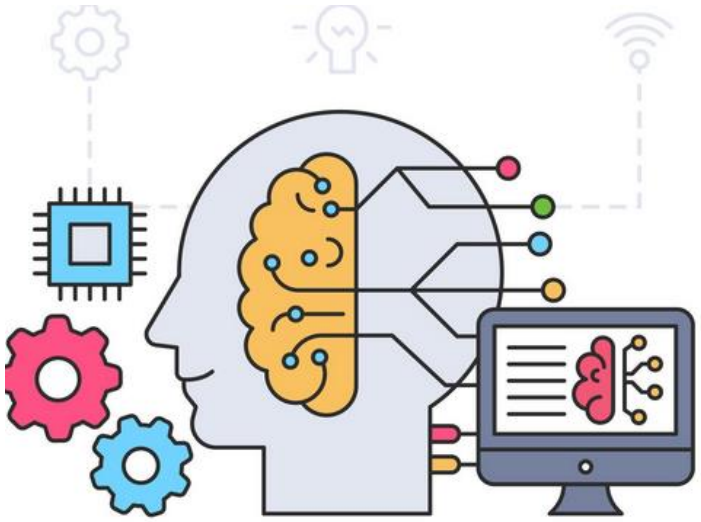


Analytics

Machine learning

Quiz – Do all methods in AI rely on machine learning? Why?





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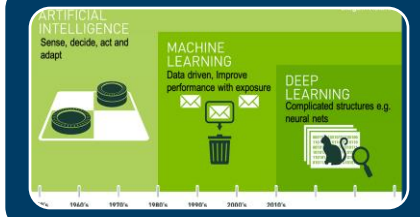

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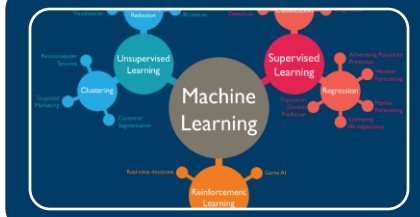

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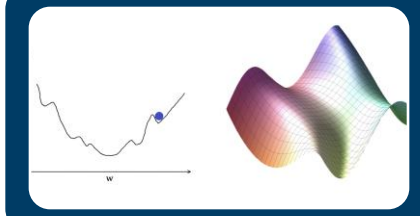

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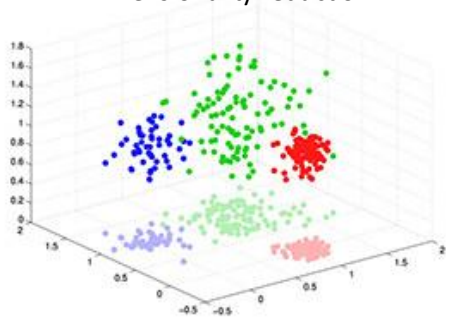
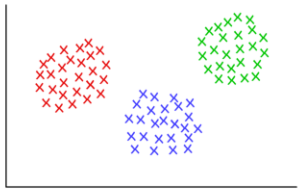
Machine-learning – A definition

- Definition:
  - A set of methods that enable computers to learn (something useful) from data
- Goal:
  - Build models that can make predictions or decisions based on data

Dimensionality reduction



Clustering



Machine Learning

Unsupervised Learning

- Dimensionality Reduction
  - Meaningful Compression
  - Structure Discovery
  - Big data alistaion
  - Feature Elicitation
- Clustering
  - Recommender Systems
  - Targetted Marketing
  - Customer Segmentation

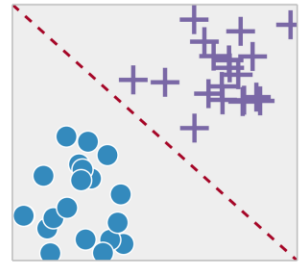
Supervised Learning

- Classification
  - Image Classification
  - Customer Retention
  - Idenity Fraud Detection
  - Diagnostics
- Regression
  - Advertising Popularity Prediction
  - Weather Forecasting
  - Population Growth Prediction
  - Market Forecasting
  - Estimating life expectancy

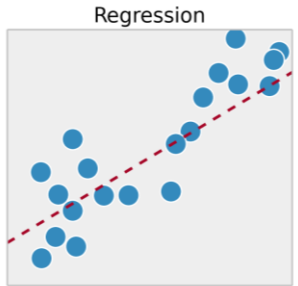
Reinforcement Learning

- Real-time decisions
- Game AI
- Robot Navigation
- Skill Acquisition
- Learning Tasks

Classification



Regression



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Supervised learning

Duck Duck Rabbit Hedgehog

Supervised learning

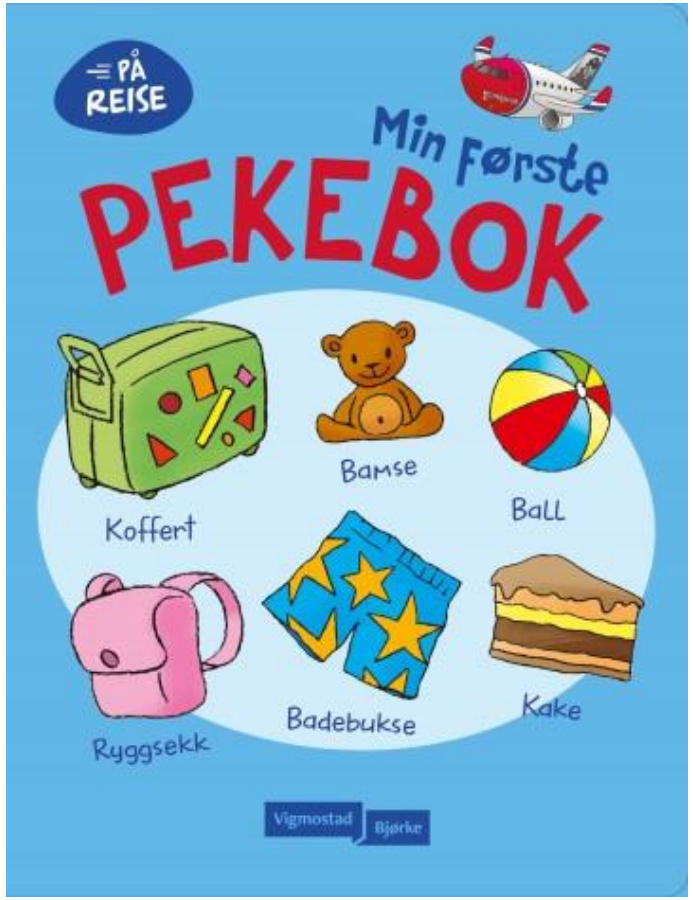
Predictive model

?

Predictive model

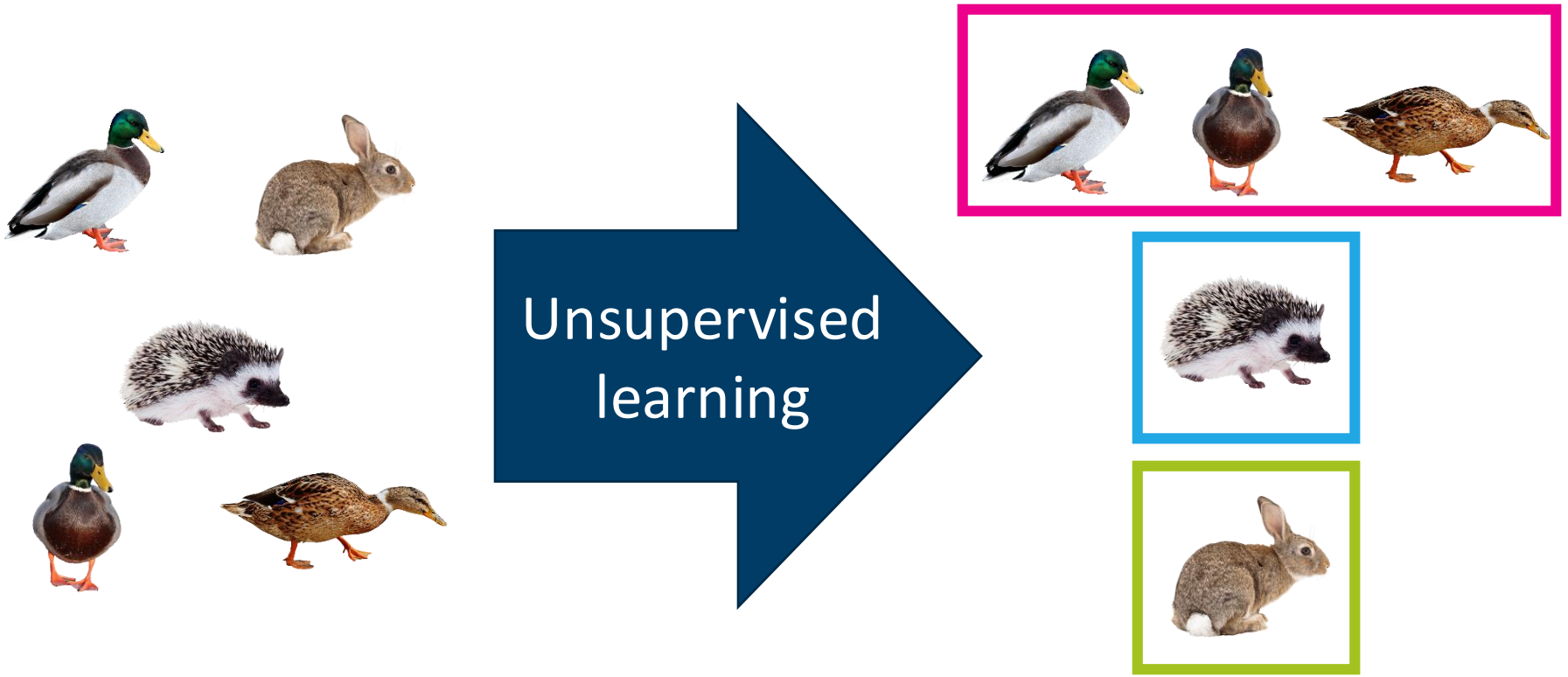
Duck

Example of supervised learning



tanum.no

Unsupervised learning



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Example on un-supervised learning

slate.com

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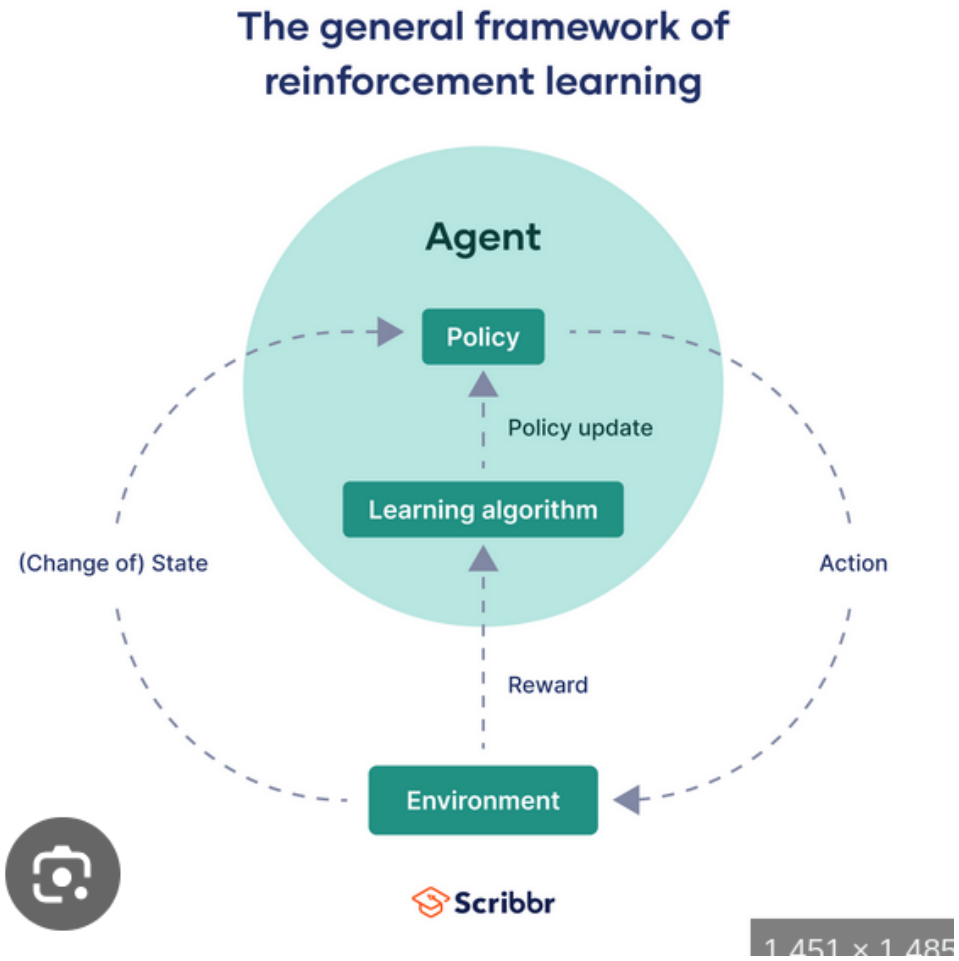
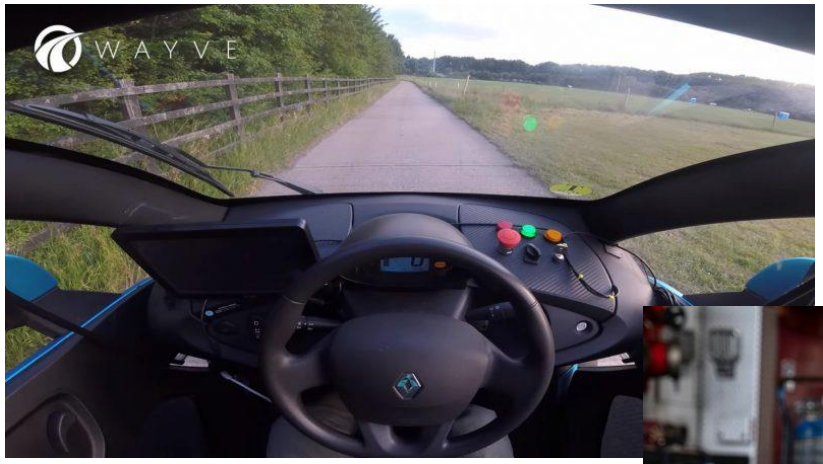
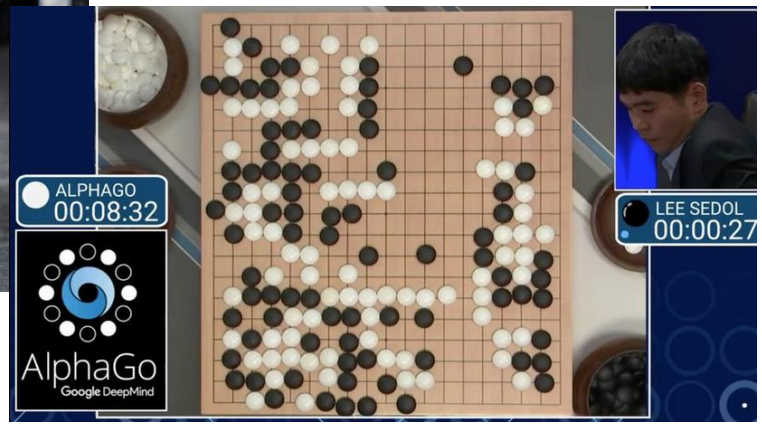
Reinforcement learning

- Goal: learn how to interact with an environment to achieve a specific objective.
- The agent receives rewards (and penalties) depending on the quality of its actions



Reinforcement learning examples: Self-driving cars, robotics and games





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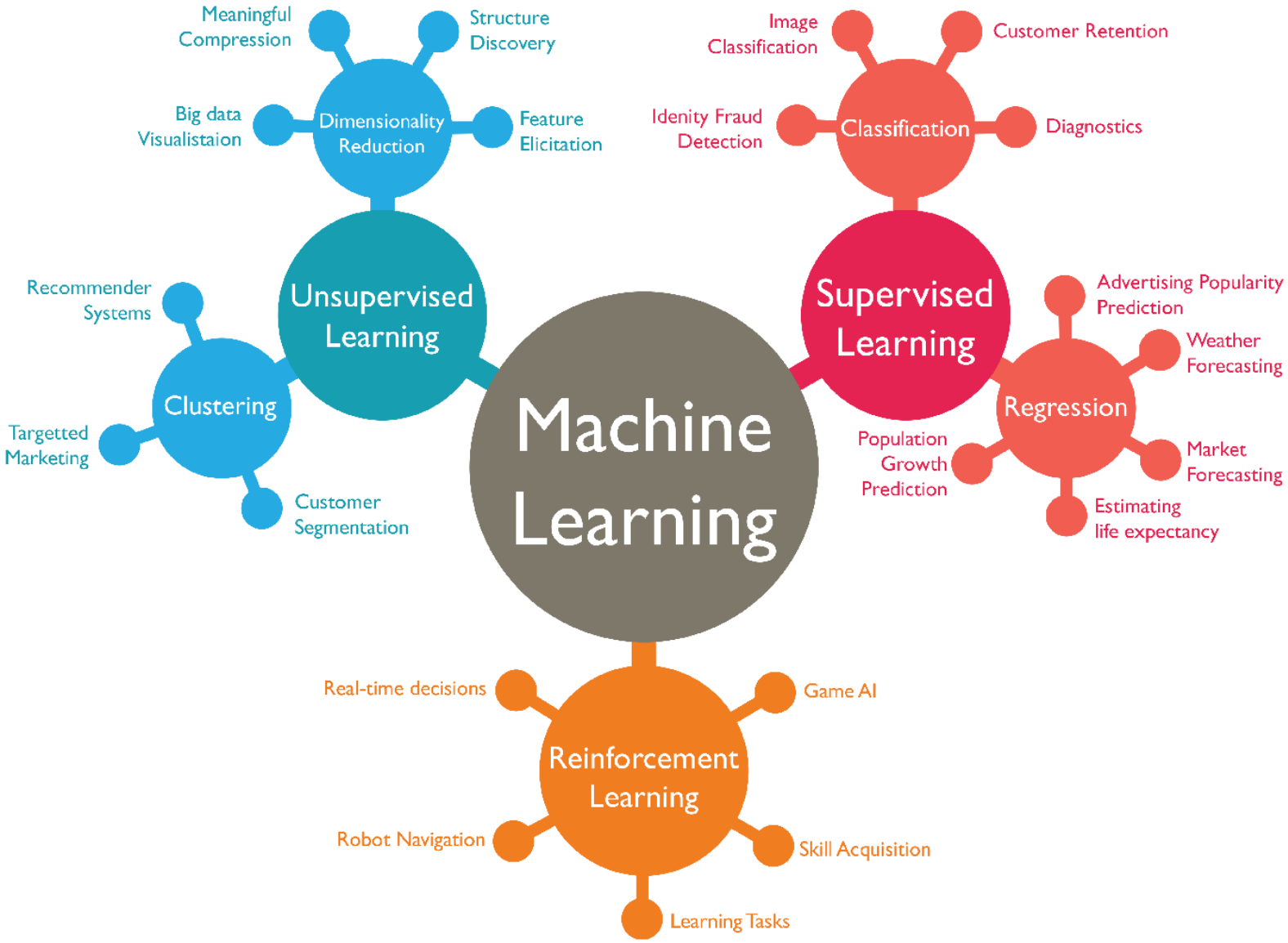
Quiz – Use-cases

- **A:** Predicting whether the train will be late
- **B:** Teaching a computer to play angry birds
- **C:** Recommending your next dining experience.



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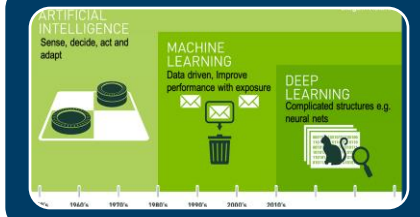

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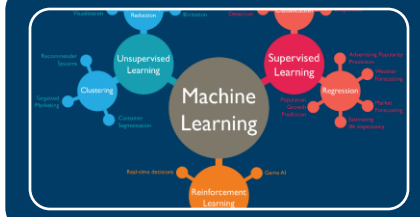

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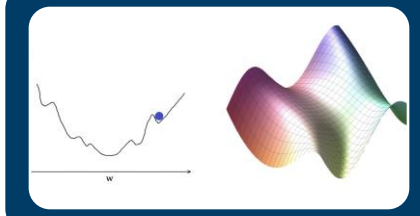

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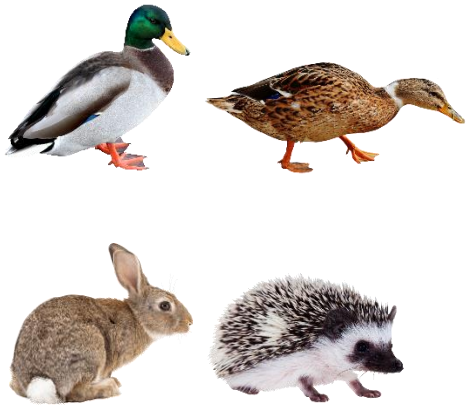
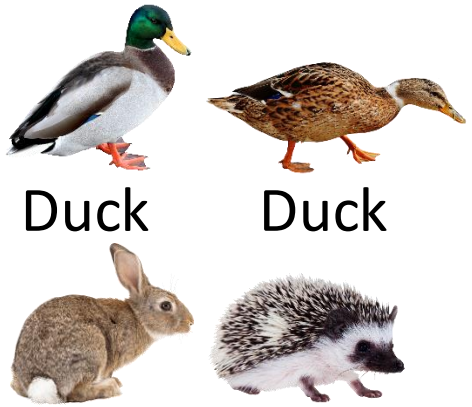
Different kind of data

Unlabelled data



Labelled data

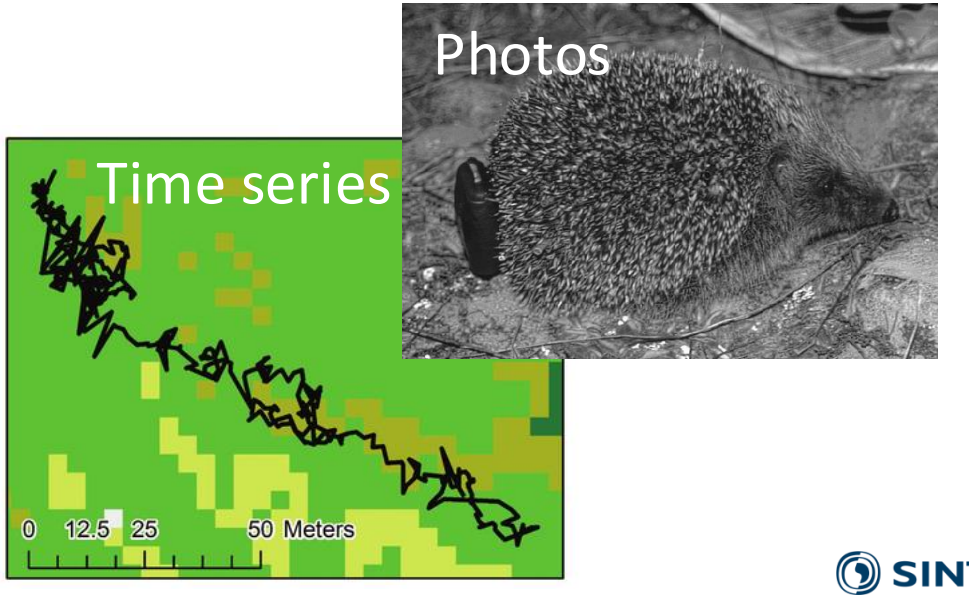


Duck Duck

Rabbit Hedgehog

Tabular data

Image number	Animal	Size in cm	Favourite food	Lays eggs
1	Duck	43	weeds	True
2	Duck	41	seeds	True
3	Rabbit	55	lettuce	False
4	Hedgehog	33	eggs	True



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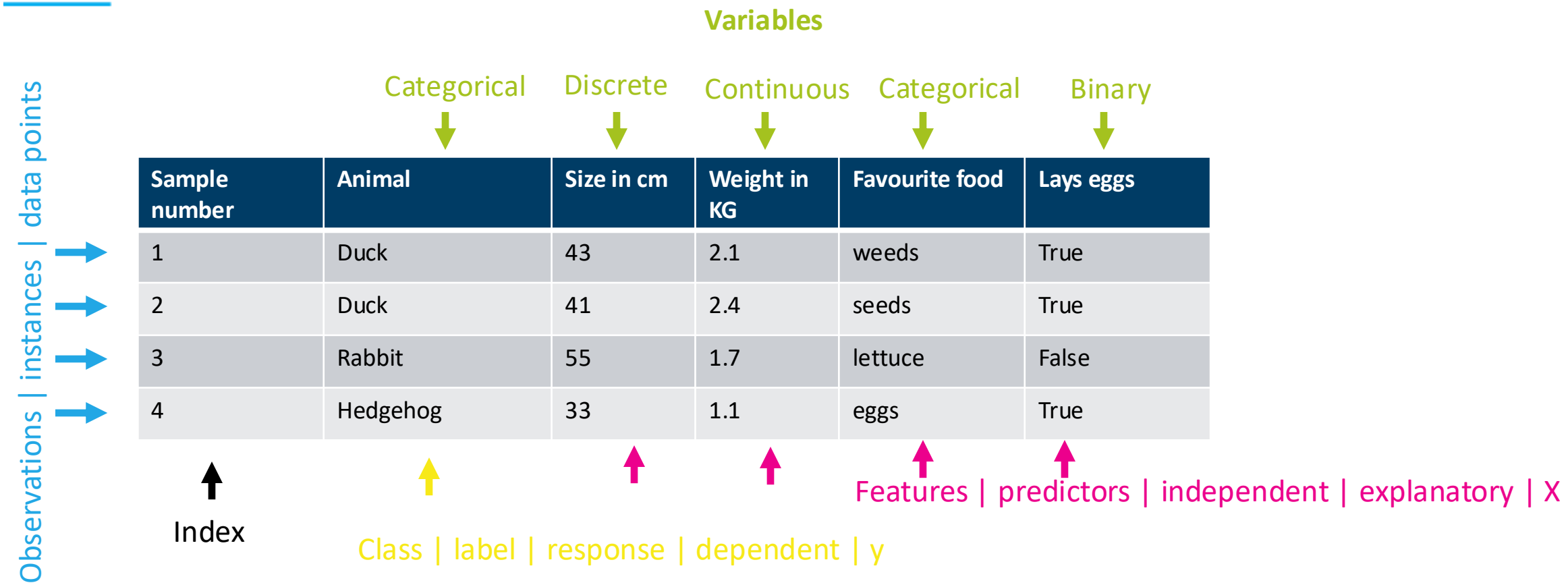
Variables and features



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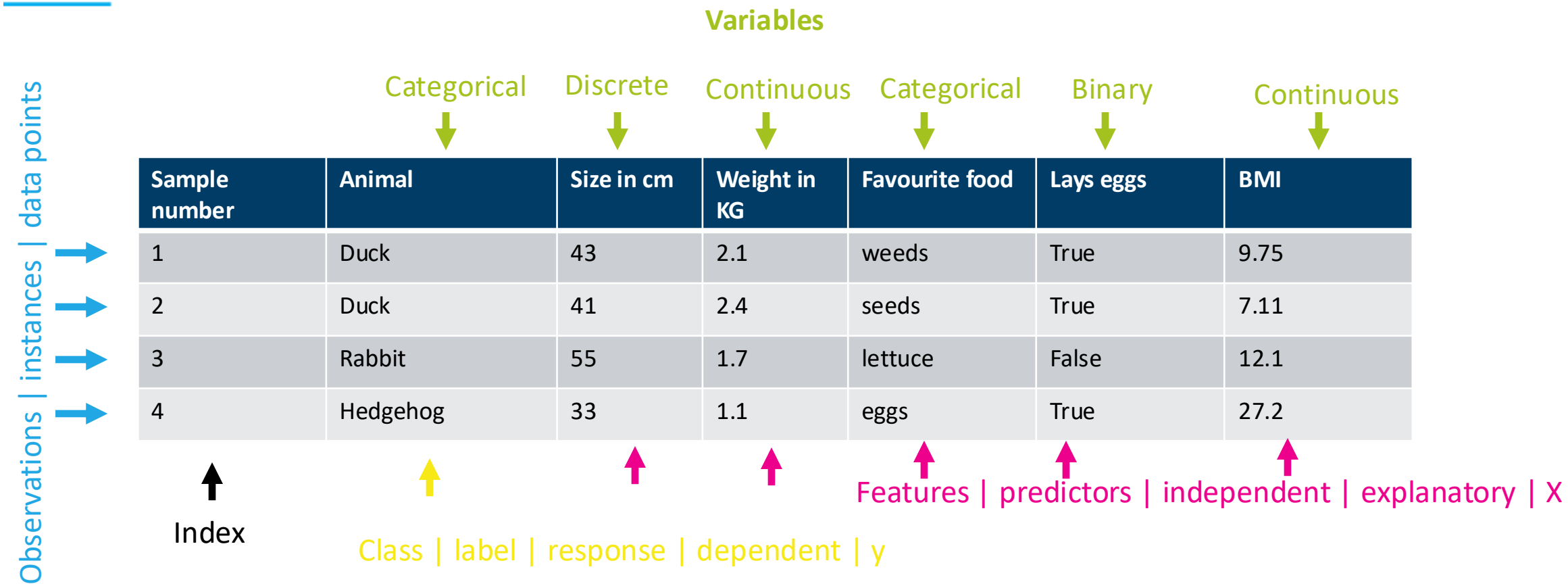
Feature Engineering

BMI = Weight / Size^2



Sample number	Animal	Size in cm	Weight in KG	Favourite food	Lays eggs	BMI
1	Duck	43	2.1	weeds	True	9.75
2	Duck	41	2.4	seeds	True	7.11
3	Rabbit	55	1.7	lettuce	False	12.1
4	Hedgehog	33	1.1	eggs	True	27.2

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Quiz -- Variables

	age	income	marital_status	subscribed
0	56	5.99	divorced	0
1	69	3.72	married	0
2	41	7.30	married	1
3	58	3.53	single	1
4	21	4.53	divorced	0
5	18	7.54	divorced	1
6	64	4.53	married	0
7	68	3.54	married	0
8	68	5.31	single	1
9	47	4.02	married	0

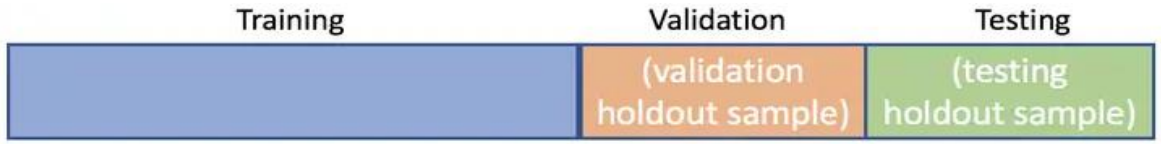
- **Application:** predicting whether a customer will subscribe to a marketing campain

A - Find the target variable

B – What are the features?

C – Name a categorical feature.

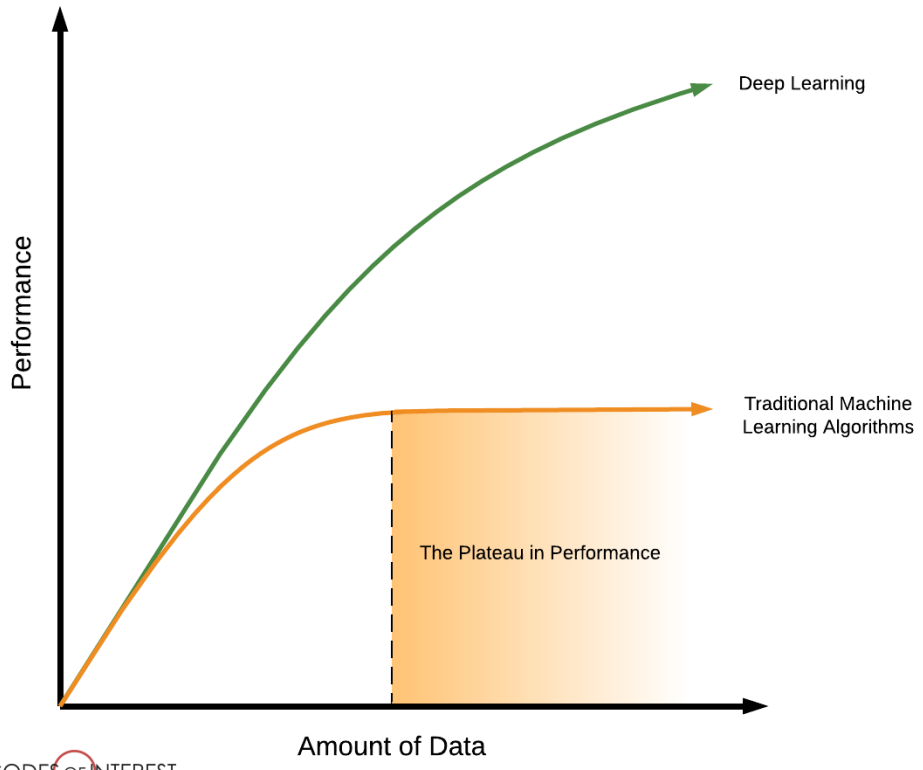
Splitting data – Test, Train and validation data

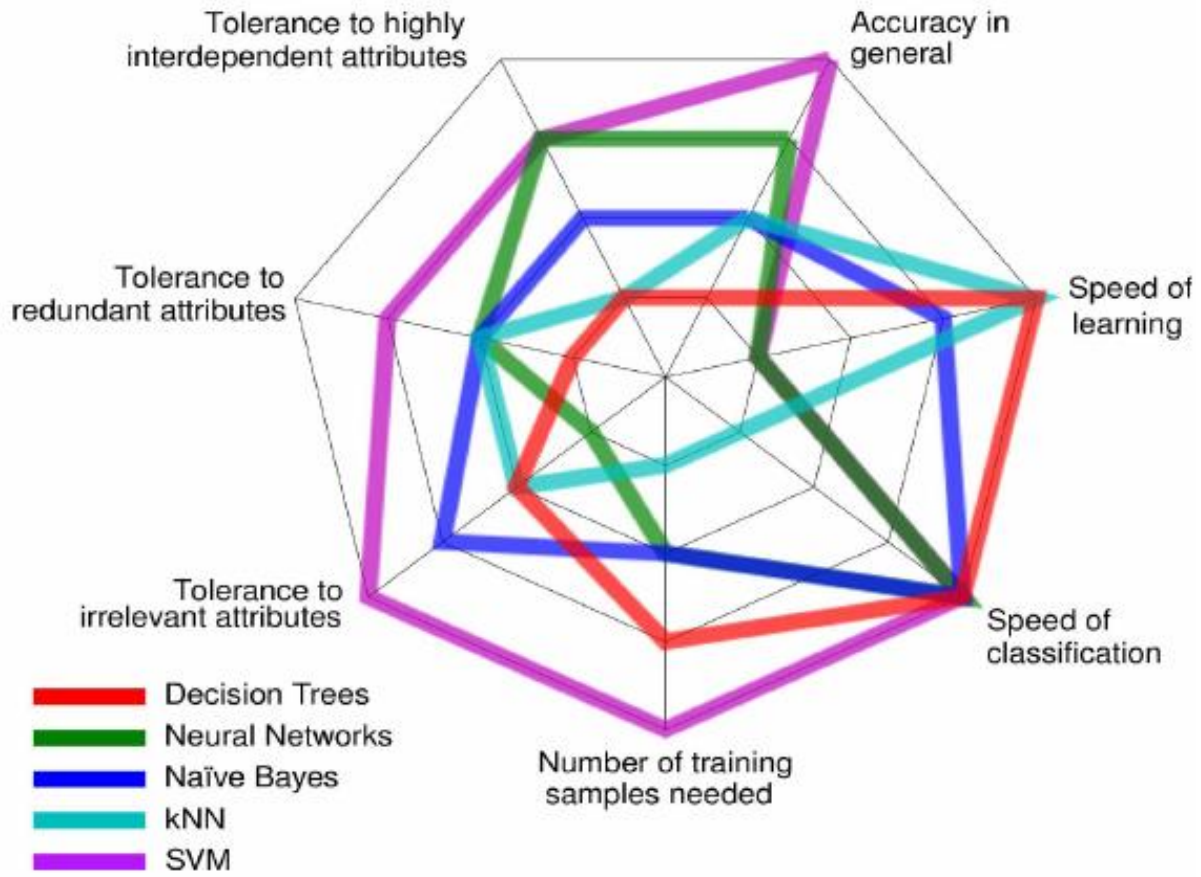


- ideally
  - Data which we use to design our models (Training set)
  - Data which we use to refine our models (Validation set)
  - Data which we use to test our models (Testing set)
- If we do not split our data, we might test our model with the same data that we use to train our model
  - Beware of *train-test contamination*

https://algotrading101.com/learn/train-test-split/

Model Performance – No magic bullet





Widanapathirana et al. 2012

CODES OF INTEREST

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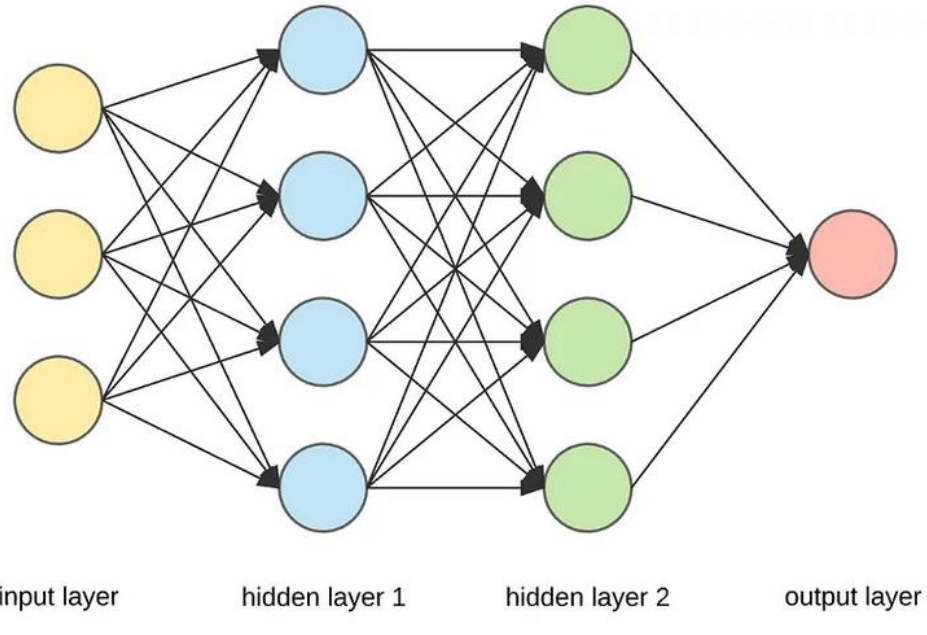
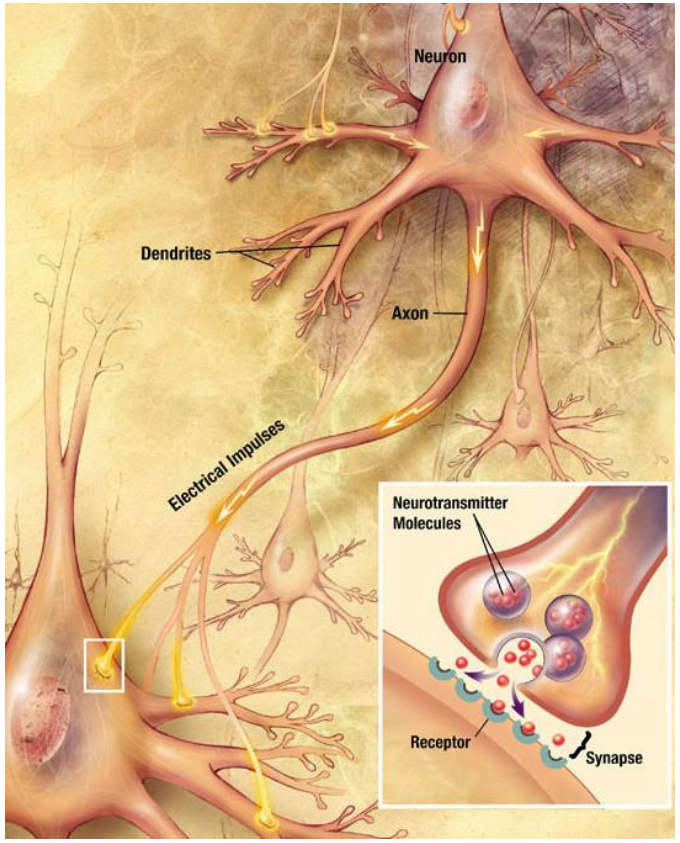
Choosing an architecture and tuning hyperparameters

A simple building block





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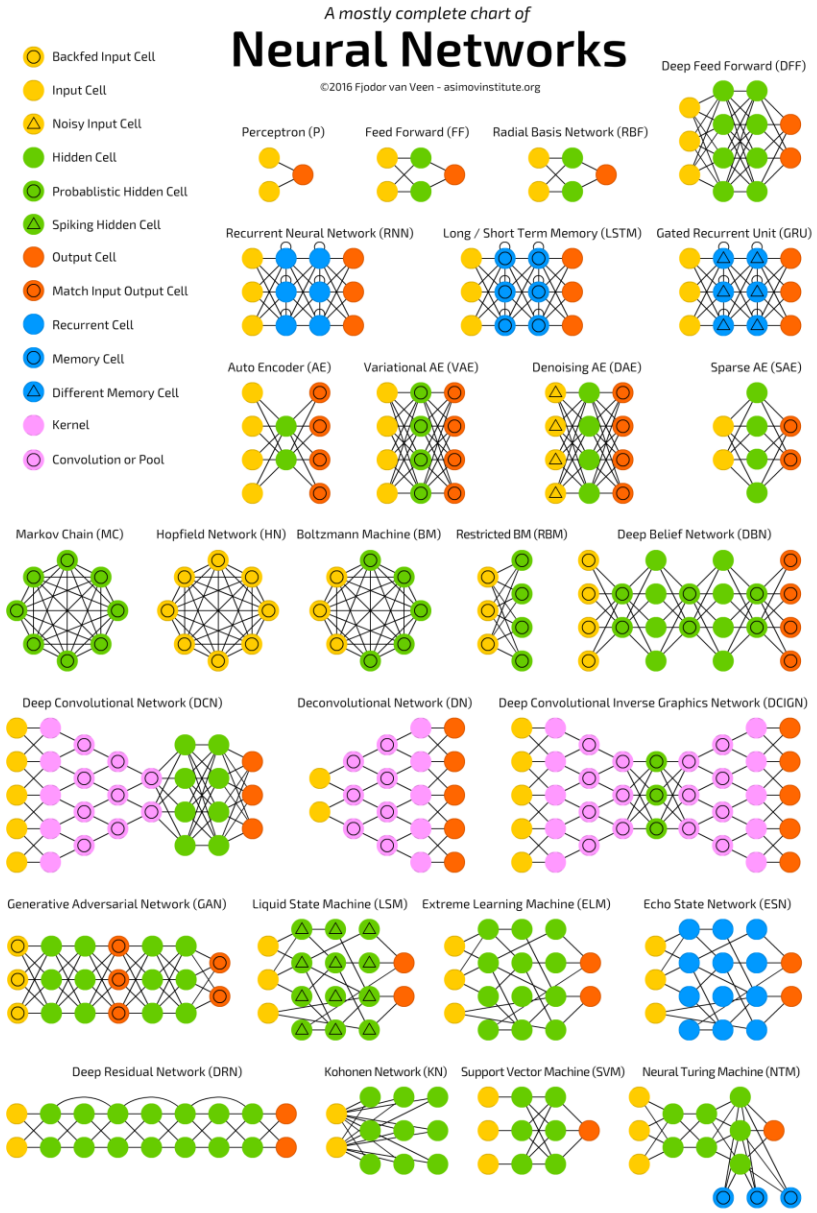
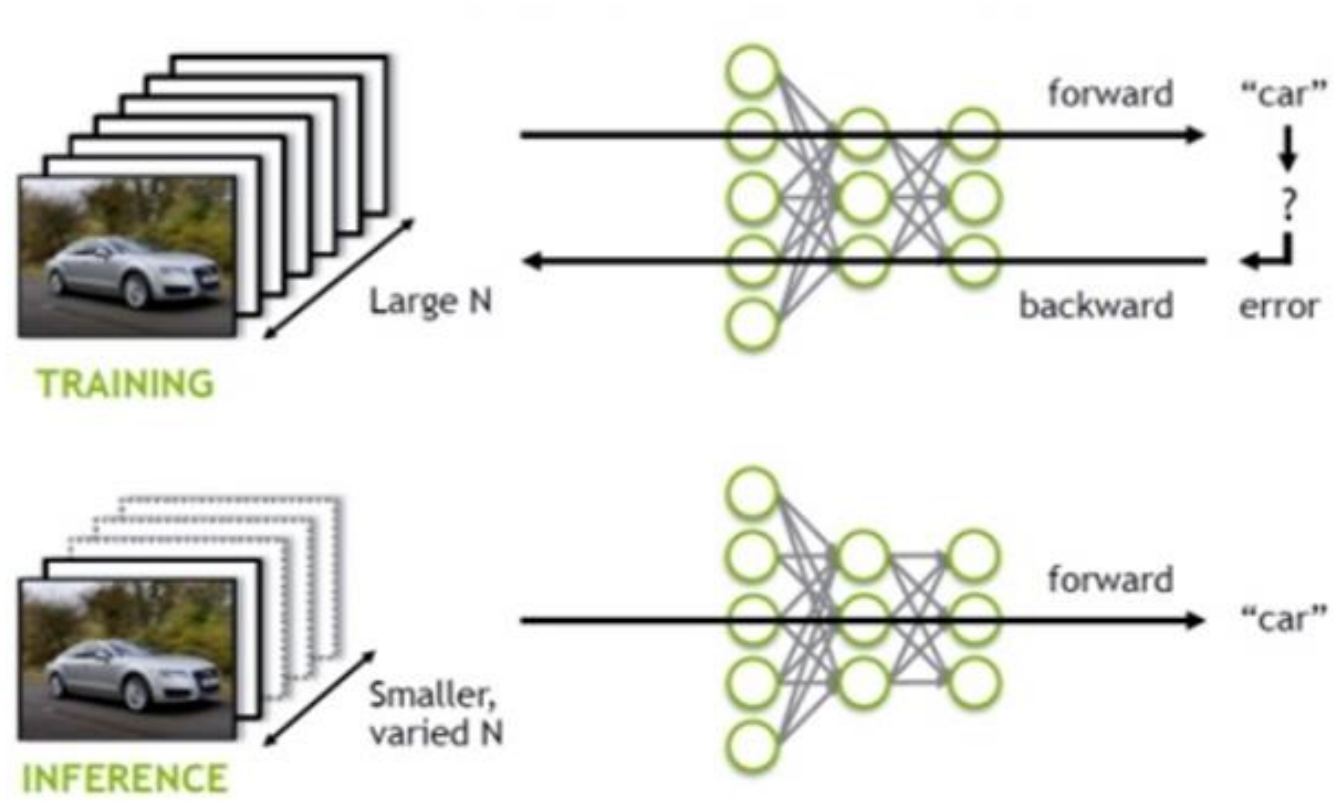
Choosing an architecture and tuning hyperparameters

For larger systems, we need to decide:

- How many layers, how many unit?
- Activation function
- Global architecture
  - Convolutional neural nets (CNN) - Good choice for spatial data
  - Recurent neural nets (RNN) - Good choice for temporal data
- How to connect the layers
- How to initialize weights
- Learning Rate
- Regularization Strength and technique



Training a model VS using a model



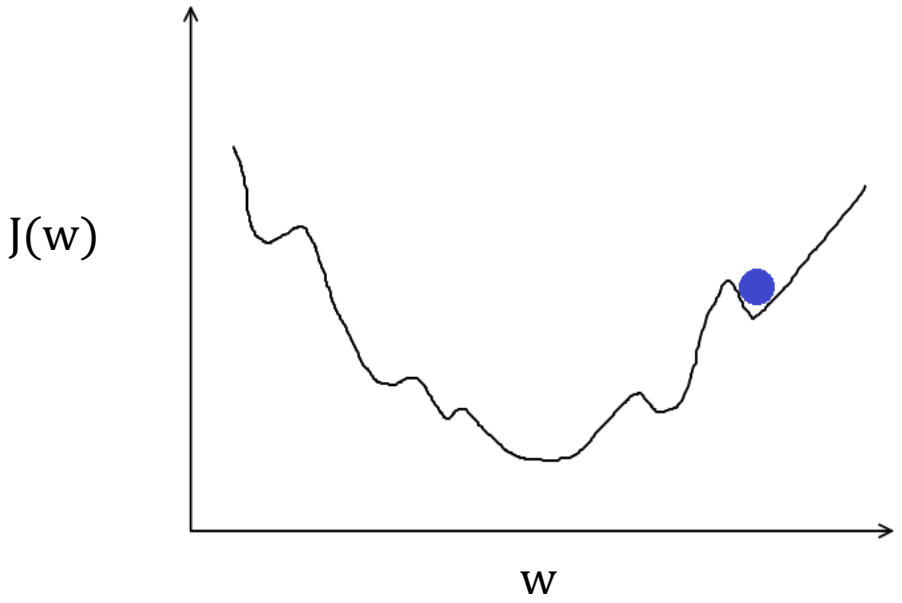
https://www.exxactcorp.com/blog/HPC/discover-the-difference-between-deep-learning-training-and-inference

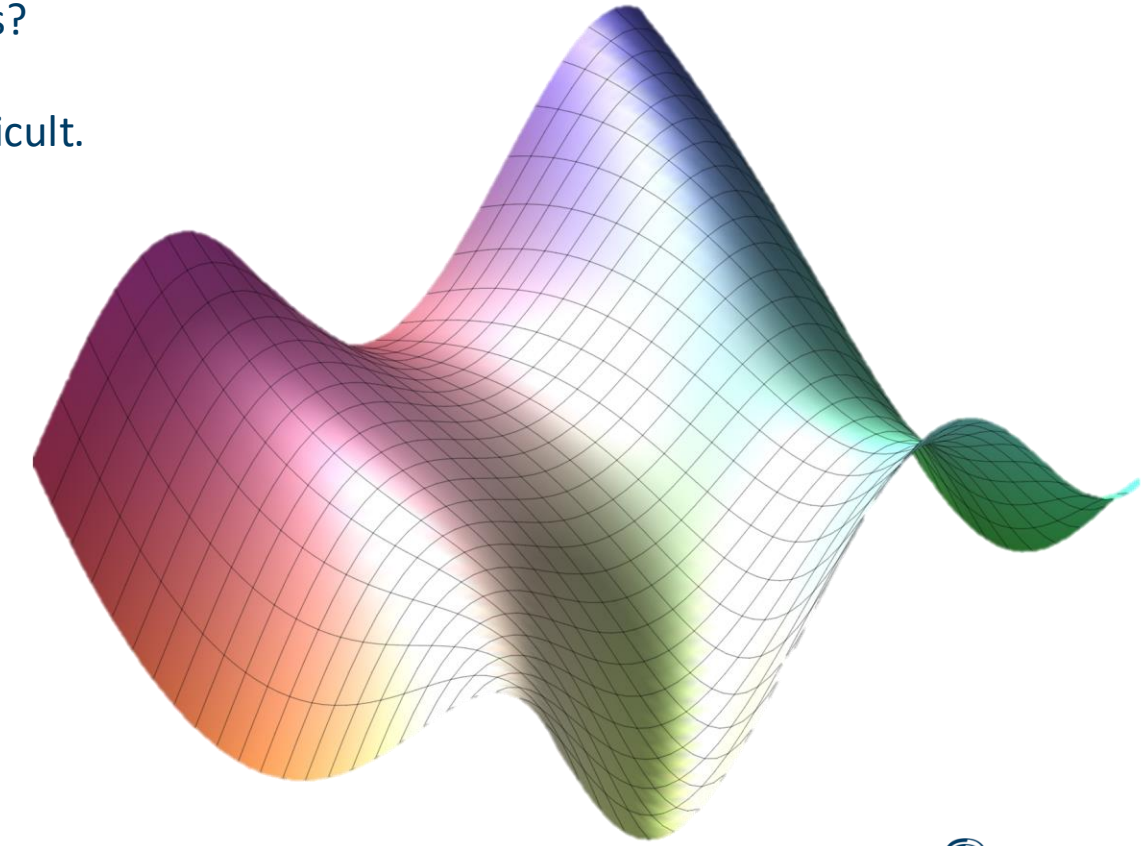
Loss/cost/value function

The loss function measures:

- how far is the model from the data/desired properties?

Finding the parameters leading to minimal loss can be difficult.





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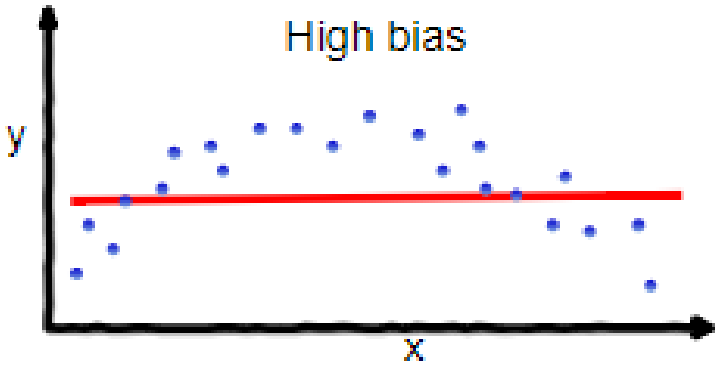
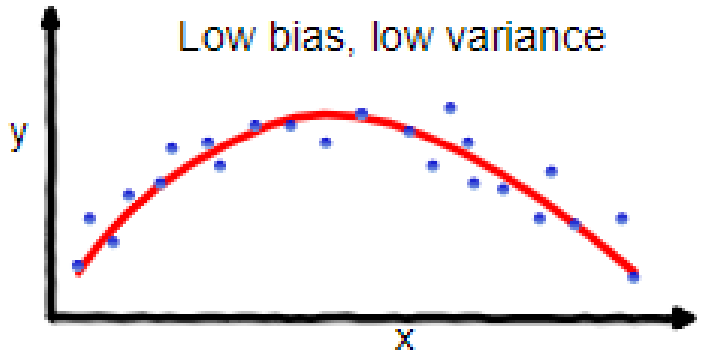
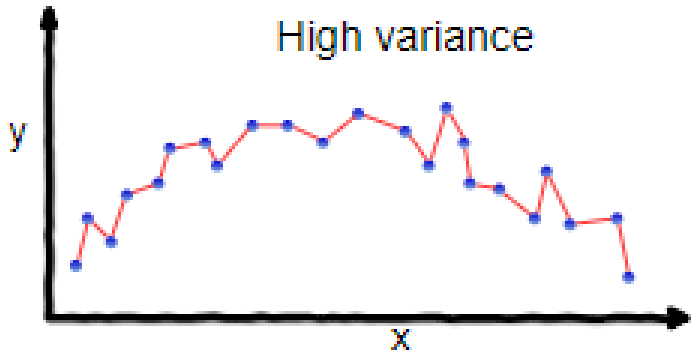
Bias-variance tradeoff



Under fitting



Good balance



Over fitting

https://en.wikipedia.org/wiki/Bias%E2%80%93variance_tradeoff

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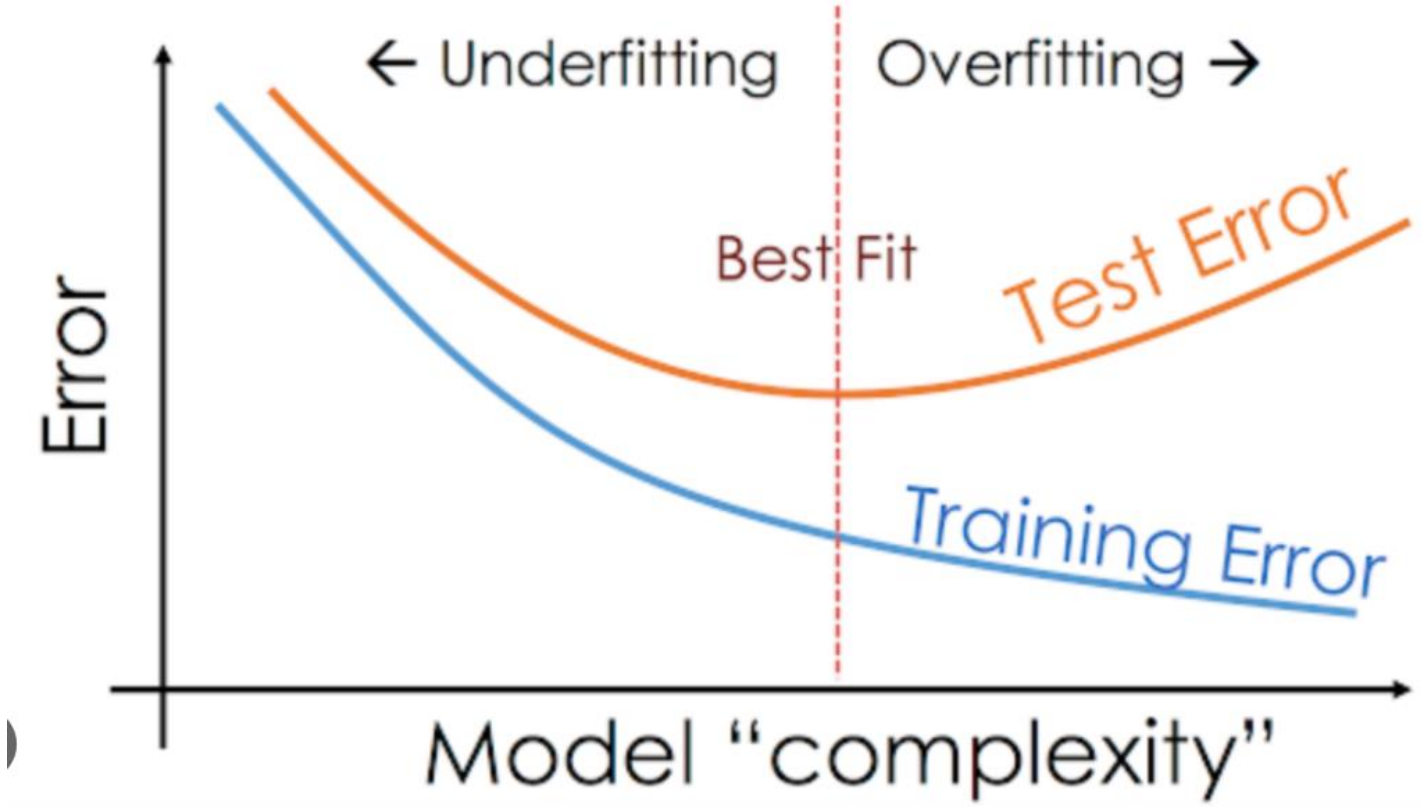
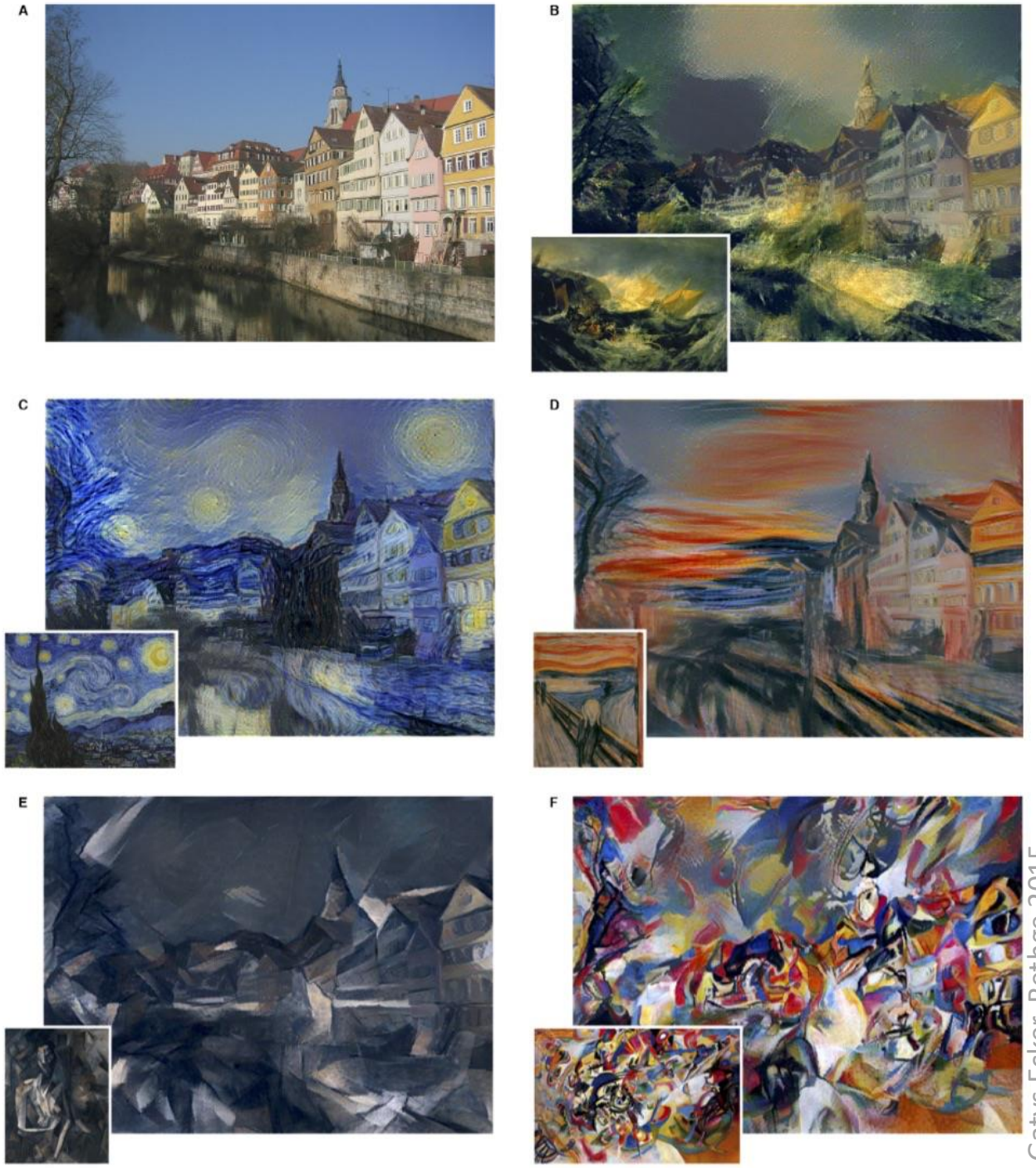


https://vitalflux.com/overfitting-underfitting-concepts-interview-questions/

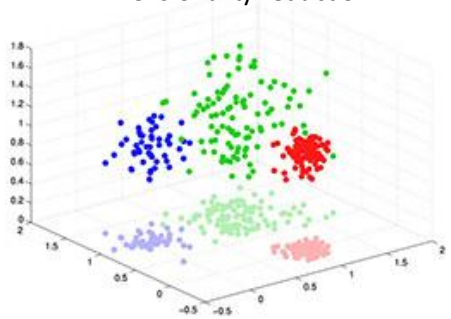
Take home messages

- Each context is different - many moving parts
- Experimentation is key
- Finding a method that works on your dataset is a science
  - (or perhaps it is an art)

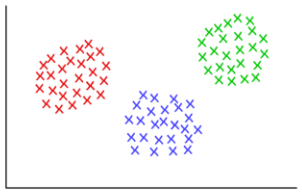


Gatys Ecker, Bethge 2015

Dimensionality reduction



Clustering



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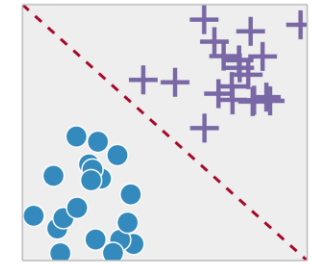
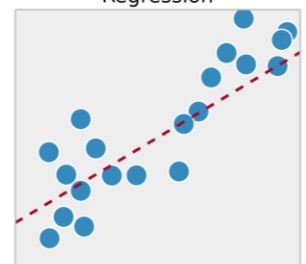
- Skill Acquisition
- Learning Tasks

Classification



Regression



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