Hands-On Machine Learning in Python

ALS User Meeting

September 11, 2023

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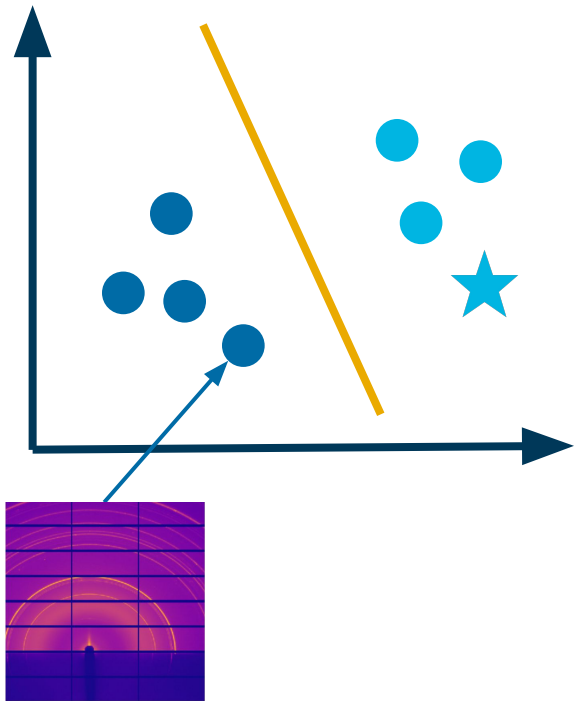
Introduction to Machine Learning

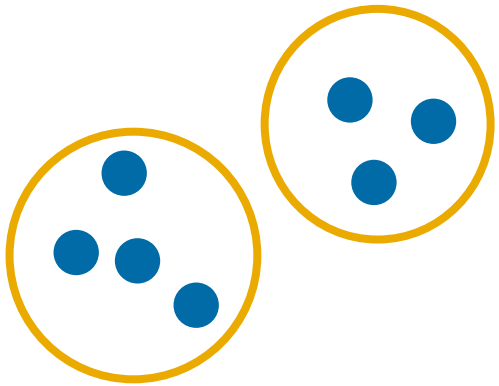
Wiebke Köpp

Types of Machine Learning

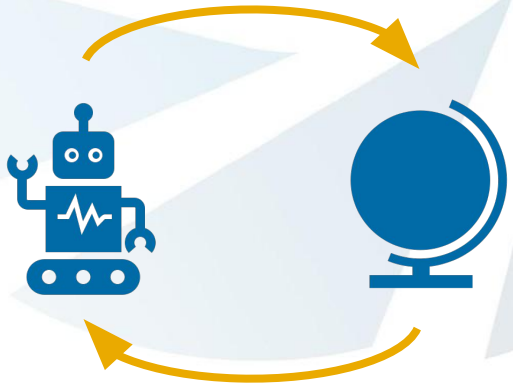
Supervised Learning



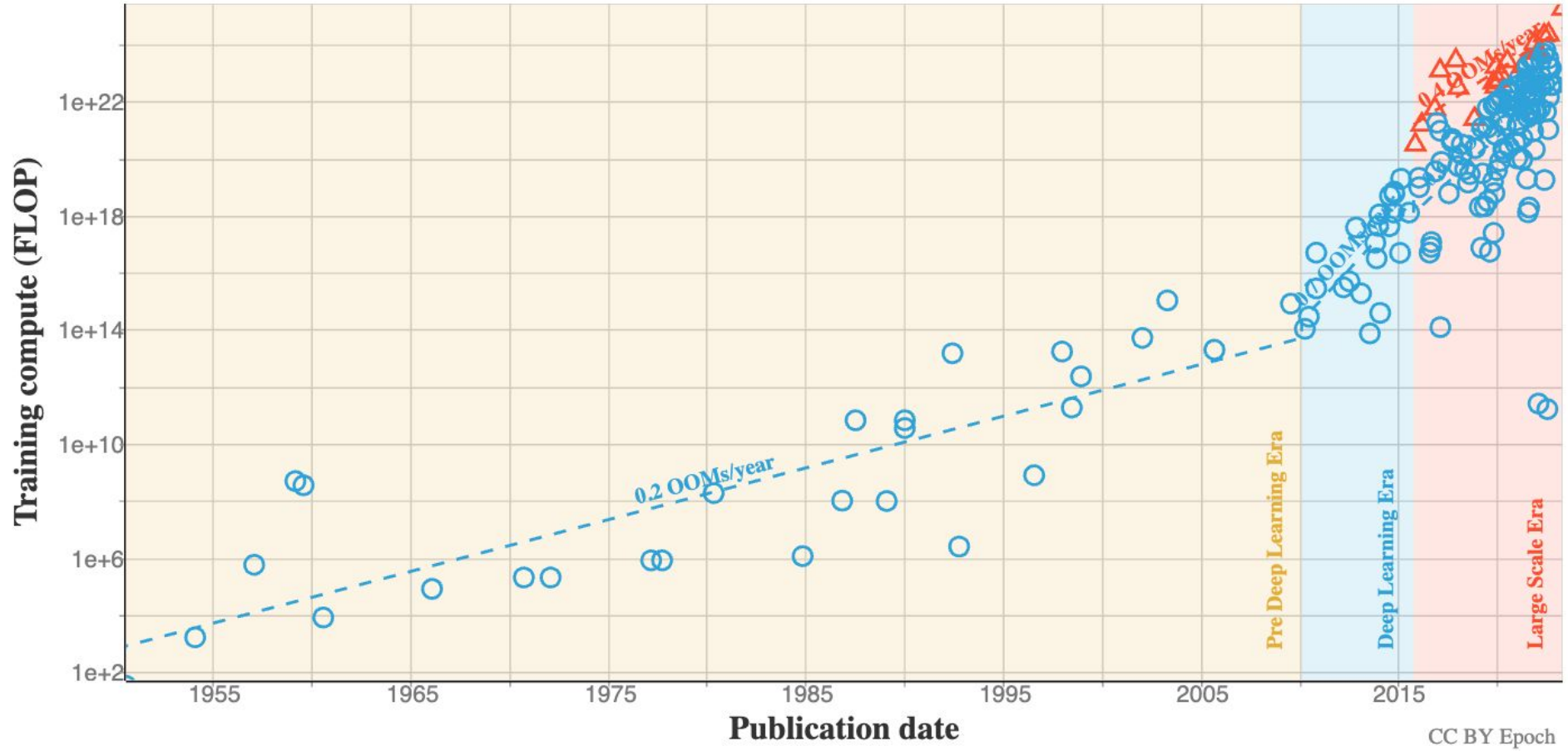
Unsupervised Learning



Reinforcement Learning



Towards larger models



https://epochai.org/mlinputs/visualization

History

Before 1950

Mathematical models for neural networks

1957: Perceptron

First programmed neural network

1950 — 1960

1950: Turing Test

Can the machine fool a human?

1950: Checkers

A computer learns to play with reinforcement learning

History

1967: Nearest Neighbors

Early example of supervised learning

1960 1970

History

AI Winter

Reduced funding and interest in AI research

1970 1980

History

1986: Backpropagation

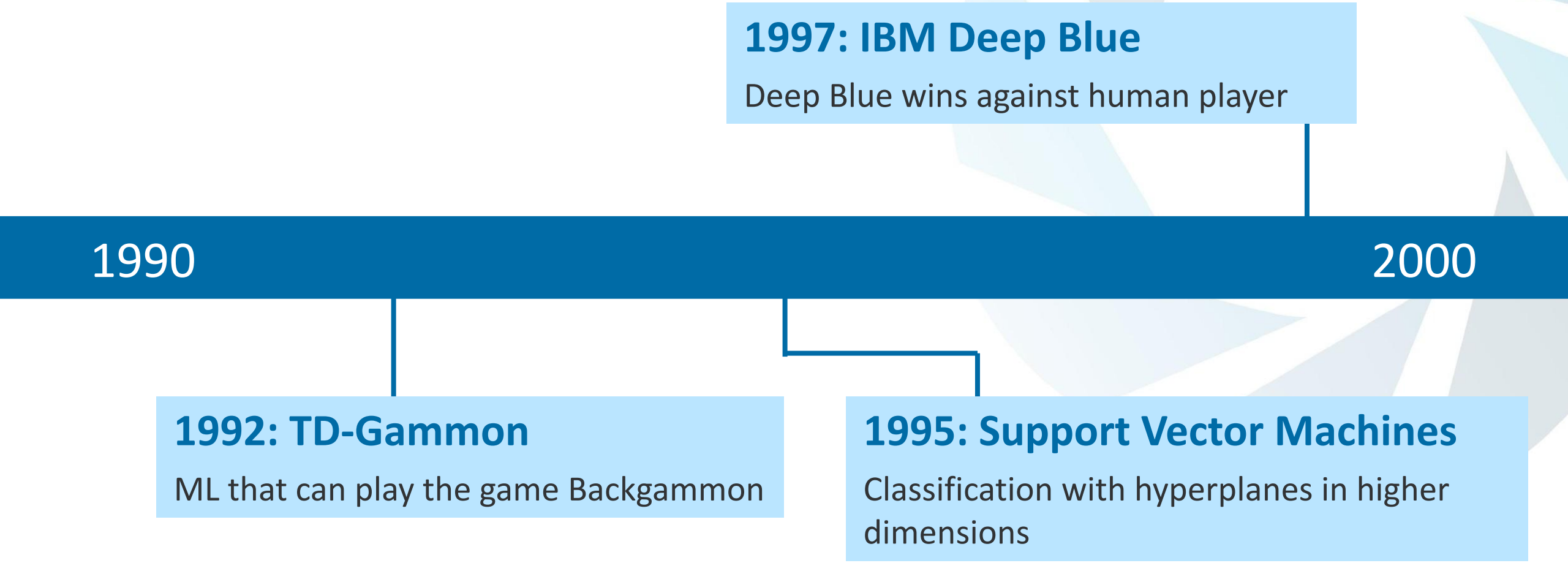
Backpropagation for MLPs

1980 1990

1982: Self-Organizing Maps

A different type of neural network

History


1997: IBM Deep Blue
Deep Blue wins against human player
1990
2000
1992: TD-Gammon
ML that can play the game Backgammon
1995: Support Vector Machines
Classification with hyperplanes in higher dimensions

History

2009: ImageNet

Large image collection with labels is released

2000 2010

History

2009: IBM Watson

Watson wins in Jeopardy

2015: ResNet

A new architecture with skip connections

2016: AlphaGo

Alpha Go beats human player

2010

2020

2012: AlexNet

CNN achieves high accuracy on ImageNet

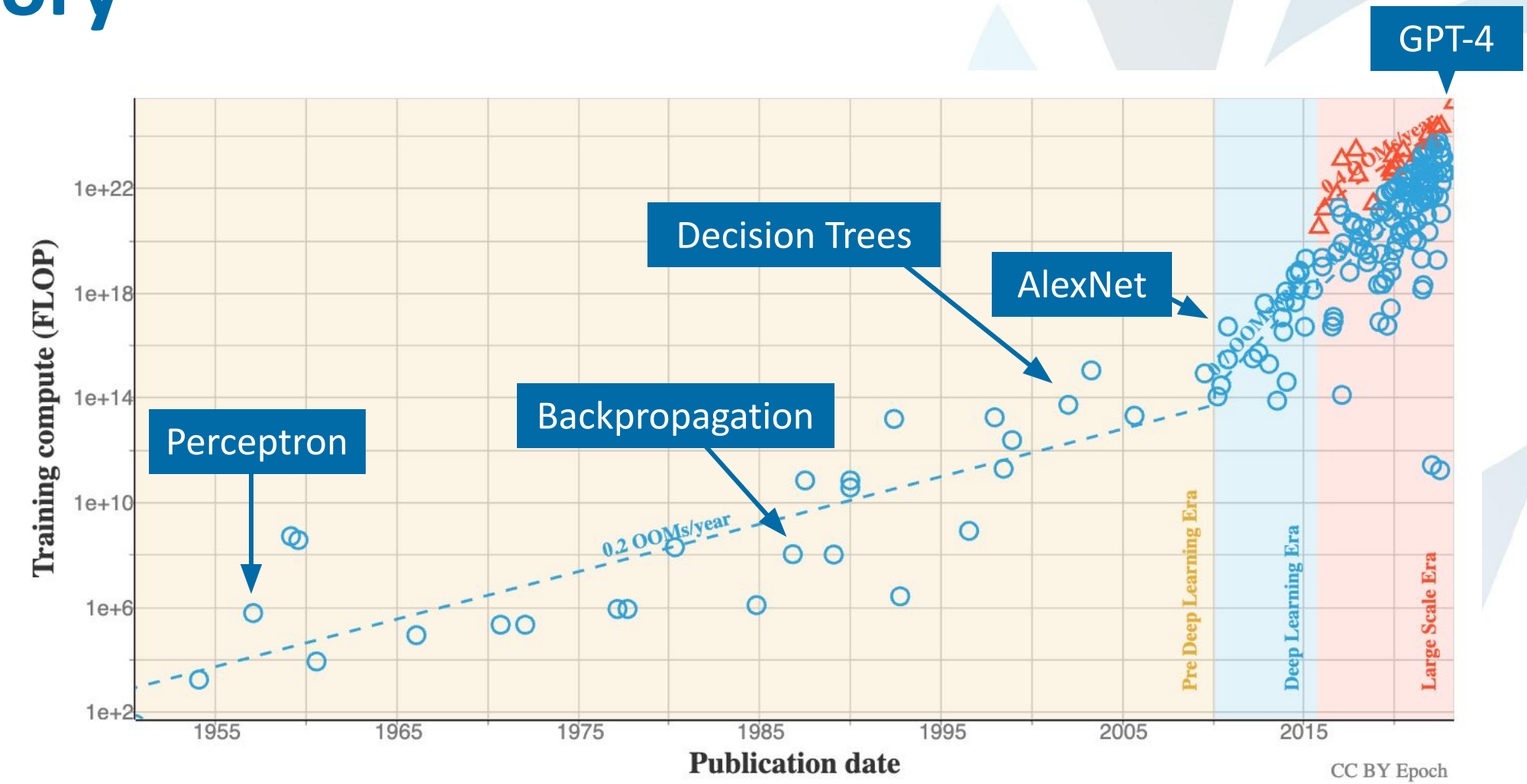
2014: GAN

Generative Adversarial Networks generate images

2017: Transformers

Basis for today's large language models (BERT, GPT, …)

History



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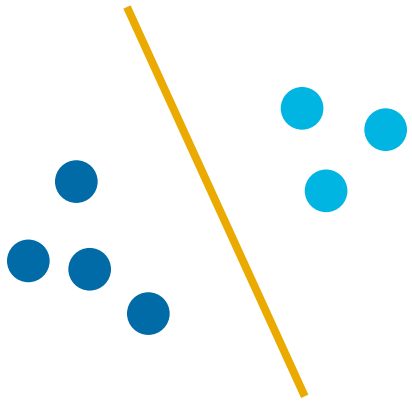
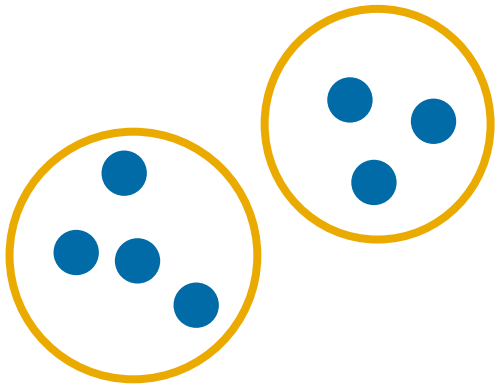
Types of Machine Learning

Supervised Learning

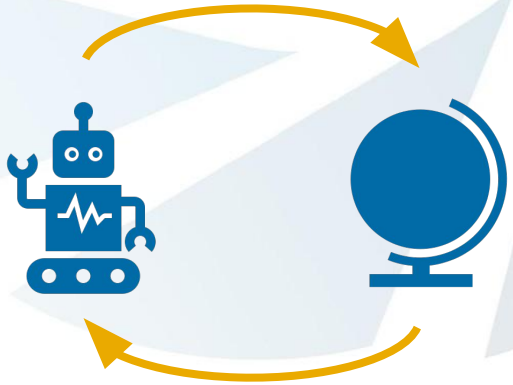


Classification | Regression

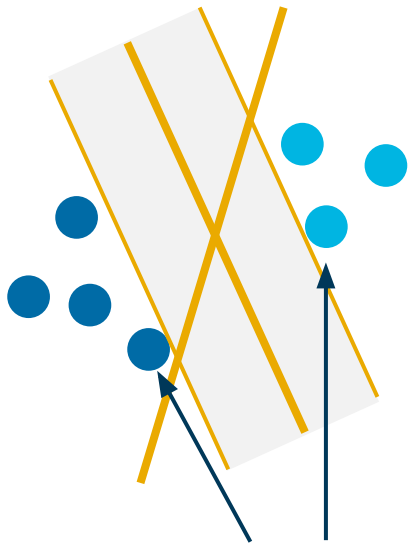
Unsupervised Learning



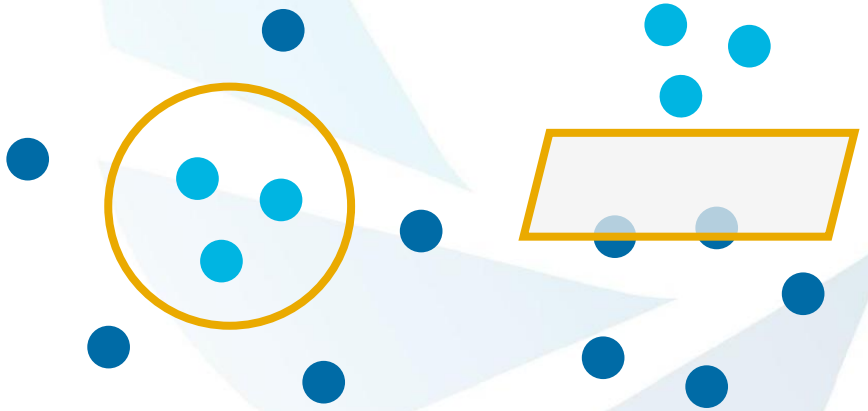
Reinforcement Learning



Supervised Learning:
Support Vector Machines / Linear Classifiers

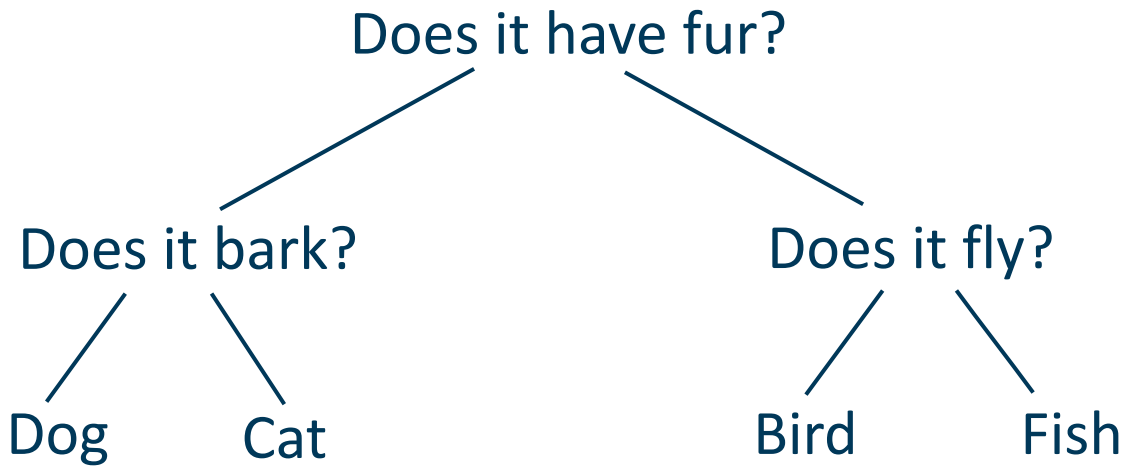


Support Vectors



Linearly separable in 3D

Supervised Learning: Decision Trees



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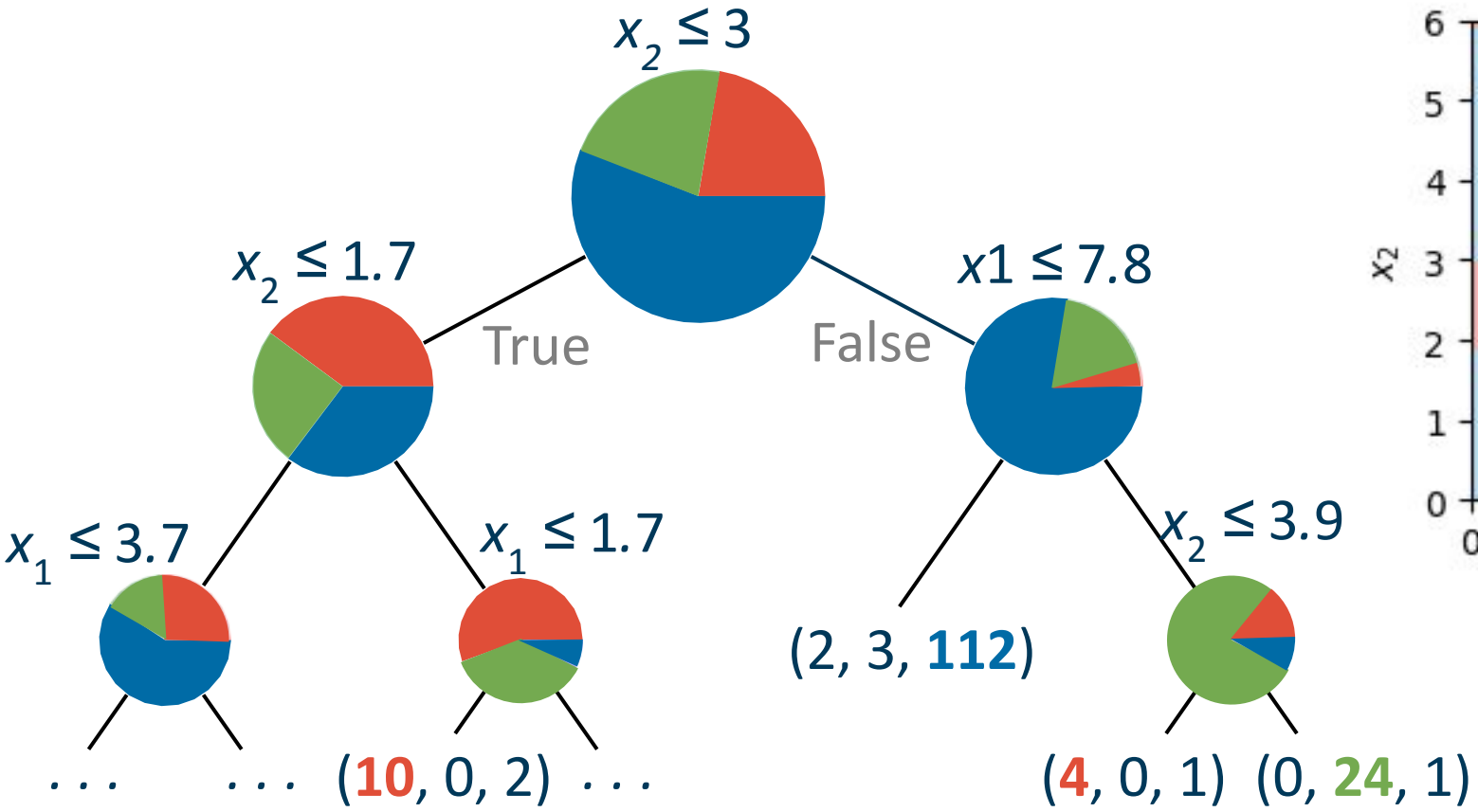
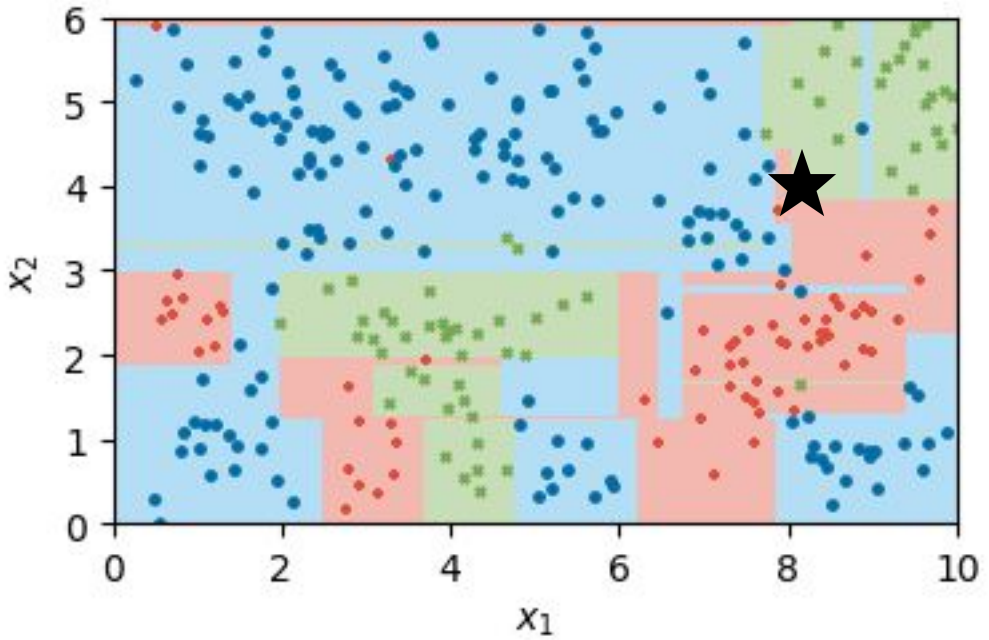
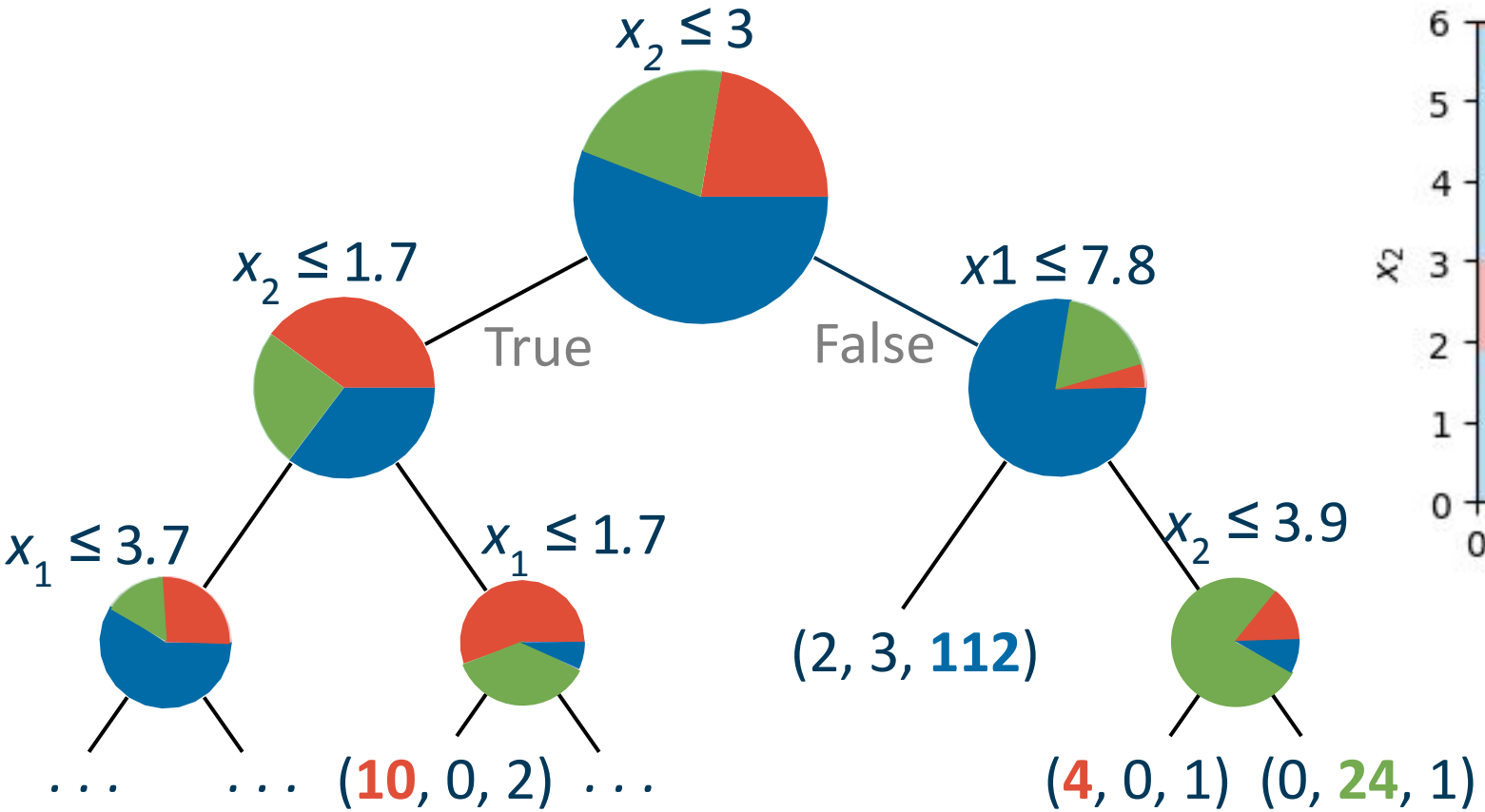
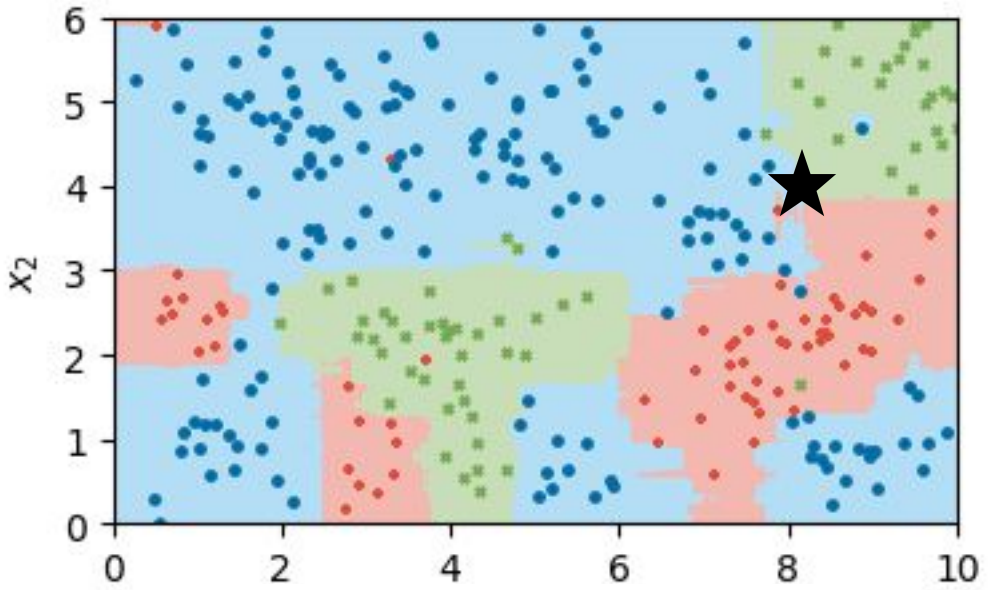


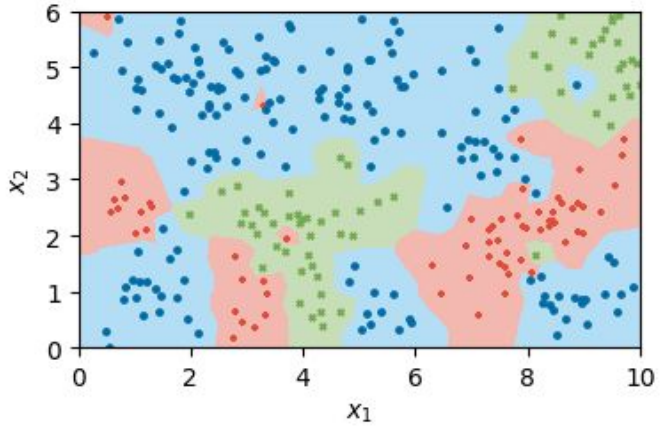


Supervised Learning:
Decision Trees – a component of Random Forests

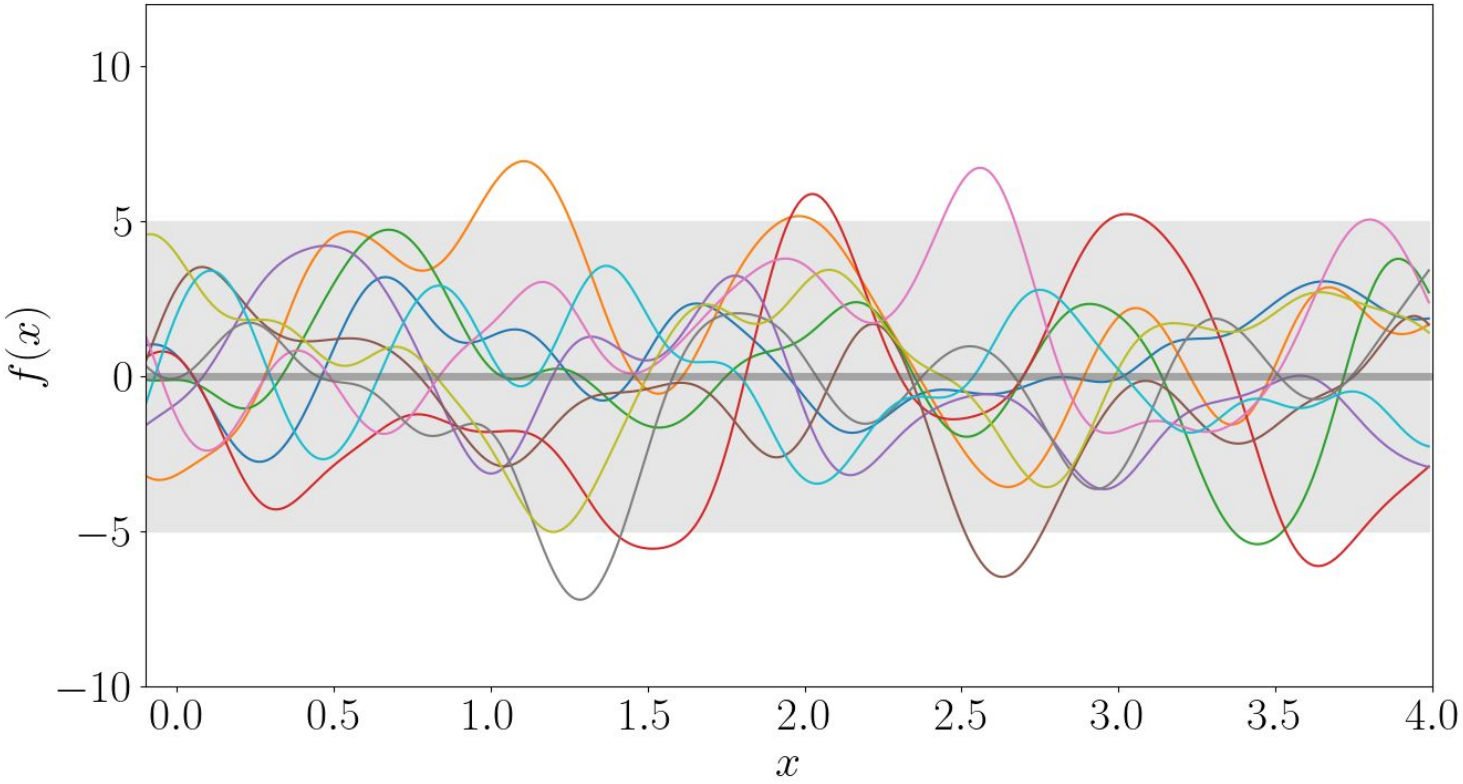


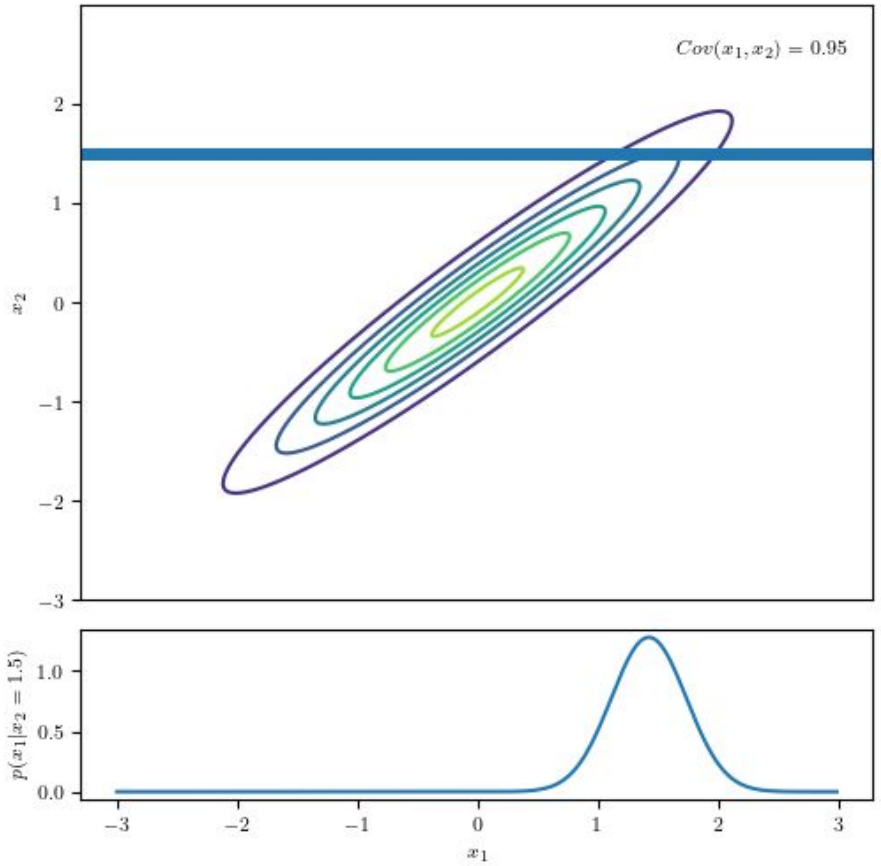


Similar result with kNN



Supervised Learning: Gaussian Processes





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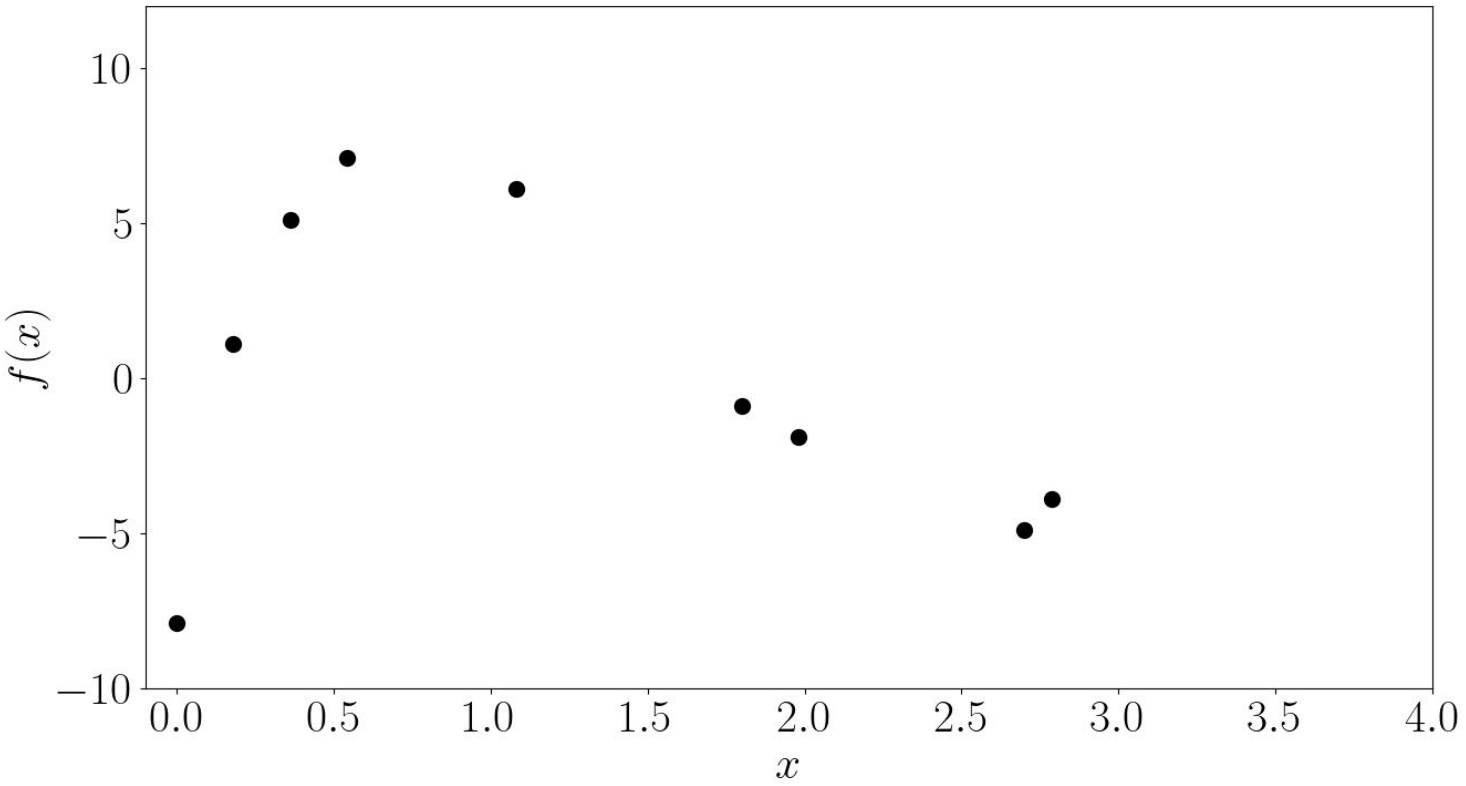

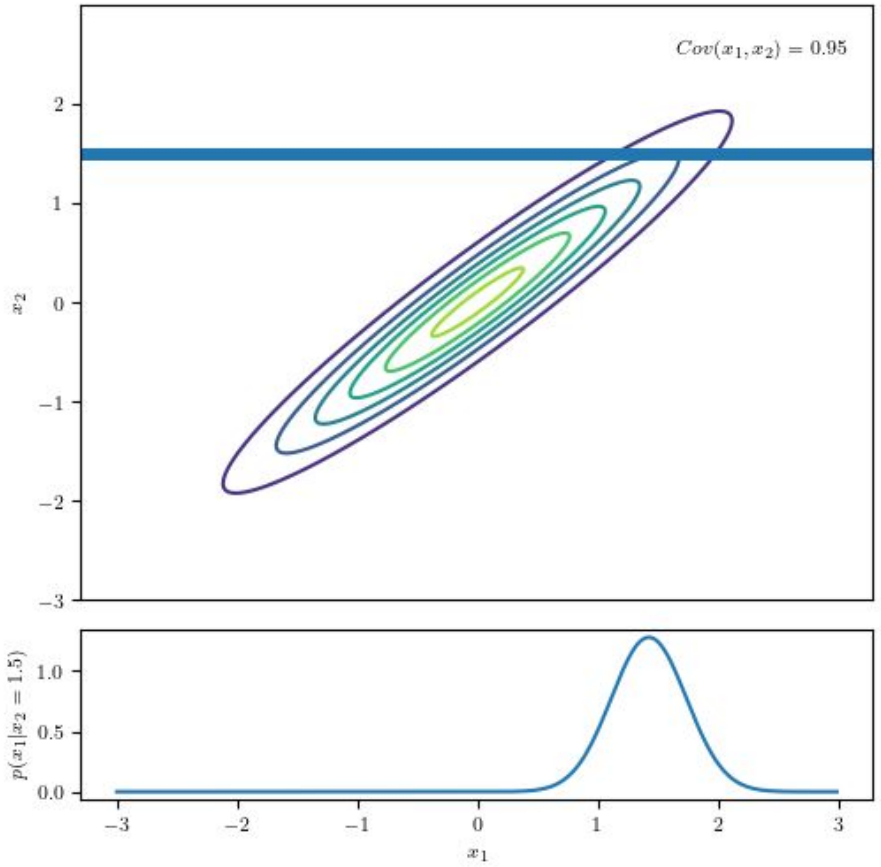

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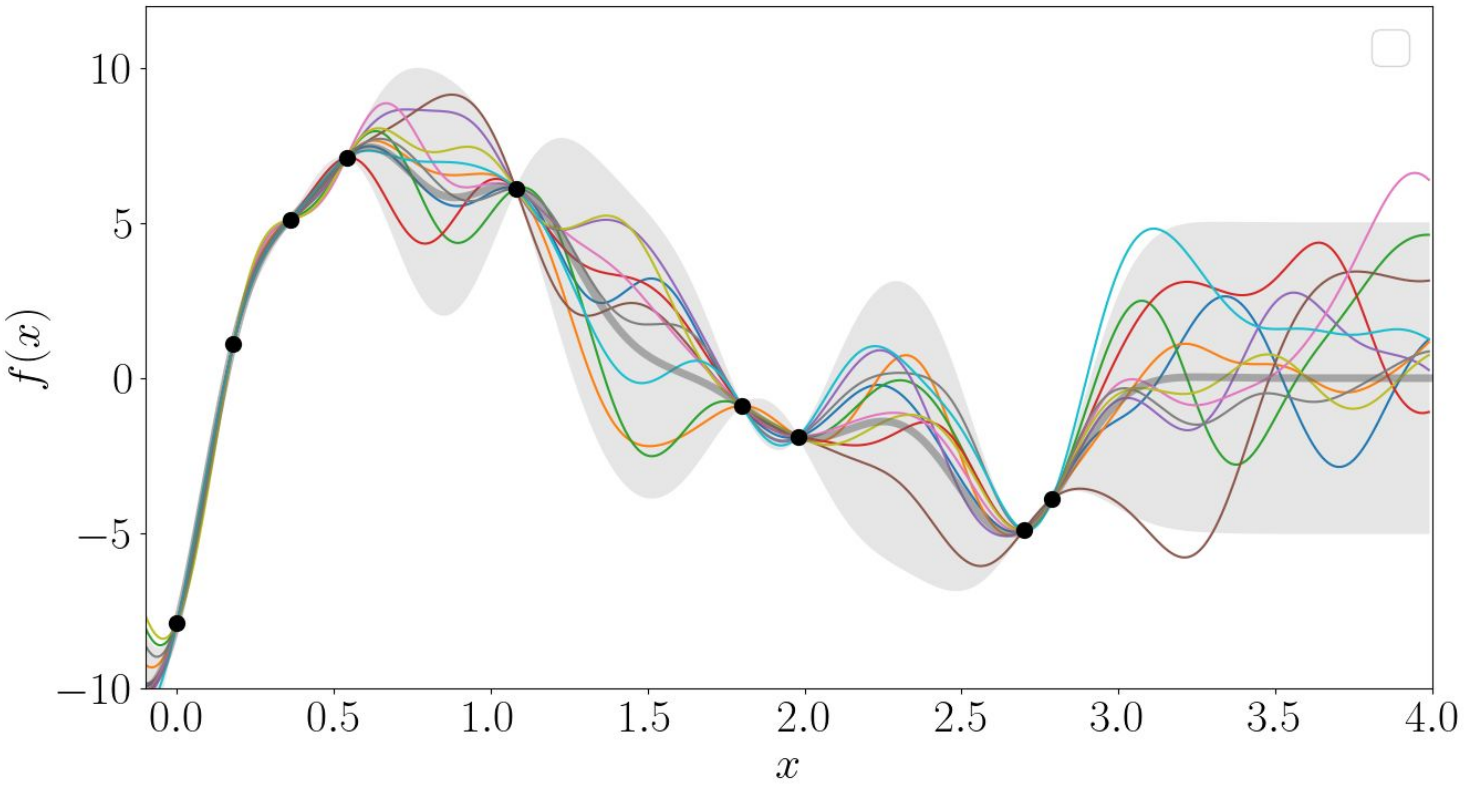
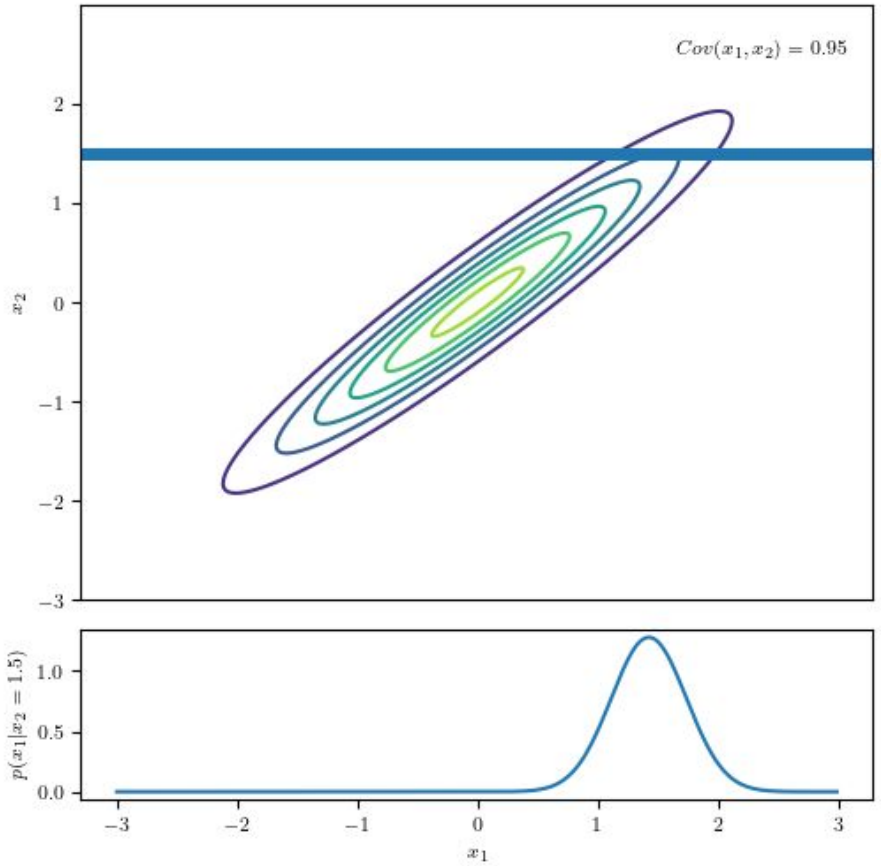
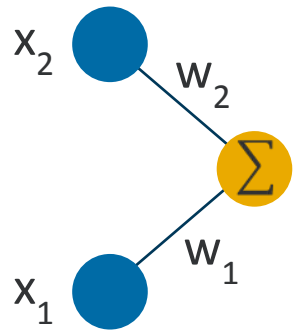




Supervised Learning: Artificial Neural Networks



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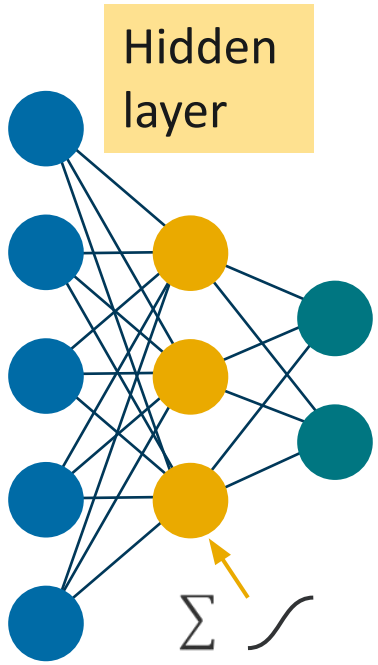
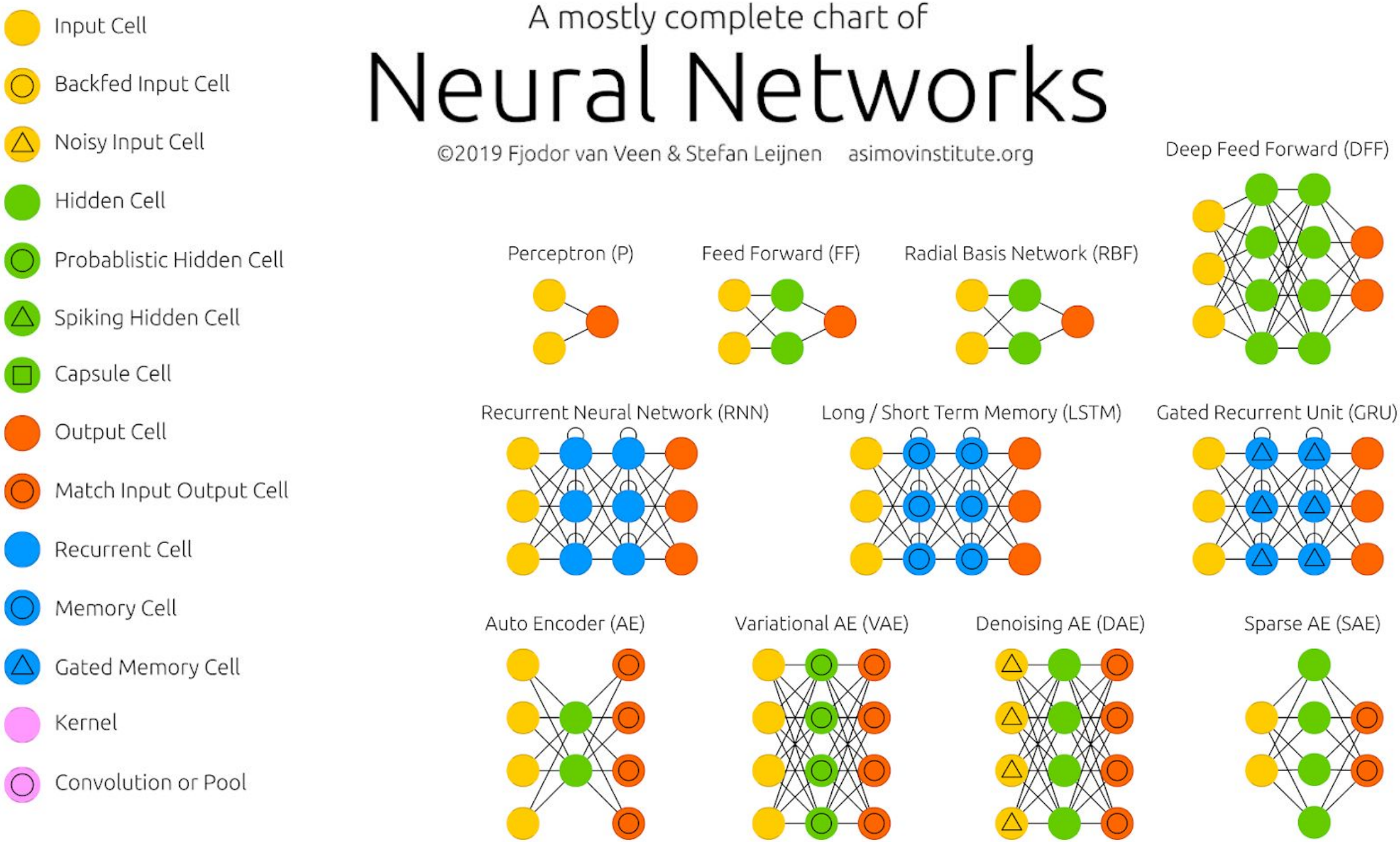


Other inputs need other architectures,
e.g., Convolutional Neural Networks (CNNs) for images


A mostly complete chart of
Neural Networks
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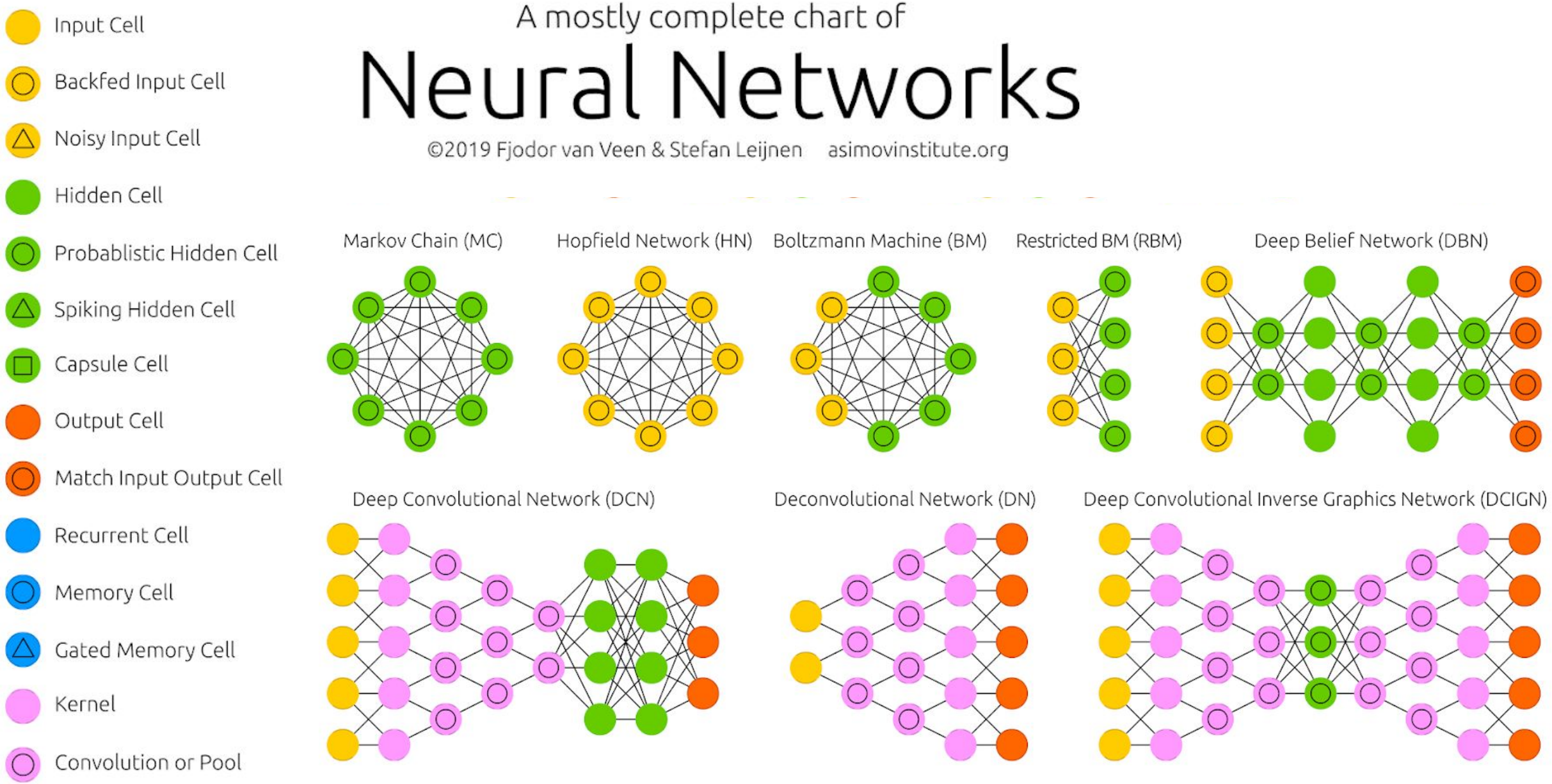
Input Cell
Backfed Input Cell
Noisy Input Cell
Hidden Cell
Probablistic Hidden Cell
Spiking Hidden Cell
Capsule Cell
Output Cell
Match Input Output Cell
Recurrent Cell
Memory Cell
Gated Memory Cell
Kernel
Convolution or Pool
Perceptron (P)
Feed Forward (FF)
Radial Basis Network (RBF)
Deep Feed Forward (DFF)
Recurrent Neural Network (RNN)
Long / Short Term Memory (LSTM)
Gated Recurrent Unit (GRU)
Auto Encoder (AE)
Variational AE (VAE)
Denoising AE (DAE)
Sparse AE (SAE)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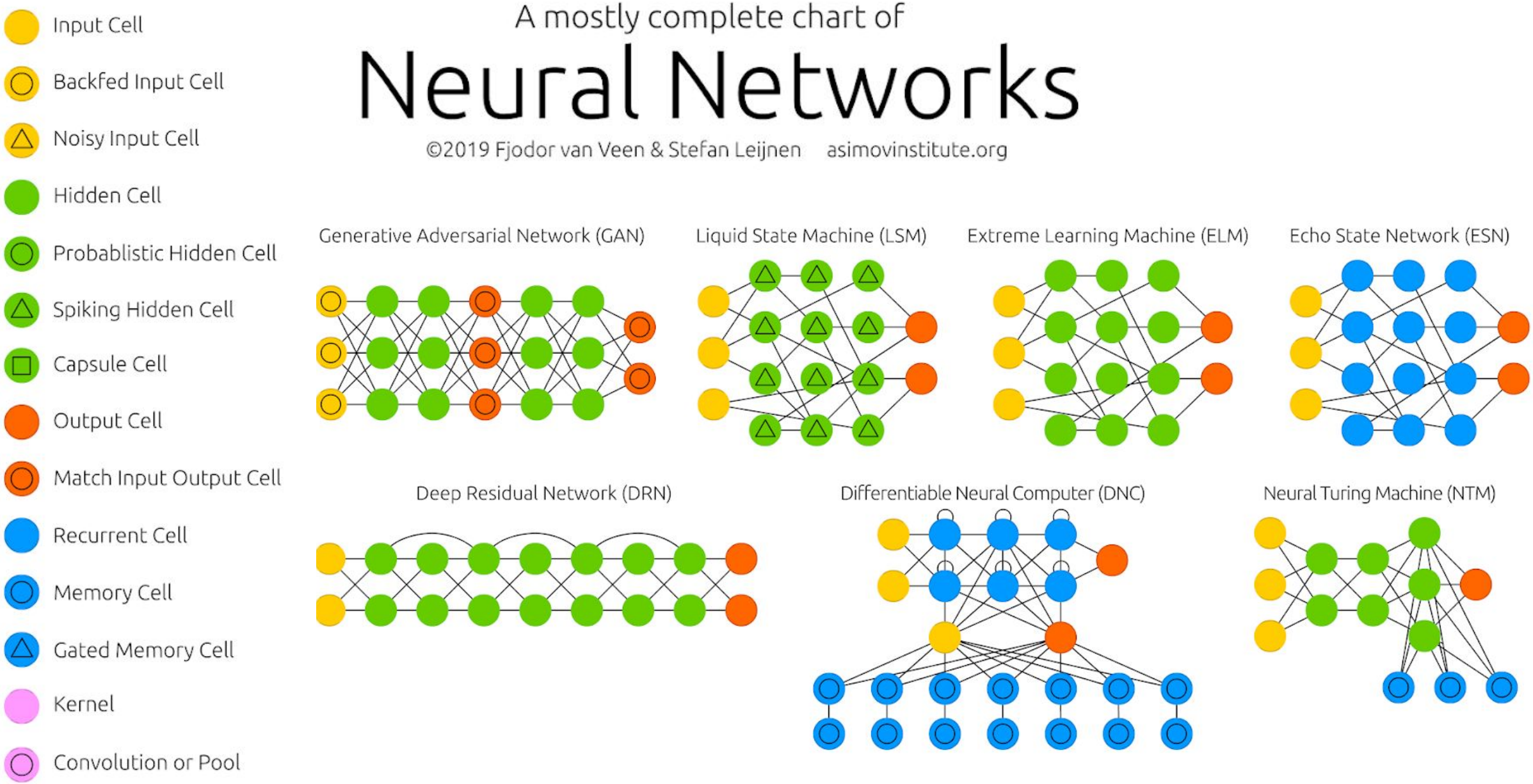
Markov Chain (MC)
Hopfield Network (HN)
Boltzmann Machine (BM)
Restricted BM (RBM)
Deep Belief Network (DBN)
Deep Convolutional Network (DCN)
Deconvolutional Network (DN)
Deep Convolutional Inverse Graphics Network (DCIGN)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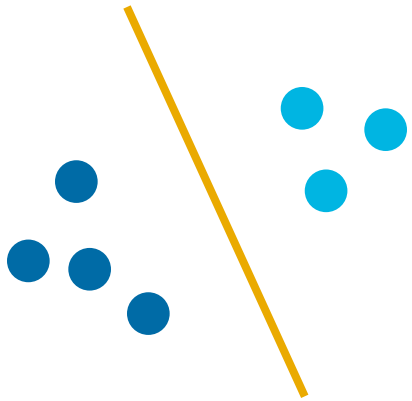
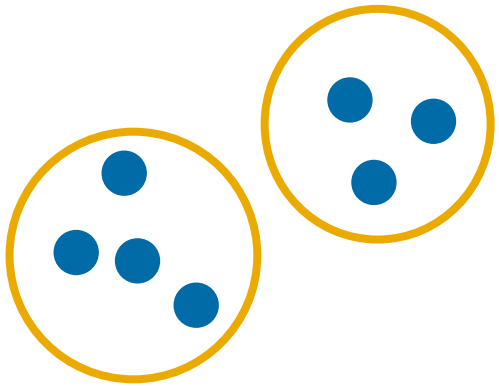
Generative Adversarial Network (GAN)
Liquid State Machine (LSM)
Extreme Learning Machine (ELM)
Echo State Network (ESN)
Deep Residual Network (DRN)
Differentiable Neural Computer (DNC)
Neural Turing Machine (NTM)

Types of Machine Learning

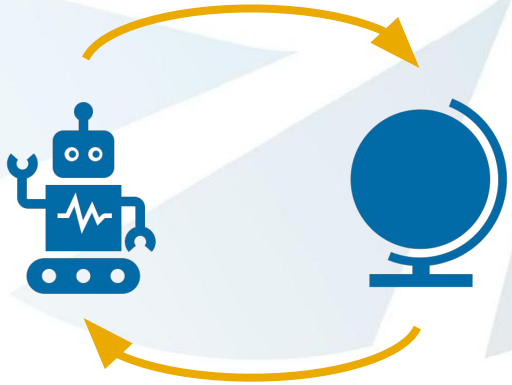
Supervised Learning



Unsupervised Learning



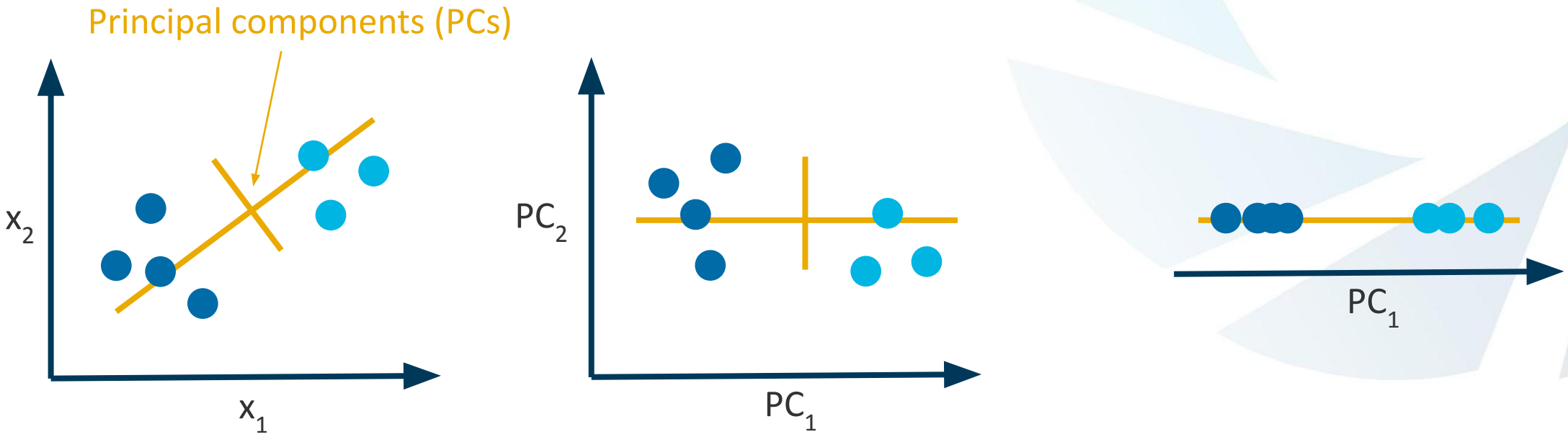
Reinforcement Learning



Dimensionality Reduction

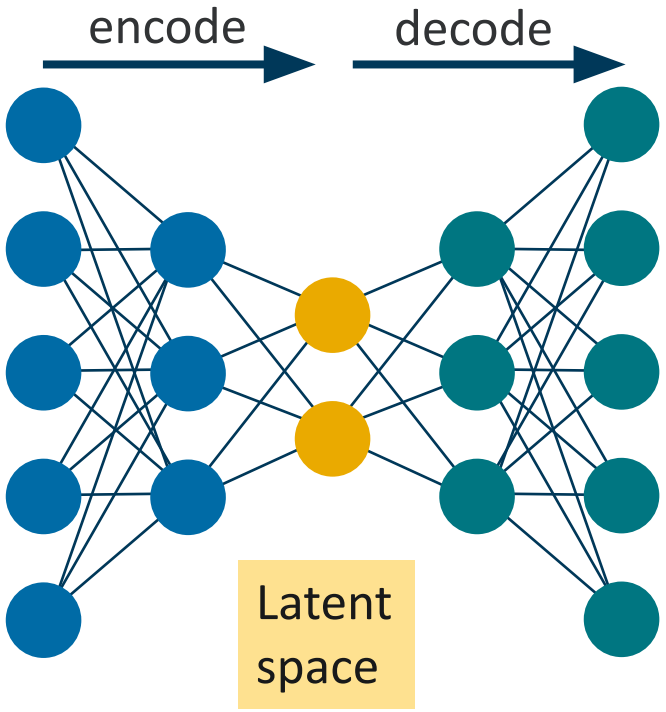
Clustering

Unsupervised Learning: Dimensionality Reduction (PCA)

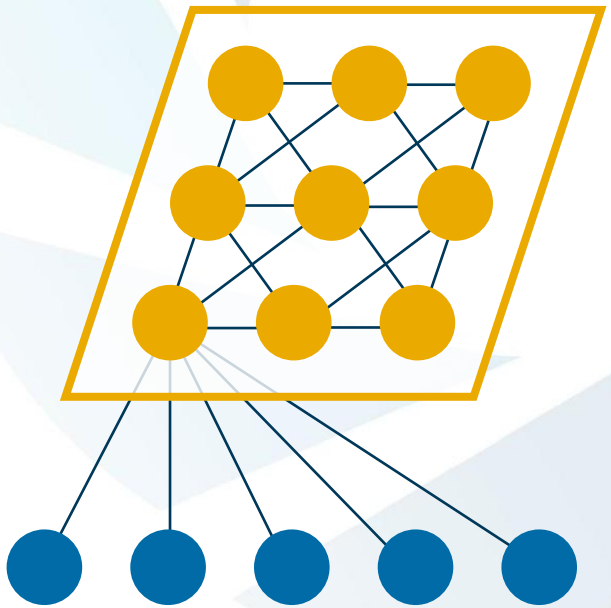


Common alternatives:
Uniform Manifold Approximation and Projection (UMAP),(t-distributed stochastic neighbor embedding) t-SNE

Unsupervised Learning: Dimensionality Reduction (ANNs)

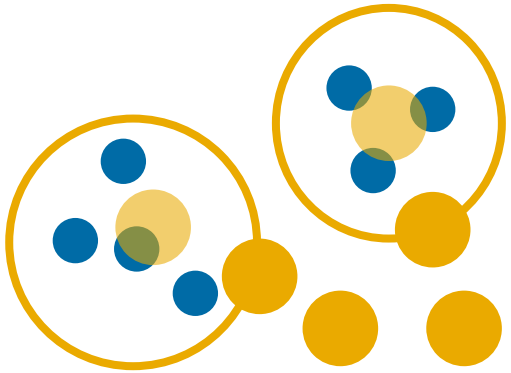


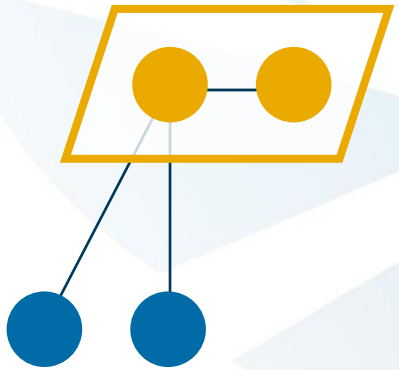
Autoencoder



Self-Organizing Maps

Unsupervised Learning: Clustering





Common alternatives:
k-Means, hierarchical clustering (divisive, agglomerative), Gaussian Mixture Models (GMMs)

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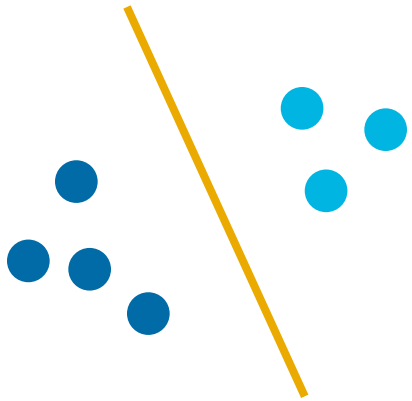
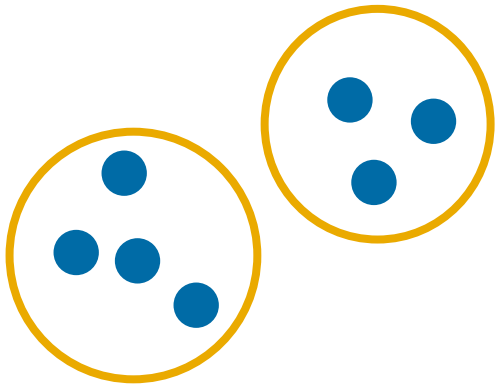
Supervised Learning



Classification

Regression

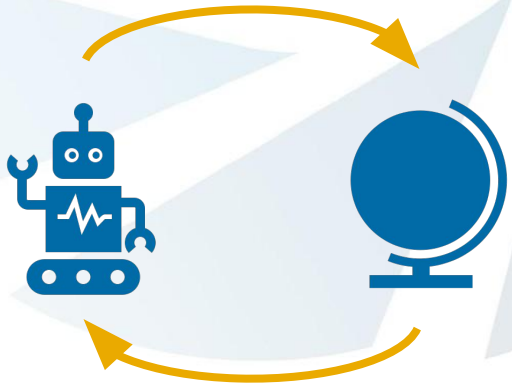
Unsupervised Learning



Dimensionality Reduction

Clustering

Reinforcement Learning



Resources

- https://www.techtarget.com/whatis/A-Timeline-of-Machine-Learning-History
- https://epochai.org/mlinputs/visualization
- ML Course at TU Munich: https://argmax.ai/ml-course/
- ANN Course at KTH Stockholm
- https://setosa.io/ev/principal-component-analysis/
- https://distill.pub/2019/visual-exploration-gaussian-processes/
- https://pair-code.github.io/understanding-umap/ + https://distill.pub/2016/misread-tsne/
- https://www.asimovinstitute.org/neural-network-zoo/
- http://www.r2d3.us/visual-intro-to-machine-learning-part-1/
- https://fleuret.org/public/lbdl.pdf