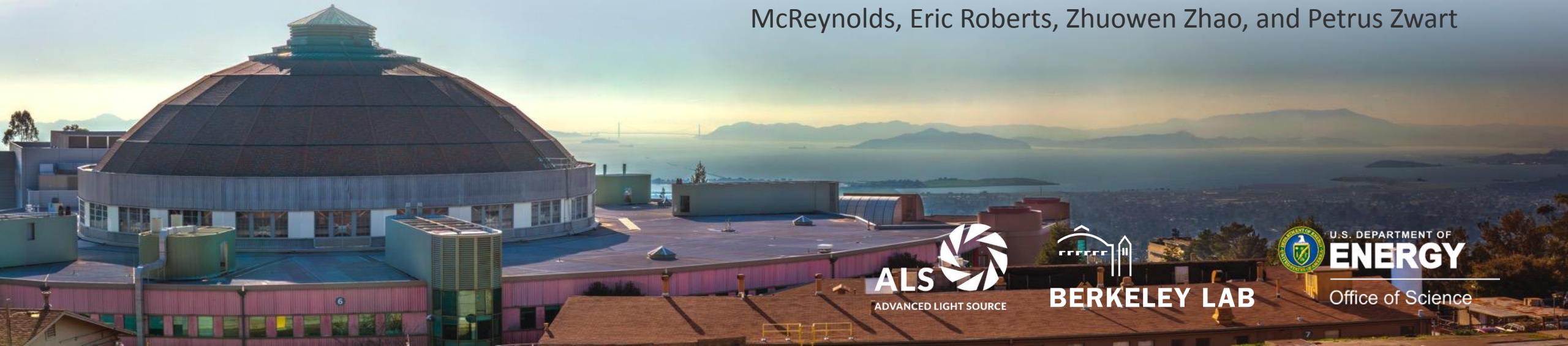


Hands-On Machine Learning in Python

ALS User Meeting
September 11, 2023

Tanny Chavez, Tibbers Hao, Alex Hexemer, Wiebke Koepp, Dylan McReynolds, Eric Roberts, Zhuowen Zhao, and Petrus Zwart

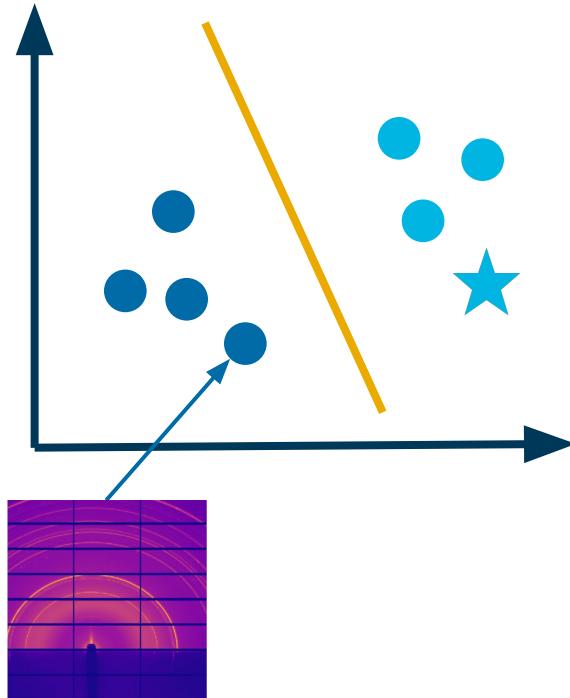


Introduction to Machine Learning

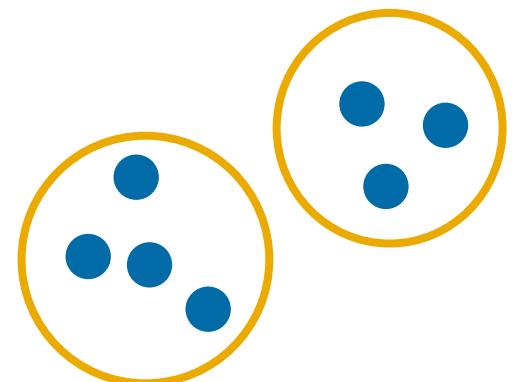
Wiebke Köpp

Types of Machine Learning

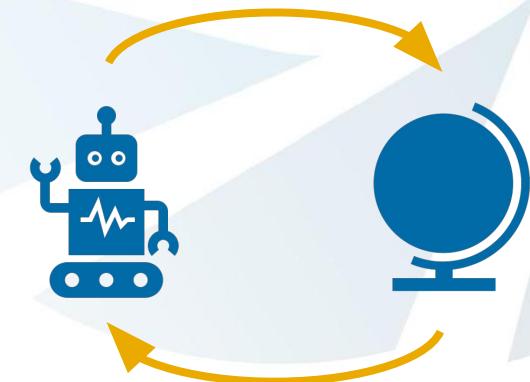
Supervised
Learning



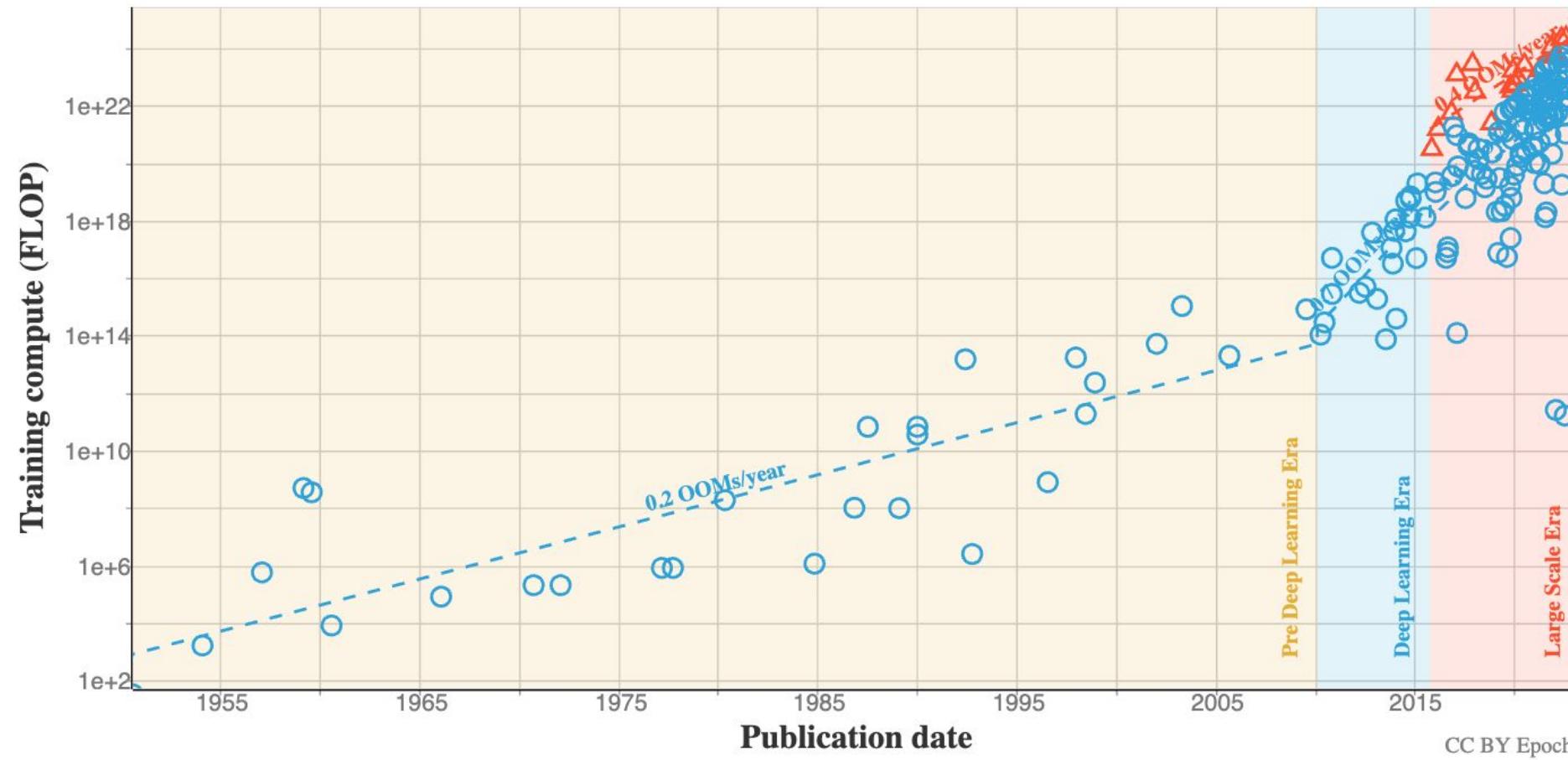
Unsupervised
Learning



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

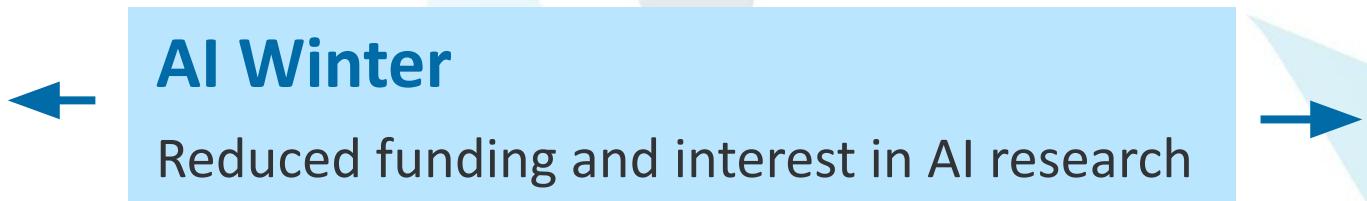
1960

1970

History

1970

1980



History

1980

1990

1986: Backpropagation

Backpropagation for MLPs

1982: Self-Organizing Maps

A different type of neural network



History

1990

1992: TD-Gammon

ML that can play the game Backgammon

2000

1997: IBM Deep Blue

Deep Blue wins against human player

History

2000

2010

2009: ImageNet

Large image collection with
labels is released

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

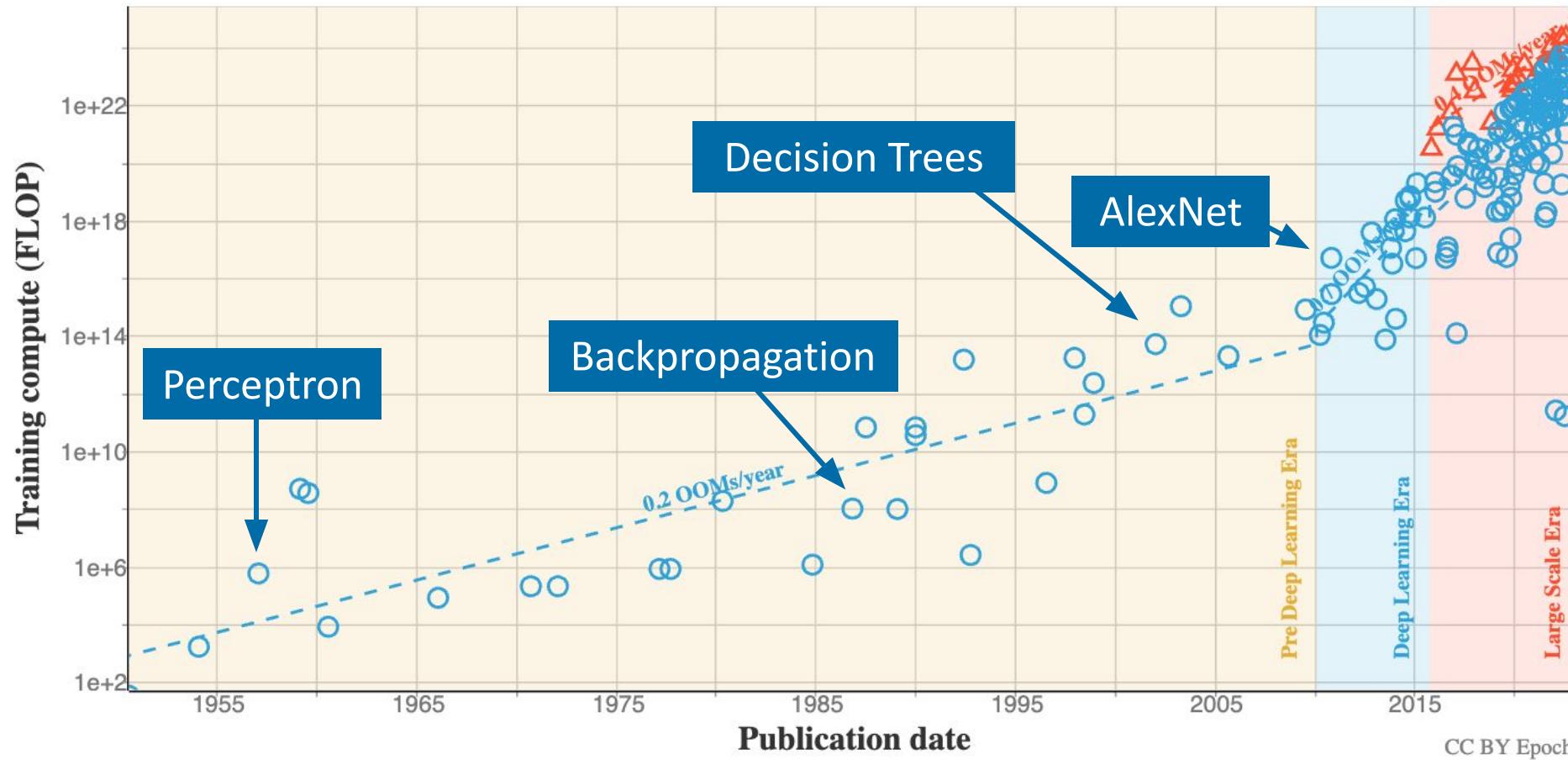
2014: GAN

Generative
Adversarial Networks
generate images

2017: Transformers

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

History



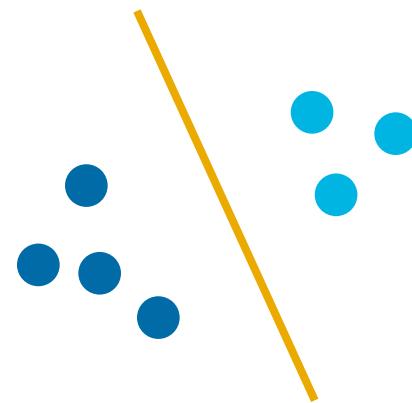
<https://epochai.org/mlinputs/visualization>

Types of Machine Learning

Supervised
Learning

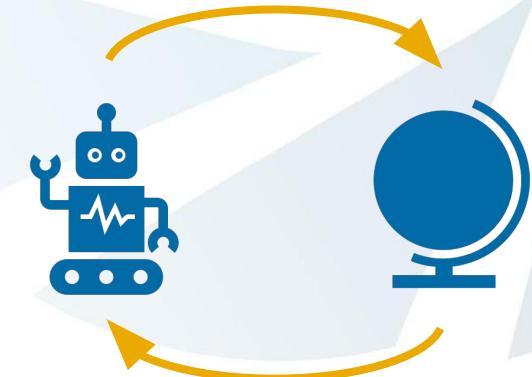
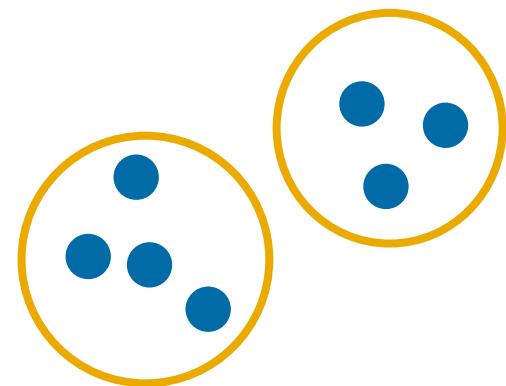
Unsupervised
Learning

Reinforcement
Learning

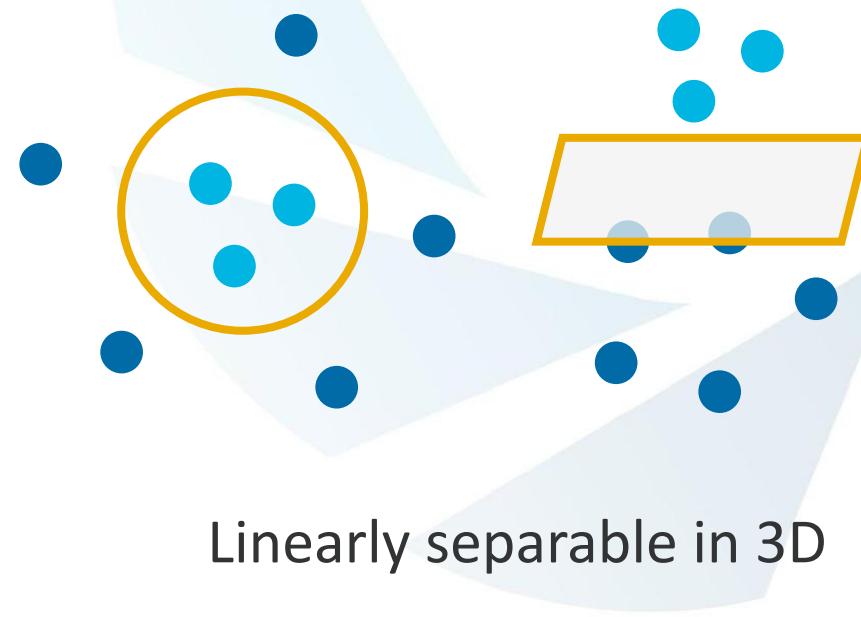
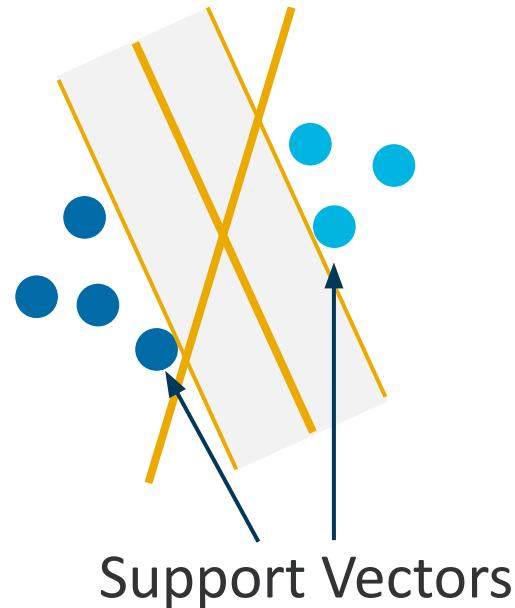


Classification

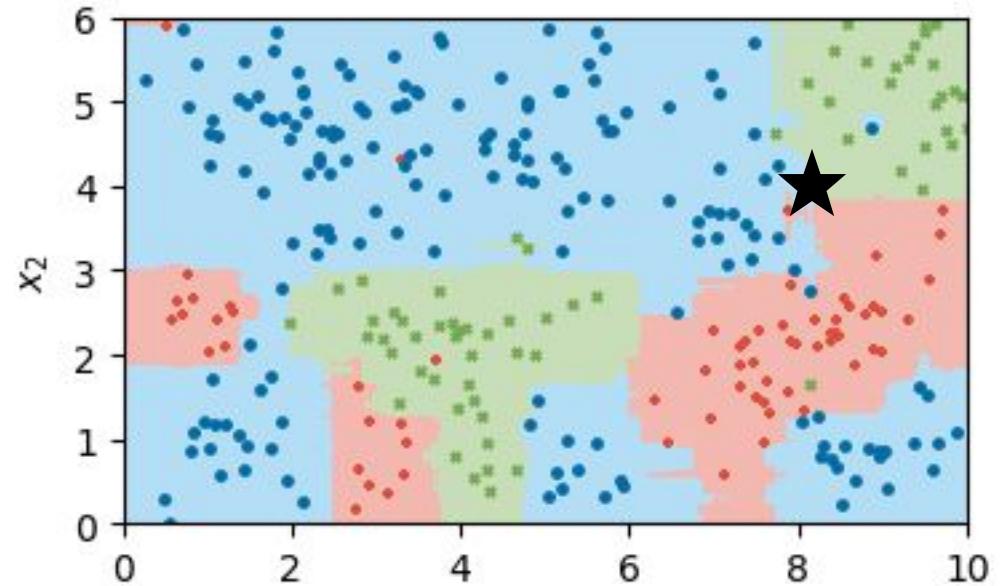
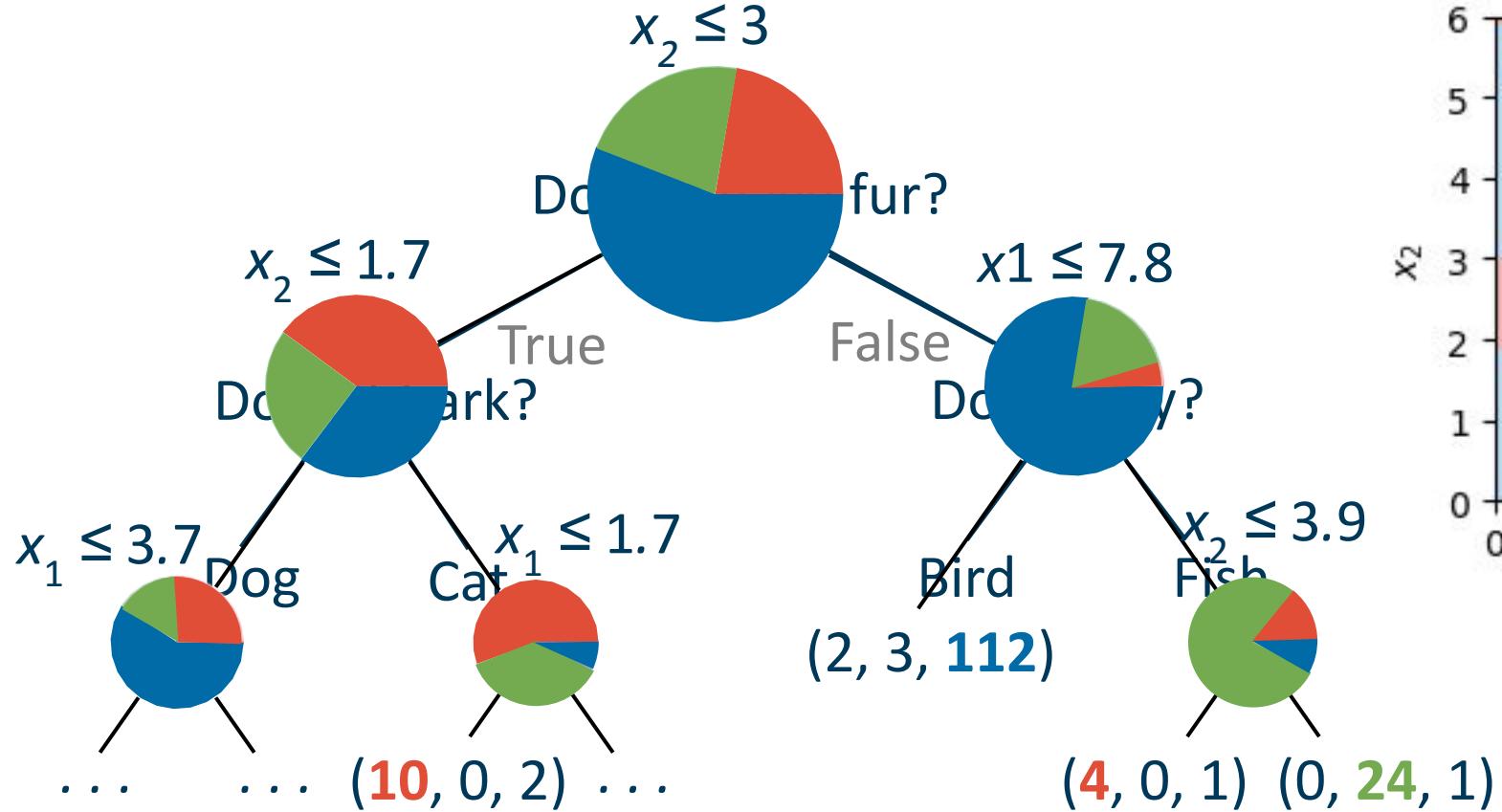
Regression



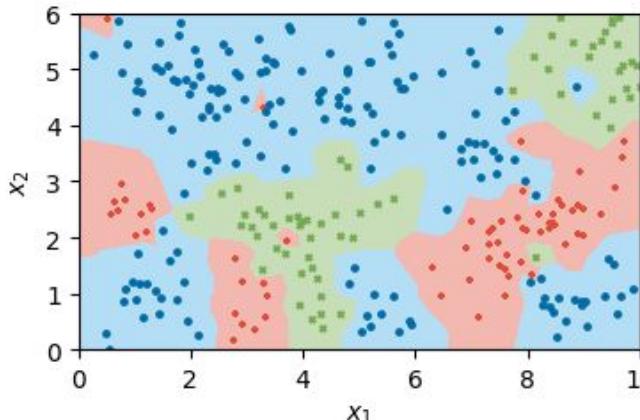
Supervised Learning: Support Vector Machines / Linear Classifiers



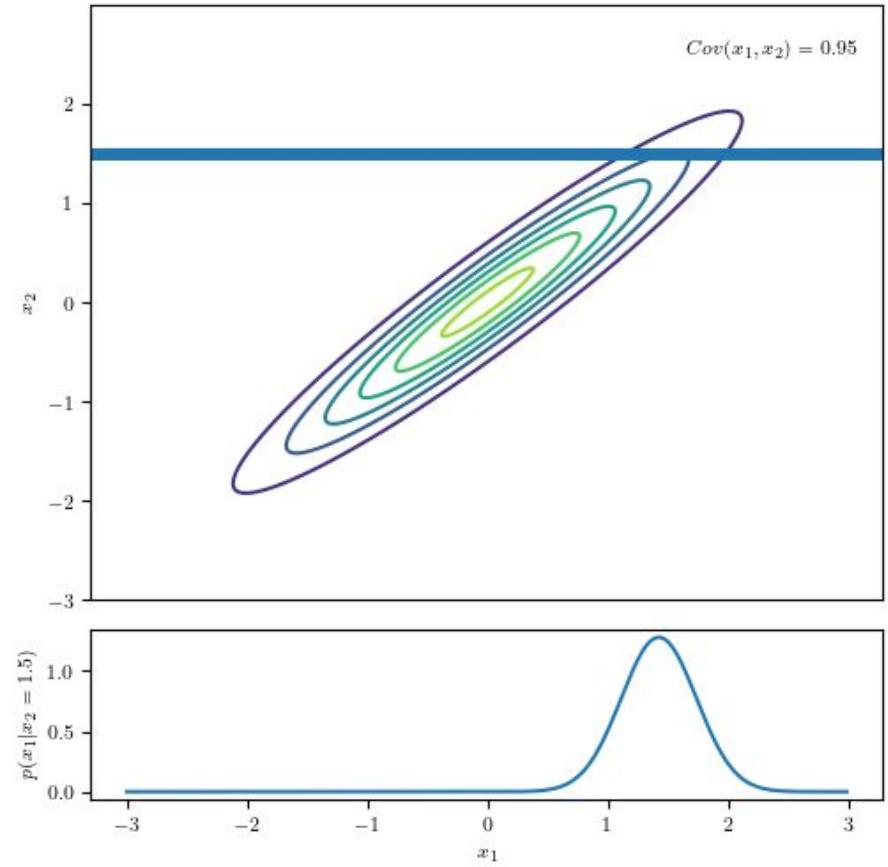
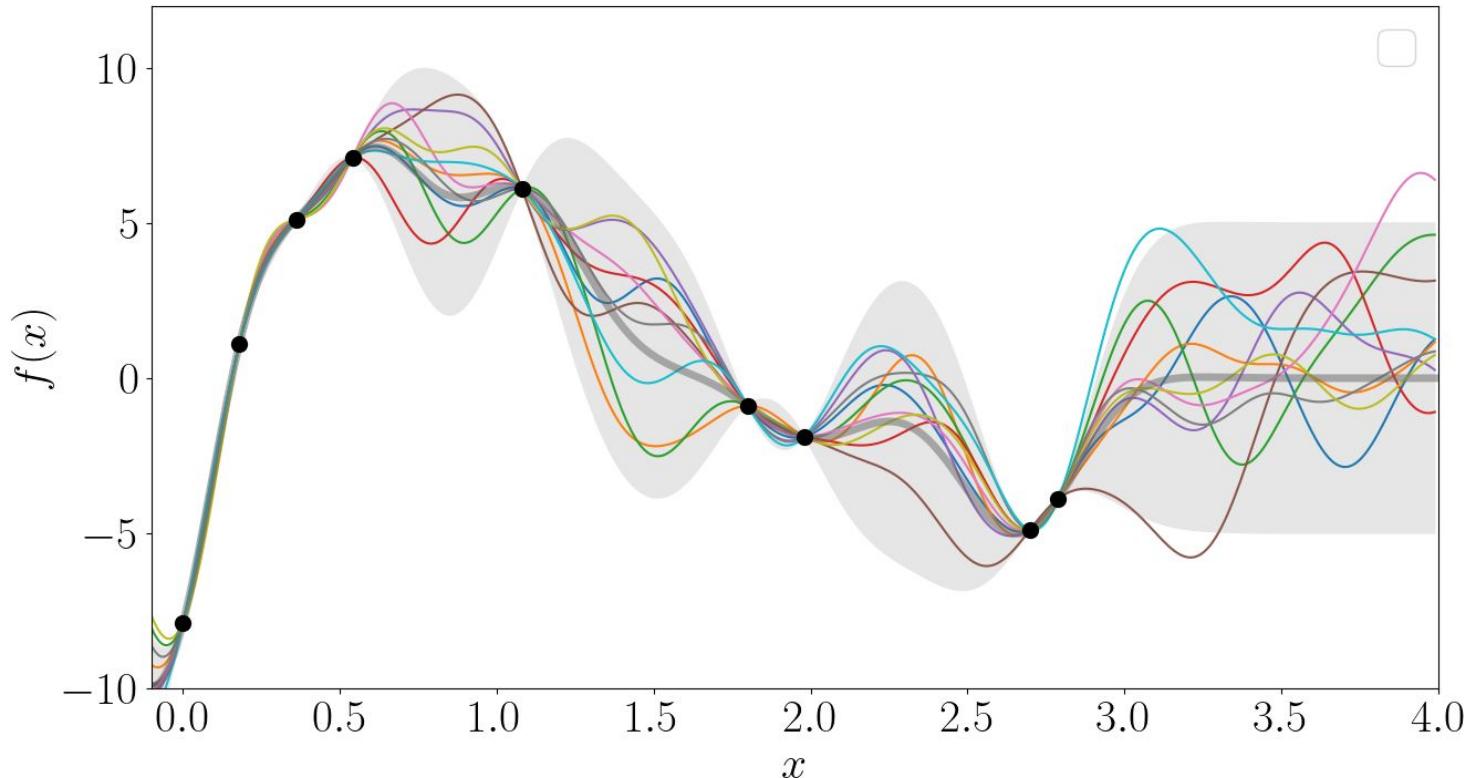
Supervised Learning: Decision Trees – a component of Random Forests



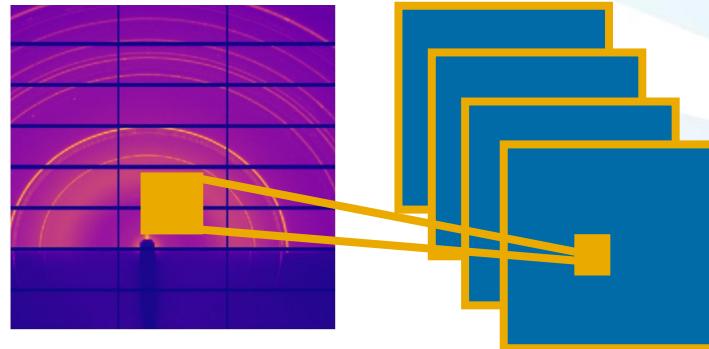
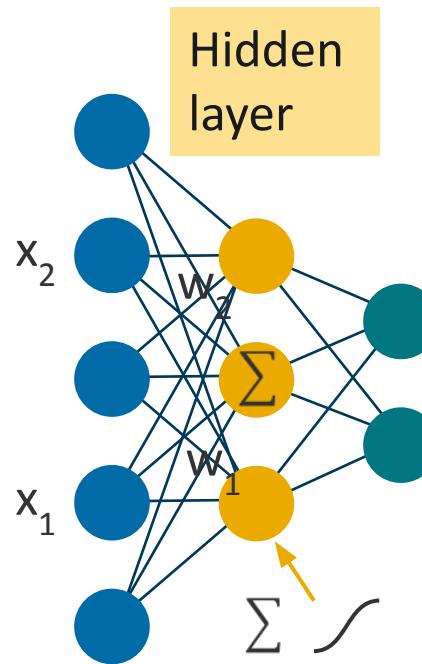
Similar result with kNN



Supervised Learning: Gaussian Processes



Supervised Learning: Artificial Neural Networks



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

 Input Cell

 Backfed Input Cell

 Noisy Input Cell

 Hidden Cell

 Probabilistic Hidden Cell

 Spiking Hidden Cell

 Capsule Cell

 Output Cell

 Match Input Output Cell

 Recurrent Cell

 Memory Cell

 Gated Memory Cell

 Kernel

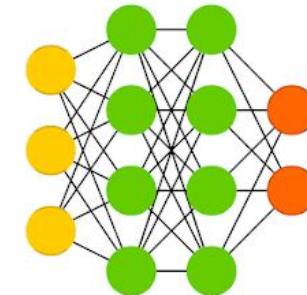
 Convolution or Pool

A mostly complete chart of

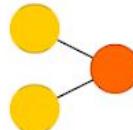
Neural Networks

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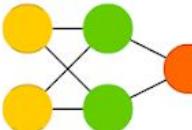
Deep Feed Forward (DFF)



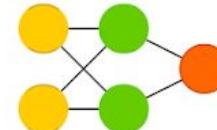
Perceptron (P)



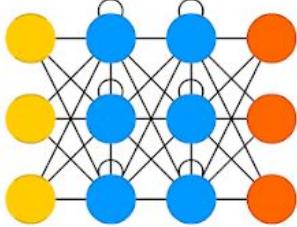
Feed Forward (FF)



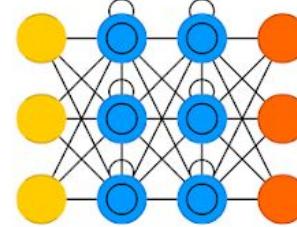
Radial Basis Network (RBF)



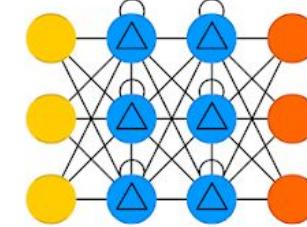
Recurrent Neural Network (RNN)



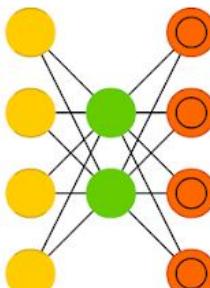
Long / Short Term Memory (LSTM)



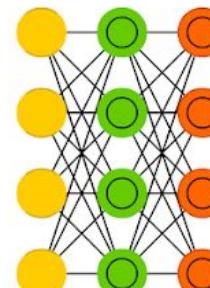
Gated Recurrent Unit (GRU)



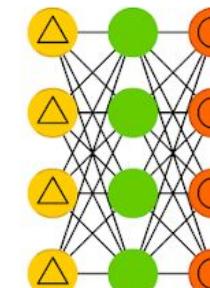
Auto Encoder (AE)



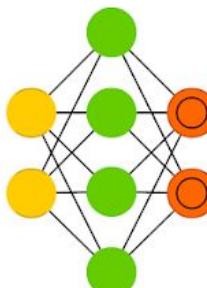
Variational AE (VAE)



Denoising AE (DAE)



Sparse AE (SAE)



 Input Cell

 Backfed Input Cell

 Noisy Input Cell

 Hidden Cell

 Probabilistic Hidden Cell

 Spiking Hidden Cell

 Capsule Cell

 Output Cell

 Match Input Output Cell

 Recurrent Cell

 Memory Cell

 Gated Memory Cell

 Kernel

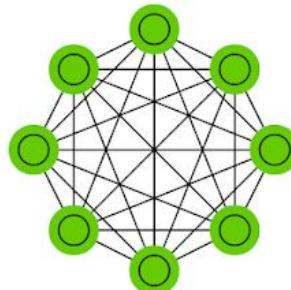
 Convolution or Pool

A mostly complete chart of

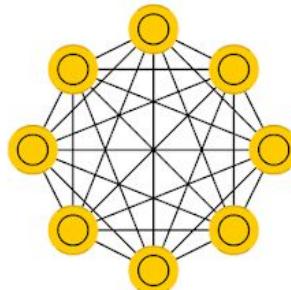
Neural Networks

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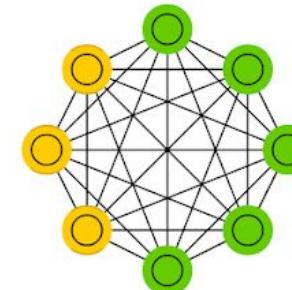
Markov Chain (MC)



Hopfield Network (HN)



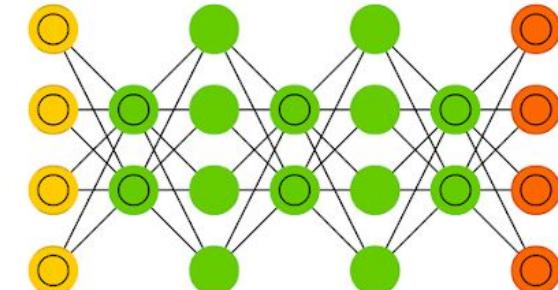
Boltzmann Machine (BM)



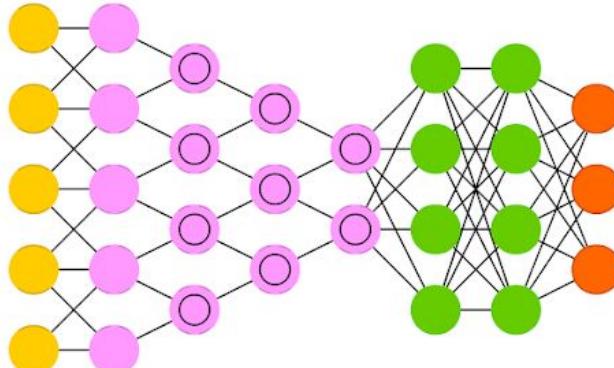
Restricted BM (RBM)



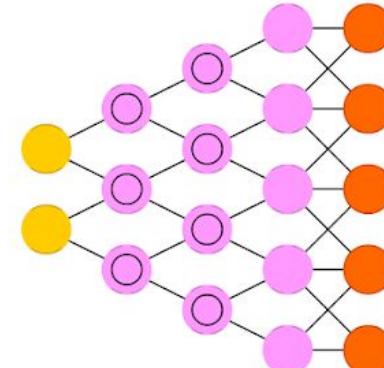
Deep Belief Network (DBN)



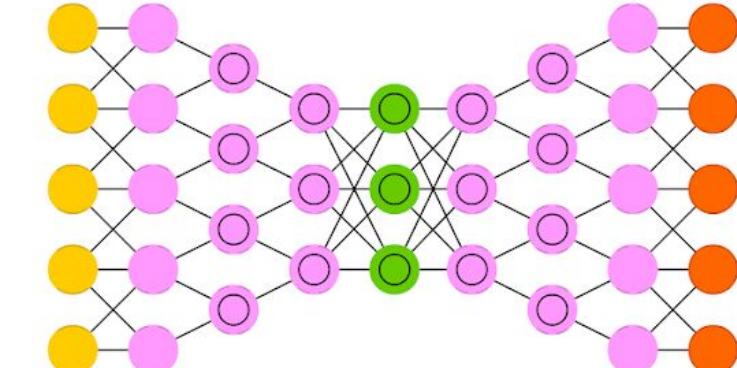
Deep Convolutional Network (DCN)



Deconvolutional Network (DN)



Deep Convolutional Inverse Graphics Network (DCIGN)



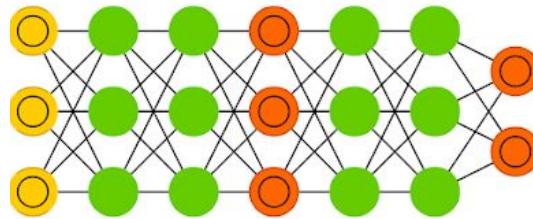
- Input Cell
- Backfed Input Cell
- △ Noisy Input Cell
- Hidden Cell
- Probabilistic Hidden Cell
- △ Spiking Hidden Cell
- Capsule Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- △ Gated Memory Cell
- Kernel
- Convolution or Pool

A mostly complete chart of

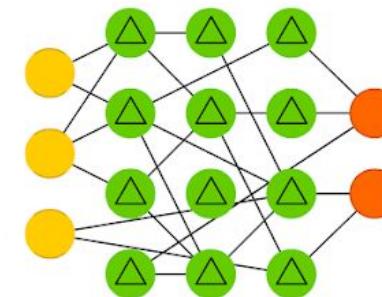
Neural Networks

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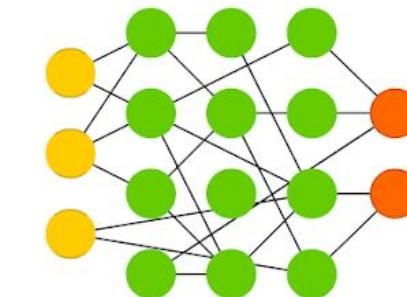
Generative Adversarial Network (GAN)



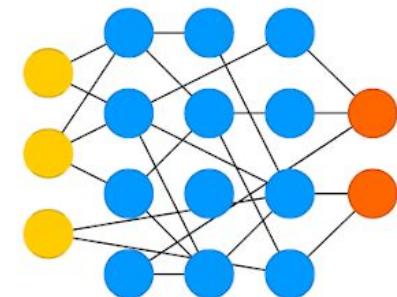
Liquid State Machine (LSM)



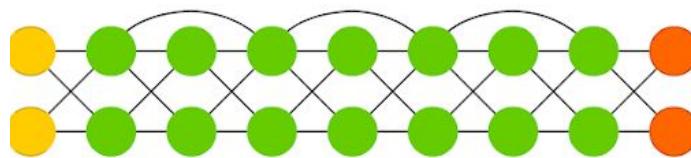
Extreme Learning Machine (ELM)



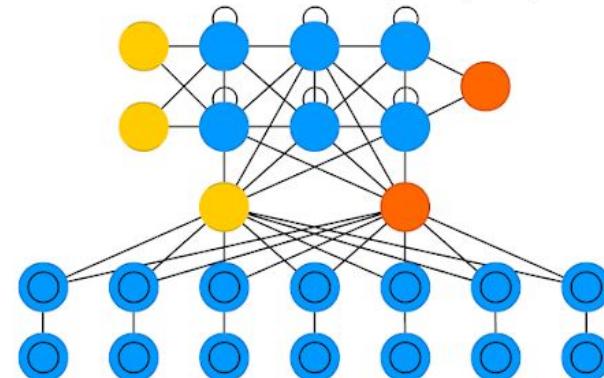
Echo State Network (ESN)



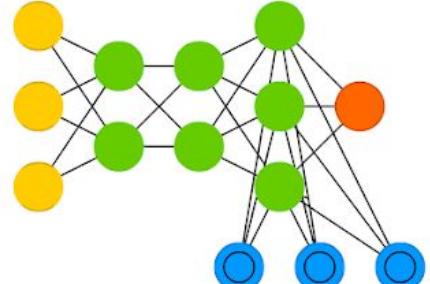
Deep Residual Network (DRN)



Differentiable Neural Computer (DNC)



Neural Turing Machine (NTM)

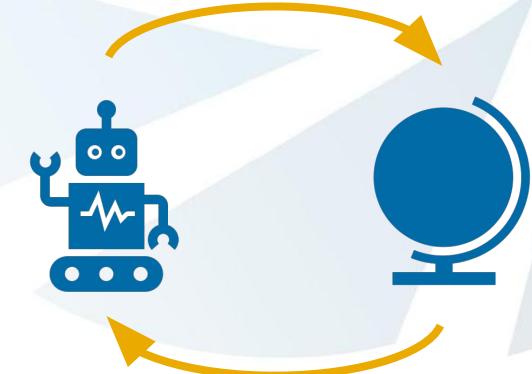
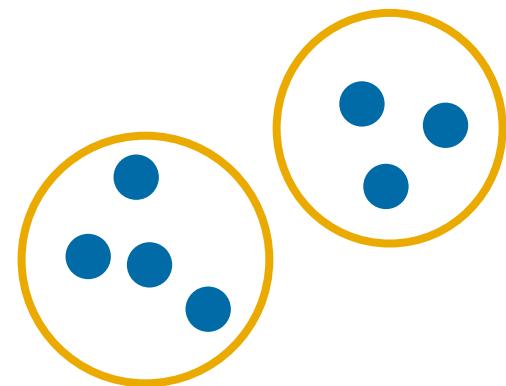
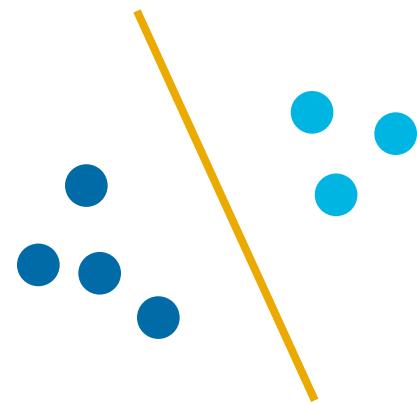


Types of Machine Learning

Supervised
Learning

Unsupervised
Learning

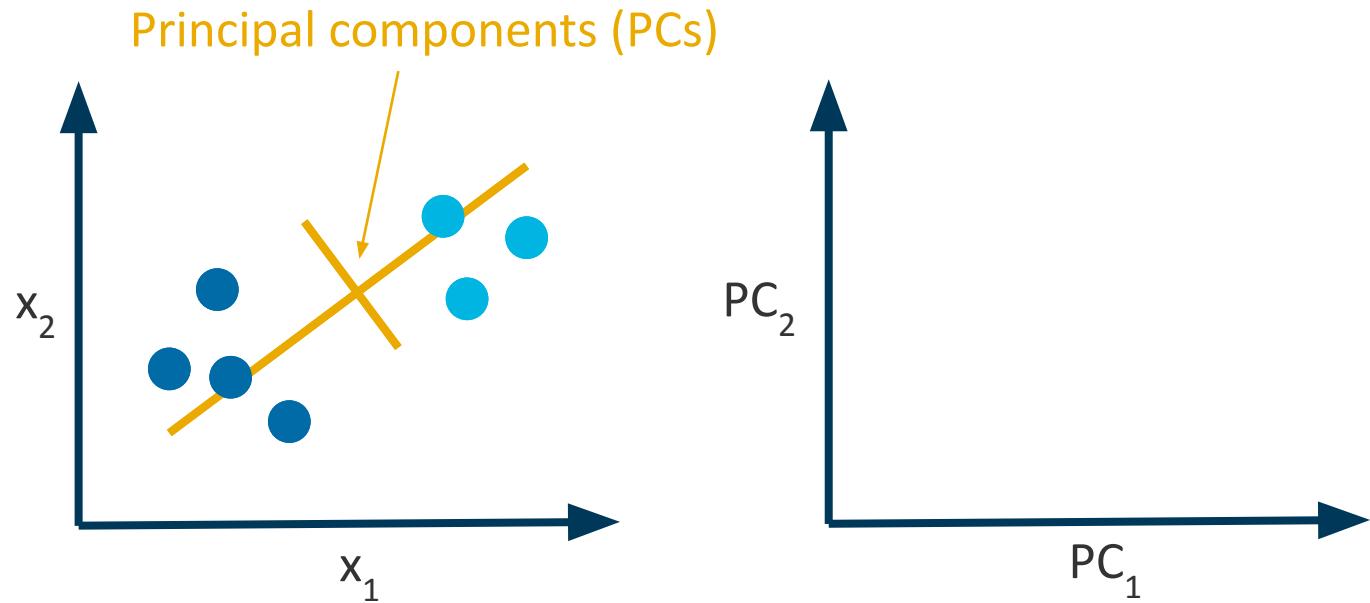
Reinforcement
Learning



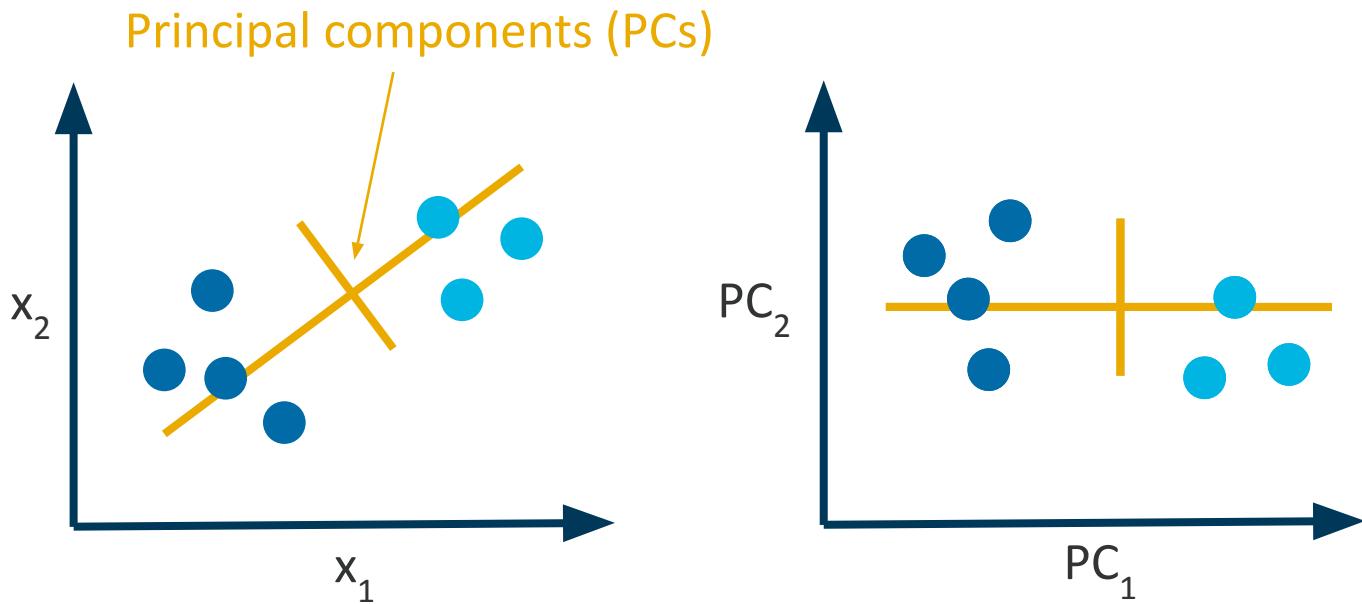
Dimensionality
Reduction

Clustering

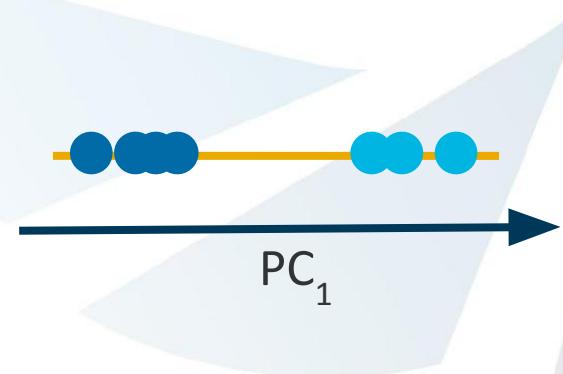
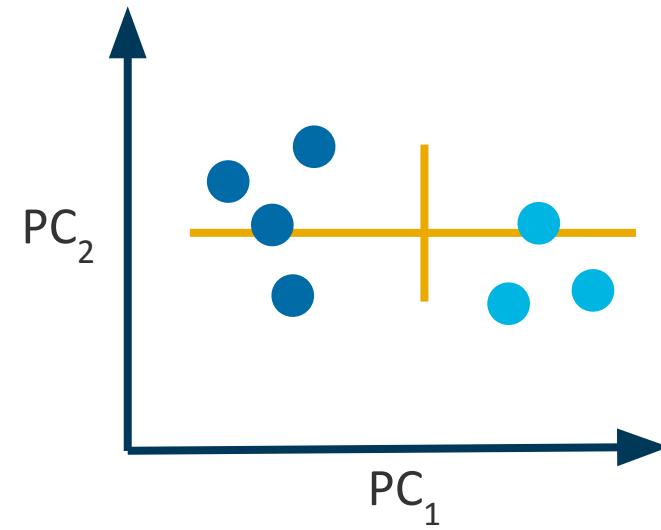
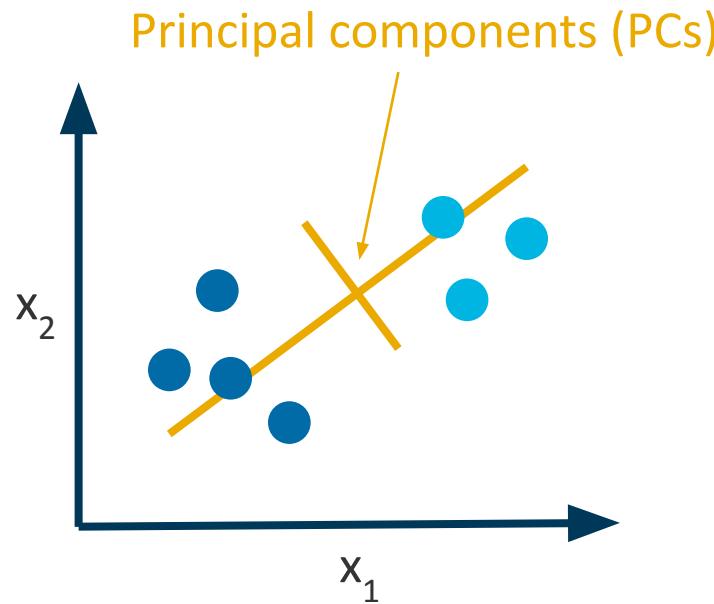
Unsupervised Learning: Dimensionality Reduction (PCA)



Unsupervised Learning: Dimensionality Reduction (PCA)



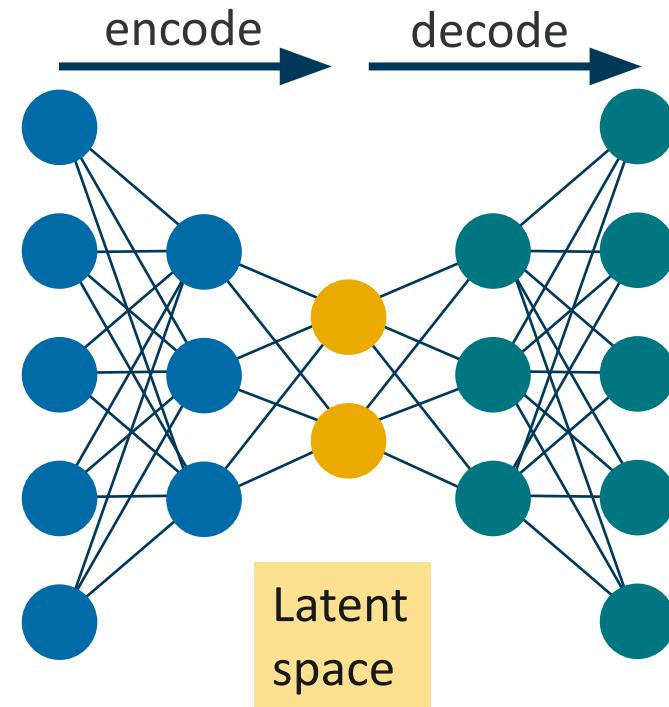
Unsupervised Learning: Dimensionality Reduction (PCA)



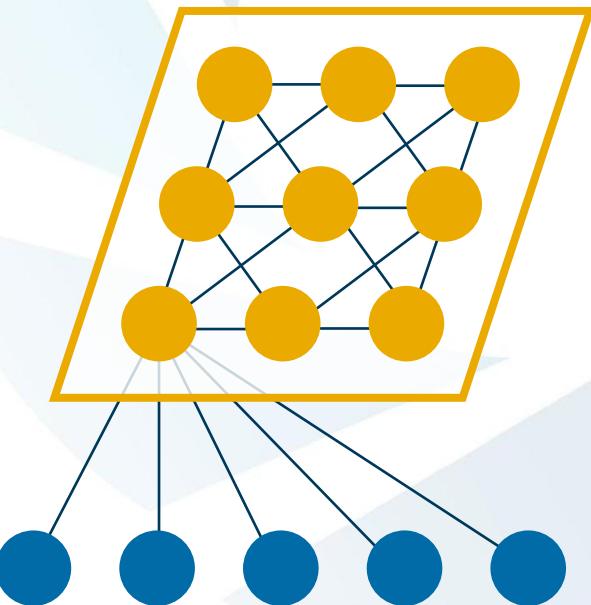
Common alternatives:

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

Unsupervised Learning: Dimensionality Reduction (ANNs)

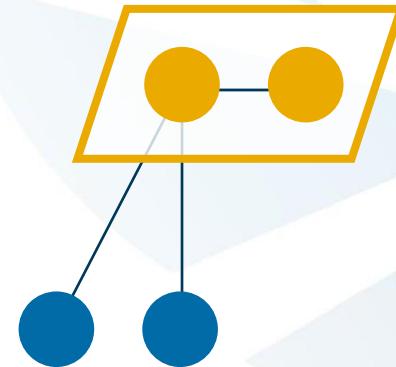
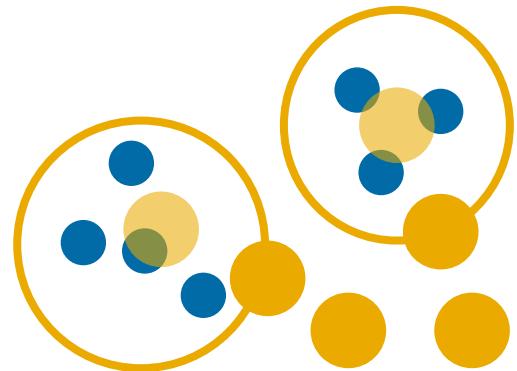


Autoencoder



Self-Organizing Maps

Unsupervised Learning: Clustering

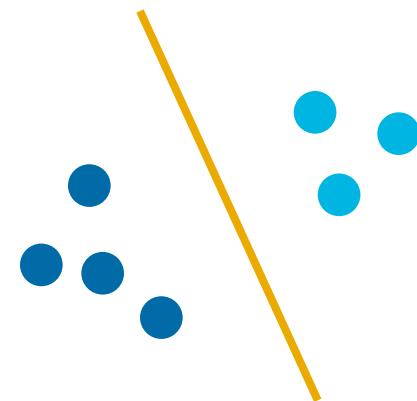


Common alternatives:

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

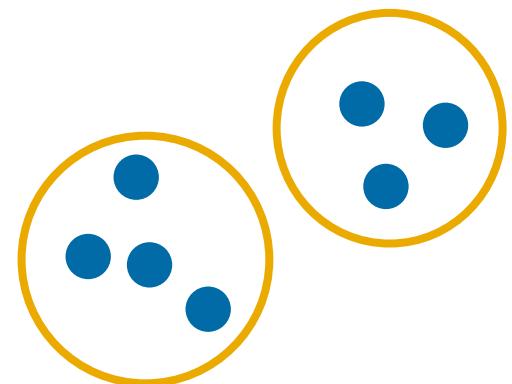
Types of Machine Learning

Supervised
Learning



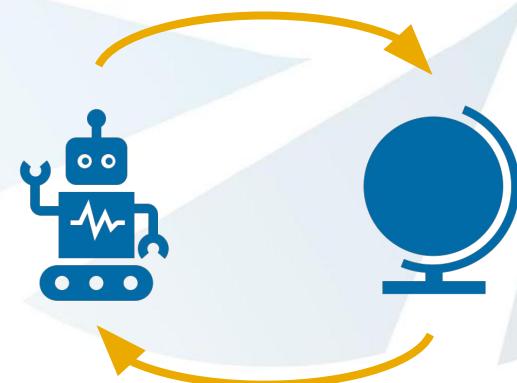
Classification
Regression

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>