

Artificial intelligence,
Machine learning,
Deep learning

is everywhere!

In my own home...



“Natural Language Processing”

Everyday tools...



How can I help you today?

Create a charter

to start a film club

Write an email

requesting a deadline extension for my project

Brainstorm incentives

for a customer loyalty program in a small bookstore

Suggest fun activities

for a family of 4 to do indoors on a rainy day

Message ChatGPT...



ChatGPT can make mistakes. Consider checking important information.

Everyday tools...

ons 4 juli



tors 28 juni



ons 27 juni



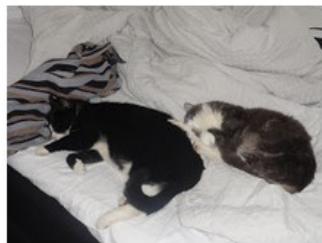
tors 21 juli 2016



lös 26 mars 2016



tors 11 juni 2015



tors 4 juni 2015



sön 7 juli 2013



Google photo
Search term:
Katt

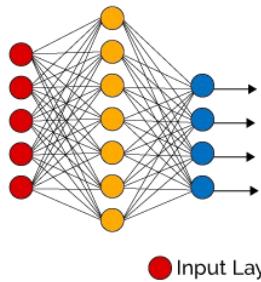
Future ...



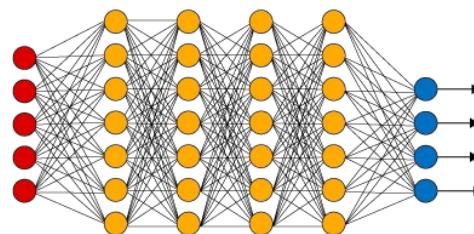
Self-driving
cars

What is deep learning?

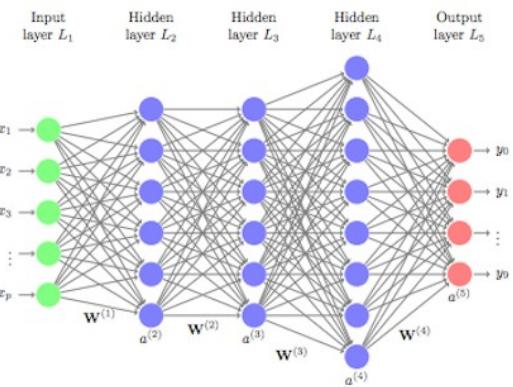
Simple Neural Network



Deep Learning Neural Network

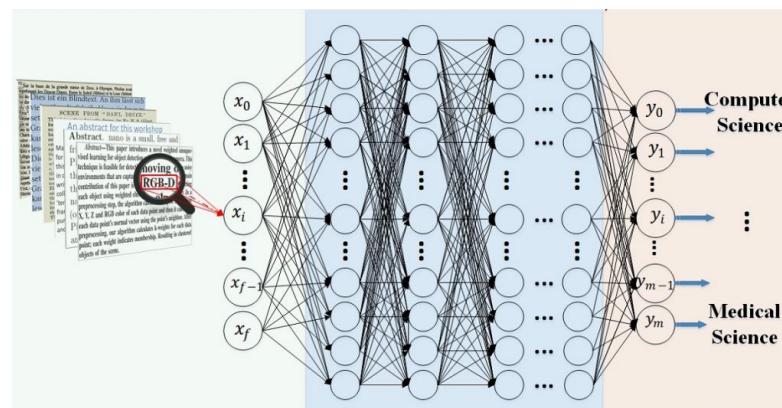


<https://becominghuman.ai/deep-learning-made-easy-with-deep-cognition-403fbe445351>



http://uc-r.github.io/feedforward_DNN

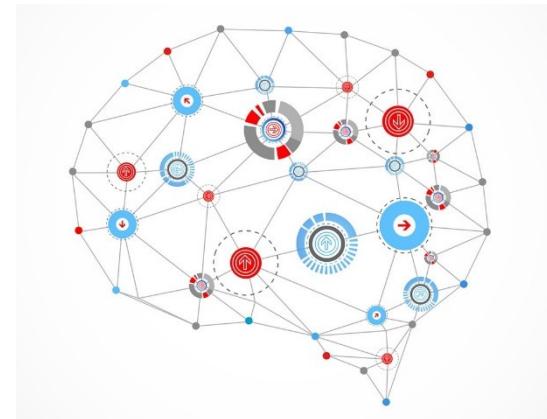
Google image search:
Deep learning



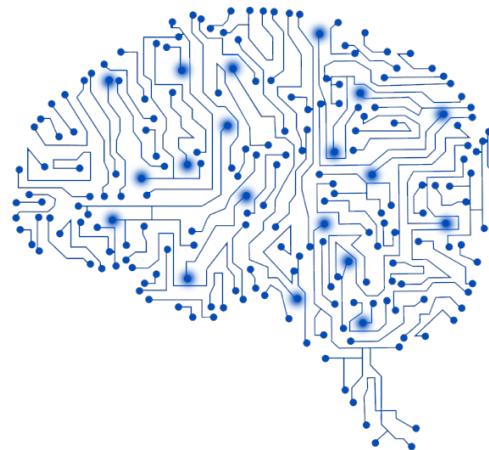
<http://www.digitalrhetoriccollaborative.org/2018/04/23/inscrutable-ai-deep-learning-and-the-problem-of-technology-and-trust/>



<https://www.zdnet.com/article/deep-learning-the-interest-is-more-than-latent/>



<https://codeburst.io/deep-learning-what-why-dd77d432f182>



<https://www.cgit.se/nyheter/vad-ar-deep-learning>

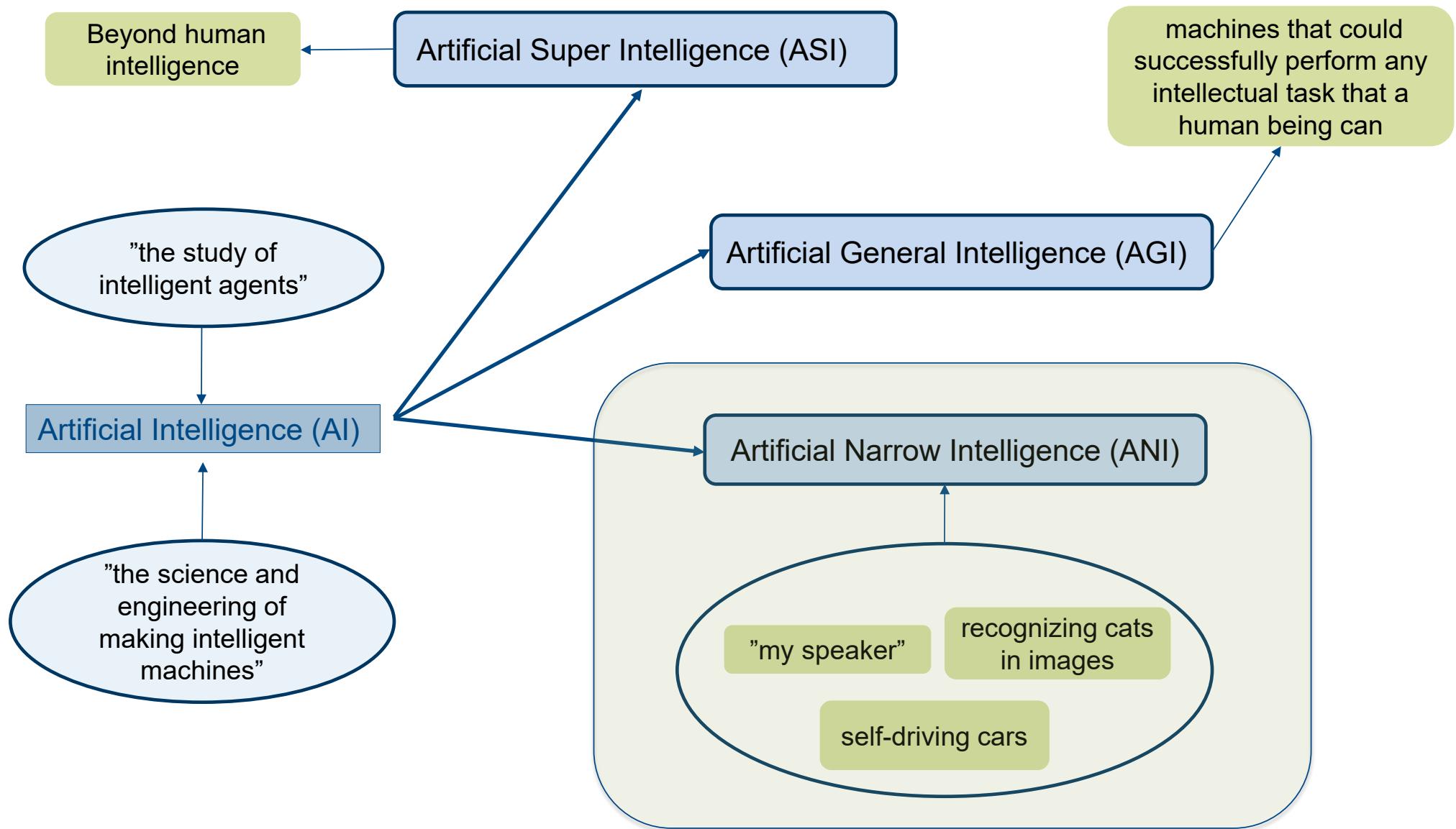
Google image search:
Deep learning

First, what about AI / ML / DL

Artificial Intelligence (AI)

Deep Learning (DL)

Machine Learning (ML)



Sparks of Artificial General Intelligence: Early experiments with GPT-4

Sébastien Bubeck Varun Chandrasekaran Ronen Eldan Johannes Gehrke
Eric Horvitz Ece Kamar Peter Lee Yin Tat Lee Yuanzhi Li Scott Lundberg
Harsha Nori Hamid Palangi Marco Tulio Ribeiro Yi Zhang

Microsoft Research

Abstract

Artificial intelligence (AI) researchers have been developing and refining large language models (LLMs) that exhibit remarkable capabilities across a variety of domains and tasks, challenging our understanding of learning and cognition. The latest model developed by OpenAI, GPT-4 [Ope23], was trained using an unprecedented scale of compute and data. In this paper, we report on our investigation of an early version of GPT-4, when it was still in active development by OpenAI. We contend that (this early version of) GPT-4 is part of a new cohort of LLMs (along with ChatGPT and Google’s PaLM for example) that exhibit more general intelligence than previous AI models. We discuss the rising capabilities and implications of these models. We demonstrate that, beyond its mastery of language, GPT-4 can solve novel and difficult tasks that span mathematics, coding, vision, medicine, law, psychology and more, without needing any special prompting. Moreover, in all of these tasks, GPT-4’s performance is strikingly close to human-level performance, and often vastly surpasses prior models such as ChatGPT. Given the breadth and depth of GPT-4’s capabilities, we believe that it could reasonably be viewed as an early (yet still incomplete) version of an artificial general intelligence (AGI) system. In our exploration of GPT-4, we put special emphasis on discovering its limitations, and we discuss the challenges ahead for advancing towards deeper and more comprehensive versions of AGI, including the possible need for pursuing a new paradigm that moves beyond next-word prediction. We conclude with reflections on societal influences of the recent technological leap and future research directions.

Machine Learning

“Machine learning is the subfield of computer science that gives computers the ability to learn without being explicitly programmed.”

(Wikipedia)

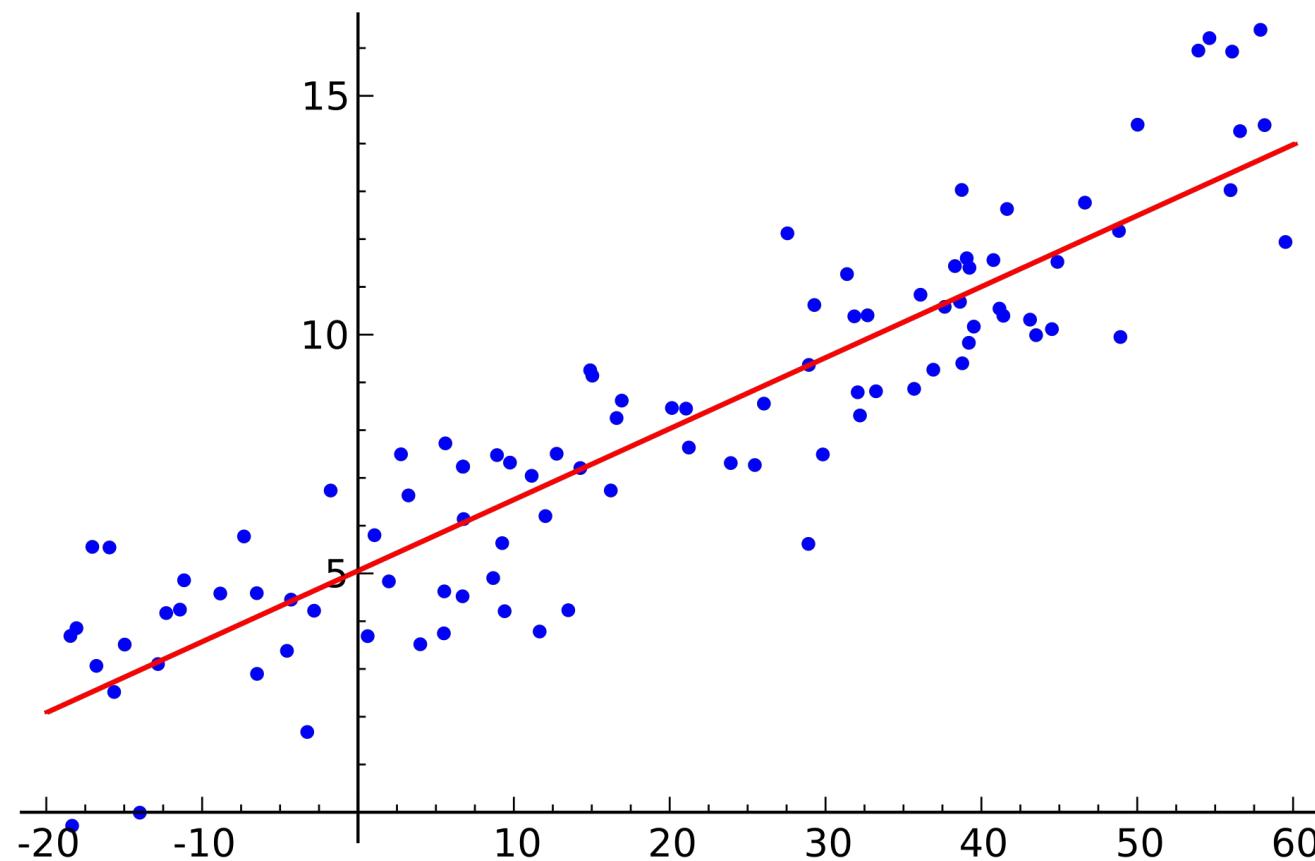
Models that learn from data!

”Machine Learning is the study of computer algorithms that learn and improve automatically through experience.”

The field of machine learning is concerned with the question of how to construct computer programs that automatically improve with experience.

(Tom Mitchell)

A simple machine learning task!



A more complicated machine learning task!

The screenshot shows the Google Translate interface. At the top, it says "Google Översätt" and has a user profile icon. Below that, there are tabs for "Text" and "Dokument". The source language is set to "ENGELSKA - IDENTIFERAT" and the target language is "SVENSKA". There are dropdown menus for "SF" and "ARABISKA". The input text is "A more complicated machine learning task|". The output text is "En mer komplicerad maskininlärningsuppgift". There are icons for microphone, edit, and more options.

An even more complicated task!



Can you give an example of a complicated machine learning task?



Certainly! One example of a complicated machine learning task is **Image Segmentation**.



In image processing, segmentation refers to the process of dividing an image into multiple segments, where each segment represents a different object or region within the image. This task is particularly challenging because it requires the model to understand the spatial relationships and boundaries between different objects in the image.

For instance, consider a medical imaging scenario where a machine learning model is tasked with segmenting different organs in a CT scan. This requires the model to not only identify the presence of organs but also accurately delineate their boundaries, which can be highly complex due to variations in shapes, sizes, and orientations.

Achieving accurate image segmentation often involves the use of advanced techniques like Convolutional Neural Networks (CNNs), which are specialized for processing grid-structured data like images. Additionally, methods like U-Net architecture and Mask R-CNN are commonly employed for tasks like semantic segmentation and instance segmentation, respectively.

The complexity arises from the fact that the model needs to understand both low-level features (like edges and textures) and high-level context (relationships between objects) in the image. Furthermore, it needs to handle variations in illumination, noise, and other factors that can make the task challenging. This makes image segmentation a complex machine learning task that is widely applied in fields like medical imaging, computer vision, and autonomous robotics.

A “famous” machine learning task!



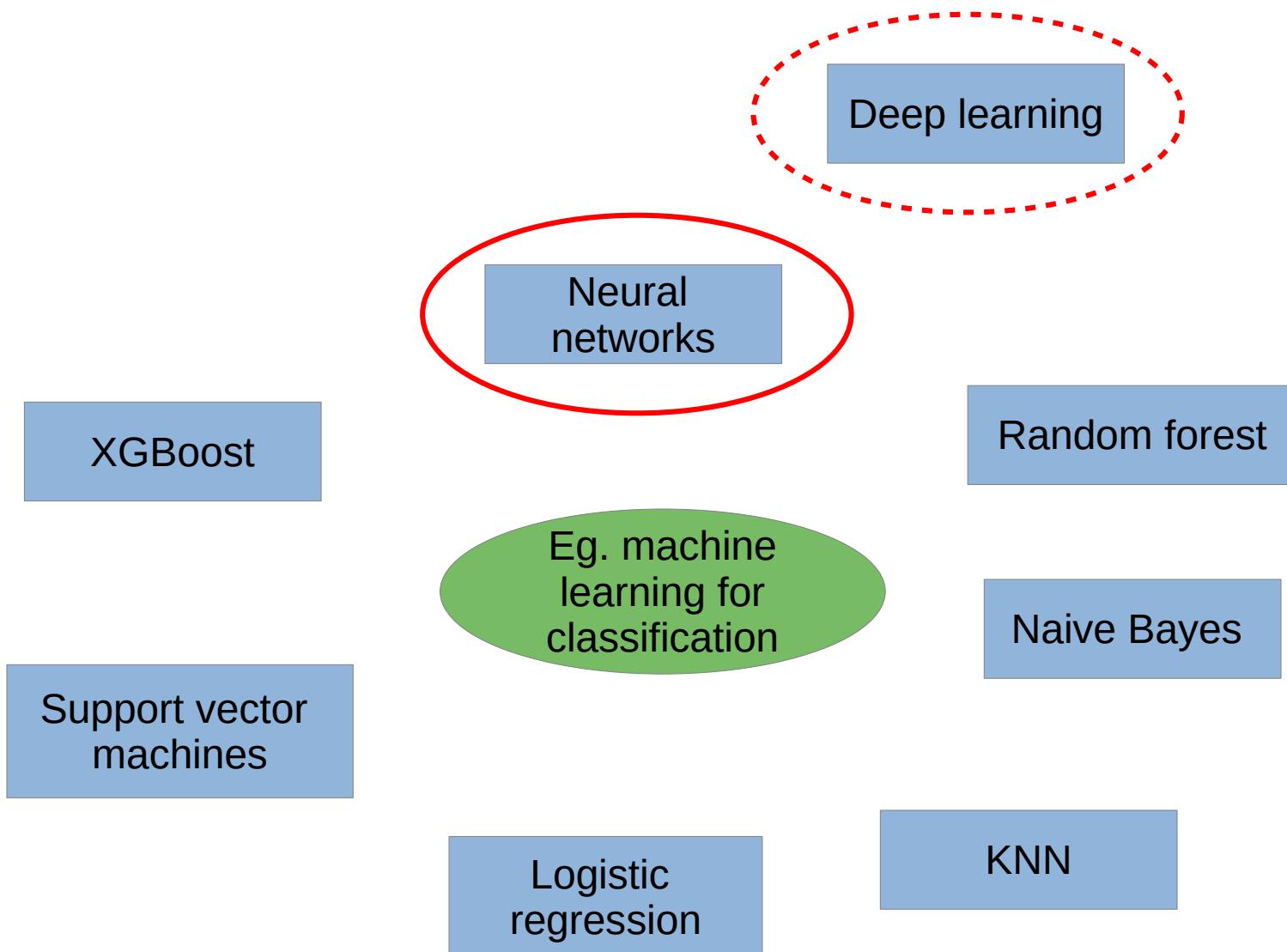
Each digit is a 28x28 “grayscale” image.

60 000 images in the training set.

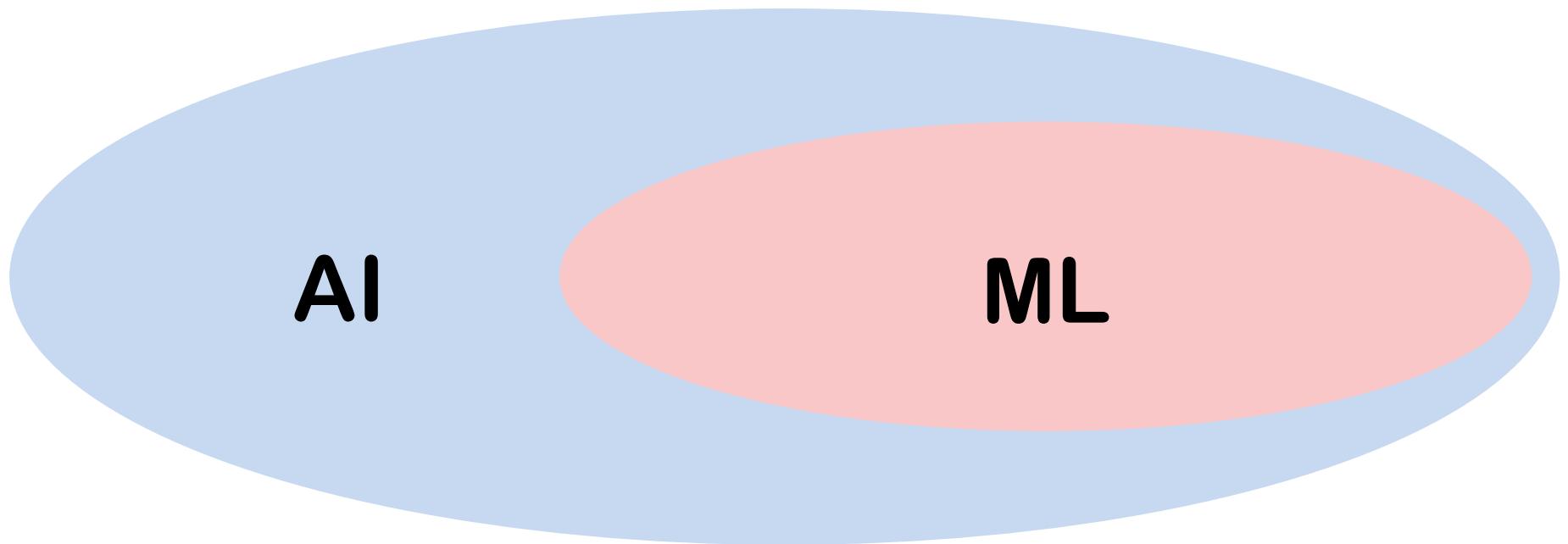
10 000 image in the test set.

Best result so far are based on (deep) convolutional neural networks or deep neural networks with an error rate of **0.21%** (21 misclassified images)

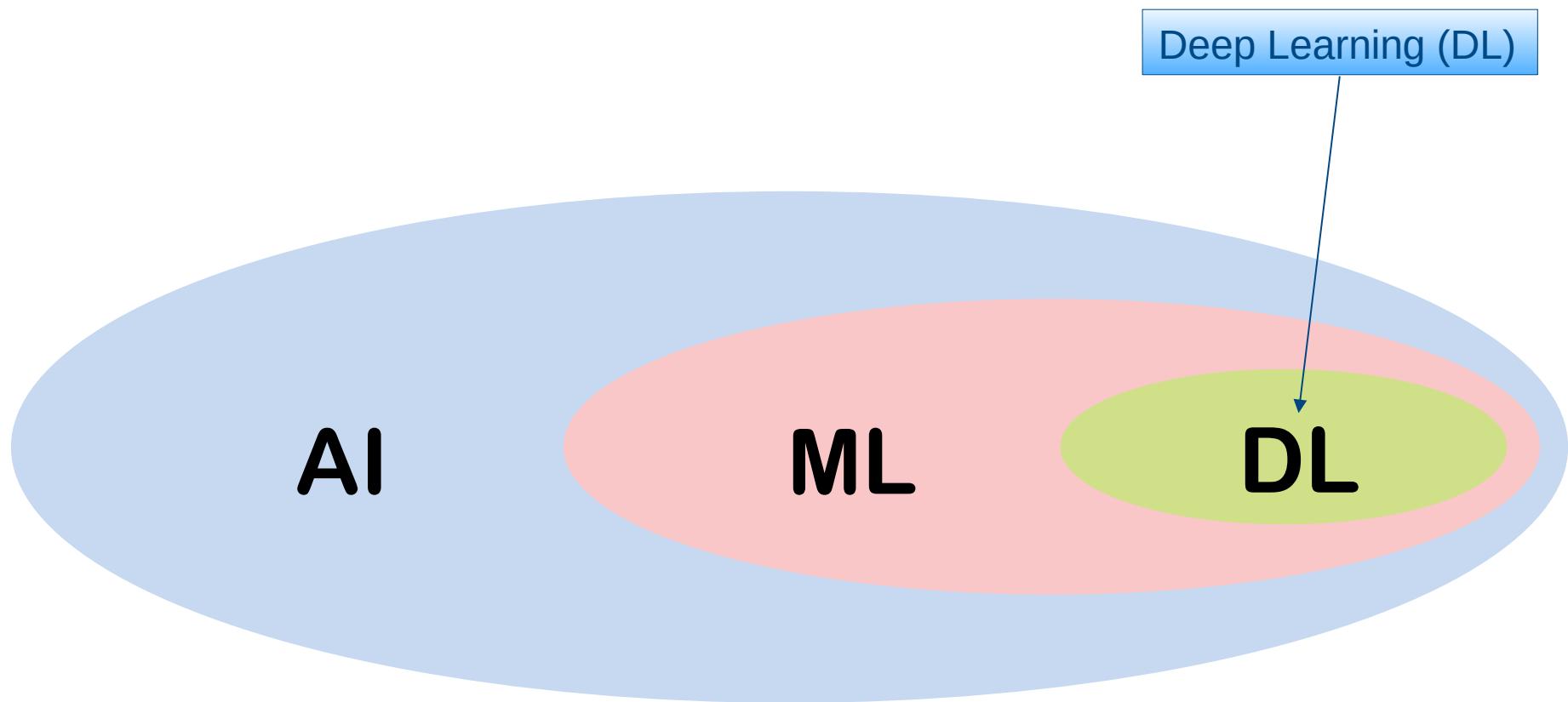
A lot of tools available for machine learning



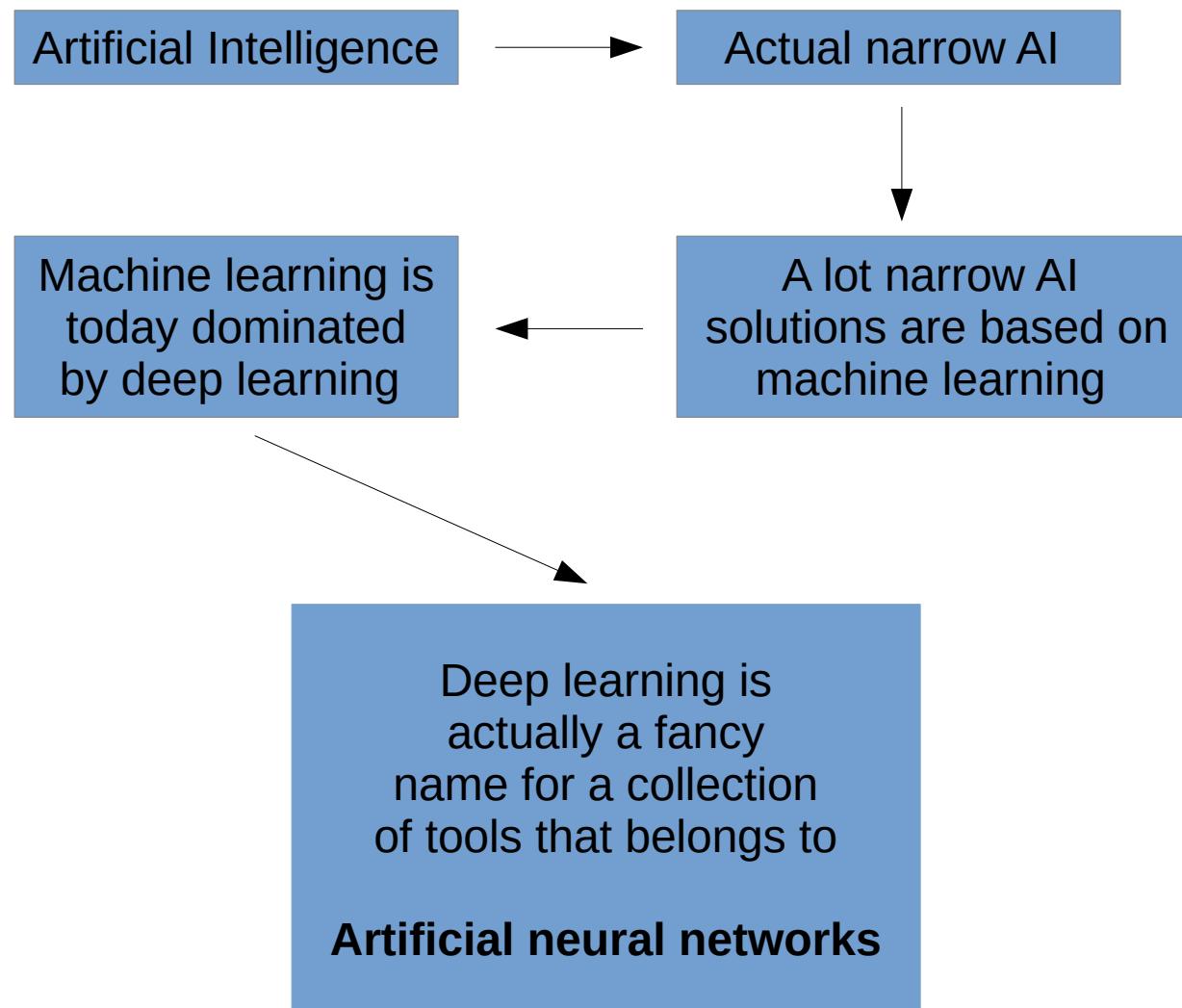
We can consider ML a subset of AI



And deep learning a subset of ML

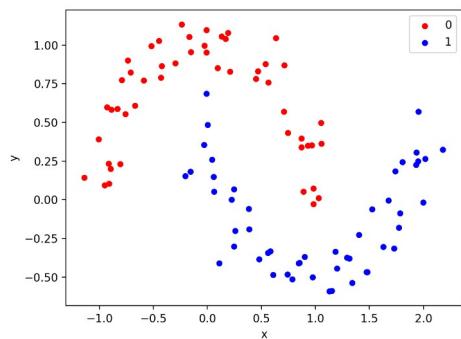


To make it simple!



What can we do with machine learning?

Machine learning tasks



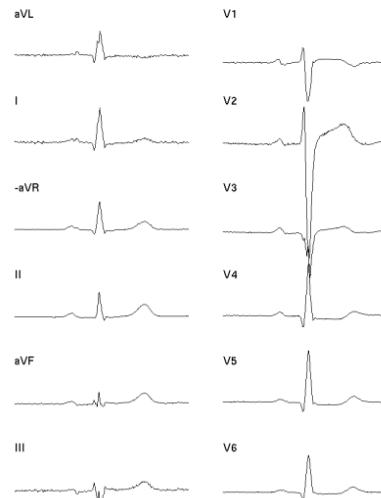
Separate red
from blue

Classification (examples):

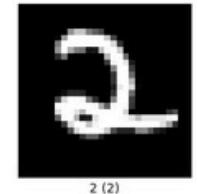
- Binary classification
- Multi-class classification
- Multi-label classification
- Imbalanced classification



or



AMI or not?

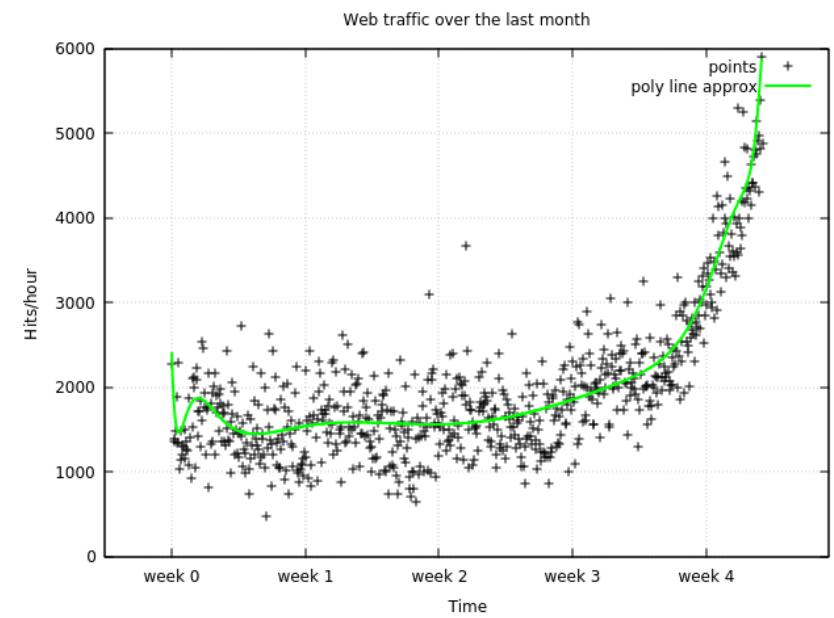
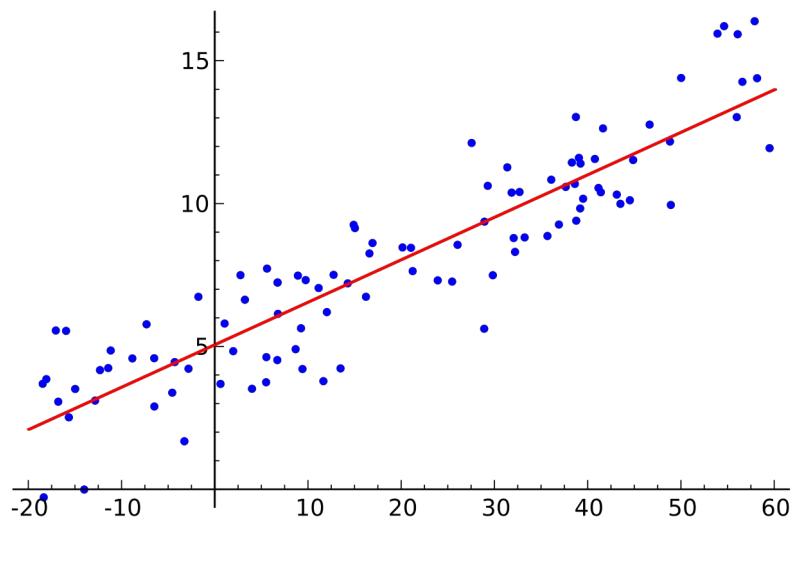


Which digit?



Does the image
contain apples
and/or oranges?

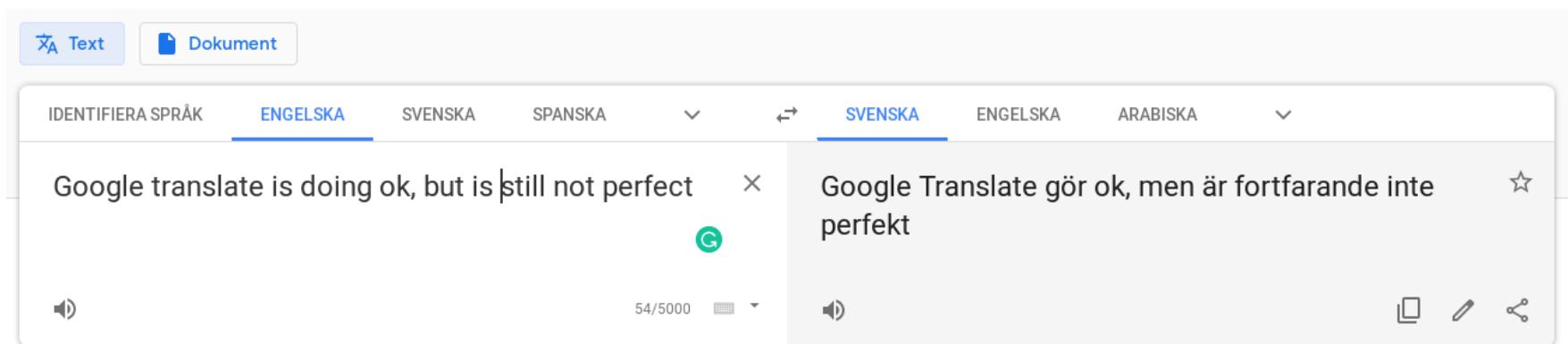
Regression: Predict a numerical output given an input



- Predict the useful remaining life of a battery

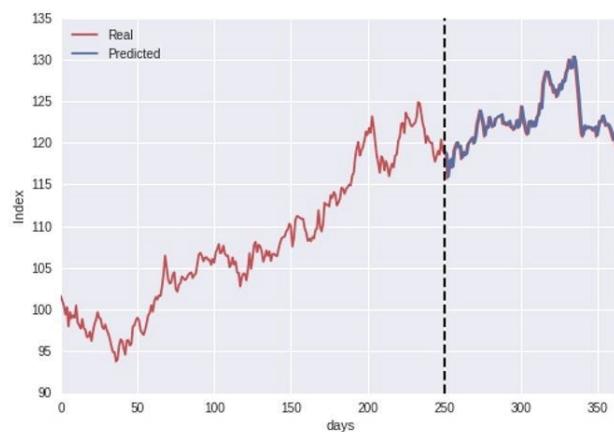
Tasks dealing with sequence data

E.g. Translation: sequence in → sequence out



The screenshot shows the Google Translate interface. On the left, under 'Text' mode, there is an English sentence: "Google translate is doing ok, but is still not perfect". Below it is a green circular icon with a 'G'. On the right, under 'Dokument' mode, the same sentence is translated into Swedish: "Google Translate gör ok, men är fortfarande inte perfekt". There are also small icons for audio, a keyboard, and sharing.

Language translation



Time series prediction

Tasks dealing with sequence data

Sentiment classification

"I love this movie.
I've seen it many times
and it's still awesome."



"This movie is bad.
I don't like it at all.
It's terrible."



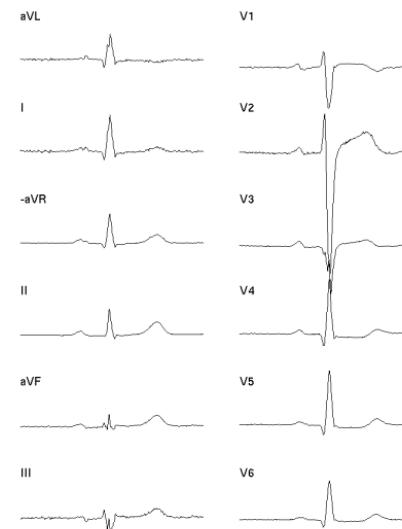
Speech recognition



Video activity recognition

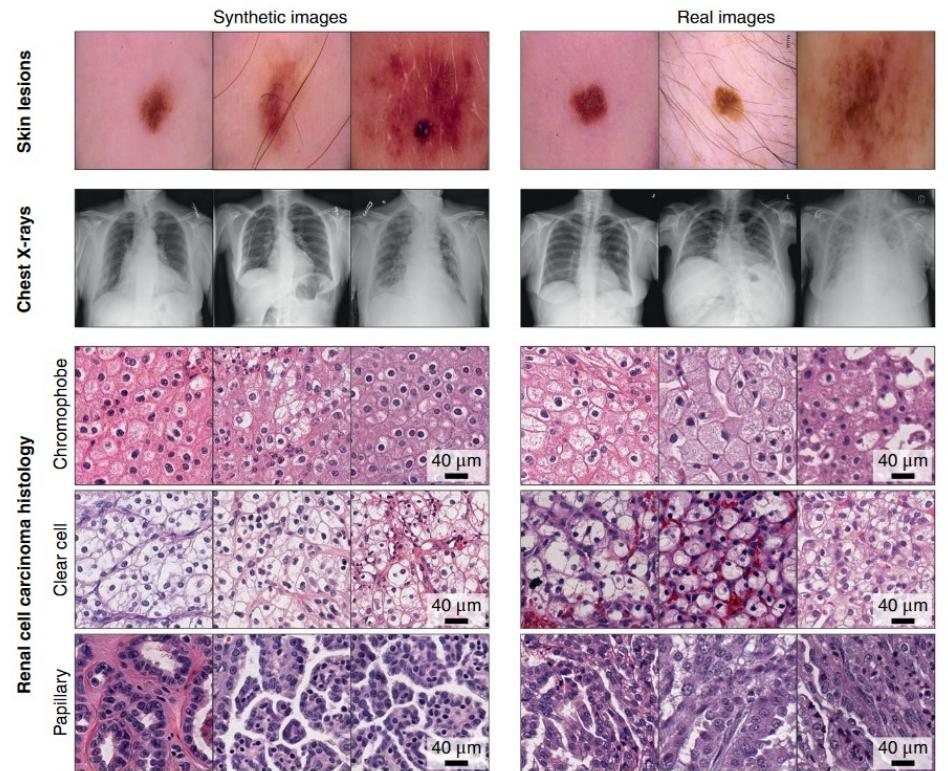


Running



AMI or not?

Synthesis and sampling: : Generate new data “similar” to the given data

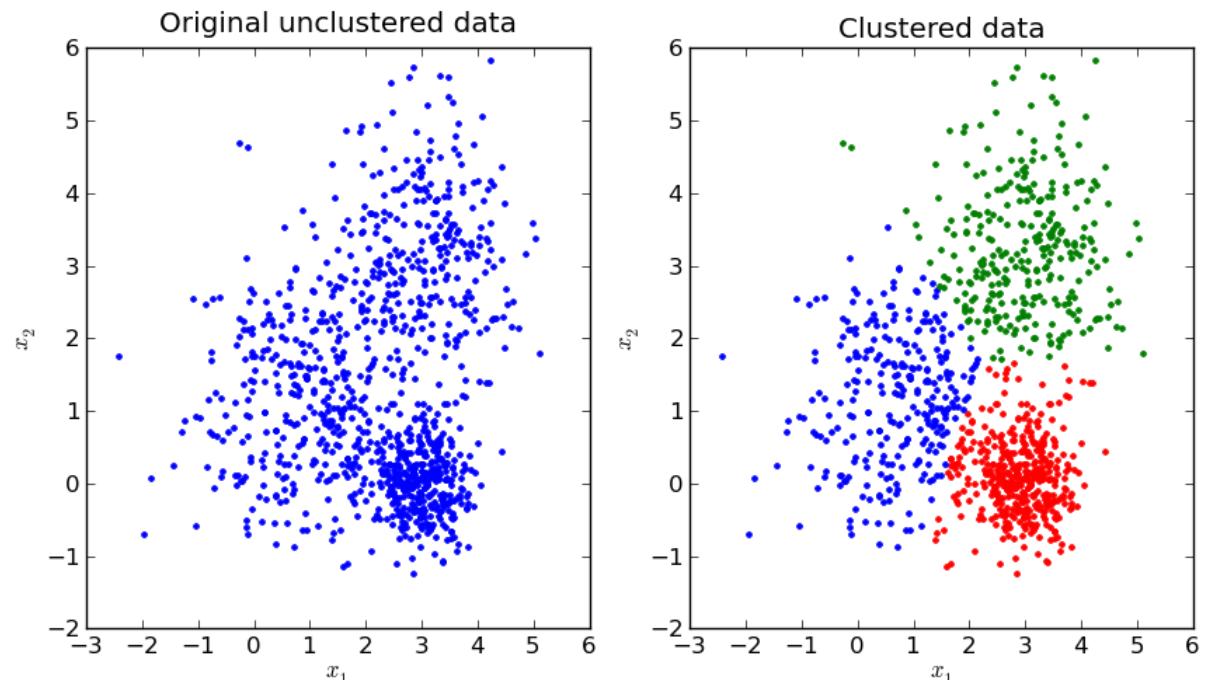
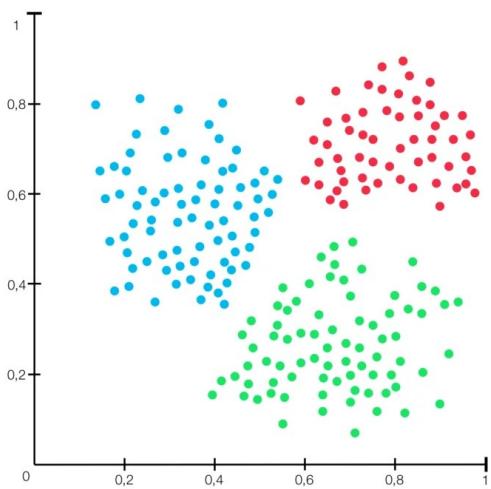


<https://generated.photos/>

Synthetic data in machine learning for medicine and healthcare

Generative AI

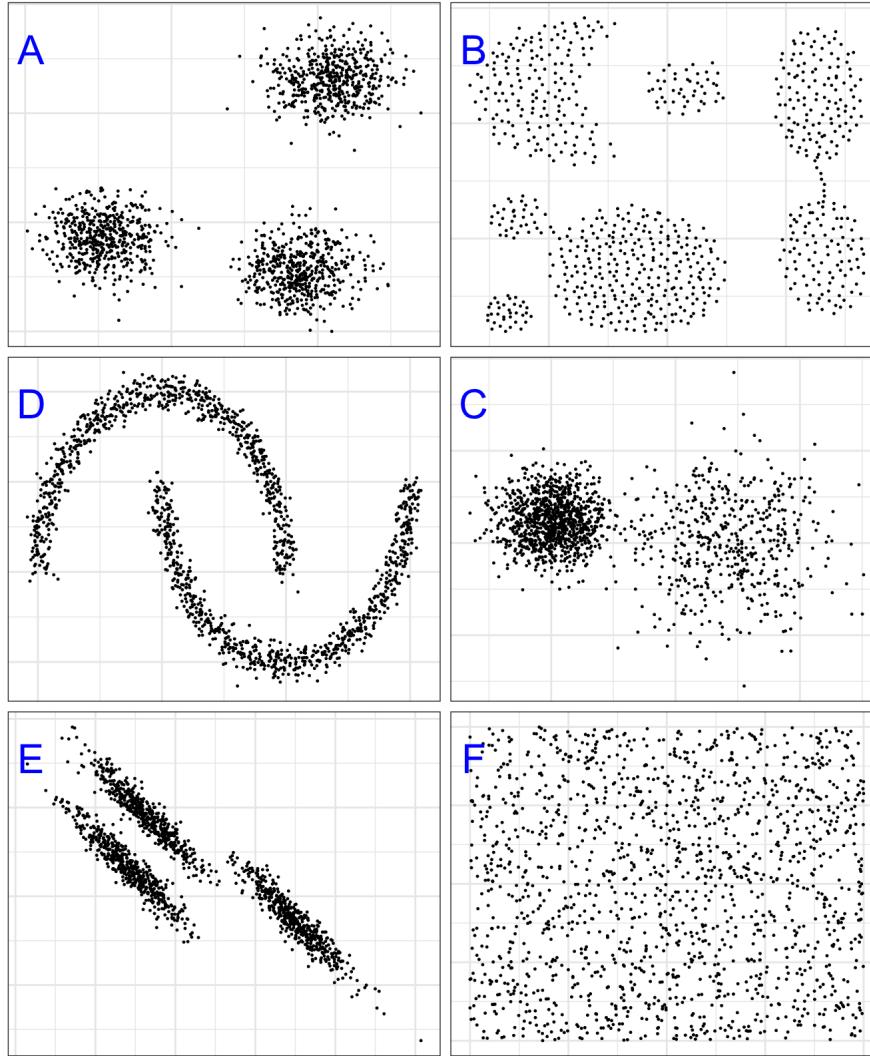
Clustering tasks: Find “natural” groupings of data



Straight forward clusters!

There is no ground truth! Many divisions
of data into clusters can be accepted!

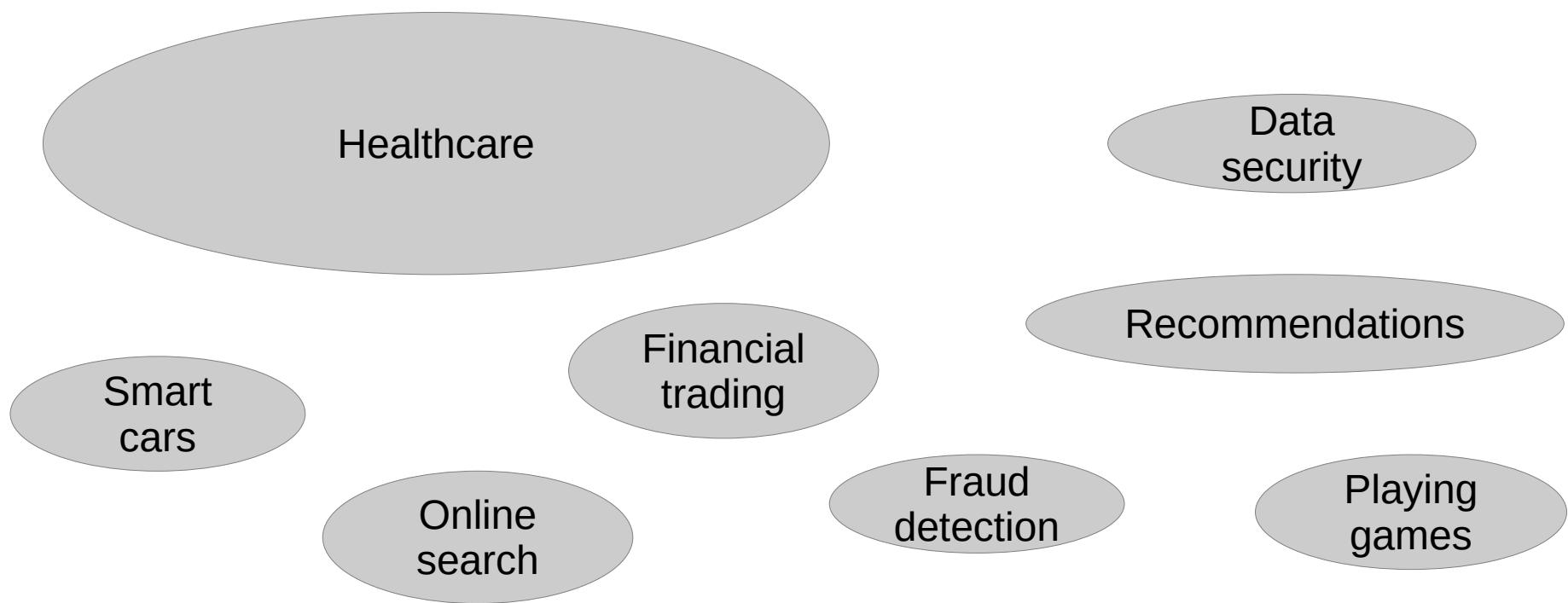
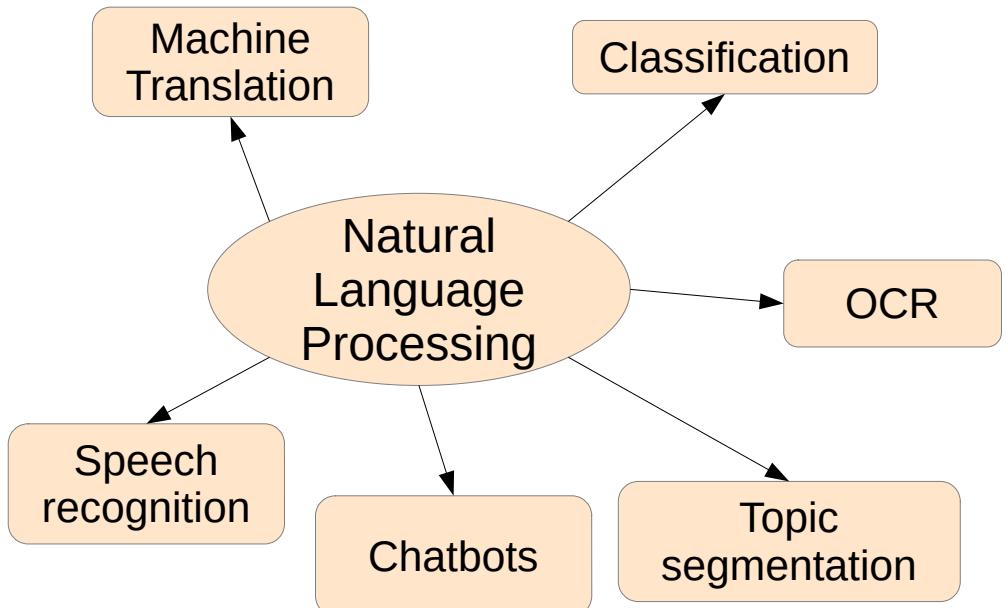
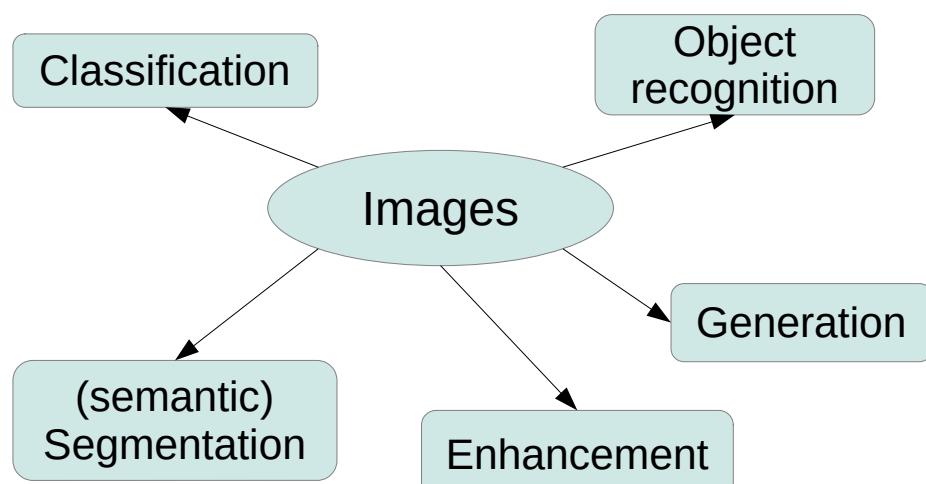
Clustering tasks: Find “natural” groupings of data



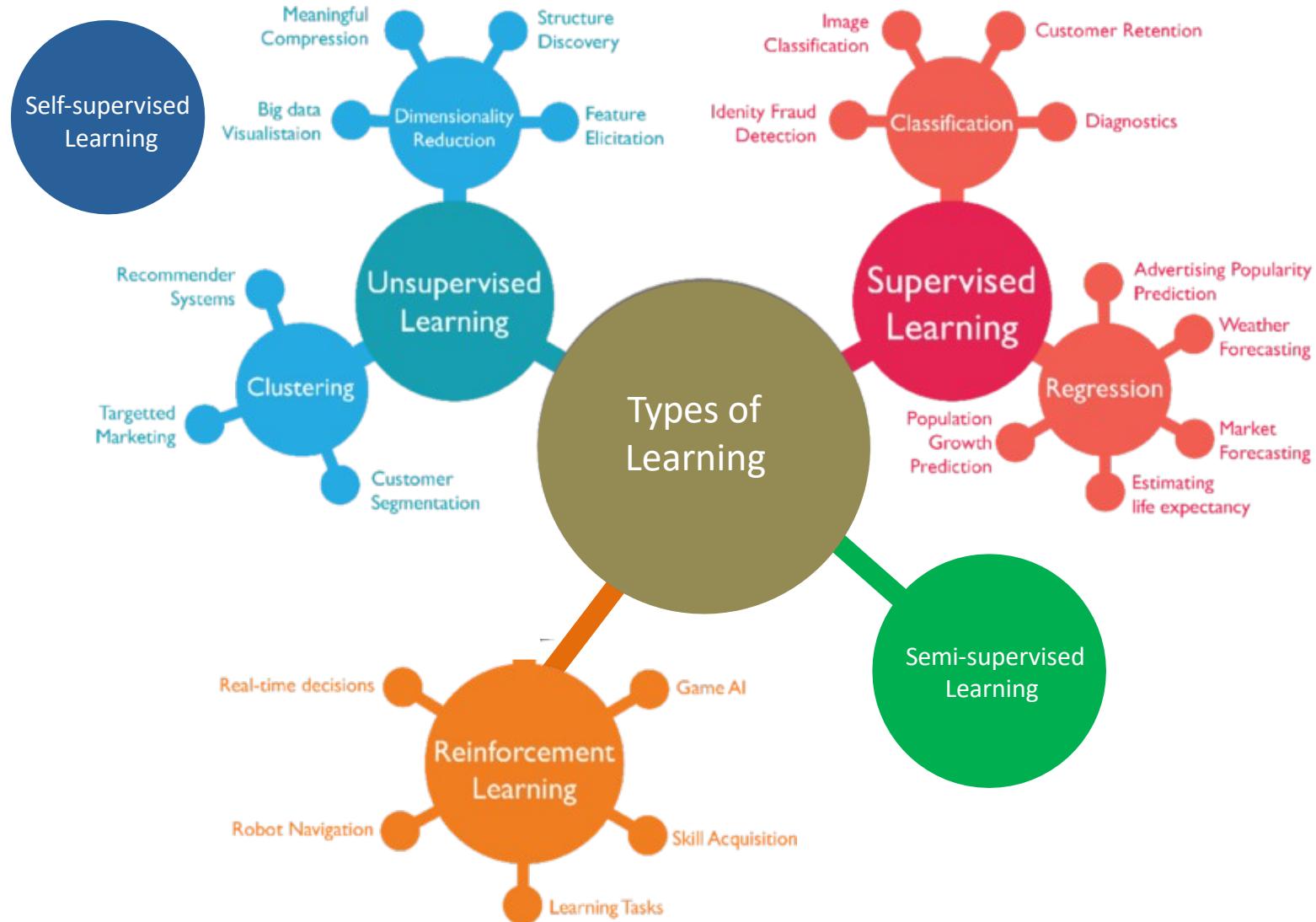
Clustering can be challenging!

And much much more...

Some application areas (growing by the day...)

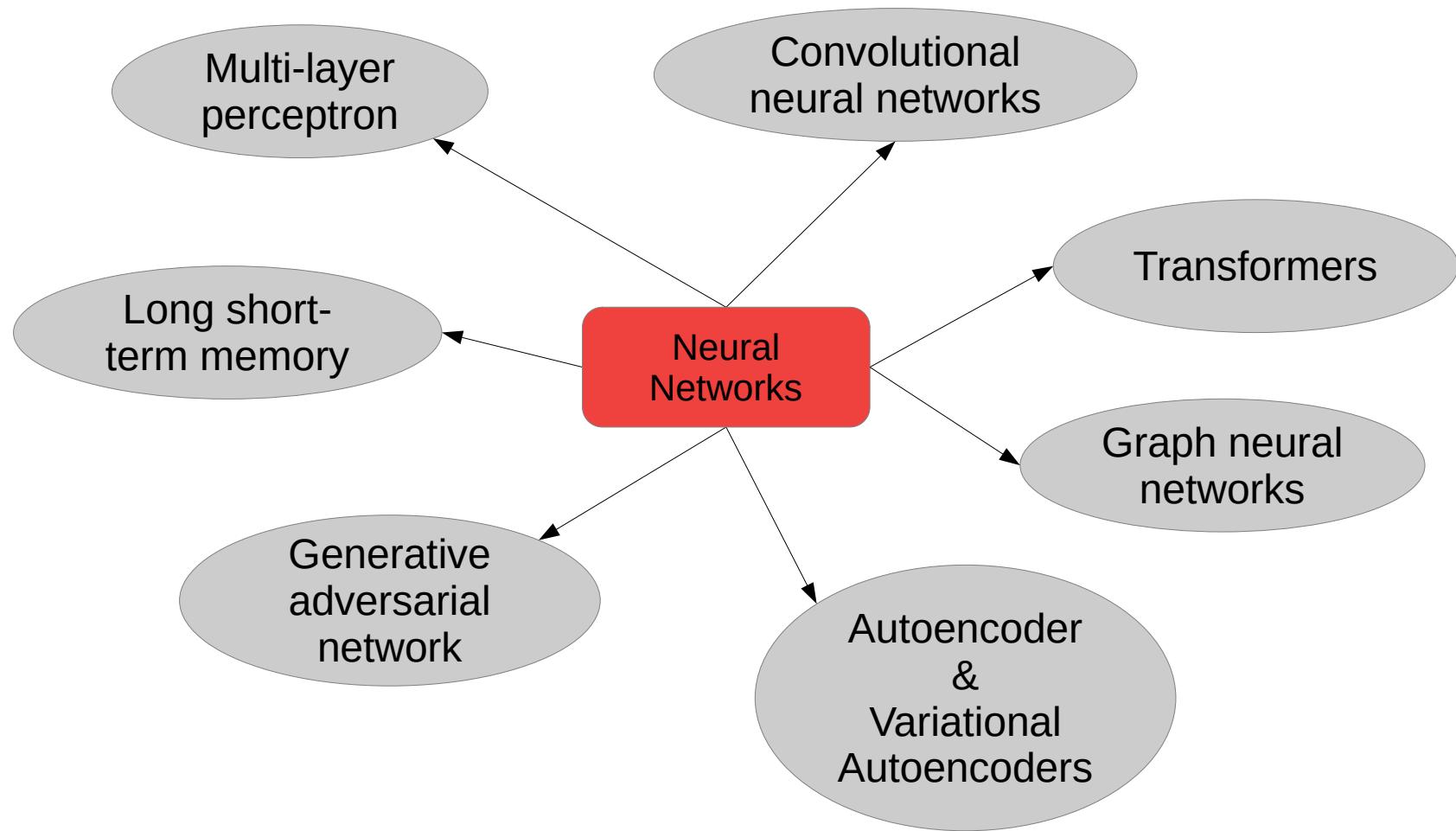


Different types of learning

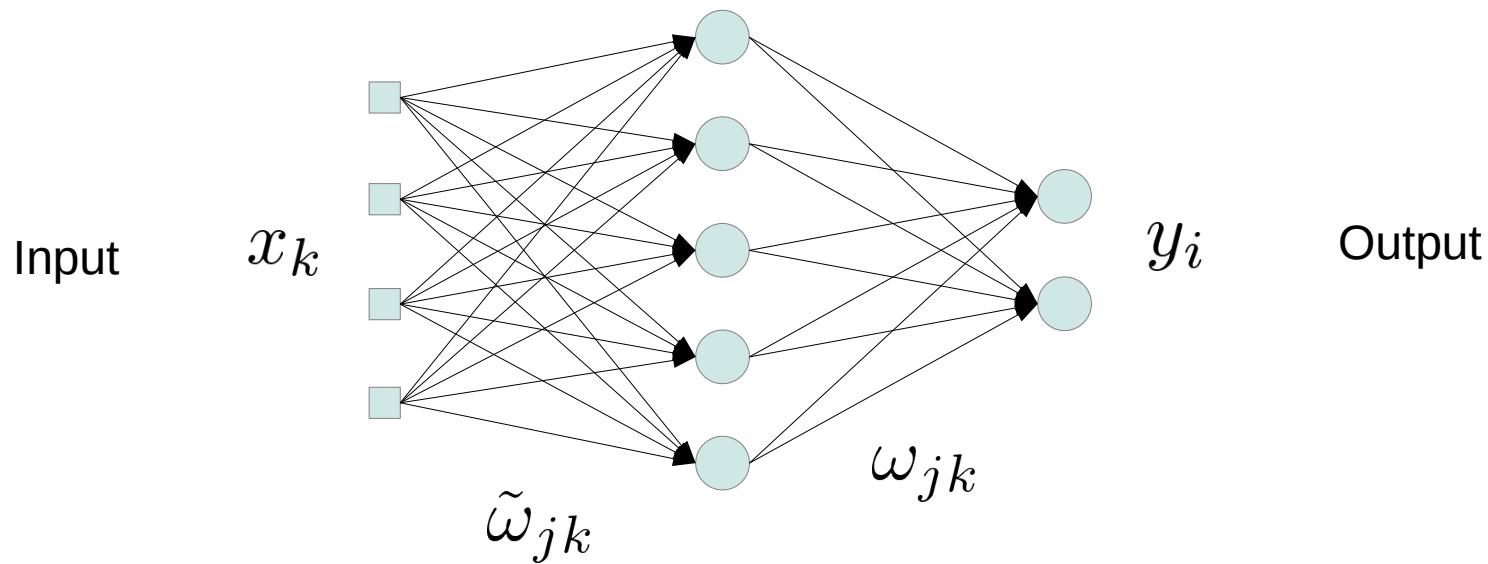


- Supervised Learning
Pattern mining given labeled data
- Unsupervised Learning
Pattern mining in unlabeled data
- Semi-supervised Learning
A mix of supervised and unsupervised learning. There are labels for a subset of the data, but not for all of it.
- Self-supervised Learning
Models are trained on supervisory signals generated by the data itself
- Reinforcement Learning
Learns to act based on feedback/reward

Today machine learning methods based on neural networks are very popular!



A simple neural network (MLP)



A mapping from “input” to “output”

$$y_i(\mathbf{x}) = \varphi_o \left(\sum_j \omega_{ij} \varphi_h \left(\sum_k \tilde{\omega}_{jk} x_k \right) \right)$$

Tunable weights

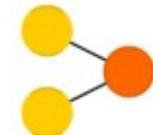
Many different kinds of network architectures

Neural Networks

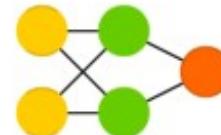
©2016 Fjodor van Veen - asimovinstitute.org

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

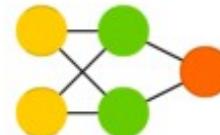
Perceptron (P)



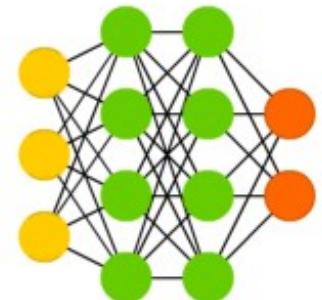
Feed Forward (FF)



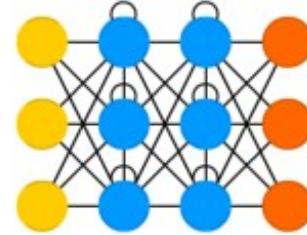
Radial Basis Network (RBF)



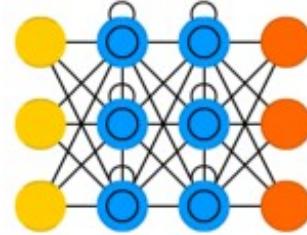
Deep Feed Forward (DFF)



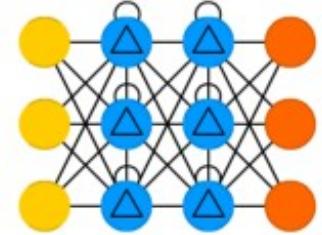
Recurrent Neural Network (RNN)



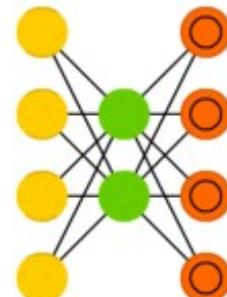
Long / Short Term Memory (LSTM)



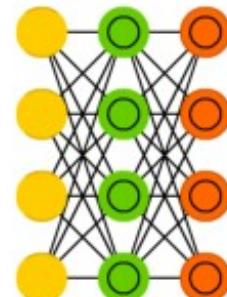
Gated Recurrent Unit (GRU)



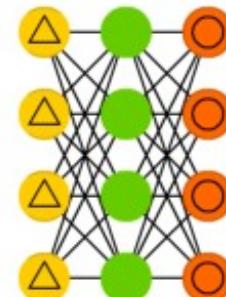
Auto Encoder (AE)



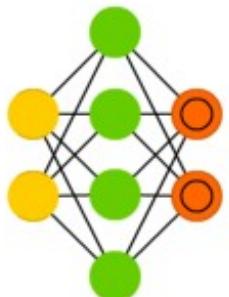
Variational AE (VAE)



Denoising AE (DAE)



Sparse AE (SAE)



Markov Chain (MC)



Hopfield Network (HN)



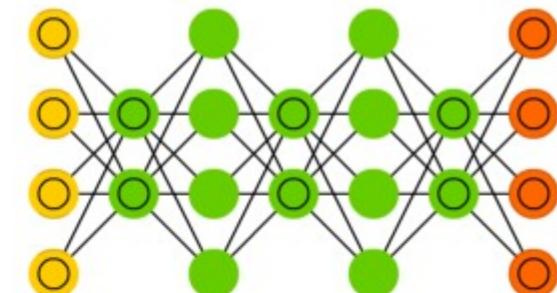
Boltzmann Machine (BM)



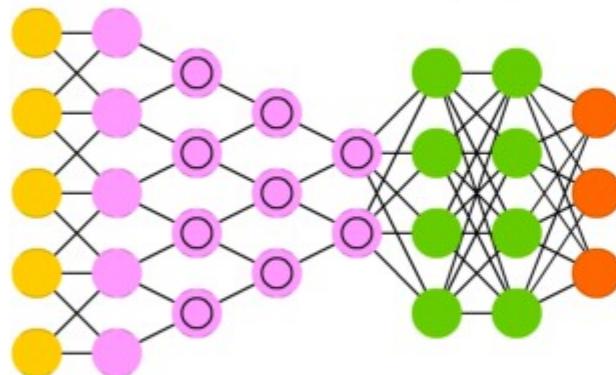
Restricted BM (RBM)



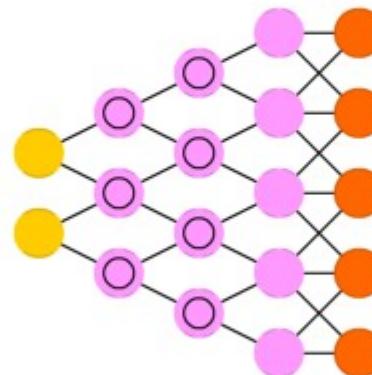
Deep Belief Network (DBN)



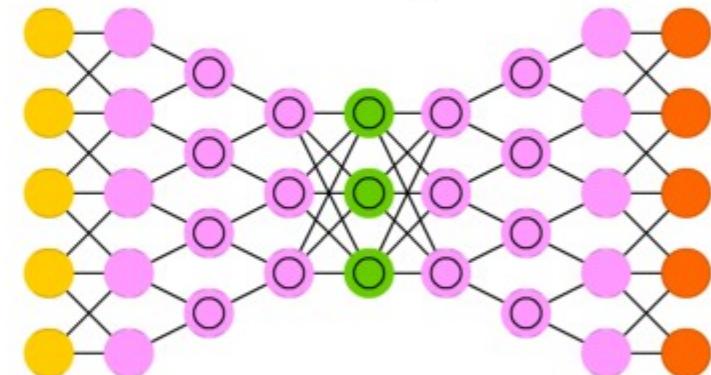
Deep Convolutional Network (DCN)



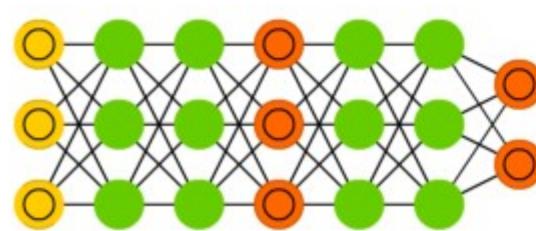
Deconvolutional Network (DN)



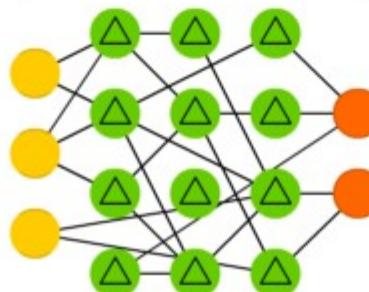
Deep Convolutional Inverse Graphics Network (DCIGN)



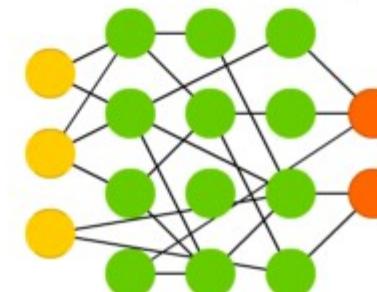
Generative Adversarial Network (GAN)



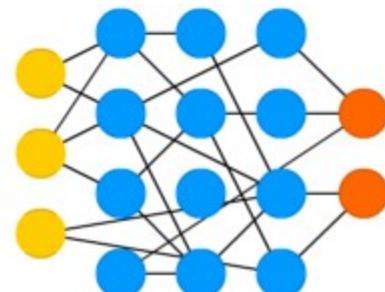
Liquid State Machine (LSM)



Extreme Learning Machine (ELM)

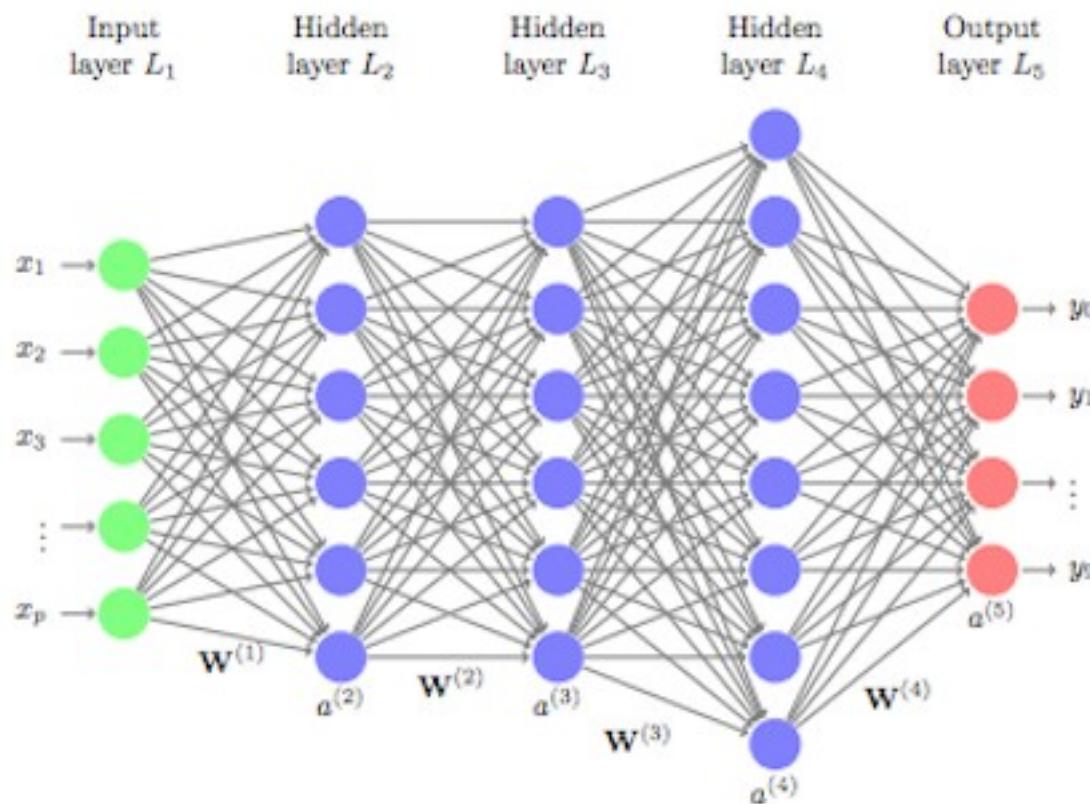


Echo State Network (ESN)



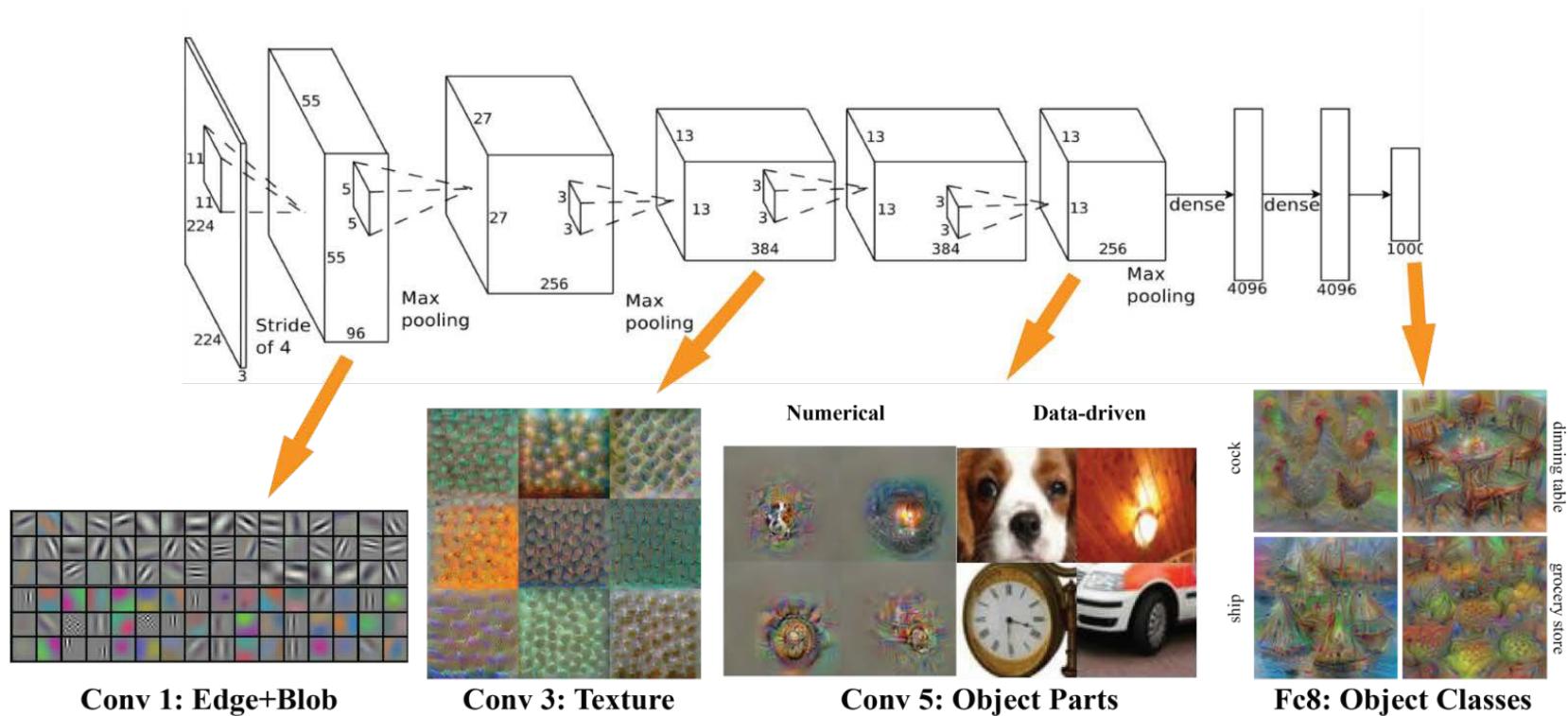
Some common architectures

Multi Layer Perceptron (MLPs)



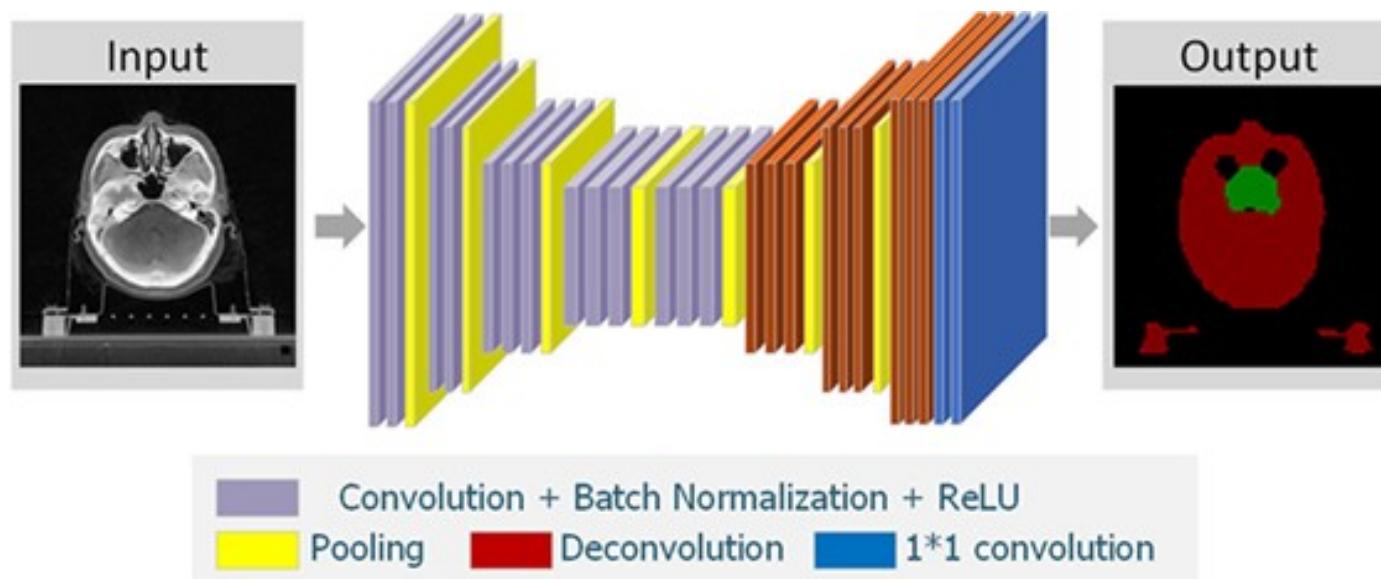
Some common architectures

Convolutional Neural Networks (CNNs)



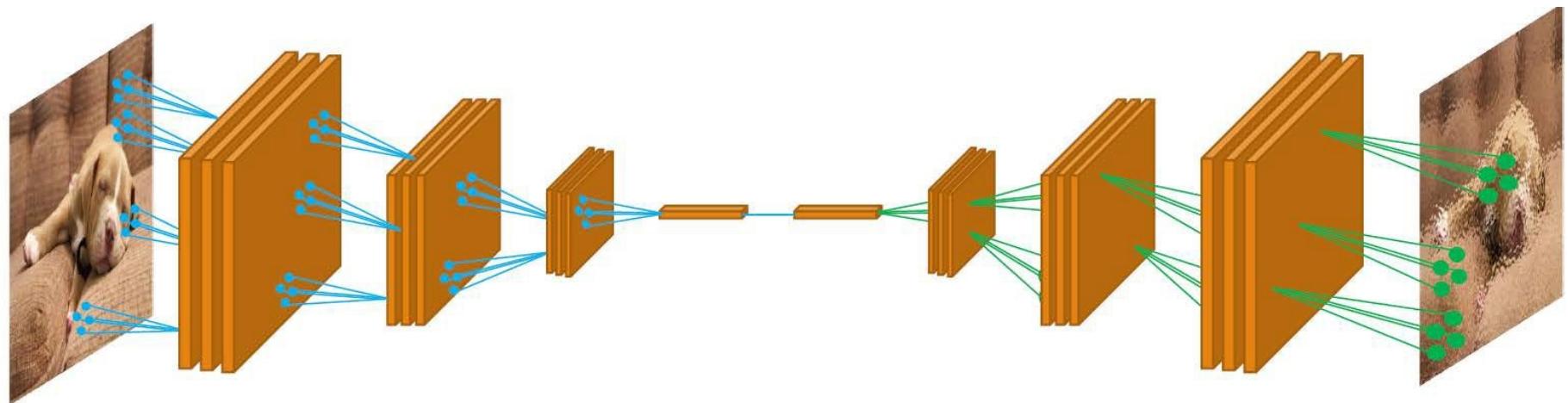
Some common architectures

Deconvolutional Neural Networks



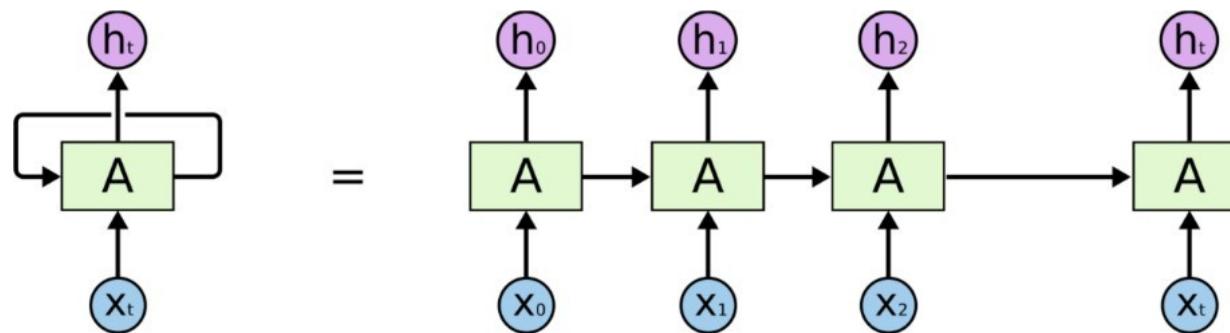
Some common architectures

Autoencoder Networks



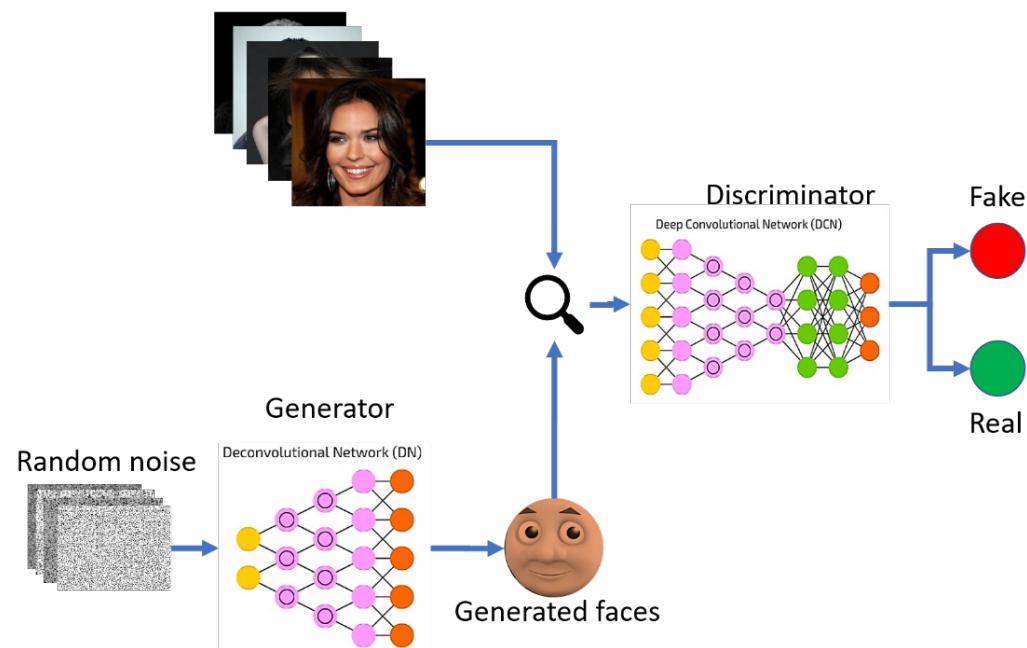
Some common architectures

Recurrent Neural Networks (RNNs)



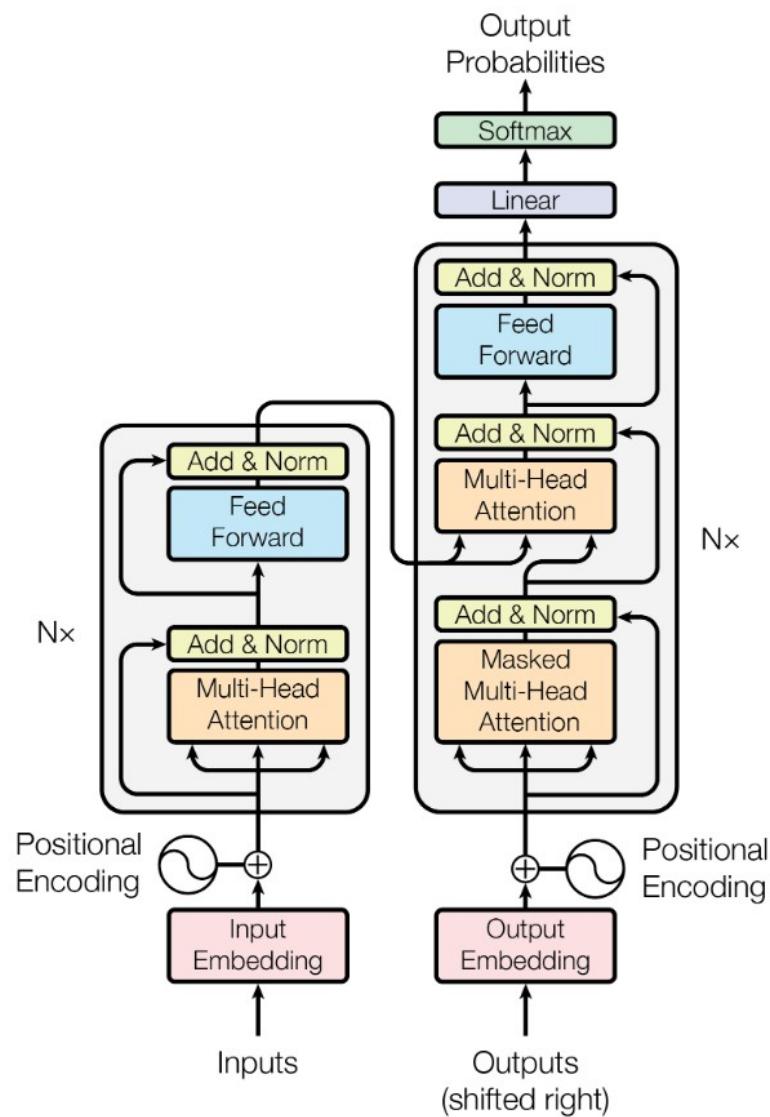
Some common architectures

Generative Adversarial Networks (GANs)

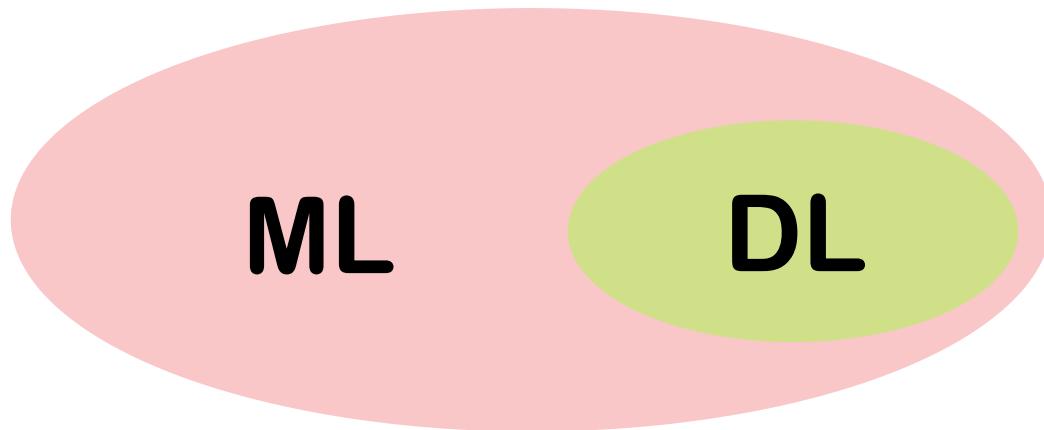


Some common architectures

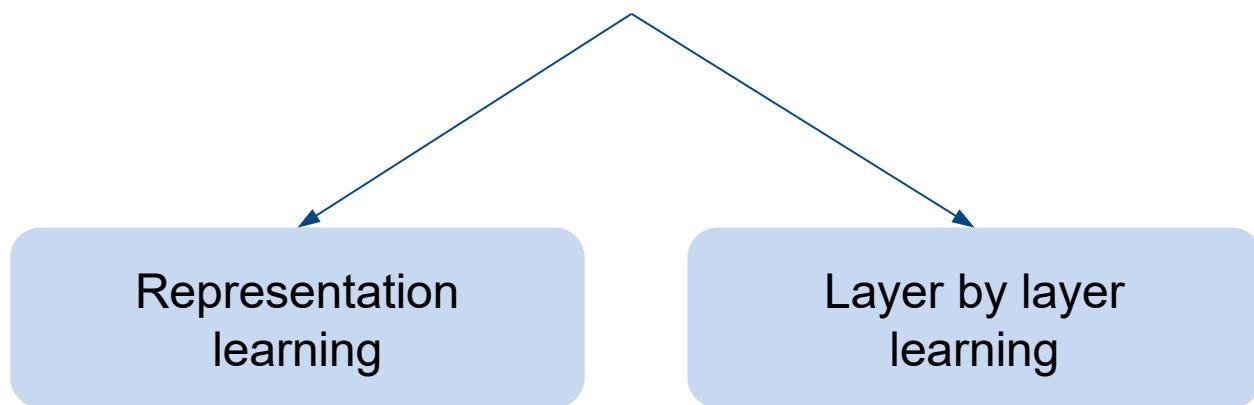
Transformer models



Some words about deep learning

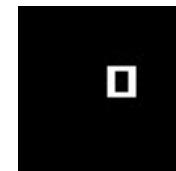
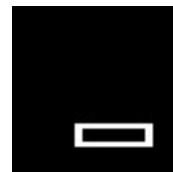
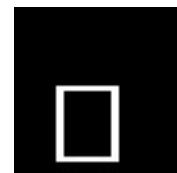


Deep learning



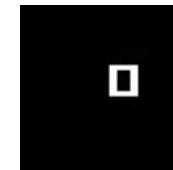
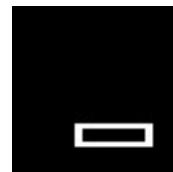
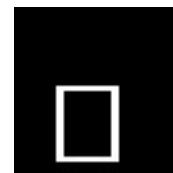
Circle or rectangle?

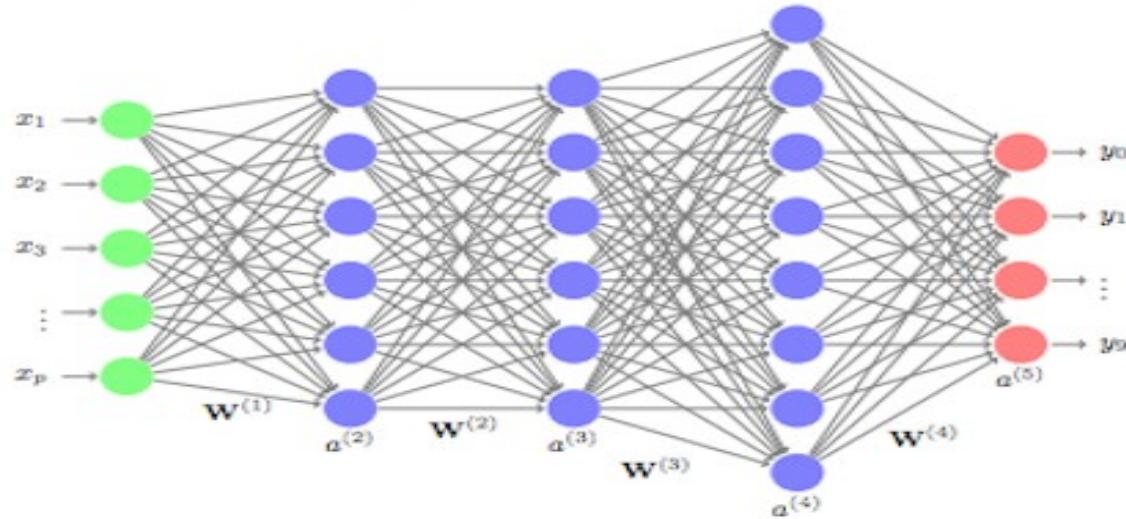
What property is important for this question?



Largest circumference?

What property is important for this question?





Layer 1

Layer 2

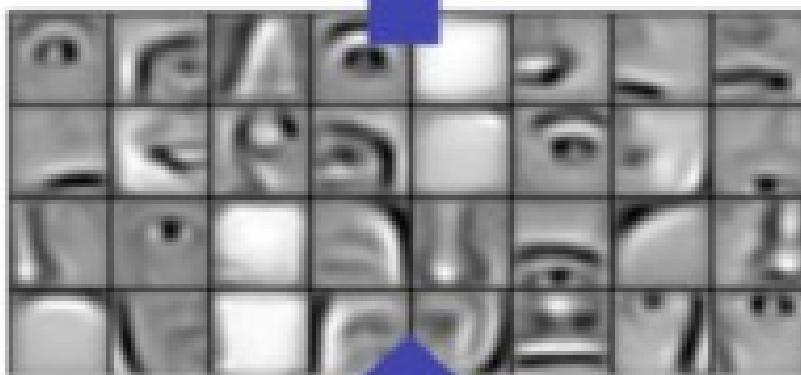
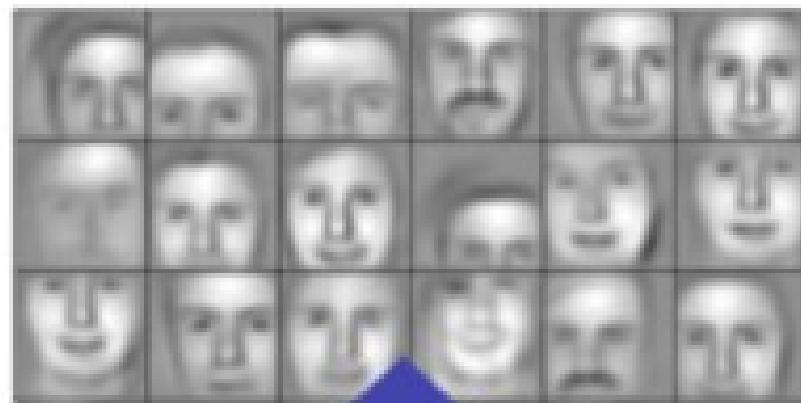
Layer 3

Simple features

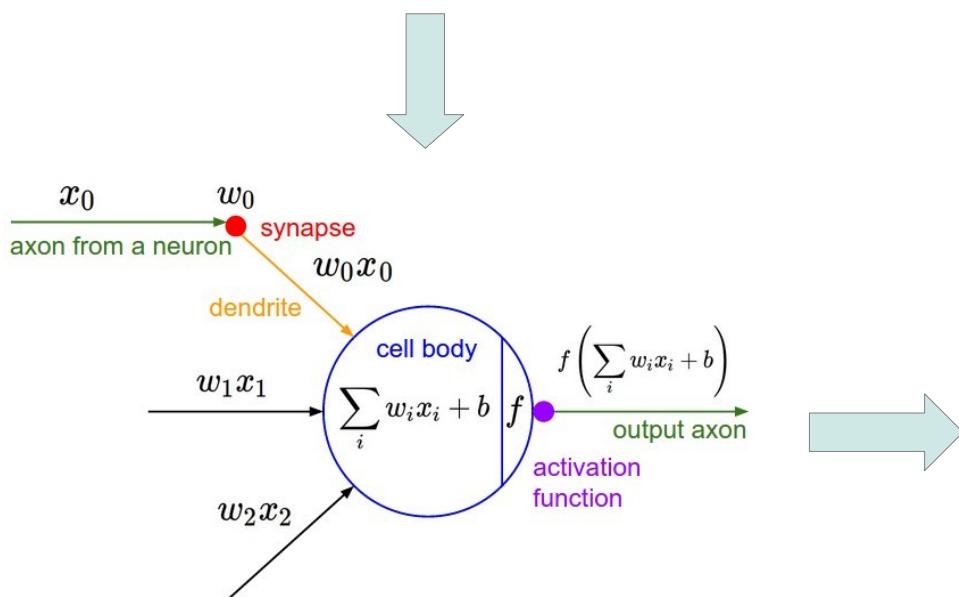
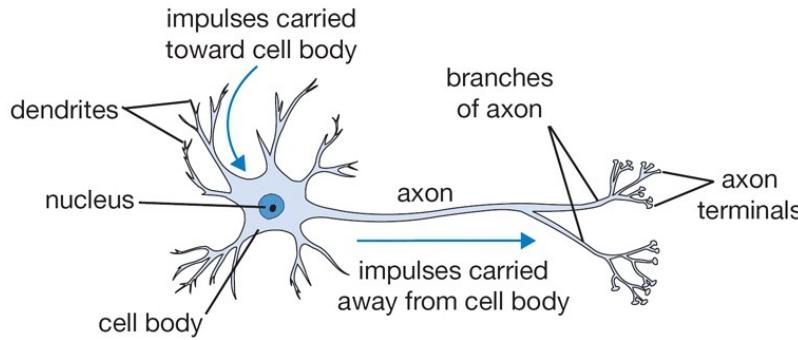
that is used to build
more complex features

that is used to build even
more complex features

Each layer is learning efficient features for the question at hand.



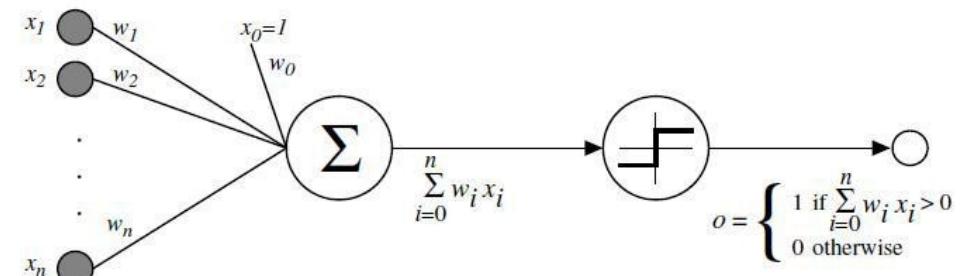
But first a bit of neural networks history

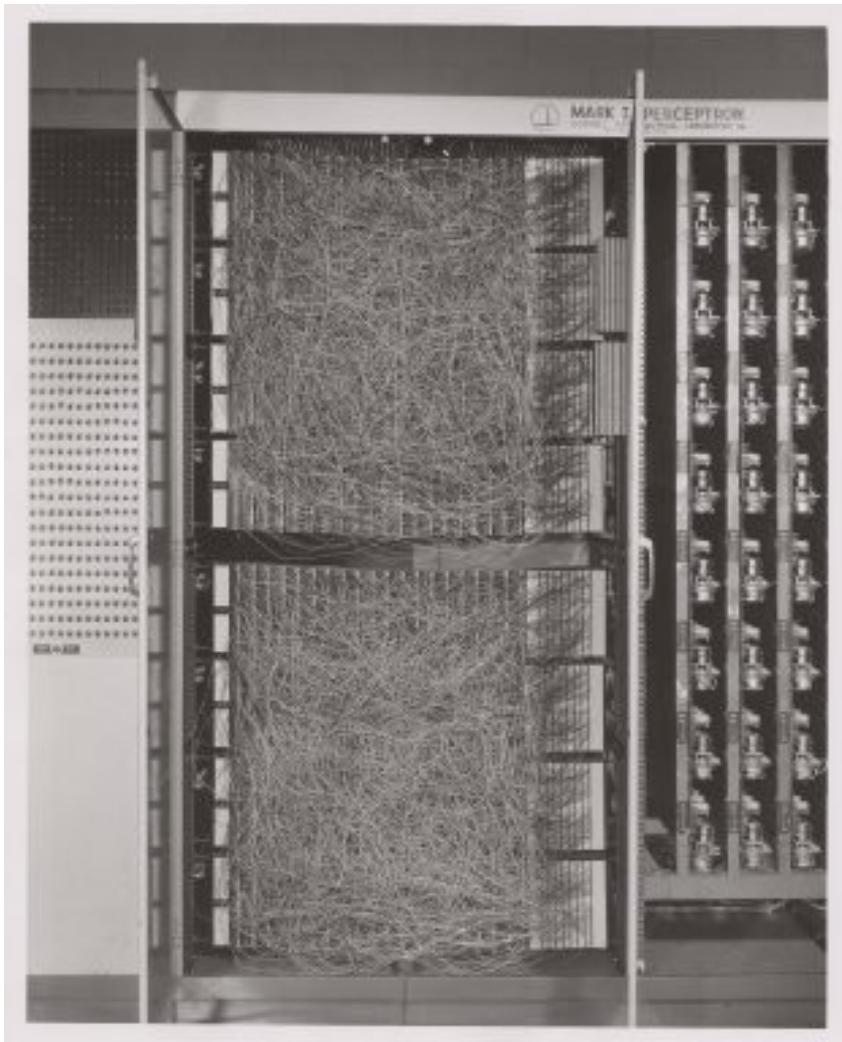


1943 McCulloch-Pitts model

1949 Hebb's rule. Learning occurs by formation and changing of synapses (weights).

1957 Rosenblatt's perceptron learning algorithm.





The Mark I Perceptron (1957-58)

- 20x20 photocells
- weights were encoded in potentiometers
- weight updates during learning were performed by electric motors

The first winter!

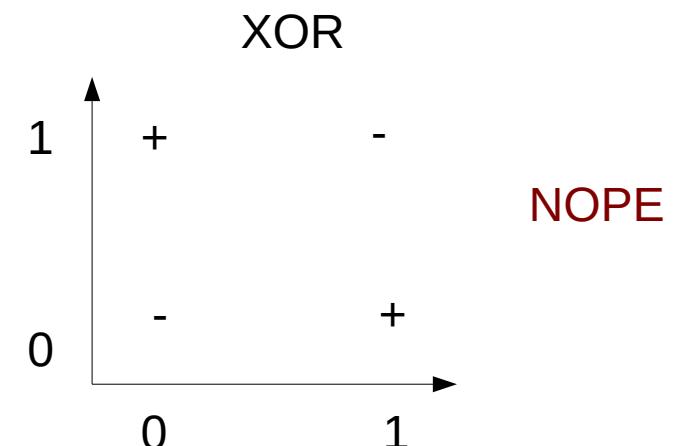
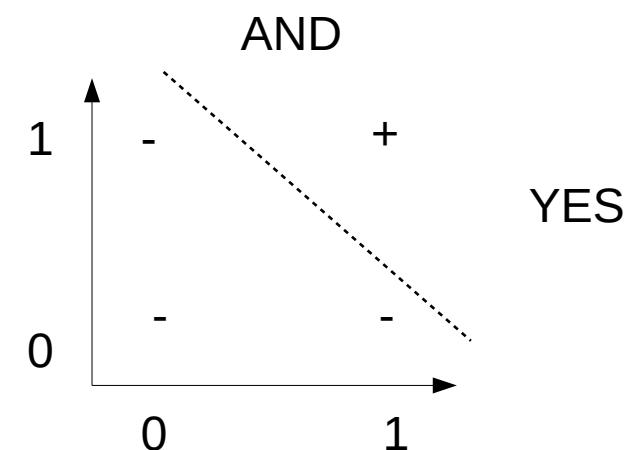
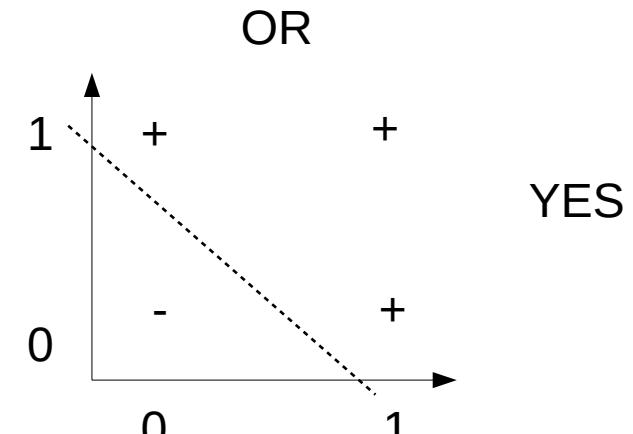
1969: Perceptrons by Minsky and Papert showed limitations of the perceptron

$$y = f\left(\sum_i x_i w_i + b\right)$$

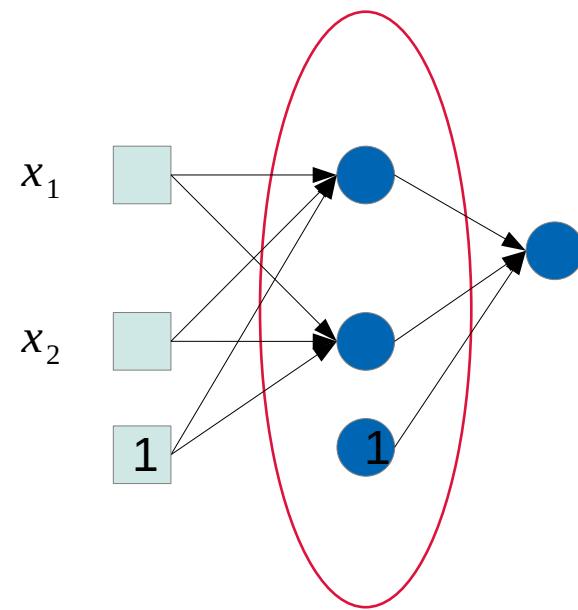
y changes class when

$$\sum_i x_i w_i + b = 0$$

→ decision boundary is a hyperplane



The solution to the XOR problem



The first return of neural networks

1982: Hopfield. "Hopfield model"

1985: Hinton: Learning in Boltzmann machines

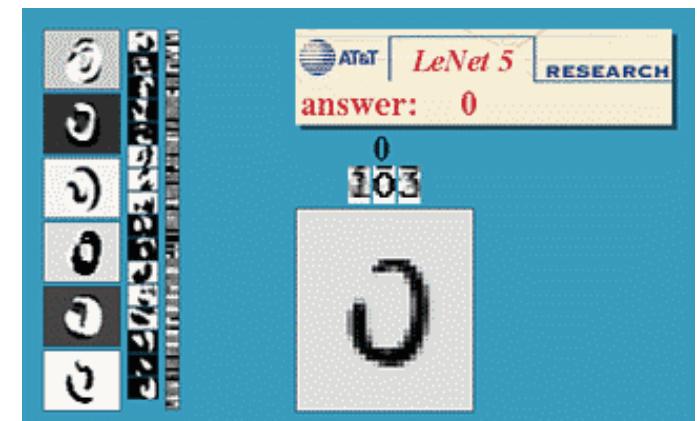
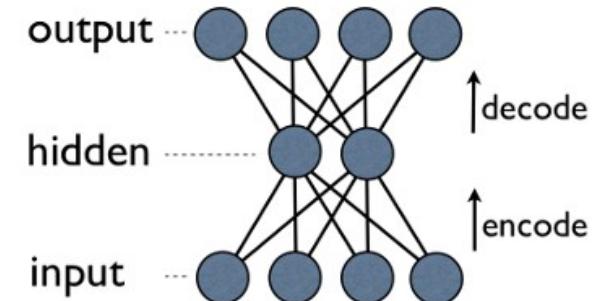
1986: Rumelhart, Hinton, Williams, backpropagation
to train networks with several layers.
(Already 1974 by Werbos)

1986: Unsupervised, The autoencoder

1989: Hornik & White: Neural networks are universal
approximators

1989: Lecun et al.: LeNet, the first convolutional
neural network. Example of classifying
handwritten digits.

: Recurrent networks, Backpropagation
through time.



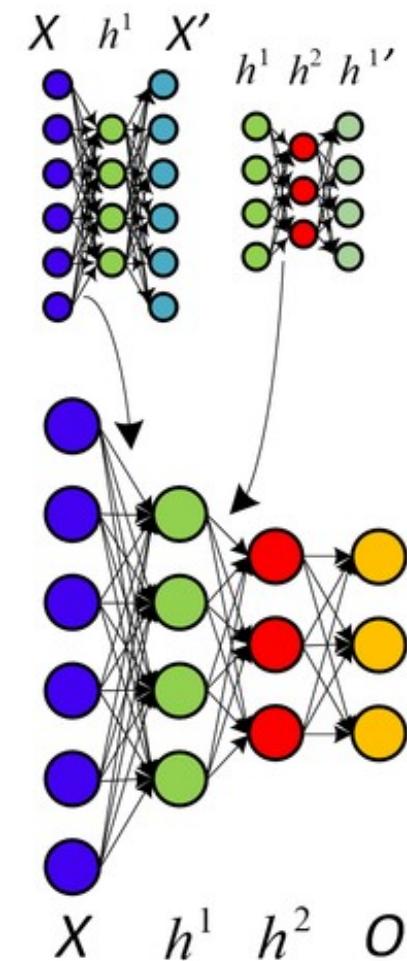
The second winter, mid 90's!

- Backpropagation does not work well for networks with many layers.
E.g. recurrent networks were difficult to train.
 - They were seen as a hassle to work with
 - Not fast enough computers
 - Some bad papers ...
 - New algorithms that in some comparisons worked better. Support vector machines, random forest etc.
 - **Machine learning community “abandoned” neural networks.**
- Schmidhuber, 1997, LSTM =
“Long short term memory”.
- Use a lot today!!

The second return of neural networks (with a new name, “deep learning”)

2006: Hinton et al., “A fast learning algorithm for deep belief nets”.

2007: Bengio et al. “Greedy layer-wise training of deep networks”

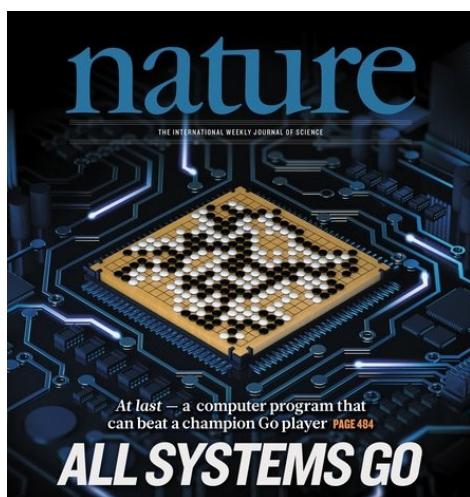


The Deep Learning Explosion...

2012: AlexNet wins ImageNet

2014: GANs

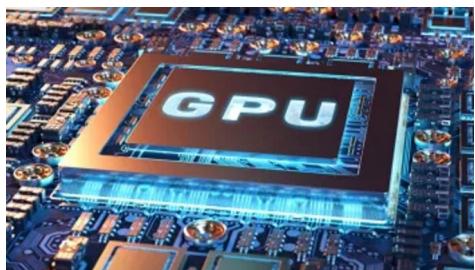
2017: AlphaGo, DeepMind



Very large momentum right now!

A few important factors!

GPU's



A lot of data!

Google
Facebook
Microsoft

1

A lot of research