Topic 1
Introduction to Deep Learning

AI HUMAN INTERFACE

Learning Outcomes

- Understand Neural Networks and Deep Learning
  - Understand Neural Networks
  - Explain machine learning based on learning data representations
  - Understand what is Deep Learning
  - Applications of Deep Learning

Understanding Neural Networks

Background

- Neural networks are one of the most beautiful programming paradigms invented. In the conventional approach to programming, we tell the computer what to do, breaking big problems up into many small, precisely defined tasks that the computer can easily perform. By contrast, neural network learns from **observational data**, figuring out its own solution to the problem at hand.

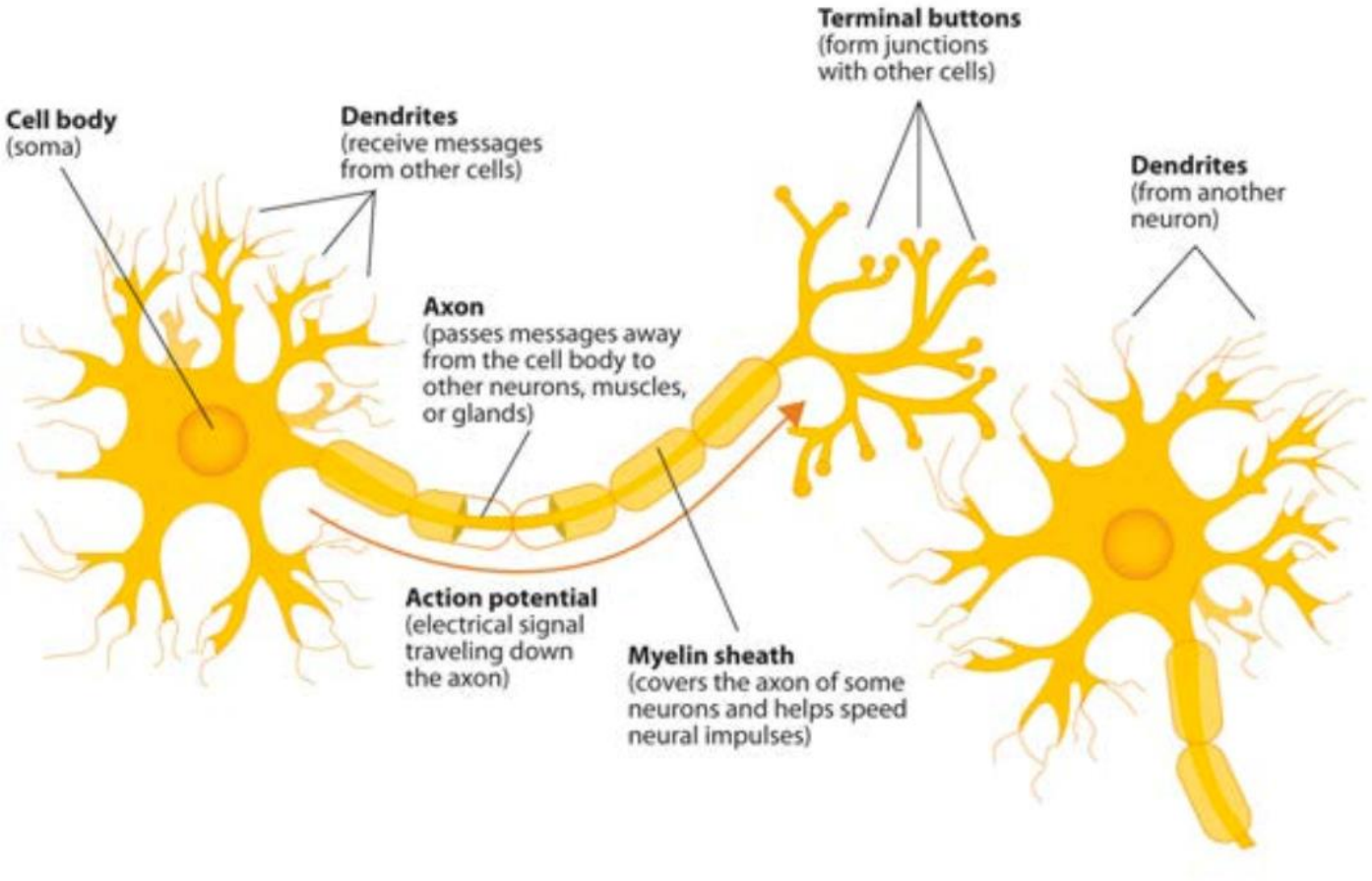
- Automatically learning from data sounds promising. However, until 2006 we didn't know how to train neural networks to surpass more traditional approaches, except for a few specialized problems. What changed in 2006 was the discovery of techniques for learning in so-called deep neural networks. These techniques are now known as deep learning. They've been developed further, and today deep neural networks and deep learning achieve outstanding performance on many important problems in **computer vision**, **speech recognition**, and **natural language processing**. They're being deployed on a large scale by companies such as Google, Microsoft, and Facebook.

The Road to Deep Learning

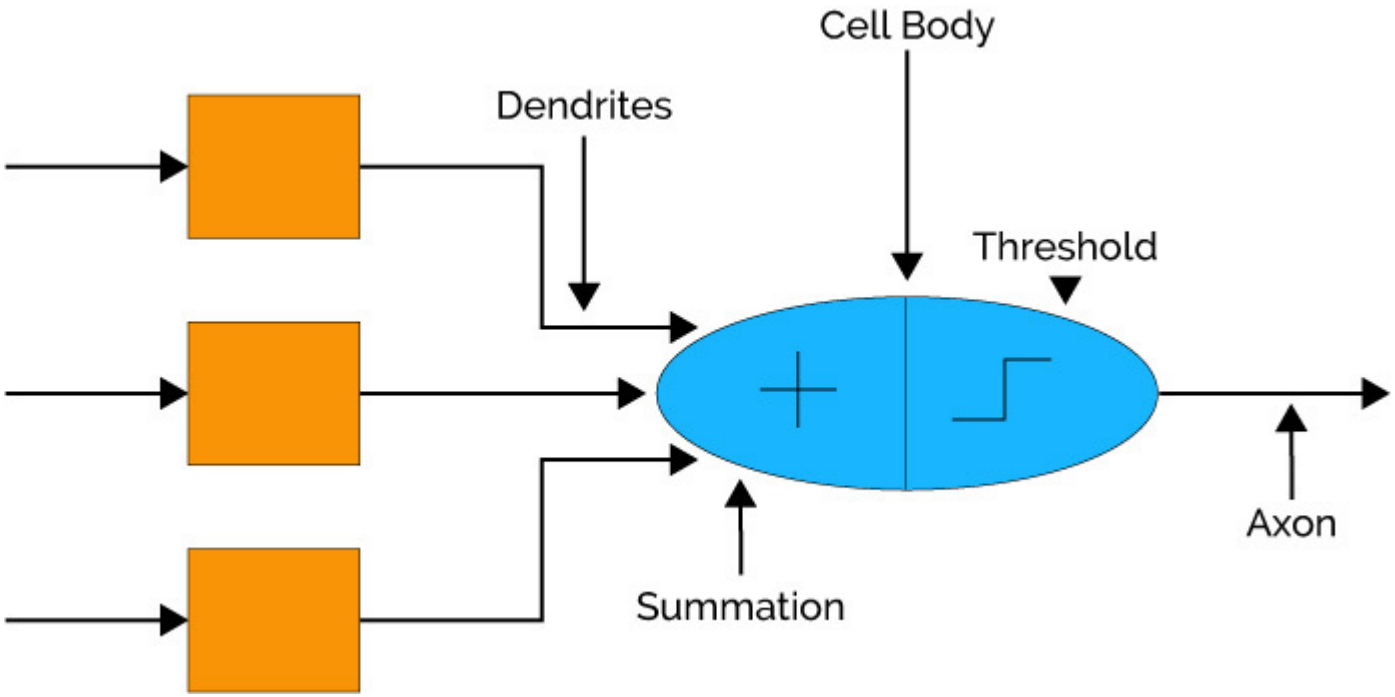
Dataset vs. computer memory and computational power

Decade	Dataset	Memory	Floating point calculations per second
1970	100 (Iris)	1 KB	100 KF (Intel 8080)
1980	1 K (House prices in Boston)	100 KB	1 MF (Intel 80186)
1990	10 K (optical character recognition)	10 MB	10 MF (Intel 80486)
2000	10 M (web pages)	100 MB	1 GF (Intel Core)
2010	10 G (advertising)	1 GB	1 TF (Nvidia C2050)
2020	1 T (social network)	100 GB	1 PF (Nvidia DGX-2)

Biological Neuron



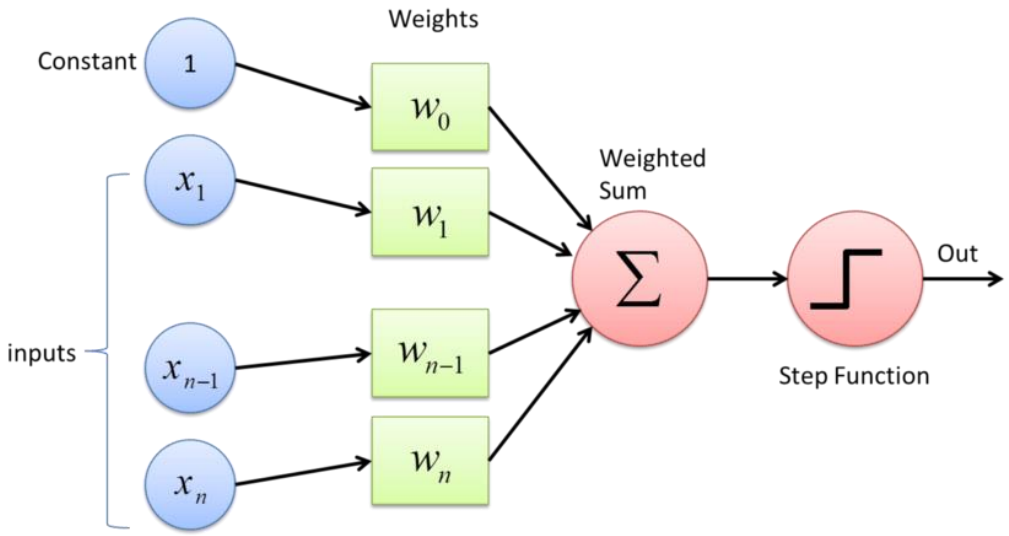
Biological Neuron (Simplification)



Artificial Neuron

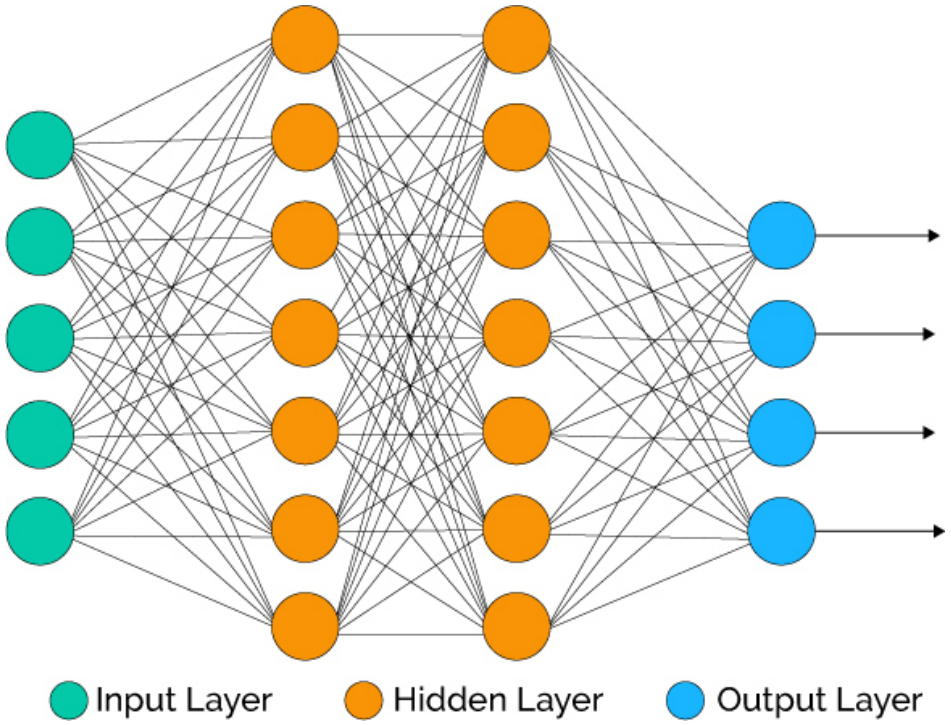
Perceptron consists of 4 parts:

- Input values
- Weights and Bias
- Net sum
- Activation Function

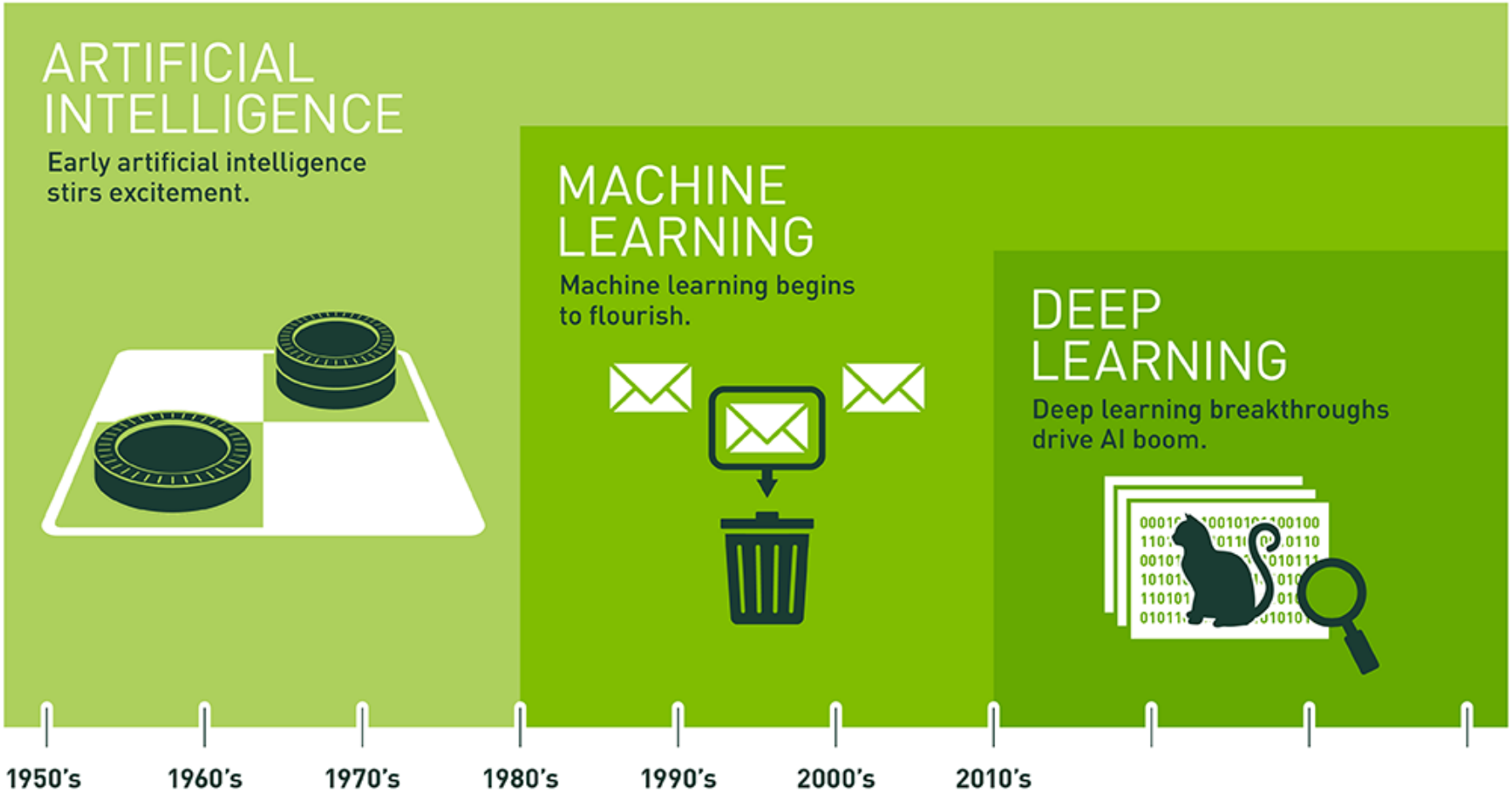


Neural Network

A typical **Neural Network** contains a large number of artificial neurons called units arranged in a series of layers.



Understanding Deep Learning



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Deep Learning

Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural networks.

Deep learning methods aim at learning feature hierarchies with features from higher levels of the hierarchy formed by the composition of lower level features. Automatically learning features at multiple levels of abstraction allow a system to learn complex functions mapping the input to the output directly from data, without depending completely on human-crafted features.

Deep Learning = Learning Hierarchical Representations

Y LeCun

Traditional Pattern Recognition: Fixed/Handcrafted Feature Extractor

Feature Extractor → Trainable Classifier

Mainstream Modern Pattern Recognition: Unsupervised mid-level features

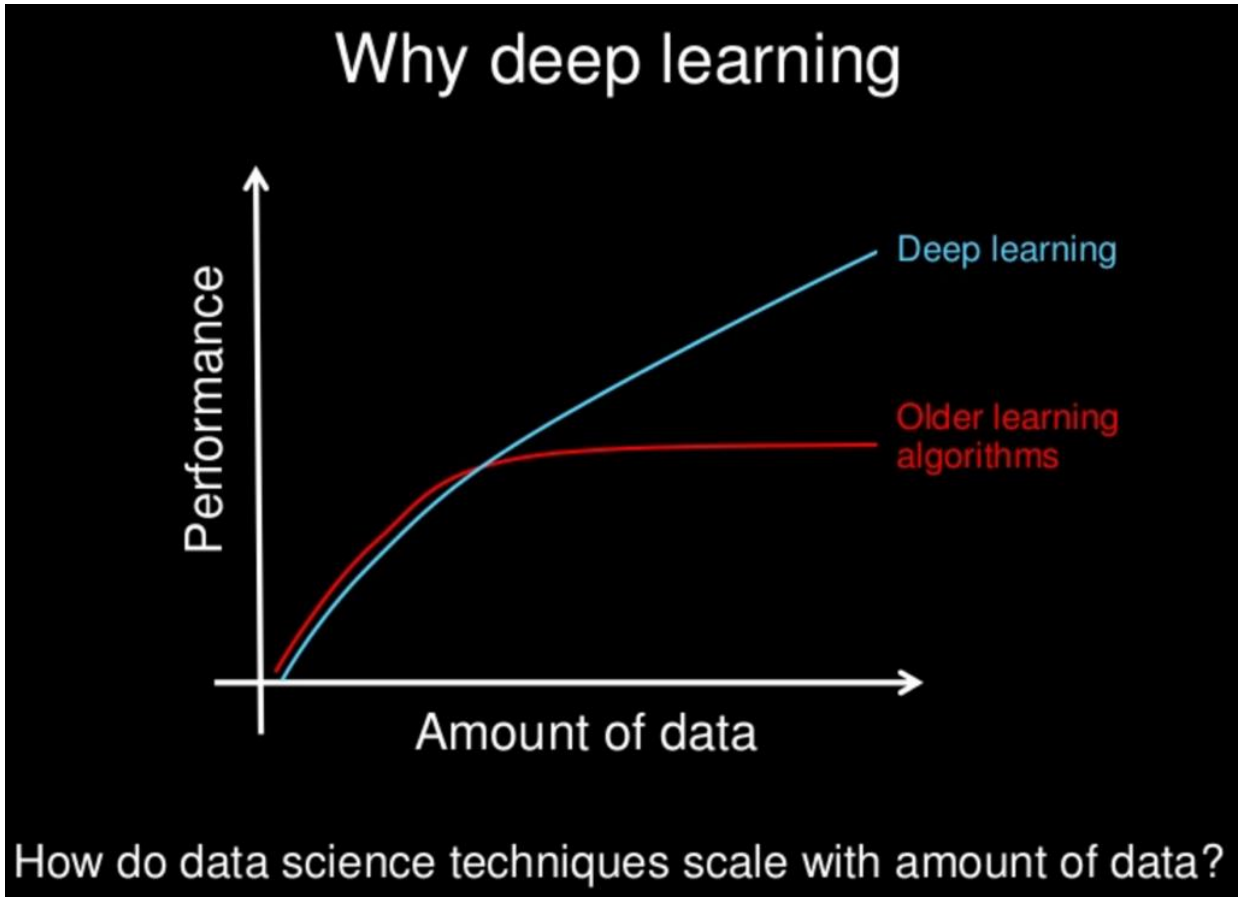
Feature Extractor → Mid-Level Features → Trainable Classifier

Deep Learning: Representations are hierarchical and trained

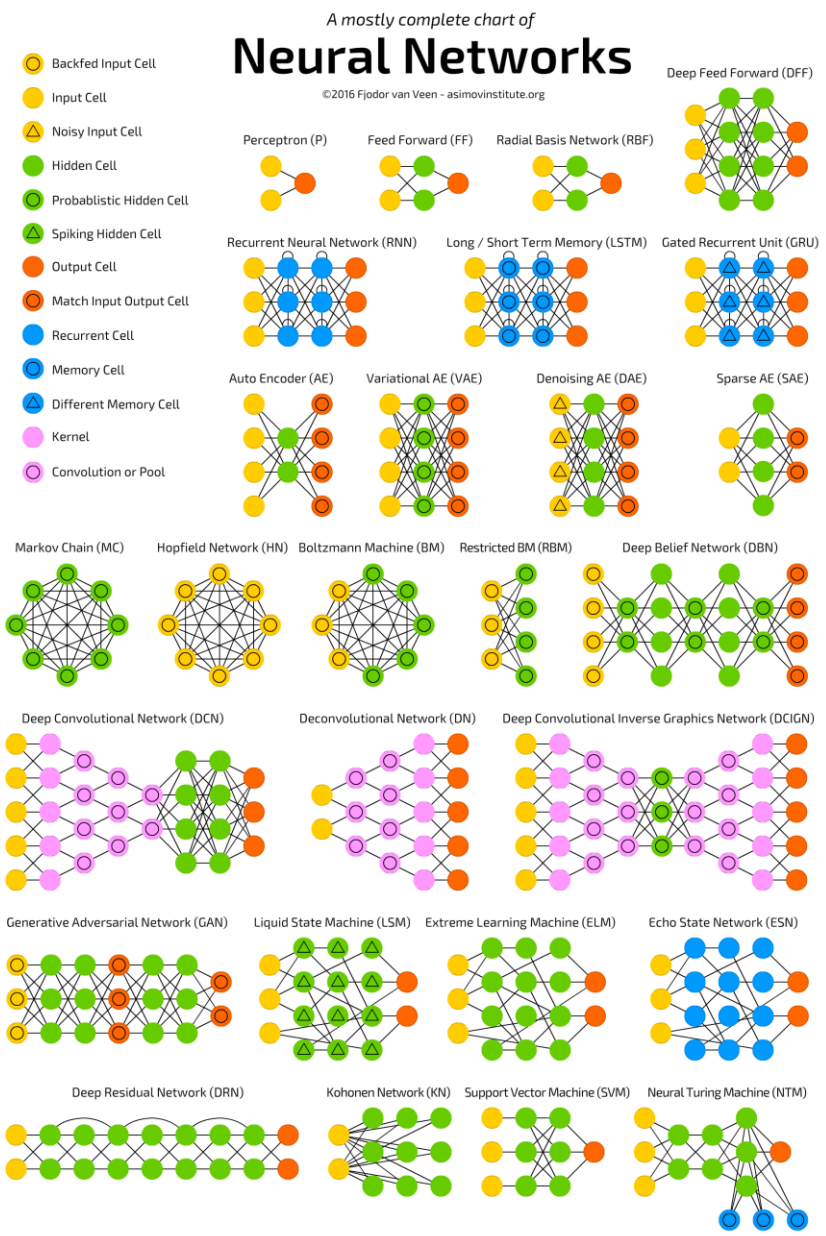
Low-Level Features → Mid-Level Features → High-Level Features → Trainable Classifier

source https://machinelearningmastery.com/what-is-deep-learning/

Deep Learning — Scalable

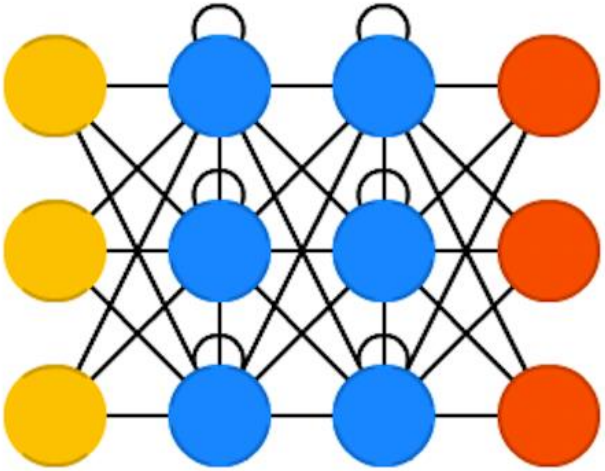


Types of Deep Learning Neural Networks: CNN, RNN, RBM, DBN



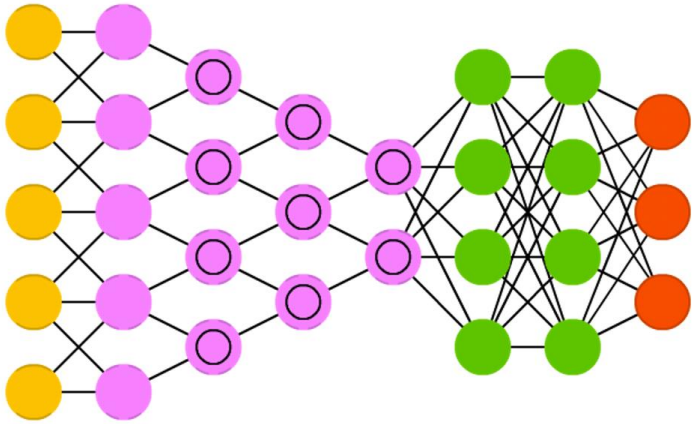
source http://www.asimovinstitute.org/neural-network-zoo/

Recurrent Neural Network (RNN)



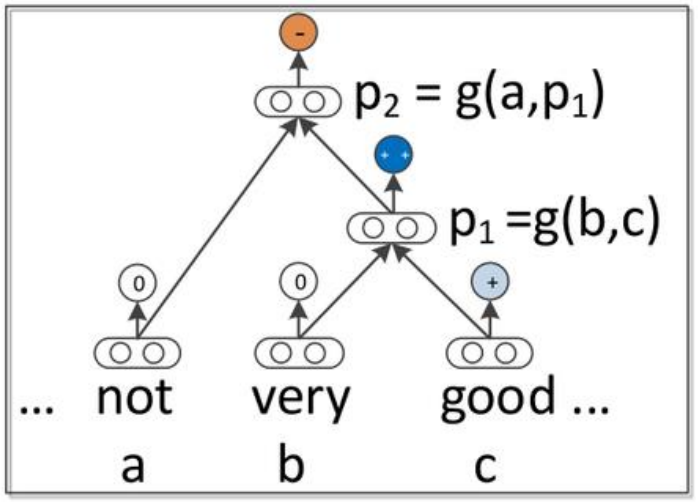
Recurrent neural networks (RNN) are Feed Forward NNs with a time twist: they are not stateless; they have connections between passes, connections through time. Neurons are fed information not just from the previous layer but also from themselves from the previous pass. This means that the order in which you feed the input and train the network matters: feeding it “milk” and then “cookies” may yield different results compared to feeding it “cookies” and then “milk”.

Convolutional Neural Network (CNN)



Convolutional neural networks (CNN) are quite different from most other networks. They are primarily used for image processing but can also be used for other types of input such as audio. A typical use case for CNNs is where you feed the network images and the network classifies the data, e.g. it outputs “cat” if you give it a cat picture and “dog” when you give it a dog picture.

Recursive Neural Tensor Network (RNTN)



Recursive neural tensor networks (RNTNs) are neural nets useful for natural-language processing. They have a tree structure with a neural net at each node. You can use recursive neural tensor networks for boundary segmentation, to determine which word groups are positive and which are negative. The same applies to sentences as a whole.

- Convolutional Neural Network (CNN)
- Recurrent Neural Network (RNN)
- Deep Belief Network (DBN)
- Recursive Neural Tensor Network (RNTN)
- Restricted Boltzmann Machine (RBM)

Applications	
Text Processing	RNTN, RNN
Image Recognition	CNN, DBM
Object Recognition	CNN, RNTN
Speech Recognition	RNN
Time series Analysis	RNN
Unlabeled data – pattern recognition	RBM

Applications of Deep Learning

SUPERVISED AND UNSUPERVISED

Deep learning

Deep learning (DL) has the ability to work with unstructured data or very high dimensional data such as speech, sequences, images, videos with better results that other machine learning algorithms.

Going back to our MCQ test example, suppose that the questions and answers are only available verbally. We need the DL algorithm to be correctly identify the different parts of speed and apply natural language processing (NLP)

Deep Learning — both supervised and unsupervised applications

SUPERVISED APPLICATION	UNSUPERVISED APPLICATION
Image Recognition	Feature Learning
Speech Recognition	Autoencoders

Use cases for DL

Image classification/object recognition (convolutional networks)

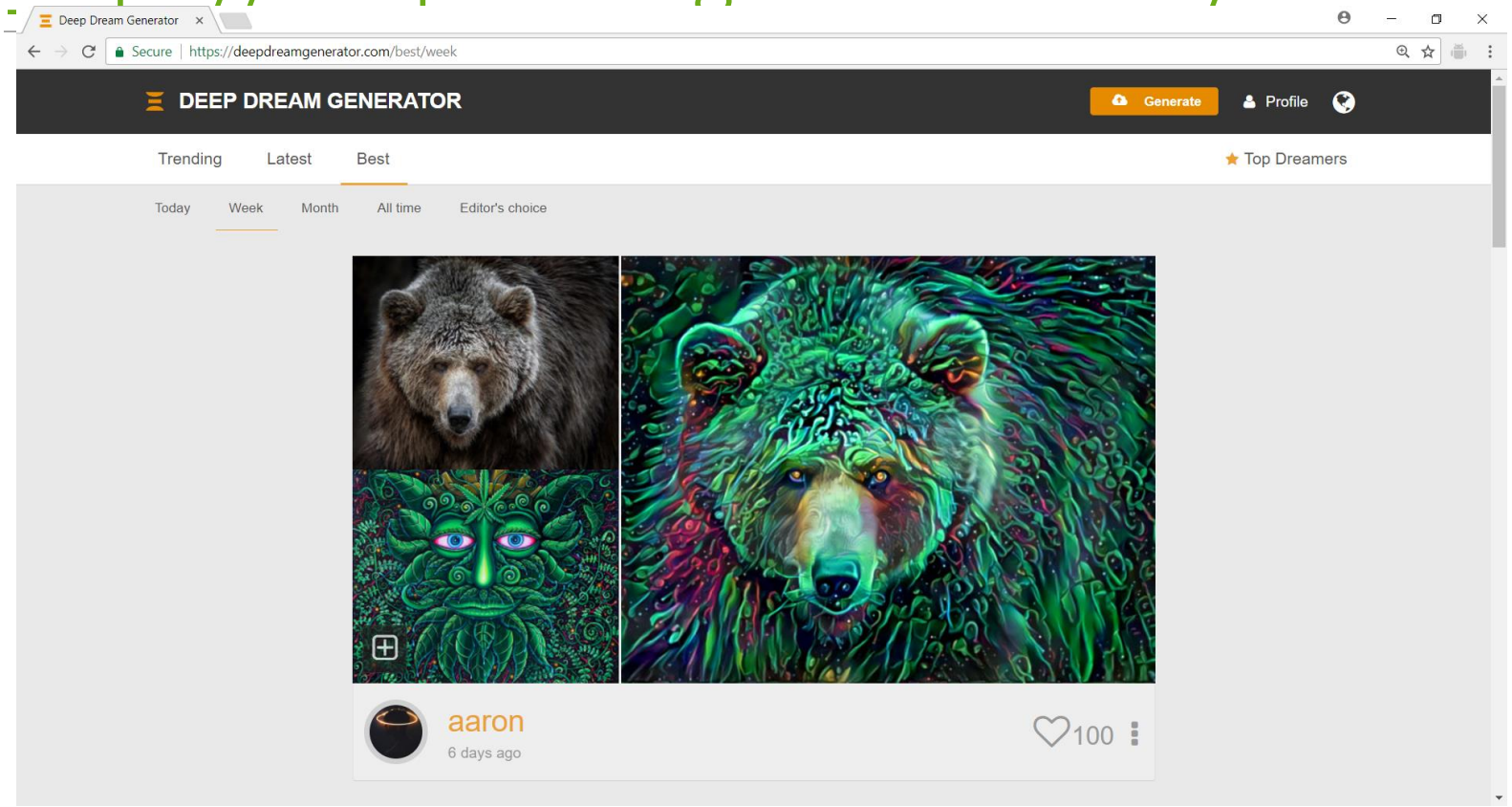
Processing sequential data (RNN/LSTM/GRU) such as language processing or forecasting

Complex decision making (deep reinforcement learning)

There are also a number of other applications that are common, such as image segmentation and super-resolution (fully convolutional networks) and similarity matching (Siamese networks).

Activity

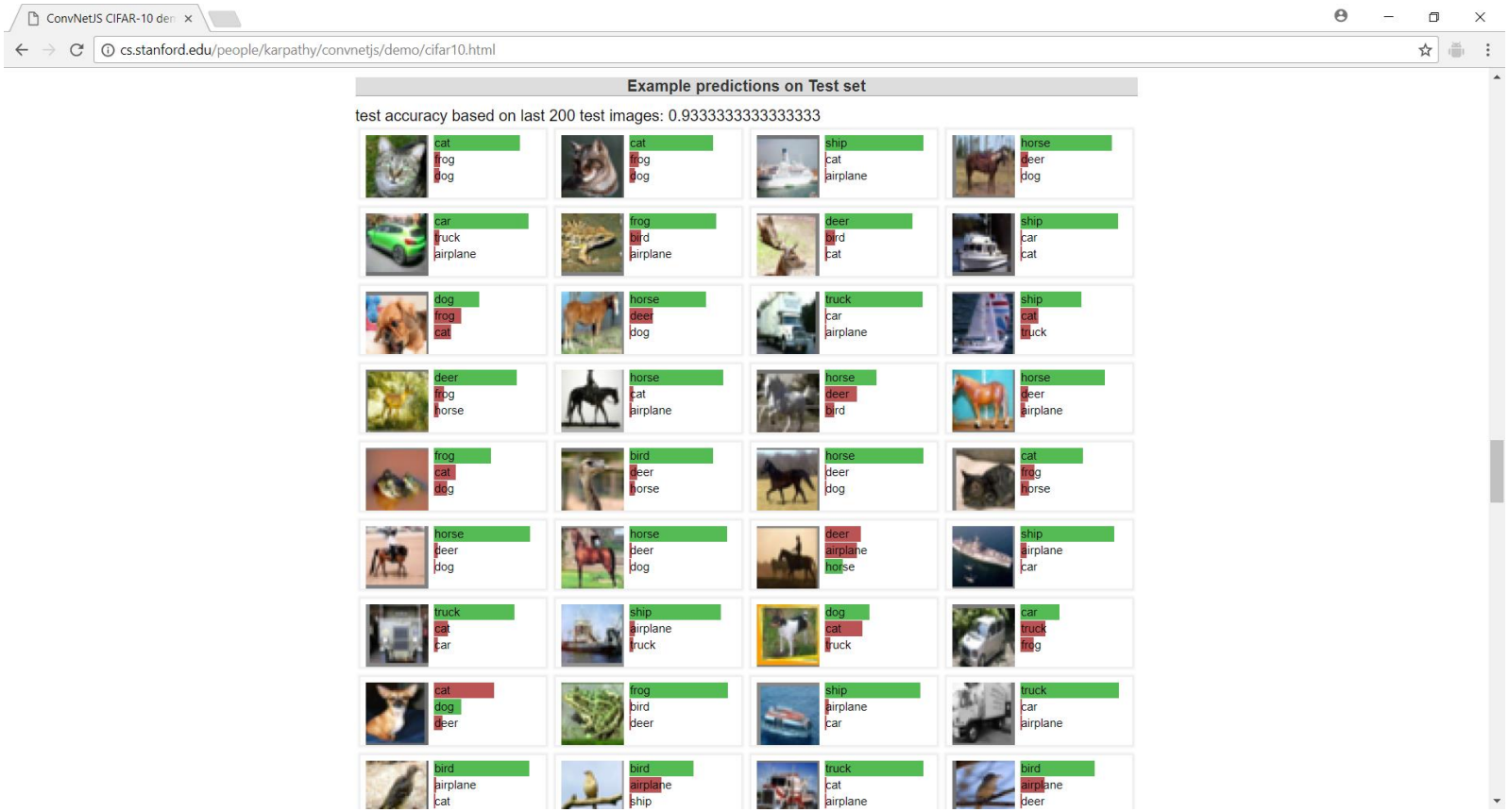
https://deepdreamgenerator.com/



source: https://research.googleblog.com/2015/06/inceptionism-going-deeper-into-neural.html
source: https://deepdreamgenerator.com/

Activity

http://cs.stanford.edu/people/karpathy/convnetjs/demo/cifar10.html



Summary

What we have learnt:

- Concepts behind Neural Networks
- Learning data representations
- Variety of Deep Learning Neural Network architectures
- Applications for Deep Learning