Tools and Algorithms

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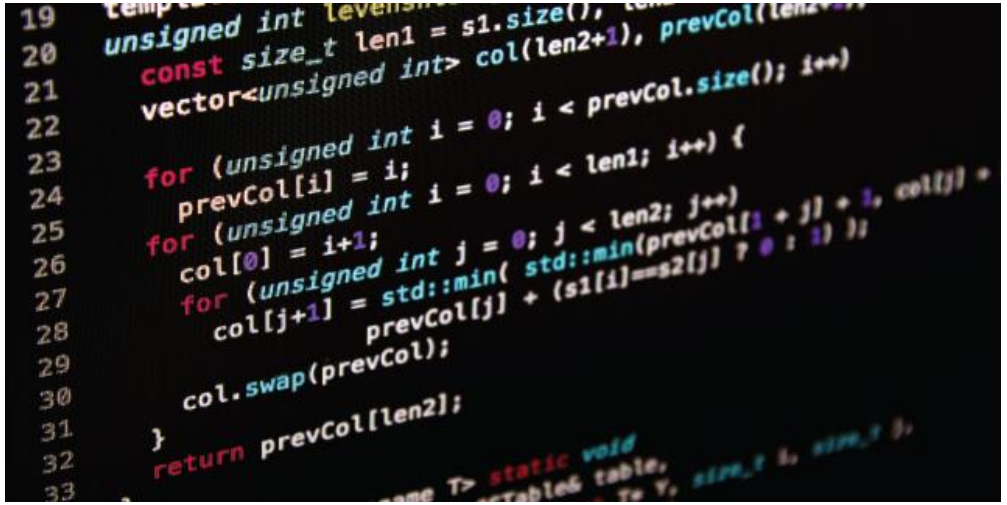
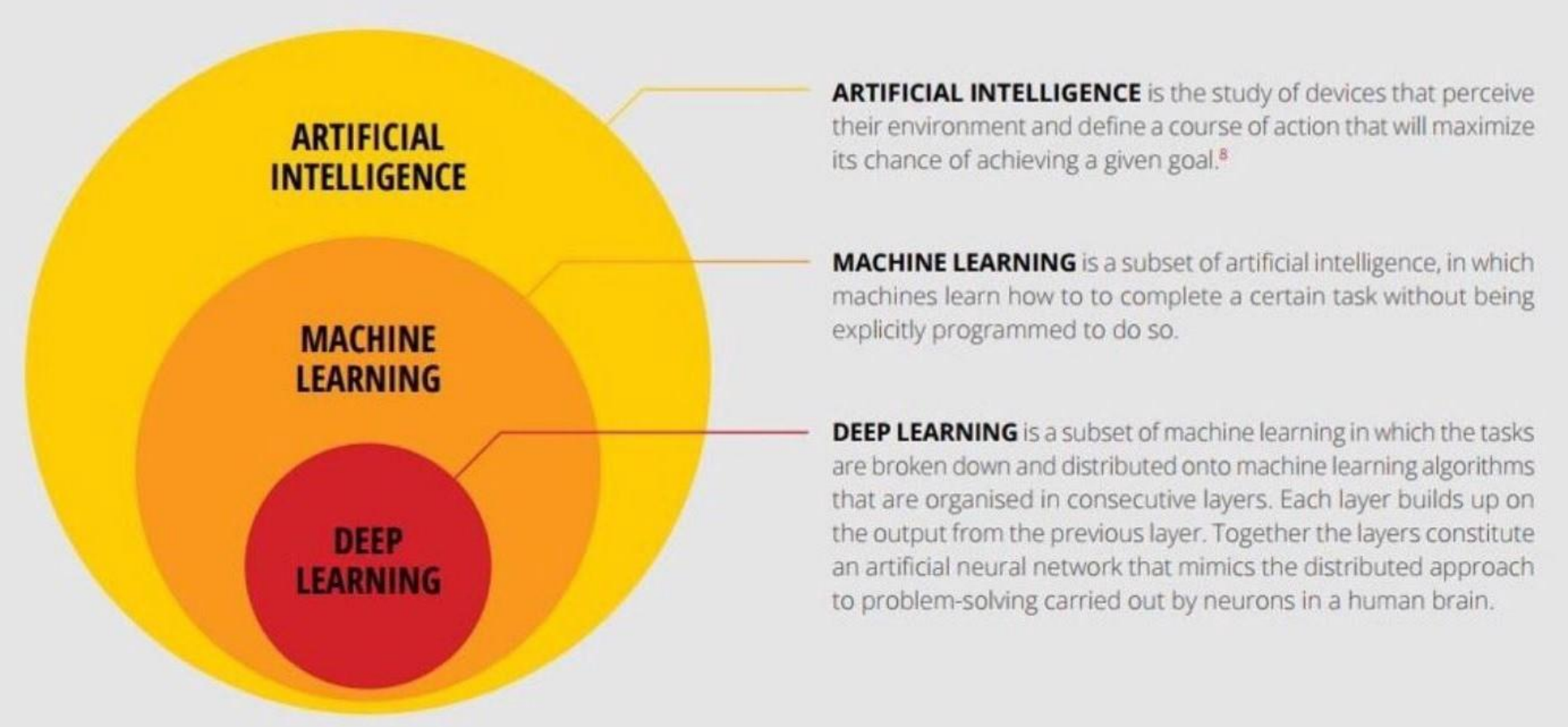
Tools and Algorithms

Developers cannot just ask, “What do I need to do to fix my algorithm?” They must rather ask: “How does my algorithm interact with society at large, and as it currently is, including its structural inequalities?” (Zimmerman, et.al., 2020)



Title Image: https://ethicstoolkit.ai/
https://www.pewresearch.org/internet/2017/02/08/code-dependent-pros-and-cons-of-the-algorithm-age/

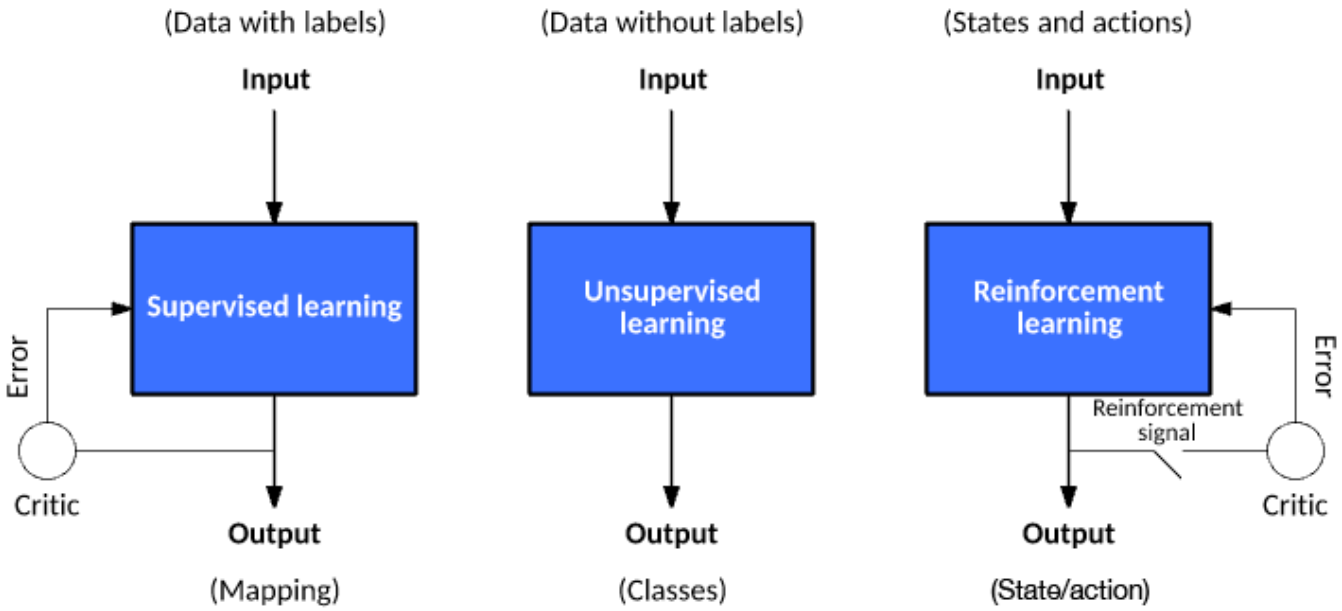
Artificial Intelligence



https://medium.com/intro-to-artificial-intelligence/deep-learning-series-1-intro-to-deep-learning-abb1780ee20

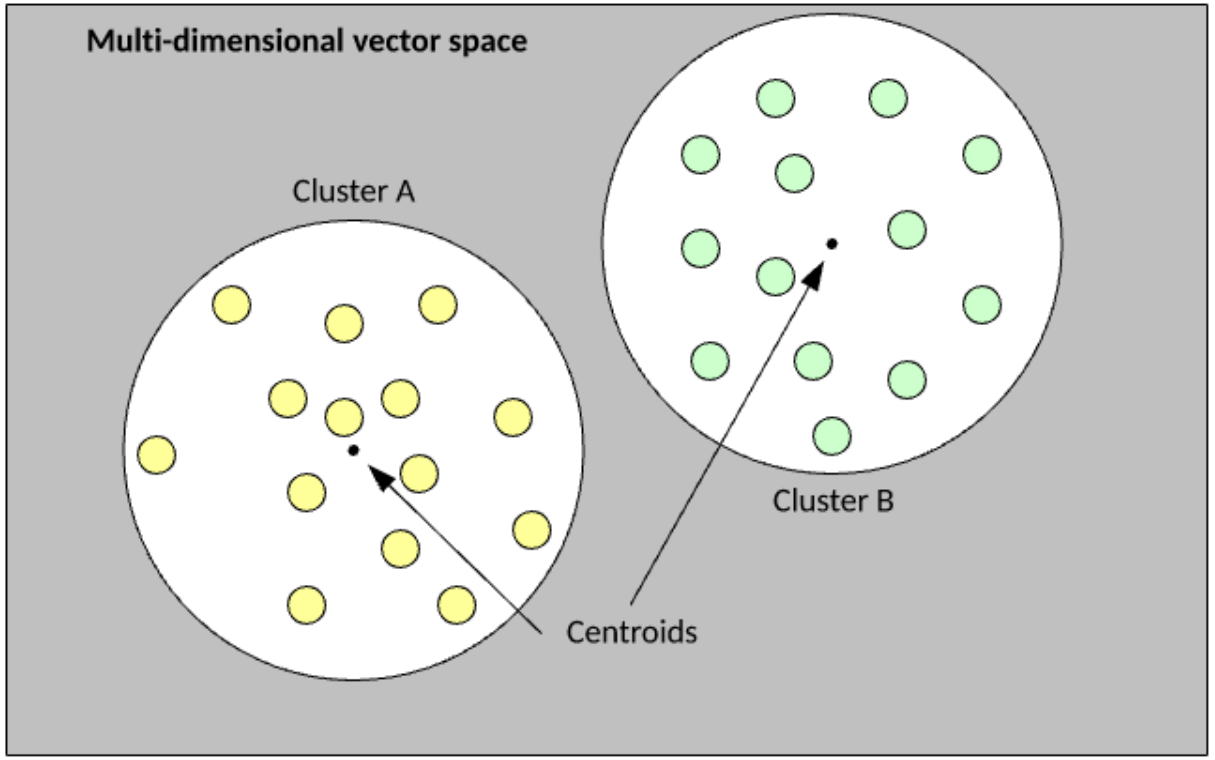
Types of Machine Learning

- Supervised
  - Uses labeled datasets to train algorithms
- Unsupervised
  - Discover hidden patterns in unlabeled data without human intervention
- Reinforcement
  - Applied within a context and uses environment states as input



https://www.ibm.com/cloud/learn/supervised-learning
https://www.ibm.com/cloud/learn/unsupervised-learning
https://developer.ibm.com/articles/cc-models-machine-learning/#reinforcement-learning

K-Means Clustering

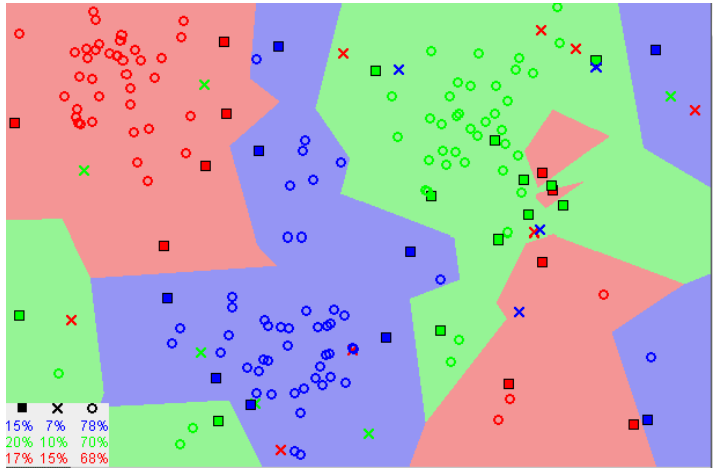


- This is an example of an unsupervised algorithm
- "The goal of the algorithm is to partition examples from a data set into *k* clusters. Each example is a numerical vector that allows the distance between vectors to be calculated as a Euclidean distance."

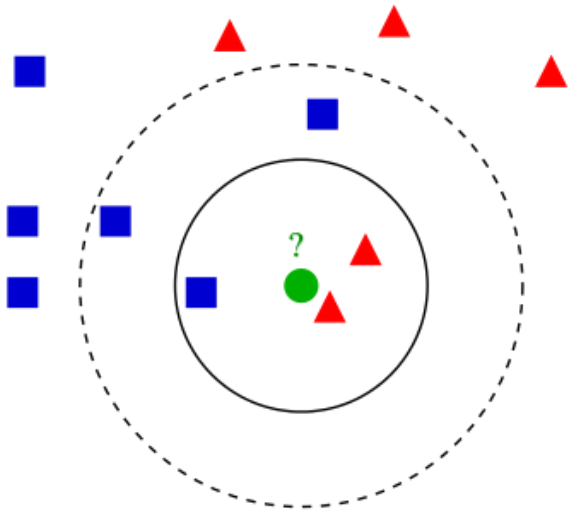
https://developer.ibm.com/articles/cc-models-machine-learning/#reinforcement-learning
https://towardsdatascience.com/understanding-k-means-clustering-in-machine-learning-6a6e67336aa1

K-Nearest Neighbors

Clusters data into groups based on similarity or proximity

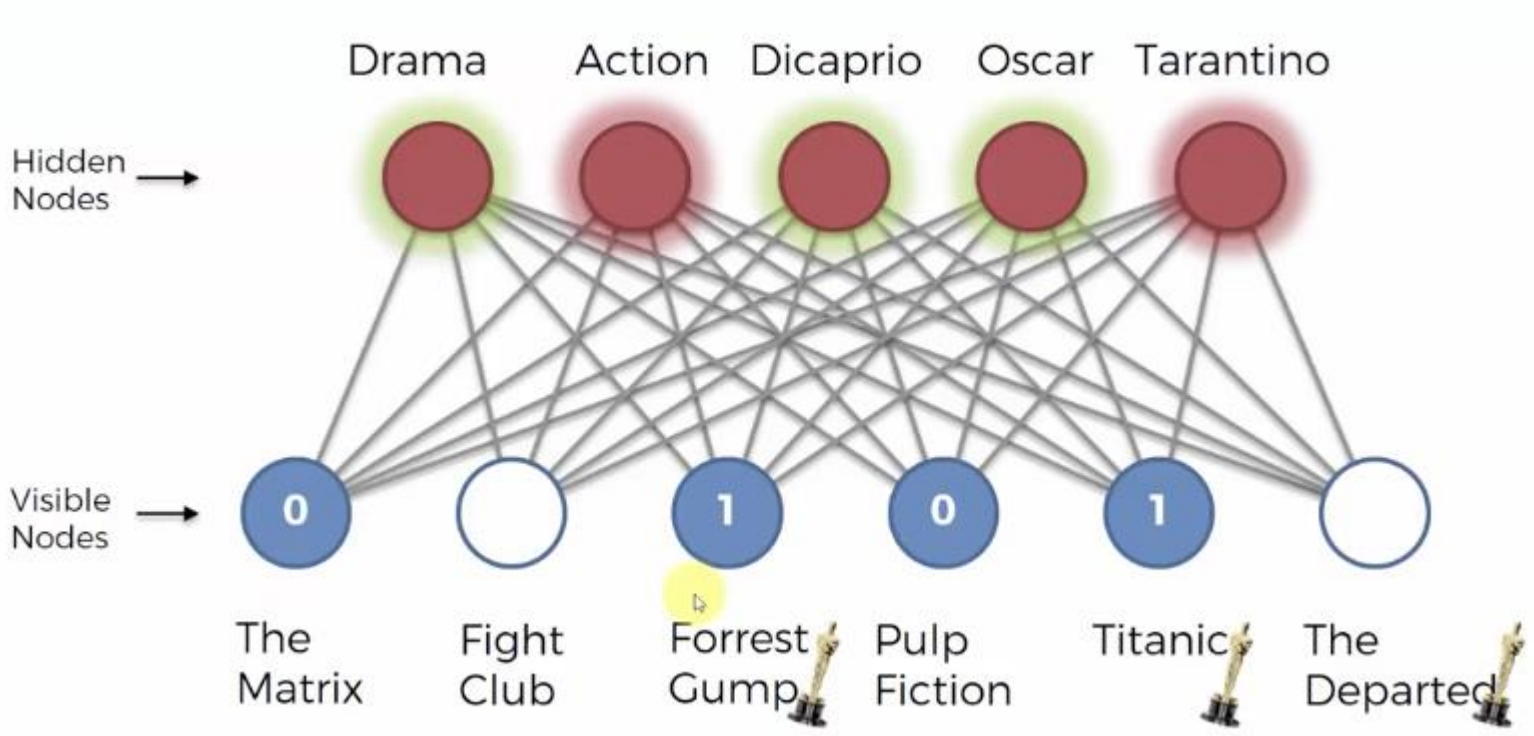


https://www.codecademy.com/learn/introduction-to-supervised-learning-skill-path/modules/k-nearest-neighbors-skill-path/cheatsheet
https://en.wikipedia.org/wiki/K-nearest_neighbors_algorithm



Example of *k*-NN classification. The test sample (green dot) should be classified either to blue squares or to red triangles. If *k = 3* (solid line circle) it is assigned to the red triangles because there are 2 triangles and only 1 square inside the inner circle. If *k = 5* (dashed line circle) it is assigned to the blue squares (3 squares vs. 2 triangles inside the outer circle).

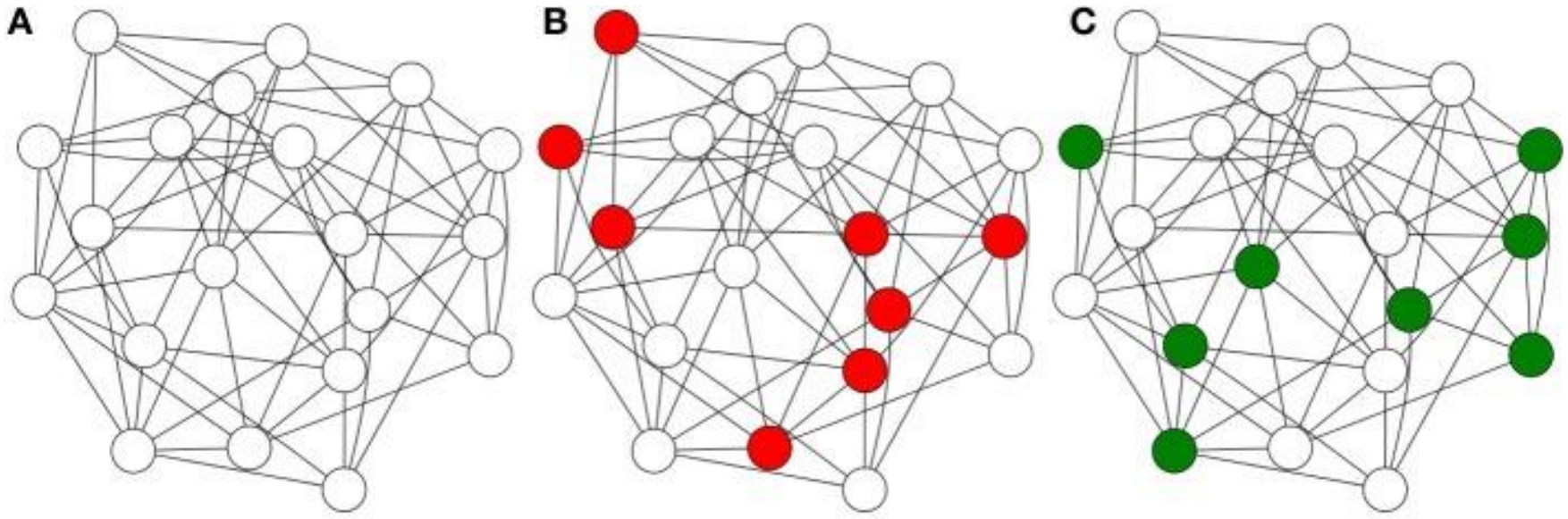
Learning Algorithms



A learning algorithm is a method or system used to update the weights between connections

Image: https://demyank.tistory.com/351

Hebbian Learning

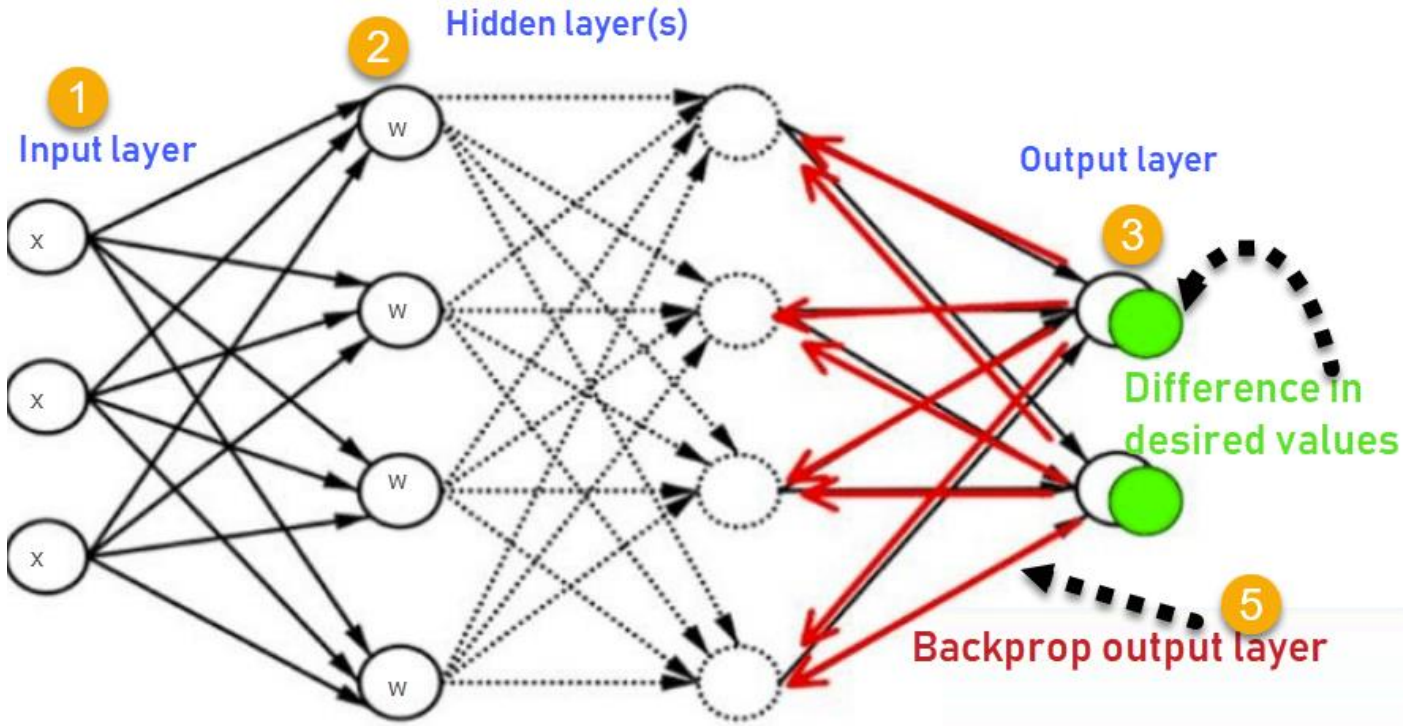


Often summarized as "Cells that fire together wire together."

https://en.wikipedia.org/wiki/Hebbian_theory
Image:https://www.researchgate.net/publication/262150025_Sparse_Distributed_Memory_understanding_the_speed_and_robustness_of_expert_memory

Backpropagation

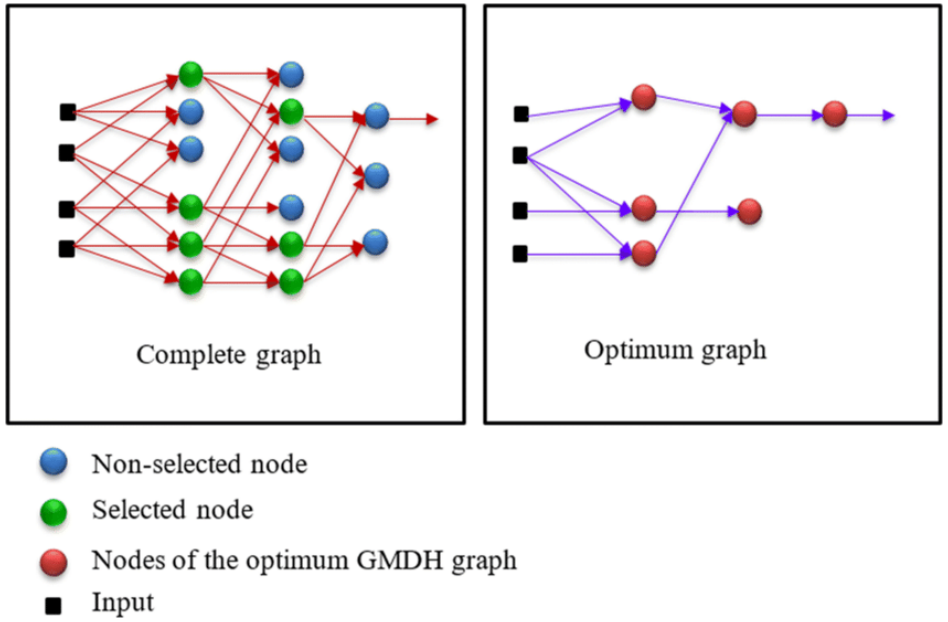
- Described previously (https://ethics.mooc.ca/presentation/59)
- Errors are measured and correction sent back through the network



https://www.guru99.com/backpropogation-neural-network.html

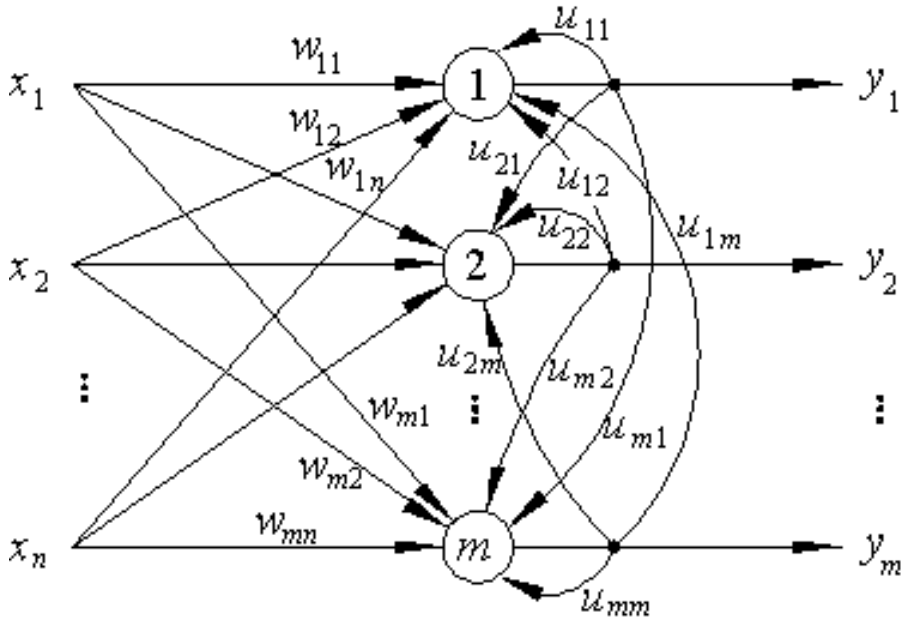
Group Method of Data Handling (GMDH)

"The algorithm develops neurons for all possible combinations of two inputs to the layer. It then continues to choose only those neurons that supply the best possible MSE."



https://en.wikipedia.org/wiki/Group_method_of_data_handling
http://www.gmdh.net/
https://www.researchgate.net/publication/315684693_Neural_Network_Training_Using_a_GMDH_Type_Algorithm

Competitive Learning

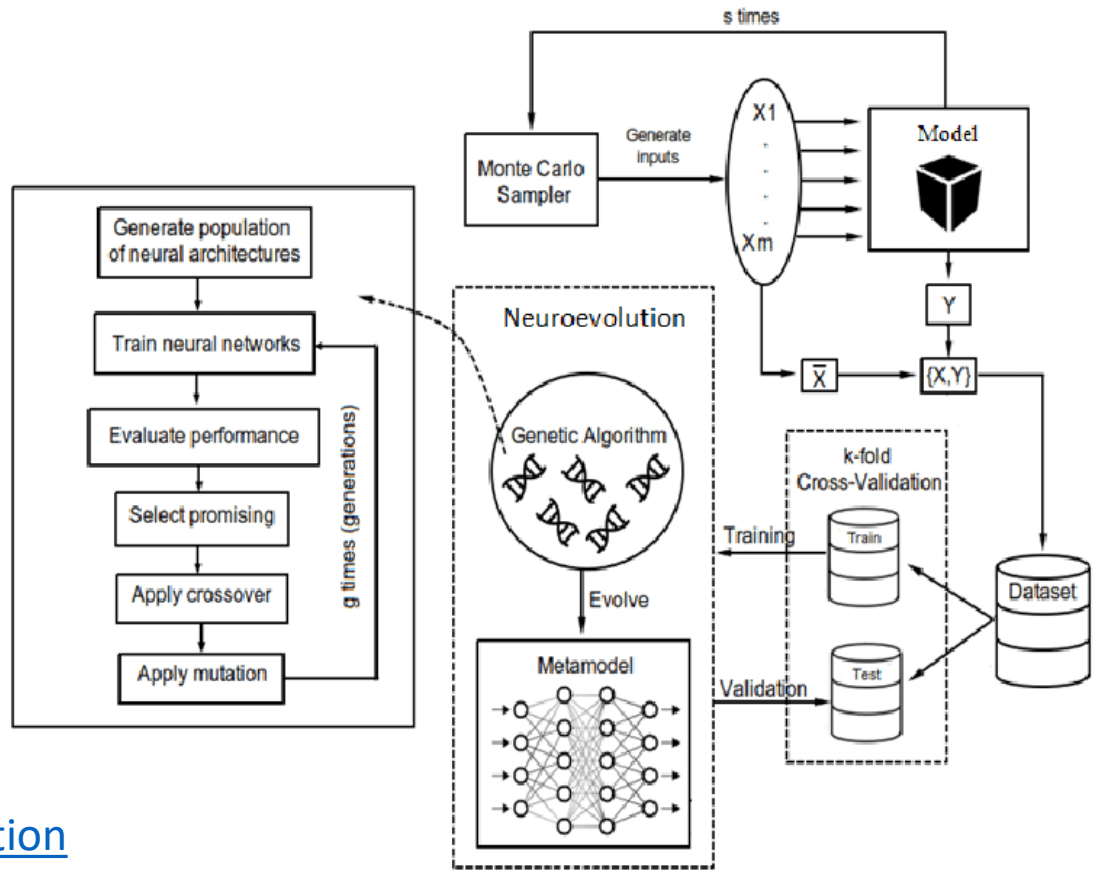


"Nodes compete for the right to respond to a subset of the input data. The individual neurons of the network learn to specialize on ensembles of similar patterns and in so doing become 'feature detectors' for different classes of input patterns."

https://neuron.eng.wayne.edu/tarek/MITbook/chap3/3_4.html
https://archive.org/details/parallel distribu00rume/page/151/mode/2up
https://en.wikipedia.org/wiki/Competitive_learning

Neuroevolution

Evolutionary algorithms generate neural networks, parameters, topology and rules.



https://www.researchgate.net/publication/349150012_Neuroevolutionary_Approach_to_Metamodel-Based_Optimization_in_Production_and_Logistics

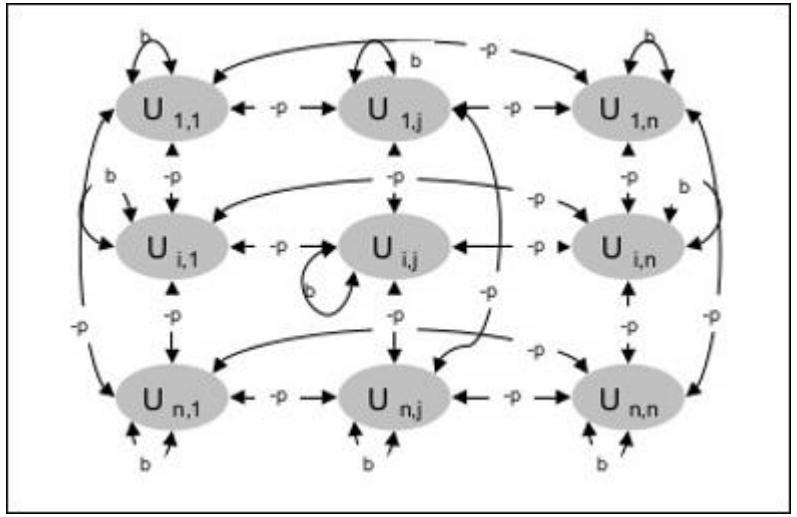
https://en.wikipedia.org/wiki/Neuroevolution

https://www.nature.com/articles/s42256-018-0006-z

https://towardsdatascience.com/a-primer-on-the-fundamental-concepts-of-neuroevolution-9068f532f7f7

Vid: https://www.youtube.com/watch?v=lu5ul7z4icQ

Restricted Boltzmann Machine



“While RBMs are occasionally used, most practitioners in the machine-learning community have deprecated them in favor of generative adversarial networks or variational autoencoders. RBMs are the Model T’s of neural networks – interesting for historical reasons, but surpassed by more up-to-date models.”

https://wiki.pathmind.com/restricted-boltzmann-machine
https://www.tutorialspoint.com/artificial_neural_network/artificial_neural_network_boltzmann_machine.htm

Network Topology

- Physical topology is the placement of network components
- Logical topology shows how data flows within a network

https://en.wikipedia.org/wiki/Network_topology

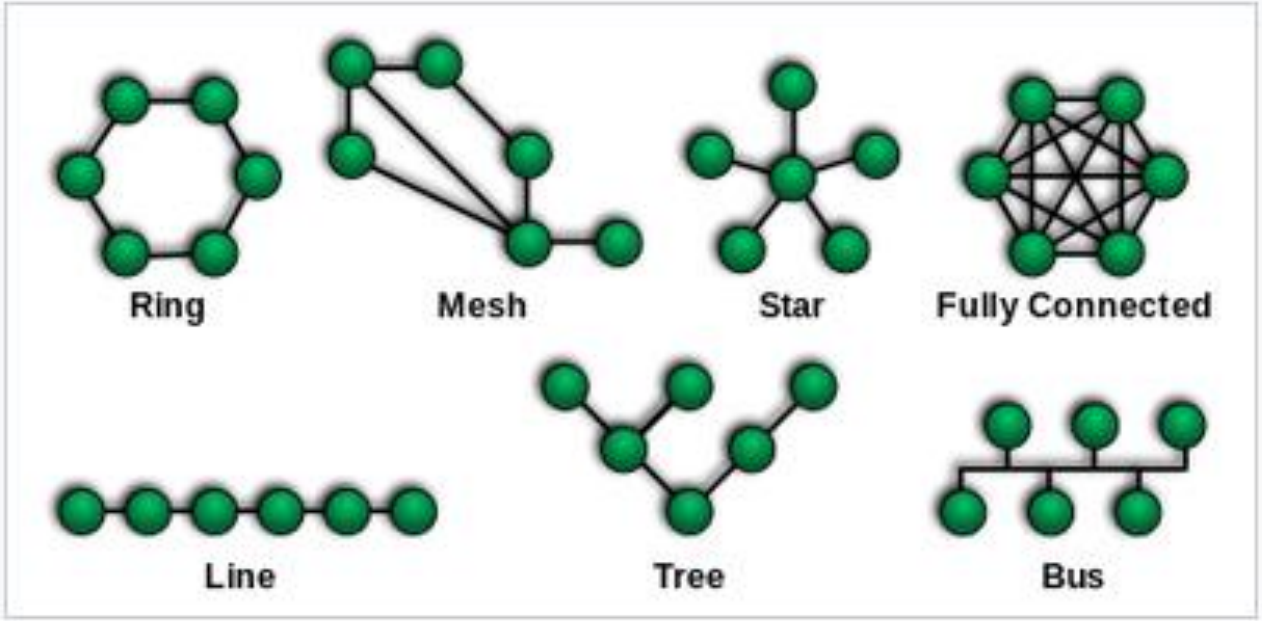
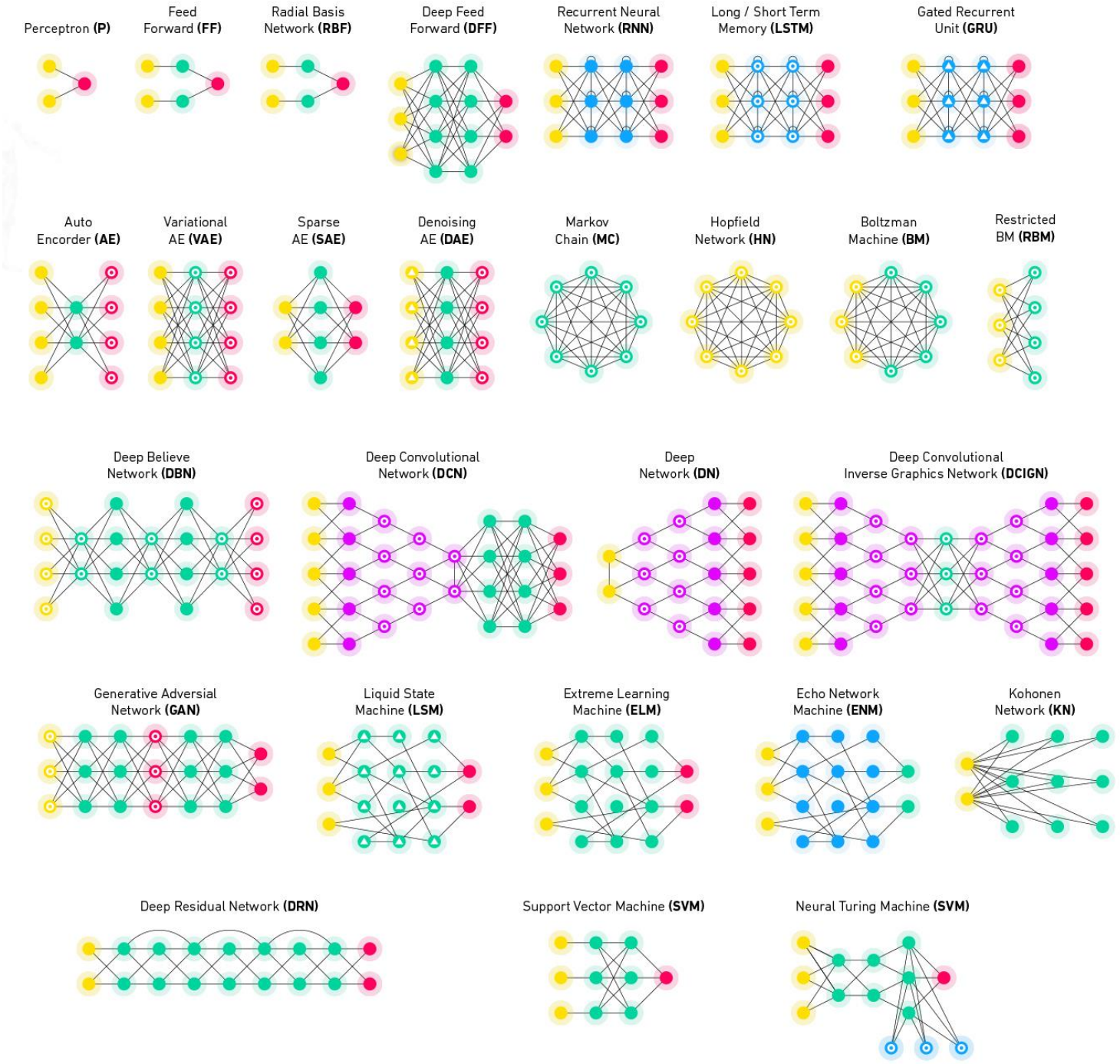


Diagram of different network topologies.

Topologies

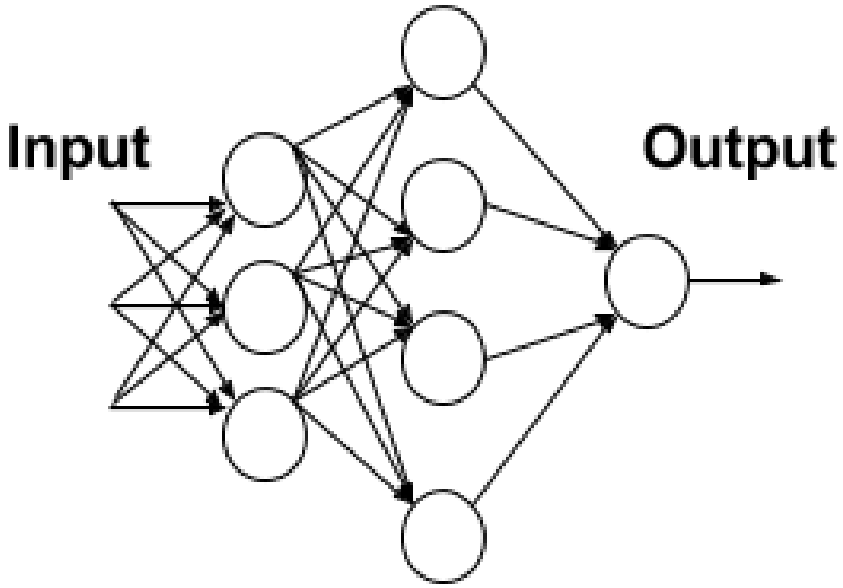
There is a rich array of machine learning and AI designs. We'll look at only a few classic ones in this presentation.



https://docs.paperspace.com/machine-learning/wiki/machine-learning-models-explained

Feedforward Neural Networks

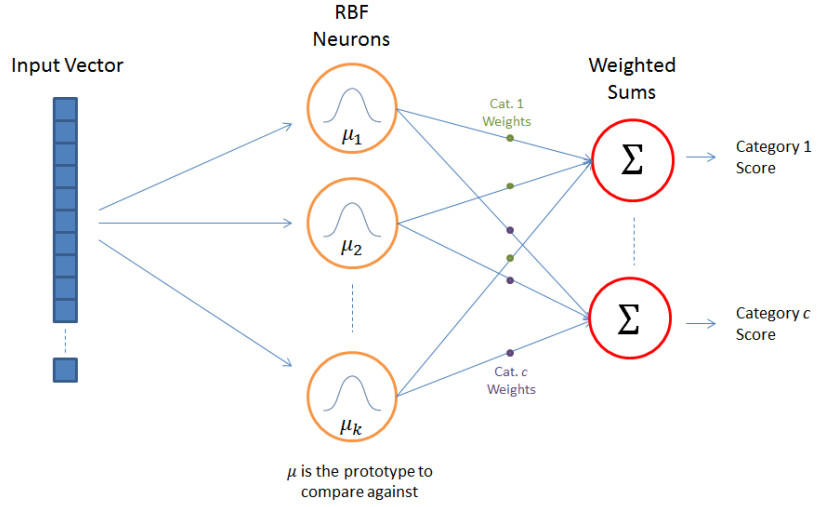
- Example: the perceptron and multi-layer perceptron
- Data flows from input to output (ie., it feeds forward)

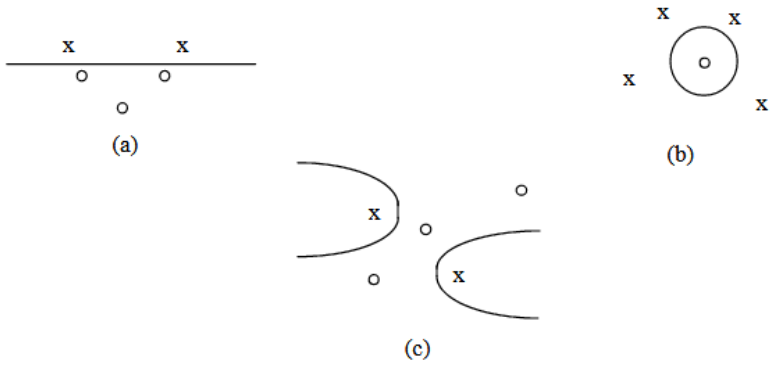


https://en.wikipedia.org/wiki/Feedforward_neural_network
https://towardsdatascience.com/deep-learning-feedforward-neural-network-26a6705dbdc7

Radial Basis Networks

- Radial Basis Function network was formulated by Broomhead and Lowe in 1988.
- These are non-linear classifiers (ie., they draw circles in data).





https://vtechworks.lib.vt.edu/bitstream/handle/10919/36847/Ch3.pdf?sequence=5

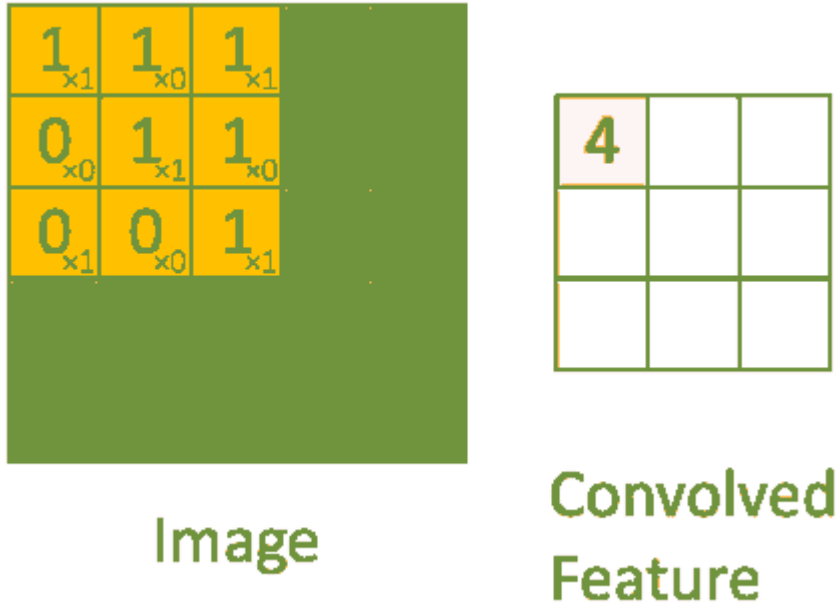
https://www.cc.gatech.edu/~isbell/tutorials/rbf-intro.pdf

Convolutional Neural Network

A CNN samples different parts of the input data using a filter. These filters can be thought of as feature detectors.

The convolution layer is usually followed with a pooling layer, which reduces the overall size of the matrix. It is then fed into (e.g.) a perceptron.

https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53



Convoluting a 5x5x1 image with a 3x3x1 kernel to get a 3x3x1 convolved feature

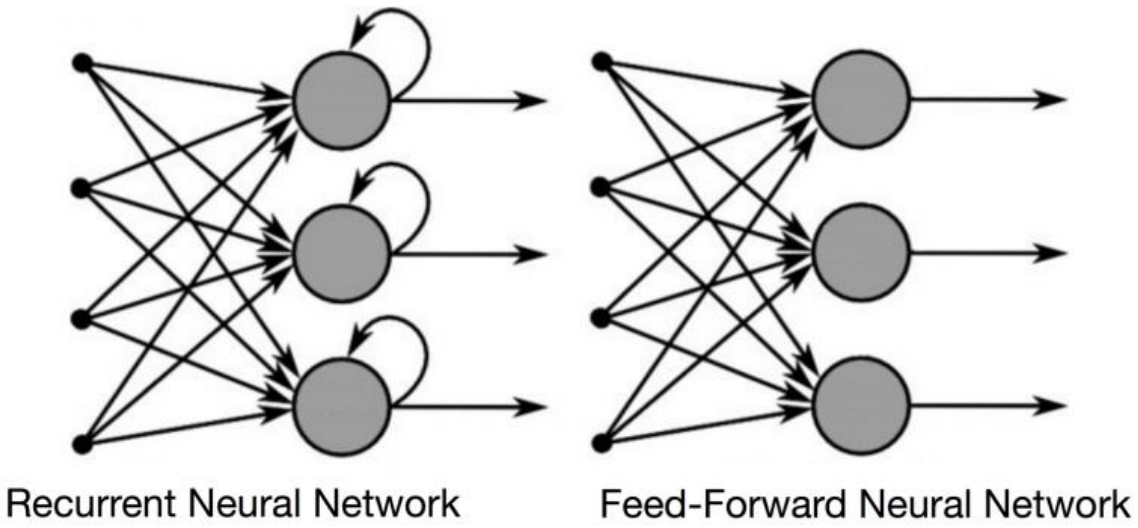
```
Kernel/Filter, K =

1   0   1
0   1   0
1   0   1
```

Recurrent Neural Networks

In RNNs the output from one neuron becomes the input for other neurons.

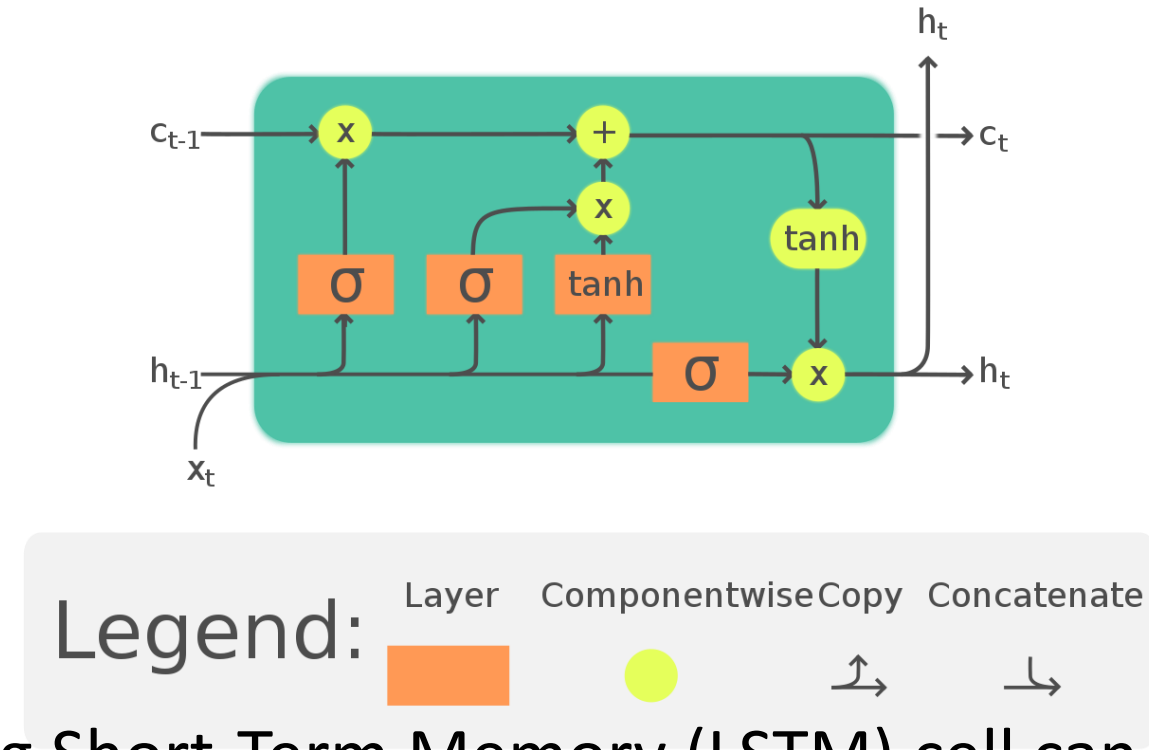
Fully recurrent neural networks (FRNN) connect all neurons to each other.

In simple recurrent networks (SRN) context units feed back into other units in a 3-layer network.



https://en.wikipedia.org/wiki/Recurrent_neural_network
https://builtin.com/data-science/recurrent-neural-networks-and-lstm

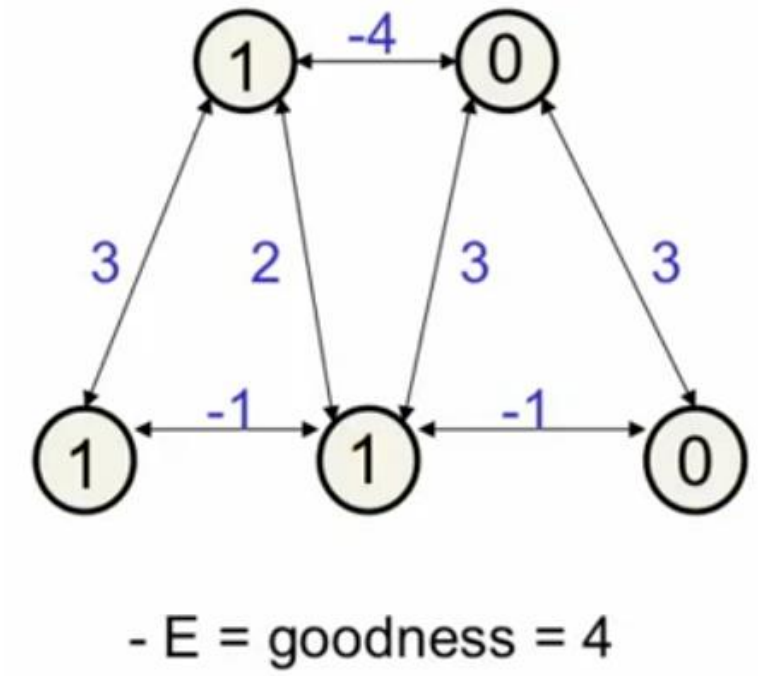
Long short-term memory (LSTM)



"The Long Short-Term Memory (LSTM) cell can process data sequentially and keep its hidden state through time… LSTM is applicable to tasks such as unsegmented, connected handwriting recognition, speech recognition and anomaly detection"

https://en.wikipedia.org/wiki/Long_short-term_memory

Hopfield Networks

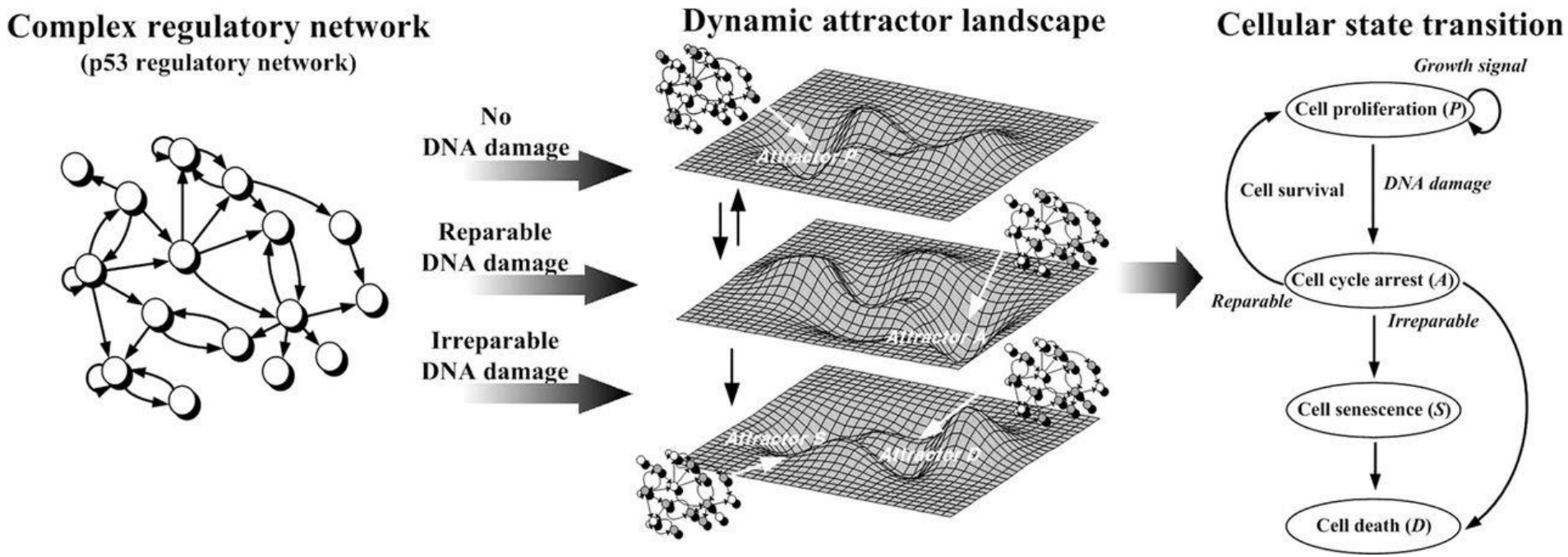


Hopfield (1982): memories could be energy minima of a neural net. “The purpose of a Hopfield net is to store 1 or more patterns and to recall the full patterns based on partial input.”

https://towardsdatascience.com/hopfield-networks-are-useless-heres-why-you-should-learn-them-f0930ebeadcd
Vid: https://www.youtube.com/watch?v=DS6k0PhBjpI

Attractor Networks

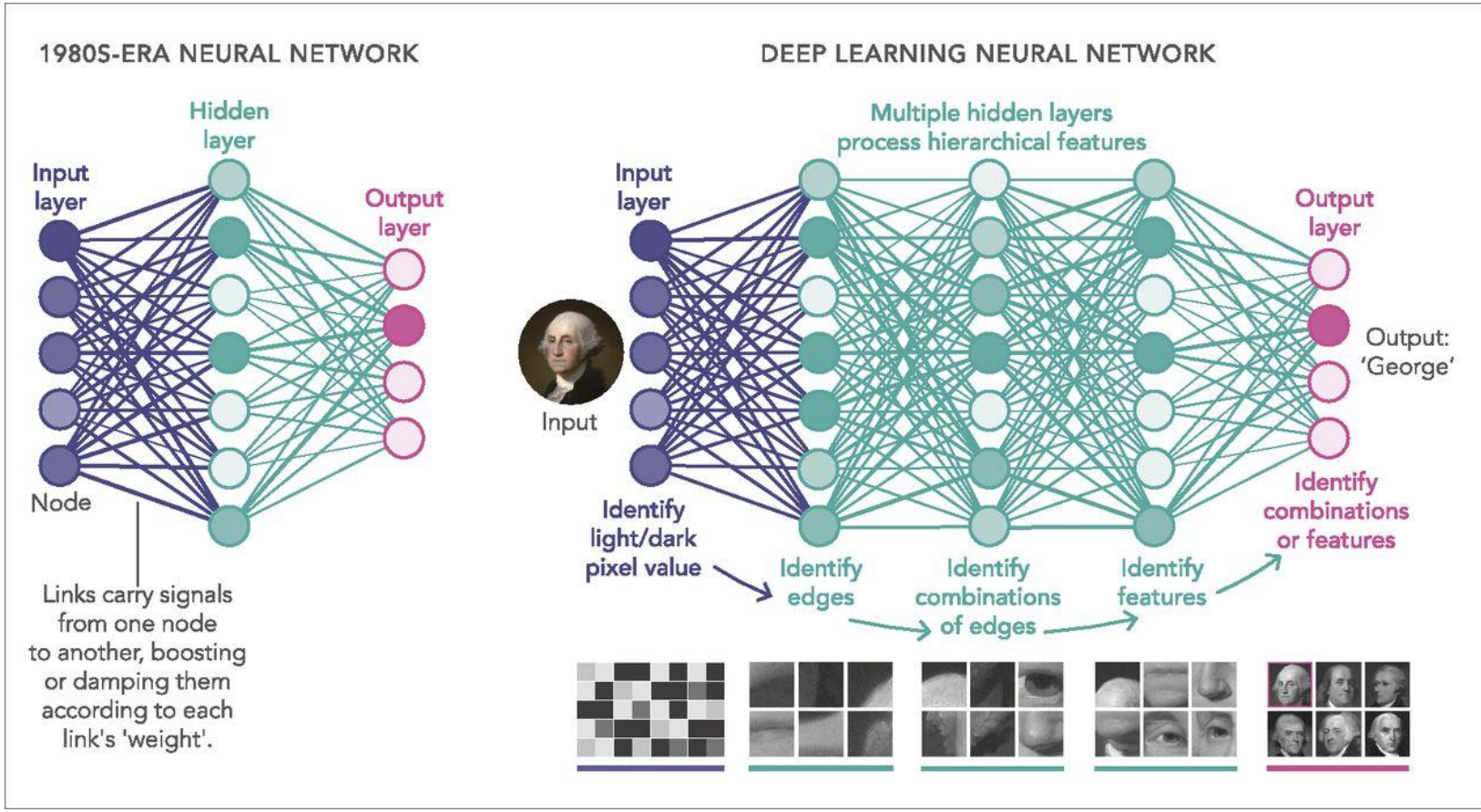
"An attractor network is a type of recurrent dynamical network that evolves toward a stable pattern over time"



https://en.wikipedia.org/wiki/Attractor_network
http://www.scholarpedia.org/article/Attractor_network

Deep Learning

Deep learning is a term used to describe neural networks with multiple hidden layers (hence, ‘deep’)



https://en.wikipedia.org/wiki/Deep_learning https://www.pnas.org/content/116/4/1074

Frameworks

- Scikit Learn
- TensorFlow
- Theano
- Caffe
- MxNet
- Keras
- PyTorch
- CNTK
- Auto ML
- OpenNN
- Google ML Kit