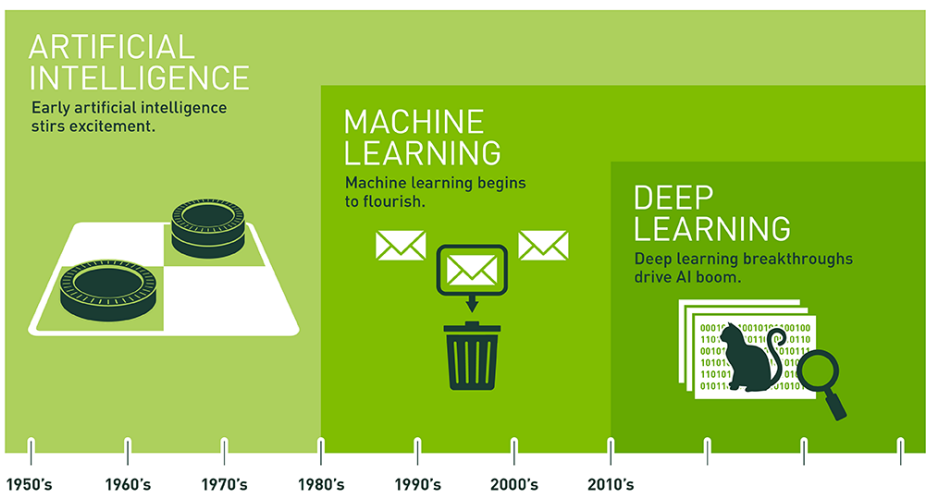
Introduction to Deep Learning

- Overview of Artificial Intelligence
- Learning Types
- Structure of a Neural Network
- Applications

What is AI, ML and DL

- Artificial Intelligence – AI
- Machine Learning – ML
- Deep Learning-DL



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.

- **Artificial intelligence** is a science like mathematics or biology. It studies ways to build intelligent programs and machines that can creatively solve problems, which has always been considered a human superiority.
- **Machine learning** is a subset of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. In ML, there are different algorithms (e.g. neural networks) that help to solve problems.
- **Deep learning**, is a subset of machine learning, which uses the neural networks to analyze different factors with a structure that is similar to the human neural system.

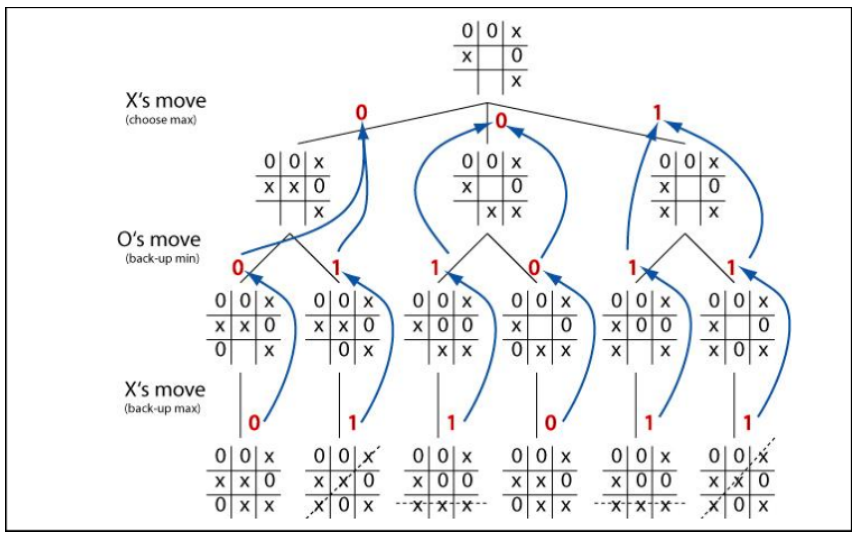
Sources:
https://serokell.io/blog/ai-ml-dl-difference
https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

Artificial Intelligence - AI

- AI provides optimal or suboptimal solution to a given problem.
- Any system of computing capable (in part or in whole) of simulating the decision-making capability of a human being.
- Agents that fall under AI but not Machine Learning are generally agents that solely utilize decision trees for logic, or agents built with rules and instructions.
- A simple AI example can be seen in the structure of Tic-Tac-Toe AI player.
- If a bot follows the following preprogrammed algorithm, it will never lose a game
- An algorithm like this doesn't possess the cognitive, learning, or problem solving abilities that most people associate an "AI" with.

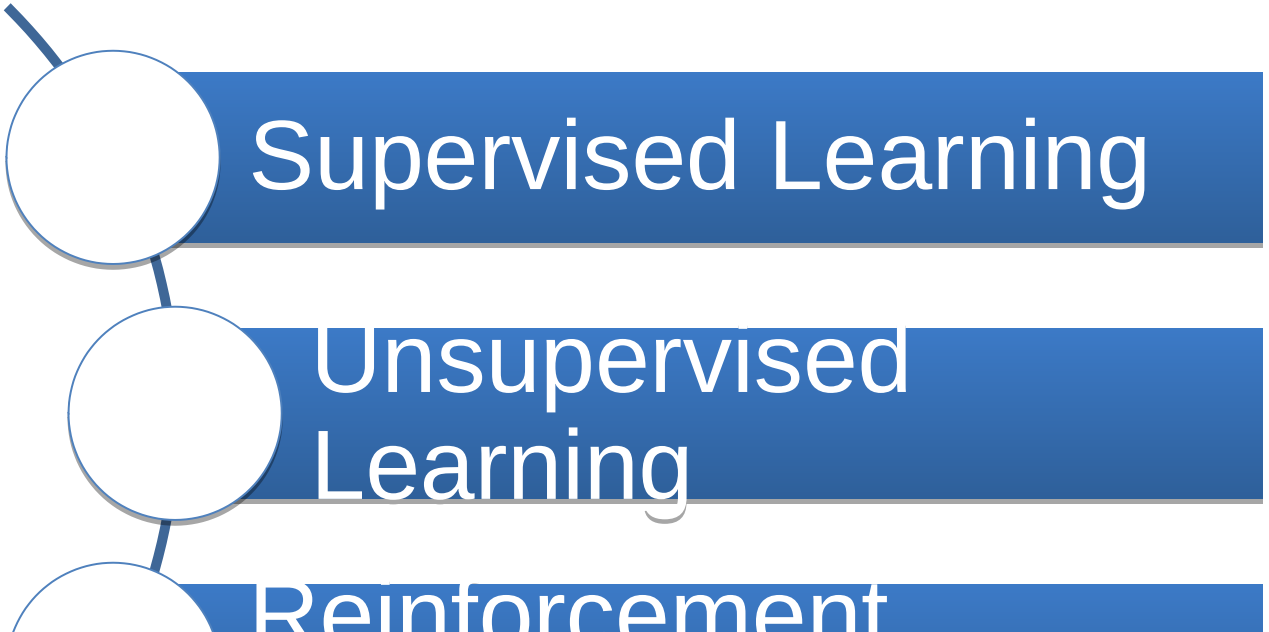
> *1. If someone has a "threat" (that is, two in a row), take the remaining square.*
>
> *2. If a move "forks" to create two threats at once, play that move. Otherwise,*
>
> *3. Take the center square if it is free. Otherwise,*
>
> *4. if your opponent has played in a corner, take the opposite corner. Otherwise,*
>
> *5. take an empty corner if one exists. Otherwise,*
>
> *6. take any empty square.*

Some Possible moves in Tic-Tac-Toe game



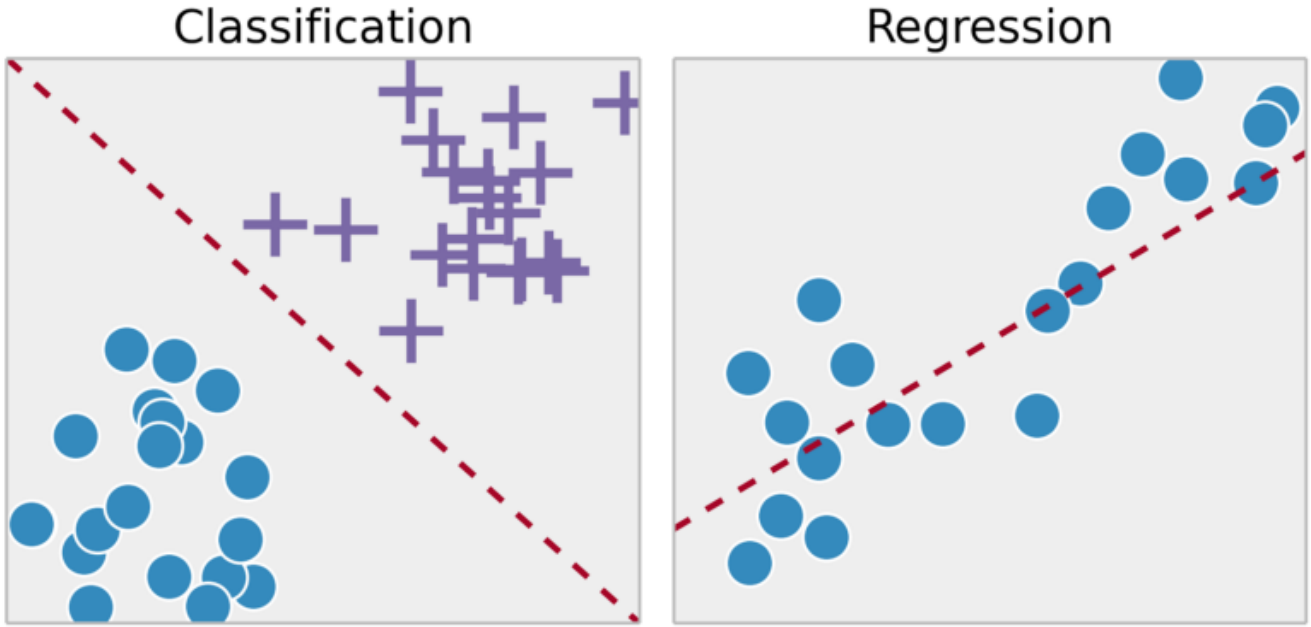
Machine Learning -ML

- Machine learning gives computers the ability to learn without being explicitly programmed (Arthur Samuel, 1959)
- Machine learning explores the study and construction of algorithms which can learn and make predictions on data
- Machine learning is done where designing and programming explicit algorithms cannot be done. They build a model from sample inputs.
- Examples include spam filtering, detection of network intruders or malicious insiders working towards a data breach, optical character recognition (OCR), search engines and computer vision



Machine Learning -ML

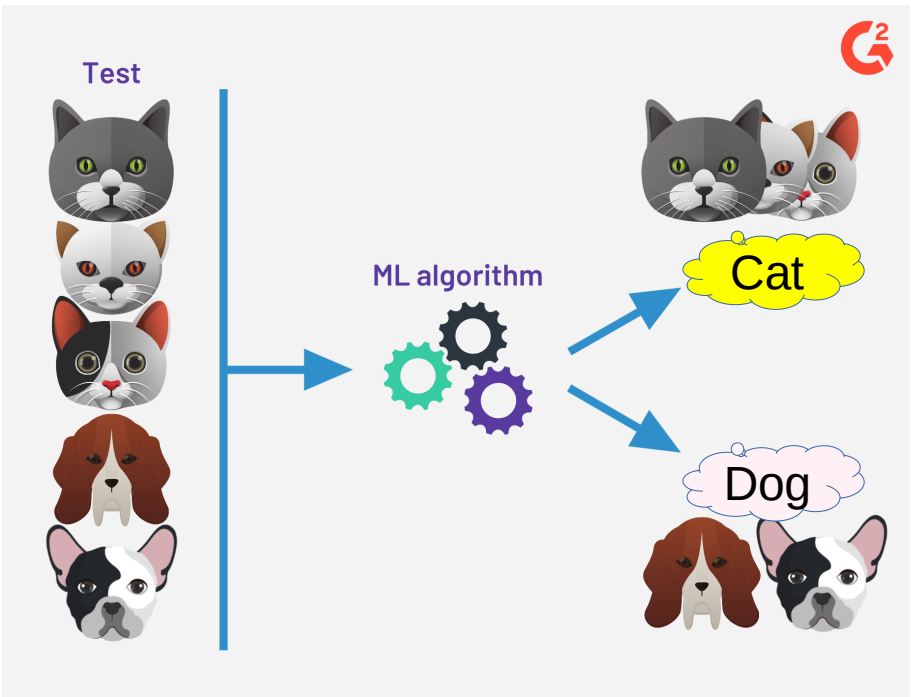
- **Supervised Learning**
- The model is trained using data sets in which outputs are defined for each sample in the dataset.
- Thus, the model is provided to obtain a correct output for similar inputs that are not used in training.



Source: https://towardsdatascience.com/machine-learning-types-and-algorithms-d8b79545a6ec

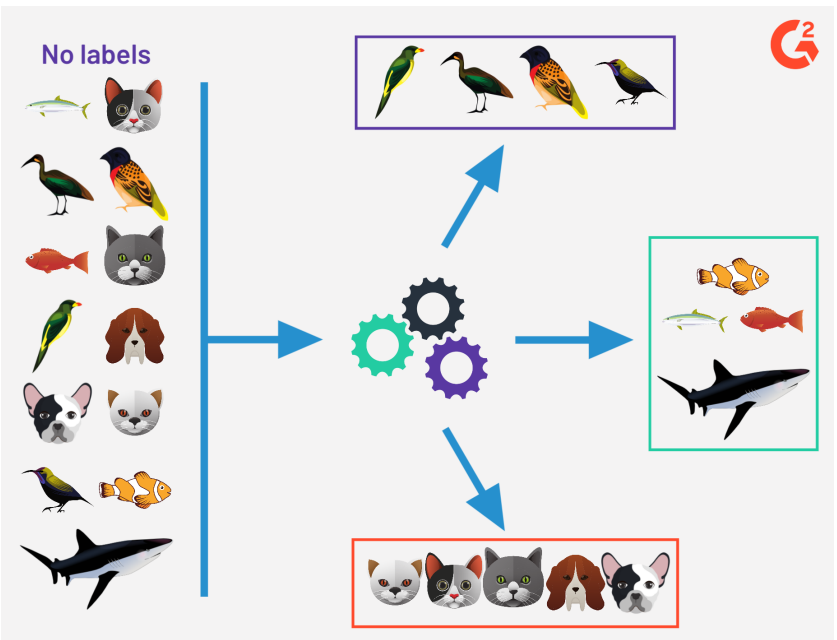
Machine Learning -ML

- **Supervised Learning**



Machine Learning -ML

- **Unsupervised Learning**
- It works by finding similarities in the data set.
- There are no data labels nor training data for context.
- Requires a learning algorithm to find naturally occurring patterns in the data.

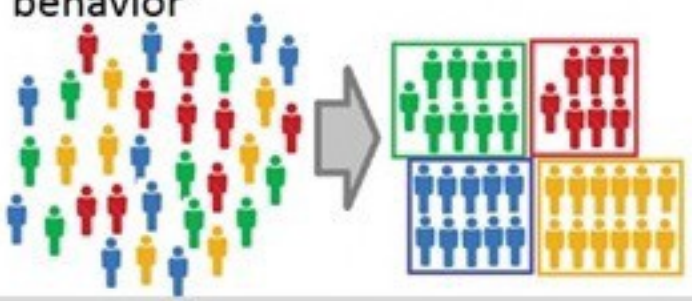


Machine Learning -ML

Unsupervised Learning

Clustering

Grouping customers by purchasing behavior



Association

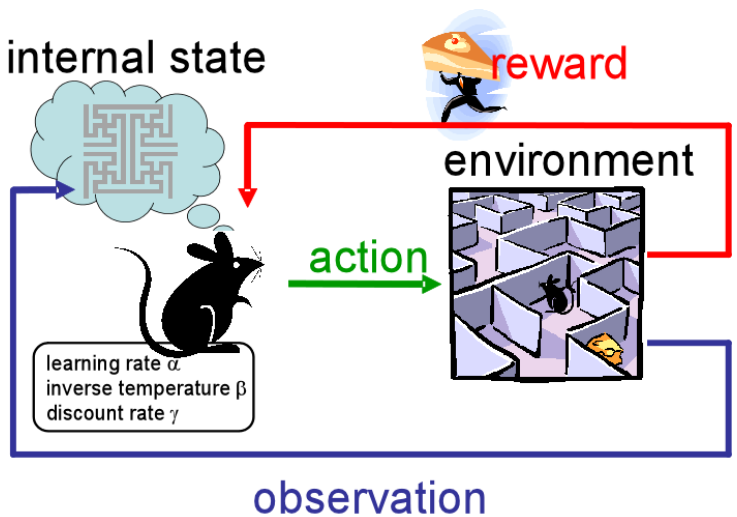
People that buy X tend to buy Y

People that buy A+B tend to buy C

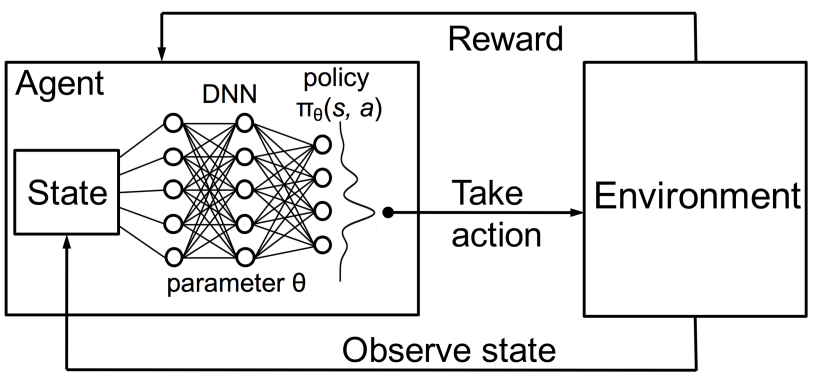
Clustering usually used to group similarities | | Association is generally used to find rules and patterns

Machine Learning -ML

- **Reinforcement Learning:**
- It is about taking appropriate action to maximize reward in a given situation.
- **There is no data set for learning** and the agent learns through **trial and error**.



Kay:https://becominghuman.ai/the-very-basics-of-reinforcement-learning-154f28a79071

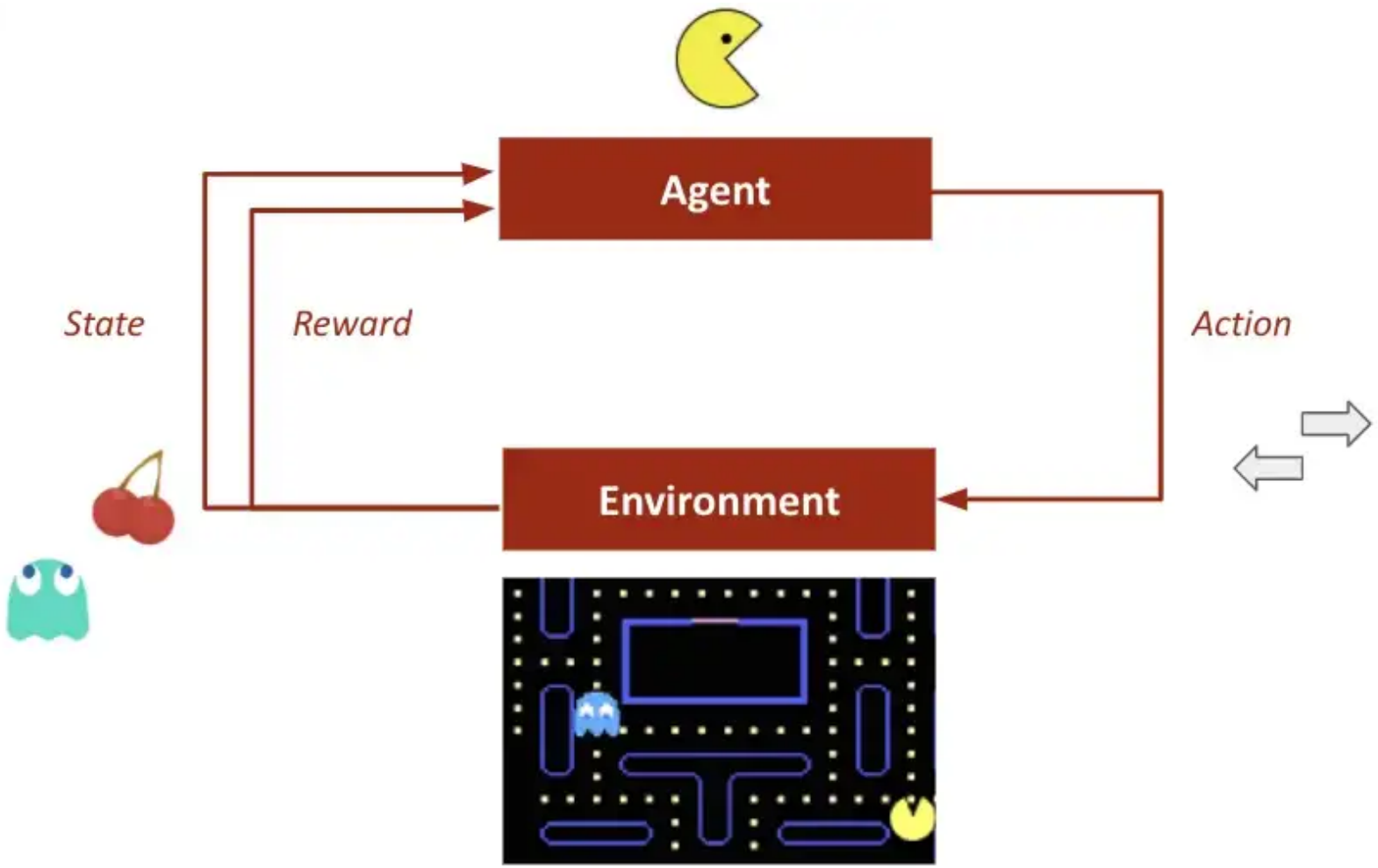


https://dl.acm.org/doi/abs/10.1145/3005745.3005750

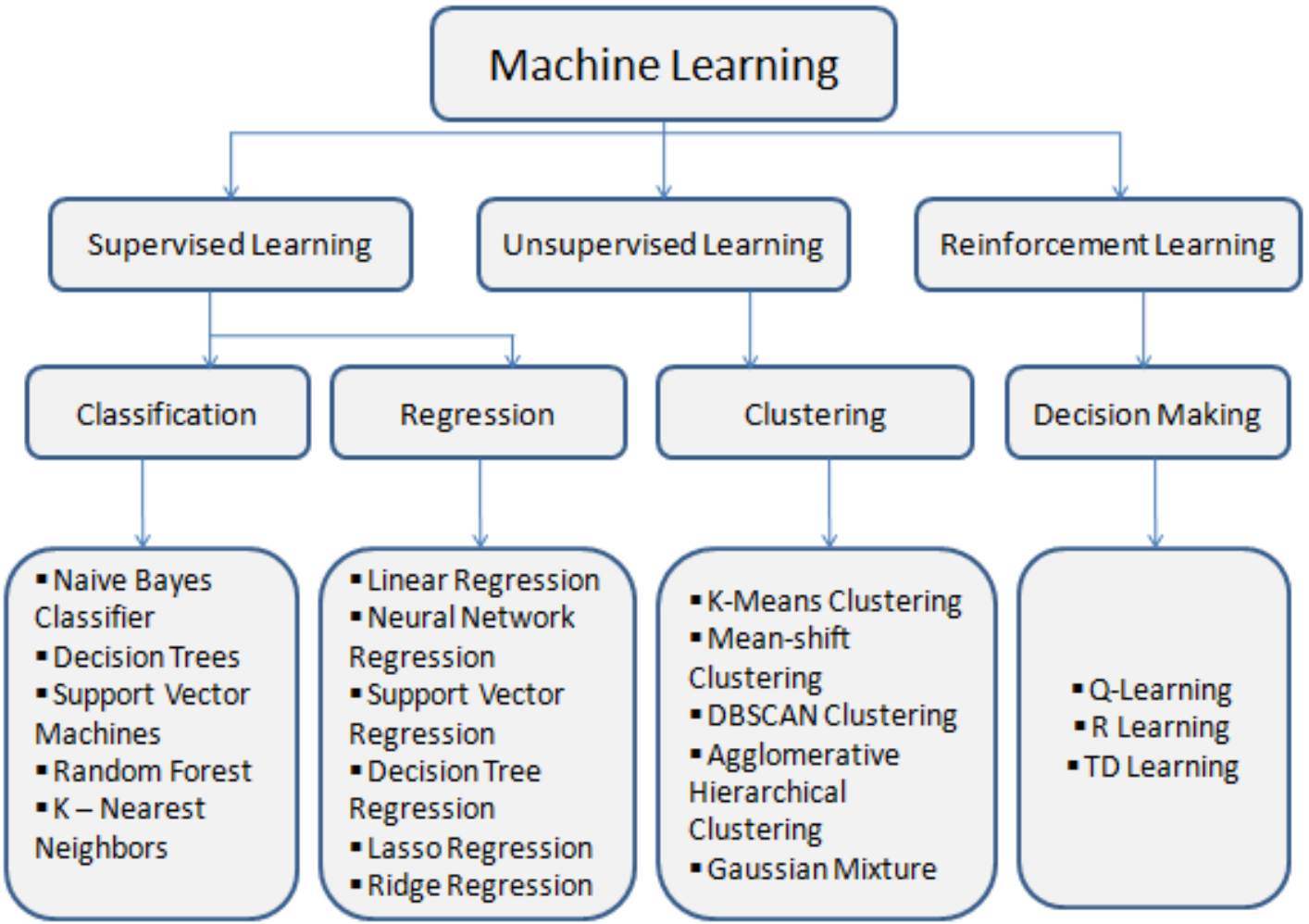
- An agent's action in an environment is interpreted as a reward and state and reported to the agent.
- Giving candy as a result of a baby crying - a reward. Over time, if the child's craving for candy is satisfied, the baby learns to cry every time he asks for candy.

Machine Learning -ML

- **Reinforcement Learning:**

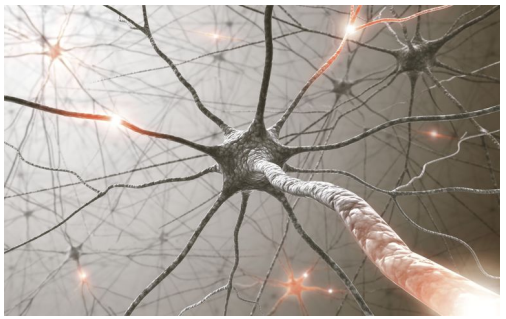


Machine Learning

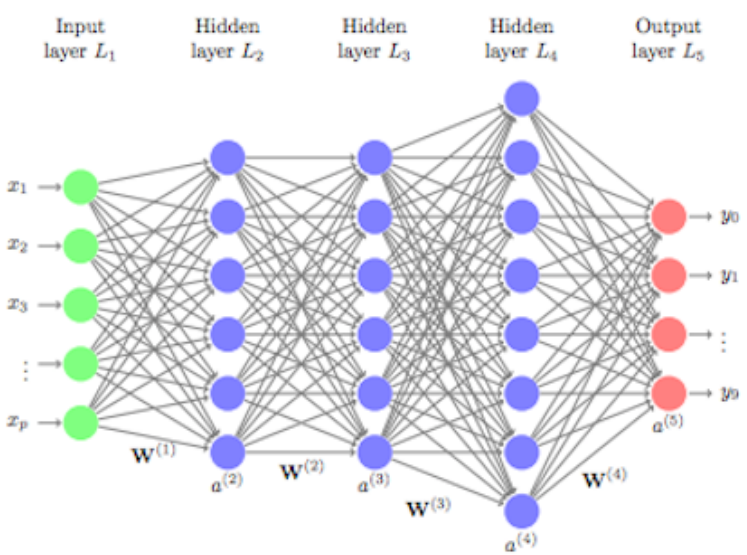


Deep Learning (DL)

- Deep learning is inspired by the structure and function of the brain, which consists of many interconnected nerves.
- Most of today's neural networks are organized in layers of nodes and they are "feed-forward", meaning data moves in one direction between them.
- Some layers, such as the Recurrent Neural Network, have feed-backs within themselves.
- There are multiple layers to process features, and generally each layer extracts some information about the applied input.



Fruit fly: 100 thousand neurons
Mouse: 75 million neurons
Cat: 250 million neurons
Chimpanzee: 7 billion neurons
Human brain: 86 billion neurons
Elephant: 257 billion neurons
https://www.verywellmind.com/how-many-neurons-are-in-the-brain-2794889



Deep Learning

- The main reasons for the recent developments in deep learning

1952 Stochastic Gradient Descent

1958 Perceptron
- Learnable Weights

1986 Backpropagation
- Multi-Layer Perceptron

1995 Deep Convolutional NN
- Digit Recognition

Neural Networks date back decades, so why the resurgence?

1. Big Data
- Larger Datasets
- Easier Collection & Storage

IMAGENET

WIKIPEDIA
The Free Encyclopedia

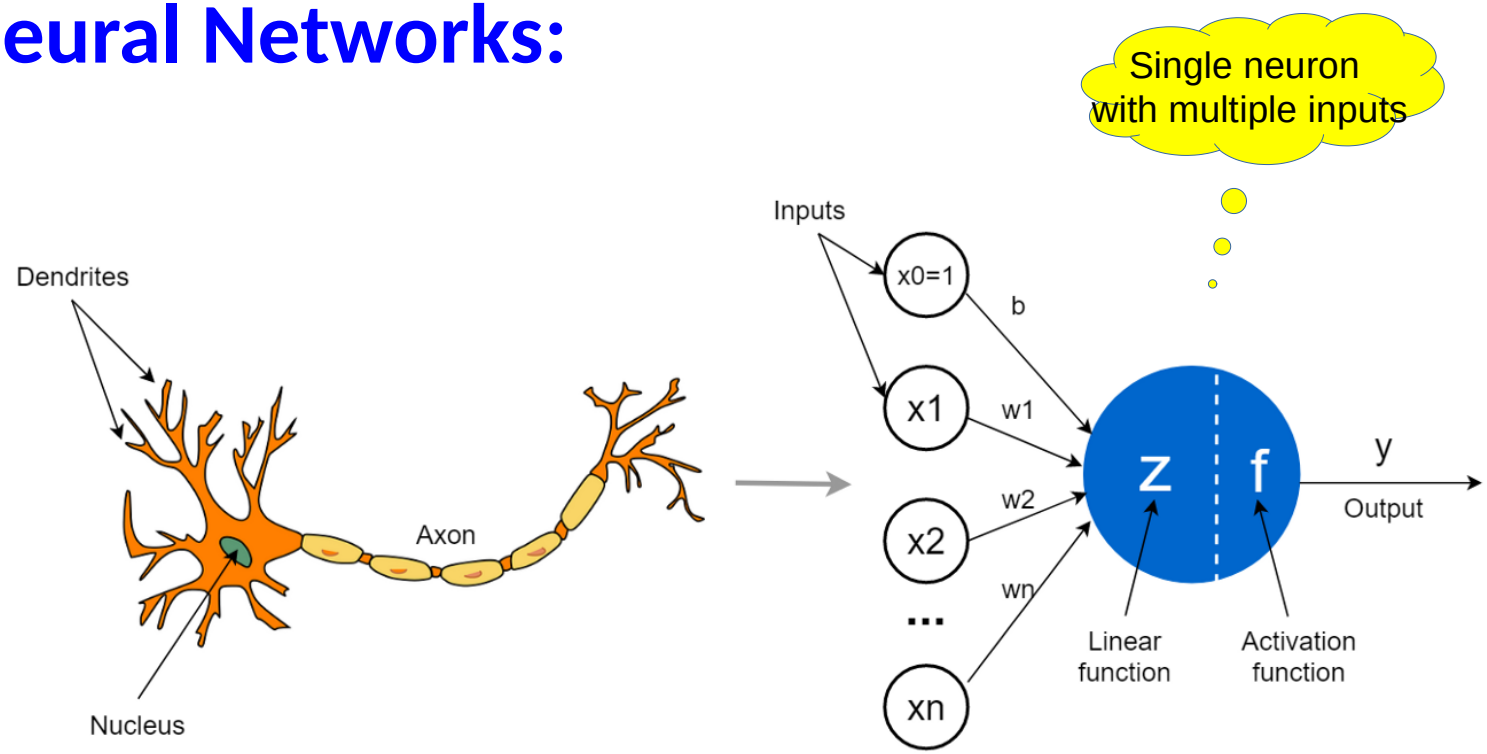
2. Hardware
- Graphics Processing Units (GPUs)
- Massively Parallelizable

3. Software
- Improved Techniques
- New Models
- Toolboxes

TensorFlow

Deep Learning (DL)

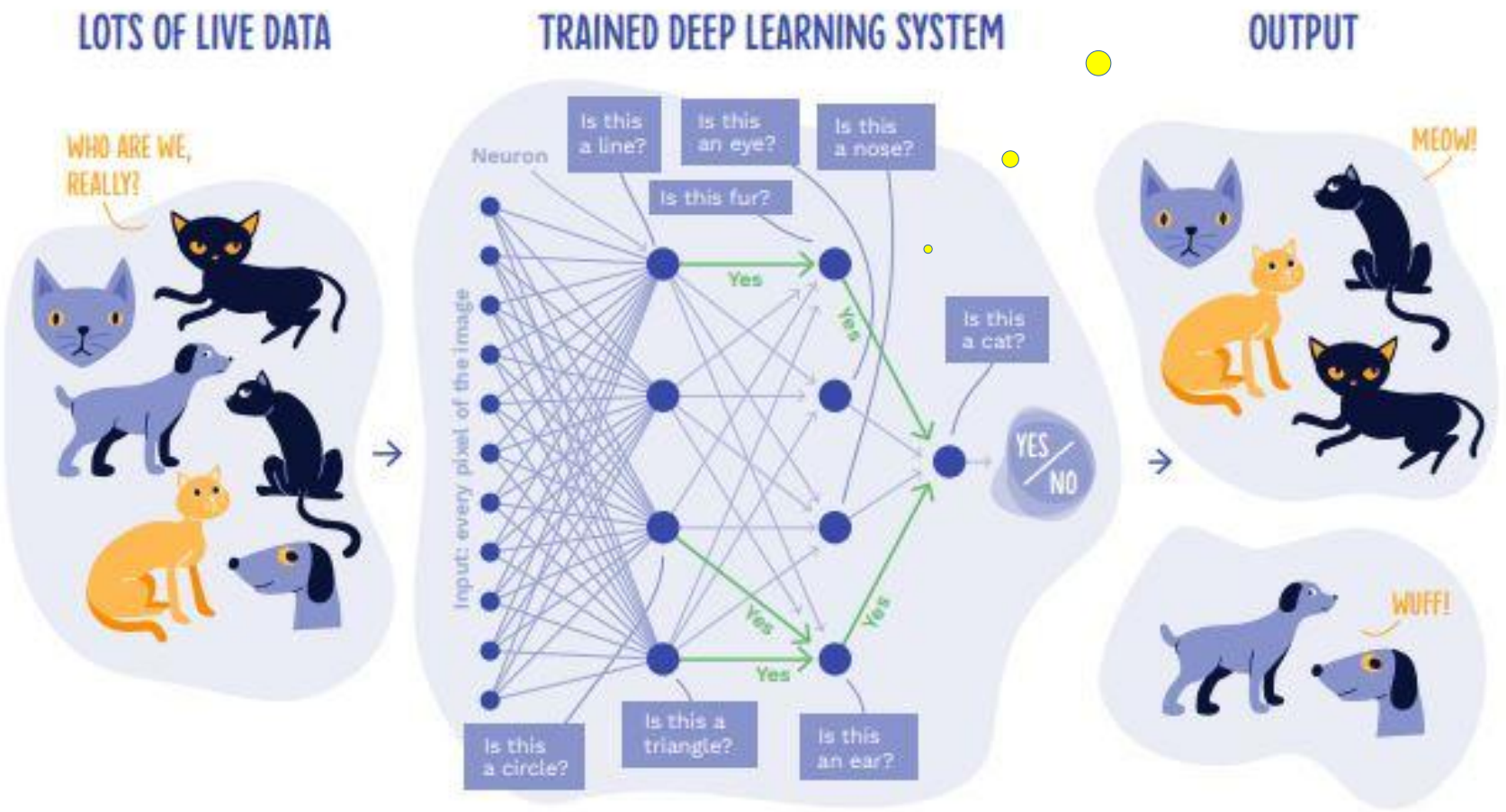
Neural Networks:



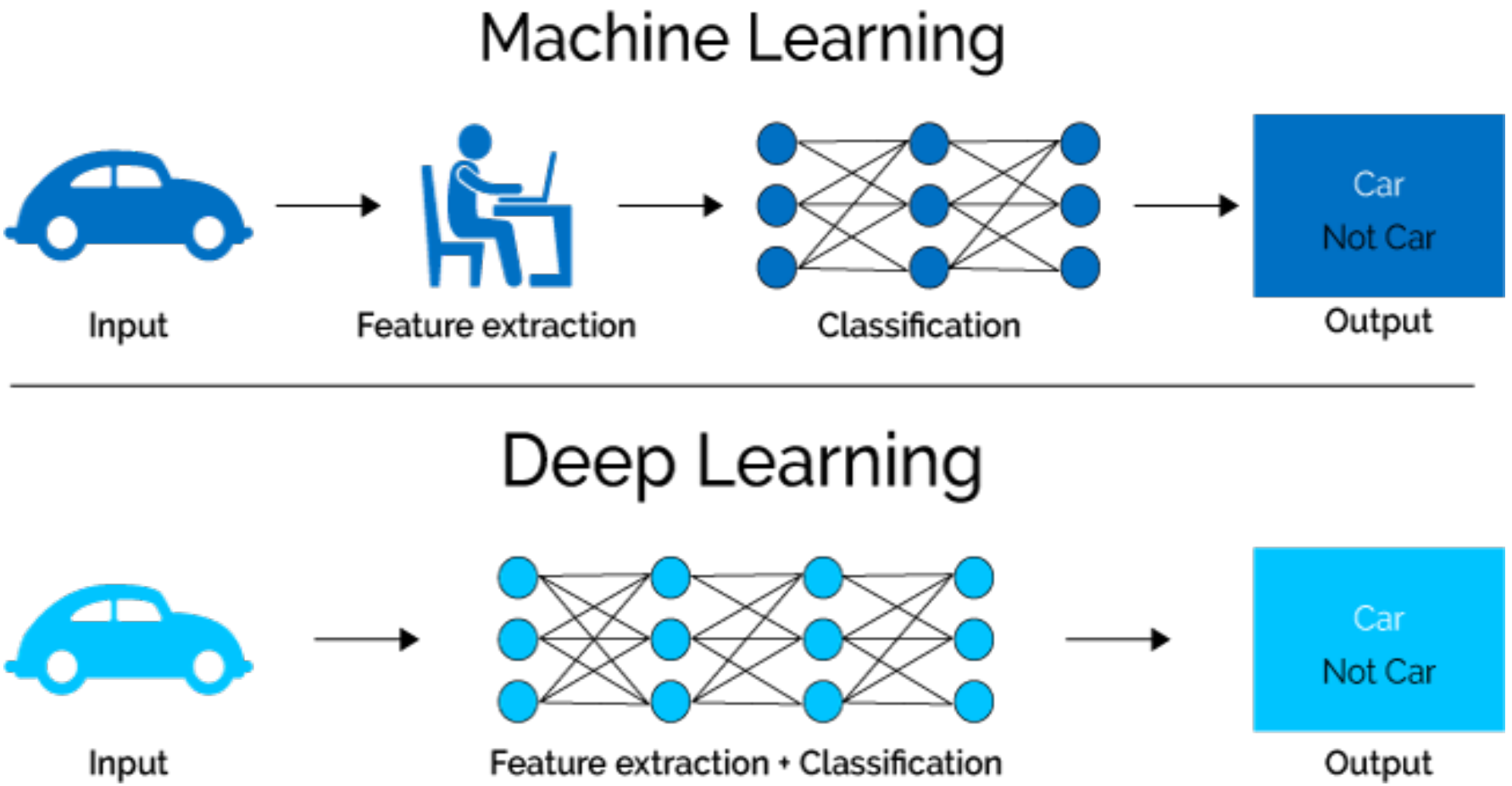
Deep Learning (DL)

Neural Networks:

Multiple neurons together solve complicated problems



Deep Learning vs. Machine Learning

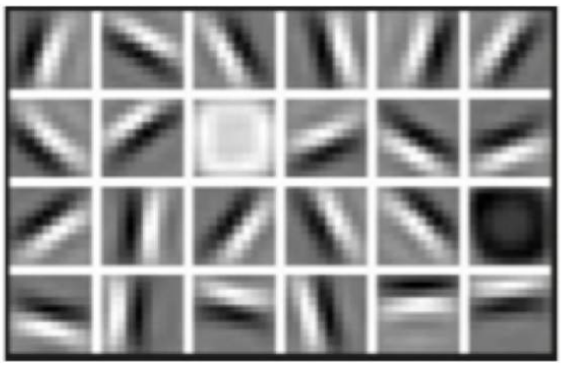


Deep Learning

Hand engineered features are time consuming, brittle and not scalable in practice

Can we learn the **underlying features** directly from data?

Low Level Features



Lines & Edges

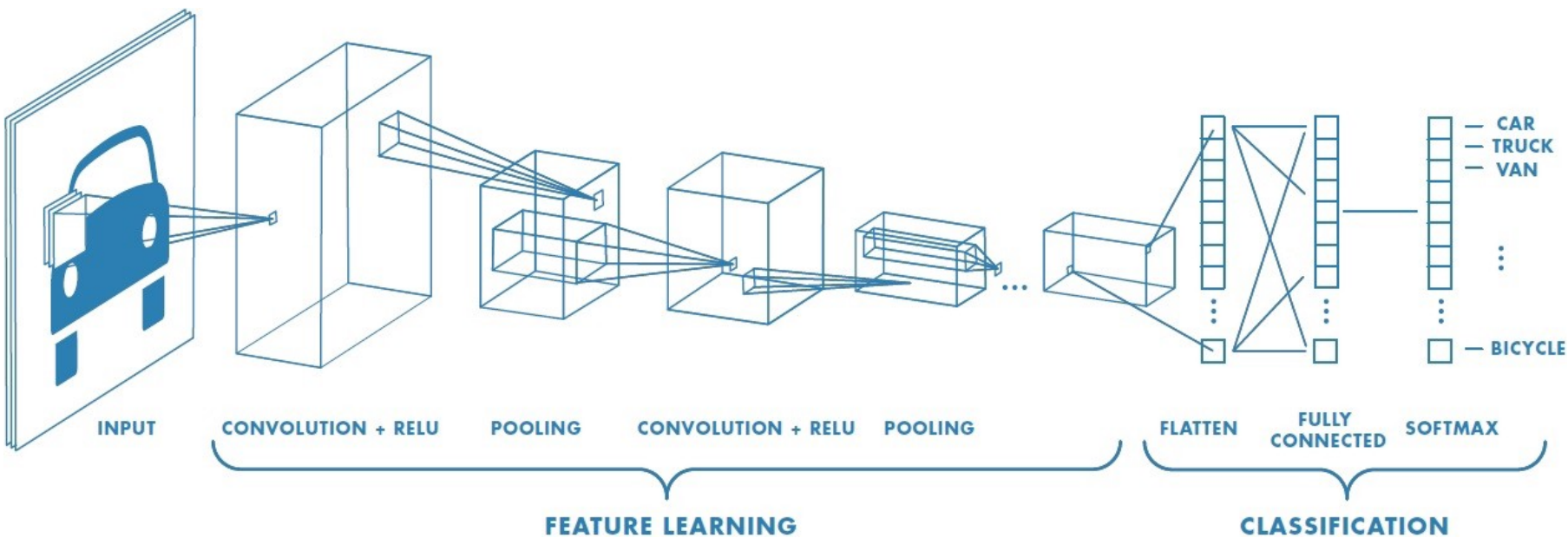
Mid Level Features

Eyes & Nose & Ears

High Level Features

Facial Structure

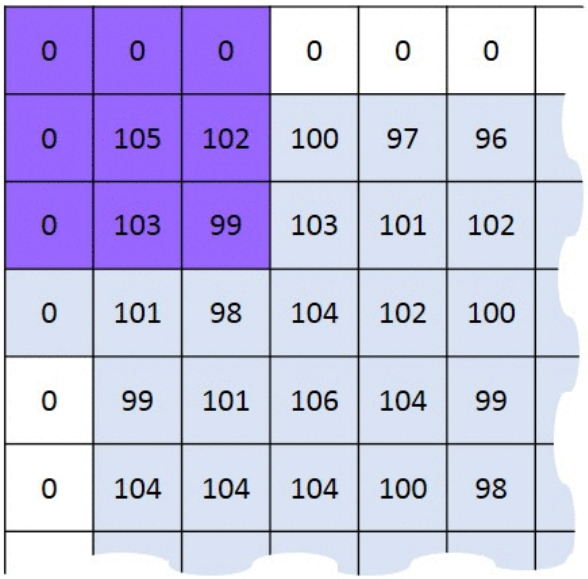
Deep Learning



The deep learning model also includes the process of extracting the necessary features of the problem before the decision-making mechanism.

Kaynak: https://medium.com/@RaghavPrabhu/understanding-of-convolutional-neural-network-cnn-deep-learning-99760835f148

2D convolution



0	0	0	0	0	0
0	105	102	100	97	96
0	103	99	103	101	102
0	101	98	104	102	100
0	99	101	106	104	99
0	104	104	104	100	98

Image Matrix

Kernel Matrix

0	-1	0
-1	5	-1
0	-1	0

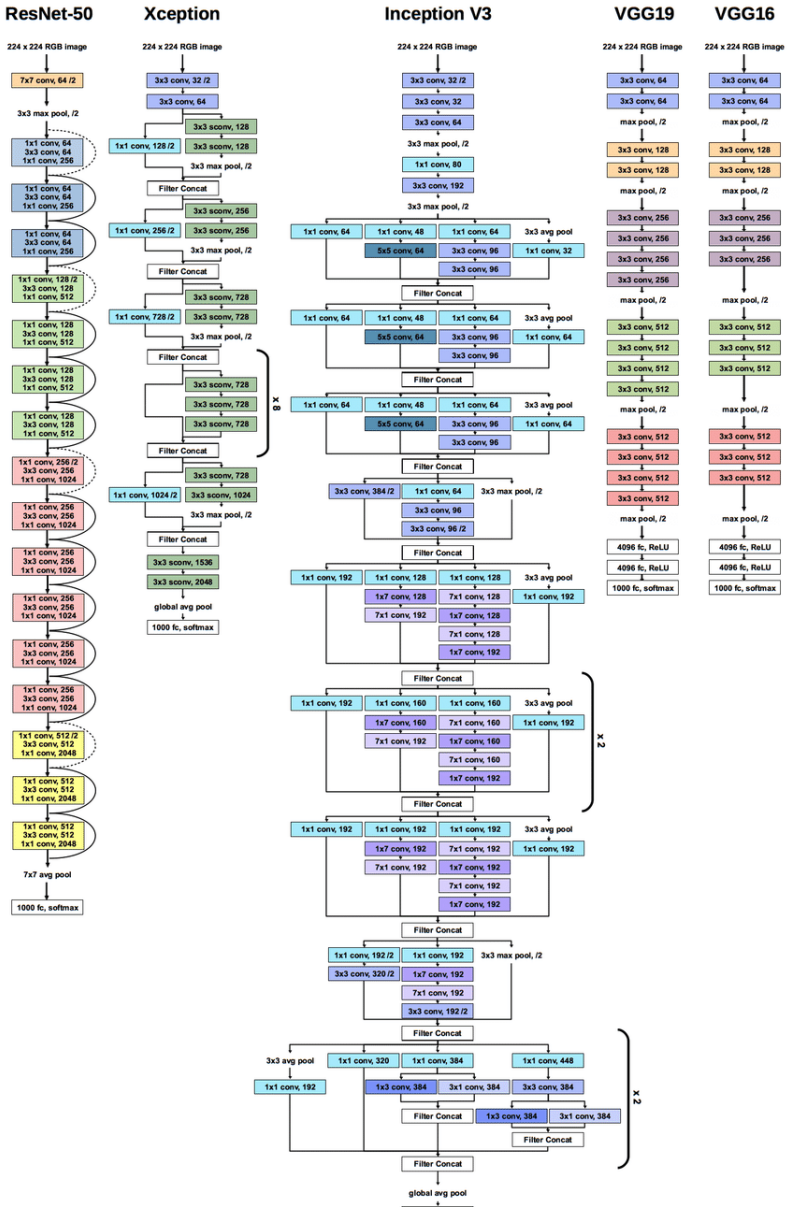
$$0*0+0*-1+0*0$$
$$+0*-1+105*5+102*-1$$
$$+0*0+103*-1+99*0 \quad = 320$$

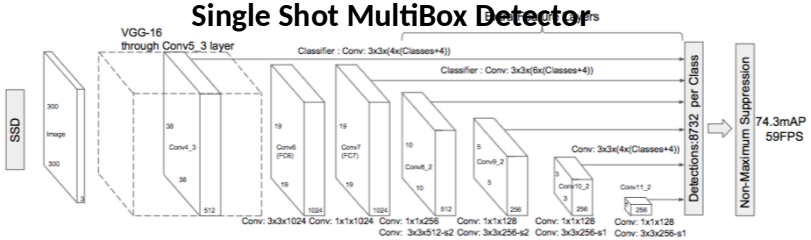
320				

Output Matrix

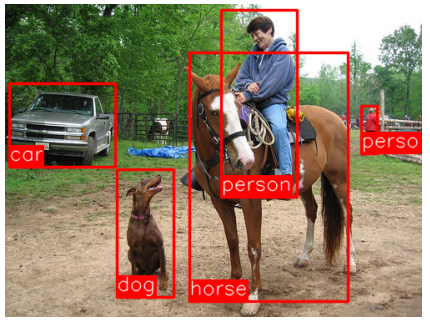
Convolution with horizontal and vertical strides = 1

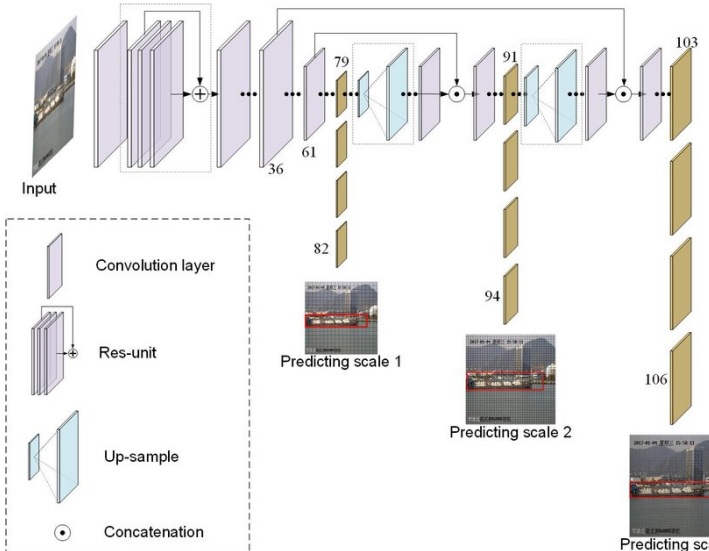
Some deep learning architectures





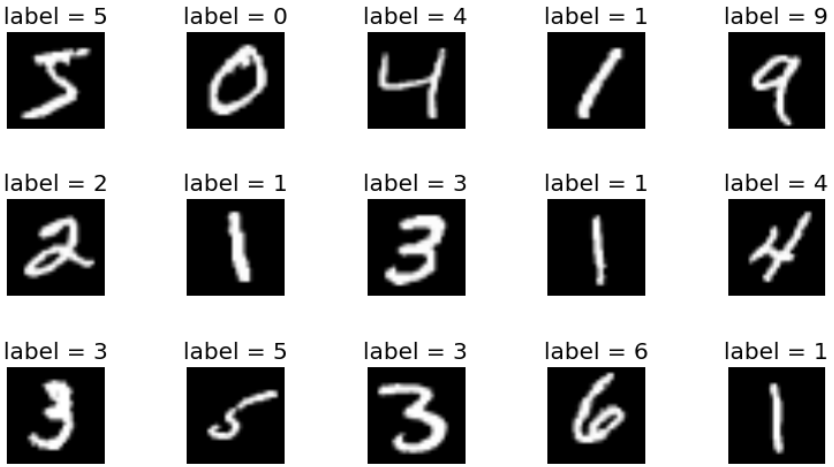
Kaynak: https://towardsdatascience.com/understanding-ssd-multibox-real-time-object-detection-in-deep-learning-495ef744fab

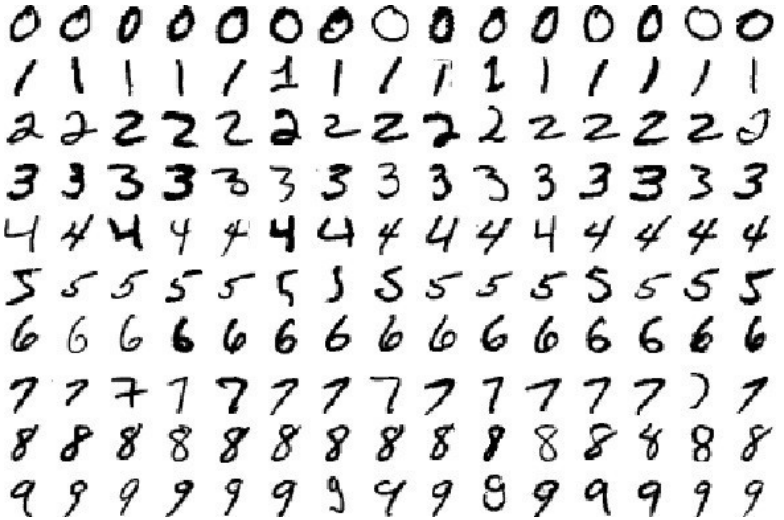


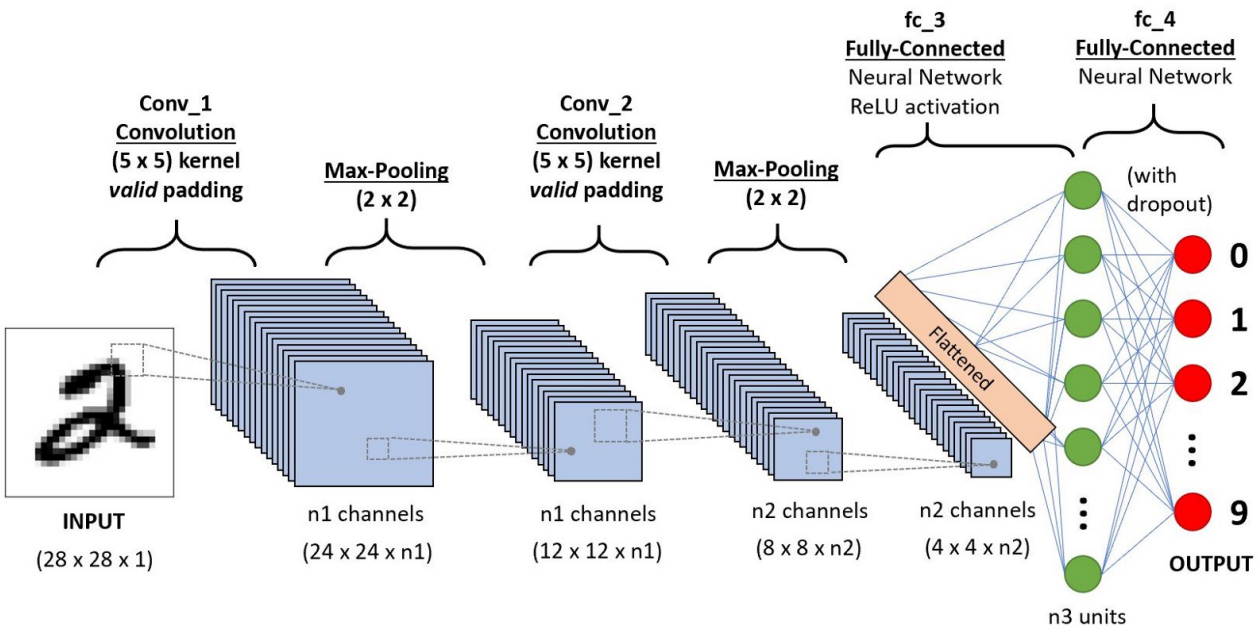


Example

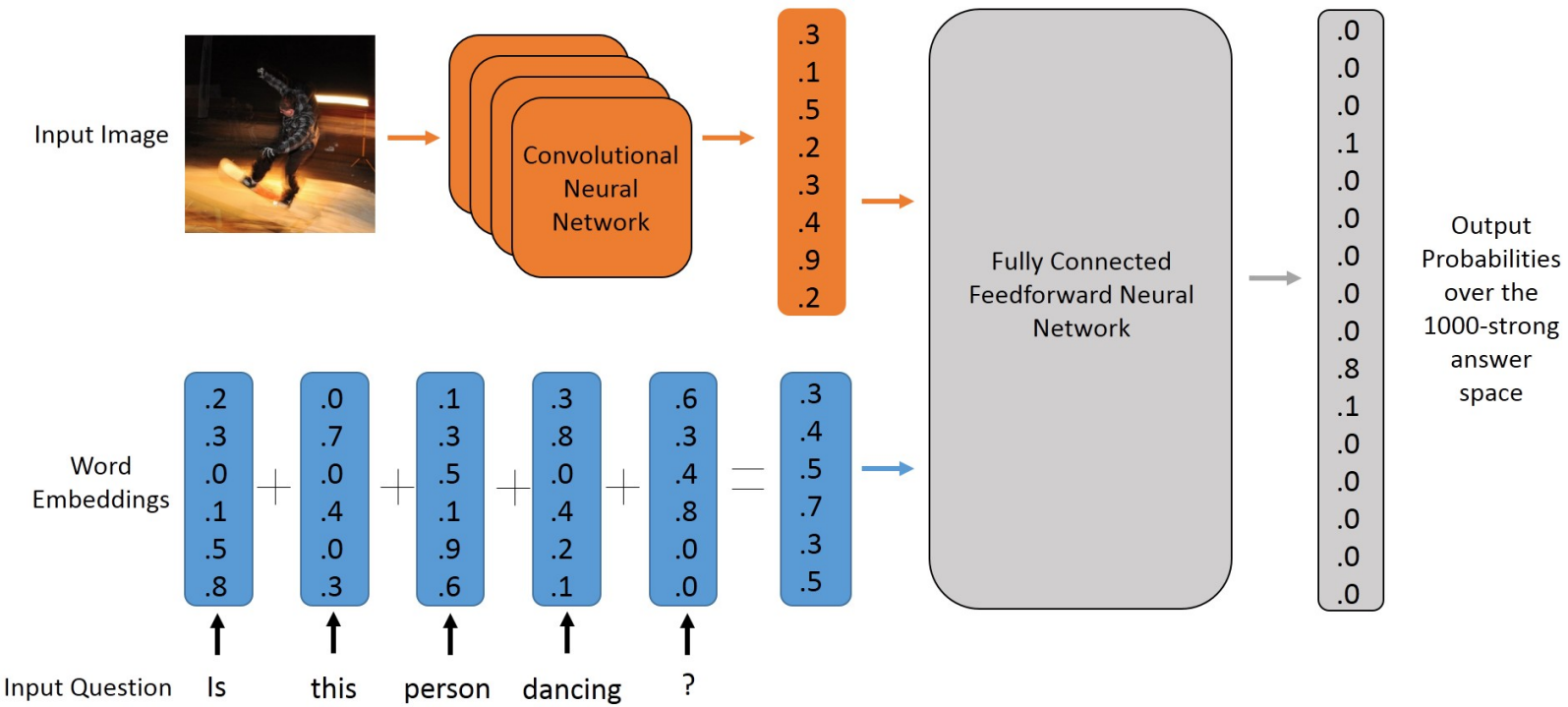
Data set





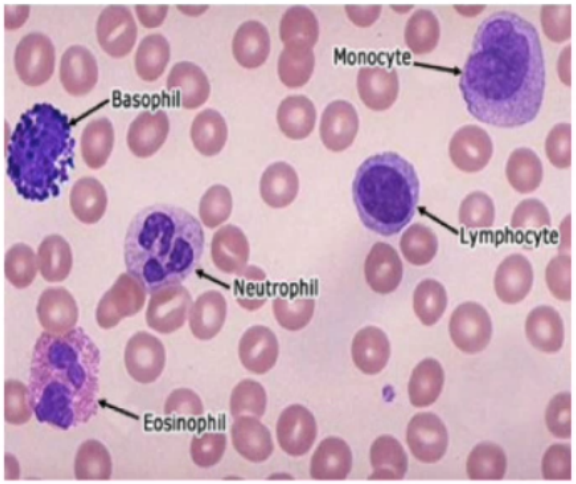


Example DL architecture

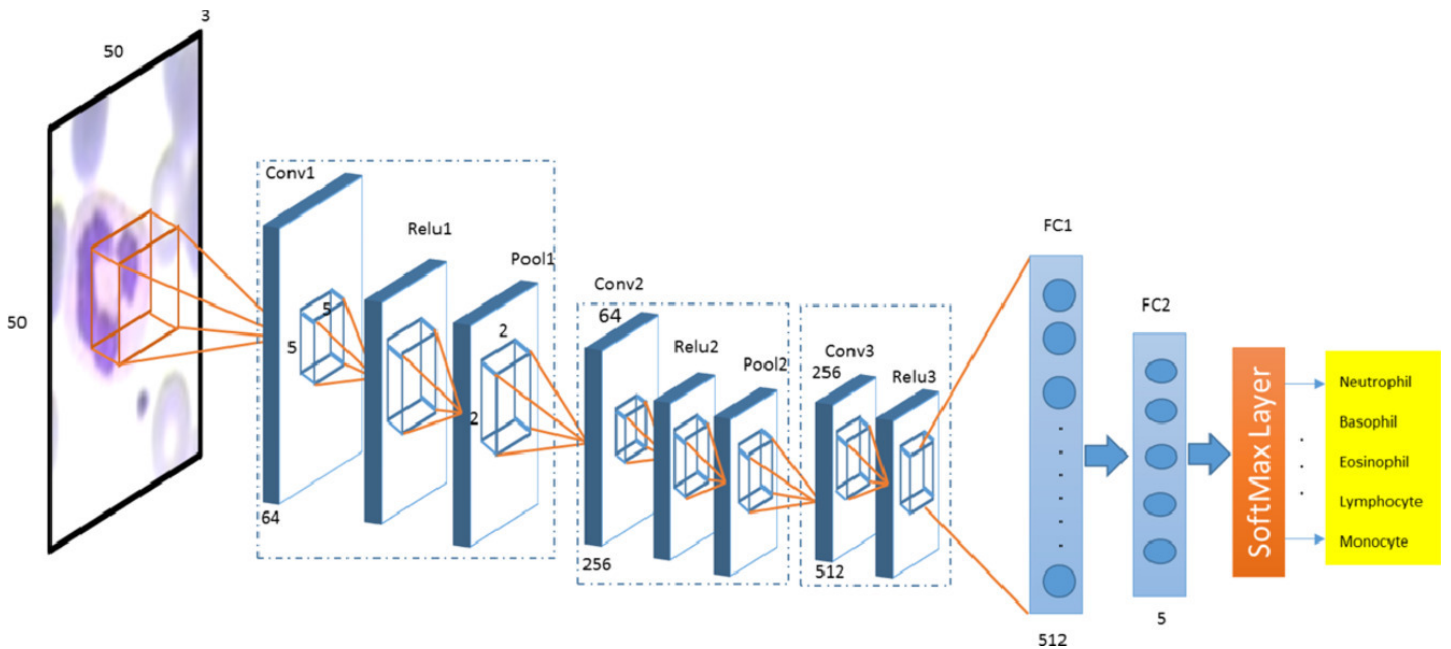


Source: https://www.kdnuggets.com/2015/11/deep-learning-visual-question-answering.html

White blood cells identification system based on convolutional deep neural learning networks



WBCs Type/Dataset	Neutrophil	Eosinophil	lymphocyte	Monocyte	Basophil	Total WBCs in each dataset
Dataset1	25	2	85	12	1	125
Dataset2	55	43	55	48	53	254
Dataset3	1412	83	525	142	10	2172
Total WBCs (Dataset_ALL)	1492	128	665	202	64	2551



Deep learning microscopy

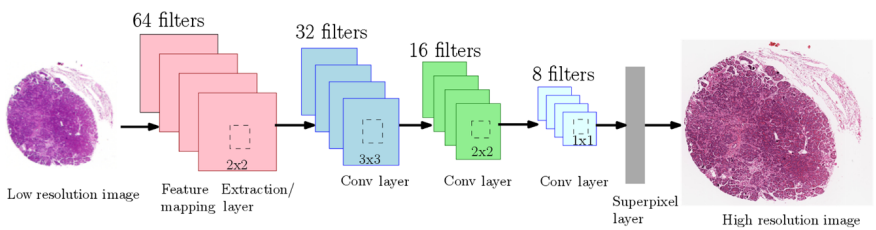


Fig. 1 Architecture of the proposed CNN for image super-resolution.

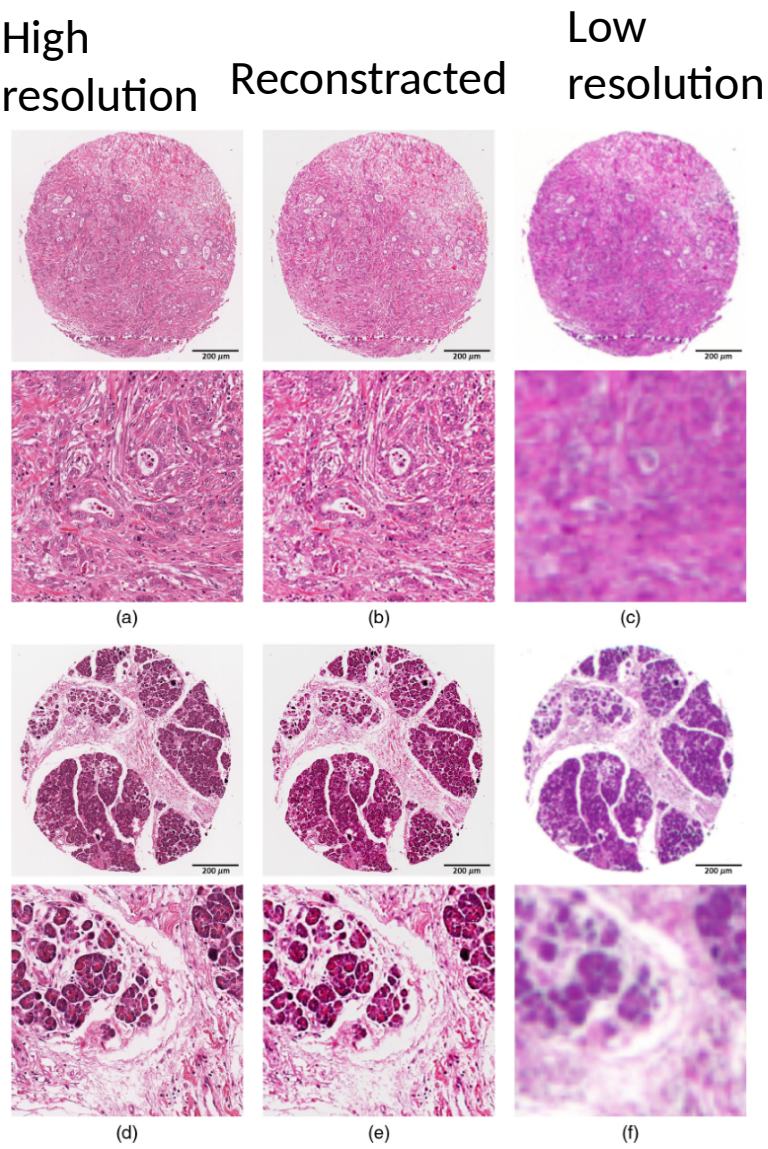


Fig. 6 Results of reconstruction of pancreatic cancer TMA: columns 1 and 3 show HR and LR images

Examples

https://transcranial.github.io/keras-js/#/mnist-cnn

https://transcranial.github.io/keras-js/#/resnet50

https://keras.io/examples/generative/random_walks_with_stable_diffusion/