Image Classification with CNNs

Innopolis University
[S23] Applied Machine Learning
BEKKOUCH Imad Eddine Ibrahim

Learning Outcomes

Neural Networks

Students can describe the components and training steps of FCNNs

Convolutional Neural Networks

Students can tell the difference between FCNN & CNN

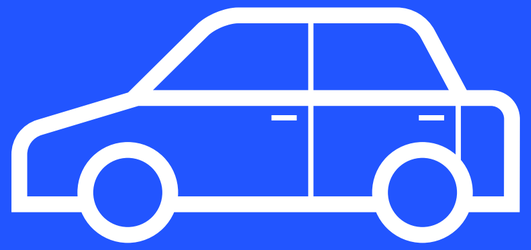
CNN's tips

Students can evaluate whether the models are overfitted or underfitted

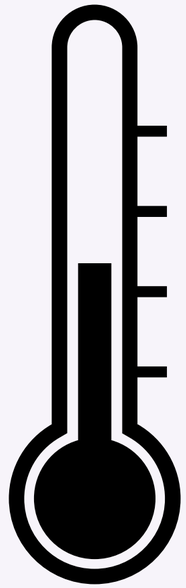
Neural Networks

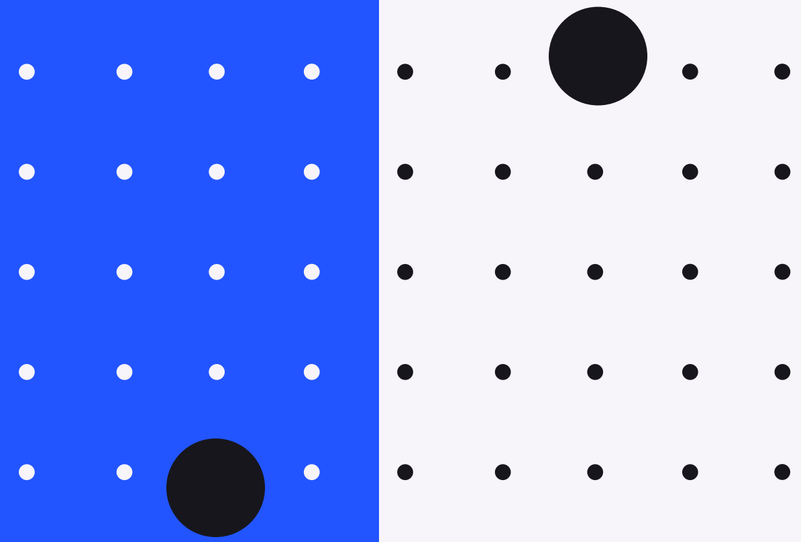
Fully Connected Neural Networks were the first architecture used and they provided a great increase of performance over traditional machine learning

- **Classification/Regression**
  cats&dogs / age&temperature
- **Logistic Regression**
  The jump from LR to FCNN
- **Loss functions**
  Mean Squared Error/Cross Entropy

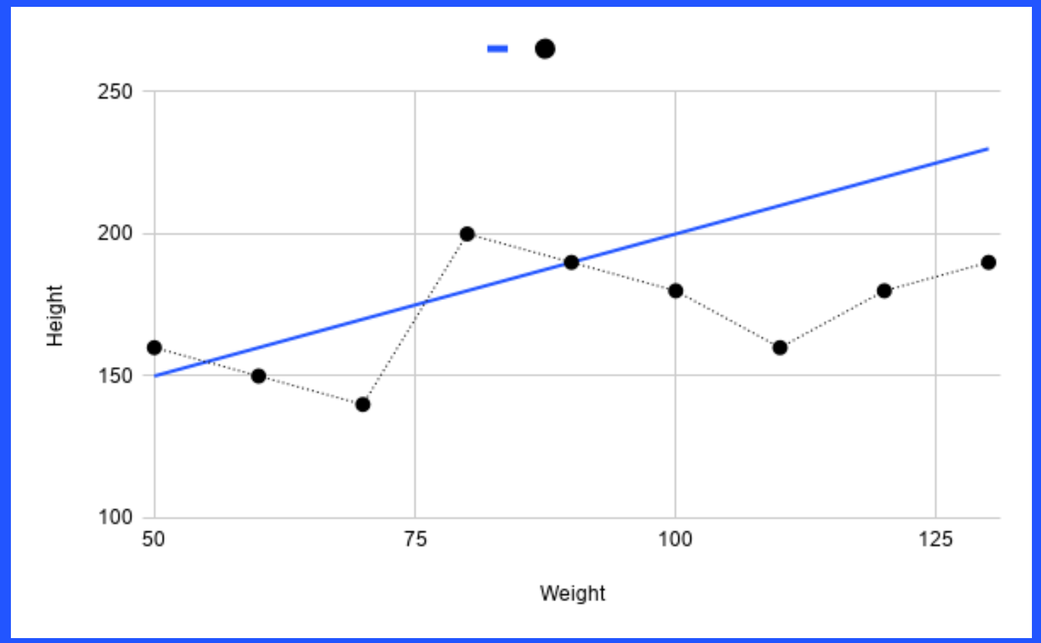


Regression



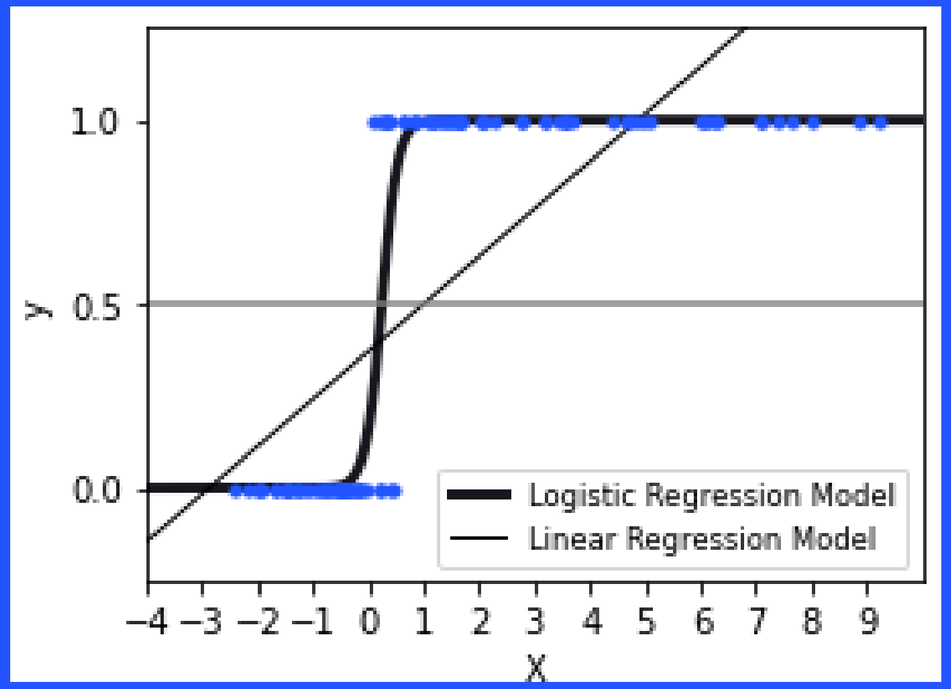


Classification



Linear Regression

Can you predict the height of a person using his weight?

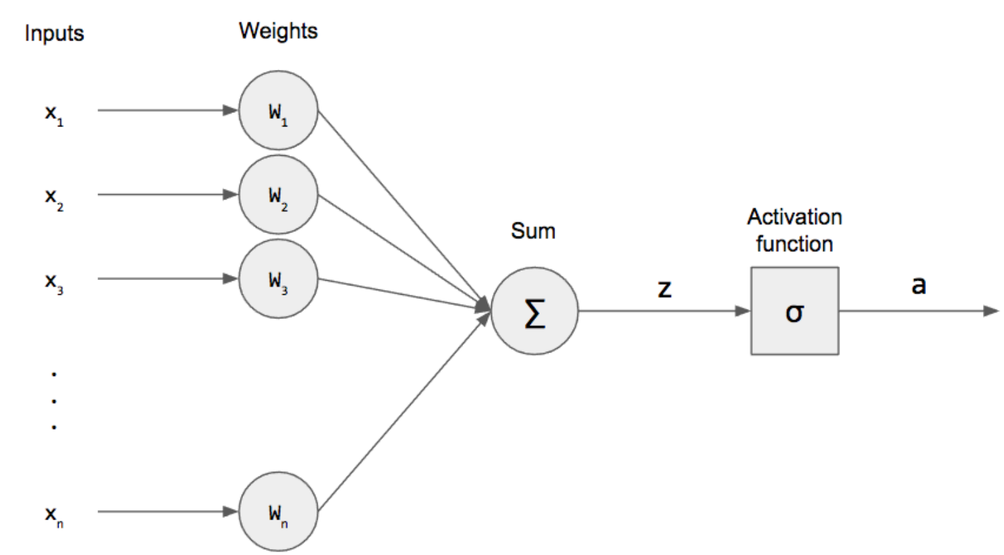


Logistic Regression

Can you predict the type of height of a person using his weight?

Perceptron

A perceptron is the first type of neural network, it is a **single-layer** NN. It consists of **5 main parts** including **input** values, **weights** and **bias**, net **sum**, and an **activation function**.



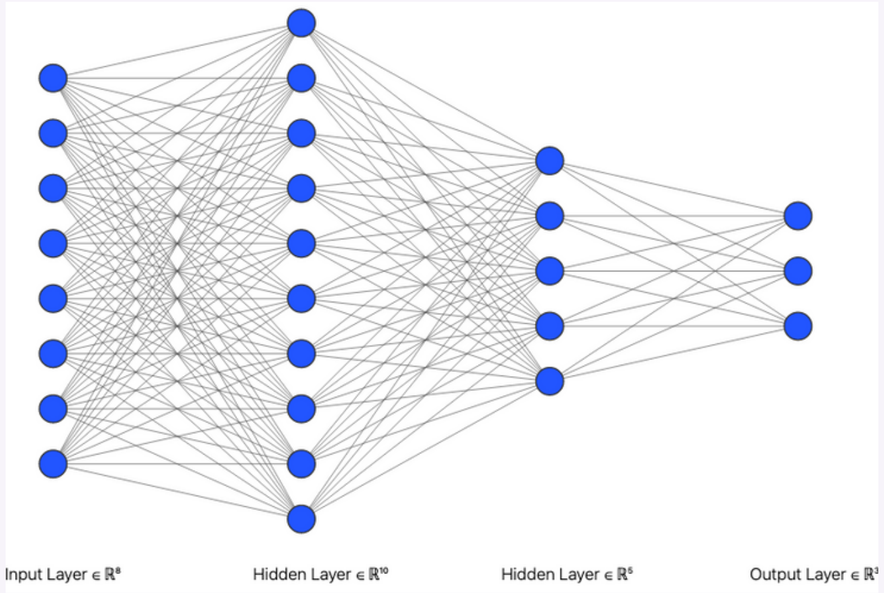
The input of a perceptron must be a flat vector representation of the data.

The weights and the biases represent the parameters of the model that need to be learned by an optimization algorithm.

The activation function is the hyperparameter of the networks and in this setting, it serves only for setting the values between 0-1 as in logistic regression models.

Multi-Layer Perceptron

Focus on four main aspects: The **activation** functions, The **architecture**, The **loss** function, and the **optimizer**.



The activation functions are used to bring non-linearity to the MLP. They are also used at the end of the MLP depending on the task and the loss function.

A bigger and wider network has more chances of giving better performance but it risks over-fitting.

Neural Networks are trained using optimizers that reduce the loss the function by changing the weights of the NN.

Neural Newtorks

1. Linea Regression

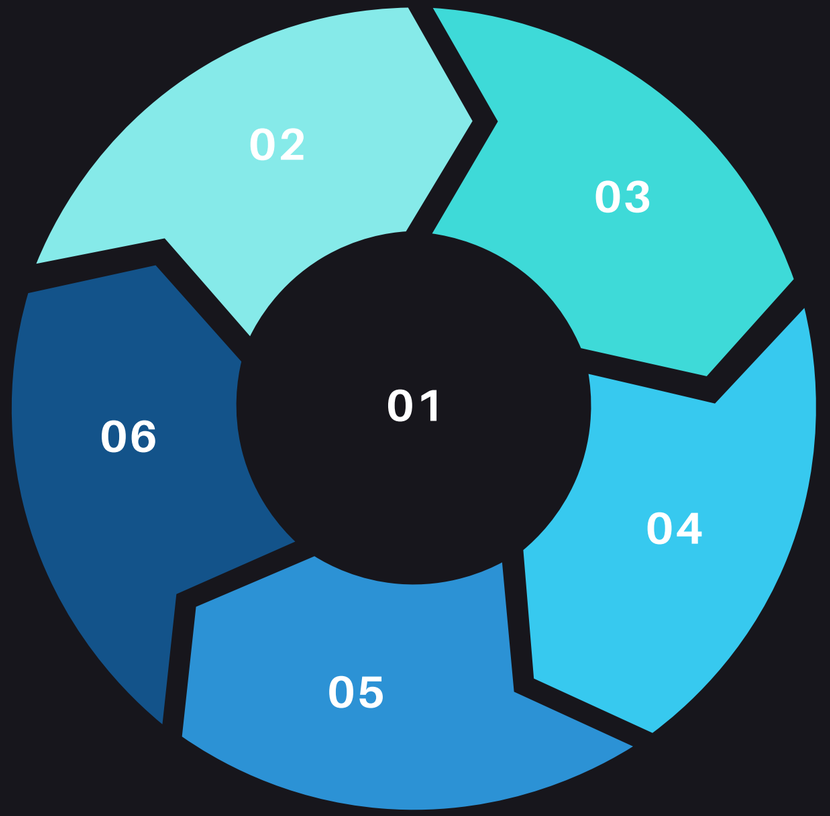
Mapping features into another space using vector mul

2. Logistic Regression

Wrapping Lin-R in a sigmoid activation function

3. Perceptron

A single neuron that is equivilant to Log-R



4. Multi-Layer Perceptron

Stacking Perceptron together

5. Convolutional Neural Networks 2D

Sliding MLP

6. Convolutional Neural Networks 3D

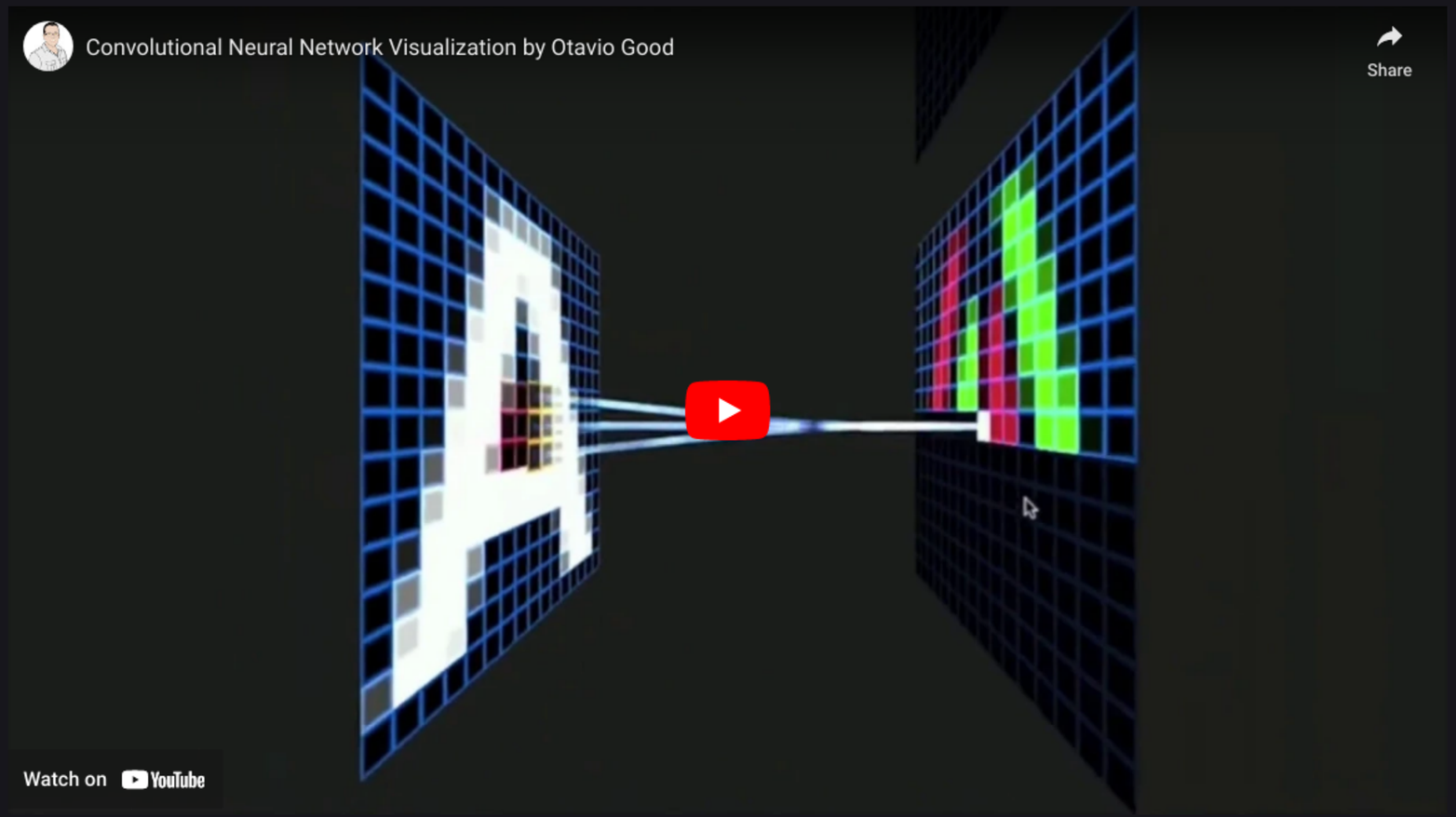
Sliding CNN 2D

Convolutional Neural Networks 2D

Convolutional networks are simply feed-forward neural networks that use the convolution operation

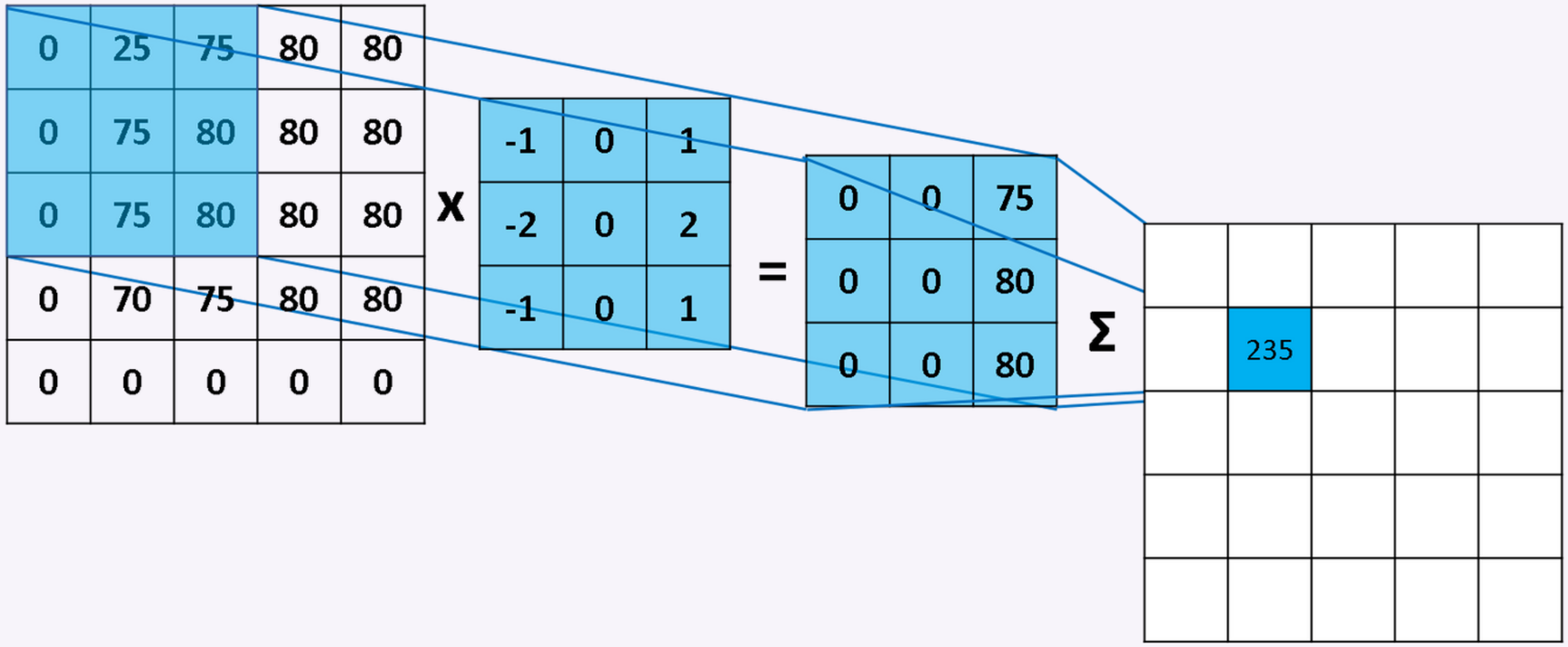
- **Convolutional Neural Nets**
  Padding, Stride, Kernel Size
- **Dimensions**
  Layer output
- **Pooling**
  Max pooling

Conolutional Neural Nets



Kernels

A moving dense layer.



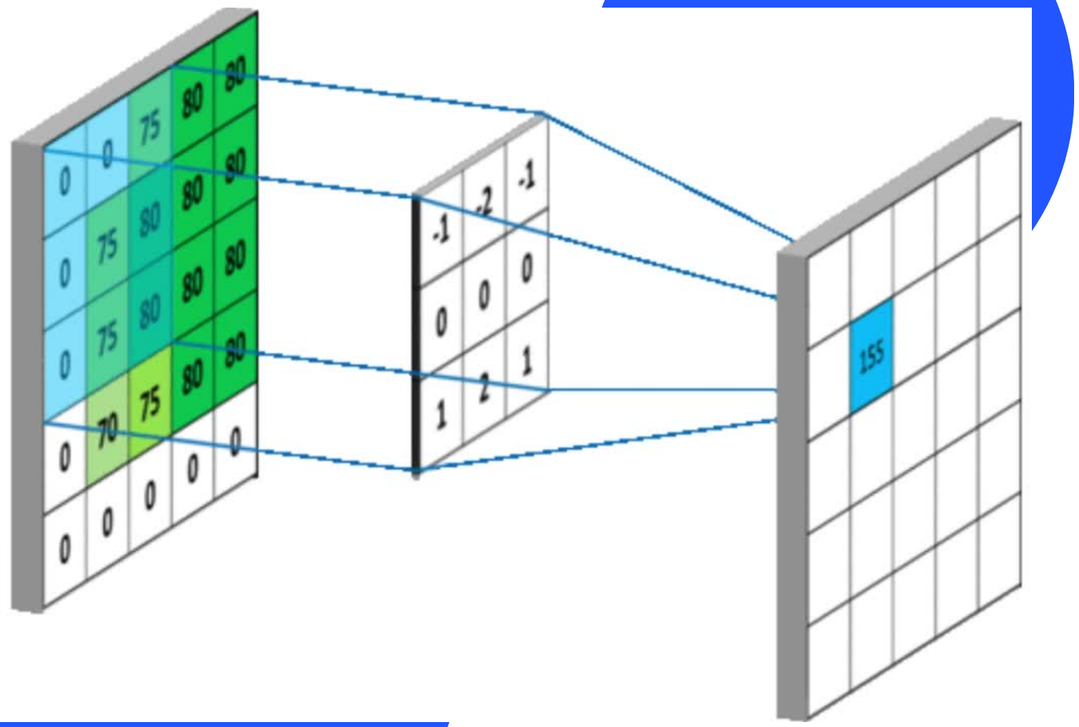
Kernels

Padding

Filling pixels which are added arround the input for 1) augmenting the size of the output. 2) increasing focus on borders.

Stride

The jump size of the kernel on the original image



Dimensions

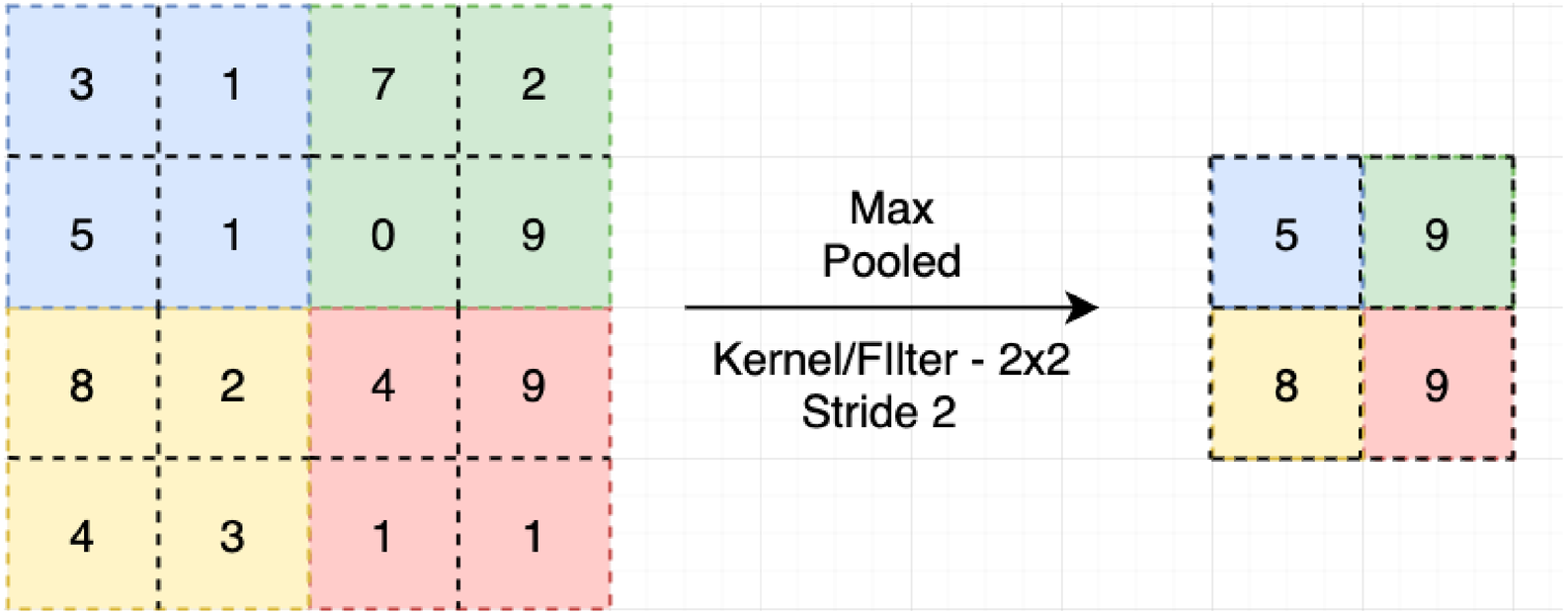
$$n_{out} = \left\lfloor \frac{n_{in} + 2p - k}{s} \right\rfloor + 1$$

n_{in}: number of input features
n_{out}: number of output features
k: convolution kernel size
p: convolution padding size
s: convolution stride size

Pooling

Max pooling

Allows to reduce the size of the images, and hence reduce the calculations.



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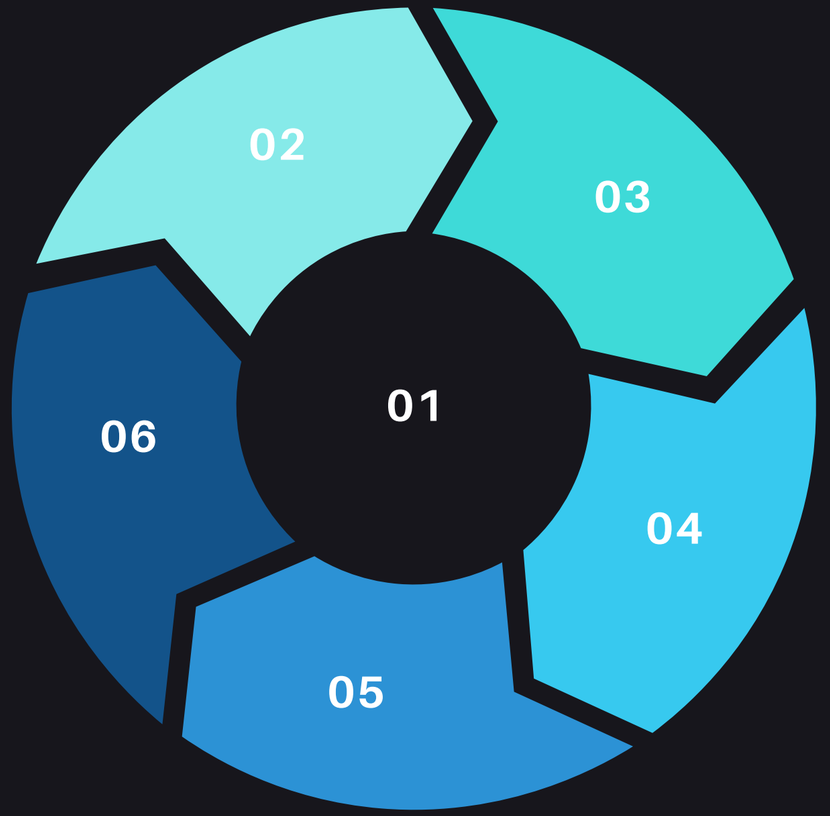

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Sliding CNN 2D

Convolutional Neural Networks 3D

Convolutional networks 3D are simply a sliding 2D CNN

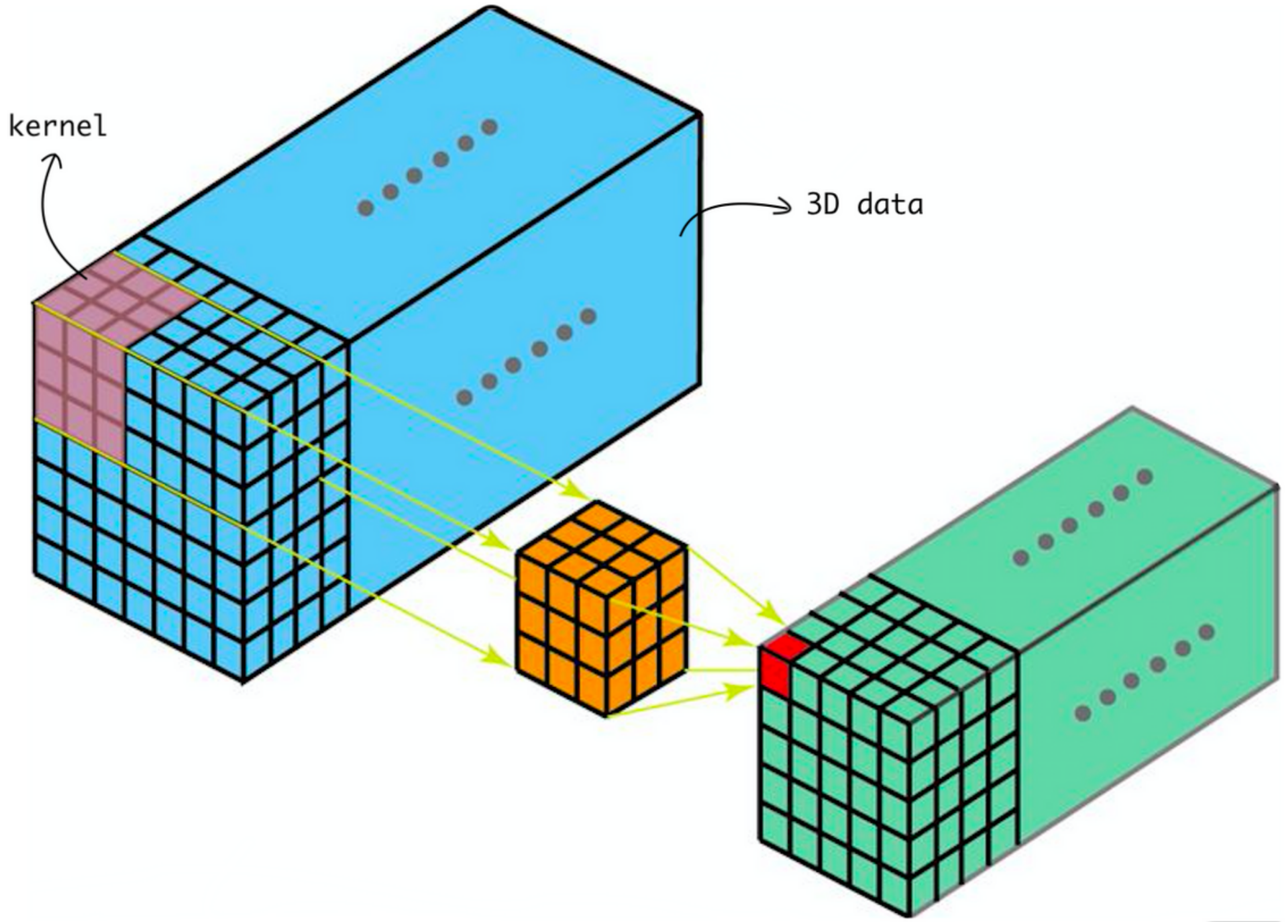
3D convolutions

Application areas, operation

3D CNN

2D CNN

3D convolutions



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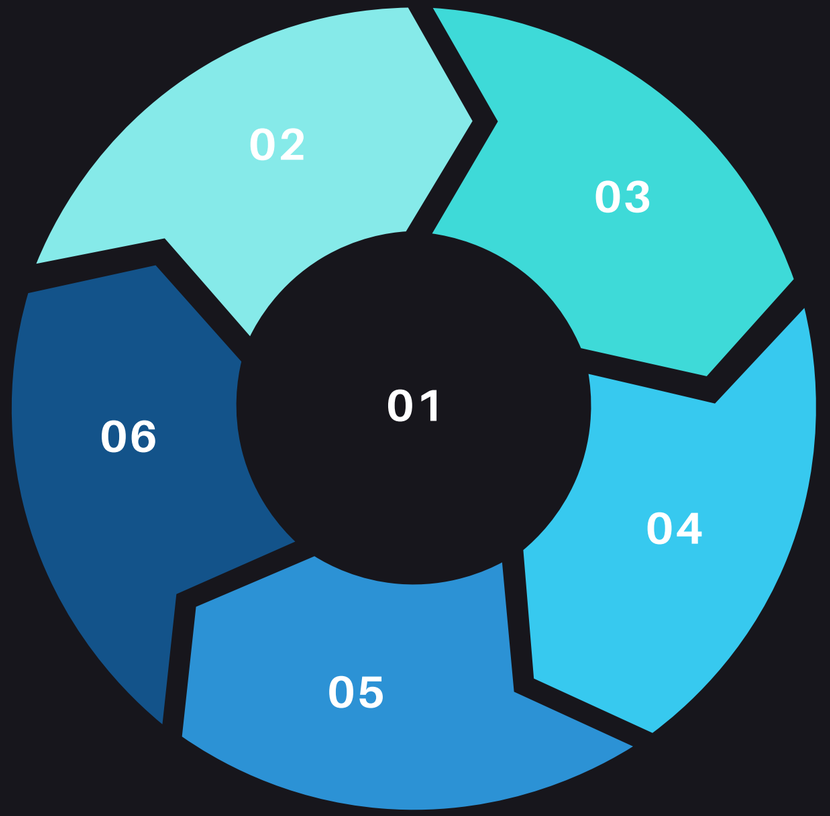

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3D CNN, Sliding CNN 2D

Ressources

- 3D-Convolutions and its Applications
- Pooling Layer — Short and Simple
- Step by Step Implementation: 3D Convolutional Neural Network in Keras
- Convolutional Neural Networks - Basics
- Deep Learning book
- Convolutional Neural Networks Stanford