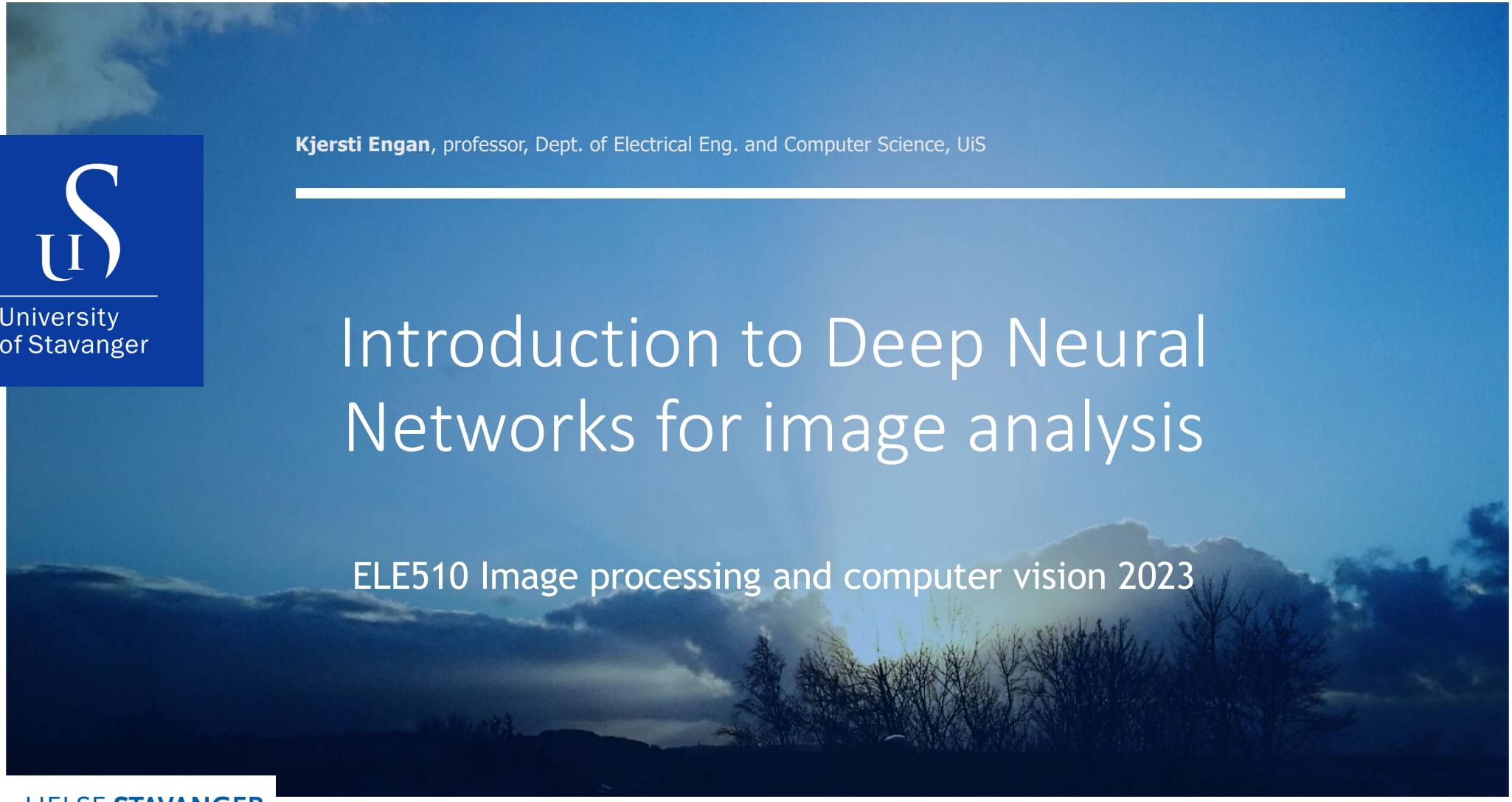


Kjersti Engan, professor, Dept. of Electrical Eng. and Computer Science, UiS

University of Stavanger

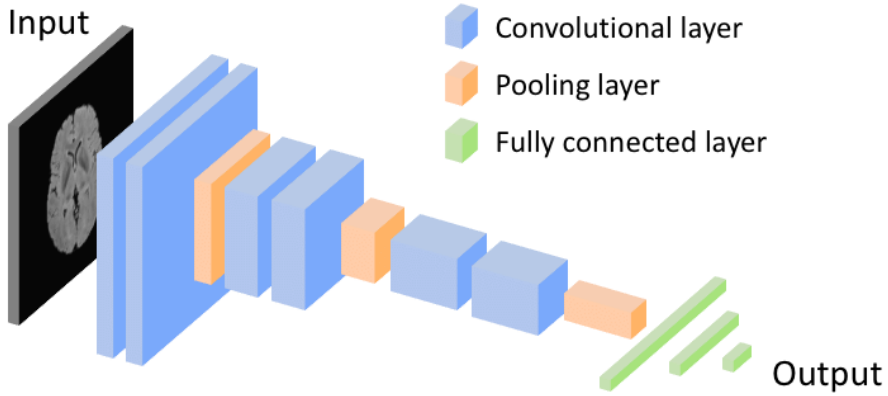
Introduction to Deep Neural Networks for image analysis

ELE510 Image processing and computer vision 2023

HELSE STAVANGER
Stavanger universitetssjukehus

Intro to Deep Neural Network for image analysis

Three points form the topic:



1. What is a artificial neuron?
2. How does convolutional neural network relate to spatial filtering (convolution)
3. What is supervised learning?

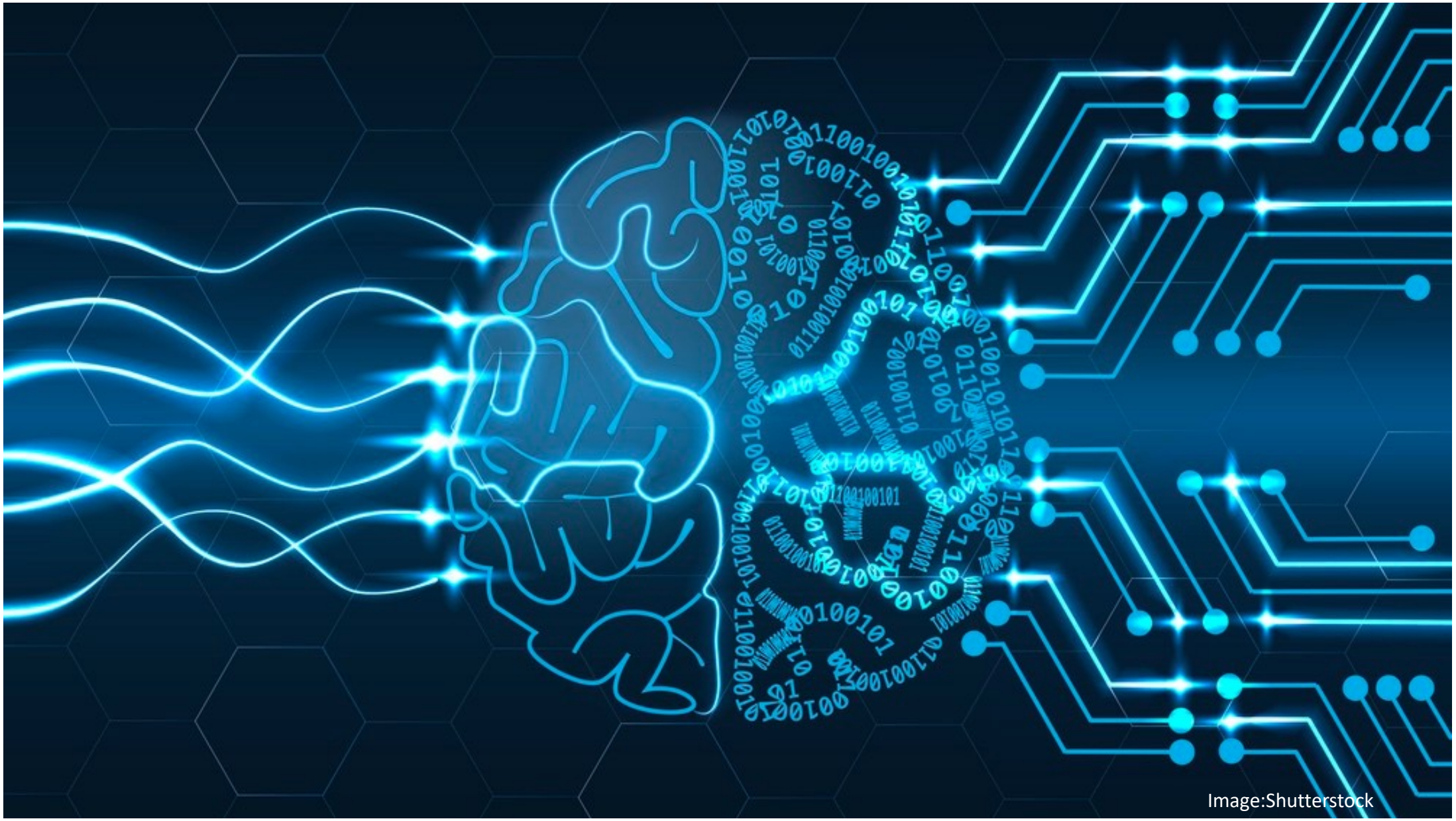
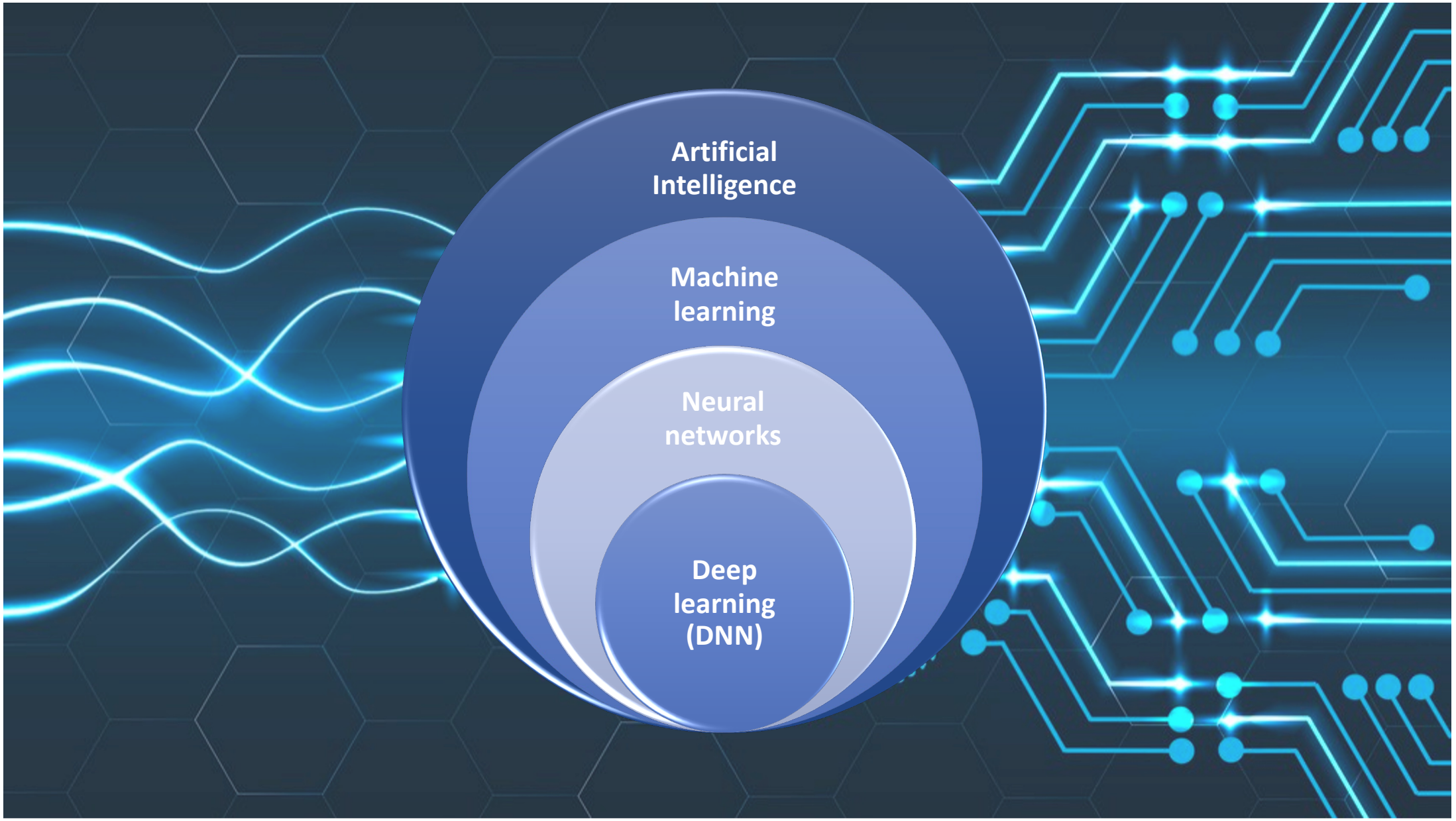


Image:Shutterstock


Artificial Intelligence
Machine learning
Neural networks
Deep learning (DNN)

Neural Networks for images

Generate an image from text - And much more..

Style transfer

"Paint" this image with the style of another image

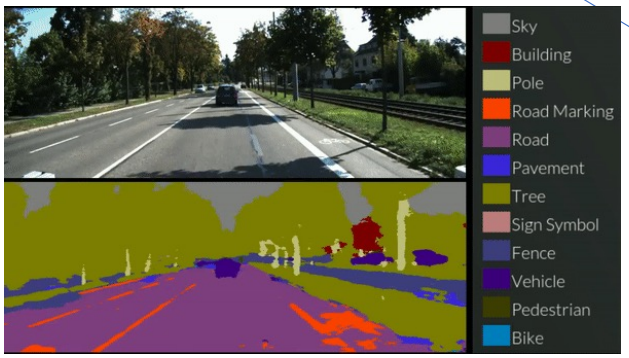
Classification, easy these days

Object detection, still a lot harder

What is in the image?

Where in the image is it?

Segmentation

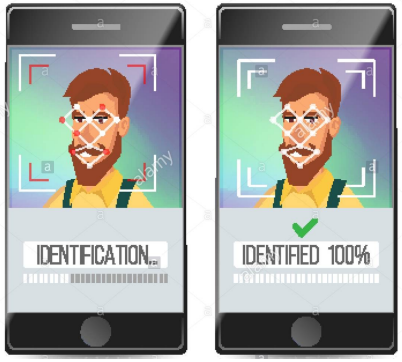


What am I seeing?

Find a specific shape in the image

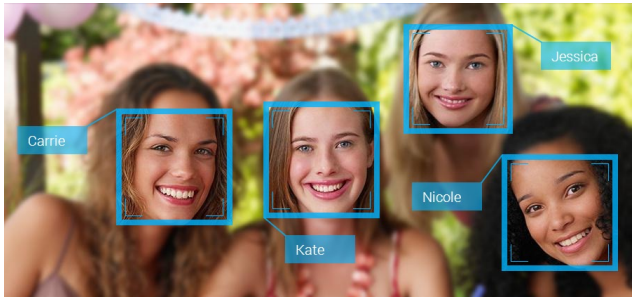
Is this person bob?

Face verification (1:1 matching)



Who is in this image?

Face recognition (1:N matching)

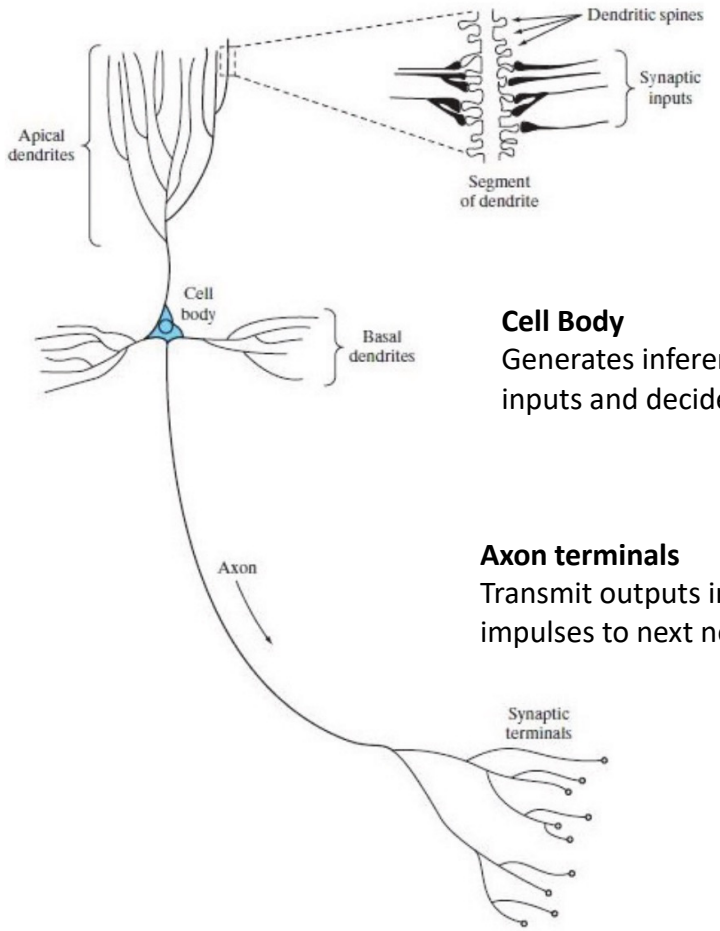


Is there a face in this image?

Face detection

Landmark detection

Biological neurons

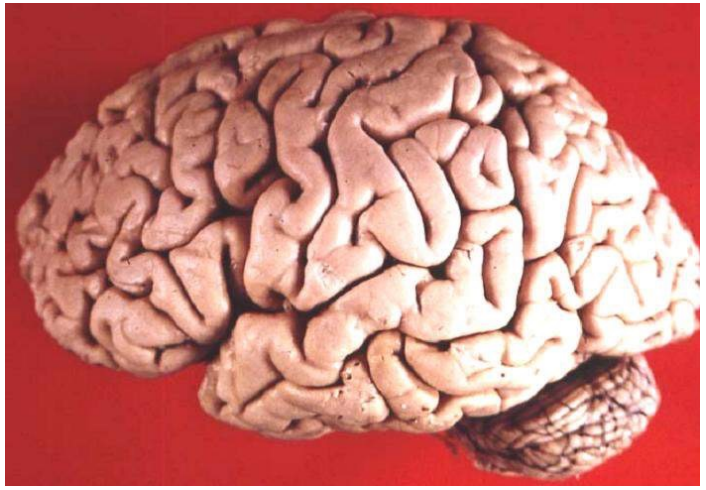


Zayegh, Amer, and Nizar Al Bassam.
"Neural network principles and applications."
Digital Systems. IntechOpen, 2018.

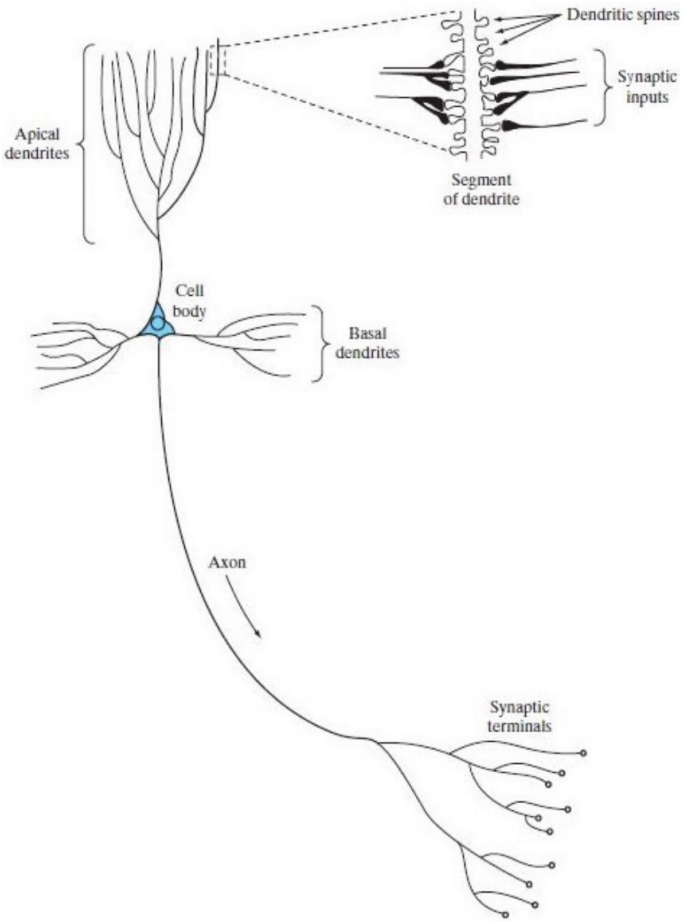
Dendrites
Input from other neurons in the network in form of electrical impulses

Cell Body
Generates inferences from the dendrite inputs and decides what action to take

Axon terminals
Transmit outputs in form of electrical impulses to next neuron

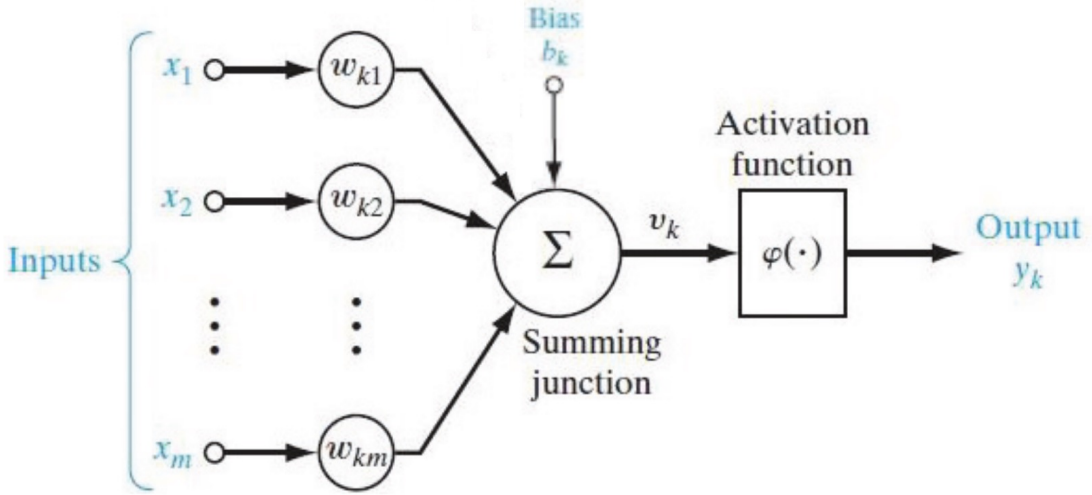


Biological neurons



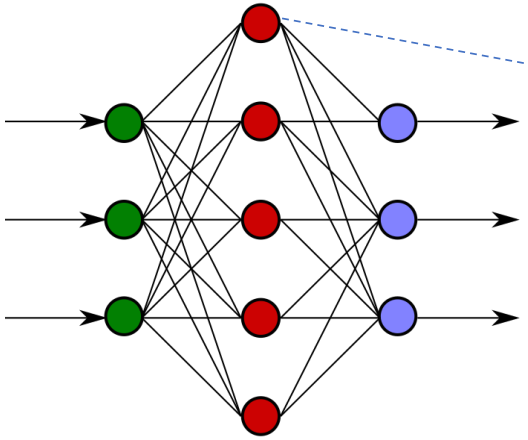
Zayegh, Amer, and Nizar Al Bassam.
"Neural network principles and applications."
Digital Systems. IntechOpen, 2018.

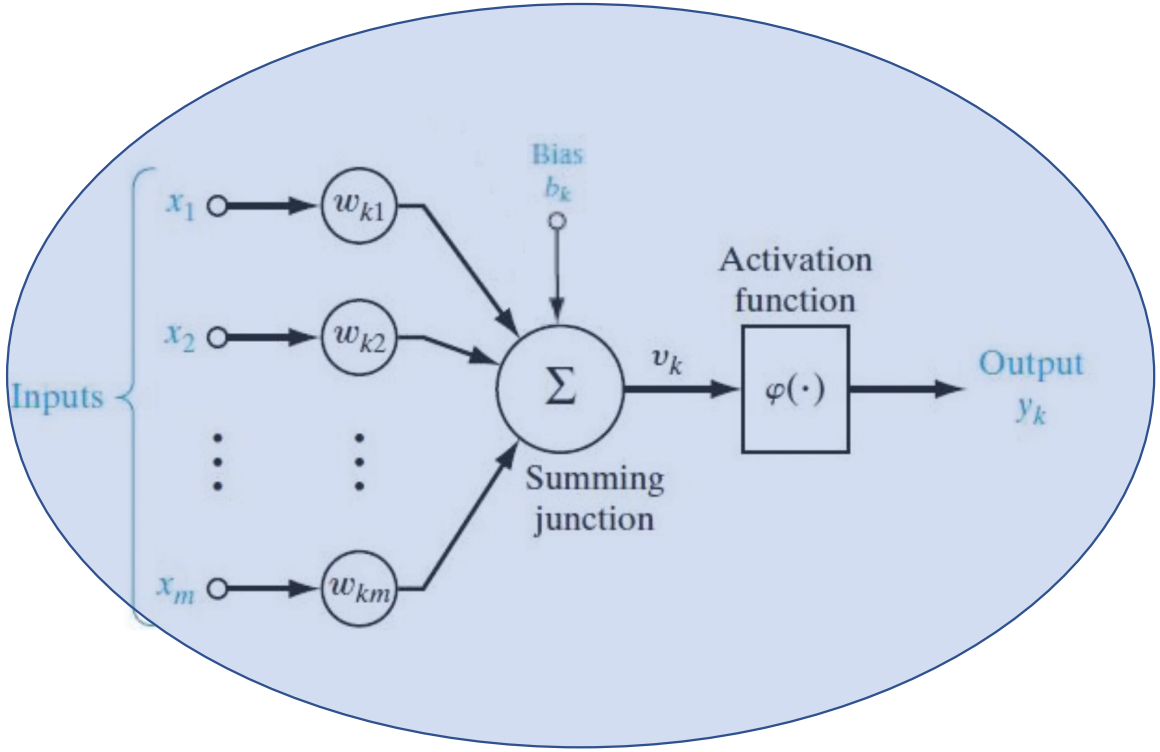
Artificial neurons
(It is only an equation)



Zayegh, Amer, and Nizar Al Bassam.
"Neural network principles and applications."
Digital Systems. IntechOpen, 2018.

Neural network



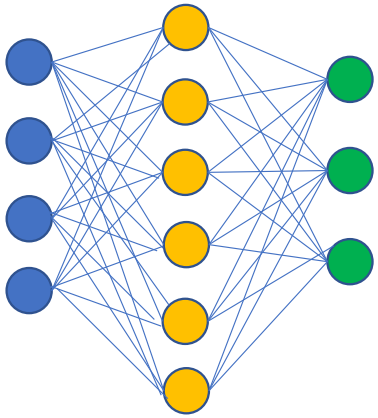


Input layer

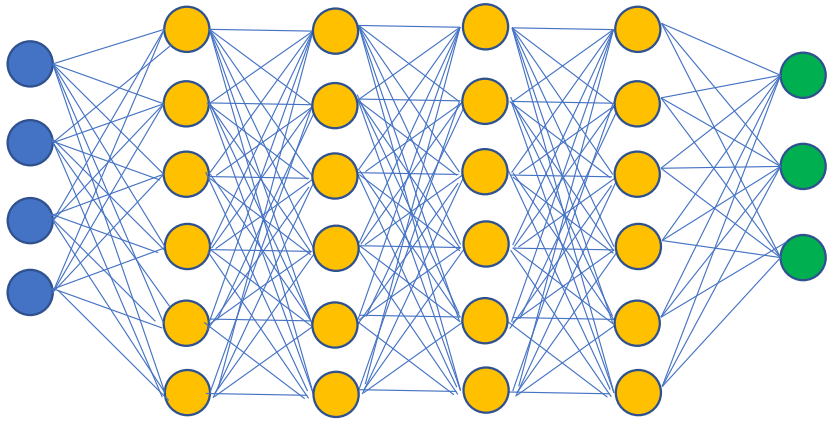
Hidden layer

Output layer

Deep learning / deep neural networks



Simple neural network



Deep neural network

Feed-forward network

Fully connected layers (FC)

Input layer neuron

Hidden layer neuron

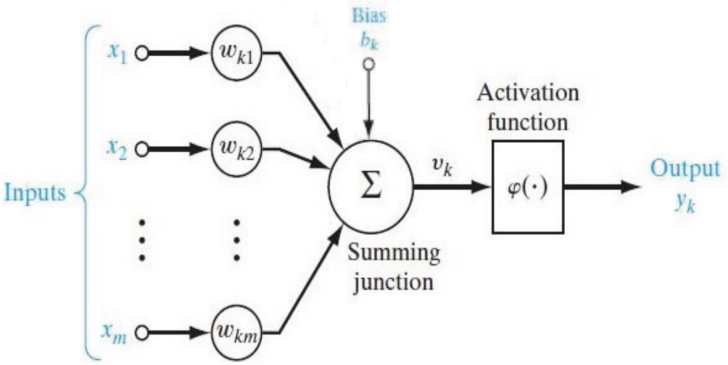
Output layer neuron

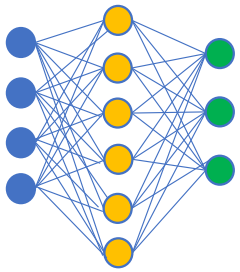
Neurons can have different activation funcitons

- Each connenction have a weight
- Each neuron have a bias

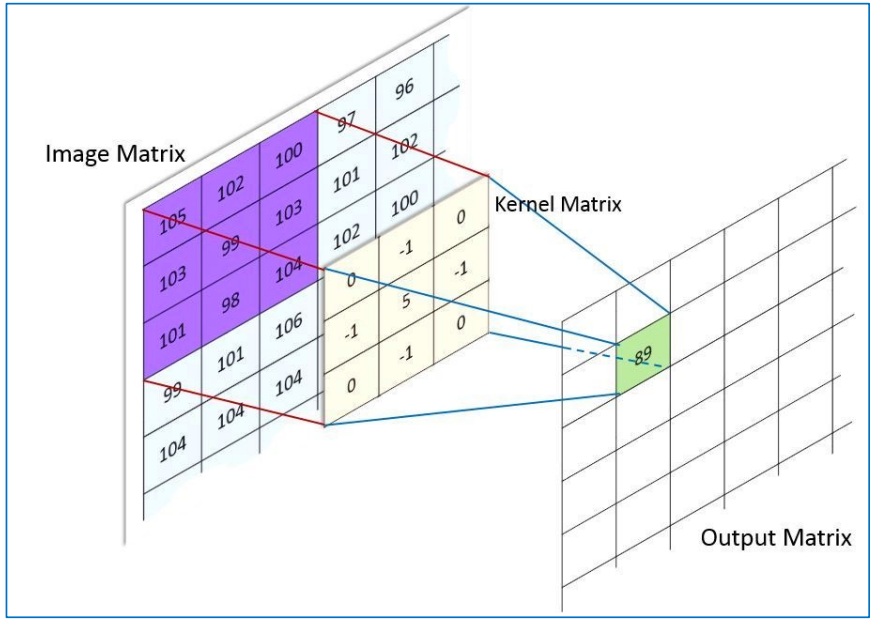
A deep neural network can have millions of parameters
These are learned using example data

Convolutional layers

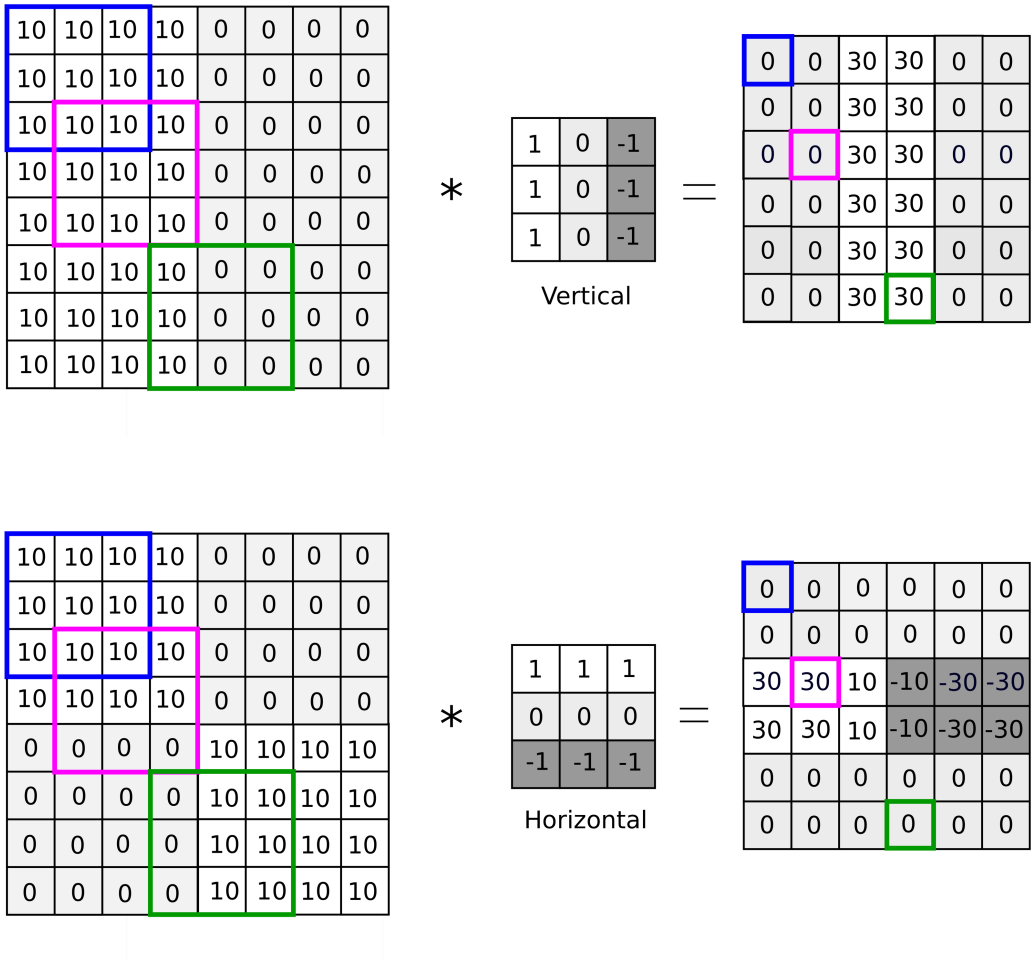




Fully connected layer



Convolution



1	0	-1
2	0	-2
1	0	-1

Sobel filter

3	0	-3
10	0	-10
3	0	-3

Scharr filter

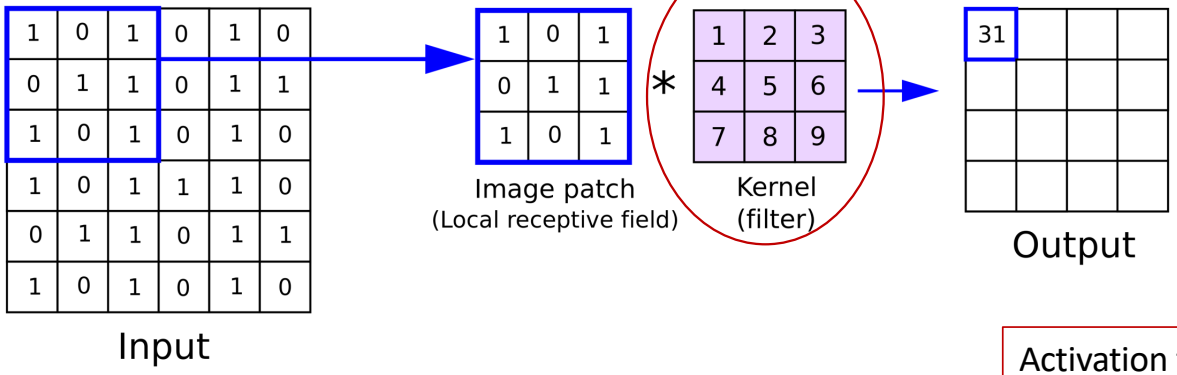
w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

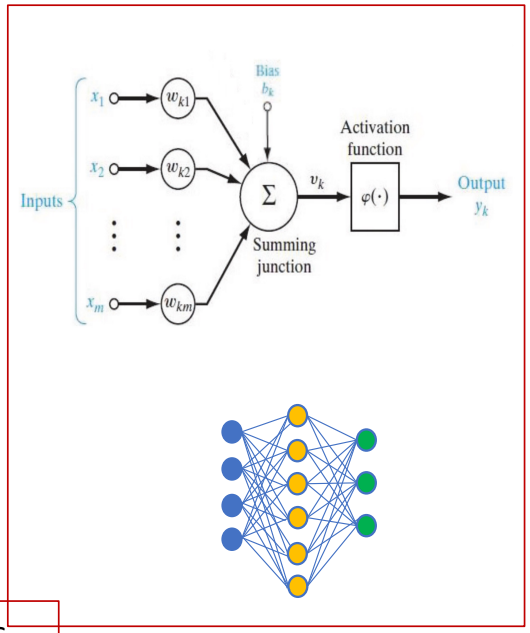
parameterized filter

https://anhreynolds.com/blogs/cnn.html

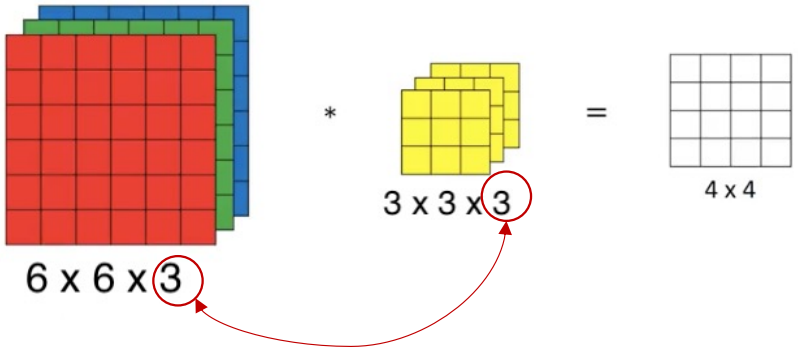
Convolution

Learnable parameters..



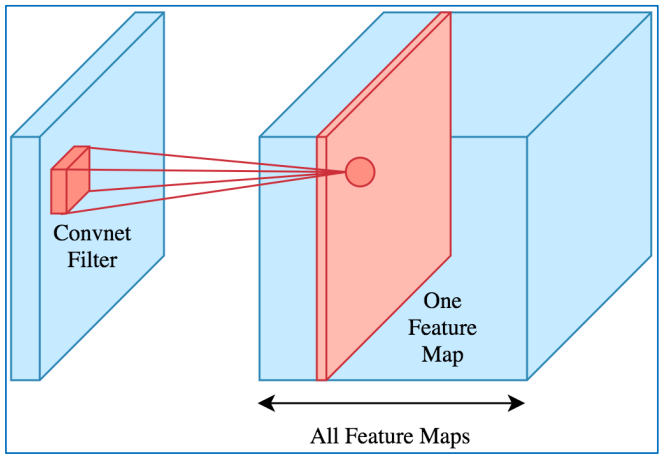


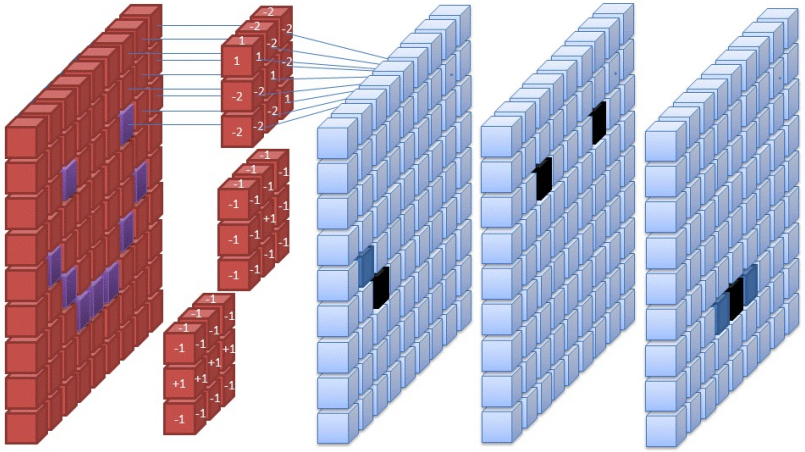
Activation function comes here (for each “pixel”)

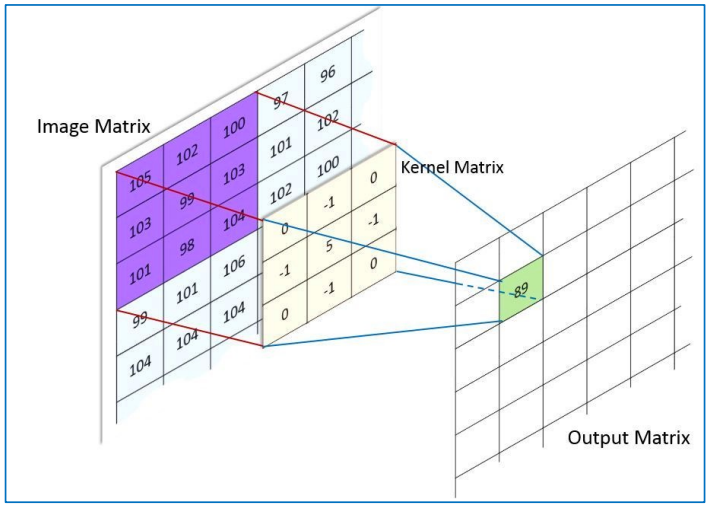


Stride s = 1,
padding p=0, (why is output smaller?)
1 filter

Convolutional layers





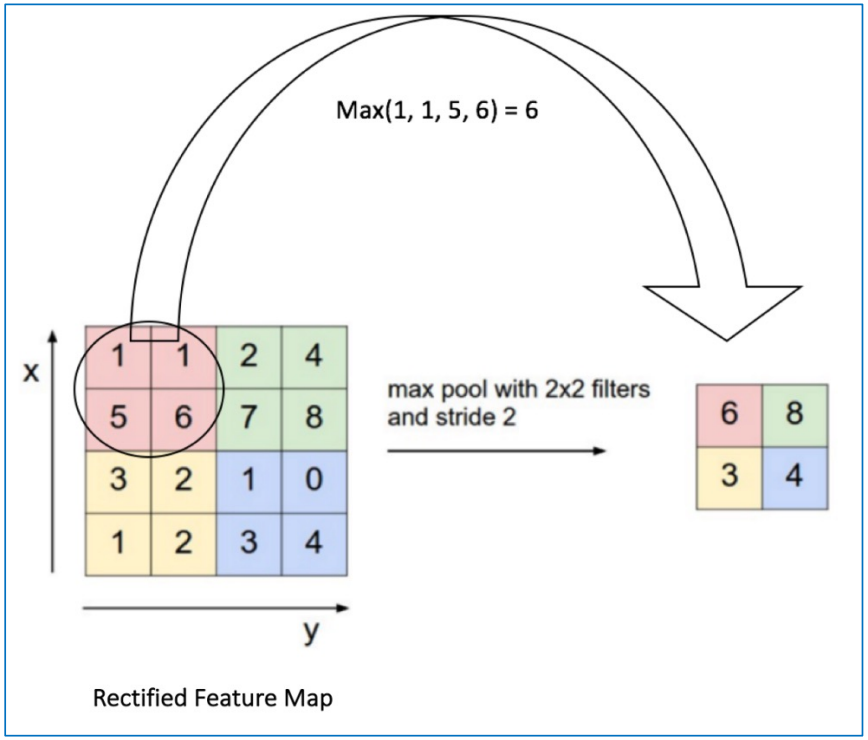


Many convolutional filters are used, give a range of feature maps. The filter coefficients are LEARNED (machine learning).

https://commons.wikimedia.org/wiki/File:3_filters_in_a_Convolutional_Neural_Network.gif

https://brilliant.org/wiki/convolutional-neural-network/

Pooling layer

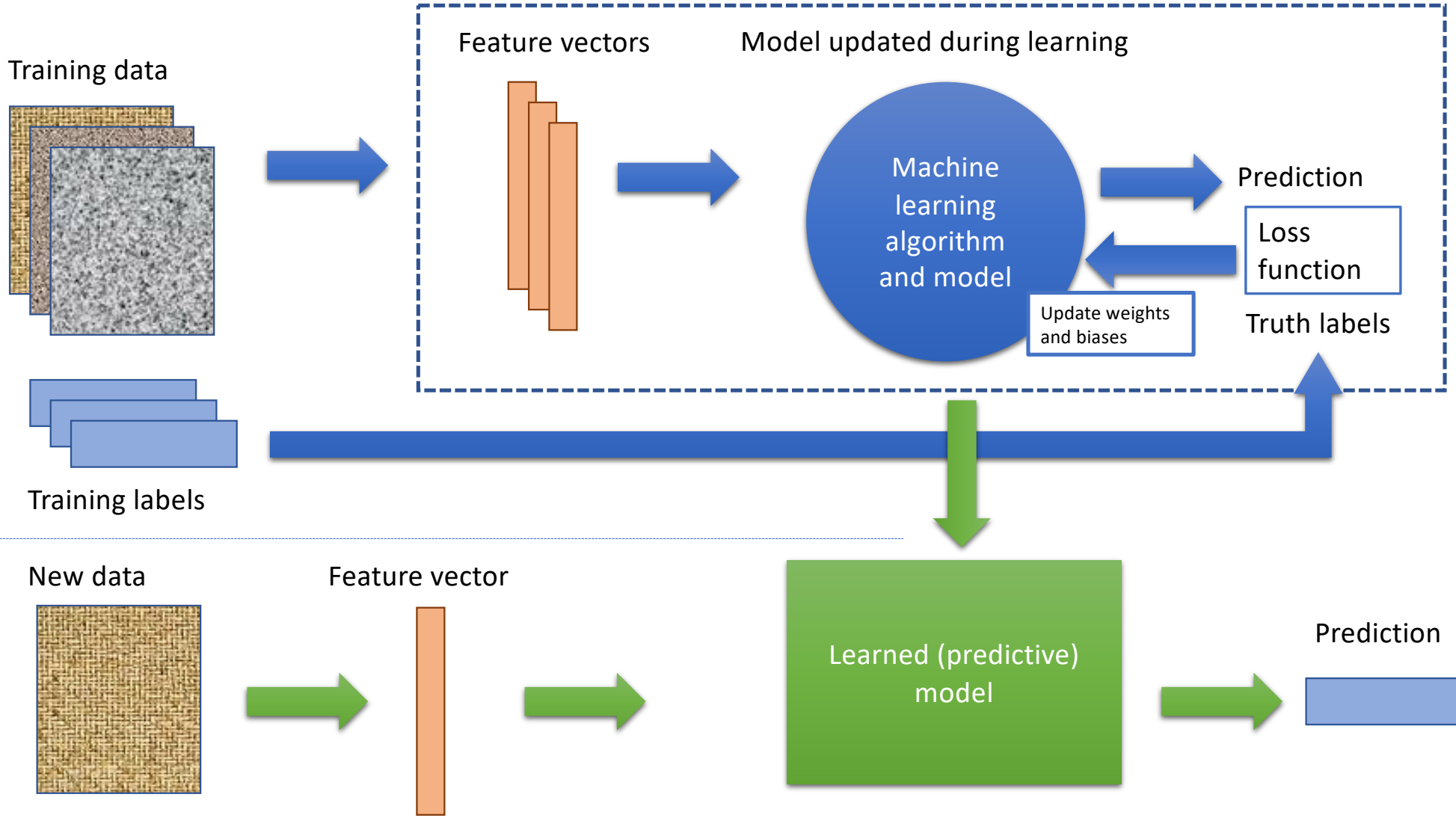


max pooling is done, reducing the size, but keeping the high outputs

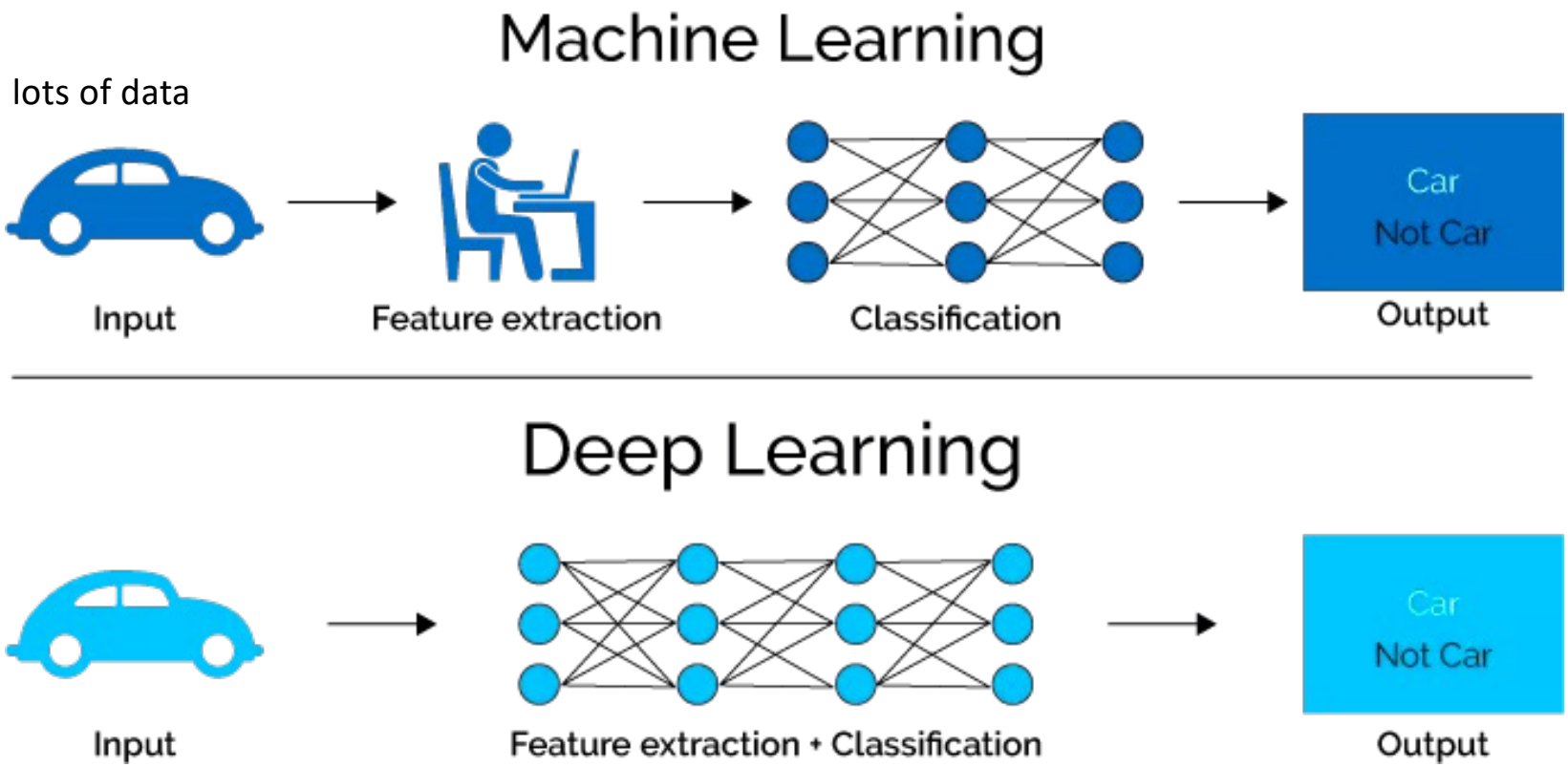
https://brilliant.org/wiki/convolutional-neural-network/


How do we learn the kernels/filters?
Machine learning
just a little teaser

Supervised learning



Need lots of data



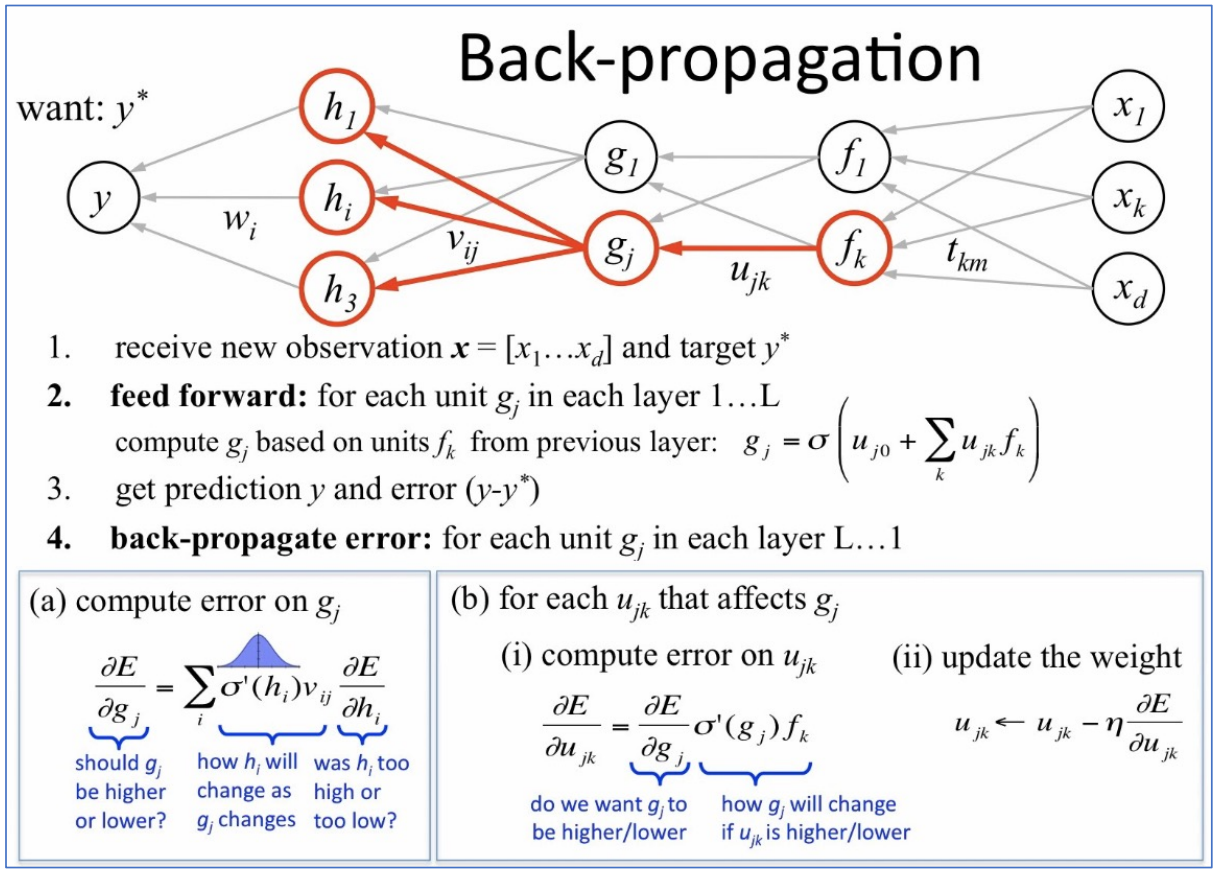
Need even more data

https://thedatascientist.com/what-deep-learning-is-and-isnt/

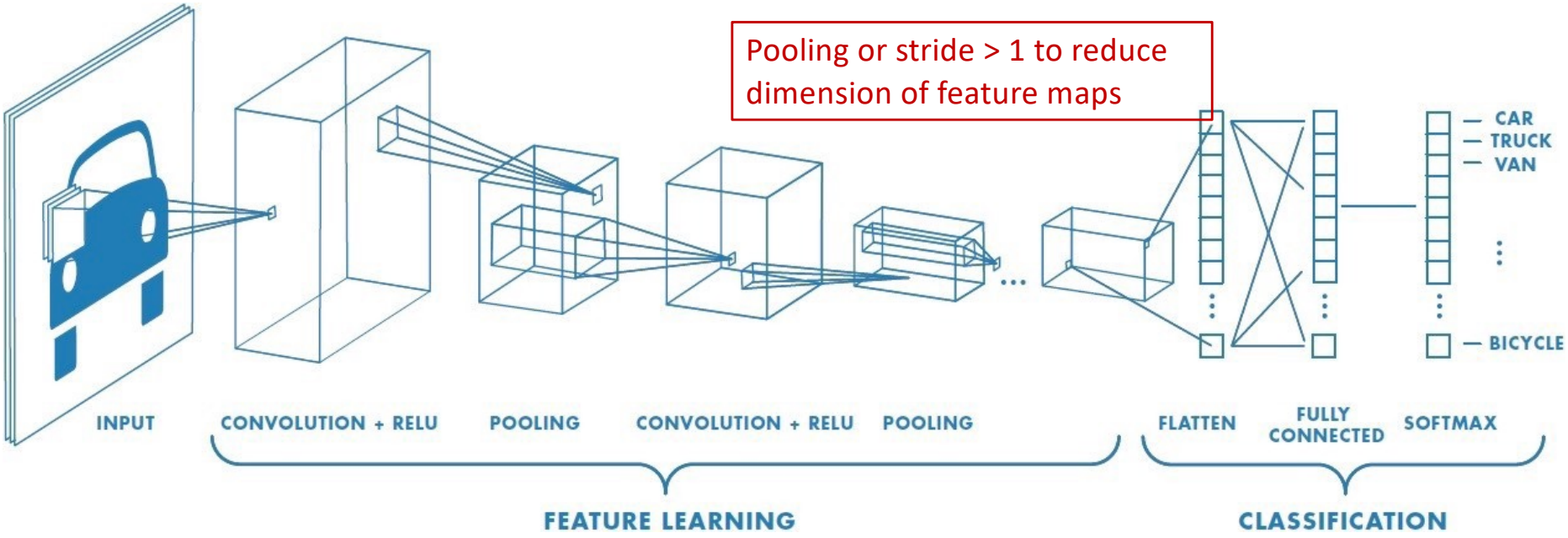
Supervised learning – how?

- Loss function
- Feed forward to compute loss
- Backpropagation of the error
- Update weights to reduce error
- Repeated many epochs

The magic force lies in a relevant loss function

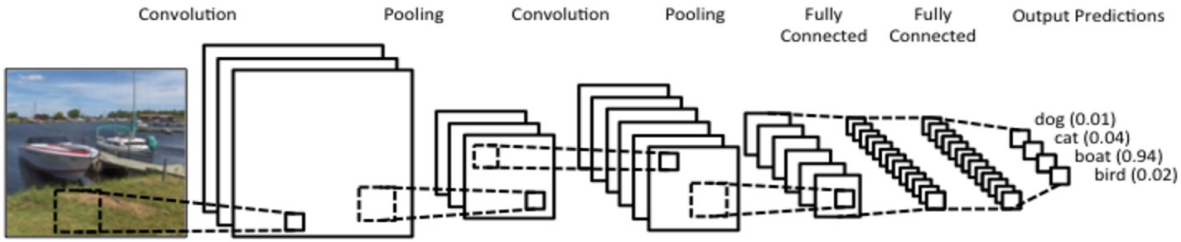


attribution: Victor Lavrenko
https://www.youtube.com/watch?v=An5z8lR8asY 6 min. video



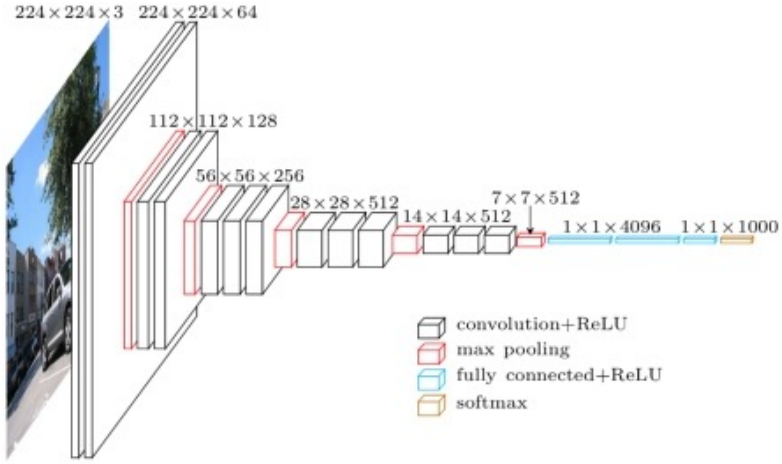
https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53
https://datahacker.rs/edge-detection/

Deep Neural Networks – works ”magically” good for many tasks



And really; it is all math…

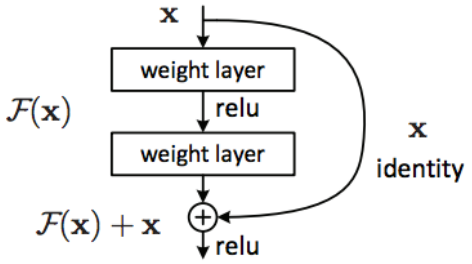
Backpropagation of the error, finding the derivatives for each layer, gradient decent for updating parameter (weigths) of the network …

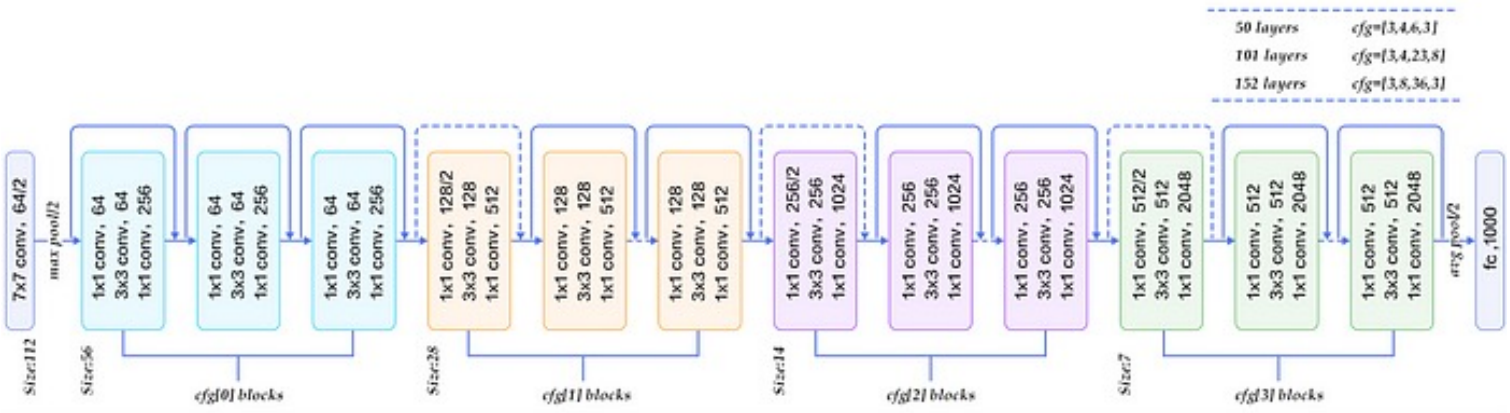


VGG16 network (16 layers + 5 pooling layers)

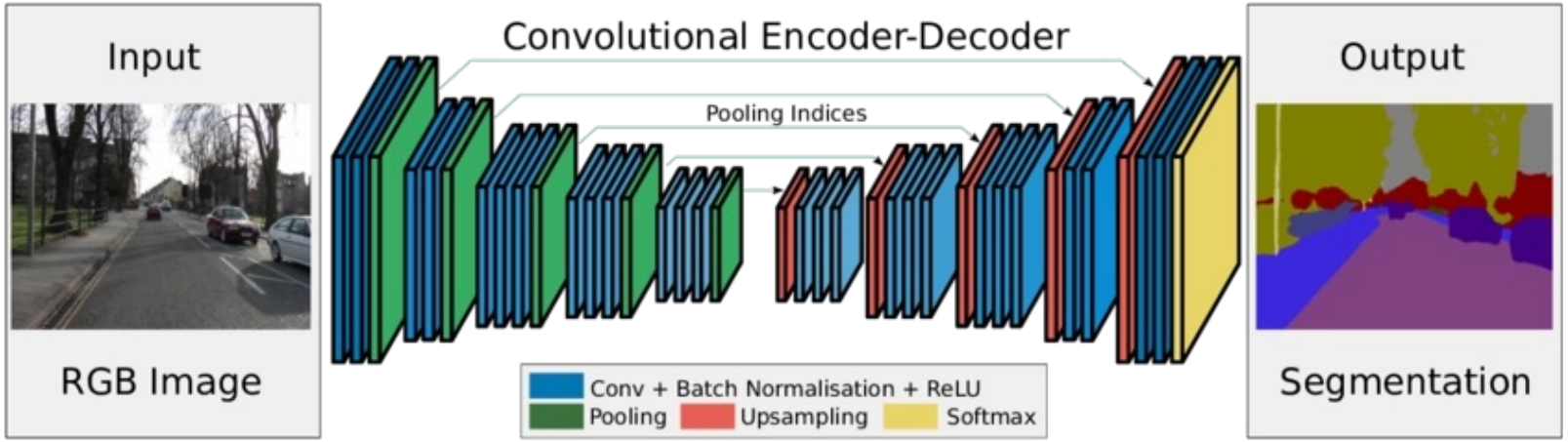
ResNet50

ResNet, short for Residual Networks is a classic neural network used as a backbone for many computer vision tasks. Introduced the skip-connections



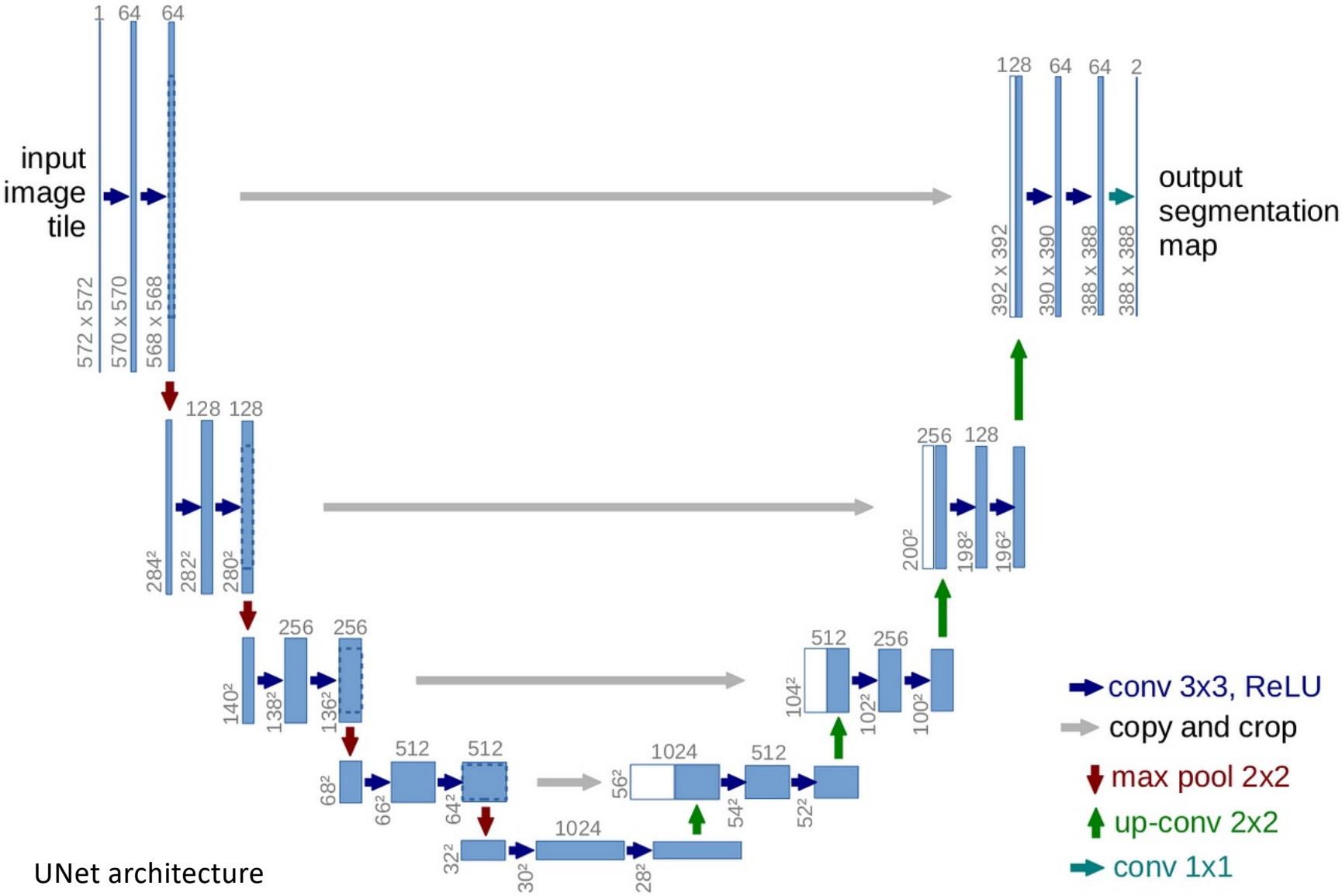


SegNet: SegNet was introduced as an architecture that can perform real-time semantic segmentation on high-resolution images.



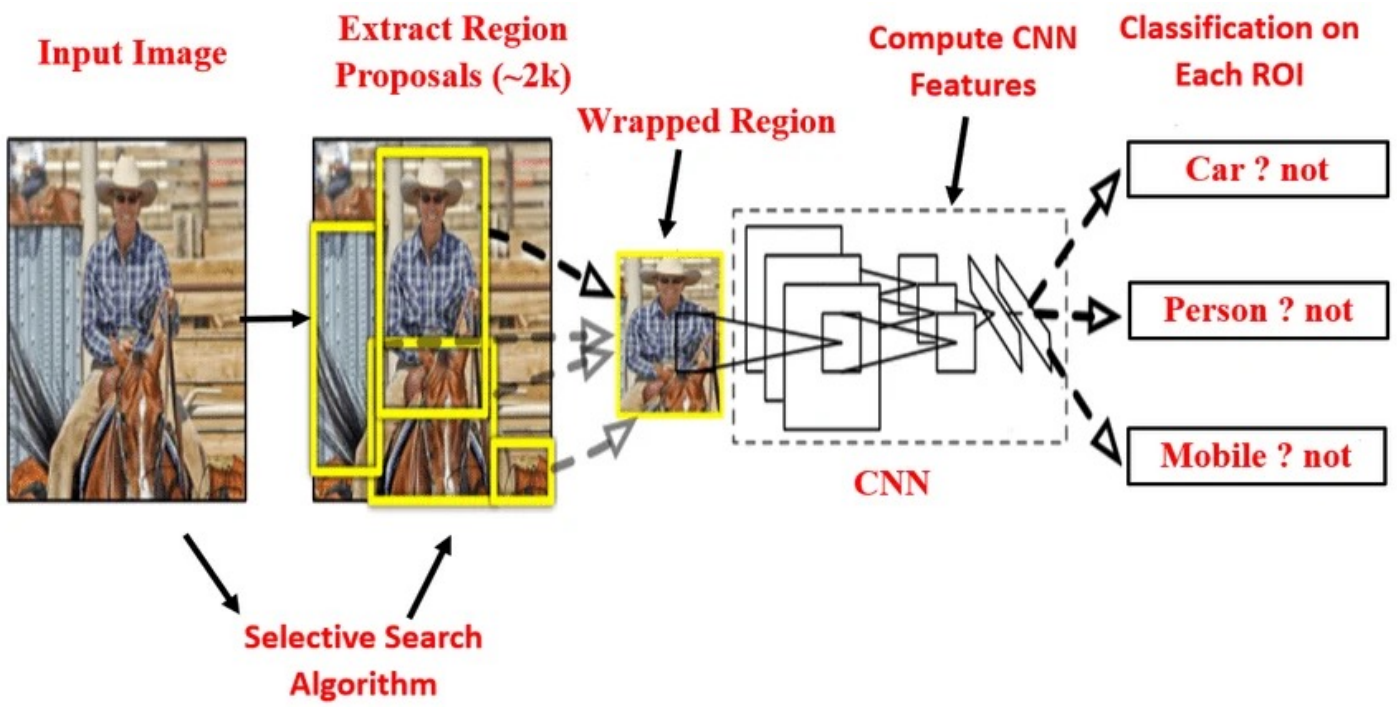
https://arxiv.org/pdf/1511.00561.pdf

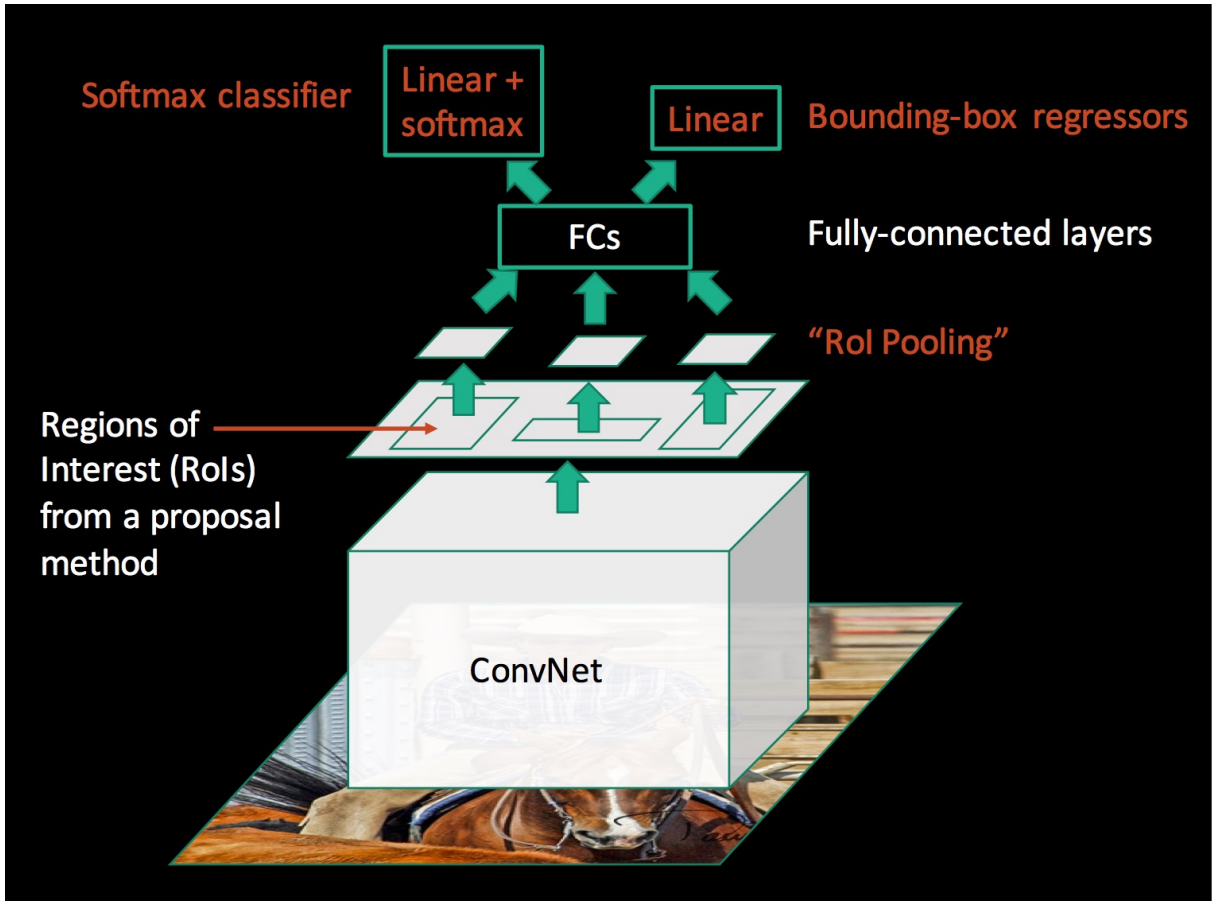
https://www.superannotate.com/blog/guide-to-convolutional-neural-networks

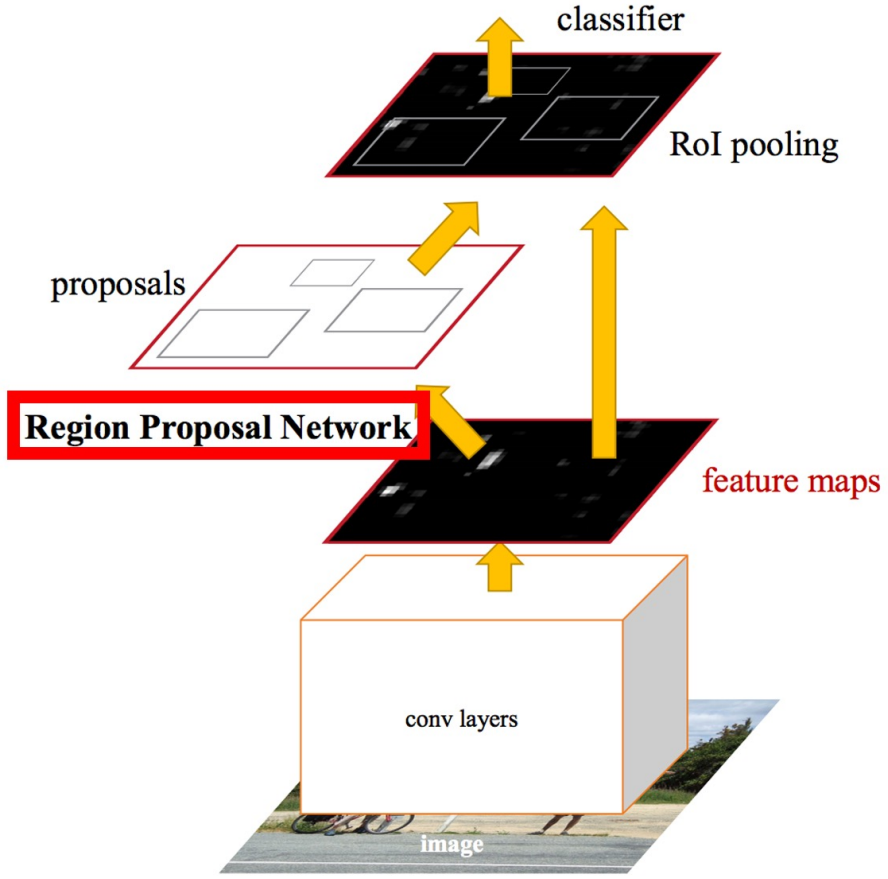


UNet architecture

RCNN: The Region-based Convolutional Neural Network (RCNN) was proposed by Ross Girshick et al. in 2014 and was one of the first successful deep learning approaches to object detection.




Softmax classifier
Linear + softmax
Linear
Bounding-box regressors
FCs
Fully-connected layers
"RoI Pooling"
Regions of Interest (RoIs) from a proposal method
ConvNet


classifier
RoI pooling
proposals
Region Proposal Network
feature maps
conv layers
image

RetinaNet is a one-stage object detection model

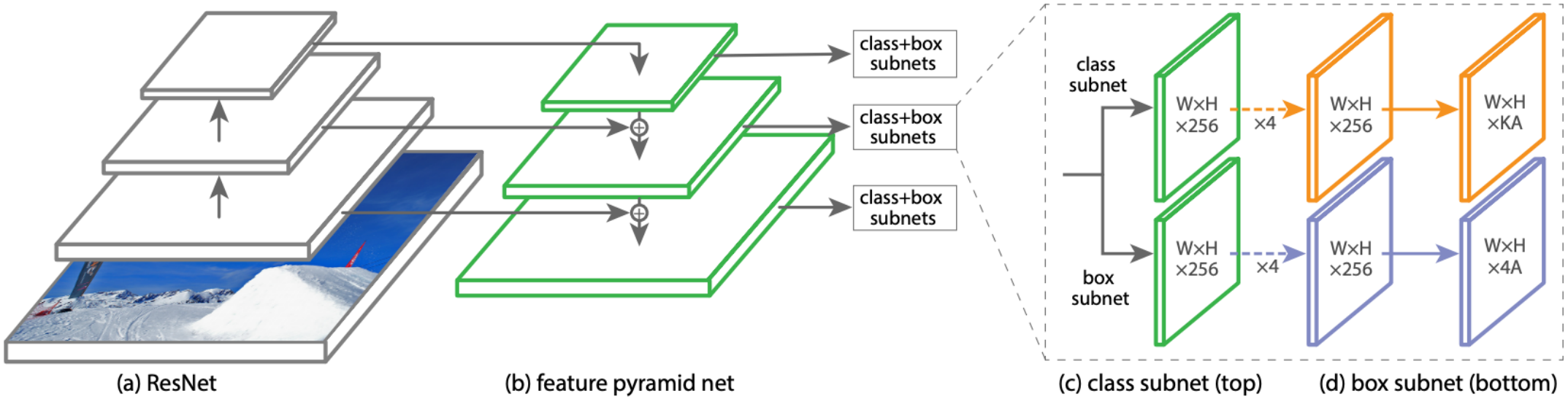
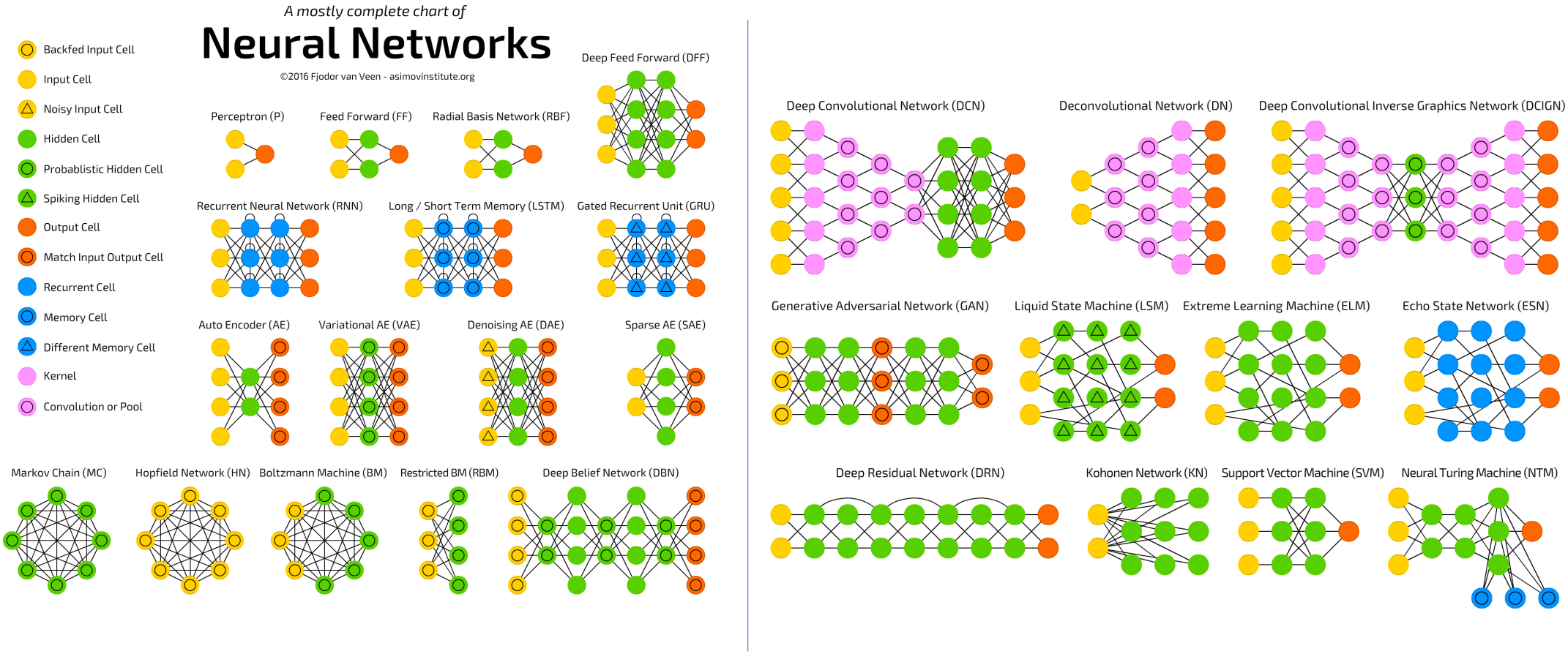
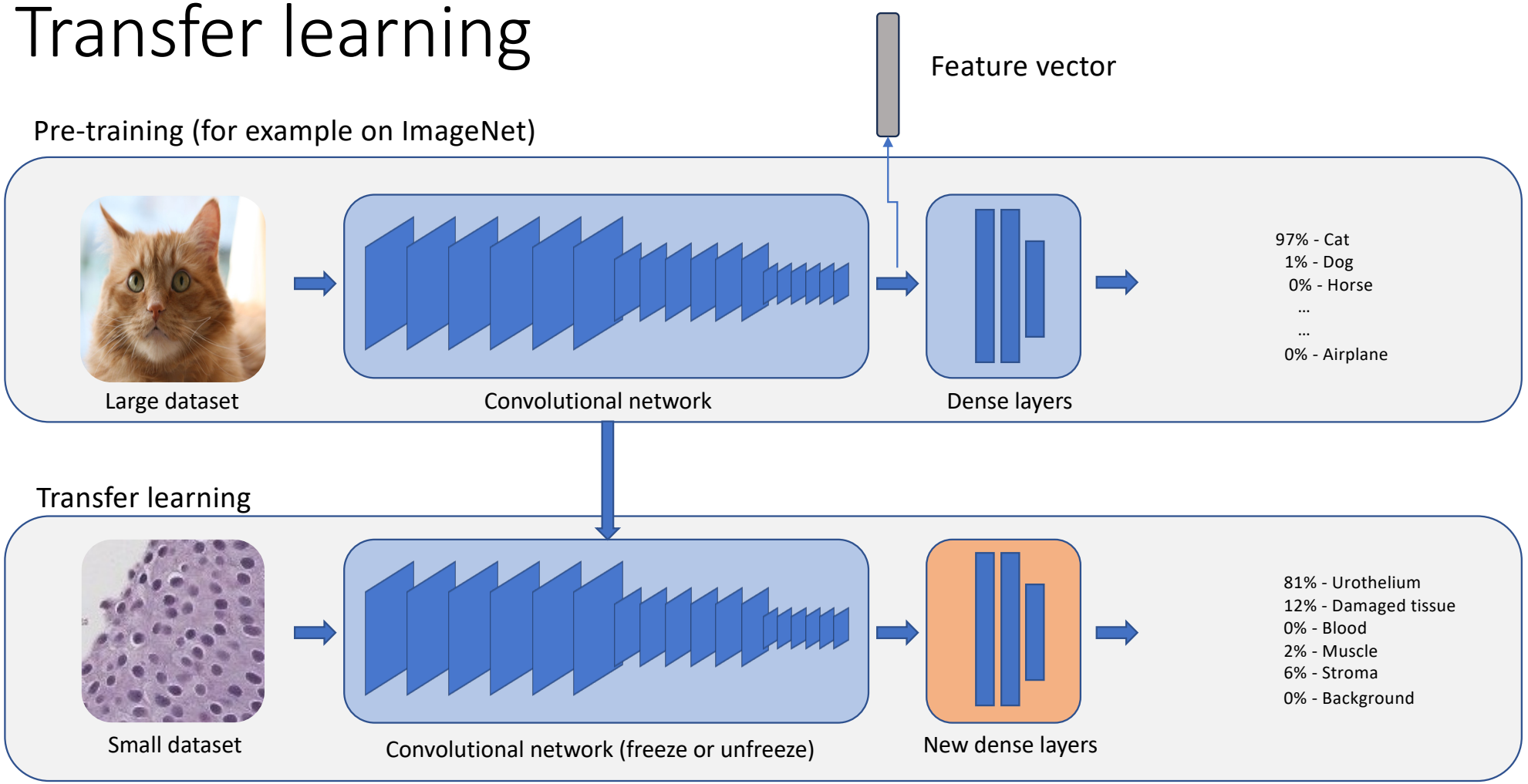


Figure 3. The one-stage **RetinaNet** network architecture uses a Feature Pyramid Network (FPN) [20] backbone on top of a feedforward ResNet architecture [16] (a) to generate a rich, multi-scale convolutional feature pyramid (b). To this backbone RetinaNet attaches two subnetworks, one for classifying anchor boxes (c) and one for regressing from anchor boxes to ground-truth object boxes (d). The network design is intentionally simple, which enables this work to focus on a novel focal loss function that eliminates the accuracy gap between our one-stage detector and state-of-the-art two-stage detectors like Faster R-CNN with FPN [20] while running at faster speeds.

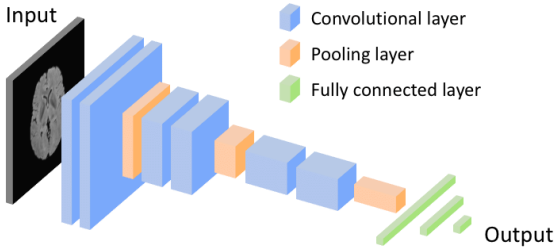


https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

Transfer learning



Intro to Deep Neural Network for image analysis



Three points form the topic:

1. What is a artificial neuron?
   - ✓ An equation, linear combination of many inputs with learnable weights, followed by nonlinearity (activation function)
2. How does convolutional neural network relate to spatial filtering (convolution)
   - ✓ Closely related. The weights are in forms of filter kernels that are slided over the image as in spatial filter (followed by non-linearity) . Filters are learned, and there are many.
3. What is supervised learning?
   - ✓ Have example data with known “labels”. Send through network, compare output to known label, send “loss” back into netwrok and change all weights tiny bit to improve. Repeat many times.