SAARBRÜCKEN

6TH SUMMER SCHOOL ON COMPUTATIONAL INTERACTION

INFERENCE, OPTIMIZATION AND MODELING FOR THE ENGINEERING OF INTERACTIVE SYSTEMS | 13 - 18 JUNE 2022

Deep Learning for Human–Computer Interaction

Session 2: Supervised learning

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UNIVERSITÉ DU LUXEMBOURG

Learning outcomes

After this lecture you will be able to:

- Understand classification and regression tasks with DL
- Recognize popular network architectures

Classification

What is classification?

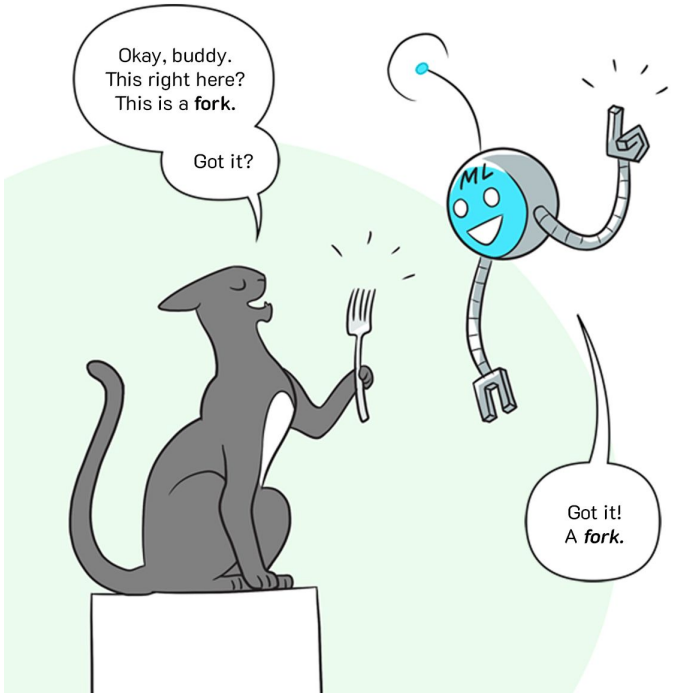
Predict a **discrete** value associated with a feature vector

Examples:

f(image) = cat

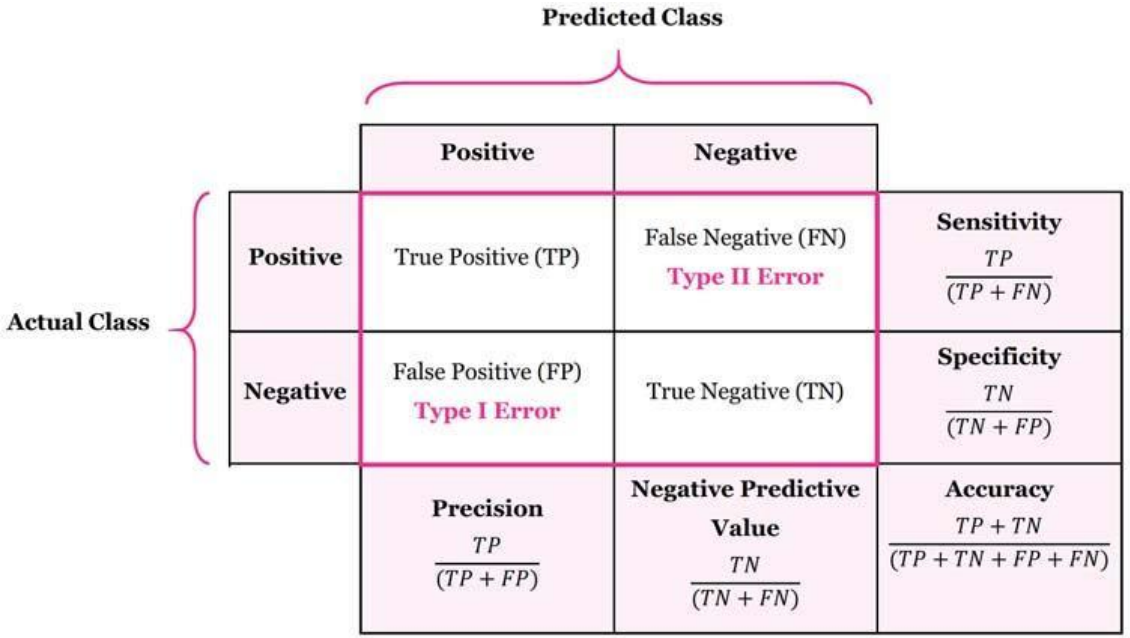
f(email) = spam

…



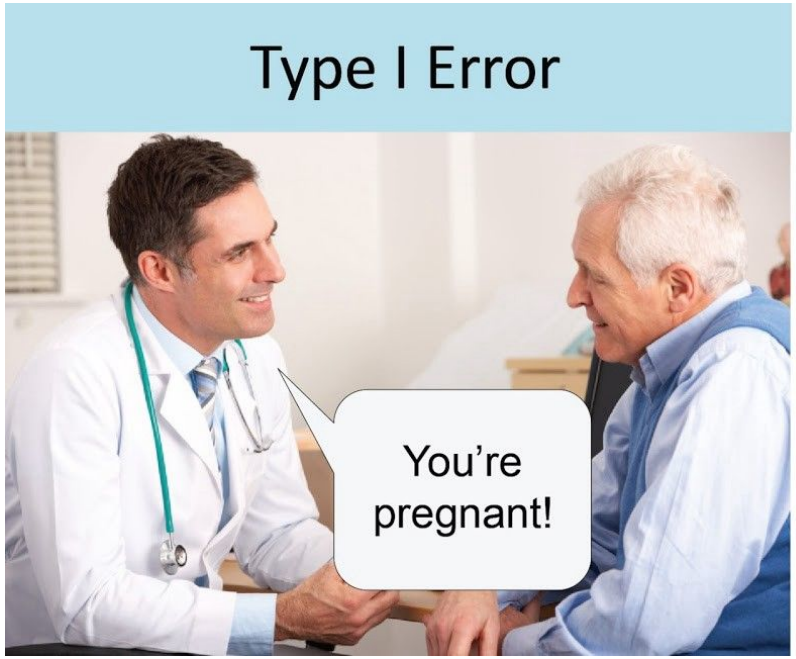
https://cloud.google.com/products/ai/ml-comic-1/

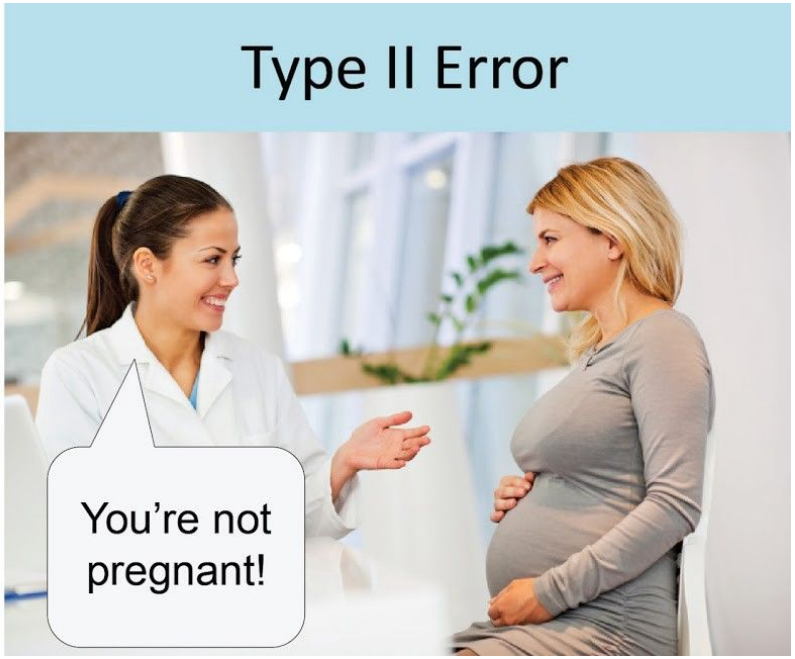
Confusion matrix



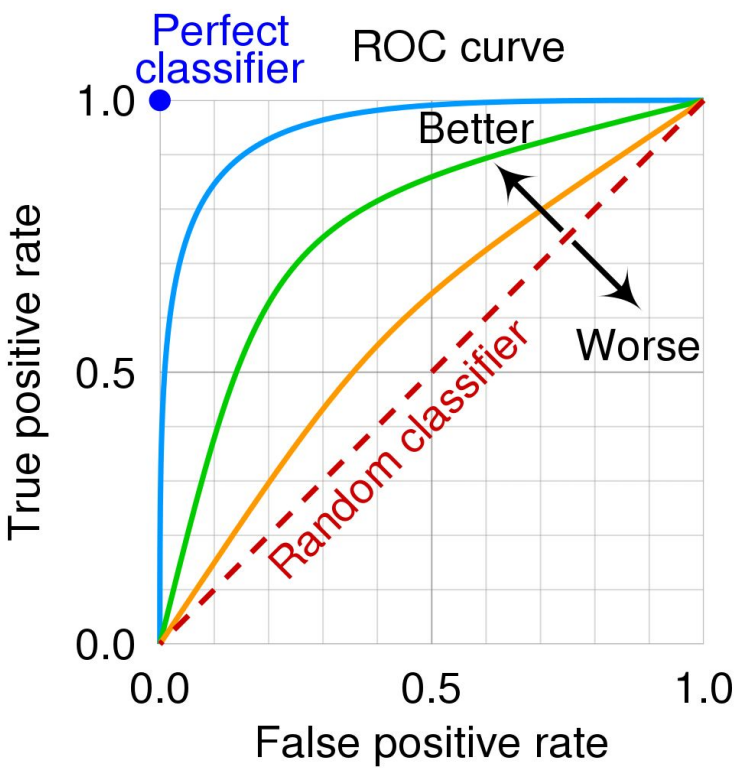
https://manisha-sirsat.blogspot.com/2019/04/confusion-matrix.html

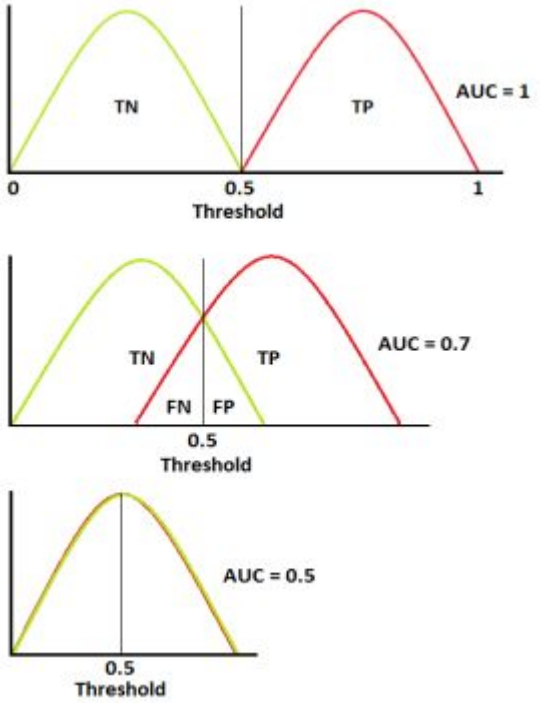
Types of error





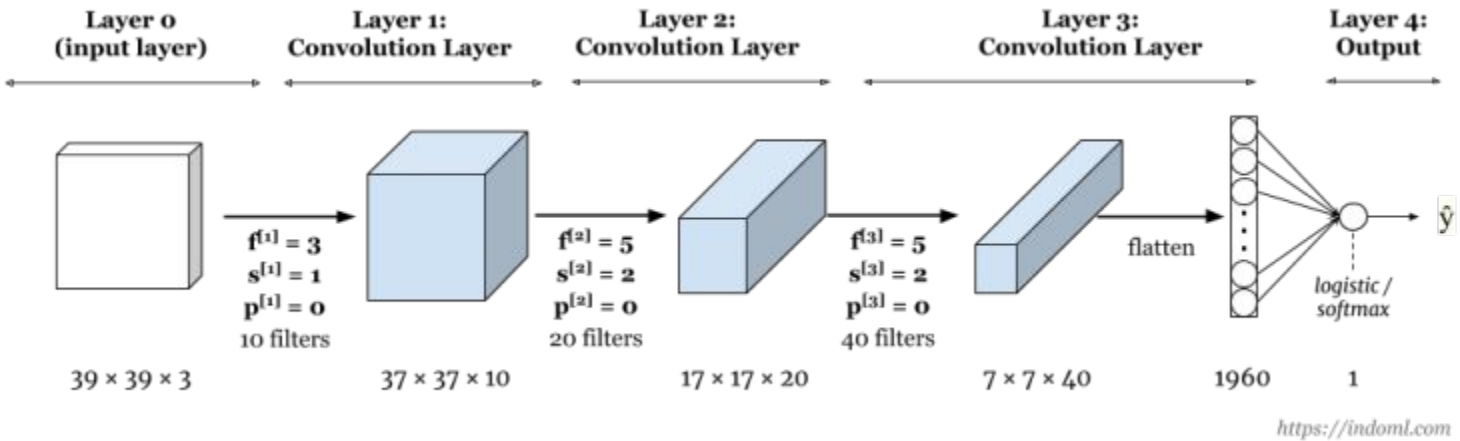
ROC and AUC





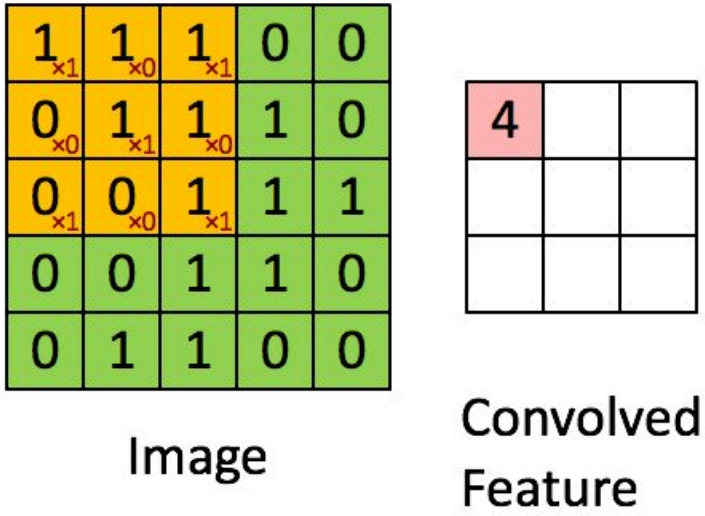
https://towardsdatascience.com/68b2303cc9c5

Convolutional Neural Net (CNN)



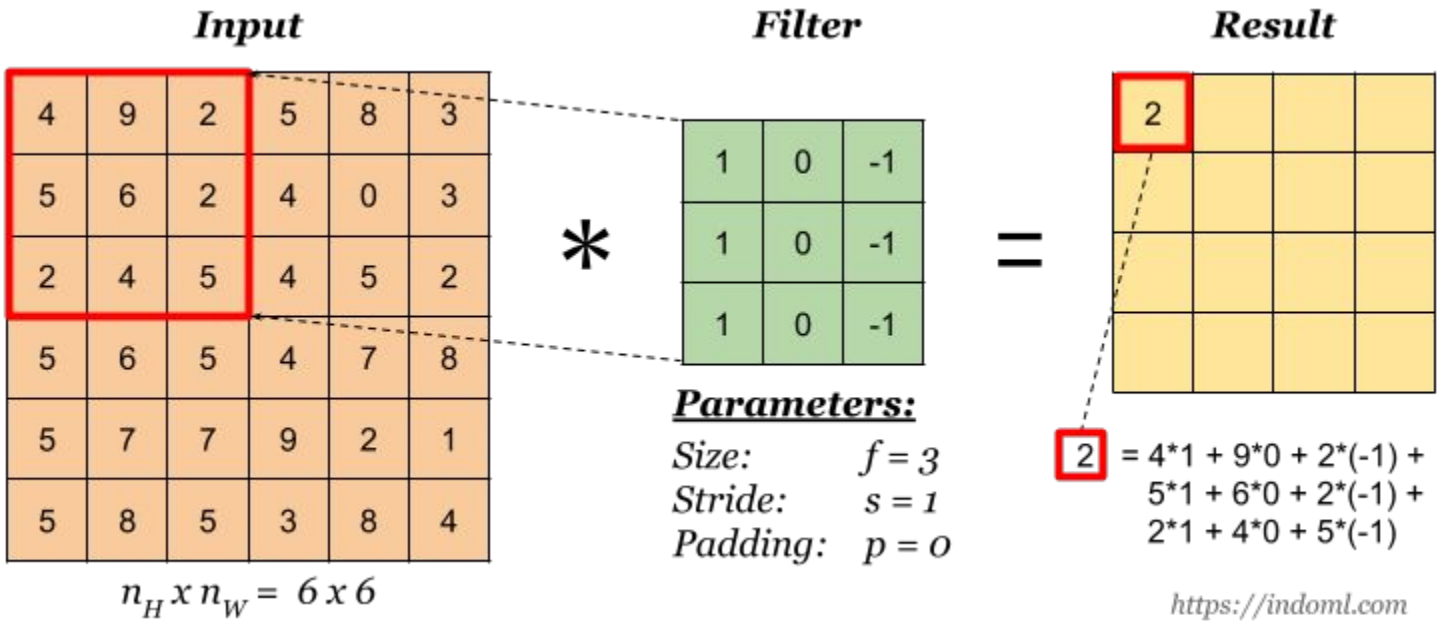
https://indoml.com/2018/03/07/student-notes-convolutional-neural-networks-cnn-introduction/

Convolution operation

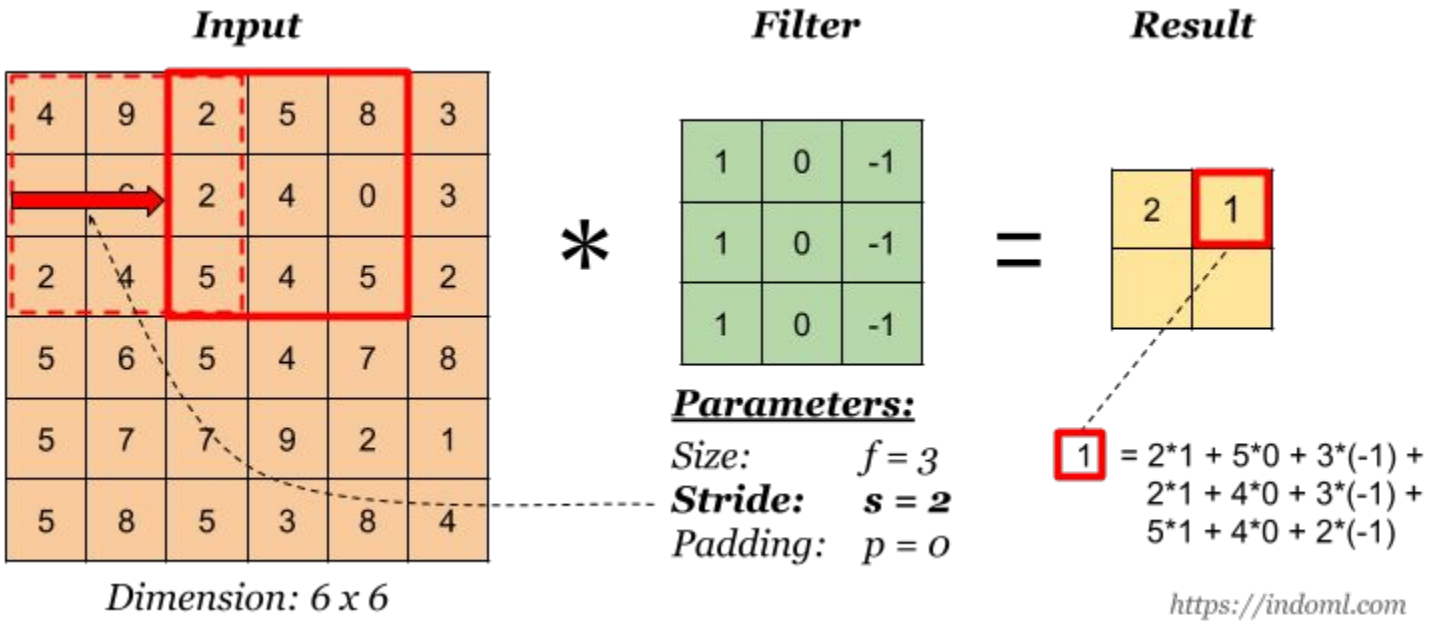


Demo at https://setosa.io/ev/image-kernels/

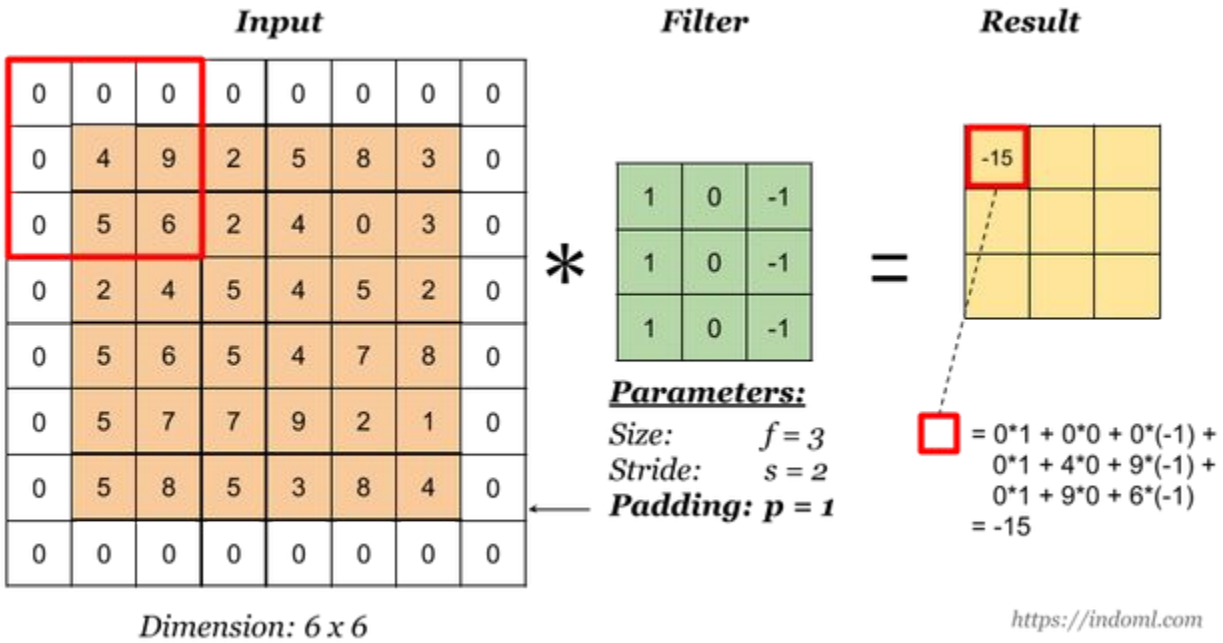
Convolution operation: **filters**



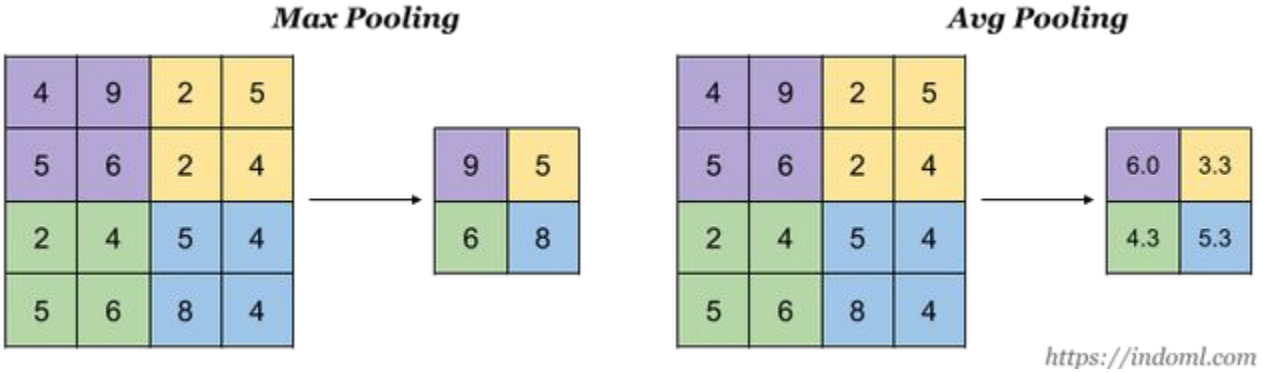
Convolution operation: **stride**



Convolution operation: **padding**



Pooling operation



Classic CNN architectures

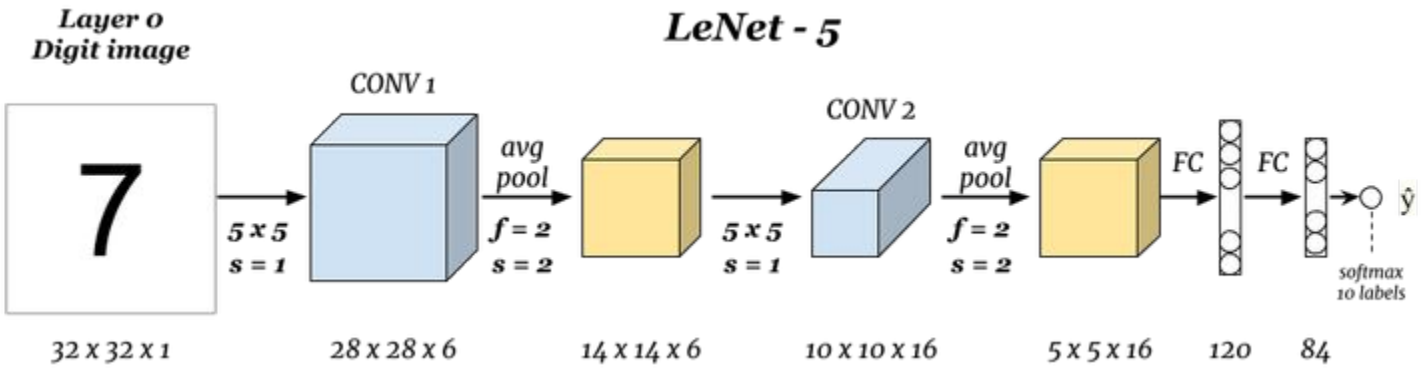
LeNet (1998)

AlexNet (2012)

VGGNet (2015)

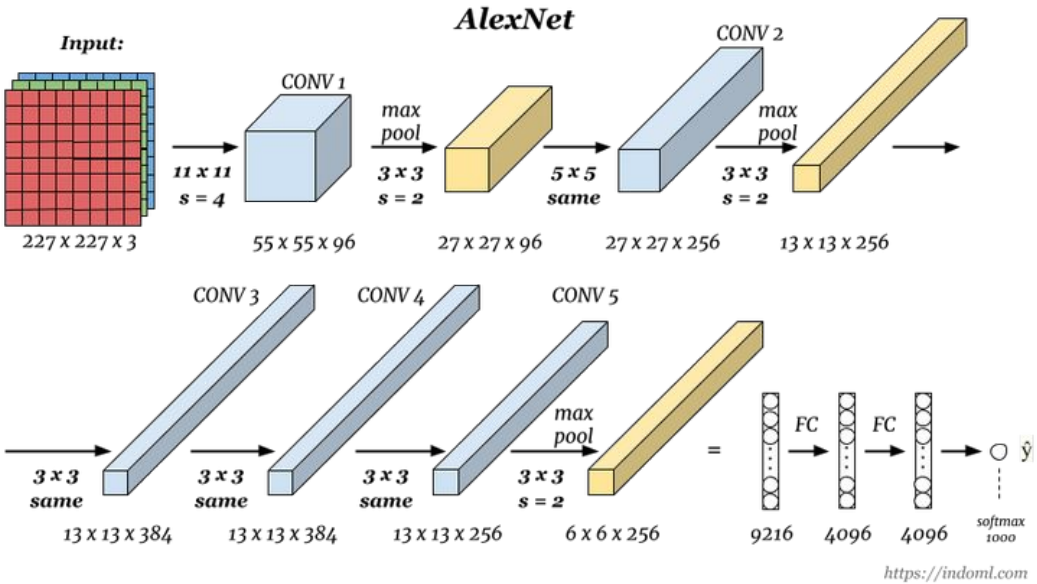
ResNet (2015)

Classic CNN: **LeNet**



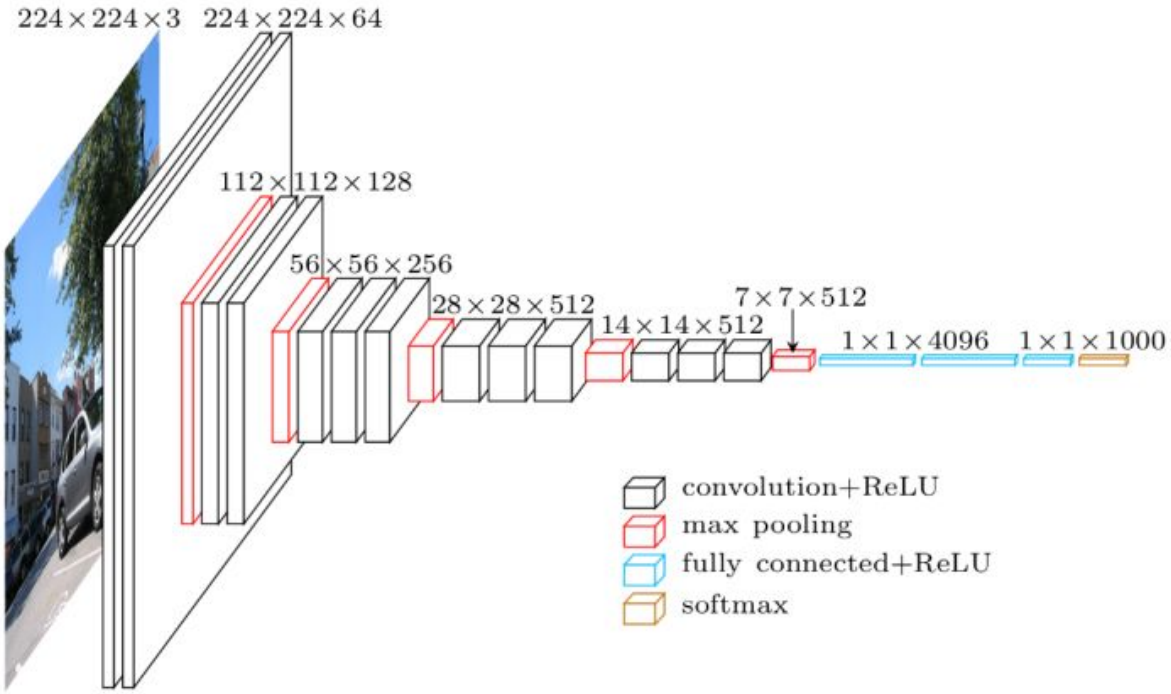
https://engmrk.com/lenet-5-a-classic-cnn-architecture/

Classic CNN: **AlexNet**



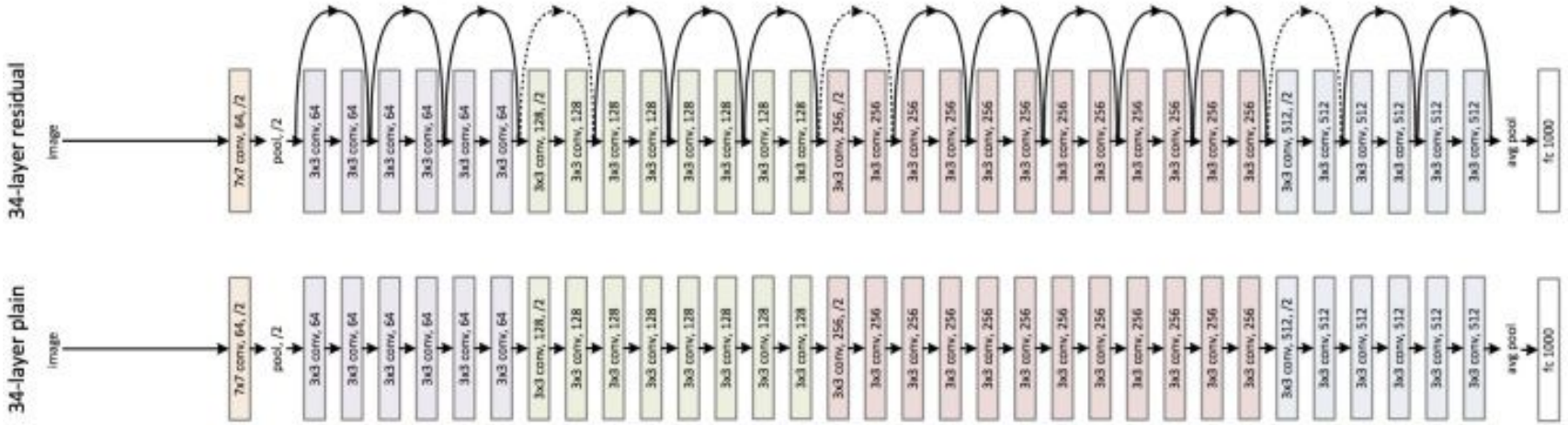
https://www.learnopencv.com/understanding-alexnet/

Classic CNN: **VGGNet**



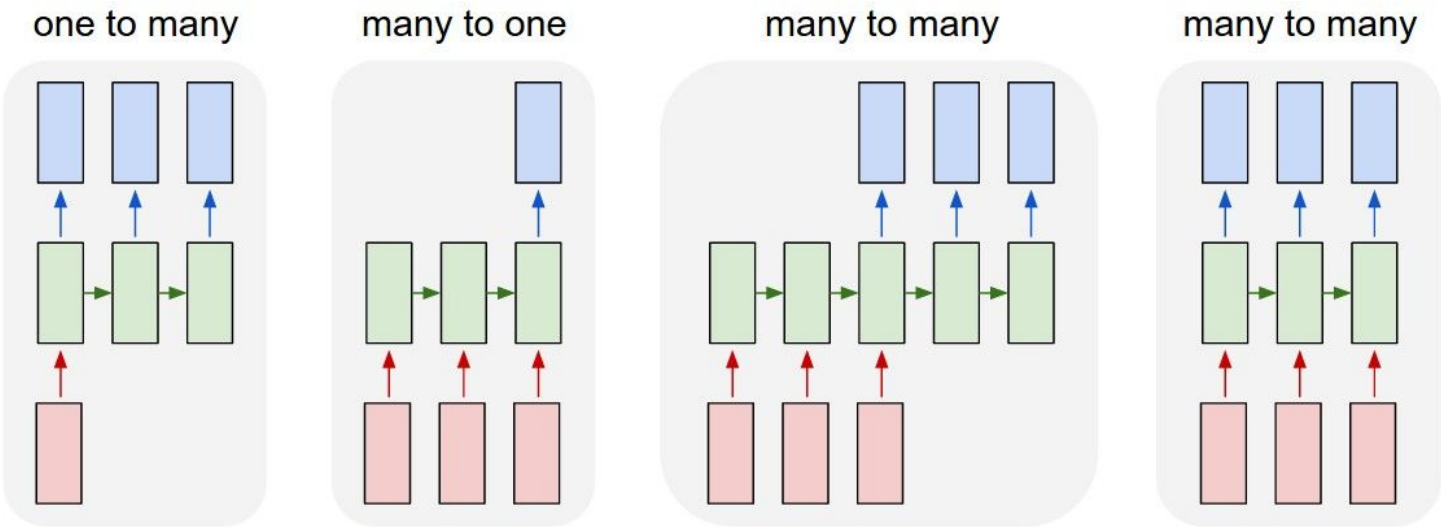
https://medium.com/coinmonks/d02355543a11

Classic CNN: **ResNet**



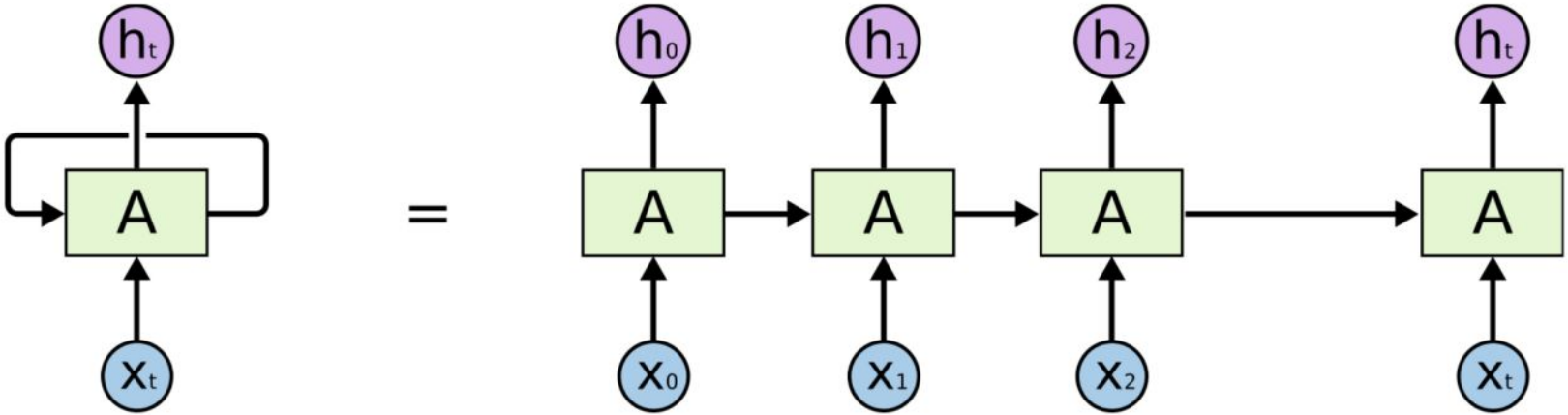
https://towardsdatascience.com/5281e2f56035

Recurrent Neural Net (RNN)



http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Recurrent Neural Net (RNN)



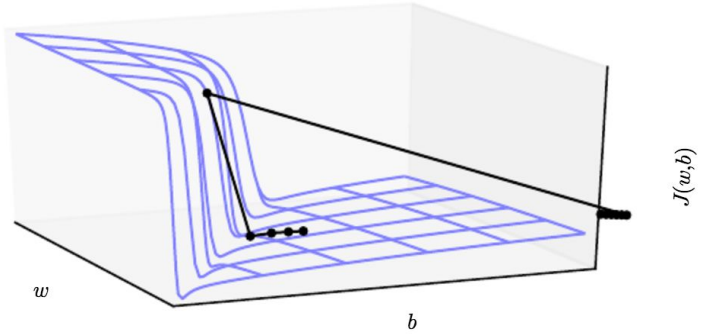
https://colah.github.io/posts/2015-08-Understanding-LSTMs/

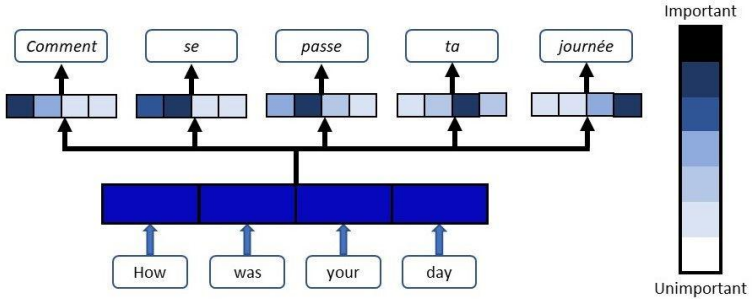
Challenges in RNNs

Vanishing gradients

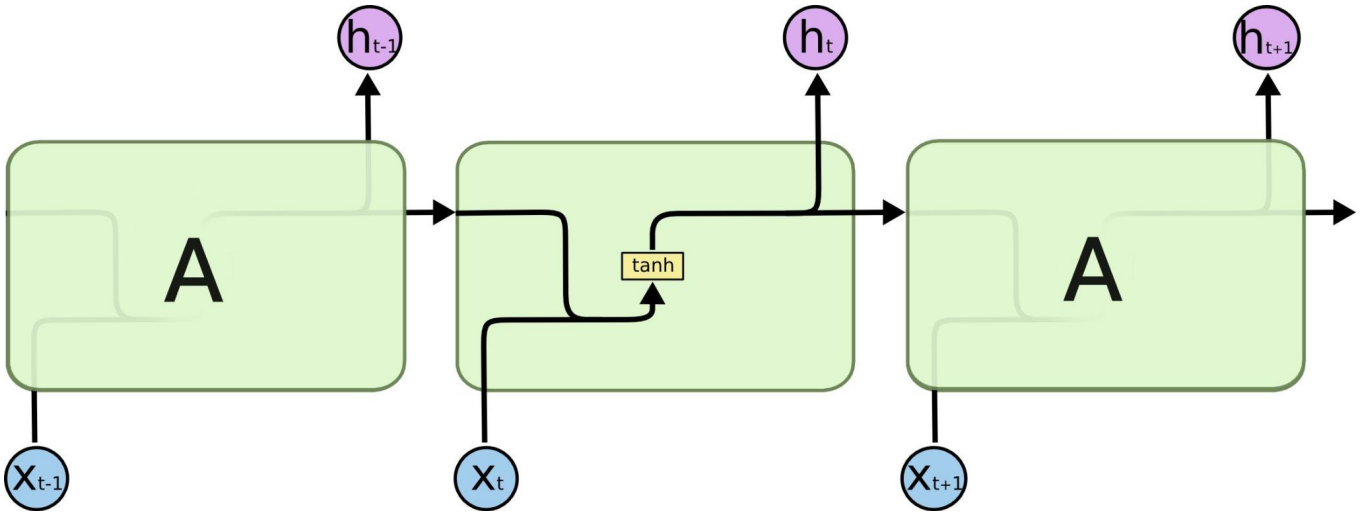
Exploding gradients (solved with *clipping*)

Coping with context (solved with *attention*)



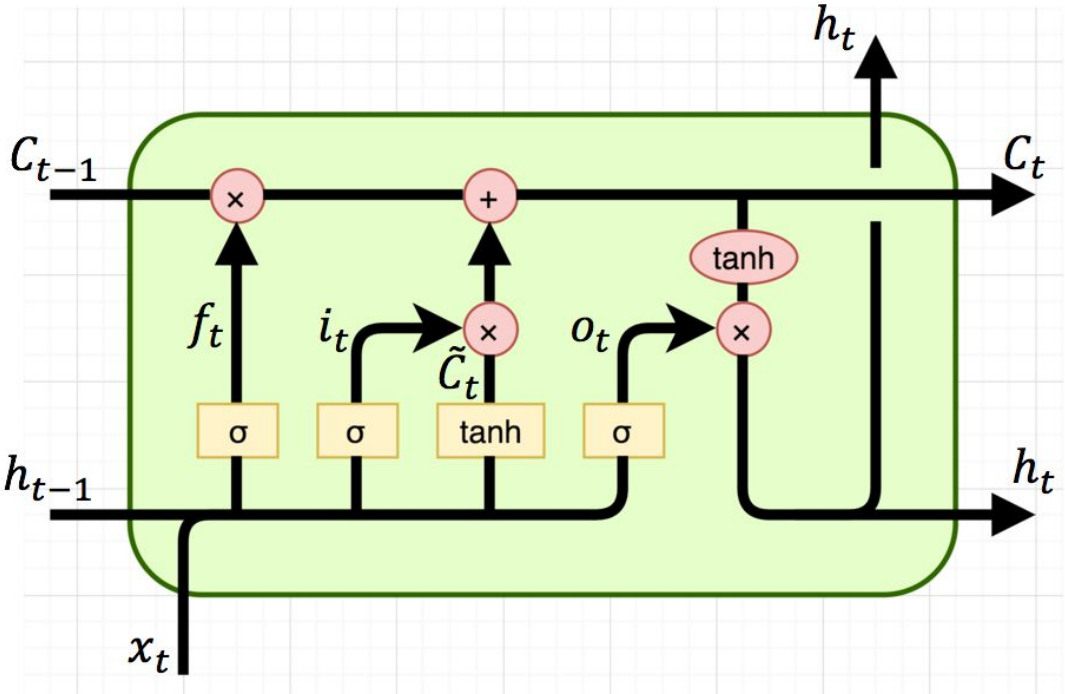


Vanilla RNN cell

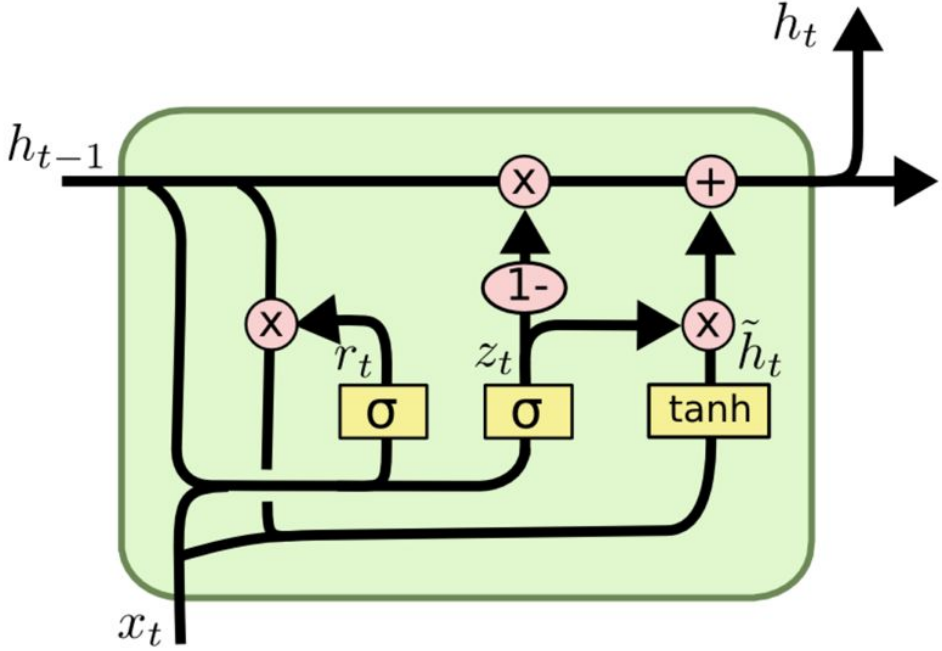


https://towardsdatascience.com/44e9eb85bf21

LSTM cell



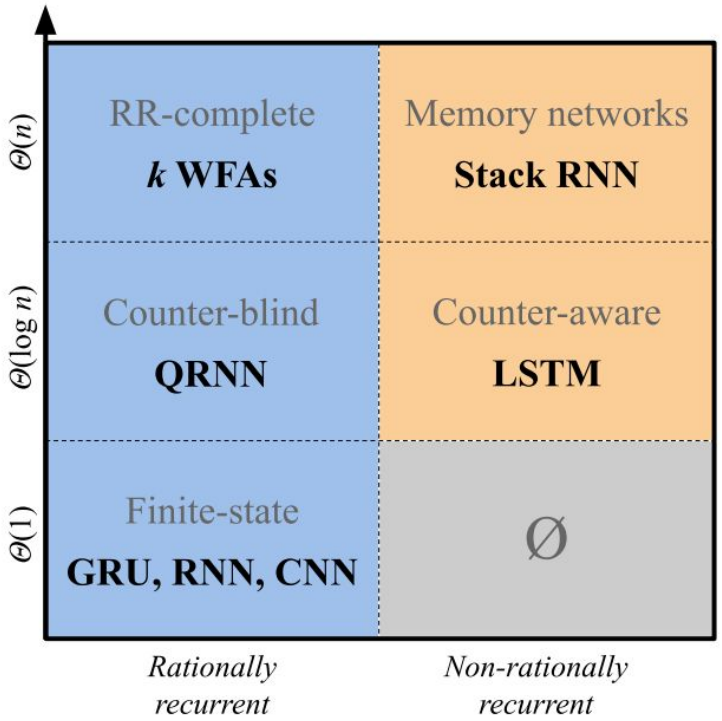
GRU cell



Classic RNN architectures

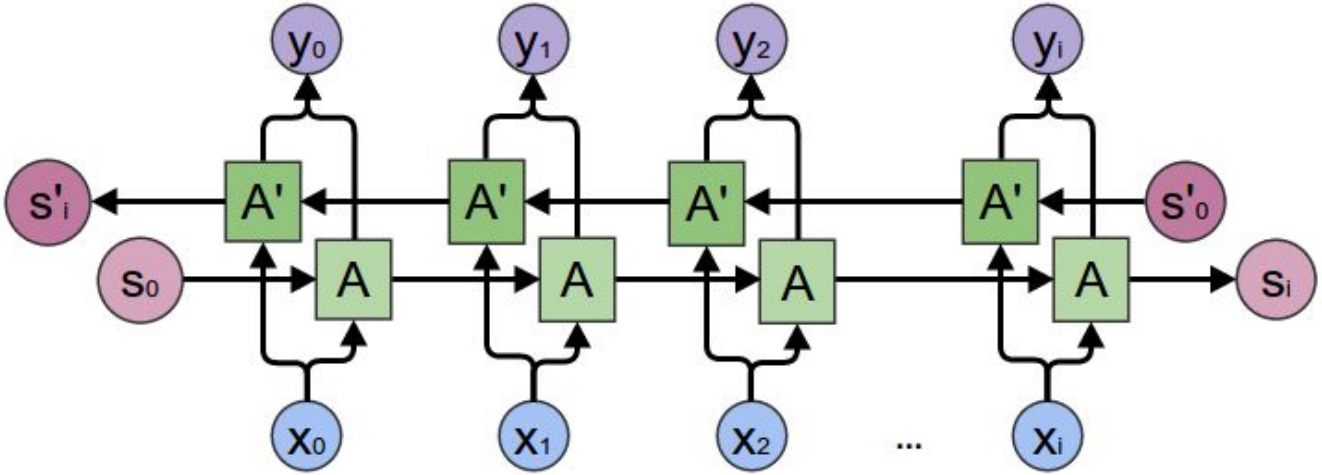
Bidirectional RNN (1997)

Sketch-RNN (2017)



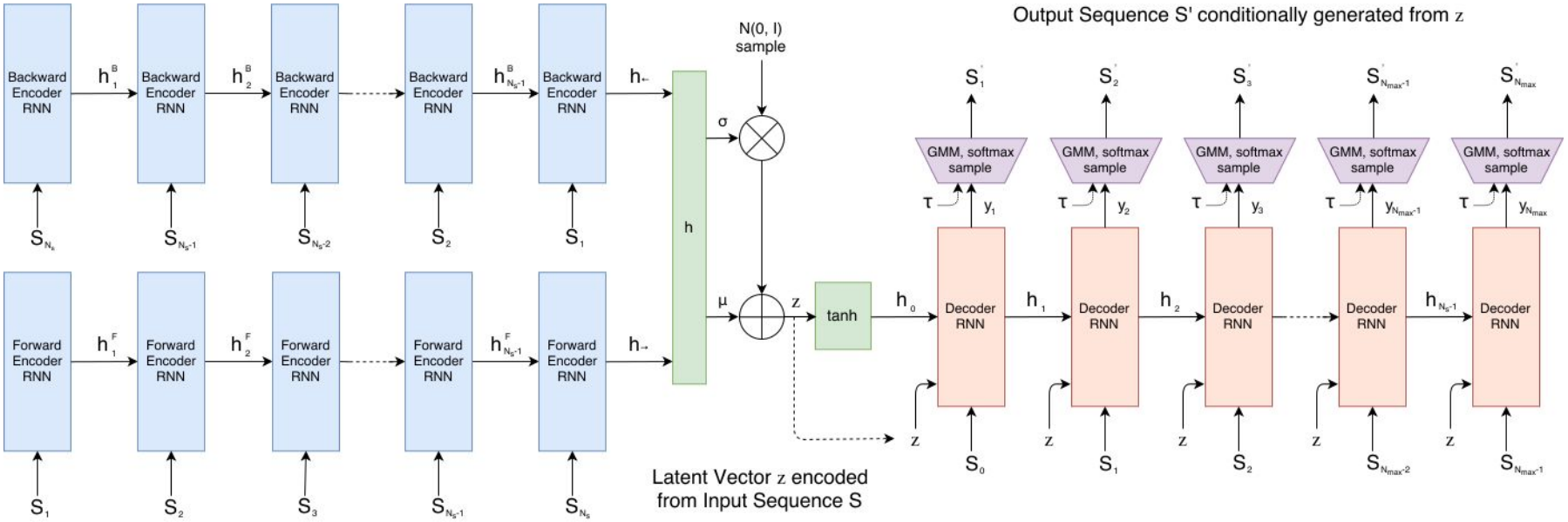
https://aclanthology.org/2020.acl-main.43.pdf

Classic RNN: **Bidirectional RNN**



http://colah.github.io/posts/2015-09-NN-Types-FP/

Classic RNN: **Sketch-RNN**

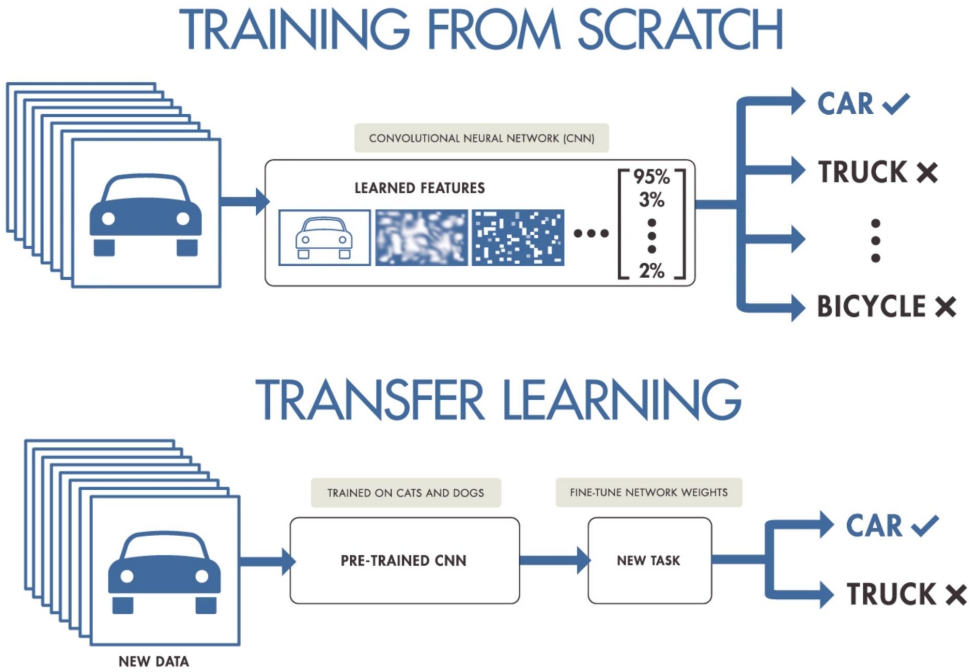


https://magenta.tensorflow.org/sketch-rnn-demo

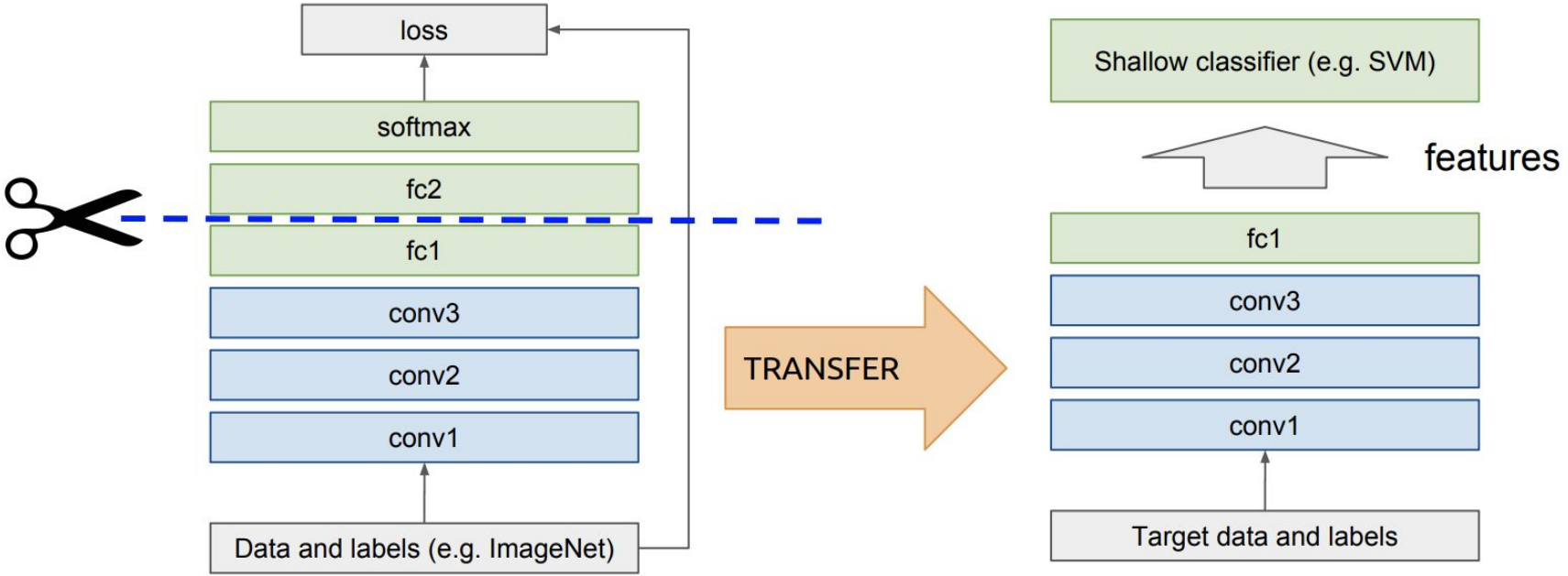
Transfer learning

Very popular with CNNs

Very scarce with RNNs



Transfer learning



http://imatge-upc.github.io/telecombcn-2016-dlcv/slides/D2L5-transfer.pdf

Regression

What is regression?

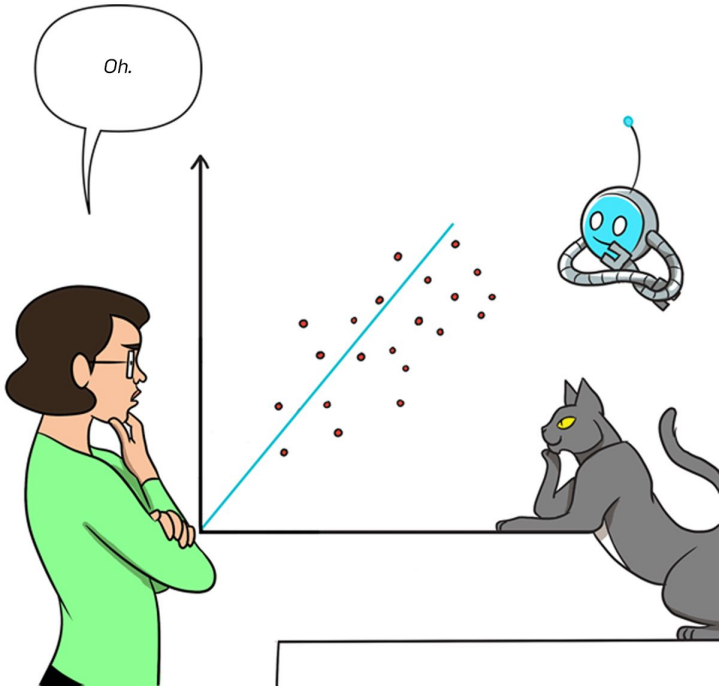
Predict a **continuous** value associated with a feature vector

Examples:

f(room) = temperature

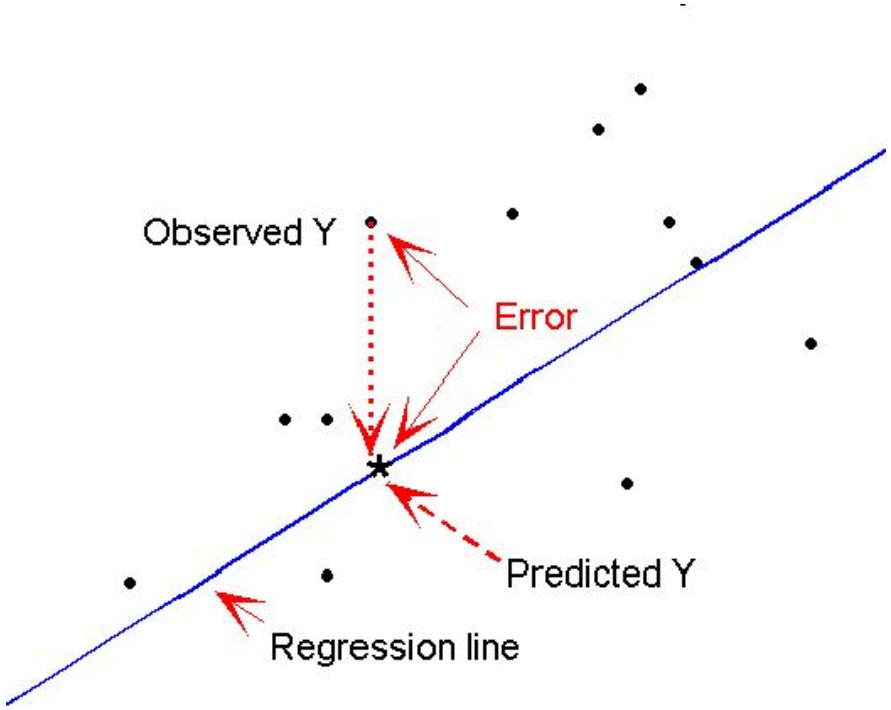
f(trajectory) = time

…

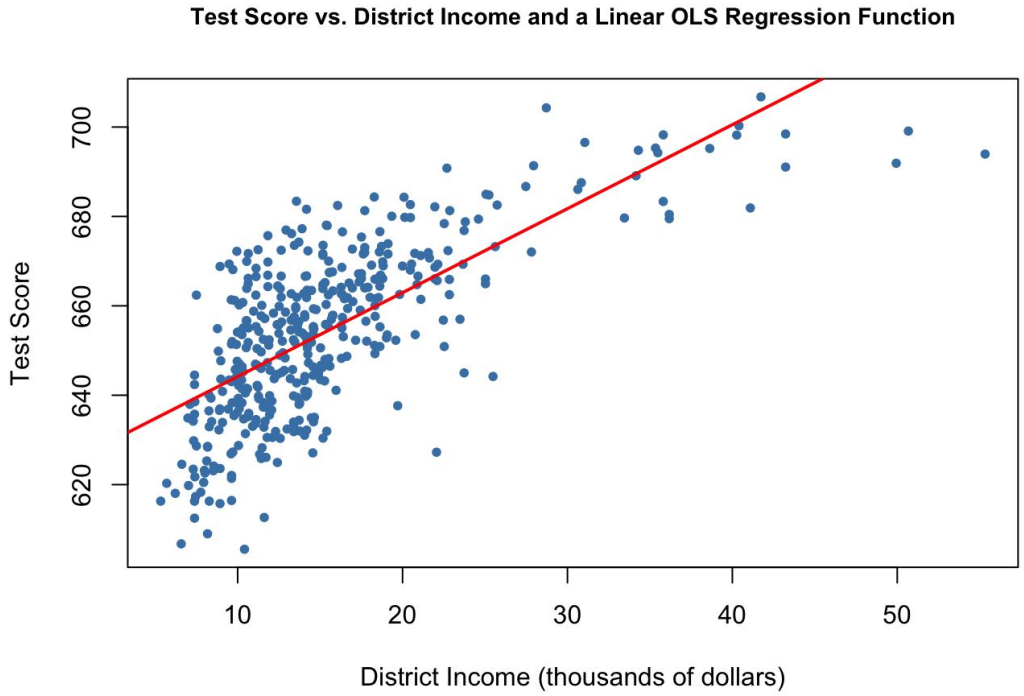


https://cloud.google.com/products/ai/ml-comic-1/

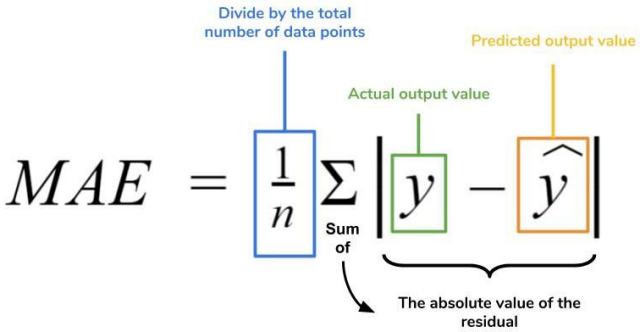
Residuals



Non-linear regression



Evaluation metrics



$$MAE = \frac{1}{n}\Sigma\left|y - \hat{y}\right|$$

$$MSE = \frac{1}{n}\Sigma\left(y - \hat{y}\right)^2$$

The square of the difference between actual and predicted

$$MPE = \frac{100\%}{n}\Sigma\left(\frac{y - \hat{y}}{y}\right)$$

RMSE = $\sqrt{MSE}$

Evaluation metrics

CASE 1: Evenly distributed errors

ID	Error	|Error|	Error^2
1	2	2	4
2	2	2	4
3	2	2	4
4	2	2	4
5	2	2	4
6	2	2	4
7	2	2	4
8	2	2	4
9	2	2	4
10	2	2	4

MAE	RMSE
2.000	2.000

CASE 2: Small variance in errors

ID	Error	|Error|	Error^2
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	3	3	9
7	3	3	9
8	3	3	9
9	3	3	9
10	3	3	9

MAE	RMSE
2.000	2.236

CASE 3: Large error outlier

ID	Error	|Error|	Error^2
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	20	20	400

MAE	RMSE
2.000	6.325

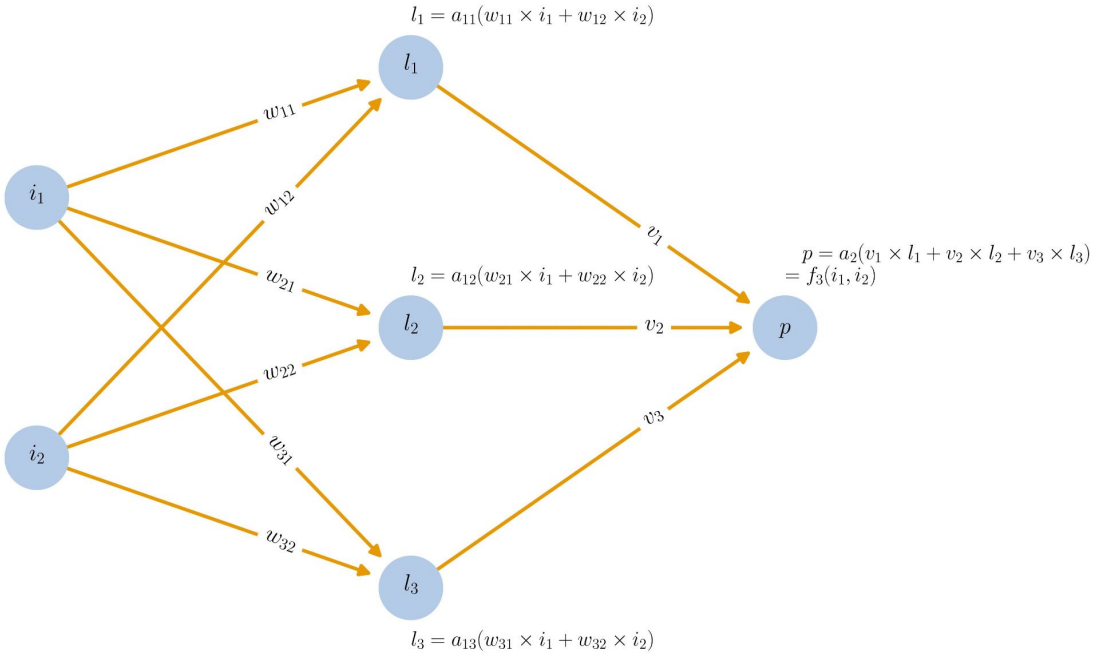
https://medium.com/human-in-a-machine-world/e60ac3bde13d

Evaluation metrics

Acronym	Name	Residual Operation	Robust To Outliers
MAE	Mean Absolute Error	Abs. diff	yes
MSE	Mean Squared Error	Squared diff	no
RMSE	Root Mean Squared Error	Squared diff	no
MAPE	Mean Absolute Percentage Error	Abs. diff	yes
MPE	Mean Percentage Error	Raw diff	yes

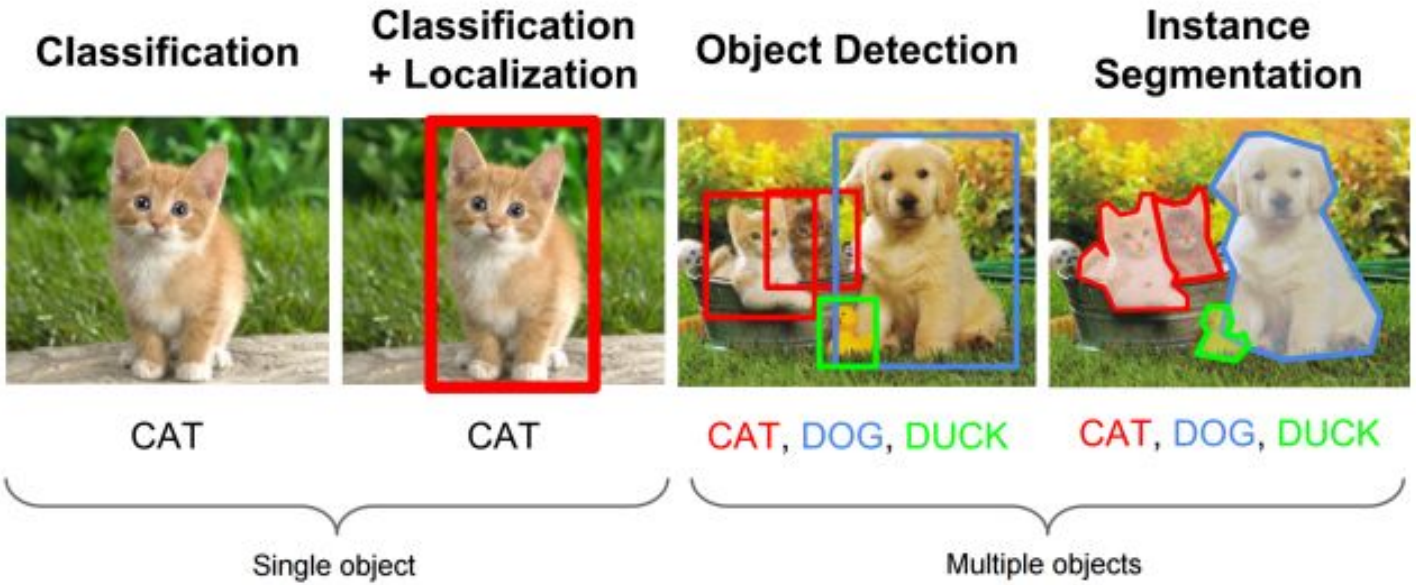
https://towardsdatascience.com/cdc5703d242d

A simple regression model architecture



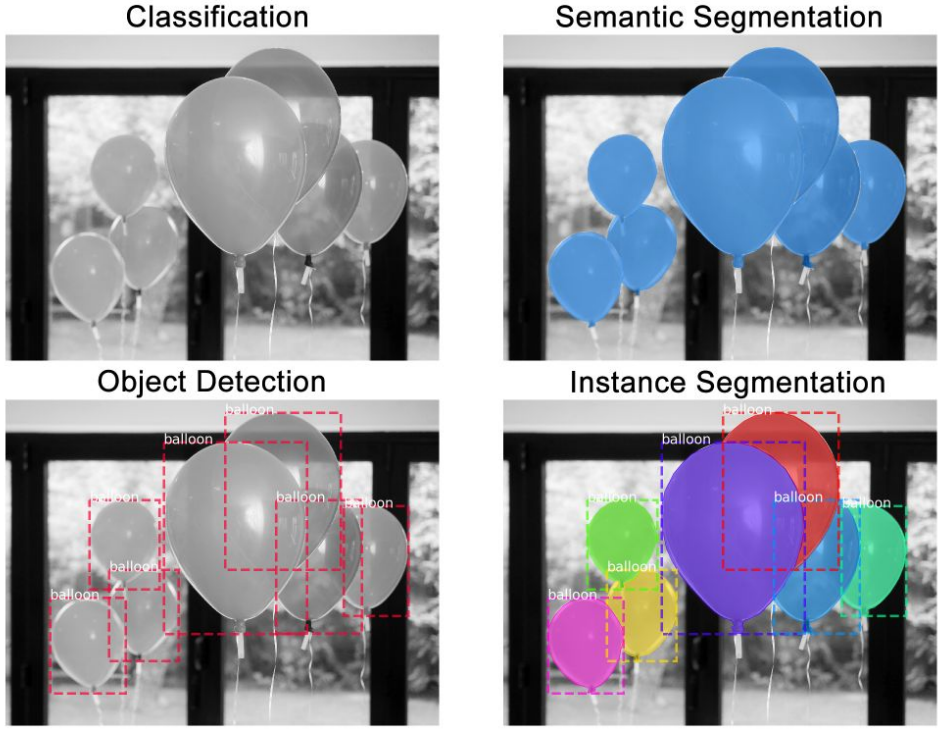
https://towardsdatascience.com/68881590760e

There is more to regression!



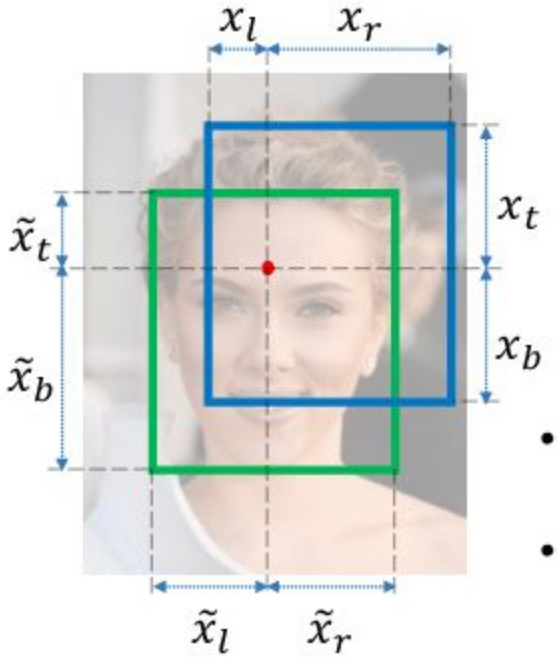
https://leonardoaraujosantos.gitbooks.io/artificial-inteligence/content/object_localization_and_detection.html

Practical use cases



https://engineering.matterport.com/7c761e238b46

Evaluation metric: Intersection over Union



Ground truth: $\tilde{x} = (\tilde{x}_t, \tilde{x}_b, \tilde{x}_l, \tilde{x}_r)$

Prediction: $x = (x_t, x_b, x_l, x_r)$

- $\ell_2 \ \ loss = ||\square - \square||_2^2$
- $IoU\ loss = -\ln \frac{Intersection(\square, \square)}{Union(\square, \square)}$

Classic architectures

FCN (2014)

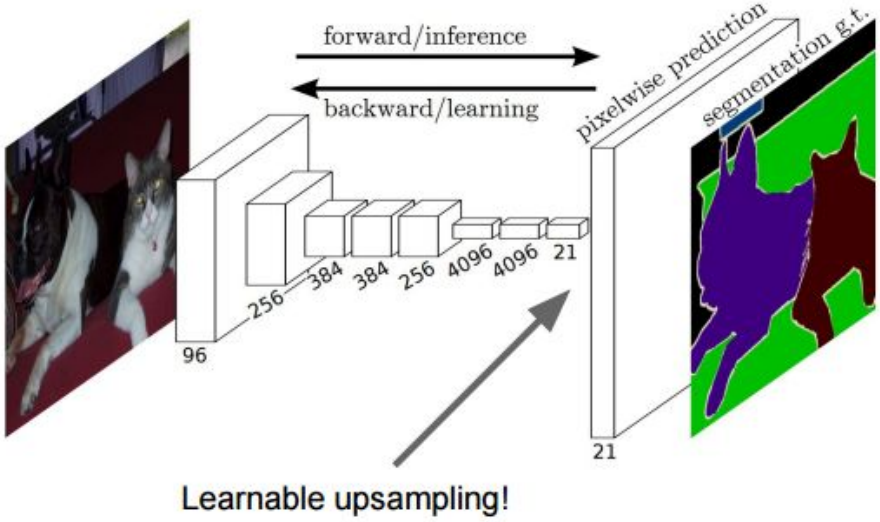
DeconvNet (2015)

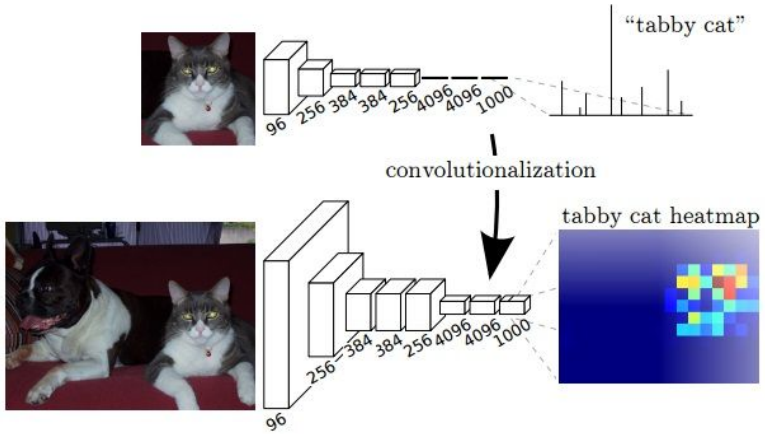
U-Net (2015)

Mask R-CNN (2017)

YOLO (2016)

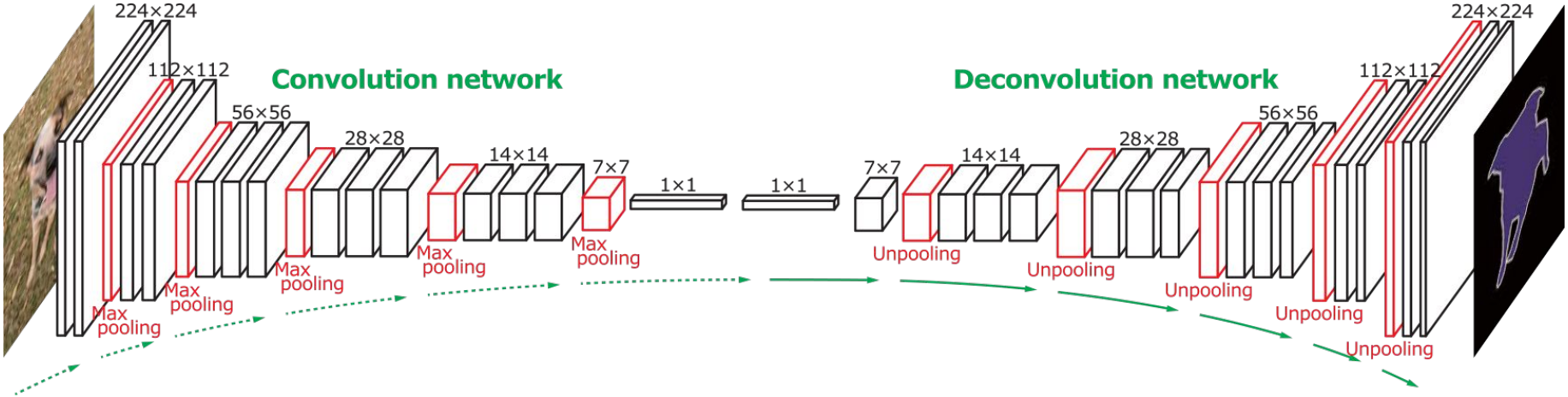
Classic architecture: **FCN**





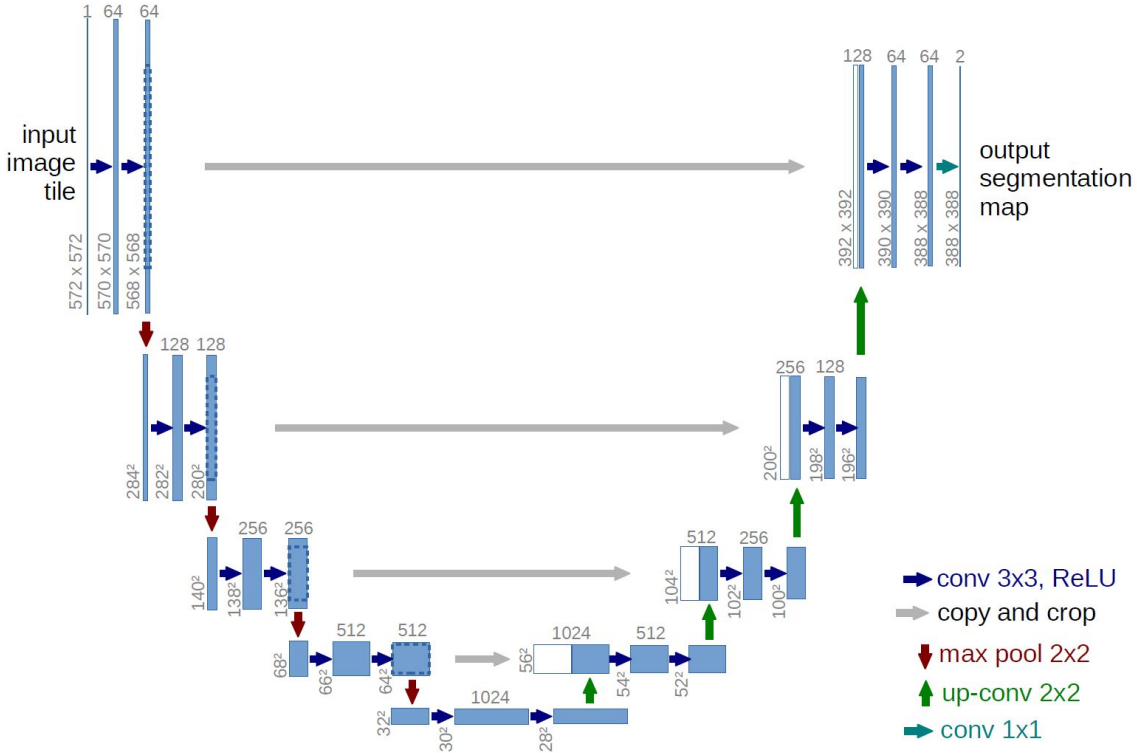
https://leonardoaraujosantos.gitbook.io/artificial-inteligence/machine_learning/deep_learning/image_segmentation

Classic architecture: **DeconvNet**



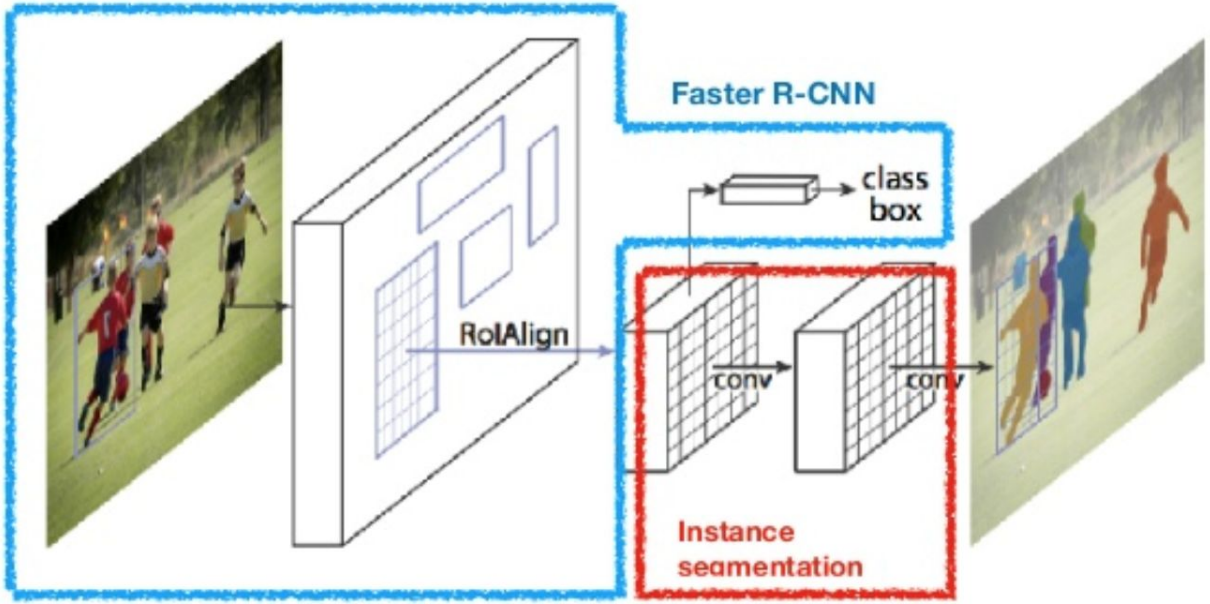
https://towardsdatascience.com/55cf8a6e380e

Classic architecture: **U-Net**



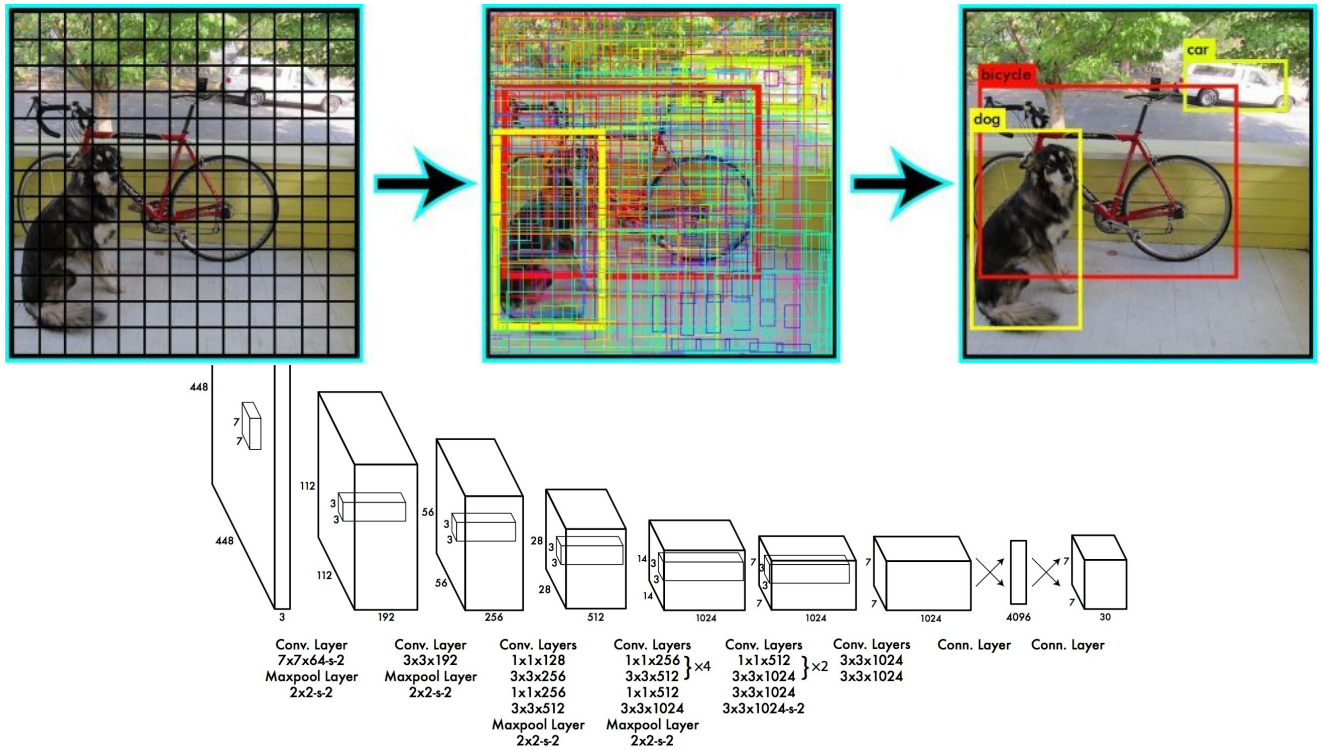
https://heartbeat.fritz.ai/ff17f6e4c1cf

Classic architecture: **Mask R-CNN**



https://lilianweng.github.io/lil-log/2017/12/31/object-recognition-for-dummies-part-3.html

Classic architecture: **YOLO**



https://dzone.com/articles/understanding-object-detection-using-yolo