Python Applied to Machine Learning & Statistics

Lecture 07: Deep Learning

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September 26, 2016

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Overview

- Motivation - Why CNNs ?
- Different layers composing CNNs
    a. Convolutional layer
    b. Activation function
    c. Pooling layer
    d. Normalisation layer
    e. Regularization : DropOut, Dataset Augmentation
- Practical Introduction Deep Learning with Keras
    - Application to MNIST

Motivation

Smart machine are part of our everyday life.

WiFi-based Indoor Localization

- Problem: Locate smart phone user inside a building.
- Challenge: WiFi signal strength is dynamic and difficult to calibrate.
- Solution: Automate the recalibration efforts.

Picture credit: The future of indoor positioning, Future lab, 2016

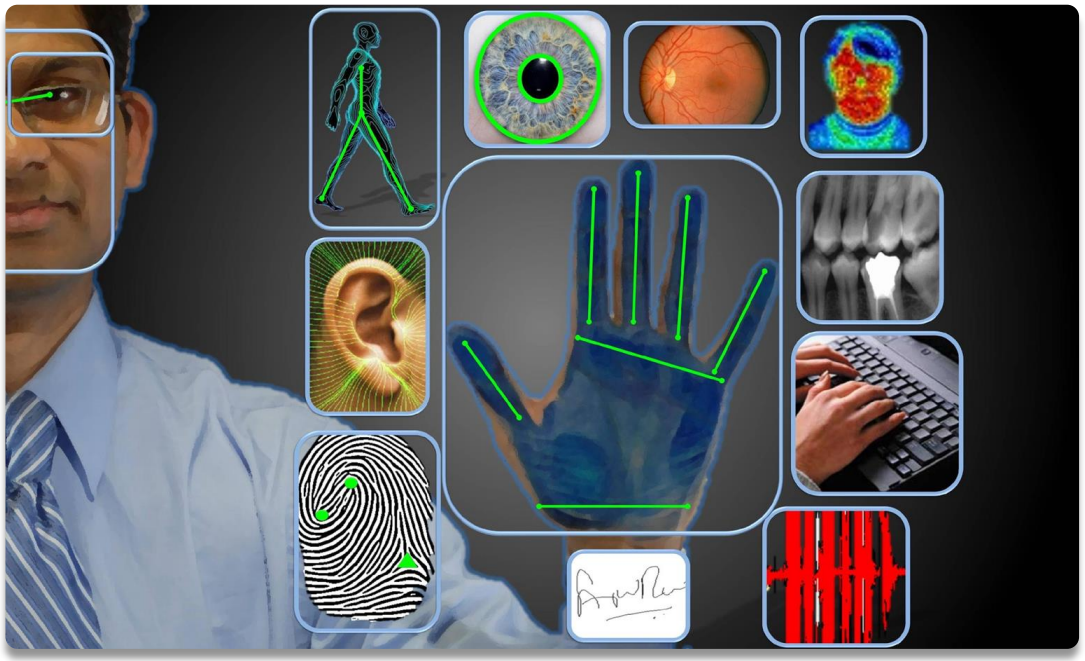
Breast Cancer Drug Discovery

- Problem: Faster drug discovery.
- Challenge: Large patient data with missing information.
- Solution: Use automated feature extraction.

Picture credit: National Institute for Health and Clinical Excellence , 2016

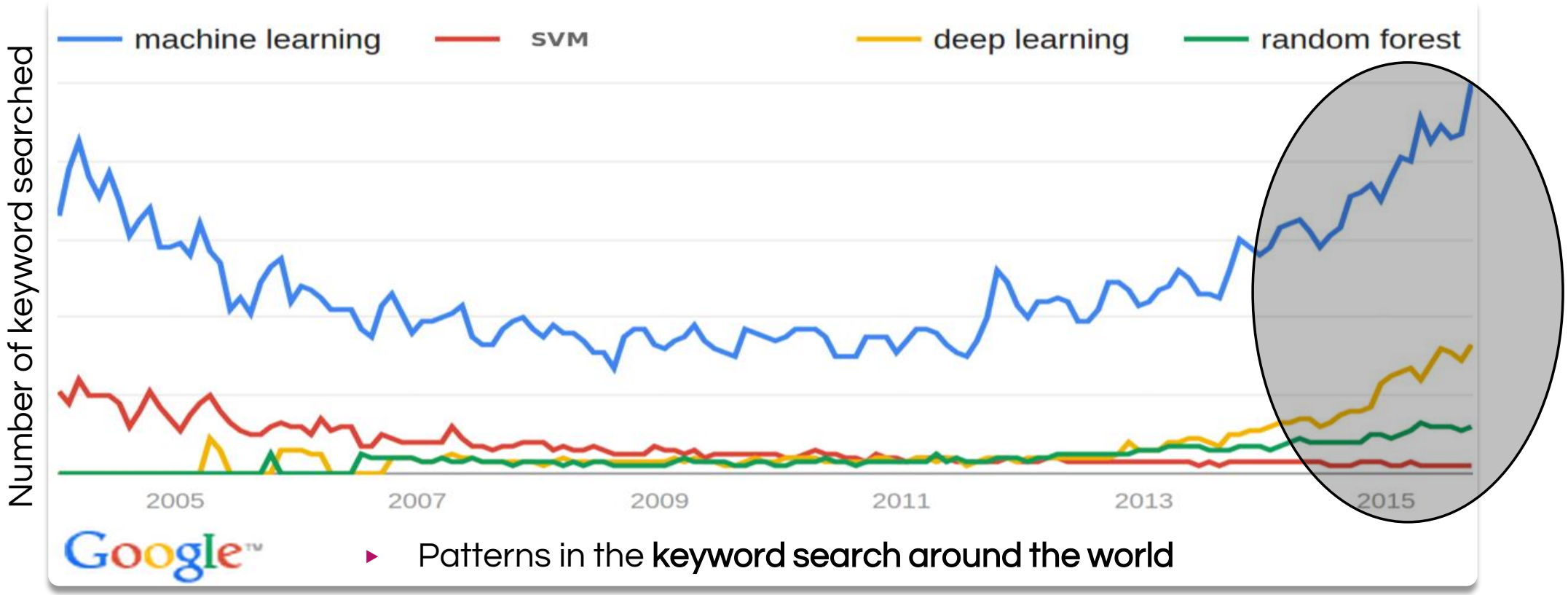
Biometrics

- Problem: Identification using biometric information.
- Challenge: Heterogeneous data.
- Solution: Use automated feature extraction.



Picture credit: Lecture Series on Digital Image Processing by Prof. P.K. Biswas, 2008

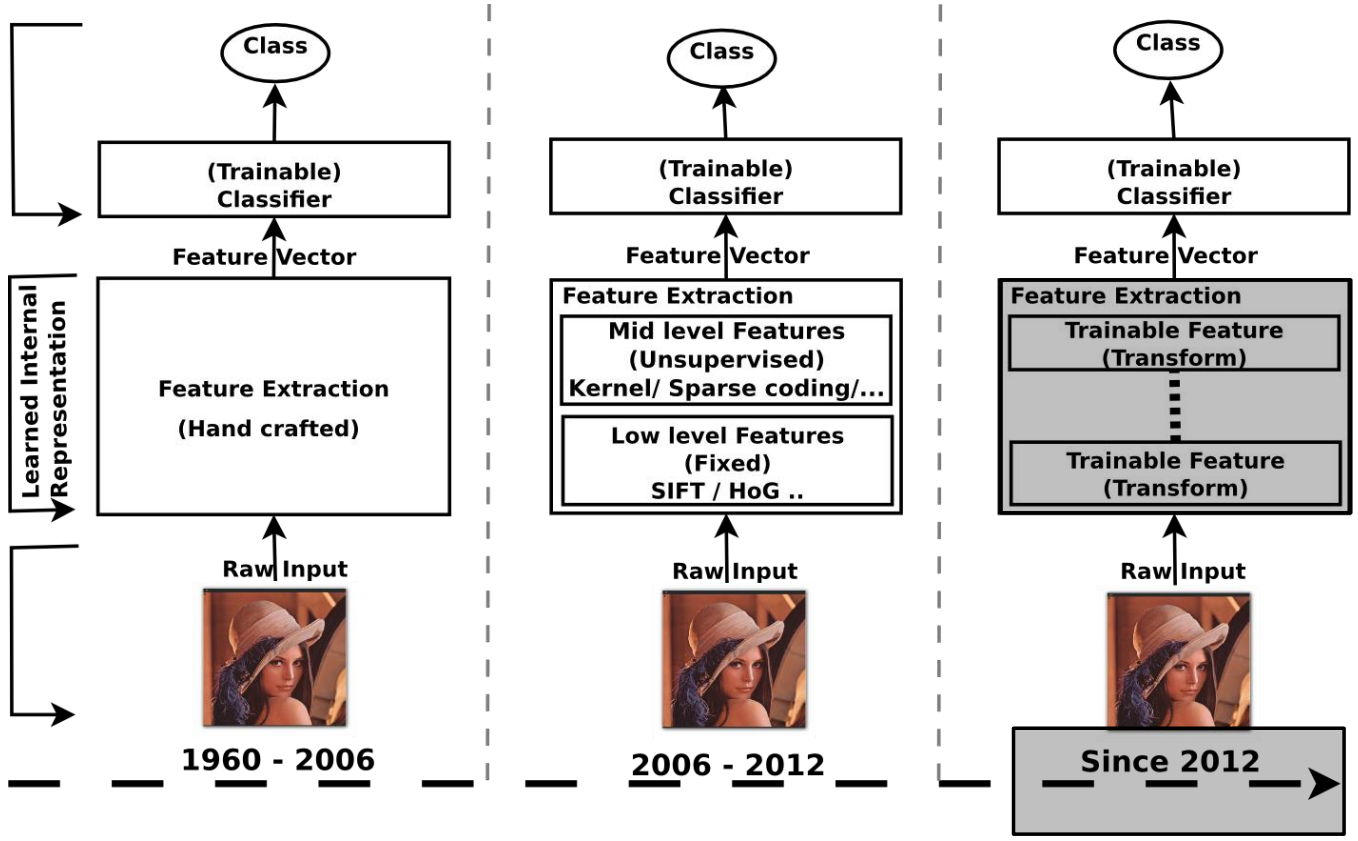
Trends in Machine Learning



- Patterns in the **keyword search around the world**

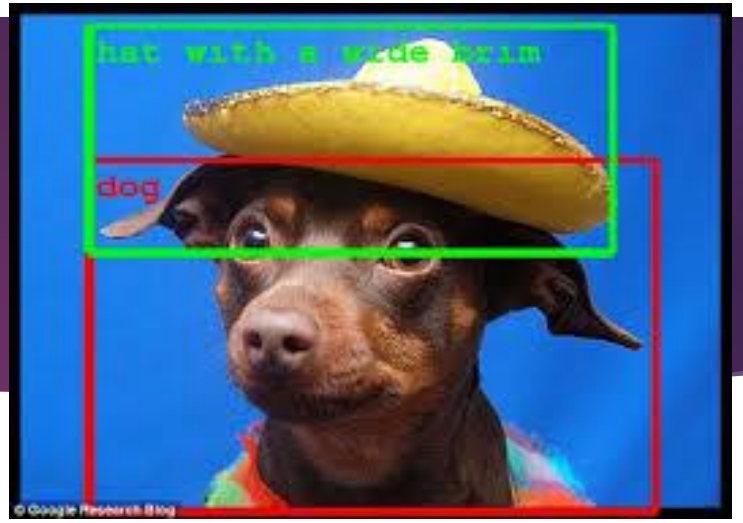
Trends in ML

- How to get computer programs to **self-learn patterns**?



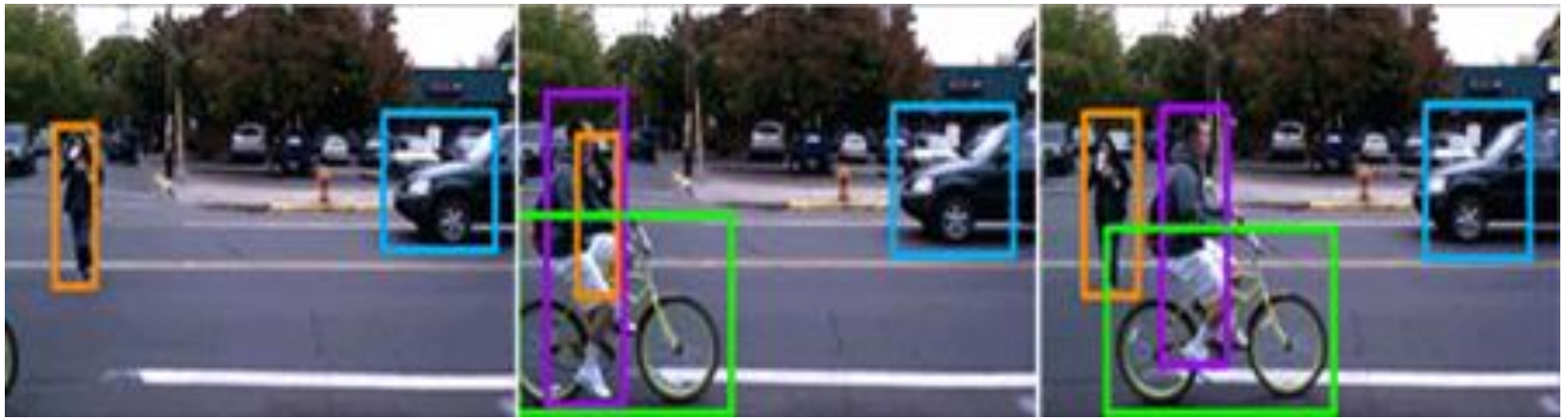
Possible applications

Object recognition



GoogleNet

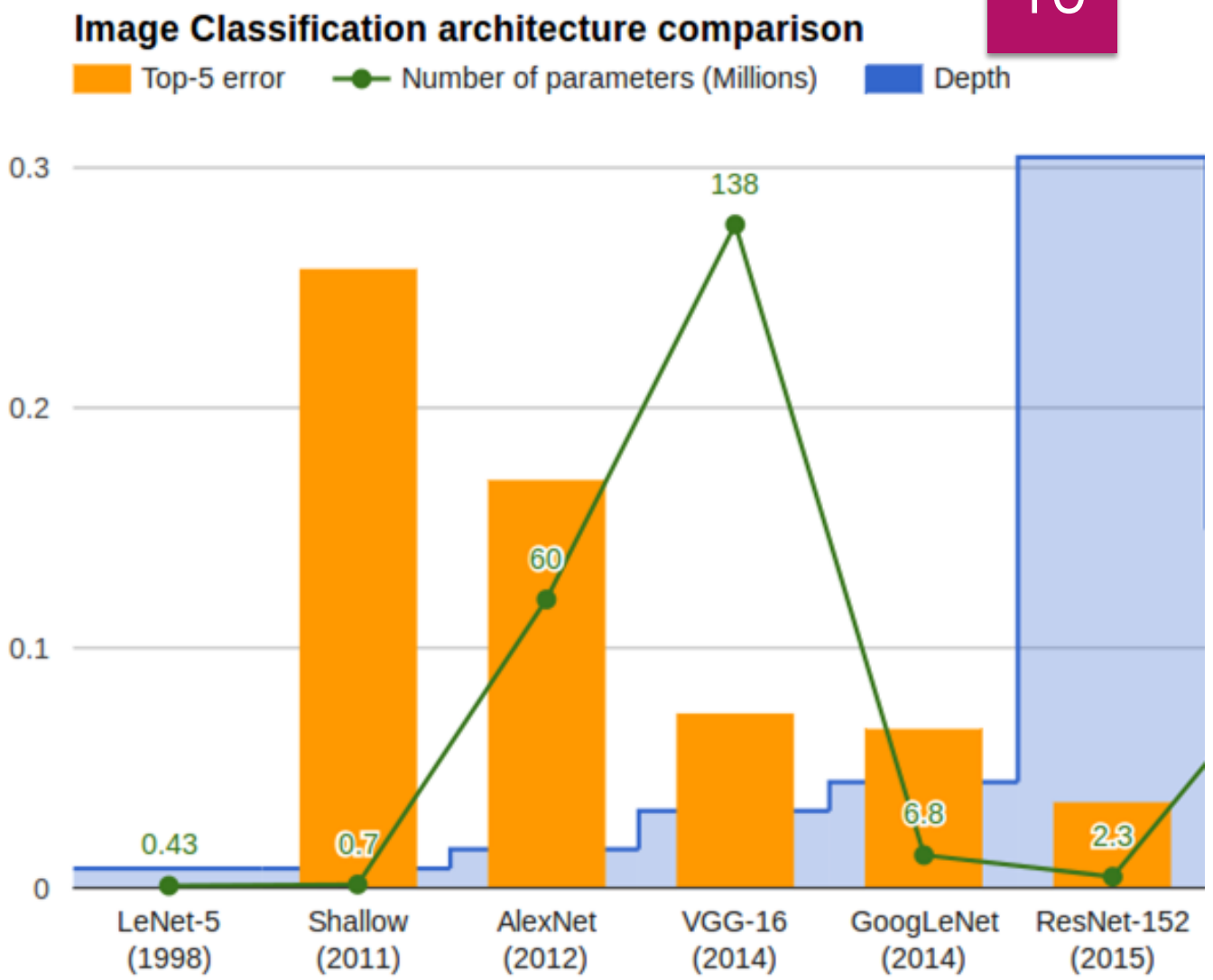
SegNet



Multi Object Tracking (Park & al., 2015)

Trends in Image recognition

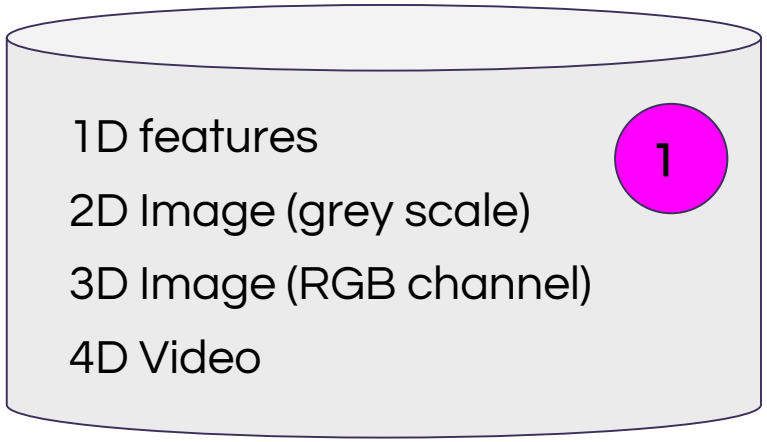
- Deep Learning (CNNs) methods outperform other methods consistently.
- Top-5% error rate reached human accuracy.
- Network depth reaches to 152 layers.
- Trainable parameters are going down.

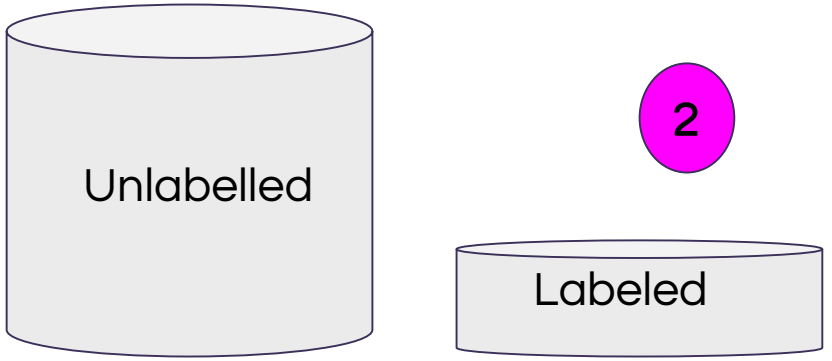


ImageNet challenge: **Large scale image recognition**

How to get computer programs to self-learn patterns?

RESEARCH CHALLENGE



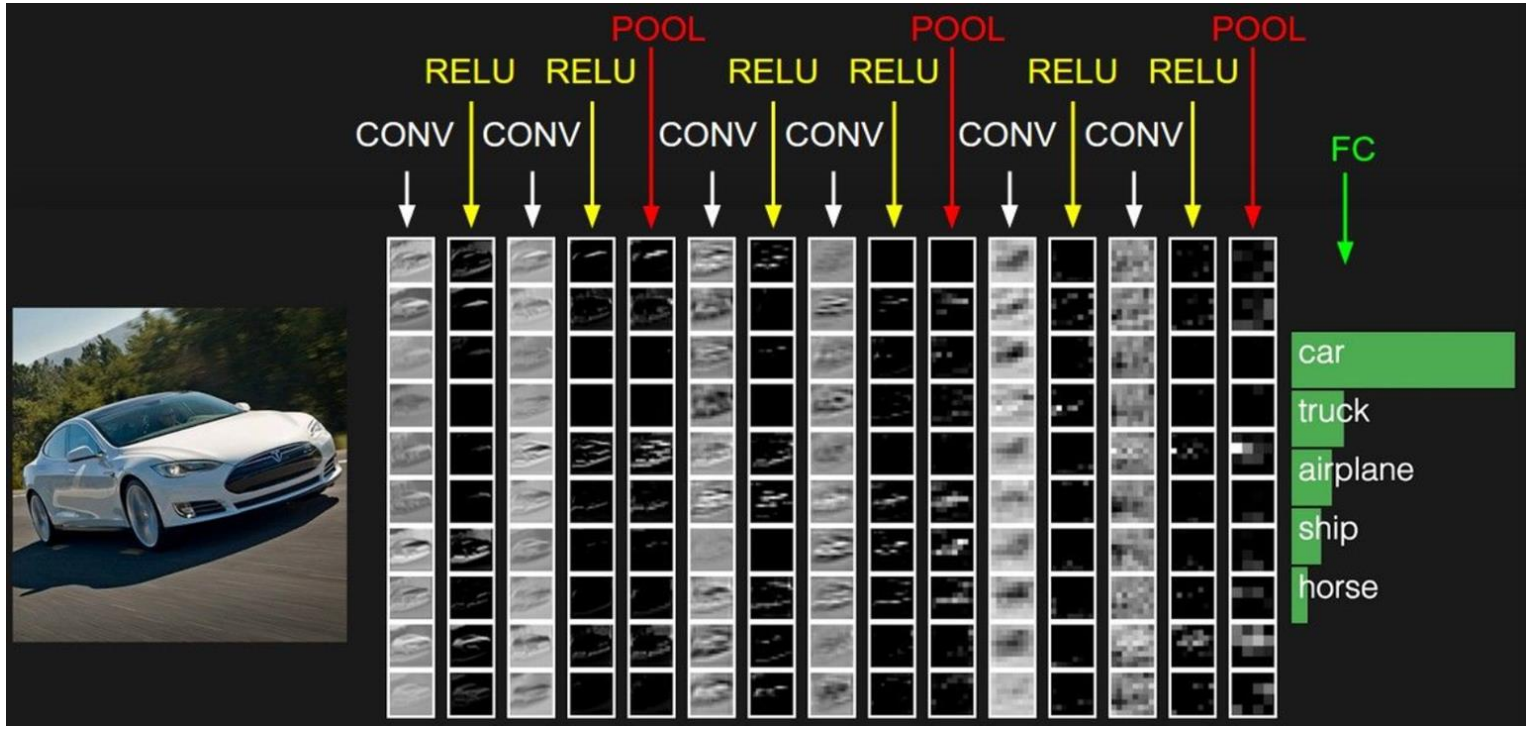


Methodologies

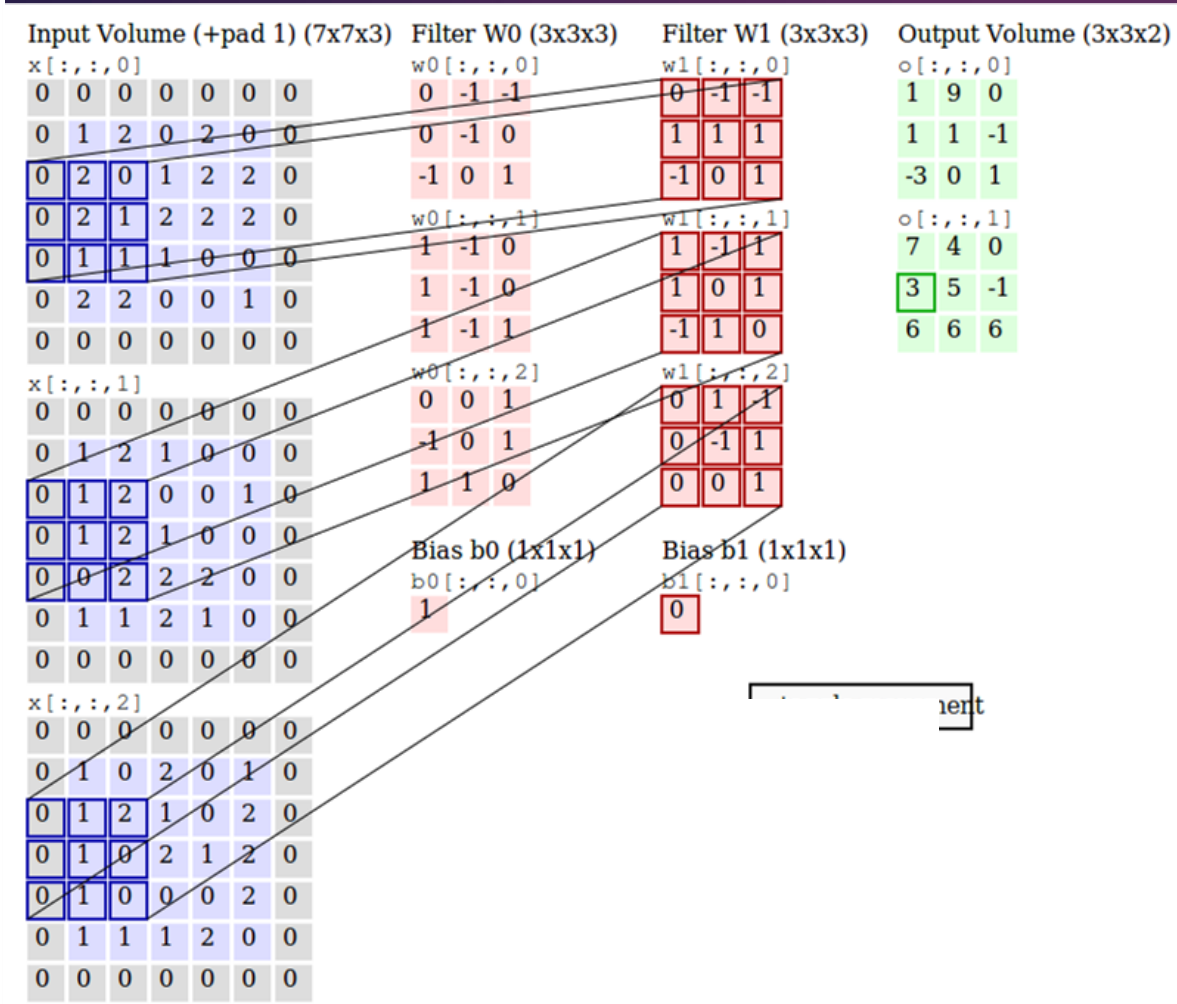
Convolutional Neural Network

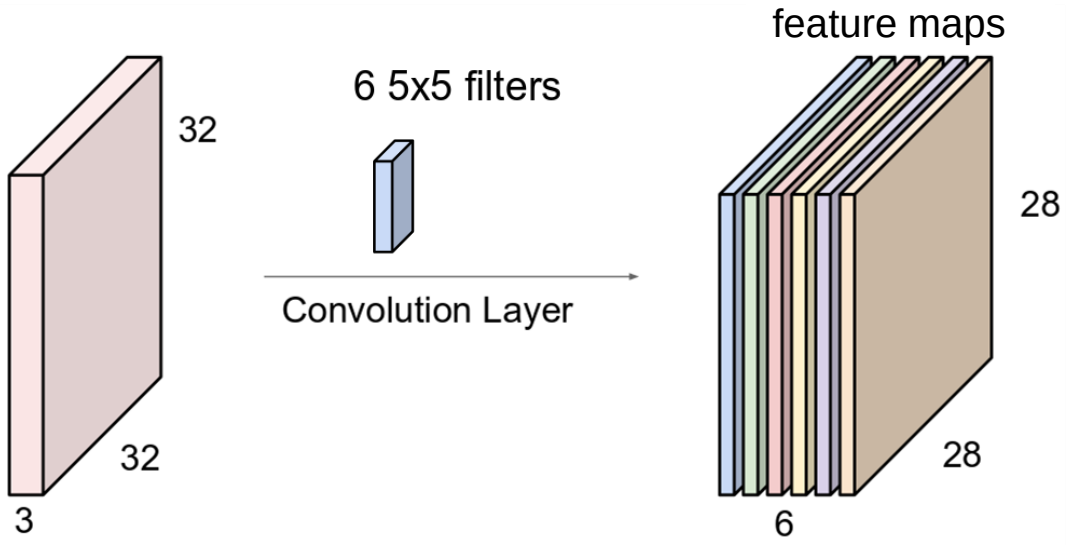
Fully connected layer

- Classifier at the output



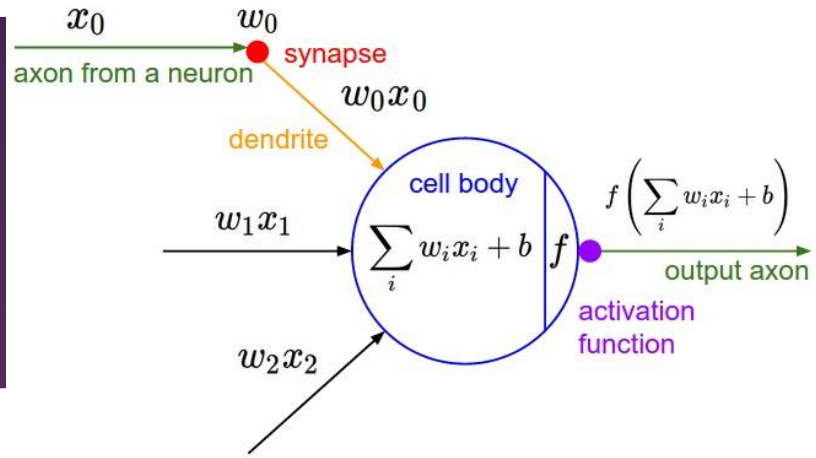
Convolutional layer



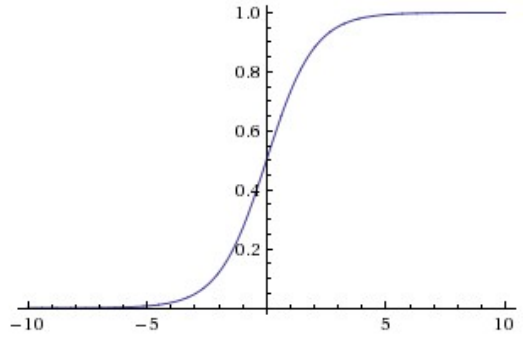


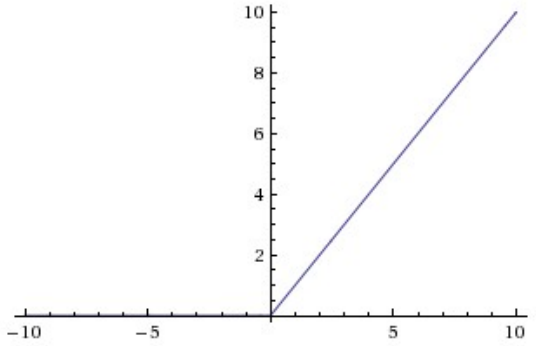
Source : http://cs231n.stanford.edu/MOOC from Andrej Karpathy

Activation function



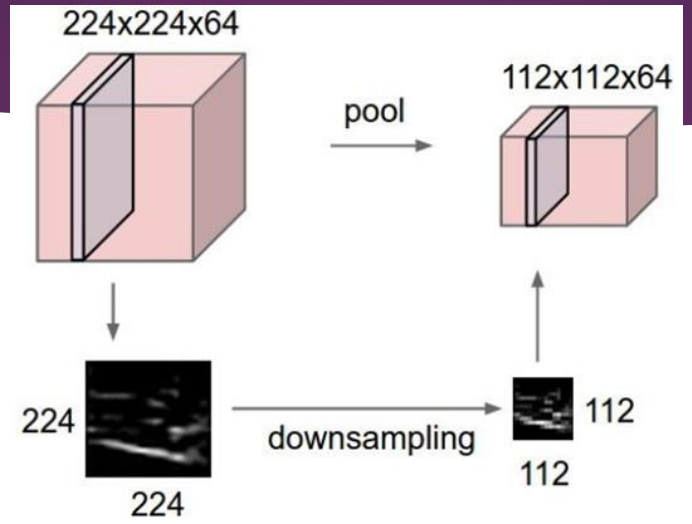
- Why activation functions ?
  - Decision making function : presence of this feature ?
- Sigmoid function
  - Problem : large inputs ⇒ saturation ⇒ gradient will be 0 Slow update of the weights, stopping the learning process
- ReLU = max(0,x)
  - Only a simple operation
  - Faster weight optimisation





Pooling layer

- Downsampling



- Max pooling

1	1	2	4
5	6	7	8
3	2	1	0
1	2	3	4

max pool with 2x2 filters
and stride 2

6	8
3	4

Normalisation layer (optional)

- Need normalisation at input of sigmoid functions to avoid saturation
- Inspired from real neurons, to implement local inhibition
  - Big activities will see many neurons competing
- But : Contribution of this layer has been shown to be minimal
  - Used in AlexNet (2012), but has become less common nowadays

Trends in Image recognition

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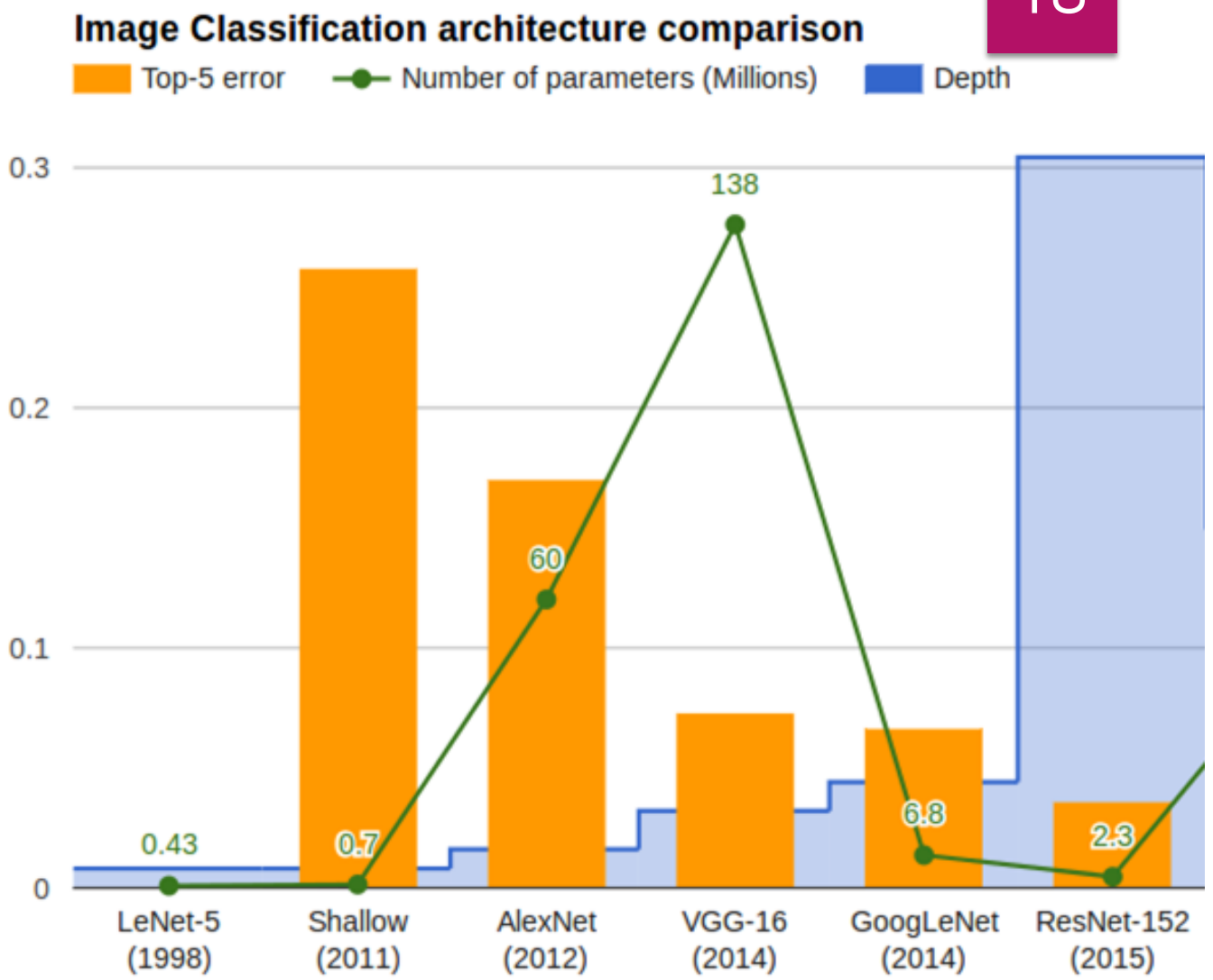
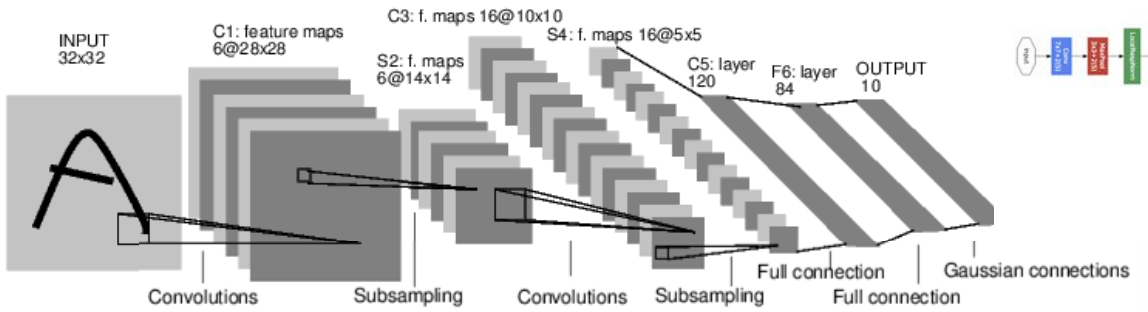
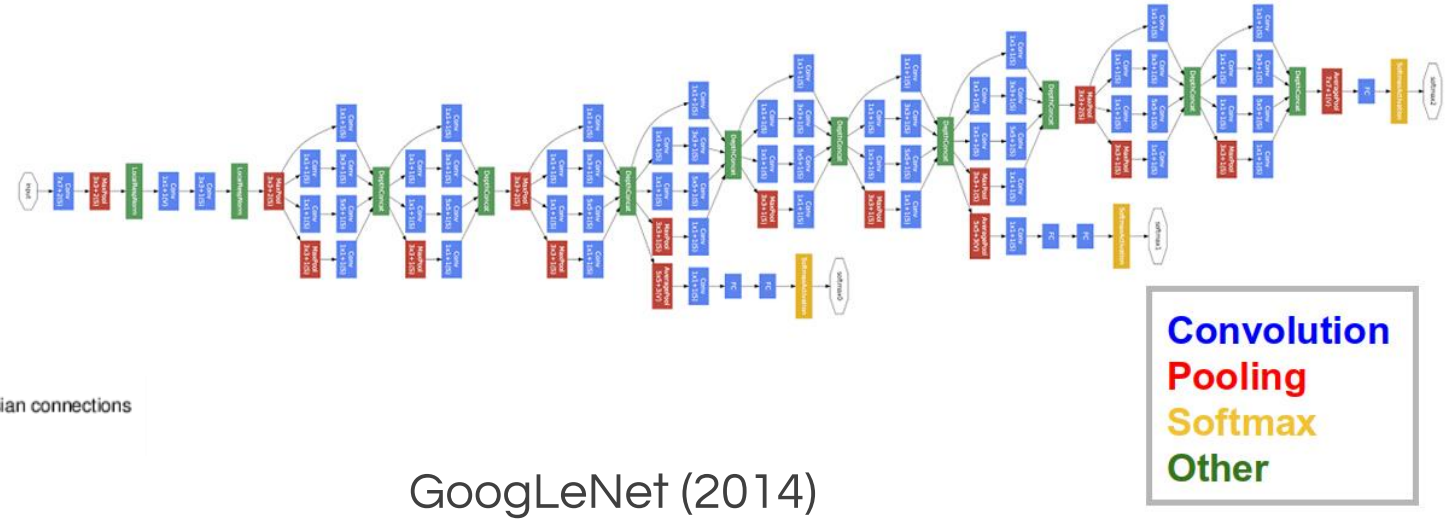


ImageNet challenge: **Large scale image recognition**

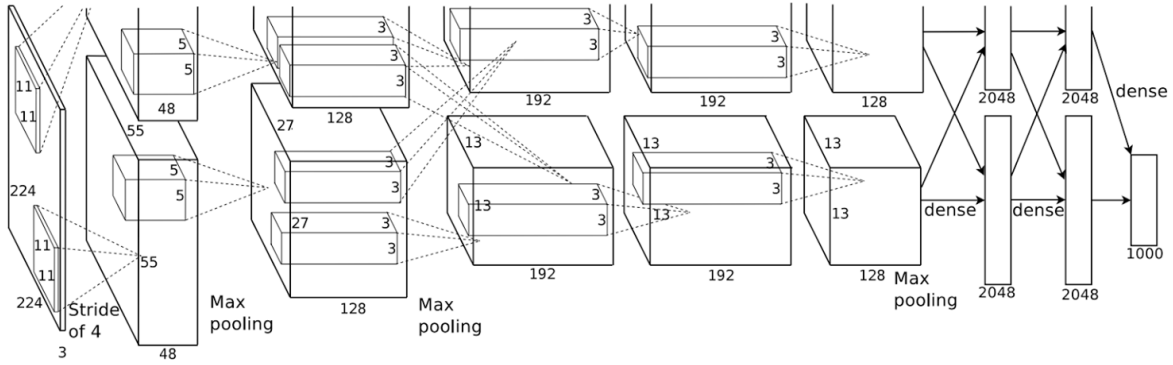
Architectures



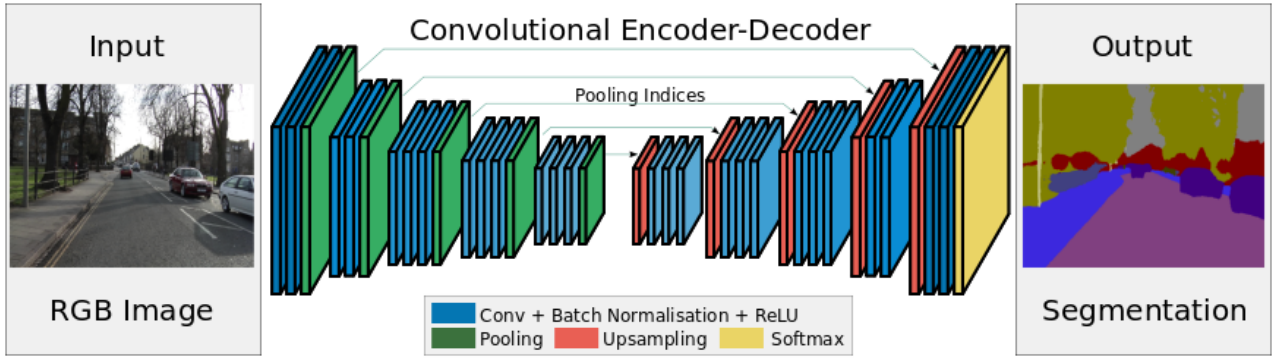
LeNet (1998)



GoogLeNet (2014)

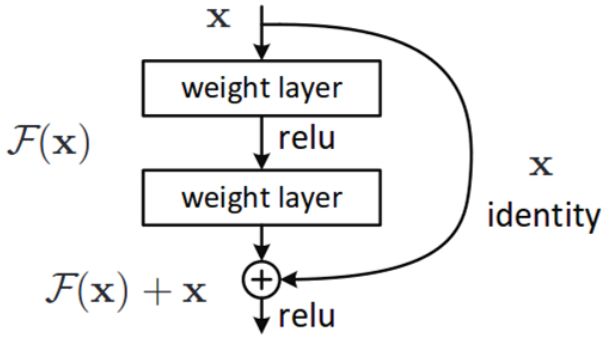


AlexNet (2012)

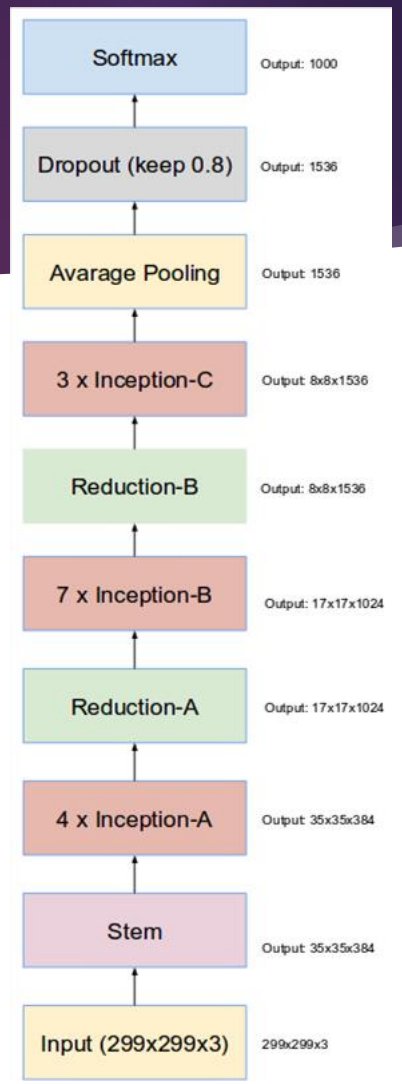


SegNet (2015)

Architectures



ResNet (2015)



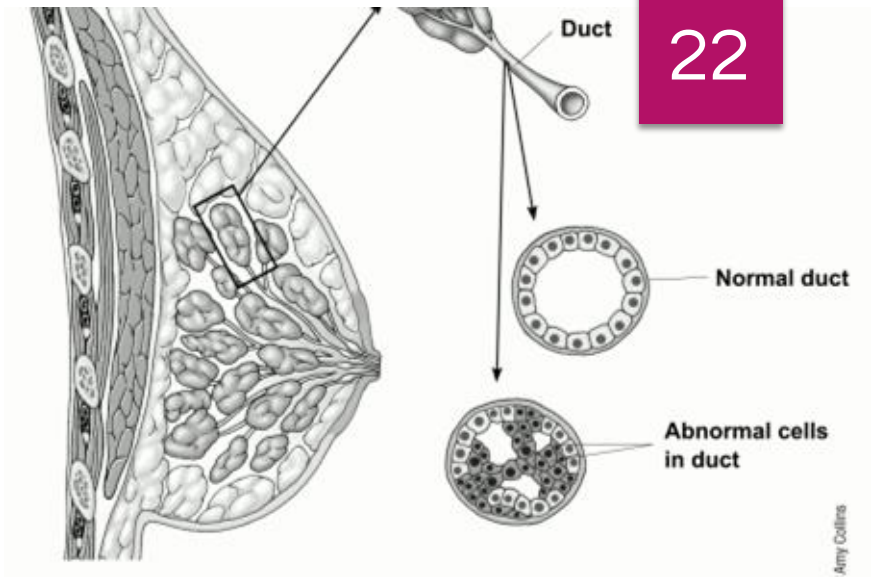
Inception-v4 (2016)

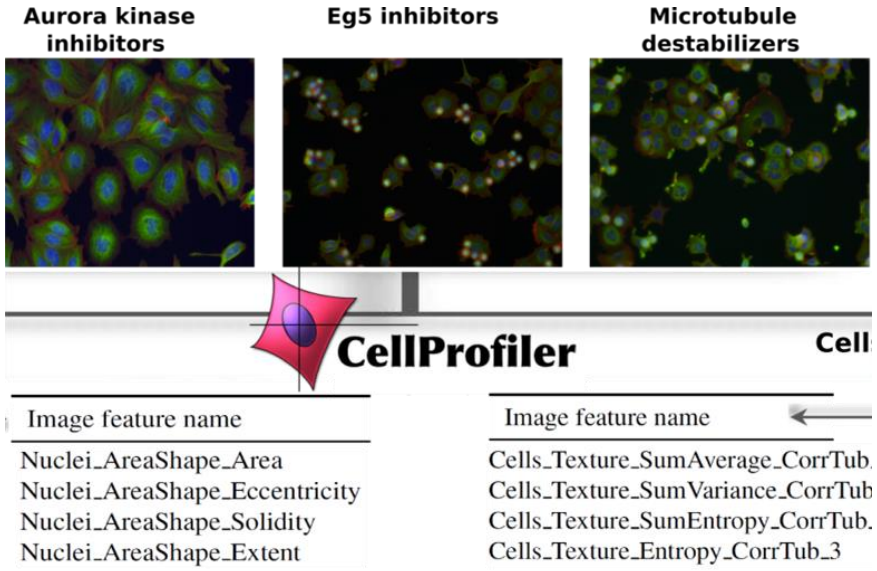
The utility of a deep learning framework

A pack of libraries
Some basal architectures easy to create
Switch between CPU use and GPU use
Pre-existing models use and modification
Embeddable

Drug-discovery

- Problem : Detect Host cell or Tumor cell
- Task : Classification of chemical mechanisms of action (MOA) by identifying substances that alter the phenotype of a cell which prevent tumor growth and metastasis.





Picture credit : Broad Bioimage Benchmark Collection (BBBC)

Application Challenge

- Thousands of new drugs tested on millions of cancerous cells everyday.
- Expensive to annotate.
- Require experts to annotate the data.

Set Nr.	Mechanism of action	Short name	Number of compounds	Batches	Common Batches
P_{set1}	Actin disruptors	Act	3	01, 02	02, 07,08
P_{set1}	DNA replication	DR	4	02, 08, 09	
P_{set1}	Epithelial	Epi	3	05, 08, 10	
P_{set1}	Kinase inhibitors	KI	3	07	
P_{set1}	Microtubule stabilizers	MS	3	01, 07	
P_{set1}	Protein degradation	PD	4	02, 06, 07	
	Total Nr. of Compounds		20		
	Total Nr. of Treatments		42		
P_{set2}	Aurora kinase inhibitors	Aur	3	01, 03, 04	01, 03, 04
P_{set2}	Cholesterol-lowering	Ch	2	09	
P_{set2}	DNA damage	DD	4	03,04	
P_{set2}	Eg5 inhibitors	Eg5	2	01,03	
P_{set2}	Microtubule destabilizers	MD	4	01,03	
P_{set2}	Protein synthesis	PS	3	03,04	
	Total Nr. of Compounds		18		
	Total Nr. of Treatments		61		

"*High-content Analysis of Breast Cancer using Single-Cell Deep Transfer Learning*", Journal of biomolecular Screening, 2016

Results

Methods	Set1		Set2	
	Accuracy (%)	Time (m)	Accuracy (%)	Time (m)
Linear SVM	20.95	32	23.49	49
Radial SVM	21.04	78	17.5	125
Deep Learning	**84.29**	506	**87.05**	698

"*High-content Analysis of Breast Cancer using Single-Cell Deep Transfer Learning*", Journal of biomolecular Screening, 2016

Biometrics

- Problem: identification of person using periocular region.

- Traditional biometric recognition are Iris, fingerprint, eye retinas.

right eye

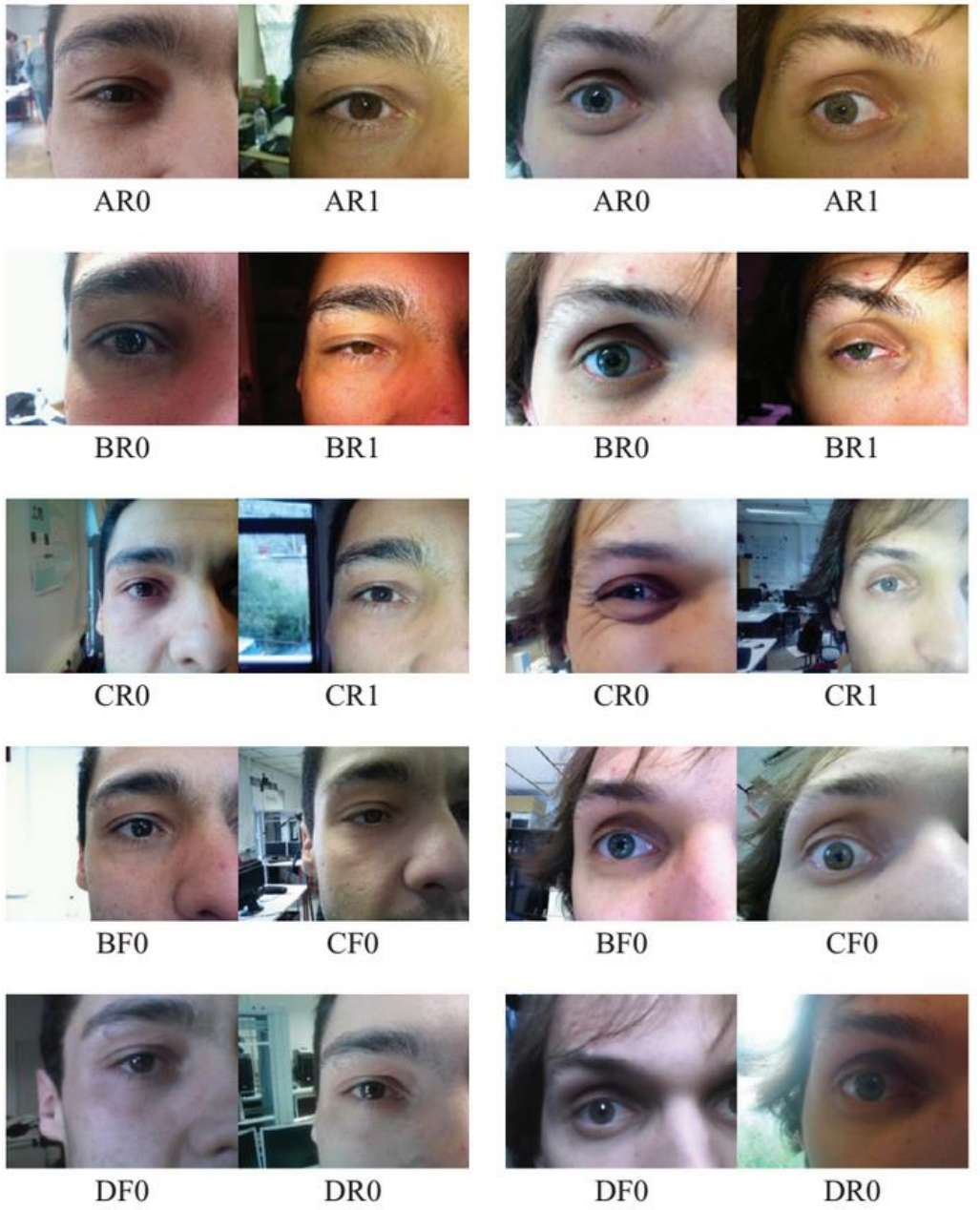
left eye

Joao C. Monteiro et al. Periocular recognition in mobile scenarios: A comparative analysis of two approaches. ISVC, 2015.

Cross-sensor Biometrics

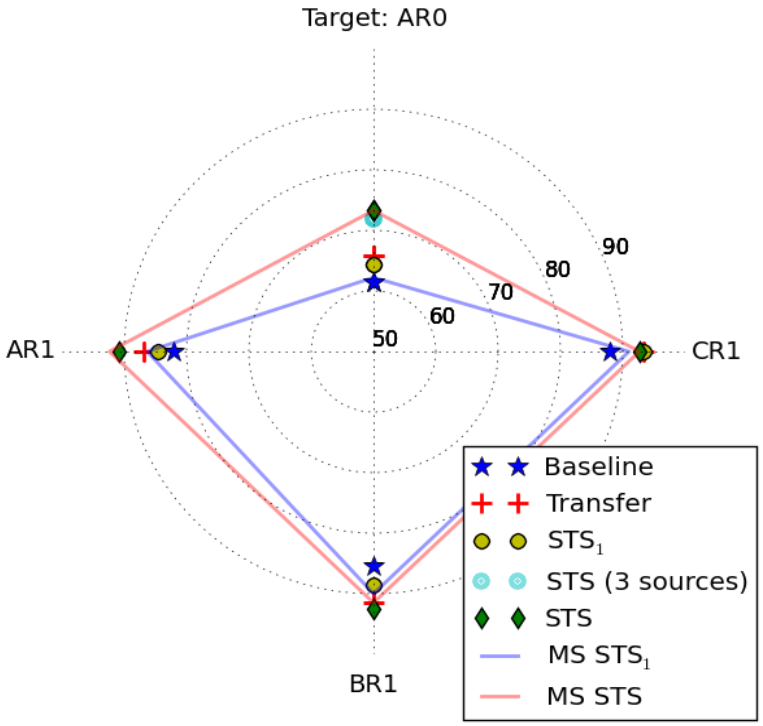
- Challenge: periocular images captured from different devices.

Setup ID	AR0	AR1
Device	*A*	
Manufacturer	Sony Ericsson	
Model	Xperia Arc S	
O.S.	Android 2.3.4	
Camera	Rear	
Resolution	3264 ×2448	
Flash	No	Yes

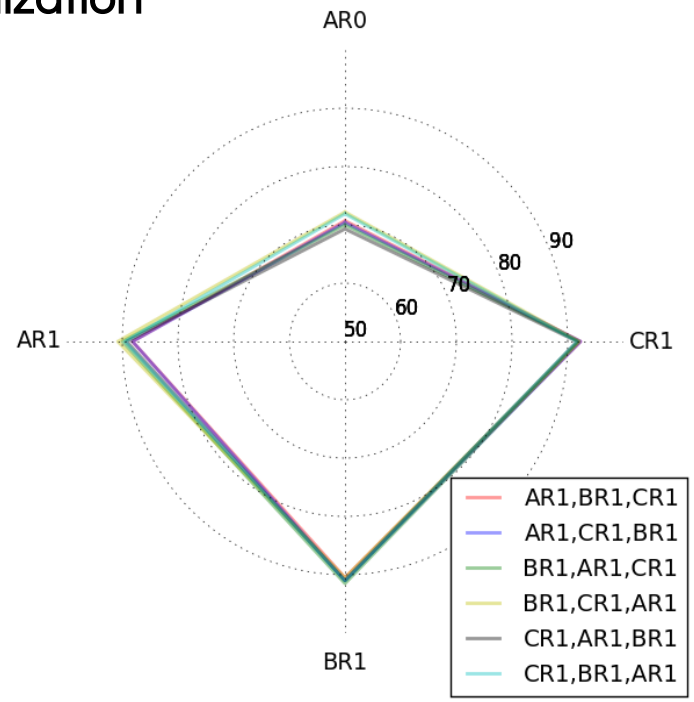


Multi-Source STS

Multi-source demonstrate **data efficiency**



Multi-source demonstrate **data generalization**



Kandaswamy, C., et.al,. Multi-source deep transfer learning for cross-sensor biometrics. Neural Computing and Applications, 2016.


THANK YOU
FOR LISTENING

WORKSHOP

References

Keras Resources:
https://github.com/fchollet/keras-resources

Standford University Course Materials:
http://vision.stanford.edu/teaching/cs231n/syllabus.html

More Deep Learning links:
http://neuralnetworksanddeeplearning.com/
http://www.bayareadlschool.org/

Youtube videos:
https://www.youtube.com/watch?v=eyovmAtoUx0&feature=youtu.be
https://www.youtube.com/watch?v=9dXiAecyJrY&feature=youtu.be