http://bit.ly/dlcv2018

#DLUPC

Day 1 Lecture 3

Image Classification

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Insight
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Overview

The image classification problem

The ImageNet large scale visual recognition challenge

Progress in ImageNet 2012 to 2017

Innovations in deep image classification

The image classification problem

$f($  $) = \text{“cat”}$

$f($  $) = \text{“horse”}$

The image classification problem

$$f(\ \ ) = \text{“cat”}$$

$$f : \mathbb{R}^{224 \times 224 \times 3} \rightarrow C$$

$$C = \{\text{dog}, \text{cat}, \text{horse}, \text{airplane}, \text{tree}\}$$

Multi-class classification

Assumption: classes are **complete** and **mutually exclusive.**

K classes. Want to predict **probability** of each class.

$$\mathbf{p} \in [0,1]^K$$

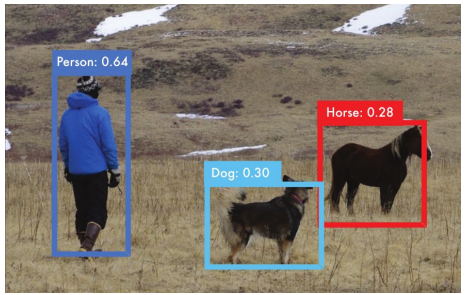
$$\sum_{i=1}^{K} \mathbf{p}_i = 1$$

(distinct from the **multi-label** classification task: classes are <u>not</u> mutually exclusive)

Classification vs ...

Recognition

Detection



Semantic segmentation

The ImageNet large scale visual recognition challenge (ILSVRC)

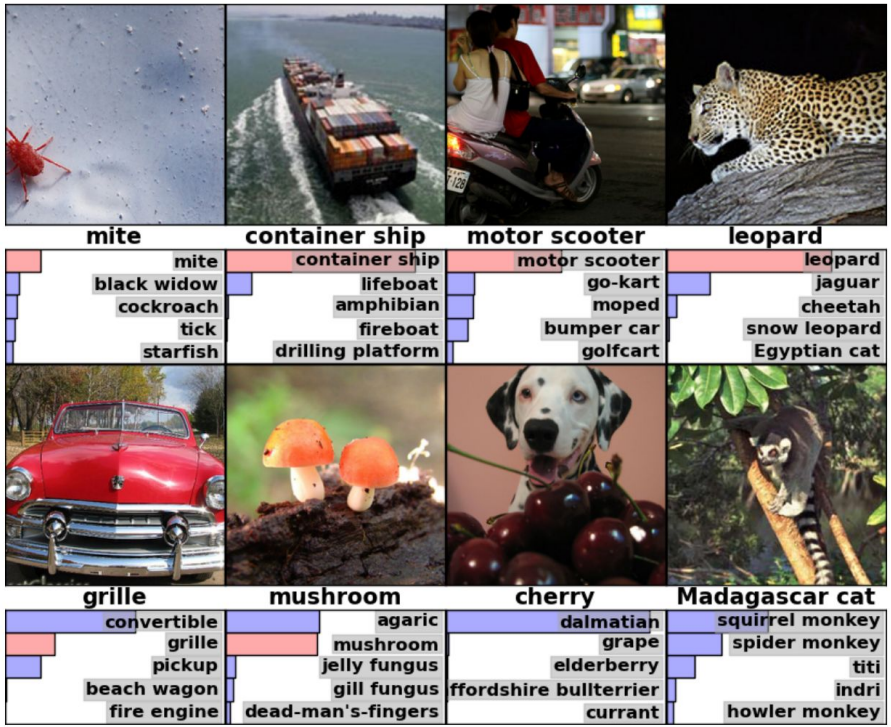
Dataset:

- 1.2 million training images
- 100 K test images
- 1,000 object classes (categories)
- Balanced dataset

Categories are leaves of the ImageNet hierarchy

- **No overlap**: presence of one category implies absence of another
- Suitable for **softmax** classification

Peculiarities: the 1000 classes contains 120 breeds of dogs!



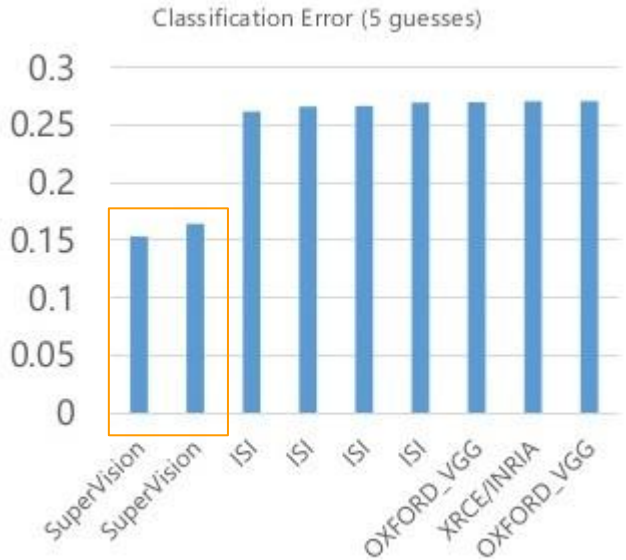
ILSVRC 2012

Pre-2012 approaches based on:

- SIFT, CSIFT, GIST, LBP, color stats
- Fisher vector encoding
- Linear SVMs
- Performance starting to saturate

2012 winner

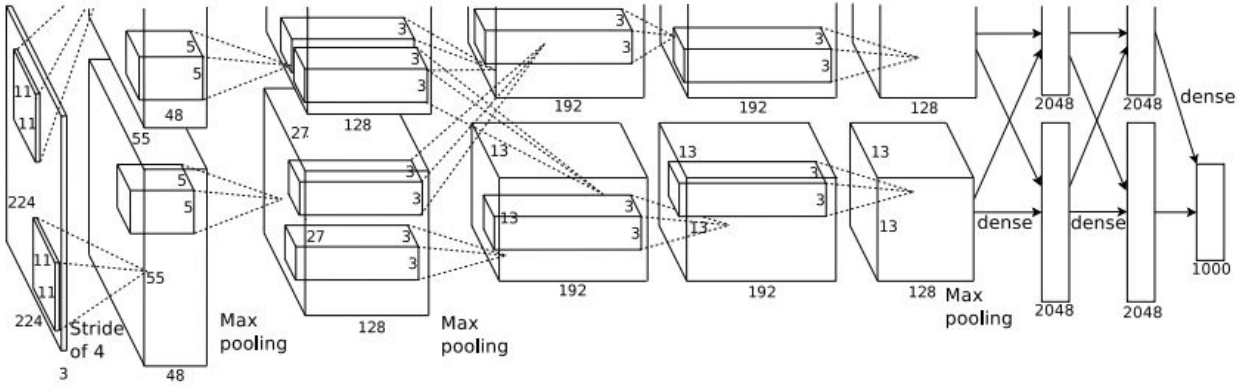
- Supervision (Krizhevsky, Hinton, ...)
- "**Alexnet**" convnet
- 10% margin on other approaches
- Revolution in computer vision
- Top-5 error: **15.315%**



Krizhevsky et al. ImageNet classification with deep convolutional neural networks. NIPS, 2012.

Alexnet

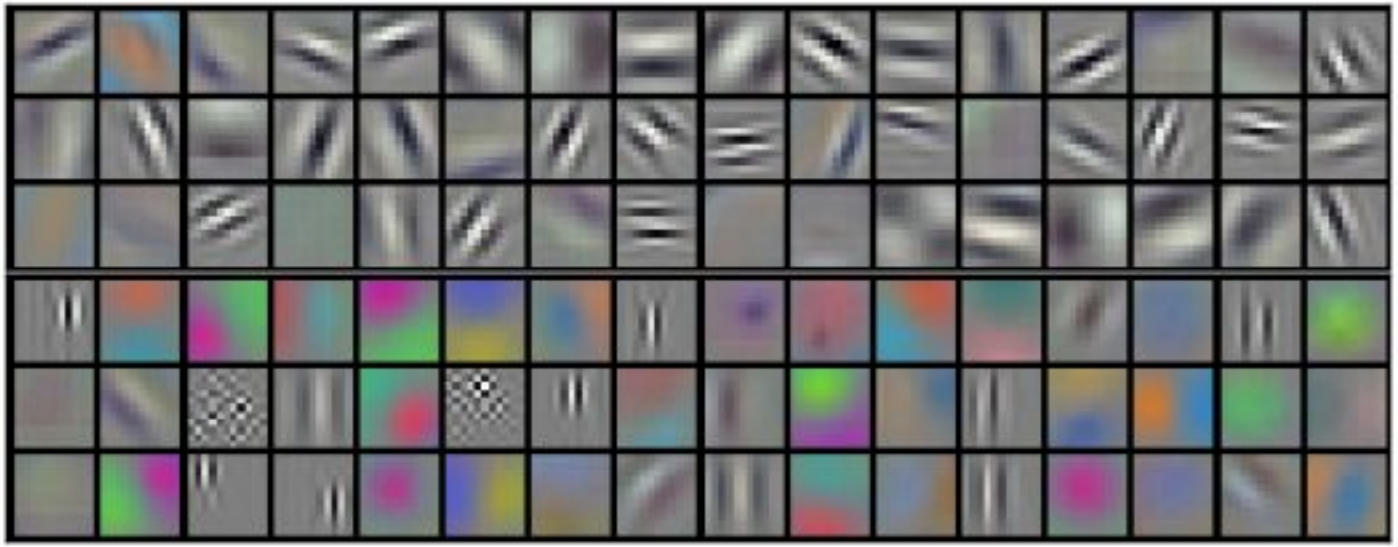
- 8 parameter layers (5 convolution, 3 fully connected)
- Softmax output
- 650,000 units
- 60 million free parameters
- Trained on two GPUs (two streams) for a week
- Ensemble of 7 nets used in ILSVRC challenge



Krizhevsky et al. ImageNet classification with deep convolutional neural networks. NIPS, 2012.

Filters learned by Alexnet

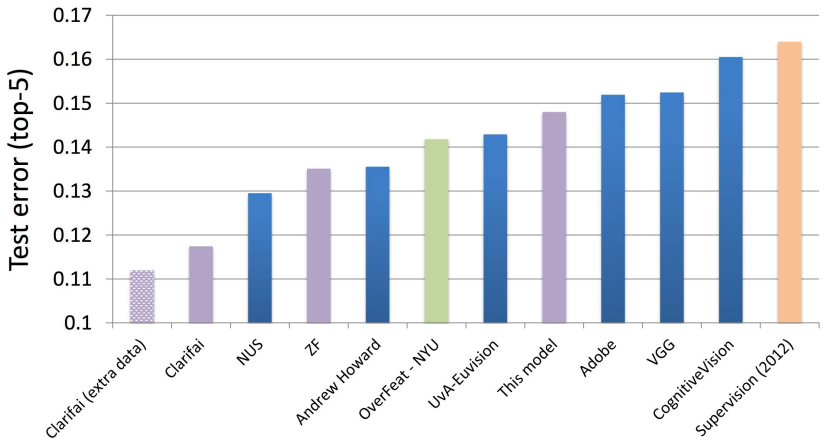
Visualization of the 96 11 x 11 filters learned by bottom layer



Krizhevsky et al. ImageNet classification with deep convolutional neural networks. NIPS, 2012.

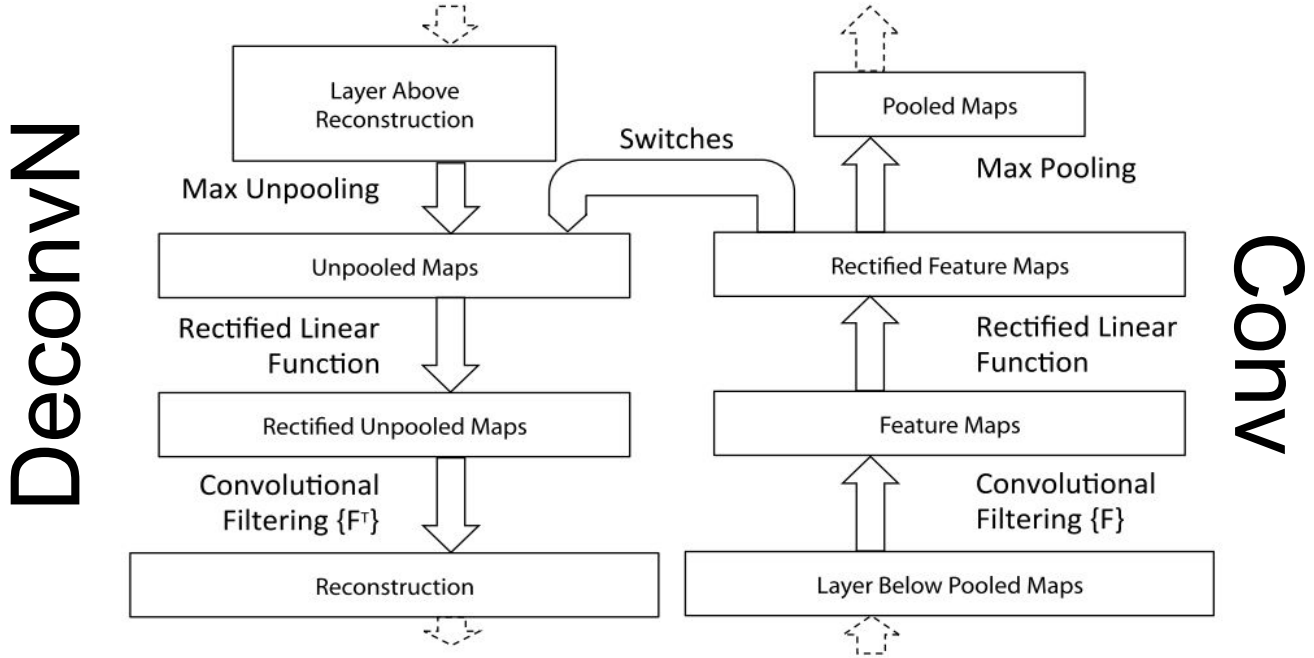
ILSVRC 2013: Zeiler and Fergus

- Simple modifications of Alexnet designed to retain more information about features in early layers and reduce the number of dead filters
  - Reduce filter size on first layer to 7x7
  - Reduce stride on first layer to 2
  - Additional dropout on input layer
- Modifications motivated by visualizing activations of Alexnet
- Won ILSVRC 2013



Zeiler and Fergus. Visualizing and understanding convolutional networks *ECCV 2014*

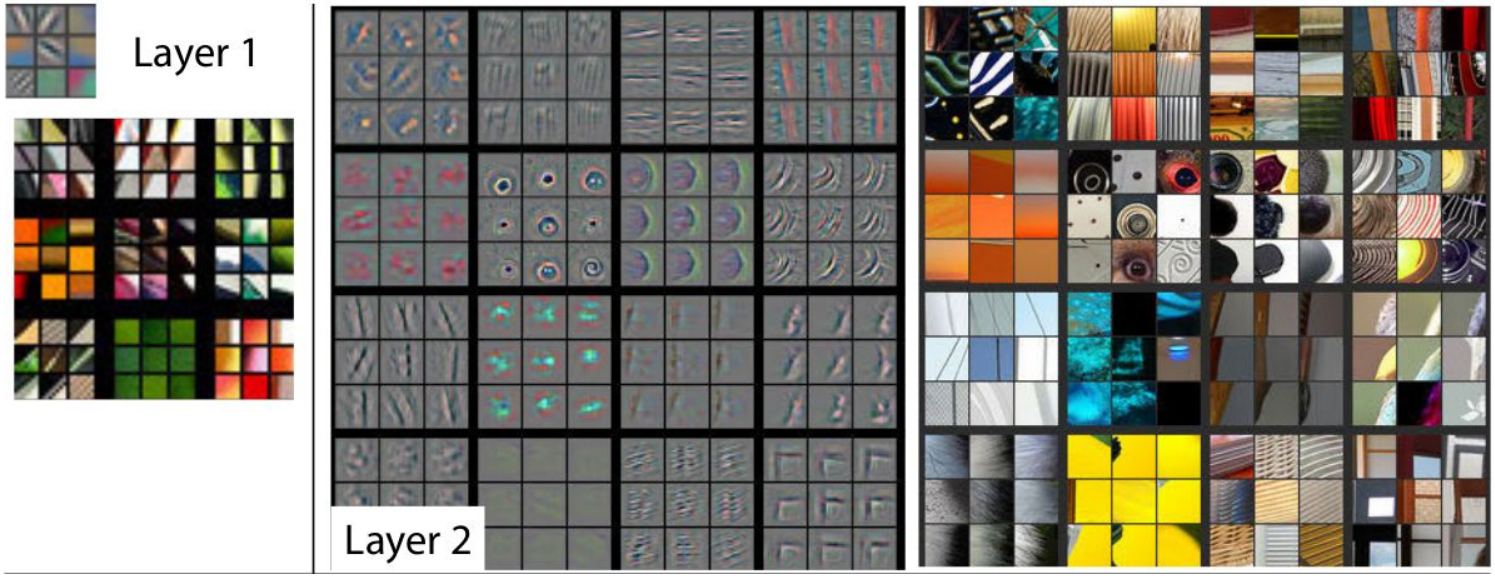
Using deconvolutions to visualize layer responses



Zeiler and Fergus. Visualizing and understanding convolutional networks *ECCV 2014*

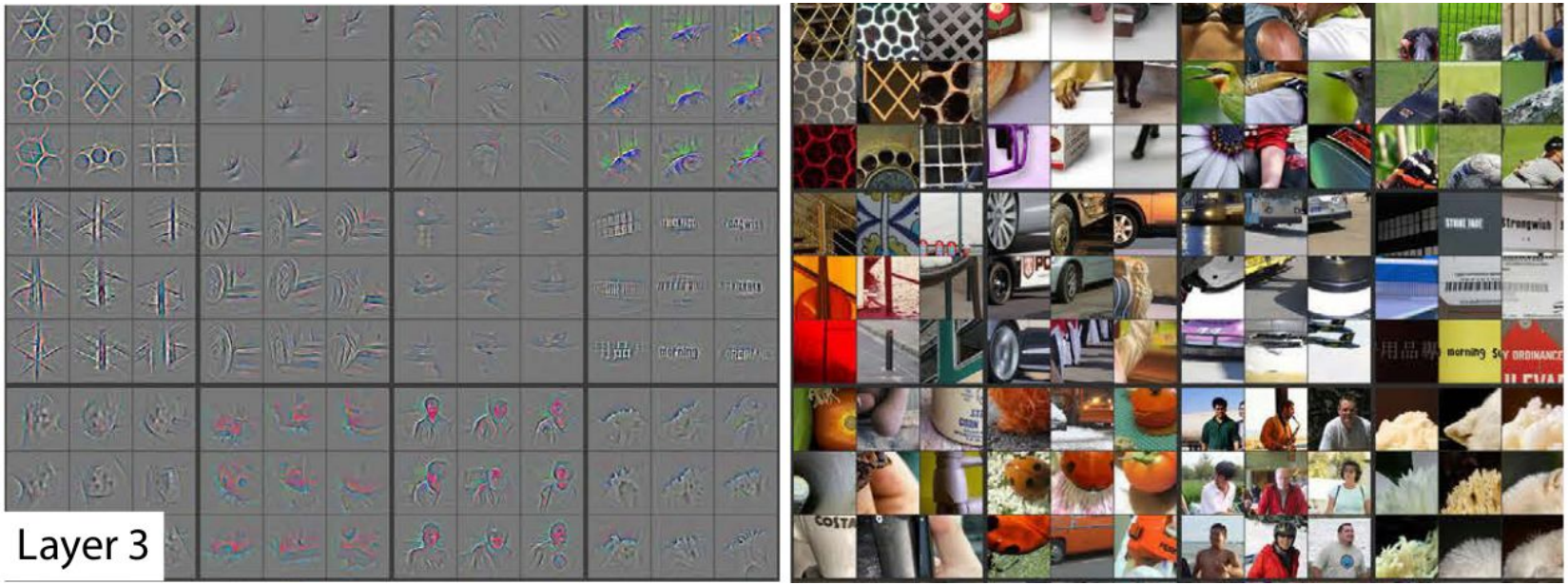
What do convnets learn?

Visualization of layer responses using a deconvolutional neural network on alexnet



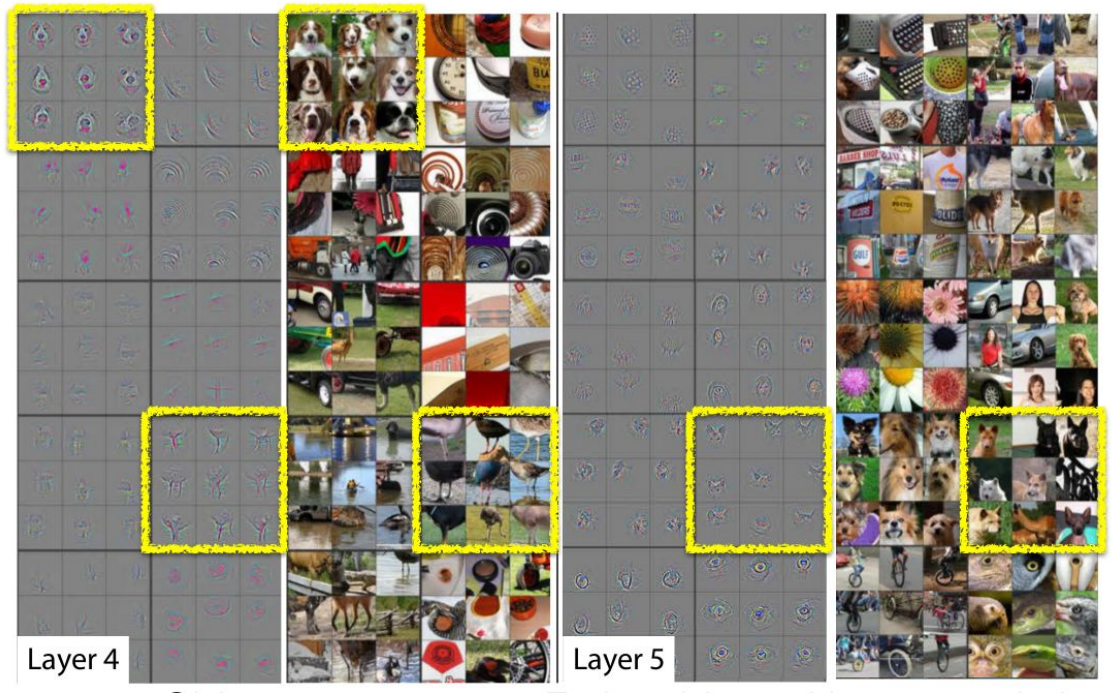
Zeiler and Fergus. Visualizing and understanding convolutional networks *ECCV 2014*

What do convnets learn?



Zeiler and Fergus. Visualizing and understanding convolutional networks *ECCV 2014*

What do convnets learn?



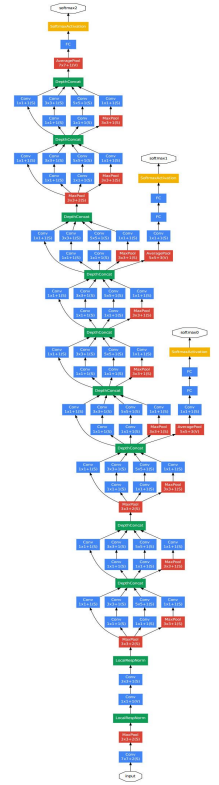
Zeiler and Fergus. Visualizing and understanding convolutional networks *ECCV 2014*

ILSVRC 2014: VGG and Inception

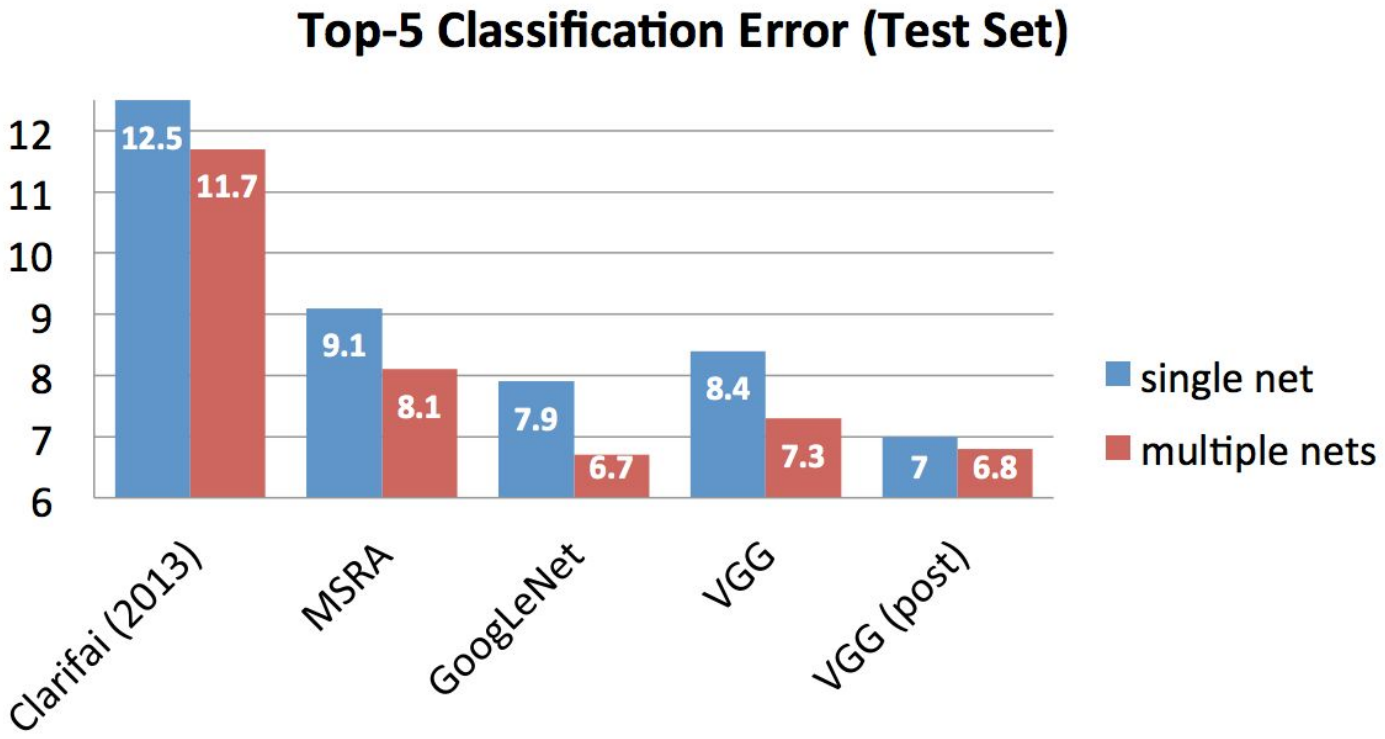
AlexNet

- image
- conv-64
- conv-192
- conv-384
- conv-256
- conv-256
- FC-4096
- FC-4096
- FC-1000

- image
- conv-64
- conv-64
- maxpool
- conv-128
- conv-128
- maxpool
- conv-256
- conv-256
- conv-256
- conv-256
- maxpool
- conv-512
- conv-512
- conv-512
- conv-512
- maxpool
- conv-512
- conv-512
- conv-512
- conv-512
- maxpool
- FC-4096
- FC-4096
- FC-1000
- softmax



ImageNet 2014: VGG and Inception



Simonyan, Karen, and Andrew Zisserman. Very deep convolutional networks for large-scale image recognition. *ICLR 2015*. [video] [slides] [project]

Modern convnets: VGG

VGG networks (Simonyan & Zisserman)

- Add more layers
- Stacked convolutions with smaller apertures (3x3) work better than a large (7x7) convolution

2 versions

- VGG-16 (16 parameter layers)
- VGG-19 (19 parameter layers)

ILSVRC 2014

- Top-5 error (16 layer): 7.5%
- Top-5 error (19 layer): 7.4%
- Top-5 error (ensemble): 7.0%

http://www.robots.ox.ac.uk/~vgg/research/very_deep/

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224 × 224 RGB image)					
conv3-64	conv3-64 **LRN**	conv3-64 **conv3-64**	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 **conv3-128**	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 **conv1-256**	conv3-256 conv3-256 **conv3-256**	conv3-256 conv3-256 **conv3-256**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 **conv3-512**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 **conv3-512**
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

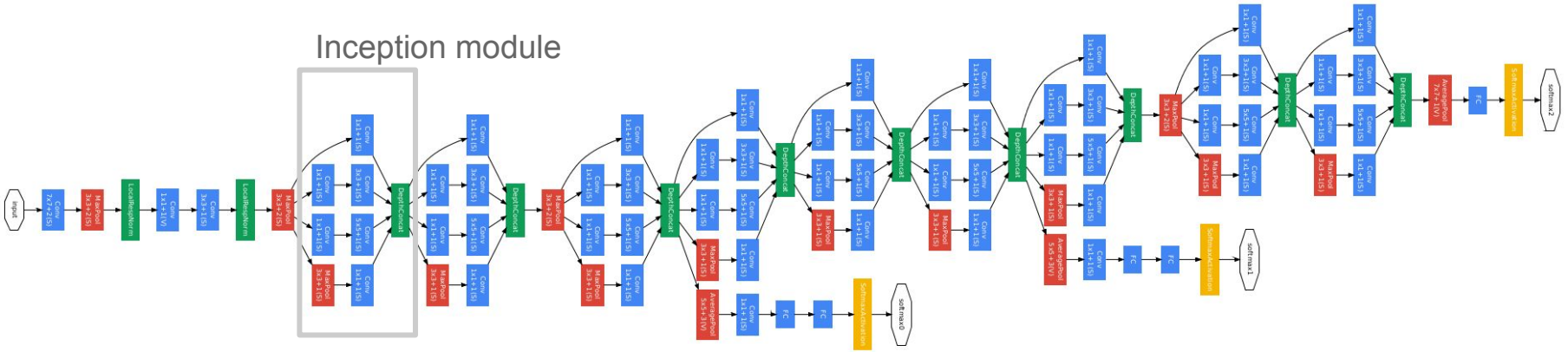
Simonyan, Karen, and Andrew Zisserman. Very deep convolutional networks for large-scale image recognition. *ICLR 2015*. [video] [slides] [project]

Modern convnets: GoogLeNet

Introduced **inception layer** for multiscale analysis

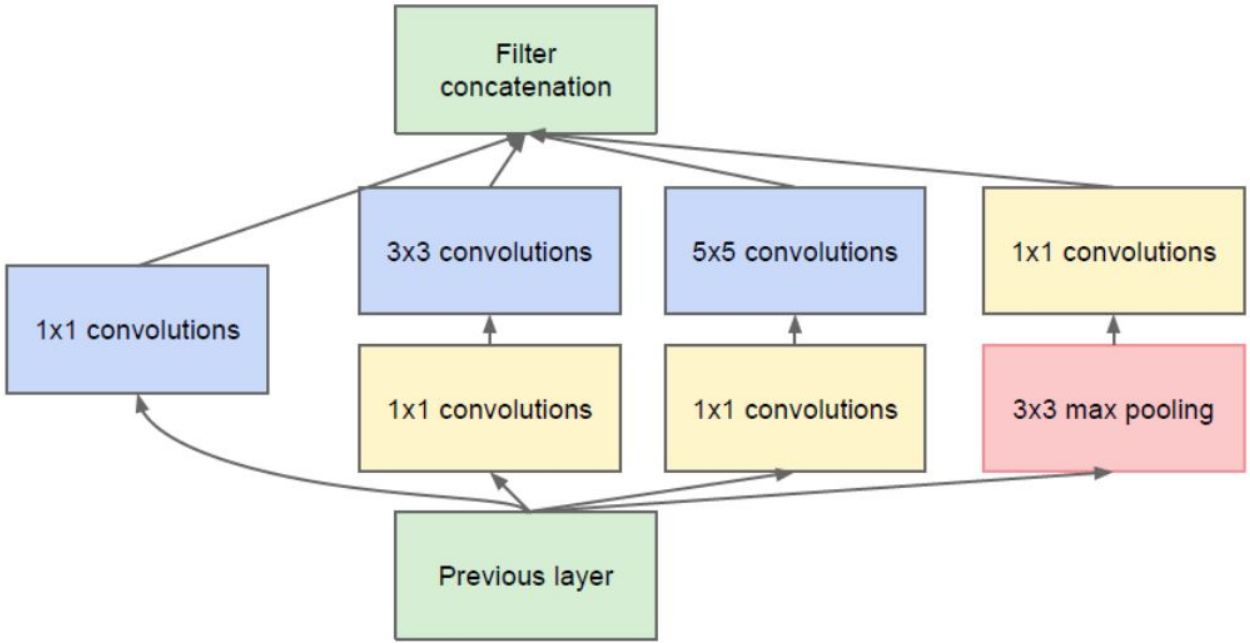
Extensive use of **1x1 convolutions** for dimensionality reduction

Very deep network. **6.65% top-5 error** ILSVRC 2014



Szegedy, Christian, et al. Going deeper with convolutions. CVPR 2015.

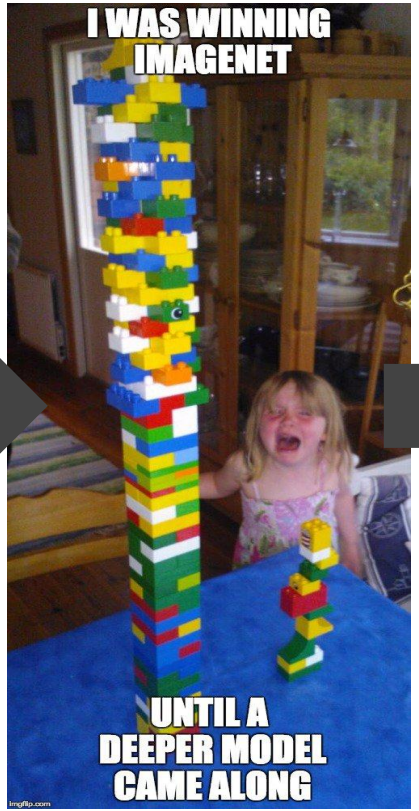
Inception module

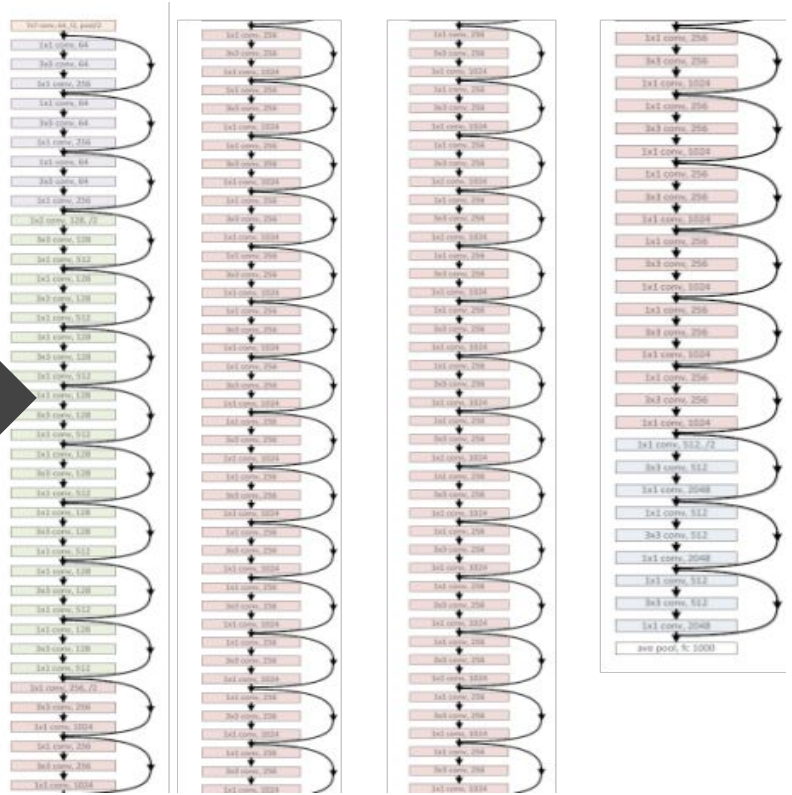


Szegedy, Christian, et al. Going deeper with convolutions. CVPR 2015.

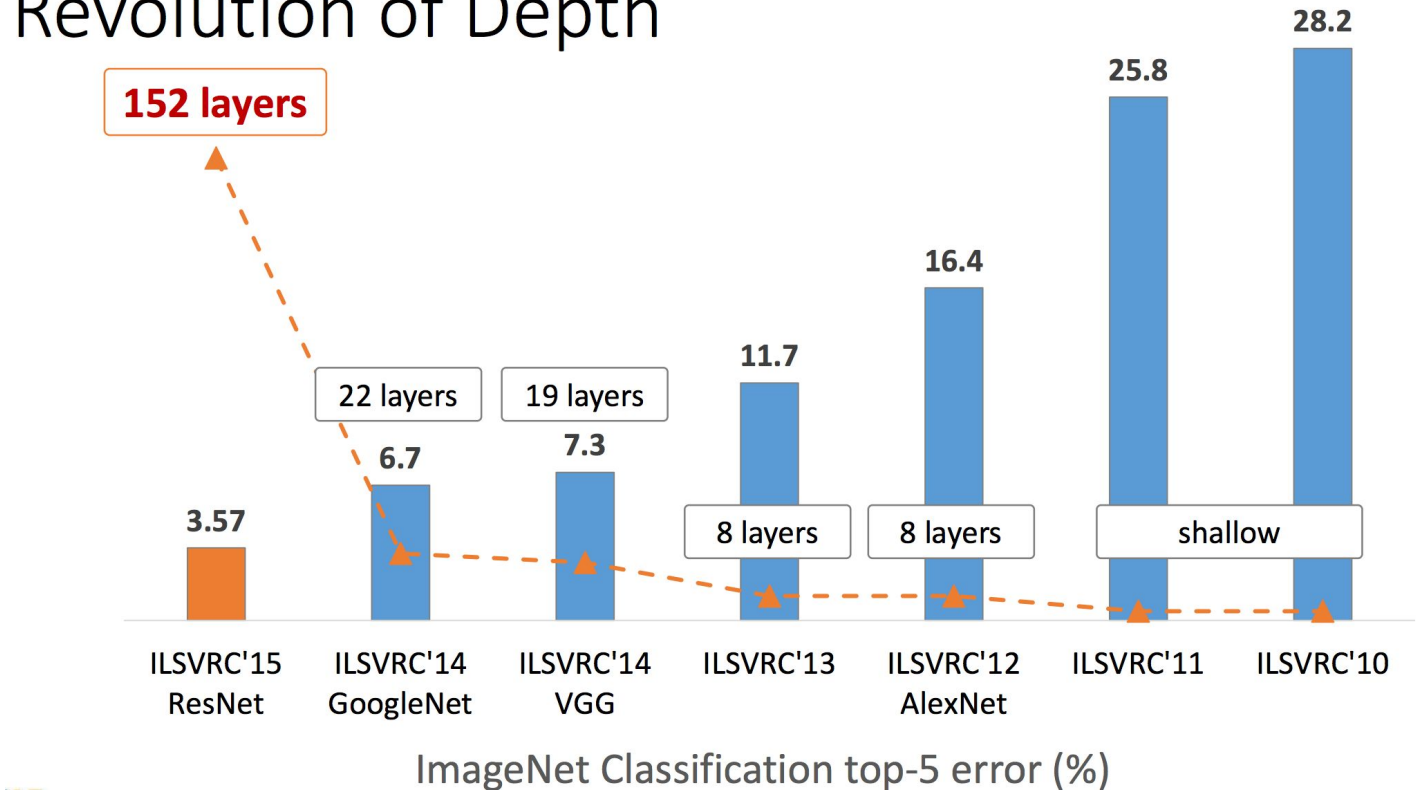
ILSVRC 2015: Resnet

image
conv-64
conv-64
maxpool
conv-128
conv-128
maxpool
conv-256
conv-256
conv-256
conv-256
maxpool
conv-512
conv-512
conv-512
conv-512
maxpool
conv-512
conv-512
conv-512
conv-512
maxpool
FC-4096
FC-4096
FC-1000
softmax



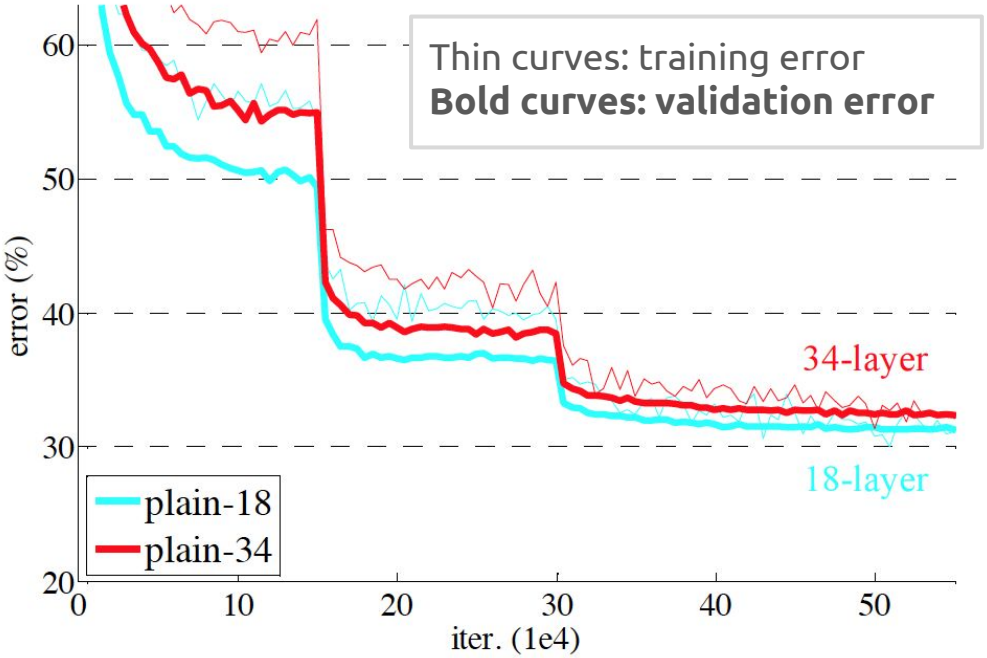


Revolution of Depth



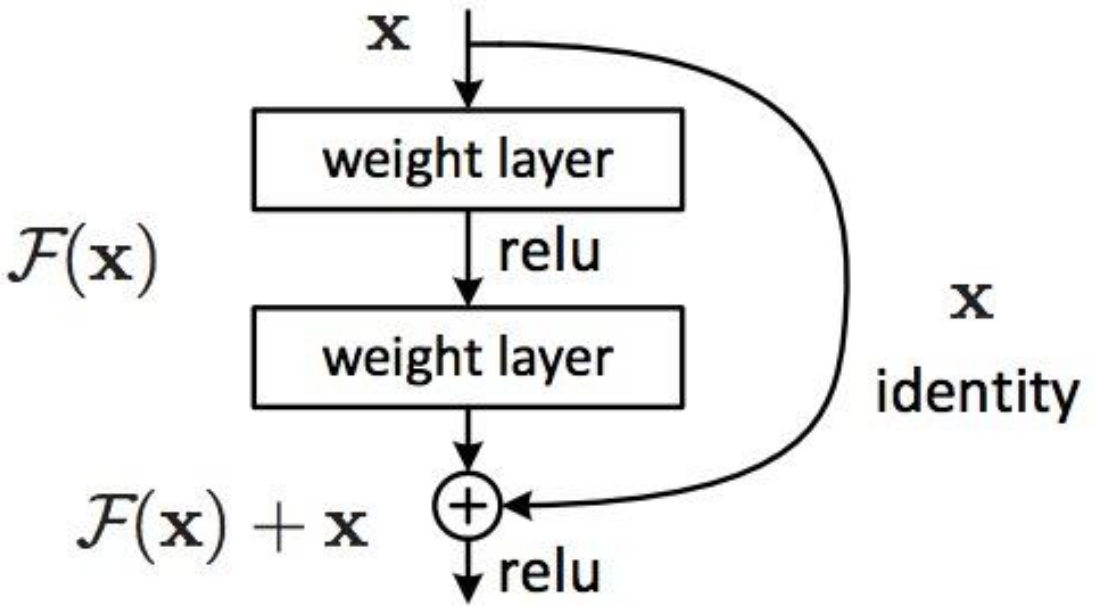
He et al. Deep Residual Learning for Image Recognition CVPR 2016

The problem with training very deep networks



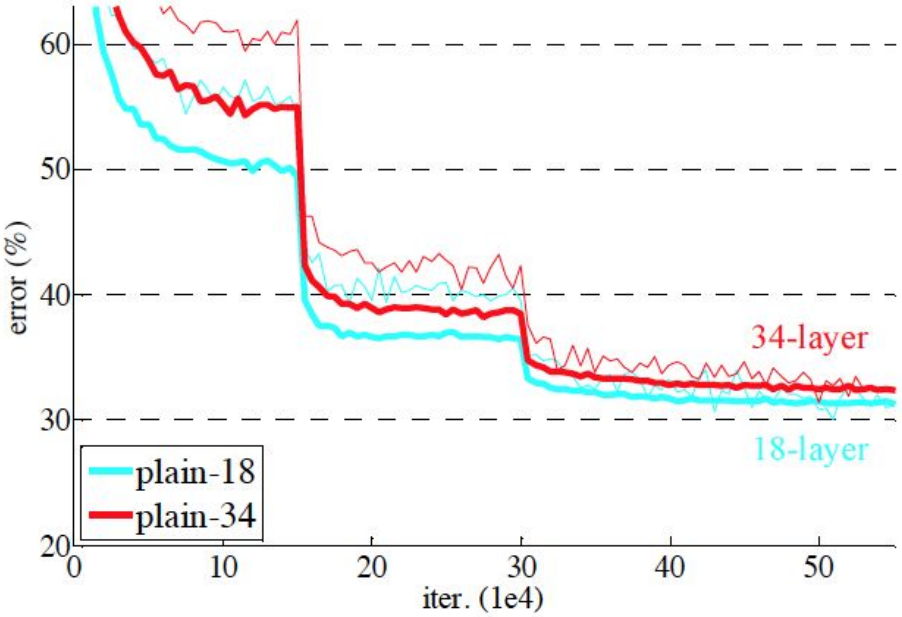
He et al. Deep Residual Learning for Image Recognition CVPR 2016

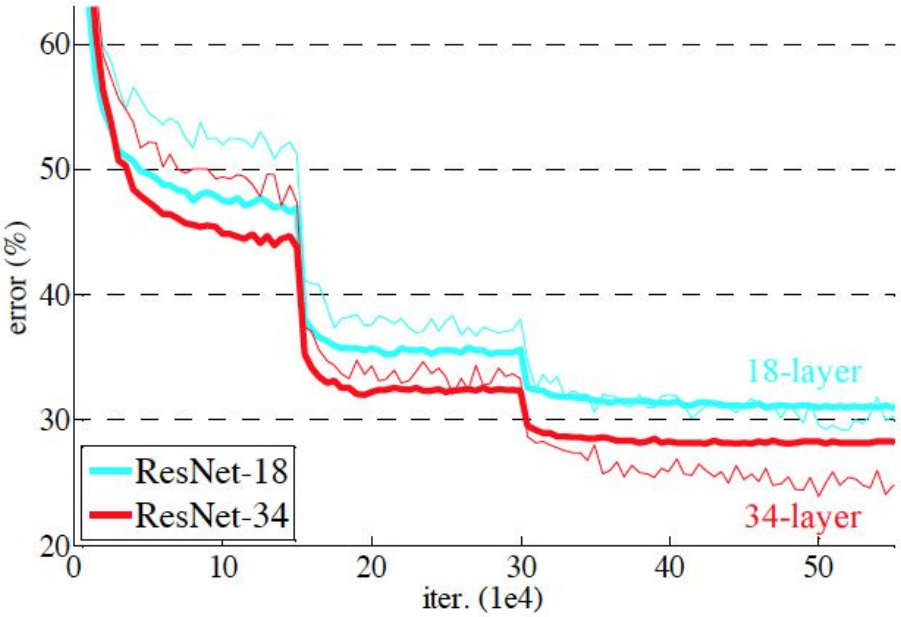
Residual blocks



He et al. Deep Residual Learning for Image Recognition CVPR 2016

34 layer plain network vs 34 layer residual network





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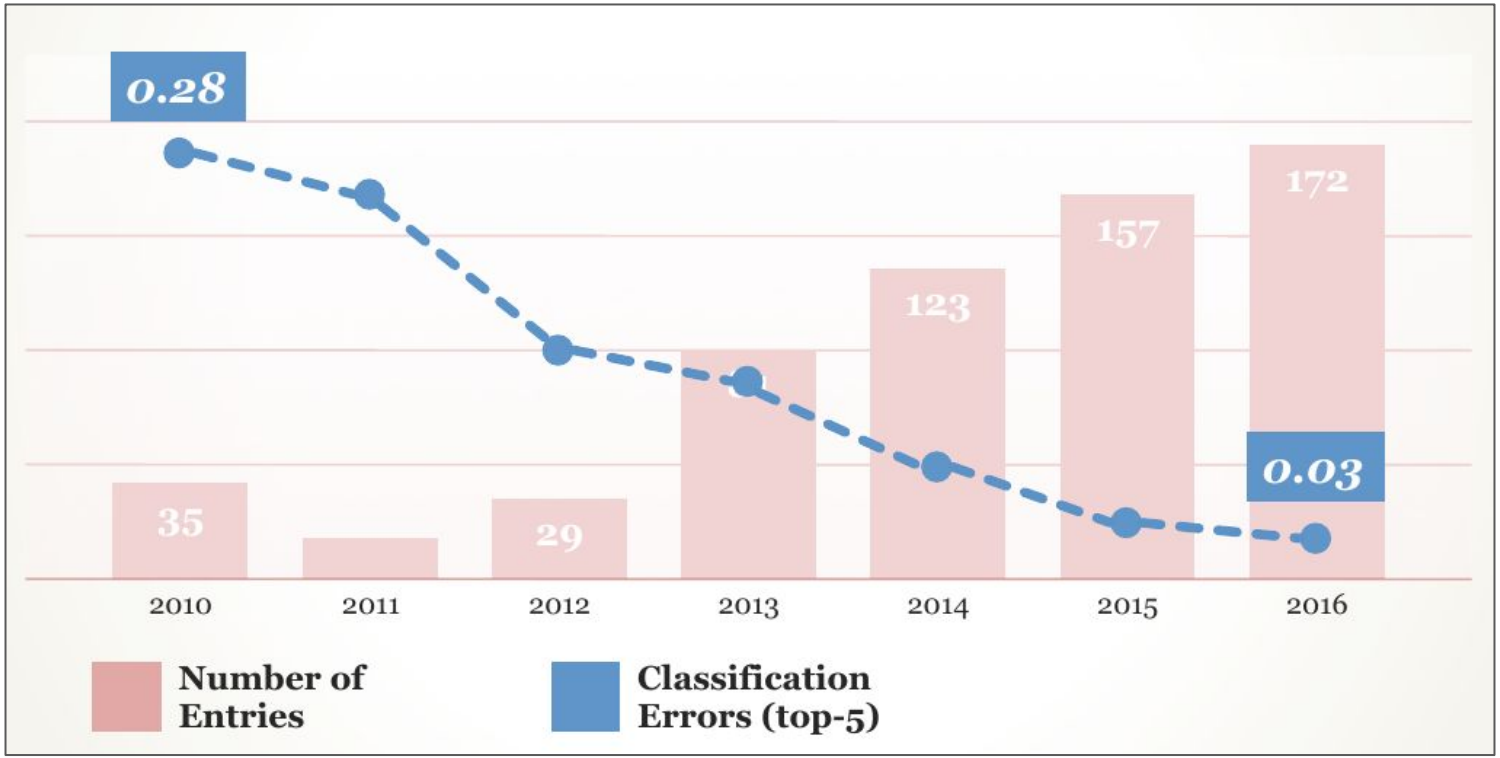
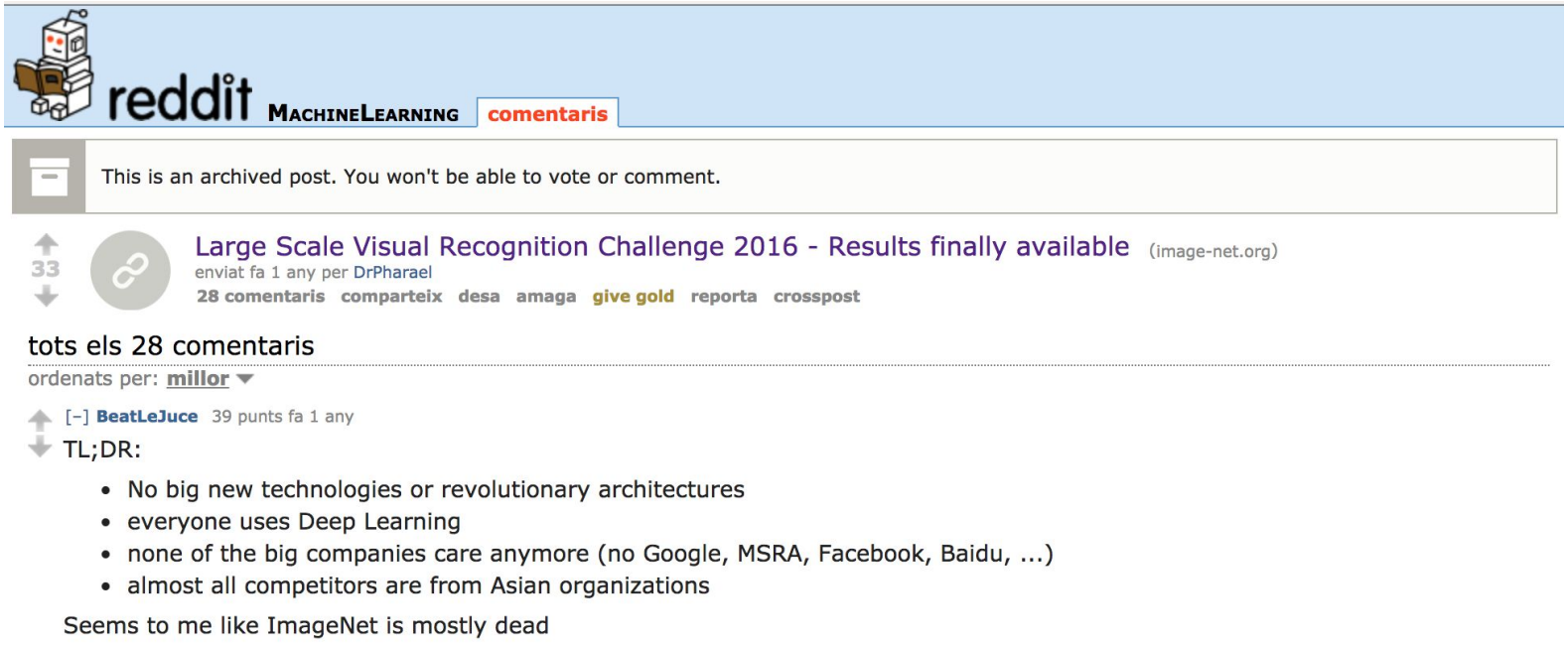
ILSVRC 2016



Source: http://image-net.org/challenges/talks_2017/imagenet_ilsvrc2017_v1.0.pdf

ILSVRC 2016



reddit MACHINELEARNING comentaris

This is an archived post. You won't be able to vote or comment.

33

Large Scale Visual Recognition Challenge 2016 - Results finally available (image-net.org)

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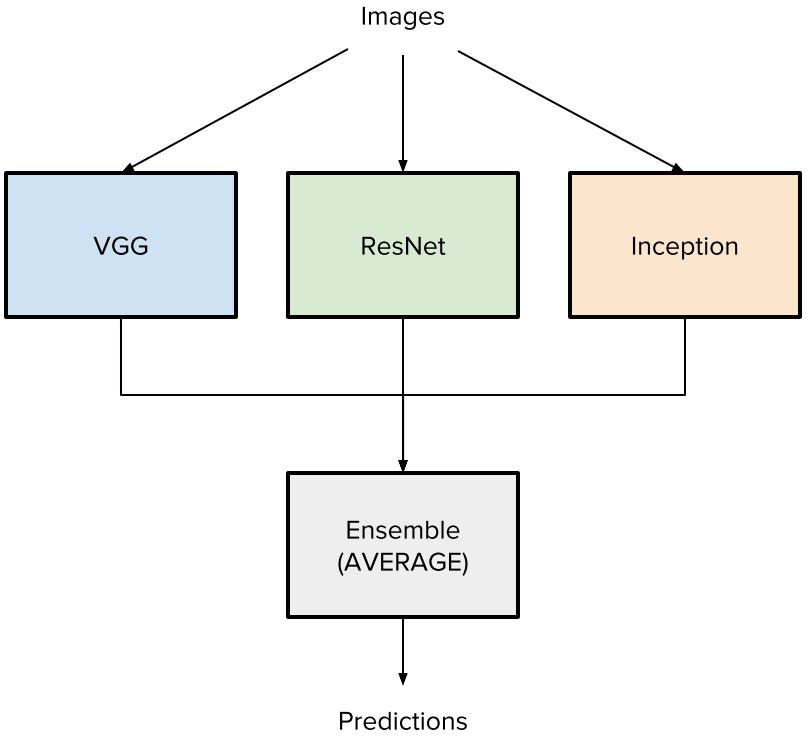
TL;DR:

- No big new technologies or revolutionary architectures
- everyone uses Deep Learning
- none of the big companies care anymore (no Google, MSRA, Facebook, Baidu, ...)
- almost all competitors are from Asian organizations

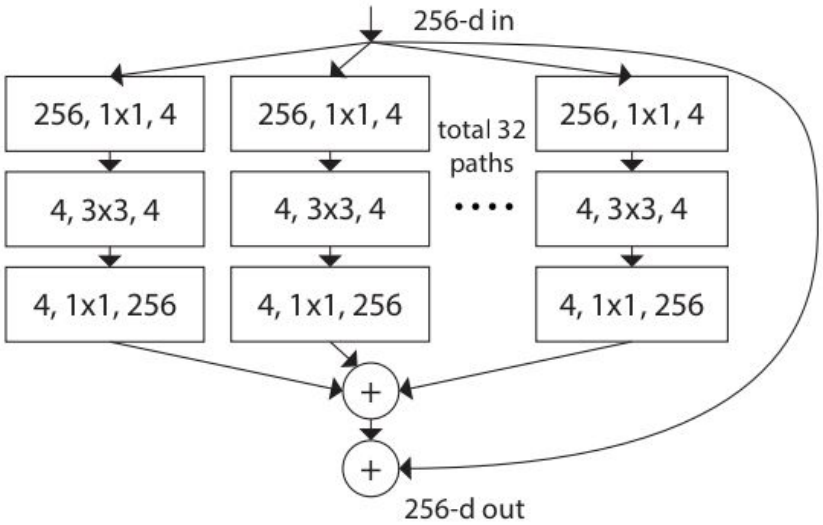
Seems to me like ImageNet is mostly dead

Ensembles (Hikivision)

- More than 20 models, including VGG, Inception, ResNet and variations of it.
- Novel data augmentation.
- Novel learning rate policy.
- ...and “some small tricks”

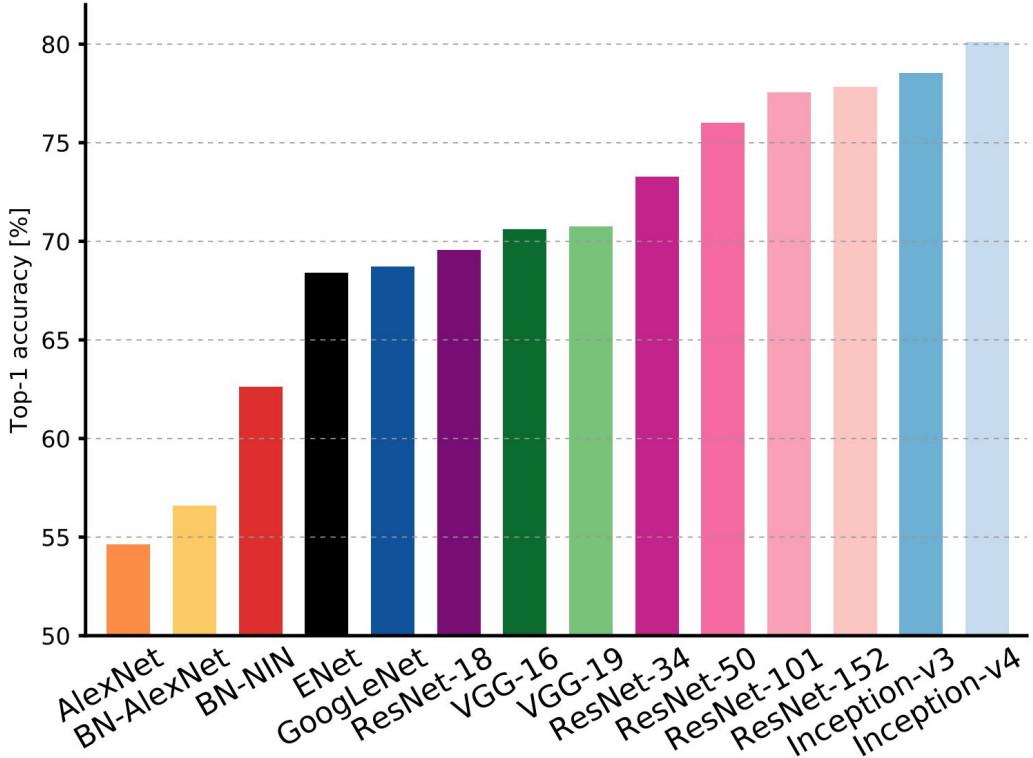


ResNext = ResNet + Inception

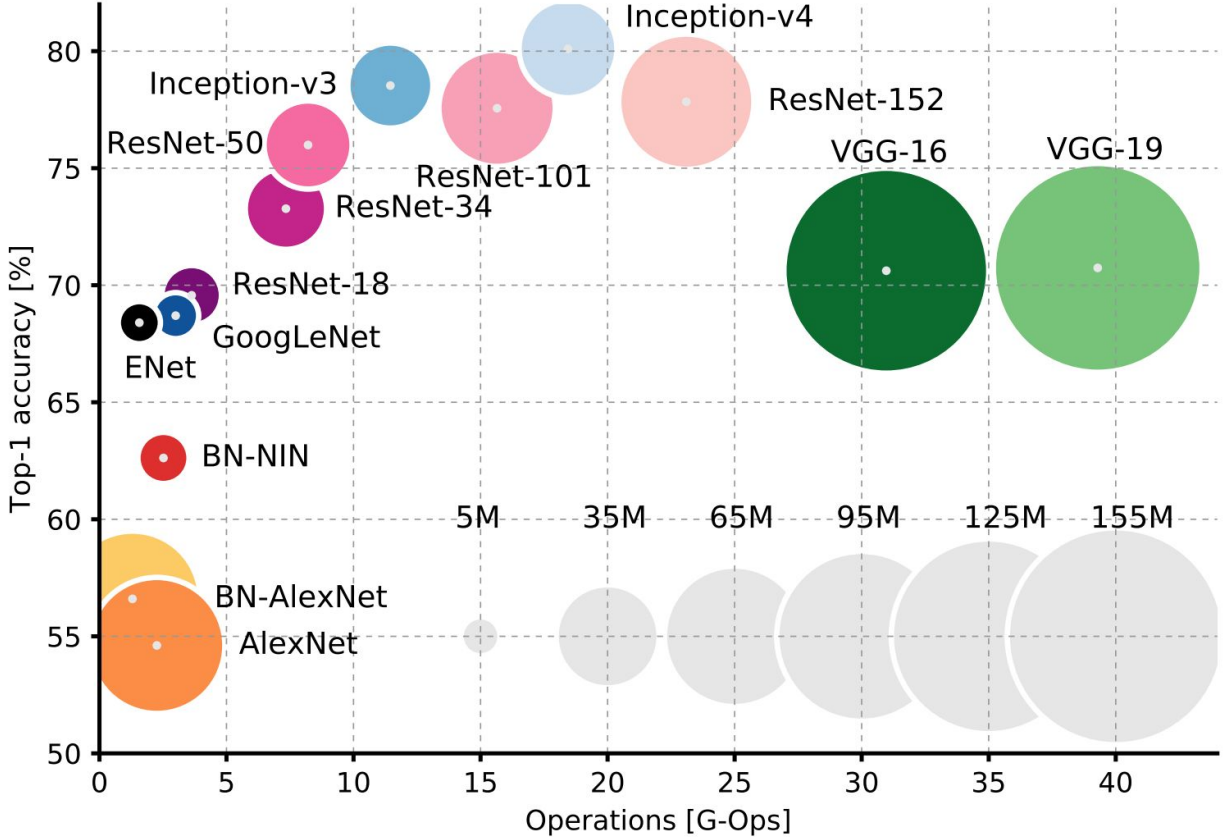


facebook research

Xie, Saining, Ross Girshick, Piotr Dollár, Zhuowen Tu, and Kaiming He. "Aggregated residual transformations for deep neural networks." CVPR 2017 [code]

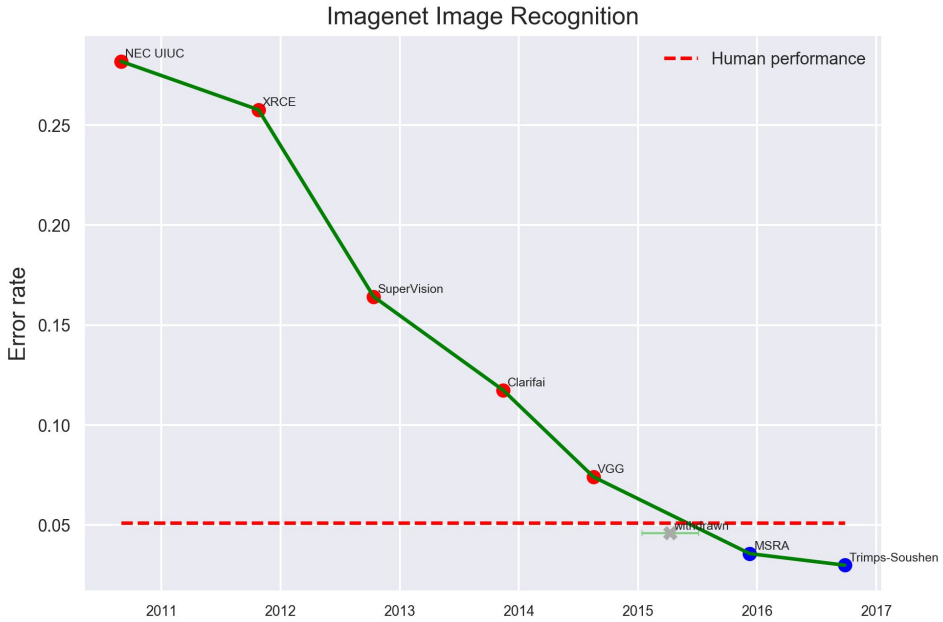


Canziani, Alfredo, Adam Paszke, and Eugenio Culurciello. "An analysis of deep neural network models for practical applications." arXiv 2016.



Canziani, Alfredo, Adam Paszke, and Eugenio Culurciello. "An analysis of deep neural network models for practical applications." arXiv 2016.

ILSVRC 2017: the end of the challenge



Electronic Frontier Foundation: “Measuring the Progress of AI Research” (2017)

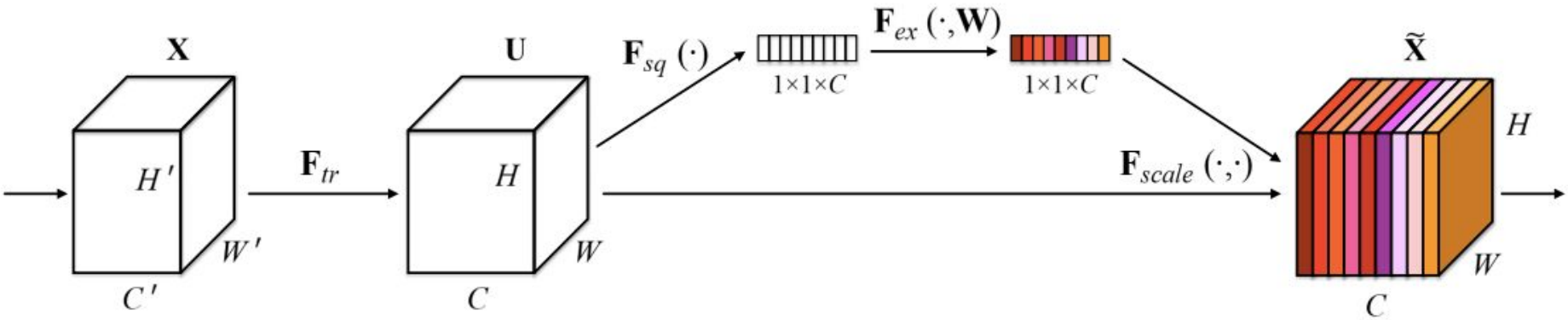
The end of the challenge

Beyond ImageNet Large Scale Visual Recognition Challenge

July 26th in conjunction with CVPR 2017

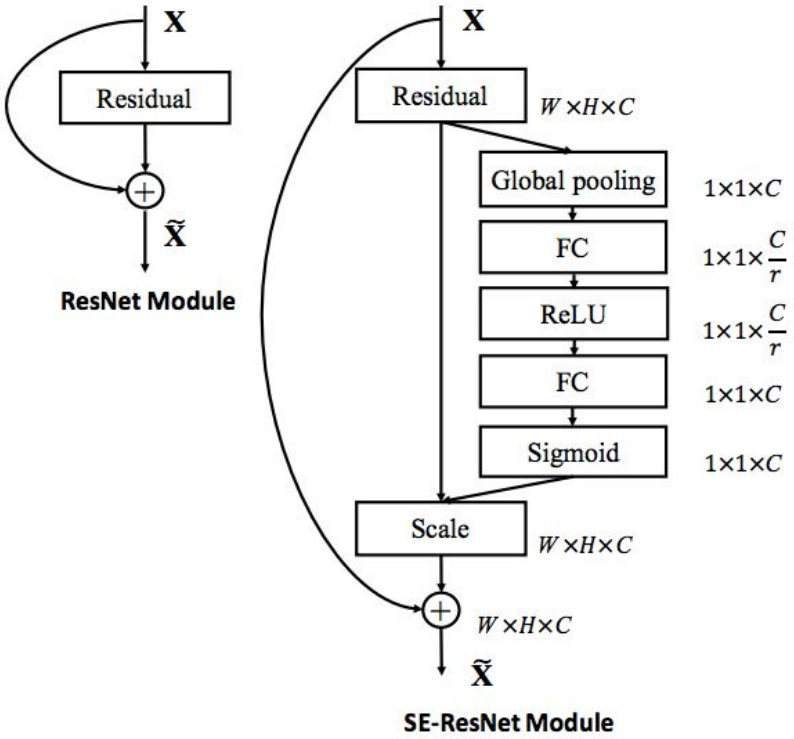
http://image-net.org/challenges/beyond_ilsvrc

Squeeze and excitation networks



Jie Hu, Li Shen, Gang Sun, Squeeze-and-Excitation Networks, CVPR 2018

Squeeze and excitation networks



Used in ILSVRC 2017

25% improvement over ResNet and ResNext

Jie Hu, Li Shen, Gang Sun, Squeeze-and-Excitation Networks, CVPR 2018

Other datasets and challenges

COCO is a large-scale object detection, segmentation, and captioning dataset. COCO has several features:

- Object segmentation
- Recognition in context
- Superpixel stuff segmentation
- 330K images (>200K labeled)
- 1.5 million object instances
- 80 object categories
- 91 stuff categories
- 5 captions per image
- 250,000 people with keypoints

Visual Genome is a dataset, a knowledge base, an ongoing effort to connect structured image concepts to language.

- 108,077 images
- 5.4M region descriptions
- 1.7M visual question answers
- 3.8M object instances
- 2.8M attributes
- 2.3M relationships
- Everything mapped to wordnet synsets

Questions?

Learn more

Li Fei-Fei, “How we’re teaching computers to understand pictures” TEDTalks 2014.

GoogleNet (Inception)

Research at Google

UNIVERSITY OF NORTH CAROLINA CHAPEL HILL

UNIVERSITY OF MICHIGAN

magic leap™

Szegedy, Christian, Wei Liu, Yangqing Jia, Pierre Sermanet, Scott Reed, Dragomir Anguelov, Dumitru Erhan, Vincent Vanhoucke, and Andrew Rabinovich. "Going deeper with convolutions." CVPR 2015. [video] [slides] [poster]

VGG

UNIVERSITY OF OXFORD

Google DeepMind

Simonyan, Karen, and Andrew Zisserman. "Very deep convolutional networks for large-scale image recognition." *ICLR 2015*. [video] [slides] [project]