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# ECE 599/692 – Deep Learning

## Lecture 6 – CNN: The Variants

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## Outline

- Lecture 3: Core ideas of CNN
  - Receptive field
  - Pooling
  - Shared weight
  - Derivation of BP in CNN
- Lecture 4: Practical issues
  - The learning slowdown problem
    - Quadratic cost function
    - Cross-entropy + sigmoid
    - Log-likelihood + softmax
  - Overfitting and regularization
    - L2 vs. L1 normalization
    - Dropout
    - Artificial expanding the training set
  - Weight initialization
  - How to choose hyper-parameters
    - Learning rate, early stopping, learning schedule, regularization parameter, mini-batch size,
    - Grid search
  - Others
    - Momentum-based GD
- Lecture 5: The representative power of NN
- Lecture 6: Variants of CNN
  - From LeNet to AlexNet to GoogleNet to VGG to ResNet
- Lecture 7: Implementation
- Lecture 8: Applications of CNN



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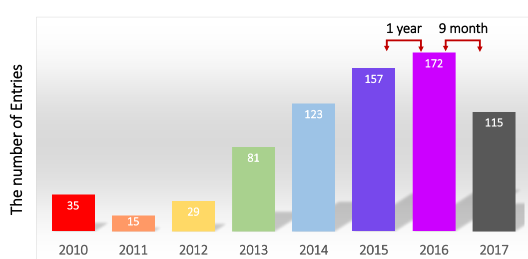
## Participation in ILSVRC over the years




Data from ImageNET Large Scale Visual Recognition Challenge (ILSVRC) 2017

## Classification results

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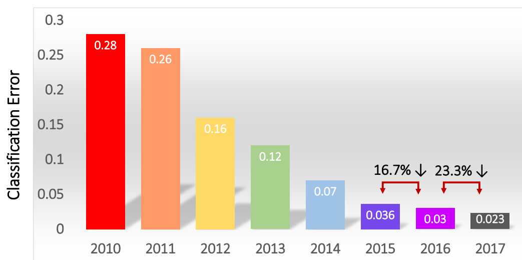


Data from ImageNET Large Scale Visual Recognition Challenge (ILSVRC) 2017



## ImageNet Large Scale Visual Recognition Challenge (ILSVRC)

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| Year | Top-5 Error | Model |
|---|---|---|
| 2010 winner | 28.2% | Fast descriptor coding |
| 2011 winner | 25.7% | Compressed Fisher vectors |
| 2012 winner | 15.3% | AlexNet (8, 60M) |
| 2013 winner | 14.8% | ZFNet |
| 2014 winner<br>2014 runner-up | 6.67% | GoogLeNet (22, 4M)<br>VGGNet (16, 140M) |
| 2015 winner | 3.57% | ResNet (152) |
| 2016 winner<br>2017 winner | 3%<br>2.3% | Ensembled approach - CUImage<br>SENet () – Momenta |

Nov. 2017, Google AutoML outperform all human-constructed models, NASNet

Human expert: 5.1%

https://www.independent.co.uk/life-style/gadgets-and-tech/news/google-child-ai-bot-nasnet-automl-machine-learning-artificial-intelligence-a8093201.html



## LeNet-5 (1989 or 1998)

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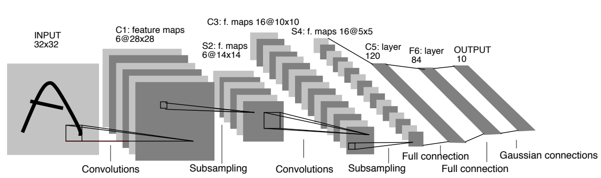

## AlexNet (2012)

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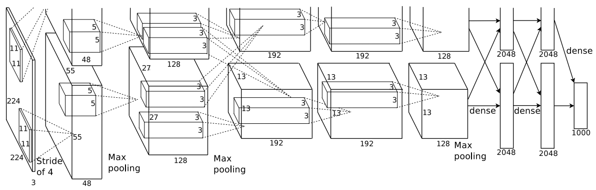


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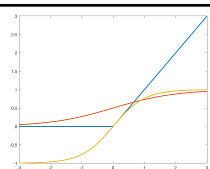
## AlexNet – Cont'

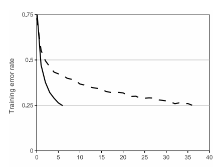
- Improvements
  - Bigger network
    - 8 layers (5 conv + 3 fc)
    - Layer 1: Conv+norm+relu+max-pooling
    - Layer 2: Conv+norm+relu+max-pooling
    - Layer 3: Conv+relu
    - Layer 4: Conv+relu
    - Layer 5: Conv+norm+relu
    - …
  - ReLU vs. Sigmoid or tanh(x)
  - Training on multiple GPUs
  - Local response normalization
  - Overlapping pooling
- Reduce overfitting
  - Data augmentation
    - Translation and horizontal mirror
    - Adding principal components from PCA
  - Dropout

$\sigma(z) = max(0, z)$

$\sigma(z) = \frac{1}{1+\exp(-z)}$

$\sigma(z) = \tanh(z)$



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## GoogLeNet (2014)

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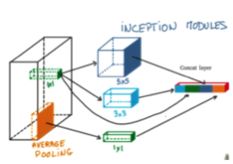
- Inception-v4
- Moving from fully connected to sparsely connected
- Finding optimal local construction and repeat spatially
- 22 layers

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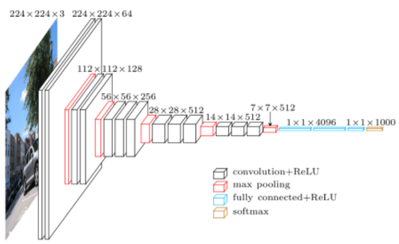
## VGGNet

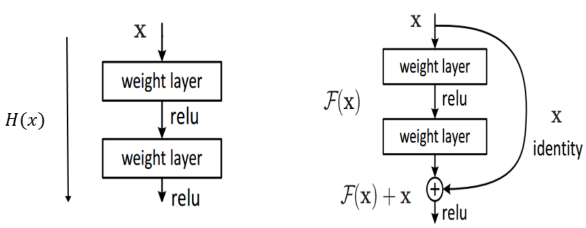
- The extreme homogeneity in architectural design




10

## ResNet

- Residual connection




11