Deep Learning application to large-scale image retrieval

Pavel Nesterov

http://pavelnesterov.info/

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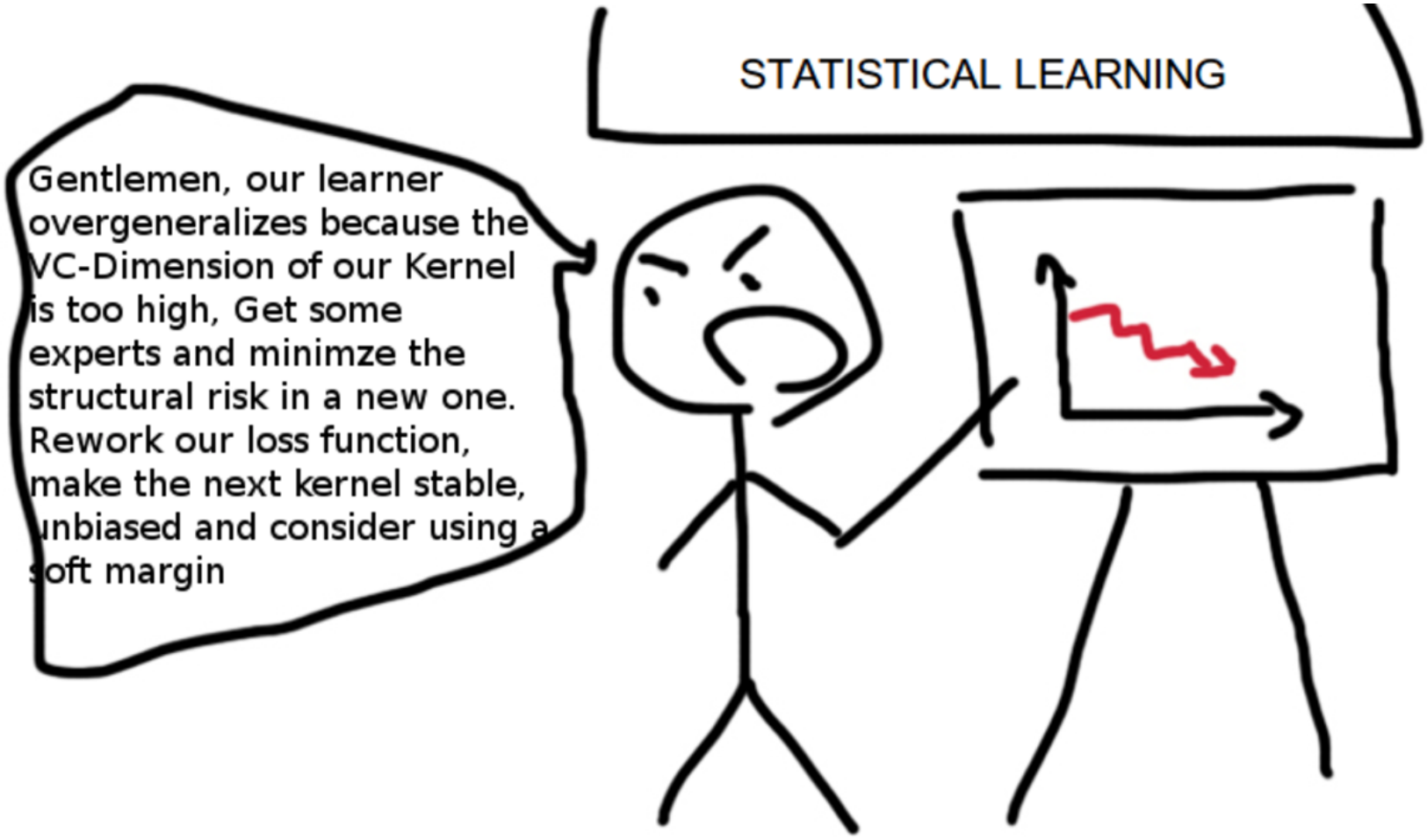
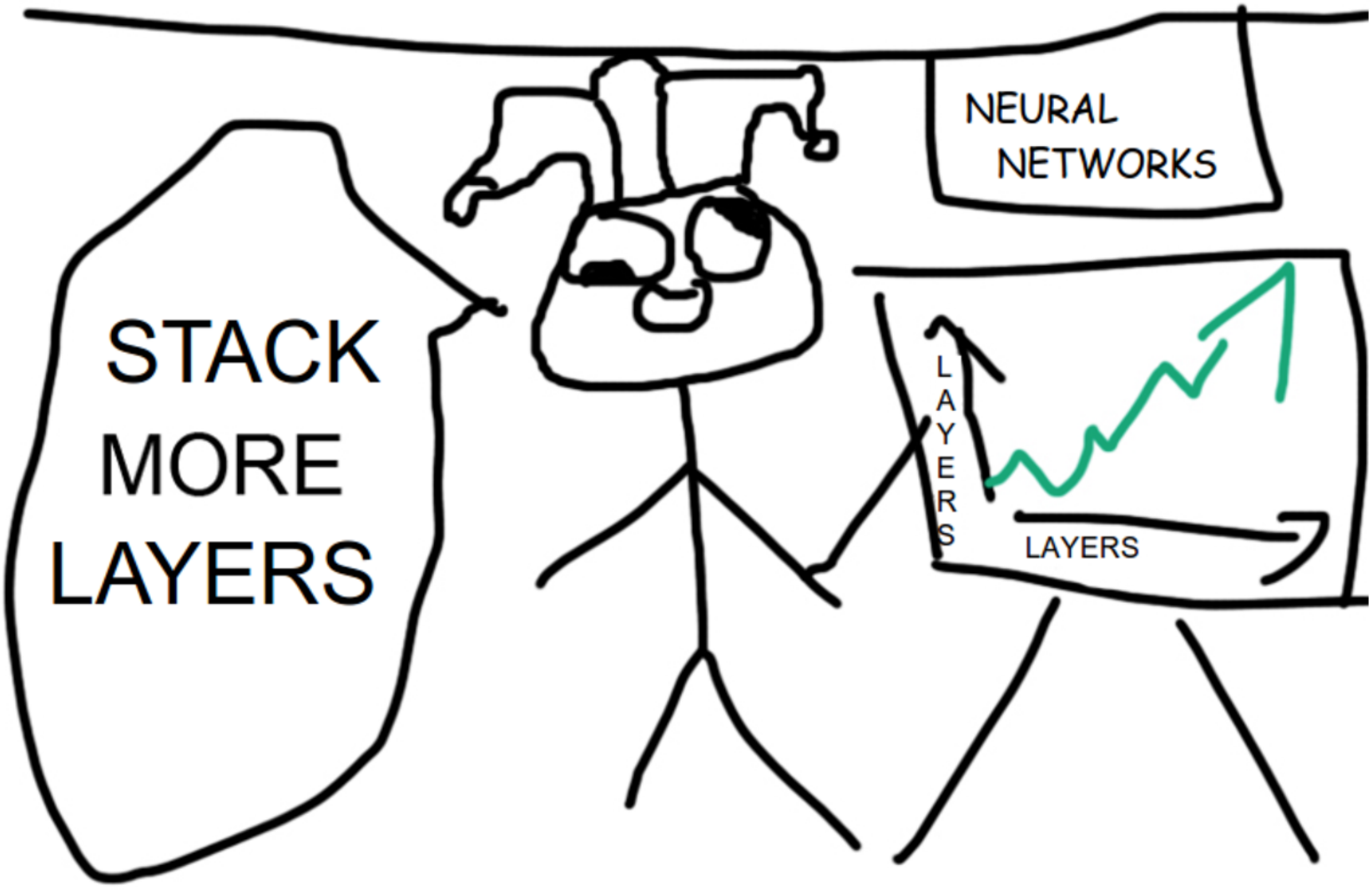

STATISTICAL LEARNING
Gentlemen, our learner overgeneralizes because the VC-Dimension of our Kernel is too high, Get some experts and minimze the structural risk in a new one. Rework our loss function, make the next kernel stable, unbiased and consider using a soft margin


NEURAL
NETWORKS
STACK
MORE
LAYERS
LAYERS
LAYERS

Linear models

Linear regression

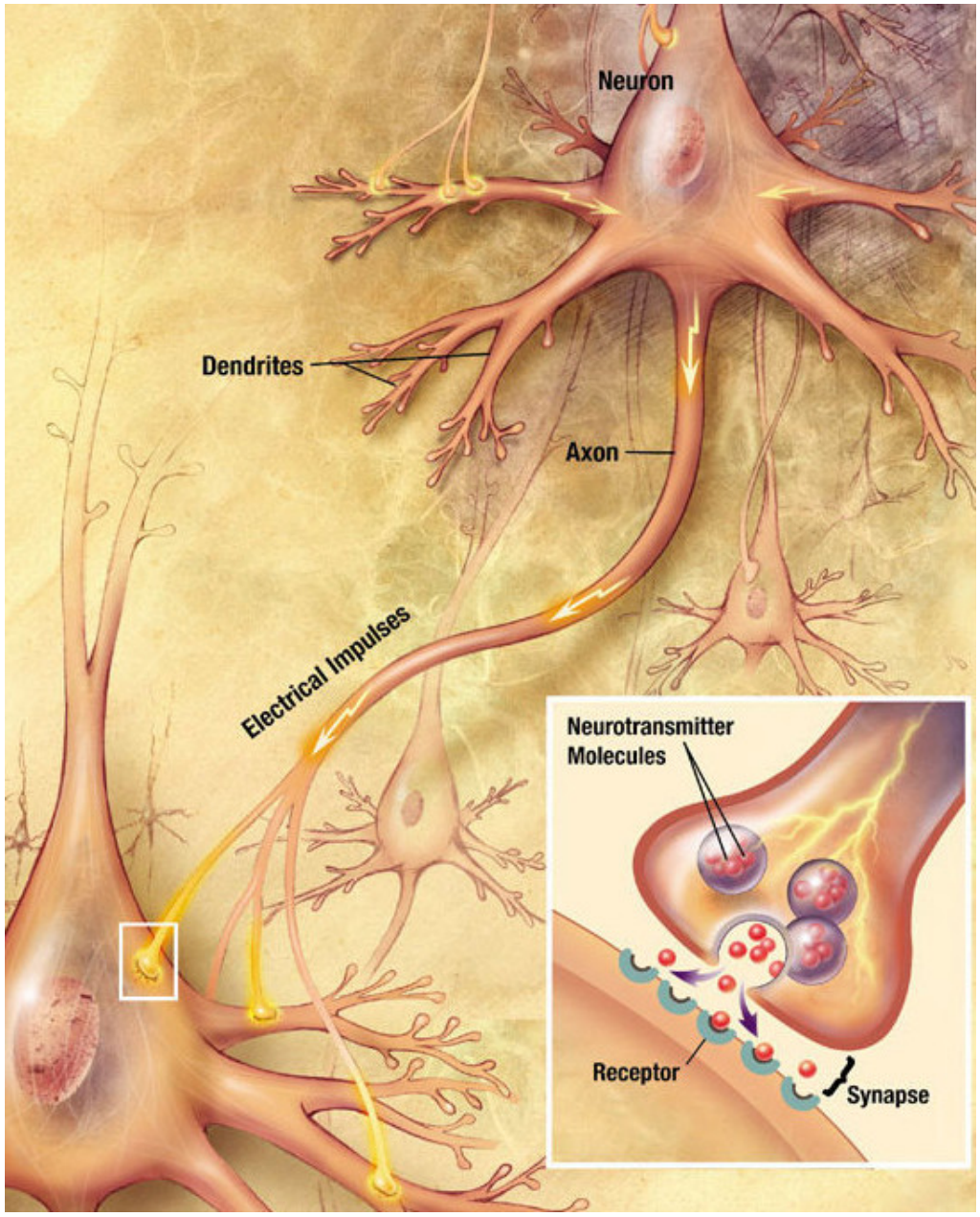
$$\hat{y} = w_0 + \sum_{i=1}^{N} w_i x_i$$

Logistic regression

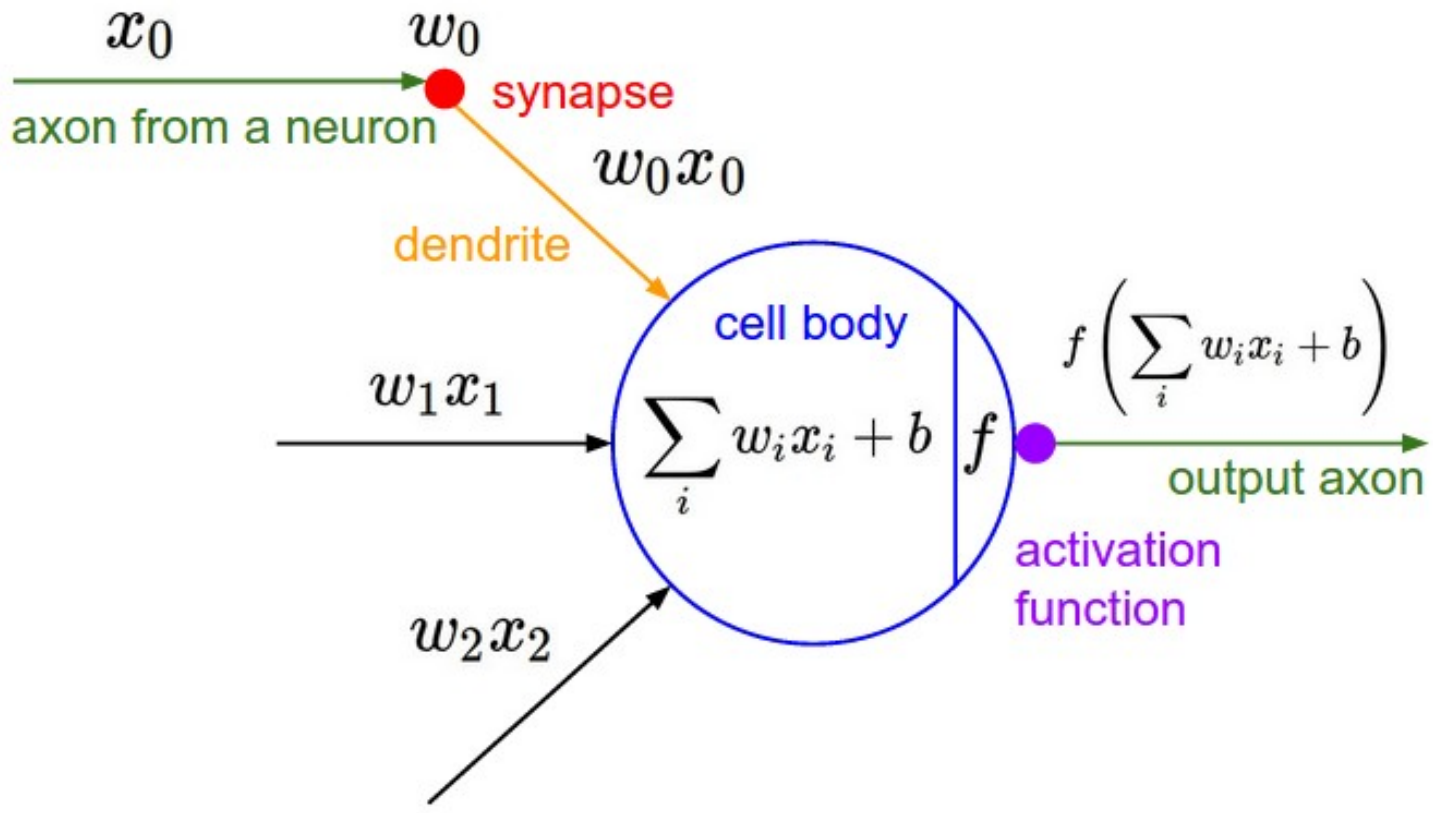
$$\hat{p}(y = 1) = \sigma\left(w_0 + \sum_{i=1}^{N} w_i x_i\right)$$

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

Biological neuron



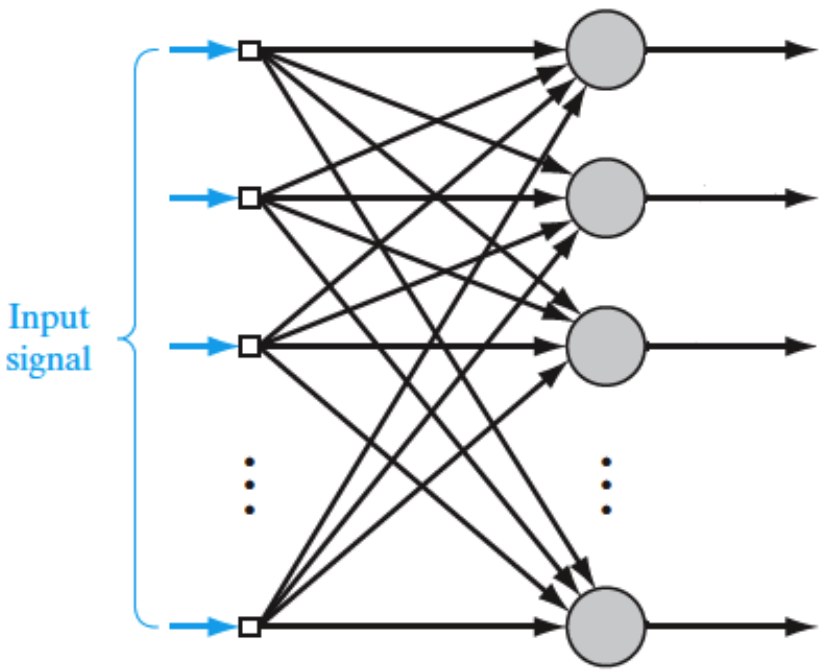
Artificial neuron



Generalized linear model

$$\hat{y} = g^{-1}\left(w_0 + \sum_{i=1}^{N} w_i x_i\right)$$

Single layer network



MaxEnt model

$$\hat{h}_k = w_{k,0} + \sum_{i=1}^{N} w_{k,i} x_i$$

$$\hat{p}(y = C_k) = \frac{e^{h_k}}{\sum_{j=1}^{K} e^{h_j}}$$

Universal approximation theorem, #1

For any function $f(x)$[1] we can build $F(x)$, such that it approximates $f(x)$ with any given precision:

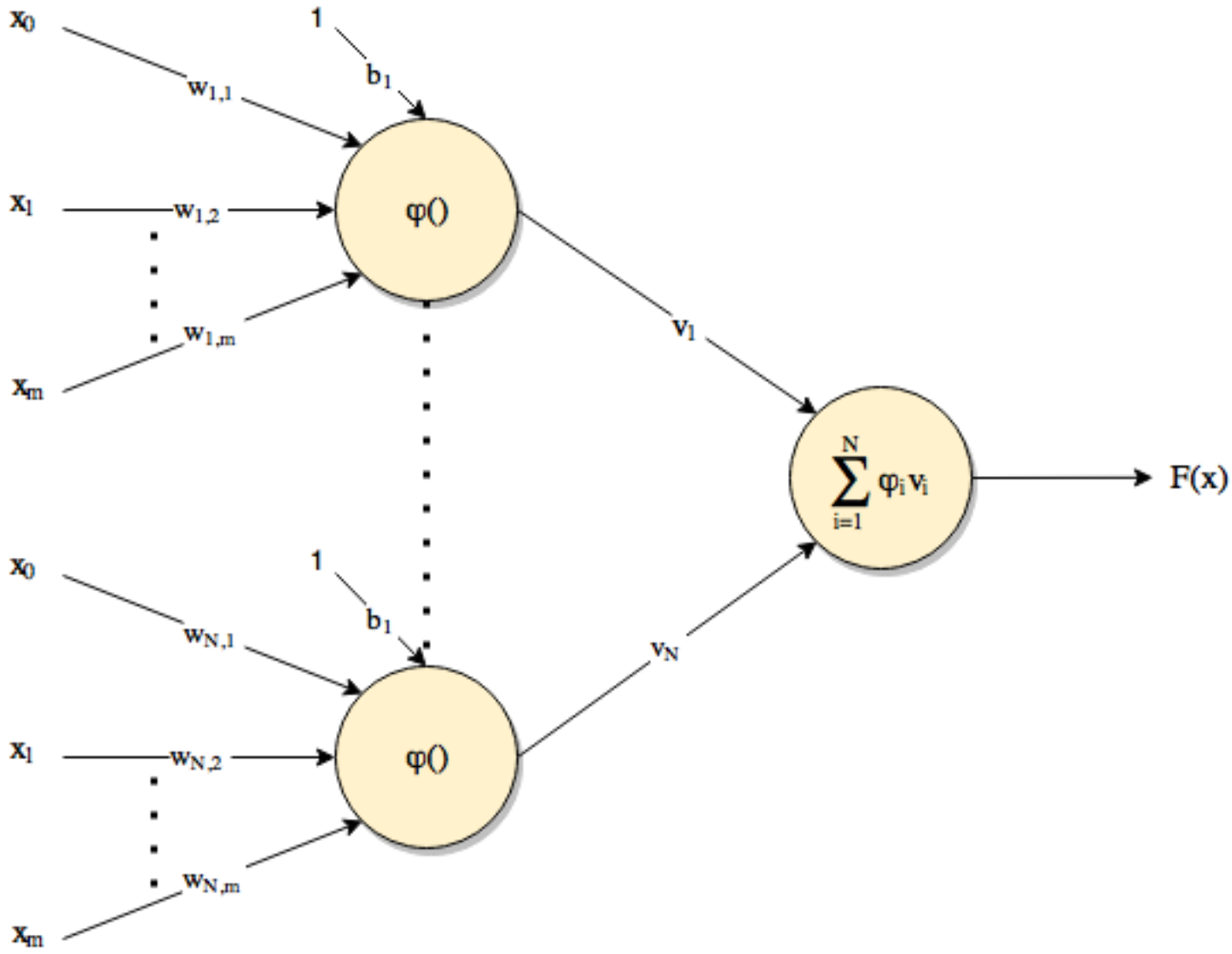
$$F(x) = \sum_{i=1}^{N} v_i \phi \left(b_i + \sum_{j=1}^{m} w_{ij} x_j \right)$$

where $\phi(x)$ is nonconstant and monotonically-increasing continuous function.

- *which network topology is produced by this theorem?*

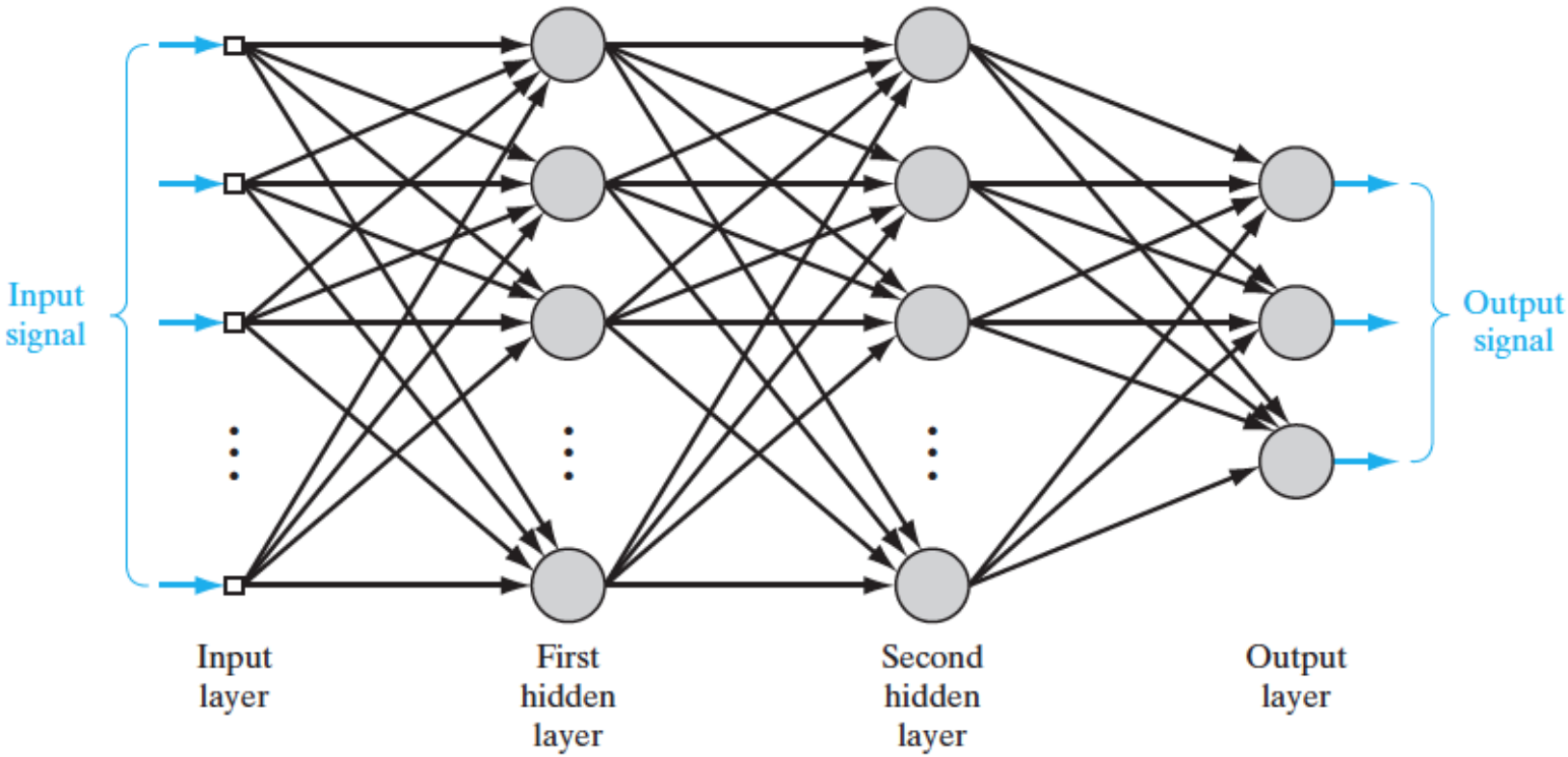
[1] actually not for any, but any function can be decomposed into several "good" ones

Universal approximation theorem, #2



- *what problem do you see in this theorem?*

Shallow fully connected network

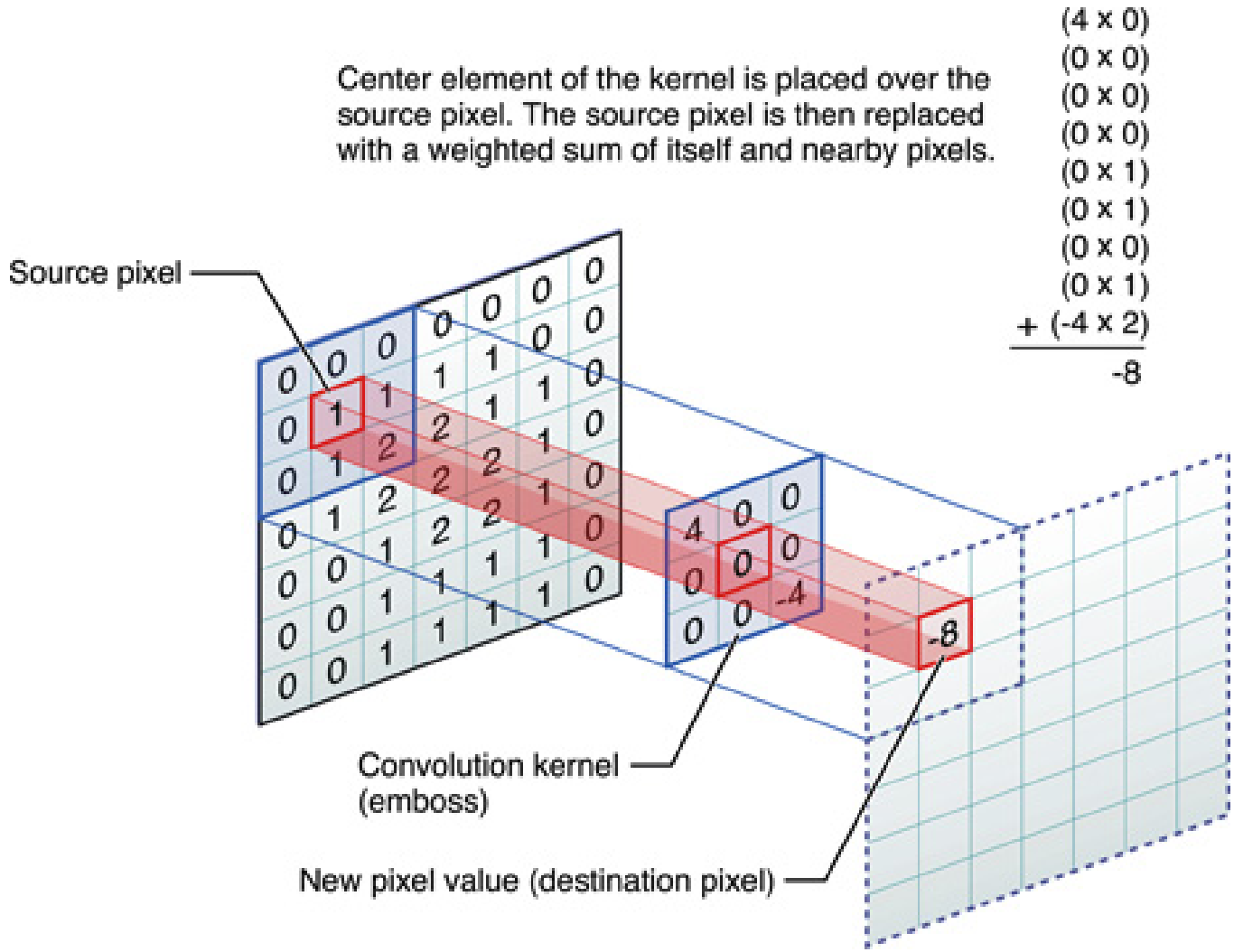


- *how many parameters second hidden layer requires?*

What next?

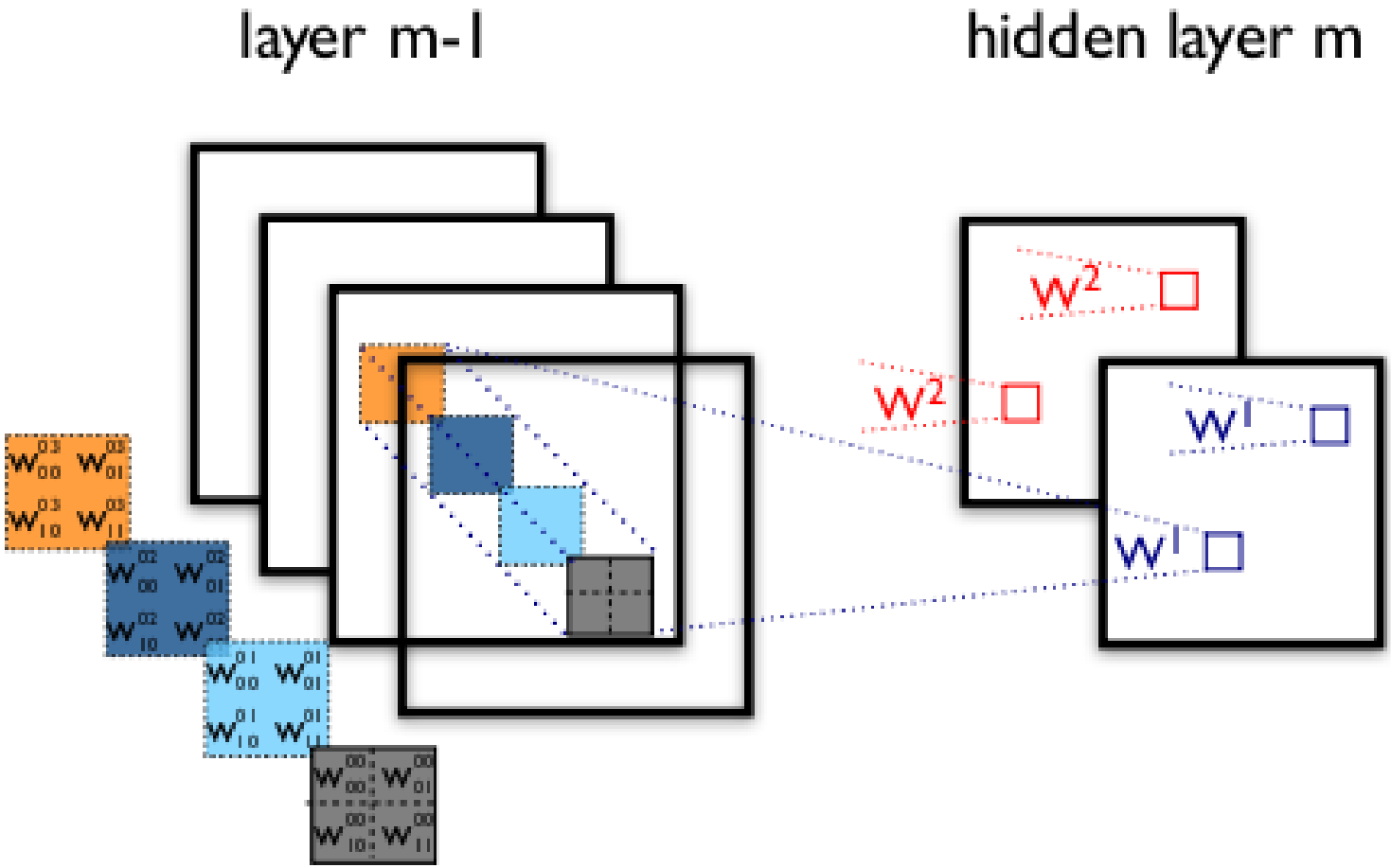
- solution is to simplify network

Convolutions



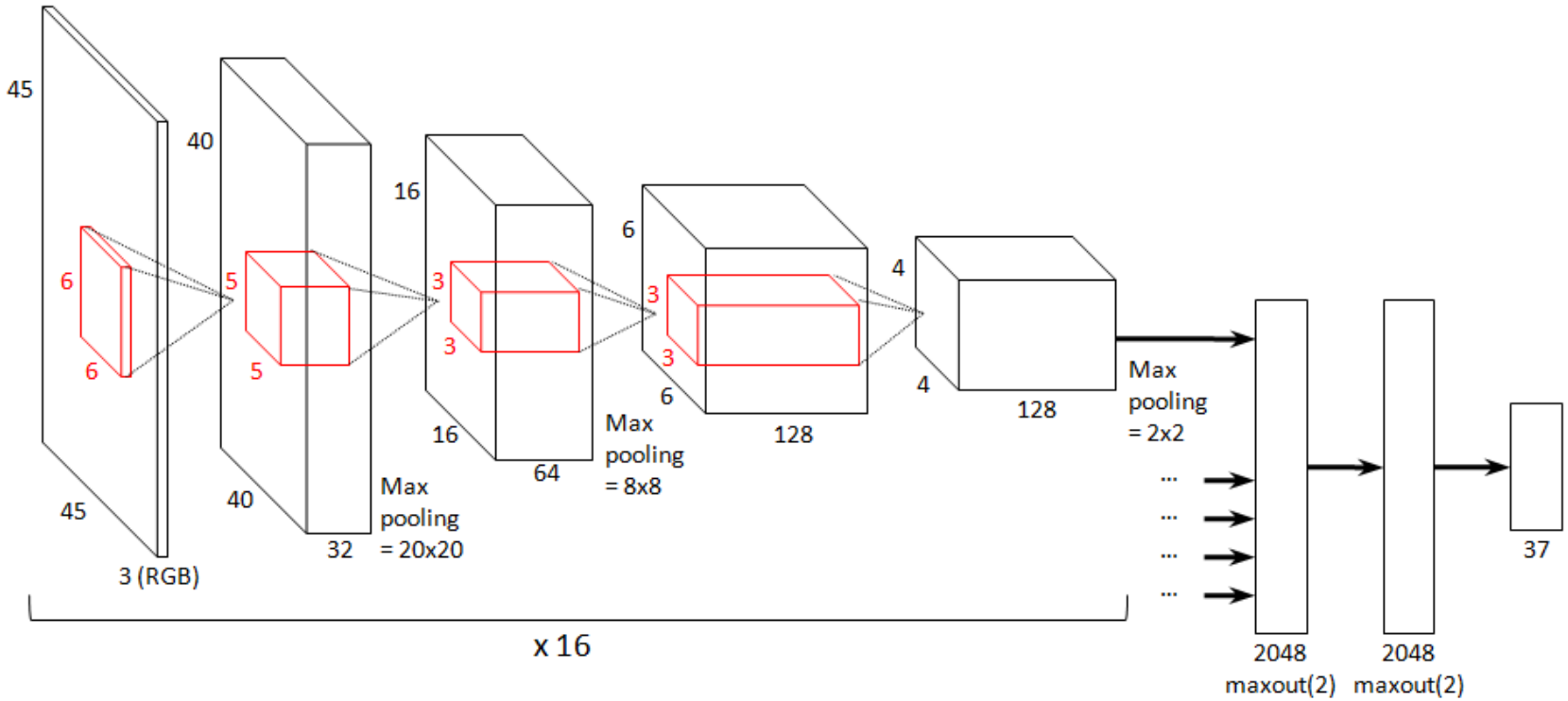
- `https://github.com/vdumoulin/conv_arithmetic`
- *nothing is free, what cost did we pay for such trick?*

Filter bank



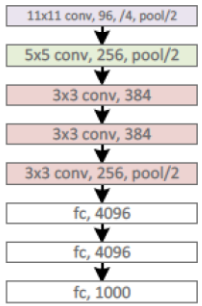
- *how many parameters second convolutional hidden layer requires now?*

Deep convolutional network

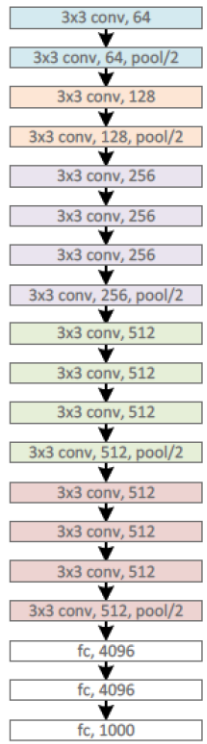


Very deep convolutional network

AlexNet, 8 layers
(ILSVRC 2012)



VGG, 19 layers
(ILSVRC 2014)



GoogleNet, 22 layers
(ILSVRC 2014)

Very very deep convolutional network

AlexNet, 8 layers
(ILSVRC 2012)

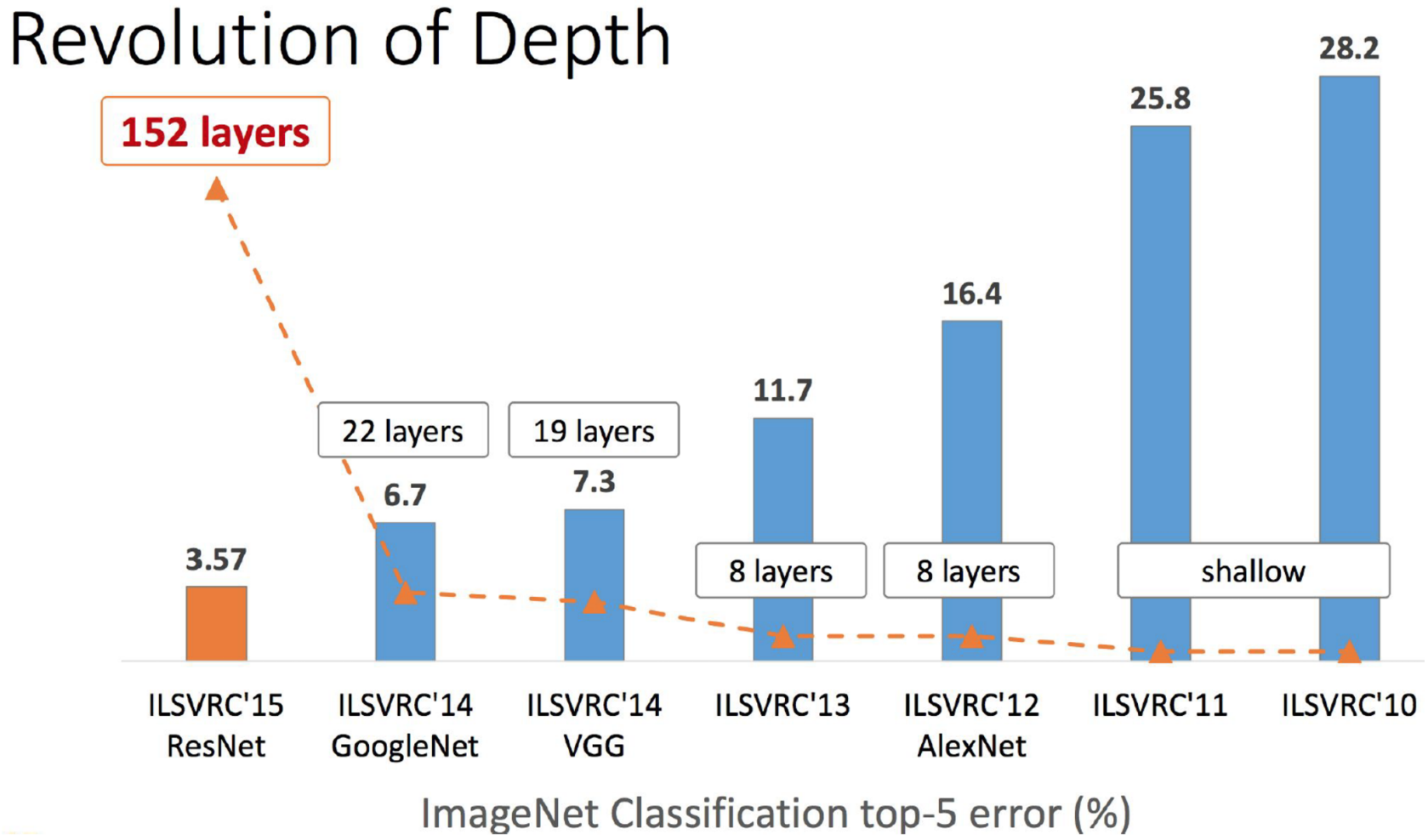
VGG, 19 layers
(ILSVRC 2014)

ResNet, 152 layers
(ILSVRC 2015)

...


MOAR LAYERS
MOAR MOAR MOAR

State-of-the-art



Opening the black box

Given a network F with parameters Θ and input image x, lets also define output of each layer as F_i:

Training

$$\Delta\Theta = -\lambda \frac{\partial F(x, \Theta)}{\partial \Theta}$$

Saliency map

$$\Delta x = \frac{\partial F_i(x, \Theta)}{\partial x}$$

How network see the world, #1

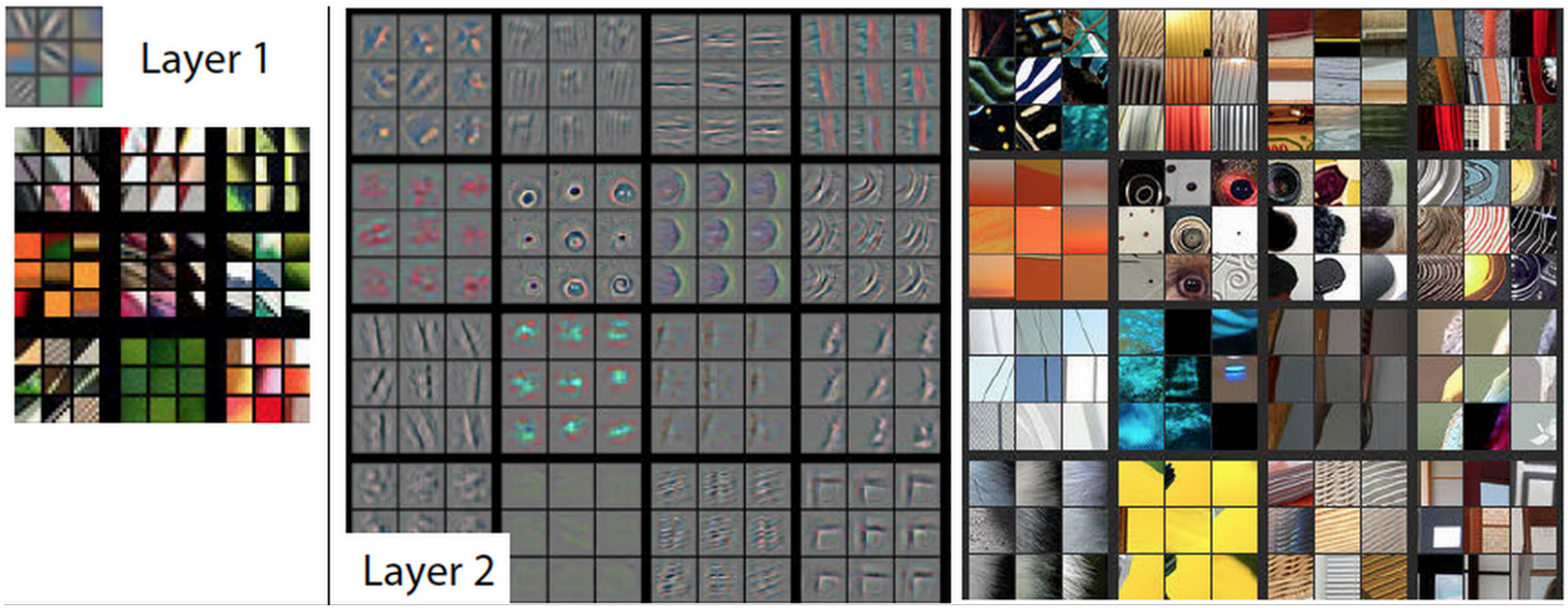
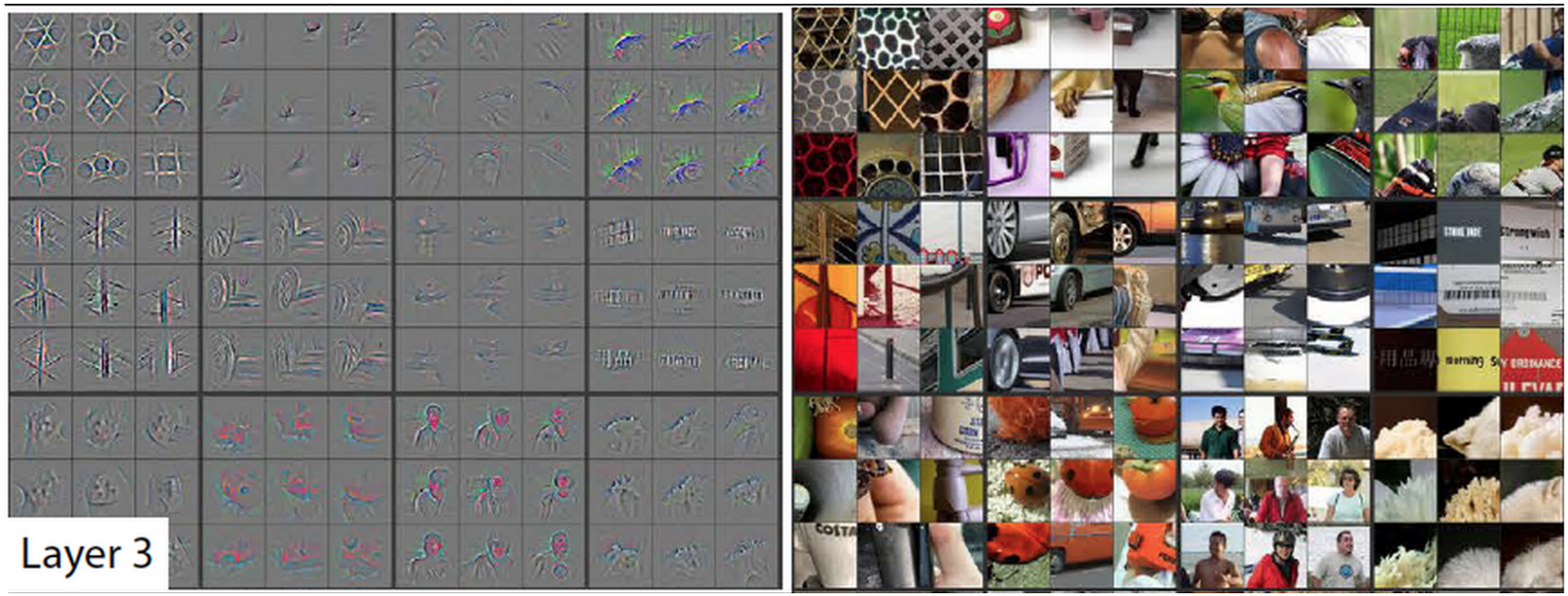


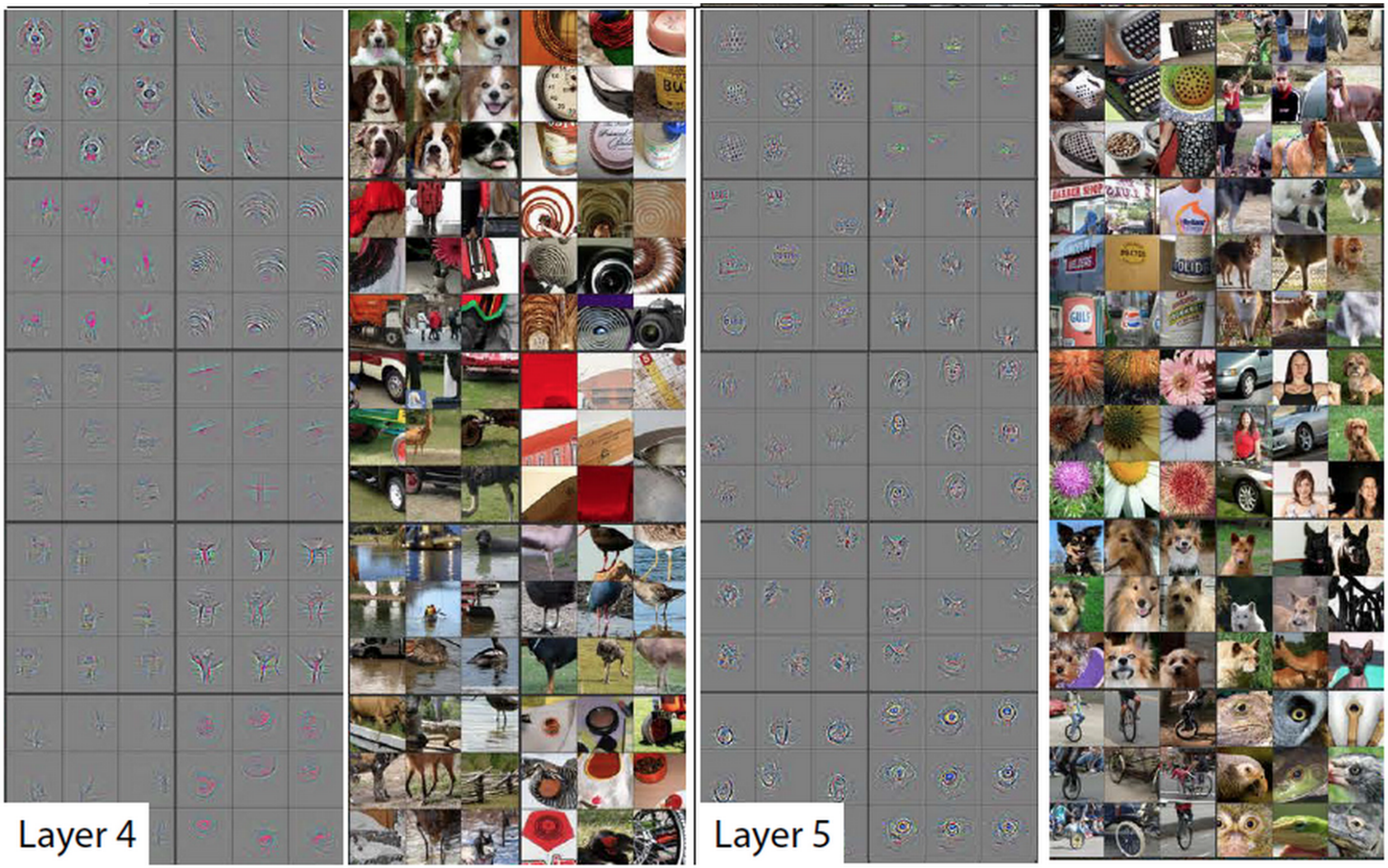
Figure 1: Visualizing and Understanding Convolutional Network [2]

[2] Matthew D. Zeiler and Rob Fergus

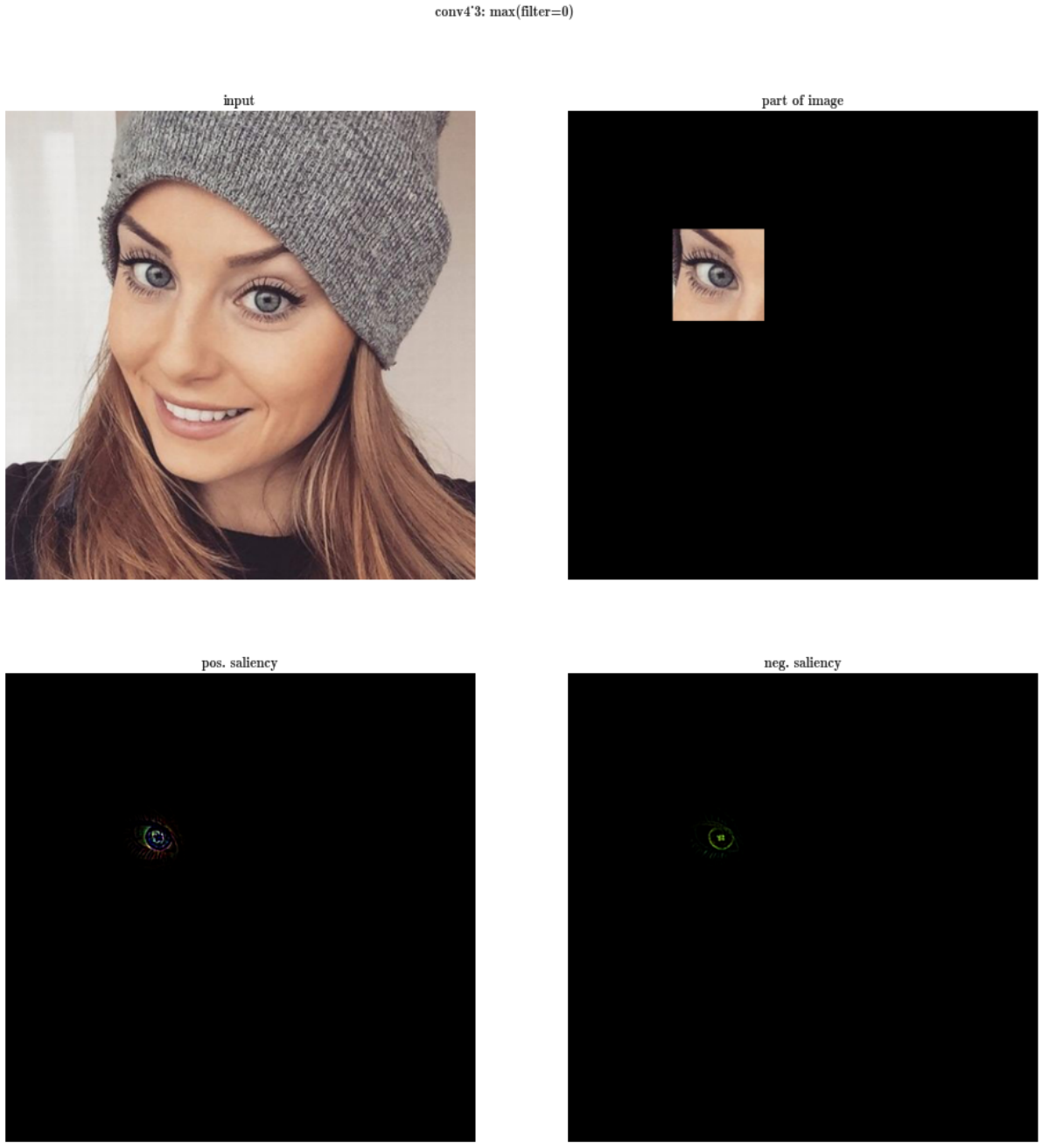
How network see the world, #2



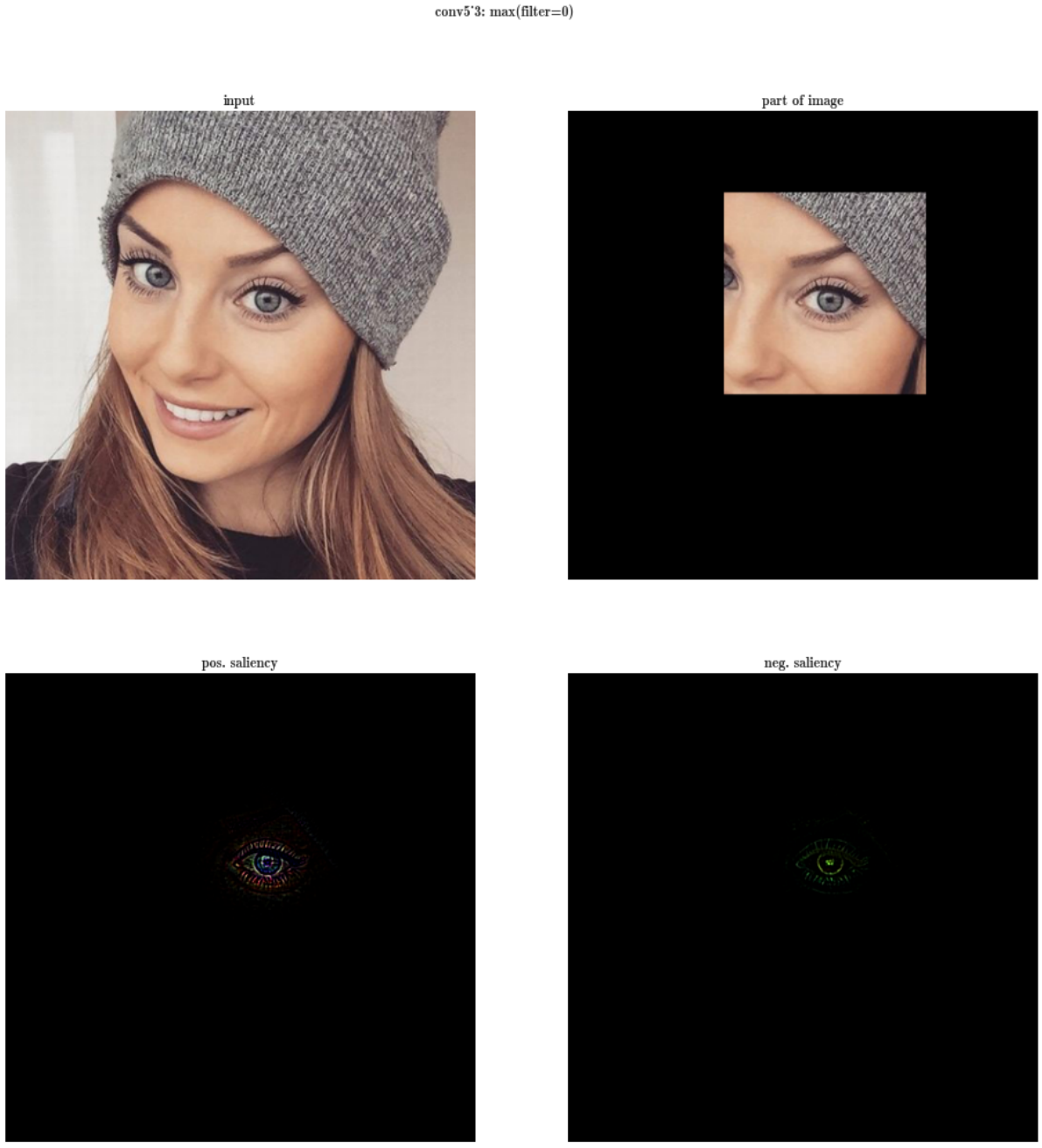
How network see the world, #3



Eye filter, #1


conv4'3: max(filter=0)
input
part of image
pos. saliency
neg. saliency

Eye filter, #2


conv5'3: max(filter=0)
input
part of image
pos. saliency
neg. saliency

Search

- shallow layers catch low-level abstract/texture features (usually it doesn't depend on the datast and on the cost function)
- deeper layers catch high-level semantic features (more specific to dataset and to cost function)
- *can we use it for image search?*

Visualization, #1


1550825.jpg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1700151.jpg


1700178.jpg


1701017.jpg


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1764518.jpg


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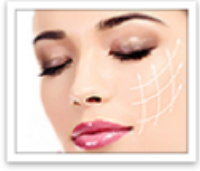
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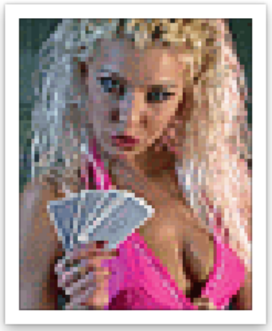
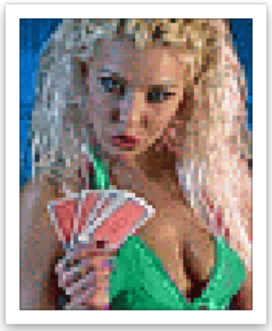
Visualization, #2



0goal.jpg



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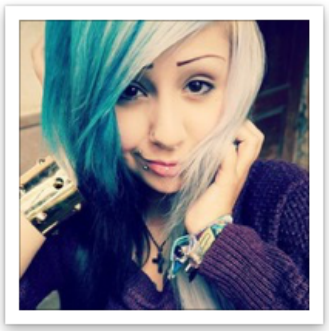

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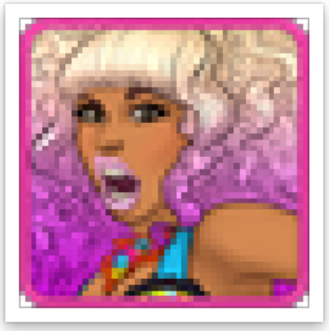

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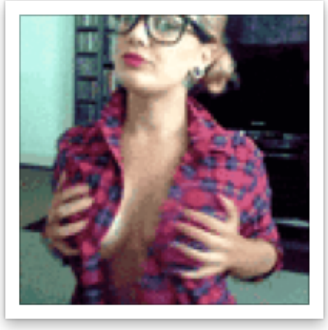

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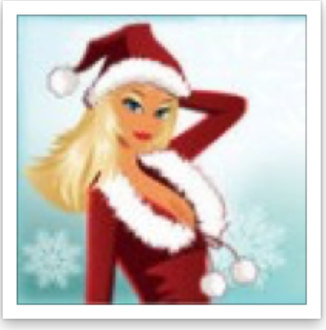

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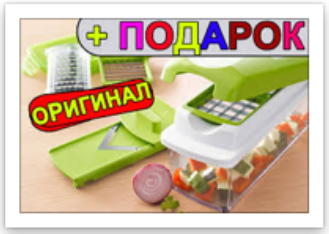
Visualization, #3

0goal.jpg



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847001.jpg

867038.jpg

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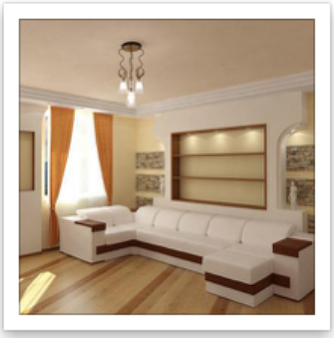
Visualization, #4



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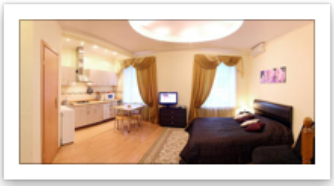

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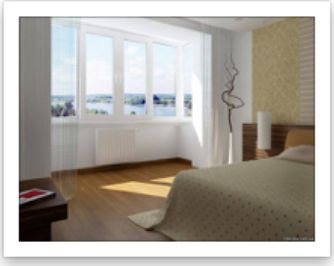

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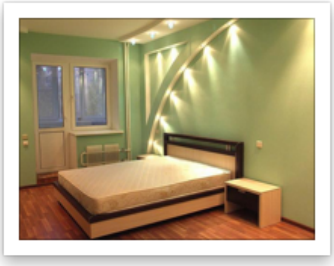

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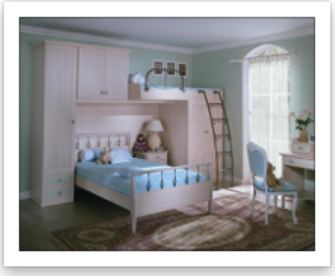

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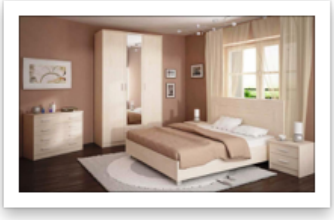

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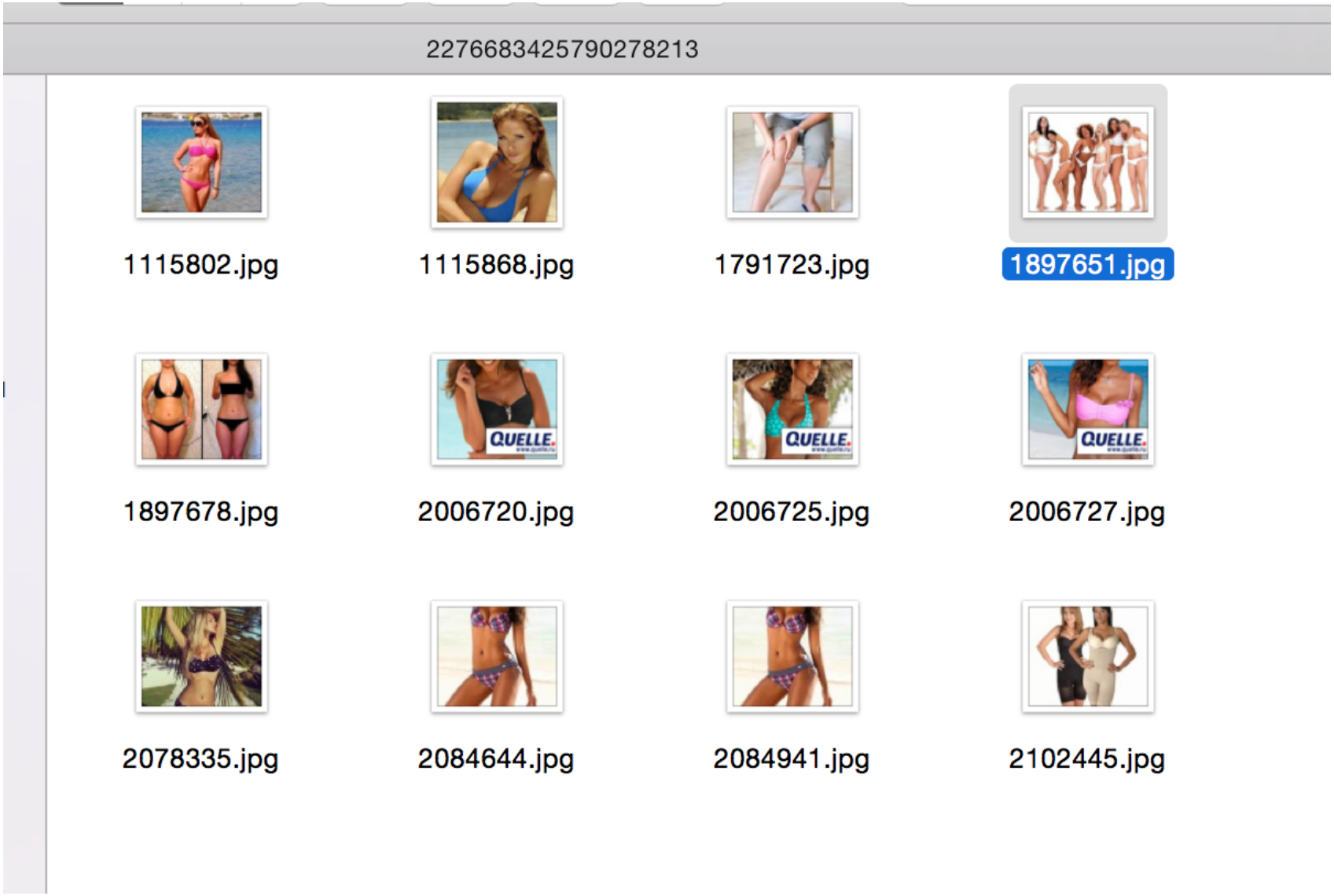
2148107.jpg

Visualization, #5



Visualization, #6


1734142.jpg

1734143.jpg

1734153.jpg


1734156.jpg


1734164.jpg

1734165.jpg


1961146.jpg


2014413.jpg


2014426.jpg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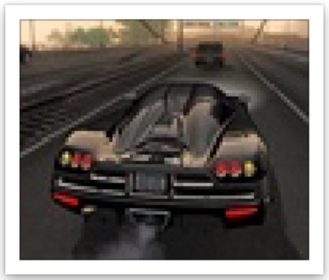
2082477.jpg

2100696.jpg

2105538.jpg

Visualization, #7

0goal.jpg



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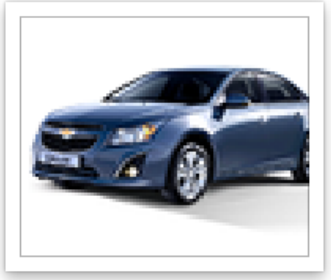

1054508.png

1179832.jpg

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1429950.jpg

1628913.jpg

Visualization, #8

- segmentation
- search + segmentation + style loss

Feel free to ask questions

Play with Artisto

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- https://www.youtube.com/watch?v=VvEqW04vocM
- https://www.youtube.com/watch?v=wOjZDo1NXaA

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