Introduction to Convolutional Networks

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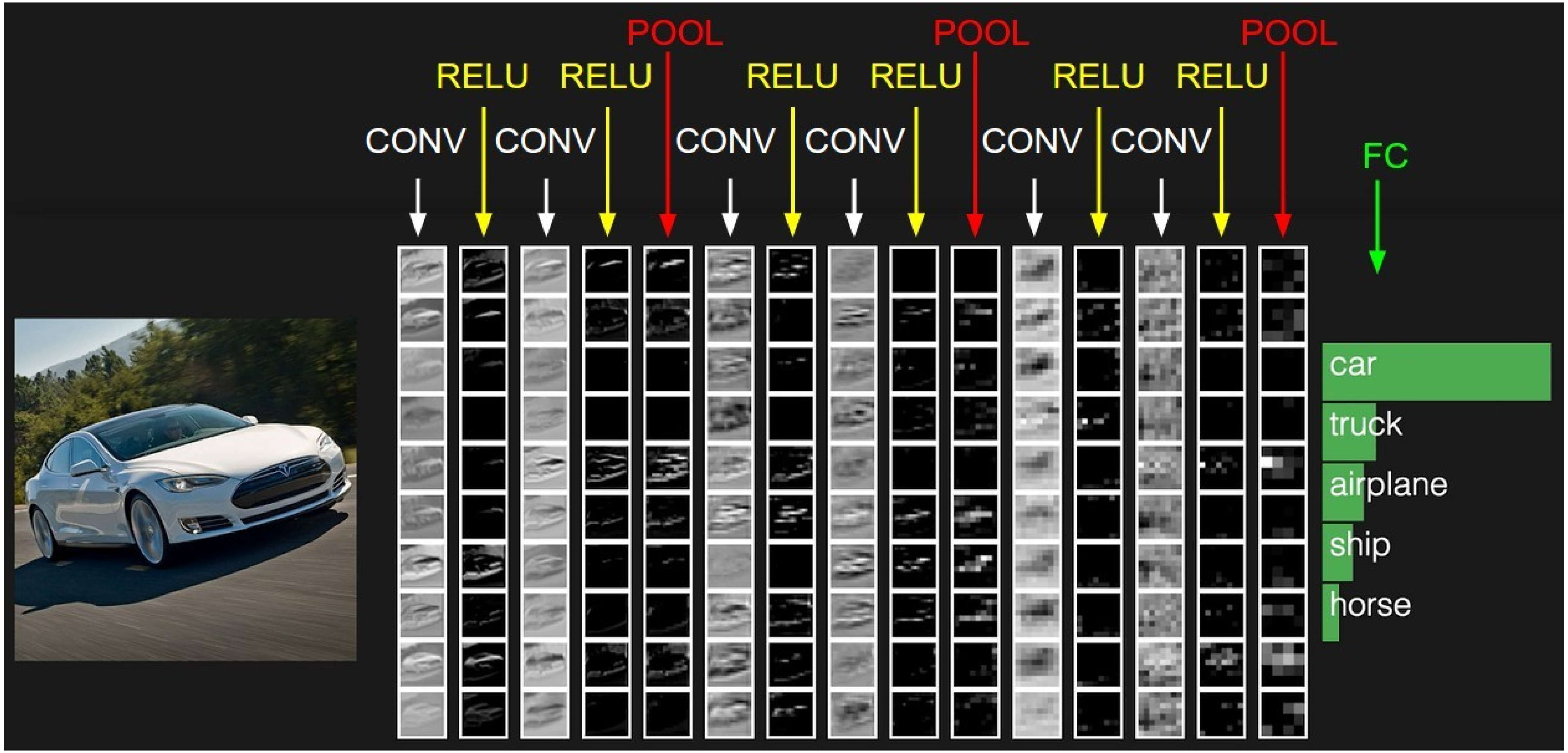
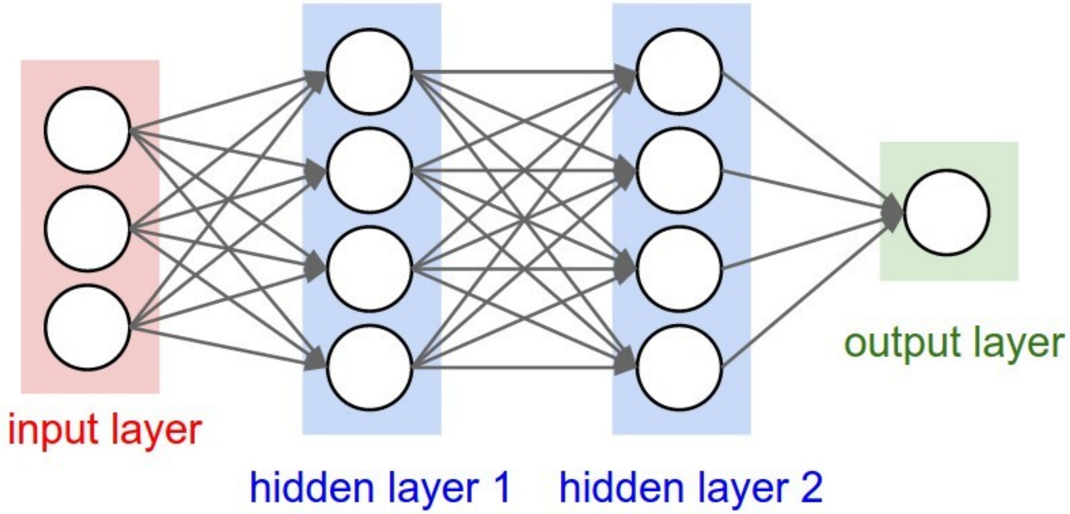


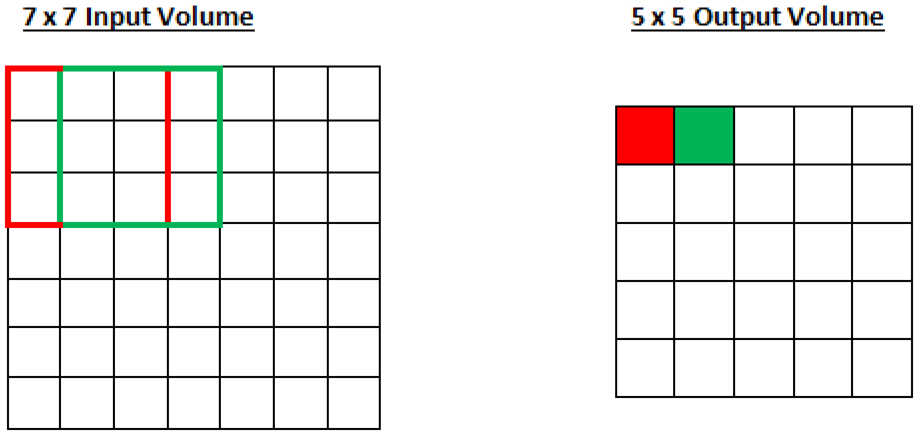
Convolutional layer

Fully connected



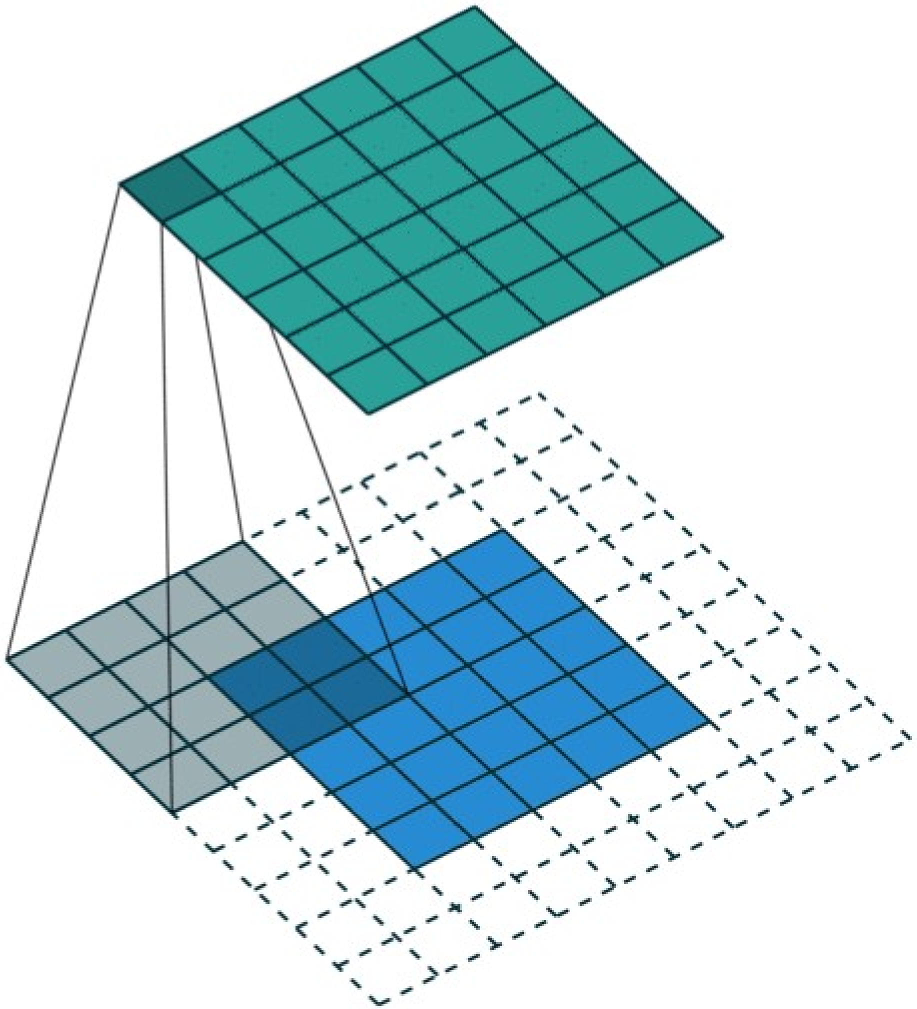
Normal Network

Local receptive field & Shared weight



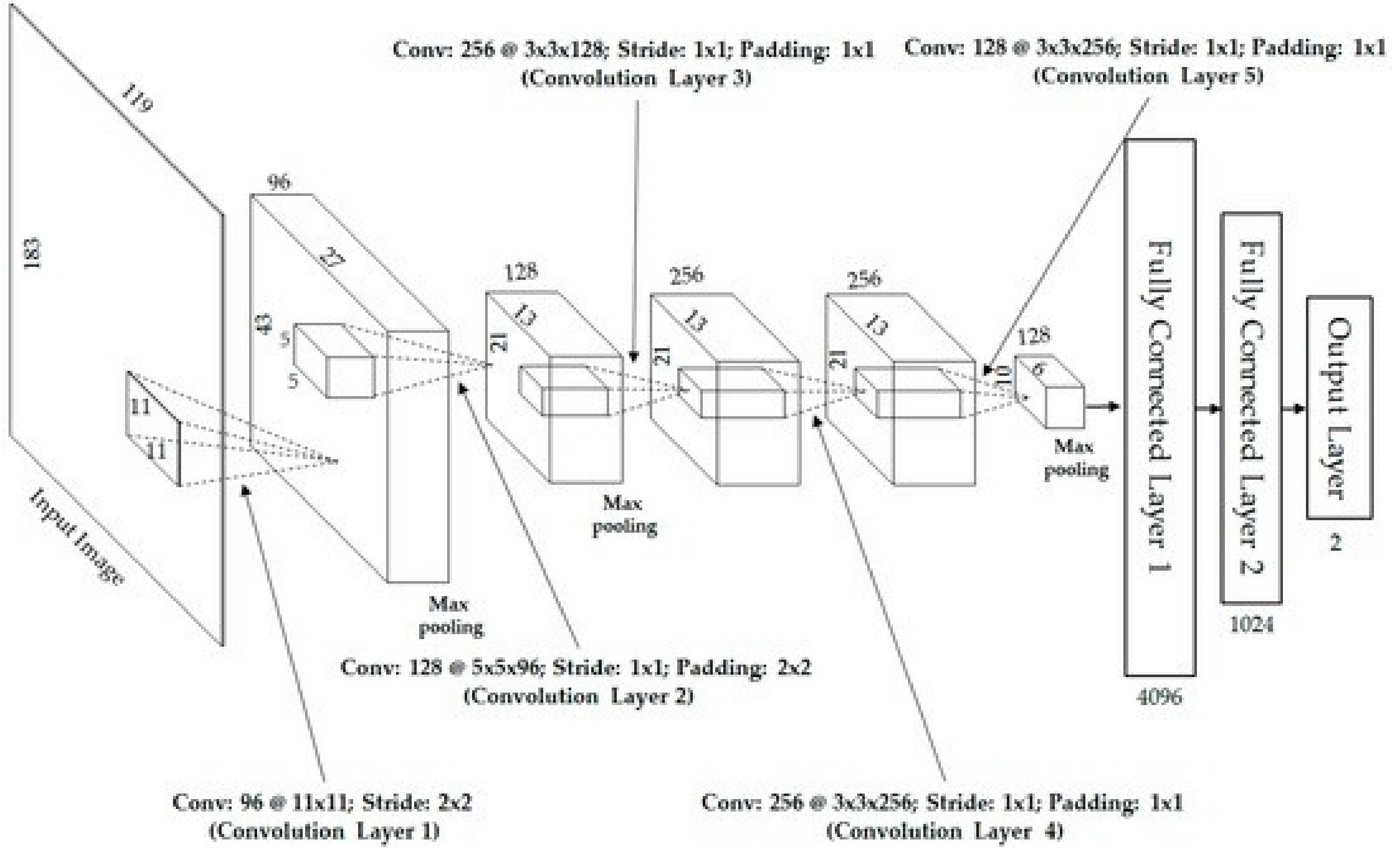
Convolutional Network

Convolutional layer



Padding and stride help us to control the output size.

Convolutional layer

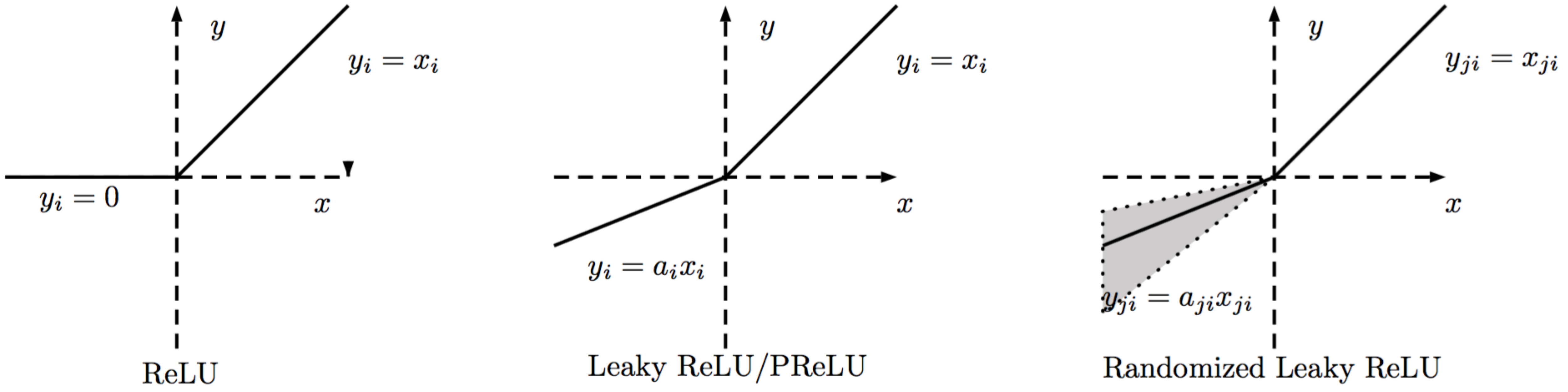


Each convolutional kernel is a 3D structure with depth equal to number of input channel (depth of input).

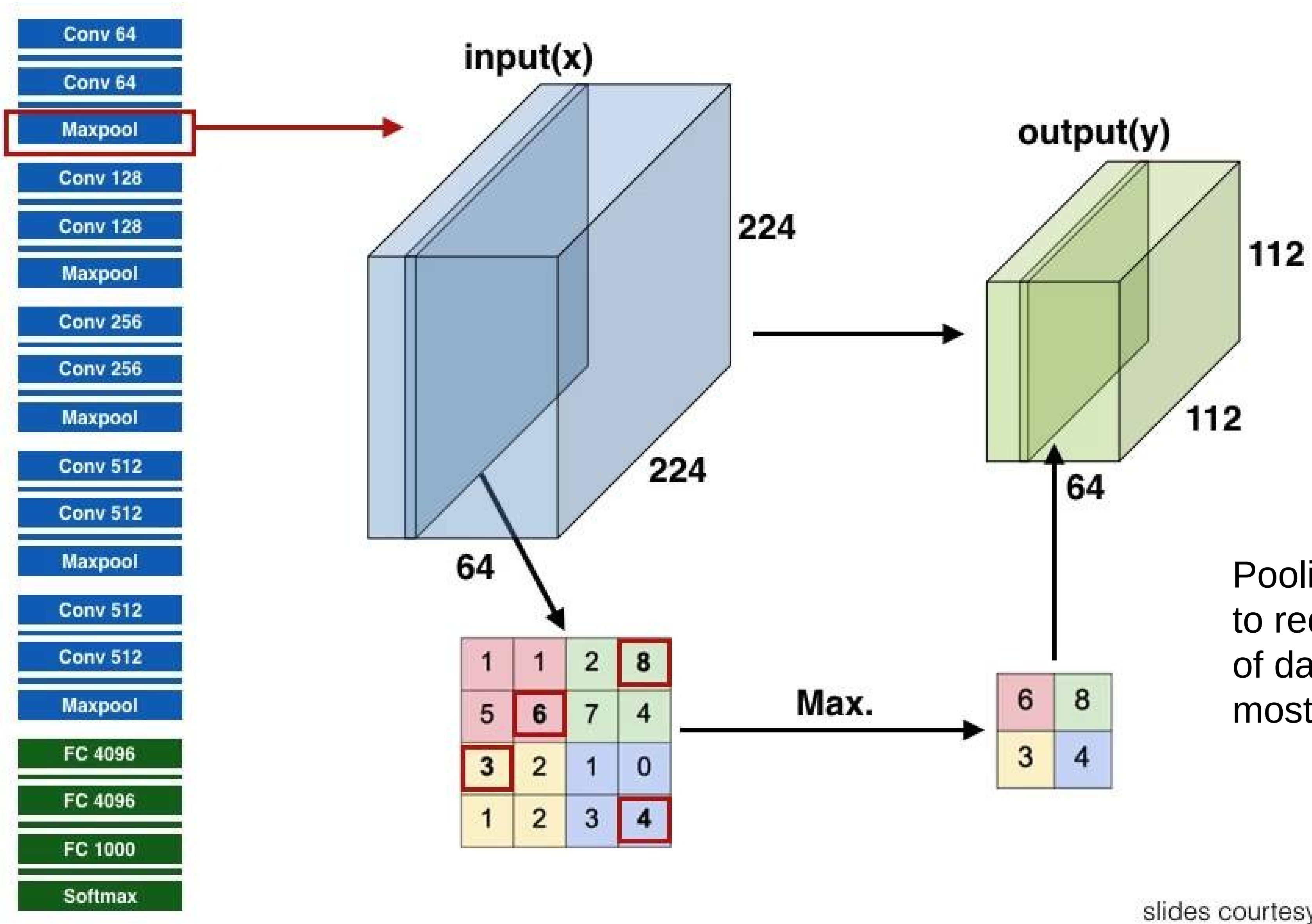
Each convolutional layer contains many kernels, the number of kernels equals to number of output channels (depth of output).

Nonlinearity

Each convolution is a linear operation. In order to represent the nonlinearities of the data, we introduce simple non-linear layers into CNN.



Pooling layer

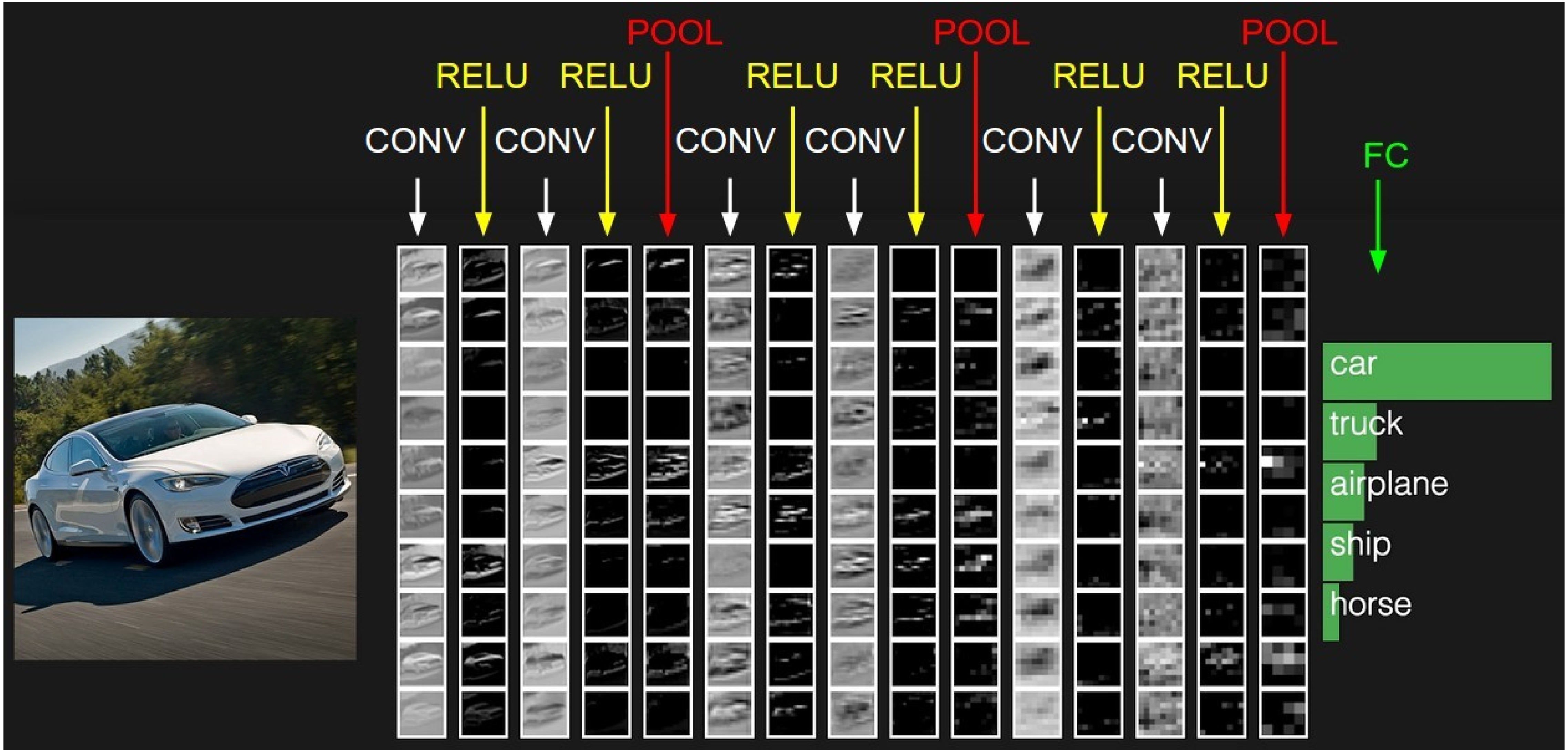


Pooling is an efficient way to reduce the dimension of data and extract the most useful information.

slides courtesy of Jonghoon Jin

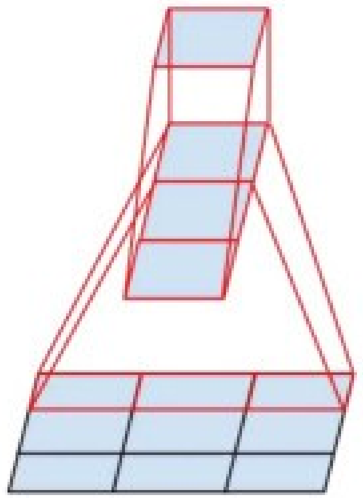
Eugenio Culurciello

A complete CNN



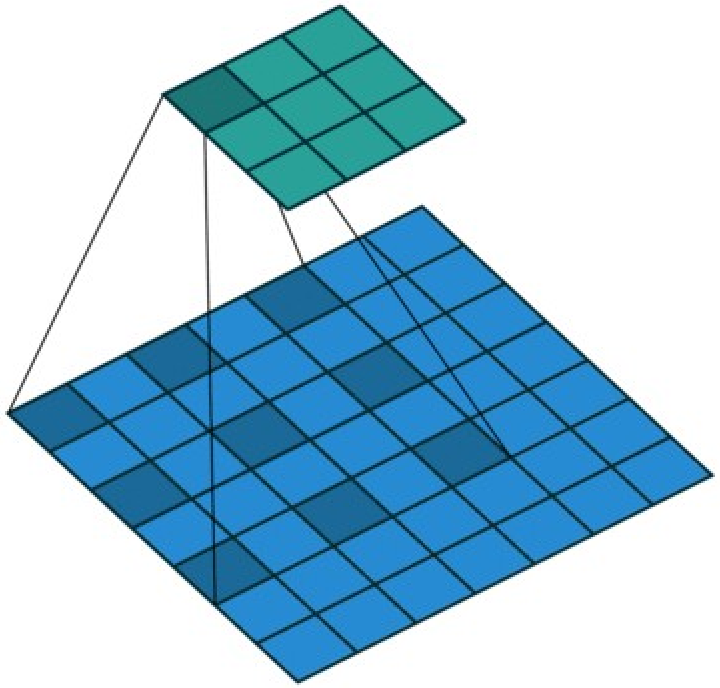
Some tricks

To save time and space



A symmetric convolution

To increase receptive field



Dilated convolution

Some tricks

Faster convergence

Input: Values of x over a mini-batch: $\mathcal{B} = \{x_{1\ldots m}\}$;
Parameters to be learned: γ, β

Output: $\{y_i = \mathrm{BN}_{\gamma,\beta}(x_i)\}$

$$\mu_{\mathcal{B}} \leftarrow \frac{1}{m}\sum_{i=1}^{m} x_i \qquad \text{// mini-batch mean}$$

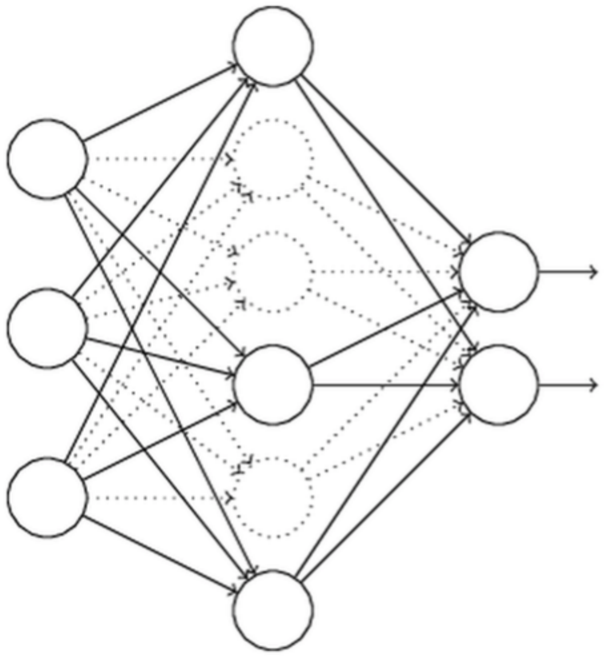
$$\sigma_{\mathcal{B}}^2 \leftarrow \frac{1}{m}\sum_{i=1}^{m} (x_i - \mu_{\mathcal{B}})^2 \qquad \text{// mini-batch variance}$$

$$\widehat{x}_i \leftarrow \frac{x_i - \mu_{\mathcal{B}}}{\sqrt{\sigma_{\mathcal{B}}^2 + \epsilon}} \qquad \text{// normalize}$$

$$y_i \leftarrow \gamma \widehat{x}_i + \beta \equiv \mathrm{BN}_{\gamma,\beta}(x_i) \qquad \text{// scale and shift}$$

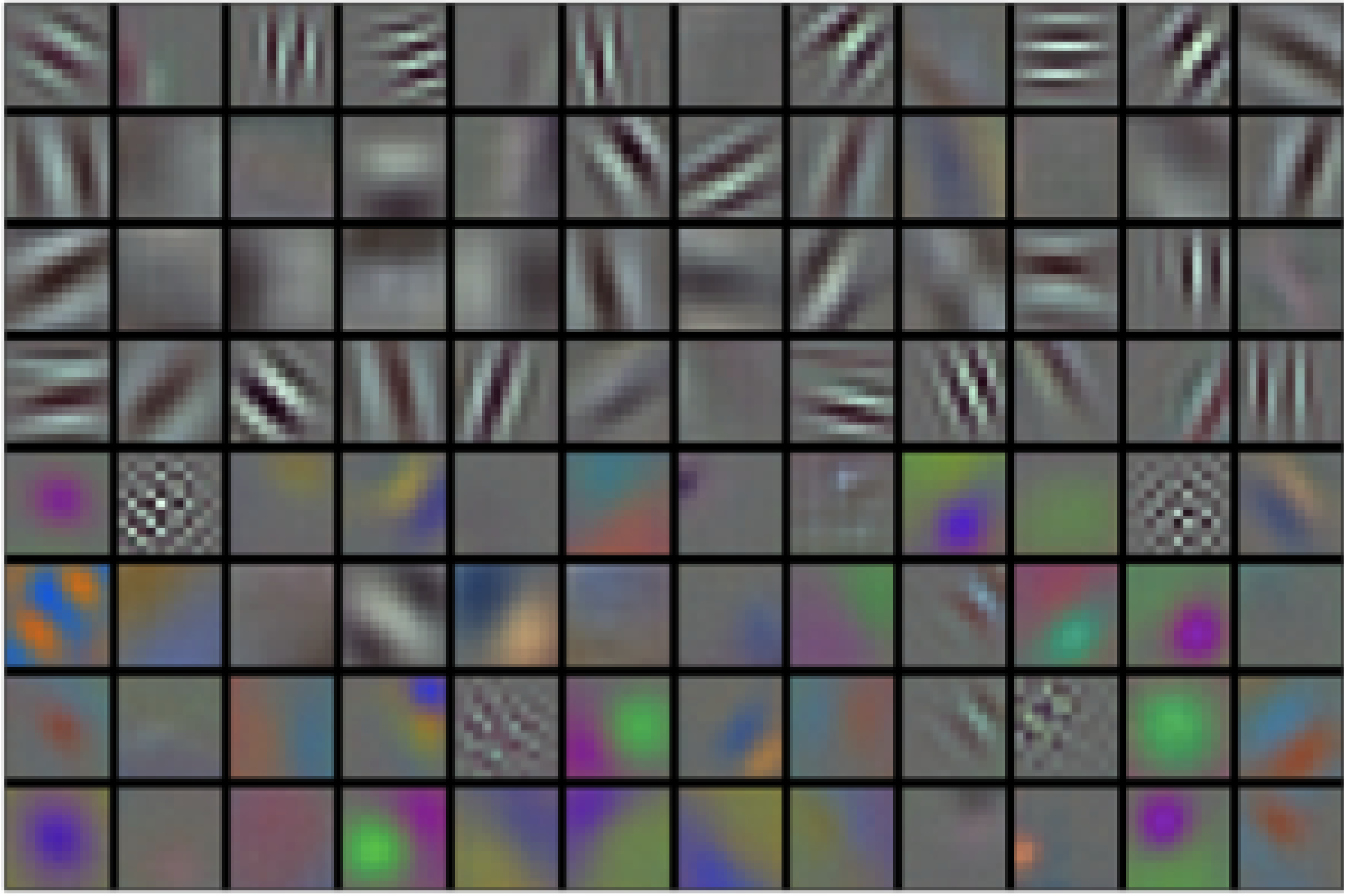
Batch normalization

Prevent overfit problem

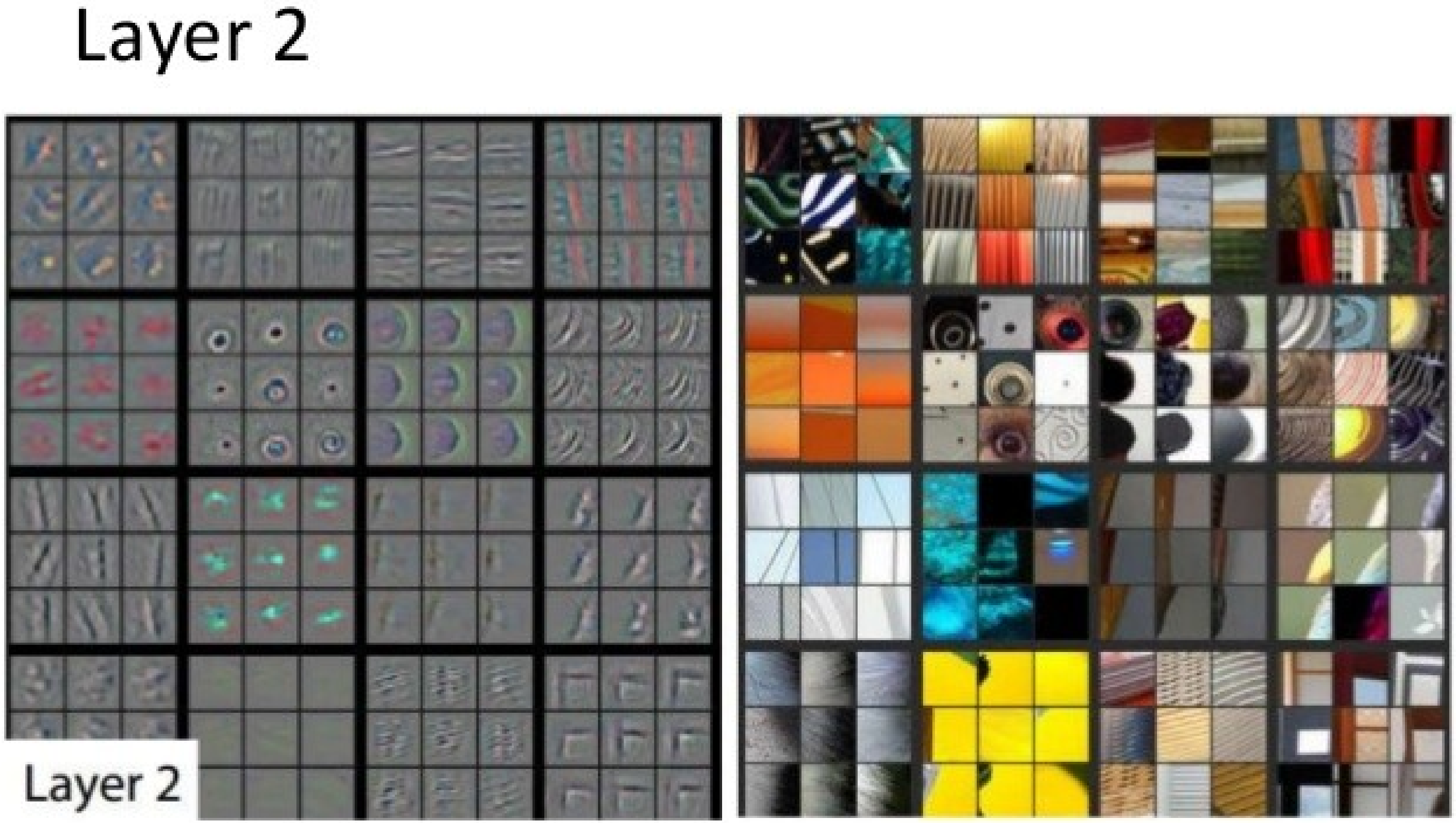


Dropout

Visualize CNN

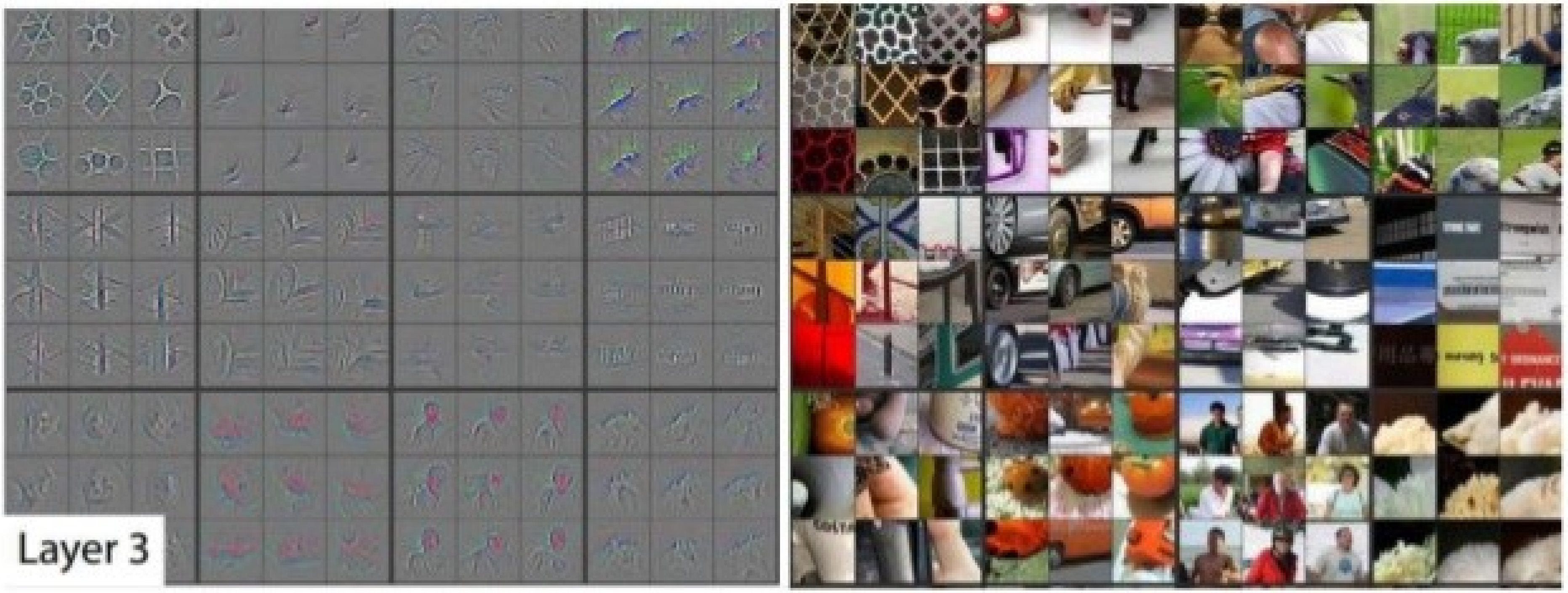


Visualize CNN



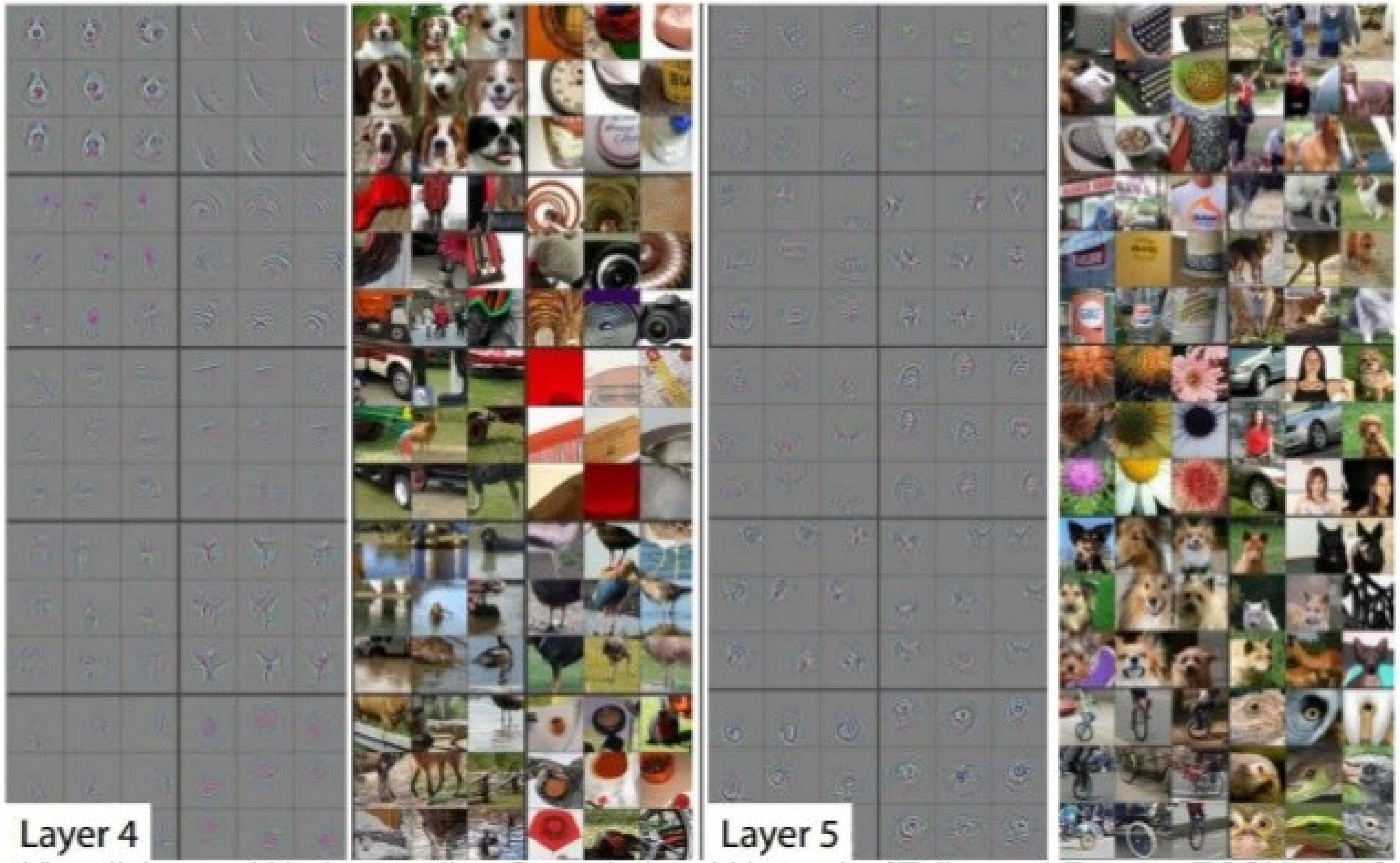
Visualize CNN

Layer 3



Visualize CNN

Layer 4 and 5



Visualizing and Understanding Convolutional Networks [Zeiler and Fergus, ECCV 2014]