Convolutional neural networks

Lecture 8

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Conv layer and Pooling layer

Outline

1. Will study further on “feature map”.
2. Will study 2nd building block: **Pooling** layer

Example: How filter works

Vertical filter

$f_w = 7$

$f_h = 7$

0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0

Role: Detect a *vertical line pattern*.

Visualization

vertical filter

input

feature map

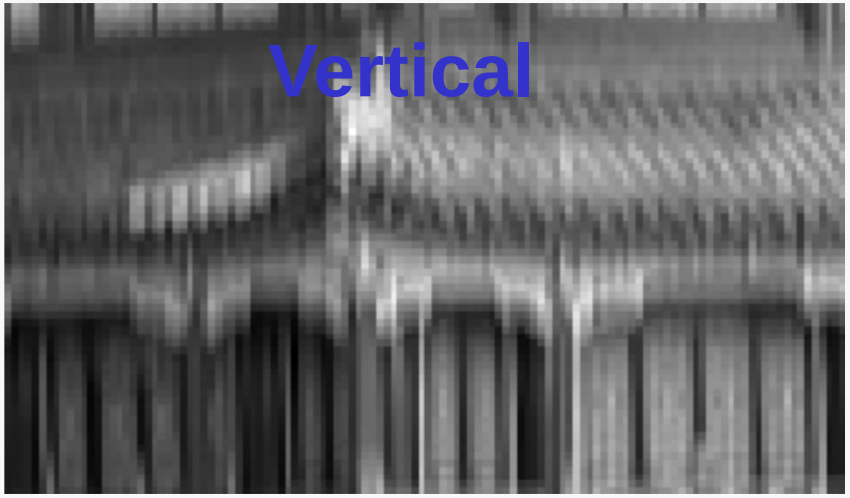
Use of multiple filters

Recall the role of a filter: Detect a certain pattern.

Note: May wish to detect multiple patterns.

Hence: Employ multiple filters, e.g., vertical filter, horizontal filter, edge-detect filter, …

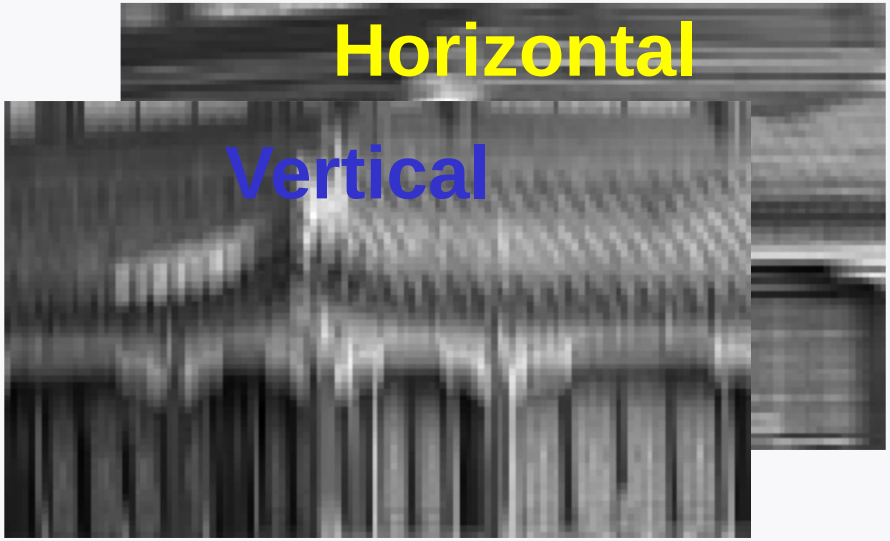
Visualization examples



Stacking multiple feature maps

filter

w **3D** tensor

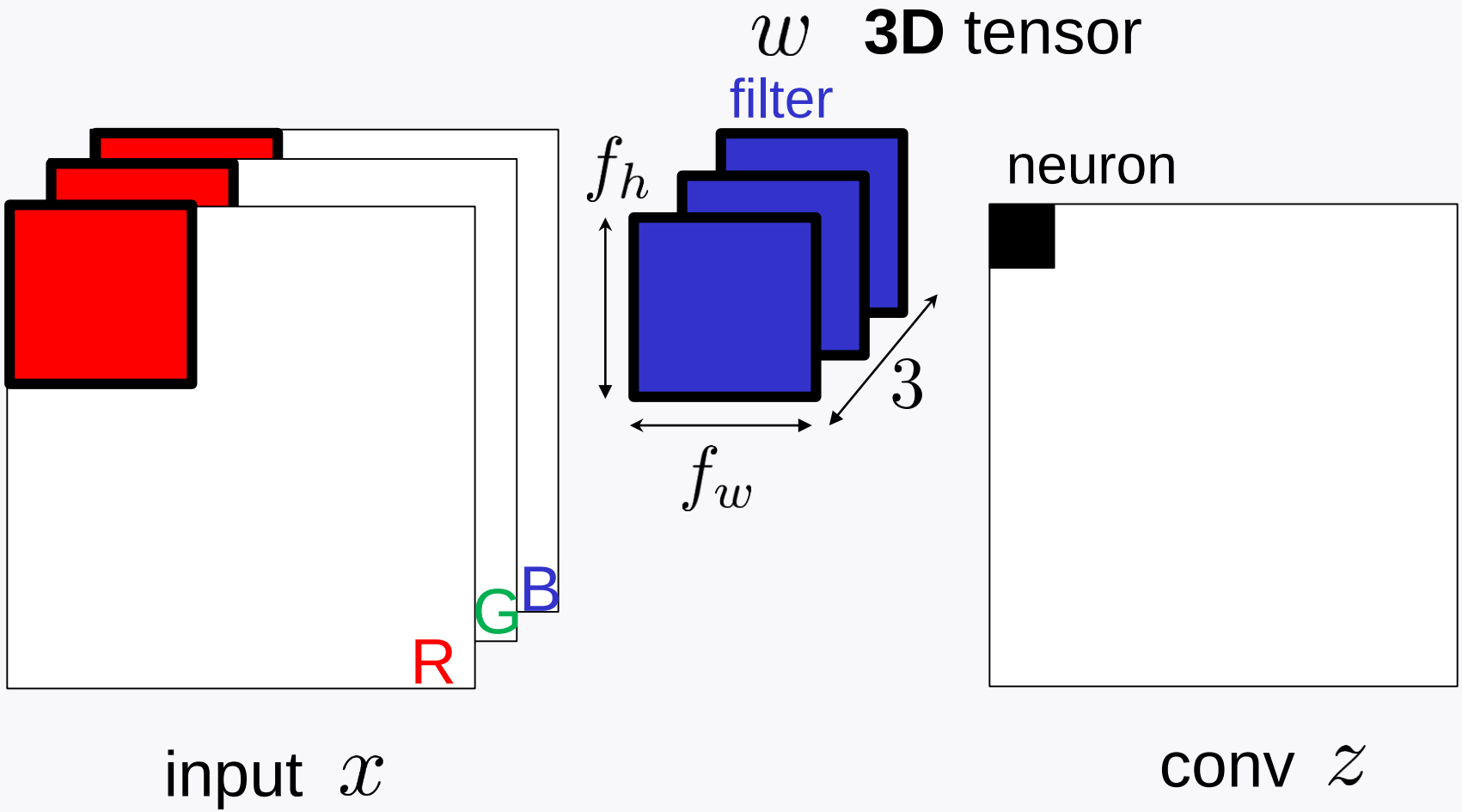


input x

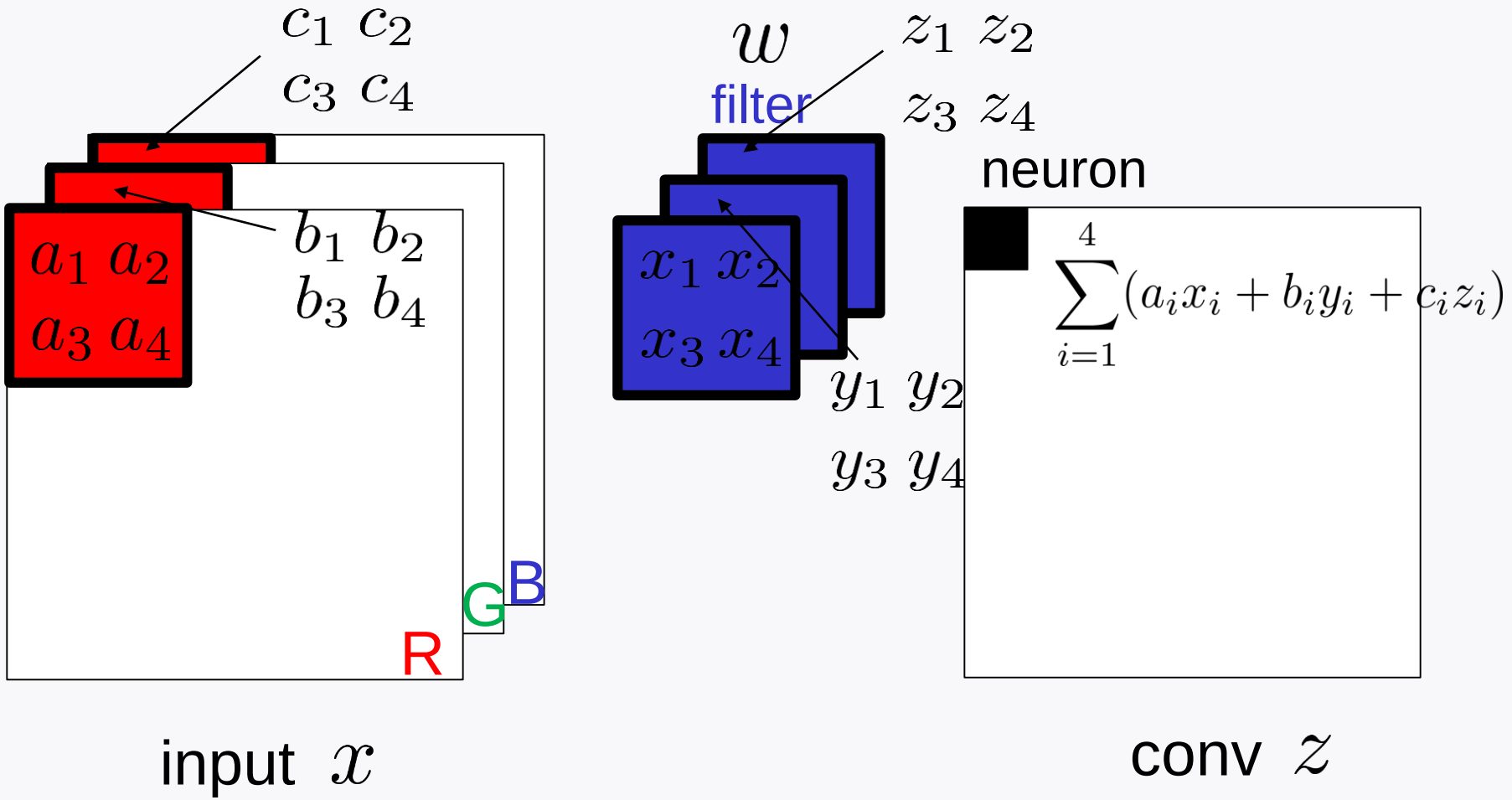
conv z

3D tensor

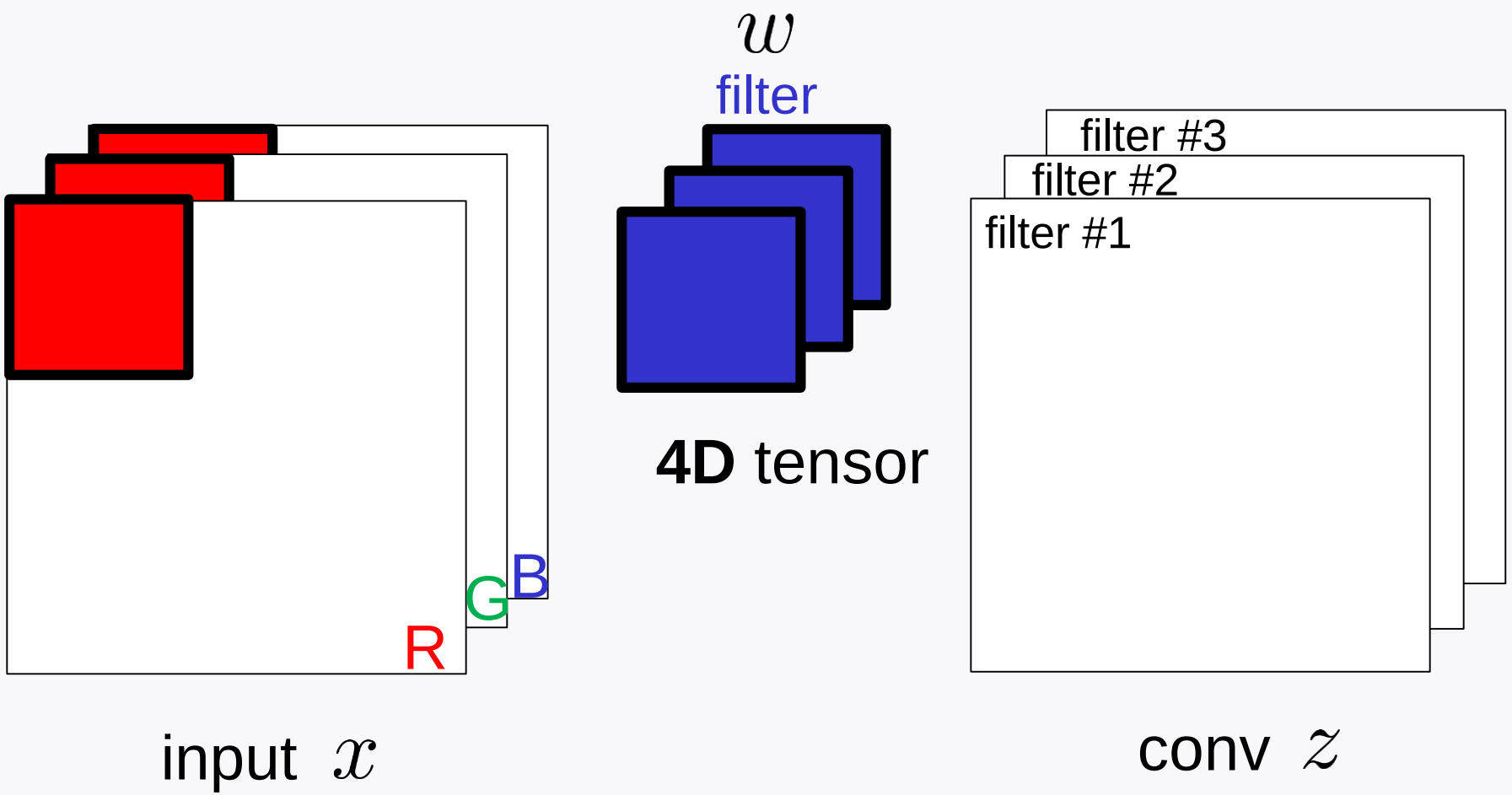
Channels



Computation of a neuron value



Dimension of weights?



Pooling layer

Serious memory issue

For training: Employ **backpropagation**.

Backpropagation requires:

Caching everything computed before.

Each conv layer requires ~ 10MB for one example.

Suppose a training batch contains **100 examples.**

→ Requires ~ 1GB per conv layer.

→ Requires much more with many layers.

Motivates us to reduce complexity

This is where **Pooling** layer kicks in.

Role of **Pooling** layer:

Downsample to reduce # parameters and therefore memory size.

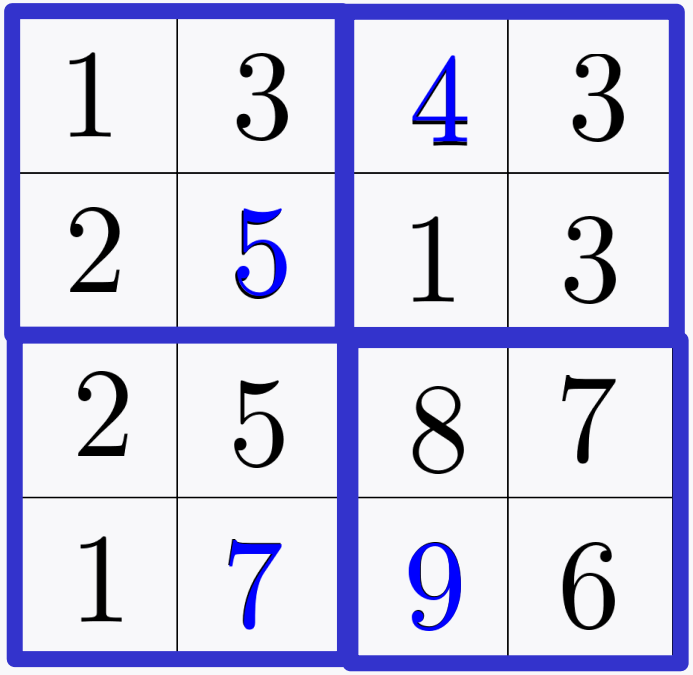
Two types of **Pooling:**

1. **Max Pooling** (most common)
2. **Average Pooling**

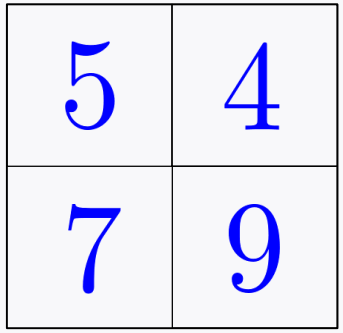
Max Pooling

pooling filter (or kernel)

Suppose: stride=2



A feature map



max pooling

Visualization example

2*2 pooling filter
stride=2

input

max pooling

Note: Works on each channel independently!

Typical CNN architecture

Repeat the following stack module:

stack [Conv] + [ReLU] + [Pooling]

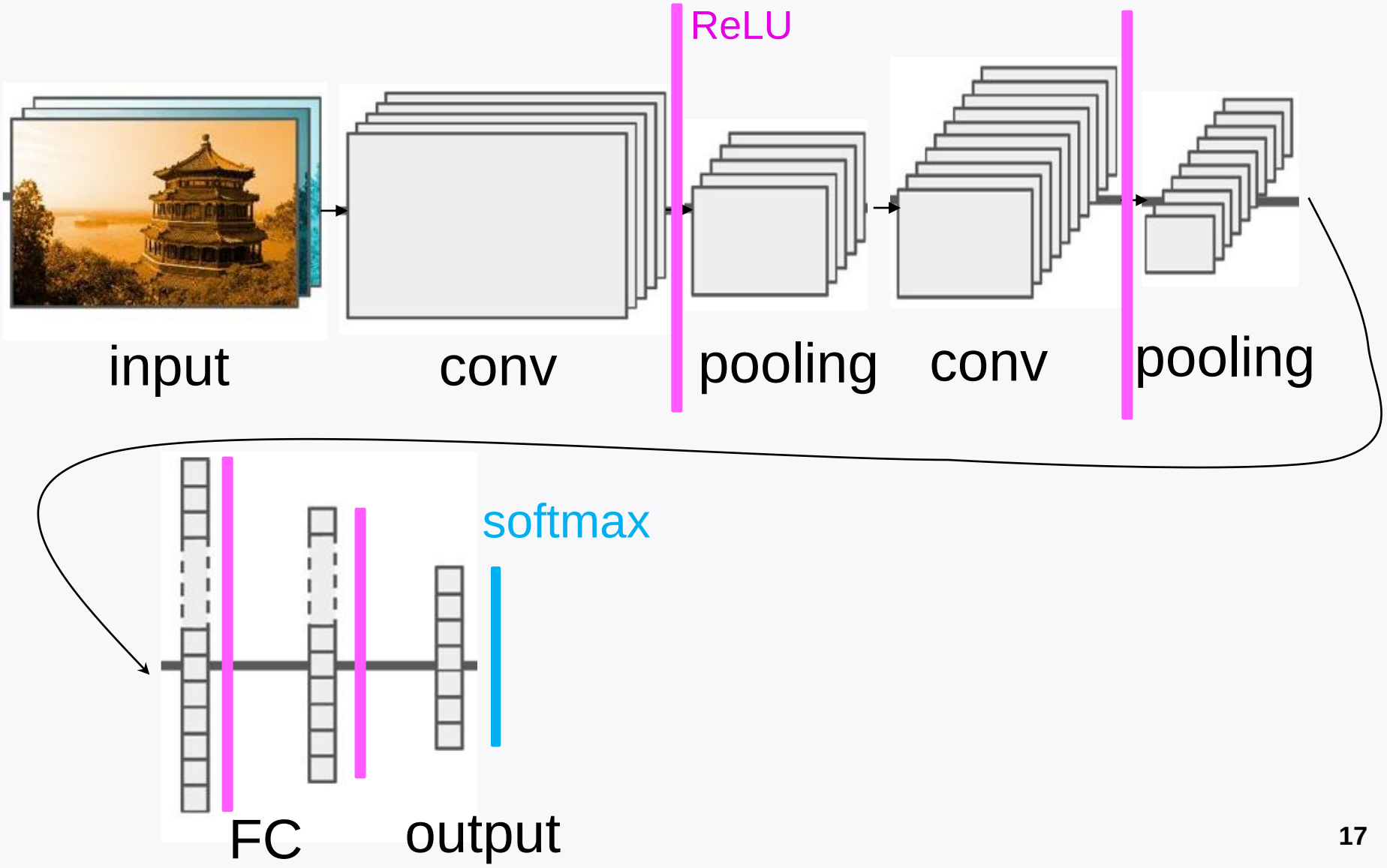
As the network gets deeper:

1. Feature map size gets smaller;
2. # of feature maps gets bigger.

At the end of the stacks:

Fully-connected (FC) layers
+ output layer (e.g., softmax)

Typical CNN architecture in picture



Two popular CNNs

1. **AlexNet** (2012)

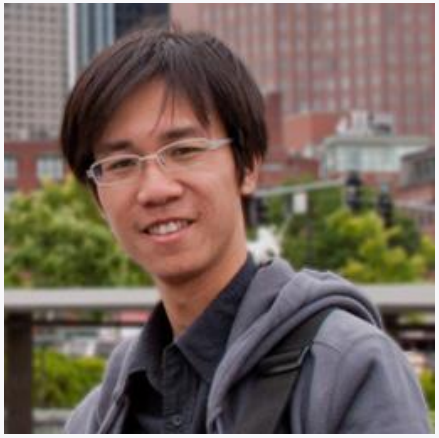
Alex Krizhevsky

Ilya Sutskever

Geoffrey Hinton

Anchored the deep learning revolution.

2. **ResNet** (2015)



Kaiming He

Currently the most powerful & arguably the simplest!

Look ahead

Will study details on AlexNet & ResNet.