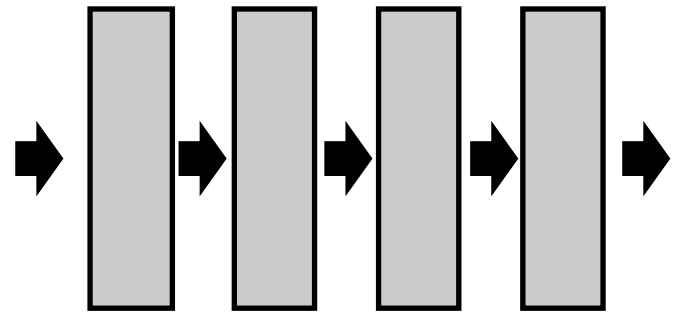
Data Mining & Machine Learning

CS57300
Purdue University

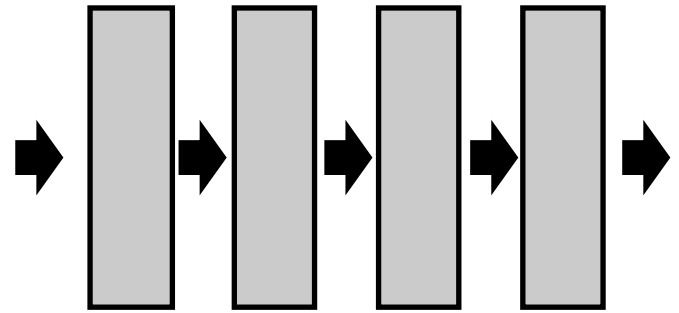
March 29, 2018

Some Deep Learning Applications (Supervised Learning)

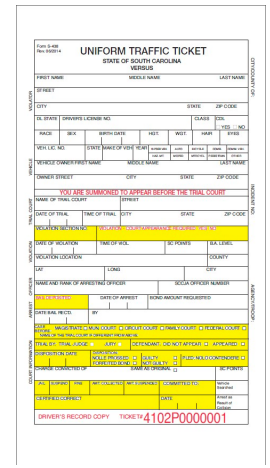
- Classification



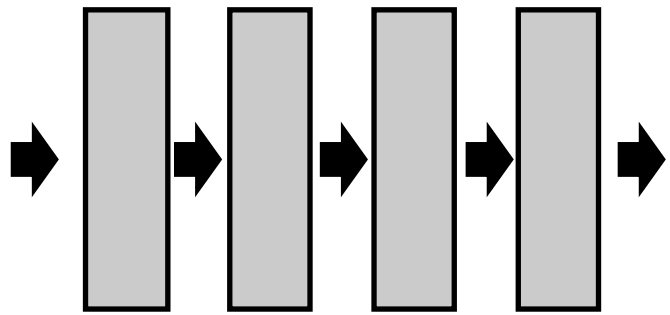
"dog"



GR8 PLA8



- Denoising (regression)



Role of Structure

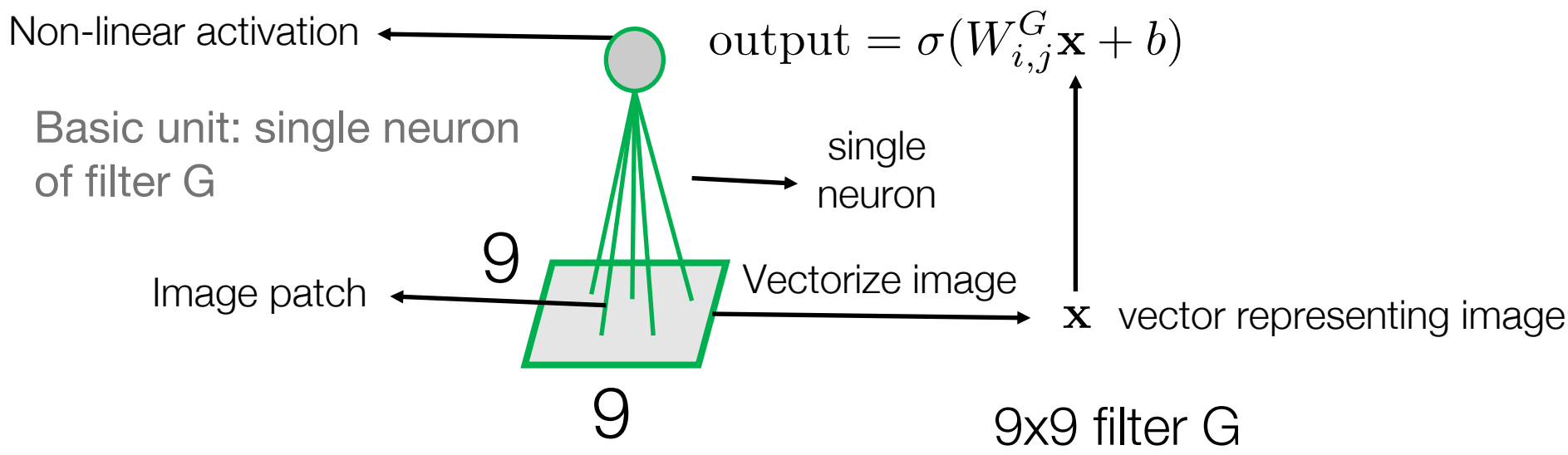
- Feedforward networks use image as input as a vector

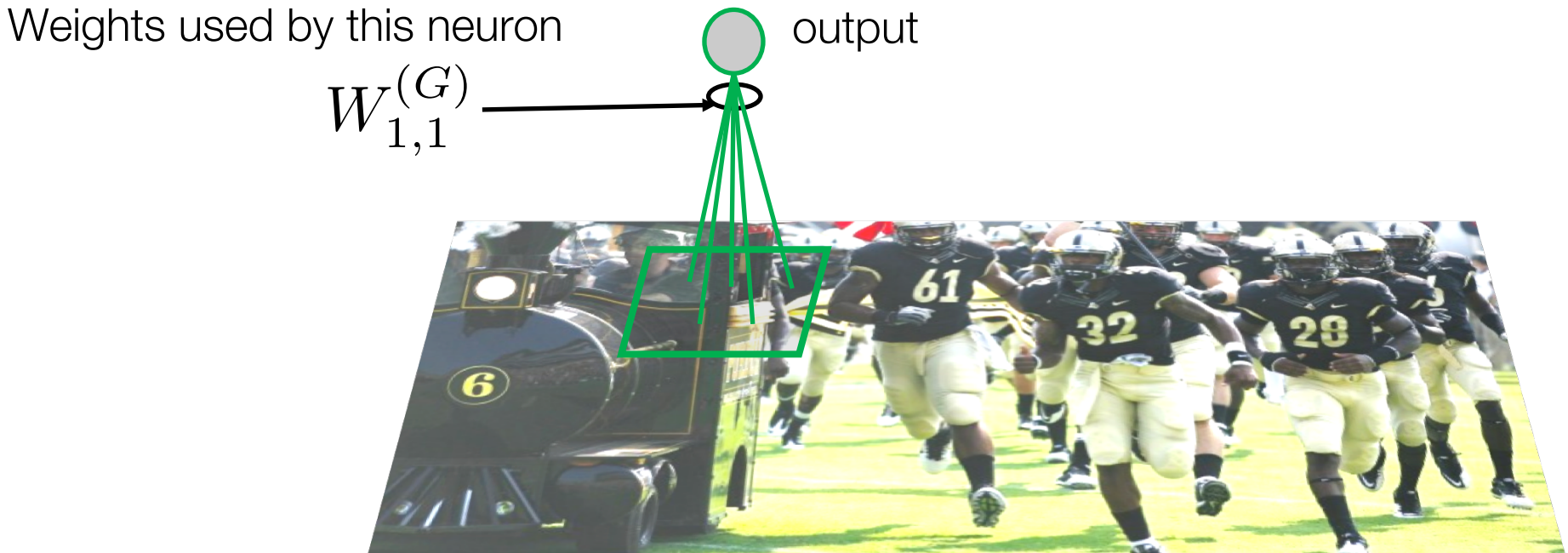
- From image to vector… hard to account for spatial correlations in the vector representation (which pixels are next to each other?)

- Even harder to account for location and colors

Convolutional Neural Network (CNN)

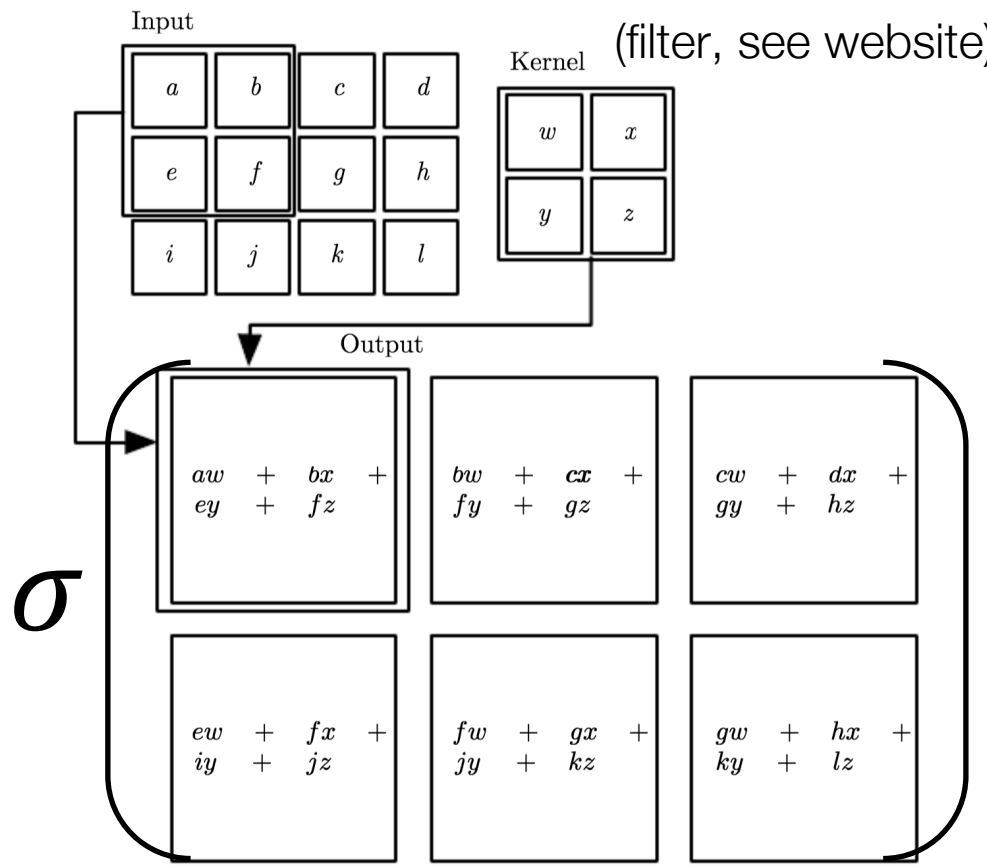
Transforms large image patch into one output





Equation View

- Equation view of a 2x2 filter applied over a 3x4 image

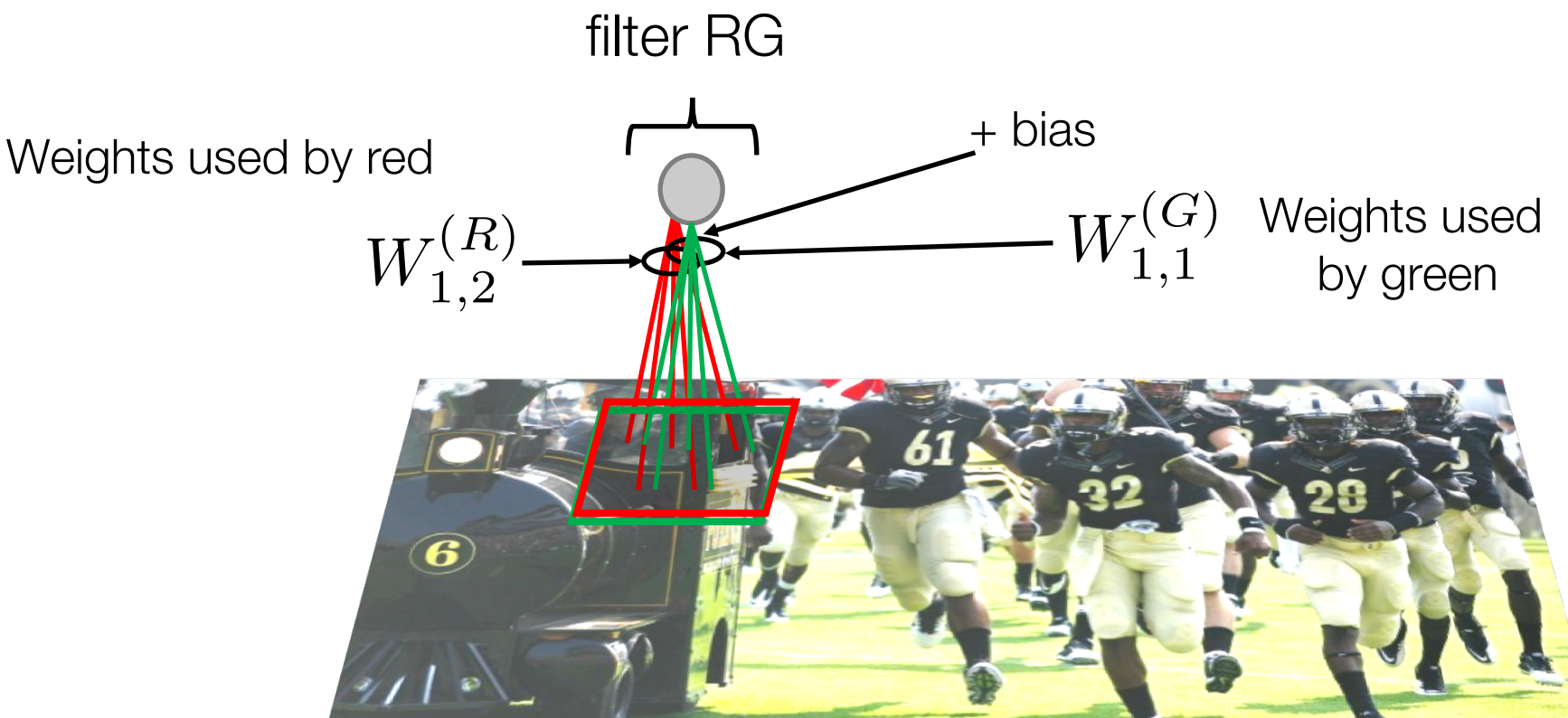


Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press

How to represent color images?

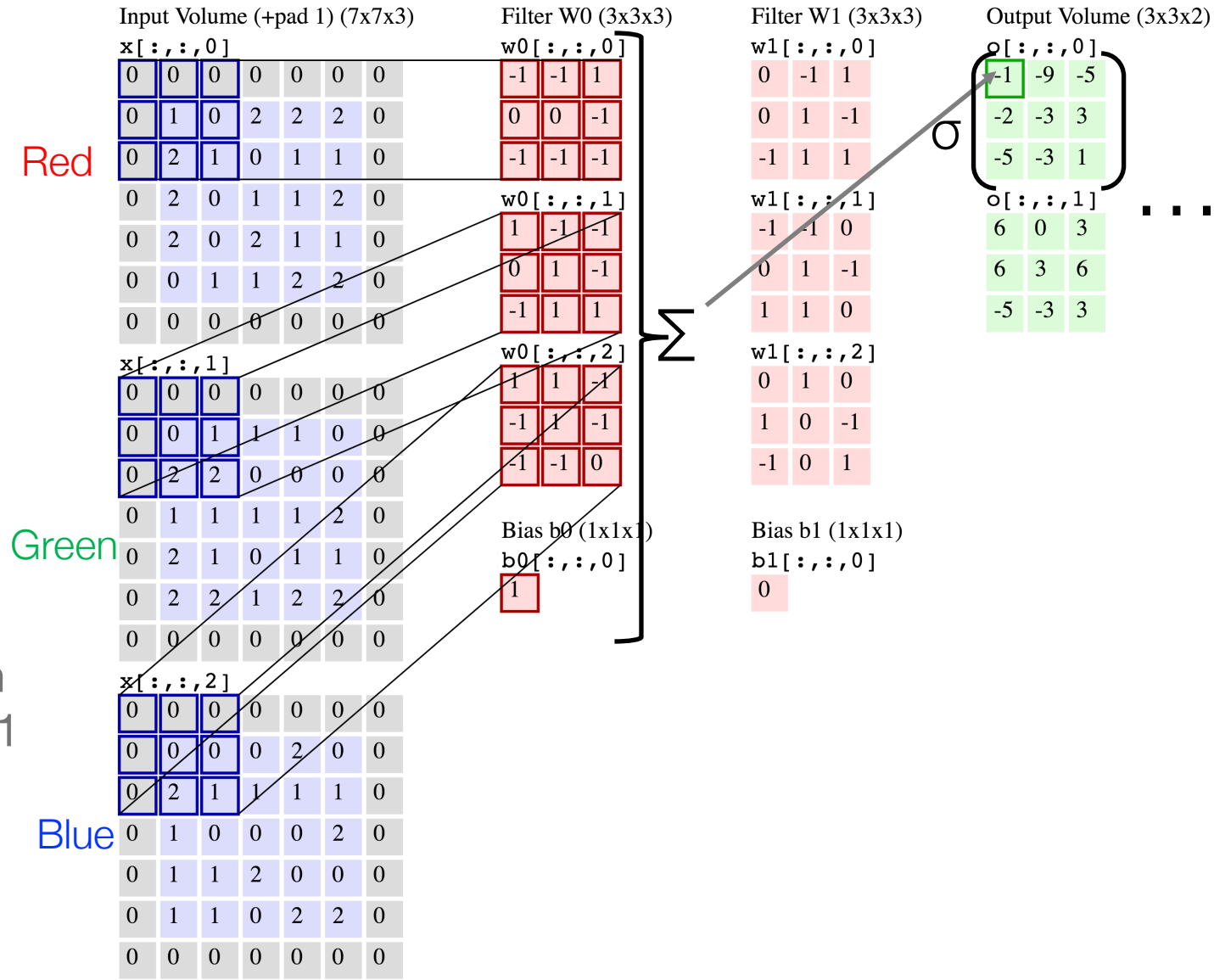
Color Image Convolutional Neural Network (CNN)

- A filter can be defined with one neuron over multiple channels
- For instance, one filter for colors Green and Red



Forward Pass of an RGB filter

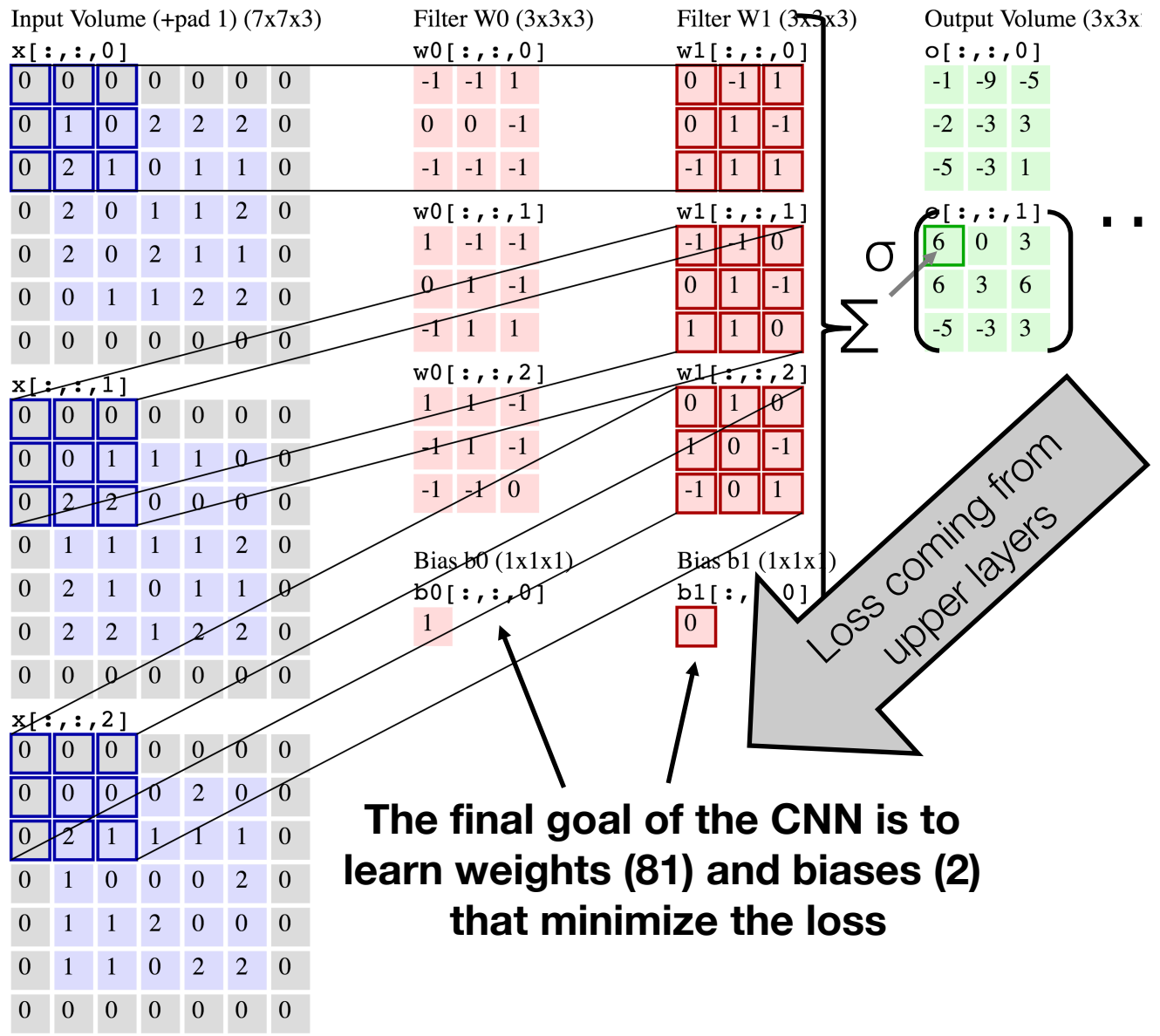
- Forward pass of a convolution
- Input: RGB image, 3 matrices
- Filter Wi:
  3x3 pixels
  1 neuron
  3 weight vectors, one for each color
  1 bias
- Apply the neuron with stride 1 and padding 1



http://cs231n.github.io/convolutional-networks/

Forward Pass of an RGB filter

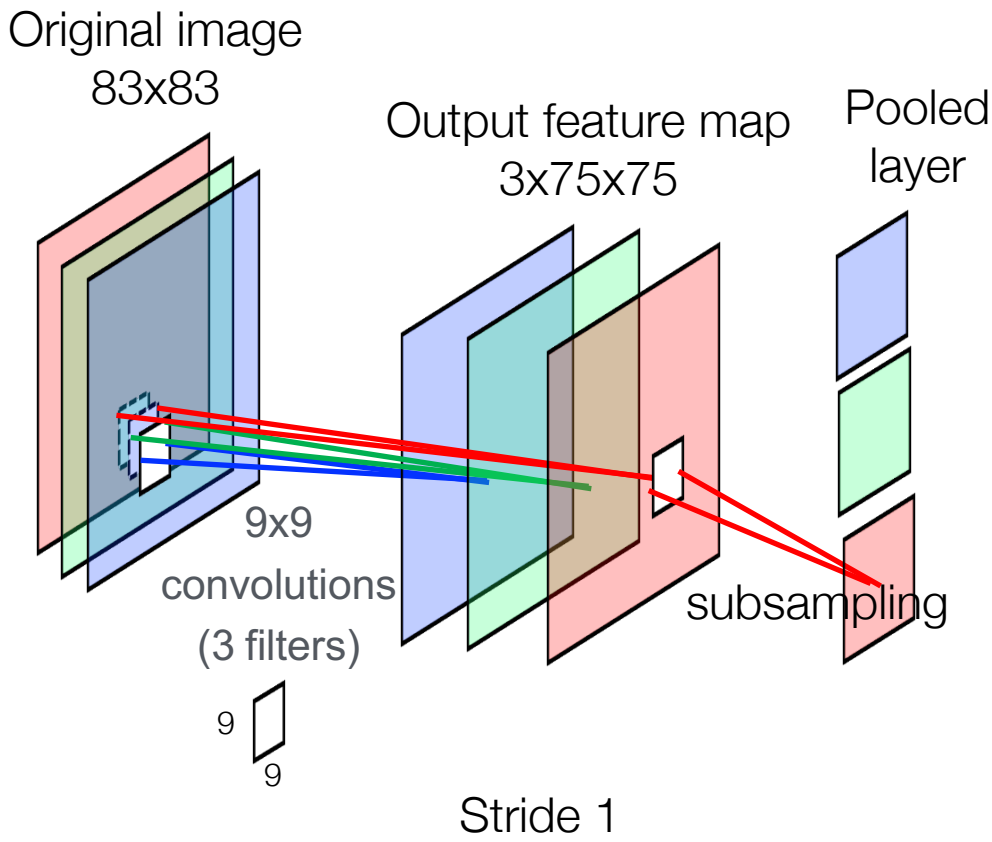
- Forward pass of a convolution
- Input: RGB image, 3 matrices
- Filter Wi:
  3x3 pixels
  1 neuron
  3 weight vectors, one for each color
  1 bias
- Apply the neuron with stride 1 and padding 1



http://cs231n.github.io/convolutional-networks/

Also Possible to Have one Filter Per Color

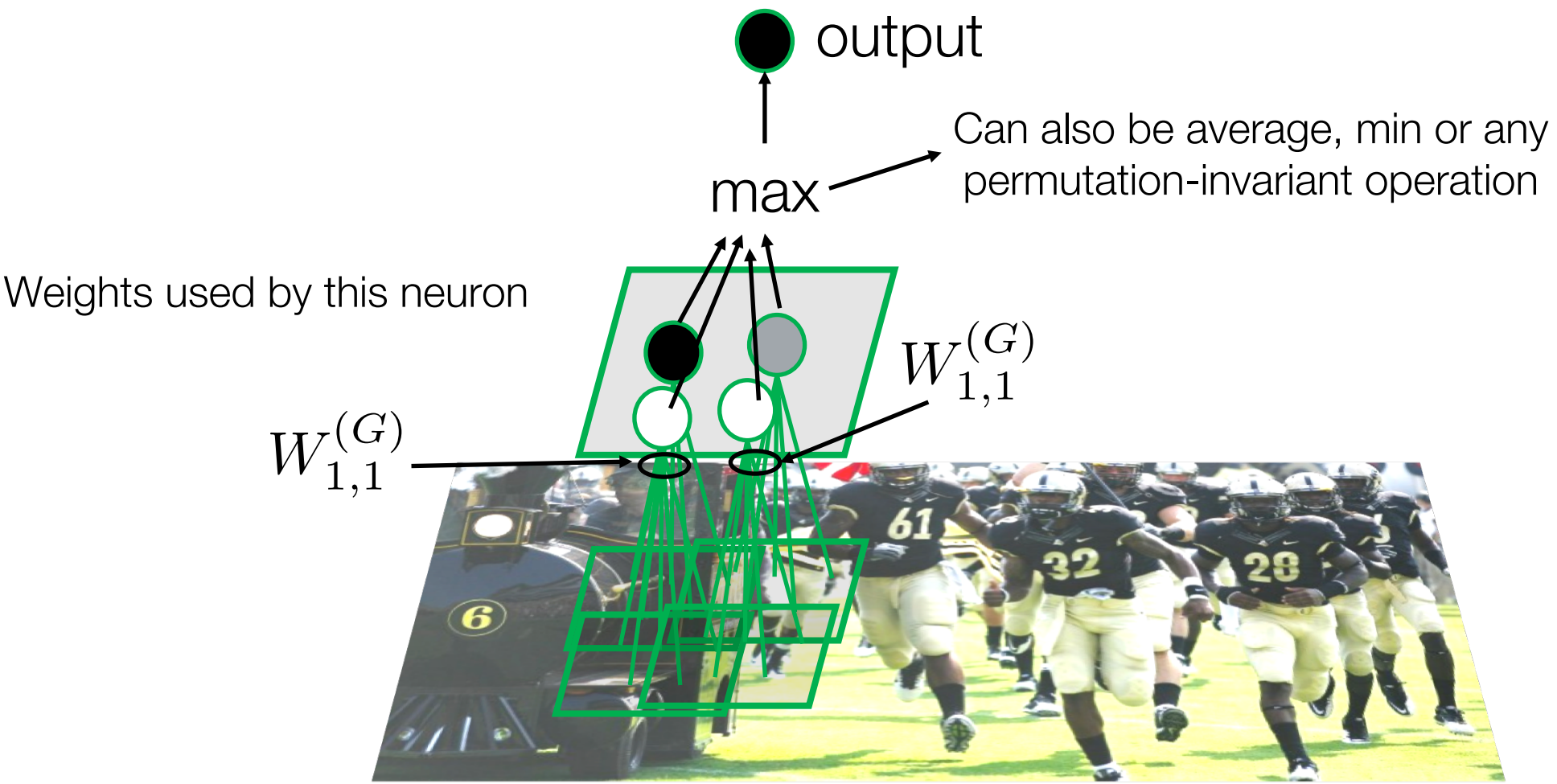
- If the input has 3 channels (R,G,B), 3 separate k by k filter can be applied to each channel
- Output of convolving 1 feature is called a feature map



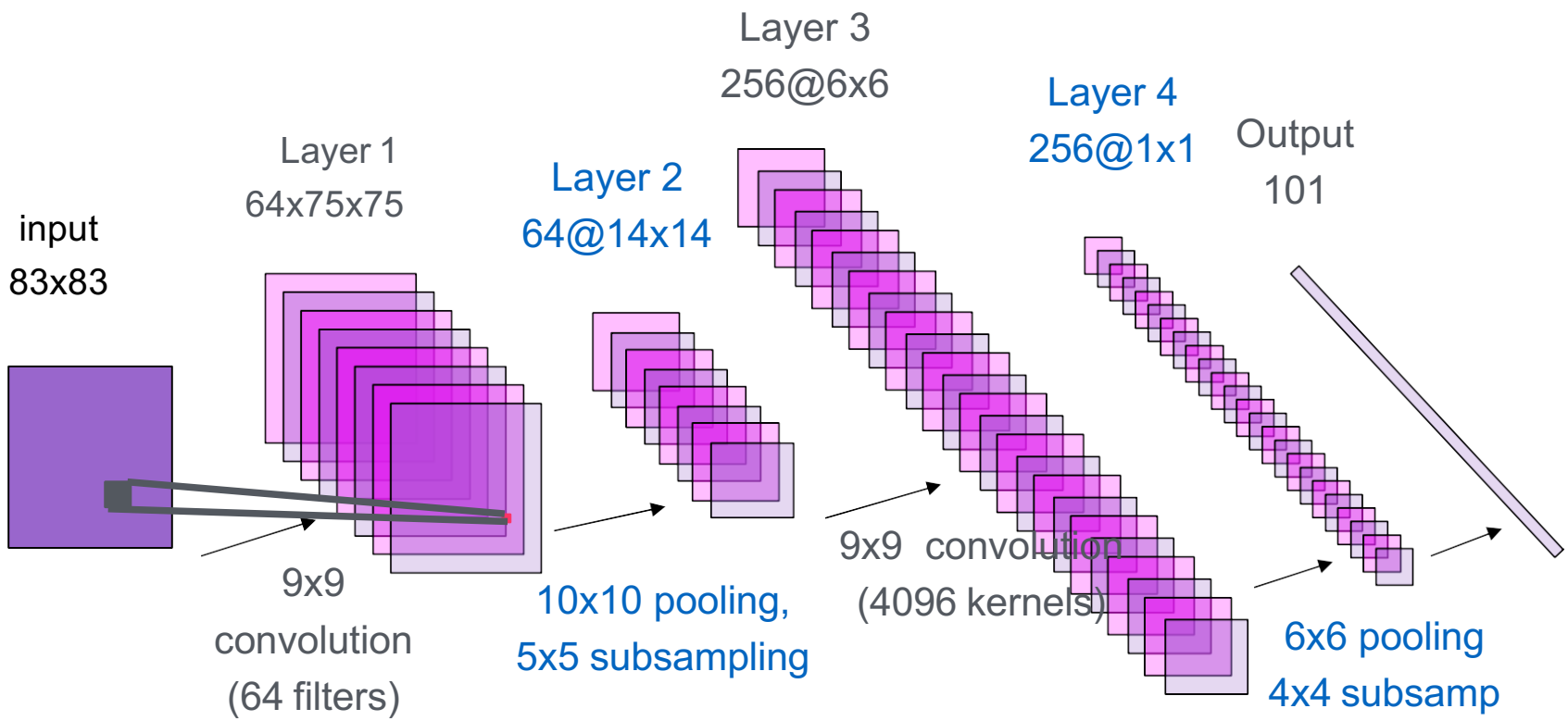
. . . Extra layers can now combine the colors of the same regions

Pooling

- Max pooling is a way to get a single output out of a filter



Convolutional Network (ConvNet)



- Non-Linearity: sigmoid, rectified linear units (ReLU)
- Pooling: max, average,…
- Training: Image labels

Original: Y. LeCun, Facebook, modified by Ribeiro

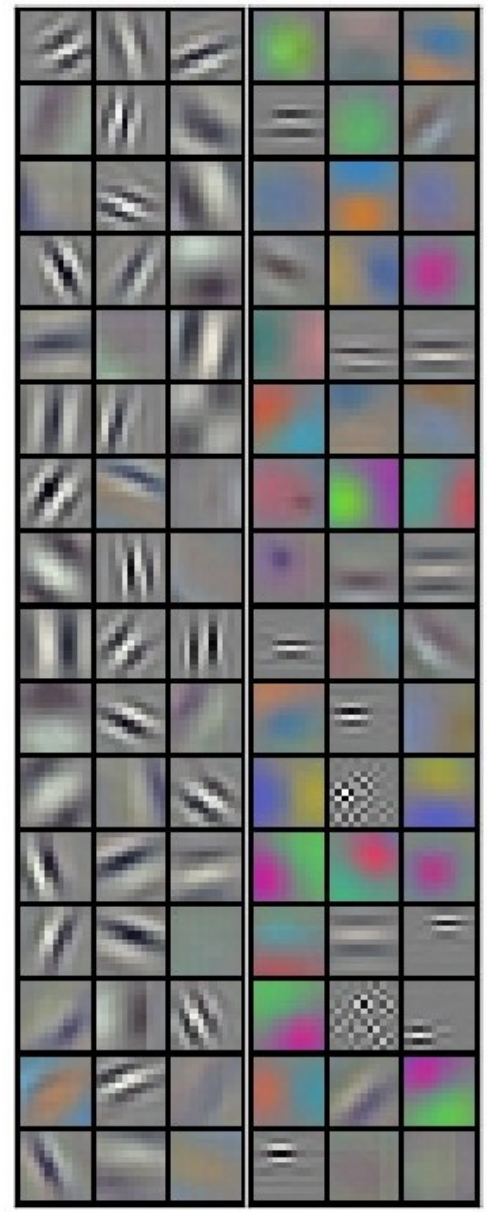
Learning parameters of the neuron in the filter

- Our goal is to learn the parameters of the neuron in the filter

- Algorithm to learn the CNN weights:
  1. Do a forward pass as described above
  2. Perform a backward pass to get the gradient of the weights
  3. Update all parameters
  4. GoTo 1

AlexNet [Krizhevsky, Sutskever, Hinton 2012]

Neuron weights (combined RGB filter):

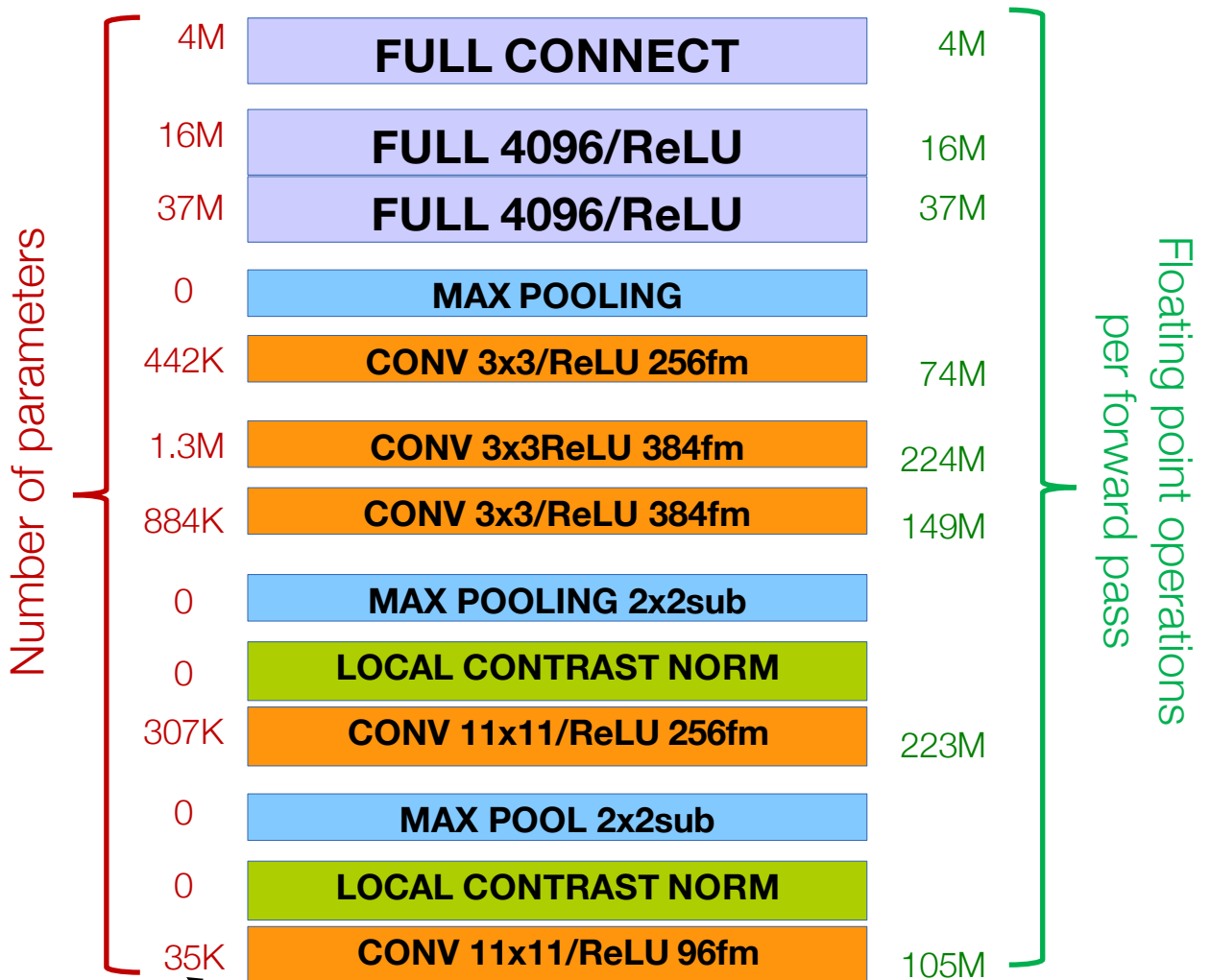


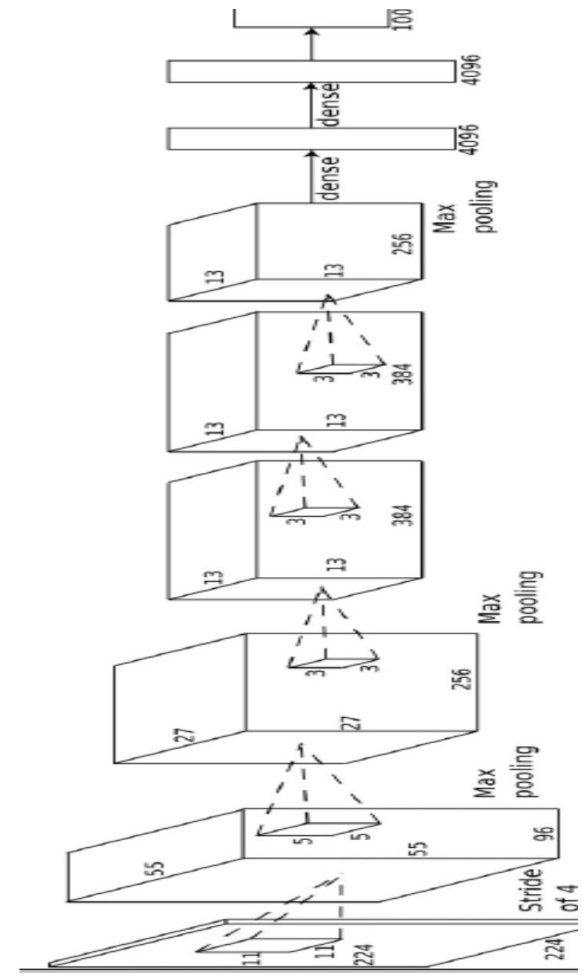
- Method: large convolutional net
  - 650K neurons, 832M synapses, 60M parameters
  - Trained with backprop on NVIDIA GPU
  - Trained “with all the tricks Yann came up with in the last 20 years, plus dropout” (Hinton, NIPS 2012)
  - Rectification, contrast normalization,...
- Error rate: 15% (whenever correct class isn't in top 5) Previous state of the art: 25% error
- **A revolution in computer vision**
- Acquired by Google in Jan 2013
- Deployed in Google+ Photo Tagging in May 2013

Credit: Y. LeCun, Facebook

AlexNet Achitecture

– Won the 2012 ImageNet LSVRC. 60 Million parameters, 832M Matrix multiplication + accumulation operations per forward pass



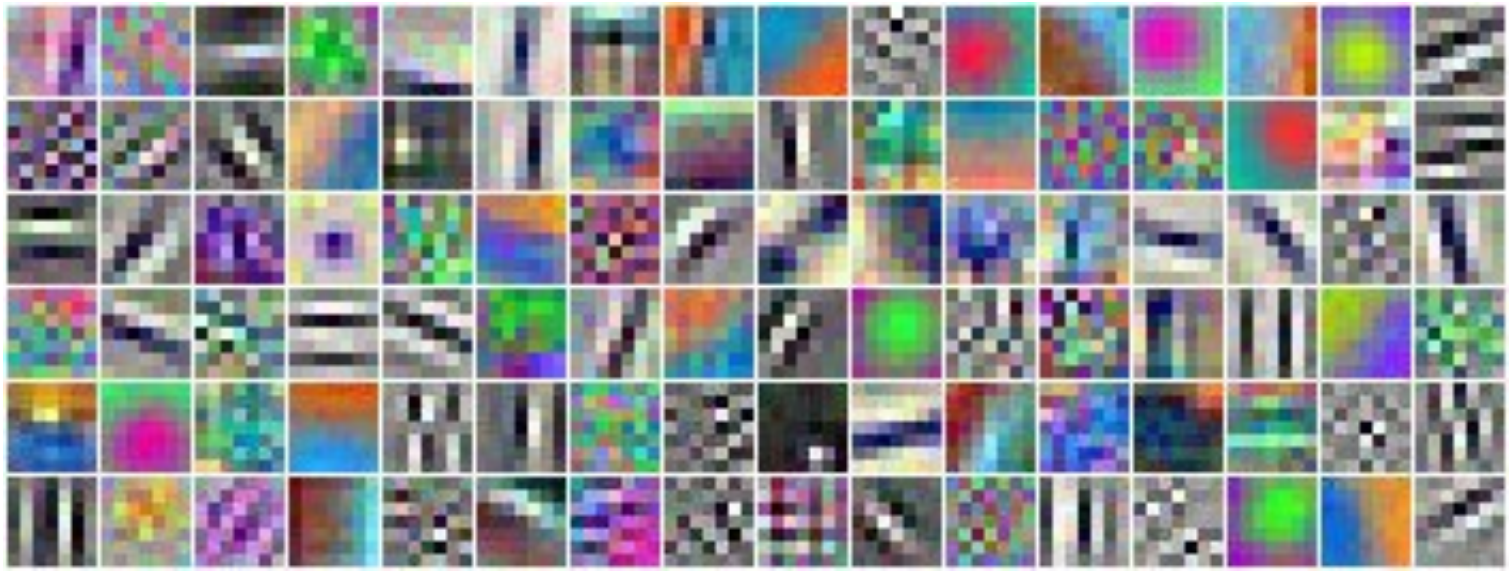


96 filters: each with 3x(11x11)+1 parameters = 34,849

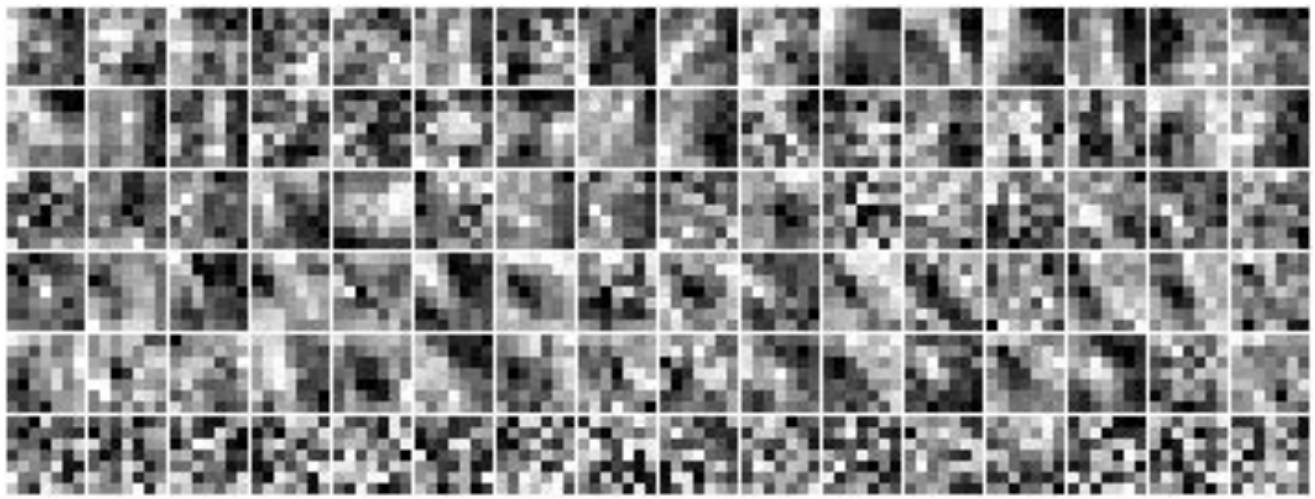
Credit: Y. LeCun, Facebook

Filters: Layer 1 (7x7) and Layer 2 (7x7)

– Layer 1: 3x96 filters, RGB->96 feature maps, 7x7 Filters, stride 2



– Layer 2: 96x256 filters, 7x7



Credit: Y. LeCun, Facebook

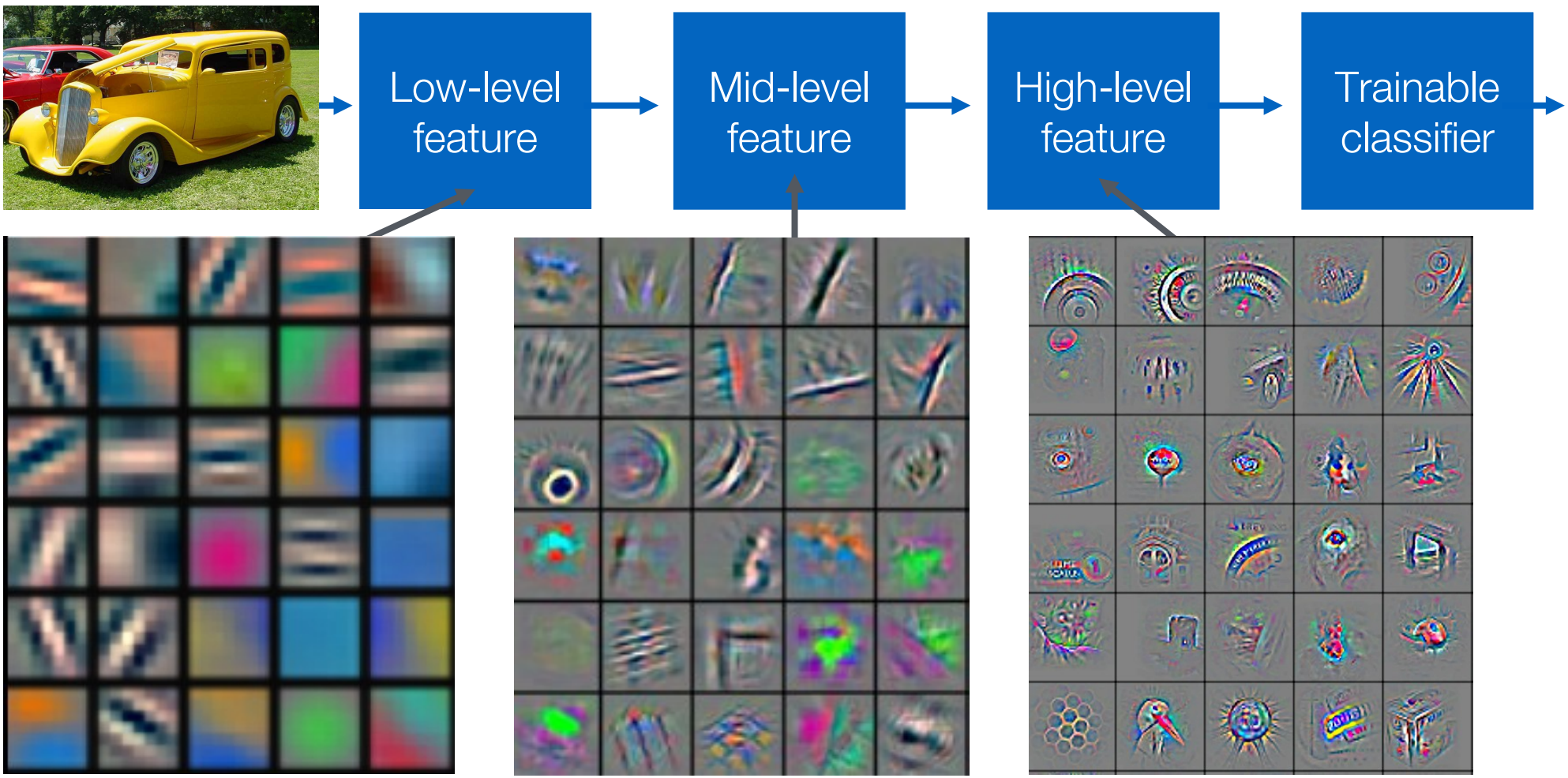
AlexNet

- Detailed View:

  Full (simplified) AlexNet architecture:
  [227x227x3] **INPUT**
  [55x55x96] **CONV1**: 96 11x11 filters at stride 4, pad 0
  [27x27x96] MAX POOL1: 3x3 filters at stride 2
  [27x27x96] NORM1: Normalization layer
  [27x27x256] CONV2: 256 5x5 filters at stride 1, pad 2
  [13x13x256] MAX POOL2: 3x3 filters at stride 2
  [13x13x256] NORM2: Normalization layer
  [13x13x384] CONV3: 384 3x3 filters at stride 1, pad 1
  [13x13x384] CONV4: 384 3x3 filters at stride 1, pad 1
  [13x13x256] CONV5: 256 3x3 filters at stride 1, pad 1
  [6x6x256] MAX POOL3: 3x3 filters at stride 2
  [4096] FC6: 4096 neurons
  [4096] FC7: 4096 neurons
  [1000] FC8: 1000 neurons (class probability output)

Deep learning = learning hierarchical representations

It's deep if it has more than one stage of non-linear feature transformation



Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

Credit: Y. LeCun, Facebook