Johns Hopkins Engineering

Applied Machine Learning for Mechanical Engineers

Popular Supervised Machine Learning Techniques, Part 1, C

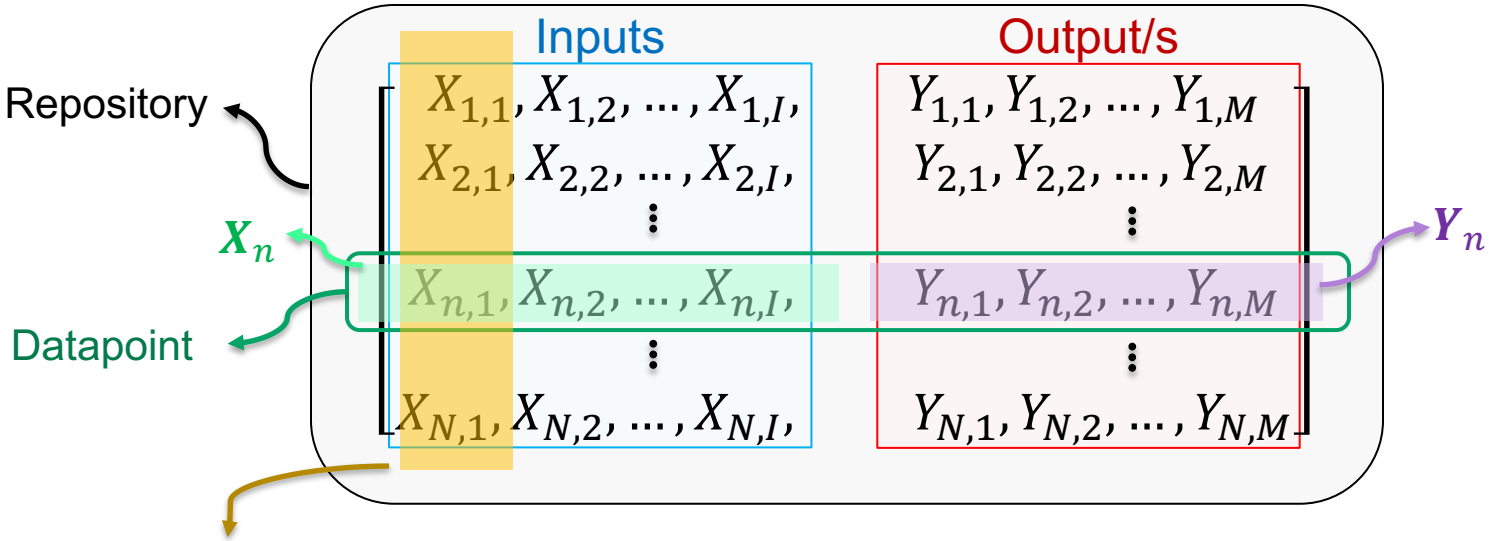
JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Convolutional Neural Networks

- By the end of this lecture you will be able to:
  - Describe data with local variations
  - Describe Convolutional Neural Networks (CNN)

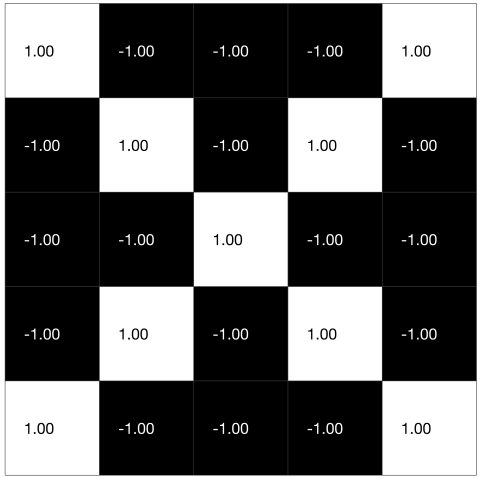
Convolutional Neural Networks

- Machine Learning data are to have unique attributes
  - What if our data have local variations (such as images, sounds, text, etc.)?

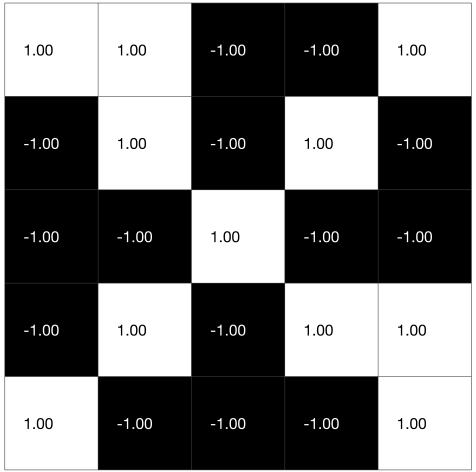


Convolutional Neural Networks

- Machine Learning data are to be inherently unique for each attribute
  - What if our data have local variations (such as images, sounds, text, etc.)?



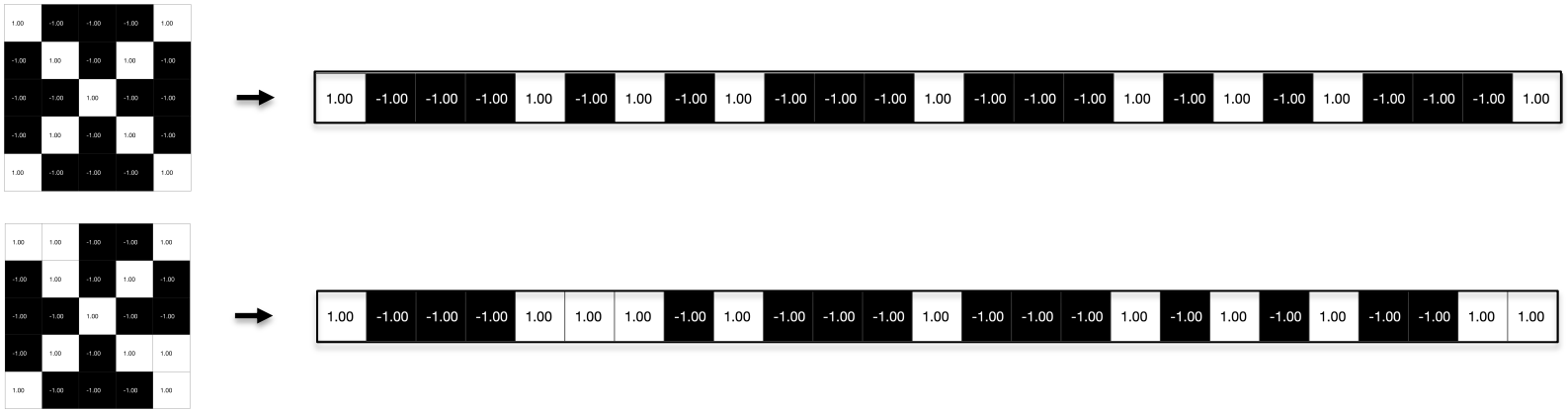
Letter X



Letter X

Convolutional Neural Networks

- Machine Learning data are to have unique attributes
  - Flatten the image to turn it into one datapoint of pixel intensities



There is no unique attribute; they are all pixel intensities

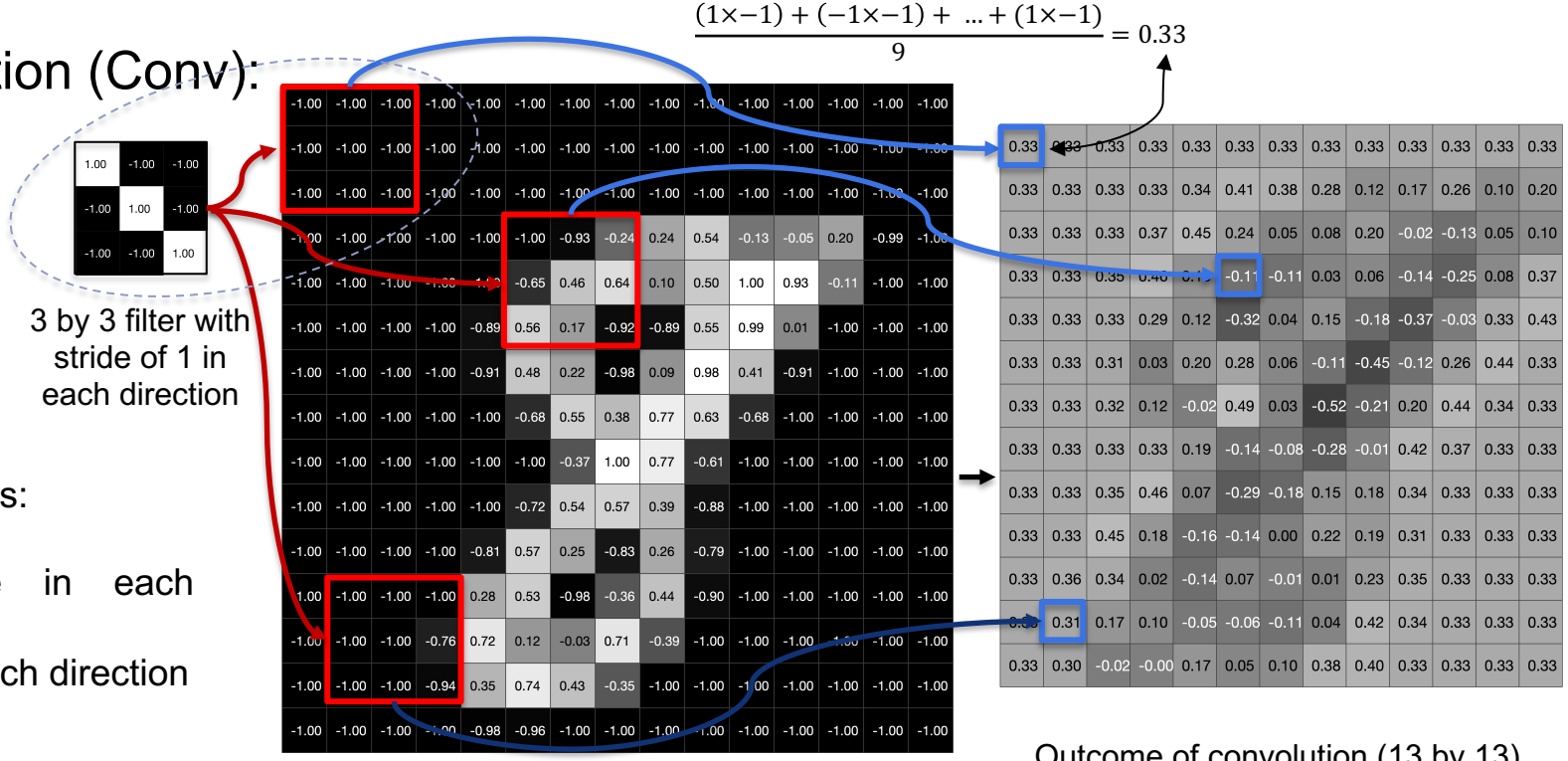
Convolutional Neural Networks

- What CNN does in general:
  - Extract features/attributes from the datapoints that address local variations of original data
  - Feed the attributes to a deep or shallow Neural Network and compute the outputs

- CNN main operations:
  - Convolution
  - Pooling
  - ReLU
  - Calibration/Normalization

Convolutional Neural Networks

- Convolution (Conv):



Important things:

- Filter size in each direction
- Stride in each direction

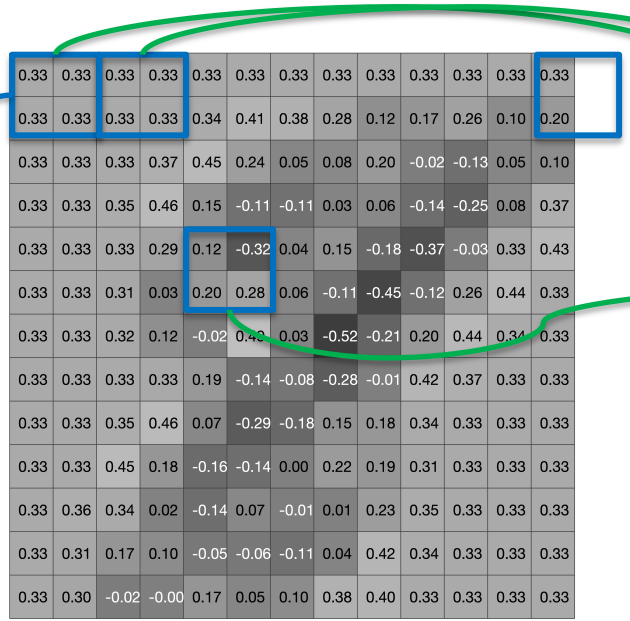
Convolutional Neural Networks

- Pooling (Pool):
  - Max pooling
  - Average Pooling

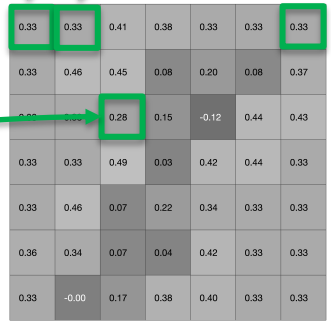
Pool of 2 by 2 with stride of 2 in each direction

Important things:

- Pool size in each direction
- Stride in each direction



Outcome of convolution (13 by 13)
(size is a function of strides and filter size)

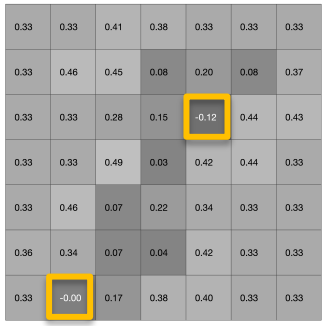


Outcome of pooling (7 by 7)
(size is a function of strides and pooling size)

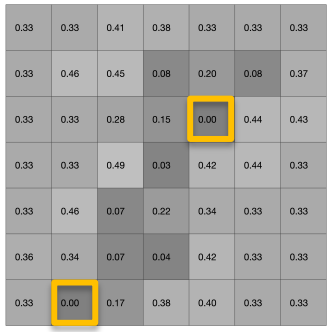
Convolutional Neural Networks

- ReLU:
  - Negative to zero

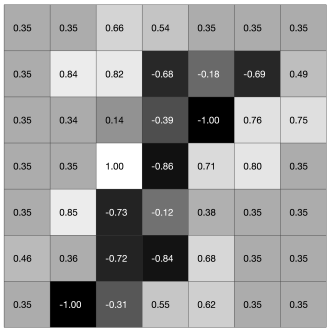
- Normalization/Calibration (NOCA)
  - Example: Calibrate calues between -1 and 1



Outcome of pooling (7 by 7) (size is a function of strides and pooling size)



Outcome of ReLU (7 by 7)



Outcome of calibration (7 by 7)

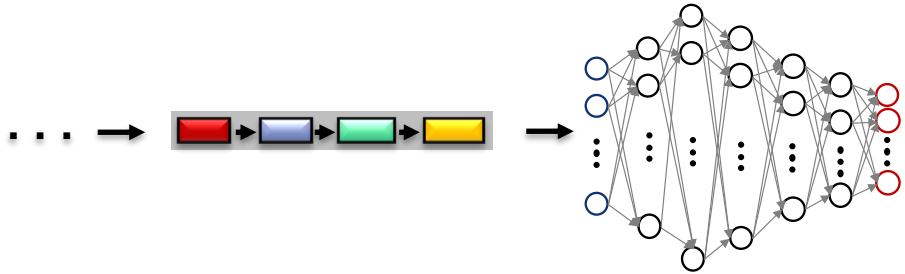
Convolutional Neural Networks

- Stack operations (also referred to as layers) and feed it to Neural Networks
  - One round

  - Stack

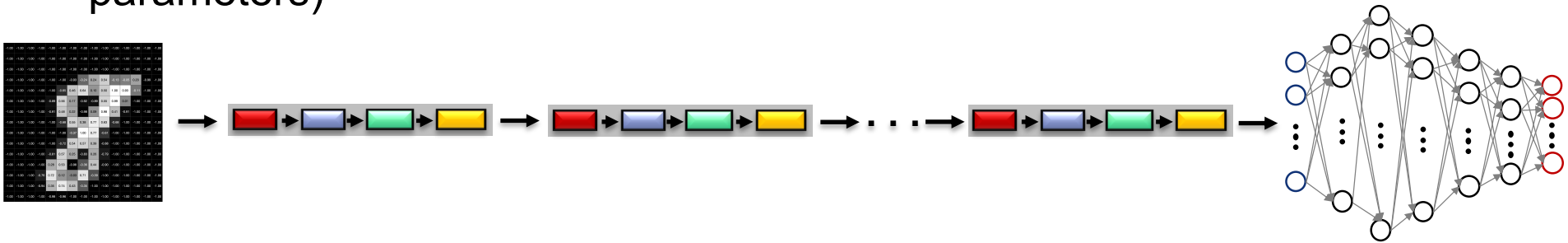
Size of filters and pooling, strides, and size of original images limit the number of times we can stack each round

  - Flatten and feed it to a deep or shallow Neural Network



Convolutional Neural Networks

- CNN Learning (initiate with random filters, weight, biases, and other parameters)



Feed forward

Backpropagation to learn weights and filters

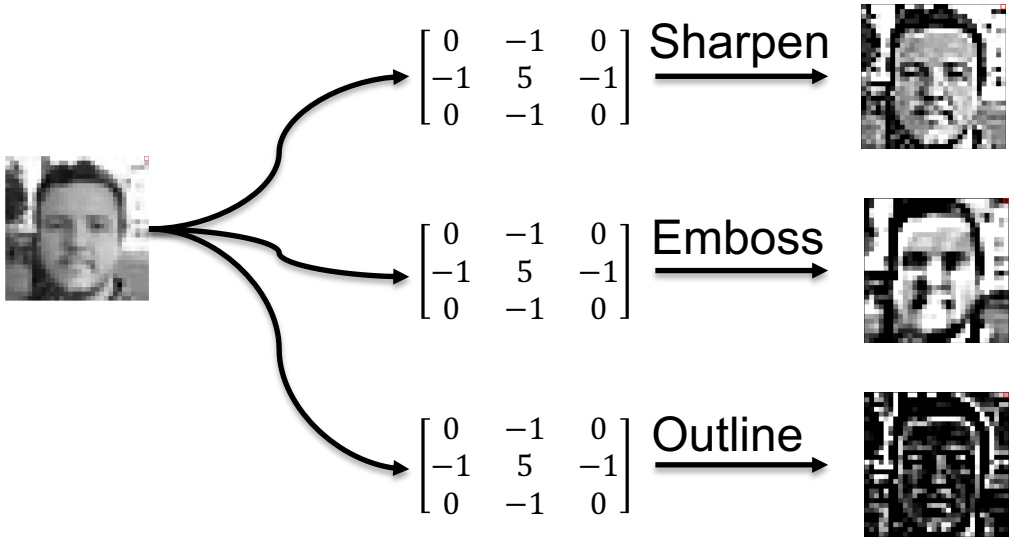
Convolutional Neural Networks

- By learning, some filters (kernels) might become pixel intensities of sensible features in an image (e.g. eyes, lips, nose, etc. in faces)

https://www.rsipvision.com/wp-content/uploads/2015/04/Slide6.png

Convolutional Neural Networks

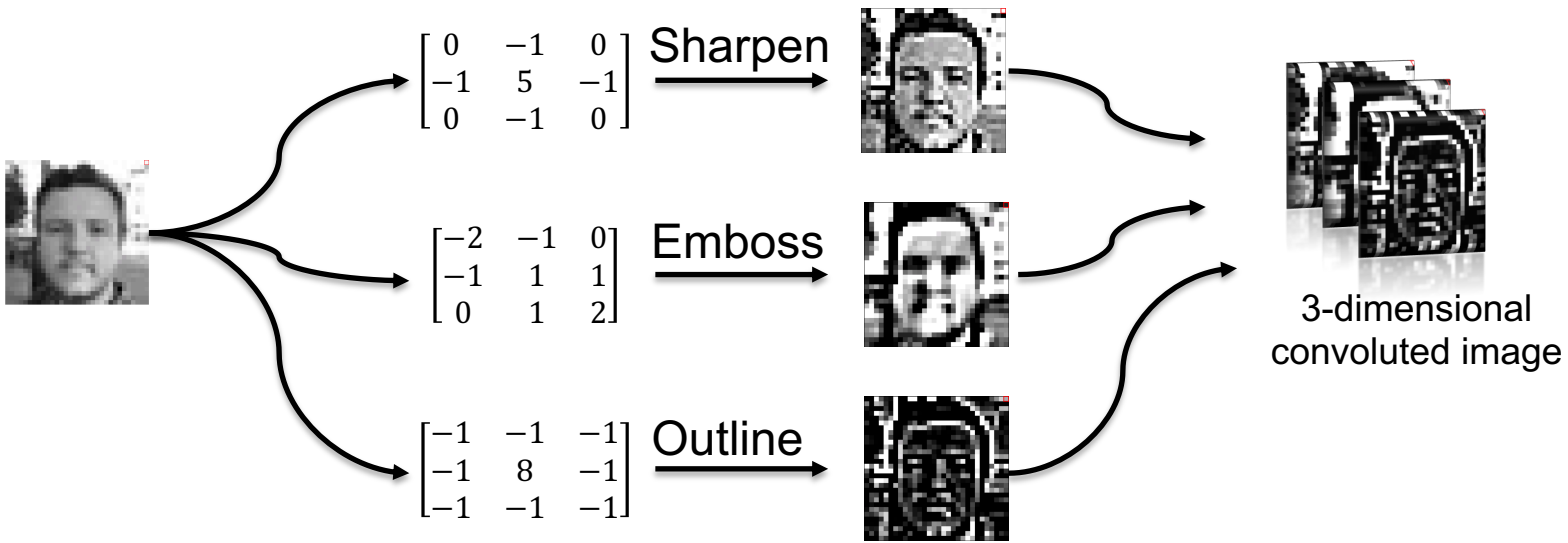
- What filters, also referred to as Kernels, actually do?
  - Detect edges, characteristics, objects, features.



https://setosa.io/ev/image-kernels/

Convolutional Neural Networks

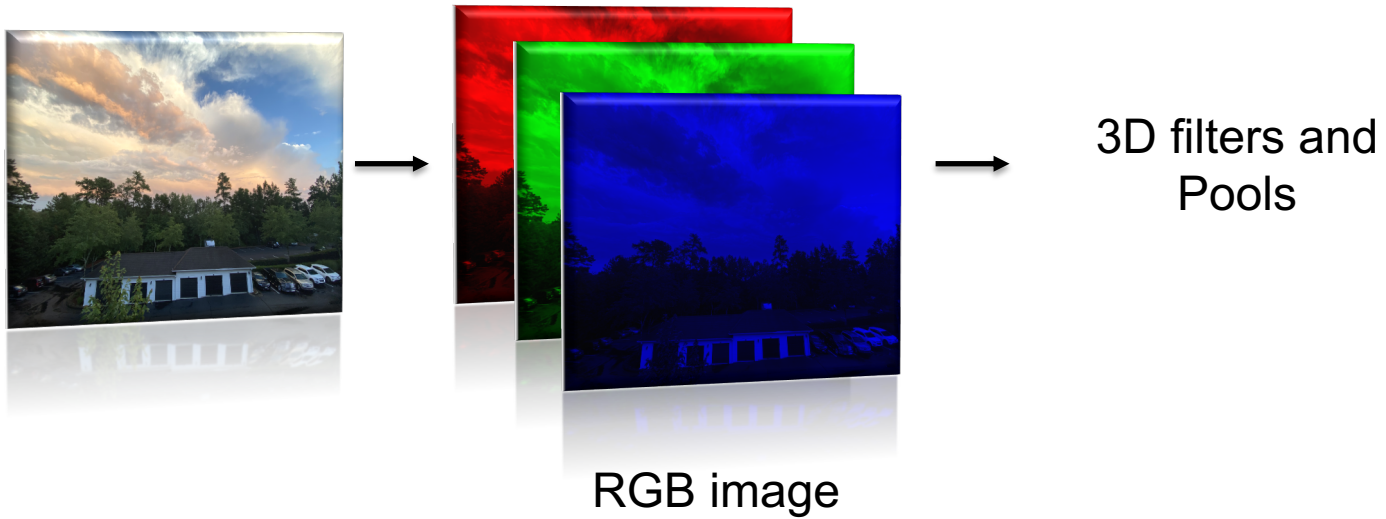
- You can have multiple filters, say K filters, in each round, then the convoluted image will be K-dimensional (i.e. K channels) where each dimension is the outcome of a different filter



https://setosa.io/ev/image-kernels/

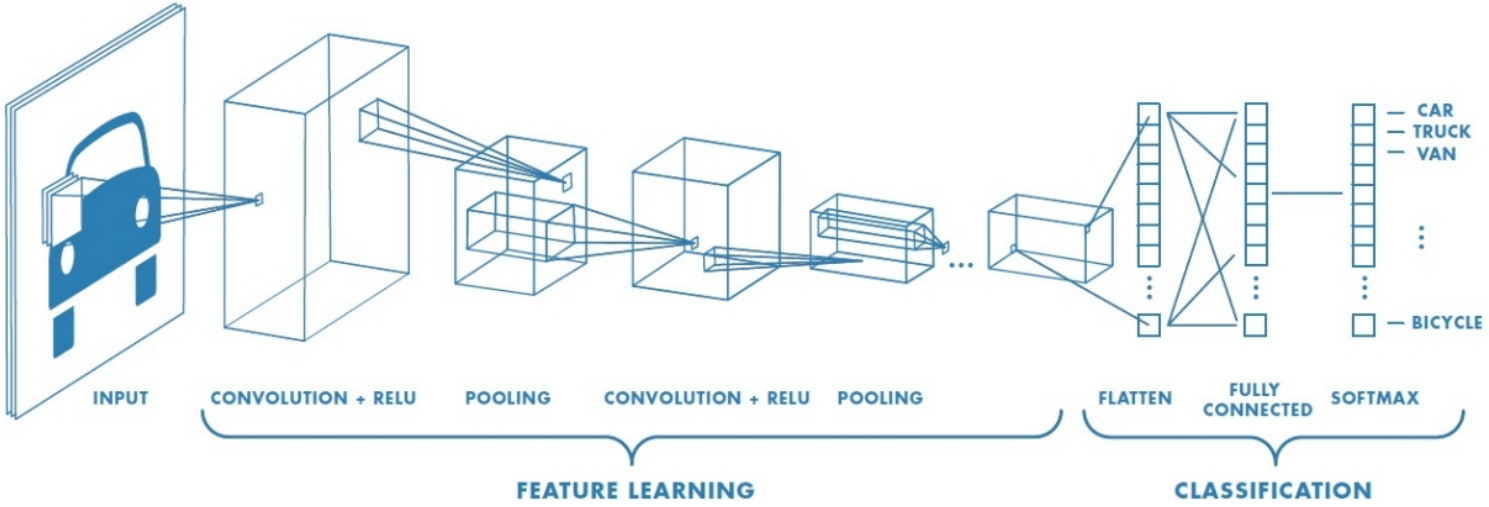
Convolutional Neural Networks

- Multi-channel data (e.g. color images)



Convolutional Neural Networks

- Multi-channel data (e.g. color images) and GPU computing



https://www.mathworks.com/solutions/deep-learning/convolutional-neural-network/_jcr_content/mainParsys/band_copy_copy_14735_1026954091/mainParsys/columns_1606542234_c/2/image.adapt.1200.high.jpg/1594751650719.jpg

Overview of Machine Learning in General

- In this lecture, you learned about:
  - Data with local variations
  - Convolutional Neural Networks (CNN)

- In the next lecture, we will briefly introduce K-Nearest Neighbor (KNN), Recurrent Neural Networks (RNN), and Long Short-Term Memory as other supervised machine learning techniques.