Convolutional Neural Networks

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Background Content

- What is a CNN?

- Why do we need CNN's? Why not just use normal feed forward NN?

- What is general architecture of CNN? (What are features unique to CNN's?) and how do CNN's work?
    - Why do we have this general kind of architecture?
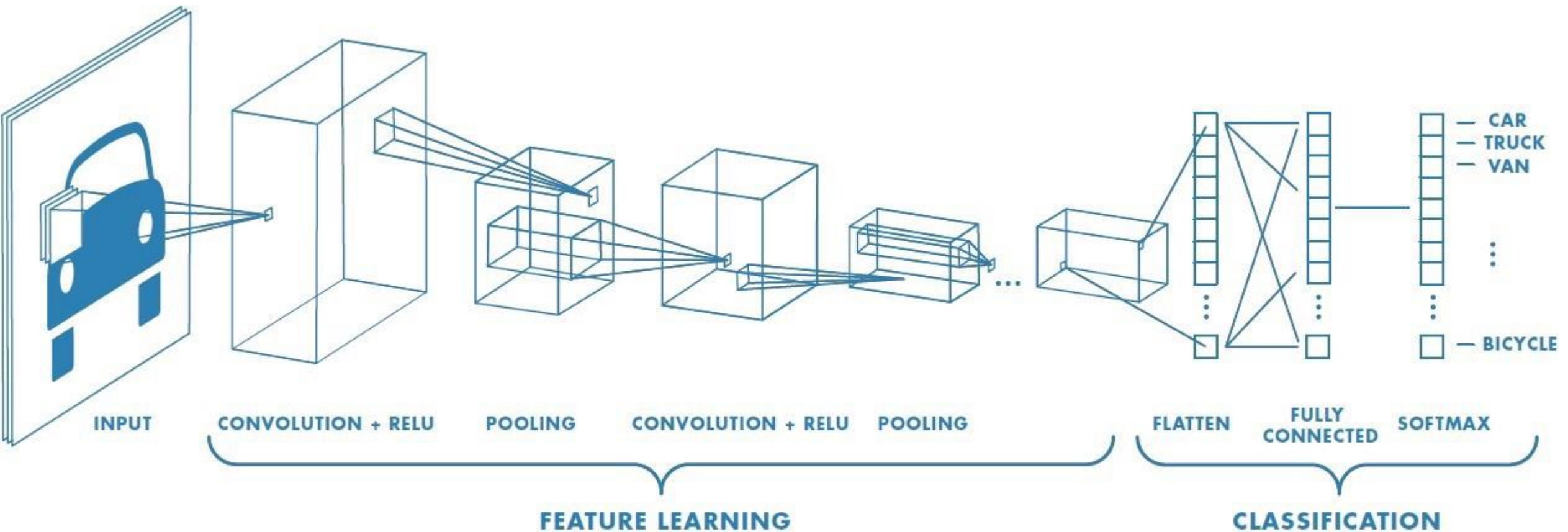
What is a CNN?

- Similar to feed forward NN, but only CNN
  - Takes advantage of order of input
    - Learning can be based on order of input
  - Takes advantage of feature locality in images
  - Assumes inputs are images
    - Allows us to encode properties into architecture such as:
      - Convolutional filters/kernels
      - Max Pooling
      - Etc.

Why do we need CNN's? Why not just use normal feed forward NN?

- Feed forward NN's don't generalize well to images (too many features to compute)
- CNN's allow us to take advantage of local spatiality in making predictions since CNN's are well suited for images
- CNN's allow us to extract latent features that humans can't extract from data by using machines

What's the general structure of CNN?

- Architecture
 - Convolution -> Pooling + Activation --> ... --> Fully Connected Layer

Recall:

- Recall from Feed Fwd NN Slides: We need activation functions in order to make the data non-linear
- We need the last layer to be fully connected/linear layer so we can classify images into different classes

What is a convolution and why do we need it?

- Array called "filter", convolves (slides) over input array
  - Matrix multiplication of original values in image with values in filter array
- Resulting image after convolutions is "activation map"/"feature map"
- Purpose: detect/learn lines, edges, and shapes in image
- More convolutions -> Learn higher level features like shapes from lower level features like lines/edges
- Higher channel size in convolutions -> Higher number of types of lines/edges can be learned
- Values in filter array are adjusted through training and backpropogation
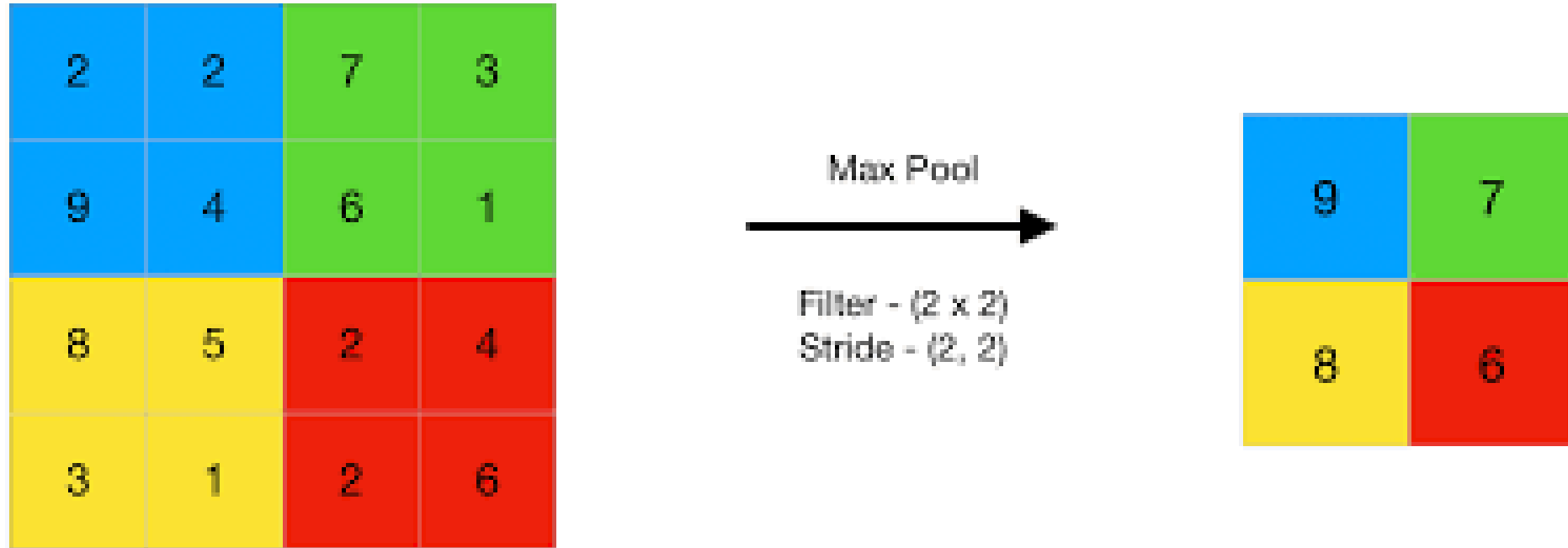
Intuitively understanding convolution
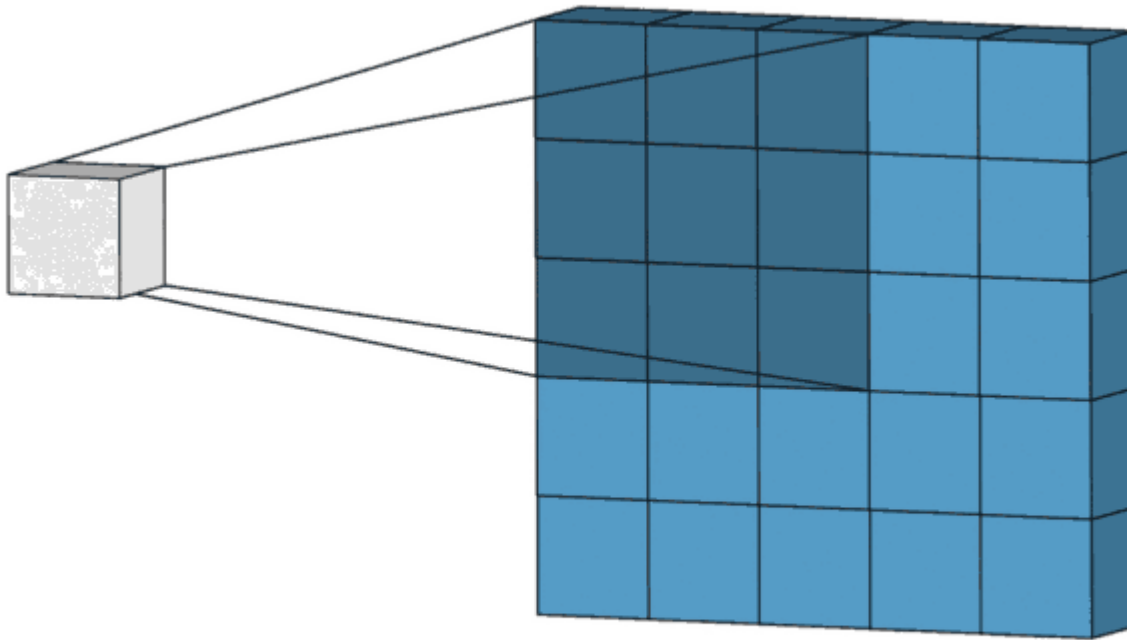
- Light blue – original image
- Dark blue – convolutional filter
- White boxes – resulting array after convolution

What is a pooling and why do we need it?

- Way to reduce amount of data being processed "by summarizing the presence of features in patches of the feature map" (https://machinelearningmastery.com/pooling-layers-for-convolutional-neural-networks/)
- Common types of pooling:
  - Max pooling
  - Average pooling

Intuitively understanding pooling

https://www.geeksforgeeks.org/cnn-introduction-to-pooling-layer/

Sample Code

- CIFAR-10 Code in PyTorch

Citations

1. https://cs231n.github.io/convolutional-networks/
2. https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53
3. https://datascience.stackexchange.com/questions/15903/why-do-convolutional-neural-networks-work
4. https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/
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6. https://machinelearningmastery.com/pooling-layers-for-convolutional-neural-networks/
7. https://www.geeksforgeeks.org/cnn-introduction-to-pooling-layer/