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Brain and Mind Research Institute

Workshop on Applied Deep Learning in Intracranial Neurophysiology

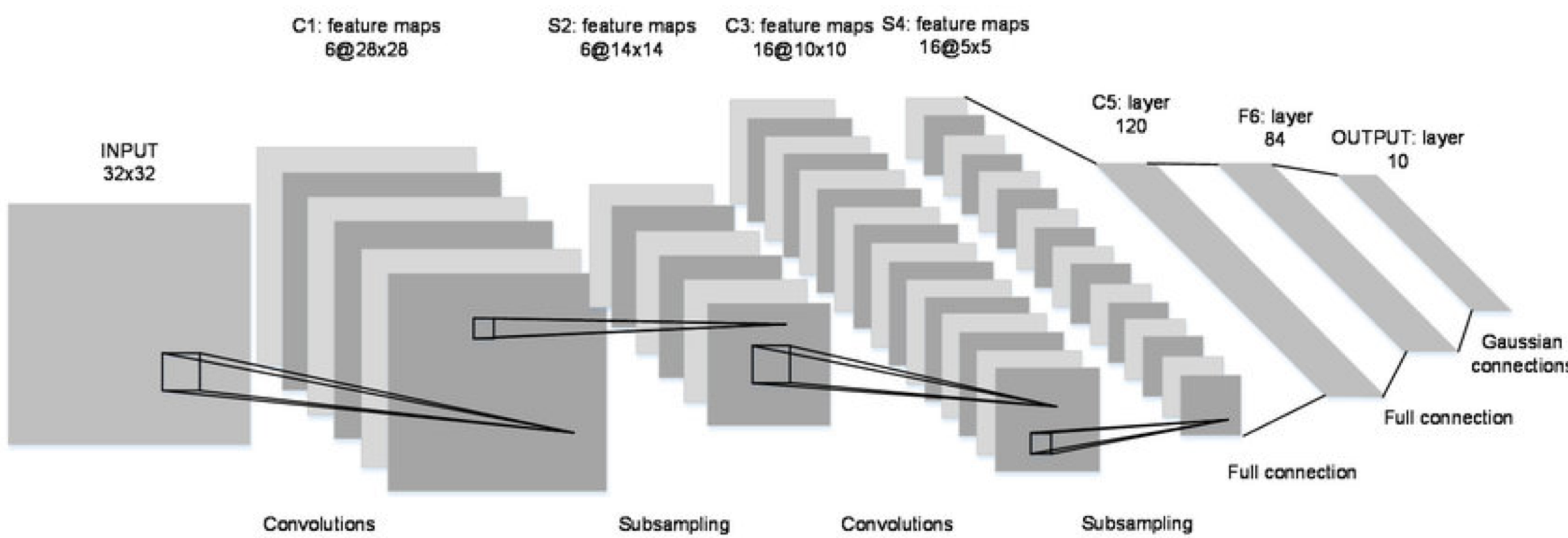
Part 3 – Using Convolutional Neural Networks to Analyze Brain Signals

September 16, 2019

Presented by Chadwick Boulay, MSc, PhD
Ottawa Hospital Research Institute
University of Ottawa

ConvNets, CNNs

- Convolutional Neural Networks have exploded in popularity due to their utility in classifying images.

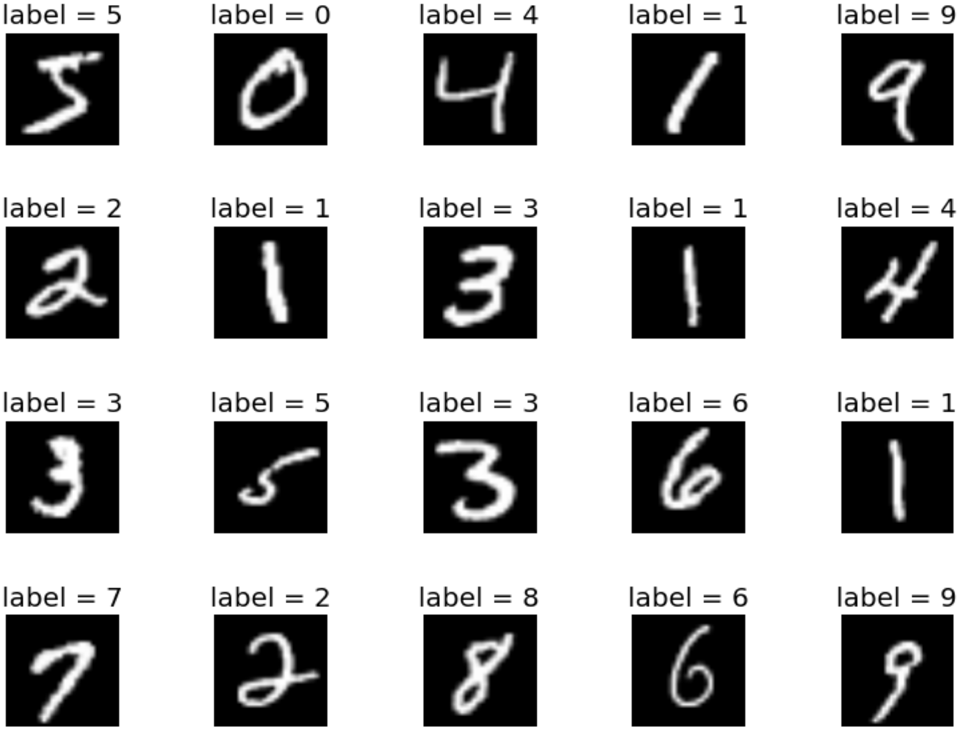


“LeNet” – Yann LeCun

[1-NIPS 1990]

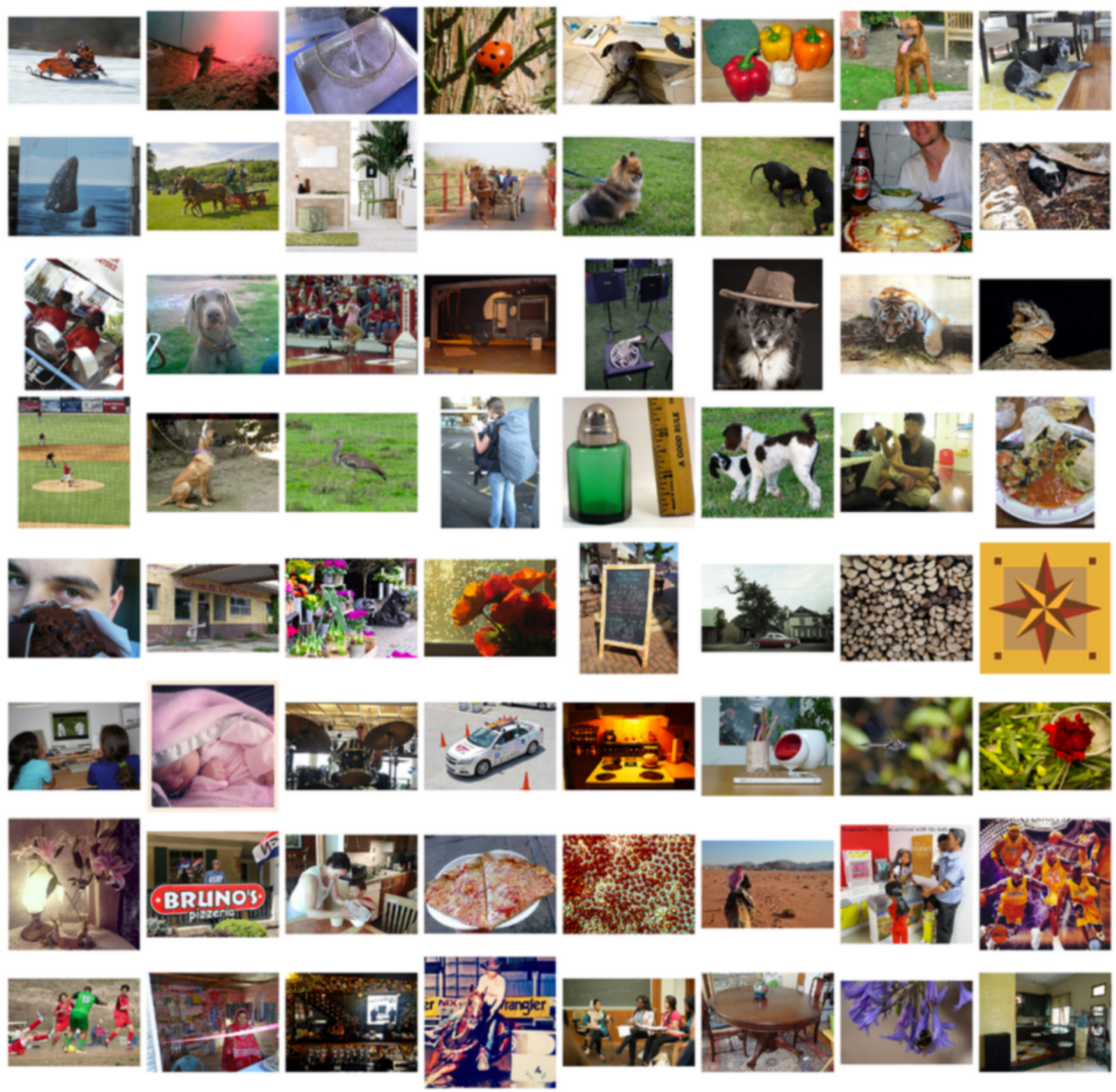
MNIST = “Hello World”

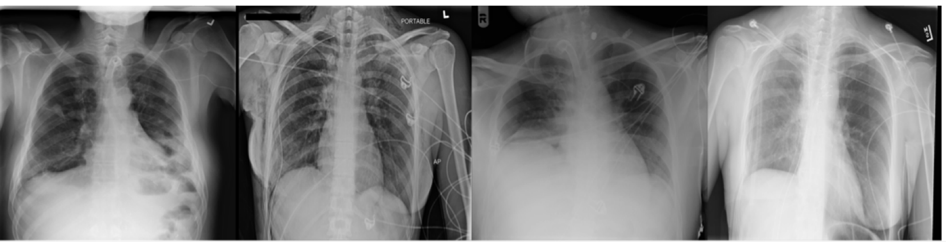
- And due to the availability of great image datasets.



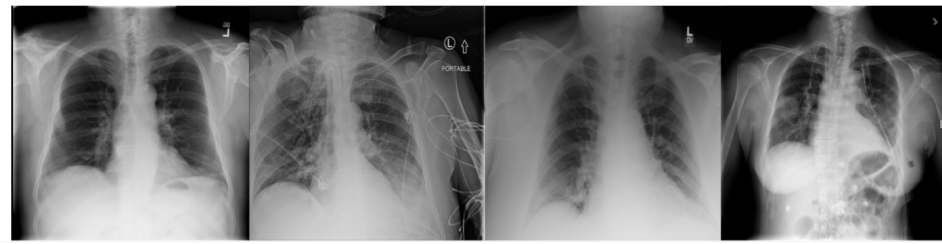
ImageNet 14M labeled images

ImageNet Large Scale Visual Recognition Challenge (ILSVRC)

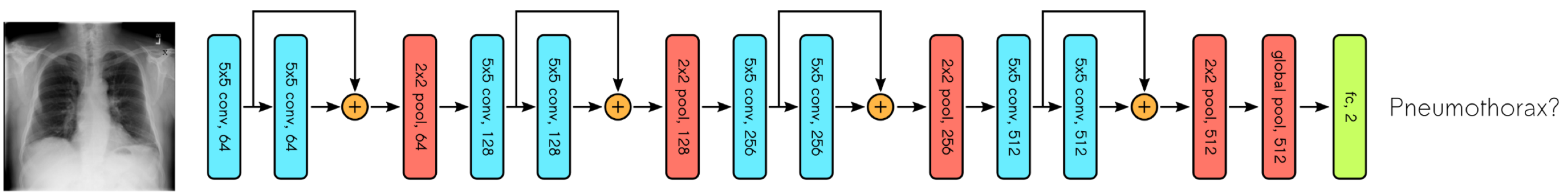


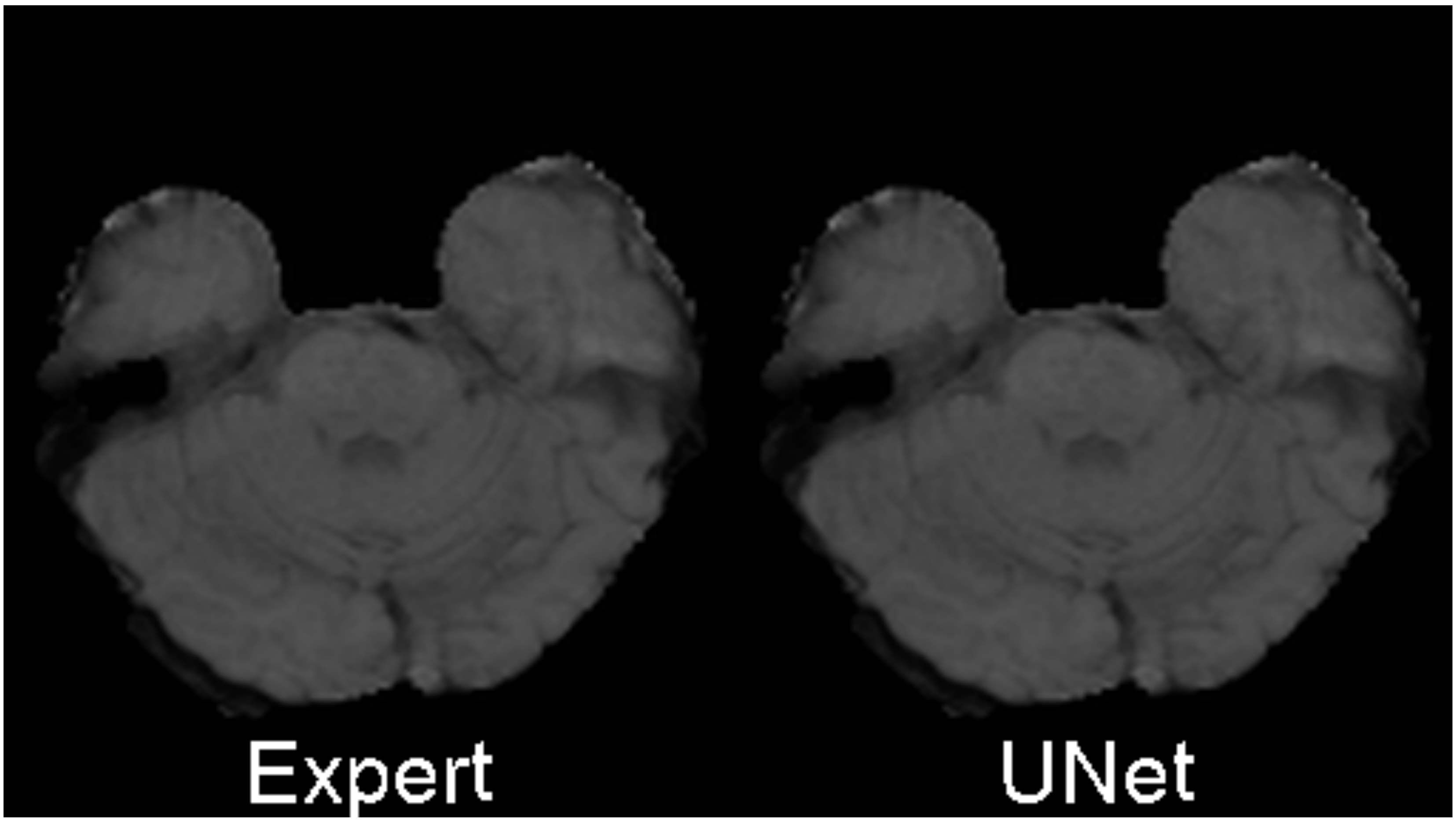


Dataset images without pneumothorax

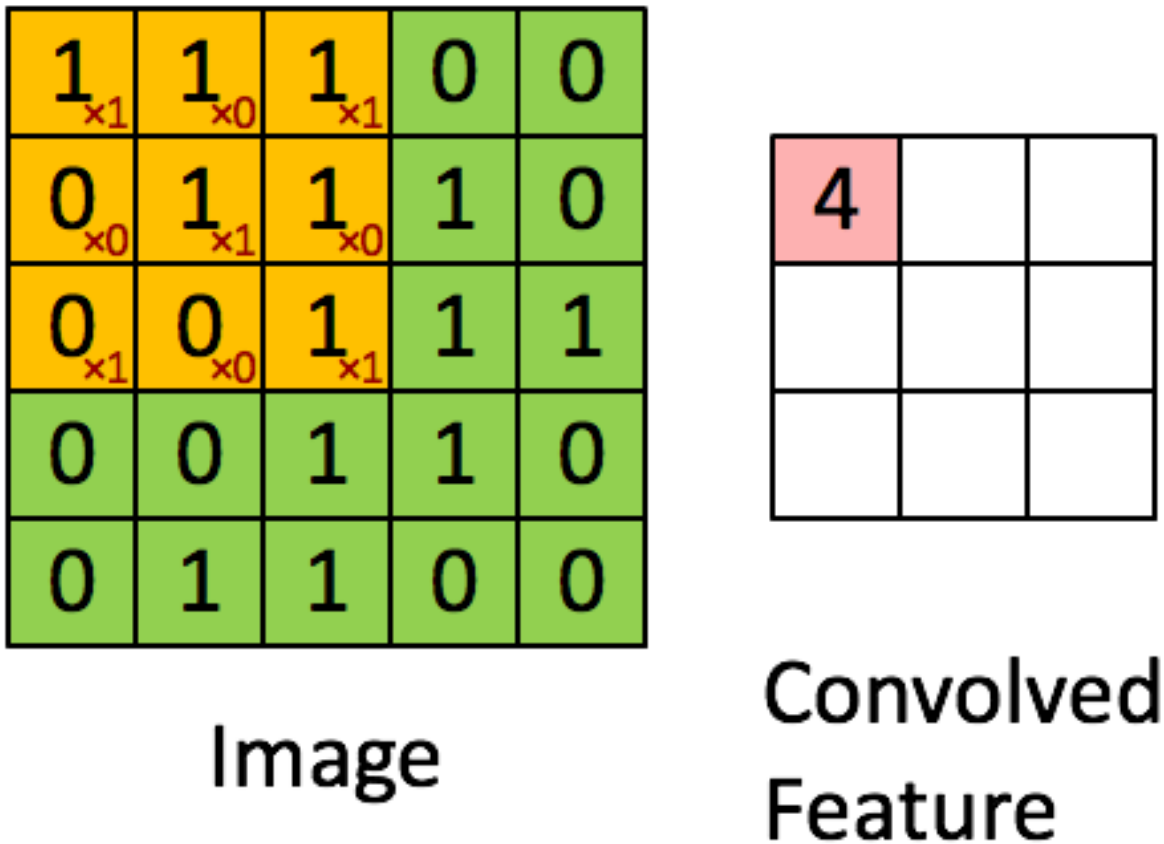


Dataset images with pneumothorax

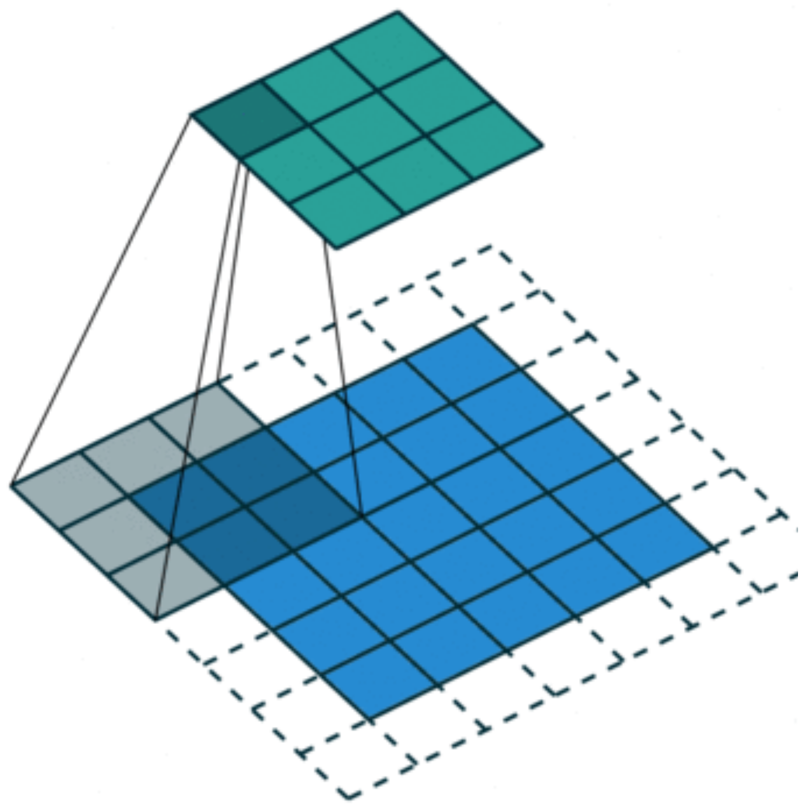



Expert
UNet

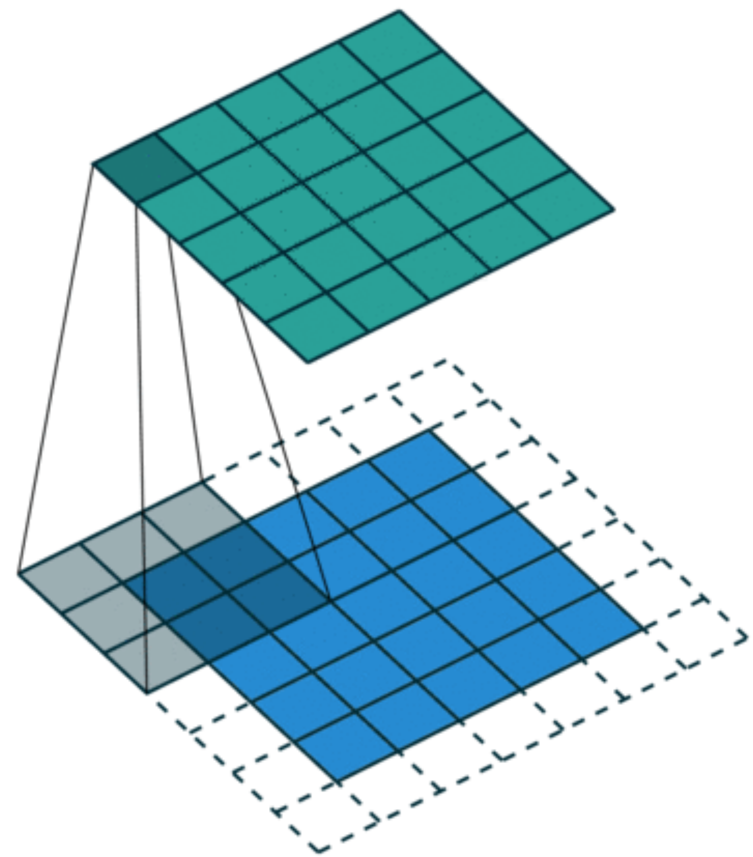
Convolution Operation



[Comprehensive Guide to CNN – ELI5]()

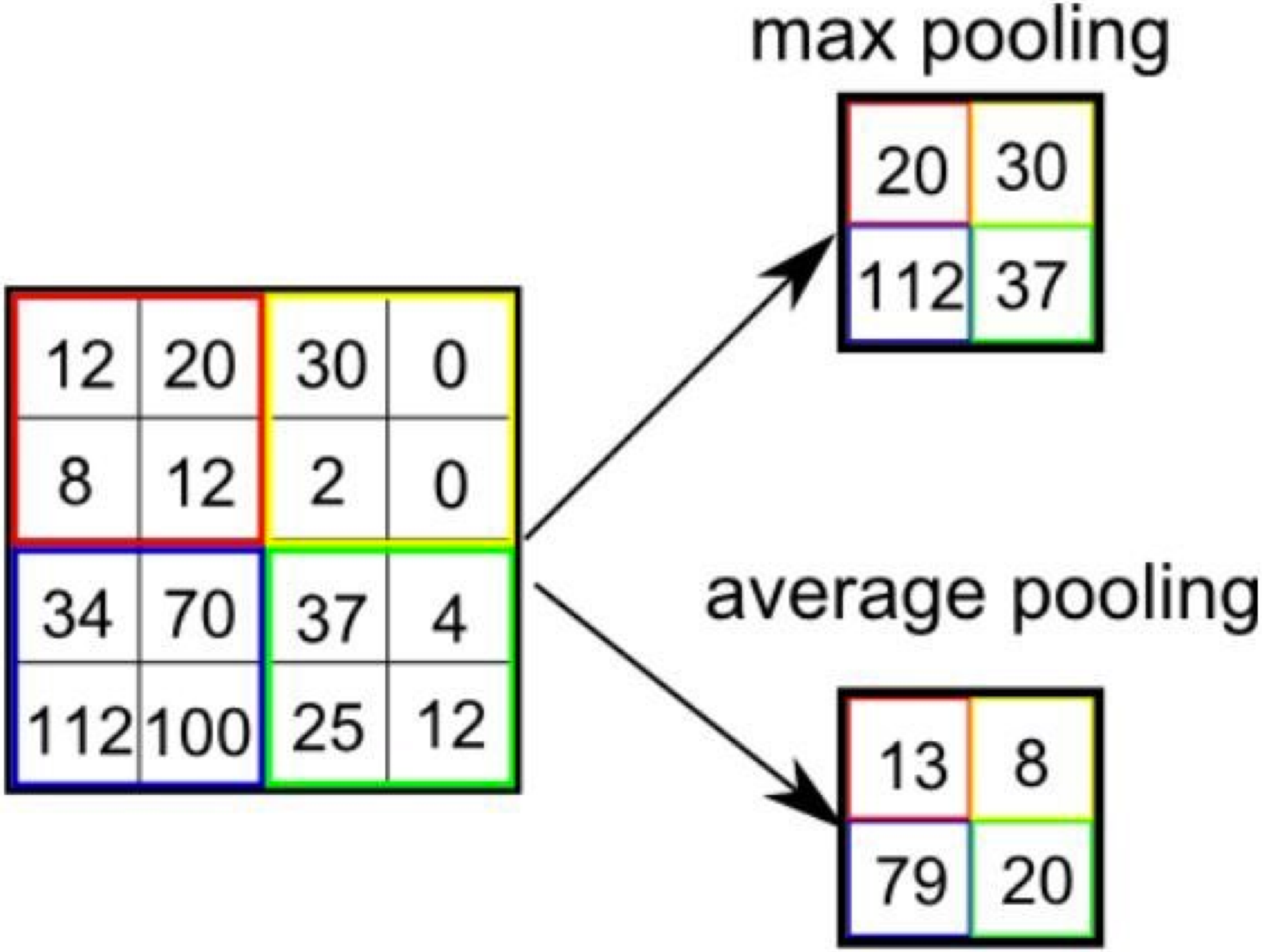


Strides = 2



Strides=1, Padding=1

Pooling: Dimensionality reduction, noise suppression, translation/rotation invariance



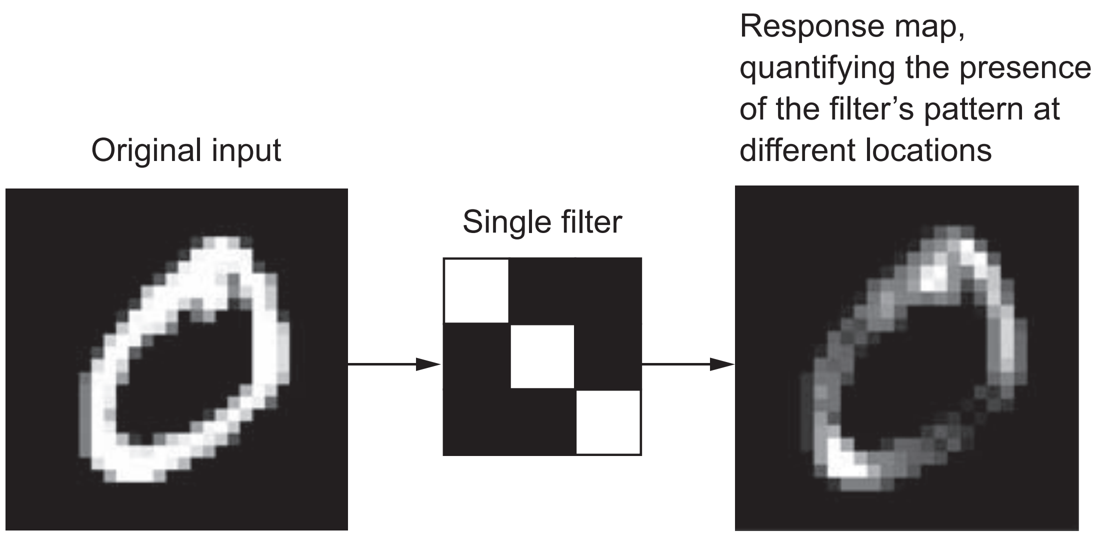


Figure 5.3 The concept of a *response map*: a 2D map of the presence of a pattern at different locations in an input

Deep Learning with Python by Chollet

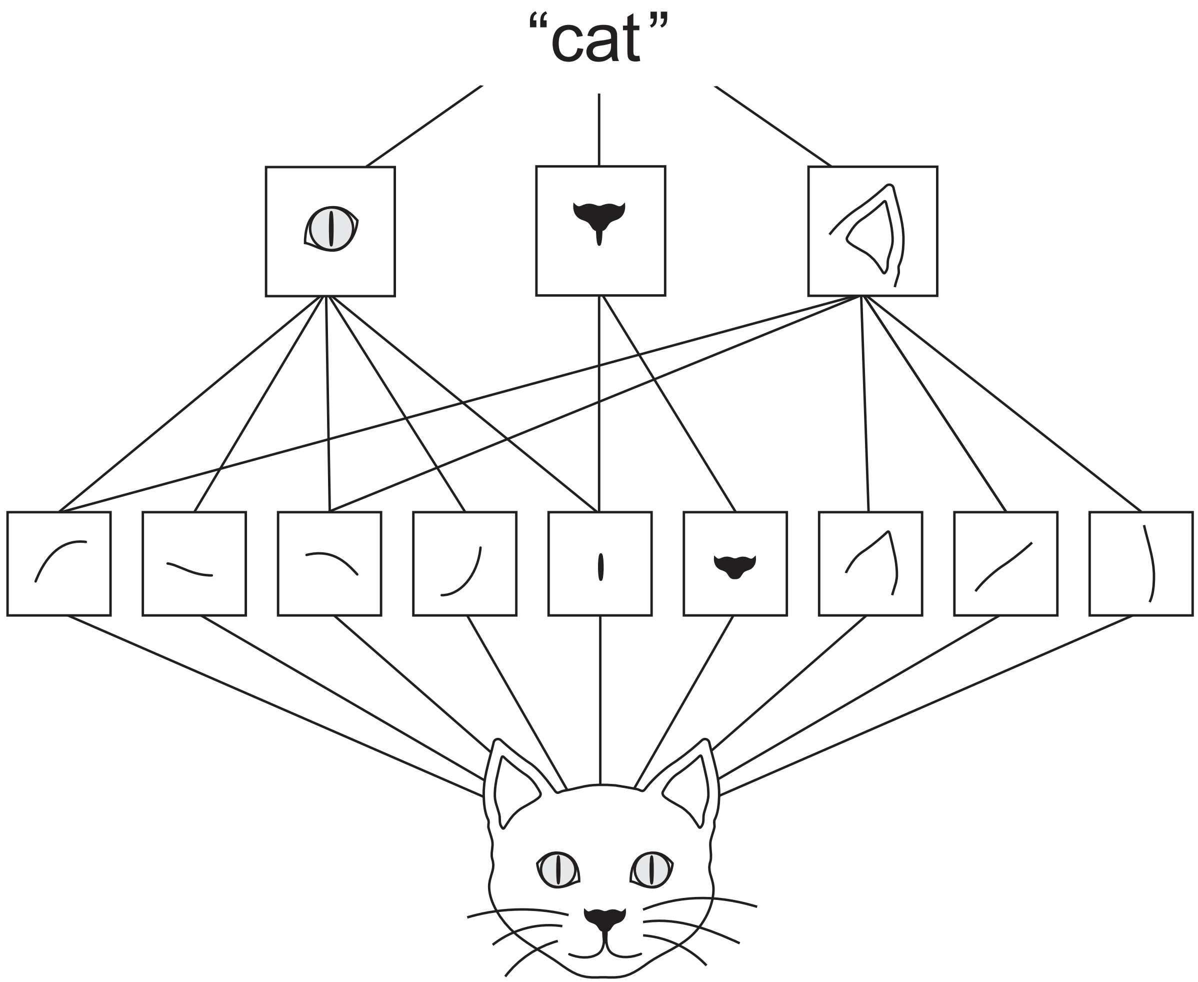


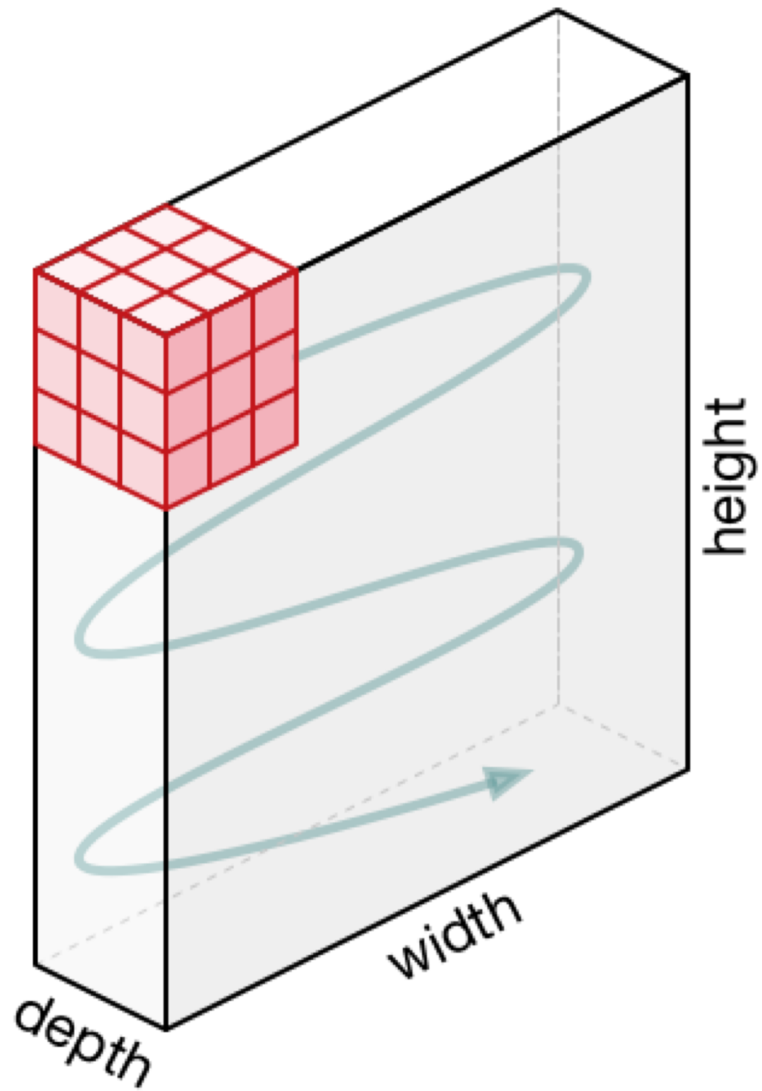
Figure 5.2 The visual world forms a spatial hierarchy of visual modules: hyperlocal edges combine into local objects such as eyes or ears, which combine into high-level concepts such as "cat."

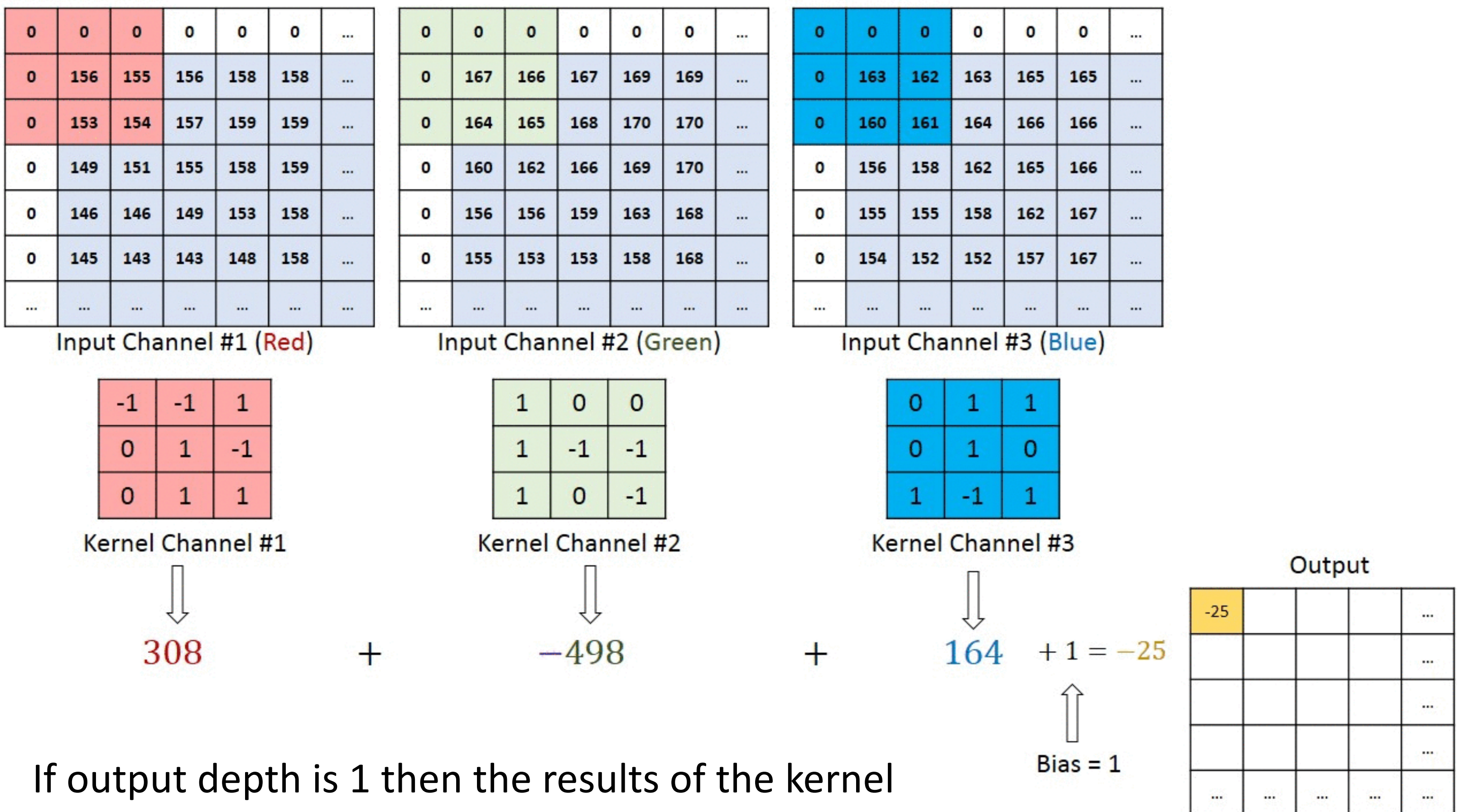
Deep Learning with Python by Chollet

Kernel has depth

In images, depth is number of channels (RGB)

In neural data, depth could be number of channels (electrodes)





If output depth is 1 then the results of the kernel multiplications are summed into a flat image.
This is rarely the case.

For each step…

Input is 3x3x2

Kernel is 3x3x3

Output is 1x1x3

Note the change in depth

2 → 3

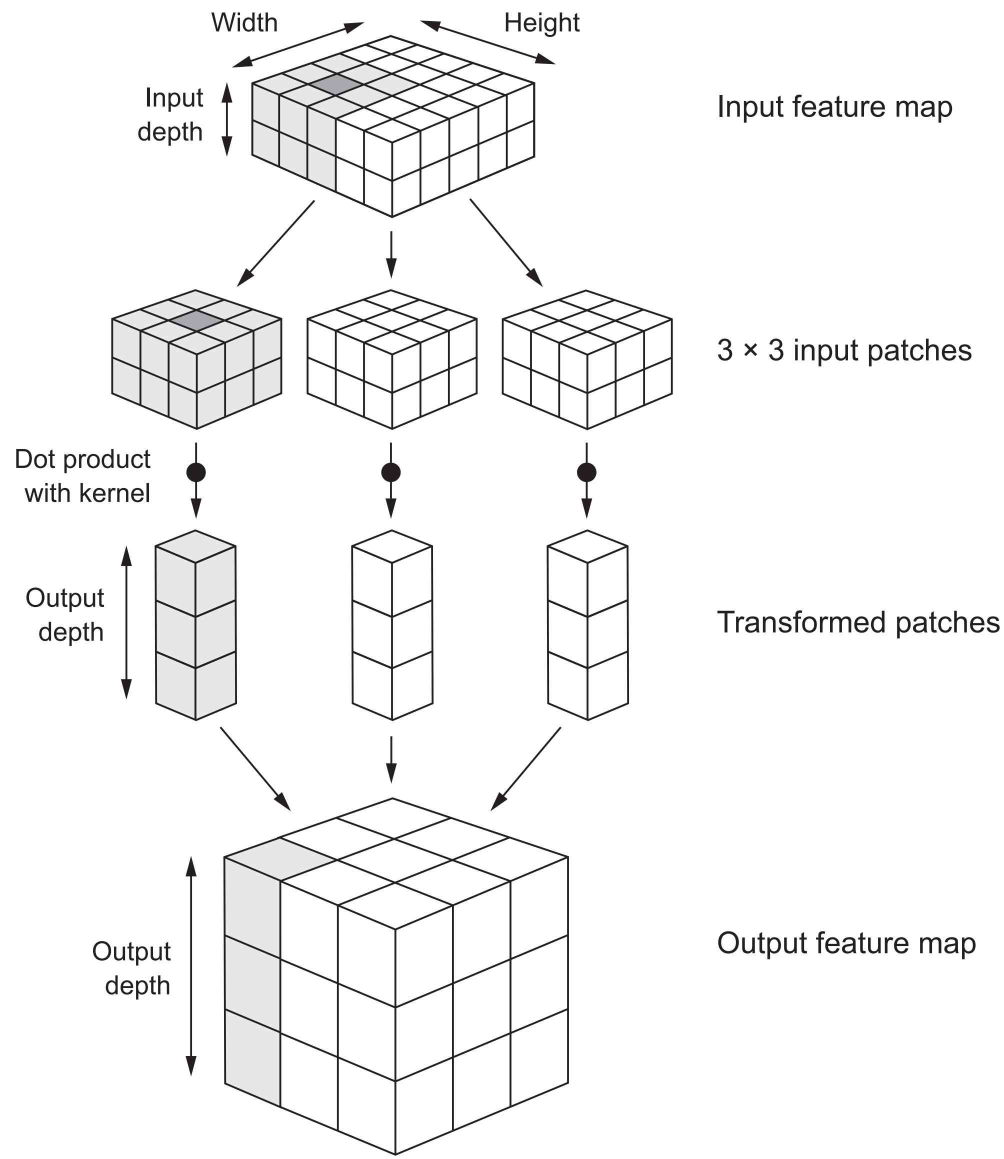


Figure 5.4 How convolution works

Deep Learning with Python by Chollet

Convolutions in 1D on timeseries

- Proceed to notebook

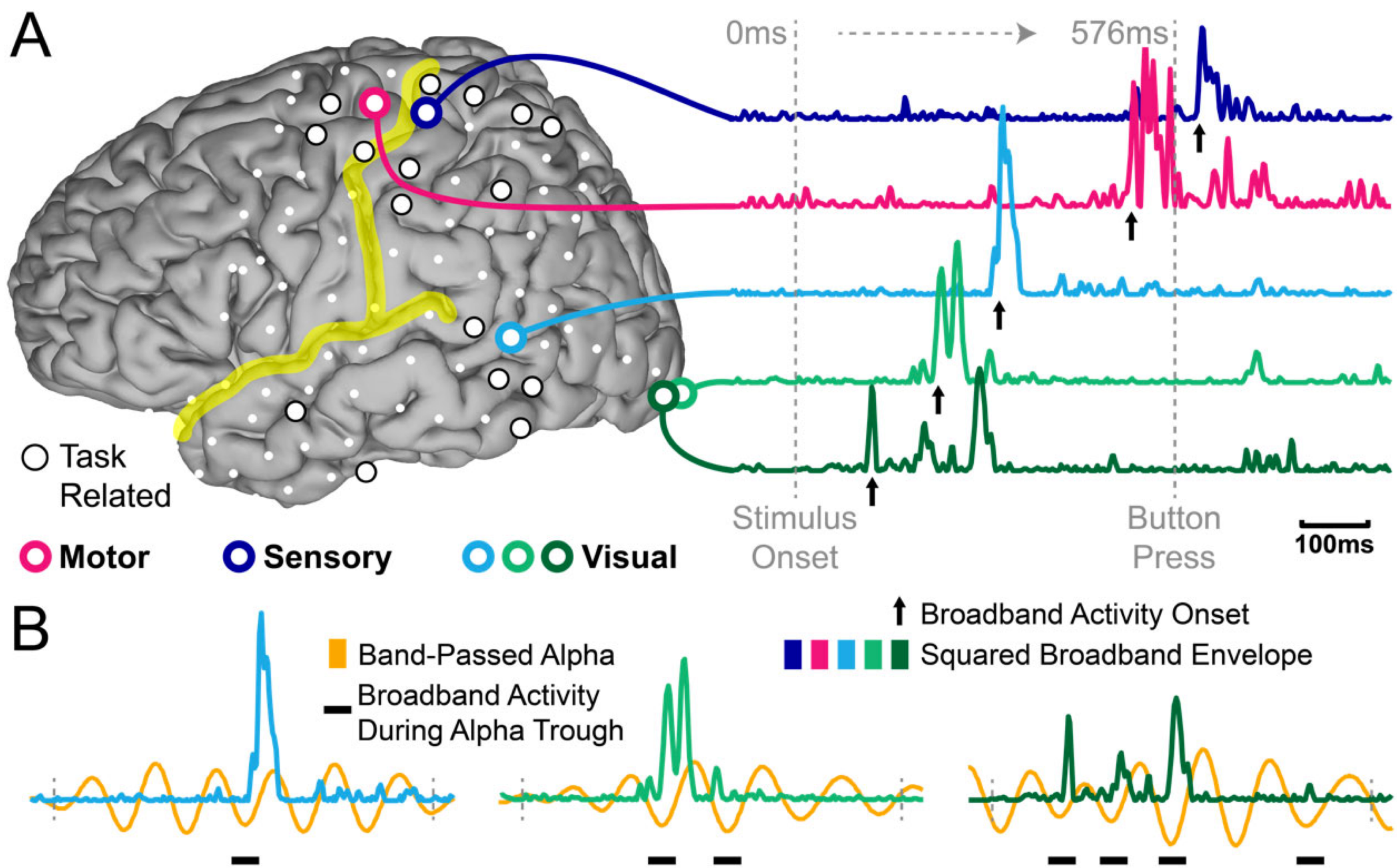
03_01_Intro_to_CNNs.ipynb

Convolutions in 1D on ECoG data

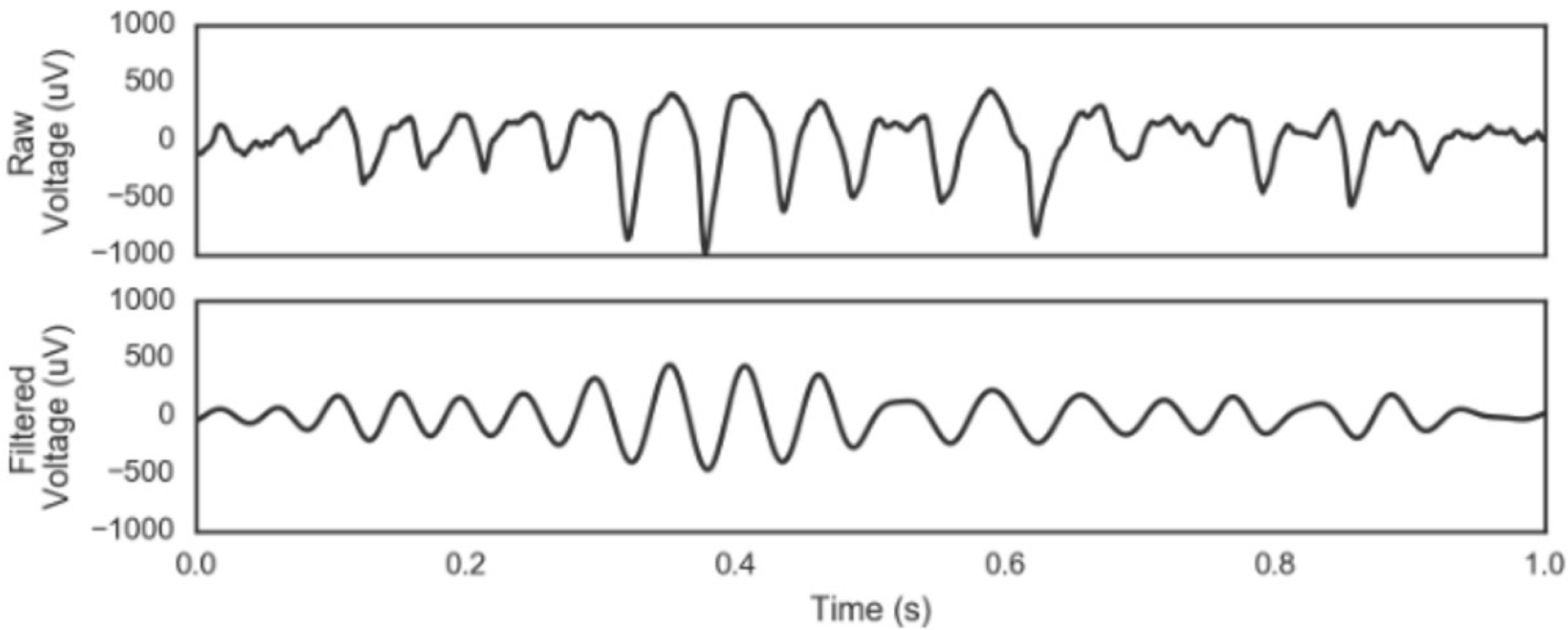
- Proceed to notebook

[03_02_CNN_faces_houses.ipynb]

Translation Invariance – Isn't that a bad thing? Maybe not.



Why train filter kernels?



Voytek Lab – [Brain Oscillations and the Importance of Waveform Shape]