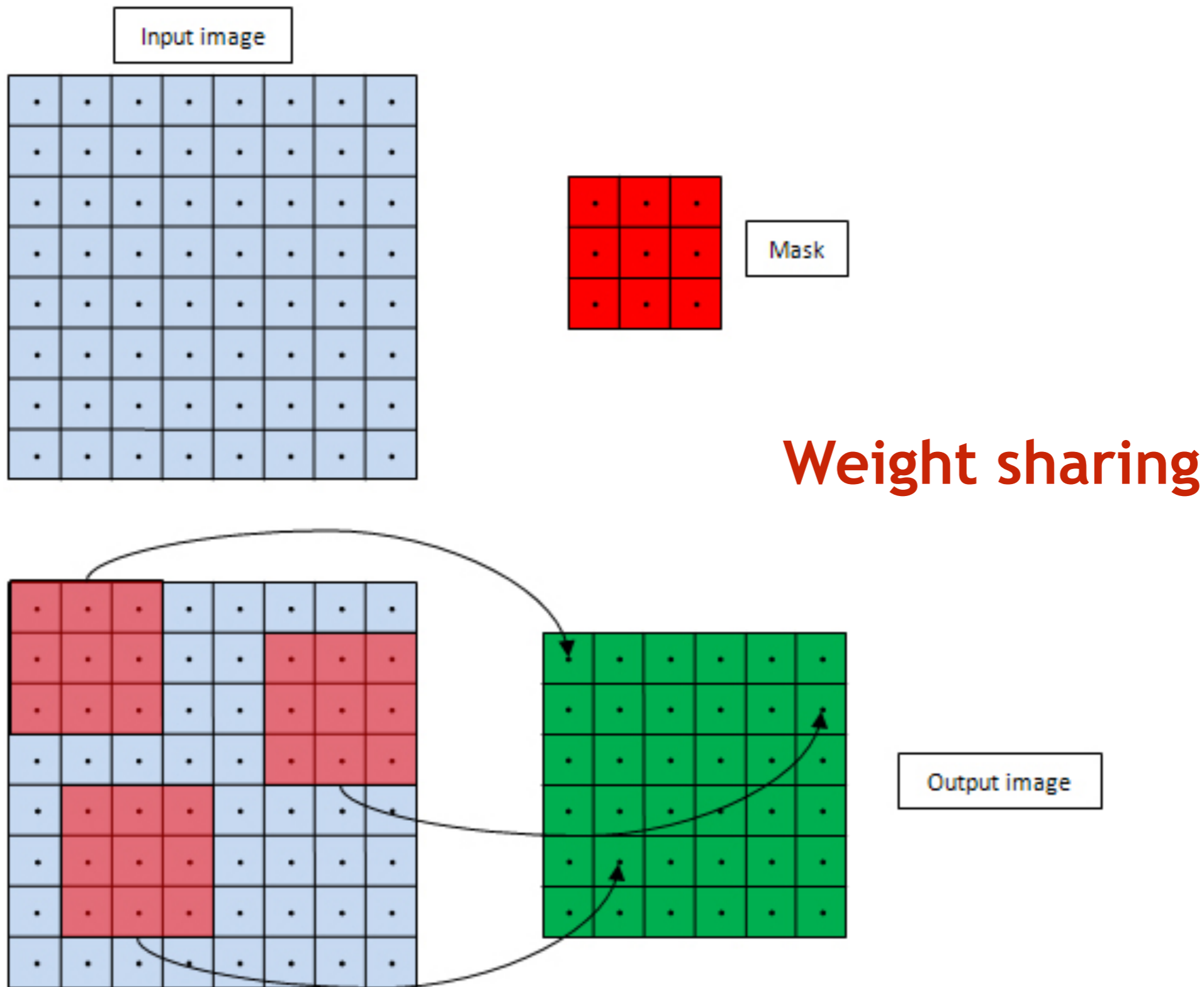


E9 205 Machine Learning for Signal Processing

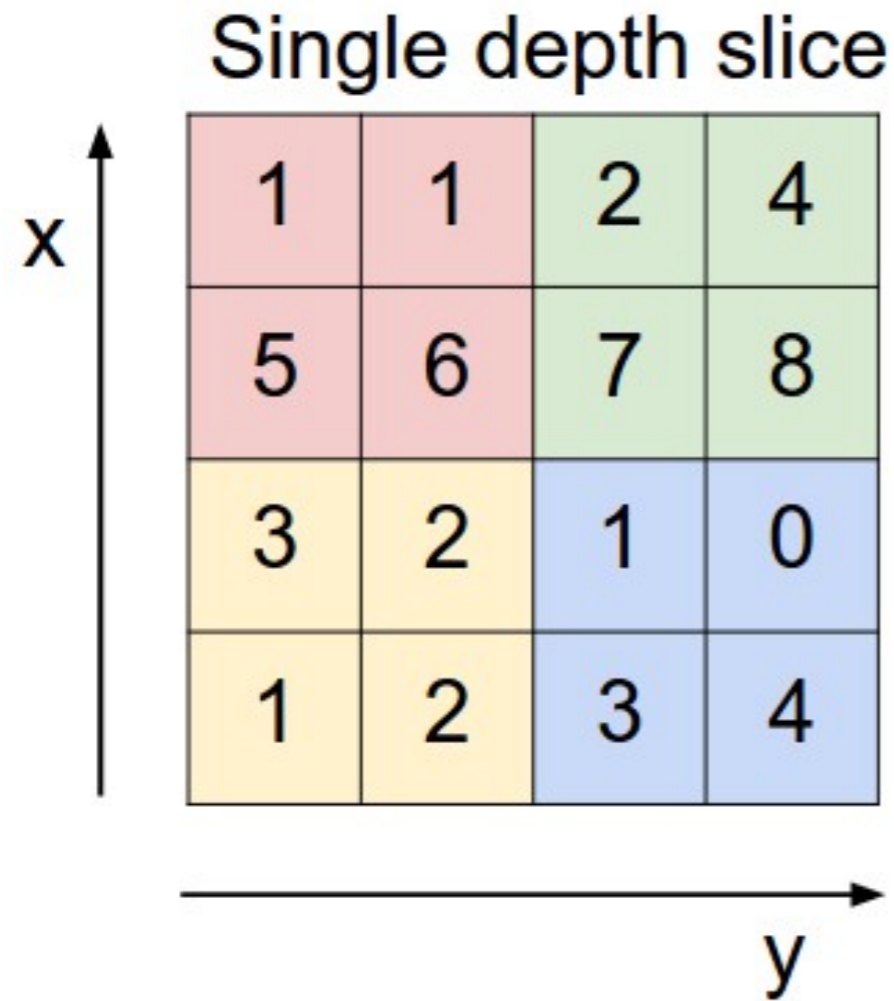
Convolutional Neural Networks

2-11-2018

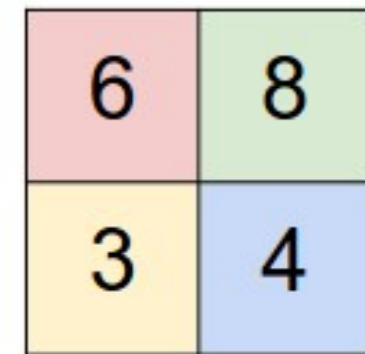
Other Architectures - Convolution Operation



Max Pooling Operation



max pool with 2x2 filters
and stride 2



Convolution Operation (Images)

File

Edit

View

Insert

Cell

Kernel

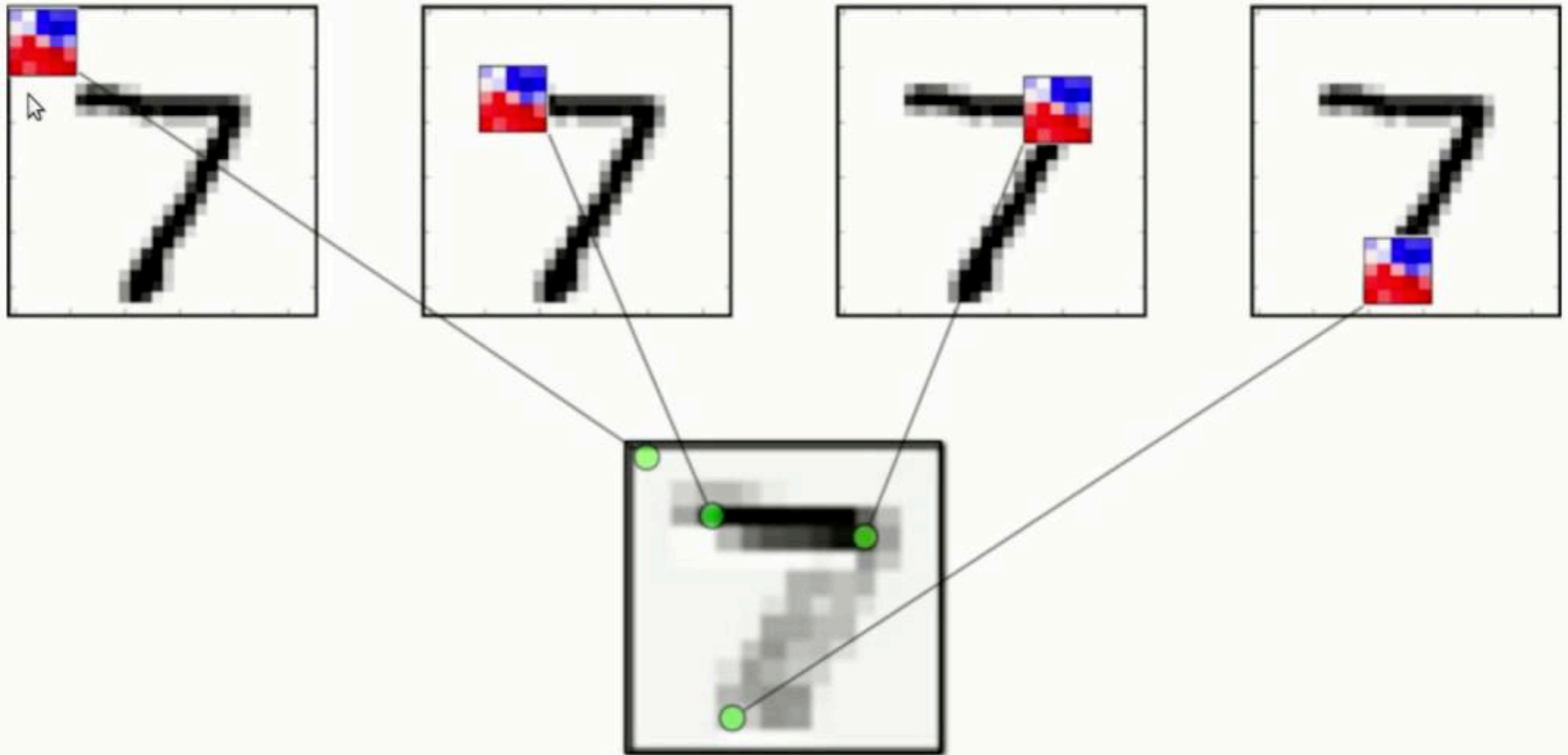
Help

Python 3

```
Image('images/02_convolution.png')
```

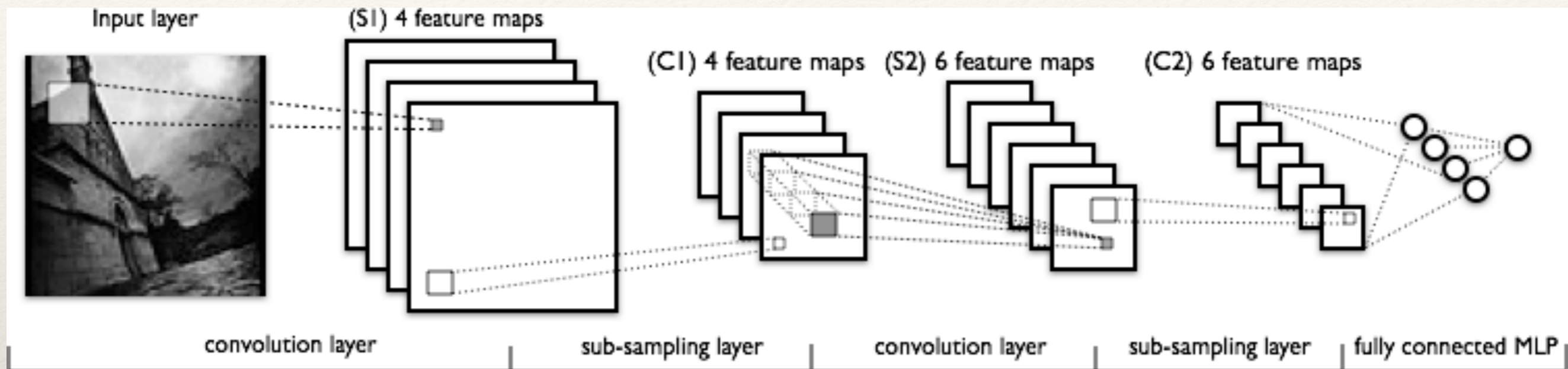
Out[2]:

Input Image with Filter Overlaid (4 copies for clarity)



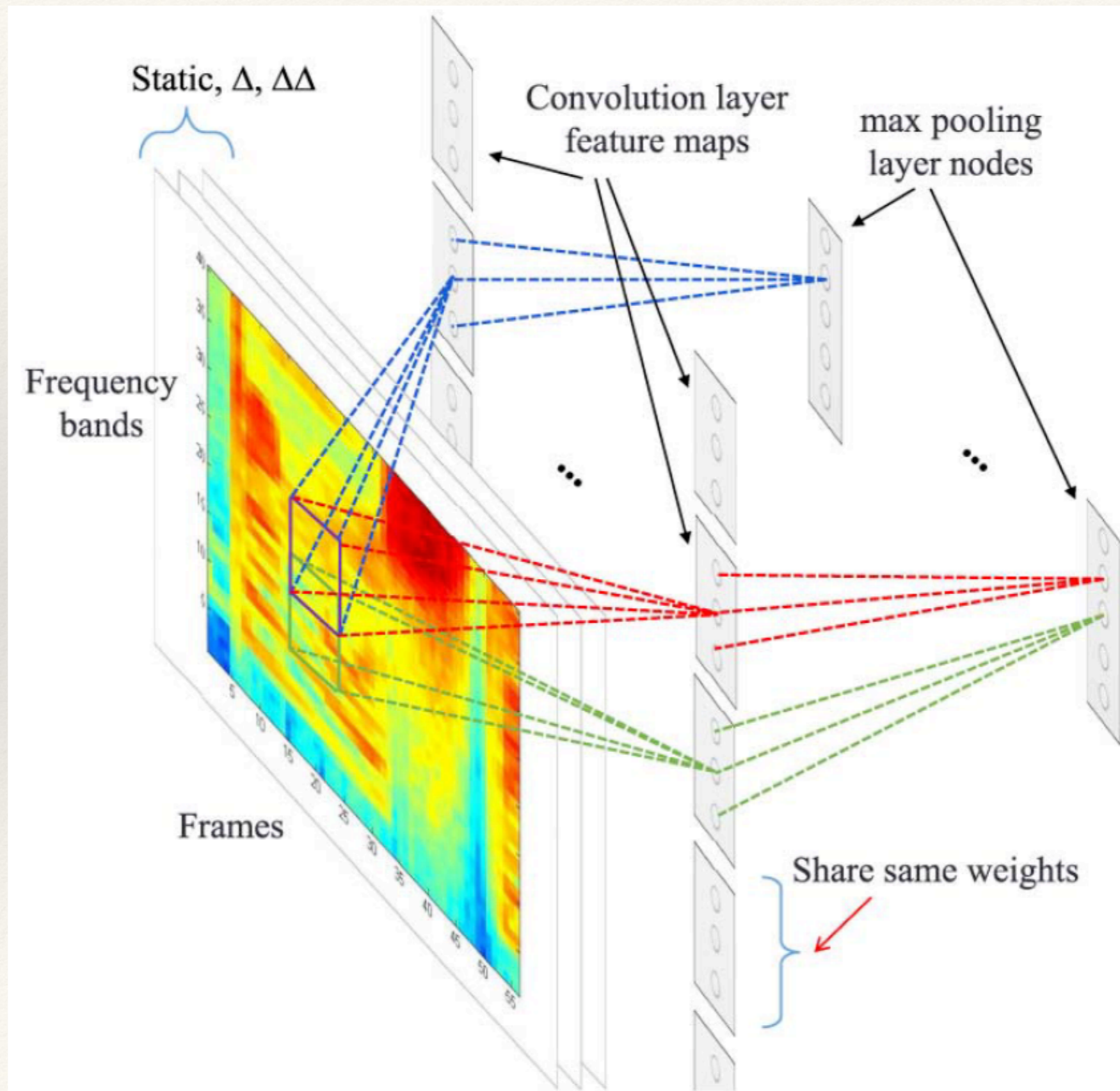
Result of Convolution

Convolutional Neural Networks



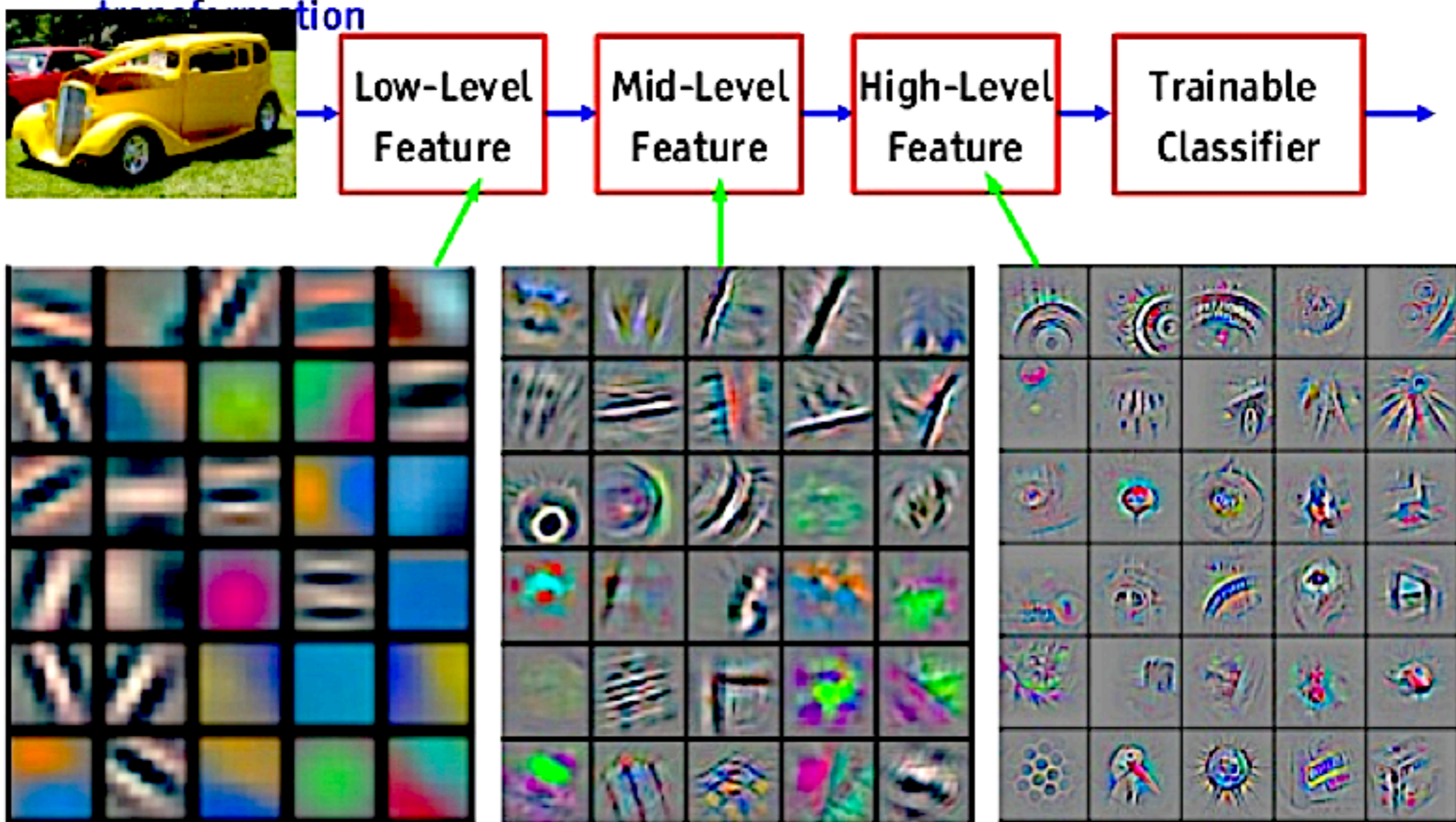
- Multiple levels of filtering and subsampling operations.
- Feature maps are generated at every layer.

CNNs for Speech and Audio



Representation Learning in CNNs

■ 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]

Representation Learning in CNNs

[Zeiler, 2014]

