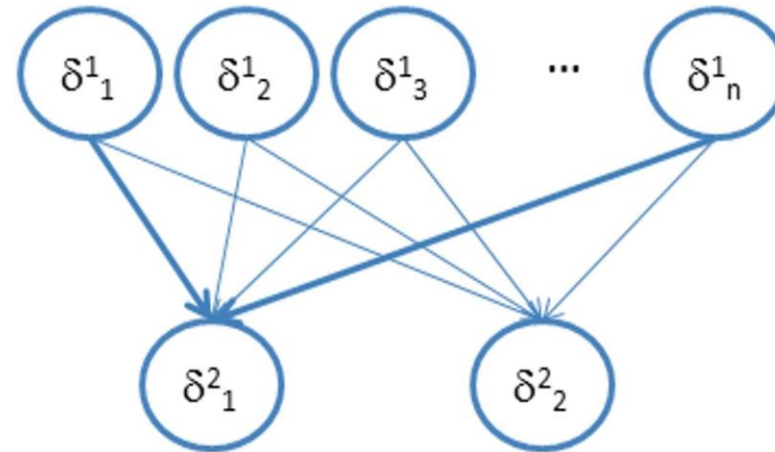# Deep Learning

Convolutional Neural Networks

What are Hidden Layers Doing?

Learning Feature Detectors

Sub Question 1: What sort of features can the neurons in a first hidden layer learn in a fully connected network?

Sub Question 2: Could a Hidden Layer learn to recognize a specific black and white face in a specific position in an image?

Problem 1: Computational Explosion

- The number of weights to be learned in a fully connected layer between input units L1 and hidden units L2 is:

$$(size(L1) + 1) \times size(L2)$$

- How many weights (or parameters) are required for a 256 x 256 three colour image that is to be fully connected to a hidden layer with 128 neurons?

25 Million!!!!

Problem 2: Local vs. Global Detection

Interesting things in images are usually **translation invariant**

In early layers we can focus on local features and leave global features until later

Edge Detection – Example of a Local Feature detector that can be applied to a whole image
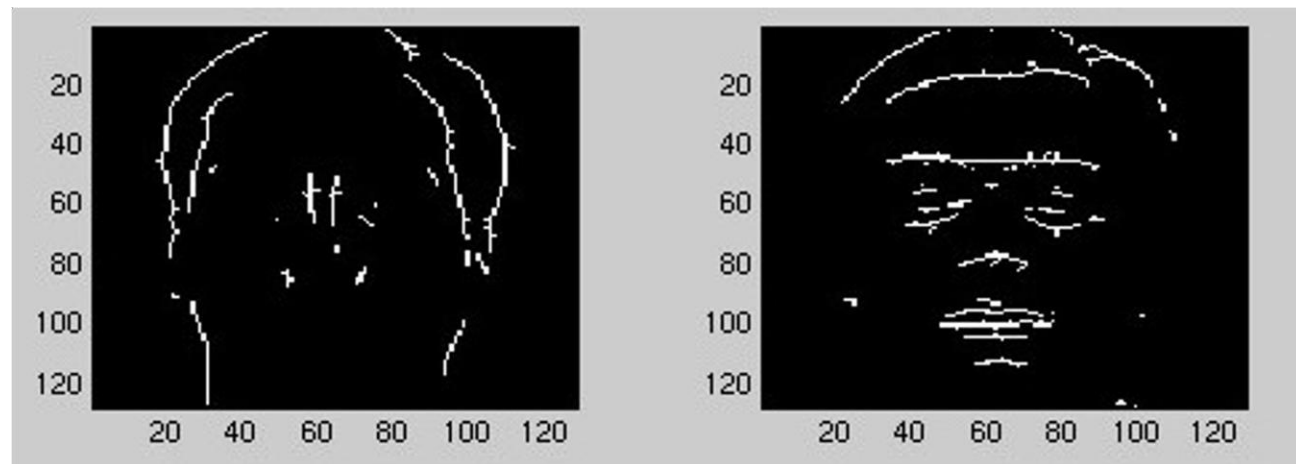
An edge is a steep gradient in intensities

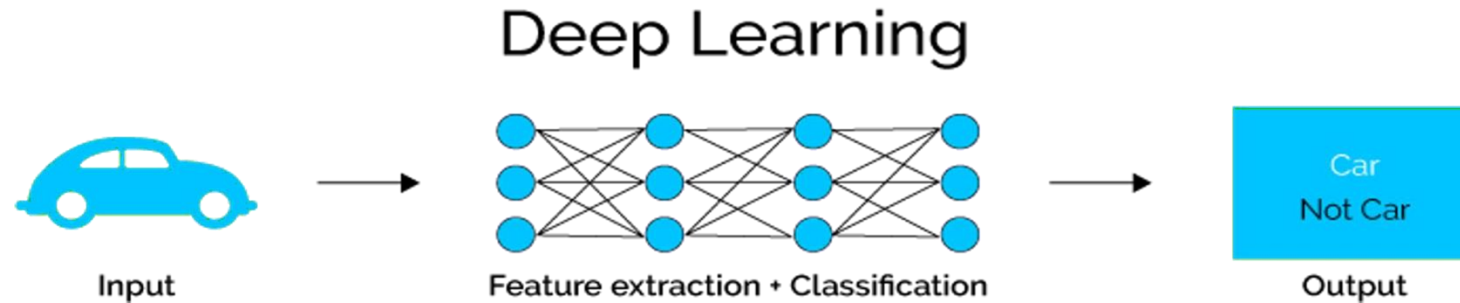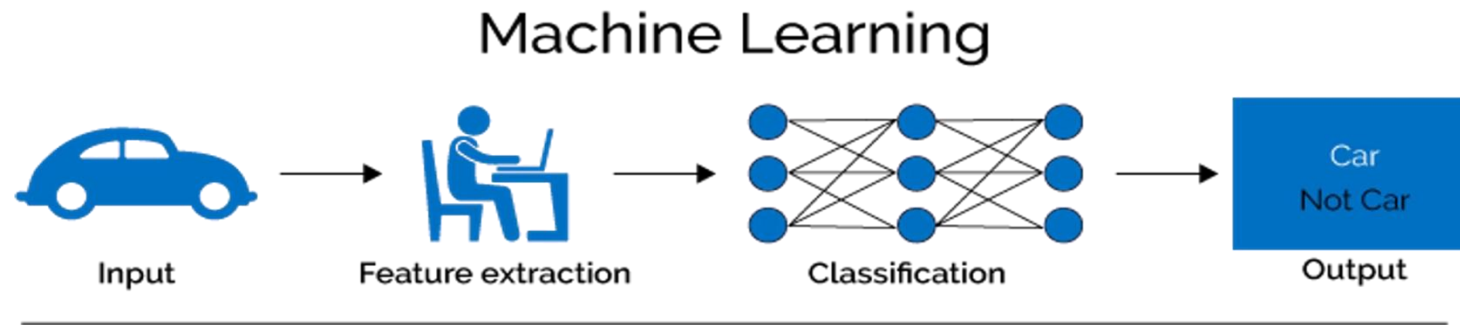| -1	0	+1
-1	0	+1
-1	0	+1

Gx

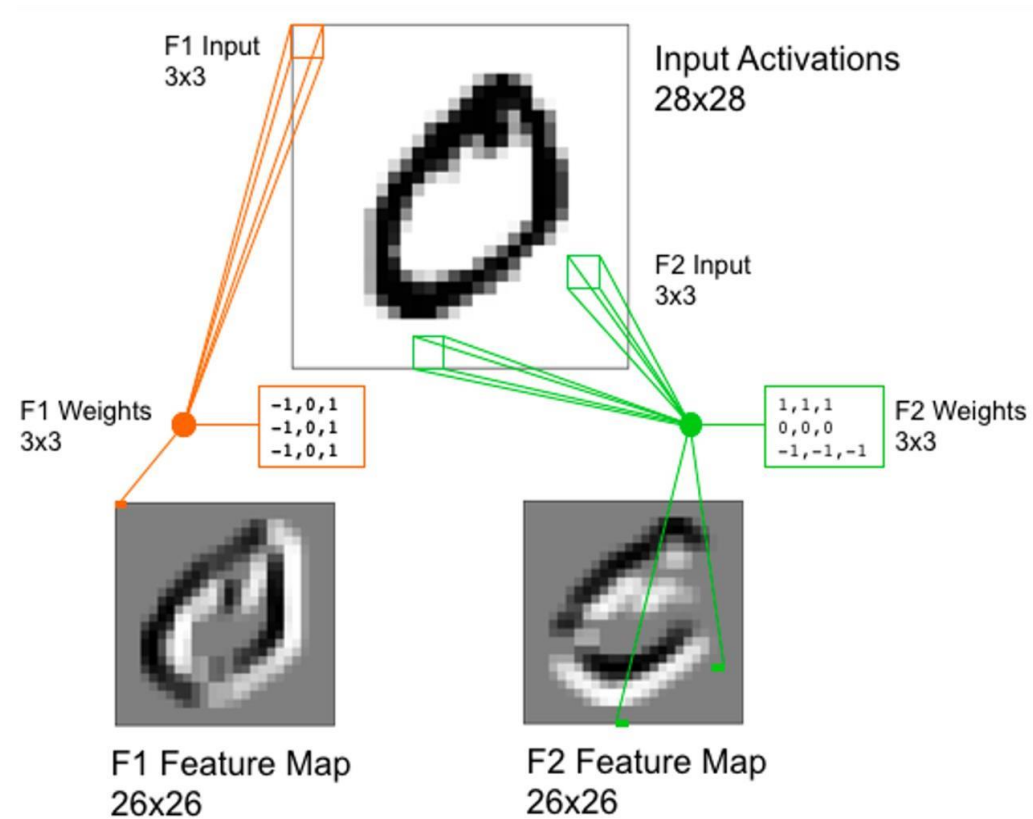| +1	+1	+1
0	0	0
-1	-1	-1

Gy

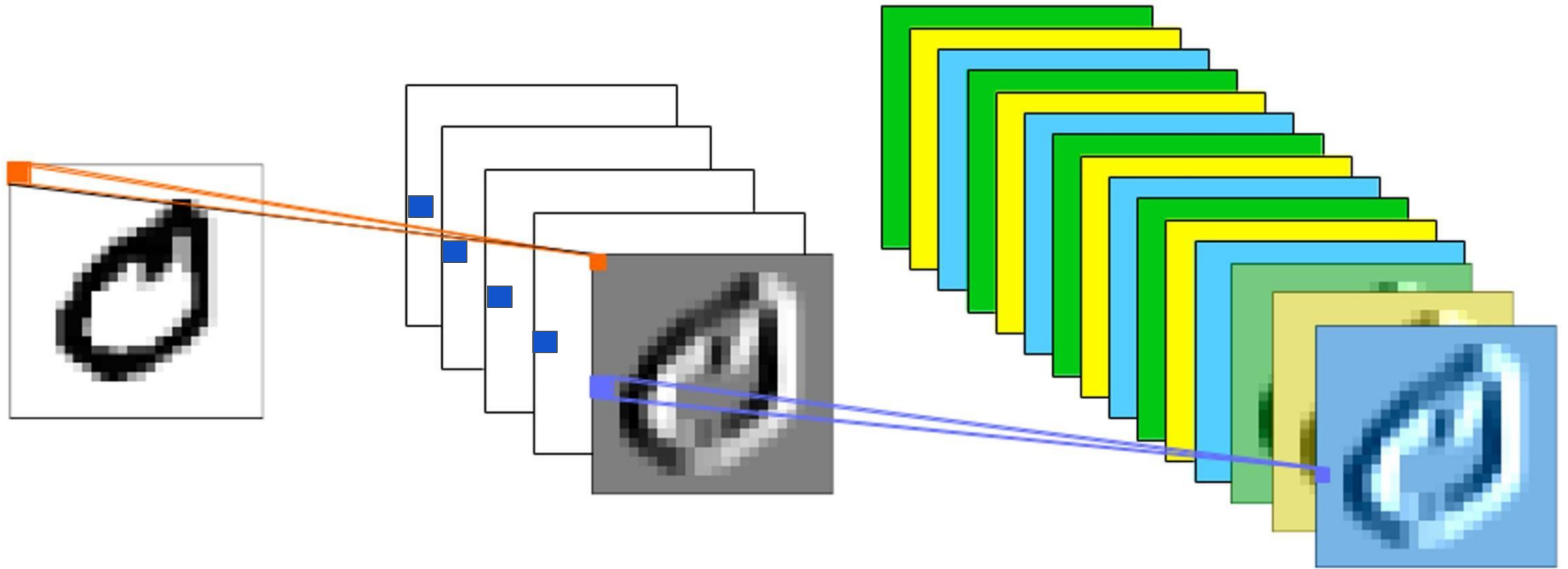*Weight matrix for edge detection*

CNNs - Let's Automate This

Edge Detectors, Filters, Features and Maps

F1 Input
3x3

Input Activations
28x28

F2 Input
3x3

F1 Weights
3x3

-1,0,1
-1,0,1
-1,0,1

1,1,1
0,0,0
-1,-1,-1

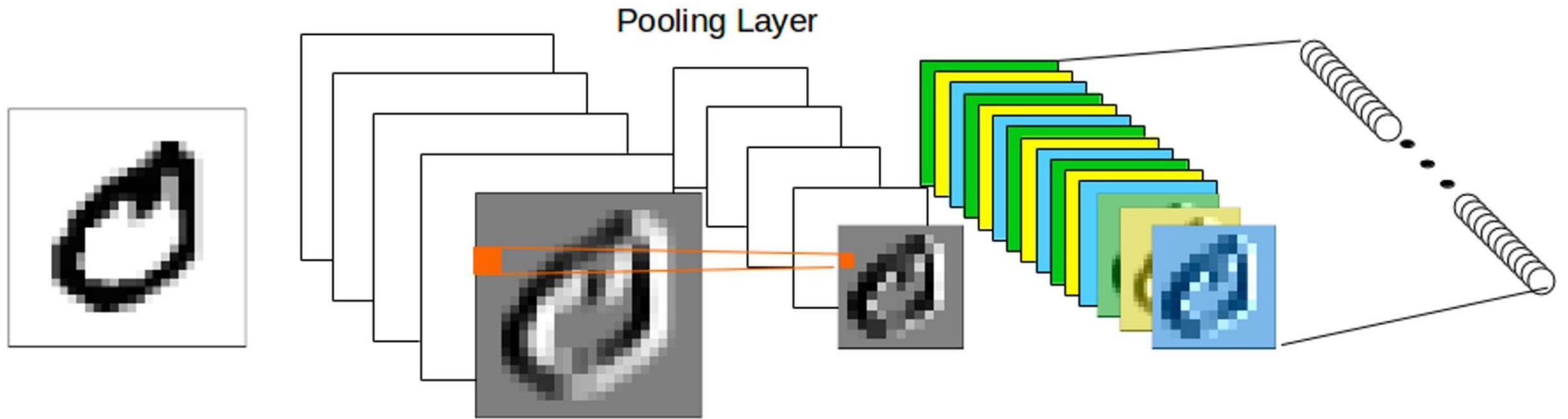F2 Weights
3x3

F1 Feature Map
26x26

F2 Feature Map
26x26

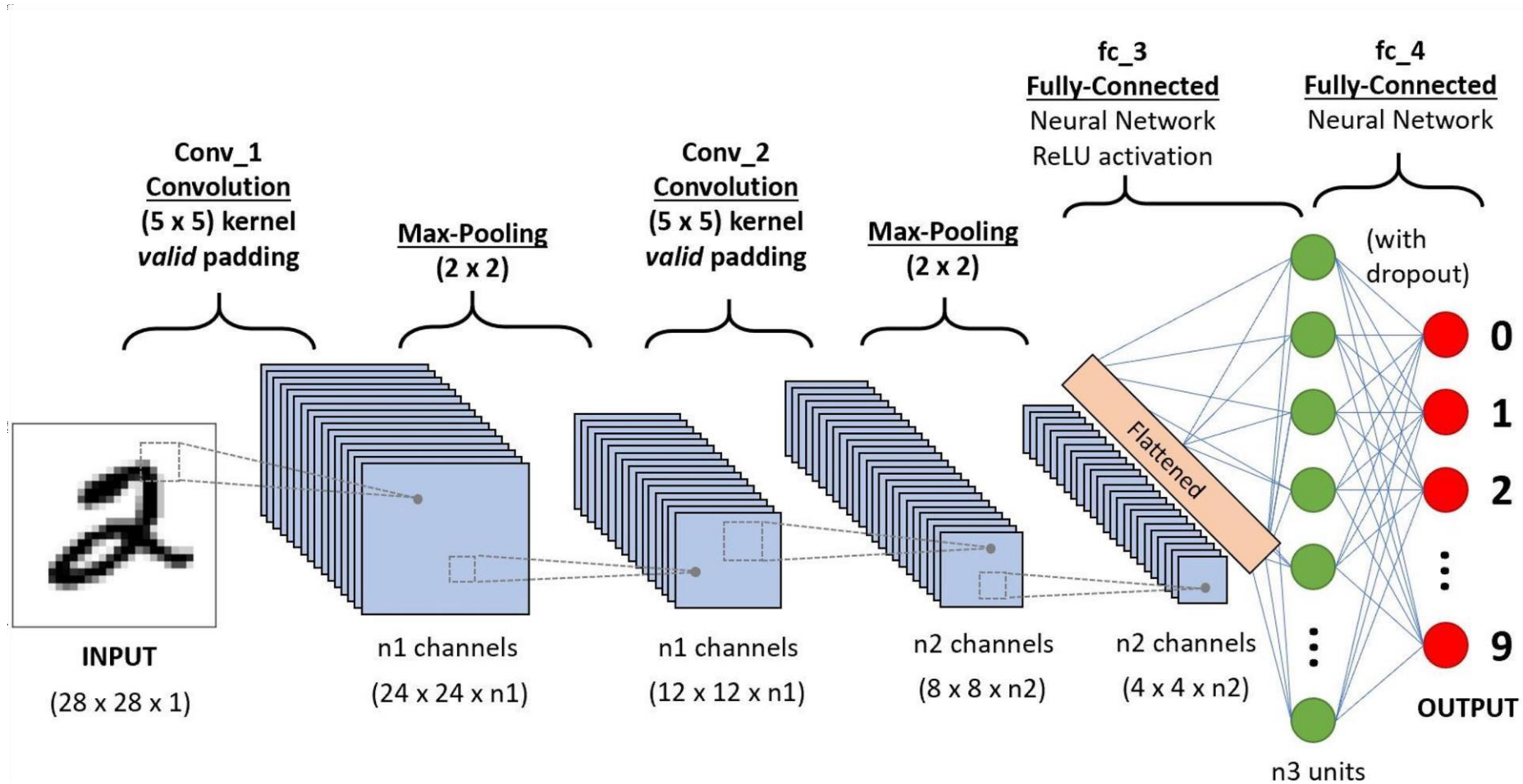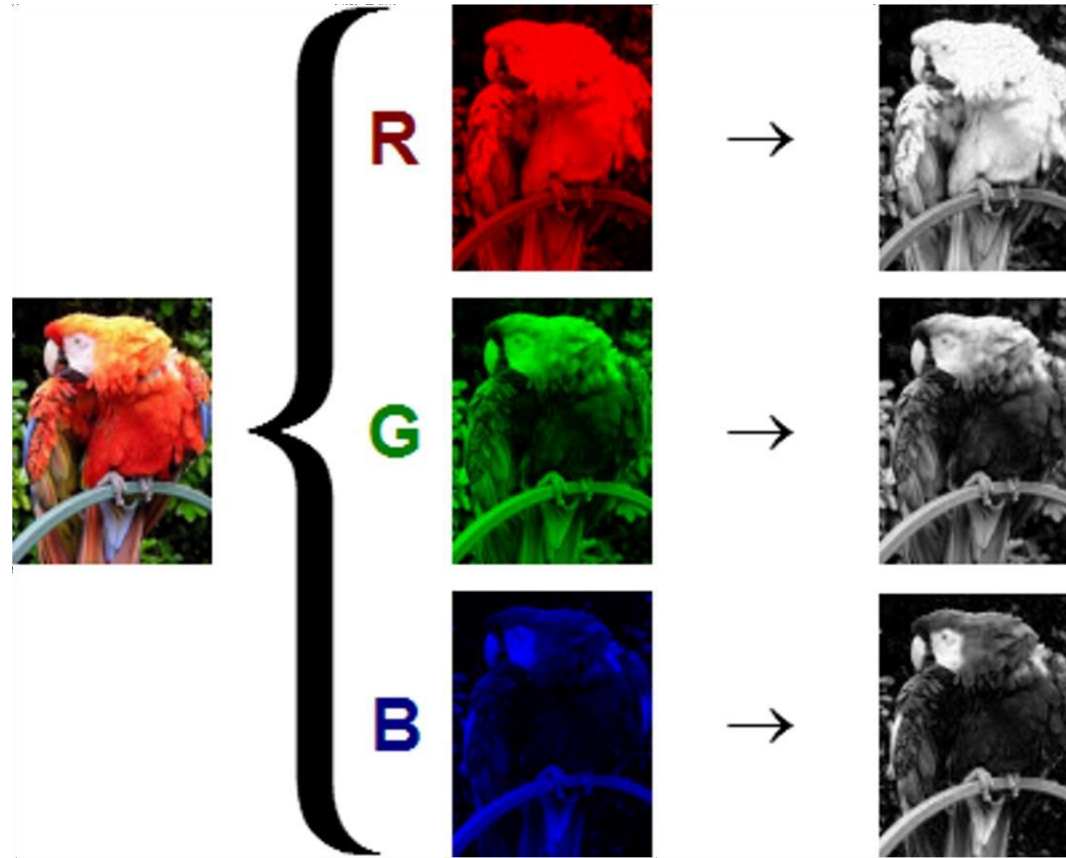# Convolutional Layer Parameters
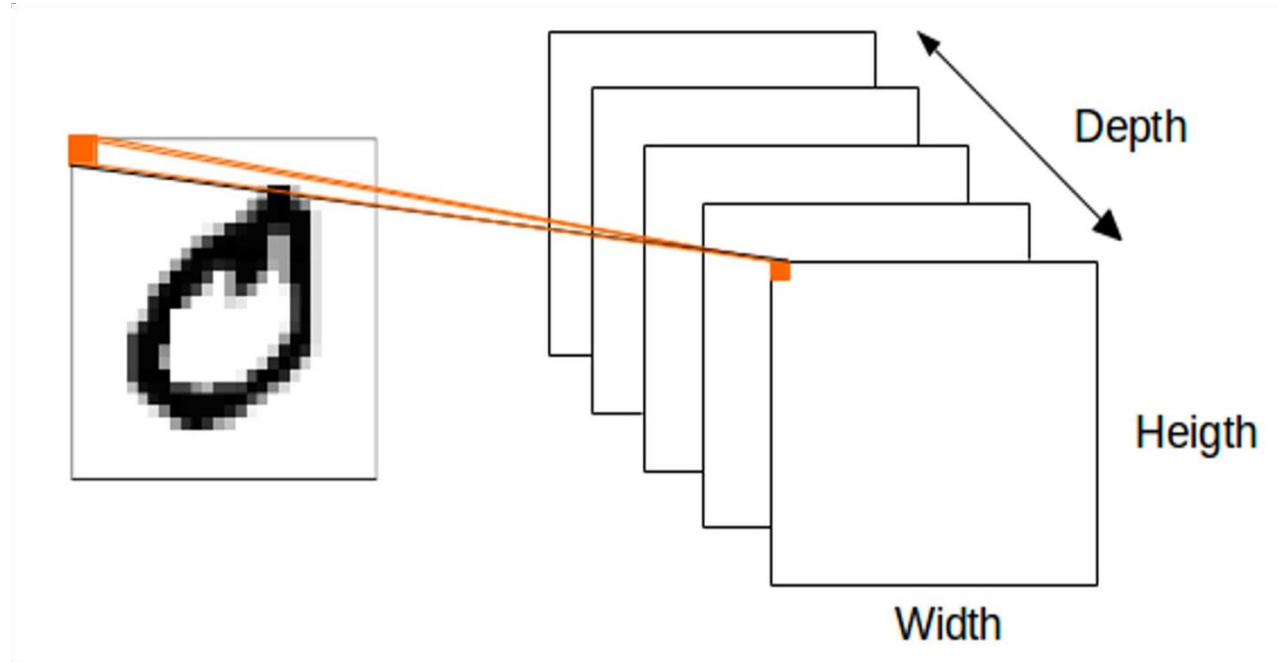
Multiple Convolutional Layers

Pooling

Pooling Layer

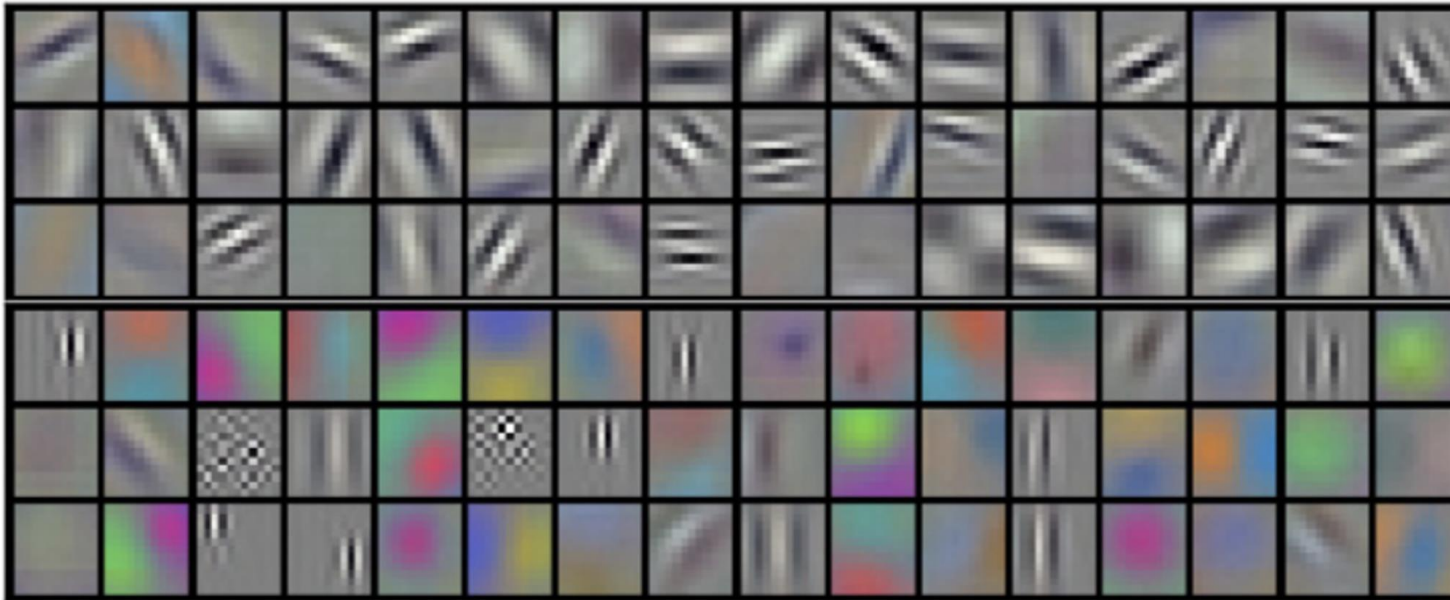# Stride and Padding

Stride = 1

Stride = 2
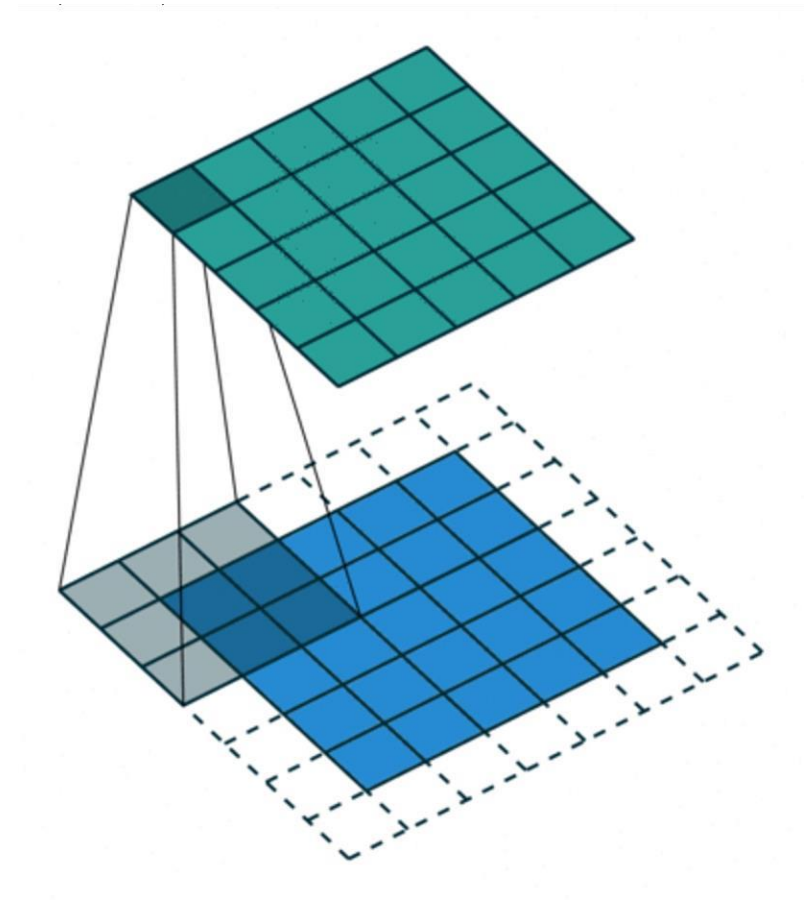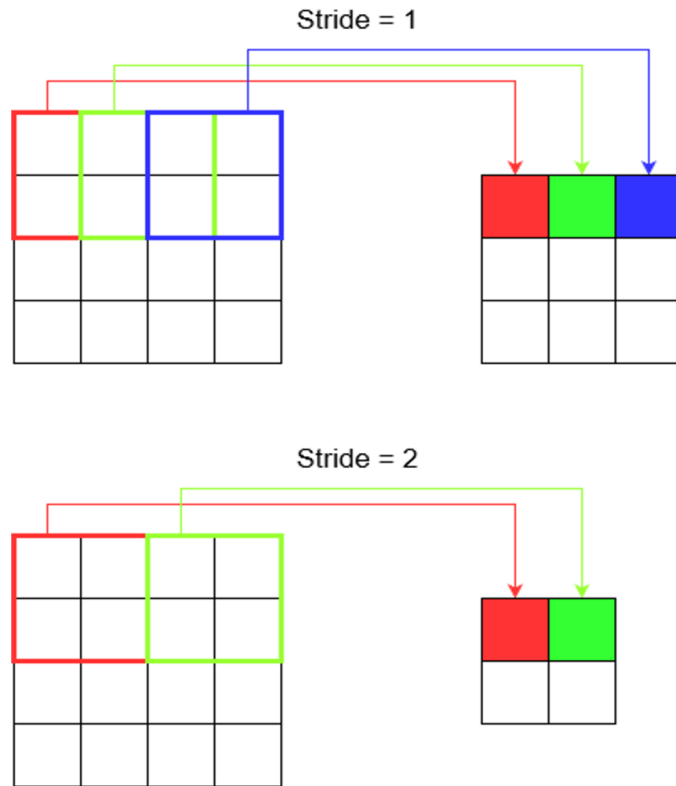
CNNs for Image Processing

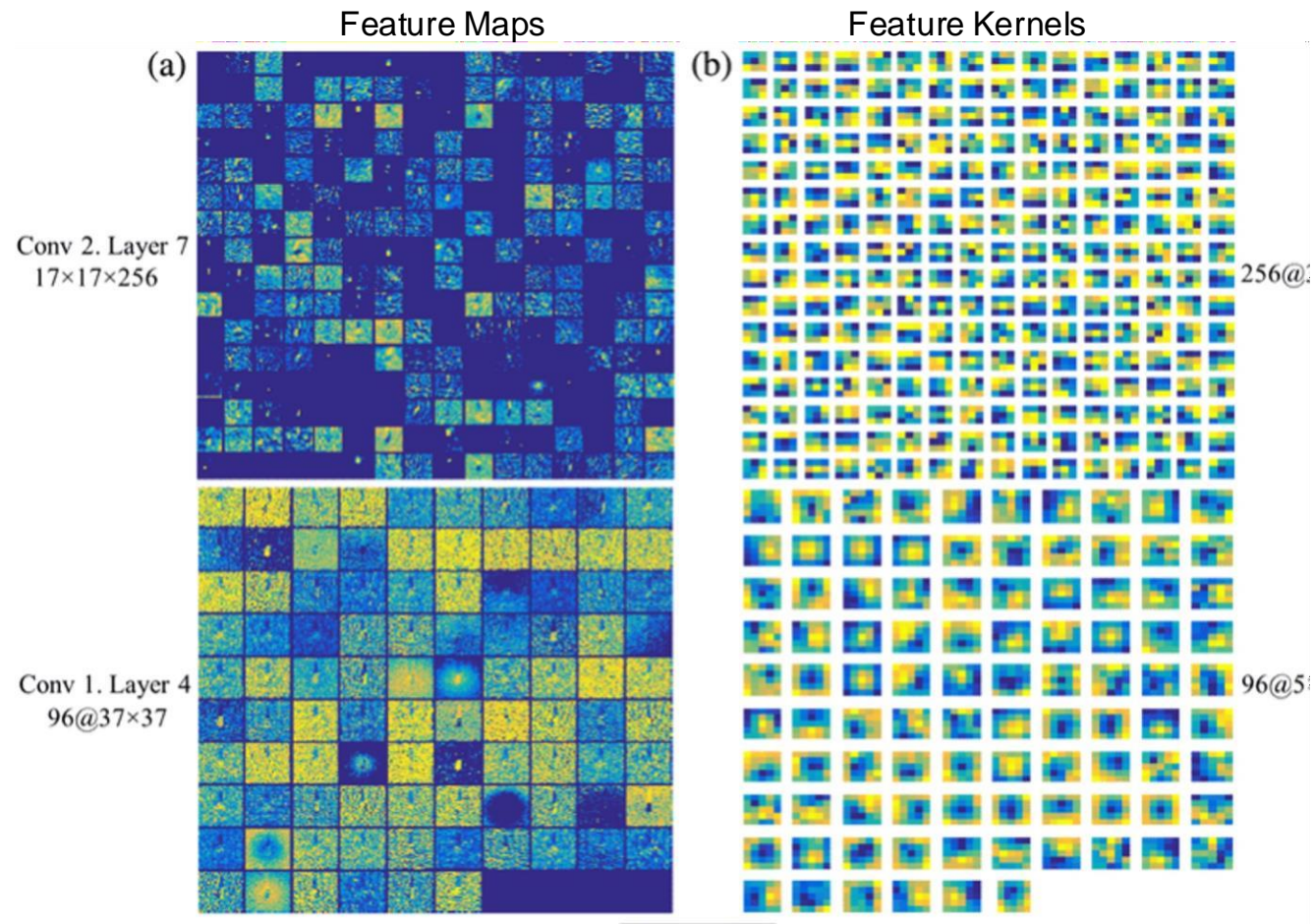# Basic Image Representation

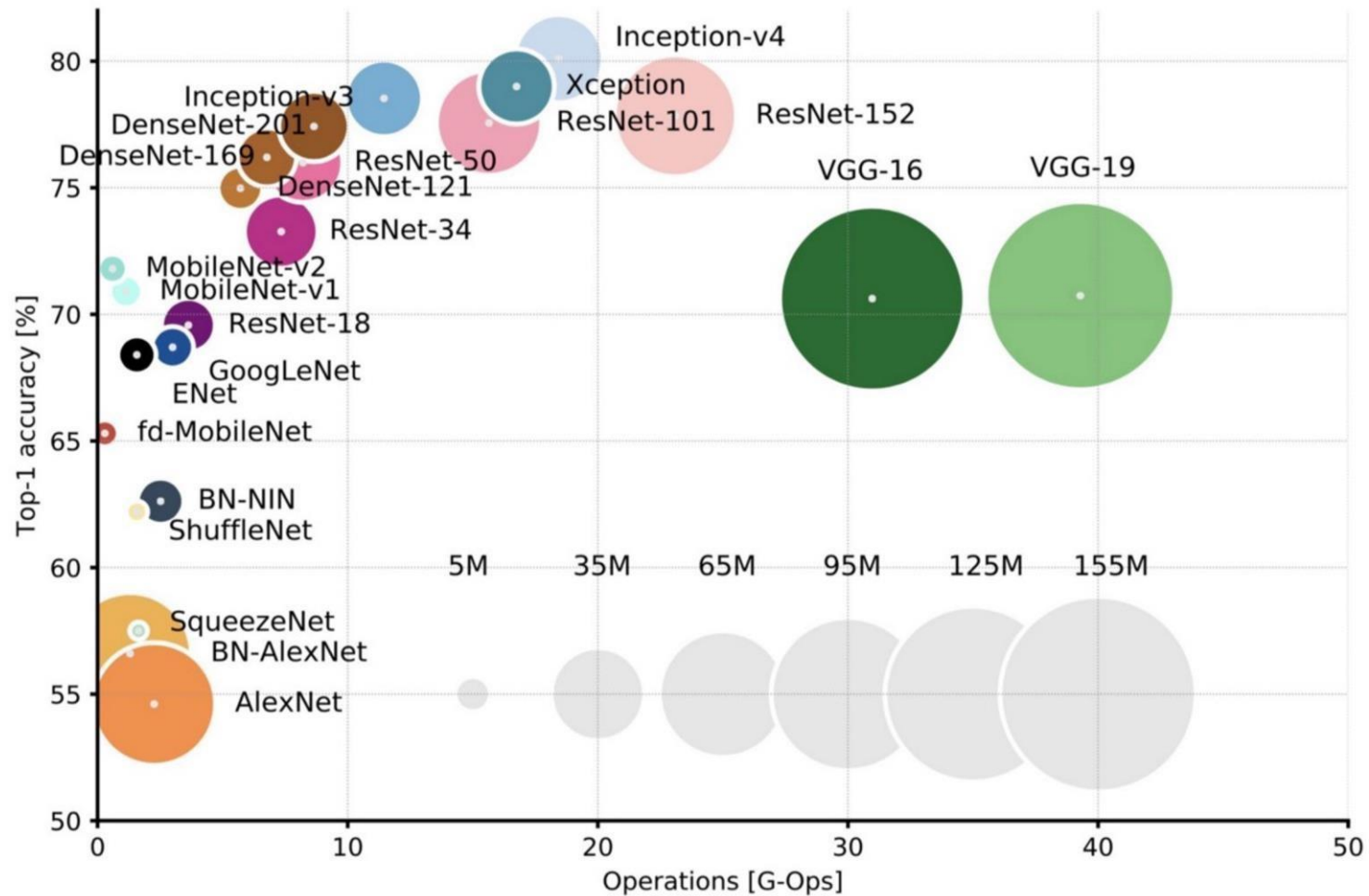# What do Feature Maps Look Like?

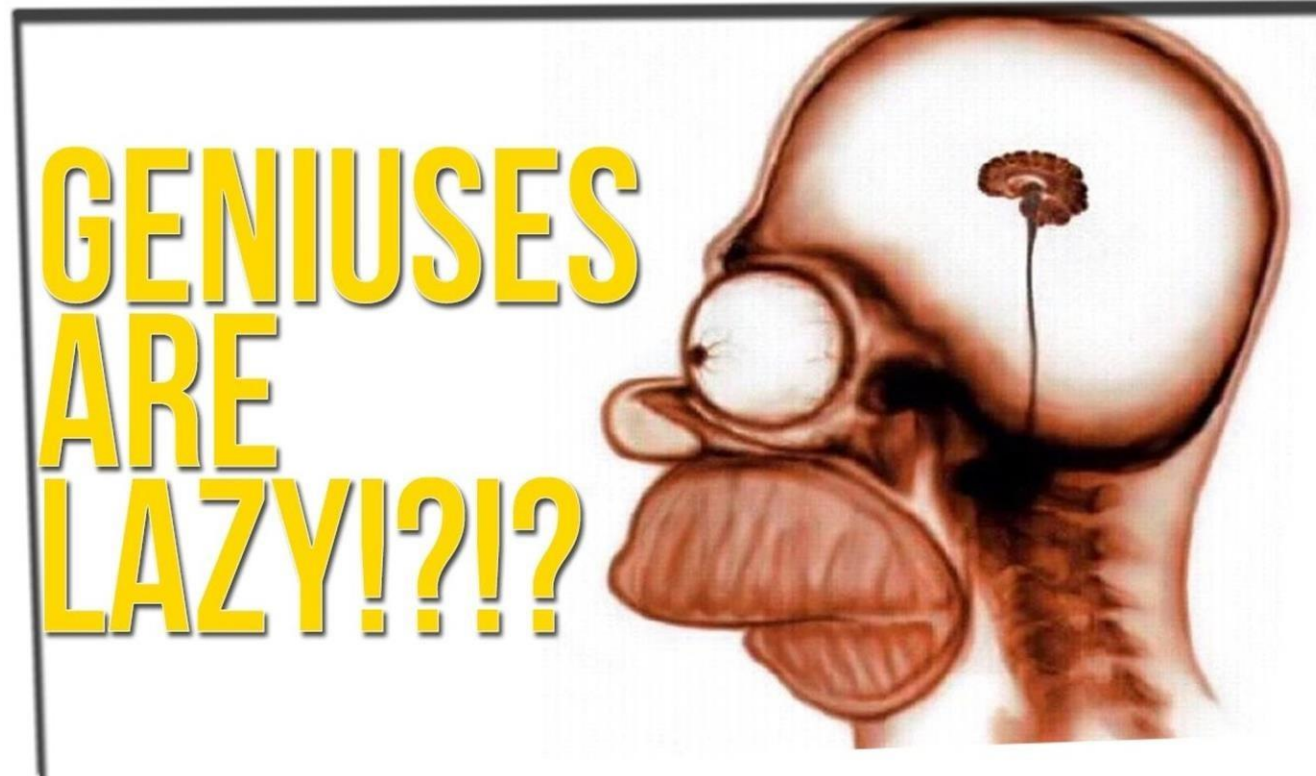Learnings of First convolution layer on image of size 224X224X3

What do Feature Maps Look Like?

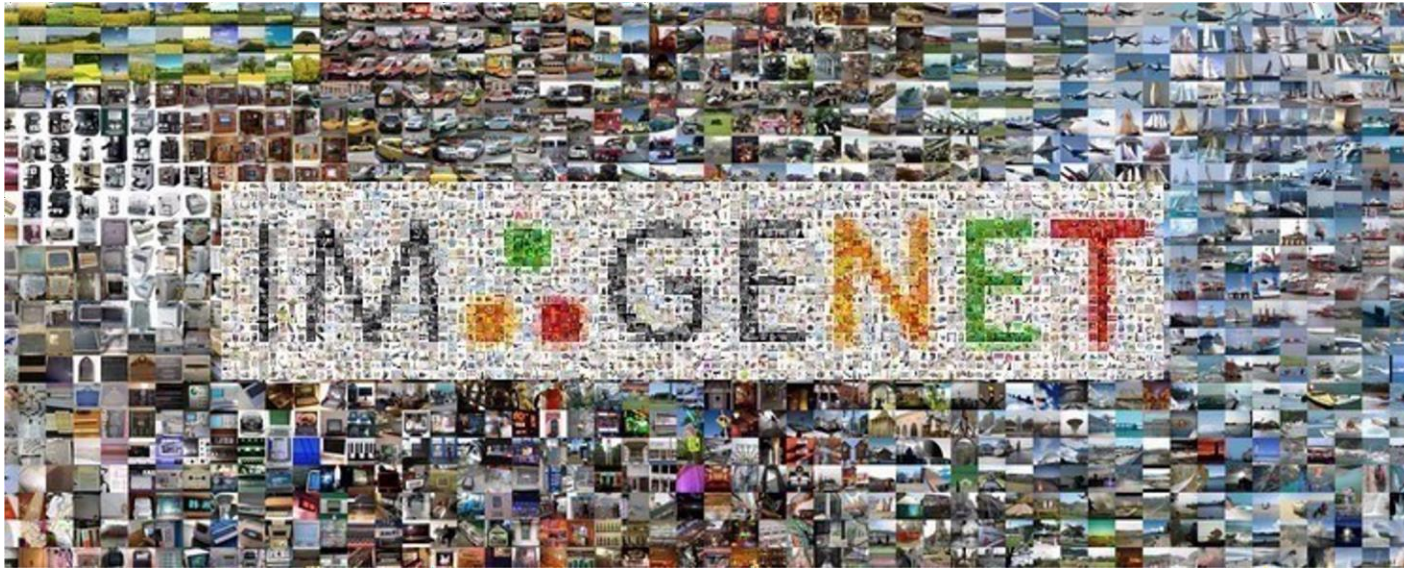# Comparison of different CNNs

Pre-Trained Weights

Sources of Training Data

Imagenet & MS COCO