CNN

Stands for
Convolutional Neural Network (ConvNN)

CNN

- Convolutional neural network (CNN) is a regularized type of feed-forward neural network that learns feature engineering by itself via filters (or kernel) optimization.

CNN applications examples:

- image and video recognition
- image classification,
- medical image analysis,
- natural language processing

Architecture

Convolution Neural Network (CNN)

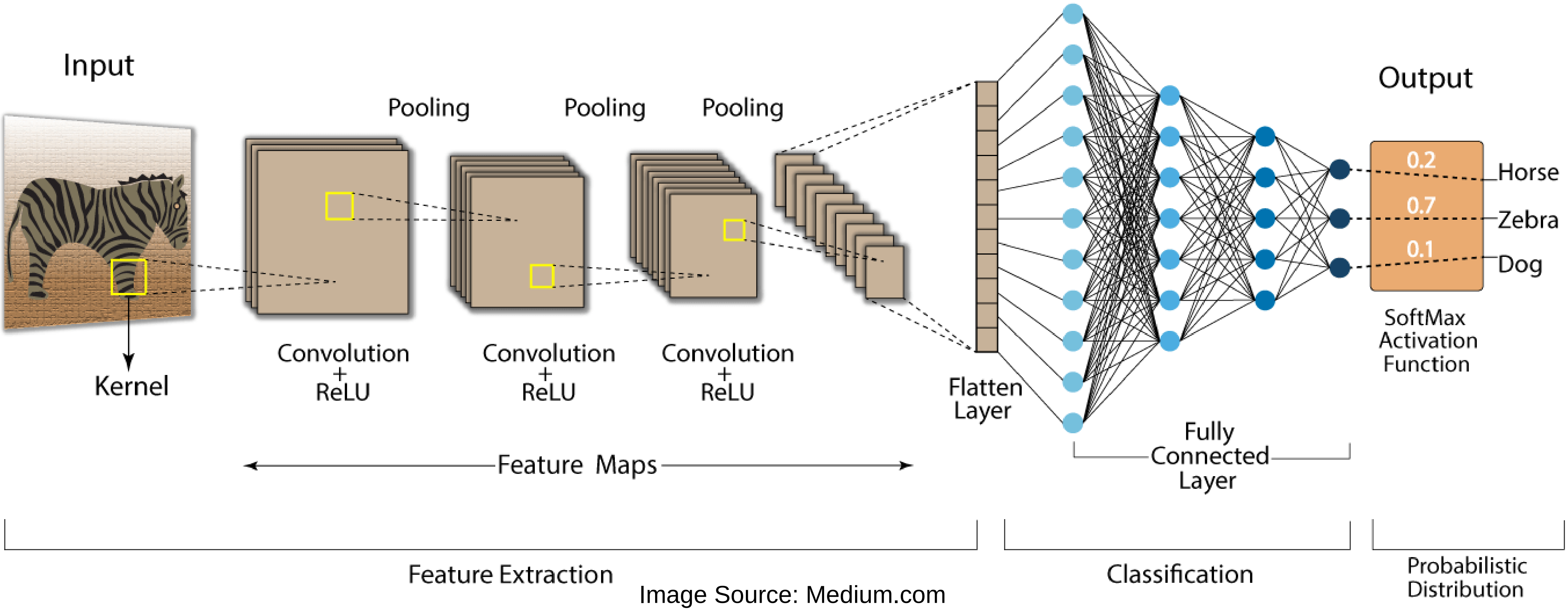
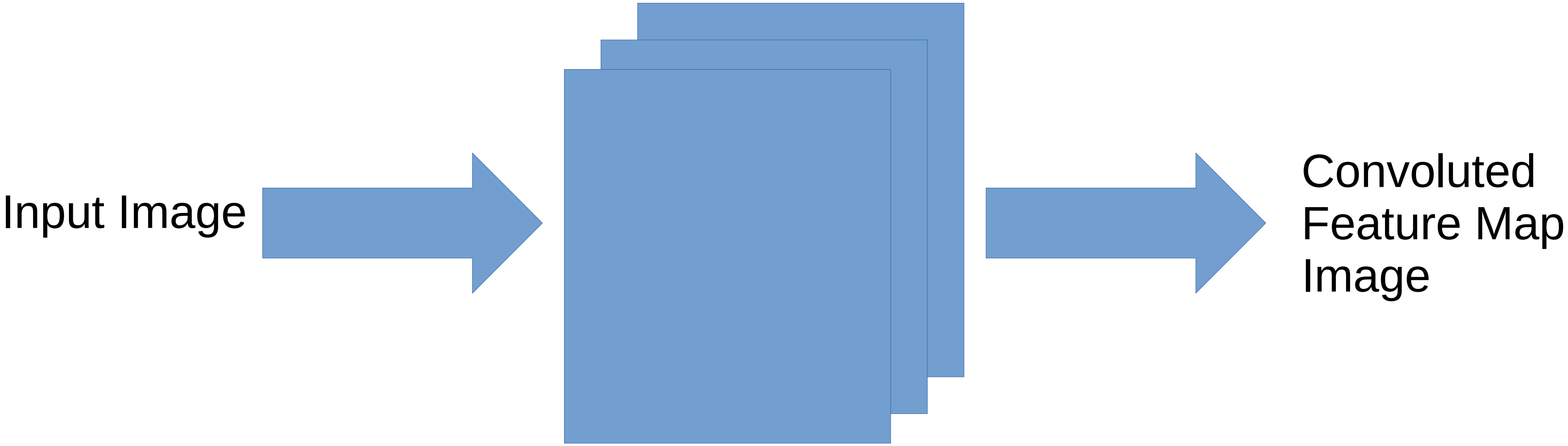
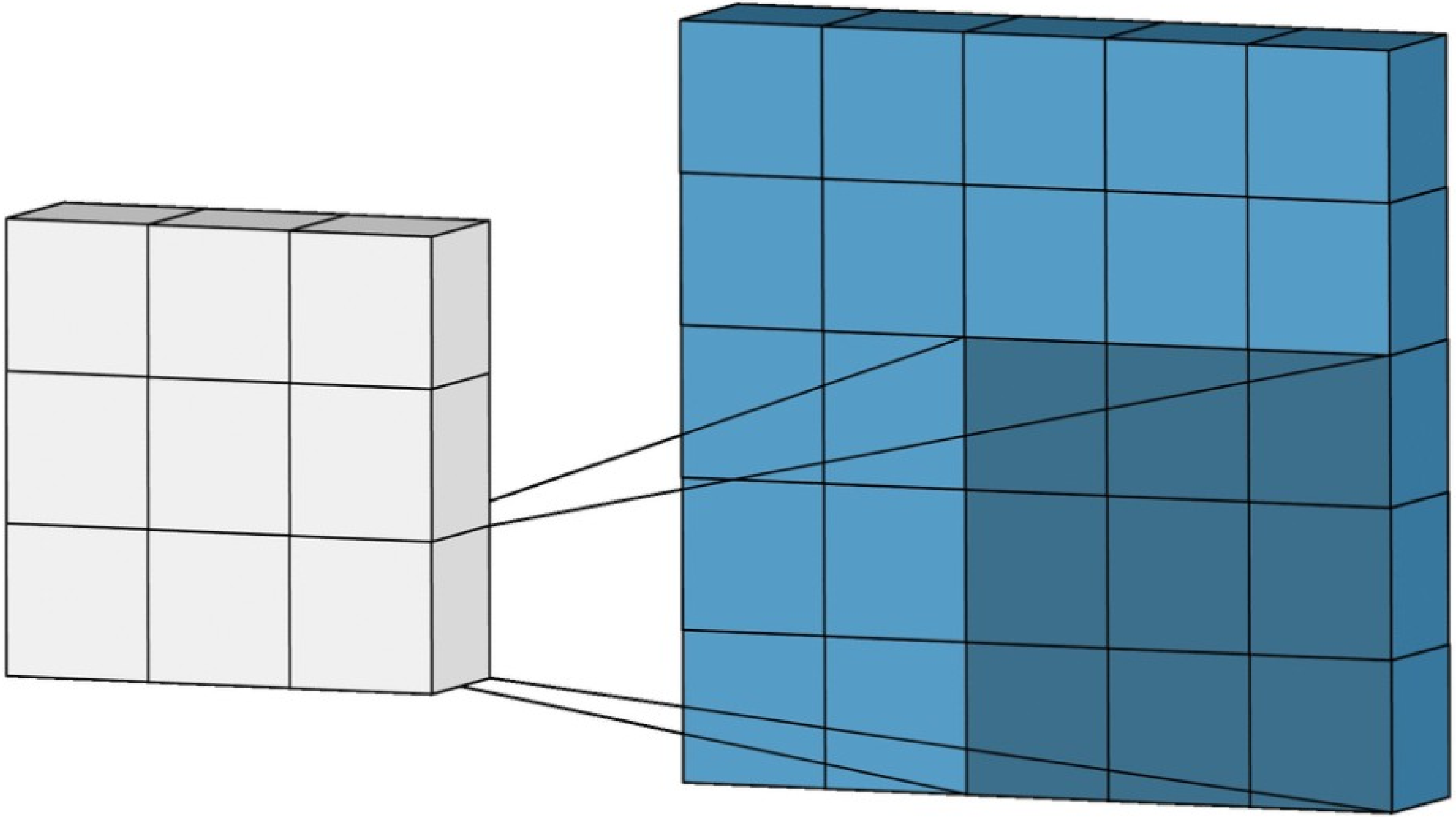


Image Source: Medium.com

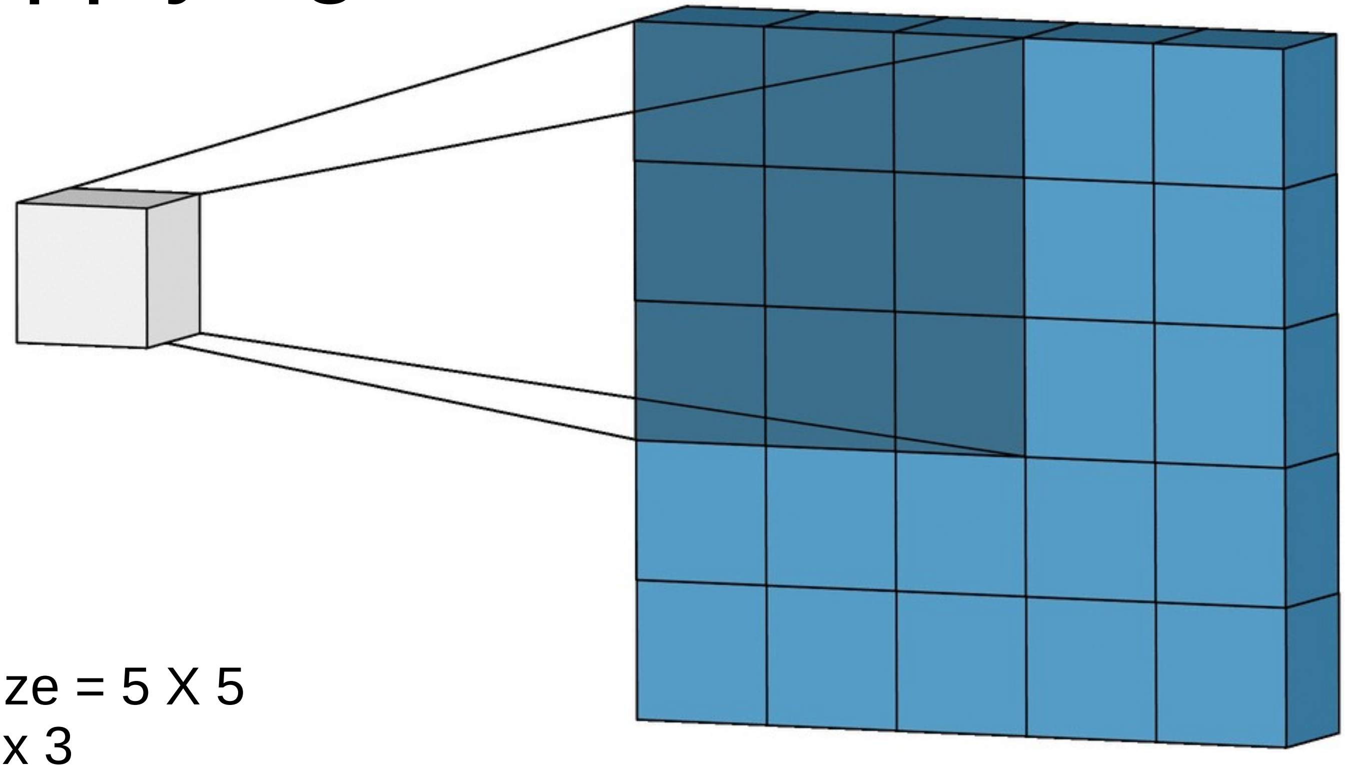
Convolutional Layer

The Primary purpose of Convolution is to extract features from input image

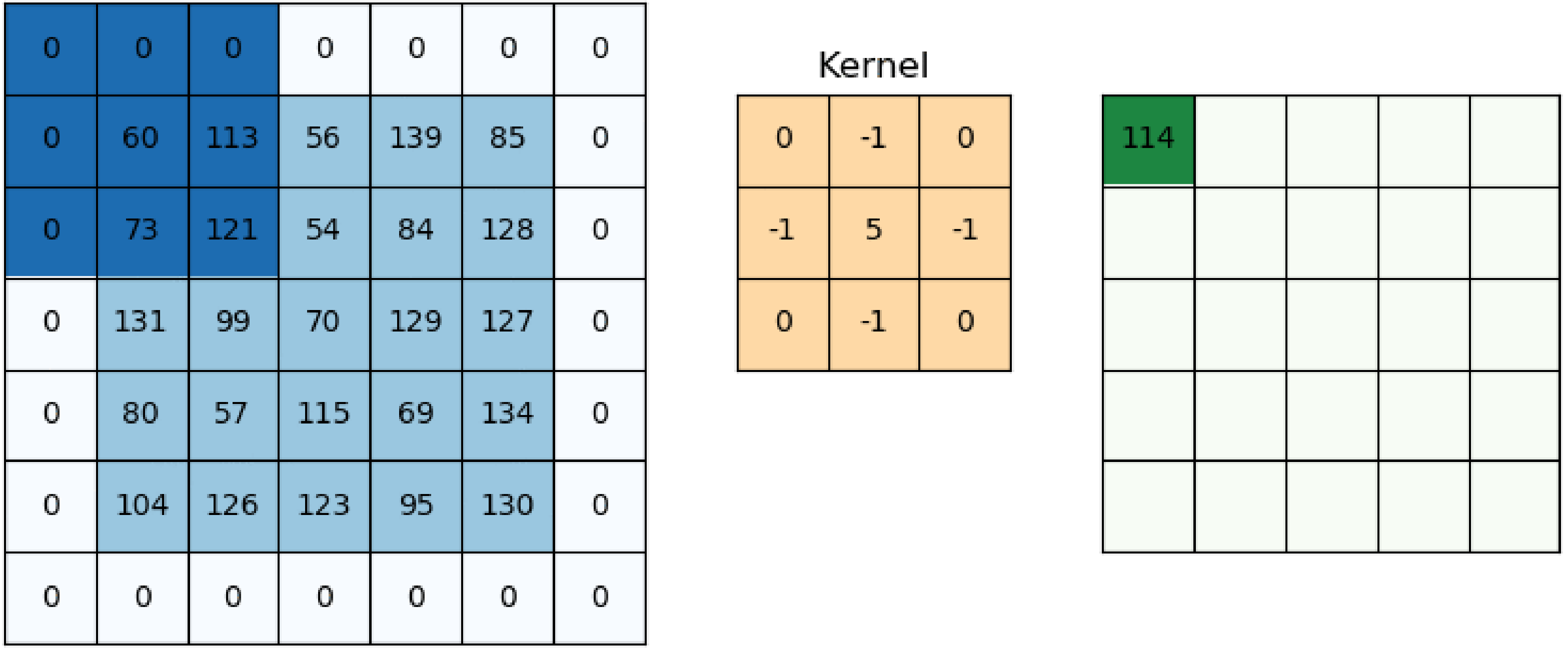




Applying filters Convolutional layer cont..



Input Image Size = 5 X 5
Filter Size = 3 x 3
Stride = 1
Padding = 0
Feature map size(output) = 3 x 3

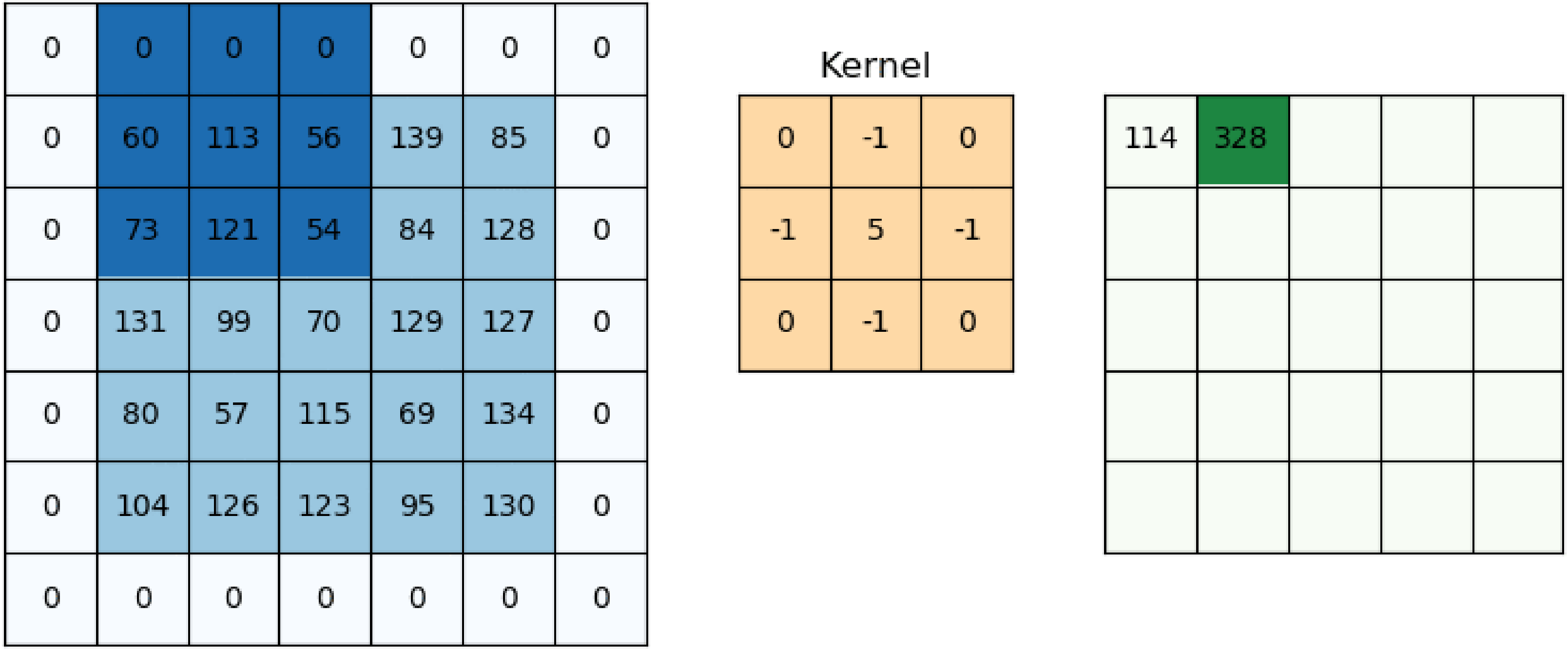


0	0	0	0	0	0	0
0	60	113	56	139	85	0
0	73	121	54	84	128	0
0	131	99	70	129	127	0
0	80	57	115	69	134	0
0	104	126	123	95	130	0
0	0	0	0	0	0	0

Kernel

0	-1	0
-1	5	-1
0	-1	0

114				



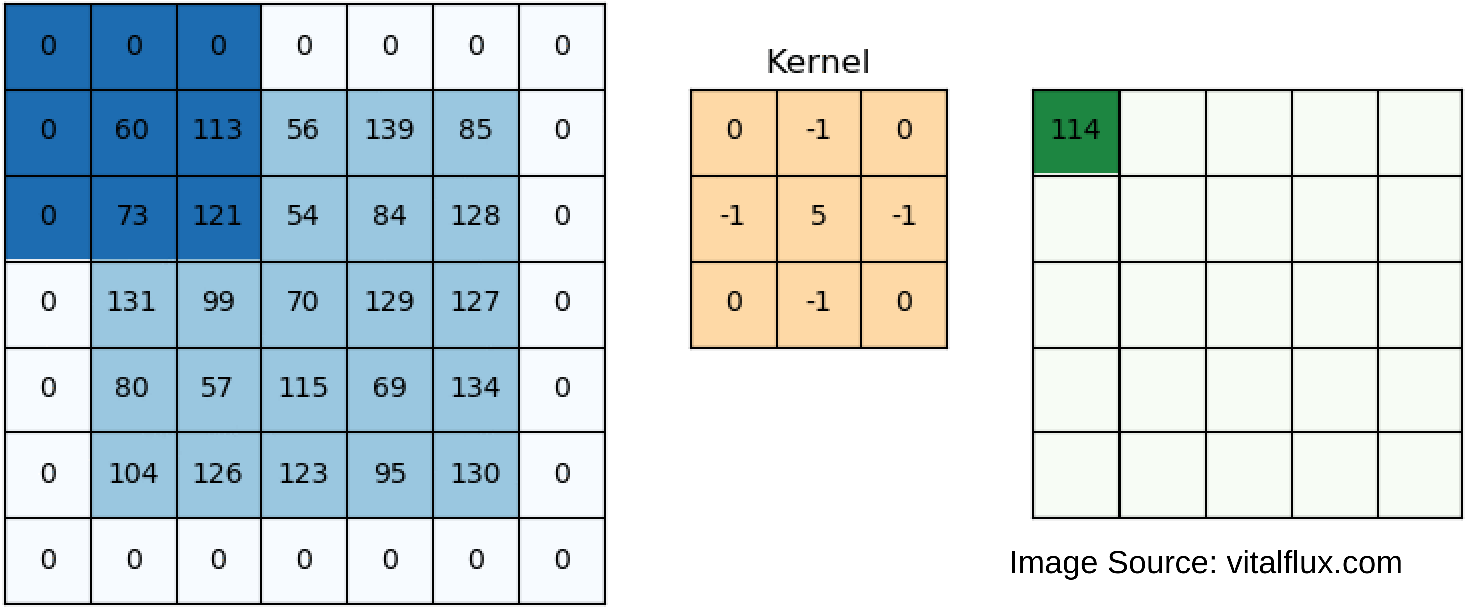
0	0	0	0	0	0	0
0	60	113	56	139	85	0
0	73	121	54	84	128	0
0	131	99	70	129	127	0
0	80	57	115	69	134	0
0	104	126	123	95	130	0
0	0	0	0	0	0	0

Kernel

0	-1	0
-1	5	-1
0	-1	0

114	328			

Applying filters Convolutional layer cont..



0	0	0	0	0	0	0
0	60	113	56	139	85	0
0	73	121	54	84	128	0
0	131	99	70	129	127	0
0	80	57	115	69	134	0
0	104	126	123	95	130	0
0	0	0	0	0	0	0

Kernel

0	-1	0
-1	5	-1
0	-1	0

114				

Image Source: vitalflux.com

Input Image Size = 5 X 5
Filter Size = 3 x 3
Stride = 1
Padding = 1
Feature map size(output) = 5 x 5

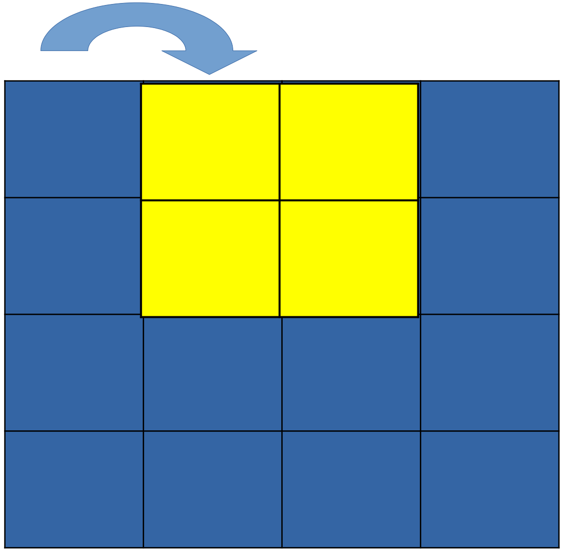
Feature map size Convolutional layer cont..

Depends on:

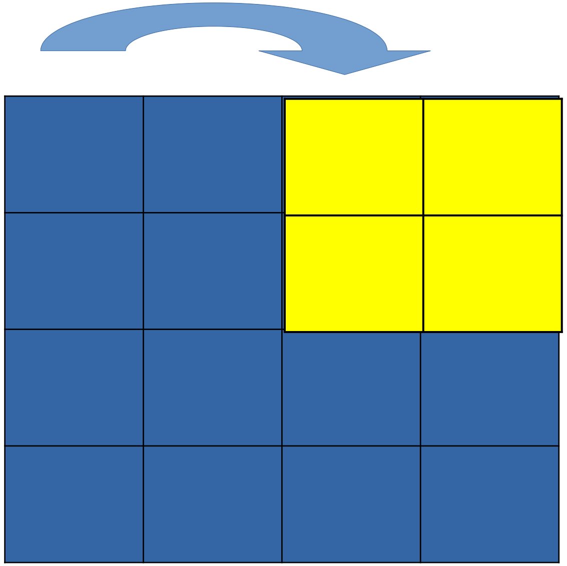
- Input Image Size n×n
- Filter Size f×f
- Stride s
- Padding p

Stride Convolutional layer cont..

- **Stride:** It denotes how many steps we are moving the filter at each step. [default is 1]



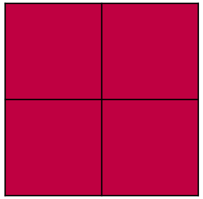
Stride = 1



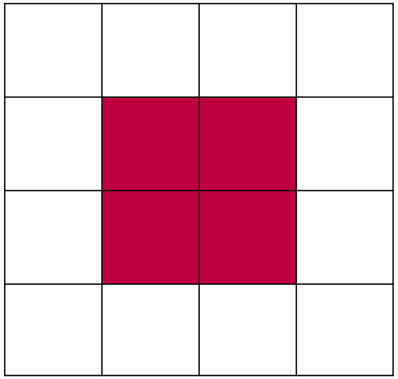
Stride = 2

Padding Convolutional layer cont..

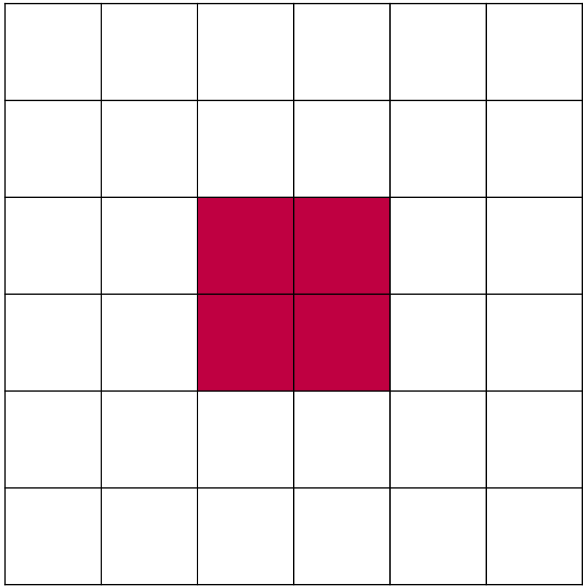
- Padding is a process of adding (row or column) to the input at each side



Padding = 0



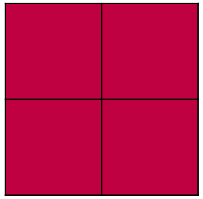
Padding = 1



Padding = 2

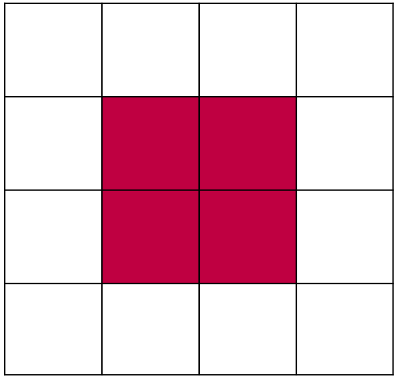
Padding Types Convolutional layer cont..

Valid Padding



Padding = 0

Same Padding



Padding = 1

Calculate Padding Convolutional layer cont..

$$p = \frac{n * s - n + f - s}{2}$$

$$let\ s = 1\ ,\ p = \frac{f - 1}{2}$$

Calculate the feature map size

$$feature\,map = \frac{n - f + 2p}{s} + 1$$

n×*n* image
f×*f* filter

Padding *p*
Stride *s*

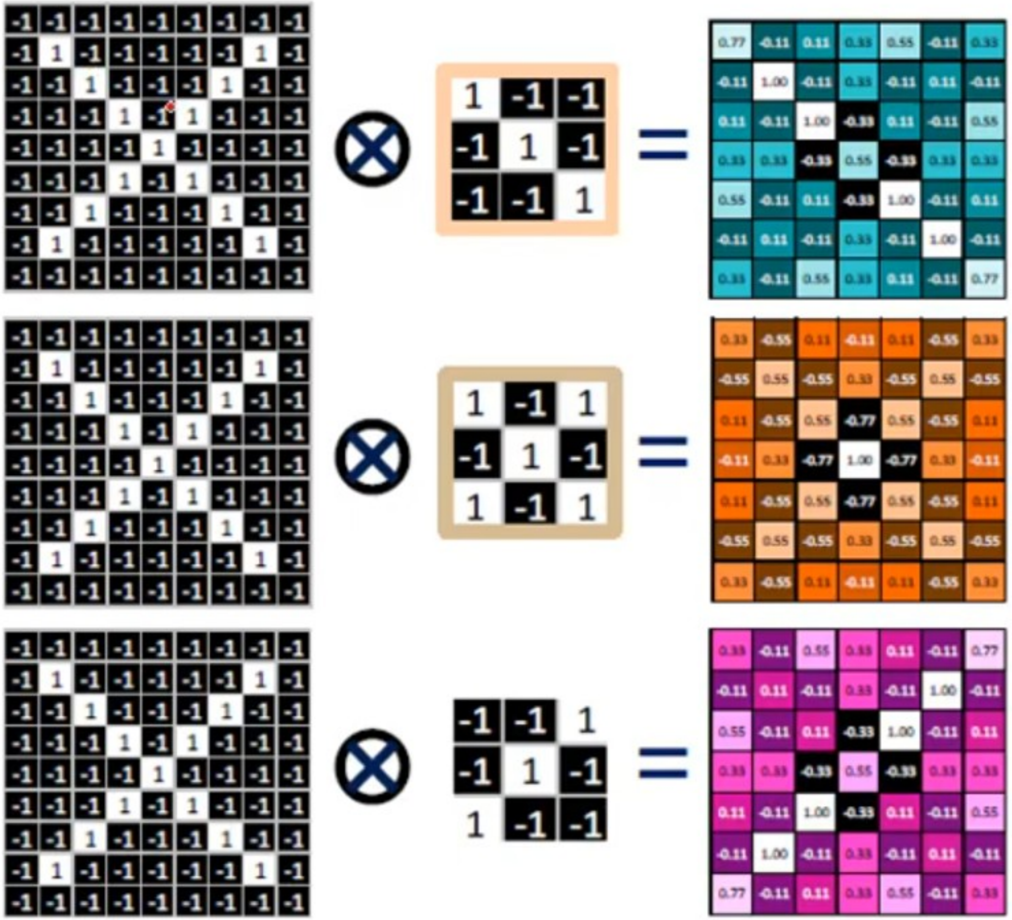
Convolutional Layer – Filters – Output Feature Map

- Output Feature Map of One complete convolution:
  - Filters: 3
  - Filter Size: 3 X 3
  - Stride: 1

- Conclusion:
  - Input Image:

    9 X 9
  - Output of Convolution:

    7 X 7 X 3



-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	-1	-1	1	-1	-1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1

⊗

1	-1	-1
-1	1	-1
-1	-1	1

=

0.77	-0.11	0.11	0.33	0.55	-0.11	0.33
-0.11	1.00	-0.11	0.33	-0.11	0.11	-0.11
0.11	-0.11	1.00	-0.33	0.11	-0.11	0.55
0.33	0.33	-0.33	0.55	-0.33	0.33	0.33
0.55	-0.11	0.11	-0.33	1.00	-0.11	0.11
-0.11	0.11	-0.11	0.33	-0.11	1.00	-0.11
0.33	-0.11	0.55	0.33	0.11	-0.11	0.77

-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	-1	-1	1	-1	-1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1

⊗

1	-1	1
-1	1	-1
1	-1	1

=

0.33	-0.55	0.11	-0.11	0.11	-0.55	0.33
-0.55	0.55	-0.55	0.33	-0.55	0.55	-0.55
0.11	-0.55	0.55	-0.77	0.55	-0.55	0.11
-0.11	0.33	-0.77	1.00	-0.77	0.33	-0.11
0.11	-0.55	0.55	-0.77	0.55	-0.55	0.11
-0.55	0.55	-0.55	0.33	-0.55	0.55	-0.55
0.33	-0.55	0.11	-0.11	0.11	-0.55	0.33

-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	-1	-1	1	-1	-1	-1	-1
-1	-1	-1	1	-1	1	-1	-1	-1
-1	-1	1	-1	-1	-1	1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1

⊗

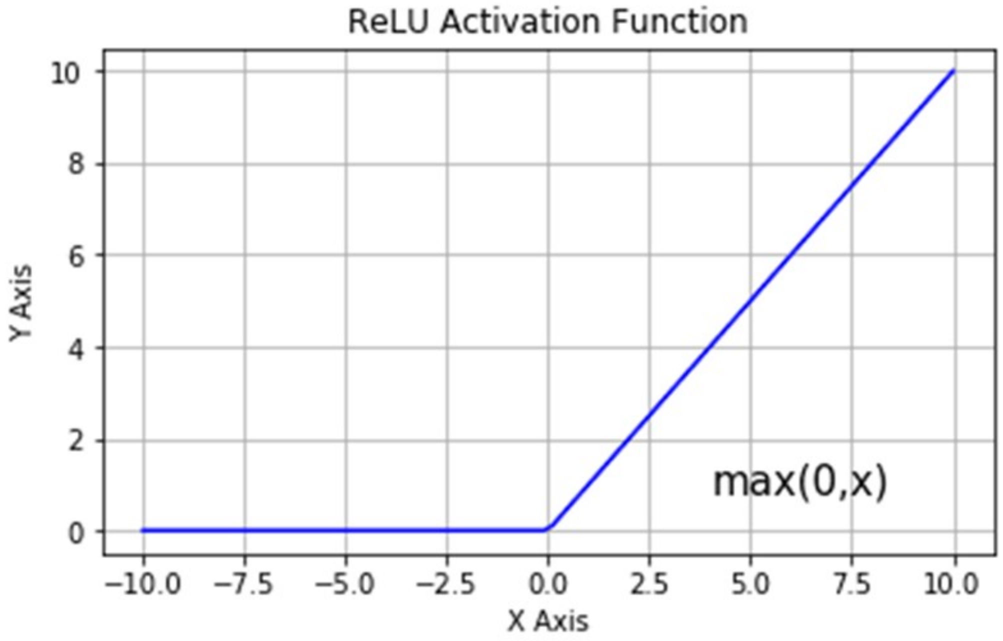
-1	-1	1
-1	1	-1
1	-1	-1

=

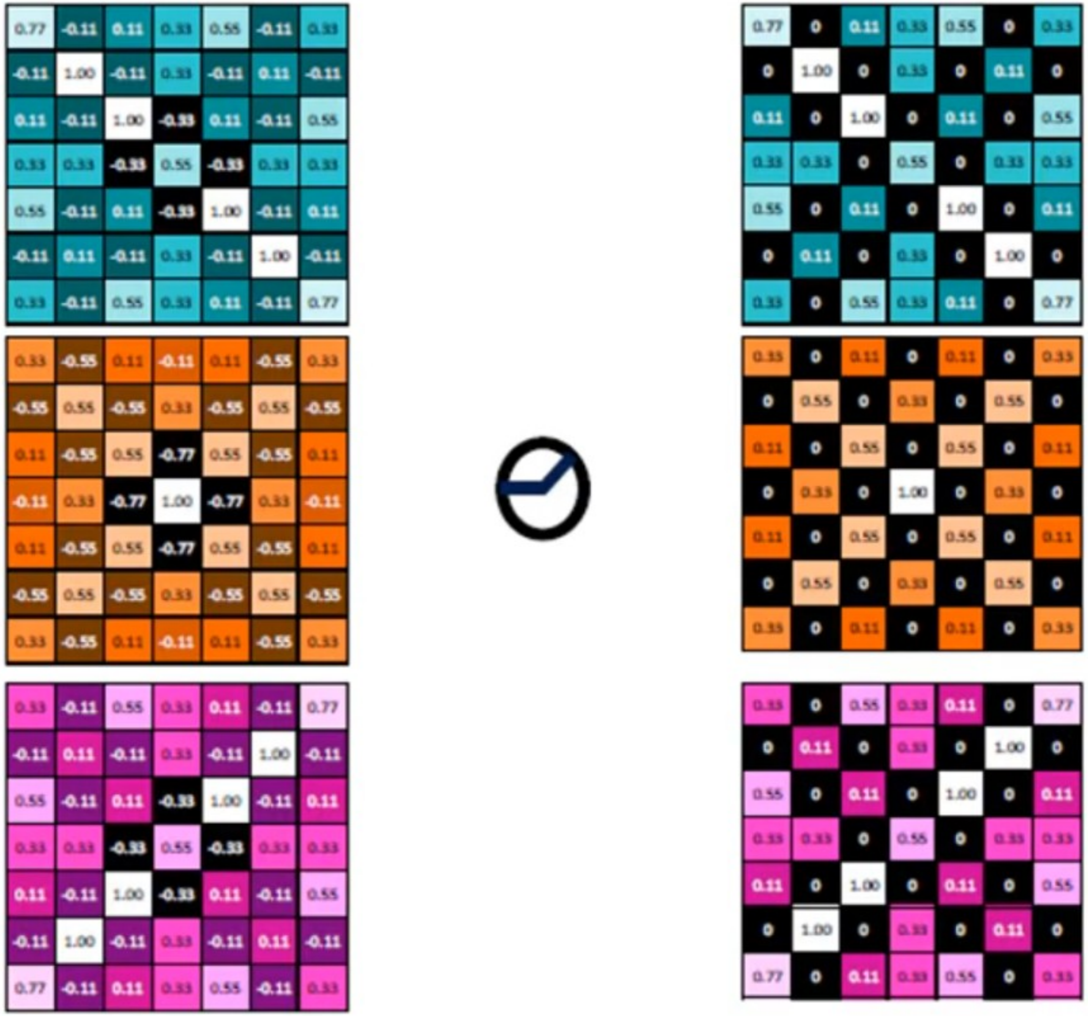
0.33	-0.11	0.55	0.33	0.11	-0.11	0.77
-0.11	0.11	-0.11	0.33	-0.11	1.00	-0.11
0.55	-0.11	0.11	-0.33	1.00	-0.11	0.11
0.33	0.33	-0.33	0.55	-0.33	0.33	0.33
0.11	-0.11	1.00	-0.33	0.11	-0.11	0.55
-0.11	1.00	-0.11	0.33	-0.11	0.11	-0.11
0.77	-0.11	0.11	0.33	0.55	-0.11	0.33

ReLU layer

- Applying max(0, x) on the previous feature map layers
- This one does not change size unlike the previous one



Relu Layer



0.77	-0.11	0.11	0.33	0.55	-0.11	0.33
-0.11	1.00	-0.11	0.33	-0.11	0.11	-0.11
0.11	-0.11	1.00	-0.33	0.11	-0.11	0.55
0.33	0.33	-0.33	0.55	-0.33	0.33	0.33
0.55	-0.11	0.11	-0.33	1.00	-0.11	0.11
-0.11	0.11	-0.11	0.33	-0.11	1.00	-0.11
0.33	-0.11	0.55	0.33	0.11	-0.11	0.77

0.33	-0.55	0.11	-0.11	0.11	-0.55	0.33
-0.55	0.55	-0.55	0.33	-0.55	0.55	-0.55
0.11	-0.55	0.55	-0.77	0.55	-0.55	0.11
-0.11	0.33	-0.77	1.00	-0.77	0.33	-0.11
0.11	-0.55	0.55	-0.77	0.55	-0.55	0.11
-0.55	0.55	-0.55	0.33	-0.55	0.55	-0.55
0.33	-0.55	0.11	-0.11	0.11	-0.55	0.33

0.33	-0.11	0.55	0.33	0.11	-0.11	0.77
-0.11	0.11	-0.11	0.33	-0.11	1.00	-0.11
0.55	-0.11	0.11	-0.33	1.00	-0.11	0.11
0.33	0.33	-0.33	0.55	-0.33	0.33	0.33
0.11	-0.11	1.00	-0.33	0.11	-0.11	0.55
-0.11	1.00	-0.11	0.33	-0.11	0.11	-0.11
0.77	-0.11	0.11	0.33	0.55	-0.11	0.33

0.77	0	0.11	0.33	0.55	0	0.33
0	1.00	0	0.33	0	0.11	0
0.11	0	1.00	0	0.11	0	0.55
0.33	0.33	0	0.55	0	0.33	0.33
0.55	0	0.11	0	1.00	0	0.11
0	0.11	0	0.33	0	1.00	0
0.33	0	0.55	0.33	0.11	0	0.77

0.33	0	0.11	0	0.11	0	0.33
0	0.55	0	0.33	0	0.55	0
0.11	0	0.55	0	0.55	0	0.11
0	0.33	0	1.00	0	0.33	0
0.11	0	0.55	0	0.55	0	0.11
0	0.55	0	0.33	0	0.55	0
0.33	0	0.11	0	0.11	0	0.33

0.33	0	0.55	0.33	0.11	0	0.77
0	0.11	0	0.33	0	1.00	0
0.55	0	0.11	0	1.00	0	0.11
0.33	0.33	0	0.55	0	0.33	0.33
0.11	0	1.00	0	0.11	0	0.55
0	1.00	0	0.33	0	0.11	0
0.77	0	0.11	0.33	0.55	0	0.33

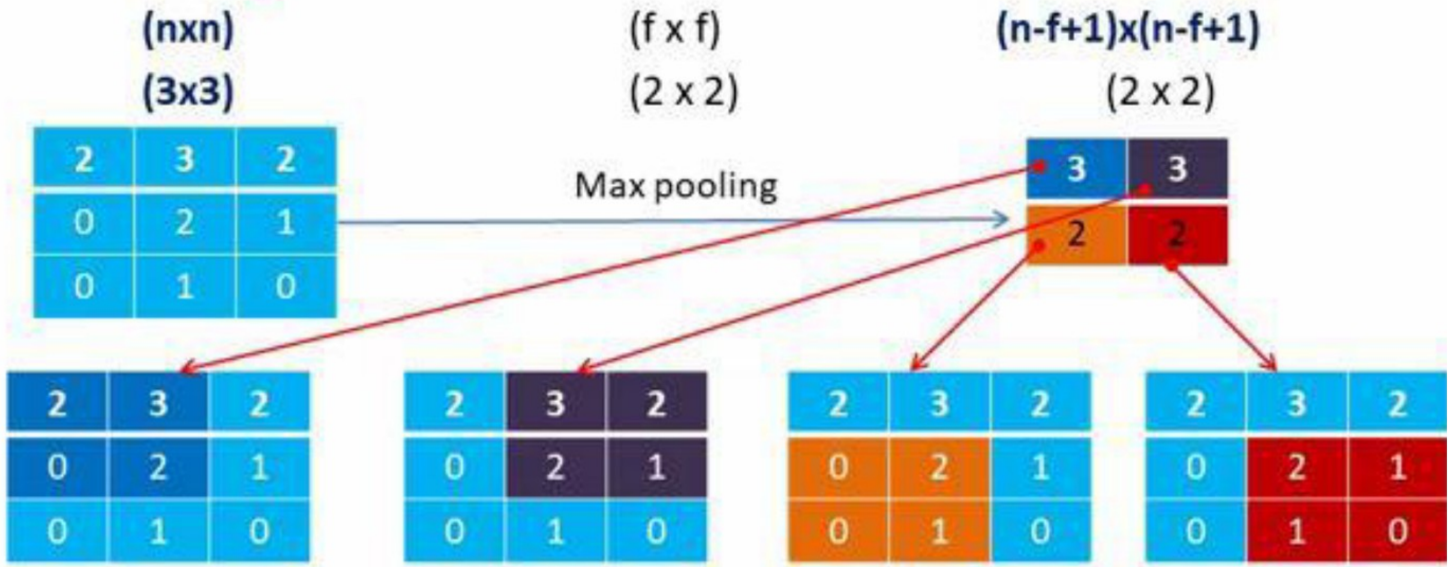
Pooling layer

- Its purpose is to gradually shrink the representation’s spatial size to reduce the number of parameters and computations in the network.
- The pooling layer treats each feature map separately.

Pooling layers

- Pooling layers would reduce the number of parameters when the inputs are too large.
- Pooling also called down sampling which reduces the dimensionality of each map but retains important information.
- There are three types of pooling namely, Max Pooling, Average Pooling, Sum Pooling.

Max Pooling:

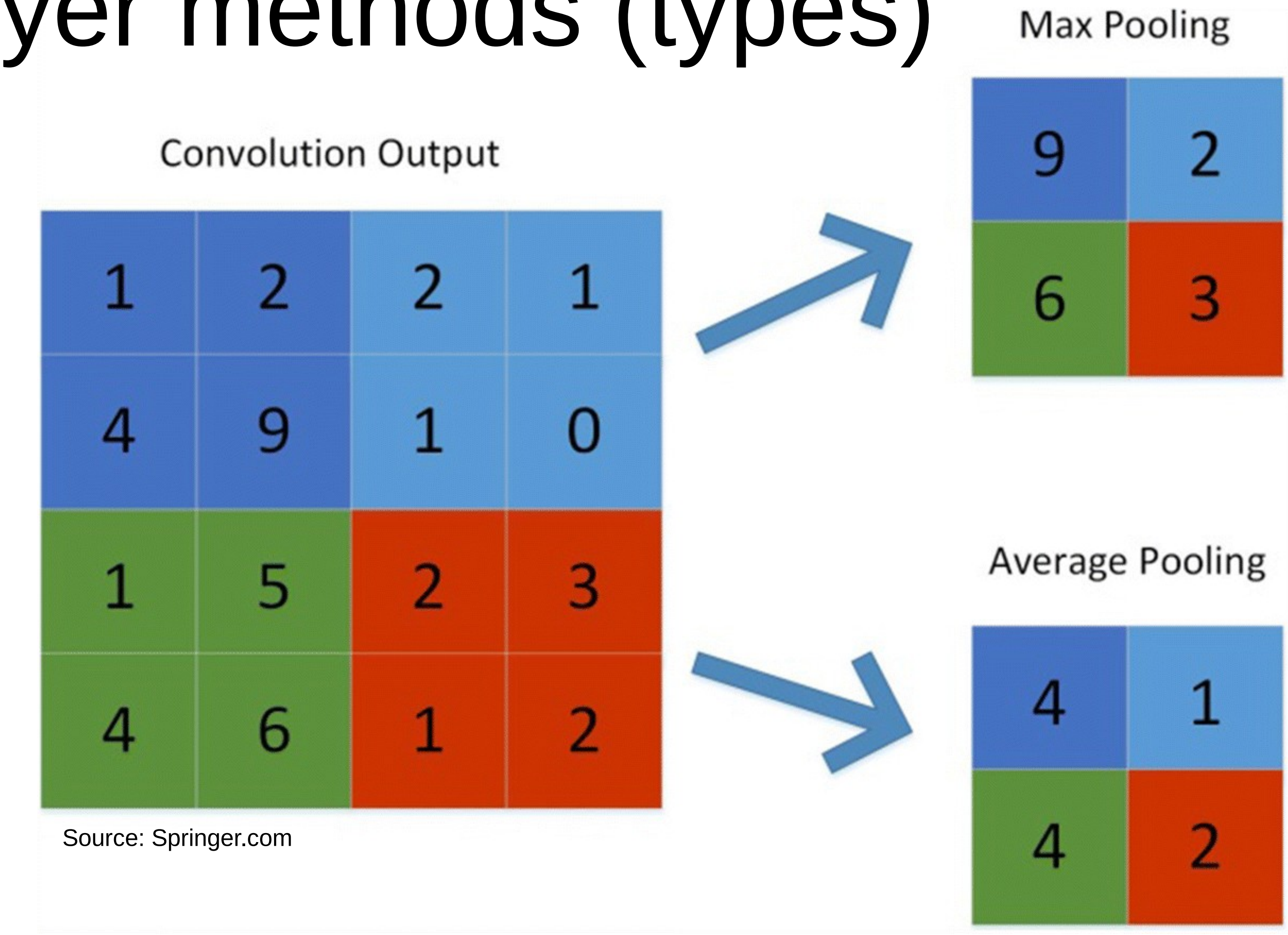


2	3	2
0	2	1
0	1	0

3	3
2	2

Pooling layer methods (types)

- Max pooling
- Average Pooling



Convolution Output

1	2	2	1
4	9	1	0
1	5	2	3
4	6	1	2

Max Pooling

9	2
6	3

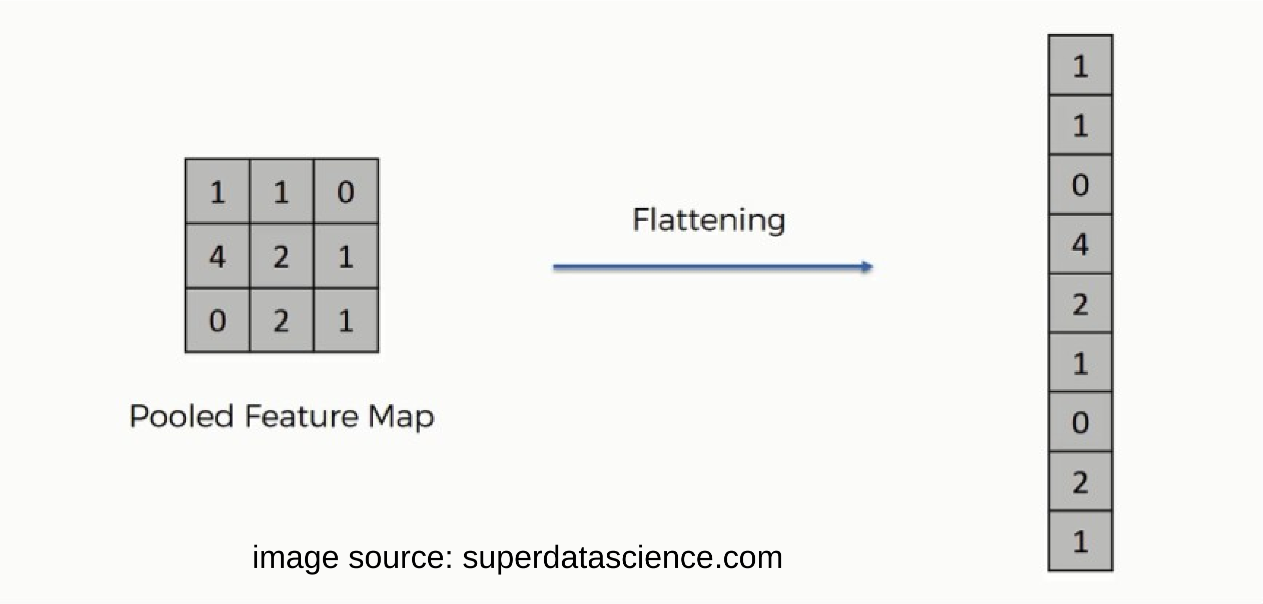
Average Pooling

4	1
4	2

Source: Springer.com

Flatten Layer

- **Flatten** is used to flatten the input. For example, if flatten is applied to layer having input shape as (3,3), then the output shape of the layer will be (9)



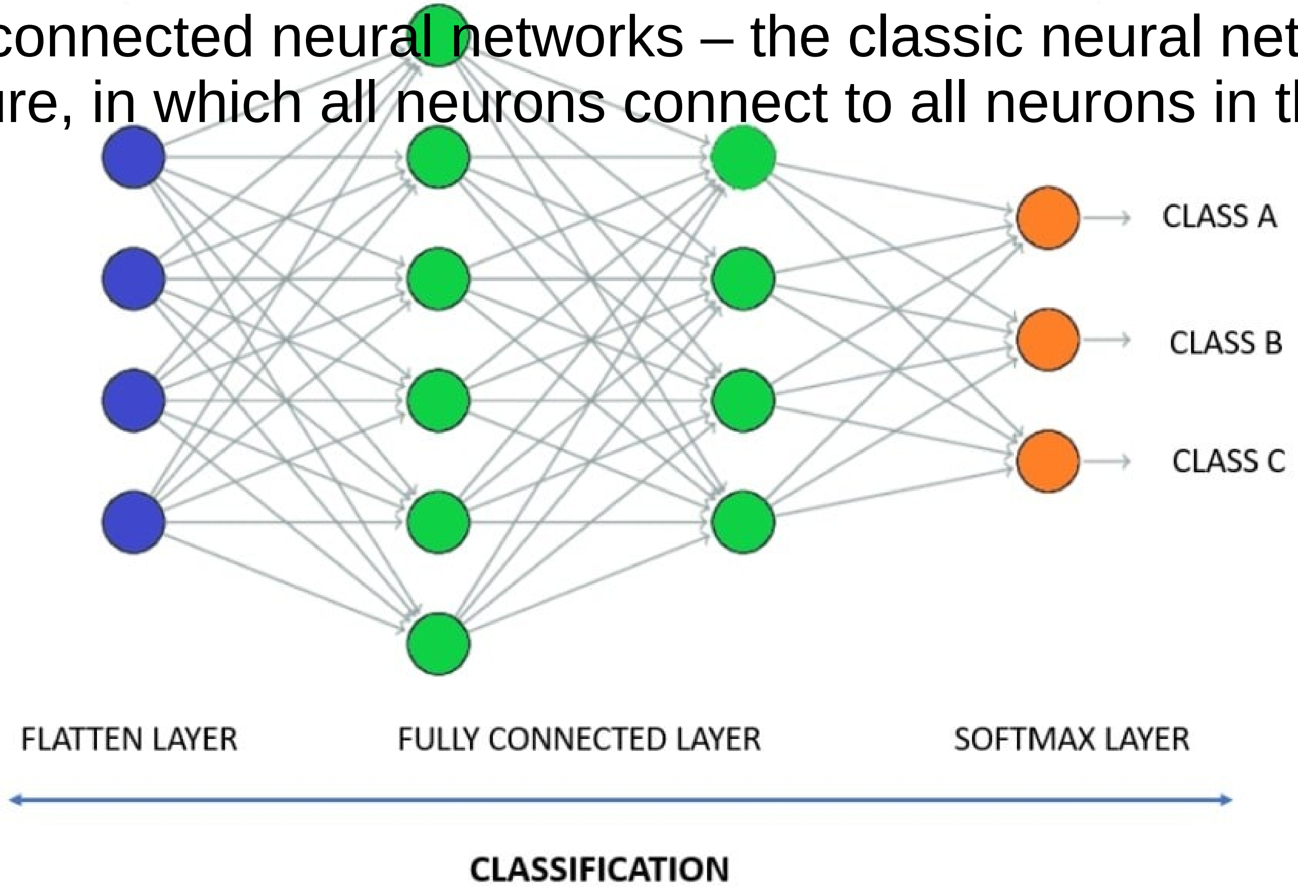
1	1	0
4	2	1
0	2	1

1
1
0
4
2
1
0
2
1

image source: superdatascience.com

Fully Connected layer

- Is a fully connected neural networks – the classic neural network architecture, in which all neurons connect to all neurons in the next layer.



MNIST Example

- MNIST is a subset of a larger set available from NIST (it's copied from http://yann.lecun.com/exdb/mnist/)
- The MNIST database of handwritten digits has a training set of 60,000 examples, and a test set of 10,000 examples.

Resources

- Convolutional neural network [wikipedia]
- Feed-forward neural network [wikipedia]
- Basics of CNN in Deep Learning
- Intuitively Understanding Convolutions for Deep Learning
- Convolutional Neural Network CNN- الشبكات العصبية الملتفة by dr. Ahmed Yousry [youtube]
- What is ReLU and Sigmoid activation function?
- Convolutional Neural Networks (CNN): Step 3 - Flattening
- Feature map size calculate in CNN | Stride, Padding | Deep Learning Animation [youtube]
- Fully Connected Layers in Convolutional Neural Networks
- Deep Neural Networks: Padding
- #02 Convolutional neural network : MNIST Dataset (99% accuracy) [youtube]
- An Image Detecting Spreadsheet: Implementing Convolutional Neural Networks From Scratch Part 1 [youtube]
- AhmedIbrahimai/How-Convolutional-Neural-Networks-CNNs-Works [github]