Convolutional Neural Networks

Rodrigo Gonzalez, PhD

Hello!

I am Rodrigo Gonzalez, PhD

You can find me at
rodrigo.gonzalez@ingenieria.uncuyo.edu.ar

Summary

1. A little of history
2. Main ideas
3. Basic CNN architecture
4. Padding and stride
5. CNN example
6. CNN in Keras
7. The book

1.

A little of history

The goals of a CNN

A little of history

1. Computer vision is the earliest and biggest success story of deep learning.
2. 1998, LeNet-5 (Yann LeCunn et al., 1989)
3. 2011, Dan Ciresan wins the ICDAR 2011 Chinese character recognition competition and the IJCNN 2011 German traffic signs recognition competition
4. 2012, AlexNet (Alex Krizhevsky et al., 2012). Hinton's group winning the high-profile ImageNet large-scale visual recognition challenge.
5. In 2013 and 2014, deep learning still faced intense skepticism from many senior
6. computer vision researchers.
7. It was only in 2016 that it finally became dominant.

2.

Main ideas

The goals of a CNN

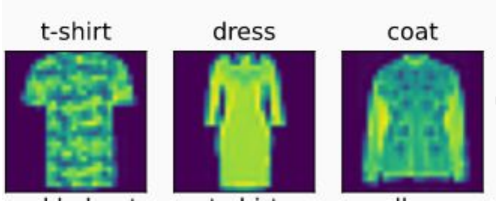
Common neural network approach

Dense layers learn **global** patterns in their input feature space

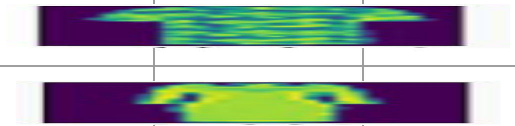
MATRIX

V

VECTOR



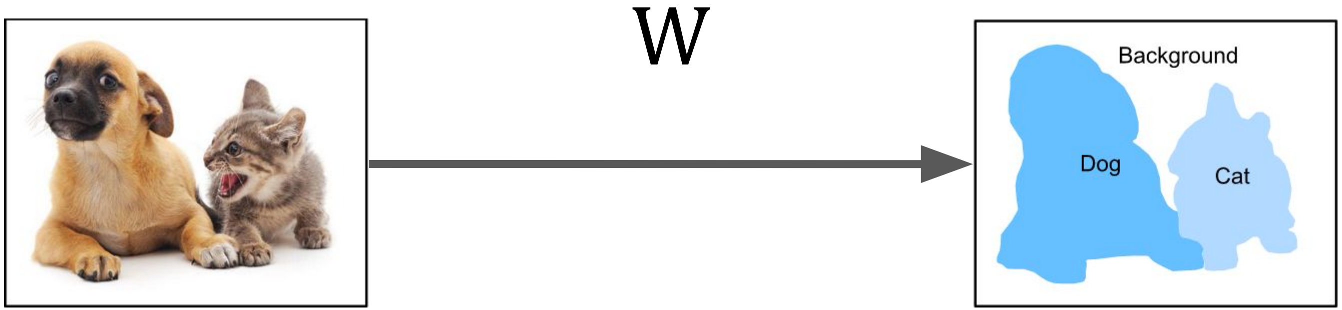
Píxel 1	Píxel ...	Píxel 307,200



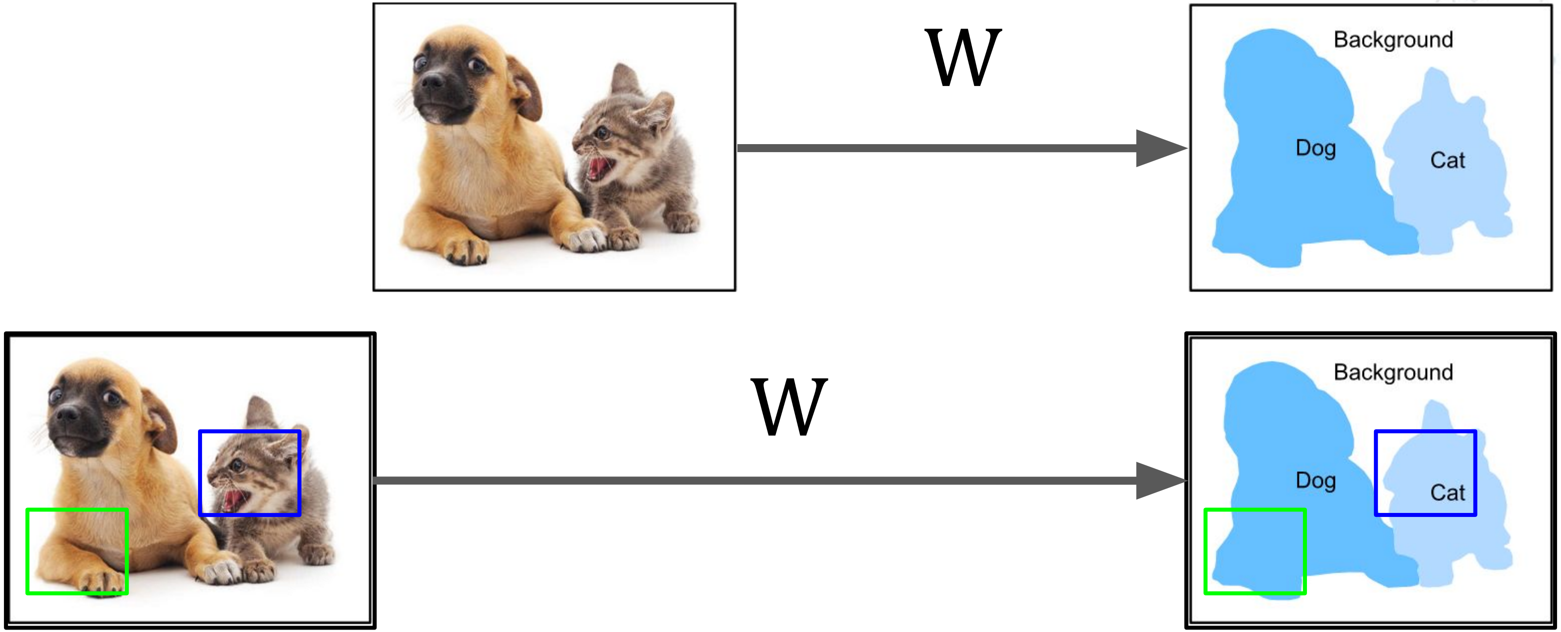
640 pixels x 480 pixels = 307,200 neurons

CNN approach

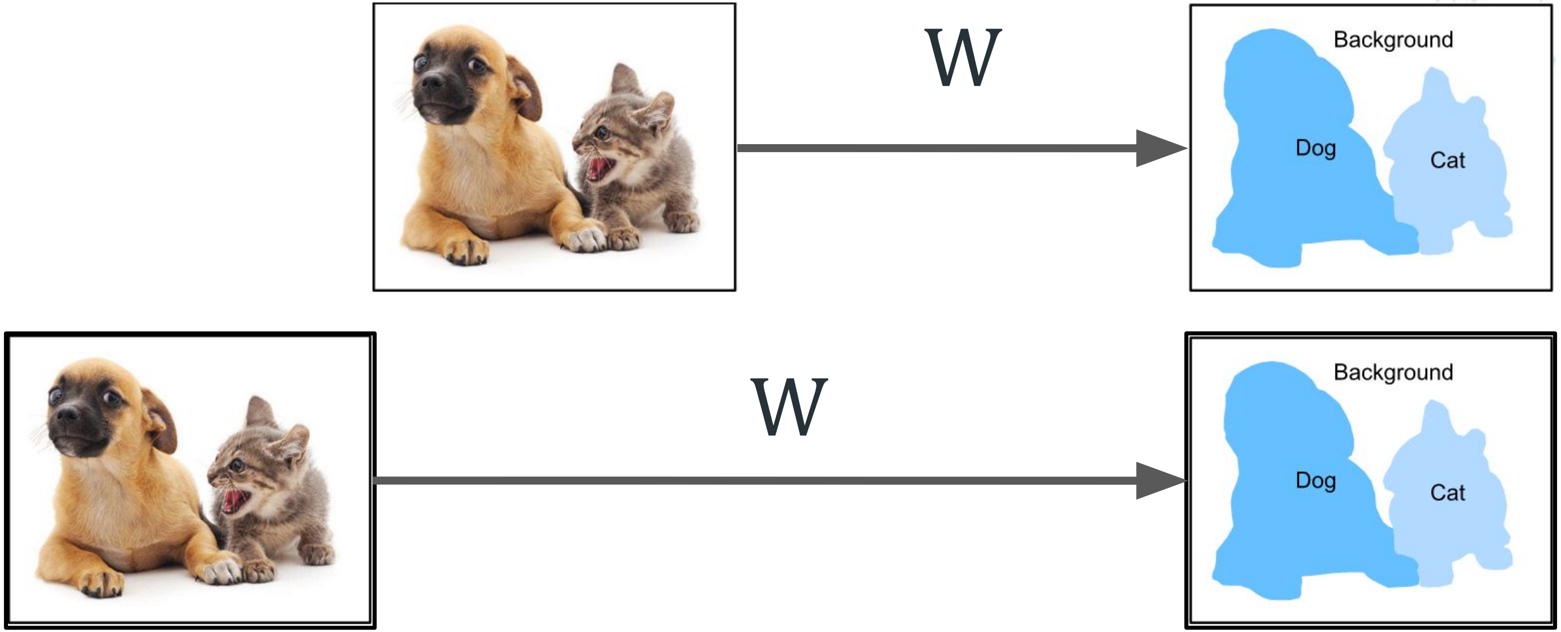
Convolution layers learn **local** patterns—in the case of images, patterns found in small 2D windows of the inputs



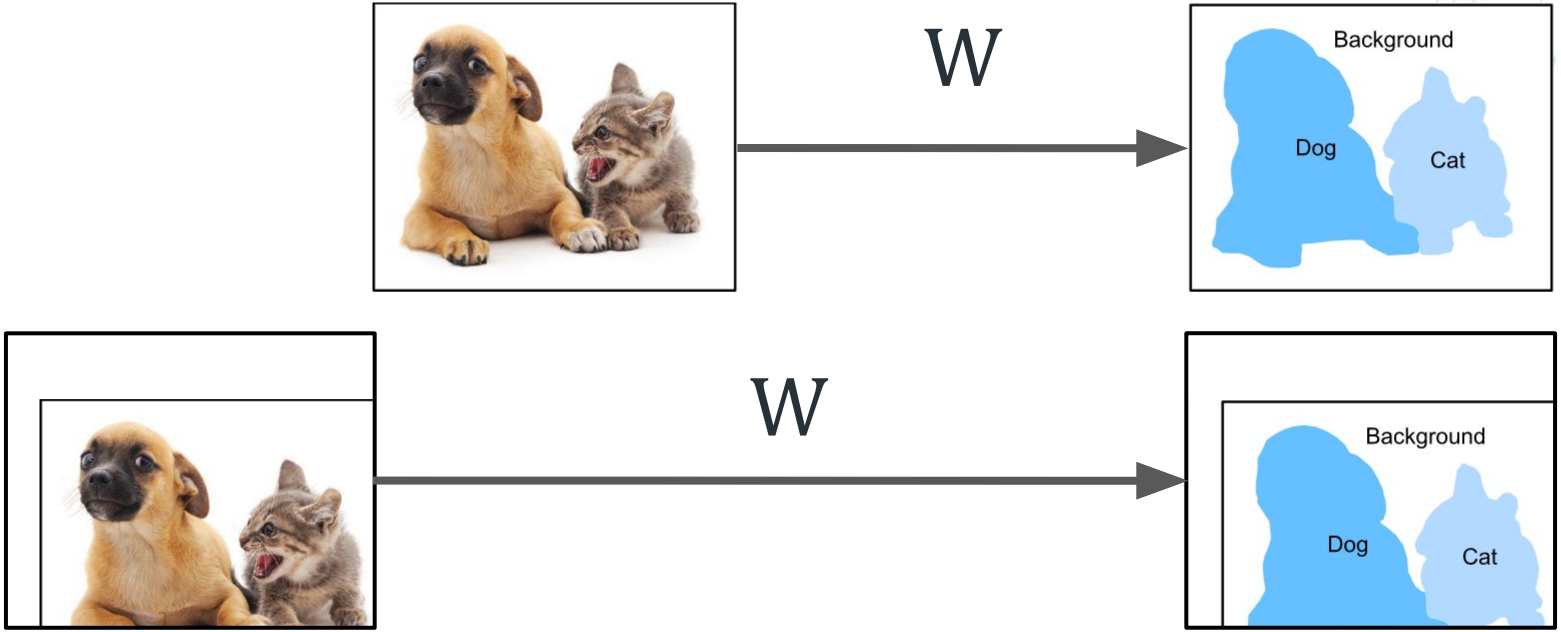
Locality



Translation invariance

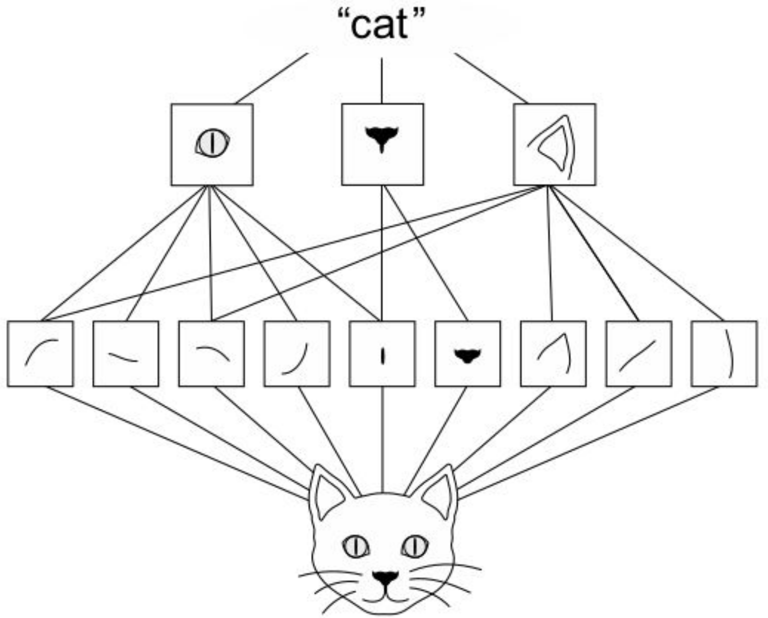


Translation invariance



Spatial hierarchies of patterns

- A first convolution layer will learn small local patterns such as edges
- A second convolution layer will learn larger patterns made of the features of the first layers, and so on

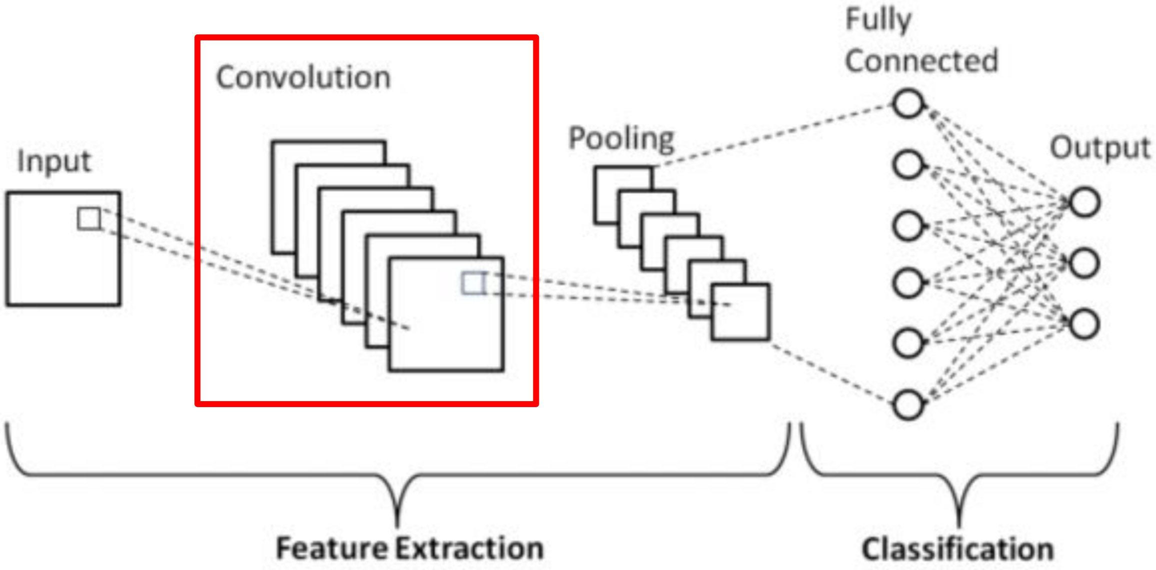


3.

Basic CNN architecture

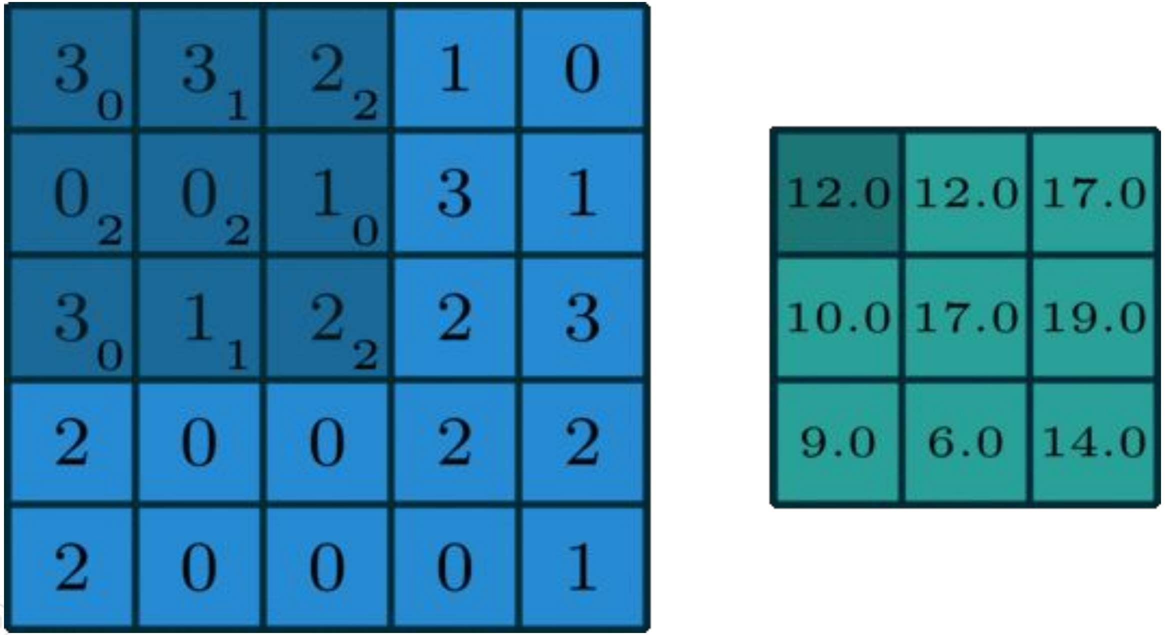
Kernel and pooling

Basic CNN architecture



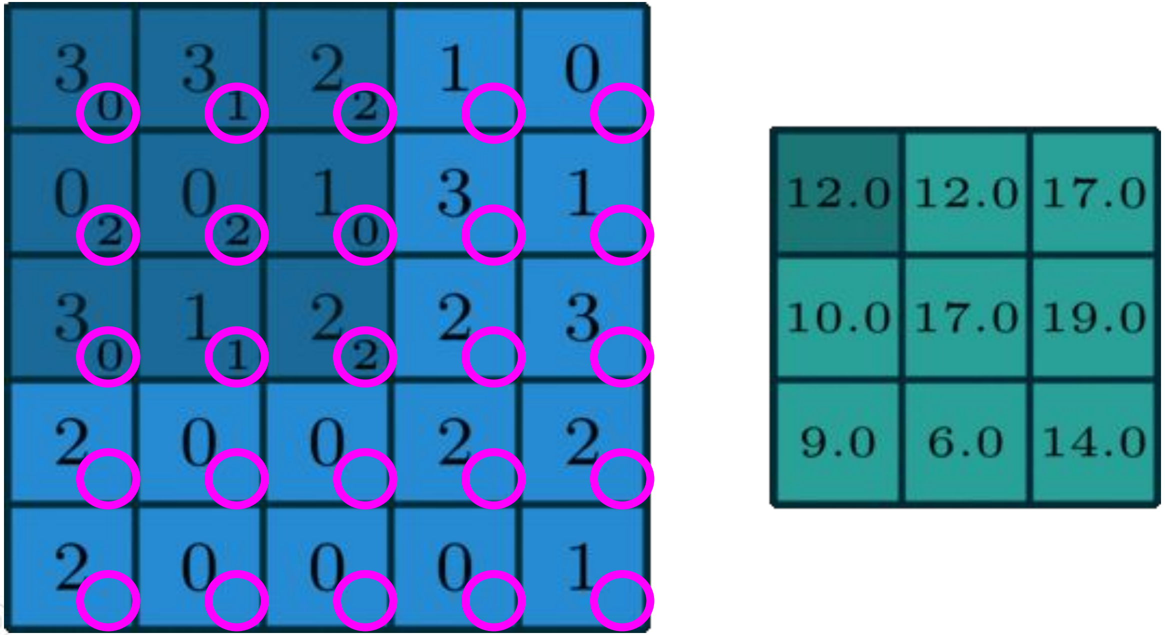
Convolution

2D convolution is a **dot product** between an image (nxn matrix) and a **kernel** (3x3)



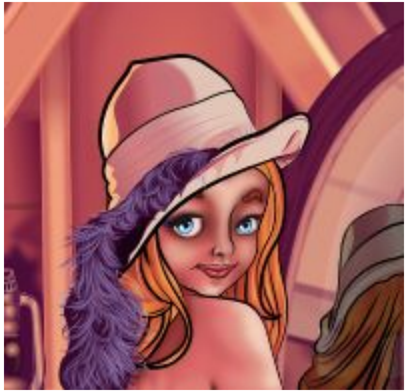
Convolution

2D convolution is a **dot product** between an image (nxn matrix) and a **kernel** (3x3)



Common 2D convolution

Edge detector



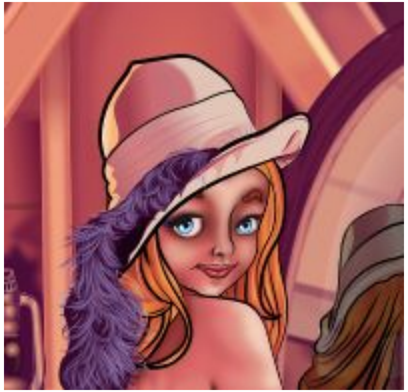
Kernel

$$\begin{vmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{vmatrix}$$

https://planetcalc.com/9313/

Common 2D convolution

Sharpening

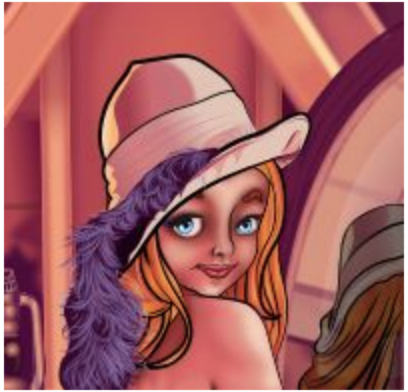


Kernel

$$\begin{vmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{vmatrix}$$

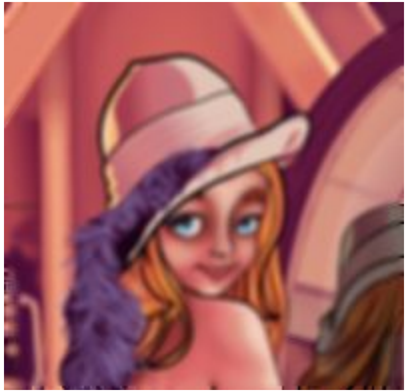
Common 2D convolution

Gaussian



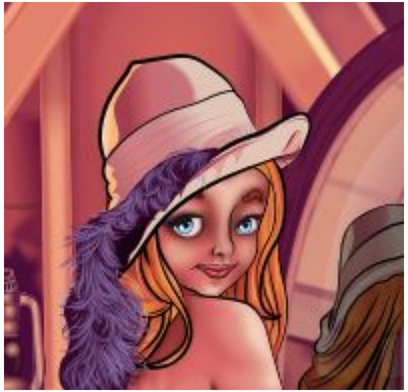
Kernel

$$\begin{vmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 5 & 4 & 2 \\ 3 & 5 & 6 & 5 & 3 \\ 2 & 4 & 5 & 4 & 2 \\ 1 & 2 & 3 & 2 & 1 \end{vmatrix}$$



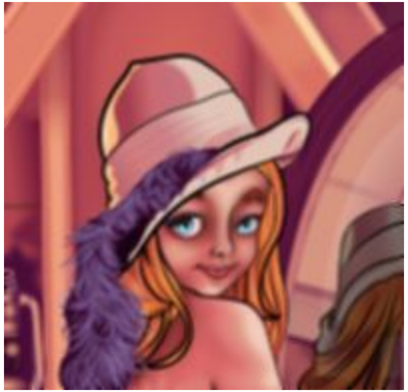
Common 2D convolution

Smoothing



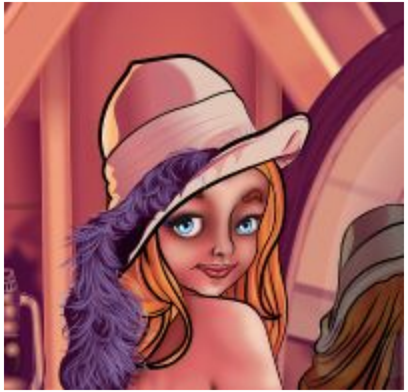
Kernel

$$\begin{vmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{vmatrix}$$



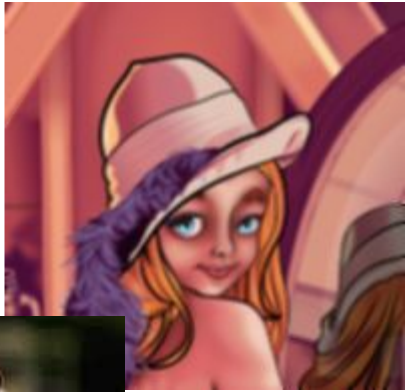
Common 2D convolution

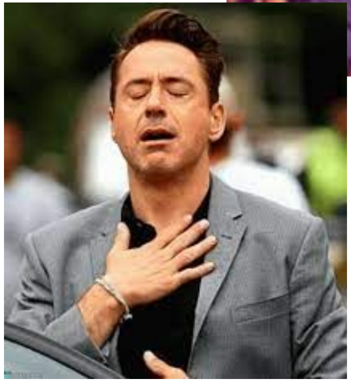
Smoothing



Kernel

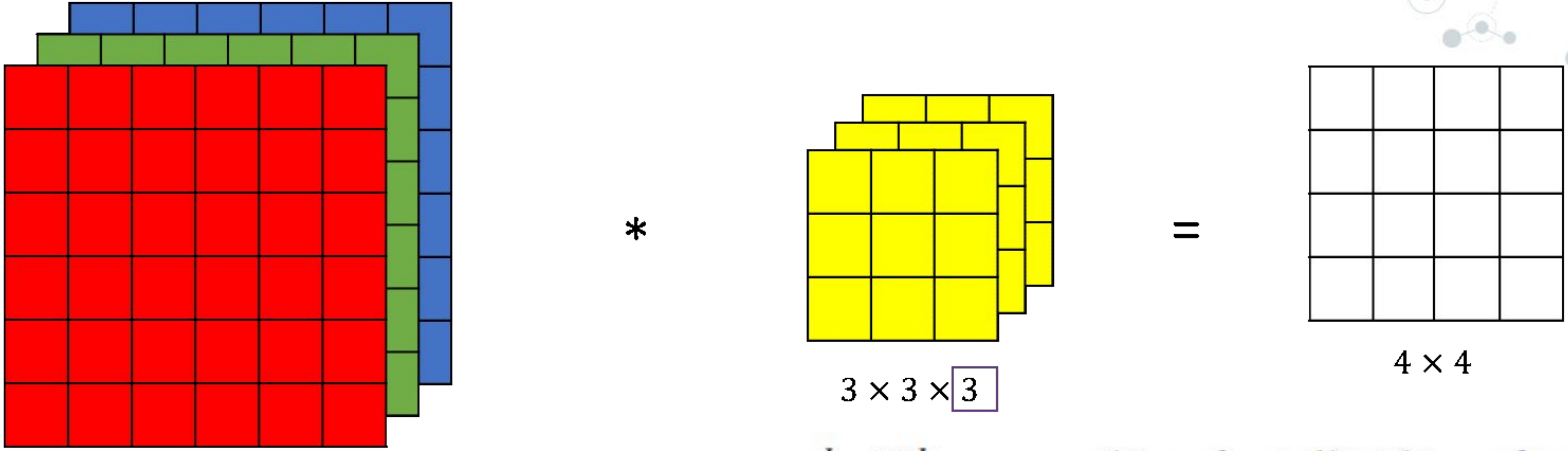
$$\begin{vmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{vmatrix}$$





Don’t worry! The CNN will learn the kernels!

Convolutions on RGB image



$6 \times 6 \times \boxed{3}$

$n_h \times n_w$

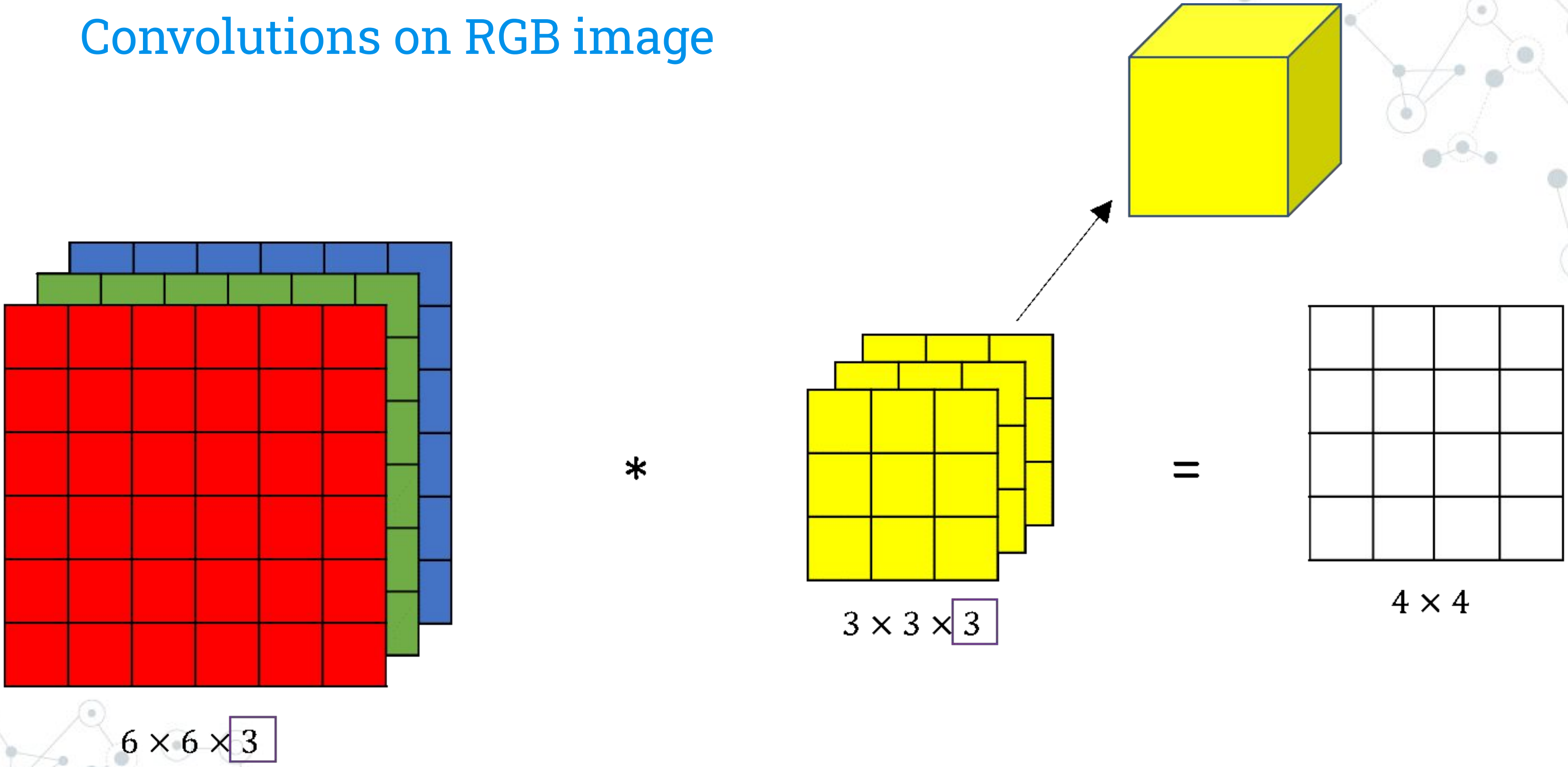
$3 \times 3 \times \boxed{3}$

$k_h \times k_w$

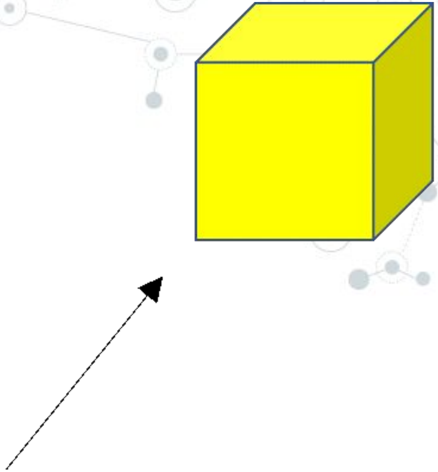
4×4

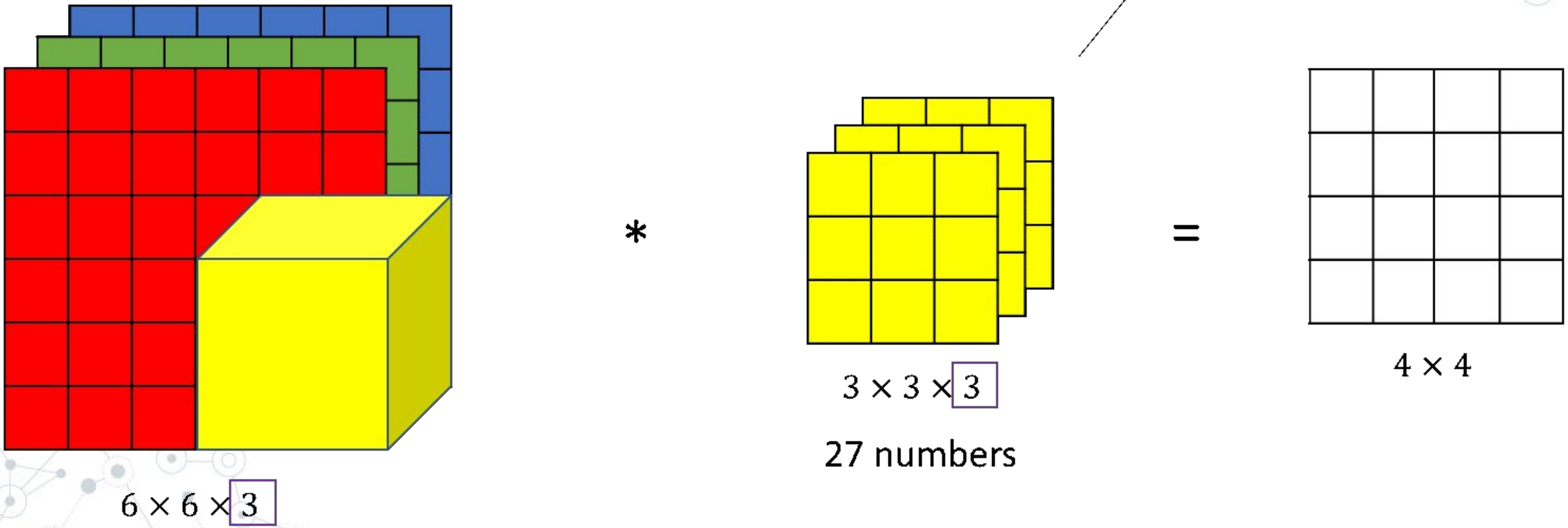
$(n_h - k_h + 1) \times (n_w - k_w + 1).$

Convolutions on RGB image

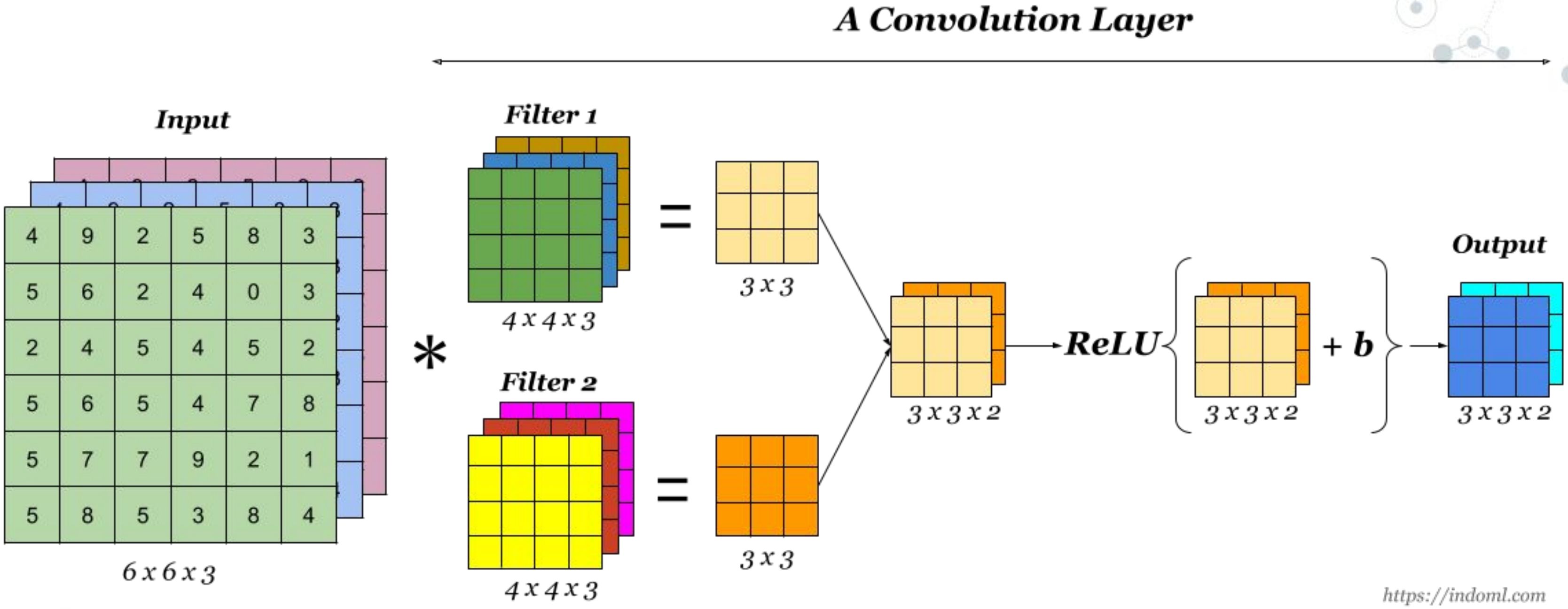


Convolutions on RGB image

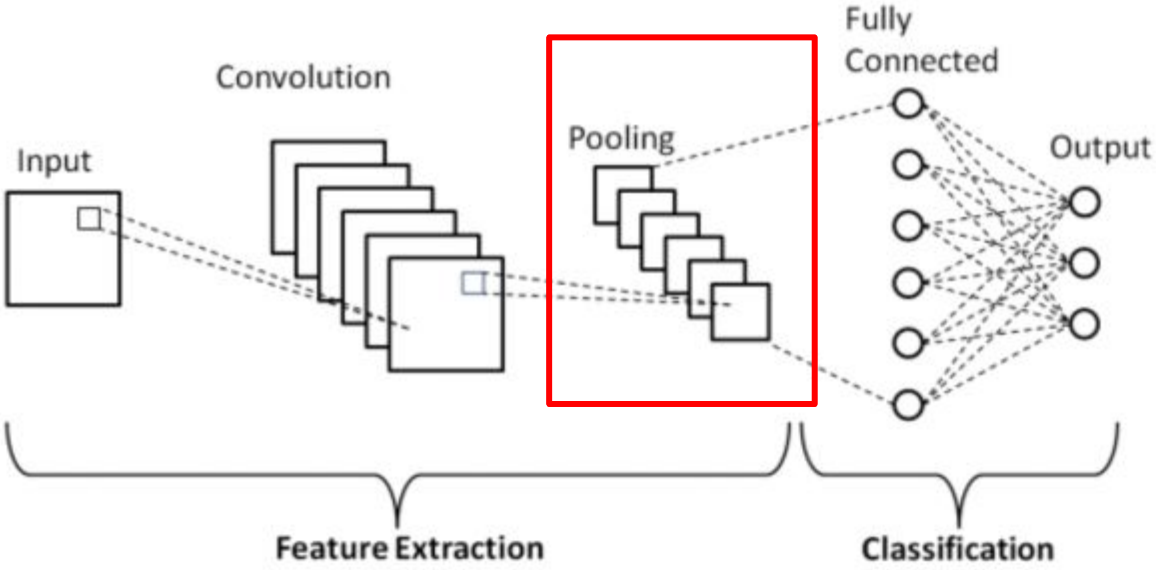




Convolutions on RGB image



Basic CNN architecture



Pooling

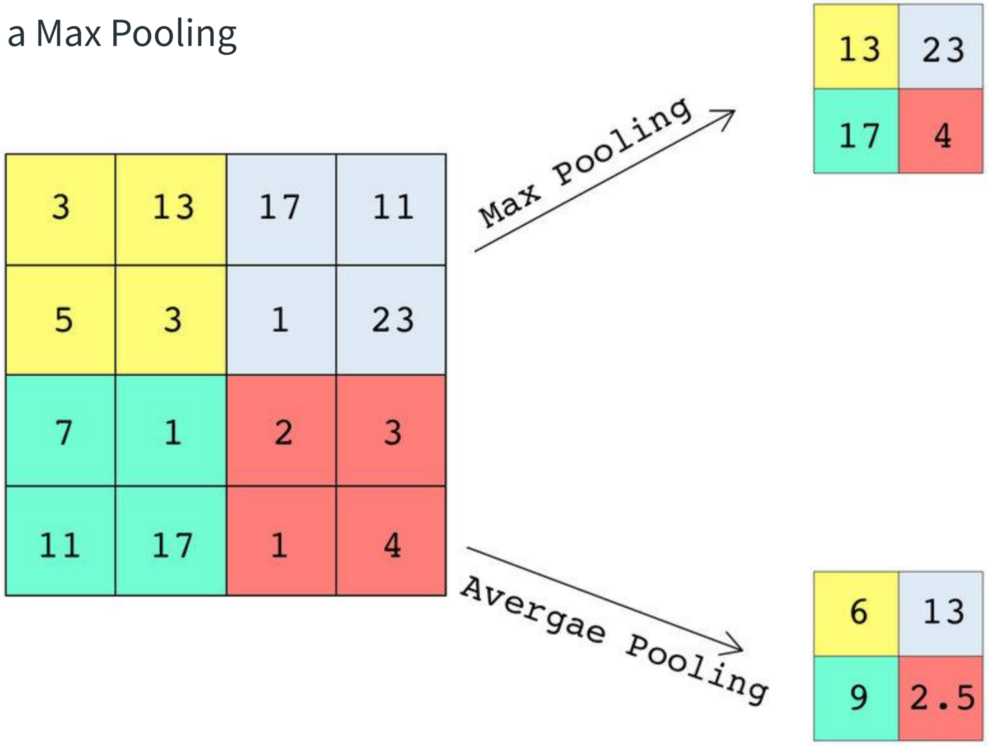
Pooling

Pooling

- Pooling is image compression
- Reduce computation

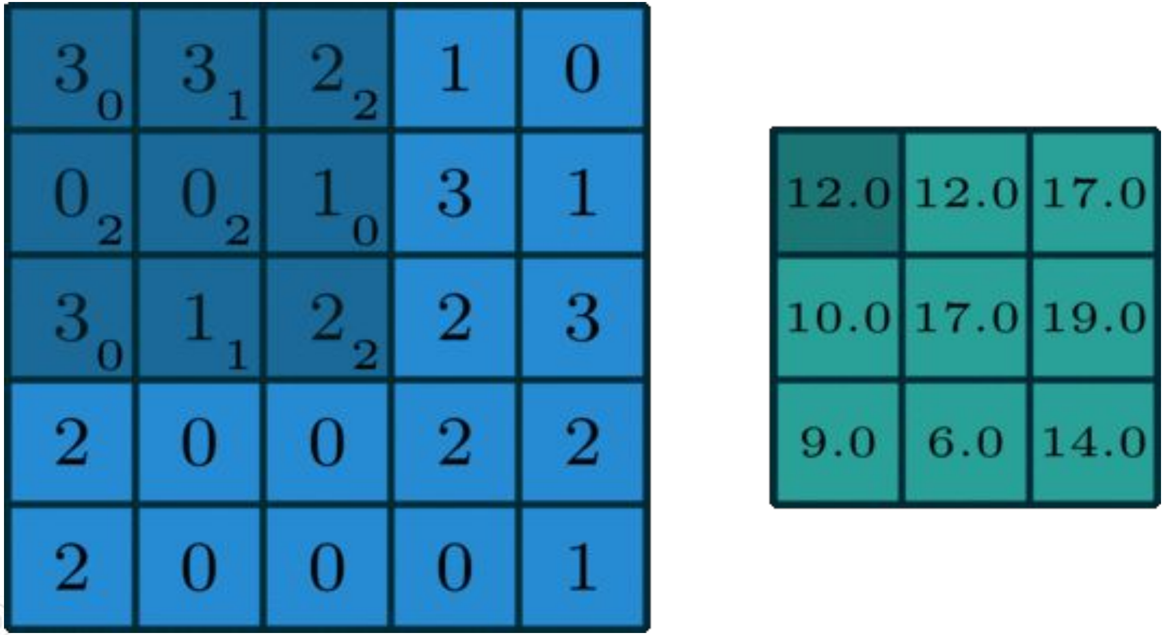
Max pooling and Average pooling

No need to learn a Max Pooling



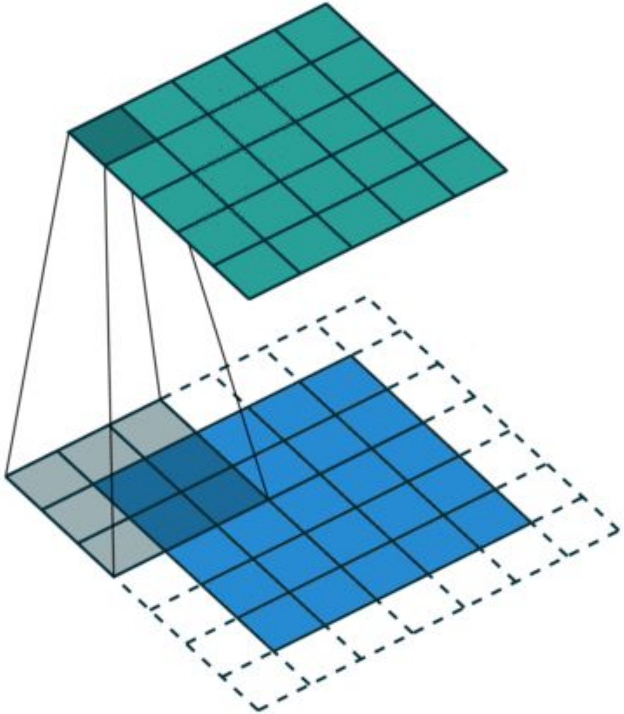
Padding

In general, a 2D convolution reduces the size of the image



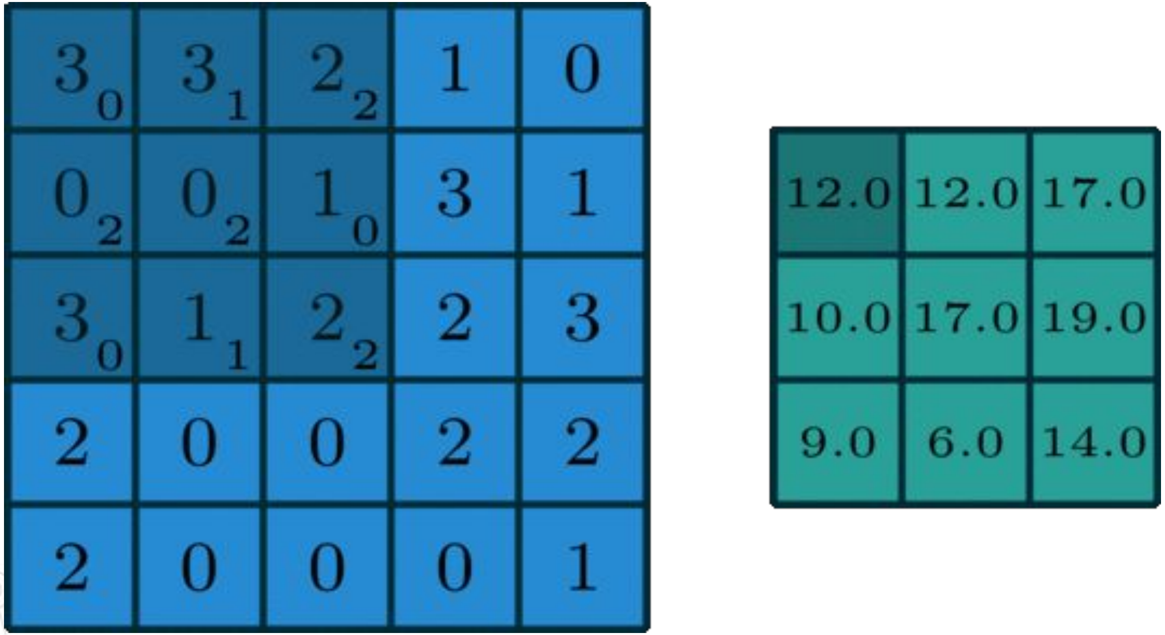
Padding

In general, a 2D convolution reduces the size of the image



Stride

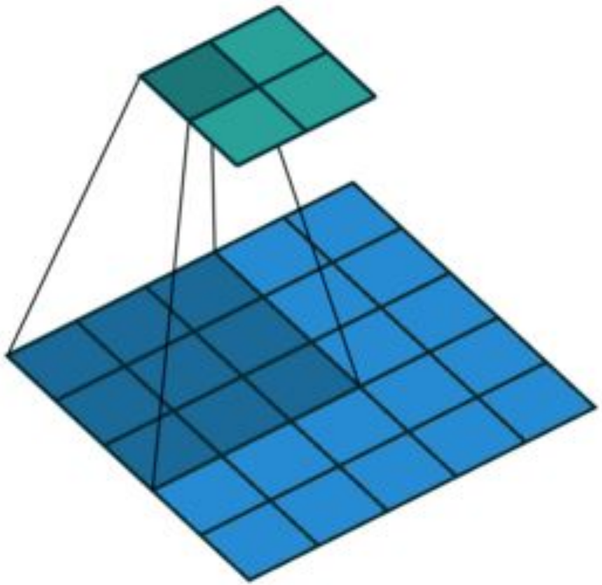
Stride is the number of rows and columns traversed per slide. In general, a 2D convolution the kernel moves 1 row at a time in both directions.



Stride

Stride of 2 vertically and 2 horizontally.

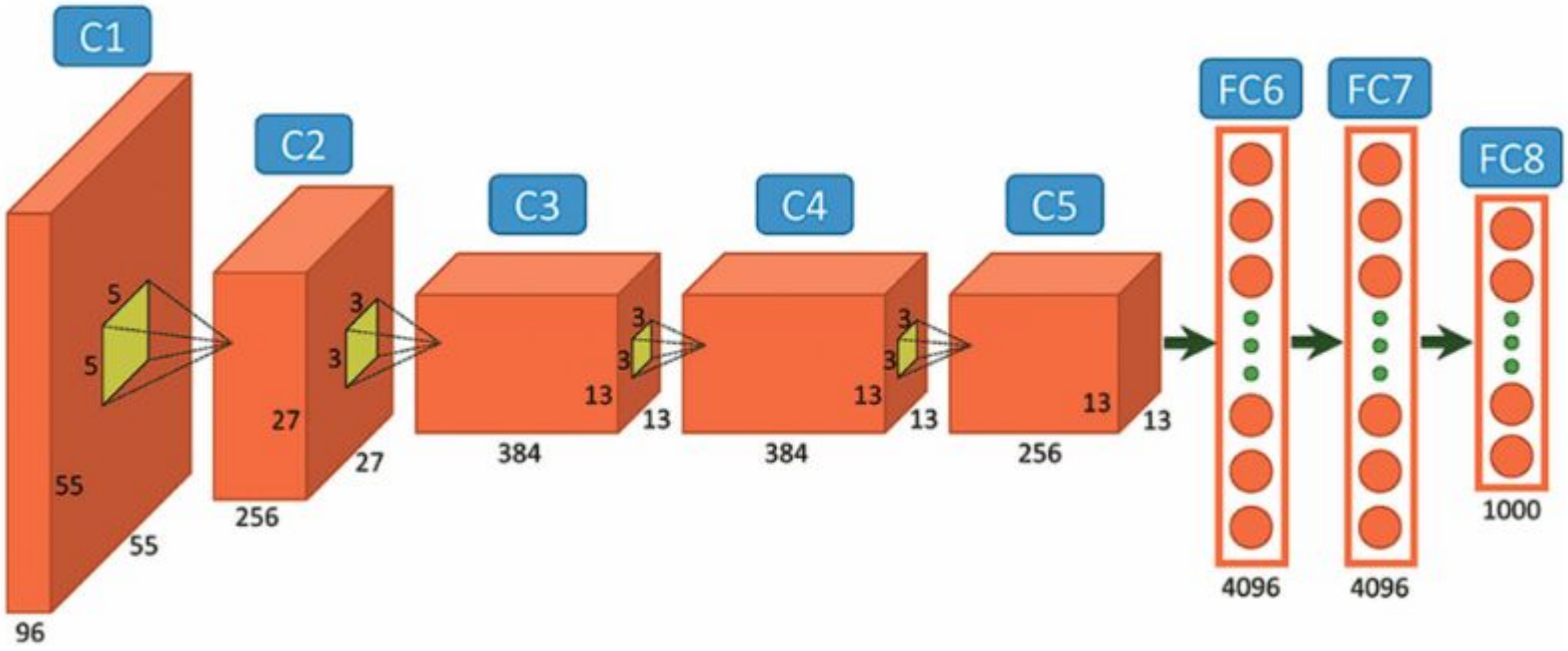
- Computational efficiency
- Downsampling



5.

CNN example

AlexNet



C1
C2
C3
C4
C5
FC6
FC7
FC8
5
5
55
55
96
3
3
27
27
256
13
13
384
384
256
4096
4096
1000

AlexNet

Input Layer

AlexNet takes images of the Input size of 227x227x3 RGB Pixels.

Convolutional Layers

1. First Layer: The first layer uses 96 kernels of size 11×11 with a stride of 4, activates them with the ReLU activation function, and then performs a Max Pooling operation.
2. Second Layer: The second layer takes the output of the first layer as the input, with 256 kernels of size 5x5x48.
3. Third Layer: 384 kernels of size 3x3x256. No pooling or normalization operations are performed on the third, fourth, and fifth layers.
4. Fourth Layer: 384 kernels of size 3x3x192.
5. Fifth Layer: 256 kernels of size 3x3x192.

Fully Connected Layers

The fully connected layers have 4096 neurons each.

Output Layer

The output layer is a SoftMax layer that outputs probabilities of the 1000 class labels.

6.

CNN in Keras

Keras

Listing 8.1 Instantiating a small convnet

```
from tensorflow import keras
from tensorflow.keras import layers
inputs = keras.Input(shape=(28, 28, 1))
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(inputs)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(10, activation="softmax")(x)
model = keras.Model(inputs=inputs, outputs=outputs)
```

7.

Colab Notebook

Colab Notebook

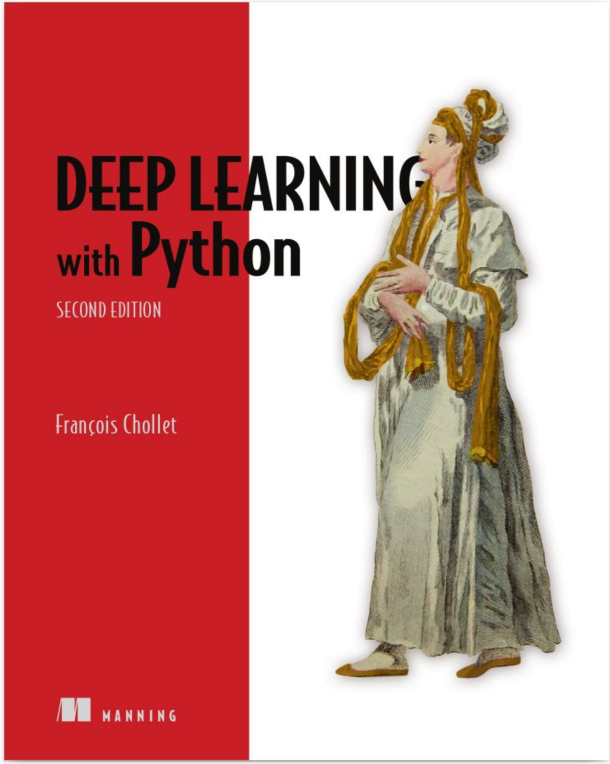
Chapter 8, Introduction to deep learning for computer vision:

https://colab.research.google.com/drive/1OzwUDL9eVLi13tw2jVpsMWcIgMFeFSFr

8.

The book

Deep Learning with Python, 2nd Ed. by Francois Chollet



- Chapter 8

Thanks!

Any questions?