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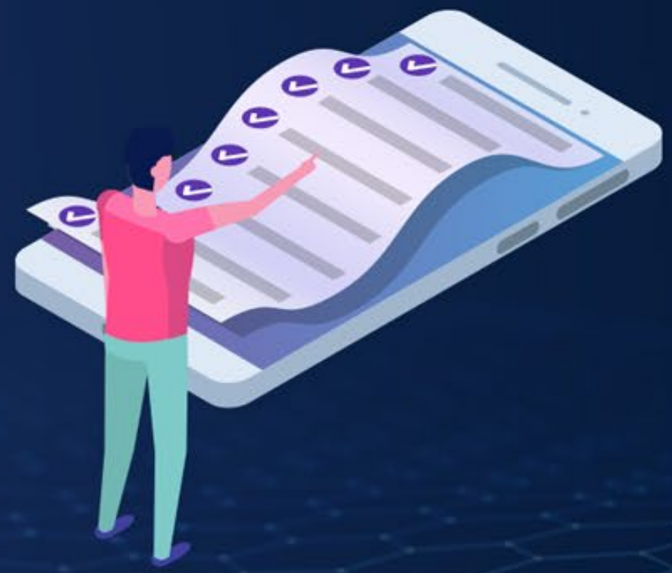
Deep Learning with Keras with TensorFlow

Convolutional Neural Net (CNN)

Learning Objectives

By the end of this lesson, you will be able to:

- Implement CNN architecture
- Implement Deep CNN
- Optimize CNNs using pooling layers



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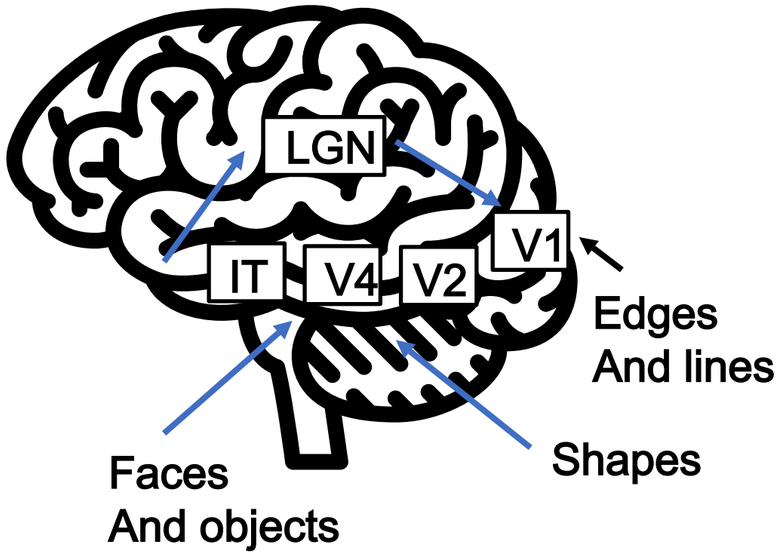
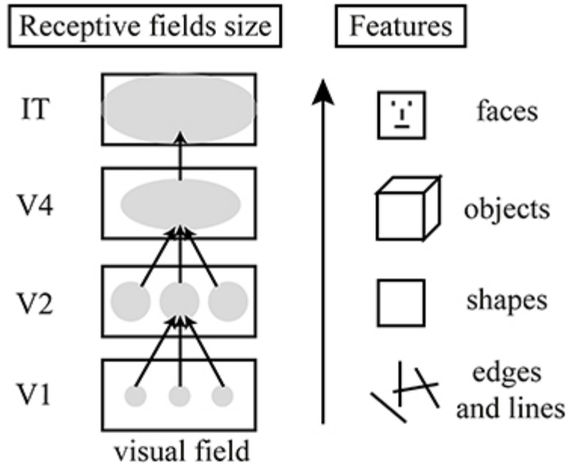
Success and History

Human Visual and CNN





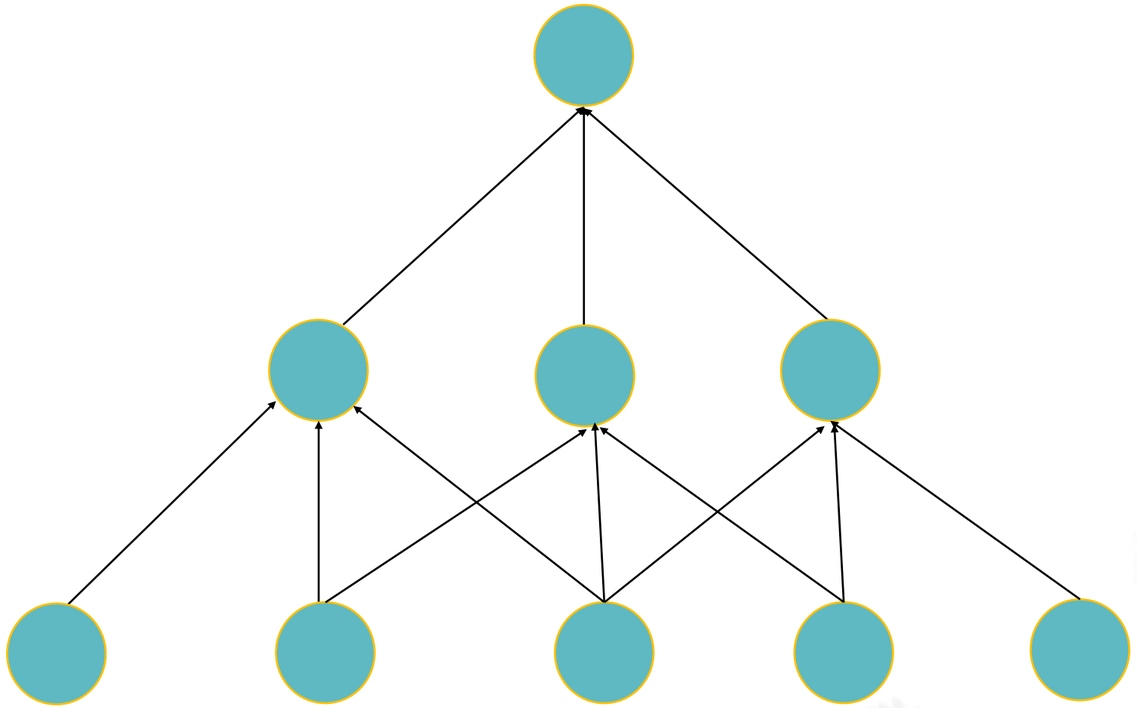
- The idea of CNNs was neurobiologically motivated by the findings of locally-sensitive and orientation-selective nerve cells in the visual cortex.
- Inventors of CNN designed a network structure that implicitly extracts relevant features.
- Convolutional Neural Networks are a special kind of multilayer neural networks.

History of CNN

*In 1995, **Yann LeCun**, professor of computer science at the New York University, introduced the concept of convolutional neural networks.*

The Core Idea Behind CNN

- Local Connections
- Layering
- Spatial Invariance



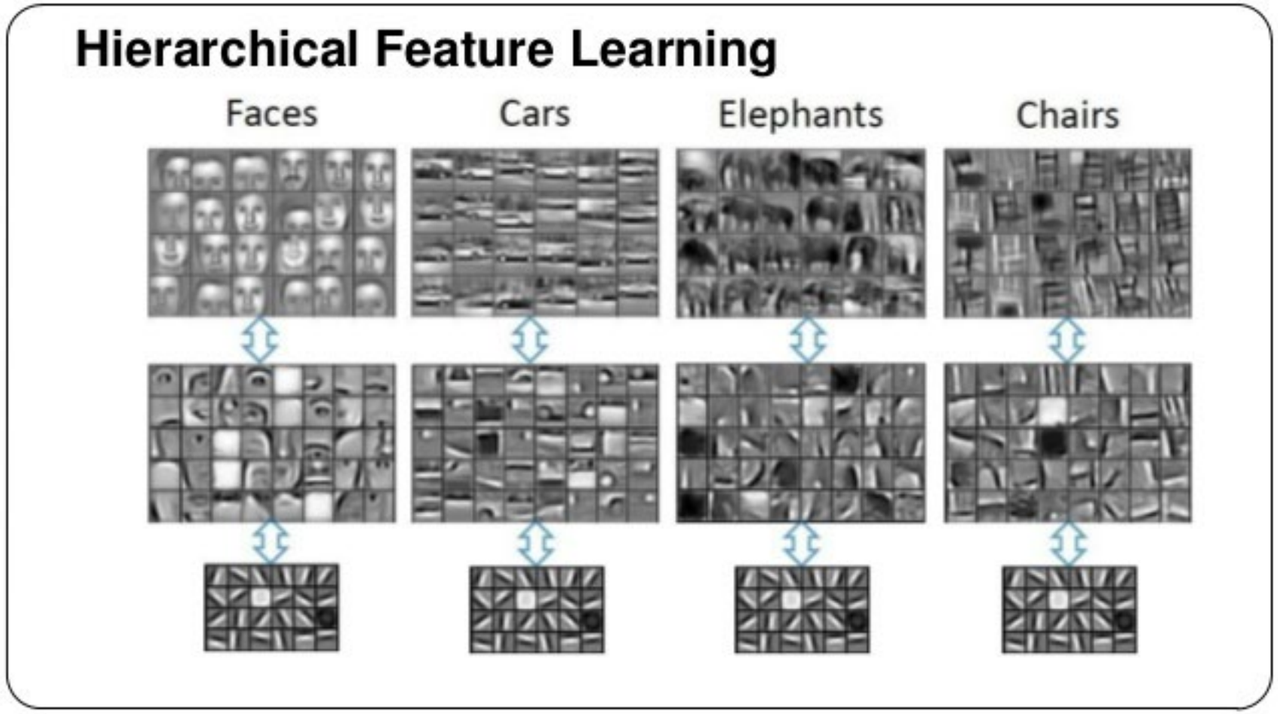
Represent how each set of neurons in a cluster is connected to each other, which in turn represents a set of features

The Core Idea Behind CNN

Local Connections

Layering

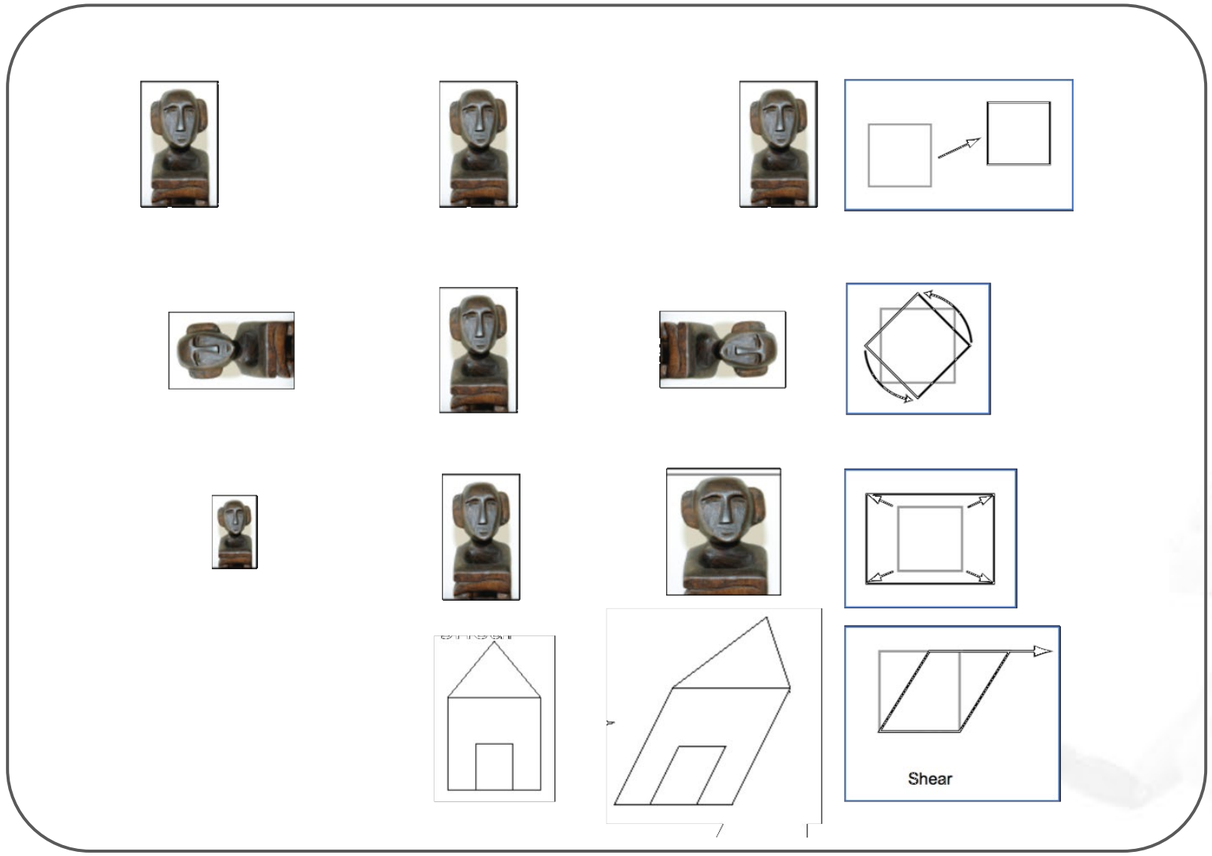
Spatial Invariance



Represents the hierarchy in features that are learned

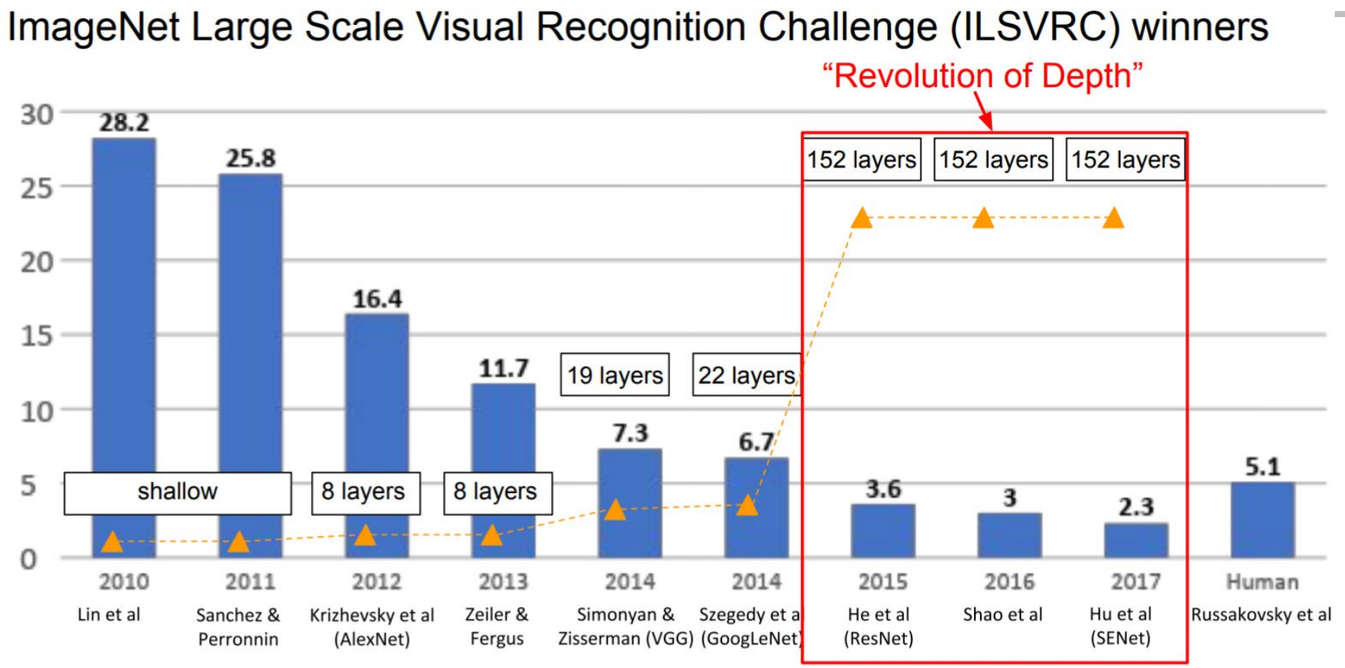
The Core Idea Behind CNN

- Local Connections
- Layering
- **Spatial Invariance**



Represents the capability of CNNs to learn abstractions invariant of size, contrast, rotation, and variation

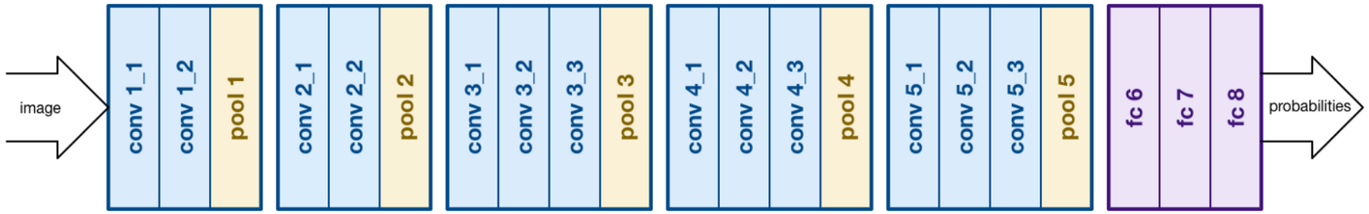
Few Popular CNNs



- LeNet, 1998
- AlexNet, 2012
- VGGNet, 2014
- ResNet, 2015

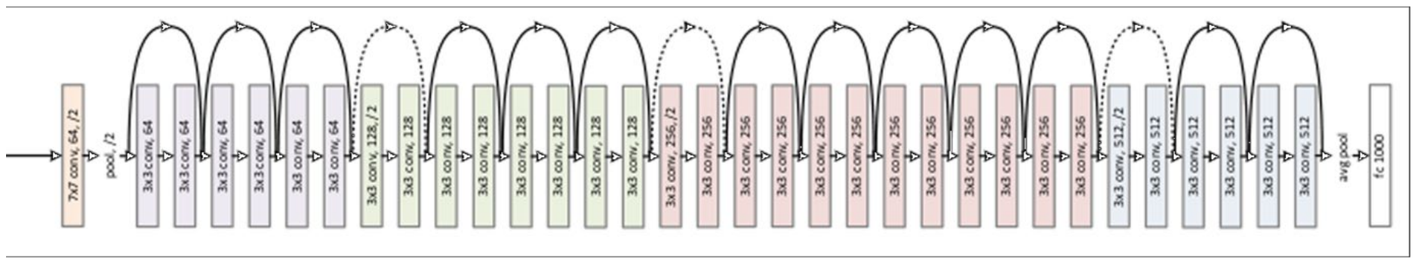
CNN Architectures

VGGNet



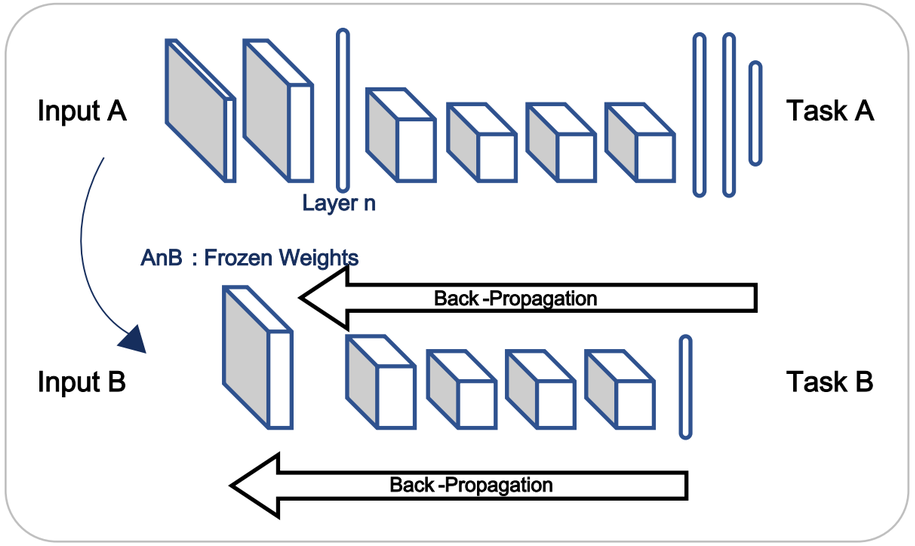
- 16 layers
- Only 3*3 convolutions
- 138 million parameters

ResNet

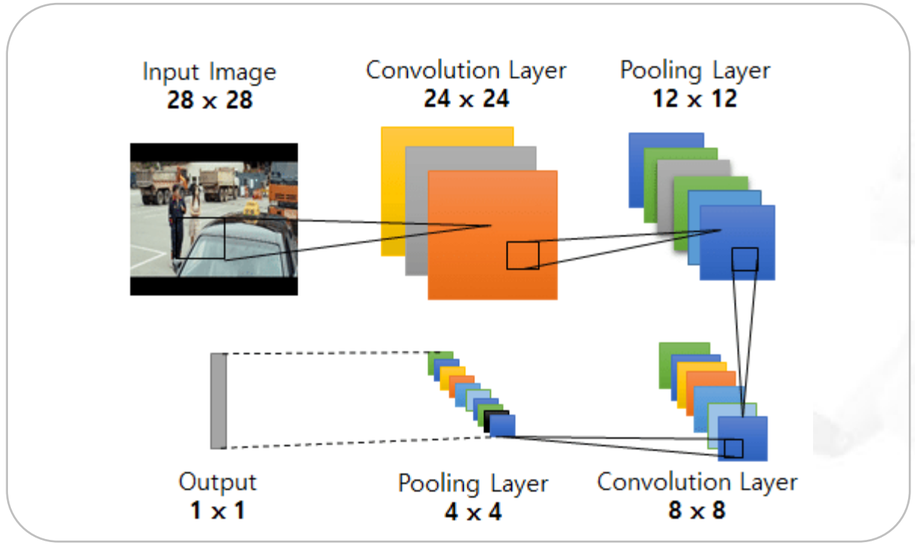


- 152 layers
- ResNet50

CNN Applications



Transfer Learning and Fine Tuning



Feature Extraction

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Working of CNNs

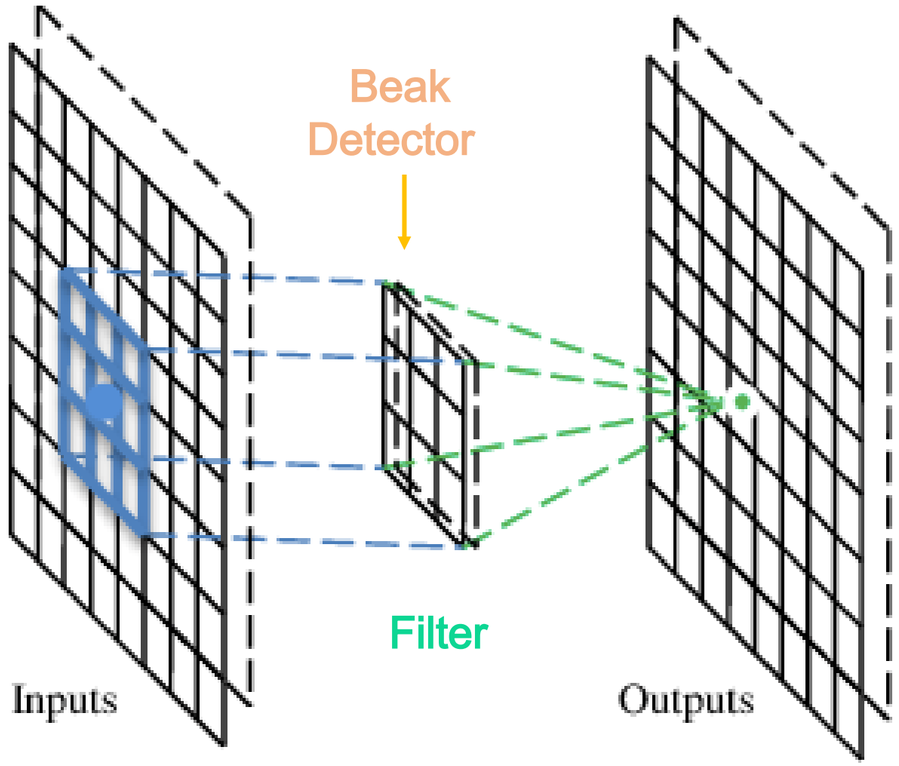
Learning an Image

CNN focuses on smaller and specific patterns than the whole image.

It's convenient and effective to represent a smaller region with fewer parameters, thereby reducing computational complexity.

The Convolutional Layer

A CNN is a neural network with convolutional layers (and other layers). A convolutional layer has several filters that perform the convolution operation.



The Convolution Operation

Consider a 6x6 image convolved with 3x3 filter(s) to give an output of size 4x4.

1	0	0	0	0	1
0	1	0	0	1	0
0	0	1	1	0	0
1	0	0	0	1	0
0	1	0	0	1	0
0	0	1	0	1	0

6 x 6 image

*

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

Filter 1

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

Filter 2

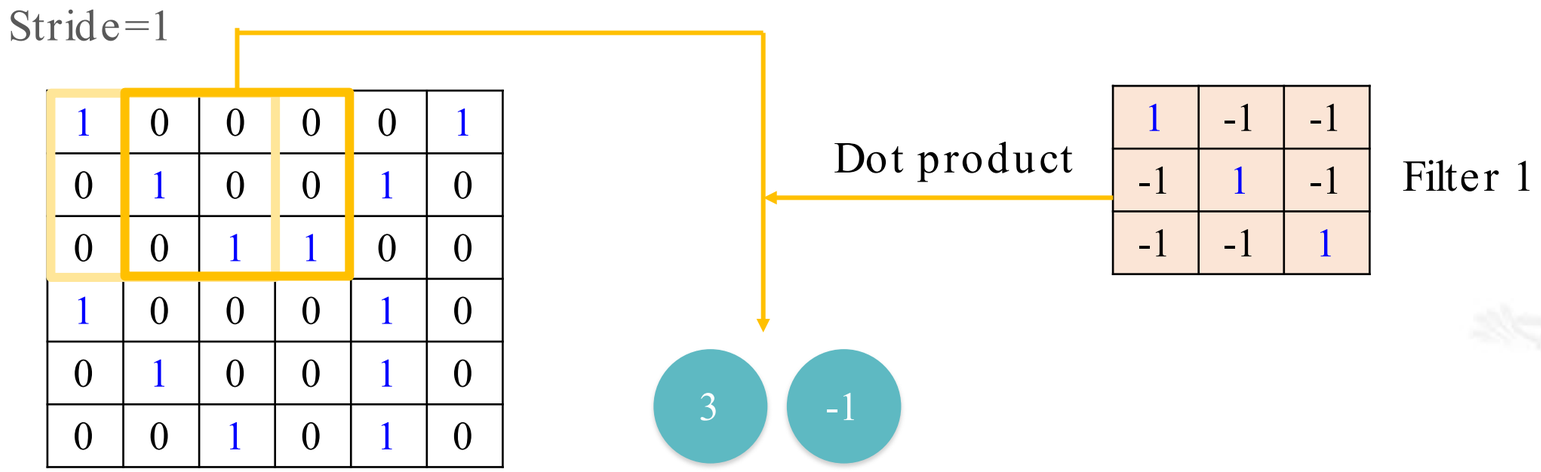
⋮ ⋮

Each filter detects a small pattern (3 x 3)

Note: Filters can be considered network parameters to be learned.

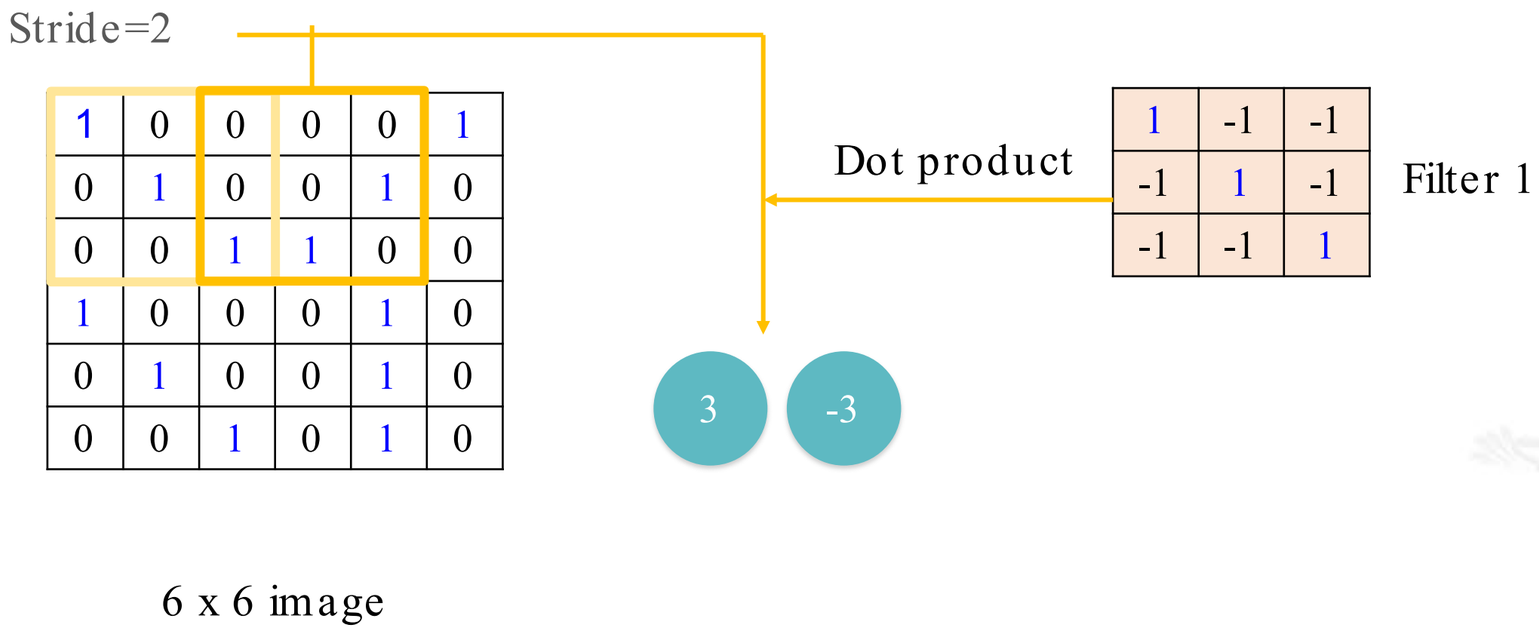
The Convolution Operation

Shift the filter around the input matrix (commonly known as stride) once a convolved output is achieved.



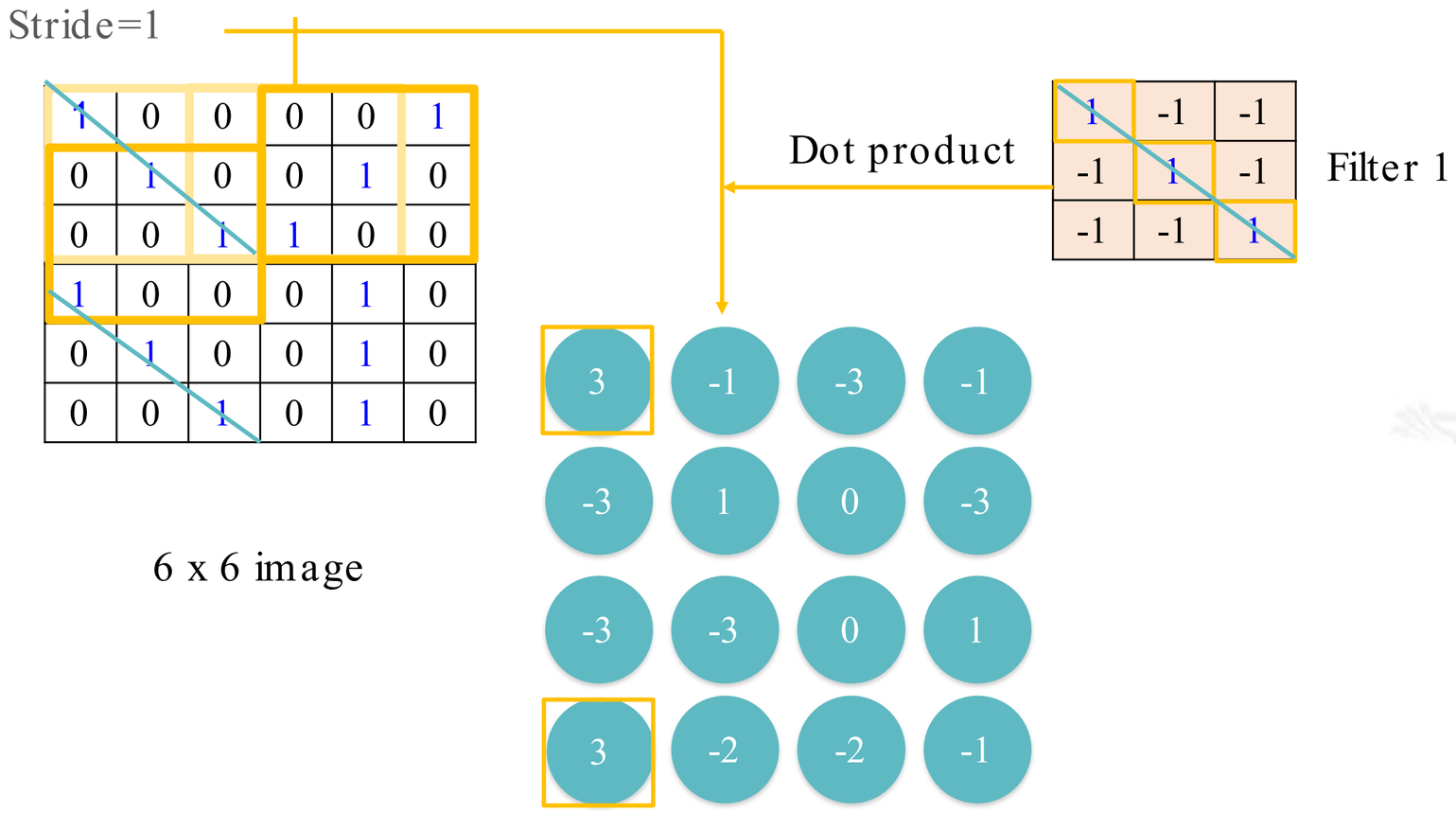
6 x 6 image

The Convolution Operation



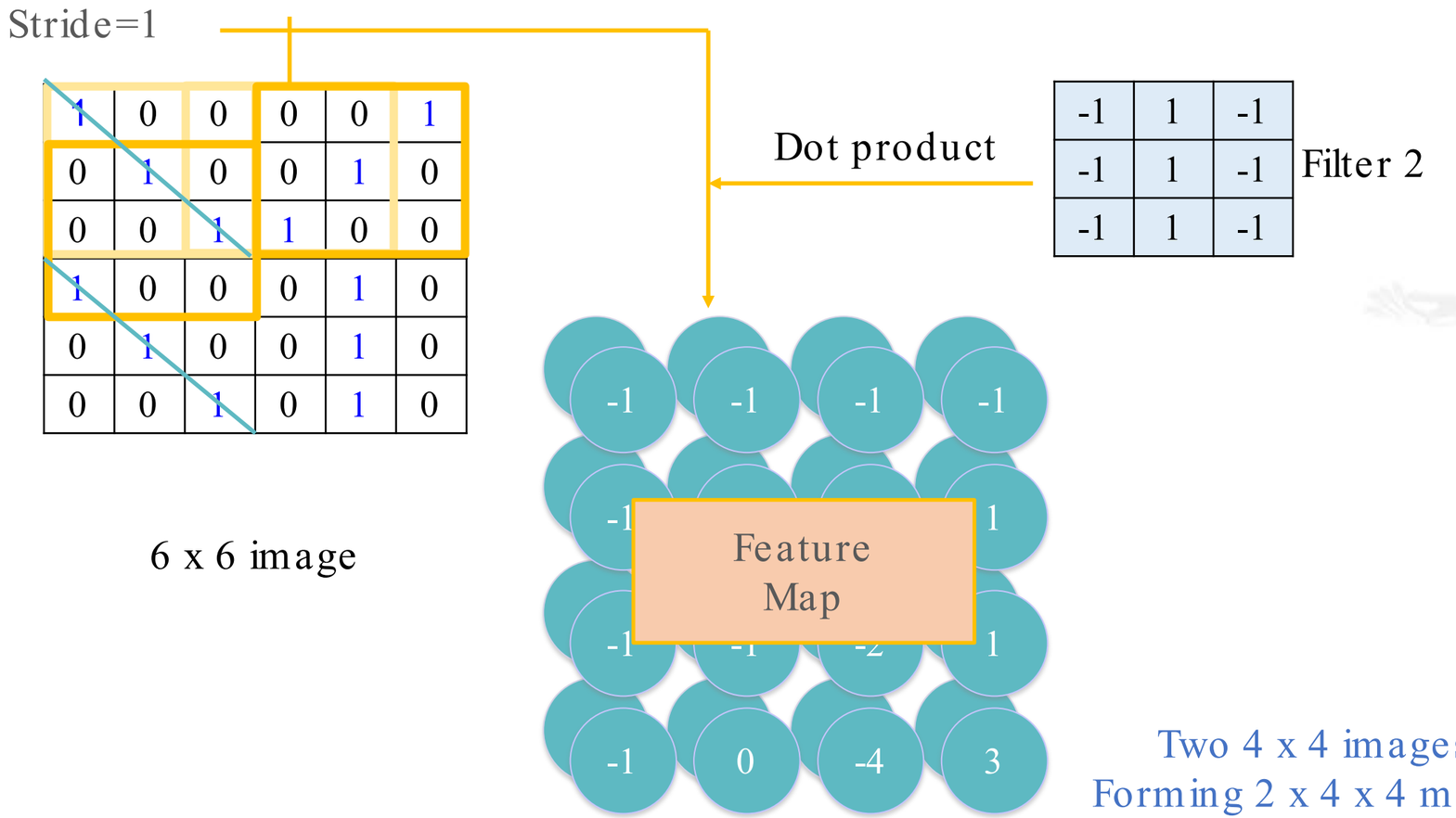
Note: If you change the stride size, the convolved output will vary (only outputting intense pixels).

The Convolution Operation



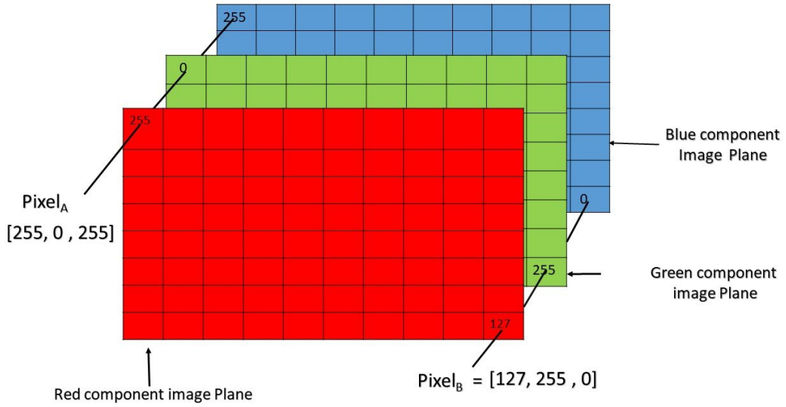
The Convolution Operation

The convolution operation gets repeated for each filter resulting in a feature map.

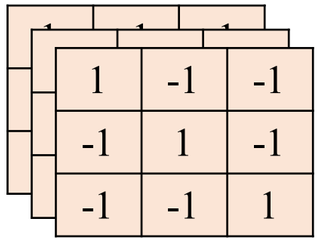


RGB Images

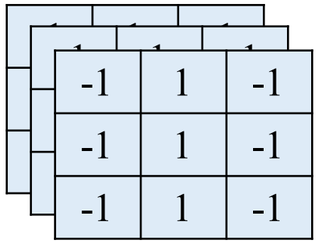
When RGB image is used as input to CNN, the depth of filter is always equal to the depth of image (3 in case of RGB).



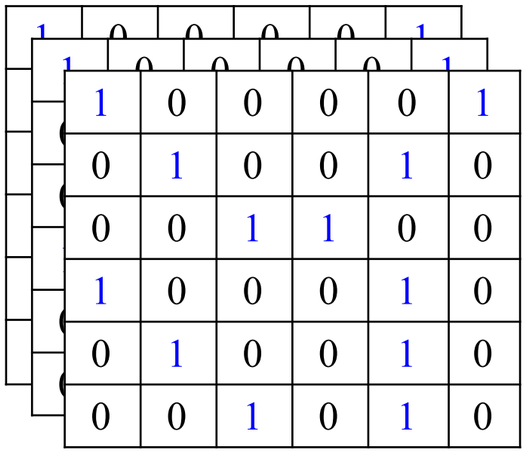
Pixel of an RGB image are formed from the corresponding pixel of the three component images



3-dimensional filter 1



3-dimensional filter 2



CNN

Problem Scenario: Consider the MNIST dataset from the previous lesson wherein, you were hired by one of the major AI giants planning to build the best image classifier model available till date. Also, to do so, you used a multilayered neural network. However, Keras being the most commonly used libraries for deep learning, you would have to use Keras this time.

Objective:

Build a Keras-based image classification model on the MNIST dataset.

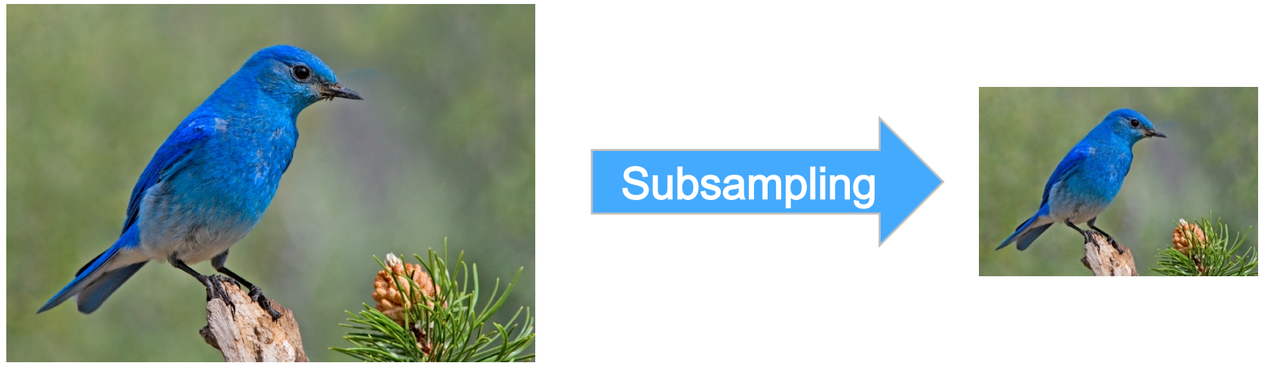
Access: Click the Practice Labs tab on the left panel. Now, click on the START LAB button and wait while the lab prepares itself. Then, click on the LAUNCH LAB button. A full-fledged jupyter lab opens, which you can use for your hands-on practice and projects.

ASSISTED PRACTICE

Pooling

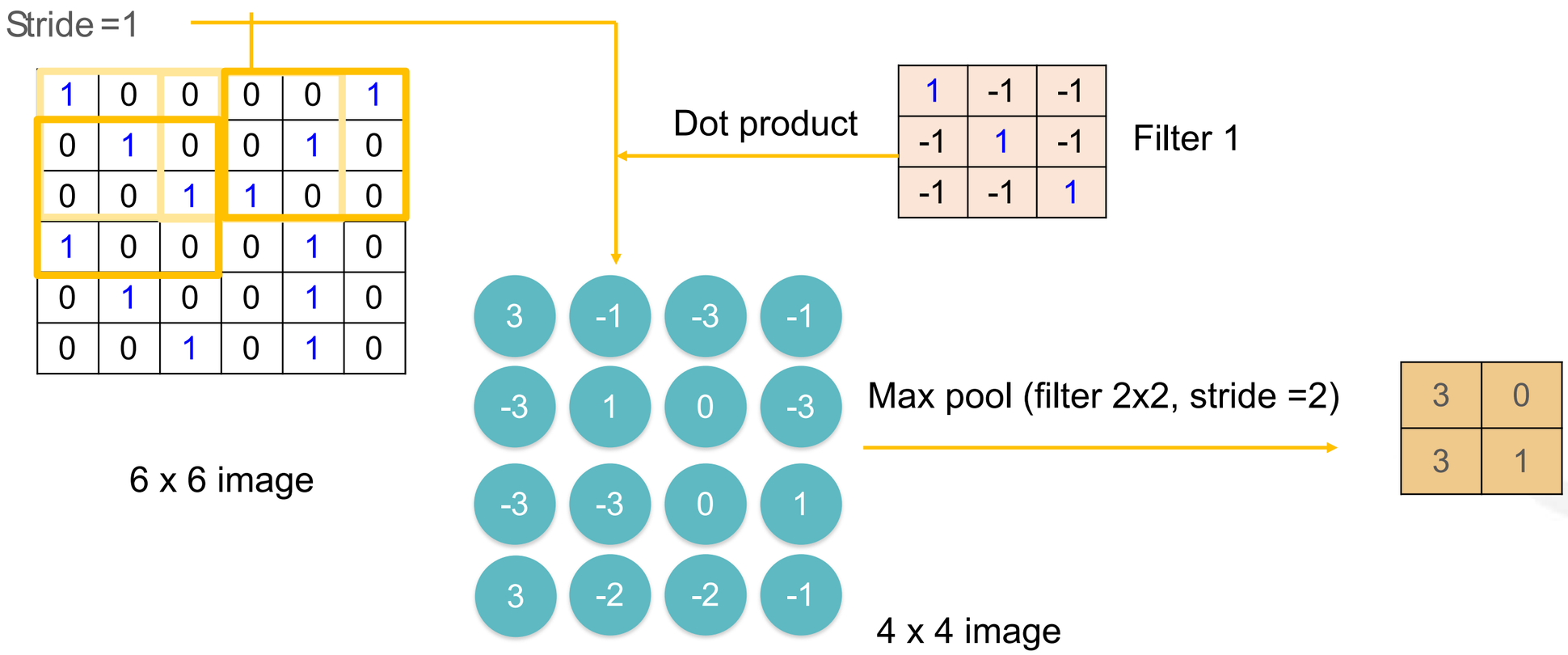
Pooling Layer

The pooling layer gradually reduces the spatial size of each matrix within the feature map such that the amount of parameters and computation is reduced in the network.



Note: The most commonly used pooling approach is max pooling.

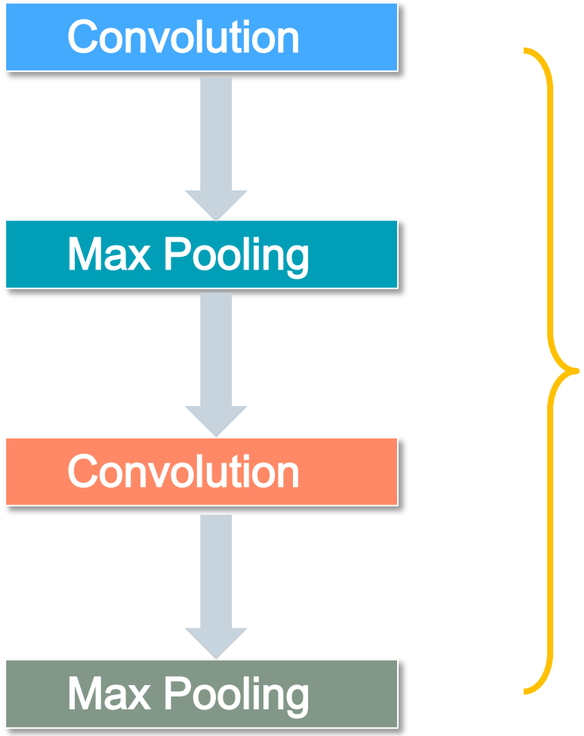
Pooling Layer



Note: The most commonly used pooling approach is max pooling.

The CNN Architecture

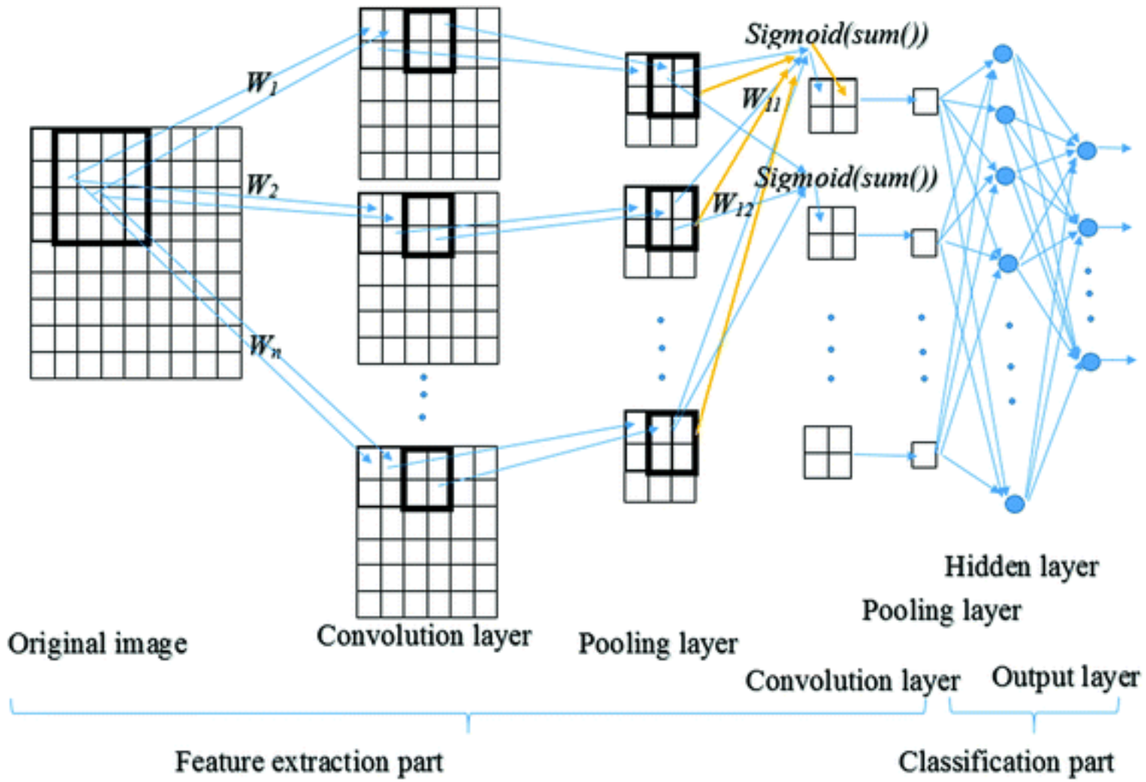
The CNN architecture comprises multiple combinations of convolution and pooling layers.



Resultant image is smaller than the original image

The CNN Architecture

The reduced image from these layers (convolution + pooling) is then passed through the activation function.



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Convolution vs. Fully -Connected Networks

Convolution vs. Fully -Connected Networks

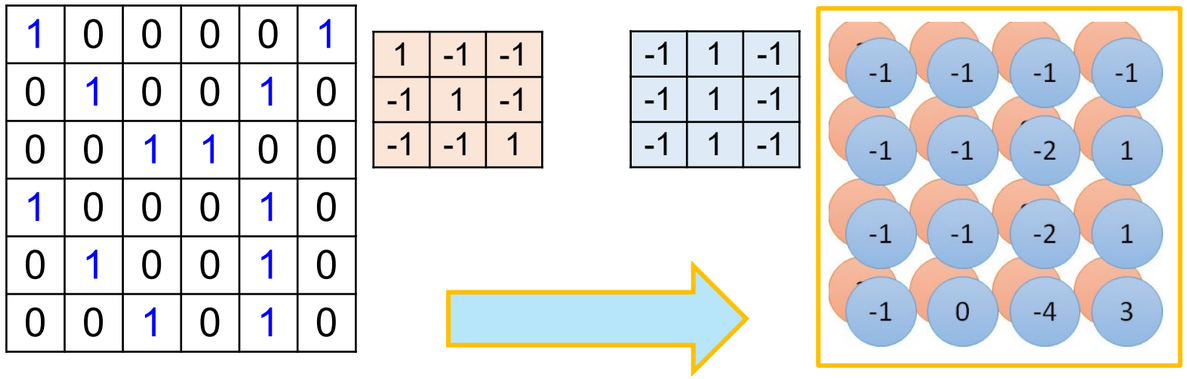
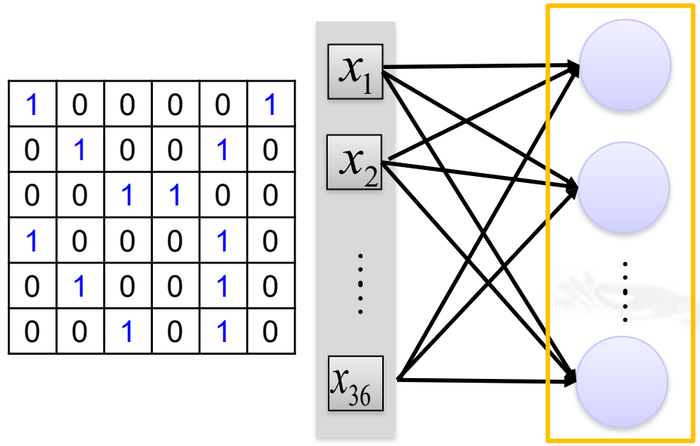


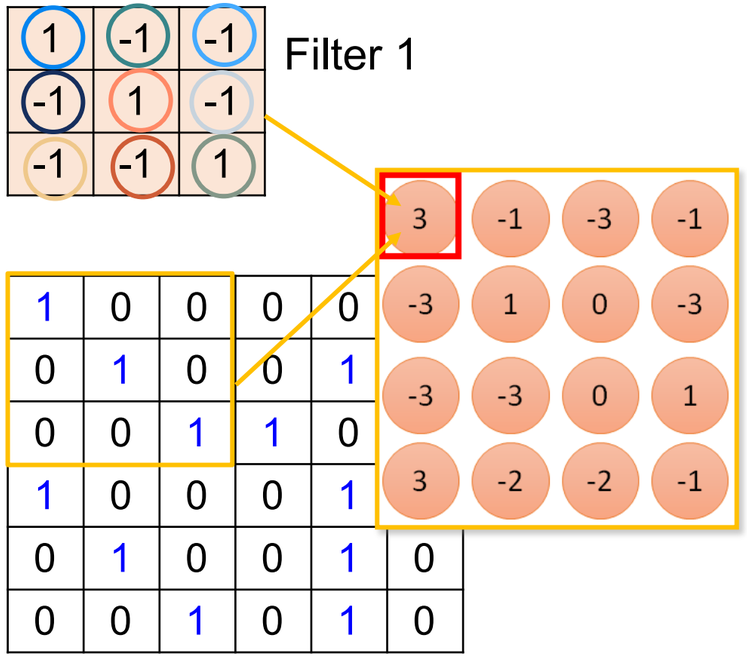
Image Convolution

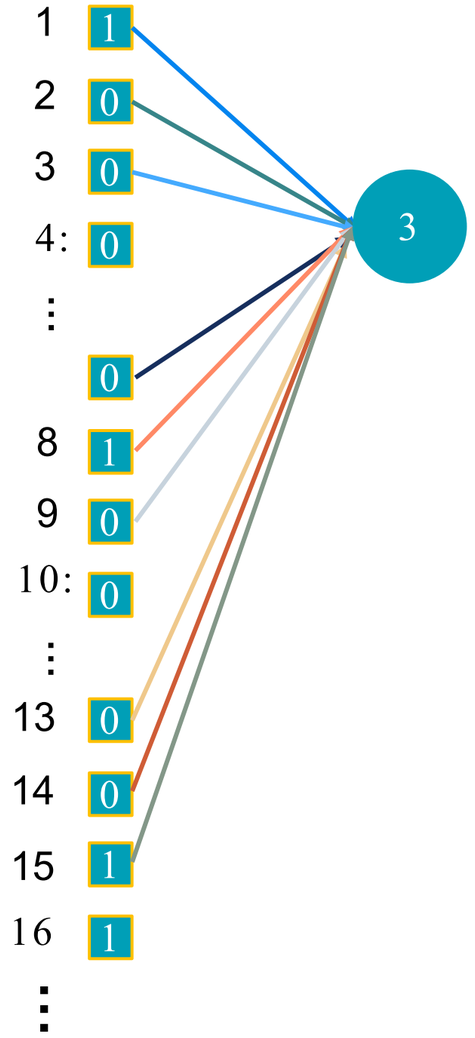


Fully-connected Network

Fewer Parameters

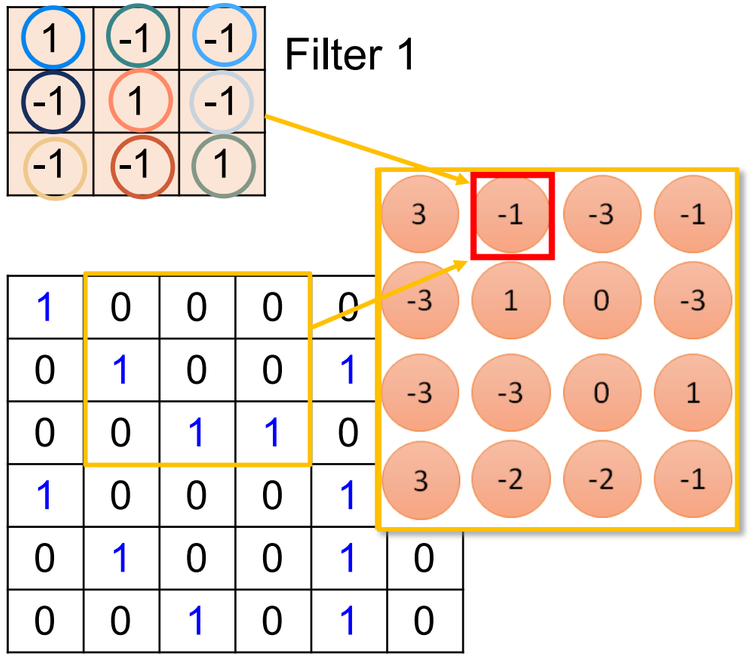
The CNN below is only connected to 9 inputs (not fully connected).

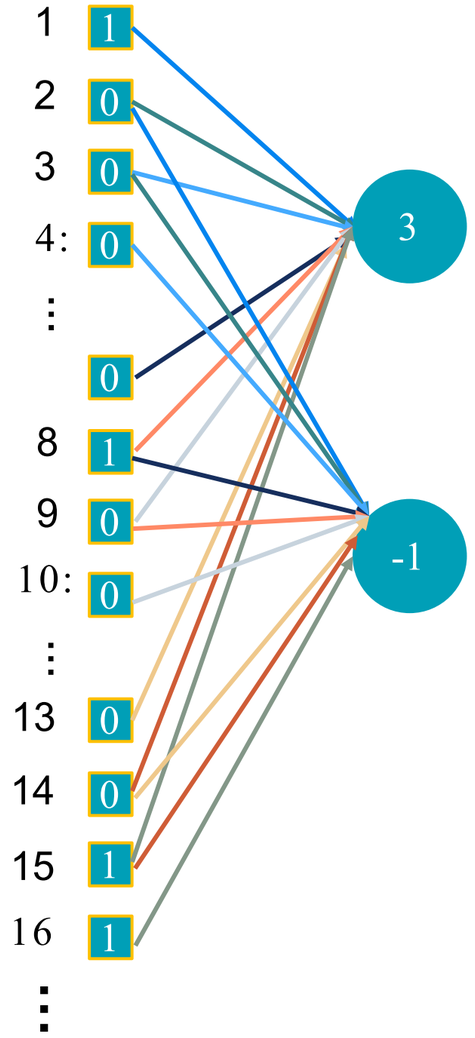




Fewer Parameters

The number of parameters are reduced even further after the first stride.





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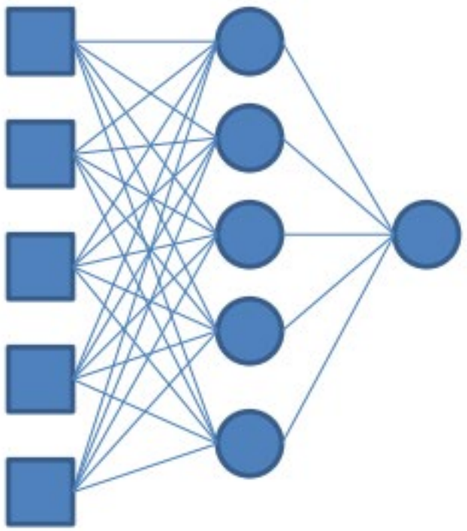
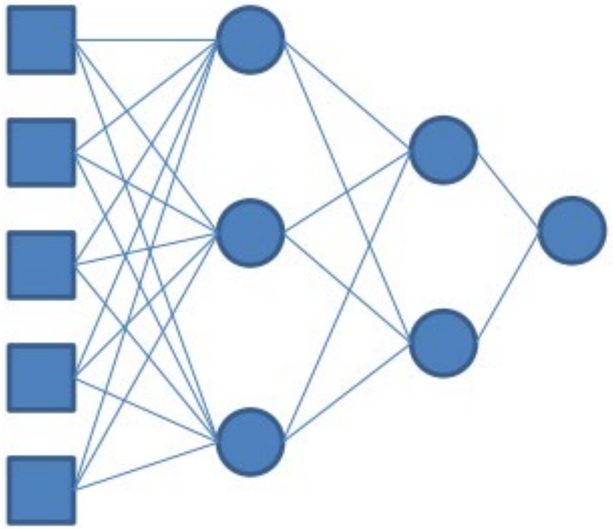
Deep Convolutional Models

Multilayered CNN

Deep nets fine-tune the features learned by the previous layers.

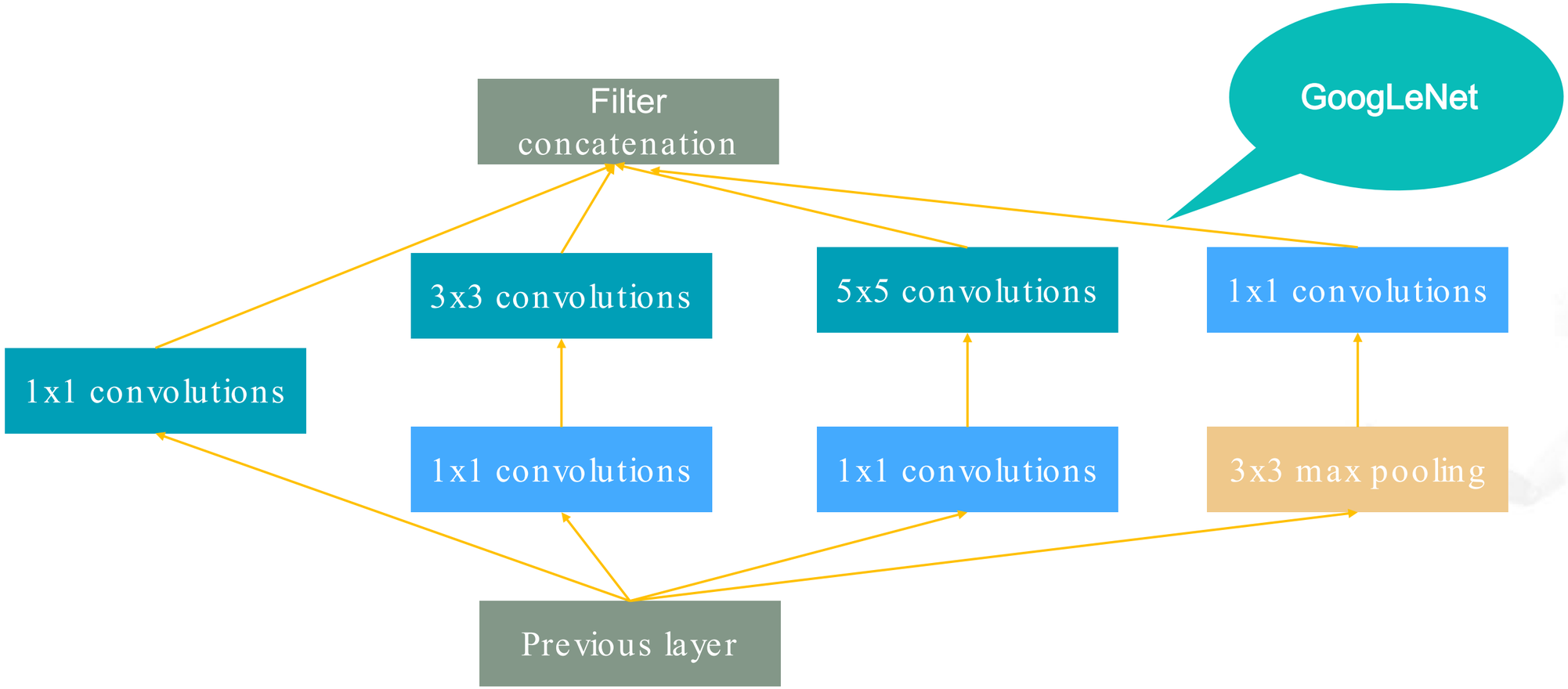


30 parameters



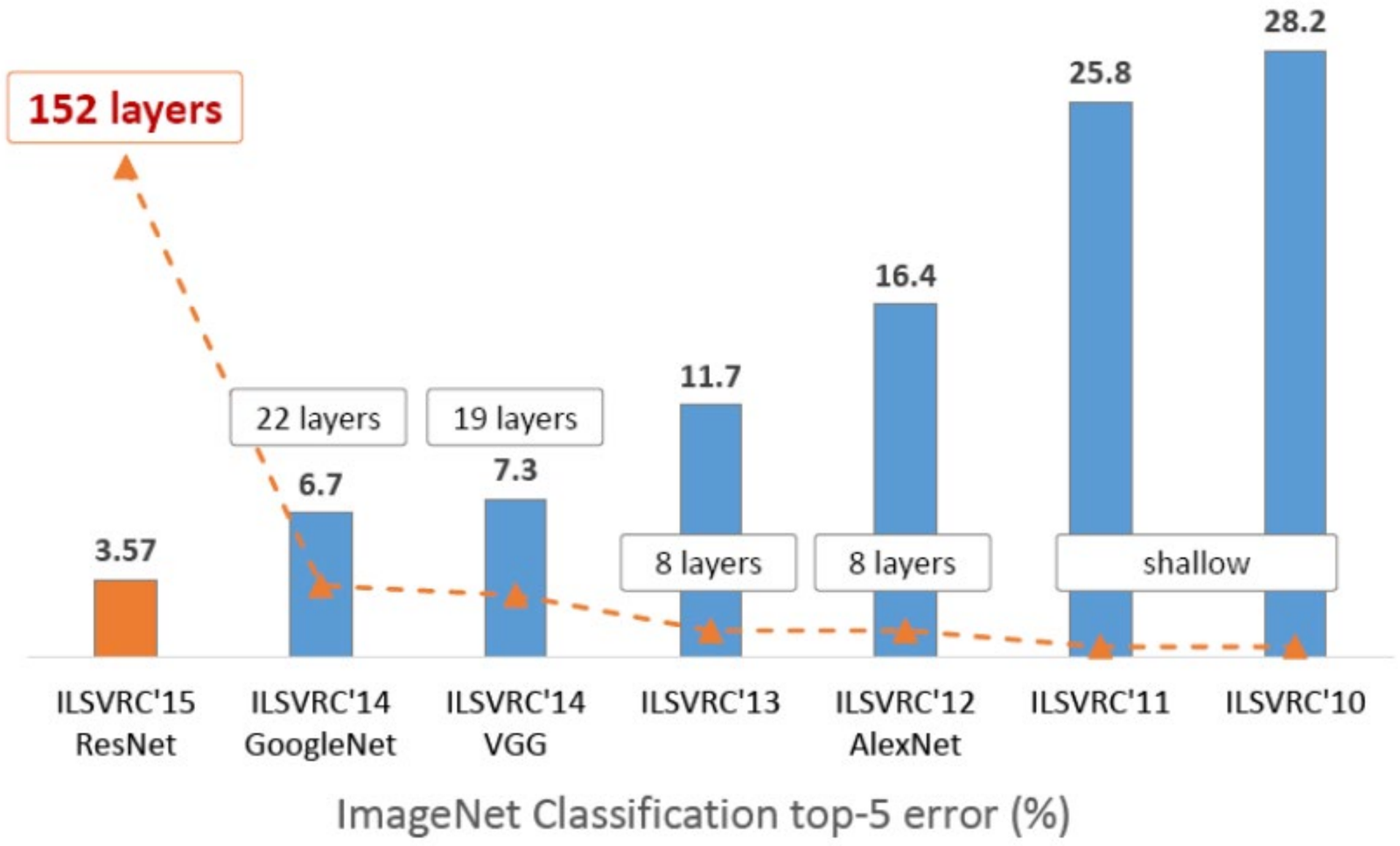
23 parameters

Deep CNN: Example



ILSVRC 2014 Winner

Deeper Is Better



Key Takeaways

Now, you are able to:

- Implement CNN architecture
- Implement Deep CNN
- Optimize CNNs using pooling layers

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Knowledge Check

Knowledge Check 1	The input image has been converted into a matrix of size 30 X 30 and a kernel/filter of size 7 X 7 with a stride of 1. What will be the size of the convoluted matrix?

a. 24 x 24

b. 21 x 21

c. 28 x 28

d. 7 x 7

Knowledge Check 1

The input image has been converted into a matrix of size 30 X 30 and a kernel/filter of size 7 X 7 with a stride of 1. What will be the size of the convoluted matrix?

a. 24 x 24

b. 21 x 21

c. 28 x 28

d. 7 x 7

The correct answer is **a**

The size of the convoluted matrix is given by C=((I -F+2P)/S)+1, where C is the size of the Convoluted matrix, I is the size of t he input image, F the size of the filter and P the padding applied to the input matrix. Here P=0, I=30, F=7 and S=1.

Knowledge Check 2	Which of the following do you typically see in a ConvNet ?

a. Multiple pool layers followed by a CONV layer

b. Multiple CONV layers followed by a pool layer

c. FC layers in the first few layers

d. All the above

Knowledge Check 2	Which of the following do you typically see in a ConvNet ?

a. Multiple pool layers followed by a CONV layer

b. Multiple CONV layers followed by a pool layer

c. FC layers in the first few layers

d. All the above

The correct answer is **b**

A typical/deep ConvNet usually comprises of multiple convolutional layers followed by a pool layer.

Image Classification

Problem Statement: Asirra (Animal Species Image Recognition for Restricting Access) is a HIP (Human Interactive Proof) that works by asking users to identify photographs of cats and dogs. This task is difficult for computers, but studies have shown that people can accomplish it quickly and accurately.

Hint: Use the dataset folder provided with csv files for importing training and testing sets. Also, use cat.jpg to validate your model.

Objective: To write an algorithm to classify whether images contain either a dog or a cat. (Use Keras for this task).

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LESSON-END PROJECT

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Thank You