

# Classificação Automática de Imagens

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# Tarefa

Receber como entrada uma imagem e como saída dizer se é um gato ou um cão.



# É fácil para nós. E para o computador?

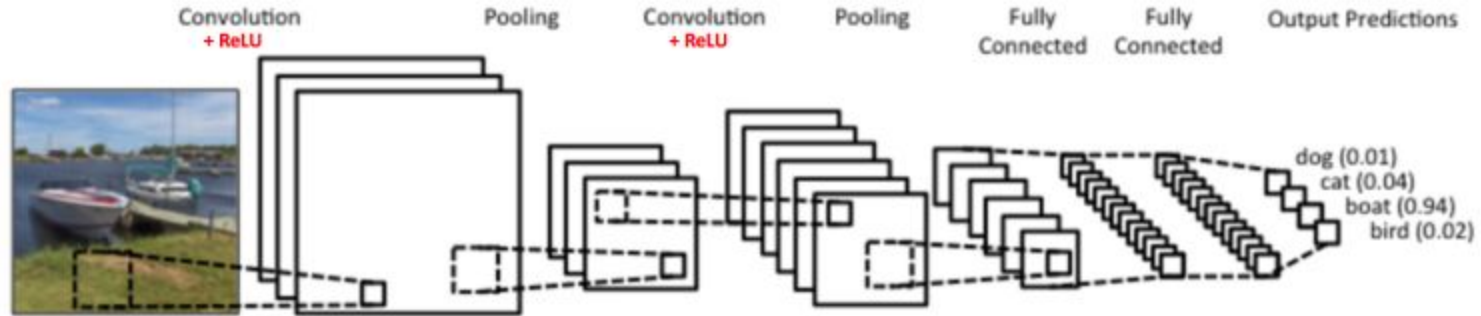


What We See

```
08 02 22 97 38 15 00 40 00 75 04 05 07 78 52 12 50 77 91 08
49 49 99 40 17 81 18 57 60 87 17 40 98 43 69 48 04 56 62 00
81 49 31 73 55 79 14 29 93 71 40 67 53 88 30 03 49 13 36 65
52 70 95 23 04 60 11 42 69 24 68 56 01 32 56 71 37 02 36 91
22 31 16 71 51 67 63 89 41 92 36 54 22 40 40 28 66 33 13 80
24 47 32 60 99 03 45 02 44 75 33 53 78 36 84 20 35 17 12 50
32 98 81 28 66 23 67 10 26 38 40 67 59 54 70 66 18 38 64 70
67 24 20 68 02 62 12 20 95 63 94 39 63 08 40 91 66 49 94 21
24 55 58 05 66 73 99 26 97 17 78 78 96 83 14 88 34 89 63 72
21 36 23 09 75 00 76 44 20 45 35 14 00 61 33 97 34 31 33 95
78 17 53 28 22 75 31 67 15 94 03 80 04 62 16 14 09 53 56 92
16 39 05 42 96 35 31 47 55 58 88 24 00 17 54 24 36 29 85 57
86 56 00 48 35 71 89 07 05 44 44 37 44 60 21 58 51 54 17 58
19 80 81 68 05 94 47 69 28 73 92 13 86 52 17 77 04 89 55 40
04 52 08 83 97 35 99 16 07 97 57 32 16 26 26 79 33 27 98 66
88 36 68 87 57 62 20 72 03 46 33 67 46 55 12 32 63 93 53 69
04 42 16 73 38 25 39 11 24 94 72 18 08 46 29 32 40 62 76 36
20 69 36 41 72 30 23 88 34 62 99 69 82 67 59 85 74 04 36 16
20 73 35 29 78 31 90 01 74 31 49 71 48 86 81 16 23 57 05 54
01 70 54 71 83 51 54 69 16 92 33 48 61 43 52 01 89 19 67 48
```

What Computers See

# Como concretizar a tarefa?



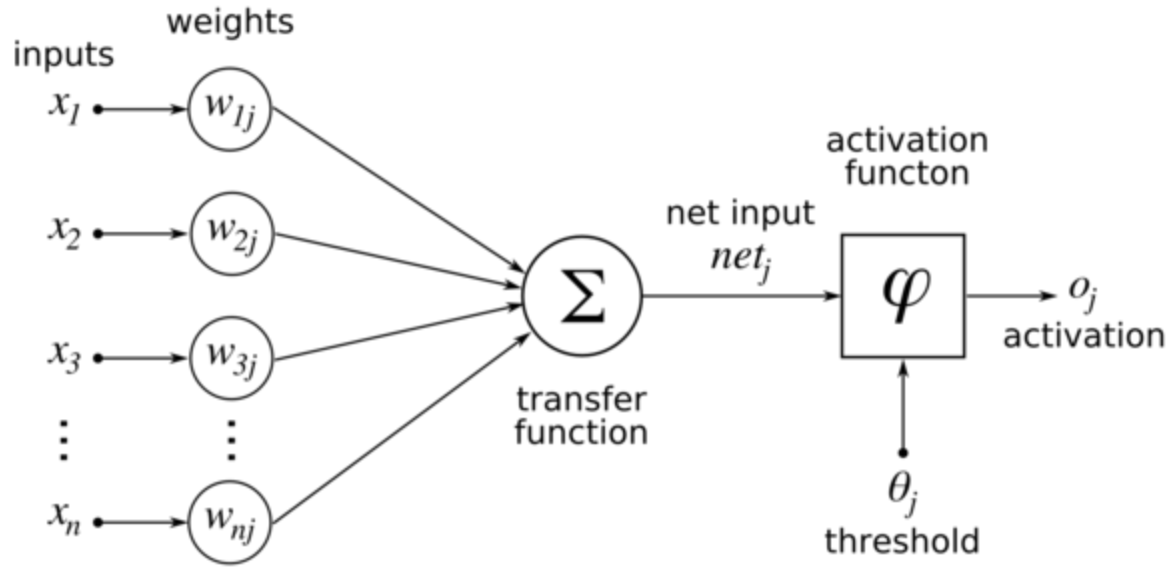
Redes Neurais Convulsão (ConvNets)

# Inspiração biológica

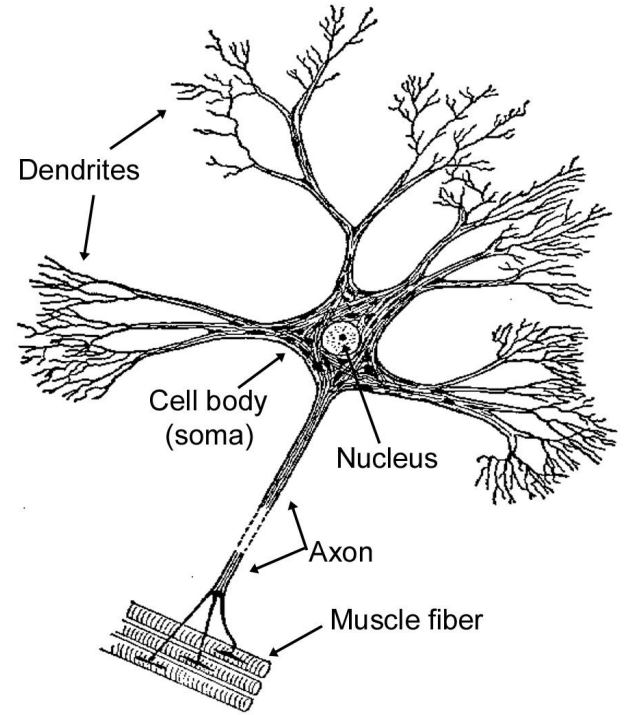
Redes Neurais de Convulsão são inspiradas no funcionamento do Cortex Visual.

Hubel and Wiesel em 1962 mostraram que certas células neuronais respondiam apenas na presença de objetos com arestas de certas orientações.

# Neurónio

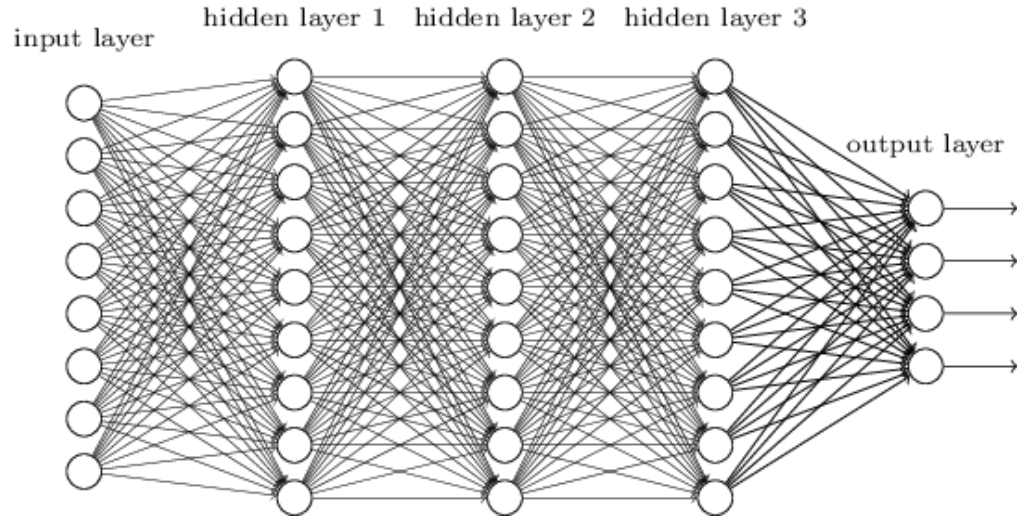


Neurónio Artificial

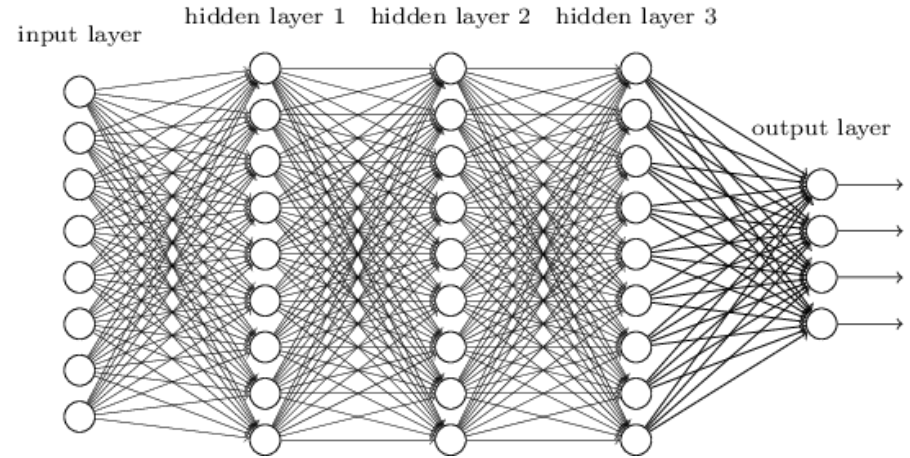
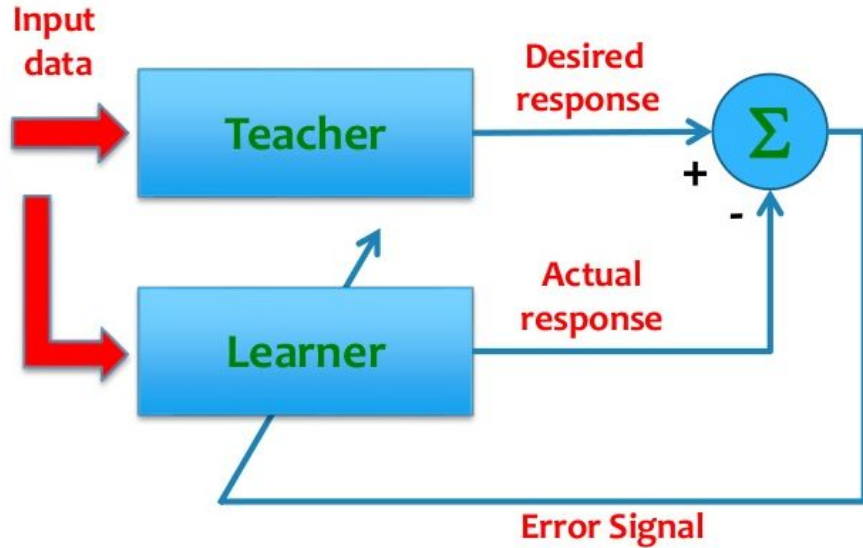


Neurónio Biológico

# Rede Neuronal

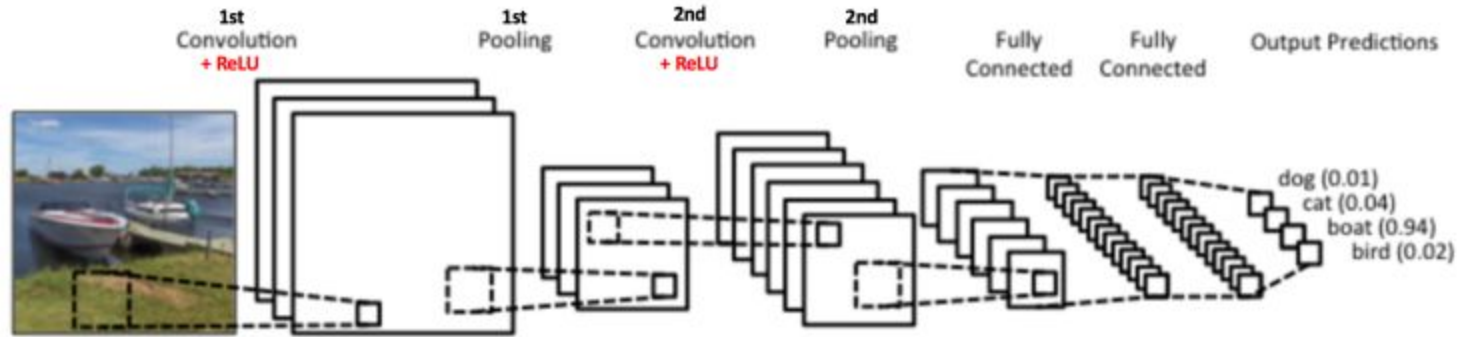


# Aprendizagem Supervisionada





# Rede Neural Convolucional (ConvNets)



# Convulsão

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

1	0	1
0	1	0
1	0	1




1 <sub>x1</sub>	1 <sub>x0</sub>	1 <sub>x1</sub>	0	0
0 <sub>x0</sub>	1 <sub>x1</sub>	1 <sub>x0</sub>	1	0
0 <sub>x1</sub>	0 <sub>x0</sub>	1 <sub>x1</sub>	1	1
0	0	1	1	0
0	1	1	0	0

Image

4		

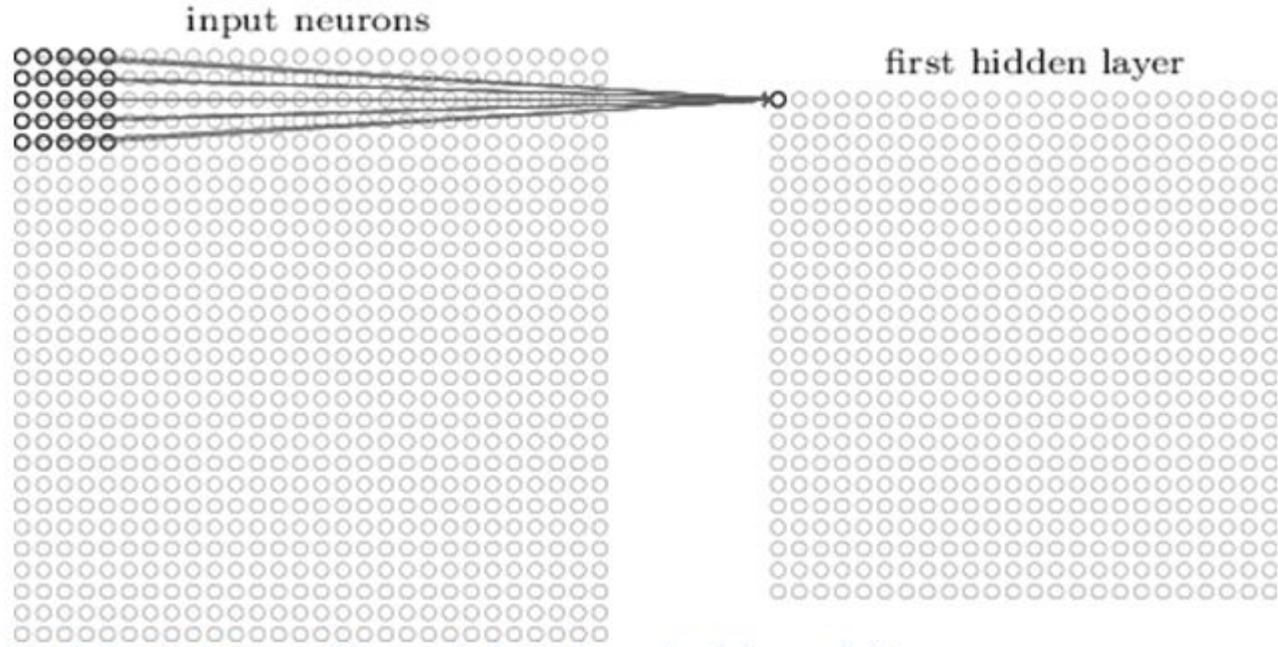
Convolved  
Feature

# Filtros

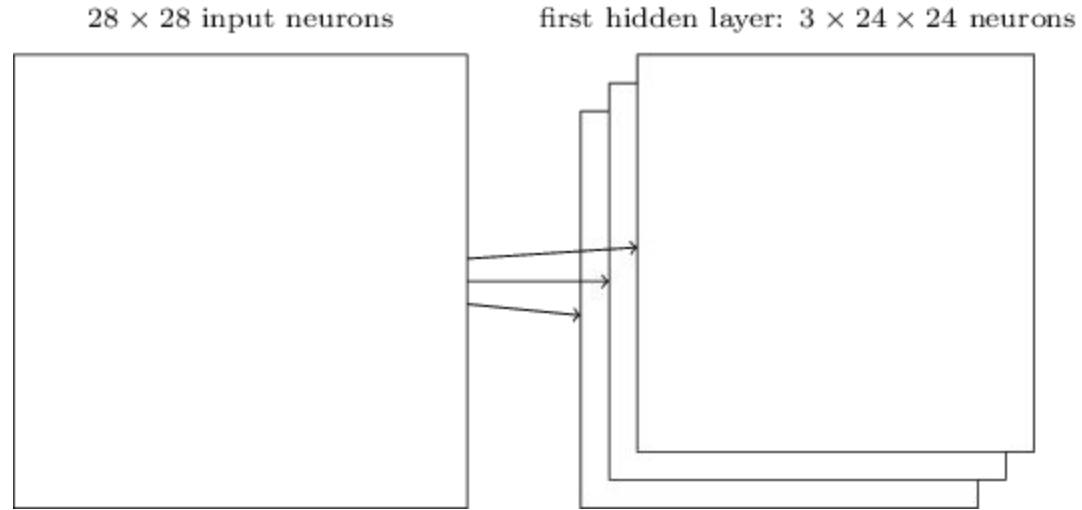
<b>Identity</b>	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
<b>Edge detection</b>	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	

<b>Sharpen</b>	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
<b>Box blur</b> (normalized)	$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
<b>Gaussian blur 3 × 3</b> (approximation)	$\frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	

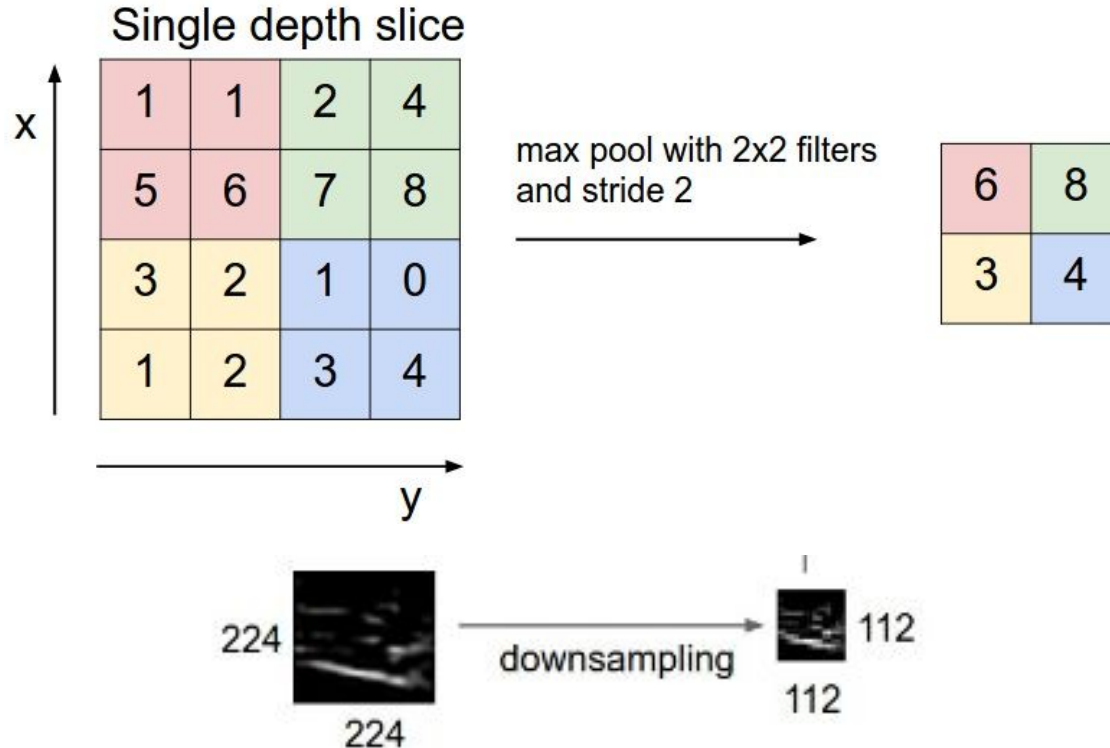
# Convulsão



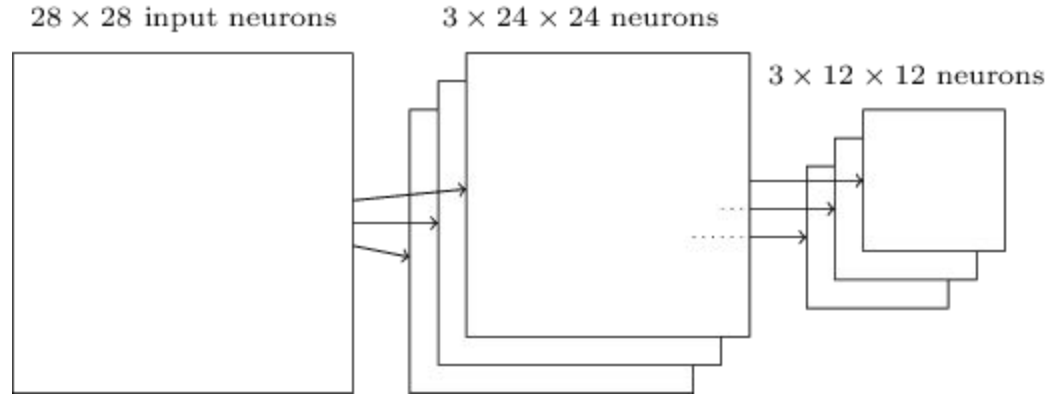
# Convulsão (Conv Layer)



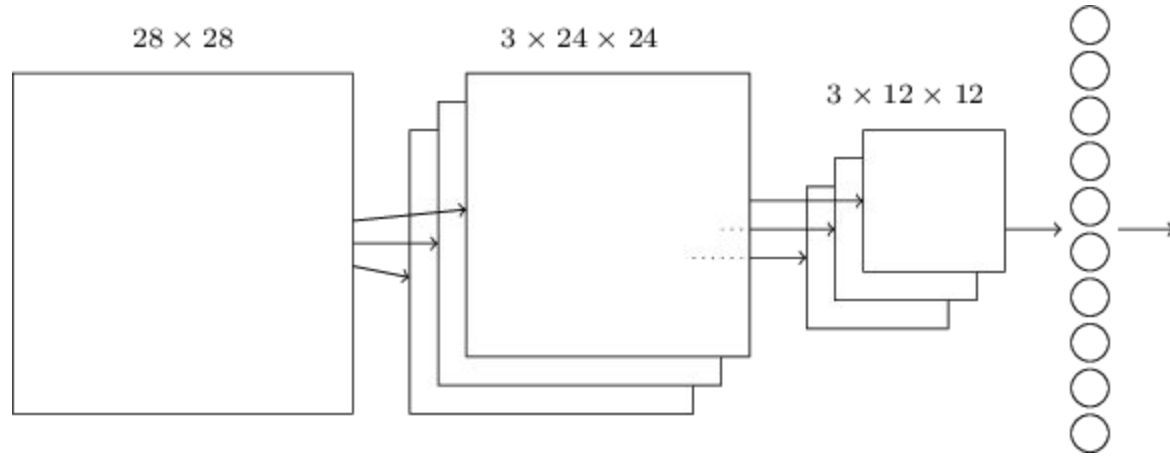
# Downsampling (Pooling Layer)



# Downsampling (Pooling Layer)

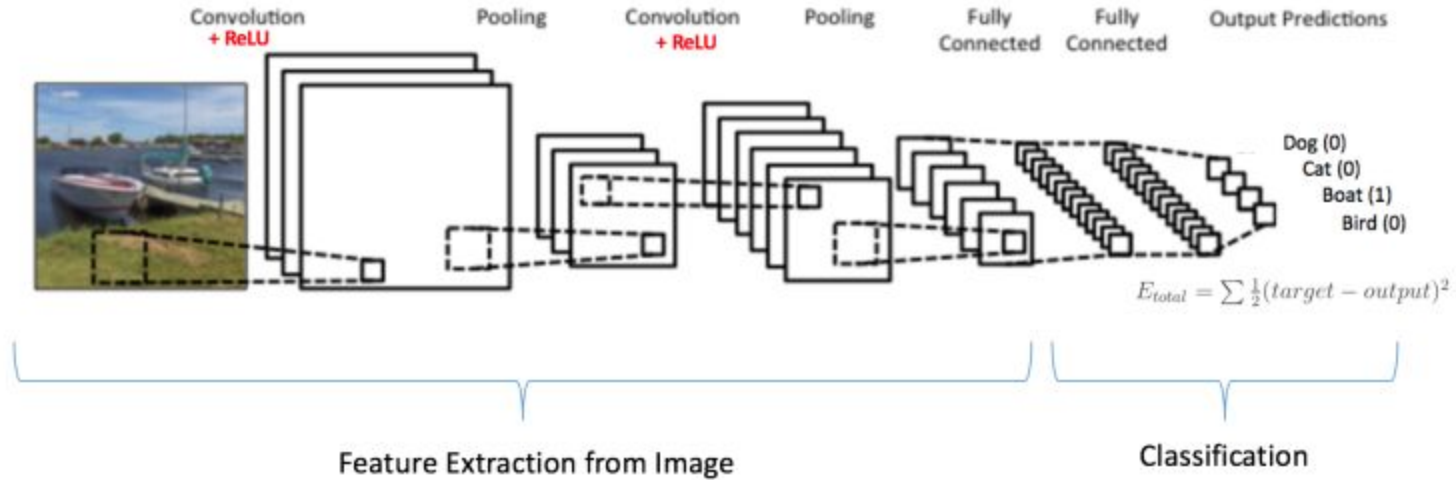


# Fully Connected Layer (FC Layer)





# Todas as camadas



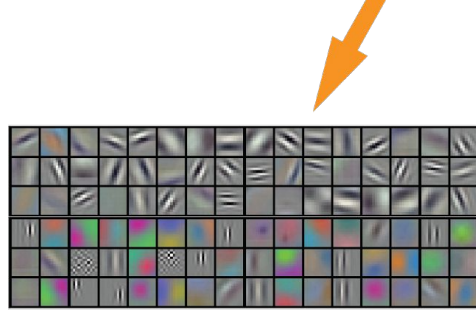
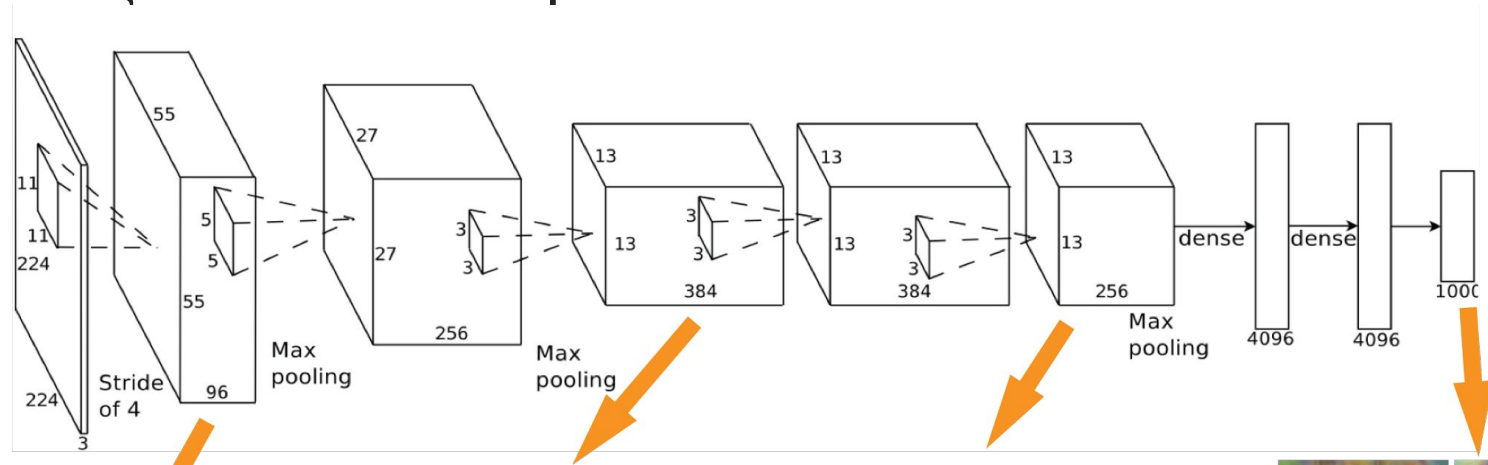
As características são **aprendidas!**

# 1 Milhão de imagens em 1000 categorias

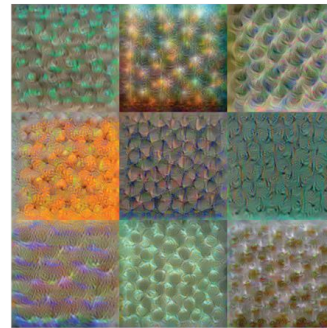


<http://image-net.org/>

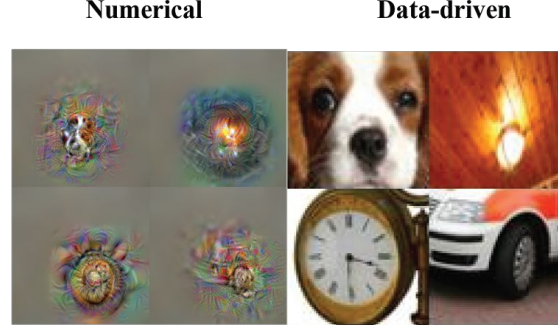
# Extração “hierárquica” de características



**Conv 1: Edge+Blob**



**Conv 3: Texture**

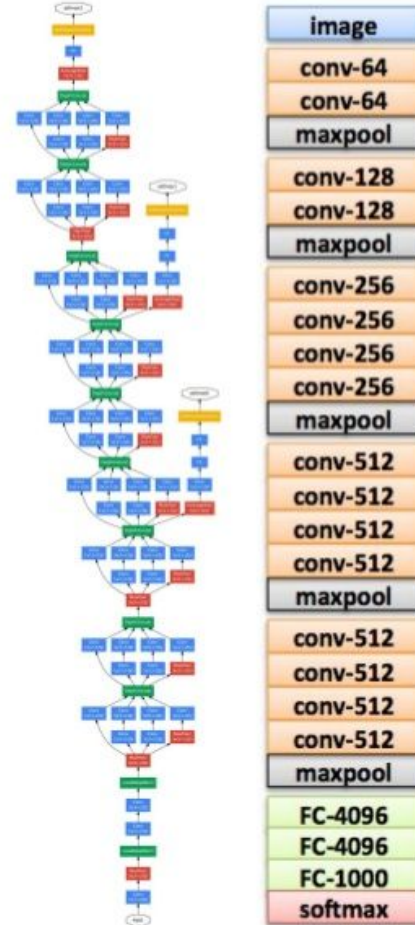
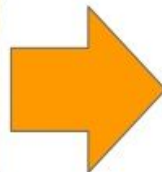


**Conv 5: Object Parts**



**Fc8: Object Classes**

## AlexNet



2012

2014

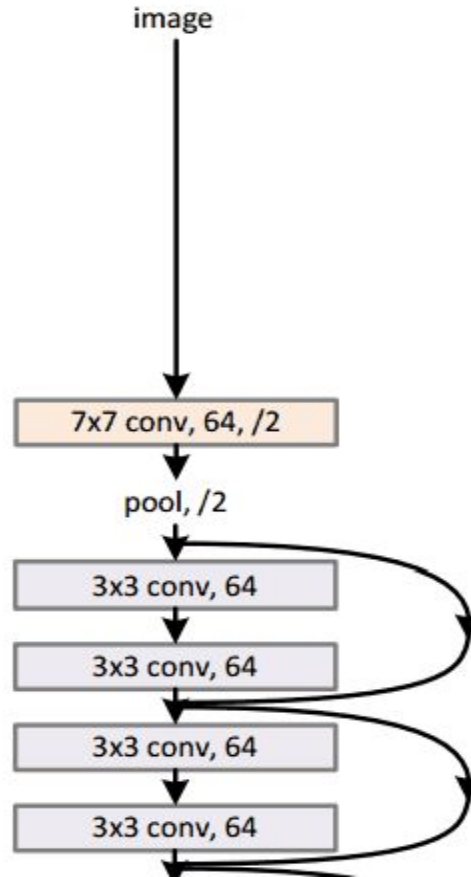


**WE NEED TO GO DEEPER**

Microsoft ResNet (2015)

152 Camadas

## 34-layer residual

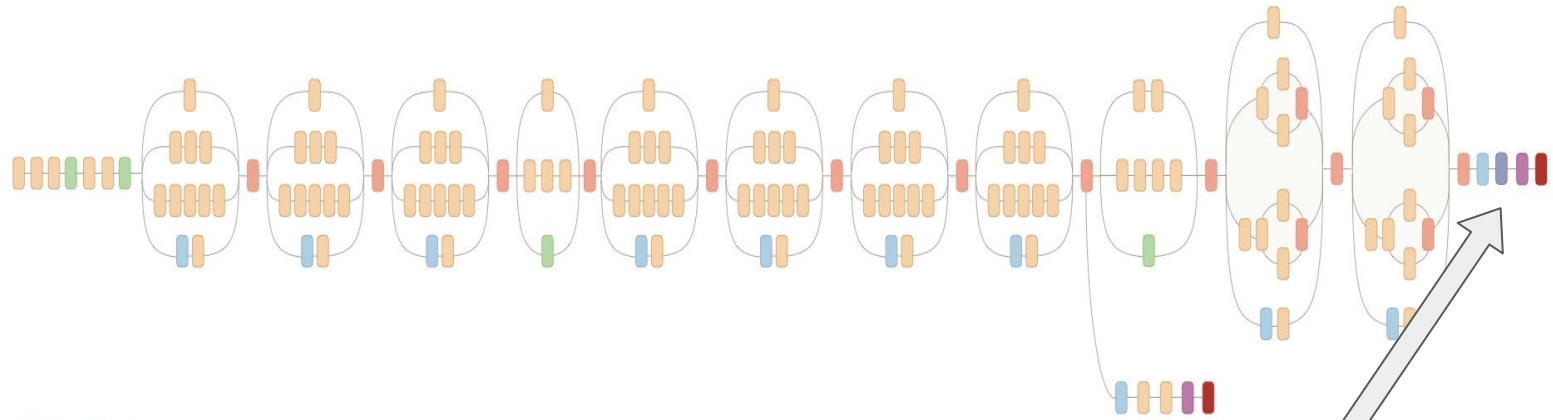


# Transfer Learning

Utiliza-se **Transfer Learning** para resolver um novo problema.

- Utilizar a ConvNet como um **extractor de características**
- **Fine-Tuning** de uma ConvNet pré-treinada

# Transfer Learning



- Convolution
- AvgPool
- MaxPool
- Concat
- Dropout
- Fully connected
- Softmax

Re-treinar