

The background of the slide is a light blue sky. In the top right corner is a bright yellow sun with a thick orange border. There are three white, fluffy clouds: a large one in the center-left, a medium one in the top center, and a smaller one to the right of the large cloud. The bottom of the slide features a green landscape with rolling hills. On the left hill is a single green tree with a brown trunk. On the right hill are two green trees with brown trunks. Small pink flowers are scattered across the green grass.

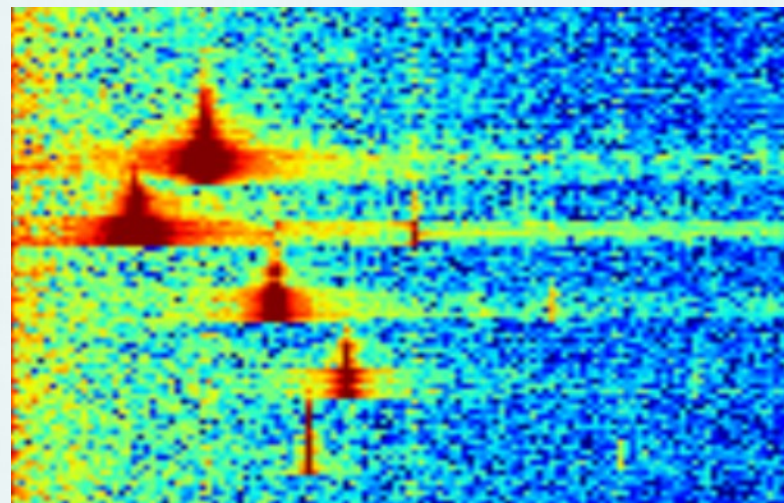
# MACHINE LEARNING AND AI

## ЛЕКЦИЯ 6

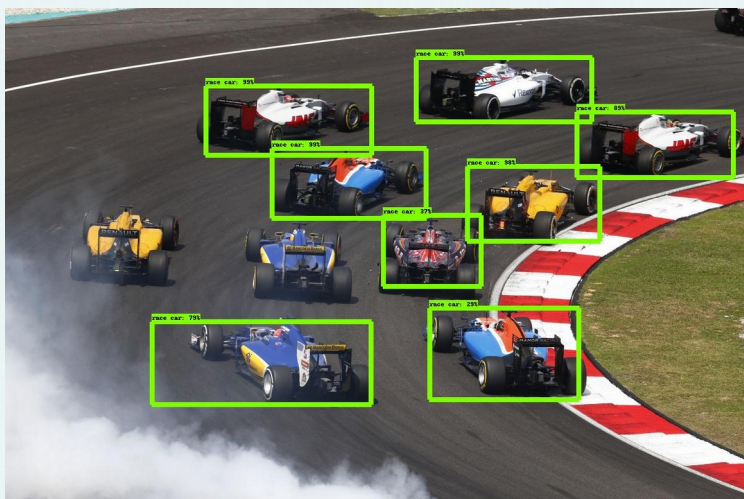
# convolutional neural network (cnn)



Собака? (0\1)



Распознавание речи



Поиск объектов



проблема – выделение контура объекта



# выделение вертикальных краёв

3	0	1	2	7	4
1	5	8	9	3	1
2	7	2	5	1	3
0	1	3	1	7	8
4	2	1	6	2	8
2	4	5	2	3	9

\*

1	0	-1
1	0	-1
1	0	-1

=

-5	-4	0	8
-10	-2	2	3
0	-2	-4	-7
-3	-2	-3	-16





# выделение вертикальных краёв

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

\*

1	0	-1
1	0	-1
1	0	-1

=

0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0



# более сложный пример

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
0	0	0	10	10	10
0	0	0	10	10	10
0	0	0	10	10	10

\*

1	1	1
0	0	0
-1	-1	-1

=

0	0	0	0
30	10	-10	-30
30	10	-10	-30
0	0	0	0



# общий случай

3	0	1	2	7	4
1	5	8	9	3	1
2	7	2	5	1	3
0	1	3	1	7	8
4	2	1	6	2	8
2	4	5	2	3	9

\*

$w_1$	$w_2$	$w_3$
$w_4$	$w_5$	$w_6$
$w_7$	$w_8$	$w_9$

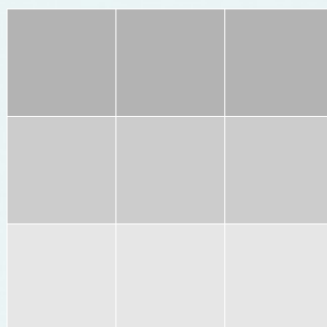
=




# добавление рамки (padding)

	3	0	1	2	7	4	
	1	5	8	9	3	1	
	2	7	2	5	1	3	
	0	1	3	1	7	8	
	4	2	1	6	2	8	
	2	4	5	2	3	9	

$n \times n$   
 $3 \times 3$   
 $n - 3 + 1$



$3 \times 3$

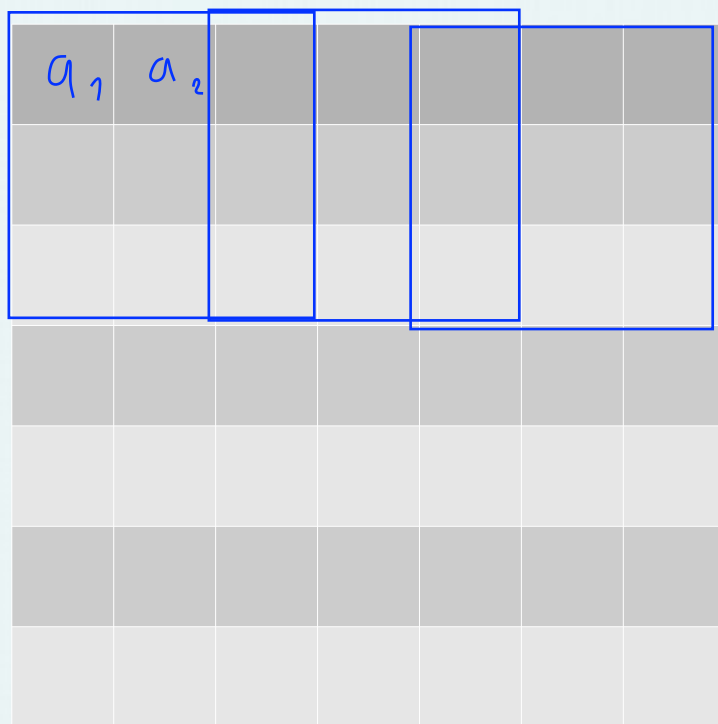
padding = 'same'

0	0	0	0	0	0	0	

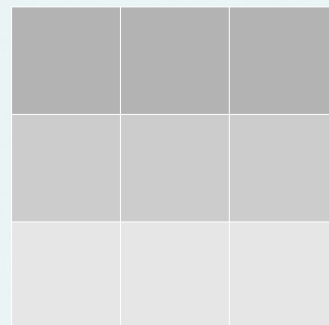




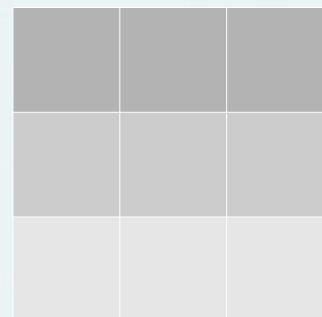
сдвиг (stride) = 1



\*



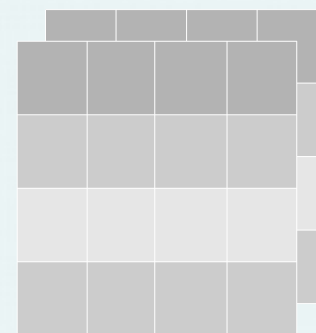
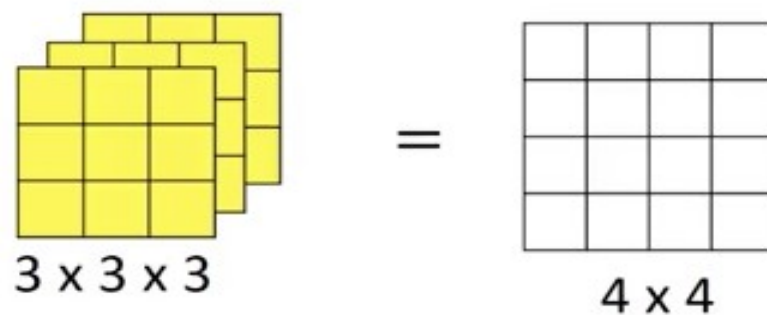
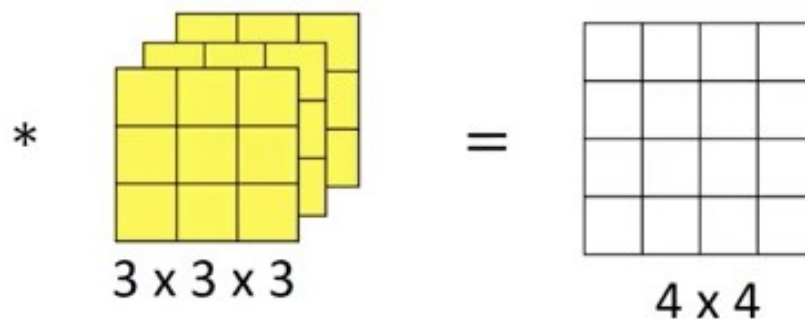
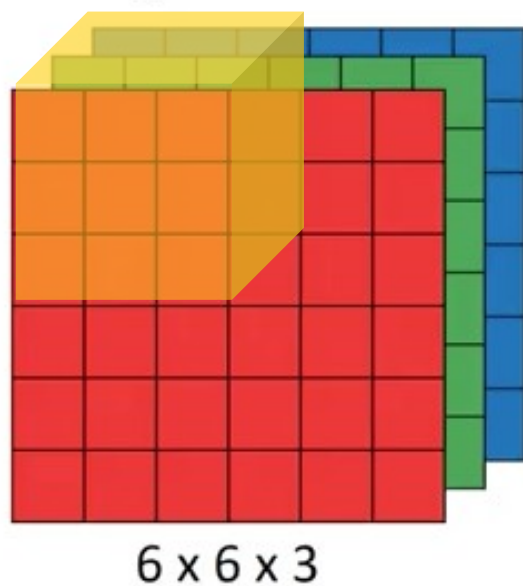
=



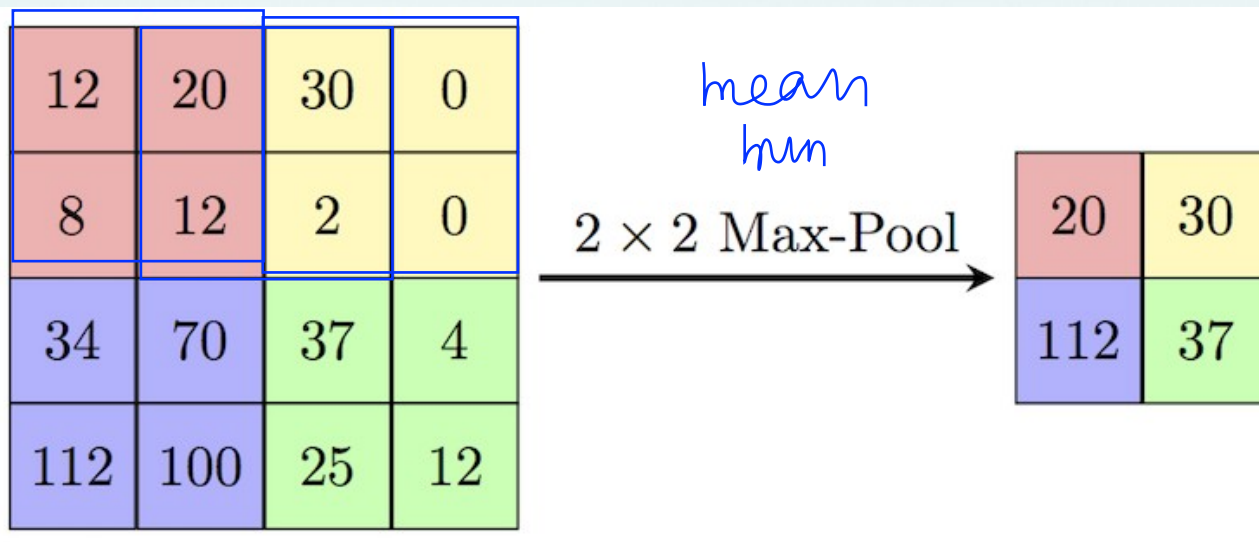
$$S = \sum_i a_i w_i \rightarrow \text{sig} \\ \text{relu}$$



# свёртка по объёму

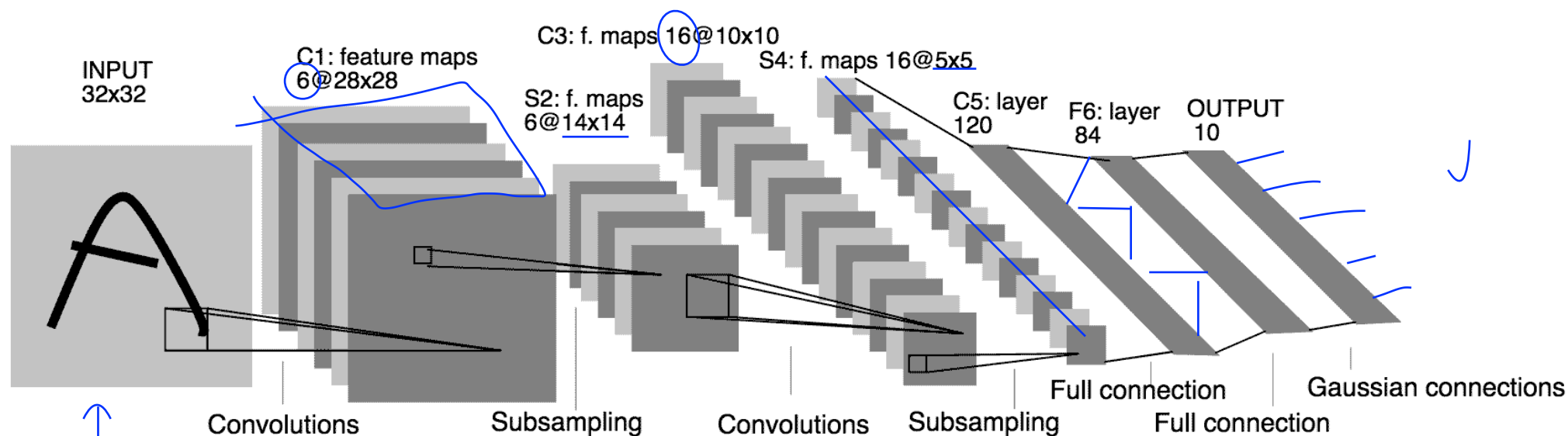


# понижение размерности (pooling)



# свёрточная нейронная сеть (cnn)

CNN Jan LeCun



Input  $\rightarrow$  conv  $\rightarrow$  conv  $\rightarrow$  conv  $\rightarrow$  pool — flat

batch-normalization

$$\frac{x - \text{mean}}{\text{std}}$$



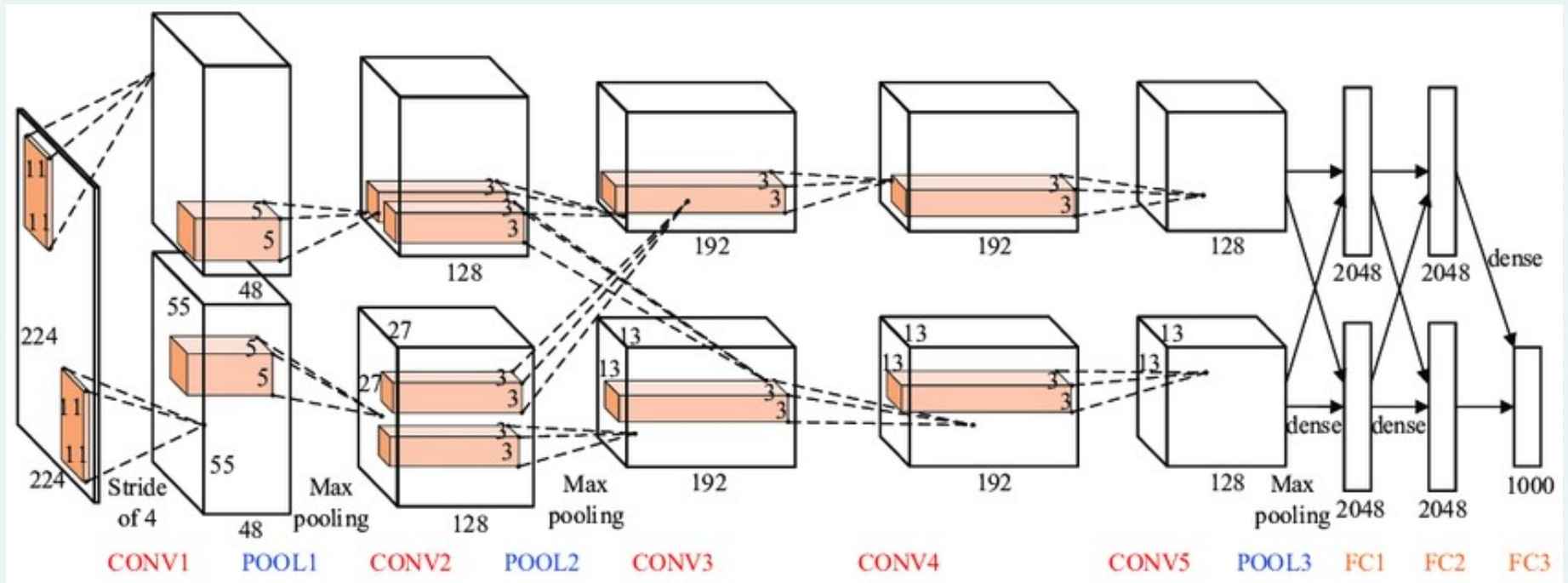
# разновидности сетей

- AlexNet →
- VGG →
- Residual Network →
- Siamese networks →
- Encoder-decoder →
- etc.

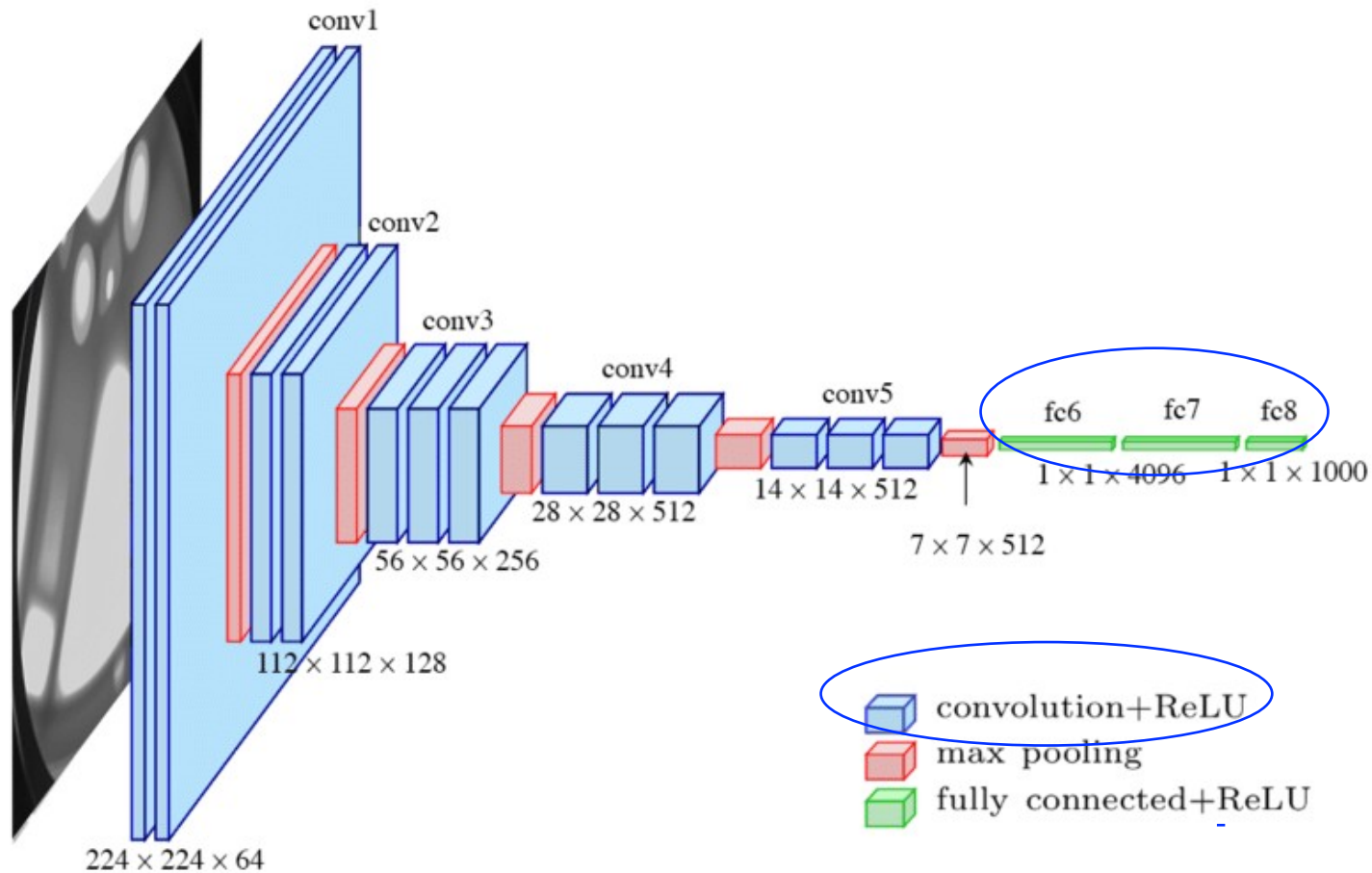




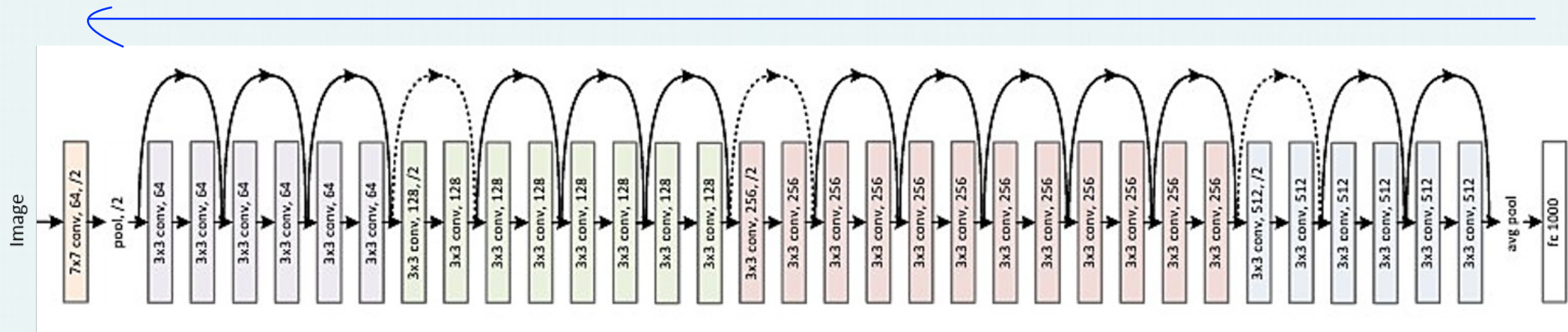
# AlexNet architecture



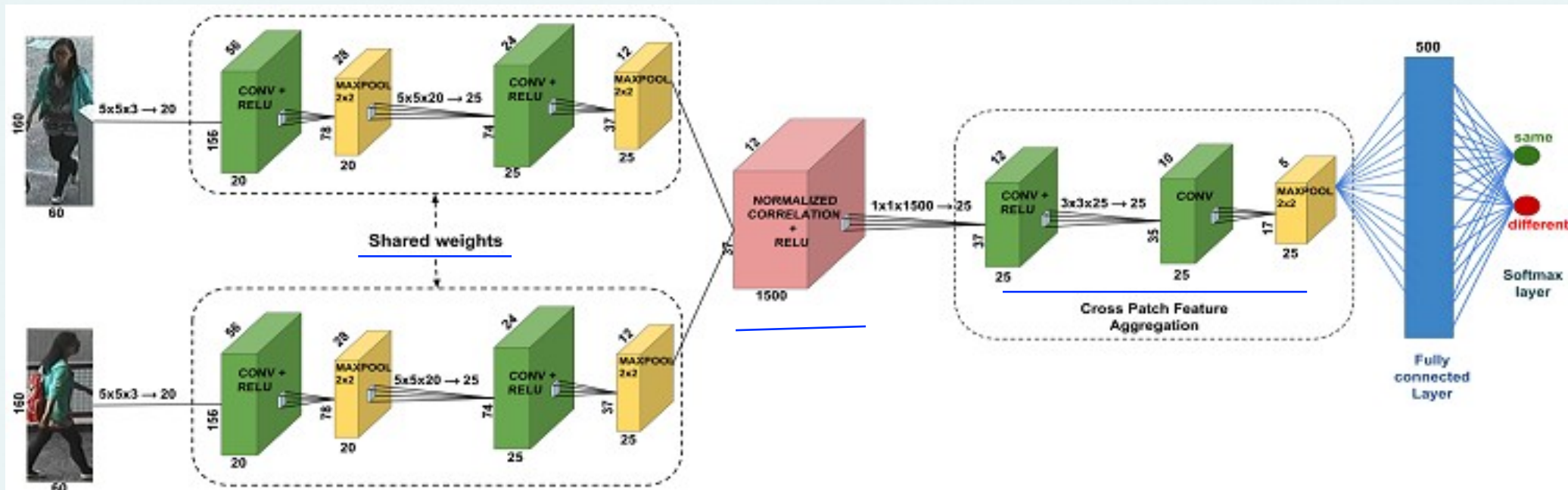
# VGG-16 architecture



# ResNet architecture



# сиамские сети



# encoder-decoder

