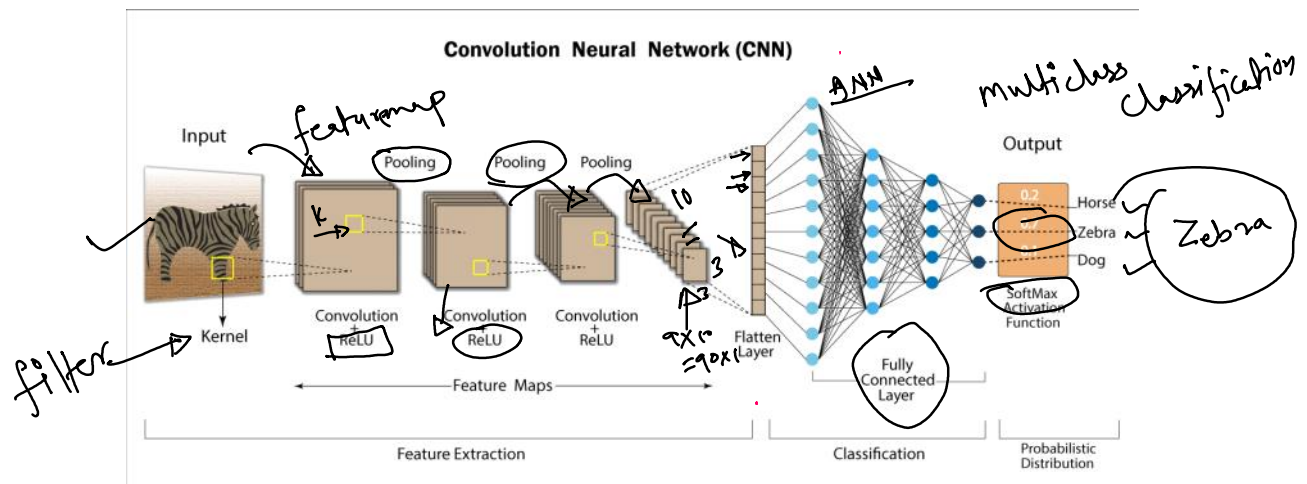


# Convolution Neural Network

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**Convolution** is the process involving **combination of two functions that produces the other function** as a result. In CNN's, the input image is subjected to convolution with use of filters that produces a **Feature map**.

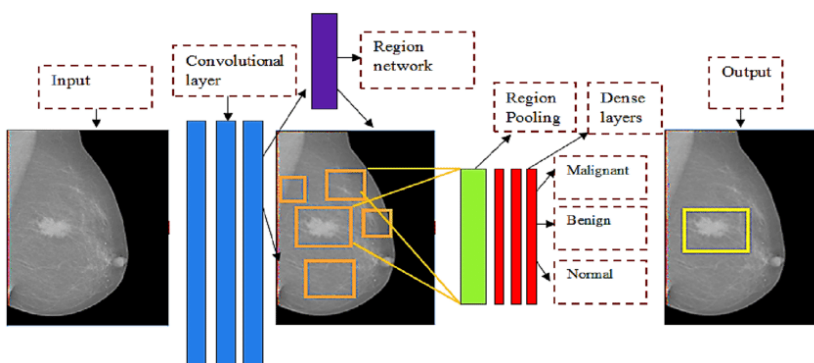
## Filters / Kernels

Filters /kernels are randomly generated vectors in the network consisting of weights and biases.

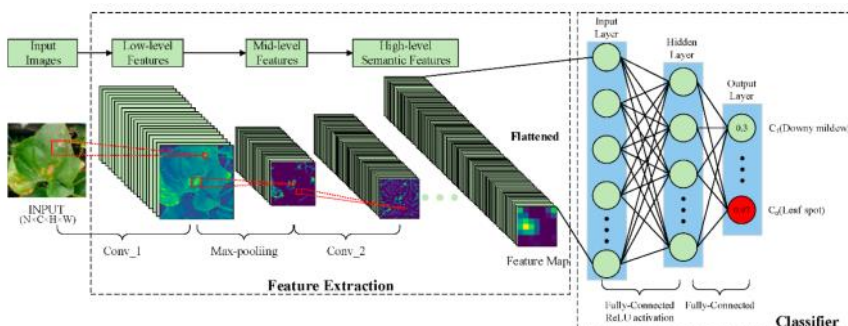




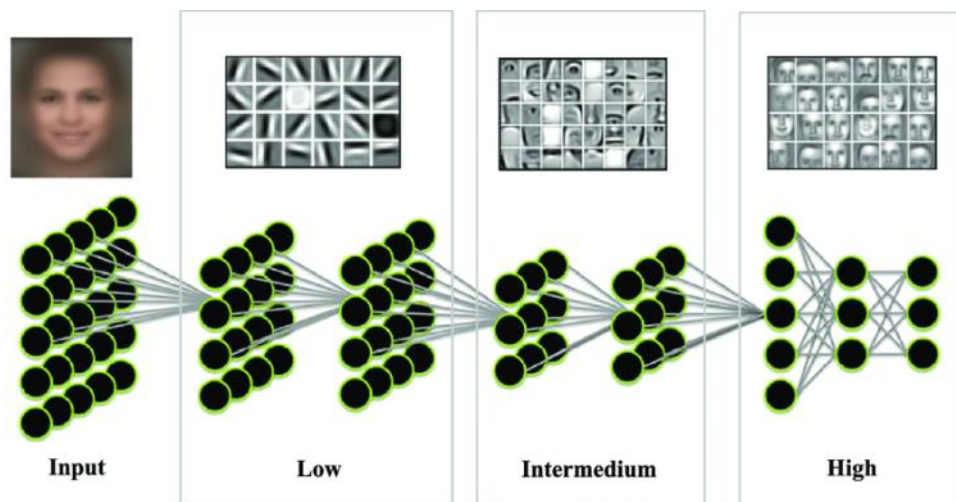
Up-scaling low-resolution images



BREAST CANCER DETECTION



LEAF DISEASE DETCTION



# Limitations of ANN

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1. High Computation Cost
2. Overfitting
3. Loss of important info like spatial features

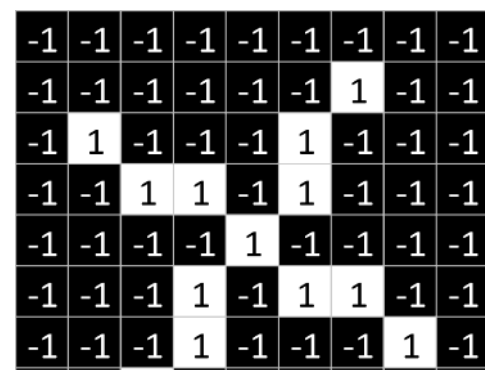
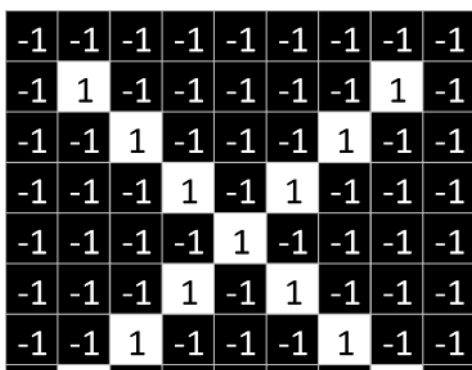
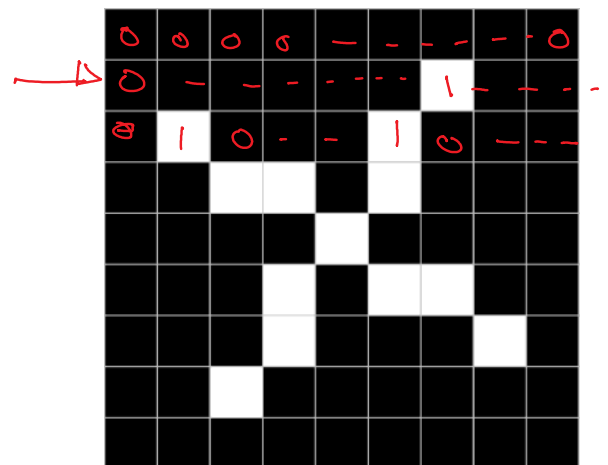
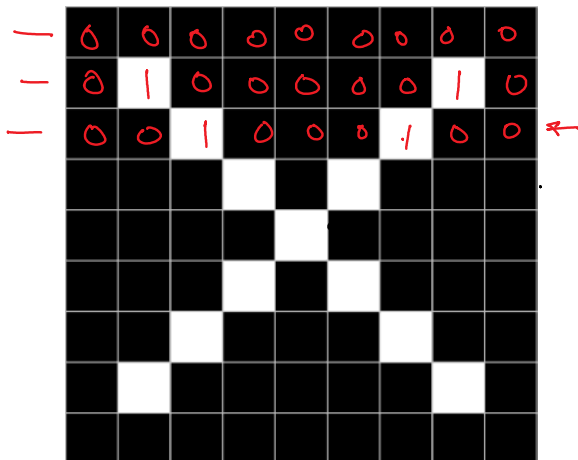


Input Layer      hidden Layer      Out Layer

$$\begin{aligned}
 &841 \times 100 + 100 = 84100 + 100 = 84200 \\
 &84200 \times 100 + 100 = 8420000 + 100 = 8420100 \\
 &8420100 \times 100 + 100 = 842010000 + 100 = 842010100
 \end{aligned}$$

1000      100      3

$1920 \times 1080 \times 128 \neq 128 =$



-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



# Convolution Operations

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<https://indoml.com/2018/03/07/student-notes-convolutional-neural-networks-cnn-introduction/>

**Input**

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

$n_H \times n_W = 6 \times 6$

**Filter/Kernel**

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

**Parameters:**  
 Size:  $f = 3$   
 Stride:  $s = 1$   
 Padding:  $p = 0$   
 $f_H \times f_W = 3 \times 3$

**Result**

2	3	1			

$O_H = n_H - f_H + 1 = 6 - 3 + 1 = 4$   
 $O_W = n_W - f_W + 1 = 6 - 3 + 1 = 4$   
 $(O_H \times O_W) = (4 \times 4)$

Handwritten calculations:  
 $4 \times 1 + 9 \times 0 + 2 \times (-1) + 5 \times 1 + 6 \times 0 + 2 \times (-1) + 2 \times 1 + 4 \times 0 + 5 \times (-1) = 2$   
 $9 \times 1 + 2 \times 0 + 5 \times -1 + 6 \times 1 + 2 \times 0 + 4 \times -1 = ?$   
 $4 \times 1 + 5 \times 0 + 4 \times -1 = ?$

**Input**

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

$n_H \times n_W = 6 \times 6$

**Filter**

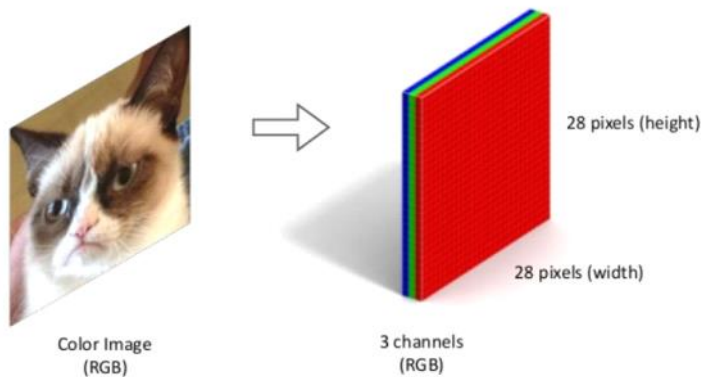
1	0	-1
1	0	-1
1	0	-1

**Parameters:**  
 Size:  $f = 3$   
 Stride:  $s = 1$   
 Padding:  $p = 0$

**Result**

2	6				

Handwritten calculation:  
 $6 = 9 \times 1 + 2 \times 0 + 5 \times (-1) + 6 \times 1 + 2 \times 0 + 4 \times (-1) + 4 \times 1 + 5 \times 0 + 4 \times (-1)$



**Input**

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

$n_H \times n_W \times n_C = 6 \times 6 \times 3$

**Filter**

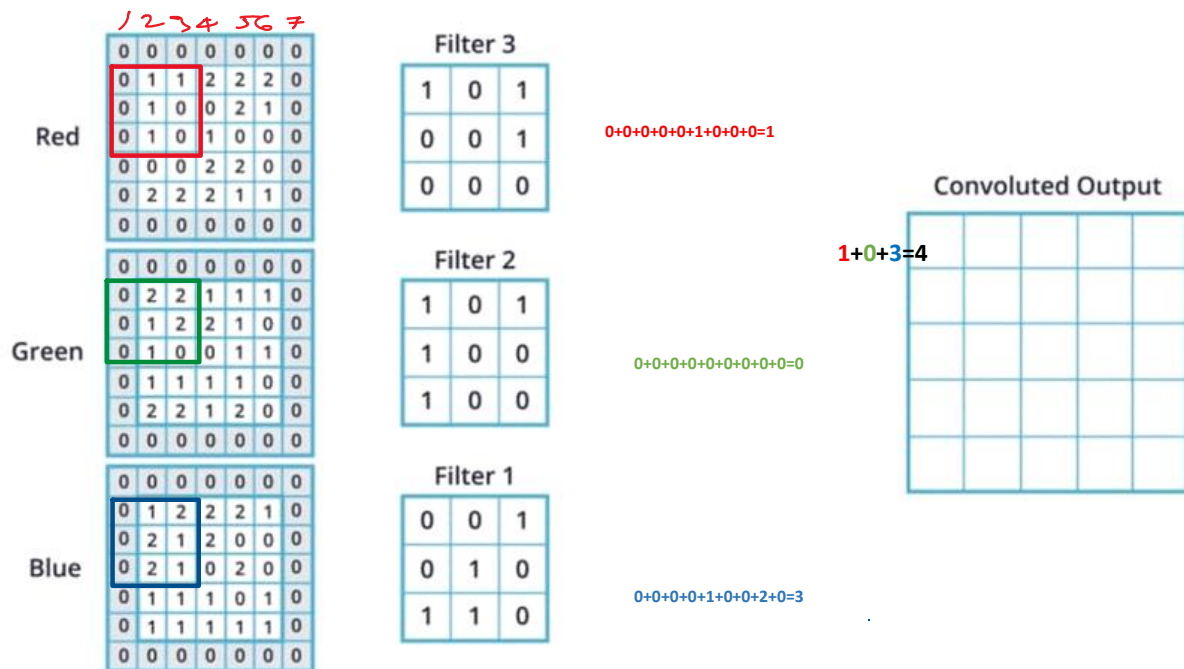
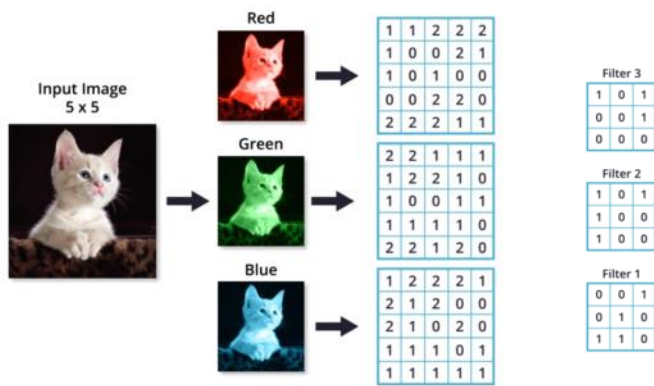
1	0	-1
1	0	-1
1	0	-1

**Parameters:**  
 Size:  $f = 3$   
 #channels:  $n_C = 3$   
 Stride:  $s = 1$   
 Padding:  $p = 0$

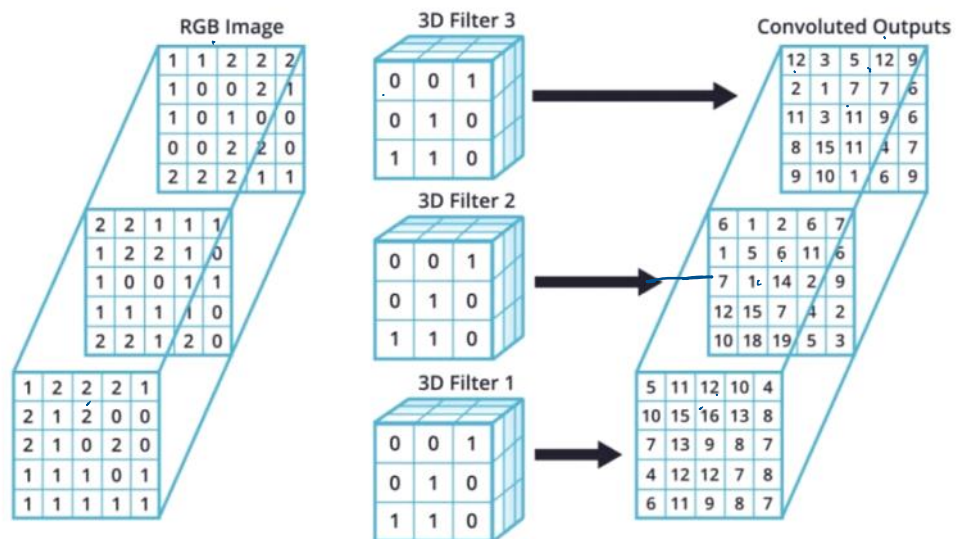
**Result**

2					

Handwritten calculation:  
 $2 = 9 \times 1 + 2 \times 0 + 5 \times (-1) + 6 \times 1 + 2 \times 0 + 4 \times (-1) + 4 \times 1 + 5 \times 0 + 4 \times (-1)$







# PADDING and STRIDES

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Pixel Values

0	0	0	0	0	0	0	0
0	1	0	4	2	125	67	0
0	8	2	5	4	34	12	0
0	20	13	25	15	240	2	0
0	76	8	6	6	100	76	0
0	34	66	134	223	201	3	0
0	255	123	89	55	32	2	0
0	0	0	0	0	0	0	0

$O_H = n_H + 2p - f_H + 1$   
 $= 6 + 2 \times 1 - 3 + 1 = 6$

Kernel 3 x 3 Pixels

1	2	1
2	4	2
1	2	1

Convolved Image

22	27	36	313	722	576
91	110	120	522	984	576
284	257	198	755	1360	798
507	567	687	1312	1689	955
1061	1288	1496	1911	1659	702
1400	1480	1269	1249	870	279

$O_W = n_W + 2p - f_W + 1$   
 $= 6 + 2 \times 1 - 3 + 1 = 6$

Input

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

Filter

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

Parameters:

- Size:  $f = 3$
- Stride:  $s = 2$
- Padding:  $p = 0$

Result

2	1

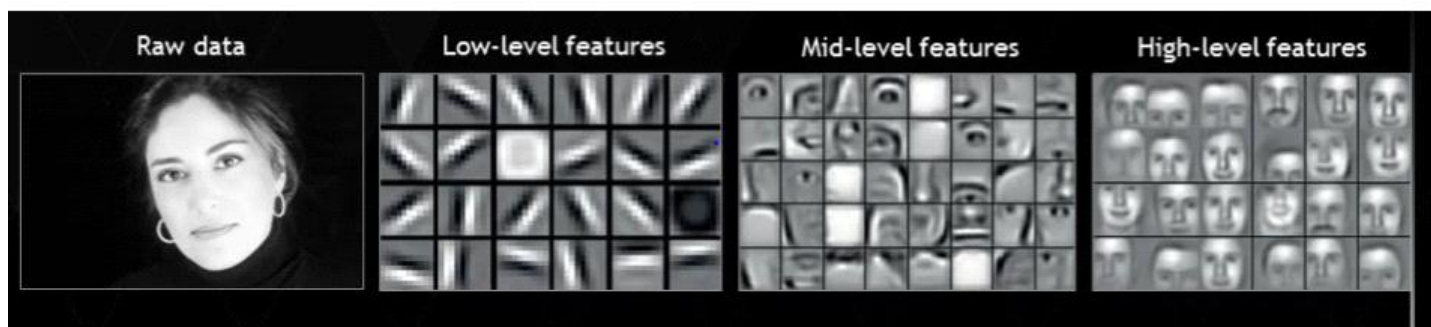
$O_H = 2$

$O_H = \frac{n_H + 2p - f_H + 1}{s} = \frac{6 + 0 - 3 + 1}{2} = \frac{4}{2} = 2$

$O_W = \frac{n_W + 2p - f_W + 1}{s} = \frac{6 + 0 - 3 + 1}{2} = \frac{4}{2} = 2$

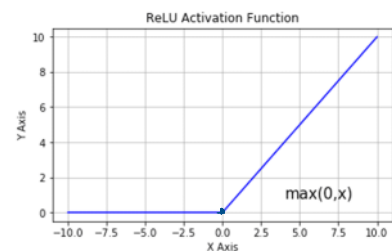
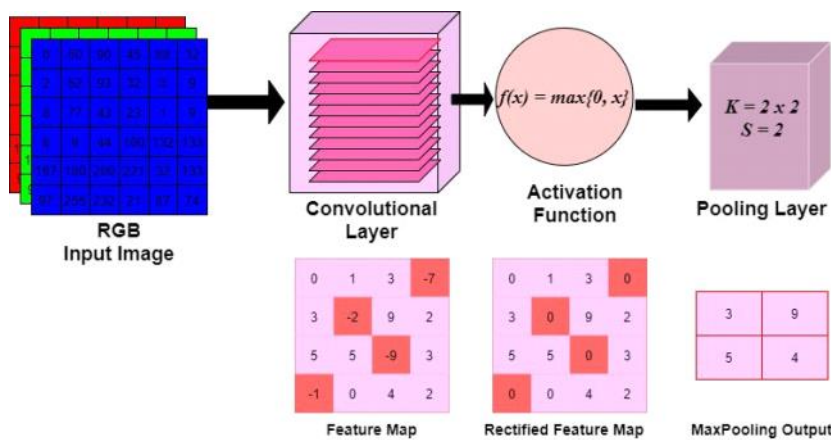
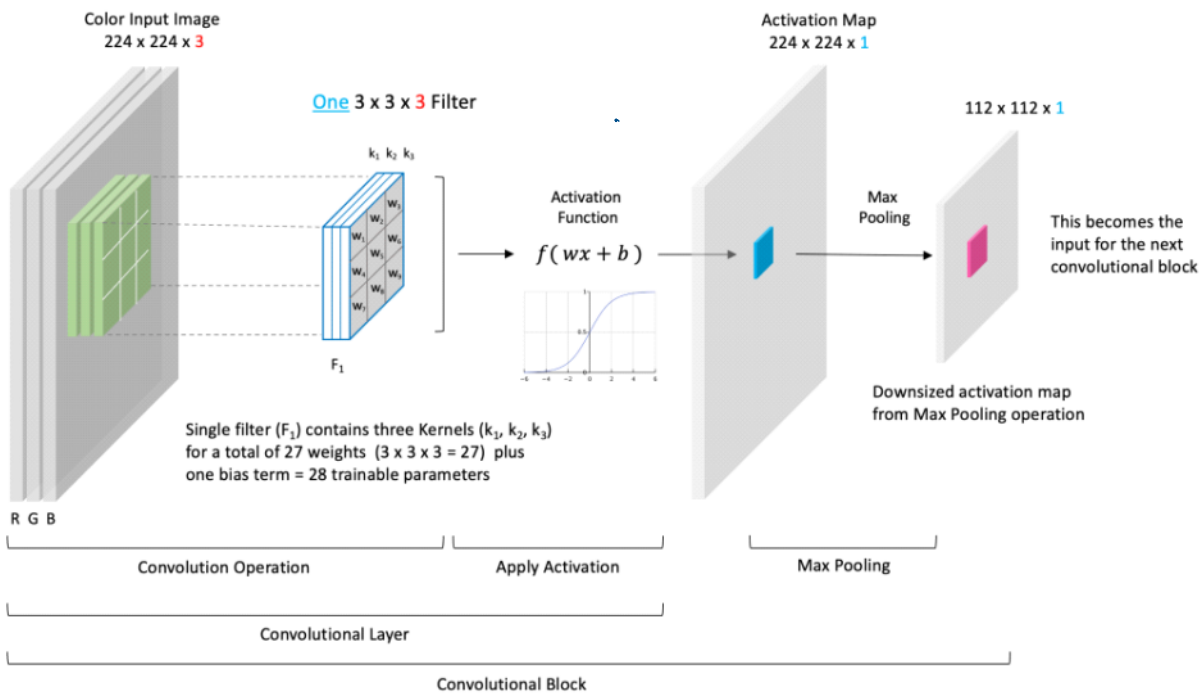
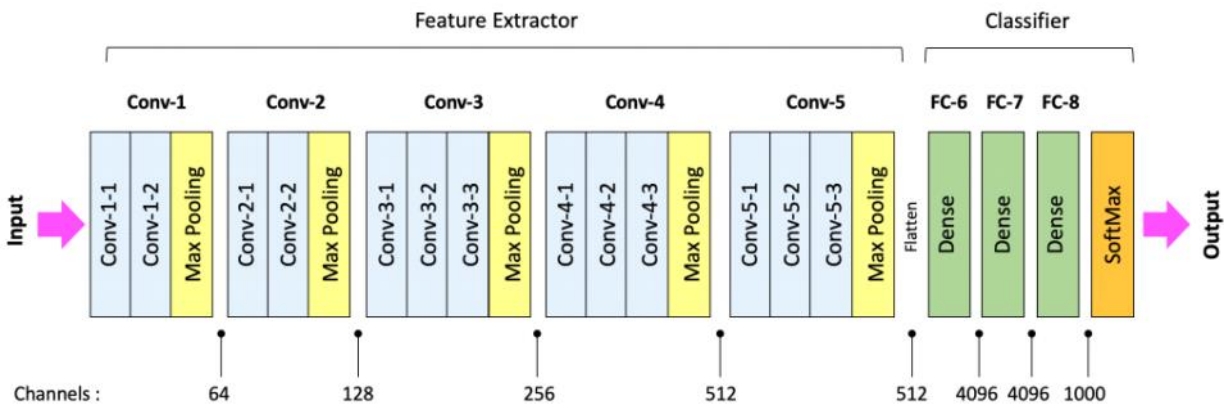
Dimension: 6 x 6

<https://indoml.com>



# Max or Average Pooling

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Max Pooling

29	15	28	184
0	100	70	38
12	12	7	2
12	12	45	6

Average Pooling

31	15	28	184
0	100	70	38
12	12	7	2
12	12	45	6

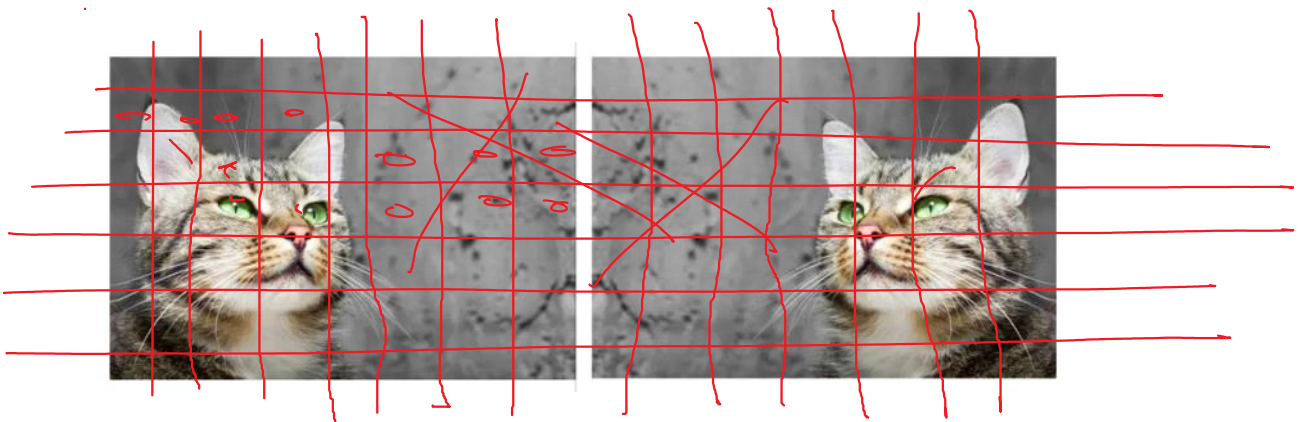
0

2 x 2  
pool size

100	184
12	45

2 x 2  
pool size

36	80
12	15



# Before Flattening

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