

# Convolutional Neural Networks Basic

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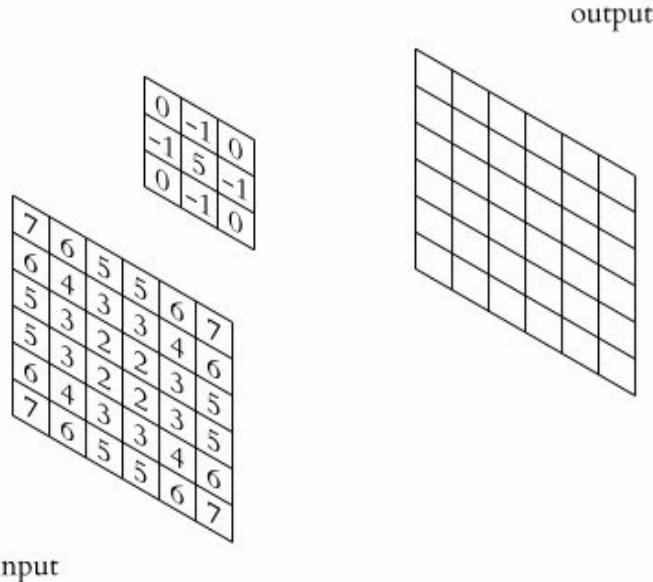
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# What is Convolution?

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A convolution operation, by definition, is an element-wise multiplication of two matrices, followed by a sum.



[https://commons.wikimedia.org/wiki/File:2D\\_Convolution\\_Animation.gif](https://commons.wikimedia.org/wiki/File:2D_Convolution_Animation.gif)

# Convolutional Layer

Example 5x5 image with binary pixels

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

Example 3x3 filter

1	0	1
0	1	0
1	0	1

bias

1
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Output

5

$$1 \times 1 + 1 \times 0 + 1 \times 1 + 0 \times 0 + 1 \times 1 + 1 \times 0 + 0 \times 1 + 0 \times 0 + 1 \times 1 = 4 + 1 = 5$$

The output here is called a **feature map**. This output goes in activation function typically **ReLU**.

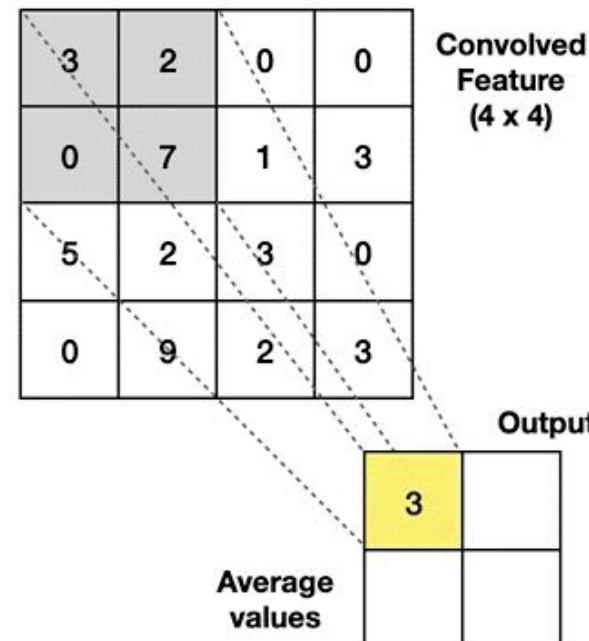
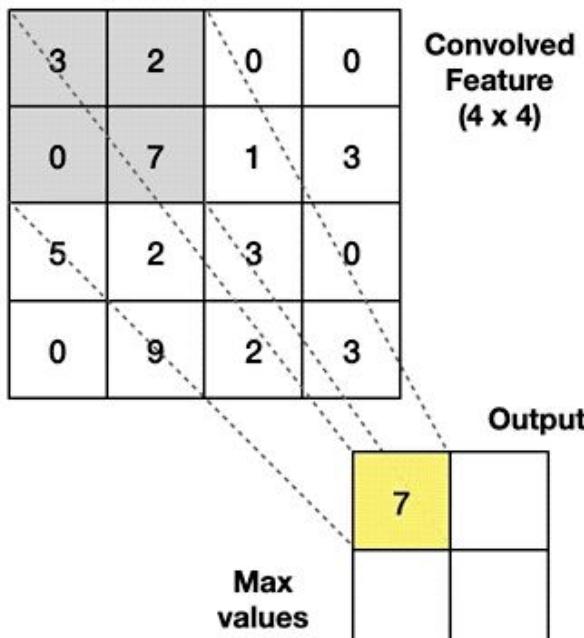
## Max Pooling

Take the **highest** value from the area covered by the kernel

## Average Pooling

Calculate the **average** value from the area covered by the kernel

Example: Kernel of size  $2 \times 2$ ; stride=(2,2)



0	0	0	0	0	0	...
0	156	155	156	158	158	...
0	153	154	157	159	159	...
0	149	151	155	158	159	...
0	146	146	149	153	158	...
0	145	143	143	148	158	...
...	...	...	...	...	...	...

Input Channel #1 (Red)

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

Kernel Channel #1



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Input Channel #2 (Green)

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

Kernel Channel #2



-498

0	0	0	0	0	0	...
0	163	162	163	165	165	...
0	160	161	164	166	166	...
0	156	158	162	165	166	...
0	155	155	158	162	167	...
0	154	152	152	157	167	...
...	...	...	...	...	...	...

Input Channel #3 (Blue)

0	1	1
0	1	0
1	-1	1

Kernel Channel #3



164 + 1 = -25

↑  
Bias = 1

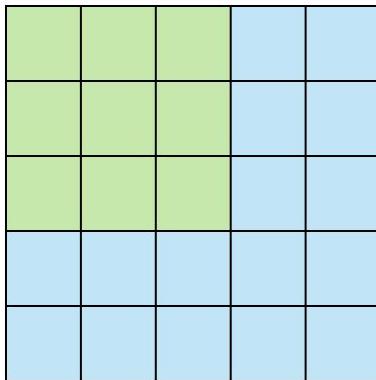
-25				...
				...
				...
				...
...	...	...	...	...

Output

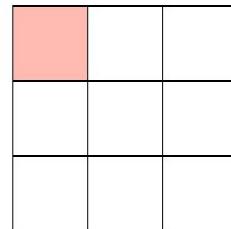
# What is Stride?

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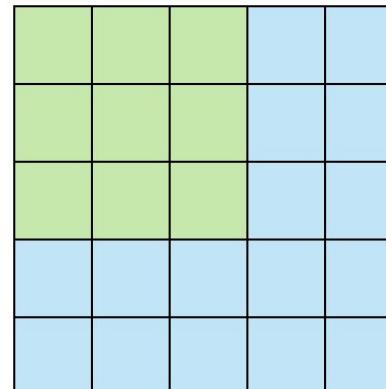
The amount of pixels by which the kernel moves over top of the input matrix is called stride.



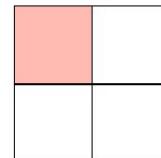
Stride 1



Feature Map

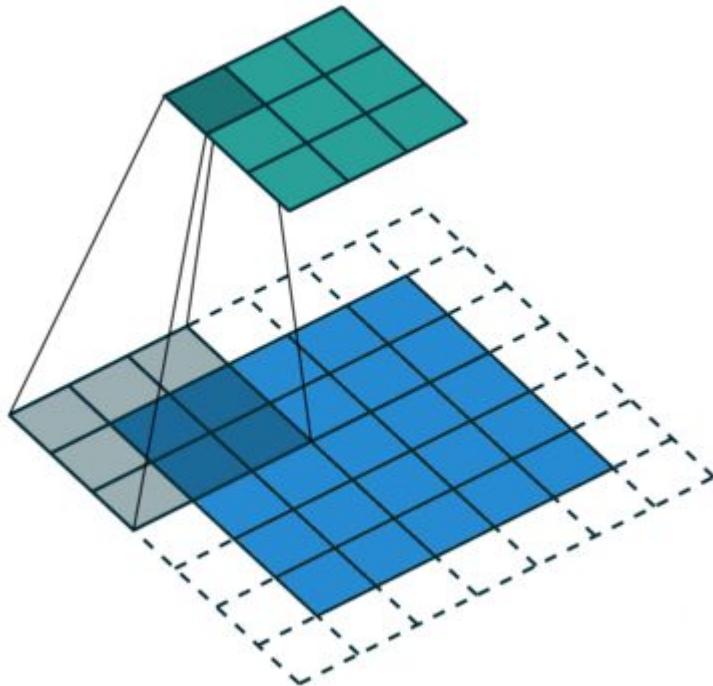


Stride 2



Feature Map

# What is Padding?



Input								Output		
0 <sub>2</sub>	0 <sub>0</sub>	0 <sub>1</sub>	0	0	0	0	0	1	6	5
0 <sub>1</sub>	2 <sub>0</sub>	2 <sub>0</sub>	3	3	3	3	0	7	10	9
0 <sub>0</sub>	0 <sub>1</sub>	1 <sub>1</sub>	3	0	3	0	0	7	10	8
0	2	3	0	1	3	0	0			
0	3	3	2	1	2	0	0			
0	3	3	0	2	3	0	0			
0	0	0	0	0	0	0	0			