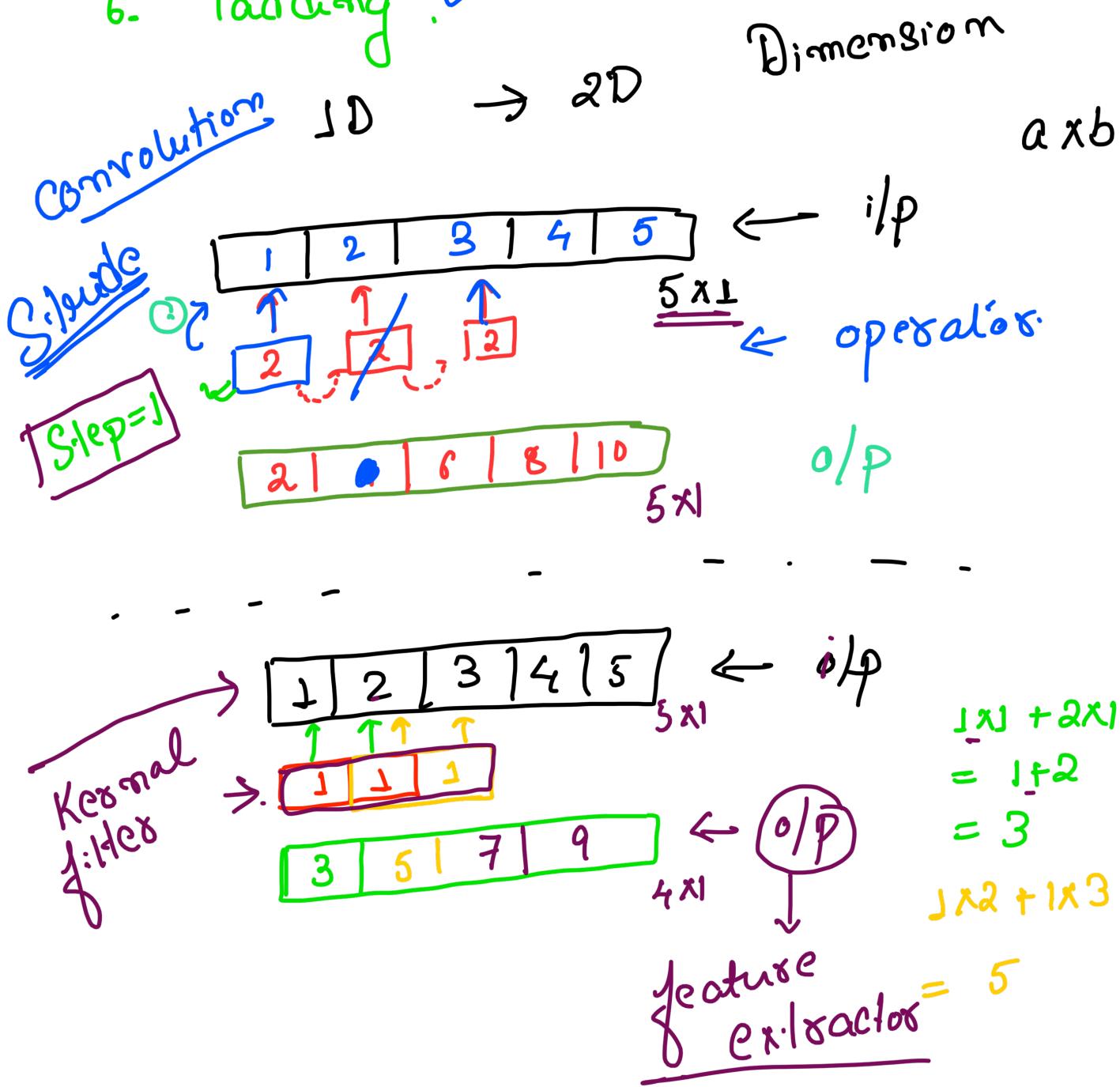


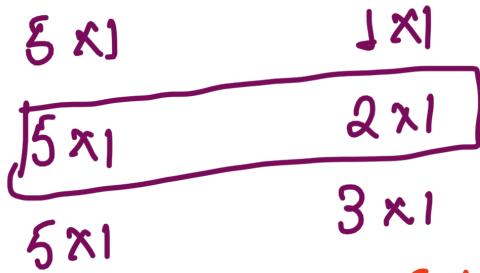
Convolutional Neural Network (CNN)

1. Convolution ✓
2. Stride ✓
3. Pooling ✗
4. Activation Function ✓
5. Fully Connected Layers
6. Padding ✓

Basic



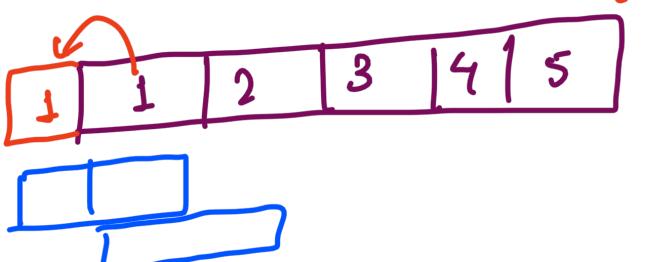
$i/p \rightarrow$



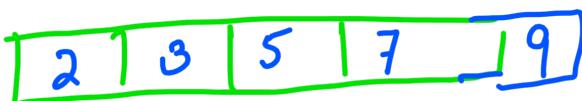
5×1

2×1 $\neq 5 \times 1$
 3×1

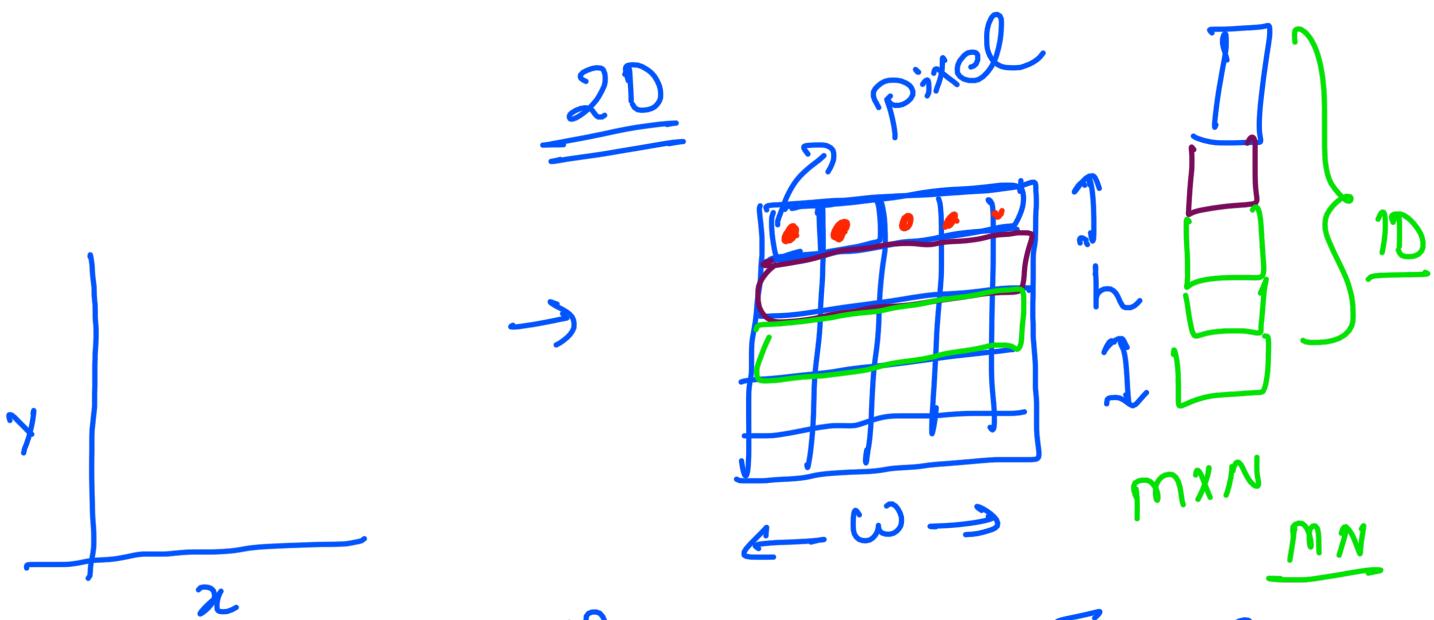
Addition
of new
elements



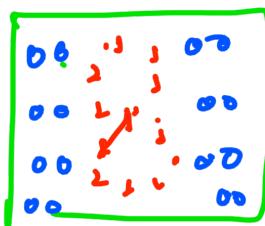
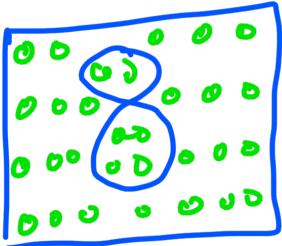
Padding



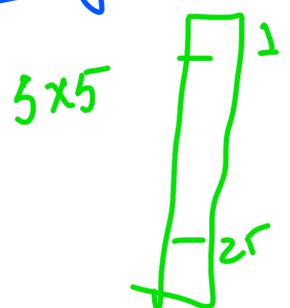
1D
2D / 3D



512×512
 1024×1024
Resolution



Image



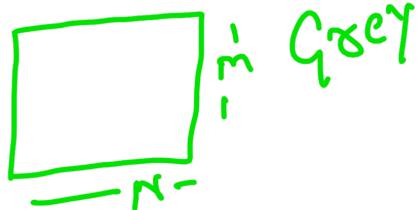
MNIST

Digit



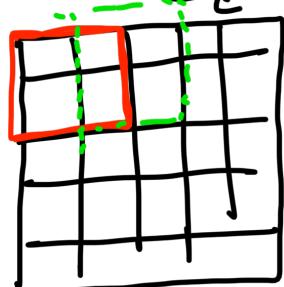
0/1

Cat



Channels = 1
 $1 \times m \times n$

2D Convolution

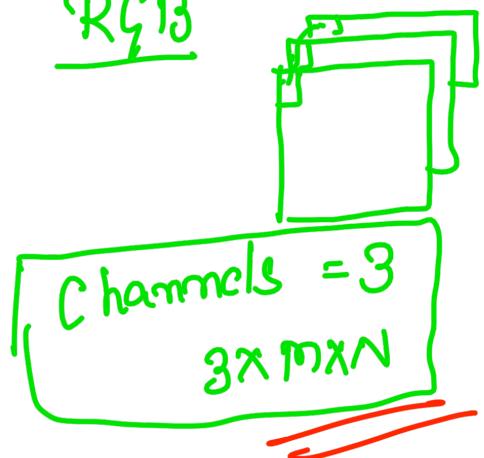


filter / Kernel

2x2

$5 \times 1 \rightarrow 5 \times 5$

RGB

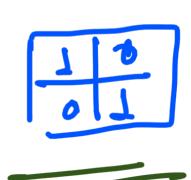


Stride = 1

iP

1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5

5x5



Square
 Rectangle

3	3	3	3
5	5	5	5

4x4

feature
 extraction

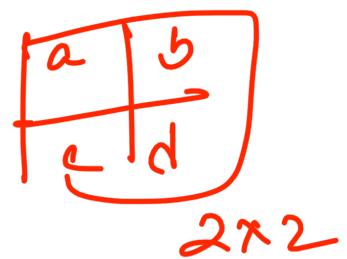
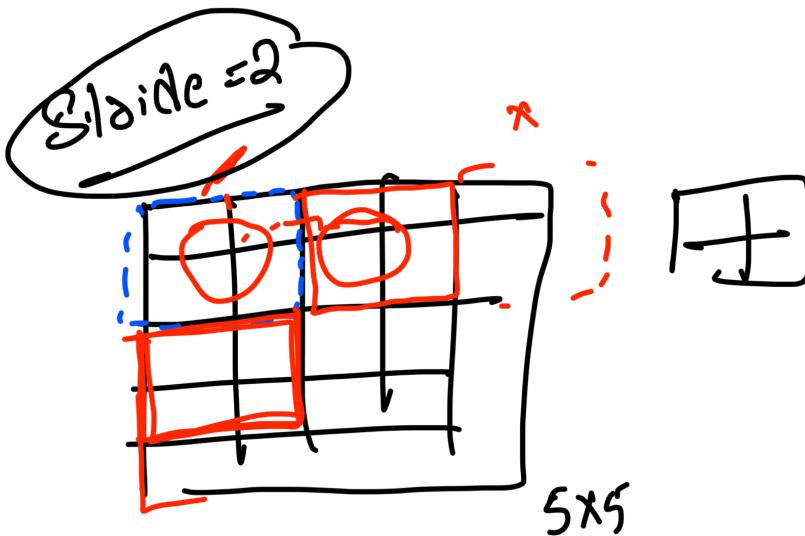
$$JxJ + 0x1 + 0x2 + 2x1$$

$$= J + 2 = 3$$

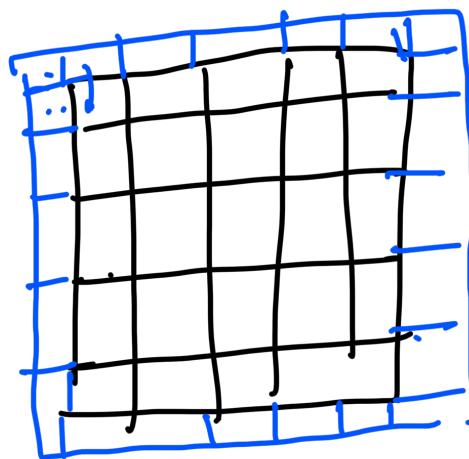
$$JxJ + 0N + 2x0 + 2N = 3$$

Padding

$$2x1 + 2x0 + 3x0 + 3N = 5$$



Padding



7x7

$\max(a, b, c, d)$

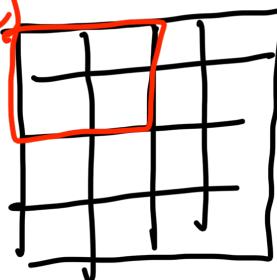
Polling

Max
Min

Average

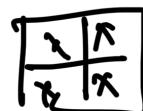
$\max(a, b, c, d)$

$\min(a, b, c, d)$



No values

9	4	-1	-10
6	3	6	3



max

9	6	6
---	---	---

Stride = 1

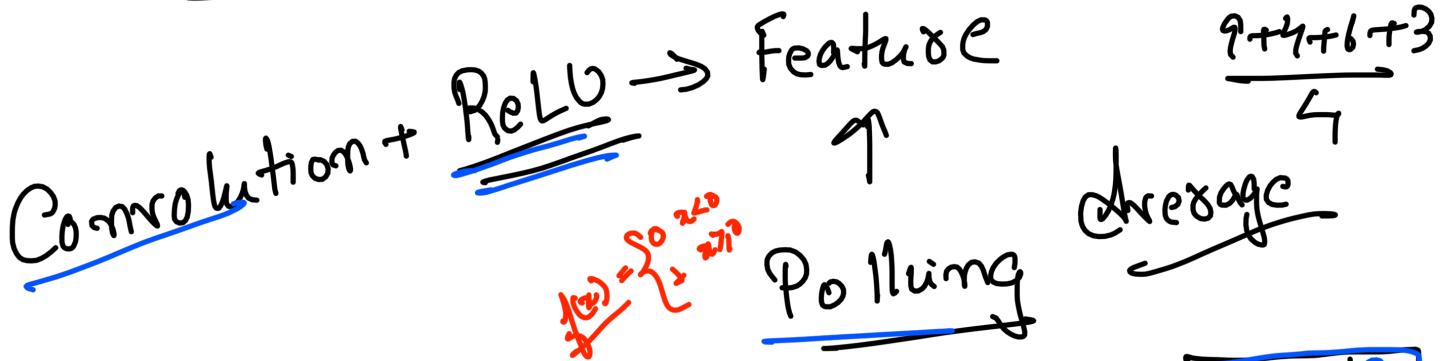
min

9	4	-1	-10
6	3	6	3

min

Stride = 1

3	-1	-16
---	----	-----



Convolution →

-1	2	-6	0
3	2	-10	4
1	-6	3	-10
-15	-11	0	2

4x4

0	2	0	0
3	2	0	4
1	0	3	0
0	0	0	1

4x4

Size Preserved
values might get changed

-

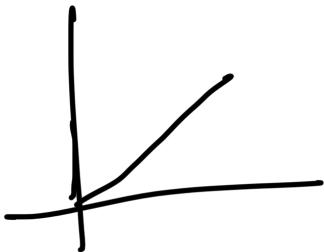
ACTIVATION FUNCTION	PLOT	EQUATION	DERIVATIVE	RANGE
Linear		$f(x) = x$	$f'(x) = 1$	$(-\infty, \infty)$
Binary Step		$f(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} 0 & \text{if } x \neq 0 \\ \text{undefined} & \text{if } x = 0 \end{cases}$	$\{0, 1\}$
Sigmoid		$f(x) = \sigma(x) = \frac{1}{1 + e^{-x}}$	$f'(x) = f(x)(1 - f(x))$	$(0, 1)$
Hyperbolic Tangent(tanh)		$f(x) = \tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$	$f'(x) = 1 - f(x)^2$	$(-1, 1)$
Rectified Linear Unit(ReLU)		$f(x) = \begin{cases} 0 & \text{if } x < 0 \\ x & \text{if } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x > 0 \\ \text{undefined} & \text{if } x = 0 \end{cases}$	$[0, \infty)$
Softplus		$f(x) = \ln(1 + e^x)$	$f'(x) = \frac{1}{1 + e^{-x}}$	$(0, 1)$
Leaky ReLU		$f(x) = \begin{cases} 0.01x & \text{if } x < 0 \\ x & \text{if } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} 0.01 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$	$(-1, 1)$
Exponential Linear Unit(ELU)		$f(x) = \begin{cases} \alpha(e^x - 1) & \text{if } x \leq 0 \\ x & \text{if } x > 0 \end{cases}$	$f'(x) = \begin{cases} \alpha e^x & \text{if } x < 0 \\ 1 & \text{if } x > 0 \\ 1 & \text{if } x = 0 \text{ and } \alpha = 1 \end{cases}$	$[0, \infty)$

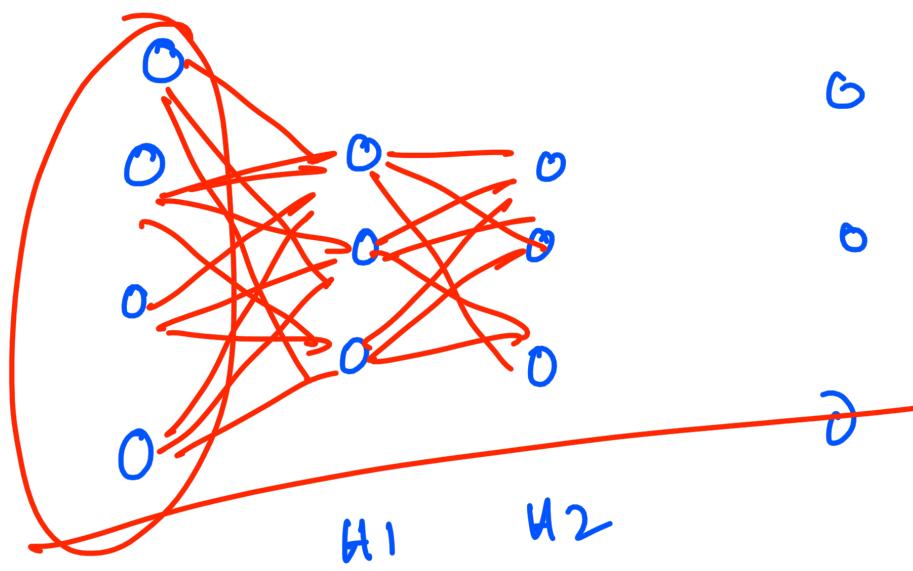
$0 < x < 0$
 $\downarrow x > 0$

$\leftarrow \underline{\text{ReLU}}$

$\underline{\text{XOR}}$

Non-linearly





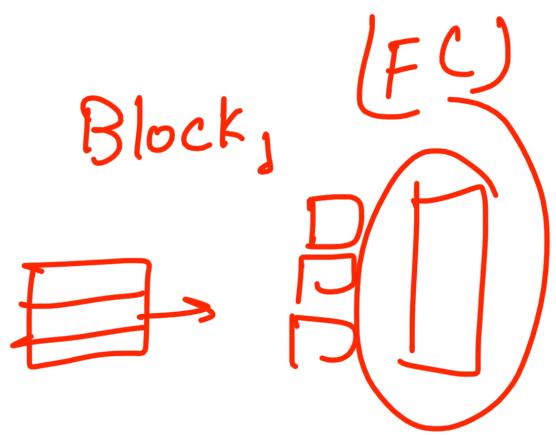
Fully Connected

$\xrightarrow{\text{Neuron } k \text{ (FC)}}$



Block

Block



Flatten