

# Convolutional Neural Networks

23 January 2024 08:23 PM

1) CONVOLUTION

2) PADDING

3) POOLING

4) STRIDES

1) CONVOLUTION OPERATION :

$$\begin{array}{c}
 A \\
 \begin{bmatrix} a_{00} & a_{01} & a_{02} \\ a_{10} & a_{11} & a_{12} \\ a_{20} & a_{21} & a_{22} \end{bmatrix}
 \end{array}
 *
 \begin{array}{c}
 F \\
 \begin{bmatrix} b_{00} & b_{01} & b_{02} \\ b_{10} & b_{11} & b_{12} \\ b_{20} & b_{21} & b_{22} \end{bmatrix}
 \end{array}
 = a_{00}b_{00} + a_{01}b_{01} + a_{02}b_{02} \\
 + a_{10}b_{10} + a_{11}b_{11} + a_{12}b_{12} \\
 + a_{20}b_{20} + a_{21}b_{21} + a_{22}b_{22}$$

Ex1:

$$\begin{bmatrix} 1 & 0 & 2 \\ 2 & 1 & 1 \\ 0 & 1 & 1 \end{bmatrix} *
 \begin{bmatrix} 3 & 0 & 1 \\ 2 & 1 & 2 \\ 1 & 0 & 1 \end{bmatrix} = 13$$

$$\begin{bmatrix} 2 & 4 & 3 \\ 7 & 3 & 6 \\ 8 & 1 & 2 \end{bmatrix} *
 \begin{bmatrix} 3 & 4 & 3 \\ 4 & 5 & 4 \\ 4 & 3 & 2 \end{bmatrix} = 13^7$$

$$\begin{array}{c}
 * \\
 \boxed{\begin{bmatrix} 1 & 0 & 2 & 3 & 1 & 1 \\ 2 & 1 & 2 & 4 & 2 & 3 \\ 3 & 2 & 0 & 1 & 4 & 1 \\ 2 & 1 & 0 & 1 & 2 & 1 \\ 1 & 0 & 3 & 2 & 1 & 3 \\ 3 & 0 & 1 & 2 & 1 & 1 \end{bmatrix}}
 \end{array}
 *
 \begin{array}{c}
 \boxed{\begin{bmatrix} 1 & 0 & 2 \\ 1 & 2 & 1 \\ 2 & 1 & 0 \end{bmatrix}} \\
 = \\
 \boxed{\begin{bmatrix} 19 & 19 & 22 & 22 \\ 18 & 14 & 13 & 24 \\ 9 & 9 & 20 & 14 \\ 12 & 12 & 16 & 15 \end{bmatrix}}
 \end{array}$$

INPUT  $(6, 6)$       FILTER  $(3, 3)$        $(4, 4)$

$$\begin{array}{c}
 * \\
 \boxed{\begin{bmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{bmatrix}}
 \end{array}
 *
 \begin{array}{c}
 \boxed{\begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}} \\
 = \\
 \boxed{\begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix}}
 \end{array}$$

$3 \times 3$        $8 \times 8$        $3 \times 3$        $6 \times 6$

$$\begin{array}{c}
 * \\
 \boxed{\text{Input: } 8 \times 8} \quad * \quad \boxed{\text{Filter: } 5 \times 5} \quad = \quad \boxed{\text{Output: } 4 \times 4}
 \end{array}$$

>  $n \times n$  : Shape of input  
 >  $n_f \times n_f$  : Shape of filter

**OUTPUT SHAPE :  $(n - n_f + 1, n - n_f + 1)$**

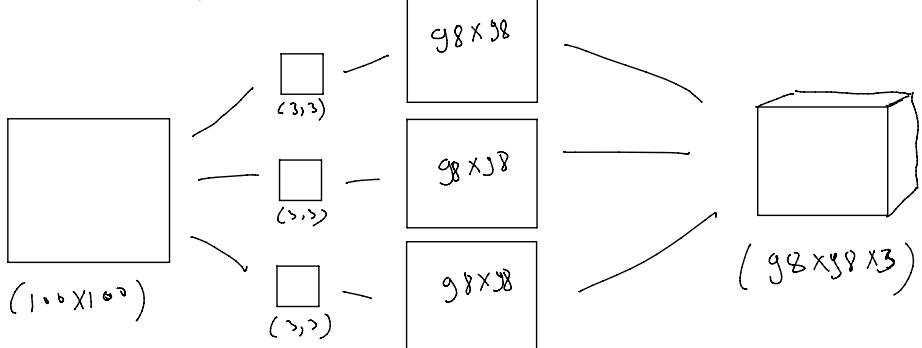
Ex.

$$\begin{array}{c}
 \boxed{\text{Input: } 100 \times 100} \quad * \quad \boxed{\text{Filter: } 3 \times 3} \quad = \quad \boxed{\text{Output: } 98 \times 98}
 \end{array}$$

\* RGB IMAGES :-

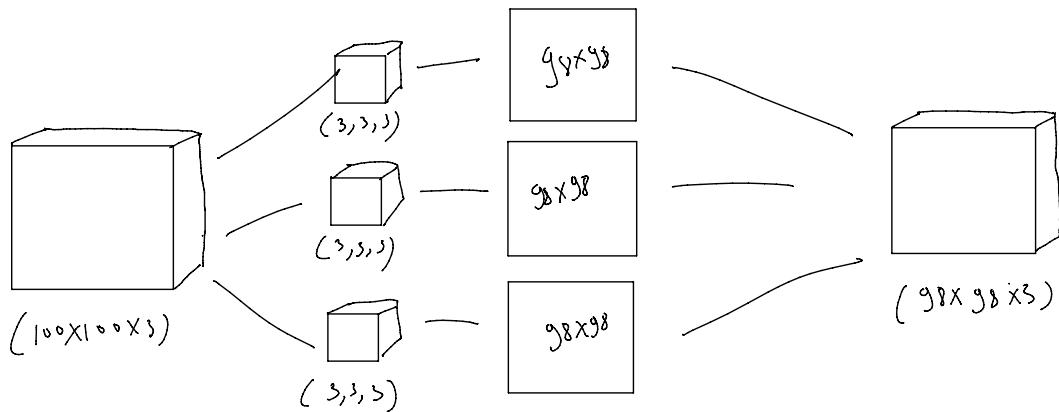
$$\begin{array}{c}
 \boxed{\text{Input: } 100 \times 100 \times 3} \quad * \quad \boxed{\text{Filter: } 3 \times 3 \times 3} \quad = \quad \boxed{\text{Output: } 98 \times 98}
 \end{array}$$

\* MULTIPLE FILTERS :-



\* MULTIPLE FILTERS (RGB) :-

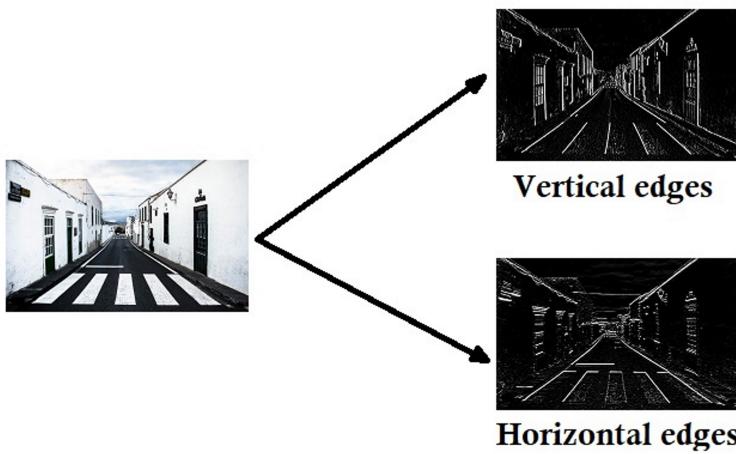
## \* MULTIPLE FILTERS (RGB) :-



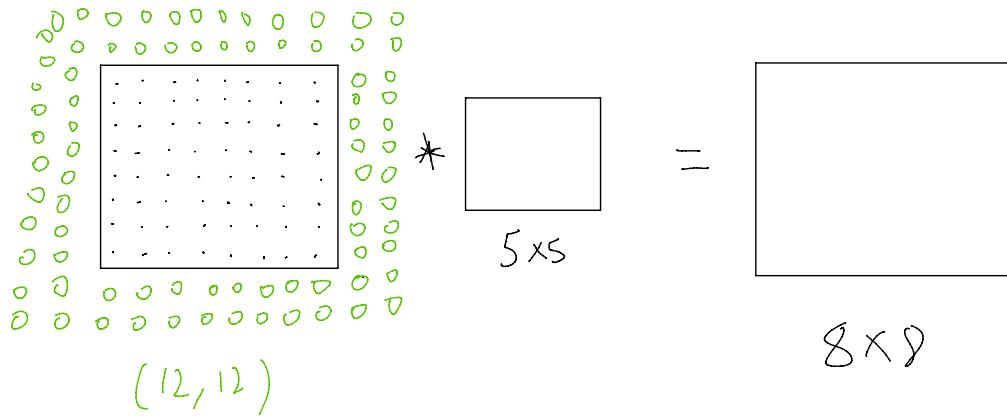
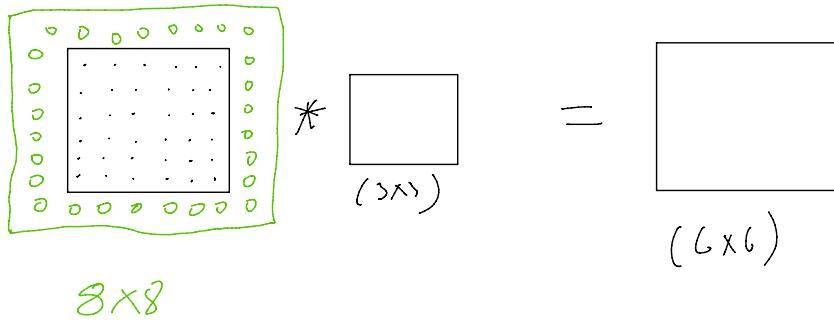
## \* SIGNIFICANCE OF CONVOLUTION OPERATION :-

$$\begin{array}{c} \text{Input Image} \\ \times \end{array} \quad \begin{array}{c} \text{Filter} \\ \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & 1 \end{bmatrix} \\ = \end{array} \quad \begin{array}{c} \text{Output Image} \\ \text{Vertical edge} \end{array}$$

$$\begin{array}{c} \text{Input Image} \\ \times \end{array} \quad \begin{array}{c} \text{Filter} \\ \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \\ = \end{array} \quad \begin{array}{c} \text{Output Image} \\ \text{Horizontal edges} \end{array}$$



## \* PADDING :-



\* VALID = No Padding

\* SAME = Maintains Resolution

- >  $n \times n$  : Shape of input
- >  $n_f \times n_f$  : Shape of filter
- >  $p$  : no. of padding layer

OUTPUT SHAPE :  $n - n_f + 1 + 2p, n - n_f + 1 + 2p$



\* STRIDES :-

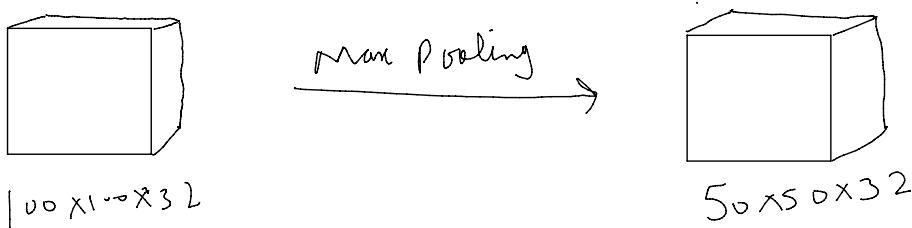
OUTPUT :  $\frac{n - n_f + 2p}{s} + 1, \frac{n - n_f + 2p}{s} + 1$

$\text{X} \rightarrow \text{X} \rightarrow \text{X} \rightarrow \text{X}$

## \* POOLING:-

### 1) MAX POOLING:-

$$\begin{matrix} 2 & 3 & 2 & 8 \\ 9 & 1 & 3 & 5 \\ 8 & 1 & 4 & 7 \\ 1 & 3 & 3 & 2 \end{matrix} = \begin{matrix} 9 & 8 \\ 8 & 7 \end{matrix}$$



### 2) AVERAGE POOLING:-

$$\begin{matrix} 2 & 3 & 2 & 8 \\ 9 & 1 & 3 & 5 \\ 8 & 1 & 4 & 7 \\ 1 & 3 & 3 & 2 \end{matrix} = \begin{matrix} 3.75 & 4.5 \\ 3.25 & 4 \end{matrix}$$

$\text{X} \rightarrow \text{X} \rightarrow \text{X} \rightarrow \text{X}$

## \* CONVOLUTIONAL NEURAL NETWORK:-

INPUT :  $28 \times 28$

$$\left\{ \begin{array}{l} \text{CONV1}(16, 3 \times 3, \text{padding: 'Same'}) : 28 \times 28 \times 16 \\ \text{MAXPOOLING}(2, 2) : 14 \times 14 \times 16 \\ \text{CONV2}(32, 3 \times 3, \text{padding: 'Valid')} : 12 \times 12 \times 32 \\ \text{MAXPOOLING}(2, 2) : 6 \times 6 \times 32 \end{array} \right.$$

$$\left\{ \begin{array}{l} \text{FLATTEN}() : [1152, 1] \\ \text{DENSE}(100) : [100, 1] \\ \text{DENSE}(10) : [10, 1] \end{array} \right.$$

{ PLATEN  
DENSE (100)  
DENSE (10)

[ 100, ]  
[ 10, ]