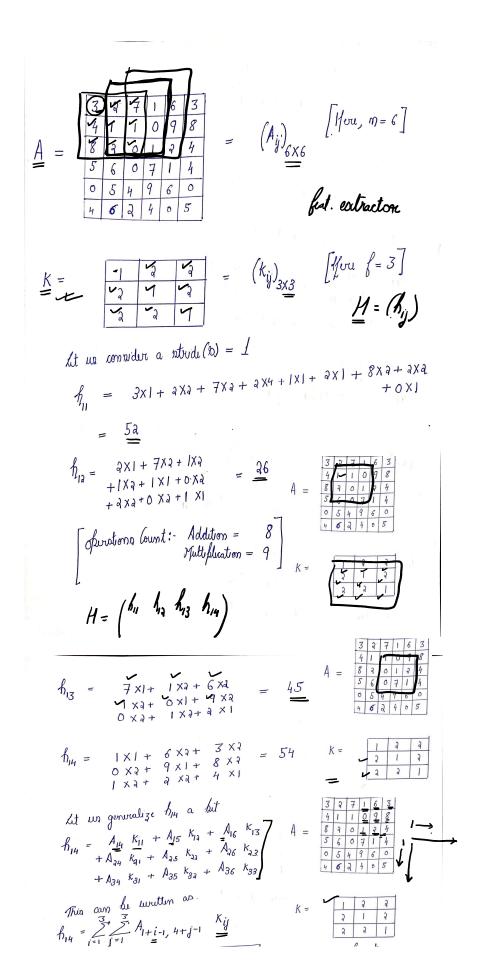
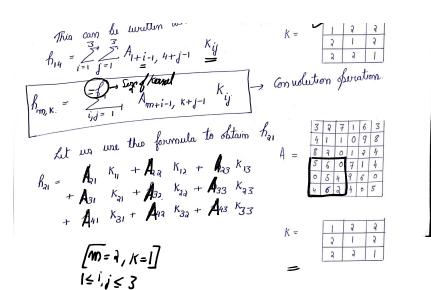
## **Convolutional Neural Networks**

Kernel: A kernel is a small matrix of weights that is convolved with the input image in order to produce a set of feature maps





=

$$= \begin{cases} 1 & x_1 + x_2 + x_3 + x_4 + x_5 + x$$

$$\hat{h}_{34} = \hat{h}_{34} k_{11} + \hat{h}_{35} k_{13} + \hat{h}_{34} k_{13} + \\
\hat{h}_{34} k_{11} + \hat{h}_{35} k_{32} + \hat{h}_{36} k_{23} + \\
k_{44} k_{31} + \hat{h}_{45} k_{32} + \hat{h}_{46} k_{33}$$

$$= 0 \times 1 + 9 \times 2 + 8 \times 2 + \\
1 \times 3 + 2 \times 1 + 4 \times 2 + 6 \times 4$$

$$= 66$$

$$\begin{split} & \int_{31} = 8x_1 + 2x_2 + 6x_2 + 5x_3 + 6x_1 + 0x_2 + 5x_3 + 6x_1 + 0x_2 + 5x_3 + 6x_1 + 0x_2 + 6x_3 + 6x_1 + 7x_2 + 6x_2 + 0x_1 + 7x_2 + 6x_2 + 0x_2 + 7x_1 + 1x_3 + 6x_1 + 6x_1 + 6x_1 + 6x_2 + 6x_1 + 6x_1 + 6x_2 + 6x_1 + 6x_2 + 6x_2 + 6x_1 + 6x_2 + 6x_3 + 6x_2 + 6x_3 + 6$$

$$f_{31} = 8x1 + 3x3 + 0x3 + 5x3 + 6x1 + 0x3 + 6x1 + 0x3 + 6x1 + 0x3 + 6x1 + 0x3 + 6x1 + 6$$

$$h_{32} = \begin{array}{rrr} 7x & 1 & + & 0x & 2 & + & 1x & 2 & + \\ 6x & 2 & + & 0x & 1 & + & 7x & 2 & + \\ 5x & 2 & + & 4x & 2 & + & 9x & 1 \end{array} = \begin{array}{rrr} 57$$

$$h_{33} = 0 \times 1 + 1 \times 2 + 2 \times 2 + 4 \times 4 + 4 \times$$

$$f_{34} = \frac{1 \times 1}{7 \times 3} + \frac{1 \times 3}{1 \times 4} + \frac{1 \times 3}{1 \times 4} + \frac{1 \times 3}{1 \times 4} = 66$$

$$\frac{7 \times 3}{1 \times 4} + \frac{1 \times 1}{1 \times 4} + \frac{1}{1 \times 4} + \frac{1}{1 \times 4} = 66$$

$$h_{43} = 0 \times 1 + 7 \times 2 + 1 \times 2 + 4 \times 2 + 9 \times 1 + 6 \times 2 + 57$$

$$2 \times 2 + 4 \times 2 + 0 \times 1$$

$$f_{44} = \frac{7 \times 1 + 1 \times 2 + 4 \times 2 +}{9 \times 2 + 6 \times 1 + 0 \times 2 +} = 54$$

$$4 \times 2 + 0 \times 2 + 5 \times 1$$

The outfut matrix after performing consolutions is

16x9 = 144

9 multiplications of 8 additions = 128

Total multiplications done = 4×4×9 = 144 Total additions done = 4×4×8 - 128.

If we consider any mxm input matrix

[X] kound size of stude = 2

The output matrix after applying consolution will be

The output matrix after applying consolution will he of rize 
$$\frac{m-l+1}{2} \times \frac{m-l+1}{2} + 1$$
  $m=6, l=3$   $6-3+1=4$ 

Hence, mumber of multiplications  $= \left\lfloor \frac{m-f}{2} + 1 \right\rfloor \times \left\lfloor \frac{m-f}{2} + 1 \right\rfloor \times \left\lfloor \frac{x}{2} \right\rfloor$ 

Number of addition 
$$a = \left[\frac{m-l+1}{2} + 1\right] \times \left[\frac{m-l+1}{2} + 1\right] \times \left(\left[\frac{k}{k}\right] - 1\right)$$

the wid formula for convolution as:  $h_{m, k} = \sum_{i,j=1}^{f} A_{m+i-1, k+j-1} K_{ij}$ 

$$3 \times 3$$
  $\begin{cases} 3 \times 3 & 6 = 3 \end{cases}$   $\begin{bmatrix} m-6 + 1 \end{bmatrix} = \begin{bmatrix} \frac{200-3}{1} + 1 \end{bmatrix}$   $= 198$ 

$$\int_{-200}^{1} \int_{-30}^{1} \int_{-300}^{1} \int_{-300}^{1} \int_{-300}^{1} \int_{-3000}^{1} \int_{-30$$

196X196X3