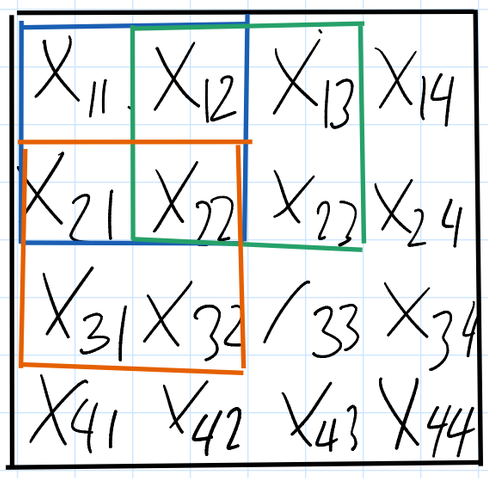
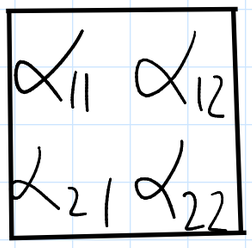
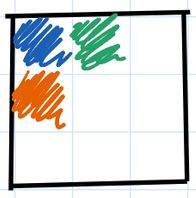
Inductive bias

Image processing

$H \times W \times C$ $\quad C = 3$







← filter, kernel

$$y = \sum_{ij} \alpha_{ij} x_{ij}$$

convolution

3×3

- Blur

$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

- Contour

$$\frac{1}{8}\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

- Sharpen

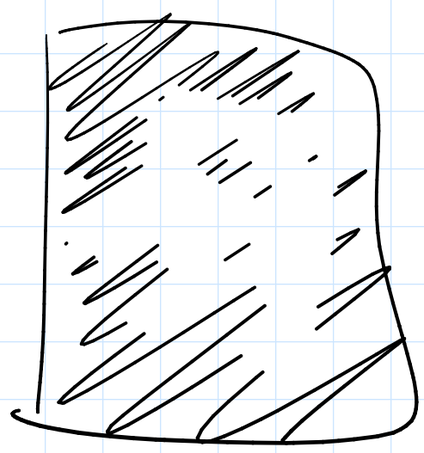
$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

- Edge detection

$$\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix}$$

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} & \cdots \\ \alpha_{21} & \cdot & \\ \vdots & & \ddots \\ \cdot & & \end{bmatrix}$$

α – learnable parameters



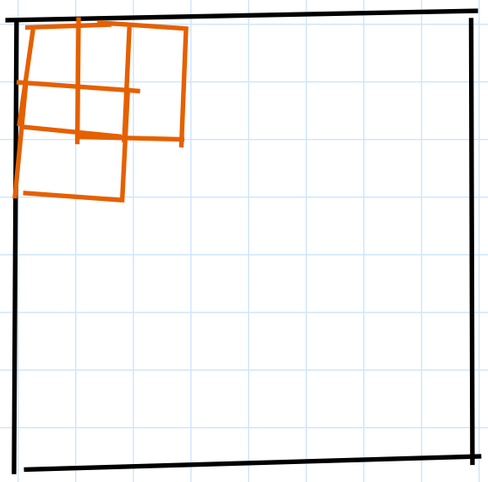
Convolutional Neural Networks

- Kernel size (k)

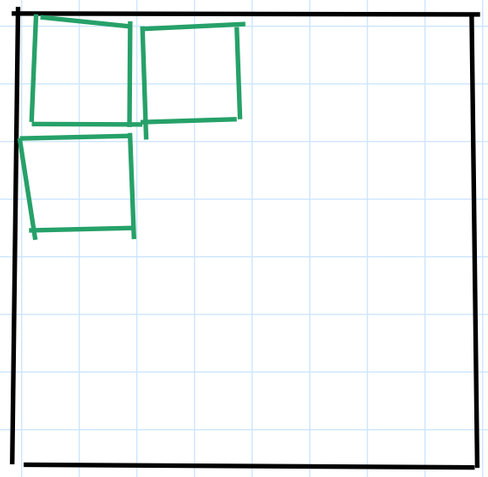
  2×2, 3×3, $k_1 \times k_2$

  k^2, $k_1 k_2$ – number of parameters

- Stride



stride = 1



stride = 2

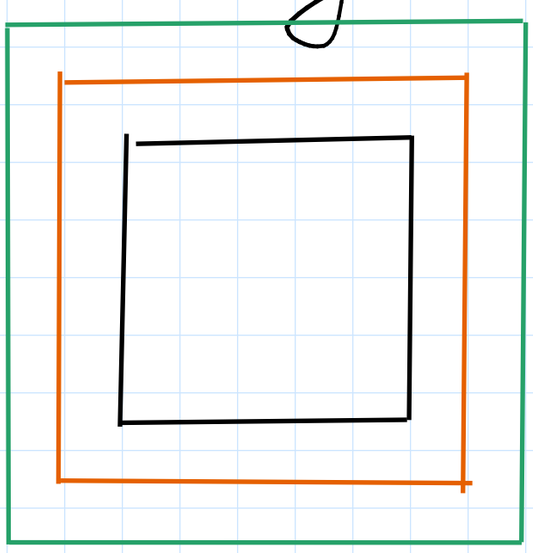
$$H \times W \rightarrow H-1 \times W-1$$

$$H \times W \rightarrow \frac{H-1}{2} \times \frac{W-1}{2}$$

$H \times W$, k, s

$$H_{out} = \frac{H-k+1}{s}$$

- Padding



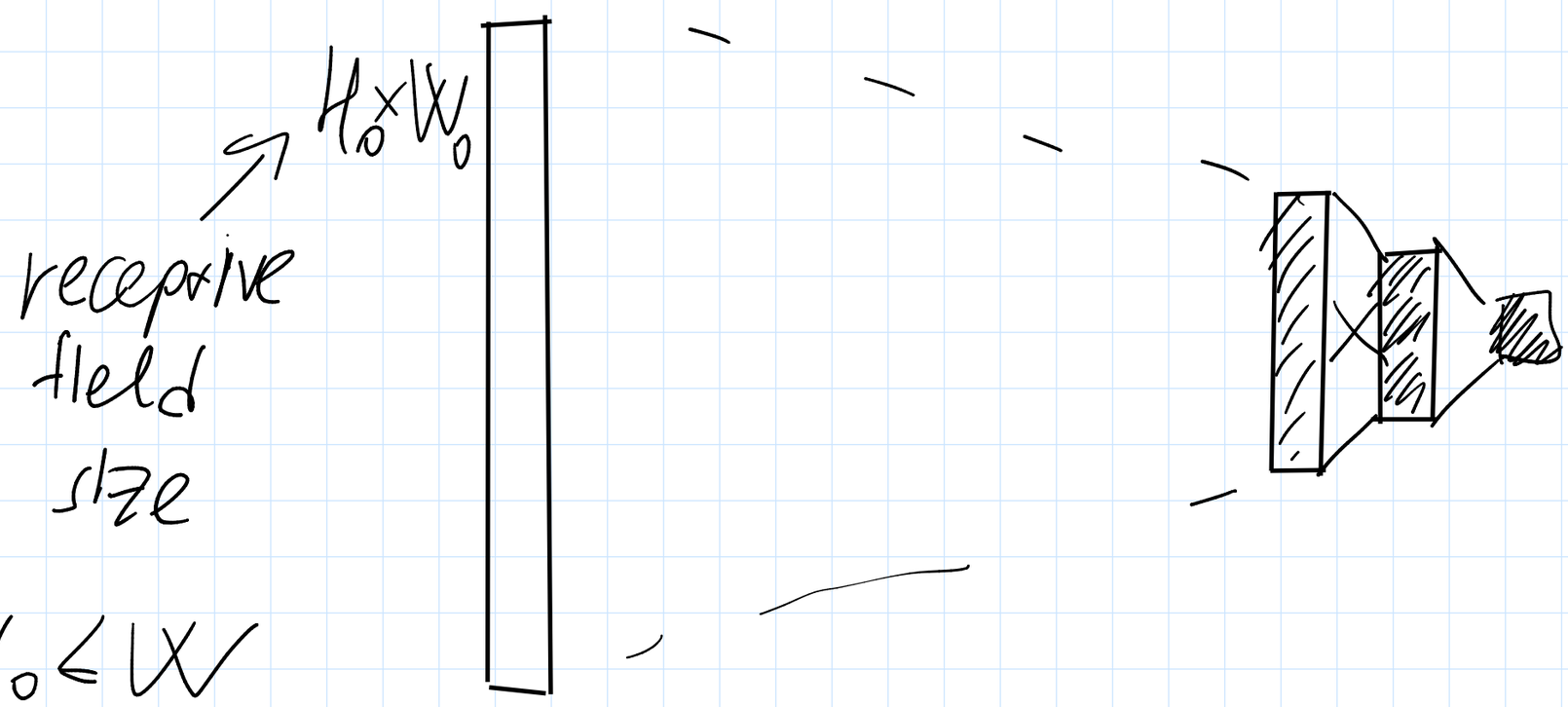
padding = 1

padding = 2

$p = (k-1)//2$ stride = 1

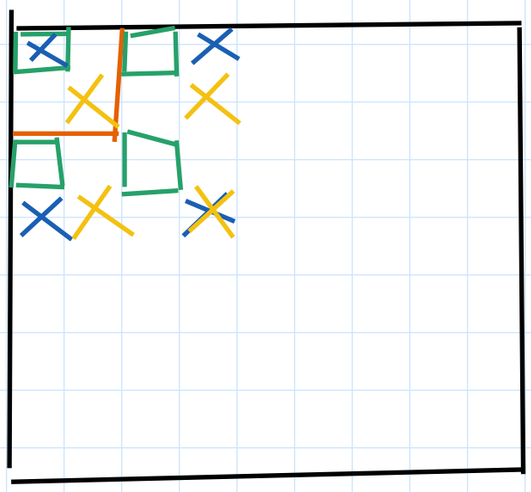
Receptive field

Image $H \times W$



$H_0 \leq H$, $W_0 \leq W$

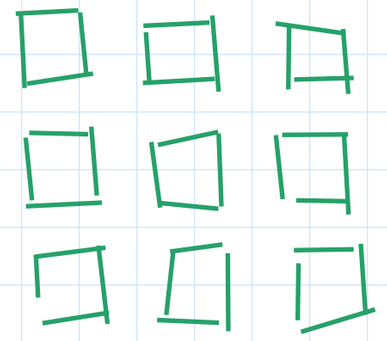
- Dilation



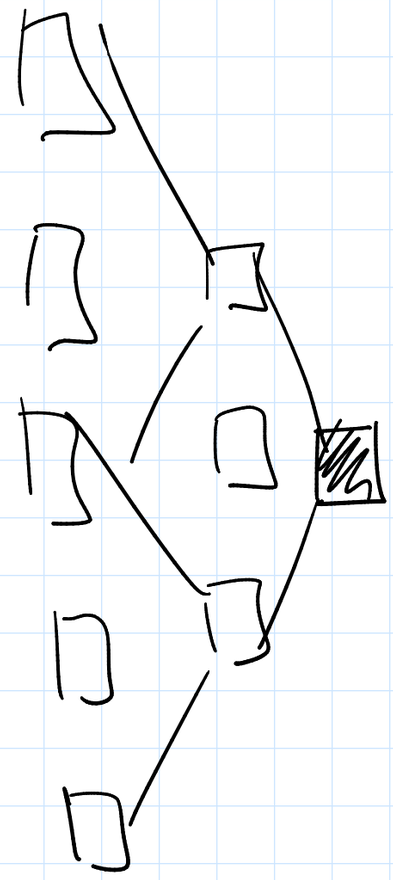
dilation = 1

dilation = 2

dilation = 3



3 x 3



feature map

$x: C_{in} \times H_{in} \times W_{in}$

$y: C_{out} \times H_{out} \times W_{out}$

$C_{in} \left(H_{in} \times W_{in} \right)$

$C_{out} \left(H_{out} \times W_{out} \right)$

$w: C_{in} \times C_{out} \times K_H \times K_W$

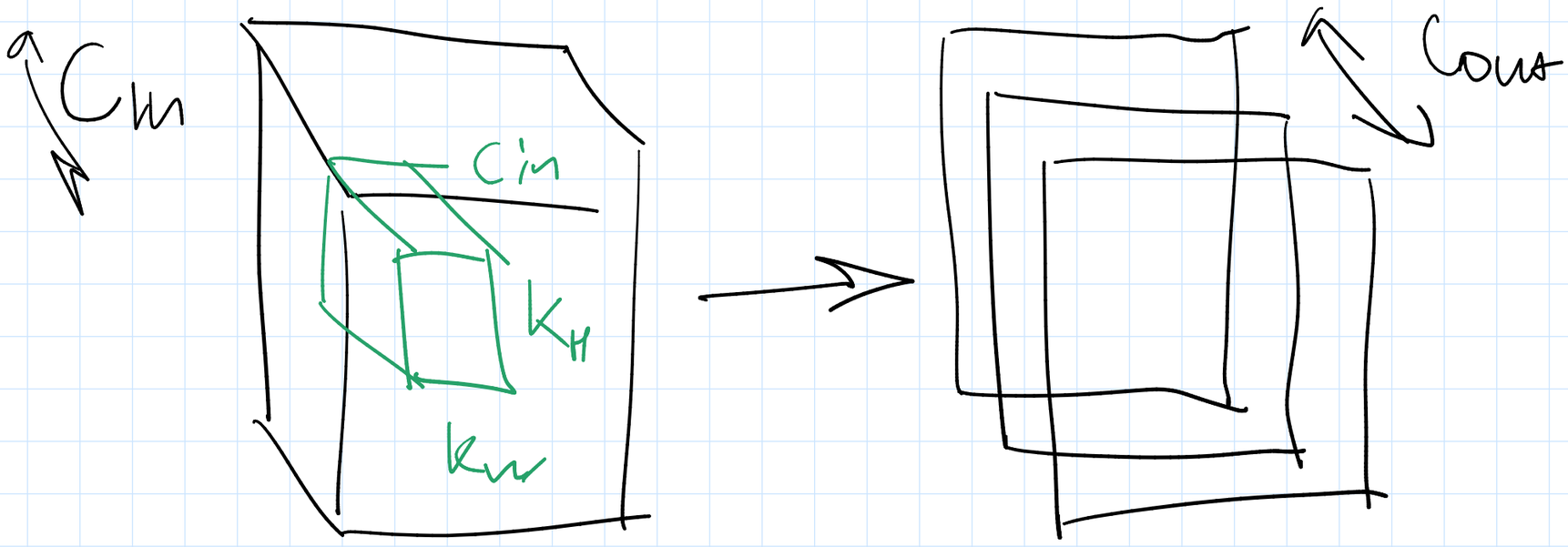
$b \in \mathbb{R}^{C_{out}}$

$1 \le i \le C_{out}$

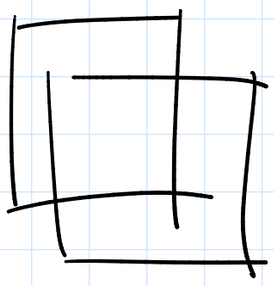
$1 \le j \le C_{in}$

$$y_i = \sum_{j=1}^{C_{in}} x_j * w_{ji} + b_i$$

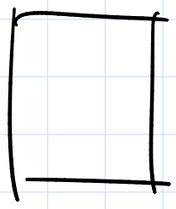
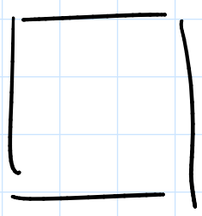
convolution



$X: 2 \times 2 \times 2$



$y: 3 \times 2 \times 2$

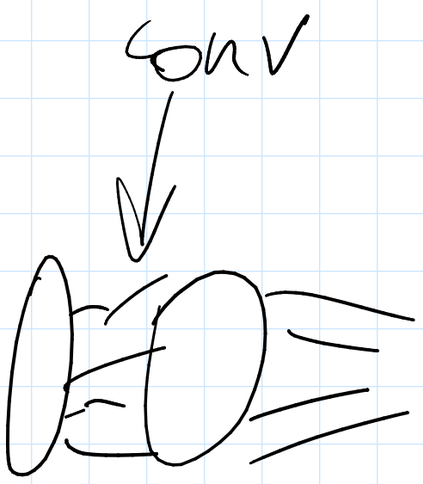
$X_1 =$  $X_2 =$ 

$C_{ij}: \overbrace{2 \times 3}^{} \times \overbrace{1 \times 1}^{}$ — 6 values

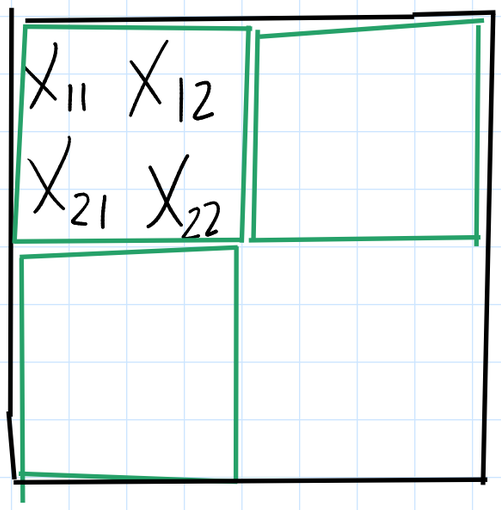
$1 \le i \le 2$

$1 \le j \le 3$

$y_j = C_{1j} \cdot \boxed{X_1} + C_{2j} \times \boxed{X_2}$



- Pooling



- Max pooling

$$y = \max_{i,j} x_{ij}$$

- Average pooling

$$y = \frac{1}{k^2} \sum_{ij} x_{ij}$$