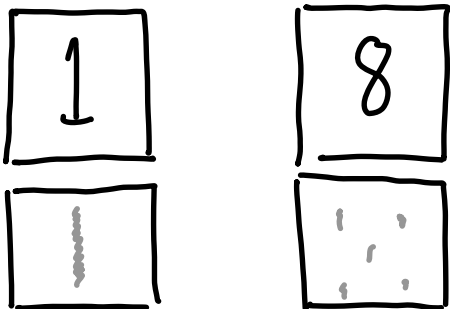
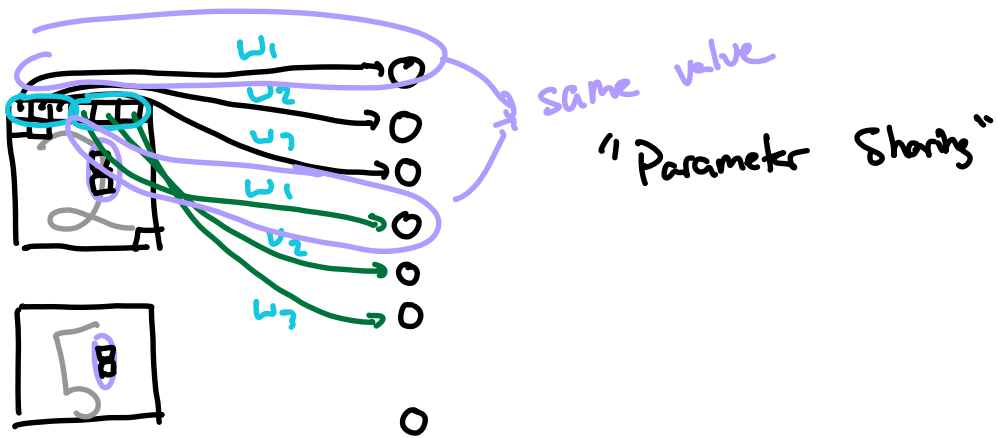
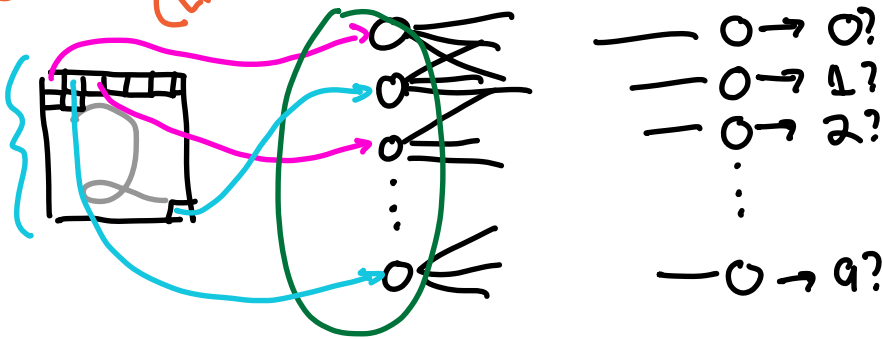
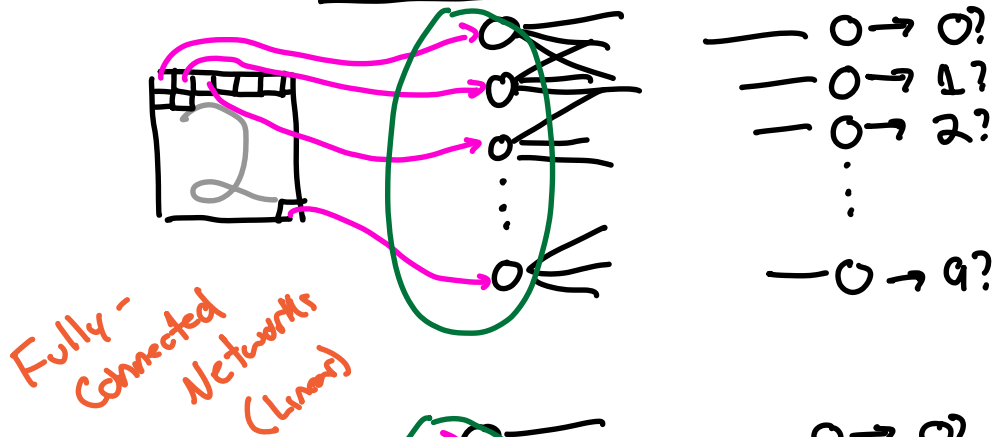
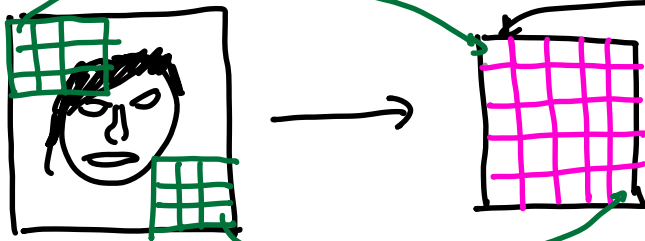


Convolutional Neural Networks (CNNs)



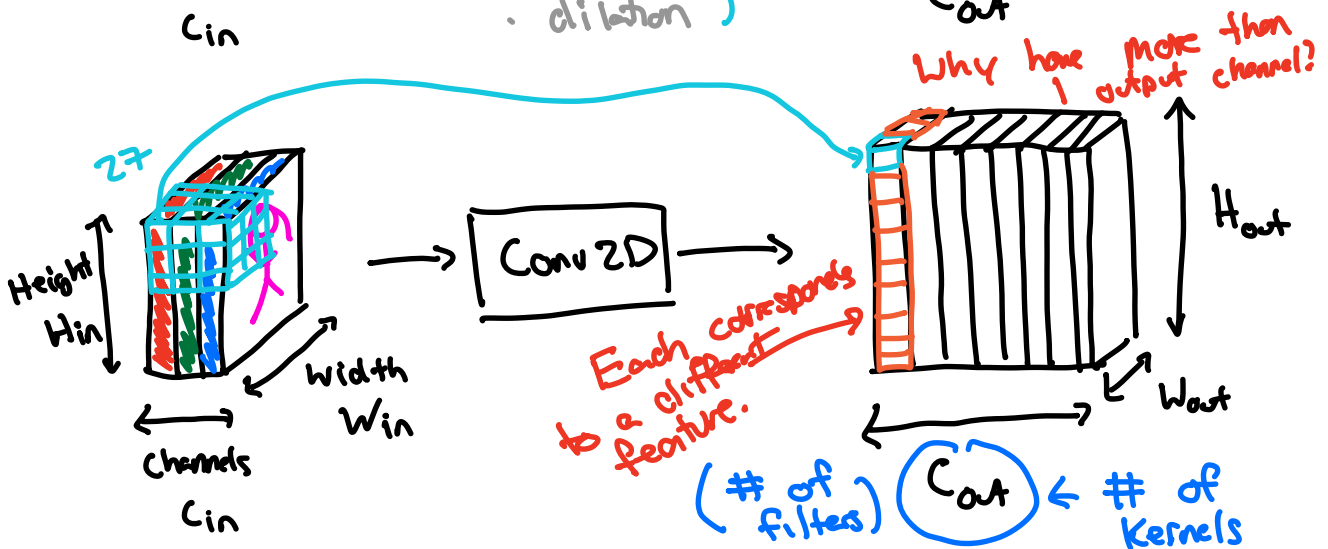
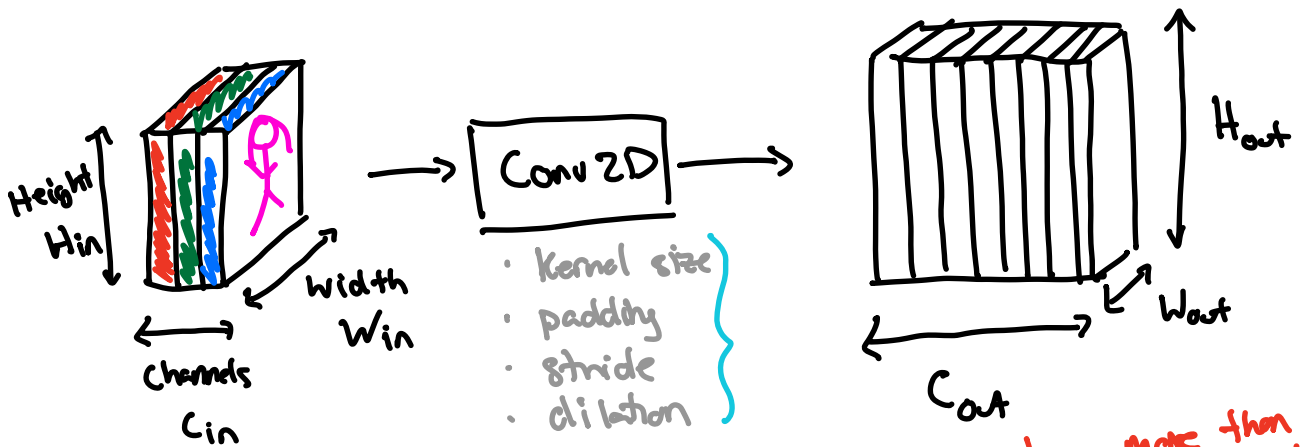
What will a right-sobel kernel highlight in these images?

3 x 3
"Kernel"



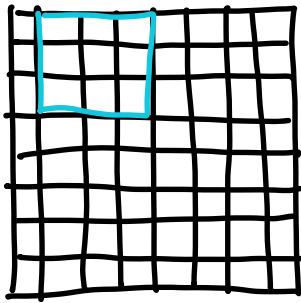
$$\begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix} * \begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix} = k_{1,1} \cdot I_{1,1} + k_{1,2} \cdot I_{1,2} \dots =$$

3 x 3 = 9 parameters
"Learned Parameters"

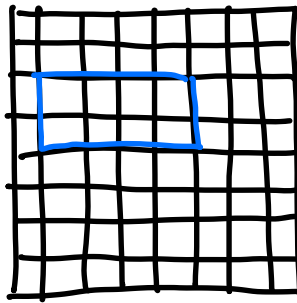


Kernel size

3x3



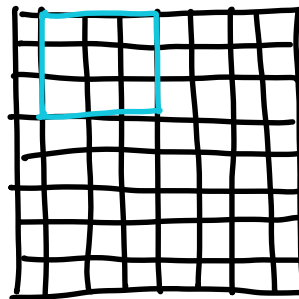
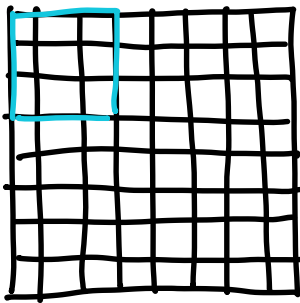
2x4



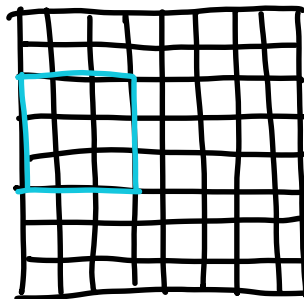
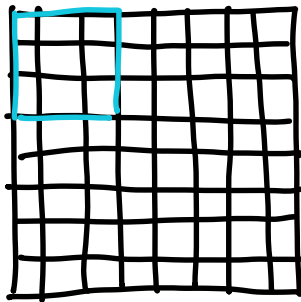
- square kernels
- odd size
- 3x3, 5x5, 7x7

Stride

Horizontal
stride = 1

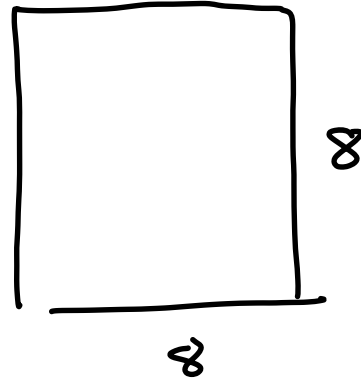
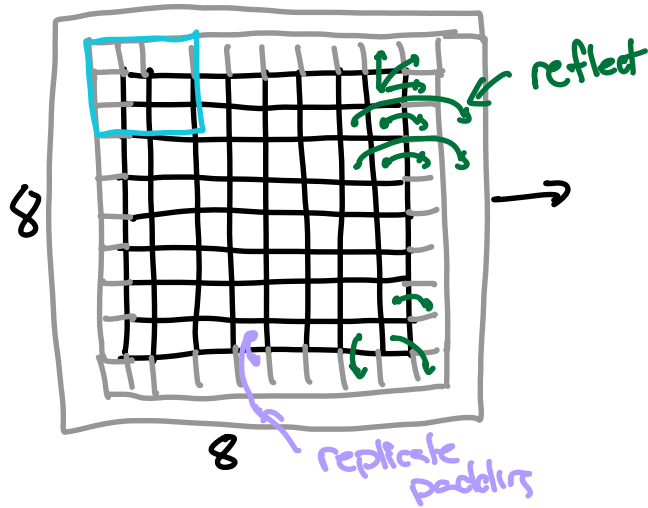
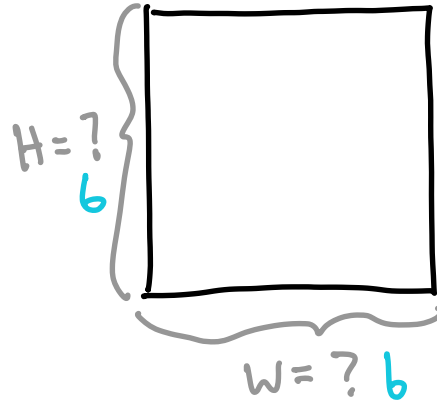
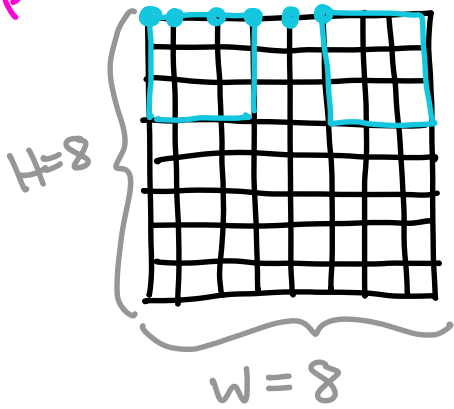


Vertical
stride = 2



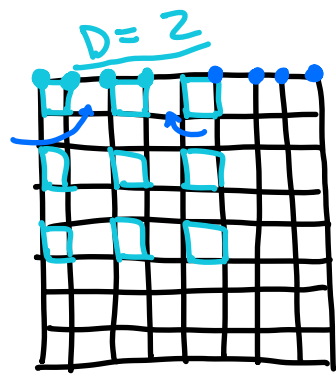
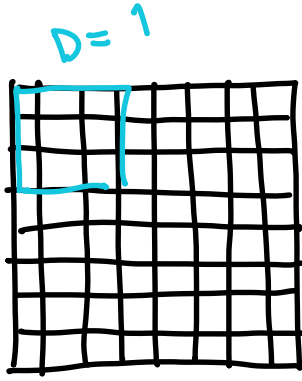
padding

$K=3 \times 3, S=1$



- zero pad
- reflection pad
- replicate

Dilation



3×3
 $S=1$
 $P=0$

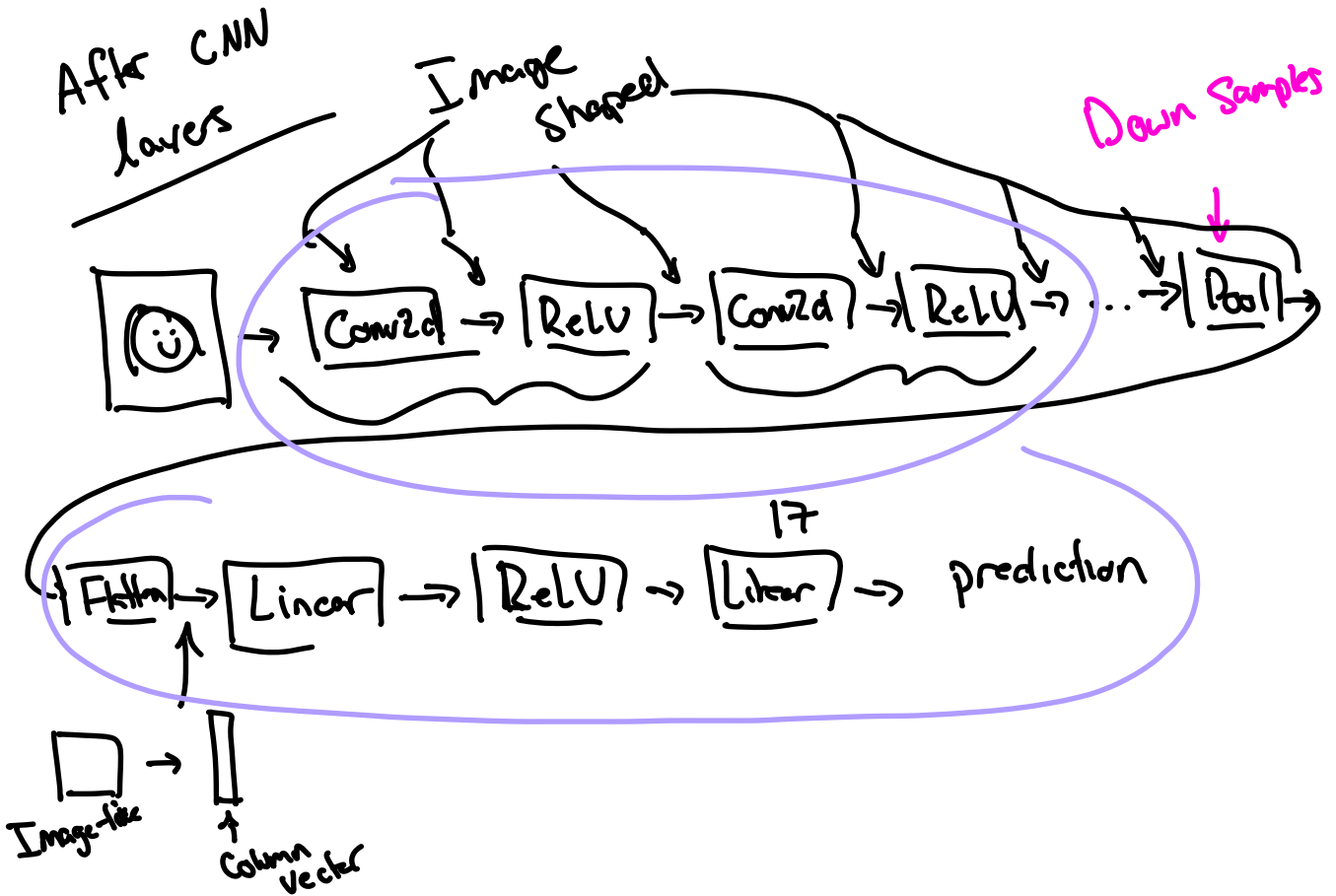
Kernel Strips

$H_{in}, W_{in}, C_{in} \rightarrow H_{out}, W_{out}, C_{out}$

of filters/
kernels

$$H_{out} = \frac{H_{in} + 2P - (D(K-1) + D) + 1}{S}$$

$$H_{out} = \frac{H_{in} + 2P - K}{S} + 1$$



CNN Analogy

