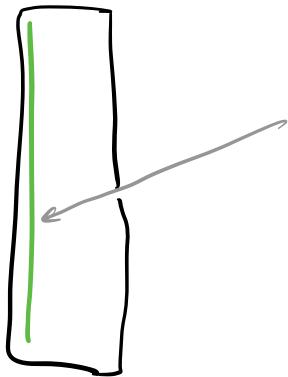


Lecture 2 - Filtering and Convolution

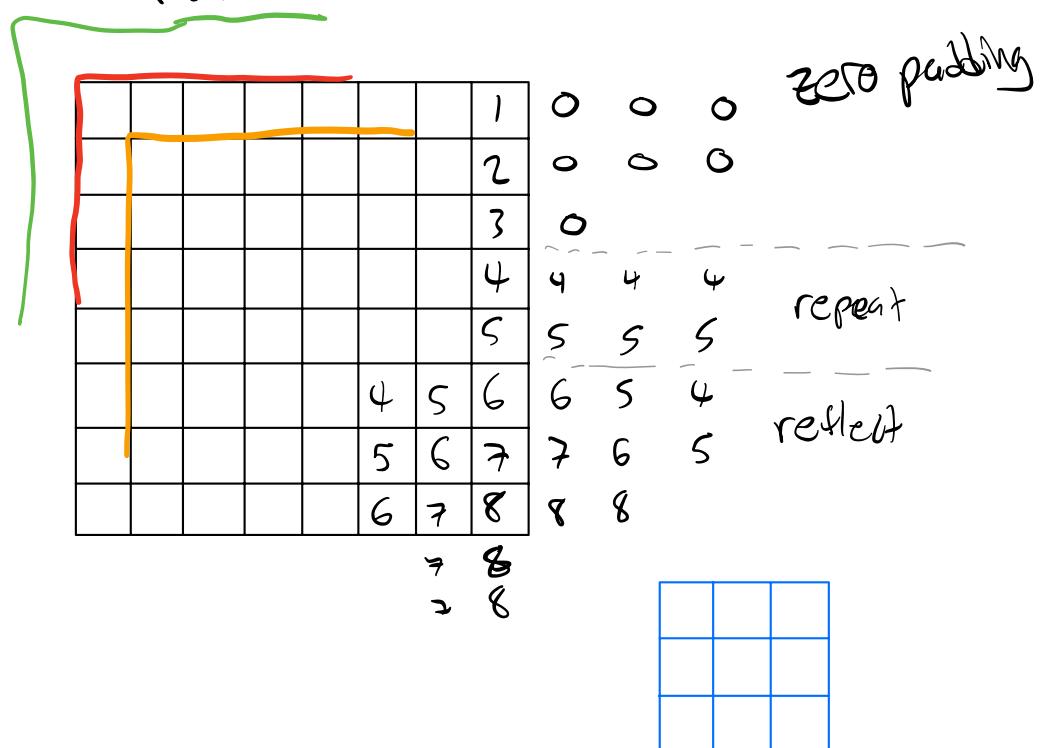


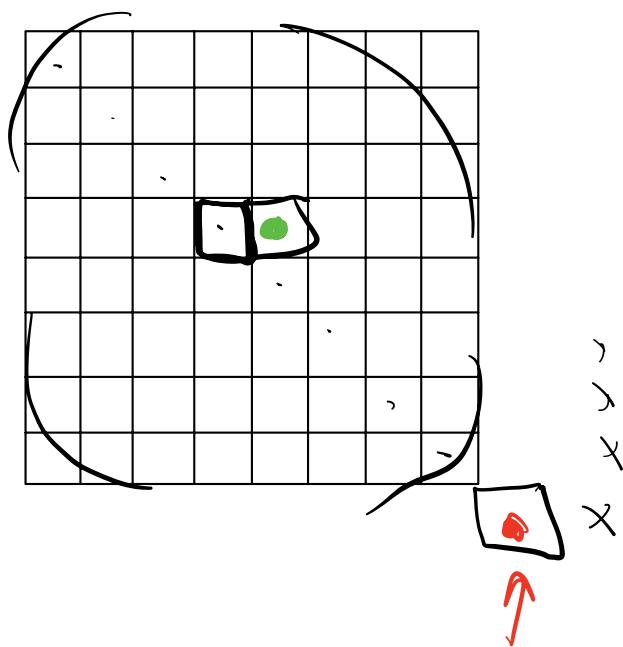
Output sizes:

— "Valid"

— "Same"

— "Full"





Hw #1

0	1	0
0	1	0
0	1	0

1	2	1
2	4	2
1	2	1

$$\begin{matrix} 3 & 6 & 3 \\ 4 & 8 & 4 \\ 3 & 6 & 3 \end{matrix}$$

Discrete Cross-correlation:

$$(f \otimes g)(x, y) = \sum_{j=-l}^l \sum_{k=-l}^l f(x+j, y+k) \cdot g(j, k)$$

Continuous:

$$(f \otimes g)(x, y) = \int_{j=-\infty}^{\infty} \int_{k=-\infty}^{\infty} f(x+j, y+k) \cdot g(j, k)$$

Properties

- Linearity

$$a(f \otimes g) = f \otimes ag = af \otimes g$$

$$(f \otimes g) + (f \otimes h) = f \otimes (g+h)$$

- Associativity: $f \otimes (g \otimes h) = (f \otimes g) \otimes h$

- Commutativity?

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \otimes \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} = \begin{bmatrix} 9 & 8 & 7 \\ 4 & 5 & 4 \\ 3 & 2 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \otimes \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 8 \end{bmatrix}$$

Sharpen:

G = blur filter

D = "doubling" filter

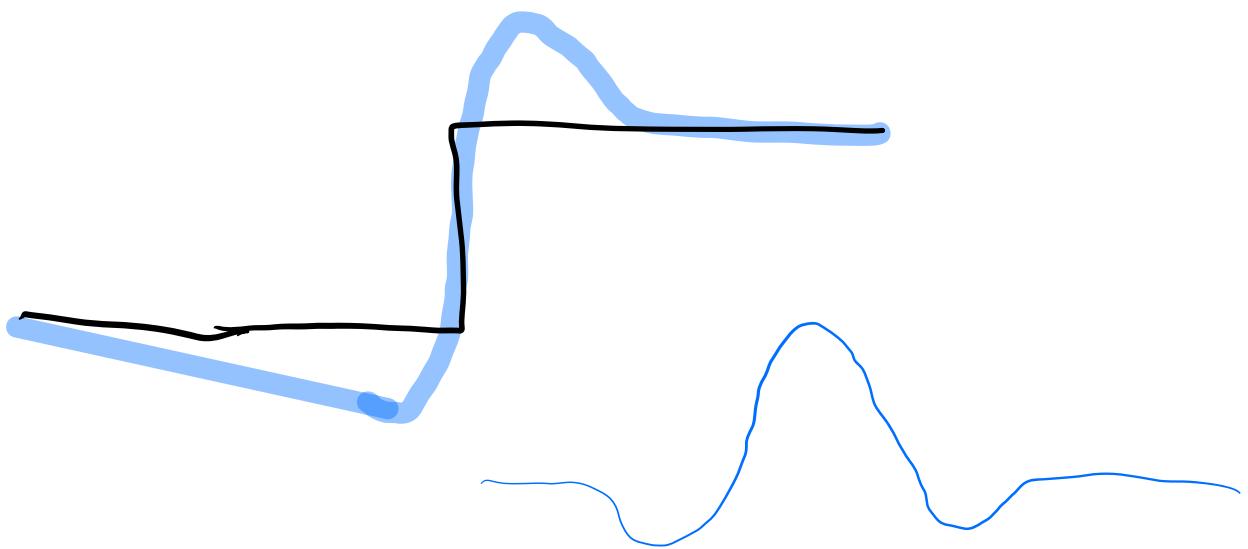
$$I' = I + (I - (I * G))$$

$$= I + I - (I * G)$$

$$= (I * D) - (I * G)$$

$D - G$ = "sharp"

$$= I * (D - G)$$



1 2 1

2

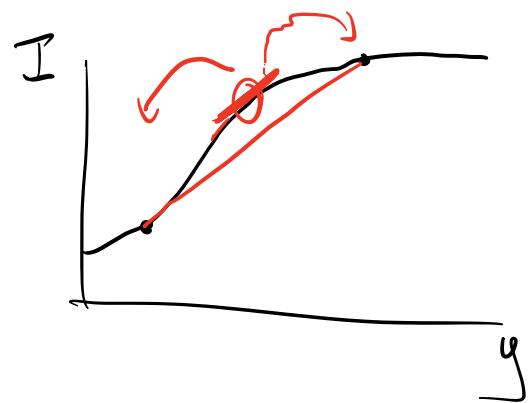
1

$$\begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$$

Image Derivatives !?

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 6 & 6 \\ 6 & 8 & 8 \end{bmatrix}$$

$$\begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix}$$



Non-max Suppression



Fourier, hand-wavy

