CS 180 Discussion #3

Filters & Frequencies!

Disc 2 Feedback Form

Konpat

Agenda!

Today we'll cover:

- Convolution + filters
- Frequency analysis

Logistics:

- HW 2 released!

Move to a person next to you, And introduce yourself 🤗 (1 min)

“Hi what’s your name?”

“What’s your favorite fruit?”

“Where are you heading to after this?”

Let’s work in pairs!

Convolutions

Convolutions, discrete

Input signal: | -1 | 0 | 1 | 0 | 0 |

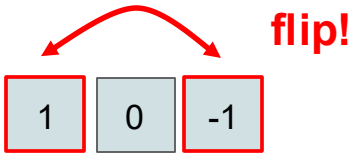
Filter: | -1 | 0 | 1 |

Convolutions, discrete

Input signal: | -1 | 0 | 1 | 0 | 0 |

Filter: | -1 | 0 | 1 |

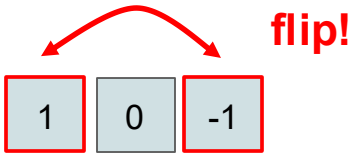
Flip filter



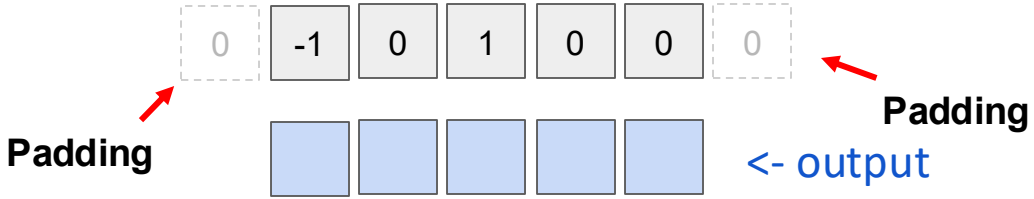
Convolutions, discrete

Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter



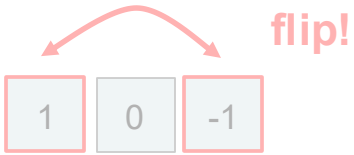
Output = sequence of dot products



Convolutions, discrete

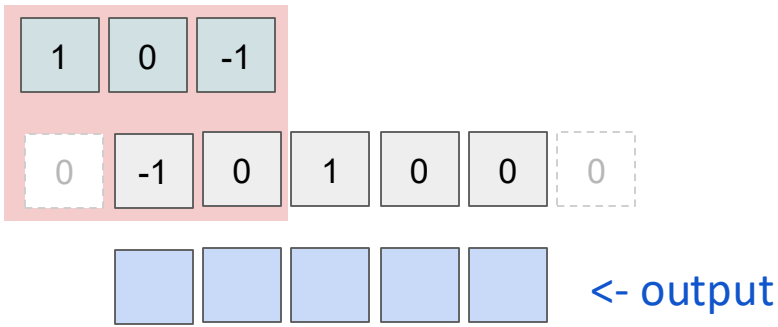
Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter



Output = sequence of dot products

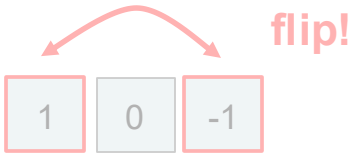
dot-product



Convolutions, discrete

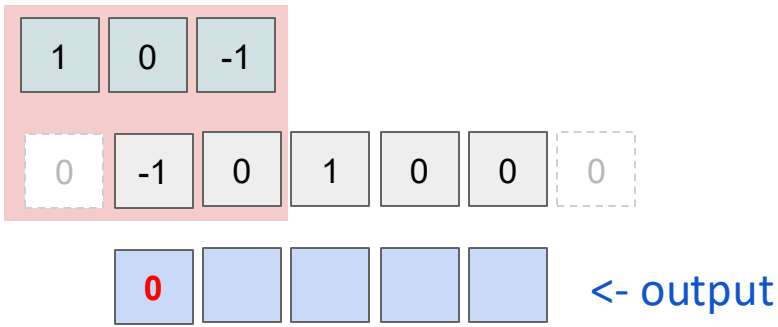
Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter



Output = sequence of dot products

dot-product

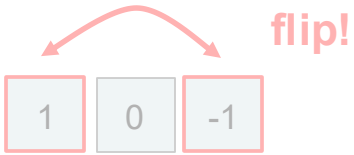


Convolutions, discrete

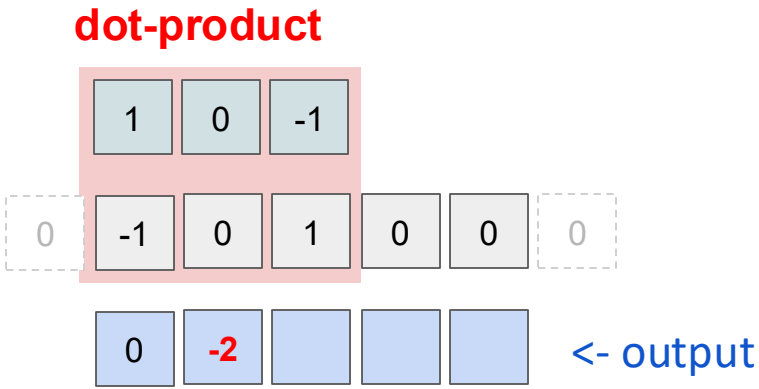
Input signal: | -1 | 0 | 1 | 0 | 0 |

Filter: | -1 | 0 | 1 |

Flip filter



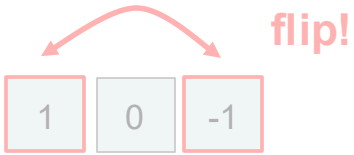
Output = sequence of dot products



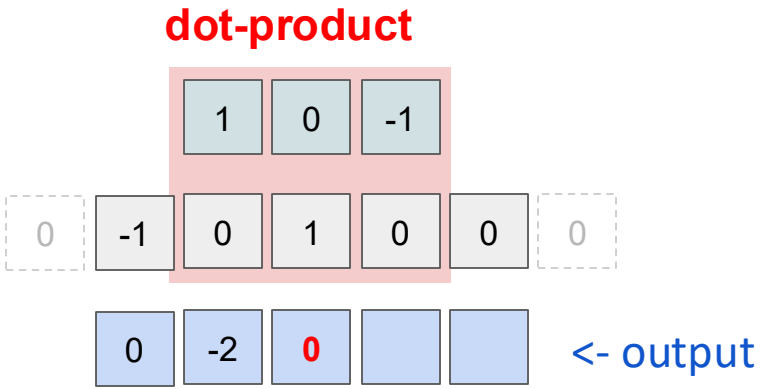
Convolutions, discrete

Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter



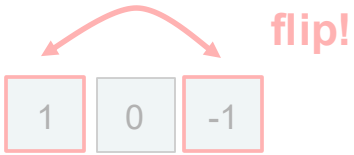
Output = sequence of dot products



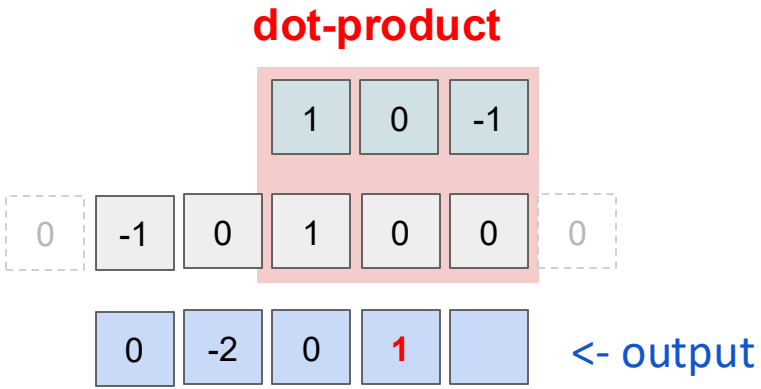
Convolutions, discrete

Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter



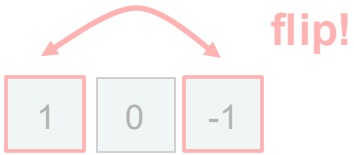
Output = sequence of dot products



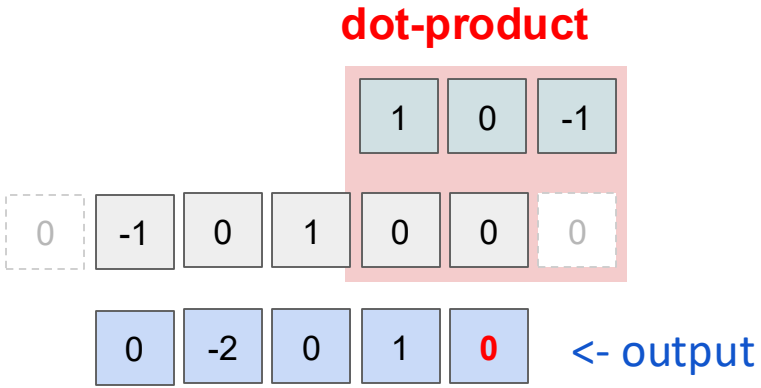
Convolutions, discrete

Input signal: -1 0 1 0 0 Filter: -1 0 1

Flip filter

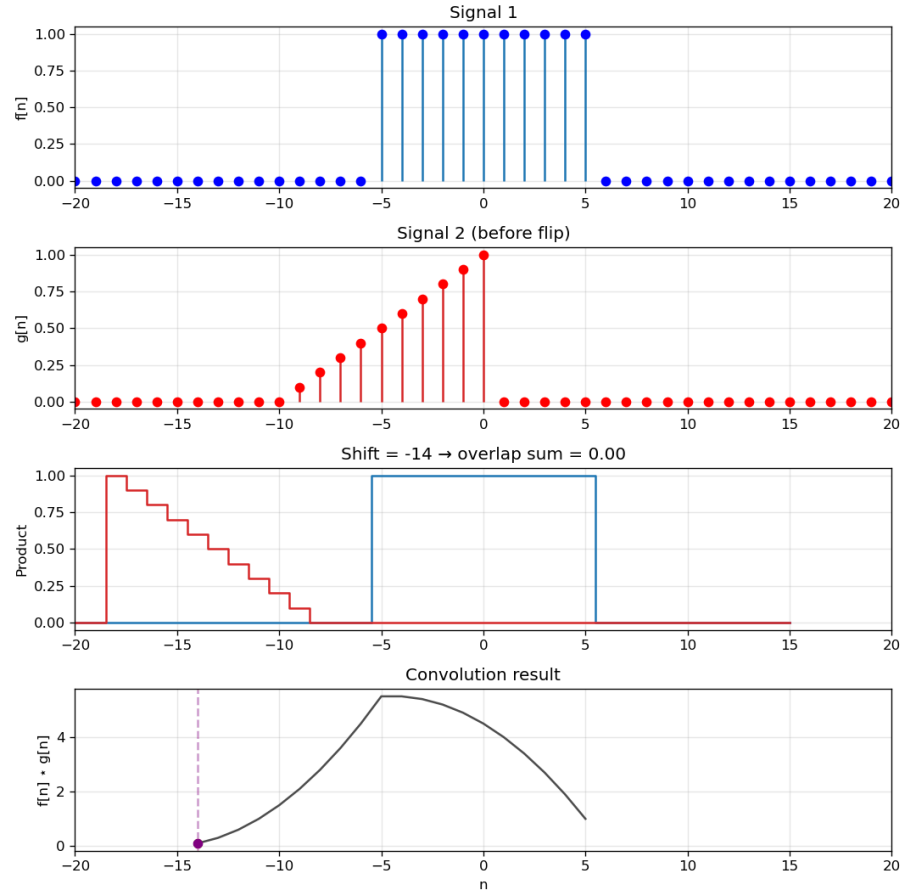


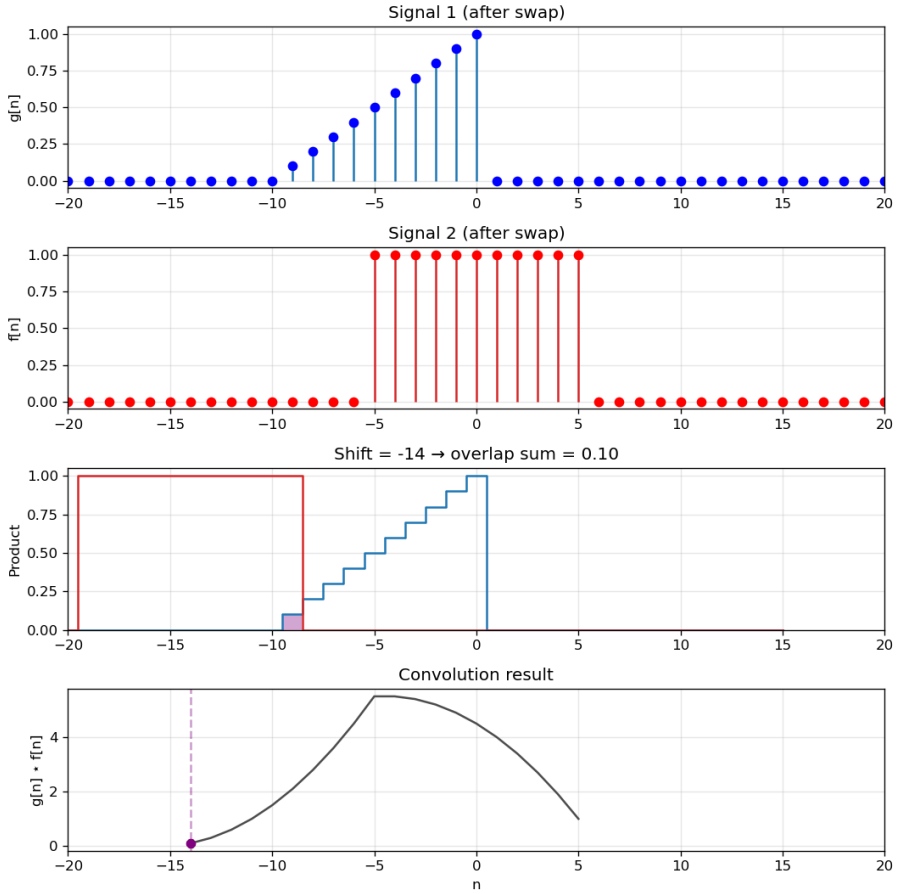
Output = sequence of dot products



Commutative!

$$\text{Signal} * \text{Filter} = \text{Filter} * \text{Signal}$$



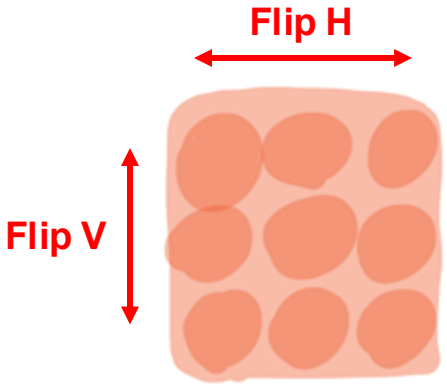


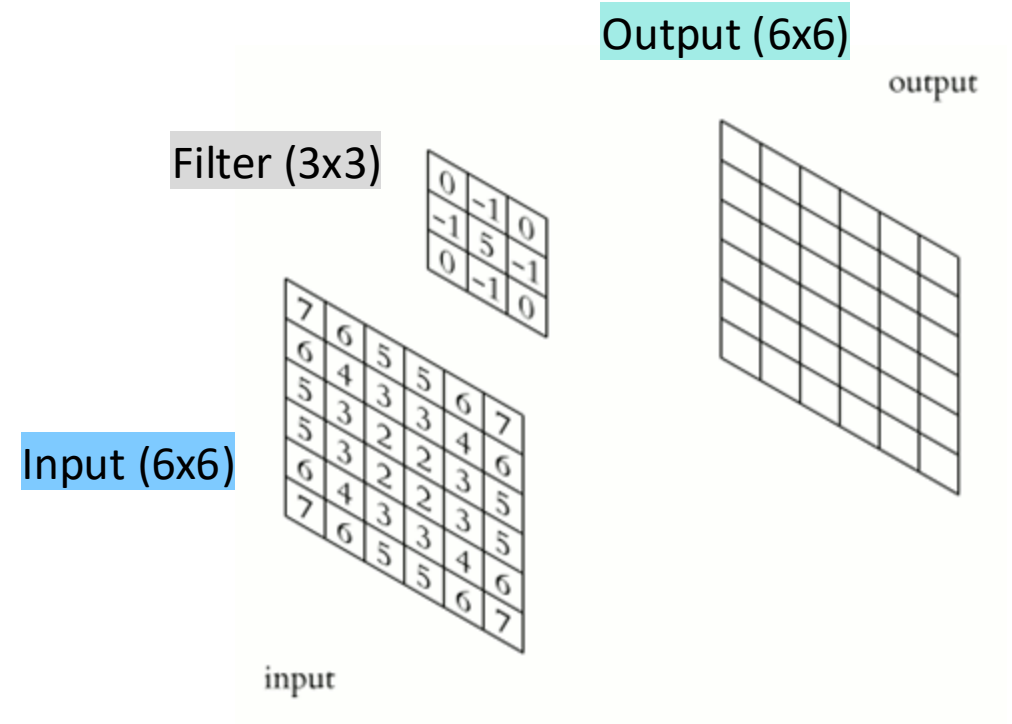
2D Convolutions

Same thing in 2D

For each output pixel: slide filter over input, compute dot product

Flip filter:





Problem #1

Sobels:

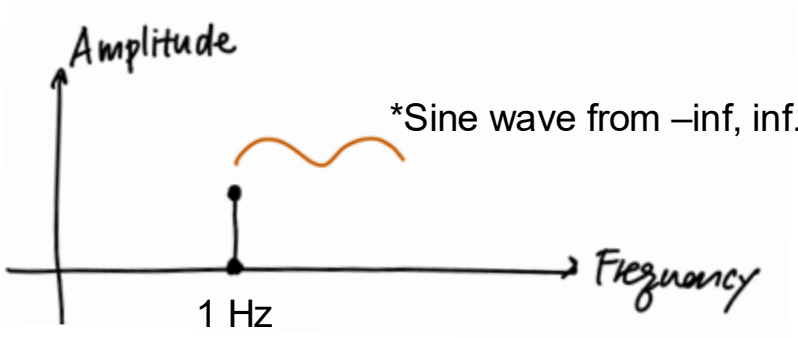
-1	0	+1
-2	0	+2
-1	0	+1

Gx

Frequencies!

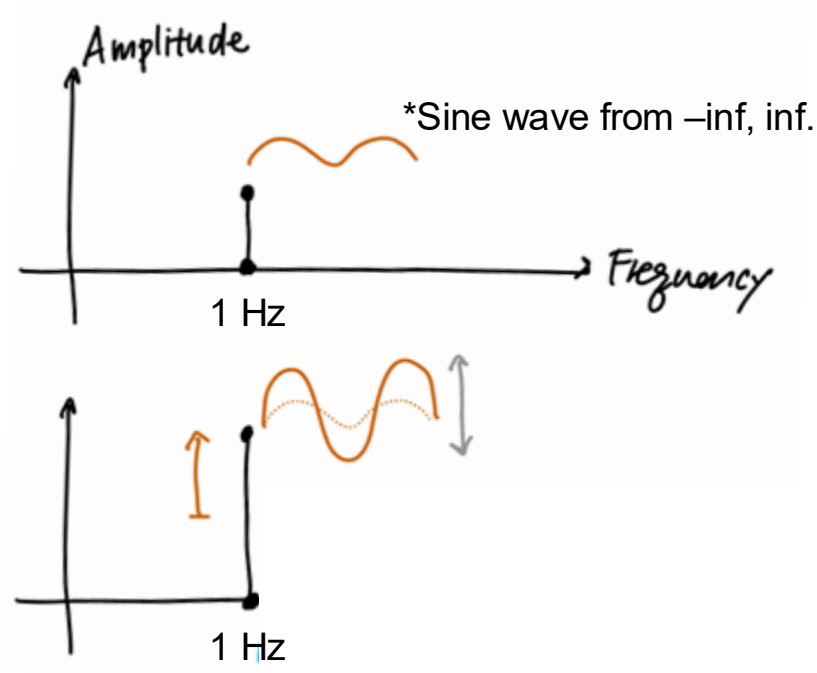
Studying frequencies (Fourier Analysis)

Visualize the **magnitude** (“how much”) and **phase** (“shift”)



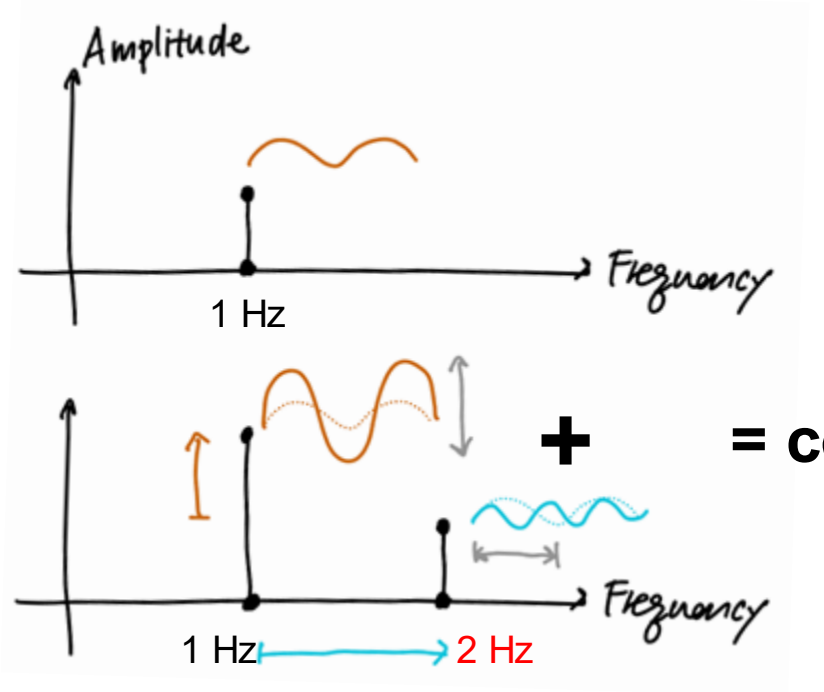
Studying frequencies (Fourier Analysis)

Visualize the **magnitude** (“how much”) and **phase** (“shift”)



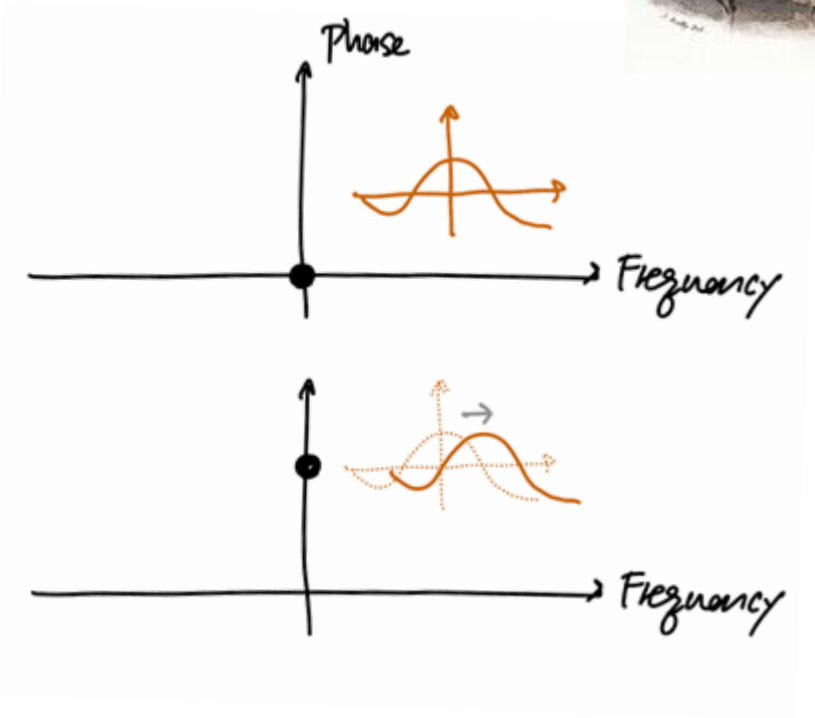
Studying frequencies (Fourier Analysis)

Visualize the **magnitude** (“how much”) and **phase** (“shift”)

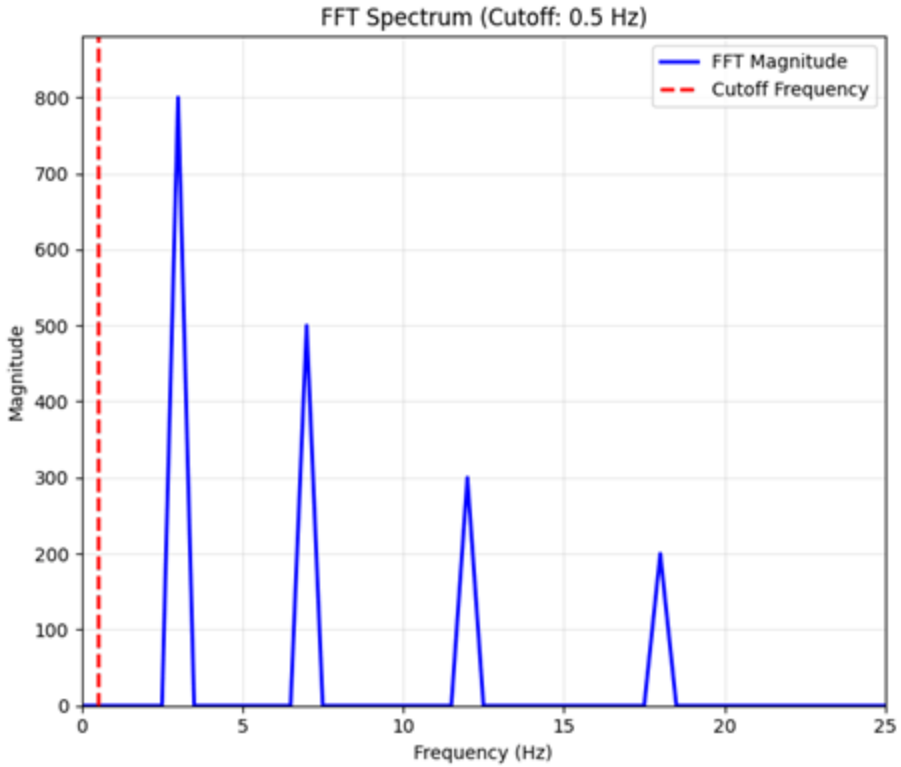


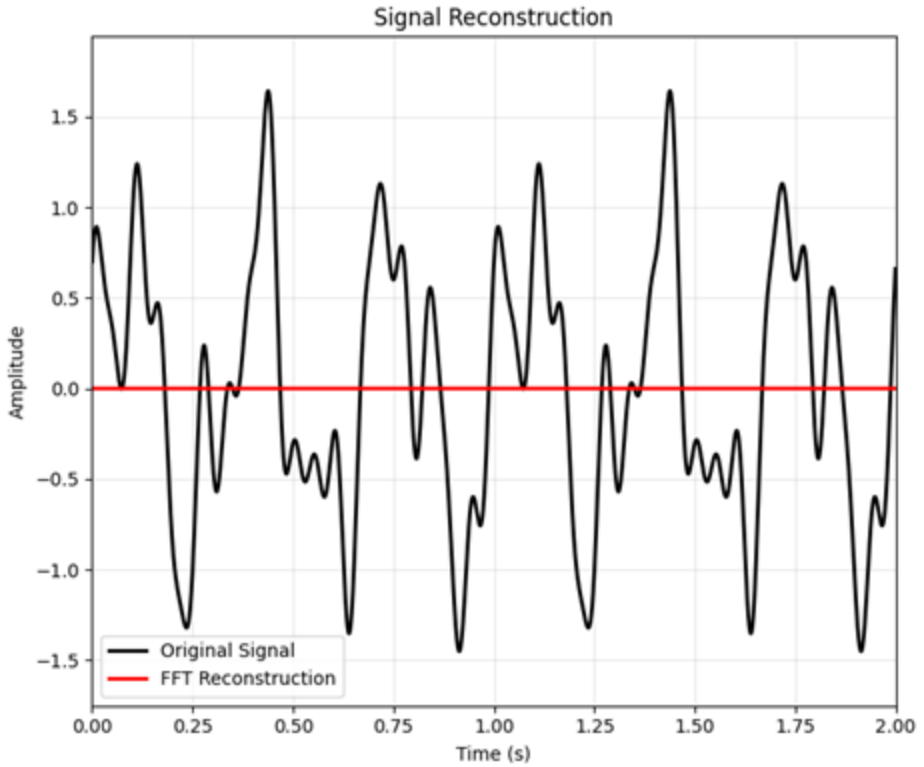
Studying frequencies (Fourier Analysis)

Visualize the **magnitude** (“how much”) and **phase** (“shift”)

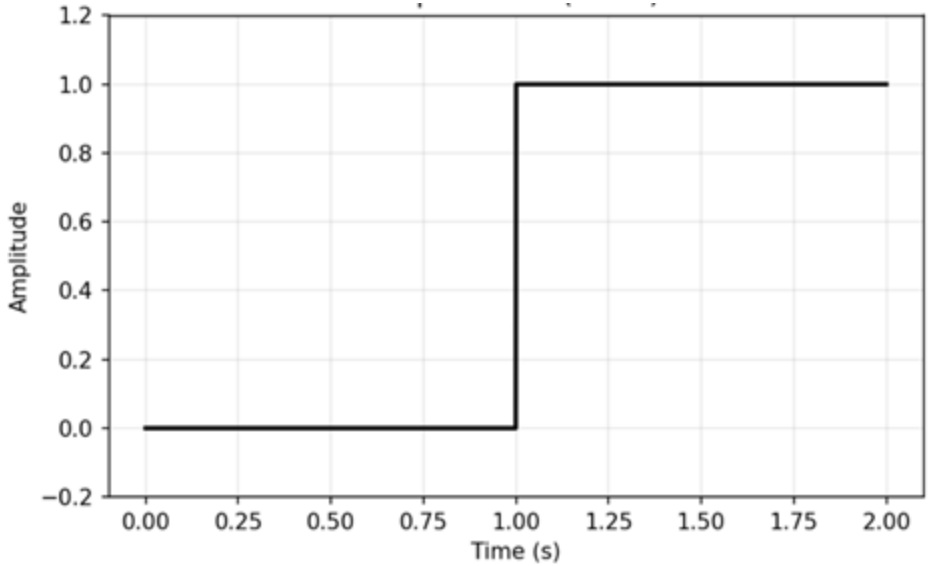


Reading FFT plots

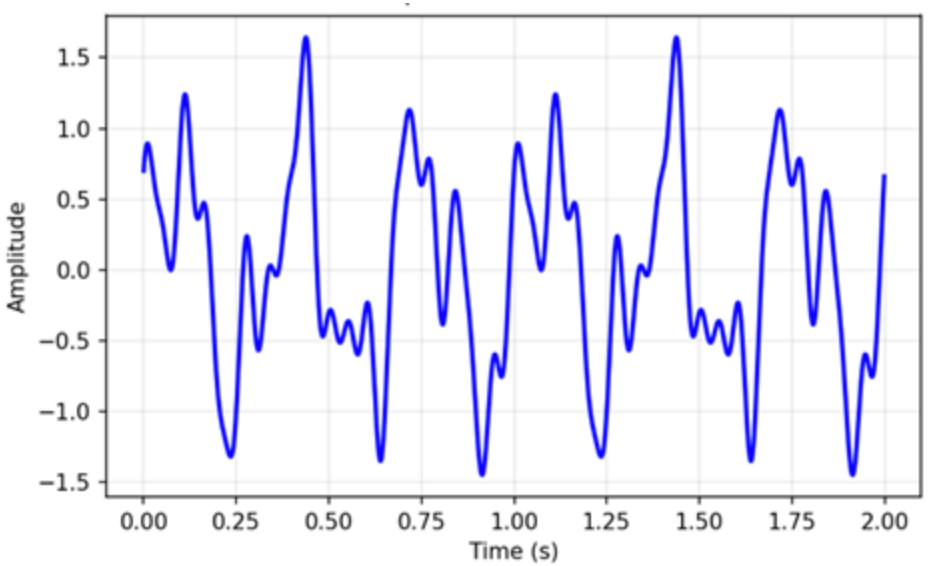




Which is **easier** to represent in frequency space?

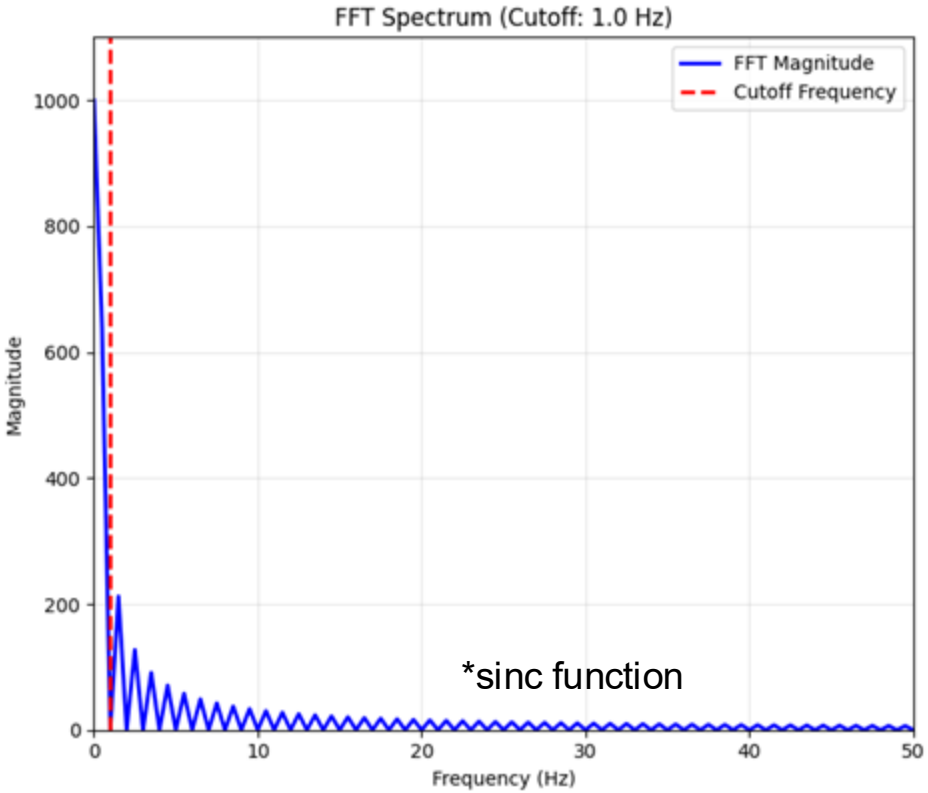


A



B

Edges are very high frequency



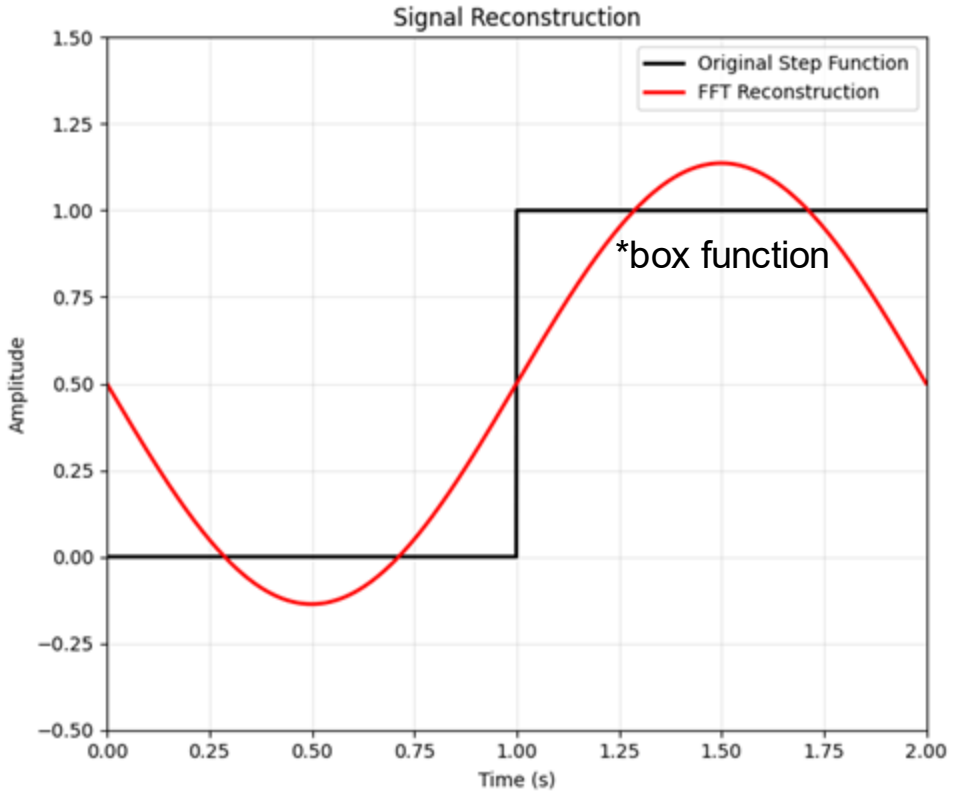
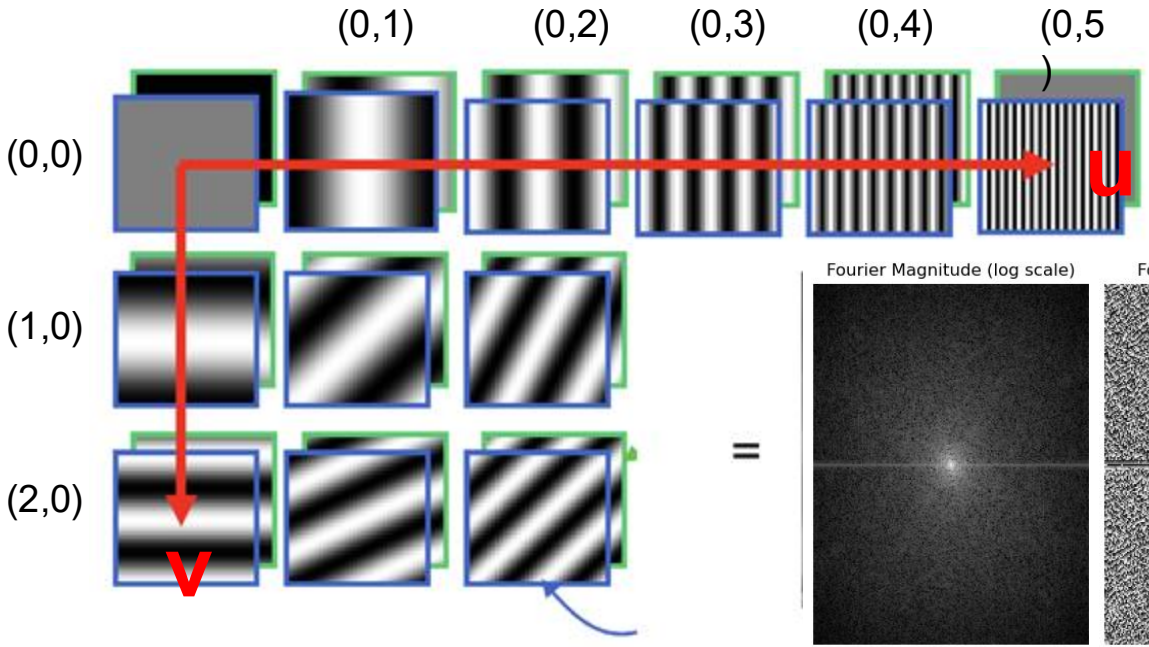


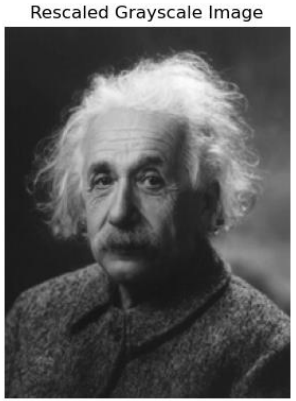
Image Frequencies!

Frequency amplitudes map



=

=

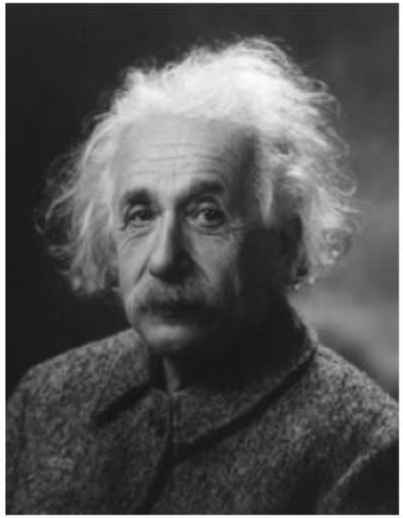


*Diagonally symmetrical

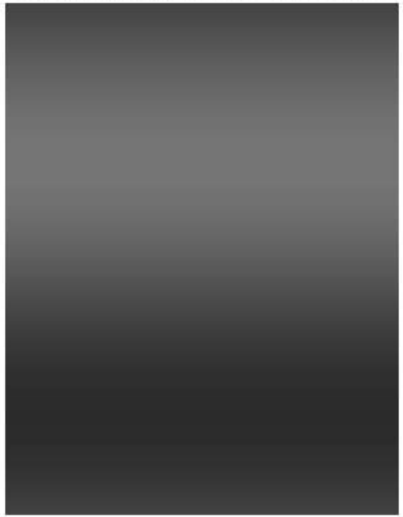
*Same storage size. H x W pixels = num(amplitudes) + num(phase)!

Component 2/25217 — frame 1/150

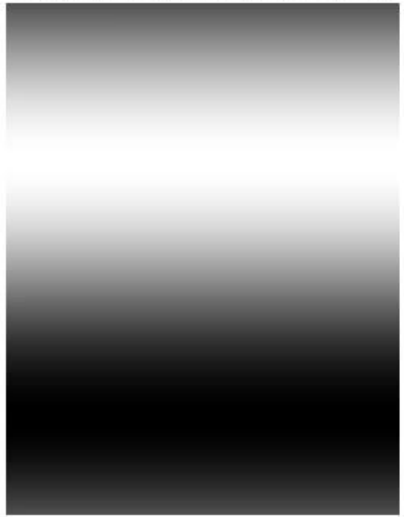
Original image



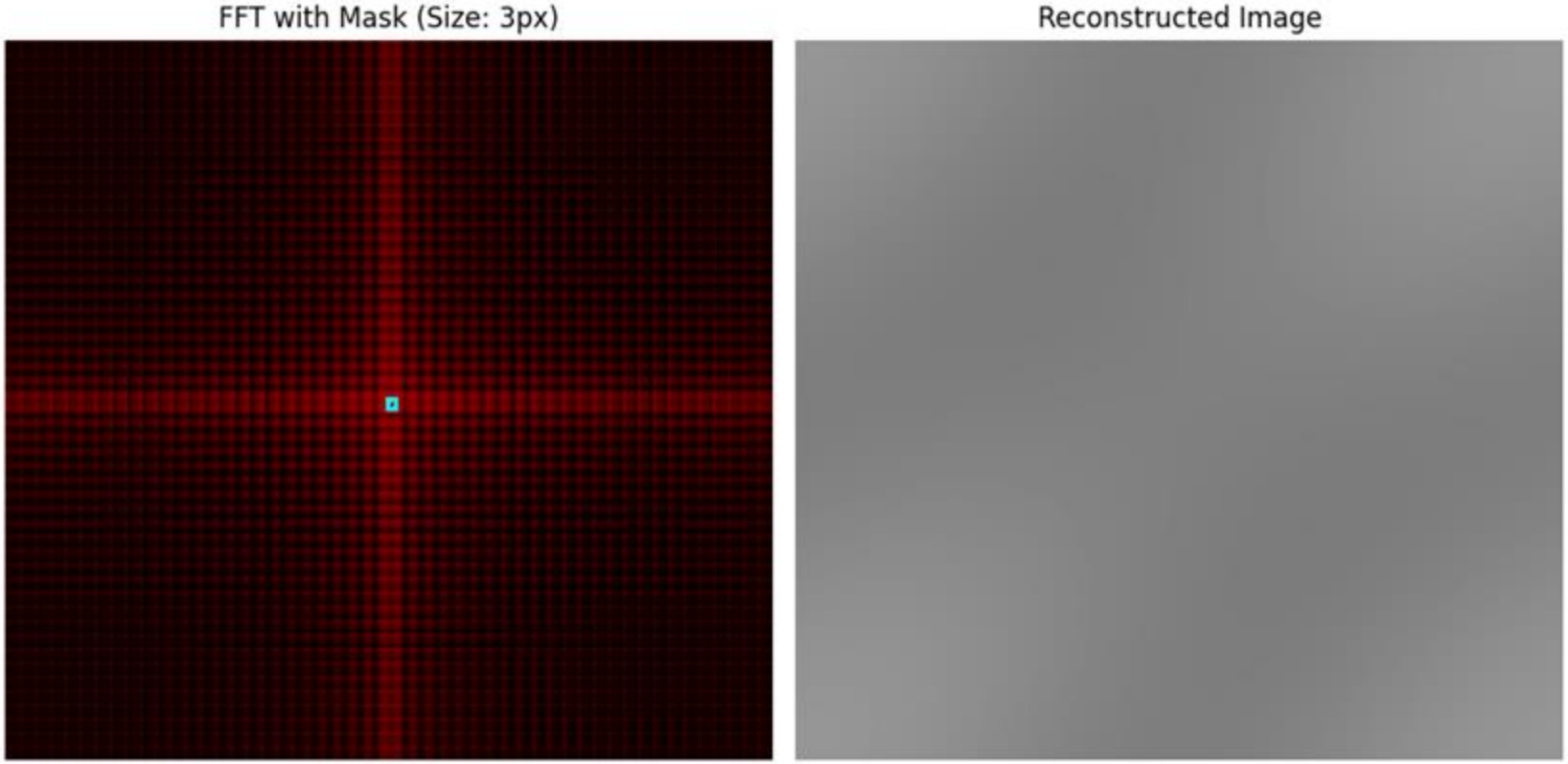
Reconstruction up to component 2



Current component (scaled)

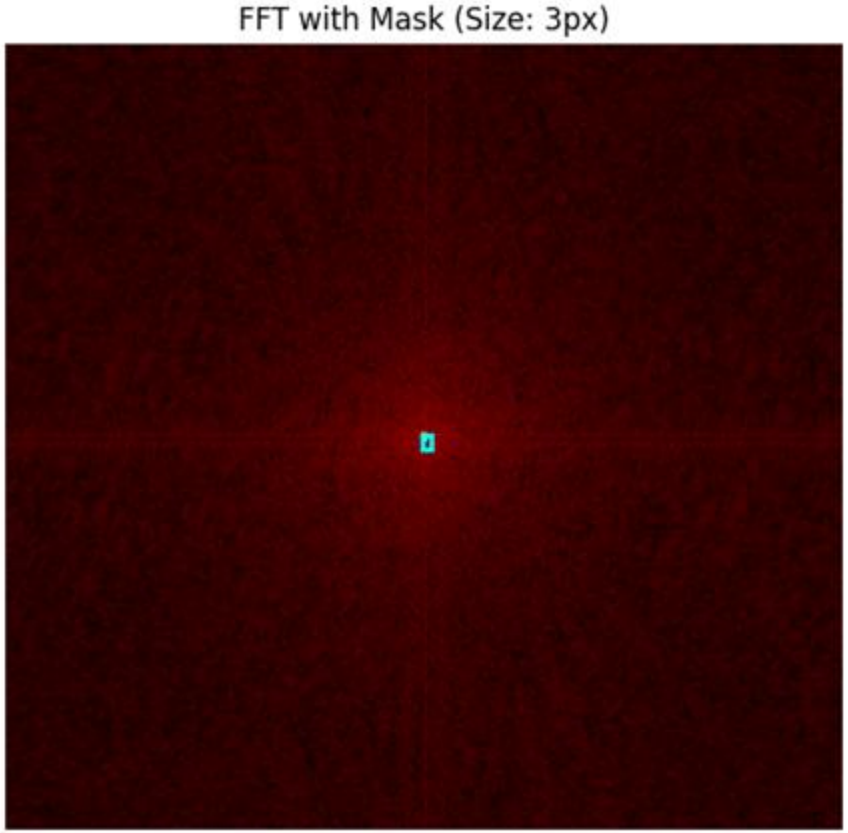


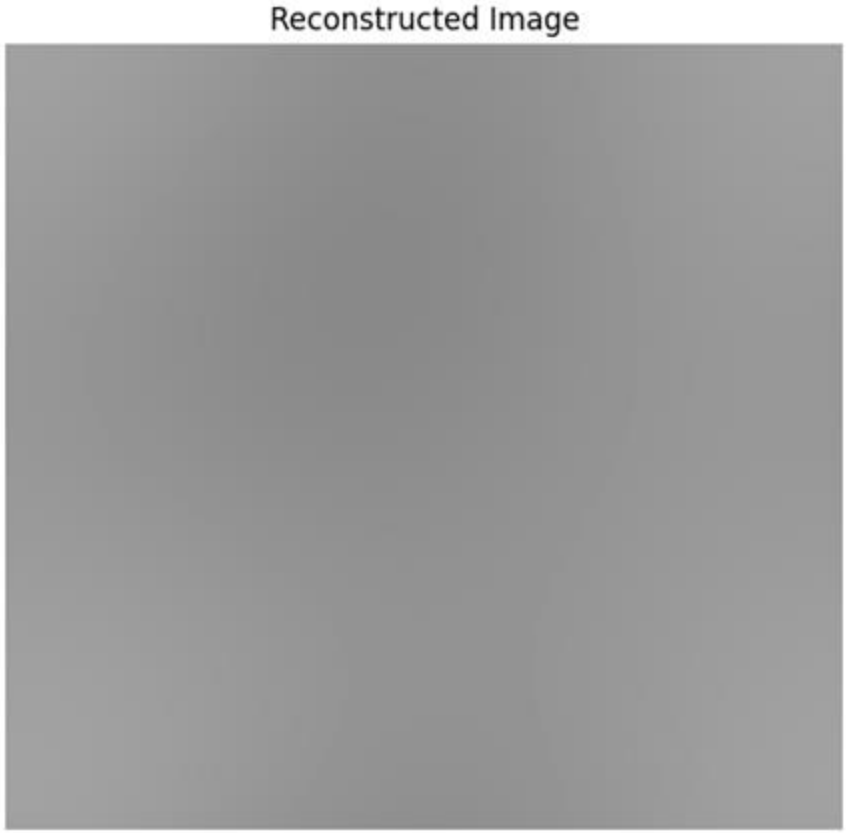
Crop in frequency space



Crop in frequency space

What does the box do?
Why the wavy pattern?





Matching images with frequencies

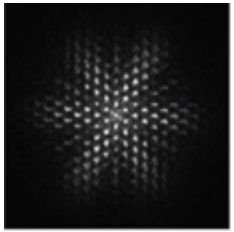
A

B

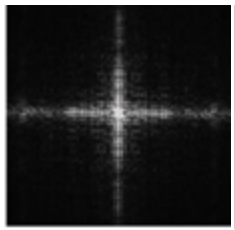
C

D

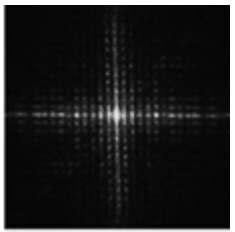
E



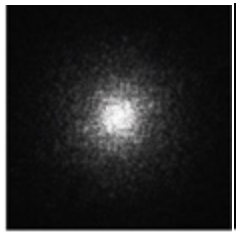
I



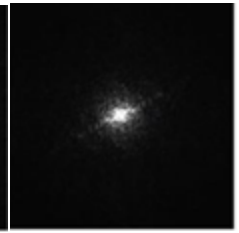
II



III



IV



V

Matching images with frequencies

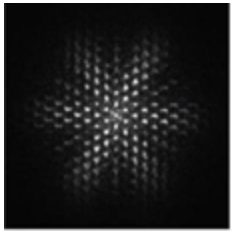
A

B

C

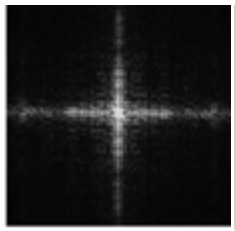
D

E



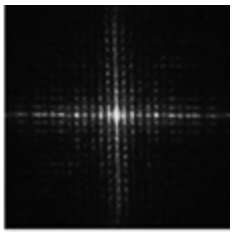
I

C



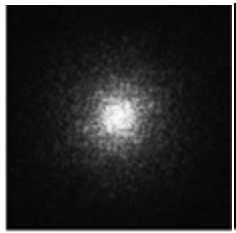
II

A



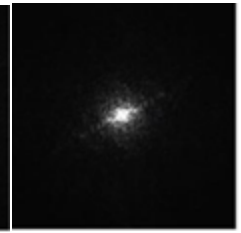
III

B



IV

E

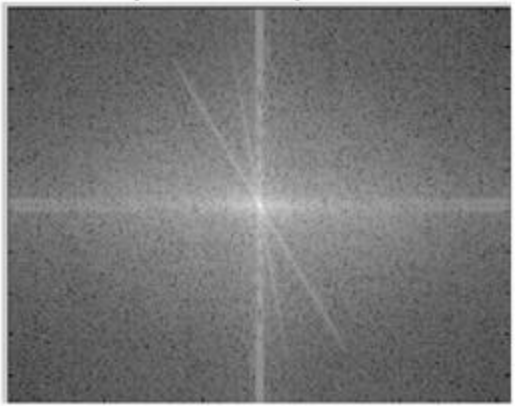


V

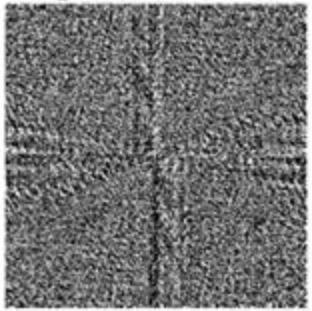
D

Phase plots can be hard to understand...

Amplitude Spectrum



Phase map:
(Hard to understand 😔)



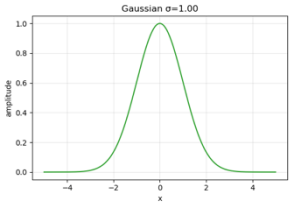
From lecture.

Problems 2.1a, 2.1d

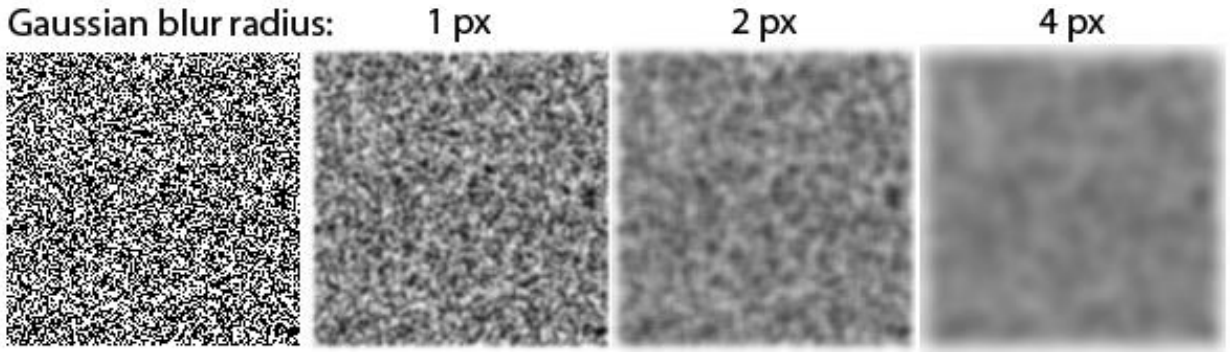
Demo!

https://cal-cs180.github.io/fa25/fft-tool.html

Low-pass = Convolve with Gaussian

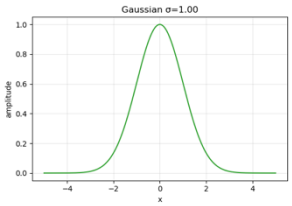


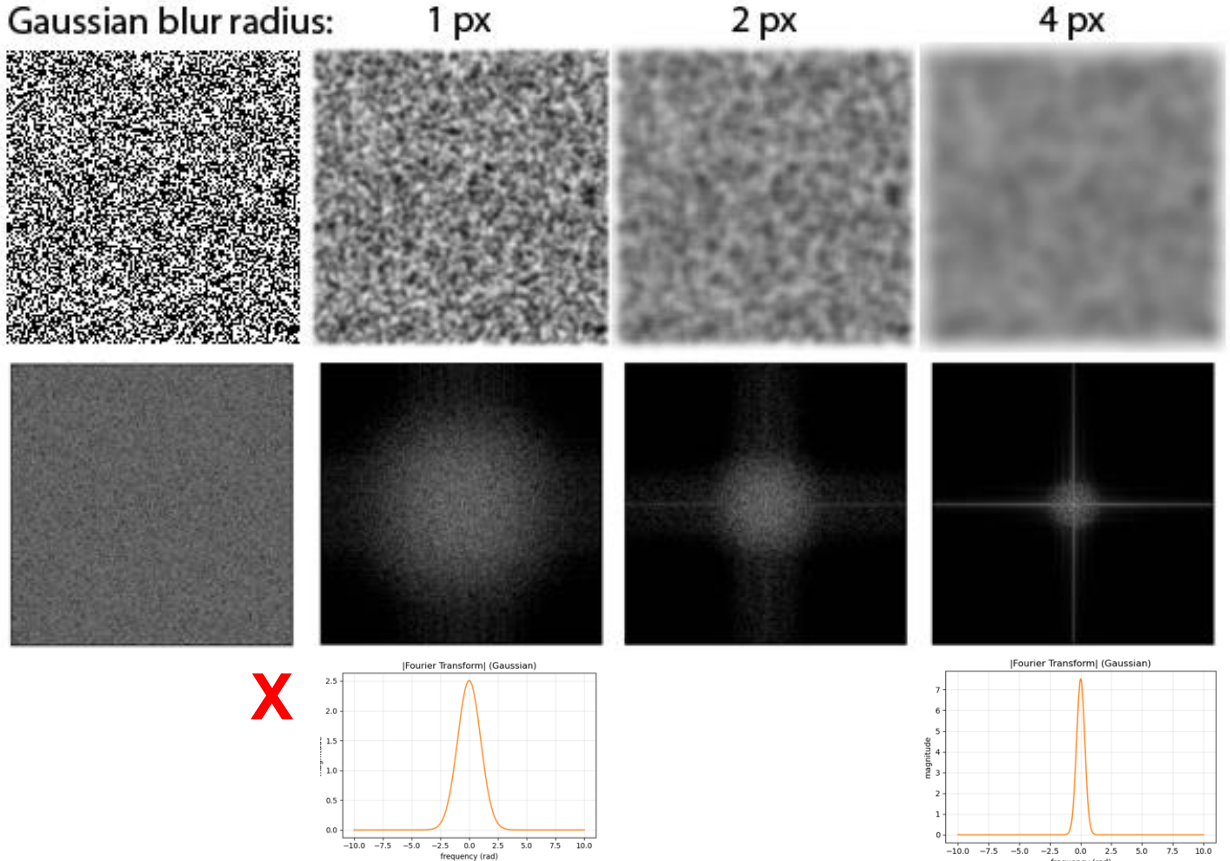
Image



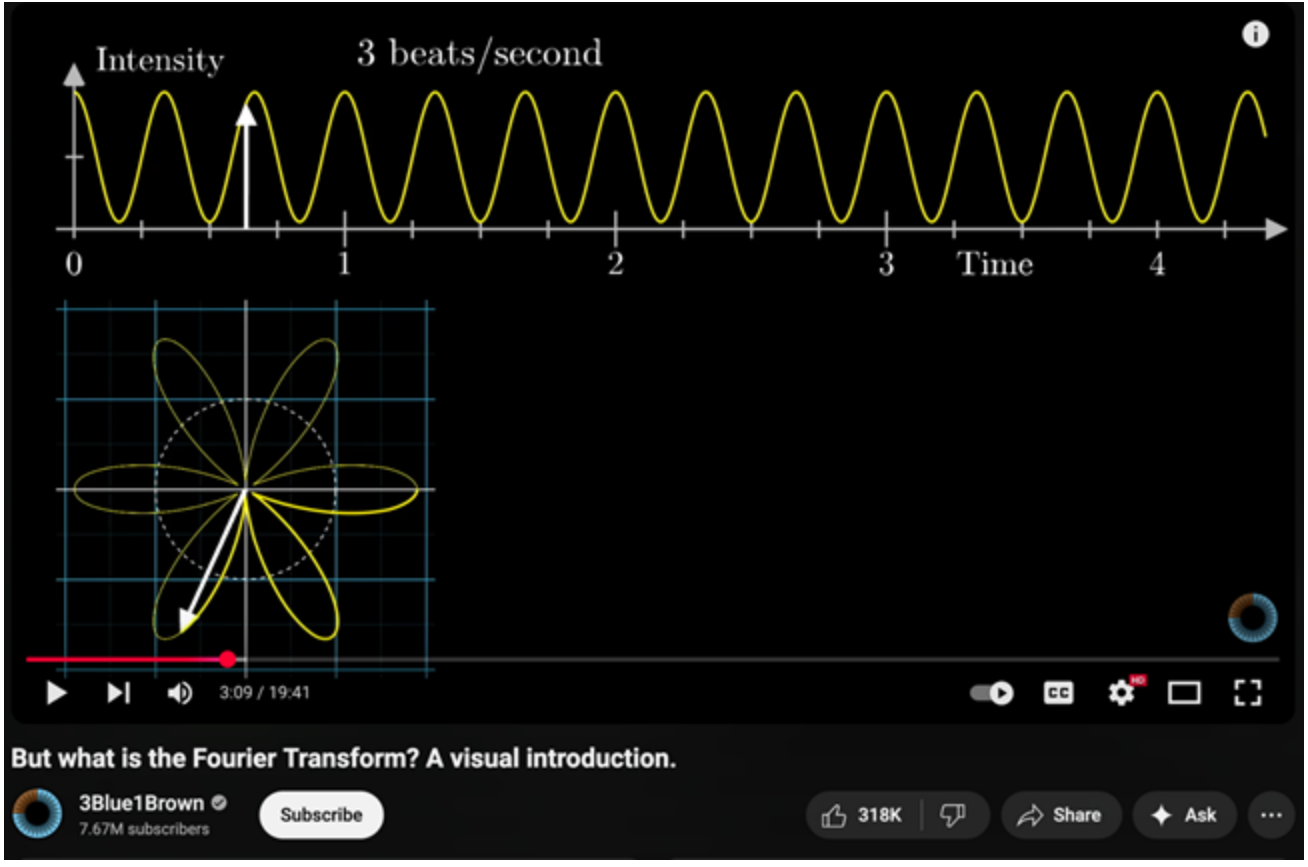
*How to get Gaussian filter?

***Convolution theorem*:**
convolving = multiplying frequencies





3b1b has great visuals if you want to dive deeper!



CS 180 Discussion #3

Filters & Frequencies!

Disc 2 Feedback Form

Konpat