CSCI 497P/597P: Computer Vision

Lecture 7:

Upsampling

A whirlwind tour of numpy

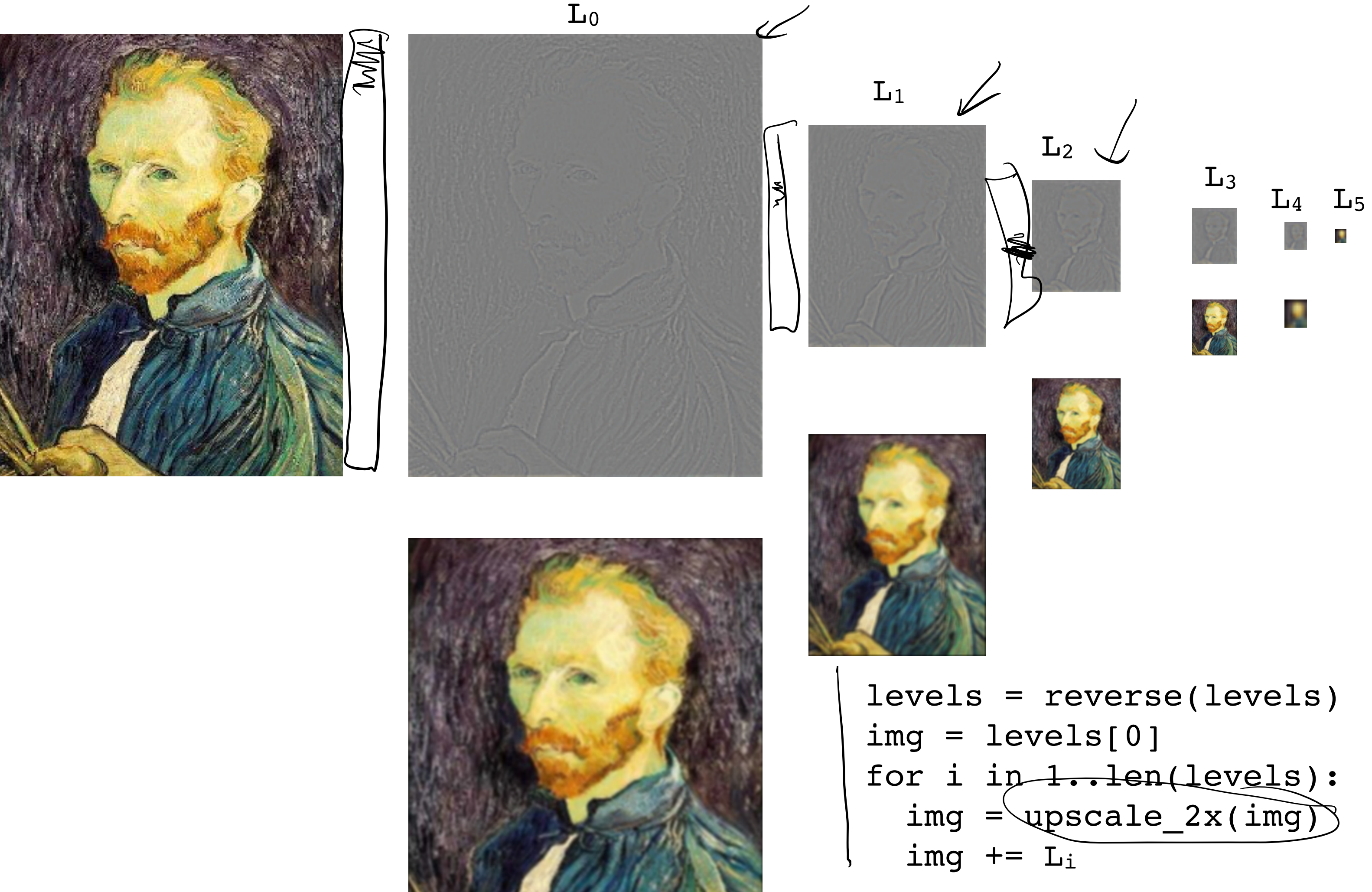
Announcements

- Project 1 out Very Soon(TM)
  - i.e., by the end of the weekend

Goals

- Know how to upsample images naively
- Know how to upsample images using reconstruction filters.
- Know the basics of how to use the numpy library

Reconstruction



```
levels = reverse(levels)
img = levels[0]
for i in 1..len(levels):
  img = upscale_2x(img)
  img += L_i
```

Upsampling

- But how do we make images bigger?
- Again: a naive way and a principled way.

```
levels = reverse(levels)
img = levels[0]
for i in 1..len(levels):
  img = upscale_2x(img)
  img += $L_i$
```

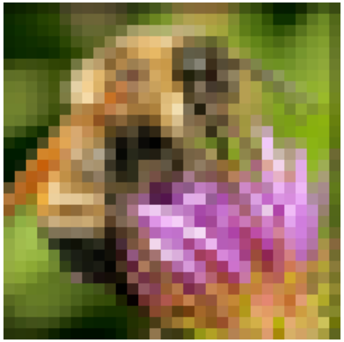
Upsampling

- This image is too small for my screen. How do I make it 10x bigger?

Upsampling

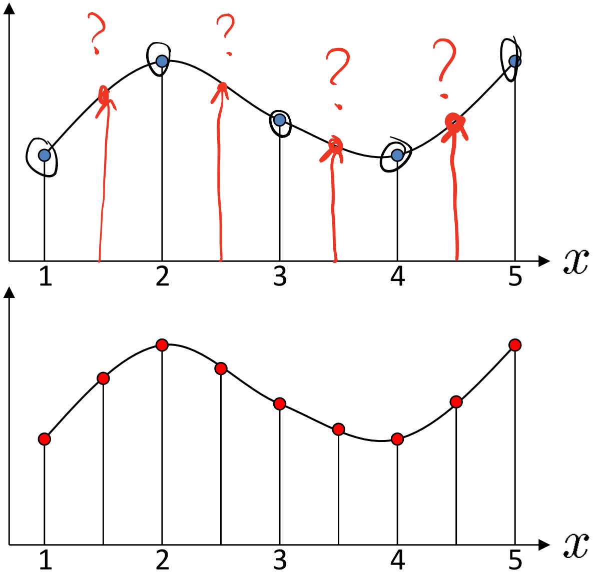
- This image is too small for my screen. How do I make it 10x bigger?

- Simple approach: repeat each row and column 10 times



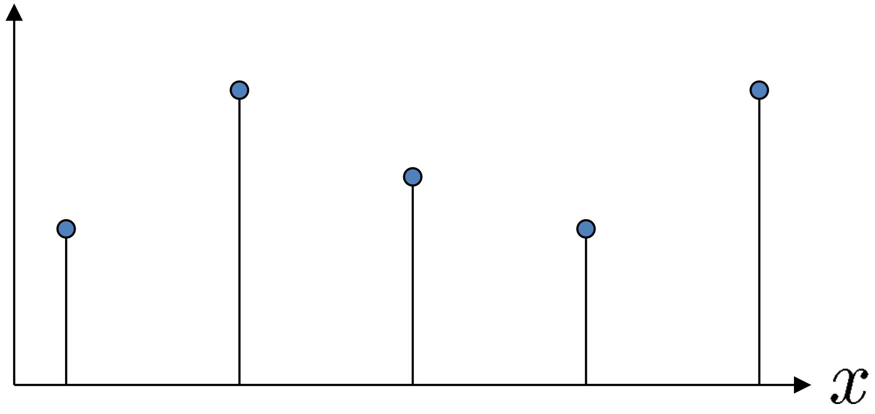
Upsampling: Interpolation

- Another way to look at this: we need to double the *sampling rate*.

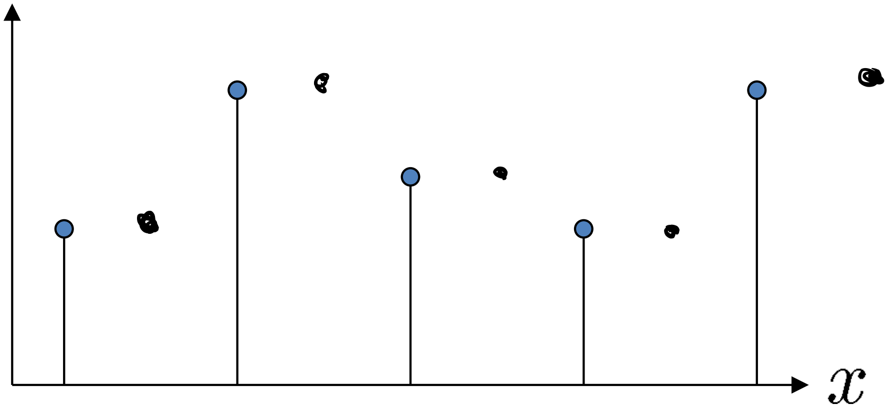


Upsampling: Interpolation

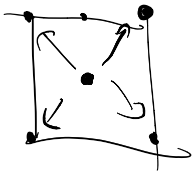
- Another way to look at this: we need to double the *sampling rate*.
- But we don't actually know the continuous function:

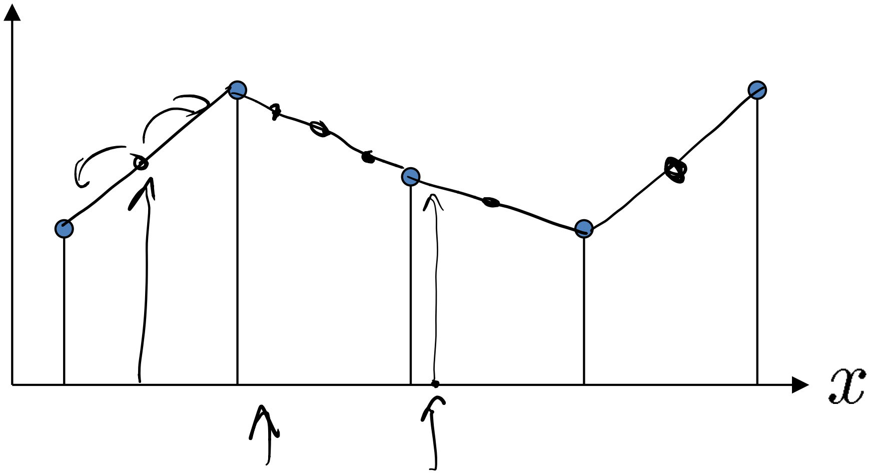


Upsampling: Nearest Neighbor



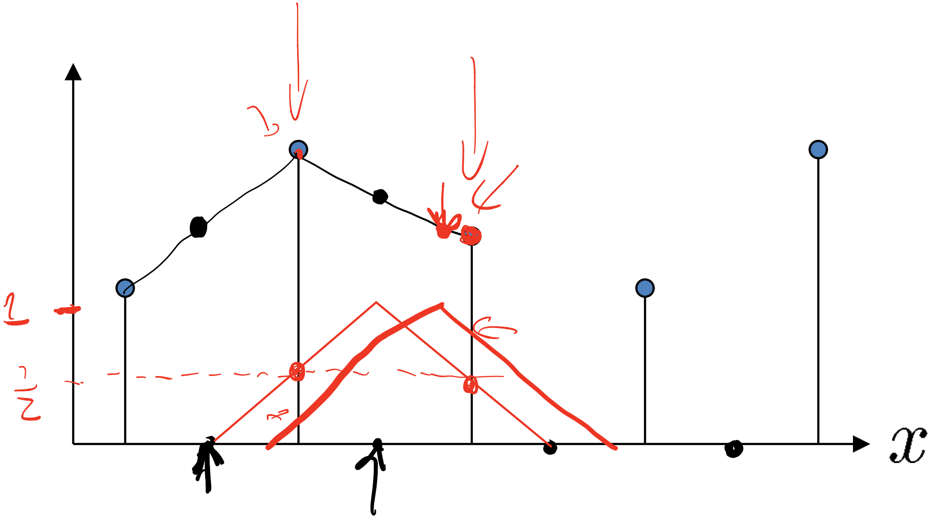
Upsampling: Linear





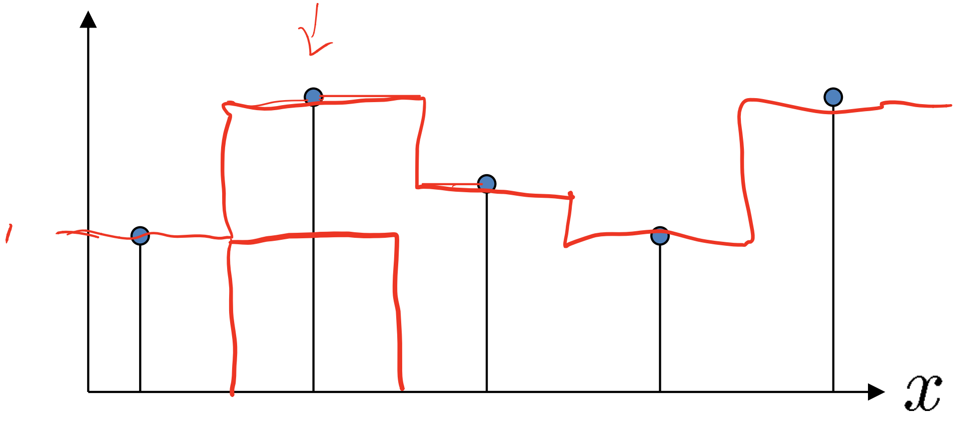
Upsampling: Linear

A filtering perspective

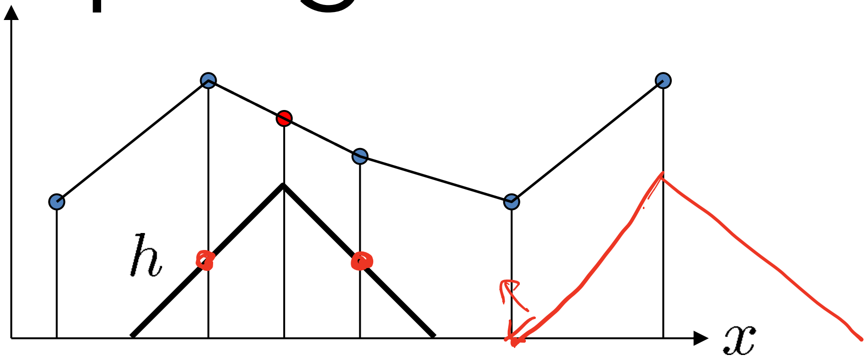


Upsampling: Nearest Neighbor

A filtering perspective

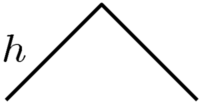


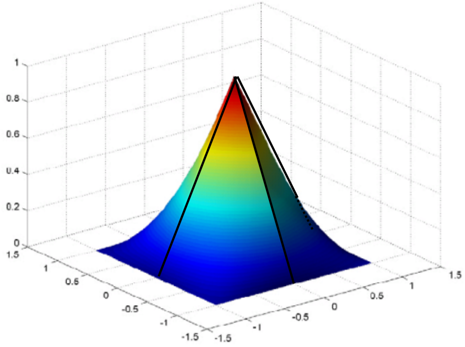
Upsampling Filters in 2D



$\frac{1}{16}$

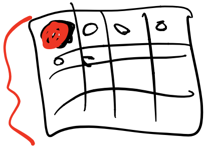
1	2	1
2	4	2
1	2	1

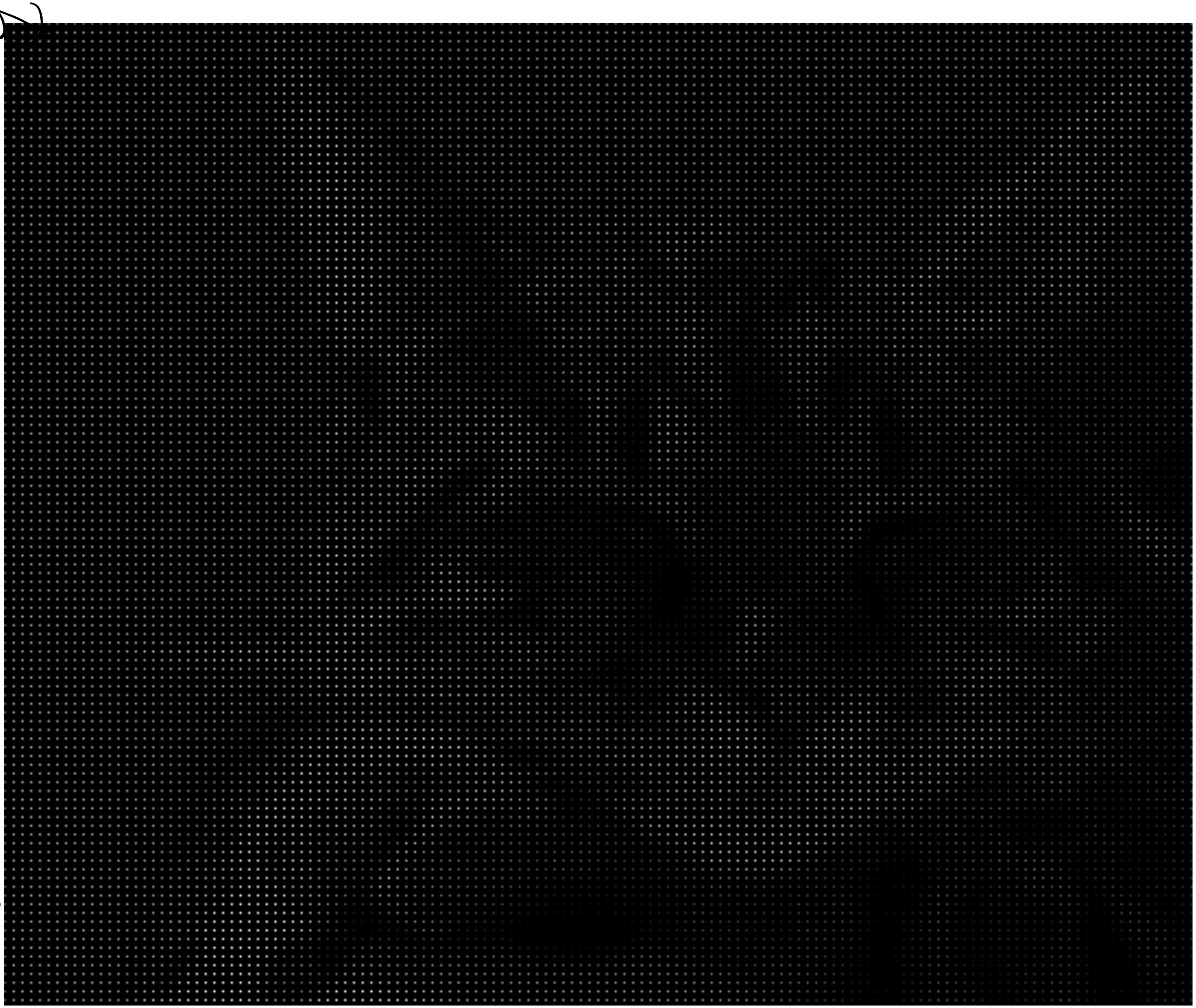
1D: 

2D: 

"tent filter"

Upsampling by 4X





1. Make 4Hx4W image of zeros.
2. Fill in every 4th pixel
3. Filter*!

*and multiply by 16

numpy

- Tutorials:
  - https://numpy.org/devdocs/user/quickstart.html
  - https://cs231n.github.io/python-numpy-tutorial/#numpy
- Demo!
- Exercises

Demo!

- Feel free to follow along

```
ssh -p 922 username@labs.cs.wwu.edu
wget https://facultyweb.cs.wwu.edu/~wehrwes/courses/csci497p_20s/lectures/L07_np/van.png
ipython3
import numpy as np
```

- Demo and image files at:
    - https://facultyweb.cs.wwu.edu/~wehrwes/courses/csci497p_20s/lectures/L07_np/

Exercises!

- Also available at

1. Suppose a is a filter and b is a patch of an image:

```
a = np.array([1, 2, 1],
             [2, 4, 2],
             [1, 2, 1]]) / 16
b = np.zeros((3,3))
b[:3,0] = 1
b[1,1] = 2
```

a. Compute the output pixel in a convolution when the filter a overlaps the image neighborhood b. Use array operations and the sum function.

b. Compute the same product as above, but using the dot function. Hint: you'll need to reshape the inputs to dot first!

2. Load the van.png image and save out a grayscale version computed by averaging the three color channels; be sure to do the averaging in floating-point

3a.Load the van image do a naive 2x subsampling: drop every other row and column and save out the half-size version.

3b. Load the van image and do a naive 2x upsampling: repeat every other row and column twice.