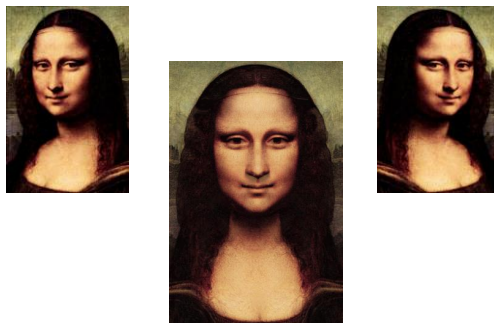# CS4670: Computer Vision
Noah Snavely
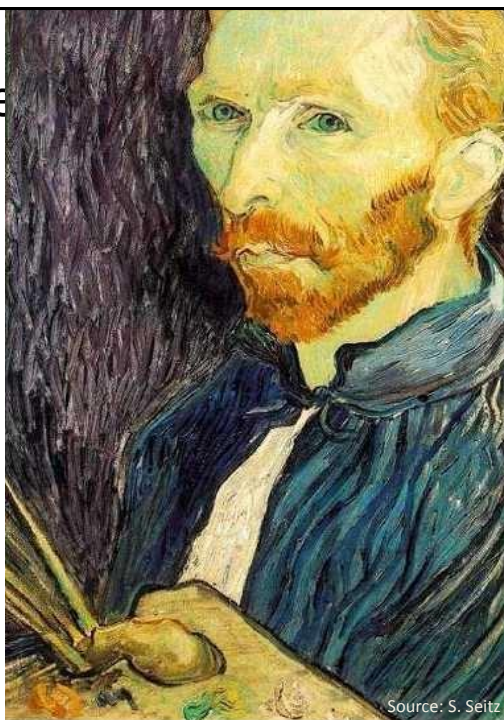
Image Interpolation

Image

Last time:

This image is too big to fit on the screen. How can we generate a half-sized version?

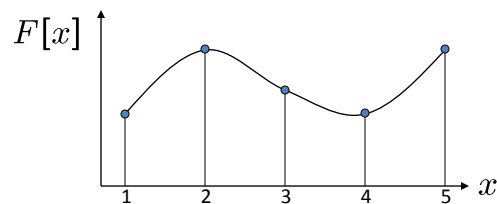Source: S. Seitz

Upsampling

- This image is too small for this screen:
- How can we make it 10 times as big?
- Simplest approach: repeat each row and column 10 times

- ("Nearest neighbor interpolation")

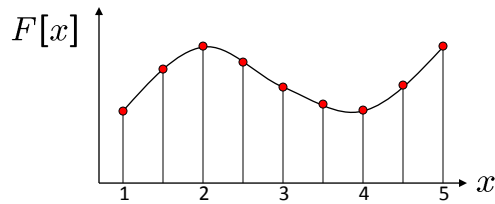# Image interpolation

$F[x]$

d = 1 in this example

Recall how a digital image is formed

$$F[x, y] = \text{quantize}\{f(xd, yd)\}$$

- It is a discrete point-sampling of a continuous function
- If we could somehow reconstruct the original function, any new image could be generated, at any resolution and scale

Adapted from: S. Seitz

Image interpolation

$F[x]$

d = 1 in this
example
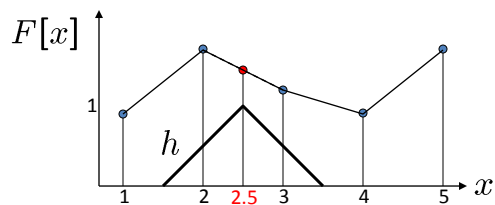
x

1   2   3   4   5

Recall how a digital image is formed

$$F[x, y] = \text{quantize}\{f(xd, yd)\}$$

- It is a discrete point-sampling of a continuous function
- If we could somehow reconstruct the original function, any new image could be generated, at any resolution and scale

Adapted from: S. Seitz

Image interpolation

$F[x]$

1

h

d = 1 in this
example

x

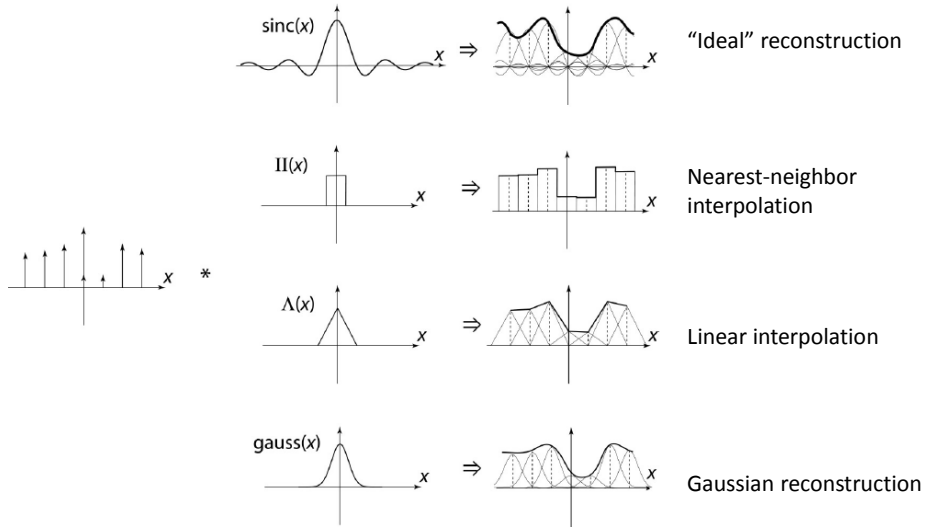1   2   2.5   3   4   5

- ## What if we don't know f ?
  - Guess an approximation: $\tilde{f}$
  - Can be done in a principled way: filtering
  - Convert F to a continuous function:
    $$f_F(x) = F(\tfrac{x}{d}) \text{ when } \tfrac{x}{d} \text{ is an integer, 0 otherwise}$$
  - Reconstruct by convolution with a *reconstruction filter, h*
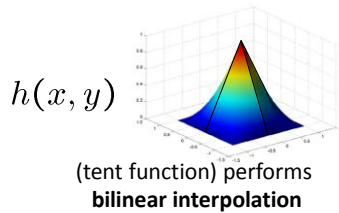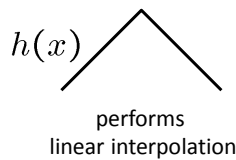 $$\tilde{f} = h * f_F$$

Adapted from: S. Seitz

Image interpolation

sinc(x) $\Rightarrow$ "Ideal" reconstruction

$\Pi(x)$ $\Rightarrow$ Nearest-neighbor interpolation

$\Lambda(x)$ $\Rightarrow$ Linear interpolation

gauss(x) $\Rightarrow$ Gaussian reconstruction

*

Source: B. Curless

Reconstruction filters

- What does the 2D version of this hat function look like?

$h(x)$

performs
linear interpolation

$h(x, y)$

(tent function) performs
bilinear interpolation

Often implemented without cross-correlation
- E.g., http://en.wikipedia.org/wiki/Bilinear_interpolation

Better filters give better resampled images
- **Bicubic** is common choice
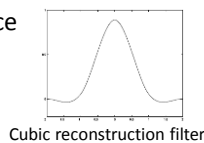
$$r(x) = \frac{1}{6}\begin{cases}(12-9B-6C)|x|^3 + (-18+12B+6C)|x|^2 + (6-2B) & |x|<1 \\ ((-B-6C)|x|^3 + (6B+30C)|x|^2 + (-12B-48C)|x| + (8B+24C) & 1 \le |x| < 2 \\ 0 & otherwise\end{cases}$$

Cubic reconstruction filter
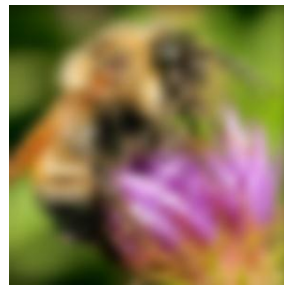
Image interpolation

Original image: x 10

Nearest-neighbor interpolation
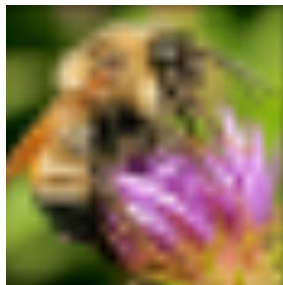
Bilinear interpolation

Bicubic interpolation

Image interpolation

Also used for *resampling*

Raster to Vector Graphics

Depixelating Pixel Art

Questions?