Image Sampling

CSE 576

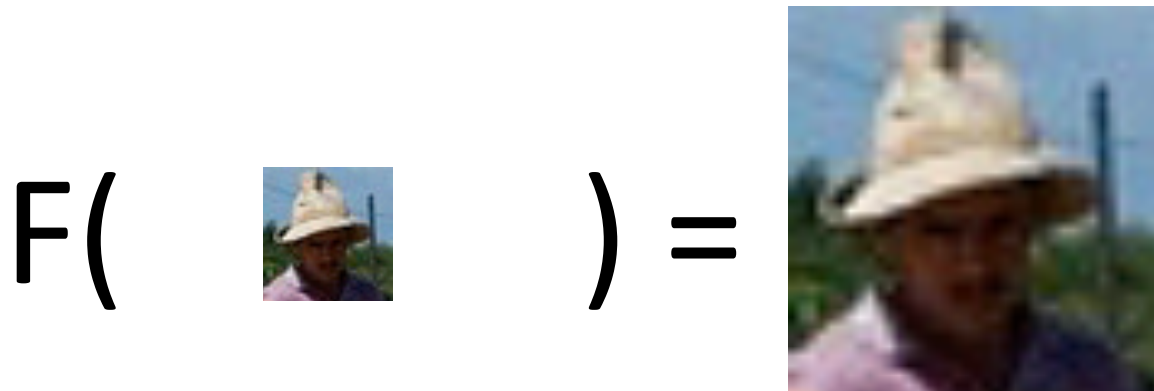## Ali Farhadi

Image Sampling

F( ) =

F( ) =

Image Scaling

This image is too big to fit on the screen. How can we reduce it?

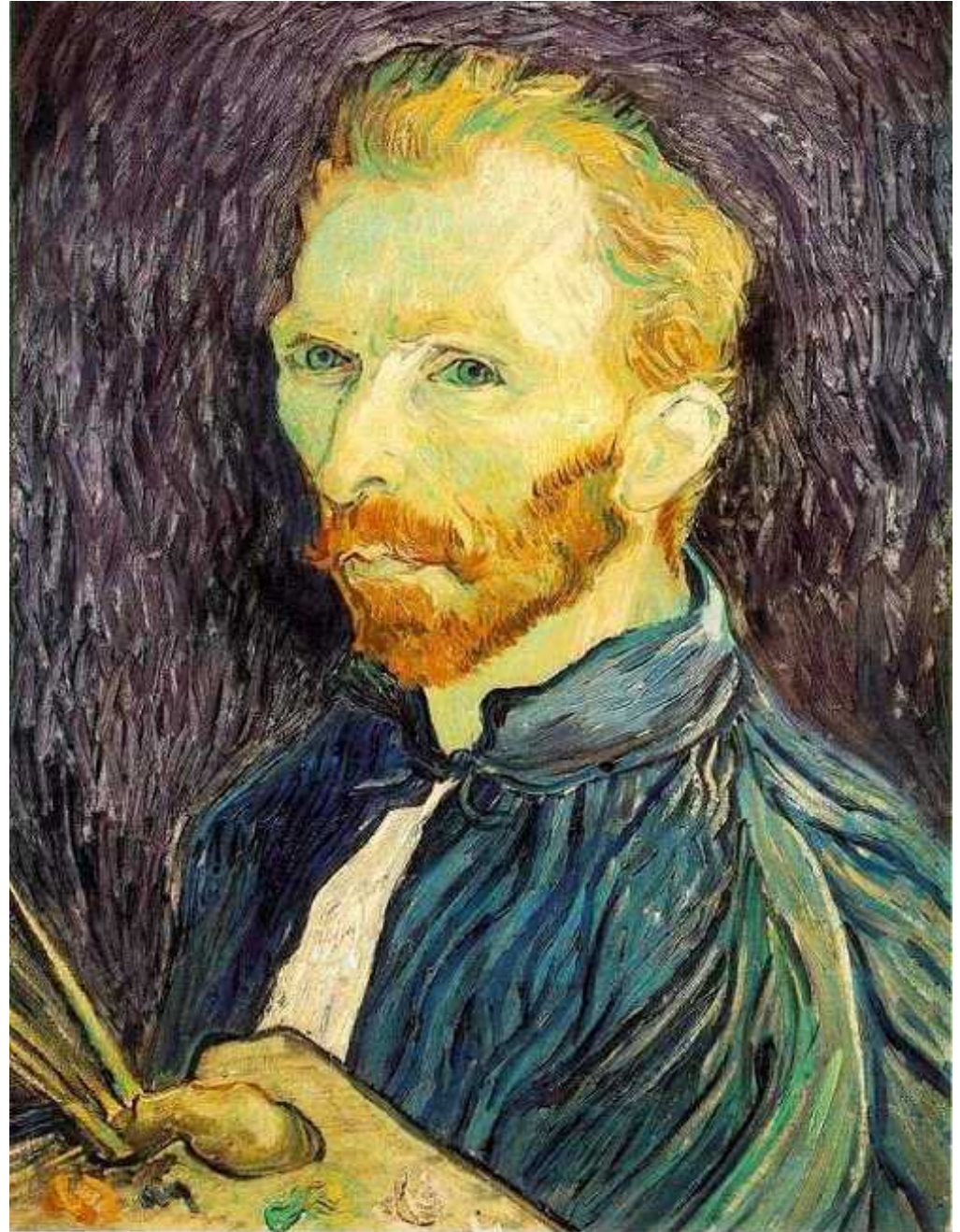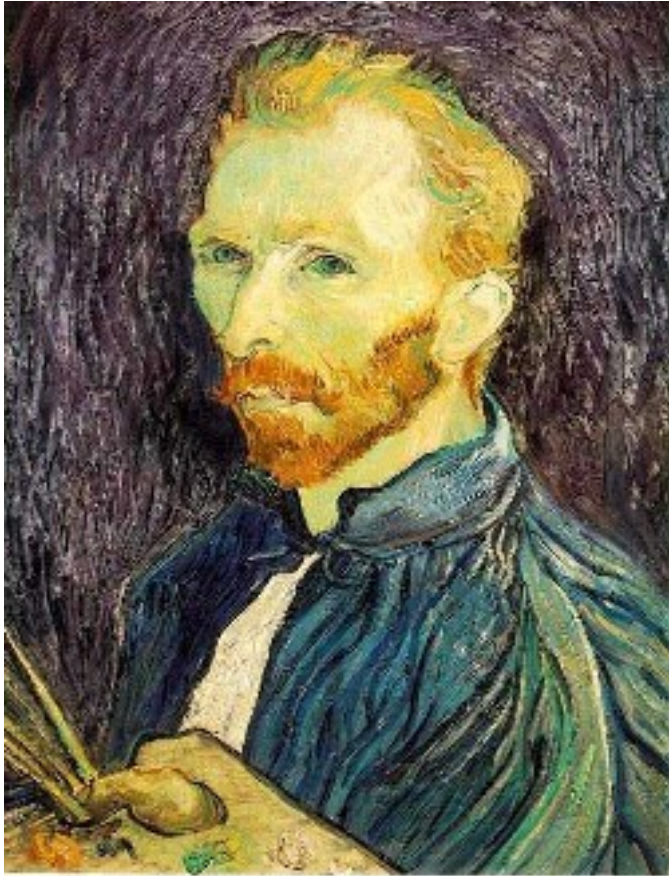How to generate a half-sized version?

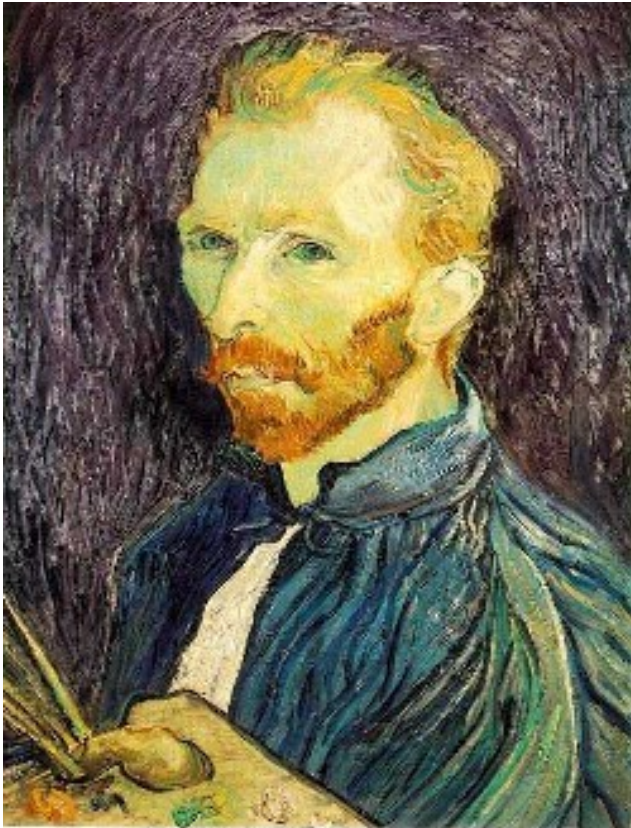# Image sub-sampling

1/4

1/8

Throw away every other row and
column to create a 1/2 size image
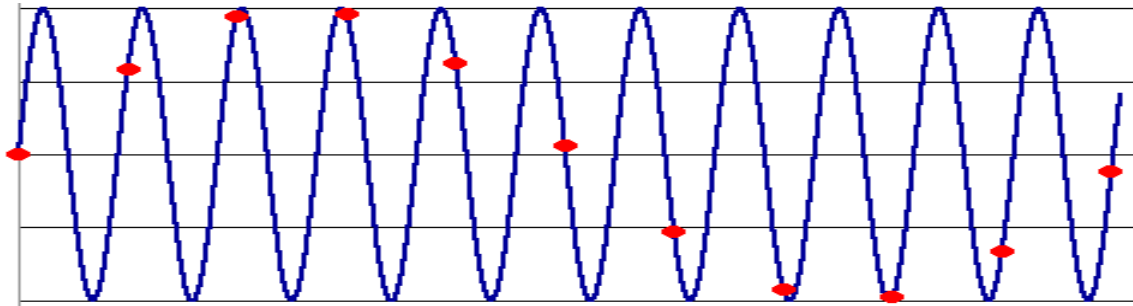- called *image sub-sampling*

Image sub-sampling

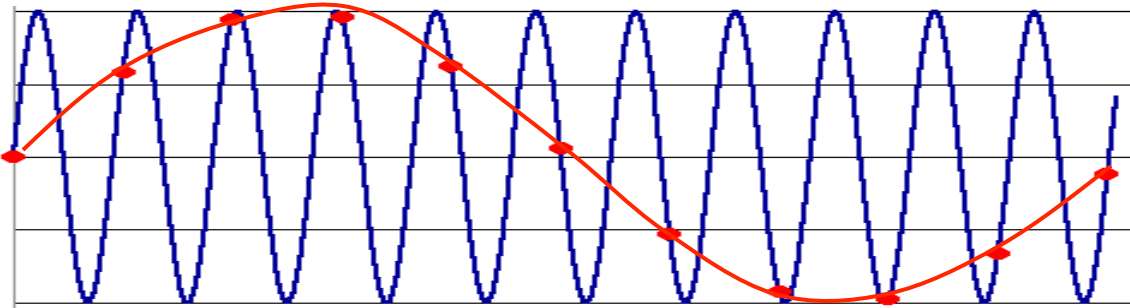1/2   1/4 (2x zoom)   1/8 (4x zoom)

Why does this look so crufty?

Down-sampling

- **Aliasing** can arise when you sample a continuous signal or image
  - occurs when your sampling rate is not high enough to capture the amount of detail in your image
  - Can give you the wrong signal/image—an *alias*
  - formally, the image contains structure at different scales
    - called "frequencies" in the Fourier domain
  - the sampling rate must be high enough to capture the highest frequency in the image

# Sampling and the Nyquist rate

- **Aliasing** can arise when you sample a continuous signal or image
  - occurs when your sampling rate is not high enough to capture the amount of detail in your image
  - Can give you the wrong signal/image—an *alias*
  - formally, the image contains structure at different scales
    - called "frequencies" in the Fourier domain
  - the sampling rate must be high enough to capture the highest frequency in the image
- To avoid aliasing:
  - sampling rate ≥ 2 * max frequency in the image
    - said another way: ≥ two samples per cycle
  - This minimum sampling rate is called the **Nyquist rate**
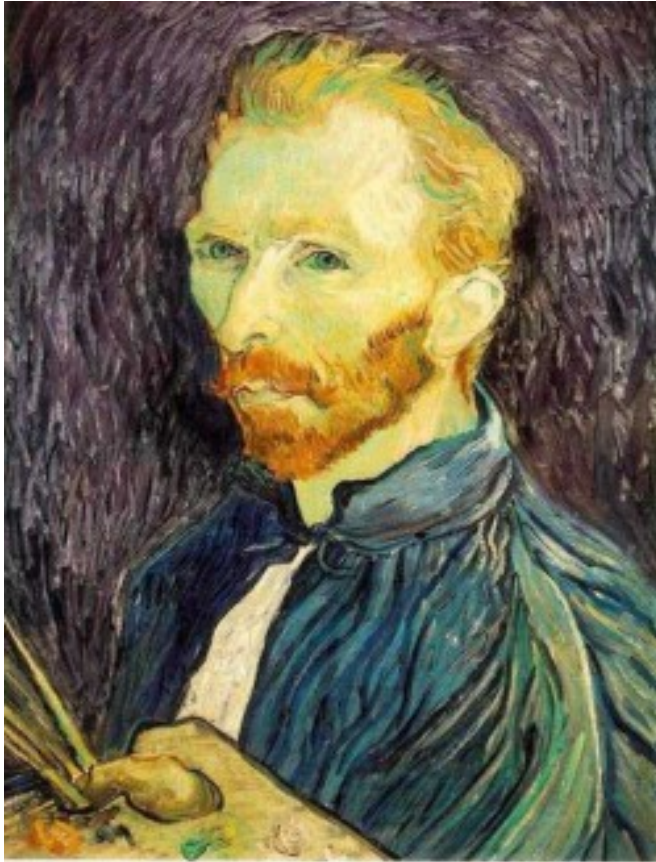
2D example
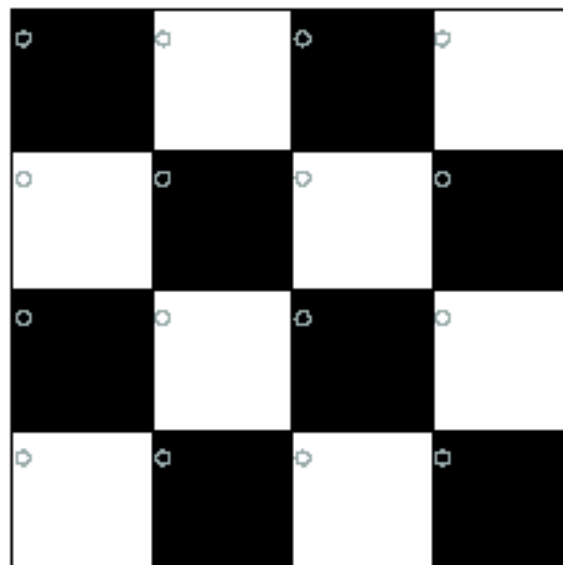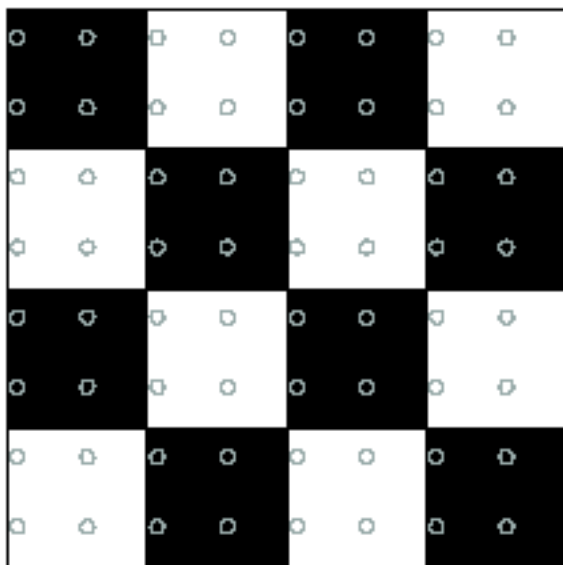
Good sampling
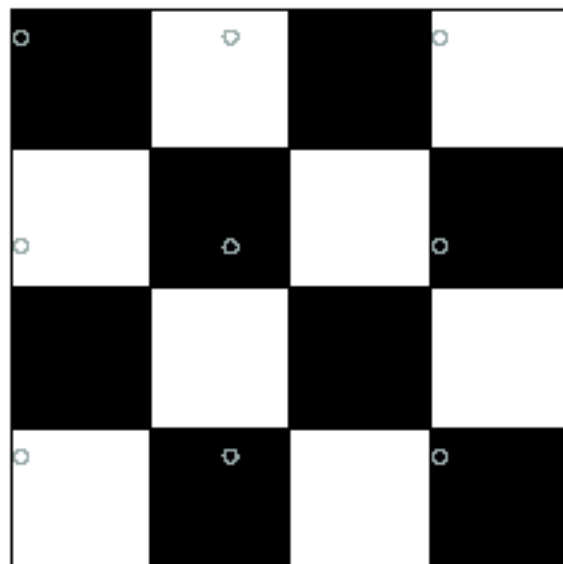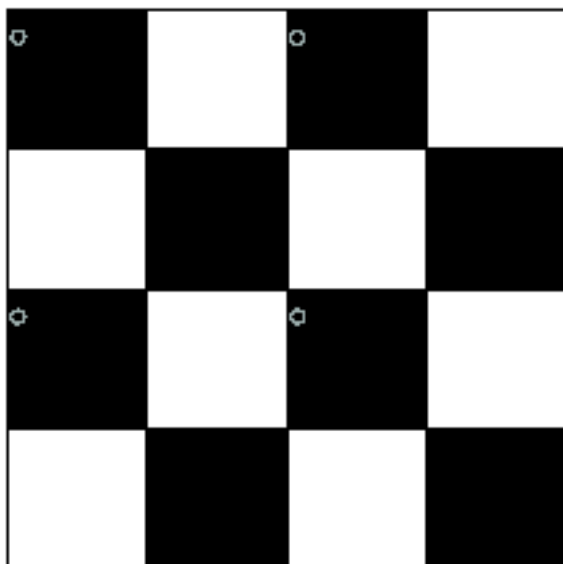
Bad sampling

Subsampling with Gaussian pre-filtering
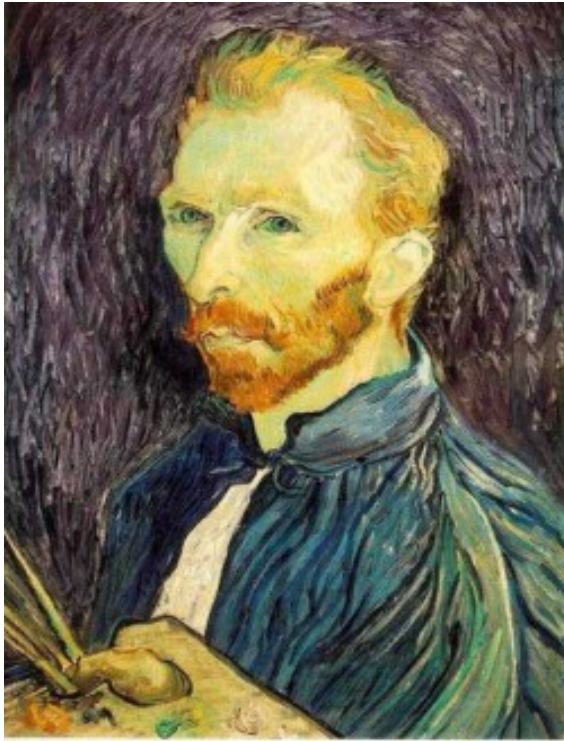

Gaussian 1/2

G 1/4

G 1/8

Solution: filter the image, *then* subsample
- Filter size should double for each ½ size reduction. Why?

Subsampling with Gaussian pre-filtering

Gaussian 1/2   G 1/4   G 1/8
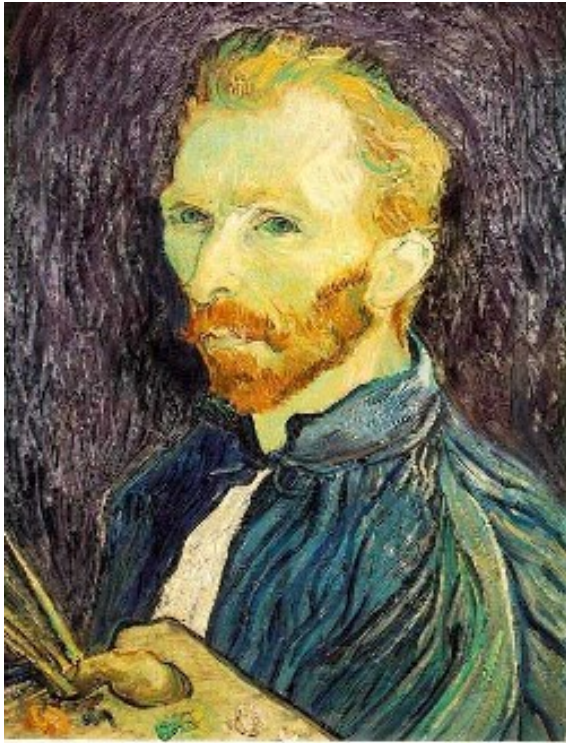
Solution: filter the image, *then* subsample
- Filter size should double for each ½ size reduction. Why?
- How can we speed this up?

Compare with…

1/2   1/4 (2x zoom)   1/8 (4x zoom)

Moire patterns in real-world images. Here are comparison images by Dave Etchells of Imaging Resource using the Canon D60 (with an antialias filter) and the Sigma SD-9 (which has no antialias filter). The bands below the fur in the image at right are the kinds of artifacts that appear in images when no antialias filter is used. Sigma chose to eliminate the filter to get more sharpness, but the resulting apparent detail may or may not reflect features in the image.
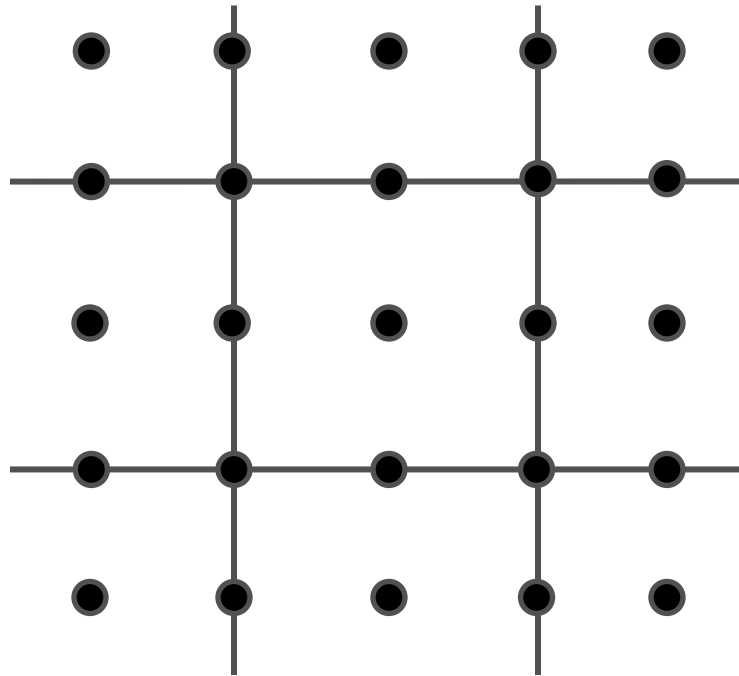
More examples

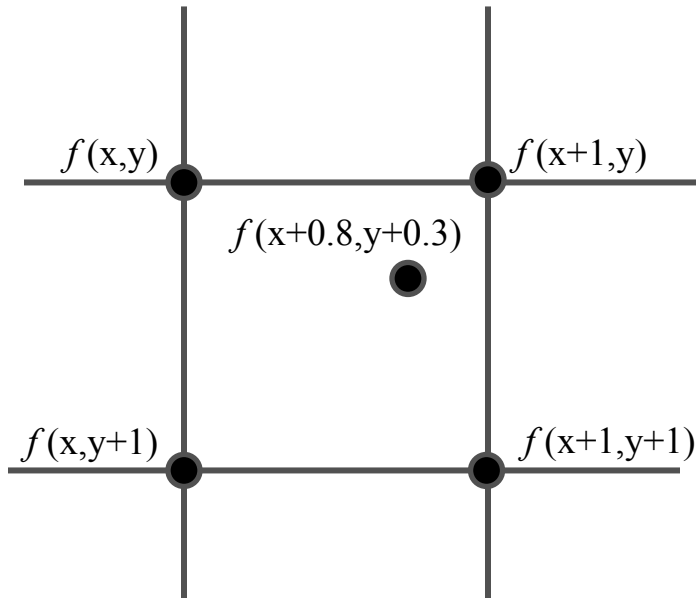
Check out Moire patterns on the web.

Up-sampling

How do we compute the values of pixels at fractional positions?

Up-sampling

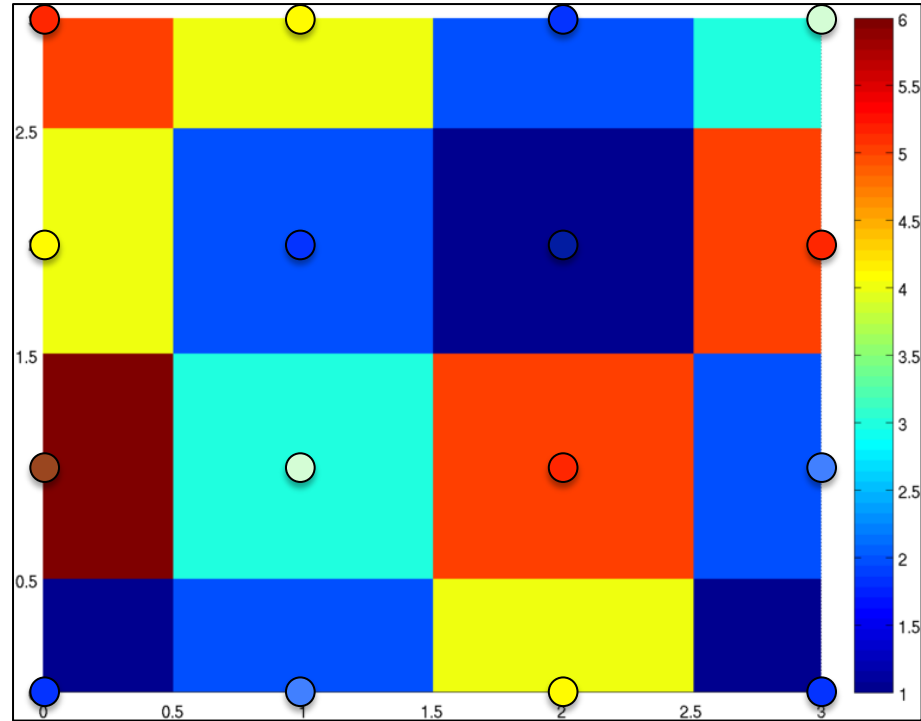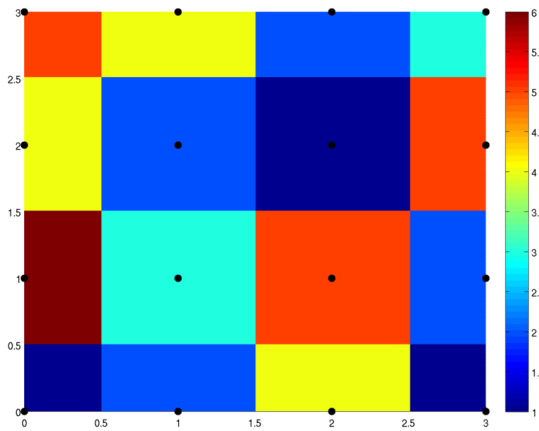How do we compute the values of pixels at fractional positions?

$f(\mathrm{x,y})$ $f(\mathrm{x+1,y})$

$f(\mathrm{x+0.8,y+0.3})$

$f(\mathrm{x,y+1})$ $f(\mathrm{x+1,y+1})$

Bilinear sampling:

$$f(\mathrm{x} + a, \mathrm{y} + b) =$$
$$(1 - a)(1 - b)\,f(\mathrm{x}, \mathrm{y}) +$$
$$a(1 - b)\,f(\mathrm{x} + 1, \mathrm{y}) +$$
$$(1 - a)b\,f(\mathrm{x,y} + 1) +$$
$$ab\,f(\mathrm{x} + 1, \mathrm{y} + 1)$$

Bicubic sampling fits a higher order function using a larger area of support.

Up-sampling Methods

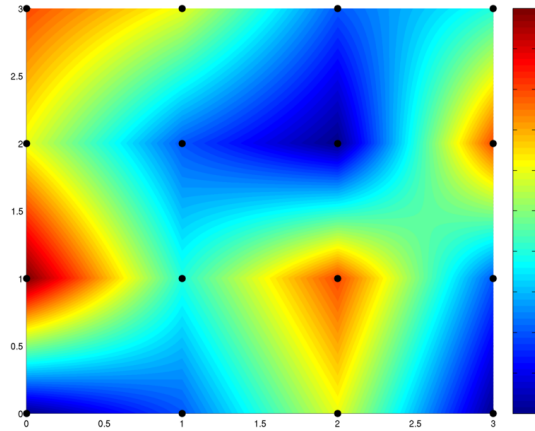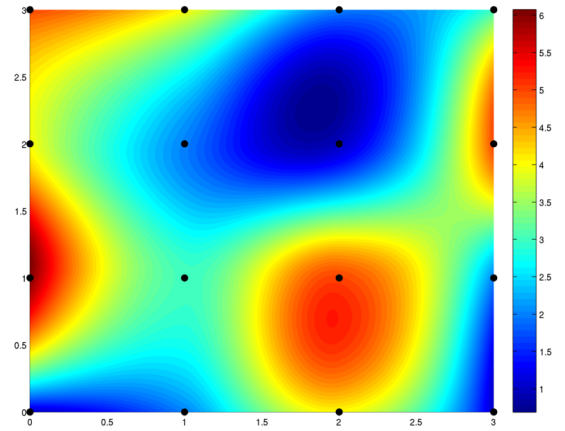# Up-sampling

Nearest neighbor   Bilinear   Bicubic

Up-sampling

Nearest neighbor   Bilinear   Bicubic