

Lecture 3, Part 3

Thinking in The Frequency Domain 1/2

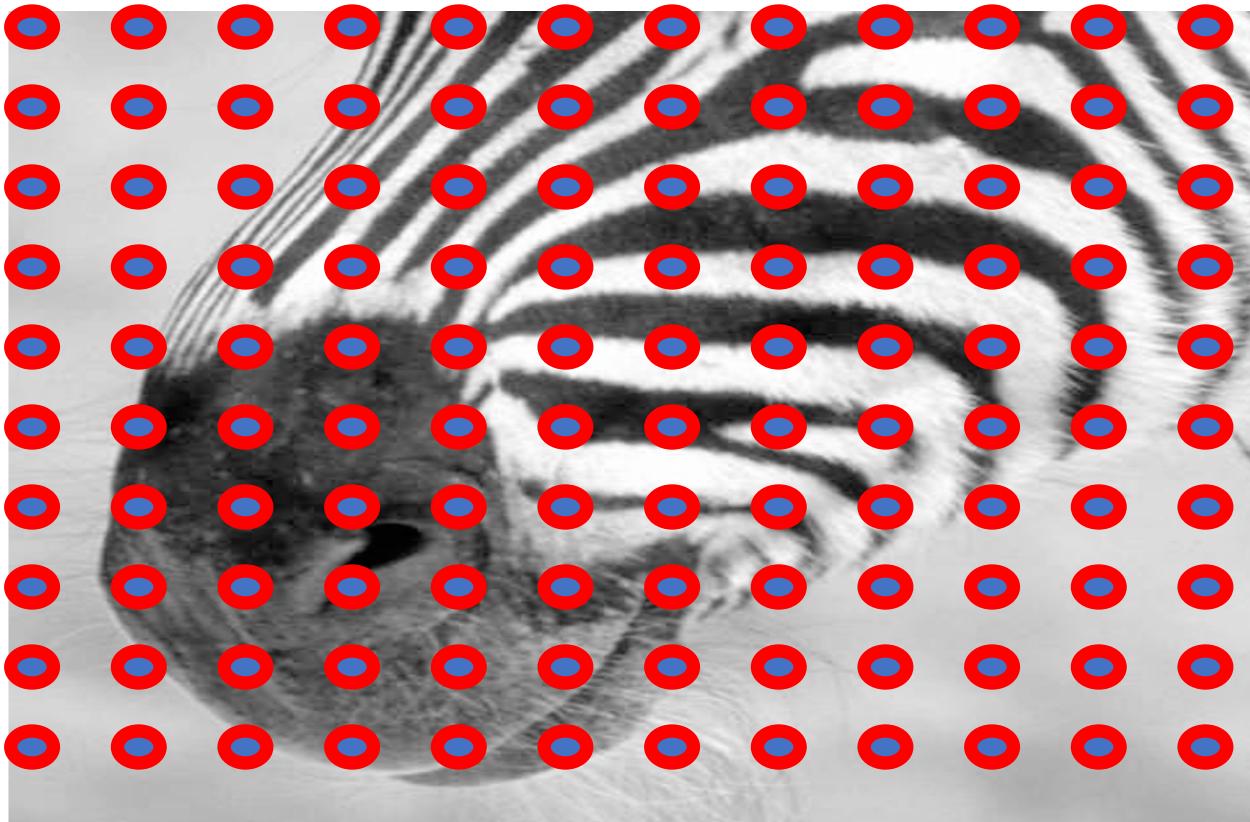
Computer Vision
Summer Semester 2022

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Frequencies

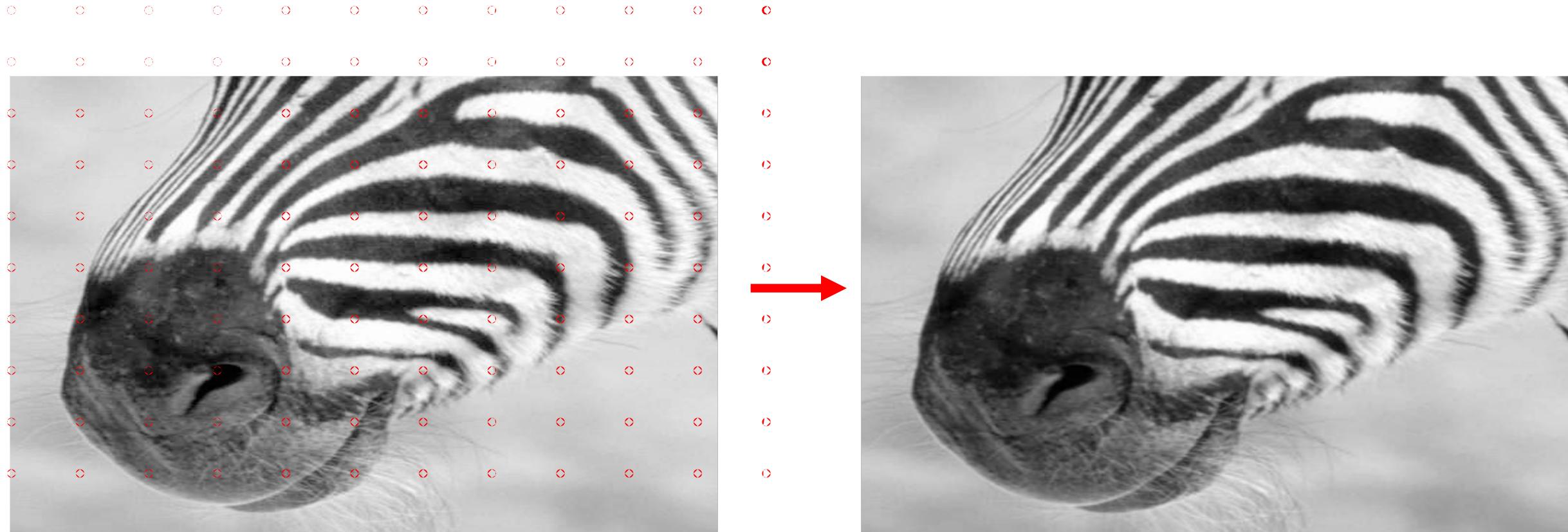
- Aliasing
- Sampling and downsampling

Subsampling by a factor of 2



Throw away every other row and column to create a $1/2$ size image

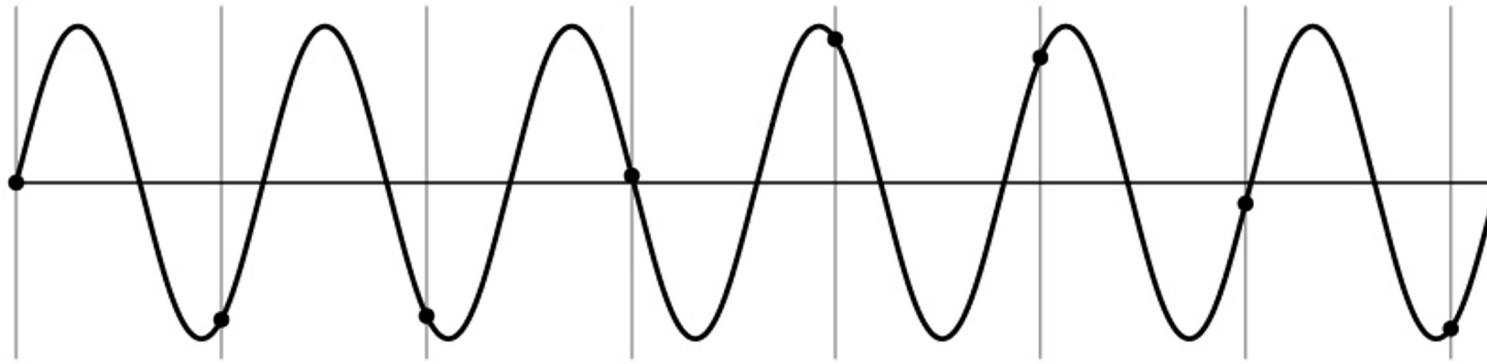
Subsampling by a factor of 2



resized to fit the same space -- for better visualization!

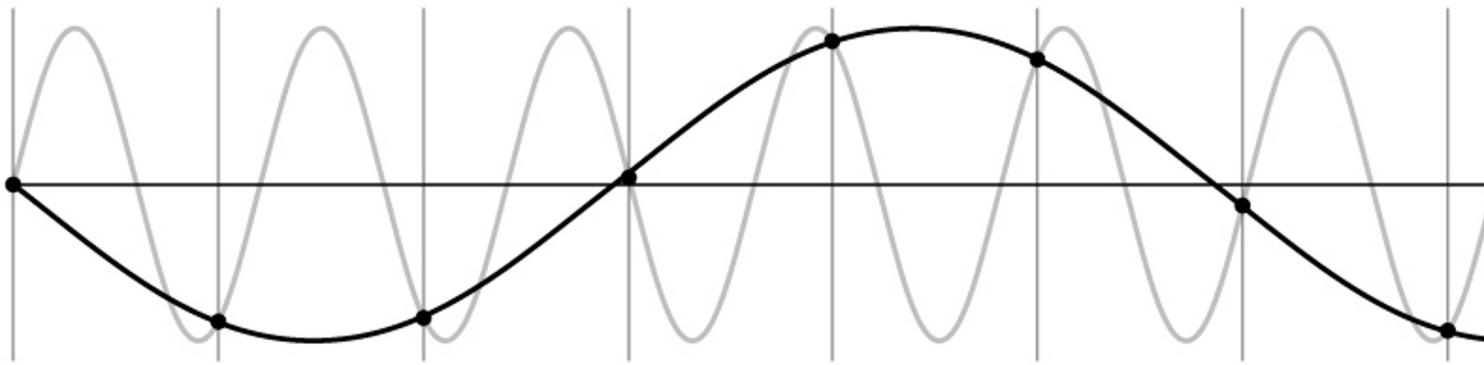
Aliasing problem

- 1D example (sinewave):



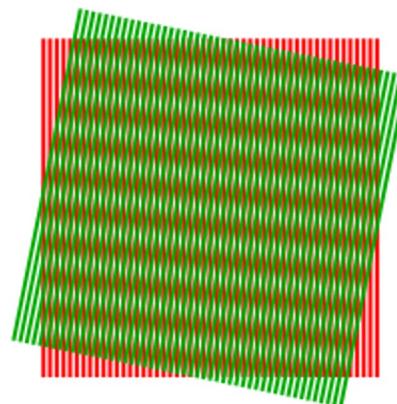
Aliasing problem

- 1D example (sinewave):



Aliasing problem

- Sub-sampling may be dangerous....
- Characteristic errors may appear:
 - “car wheels rolling the wrong way in movies”
 - “checkerboards disintegrate in ray tracing”
 - “striped shirts look funny on color television”
 - Moiré patterns

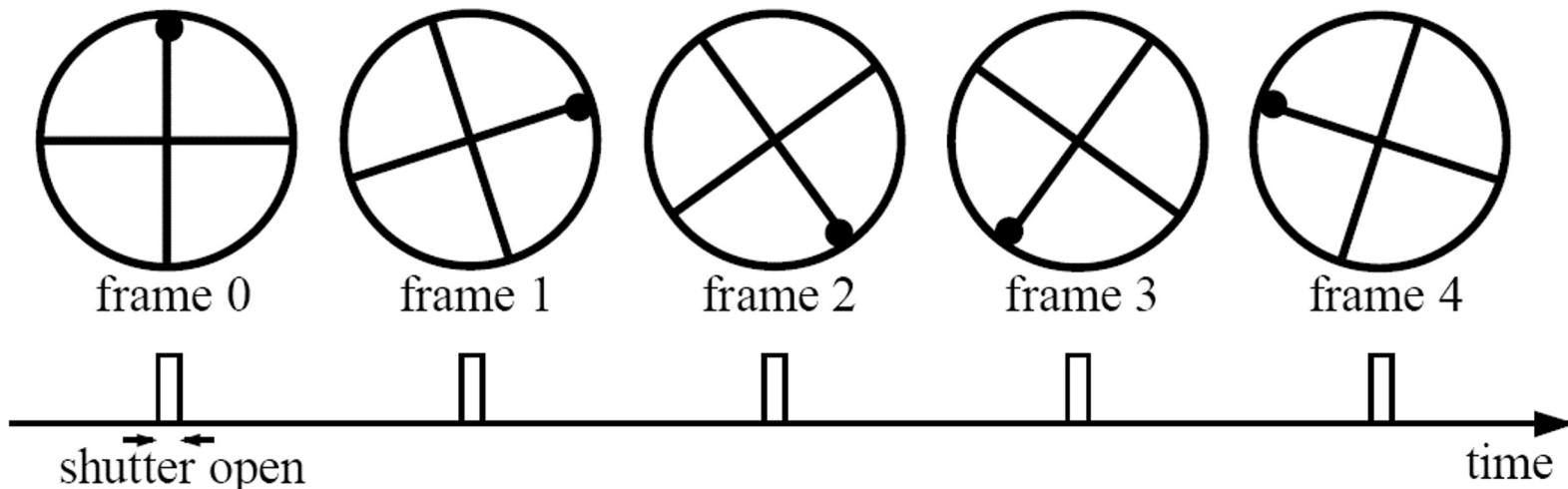


Aliasing in graphics



Aliasing in video

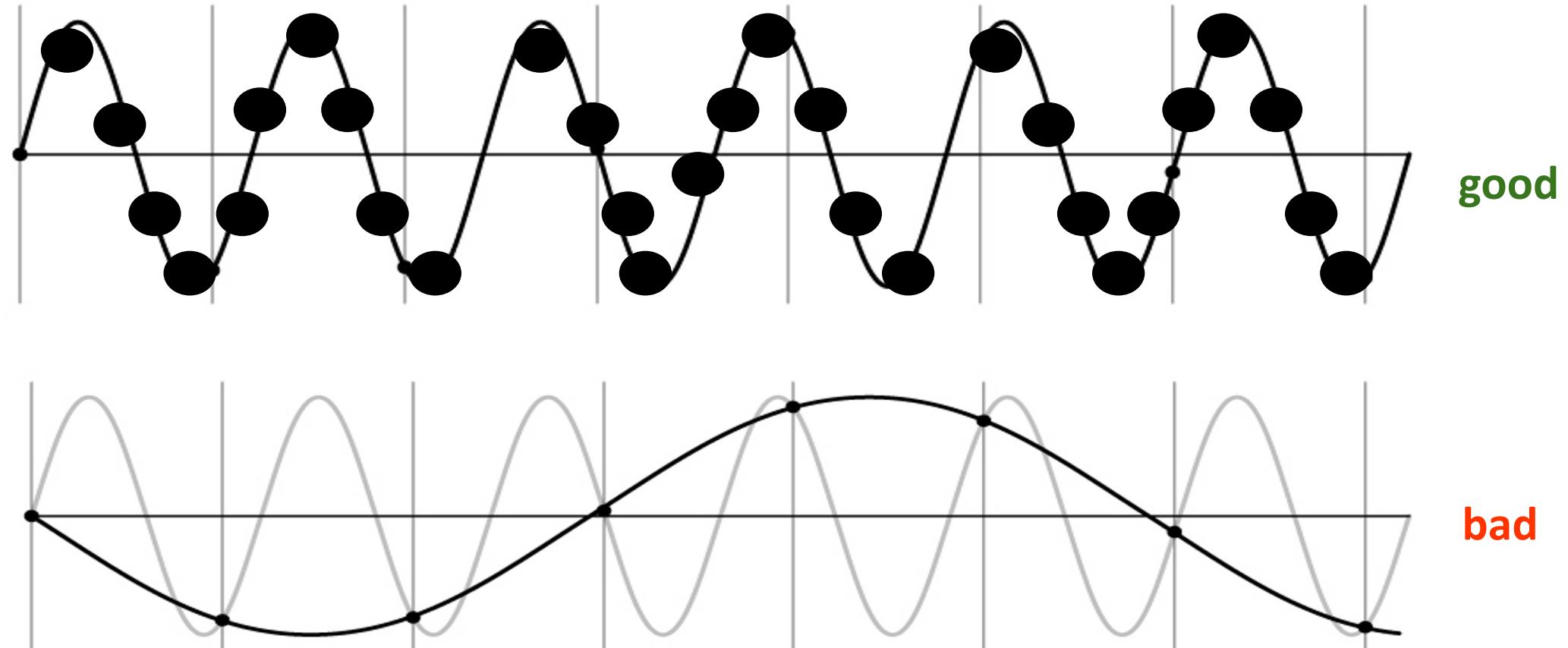
Imagine a spoked wheel moving to the right (rotating clockwise).



Nyquist-Shannon Sampling Theorem

- When sampling a signal at discrete intervals, the sampling frequency must be $\geq 2 \times f_{\max}$
- f_{\max} = max frequency of the input signal
- This will allow to reconstruct the original perfectly from the sampled version

Nyquist-Shannon Sampling Theorem



How to fix aliasing?

Solutions:

- Better sensor: sample more often (**trivial and not always available**)
- Anti-aliasing: Remove all frequencies that are greater than half the new sampling frequency *prior to sampling*
 - Will lose information
 - But better than aliasing
 - Apply a smoothing (low pass) filter (**filtering from previous lecture!**)

Algorithm for downsampling by factor of 2

1. Start with $\text{image}(h, w)$

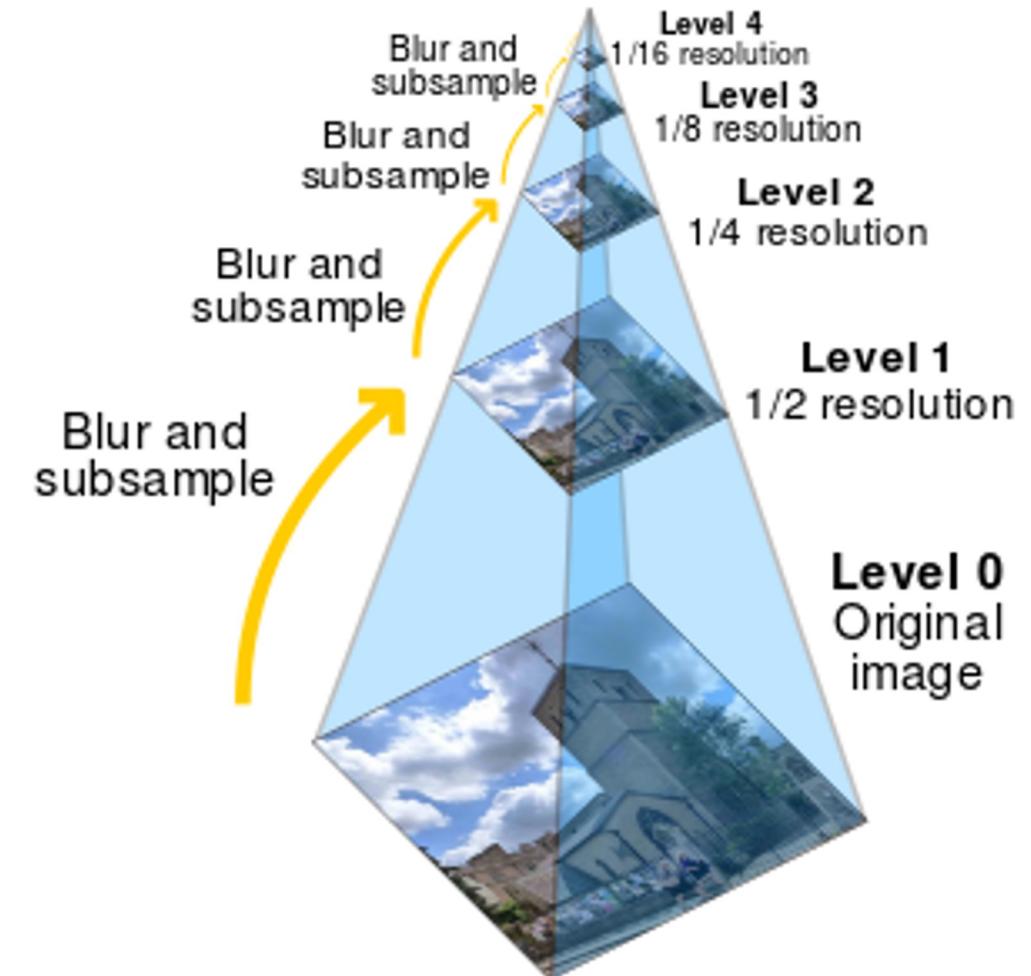
2. Apply low-pass filter

```
im.blur = imfilter( image,  
    fspecial('gaussian', 7, 1) )
```

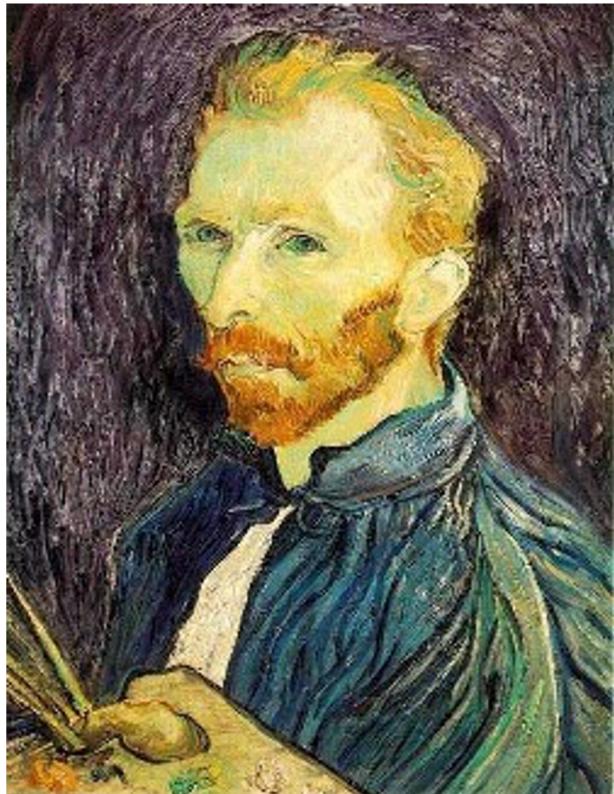
3. Sample every other pixel

```
im.small = im.blur(1:2:end,  
    1:2:end );
```

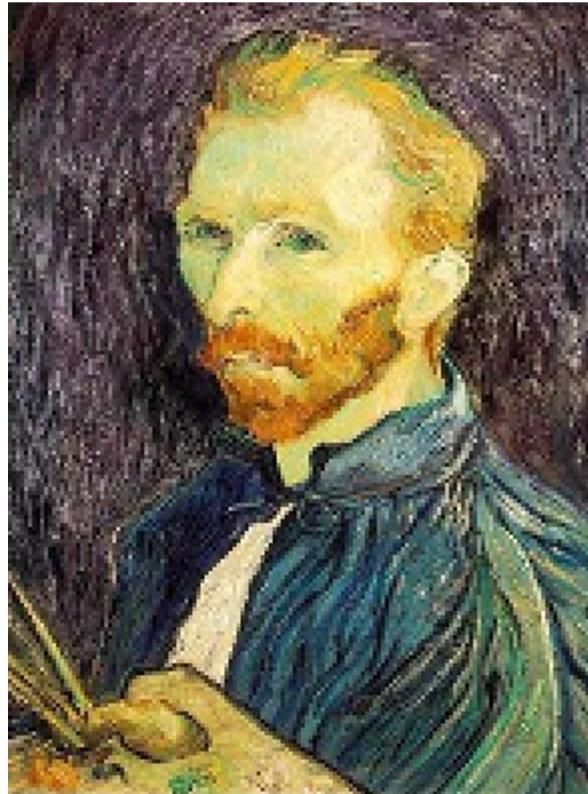
- **Image pyramid =
iterated downsampling**



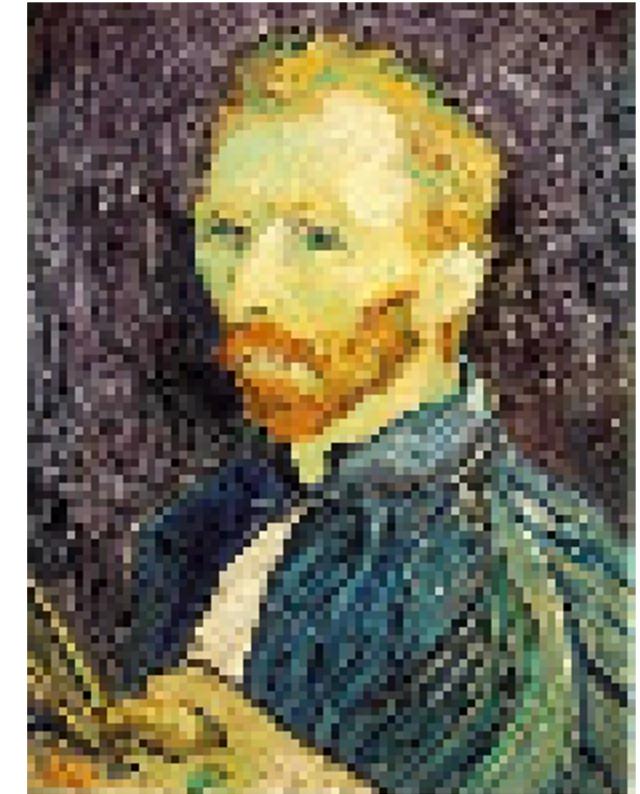
Subsampling without pre-filtering



1/2

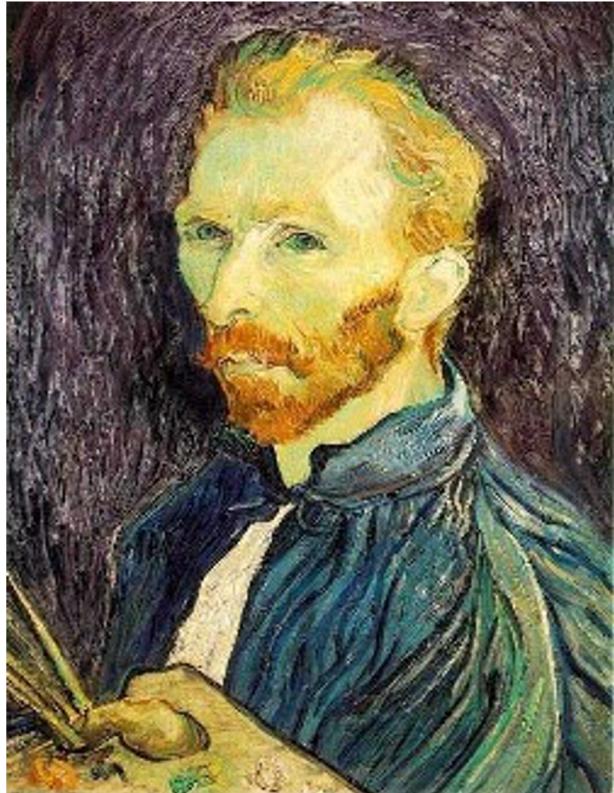


1/4 (2x zoom)



1/8 (4x zoom)

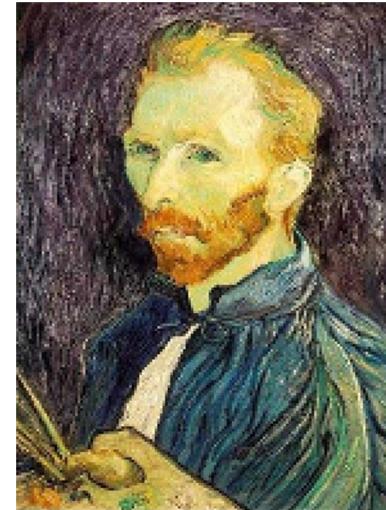
Subsampling without pre-filtering



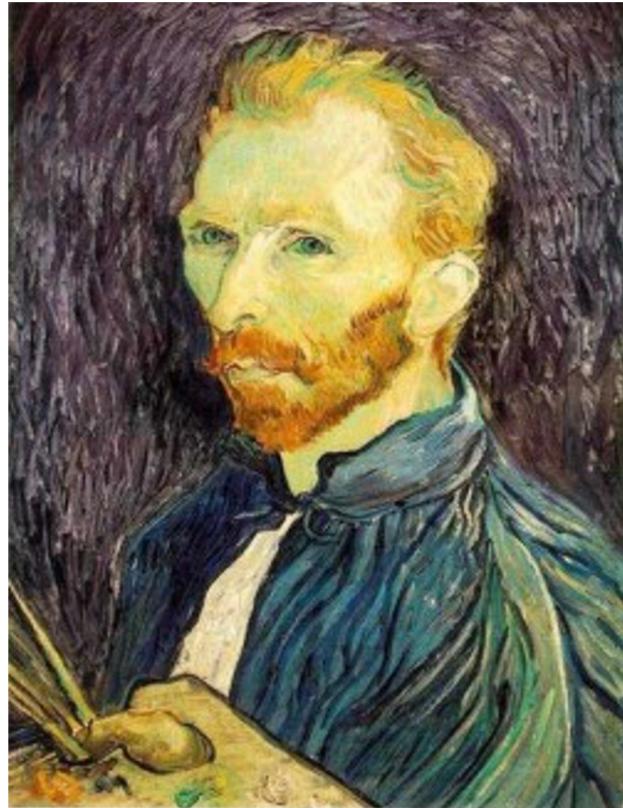
1/2

1/4 (2x zoom)

1/8 (4x zoom)



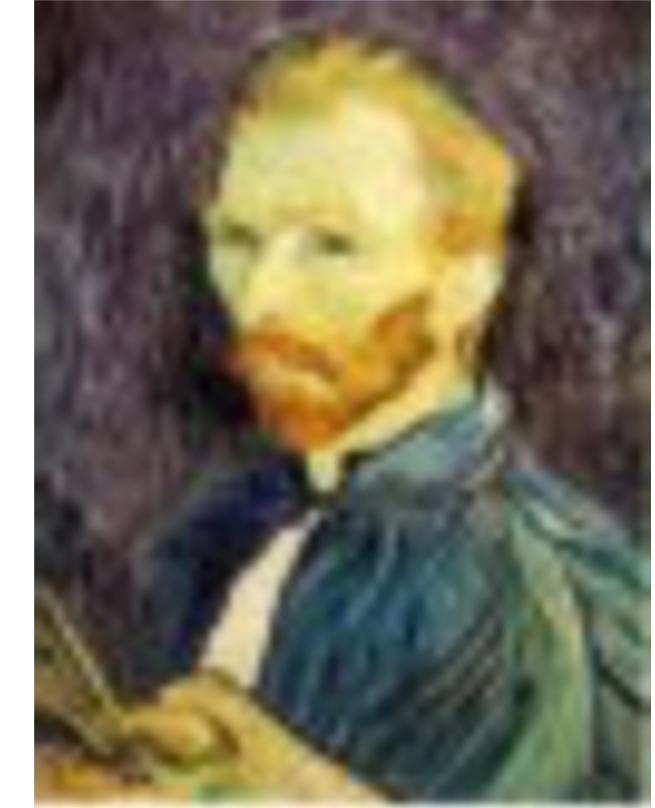
Subsampling with Gaussian pre-filtering



Gaussian 1/2

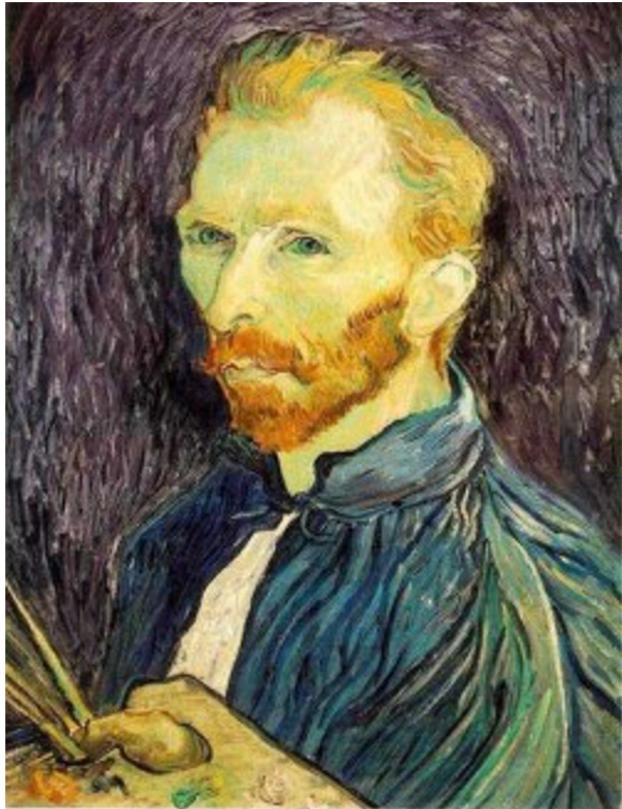


G 1/4

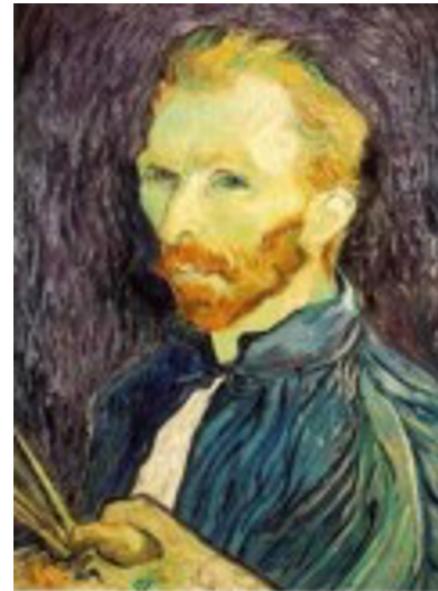


G 1/8

Subsampling with Gaussian pre-filtering



Gaussian 1/2



G 1/4



G 1/8