Computer Vision

CSC-455

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Today's Lecture

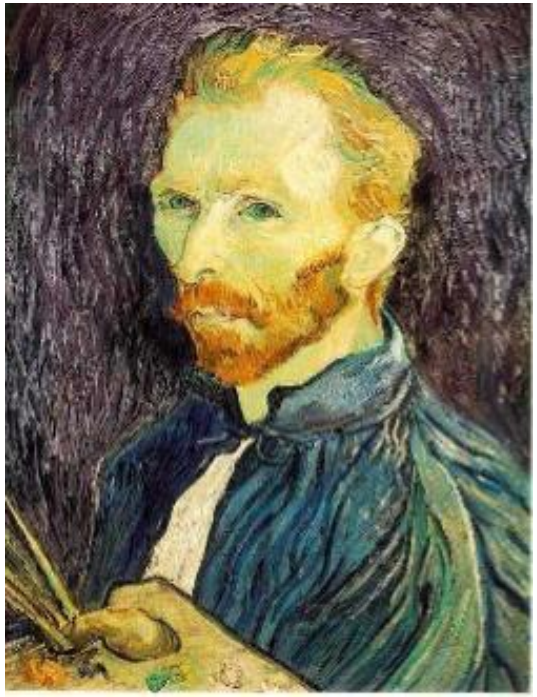
Image representation

- Pixels: great for spatial resolution, poor access to frequency

- Fourier transform: great for frequency, not for spatial info

- Pyramids/filter banks: balance between spatial and frequency information

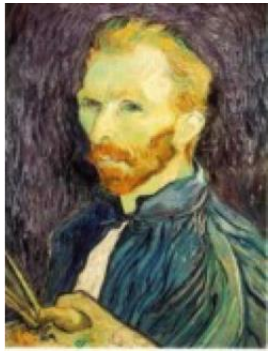
Better image downsampling



1/2

Apply a smoothing filter first, then throw away half the rows and columns

Gaussian filter
delete even rows
delete even columns

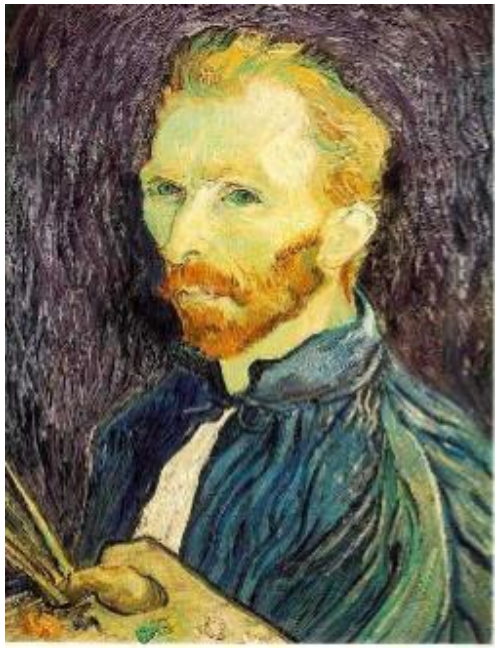


1/4

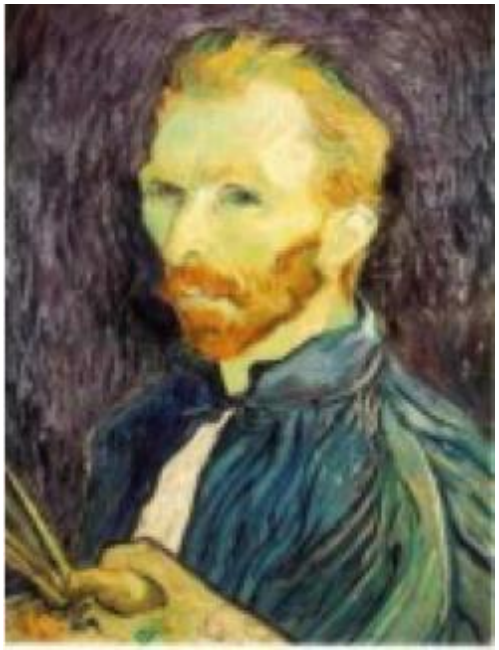
Gaussian filter
delete even rows
delete even columns

1/8

Better image downsampling



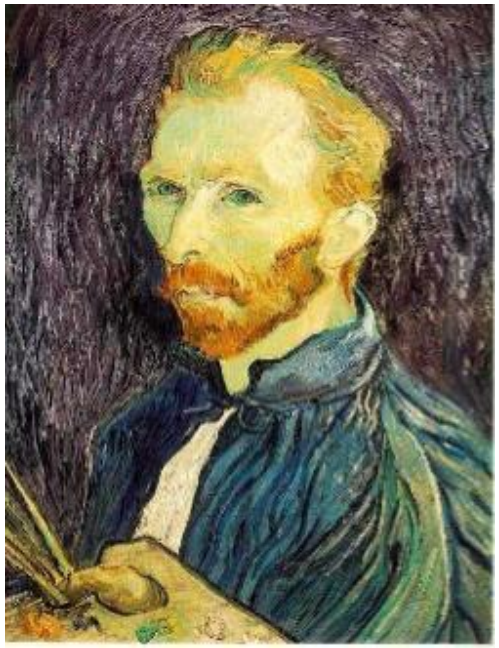
1/2



1/4 (2x zoom)

1/8 (4x zoom)

Naïve image downsampling



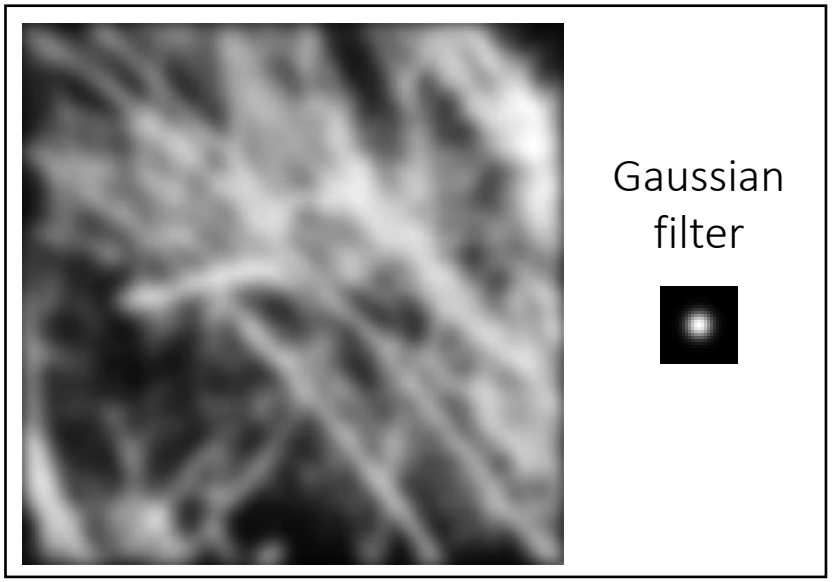
1/2

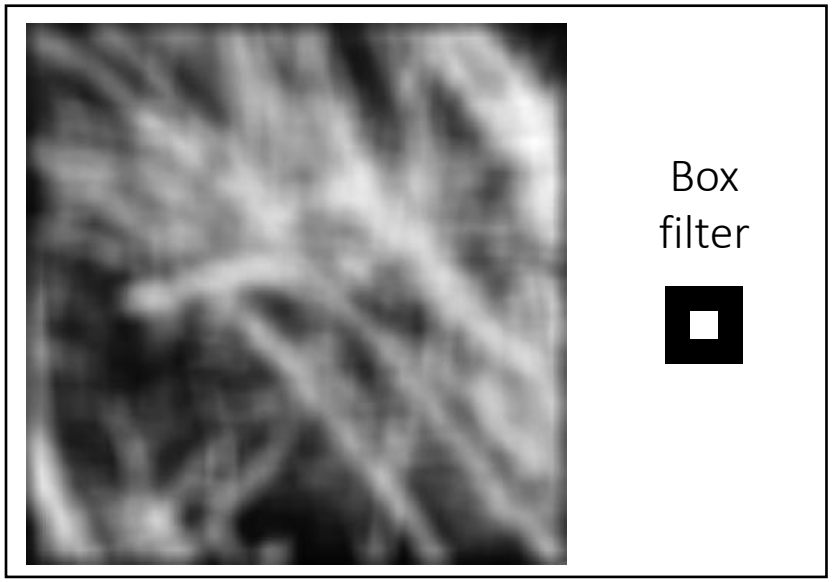
1/4 (2x zoom)

1/8 (4x zoom)

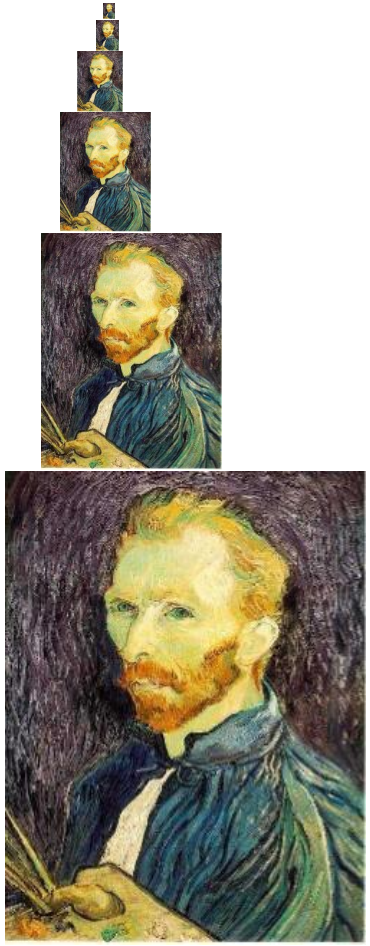
Revisiting blurring

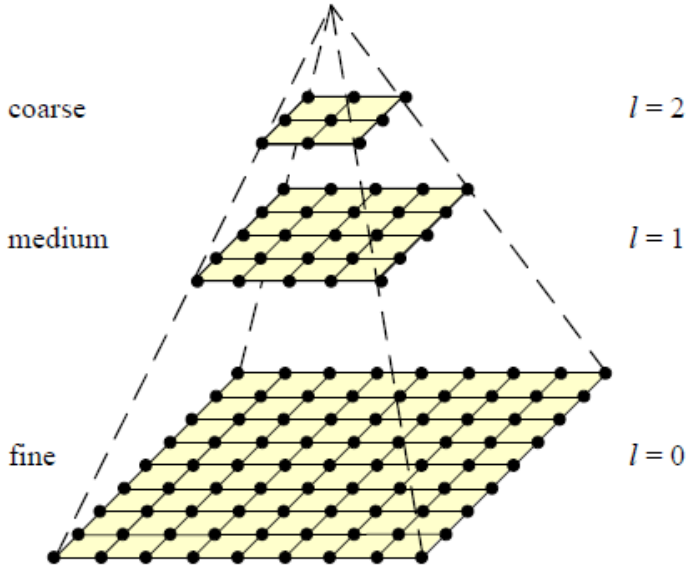
Why does the Gaussian give a nice smooth image, but the square filter give edgy artifacts?





Gaussian image pyramid





The name of this sequence of subsampled images

Constructing a Gaussian pyramid

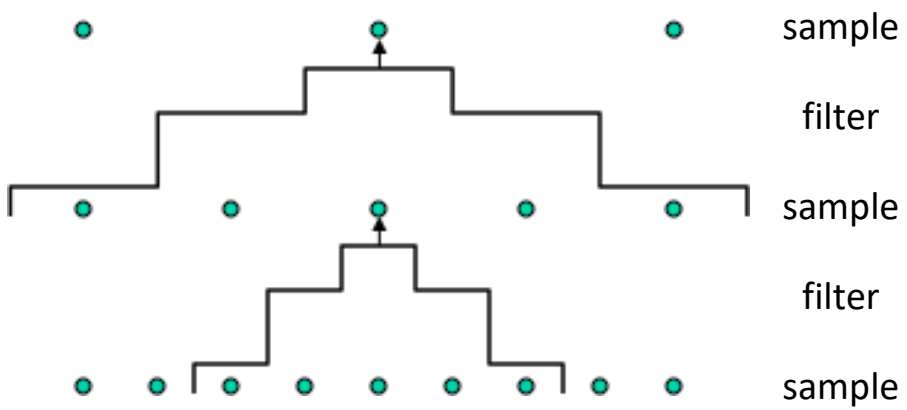
Algorithm

repeat:

filter

subsample

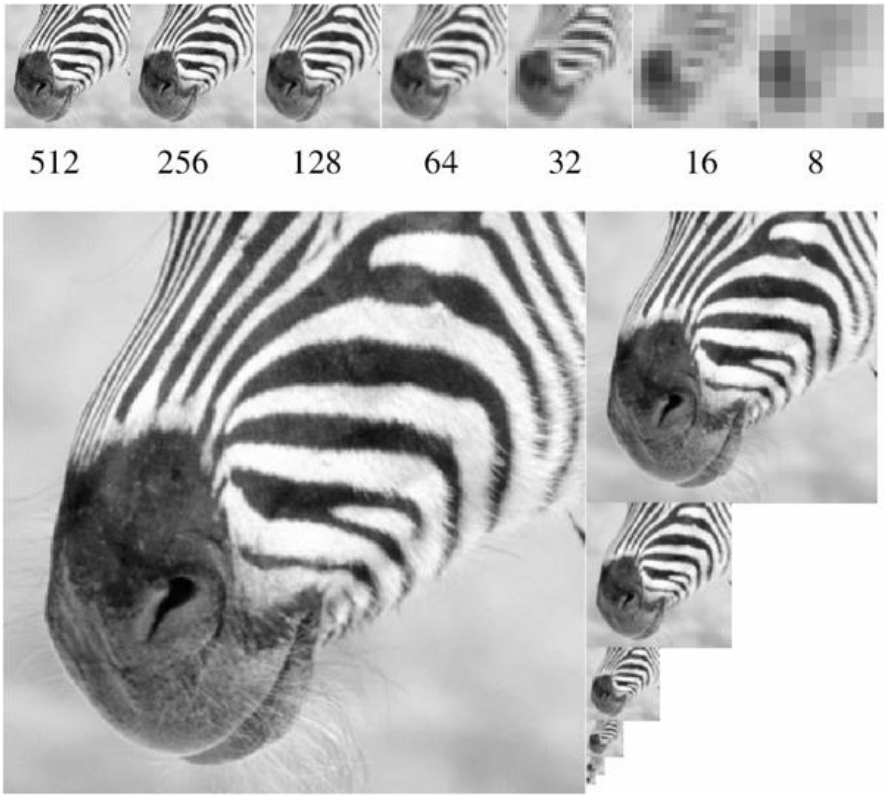
until min resolution reached



Question: How much bigger than the original image is the whole pyramid?

Answer: Just 4/3 times the size of the original image! (How did I come up with this number?)

Some properties of the Gaussian pyramid



What happens to the details of the image?

- They get smoothed out as we move to higher levels.

What is preserved at the higher levels?

- Mostly large uniform regions in the original image.

How would you reconstruct the original image from the image at the upper level?

- That's not possible.

Blurring is lossy

level 0

-

level 1 (before downsampling)

=

residual

What does the residual look like?

Blurring is lossy

level 0

-

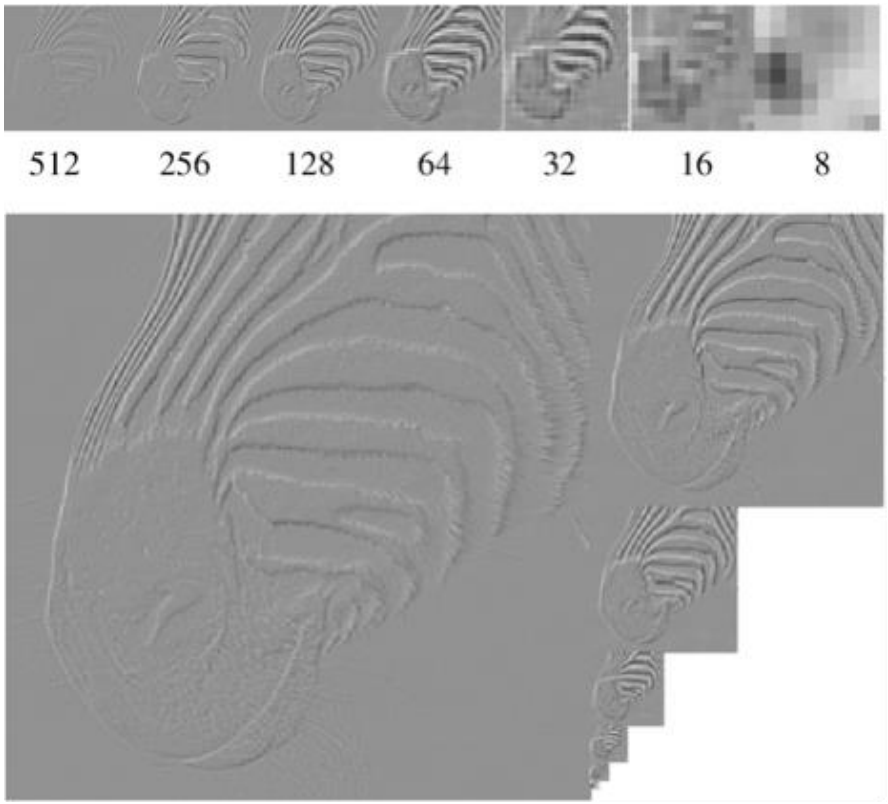
level 1 (before downsampling)

=

residual

Can we make a pyramid that is lossless?

Laplacian image pyramid



At each level, retain the residuals instead of the blurred images themselves.

Can we reconstruct the original image using the pyramid?

- Yes we can!

What do we need to store to be able to reconstruct the original image?

Let’s start by looking at just one level

level 0

=

level 1 (upsampled)

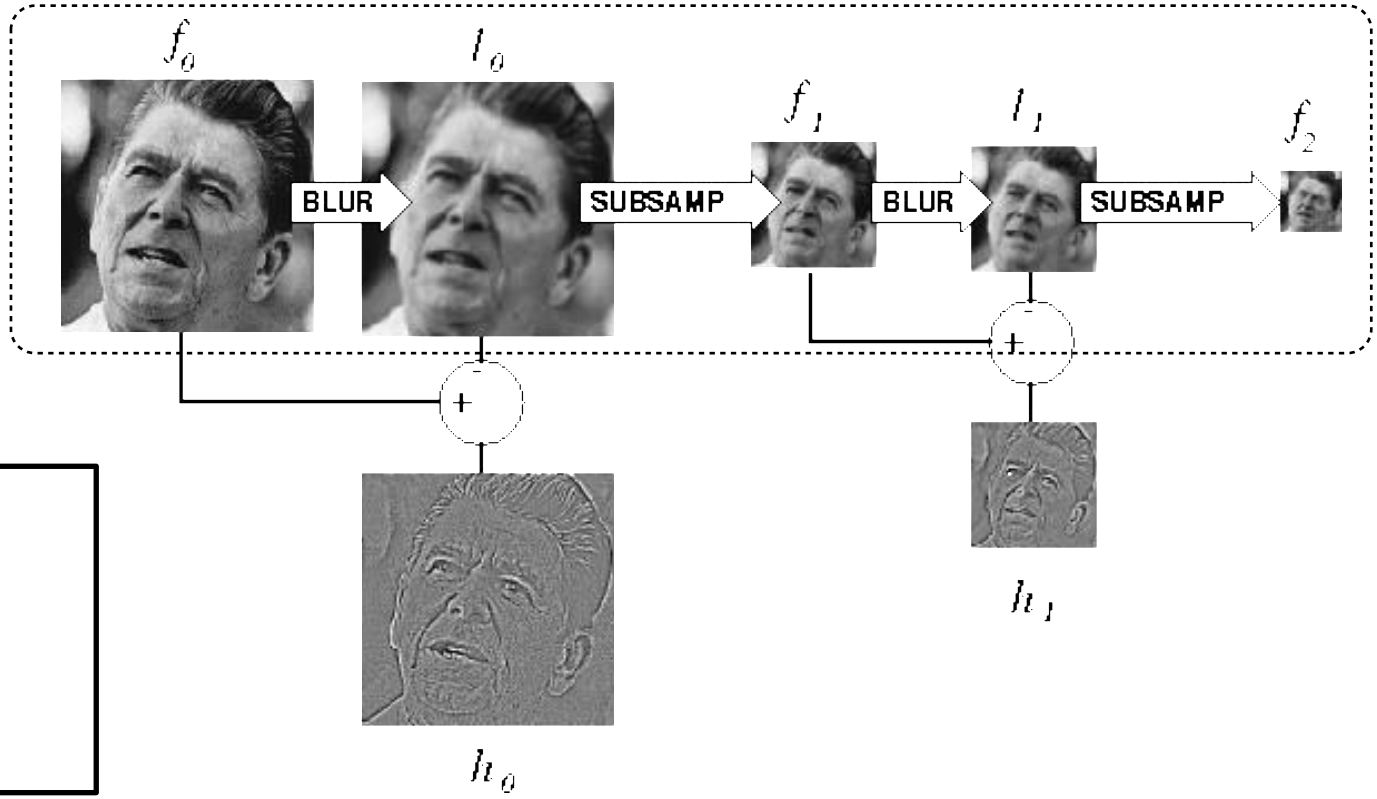
+

residual

Does this mean we need to store both residuals and the blurred copies of the original?

Constructing a Laplacian pyramid

It's a Gaussian pyramid.



Algorithm

repeat:

- filter
- compute residual
- subsample

until min resolution reached

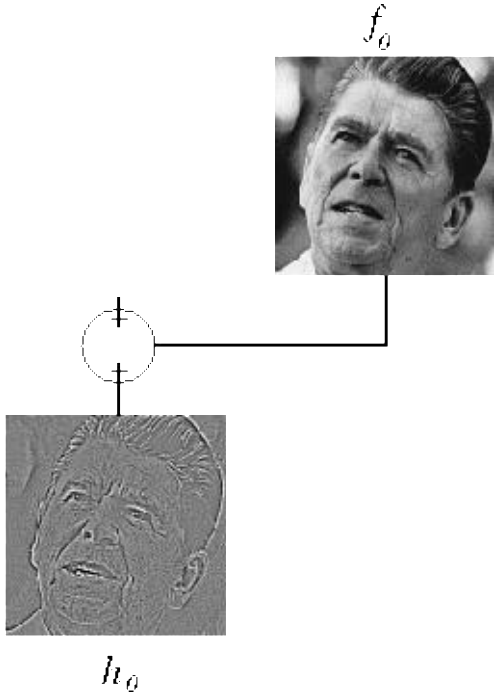
What do we need to construct the original image?

f_0

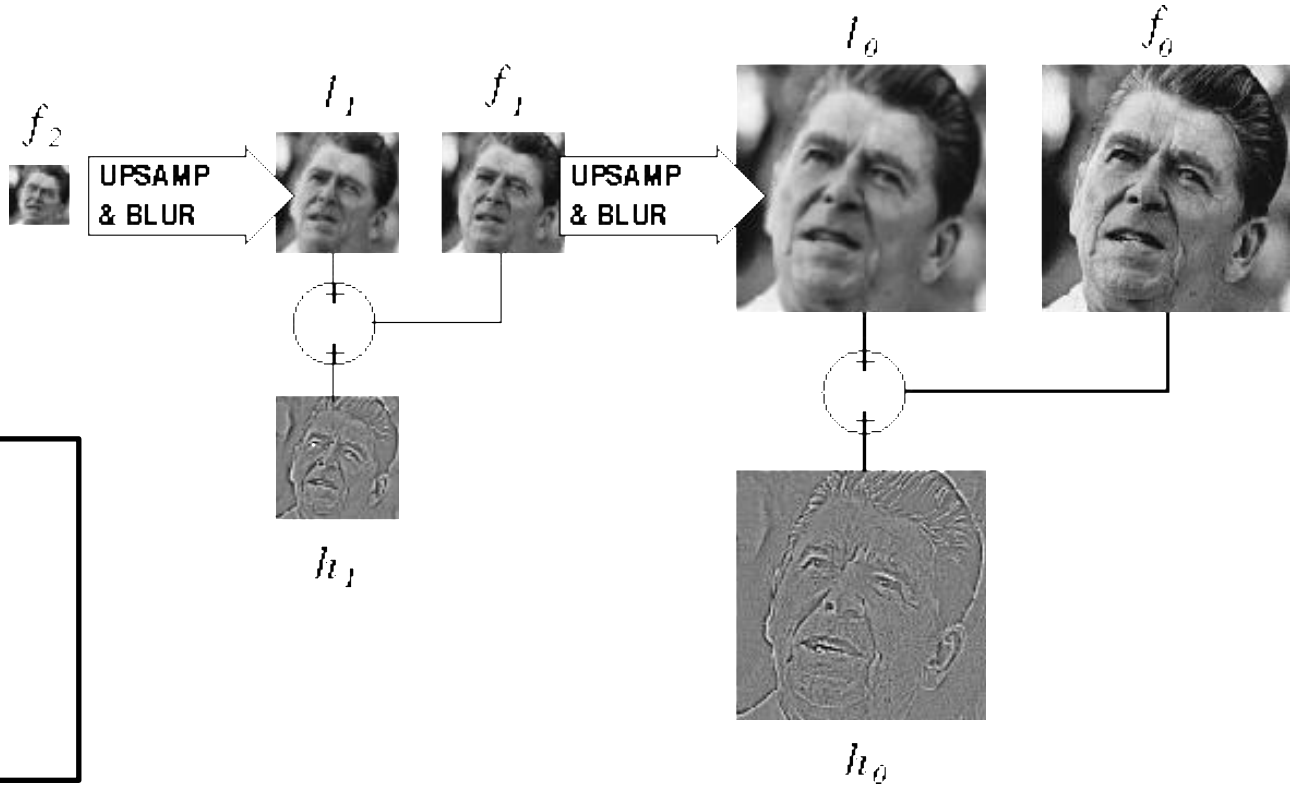
What do we need to construct the original image?

(2) smallest image

(1) residuals



Reconstructing the original image



Algorithm

repeat:

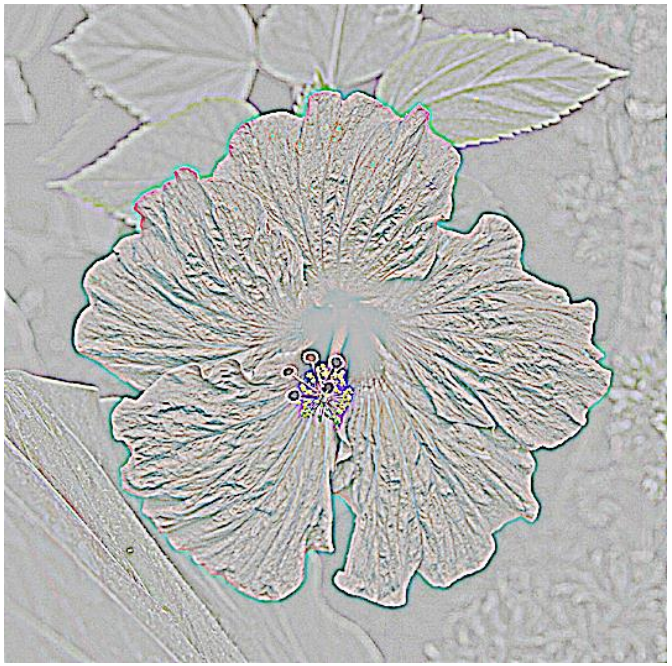
upsample

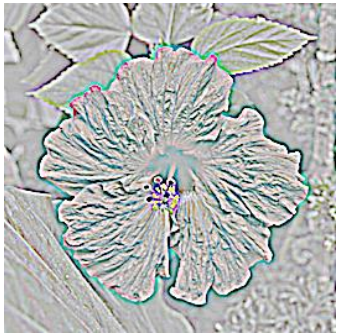
sum with residual

until orig resolution reached

Gaussian vs Laplacian Pyramid

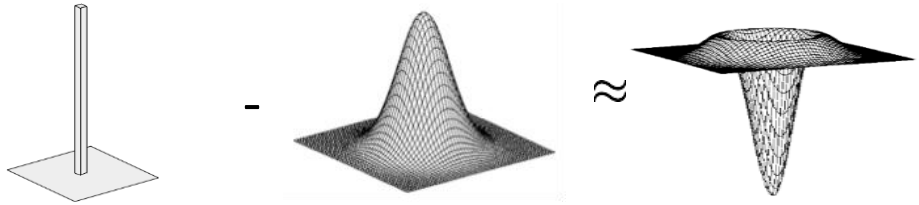
Shown in opposite order for space.



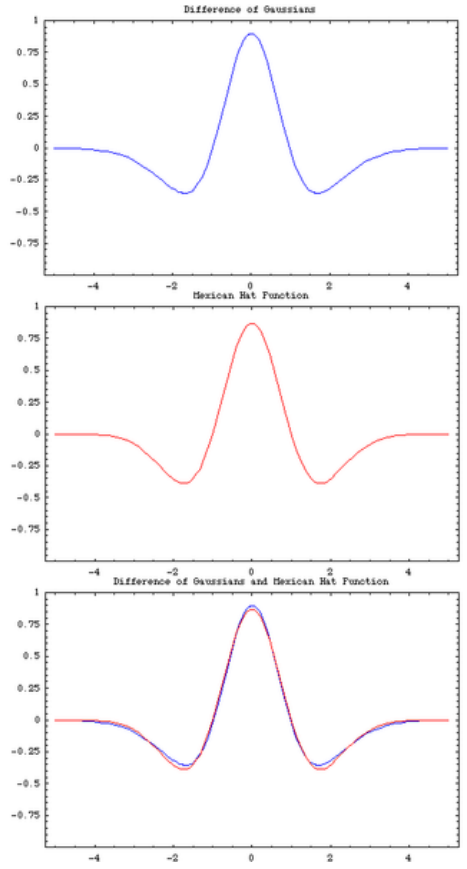


Which one takes more space to store?

Why is it called a Laplacian pyramid?



unit Gaussian Laplacian



Difference of Gaussians approximates the Laplacian

Still used extensively

Still used extensively

foreground details enhanced, background details reduced

input image

user-provided mask

What are image pyramids used for?

image compression

multi-scale texture mapping

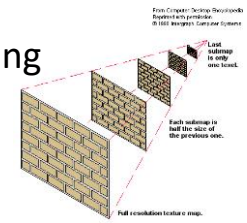
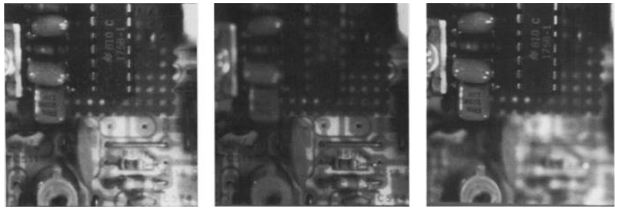
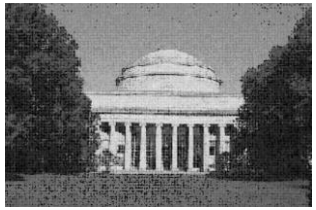


image blending

focal stack compositing

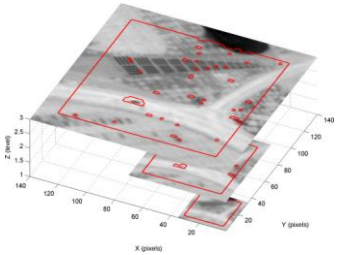


denoising



multi-scale detection

multi-scale registration



References

- Some Slide material has been taken from Dr M. Usman Akram Computer Vision Lectures
- CSCI 1430: Introduction to Computer Vision by James Tompkin
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