Image Pyramids

Visual Information Processing and Management
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Simone Bianco

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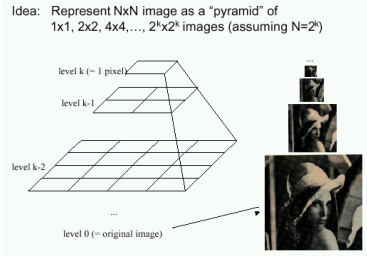
Image Pyramids

Idea: Represent NxN image as a "pyramid" of 1x1, 2x2, 4x4,…, 2^kx2^k images (assuming N=2^k)



Known as a **Gaussian Pyramid** [Burt and Adelson, 1983]

- In computer graphics, a *mip map* [Williams, 1983]
- A precursor to *wavelet transform*

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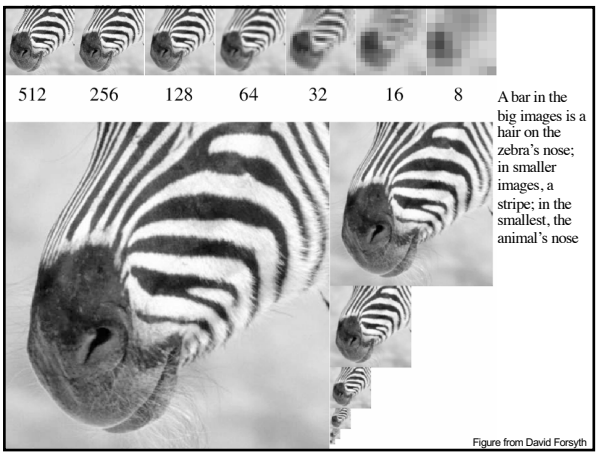

A bar in the big images is a hair on the zebra's nose; in smaller images, a stripe; in the smallest, the animal's nose

Figure from David Forsyth

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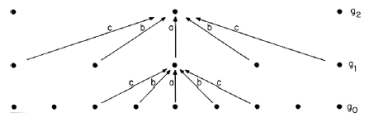
Gaussian Pyramid for encoding

[Burt & Adelson, 1983]

GAUSSIAN PYRAMID



g_0 = IMAGE

g_L = REDUCE [g_{L-1}]

1) **Prediction using weighted local Gaussian average**
2) **Encode the difference as the Laplacian**
3) **Both Laplacian and the Averaged image is easy to encode**

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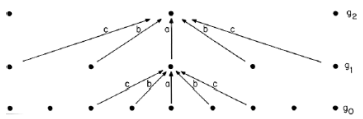
Gaussian pyramid

GAUSSIAN PYRAMID



g_0 = IMAGE

g_L = REDUCE [g_{L-1}]

$$g_l(i,j) = \sum_{m=-2}^{2} \sum_{n=-2}^{2} w(m,n)\, g_{l-1}(2i+m, 2j+n).$$

$$w(m,n) = \hat{w}(m)\,\hat{w}(n). \qquad \sum_{m=-2}^{2} \hat{w}(m) = 1 \qquad \hat{w}(i) = \hat{w}(-i)$$

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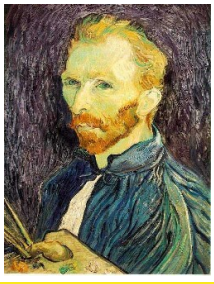
Image sub-sampling



1/4

1/8

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

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Image sub-sampling

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

Why does this look so bad?

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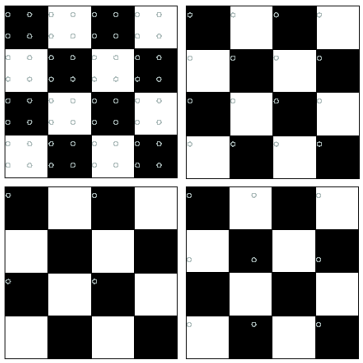
Sampling



Good sampling:
•Sample often or,
•Sample wisely

Bad sampling:
•see aliasing in action!

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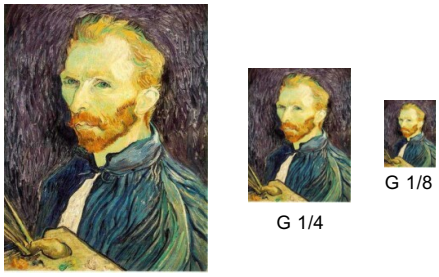
Gaussian pre-filtering



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?

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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?

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Compare with...

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

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What does blurring take away?

original

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What does blurring take away?

smoothed (5x5 Gaussian)

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High-Pass filter

smoothed – original

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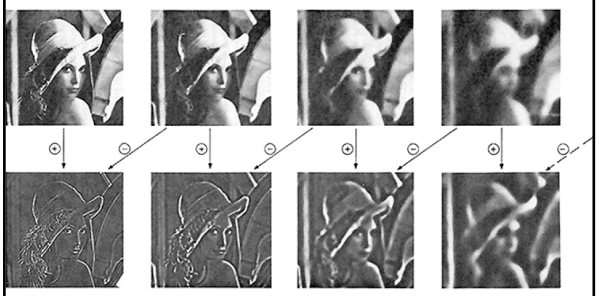

Gaussian pyramid is smooth=> can be subsampled

Laplacian pyramid has narrow band of frequency=> compressed

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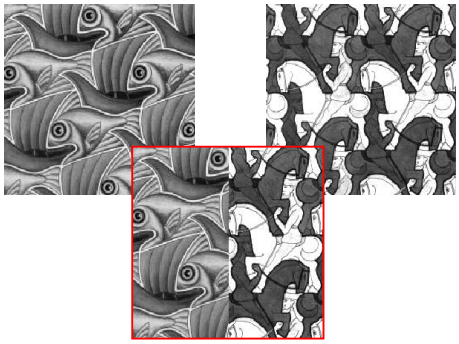
Image Blending



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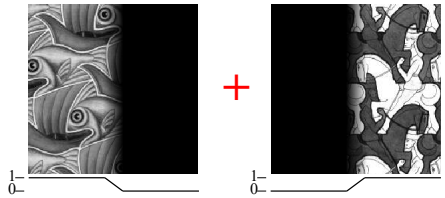
Feathering



+

=

Encoding transparency

$I(x,y) = (\alpha R, \alpha G, \alpha B, \alpha)$

$I_{blend} = I_{left} + I_{right}$

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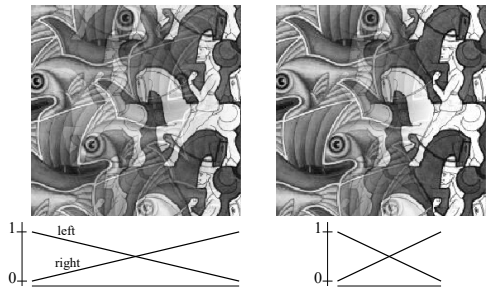
Affect of Window Size



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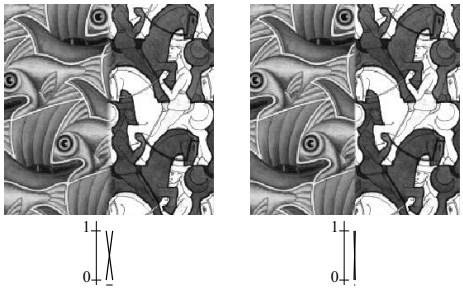
Affect of Window Size



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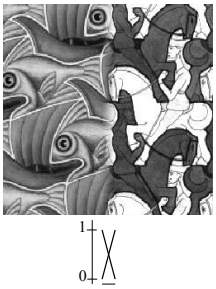
Good Window Size



"Optimal" Window: smooth but not ghosted

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What is the Optimal Window?

To avoid seams

- window >= size of largest prominent feature

To avoid ghosting

- window <= 2*size of smallest prominent feature

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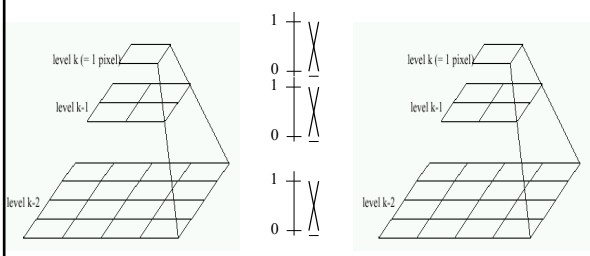
Pyramid Blending



Left pyramid blend Right pyramid

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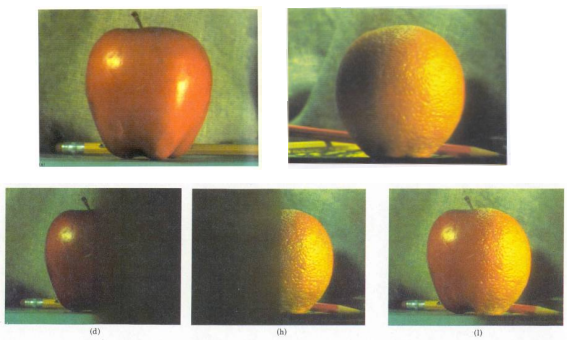
Pyramid Blending



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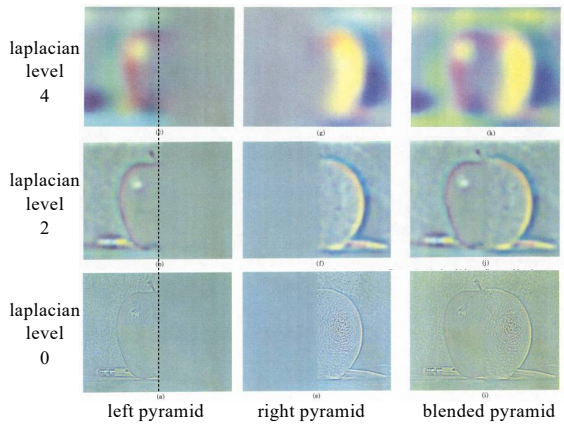

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Laplacian Pyramid: Blending

General Approach:

1. Build Laplacian pyramids *LA* and *LB* from images *A* and *B*
2. Build a Gaussian pyramid *GR* from selected region *R*
3. Form a combined pyramid *LS* from *LA* and *LB* using nodes of *GR* as weights:
   - *LS(i,j) = GR(I,j,)*LA(I,j) + (1-GR(I,j))*LB(I,j)*
4. Collapse the *LS* pyramid to get the final blended image

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Blending Regions

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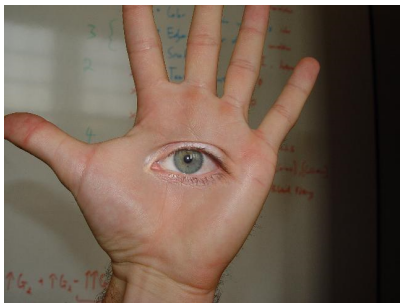
Horror Photo



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