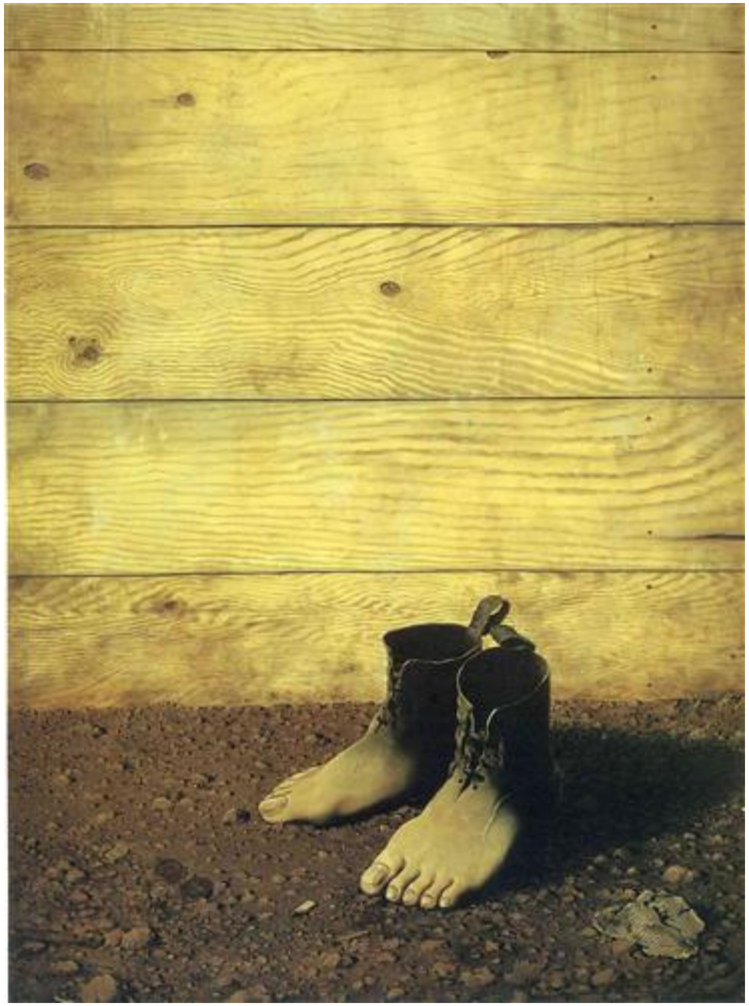
Blending and Compositing



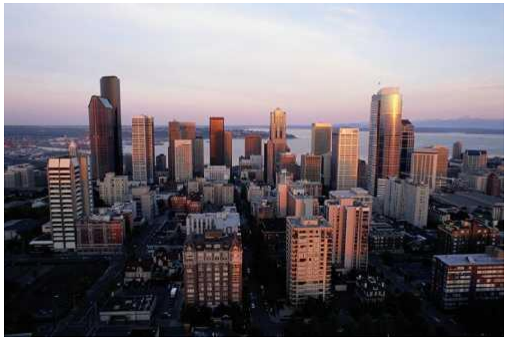
René Magritte, "The Red Model"

Many slides from Alexei Efros, Allan Jepson, Robert Collins

CSC320: Introduction to Visual Computing
Michael Guerzhoy

Image Compositing

1. Extract Sprites (e.g using *Intelligent Scissors* in Photoshop)



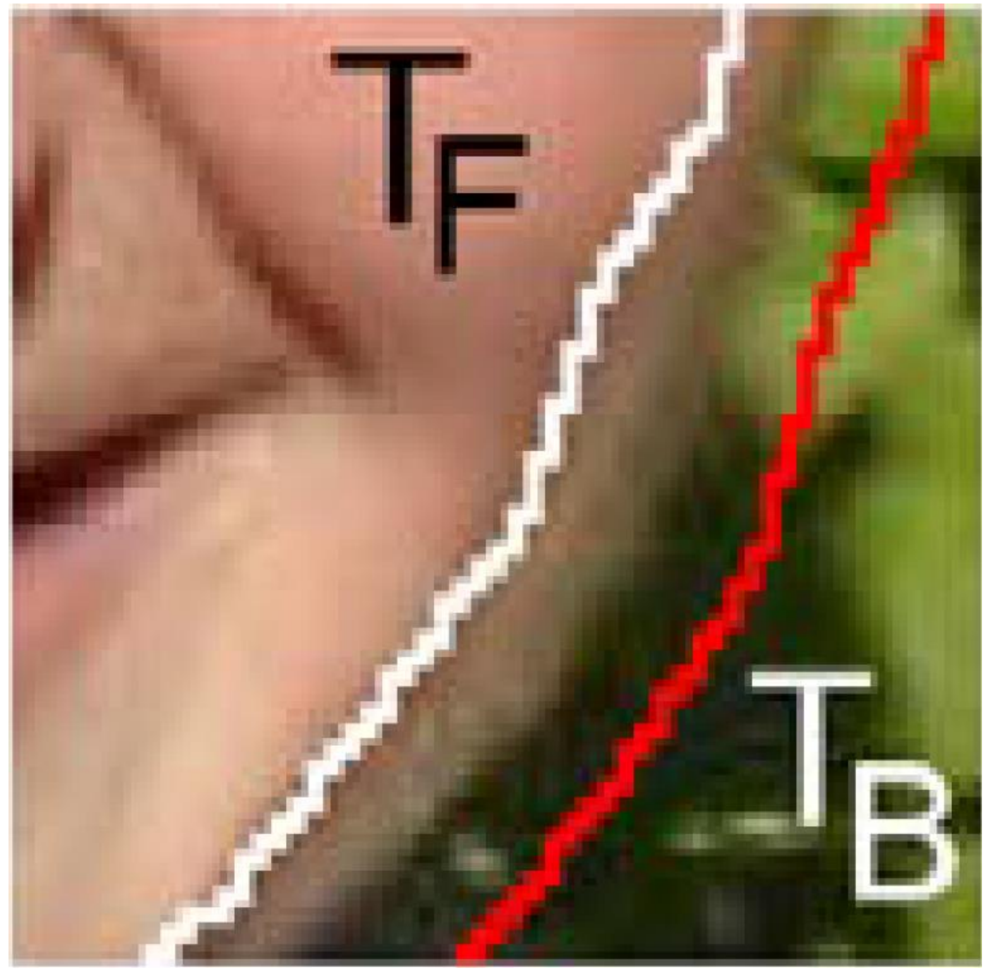
Joe Marquette / AP file

2. Blend them into the composite (in the right order)

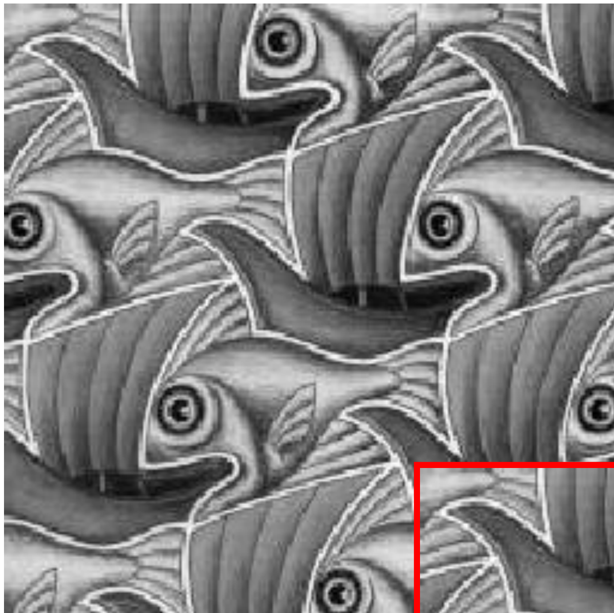
Composite by
David Dewey

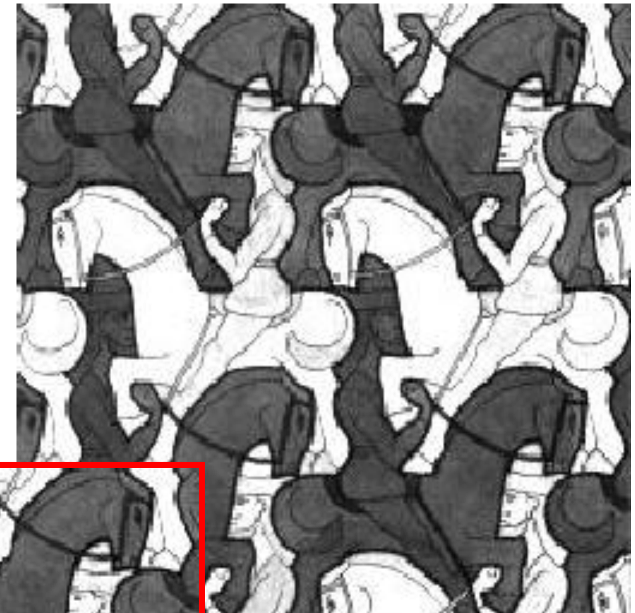
Need Blending for Compositing

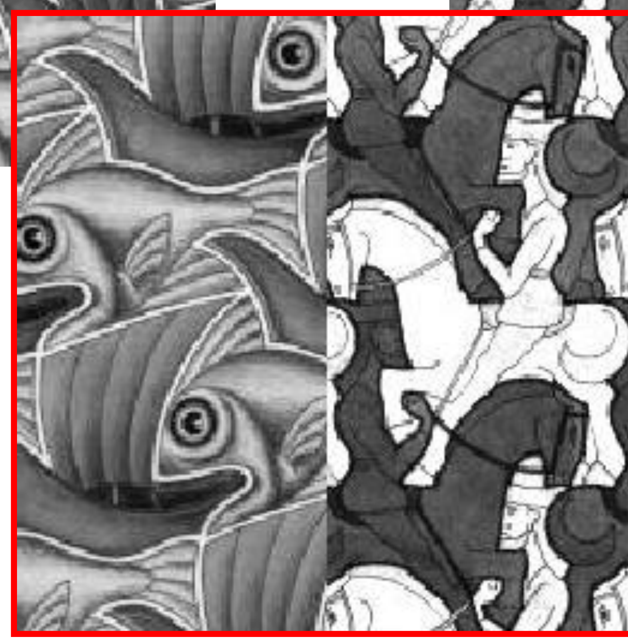
- The transition between the object and the background in real images is not sudden
- Thin features (e.g., hair) cause “mixed“ pixels
- Motion while the picture is taken causes blur
- Semi-transparent objects



Combining Two Images

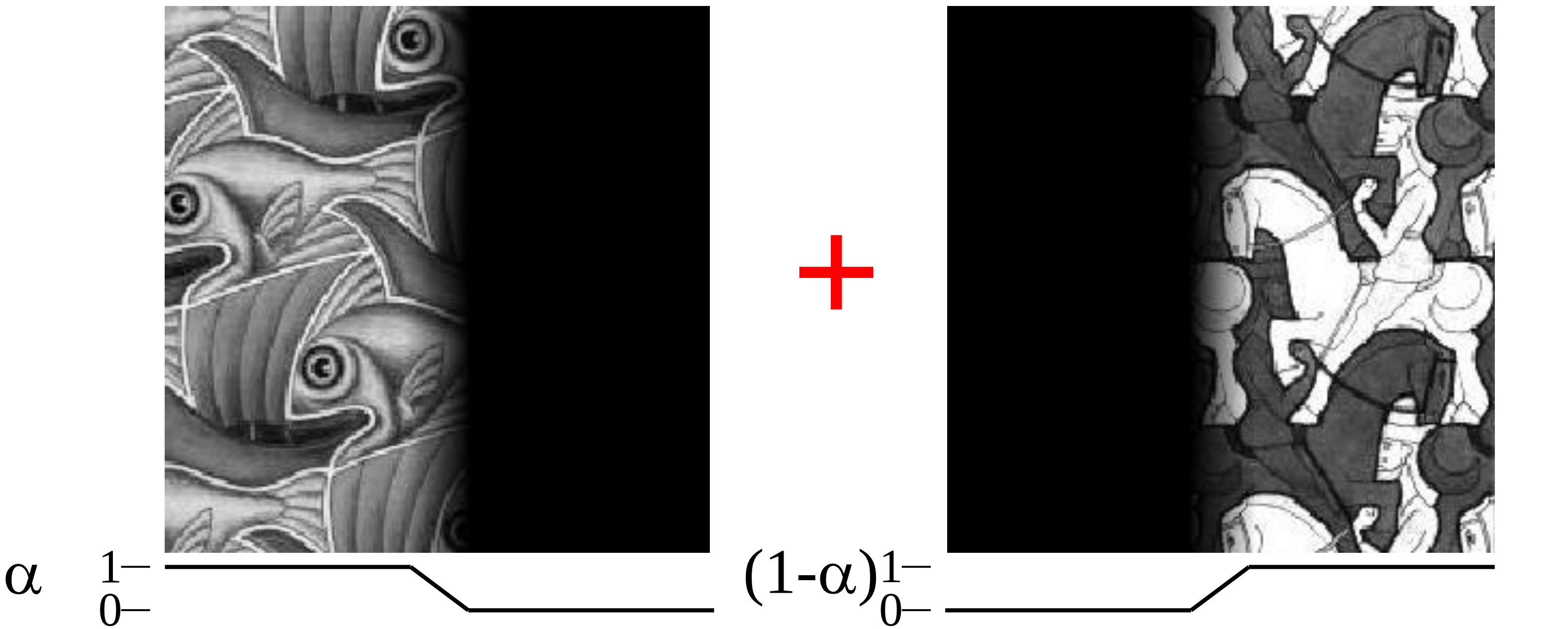


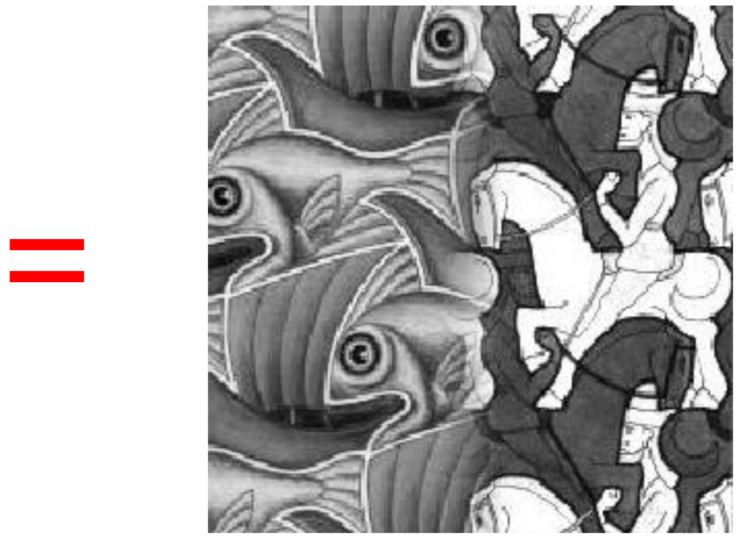




- The transition is not smooth

Alpha Blending / Feathering





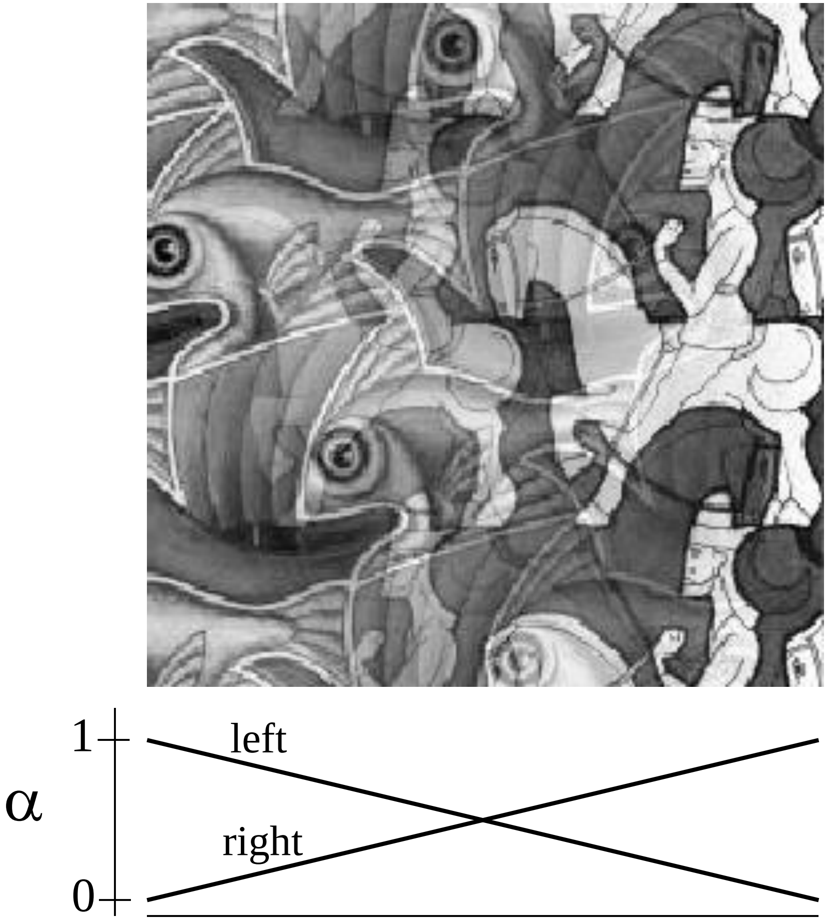
$$I_{blend} = \alpha I_{left} + (1-\alpha) I_{right}$$

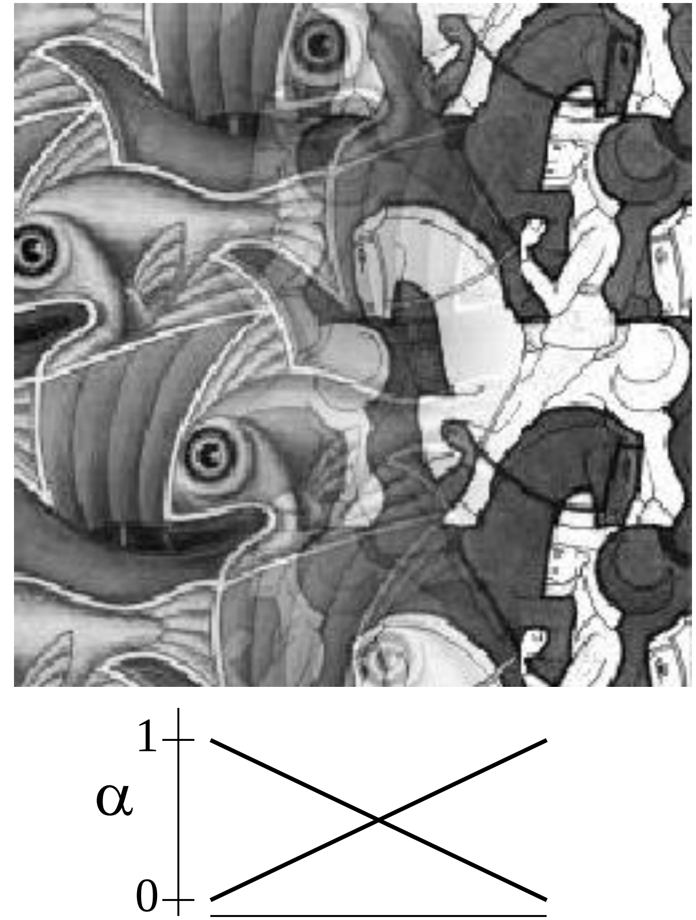
The Alpha Matte

- An array the same size as the image
- α can be 1 (object 1), 0 (background/object 2), or between 0 and 1 (somewhere in between)

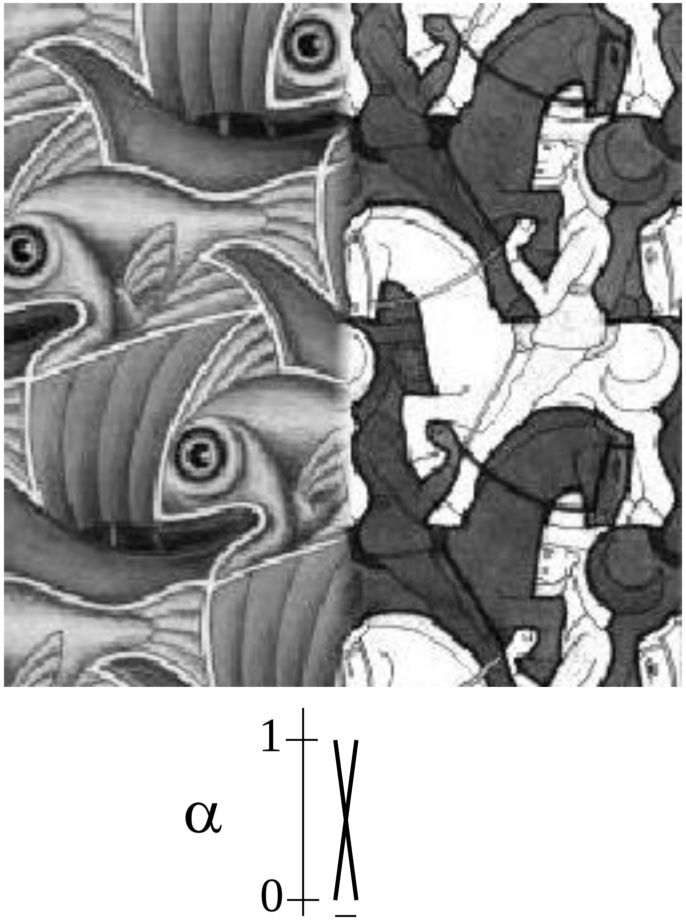
Effect of Window Size

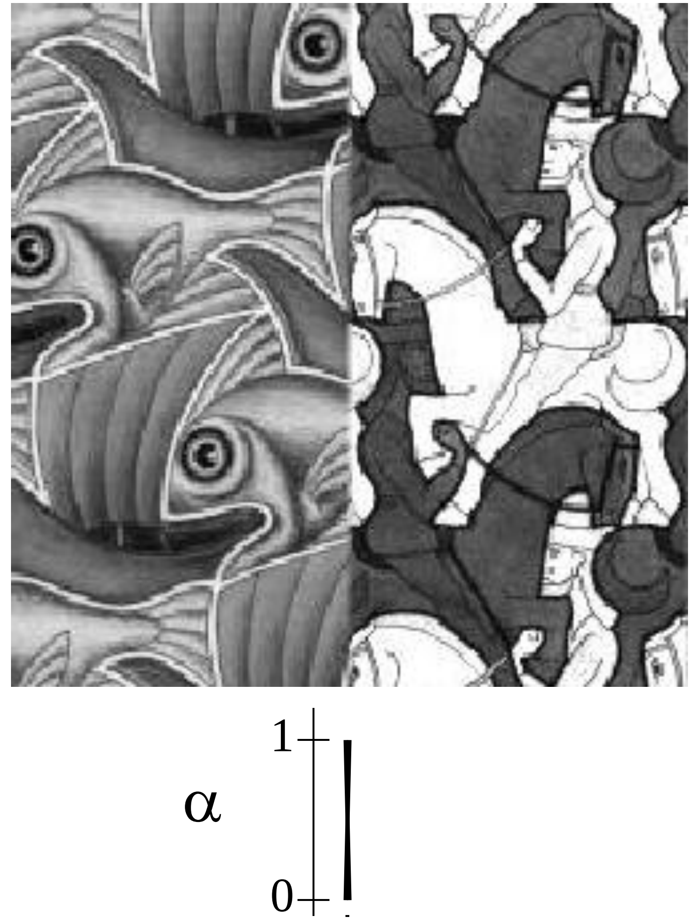




- “Ghosting” happens if the transition is too slow

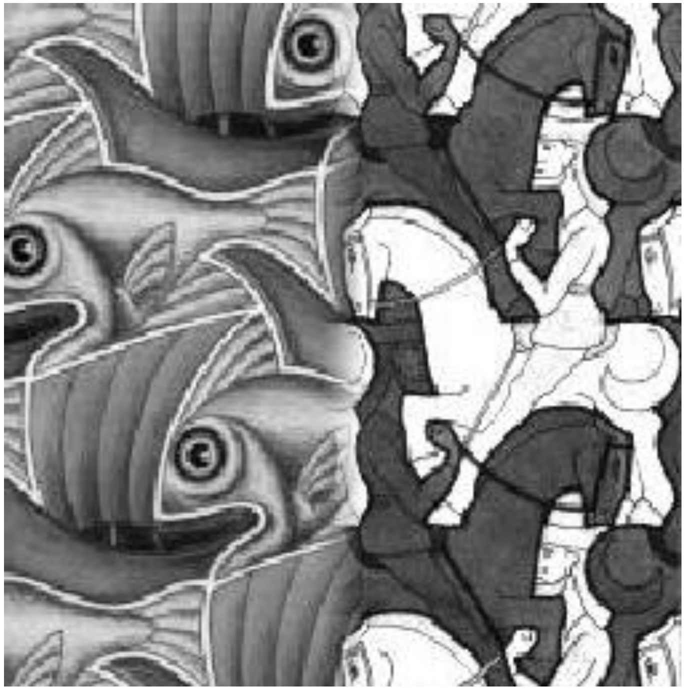
Effect of Window Size

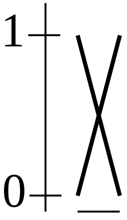




- “Seams” are visible if the transition is too fast

Good Window Size





“Optimal” Window: smooth but not ghosted

What is the Optimal Window?

To avoid seams

- window $\geq$ size of largest prominent feature (and all the features)

To avoid ghosting

- window $\leq 2 \times$ size of smallest prominent feature

(explanation on the blackboard)

What is the Optimal Window?

For feathering to work:

- largest frequency <= 2*size of smallest frequency
- So image frequency content should occupy one "octave" (power of two)
  - I.e., $|F(\omega)|$ is large only for $2^k \leq |\omega| \leq 2^{\{k+1\}}$

- Key idea: Coarse structure should blend very slowly between images (lots of feathering), while fine details should transition more quickly

Reminder: 2D Discrete Fourier Transform

$$\hat{h}(k,l) \;=\; \sum_{n=0}^{N-1}\sum_{m=0}^{M-1} e^{-i(\omega_k n + \omega_l m)} h(n,m)$$

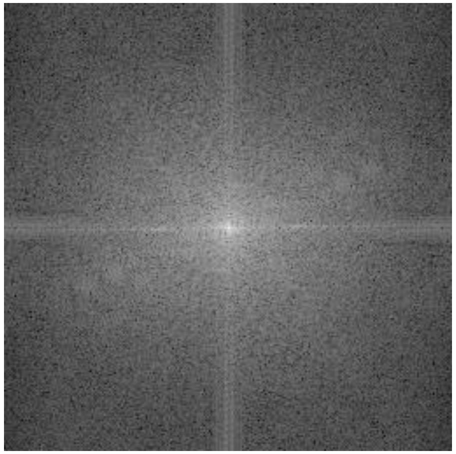
$$h(n,m) \;=\; \frac{1}{NM}\sum_{k=0}^{N-1}\sum_{l=0}^{M-1} e^{i(\omega_k n + \omega_l m)} \hat{h}(k,l)$$

Often it is convenient to express frequency in vector notation with $\vec{k} = (k,l)^t$, $\vec{n} = (n,m)^t$, $\vec{\omega}_{kl} = (\omega_k, \omega_l)^t$ and $\vec{\omega}^t\vec{n} = \omega_k\, n + \omega_l\, m$.

2D Fourier Basis Functions: Sinusoidal waveforms of different wavelengths (scales) and orientations. Sinusoids on $N \times M$ images with 2D frequency $\vec{\omega}_{kl} = (\omega_k,\, \omega_l) = 2\pi(k/N,\, l/M)$ are given by:

$$e^{i\,(\vec{\omega}^t\vec{n})} \;=\; e^{i\,\omega_k n}\, e^{i\,\omega_l m} \;=\; \cos(\vec{\omega}^t\vec{n}) + i\sin(\vec{\omega}^t\vec{n})$$

What if the Frequency Spread is Wide

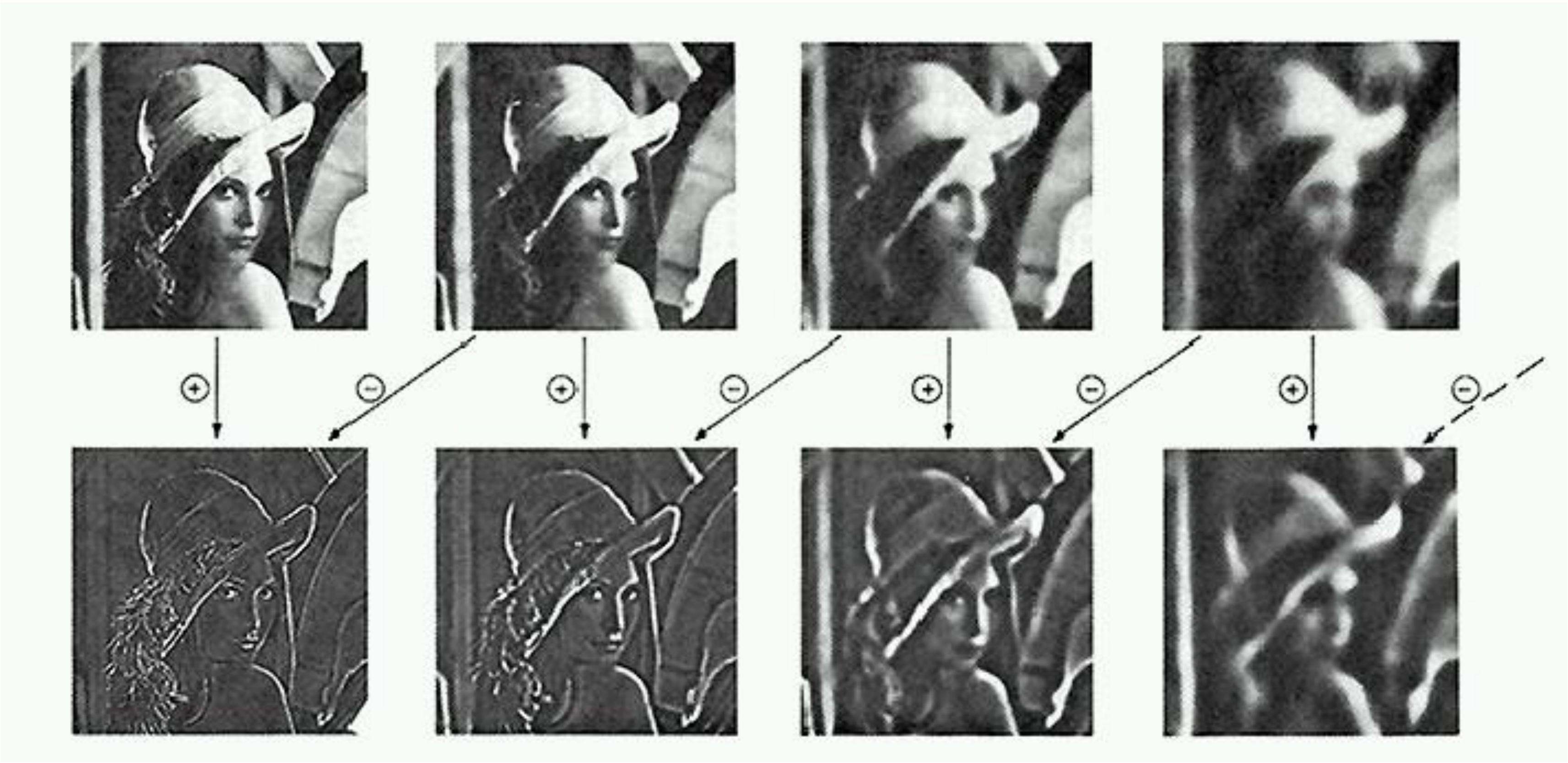


Idea (Burt and Adelson)

- Compute $F_{left} = FFT(I_{left})$, $F_{right} = FFT(I_{right})$
- Decompose Fourier image into octaves (bands)
  - $F_{left} = F_{left}^1 + F_{left}^2 + \ldots$
- Feather corresponding octaves F_{left}^i with F_{right}^i
  - Can compute inverse FFT and feather in spatial domain
- Sum feathered octave images in frequency domain
- (In practice, we implement this in spatial domain)

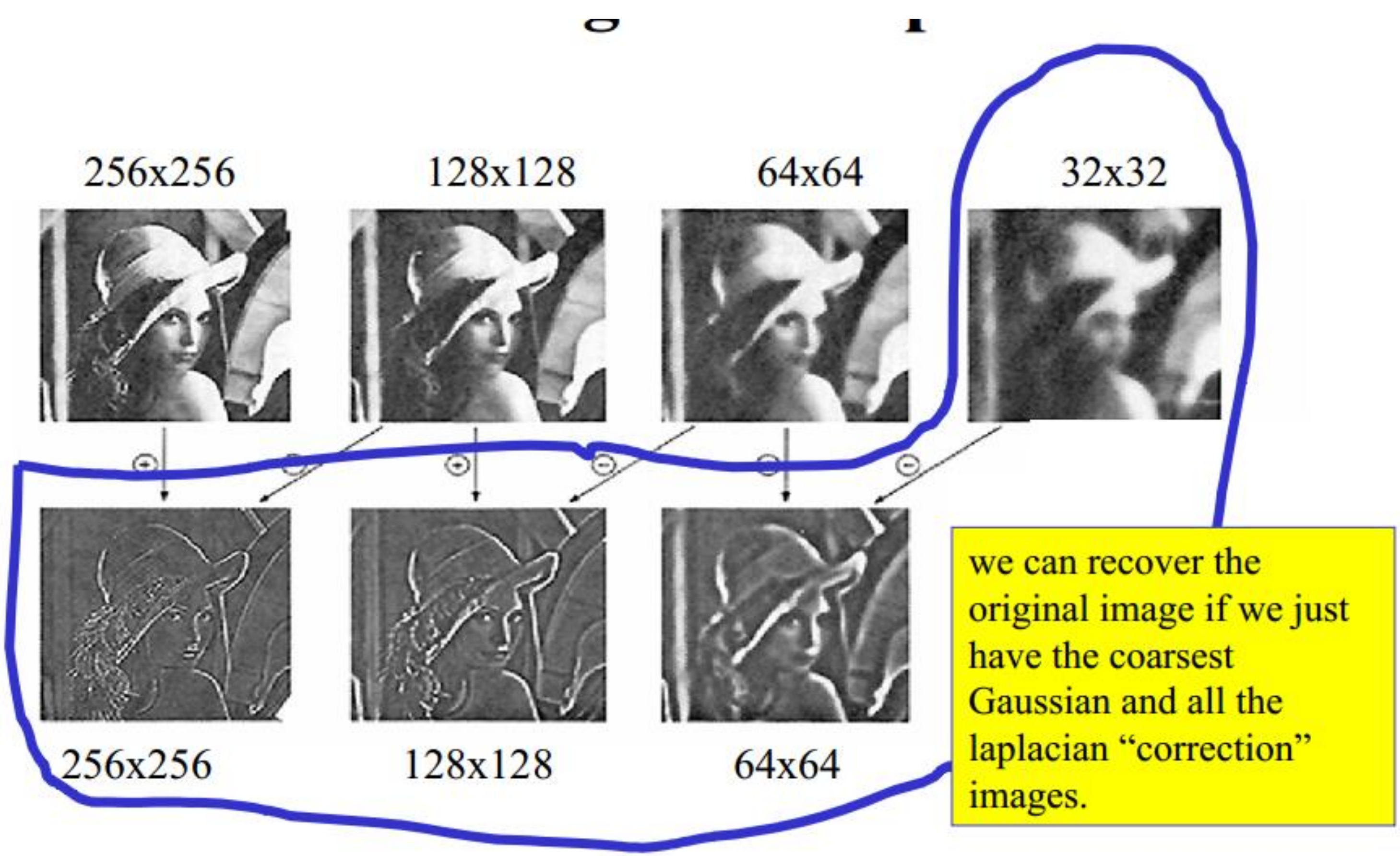
Laplacian Pyramid: Overview

Lowpass Images



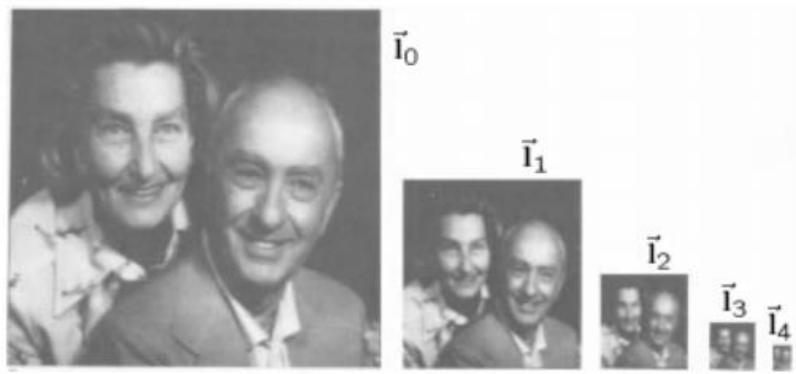
Bandpass Images

Laplacian Pyramid: Overview



Reminder: Gaussian Pyramid

- Multi-level representation of an image
- The next level is smoothed and then downsampled every time

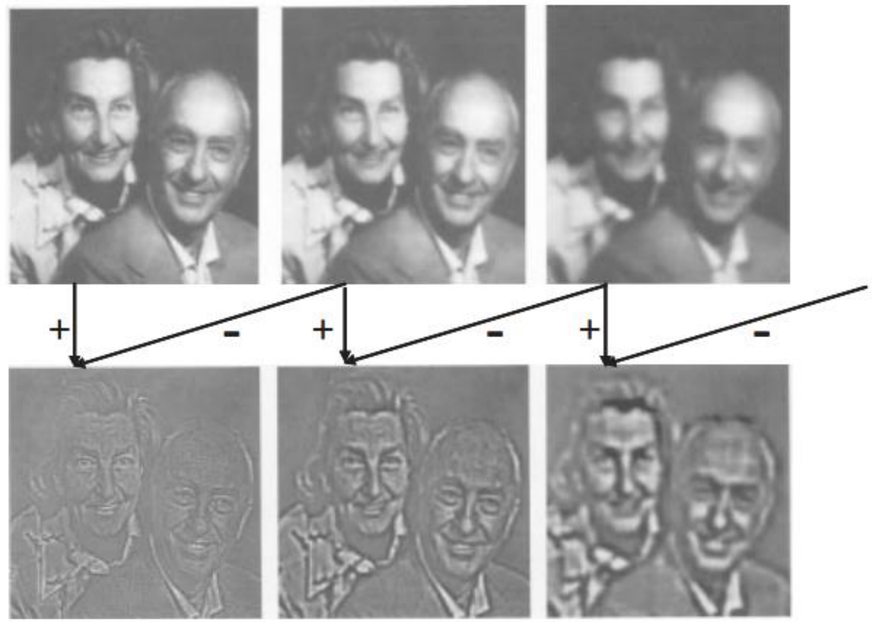


First three levels scaled to be the same size:

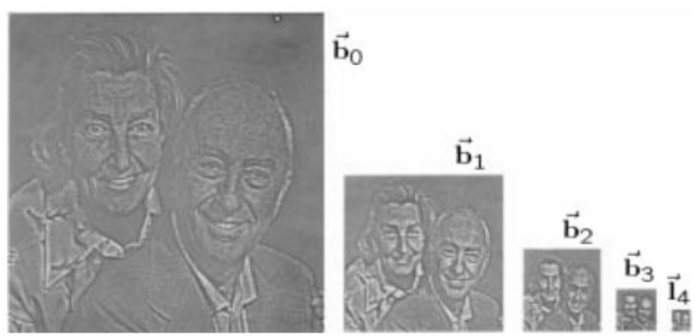
Laplacian Pyramid

- Each band of the Laplacian pyramid is the difference between two adjacent levels of the Gaussian pyramid, $[\vec{\mathbf{I}}_0, \vec{\mathbf{I}}_1, \ldots, \vec{\mathbf{I}}_N]$
  - $\vec{\mathbf{b}}_k = \vec{\mathbf{I}}_k - \mathbf{E}\,\vec{\mathbf{I}}_{k+1}$
  - EI_{k+1} is the up-sampled smoothed version of I_{k+1}

Laplacian Pyramid



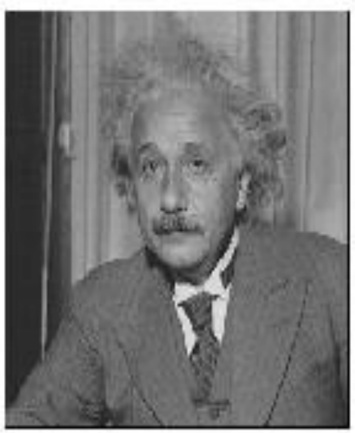
A Laplacian pyramid with four levels:

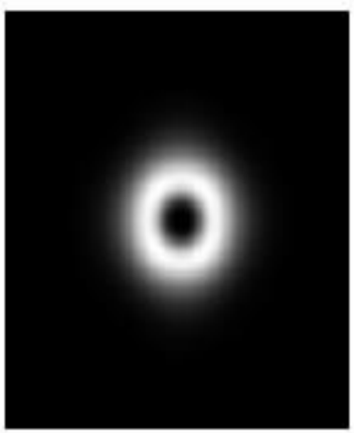


The Laplacian Pyramid in Frequency Domain

- Reminder:
  - Each level of the Laplacian pyramid is the result of filtering an image with a band-pass filter

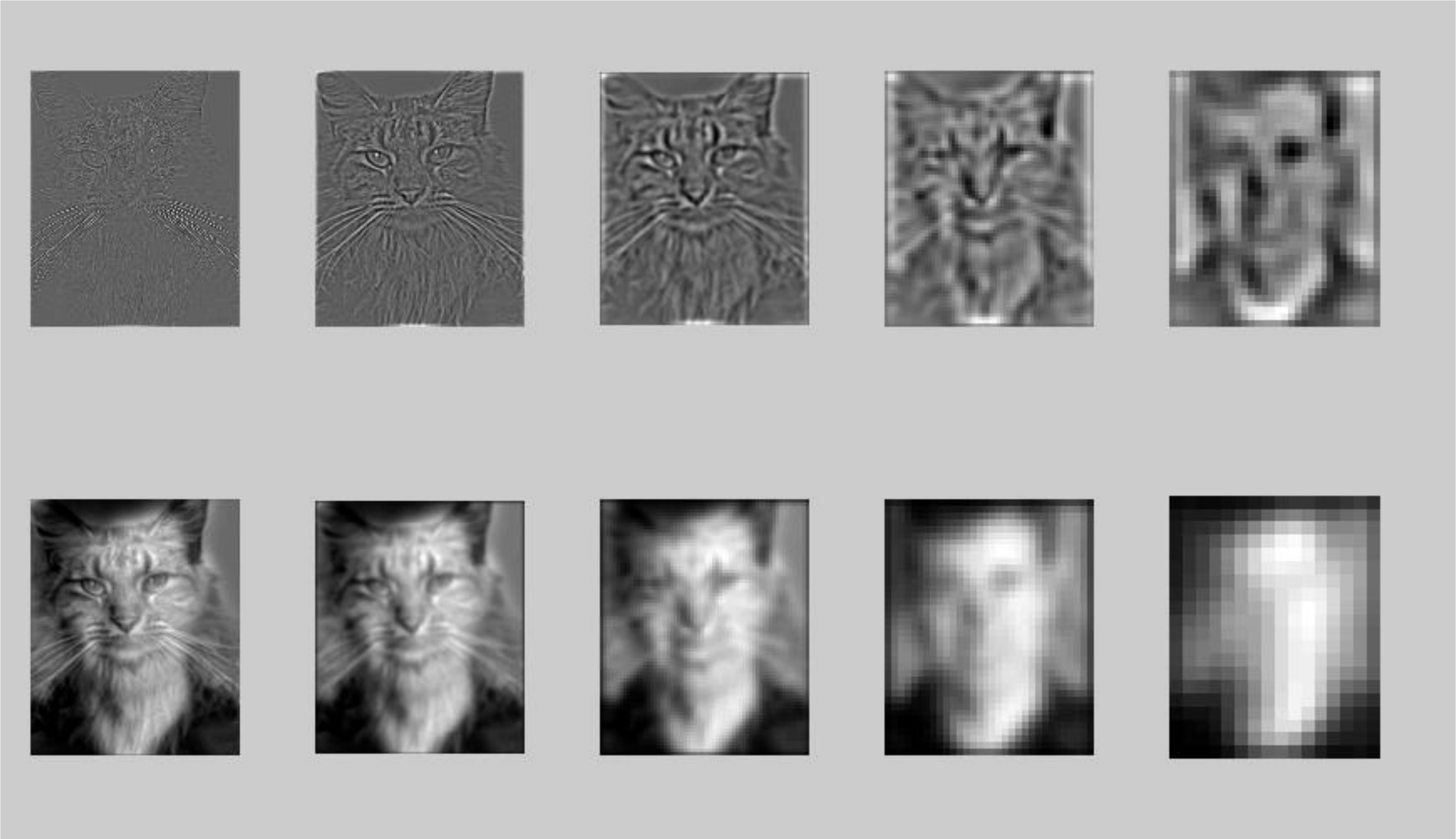
High-pass / band-pass:





Band-passed Hybrid Image

High frequency → Low frequency



Reconstructing the Image from the Laplacian

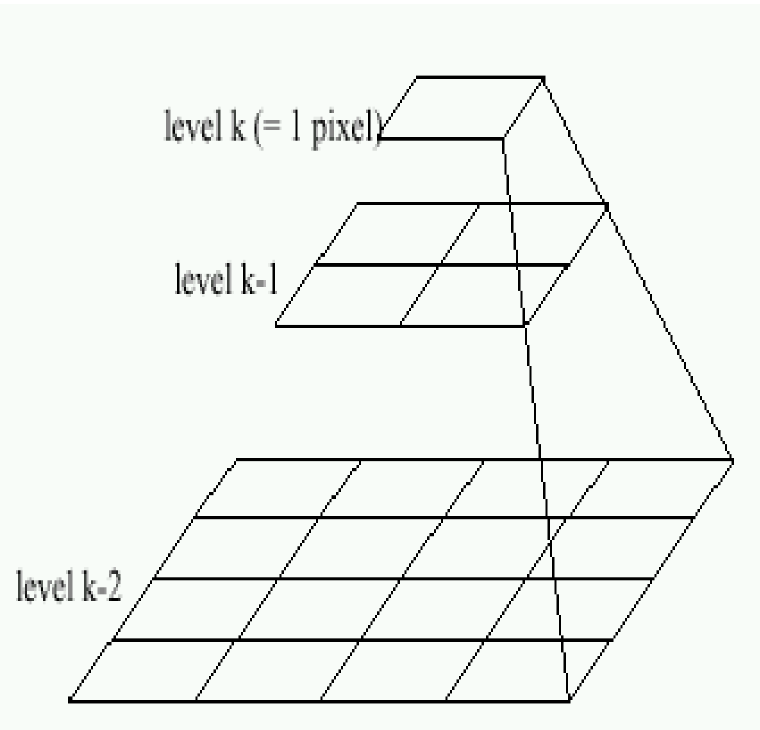
Construction: of $[\vec{\mathbf{b}}_0, \vec{\mathbf{b}}_1, ..., \vec{\mathbf{b}}_{L-1}, \vec{\mathbf{l}}_L]$.

$$\begin{aligned}\vec{\mathbf{l}}_0 &= \vec{\mathbf{I}}\\ \vec{\mathbf{l}}_{k+1} &= \mathbf{R}\,\vec{\mathbf{l}}_k\\ \vec{\mathbf{b}}_k &= \vec{\mathbf{l}}_k - \mathbf{E}\,\vec{\mathbf{l}}_{k+1}\end{aligned}$$

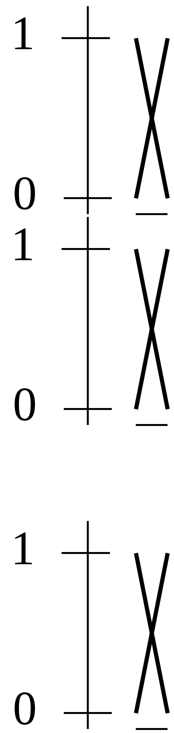
Reconstruction: of $\vec{\mathbf{I}}$ is exact (for any filters) and straightforward:

$$\begin{aligned}\vec{\mathbf{l}}_k &= \vec{\mathbf{b}}_k + \mathbf{E}\,\vec{\mathbf{l}}_{k+1}\\ \vec{\mathbf{I}} &= \vec{\mathbf{l}}_0\end{aligned}$$

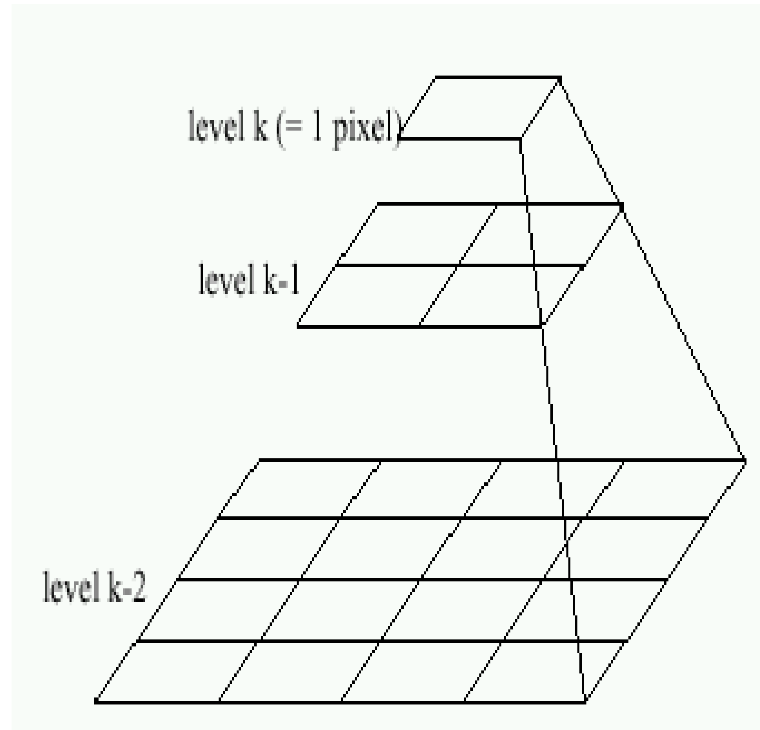
Pyramid Blending



Left pyramid

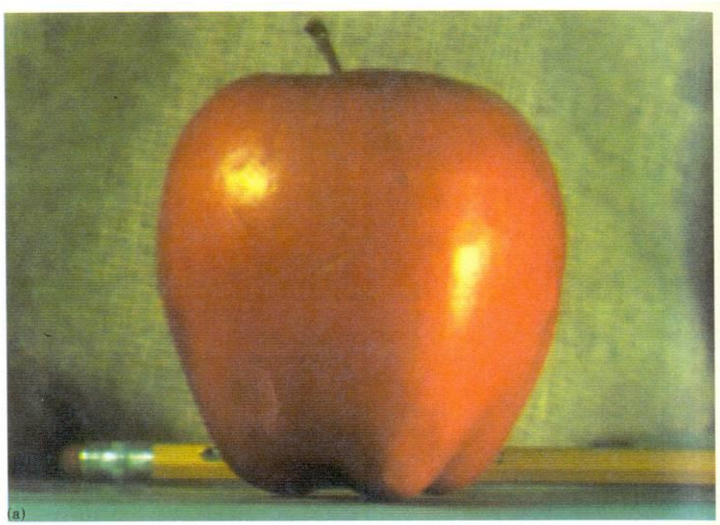


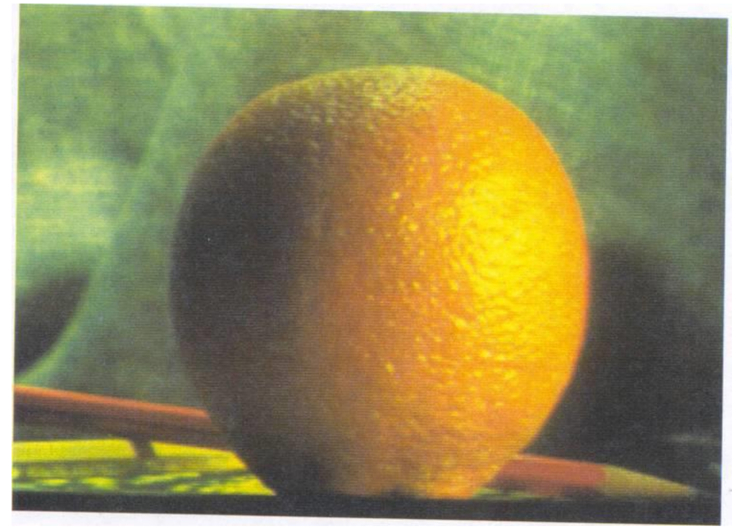
blend

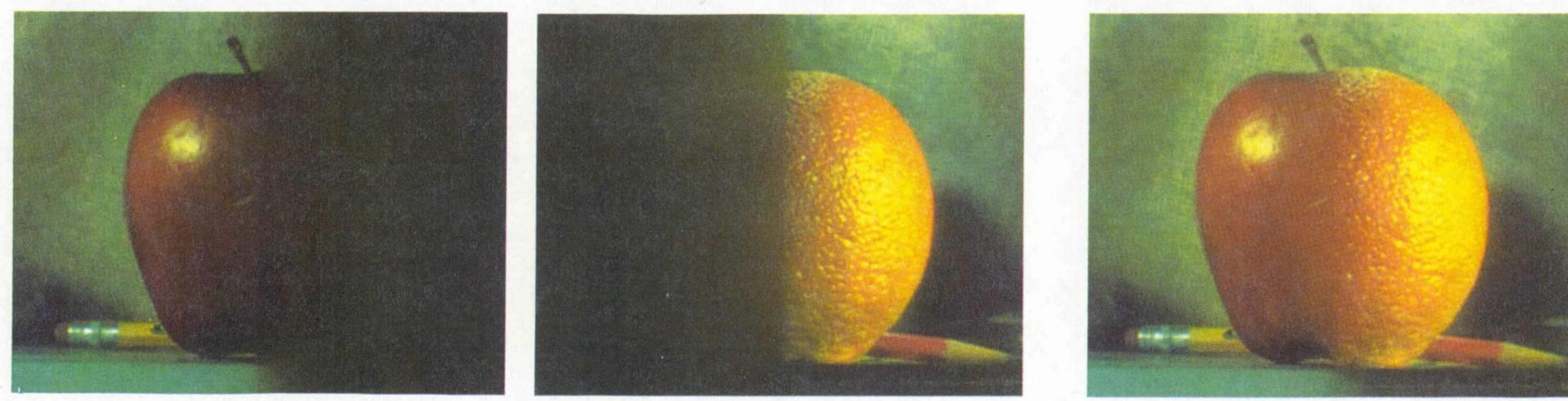


Right pyramid

Pyramid Blending





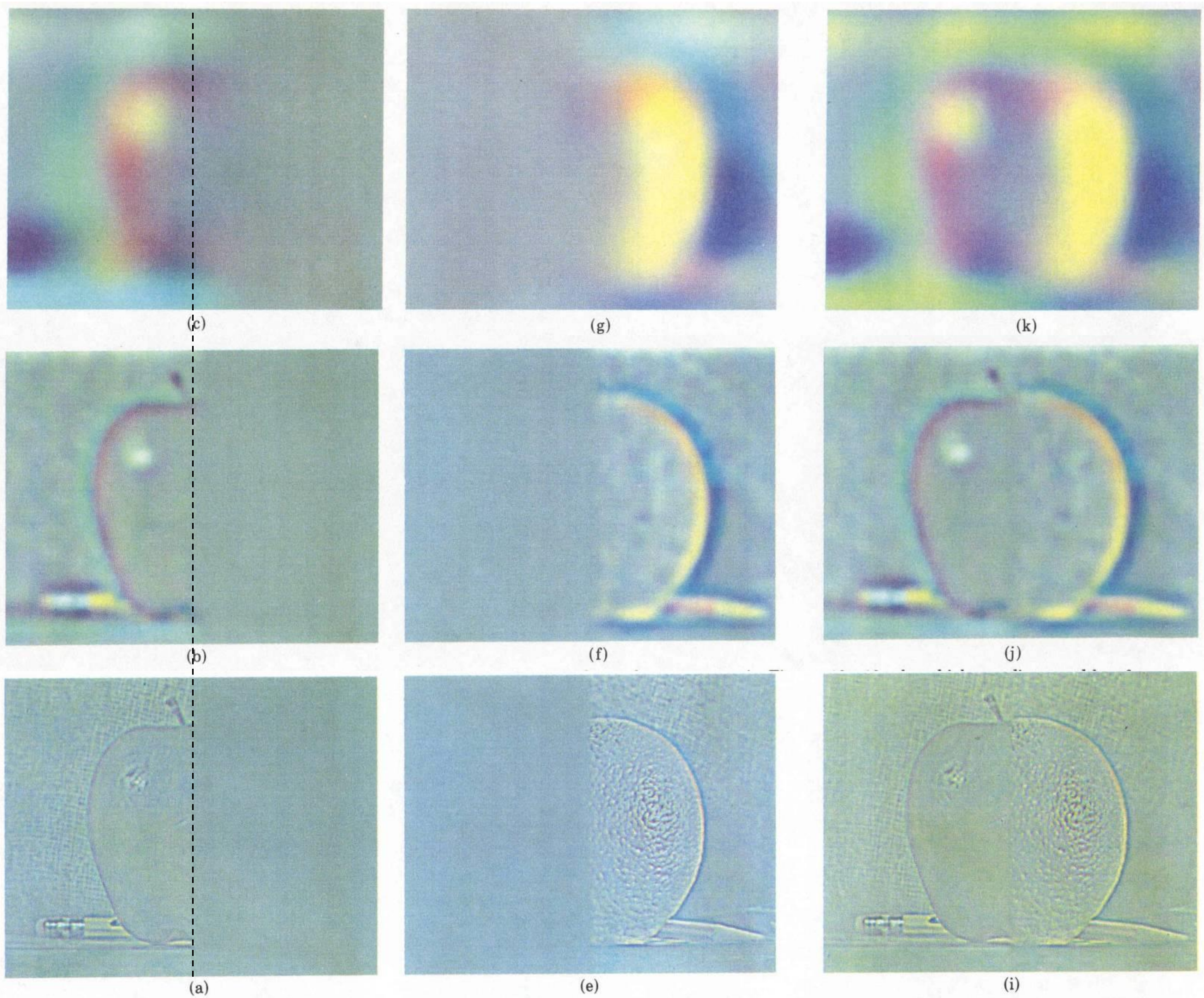


(d) (h) (l)

laplacian level 4

laplacian level 2

laplacian level 0



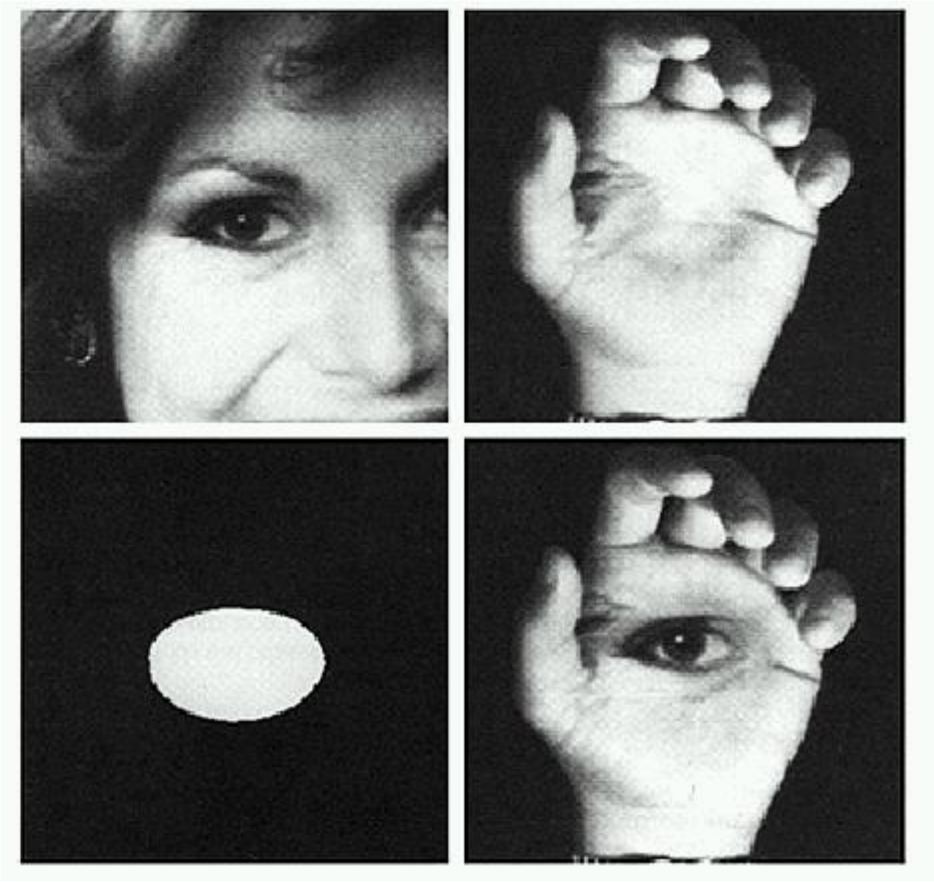
left pyramid right pyramid blended pyramid

Laplacian Pyramid: Blending

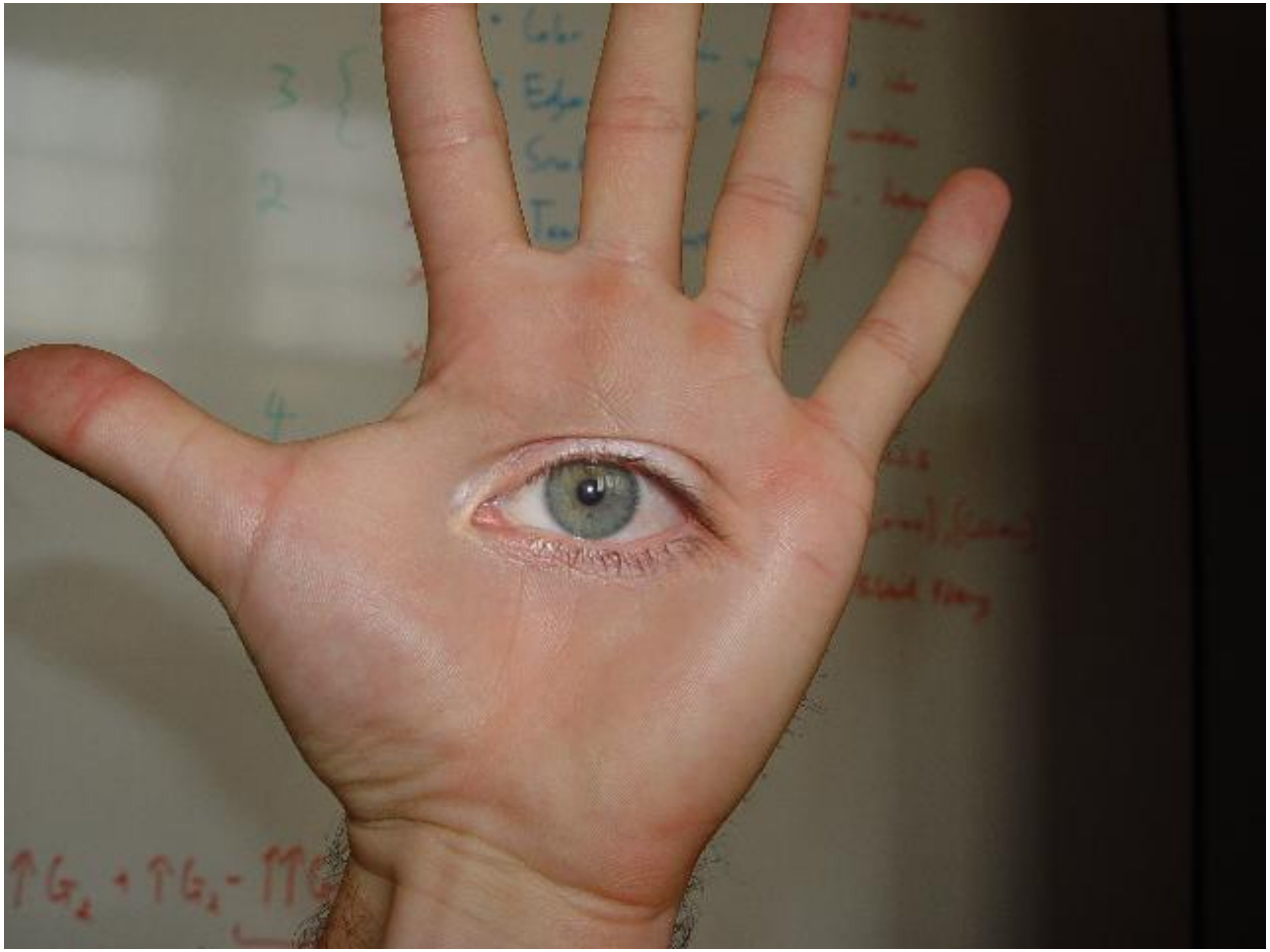
General Approach:

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

Blending Regions



Horror Photo



© david dmartin (Boston College)

Stitching Photos for Panoramas

Simplification: Two-band Blending

Brown & Lowe, 2003

- Only use two bands: high freq. and low freq.
- Blends low freq. smoothly
- Blend high freq. with no smoothing: use binary alpha

2-band Blending

Low frequency (λ > 2 pixels)

High frequency (λ < 2 pixels)

Linear Blending

2-band Blending

Don’t blend, CUT!

Moving objects become ghosts

So far we only tried to blend between two images.
What about finding an optimal seam?

Minimal error boundary