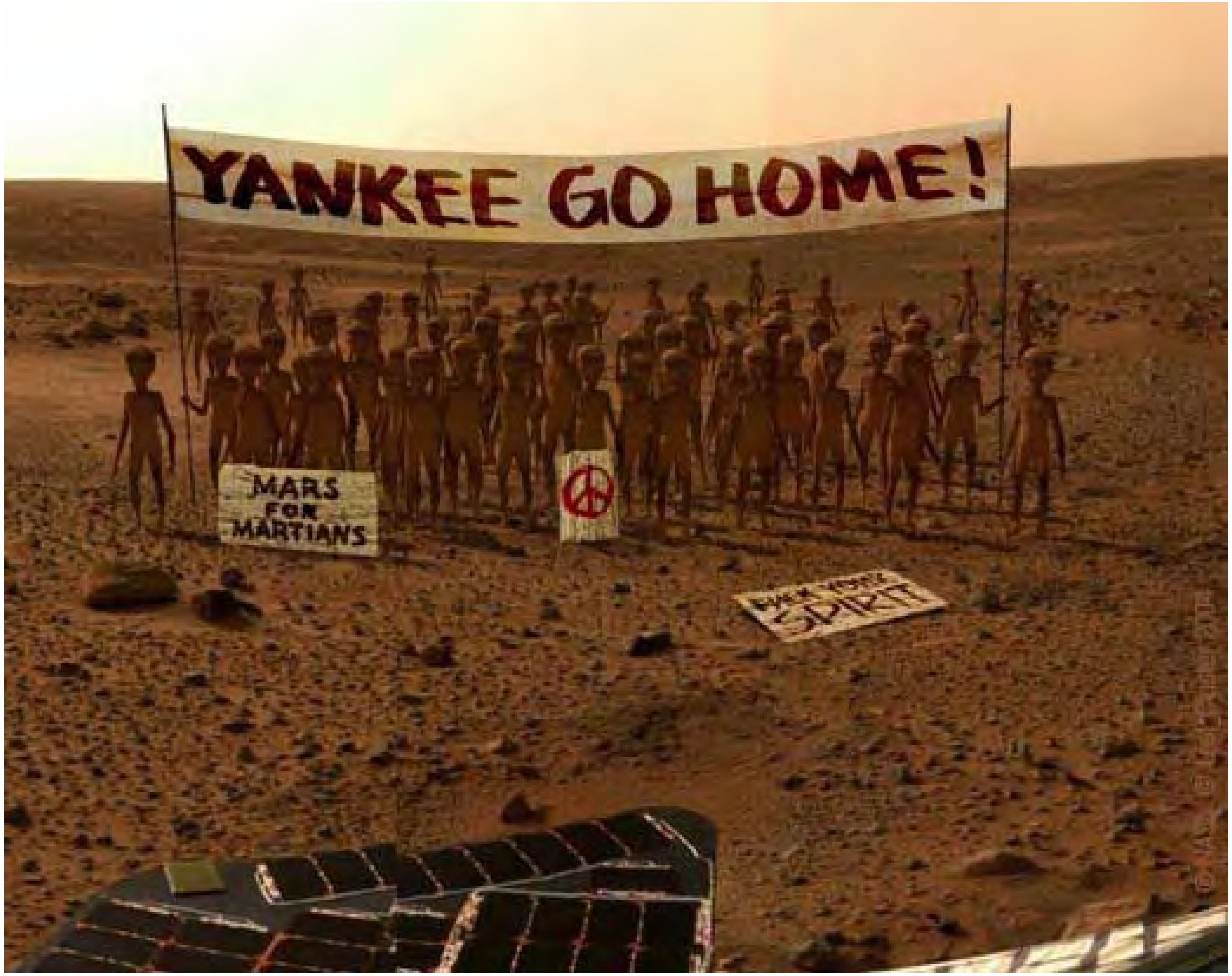
Image Compositing and Blending



15-463: Computational Photography
Alexei Efros, CMU, Fall 2007

Image Compositing

Compositing Procedure

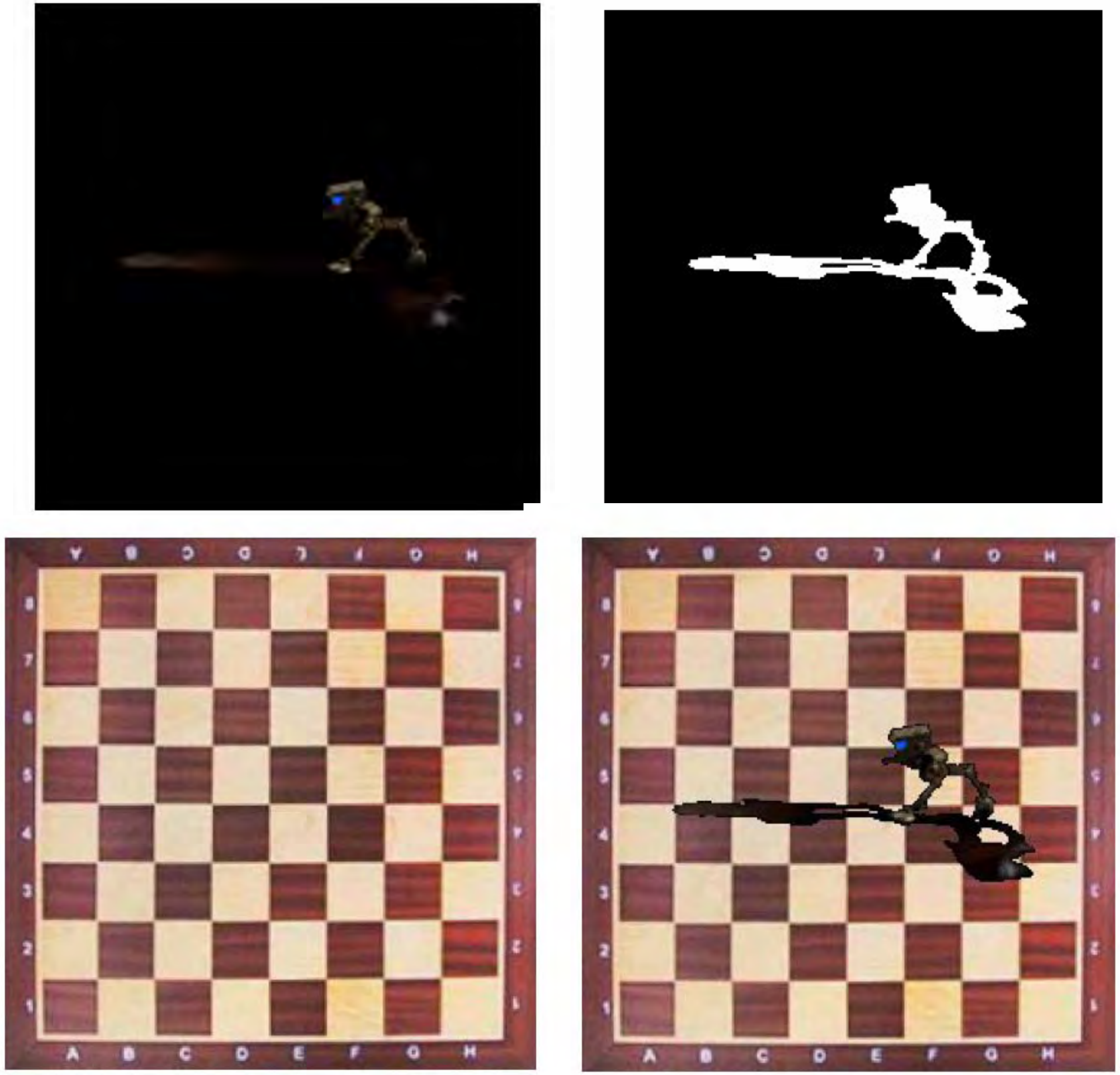
1. Extract Sprites (e.g using *Intelligent Scissors* in Photoshop)



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

Composite by
David Dewey

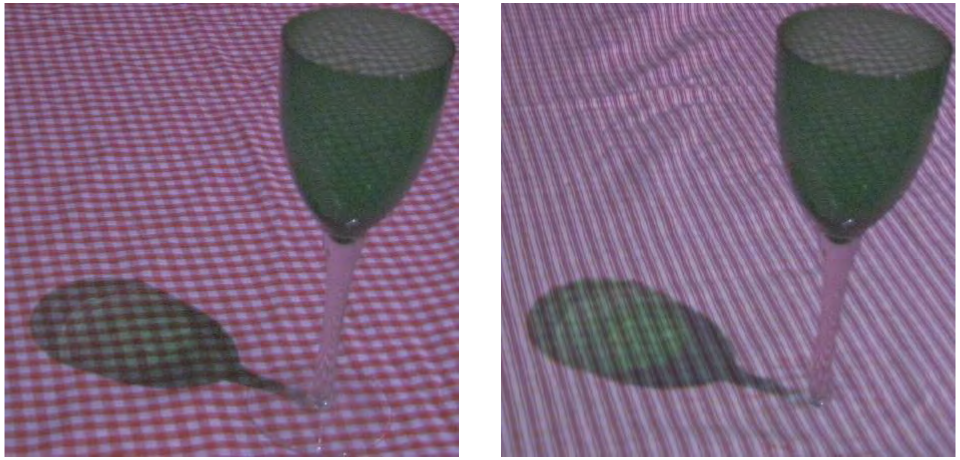
Just replacing pixels rarely works



Binary mask

Problems: boundries & transparency (shadows)

Two Problems:



Semi-transparent objects

Pixels too large

Solution: alpha channel

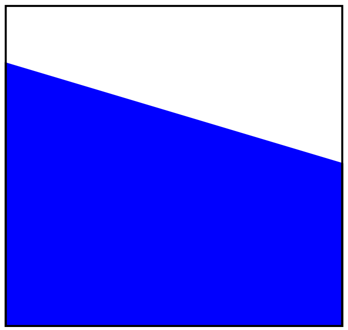
Add one more channel:

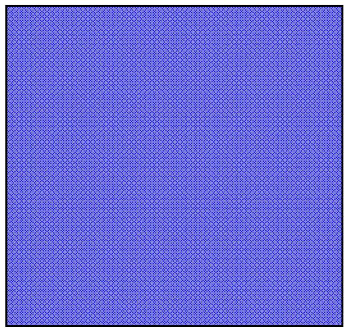
- Image(R,G,B,alpha)

Encodes transparency (or pixel coverage):

- Alpha = 1: opaque object (complete coverage)
- Alpha = 0: transparent object (no coverage)
- 0<Alpha<1: semi-transparent (partial coverage)

Example: alpha = 0.3



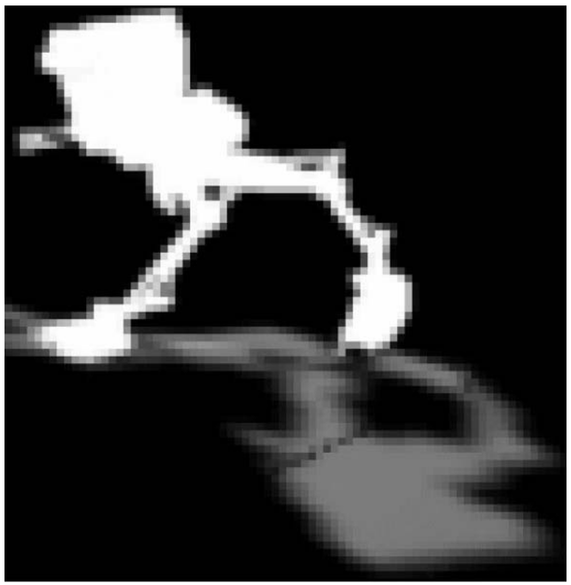


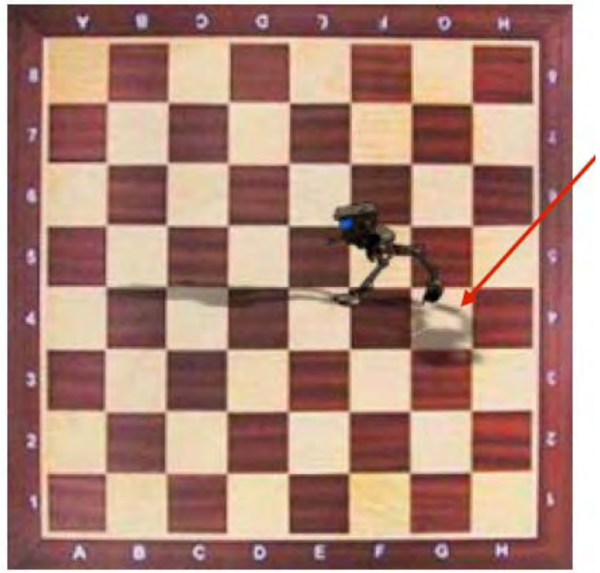
Partial coverage or semi-transparency

Alpha Blending

$$I_{comp} = \alpha I_{fg} + (1-\alpha) I_{bg}$$

alpha
mask





shadow

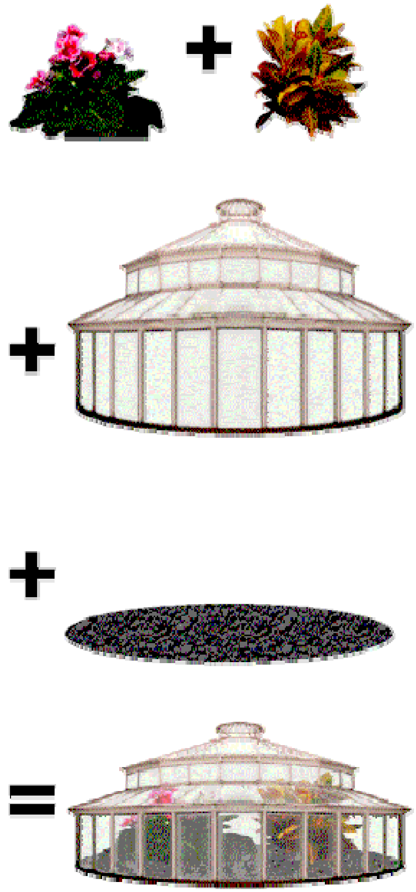
Multiple Alpha Blending

So far we assumed that one image (background) is opaque.

If blending semi-transparent sprites (the “A over B” operation):

$$I_{comp} = \alpha_a I_a + (1-\alpha_a)\alpha_b I_b$$

$$\alpha_{comp} = \alpha_a + (1-\alpha_a)\alpha_b$$

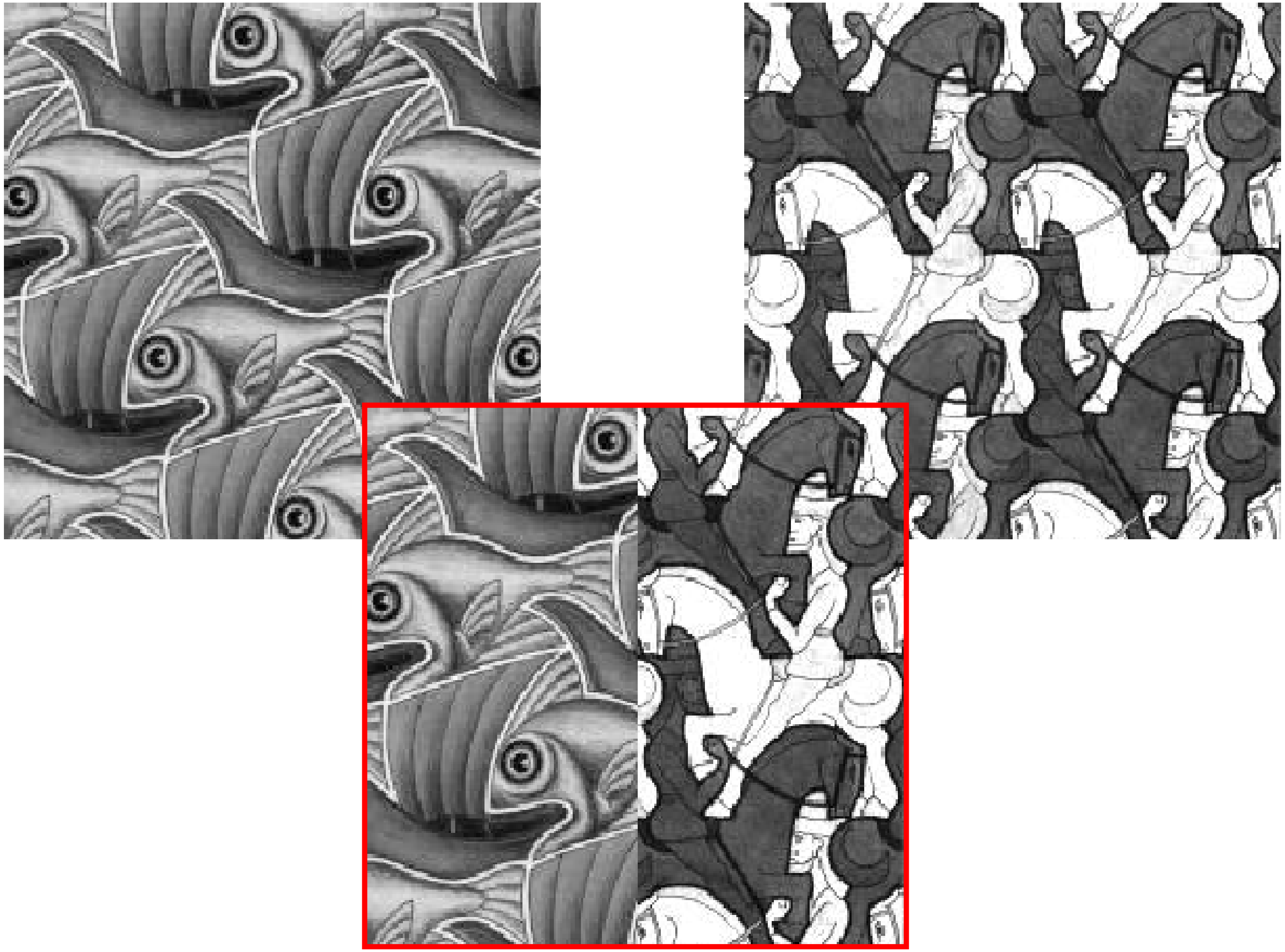


Note: sometimes alpha is premultiplied: im(αR,αG,αB,α):

$$I_{comp} = I_a + (1-\alpha_a)I_b$$

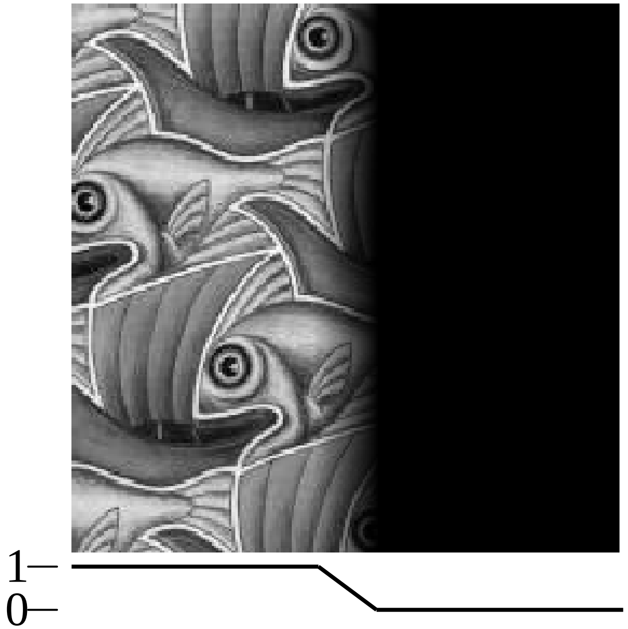
(same for alpha!)

Alpha Hacking…

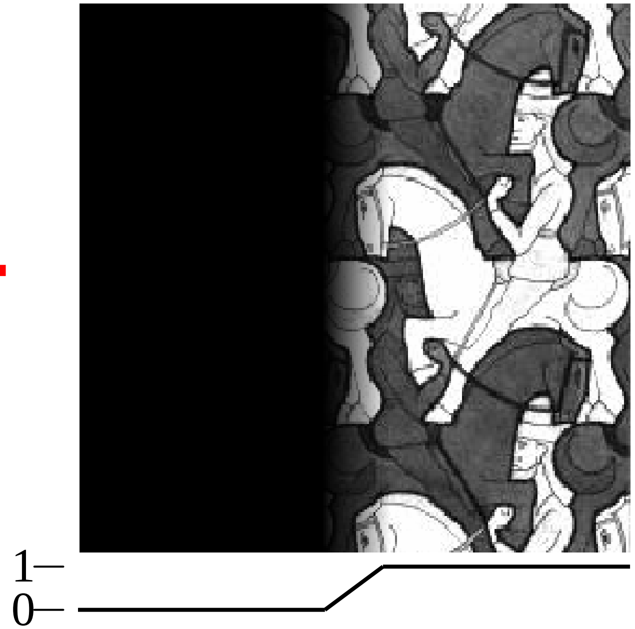


No physical interpretation, but it smoothes the seams

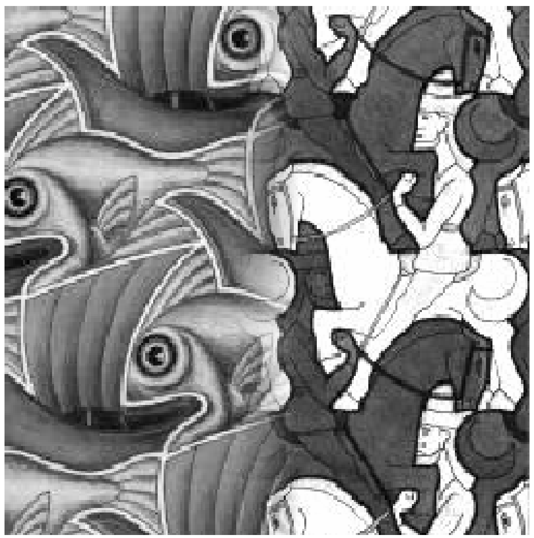
Feathering



+



=



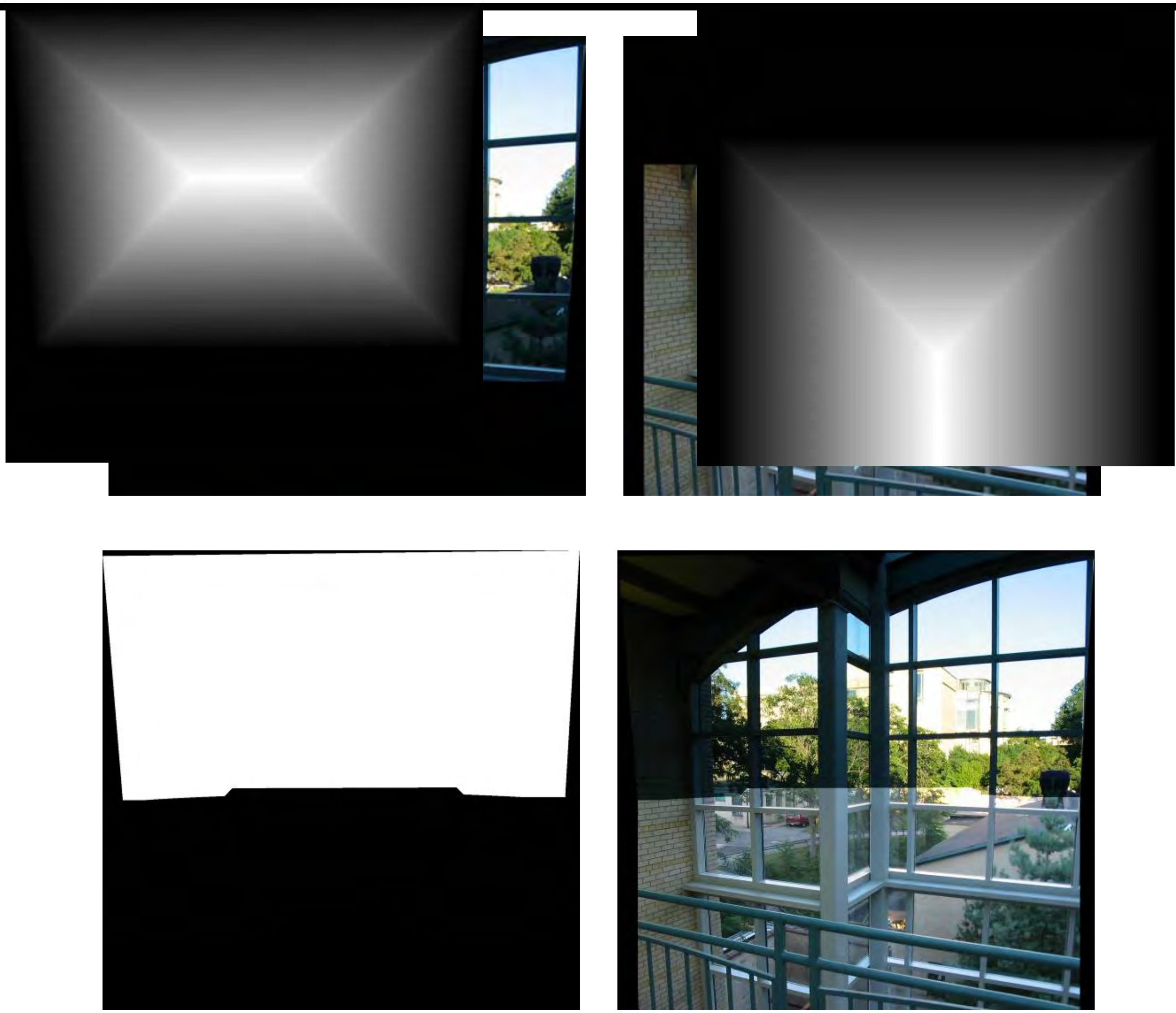
Encoding as transparency

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

Setting alpha: simple averaging

Alpha = .5 in overlap region

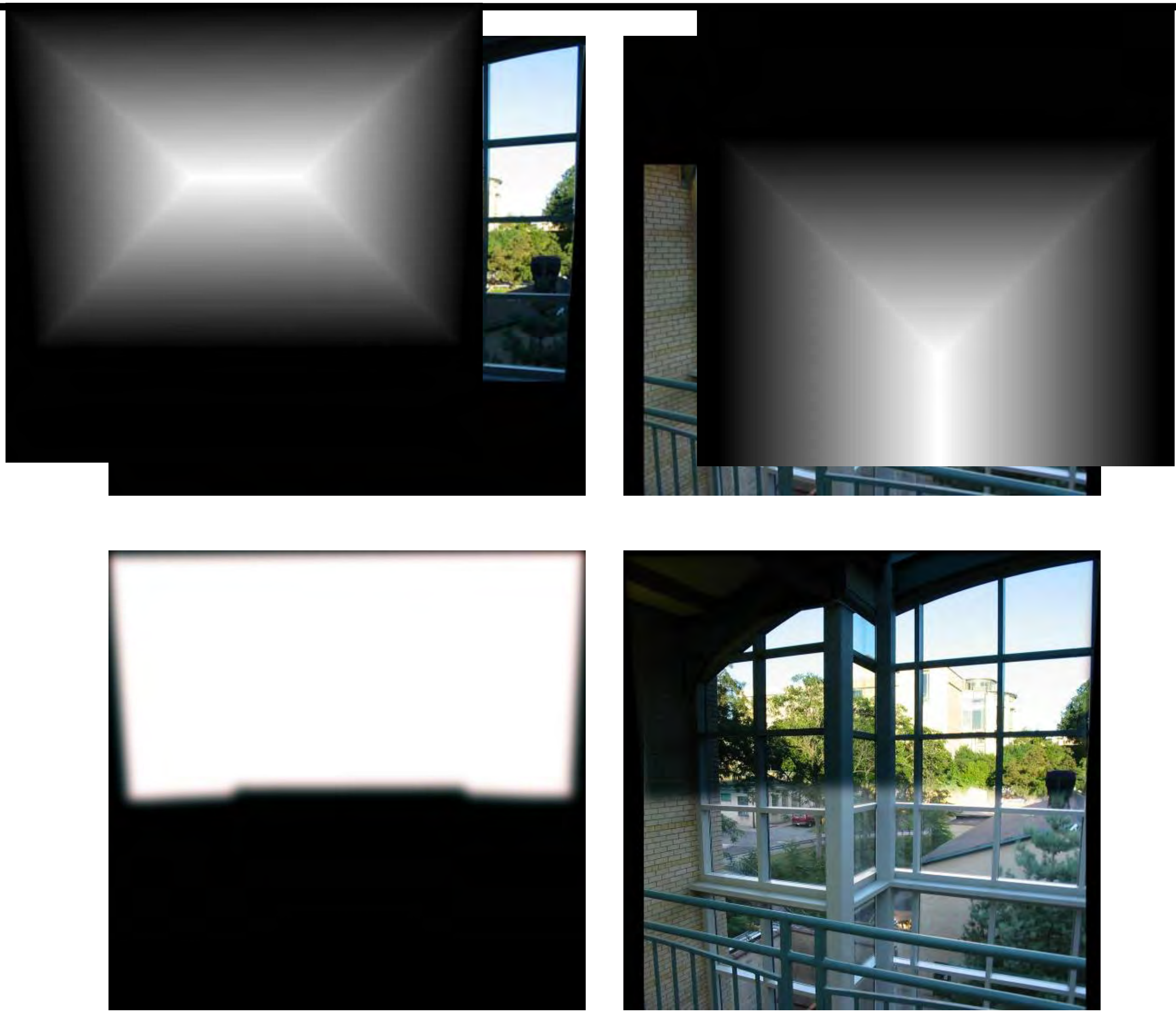
Setting alpha: center seam



Distance transform

Alpha = logical(dtrans1>dtrans2)

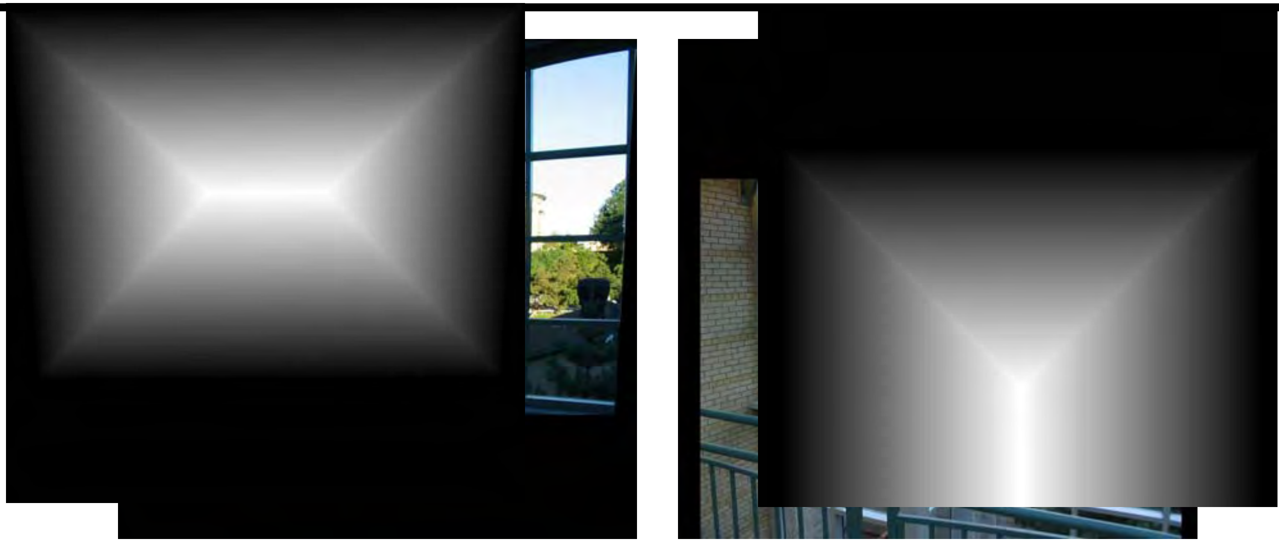
Setting alpha: blurred seam



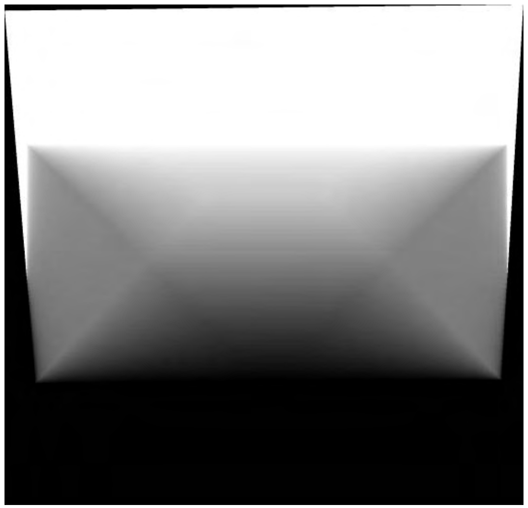
Distance transform

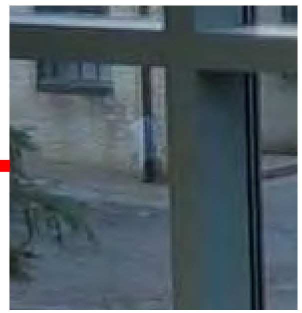
Alpha = blurred

Setting alpha: center weighting



Distance transform

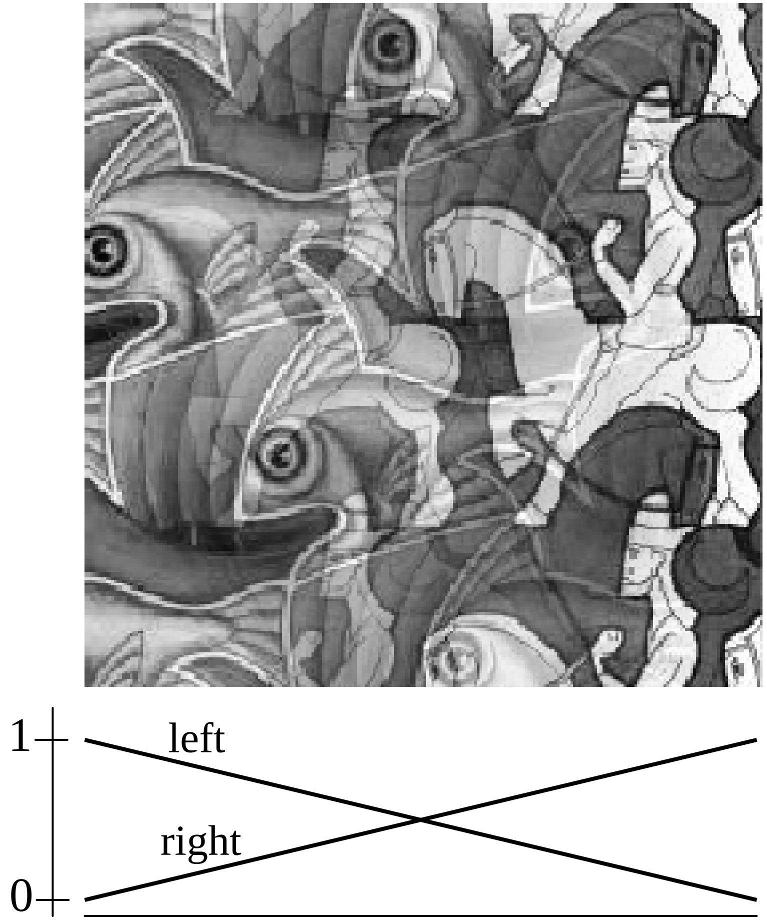


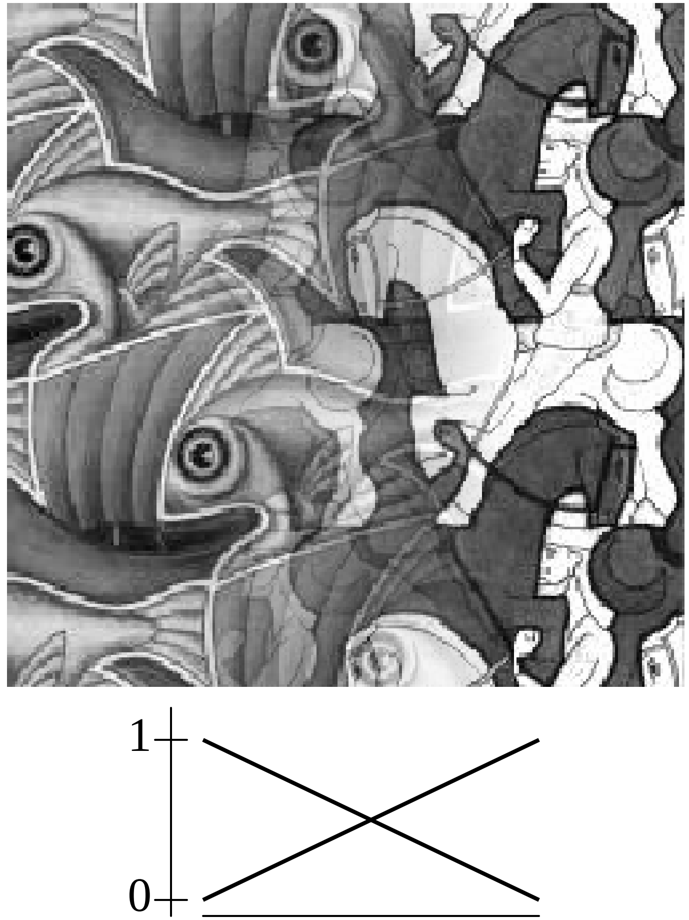


Ghost!

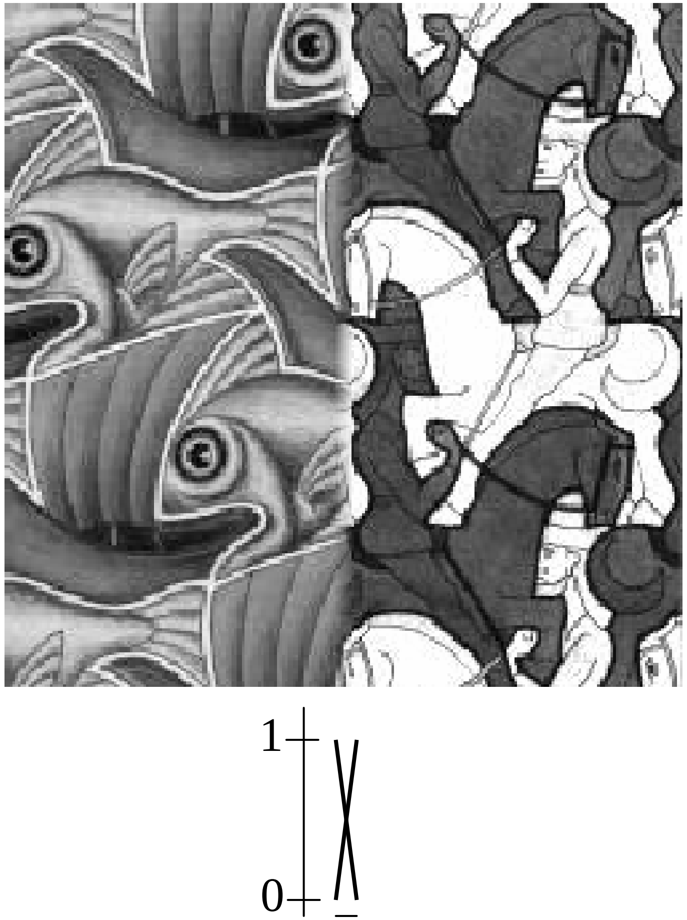
Alpha = dtrans1 / (dtrans1+dtrans2)

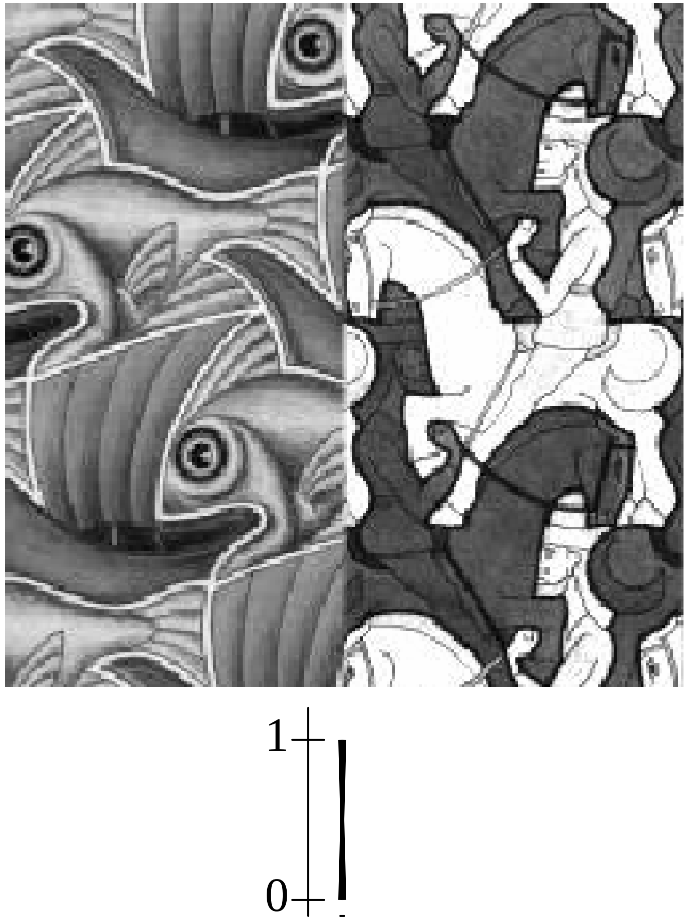
Affect of Window Size



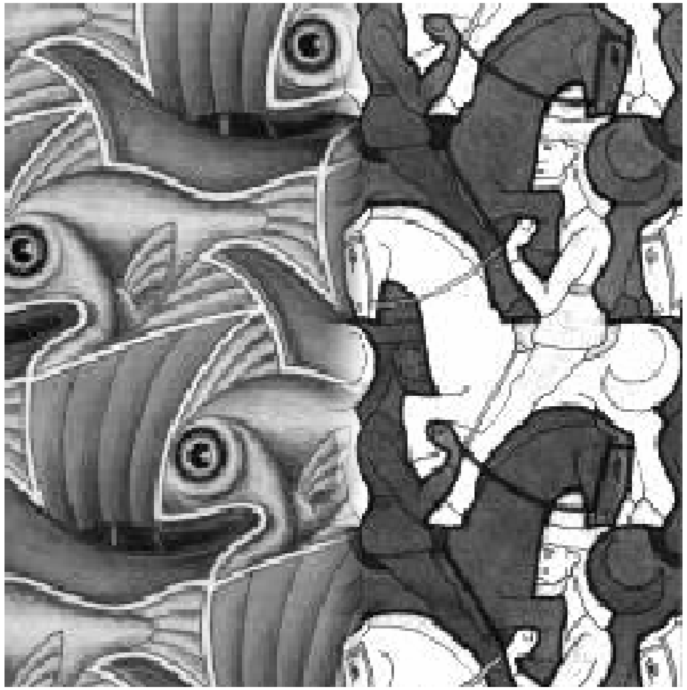


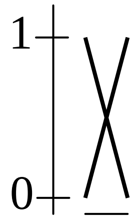
Affect of Window Size





Good Window Size





"Optimal" Window: smooth but not ghosted

What is the Optimal Window?

To avoid seams

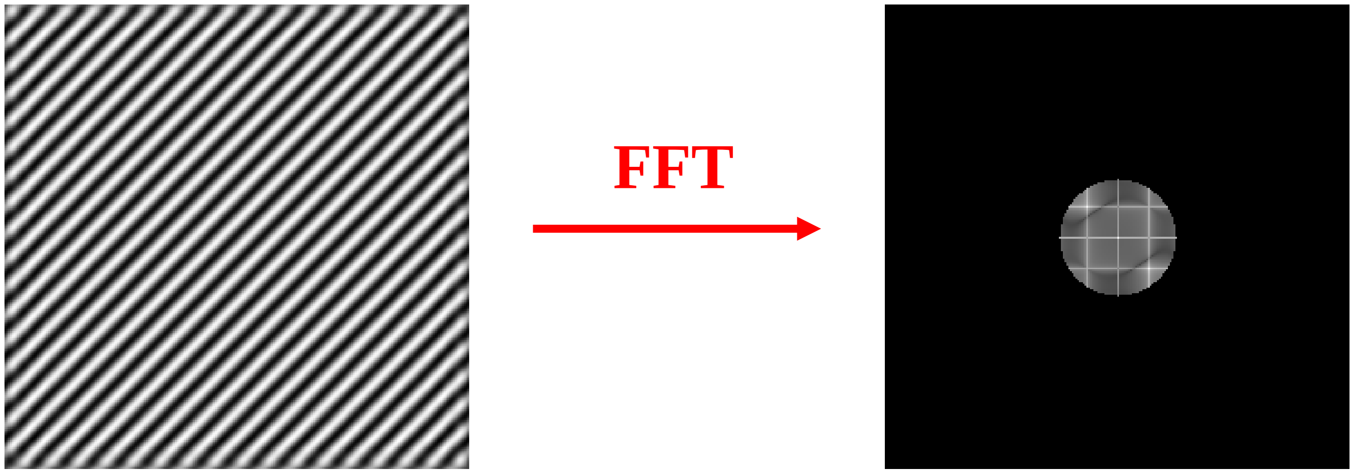
- window = size of largest prominent feature

To avoid ghosting

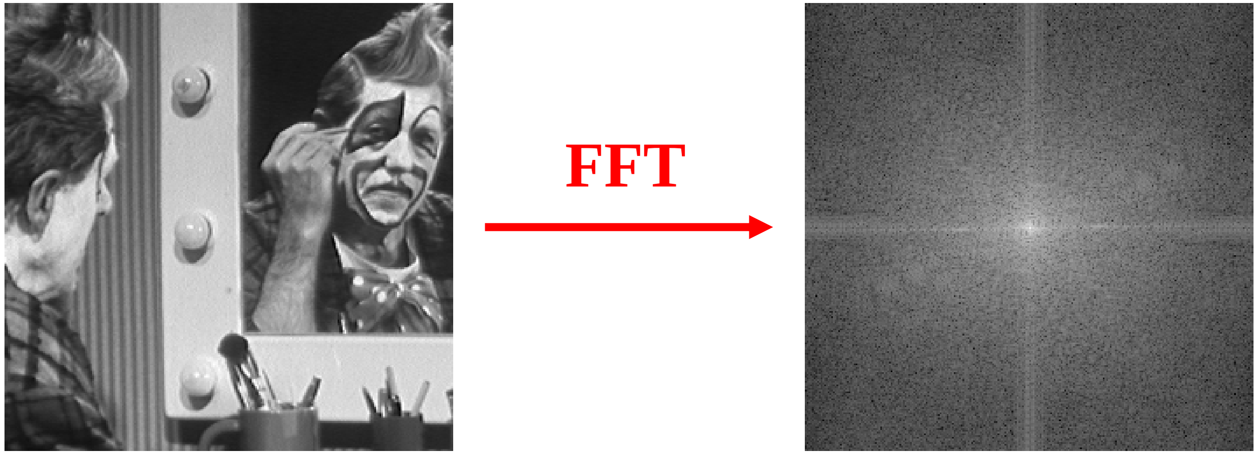
- window <= 2*size of smallest prominent feature

Natural to cast this in the *Fourier domain*

- largest frequency <= 2*size of smallest frequency
- image frequency content should occupy one “octave” (power of two)



What if the Frequency Spread is Wide



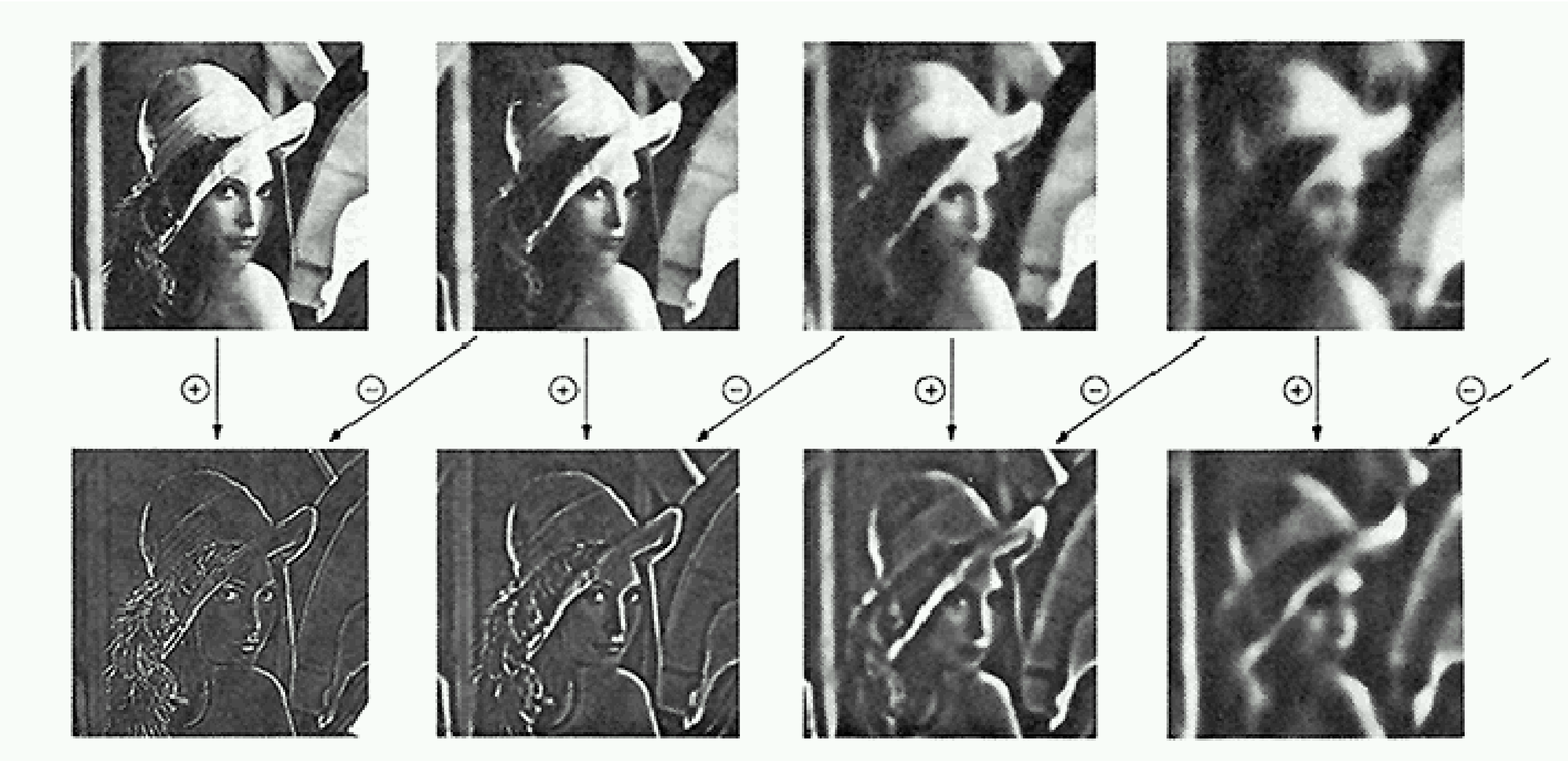
Idea (Burt and Adelson)

- 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

Better implemented in *spatial domain*

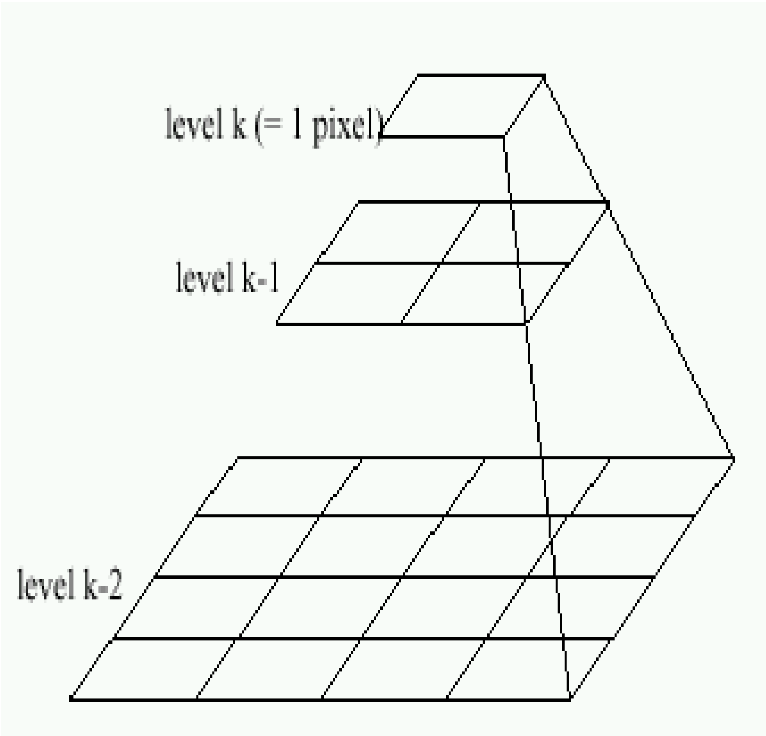
Octaves in the Spatial Domain

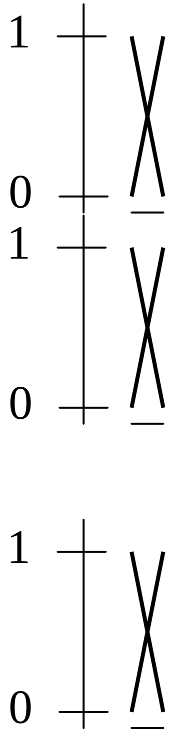
Lowpass Images

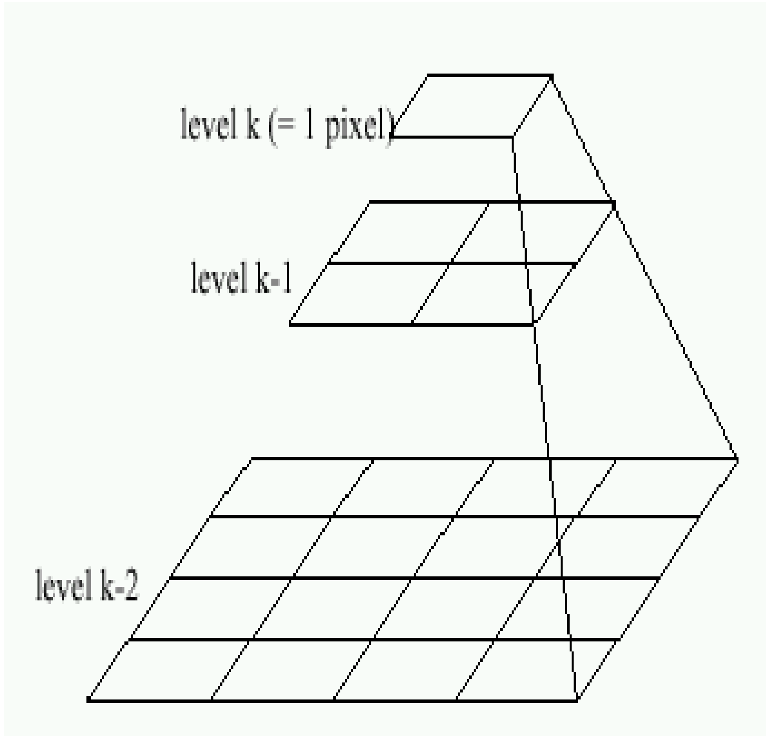


Bandpass Images

Pyramid Blending





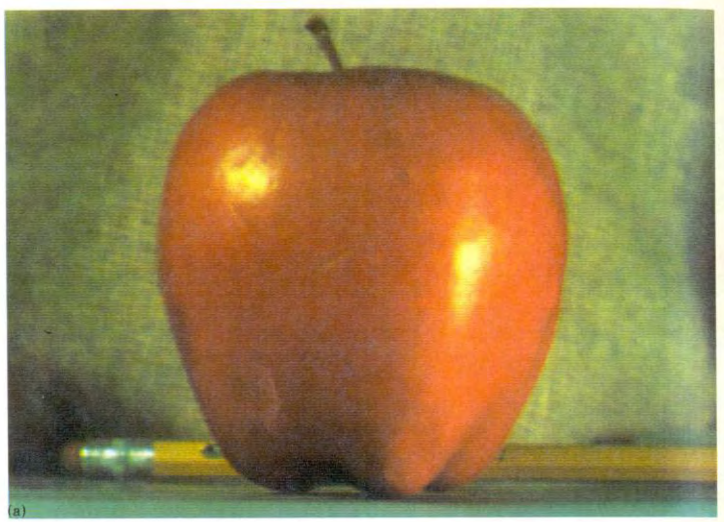


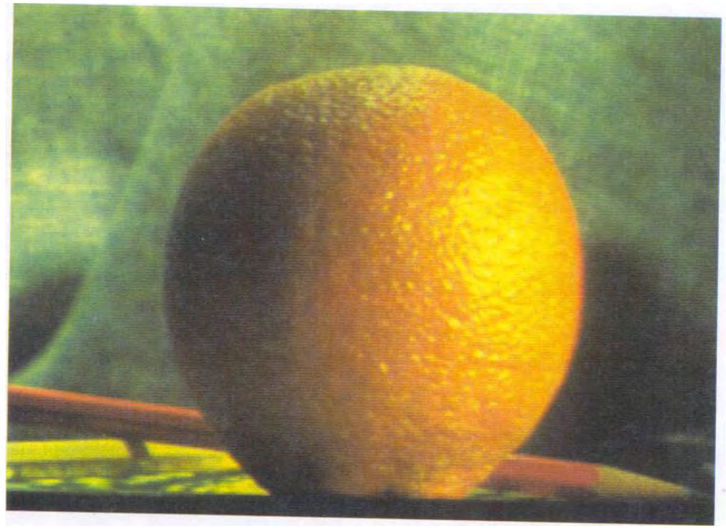
Left pyramid

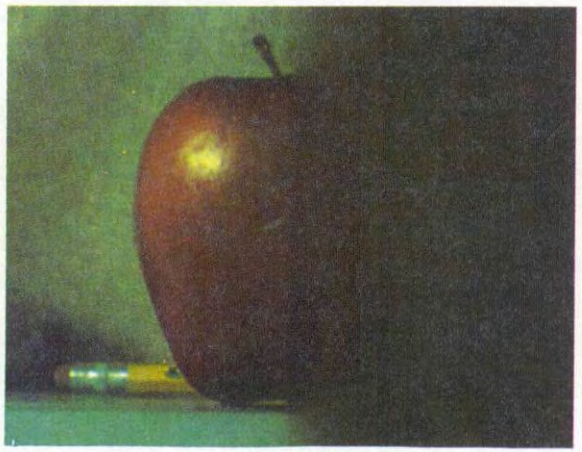
blend

Right pyramid

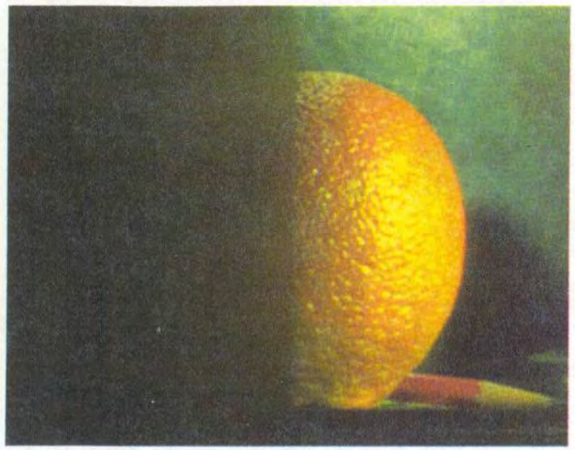
Pyramid Blending



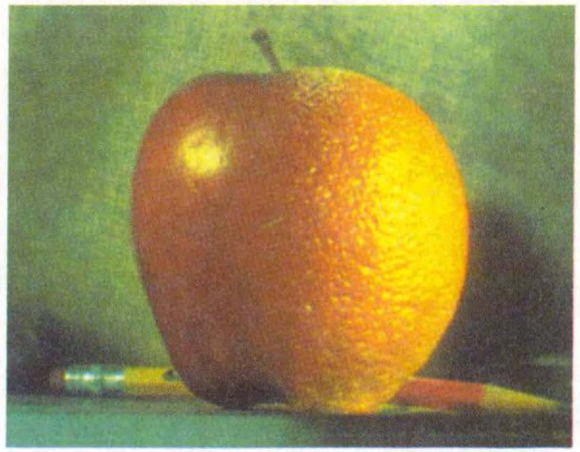




(d)



(h)

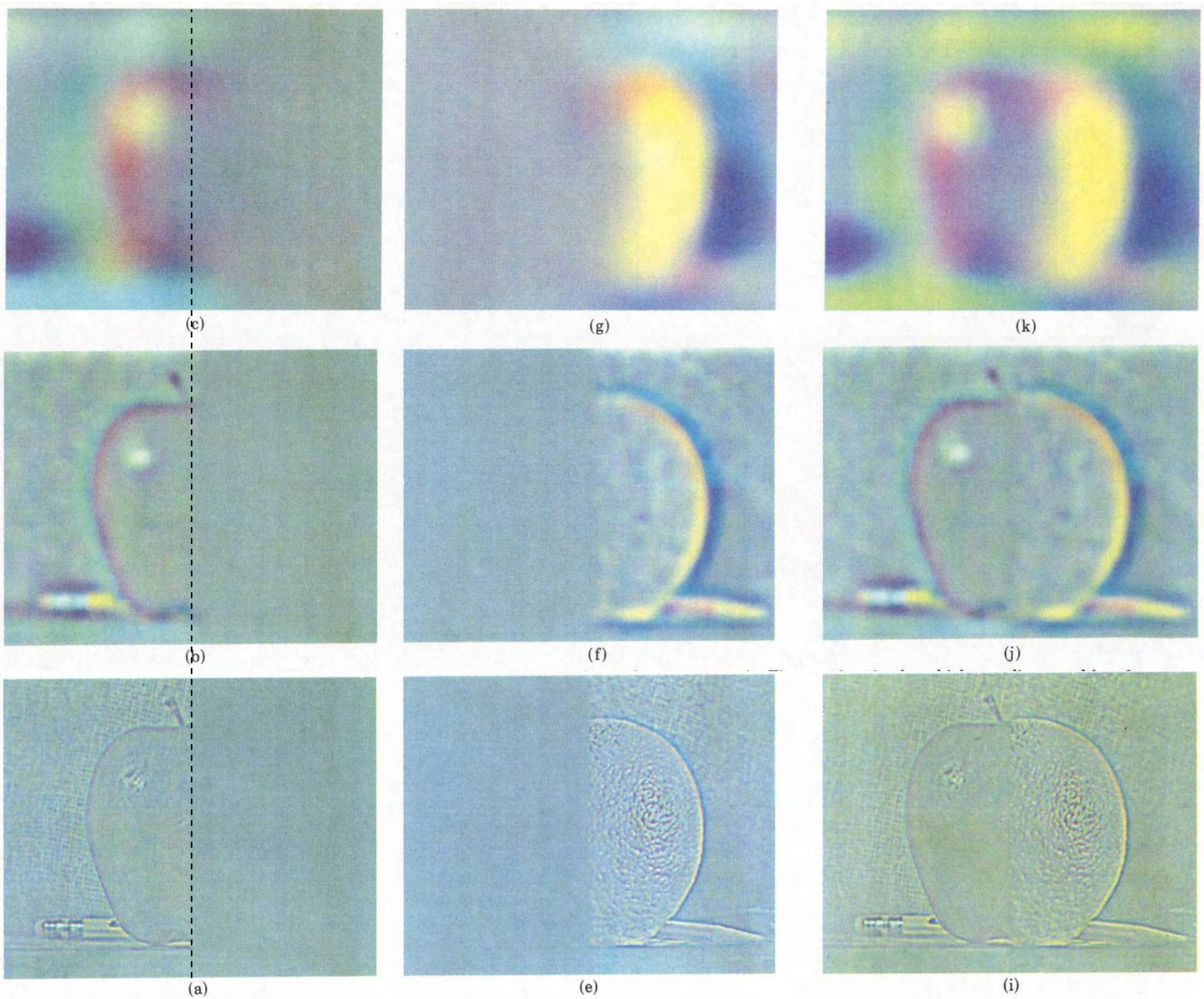


(l)

laplacian level 4

laplacian level 2

laplacian level 0



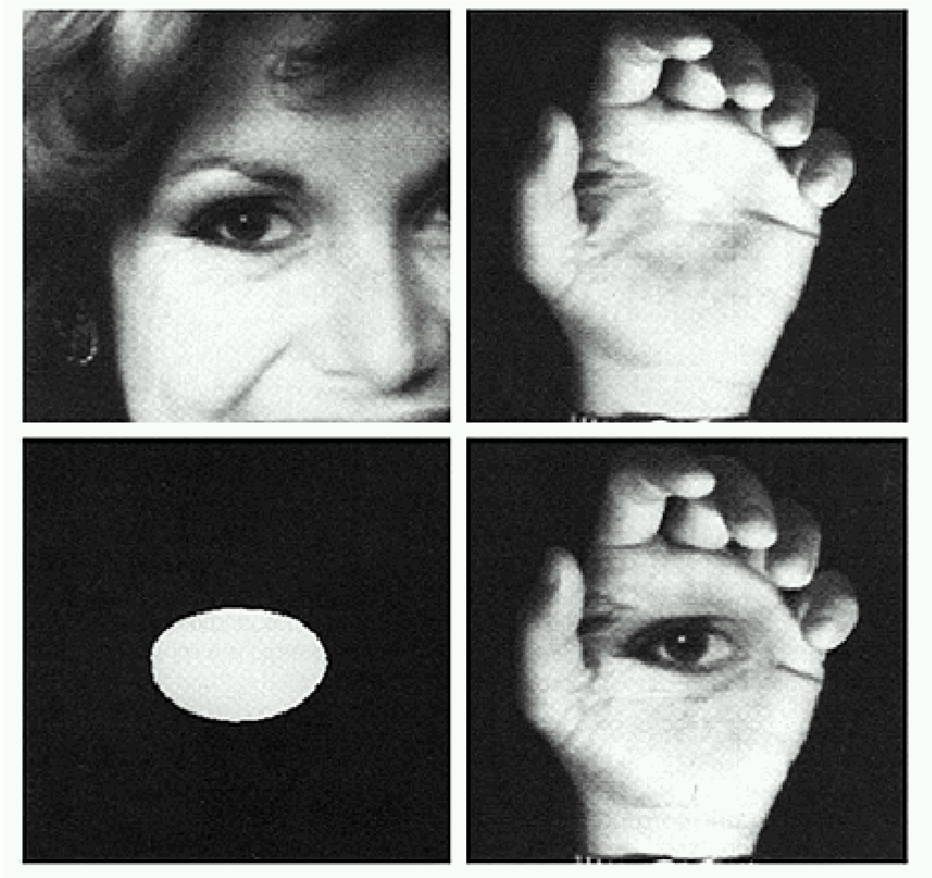
left pyramid | right pyramid | blended pyramid

Laplacian Pyramid: Blending

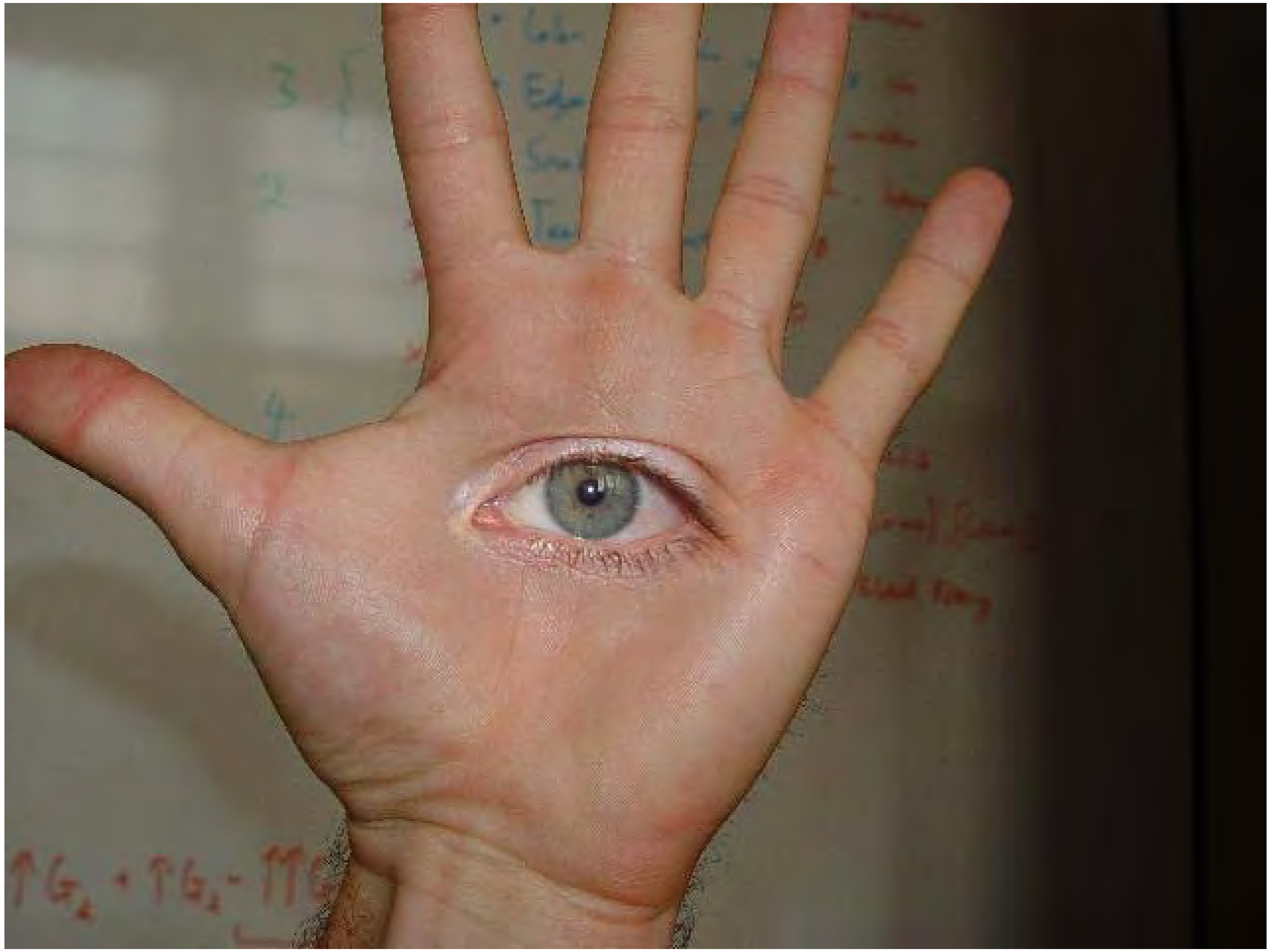
General Approach:

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)

Results from this class (fall 2005)

© Chris Cameron

Season Blending (St. Petersburg)

Season Blending (St. Petersburg)

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

Gradient Domain

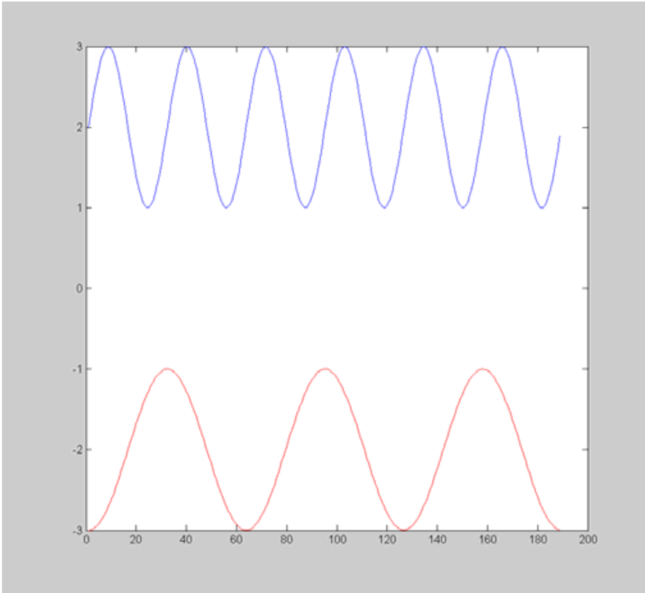
In Pyramid Blending, we decomposed our image into 2^{nd} derivatives (Laplacian) and a low-res image

Let us now look at 1^{st} derivatives (gradients):

- No need for low-res image
  - captures everything (up to a constant)
- Idea:
  - Differentiate
  - Blend
  - Reintegrate

Gradient Domain blending (1D)

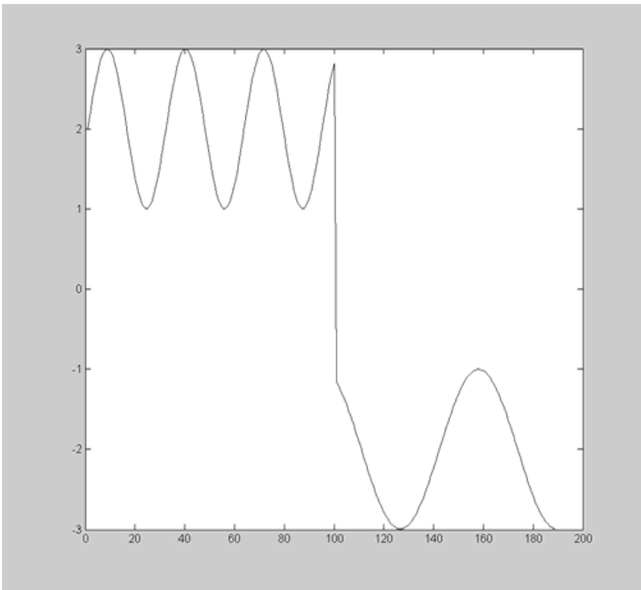
Two signals

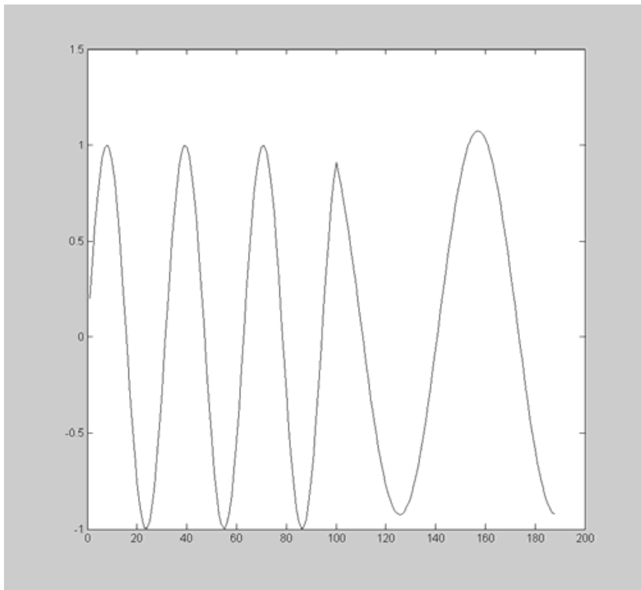


bright

dark

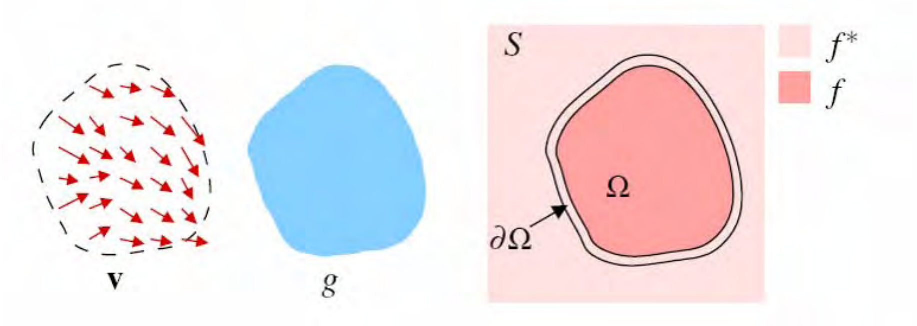
Regular blending





Blending derivatives

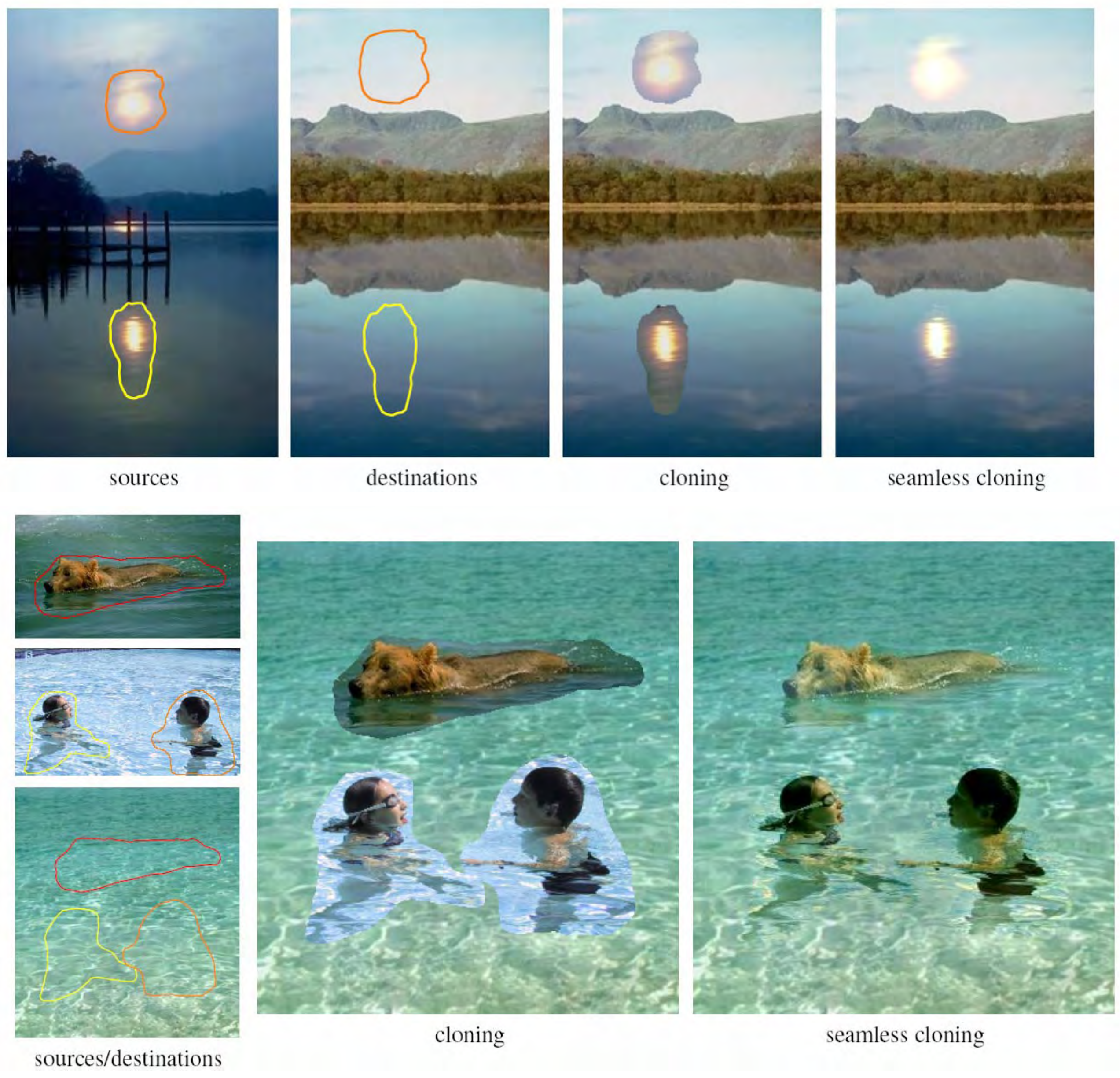
Gradient Domain Blending (2D)



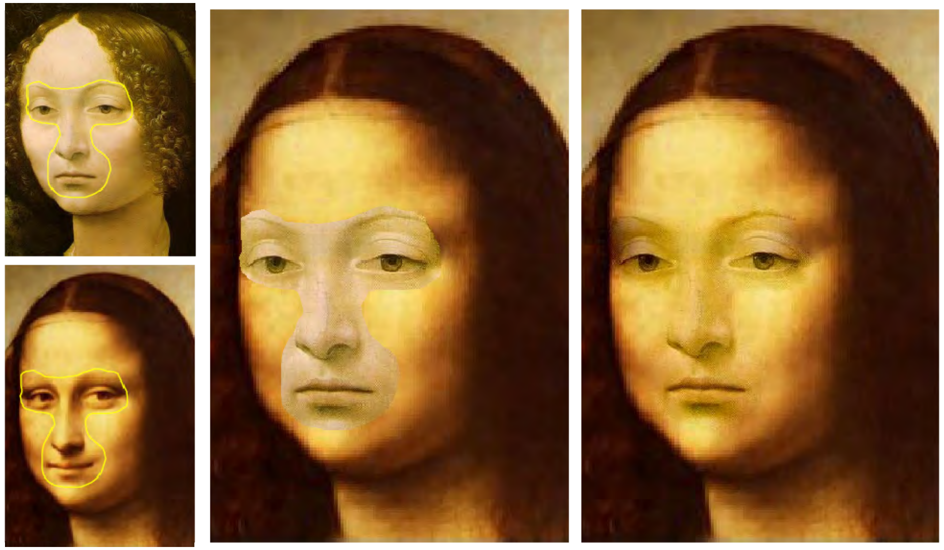
Trickier in 2D:

- Take partial derivatives dx and dy (the gradient field)
- Fidle around with them (smooth, blend, feather, etc)
- Reintegrate
  - But now integral(dx) might not equal integral(dy)
- Find the most agreeable solution
  - Equivalent to solving Poisson equation
  - Can use FFT, deconvolution, multigrid solvers, etc.

Perez et al., 2003



Perez et al, 2003



source/destination cloning seamless cloning

editing

Limitations:

- Can’t do contrast reversal (gray on black -> gray on white)
- Colored backgrounds “bleed through”
- Images need to be very well aligned

Don’t blend, CUT!

Moving objects become ghosts

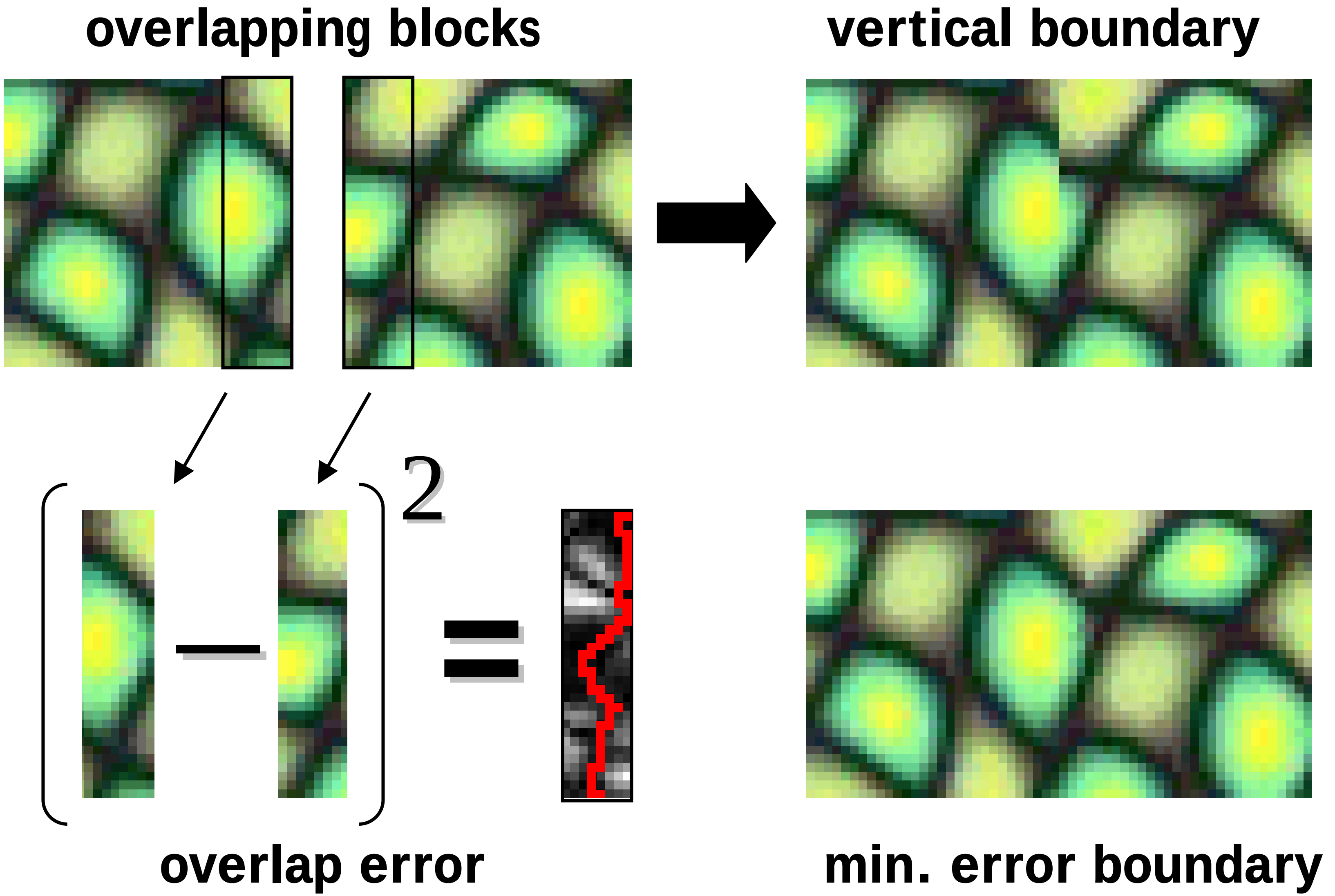
So far we only tried to blend between two images. What about finding an optimal seam?

Davis, 1998

Segment the mosaic

- Single source image per segment
- Avoid artifacts along boundries
  - Dijkstra’s algorithm

Minimal error boundary



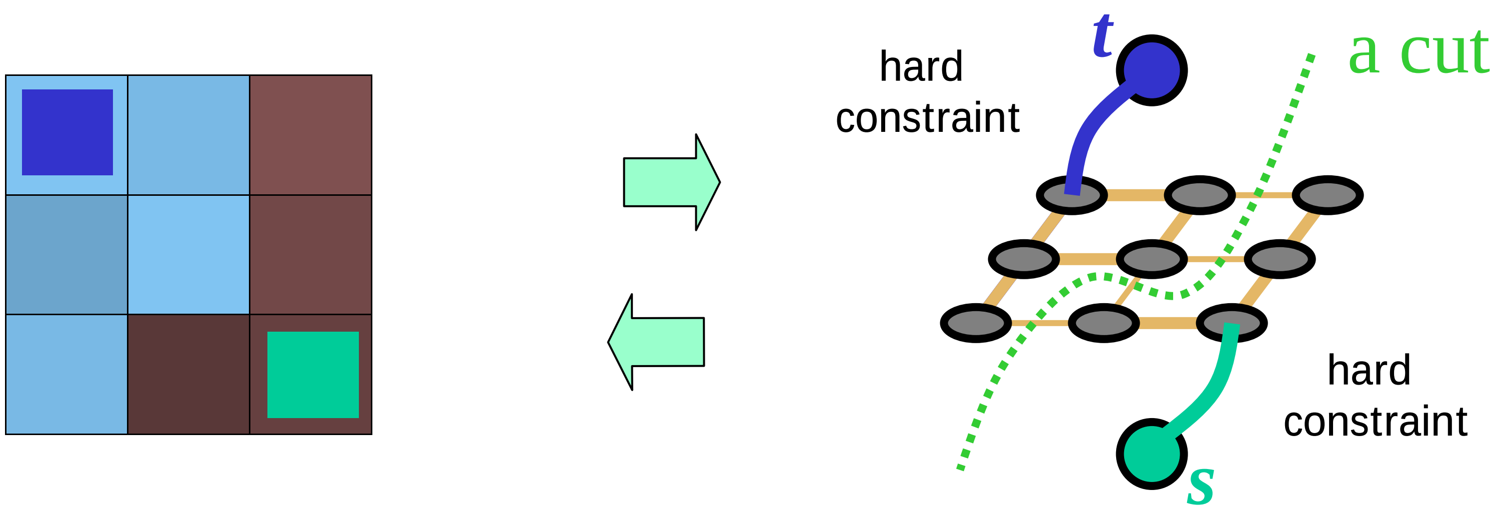
Graphcuts

What if we want similar “cut-where-things-agree” idea, but for closed regions?

- Dynamic programming can’t handle loops

Graph cuts

(simple example à la Boykov&Jolly, ICCV'01)



Minimum cost cut can be computed in polynomial time

(max-flow/min-cut algorithms)

Kwatra et al, 2003

Actually, for this example, DP will work just as well…

Lazy Snapping

(a) Girl (4/2/12) (b) Ballet (4/7/14) (c) Boy (6/2/13)

(c) Grandpa (4/2/11) (d) Twins (4/4/12)

Interactive segmentation using graphcuts

Putting it all together

Compositing images/mosaics

- Have a clever blending function
  - Feathering
  - Center-weighted
  - blend different frequencies differently
  - Gradient based blending
- Choose the right pixels from each image
  - Dynamic programming – optimal seams
  - Graph-cuts

Now, let’s put it all together:

- Interactive Digital Photomontage, 2004 (video)

Interactive Digital Photomontage

Aseem Agarwala, Mira Dontcheva
Maneesh Agrawala, Steven Drucker, Alex Colburn
Brian Curless, David Salesin, Michael Cohen