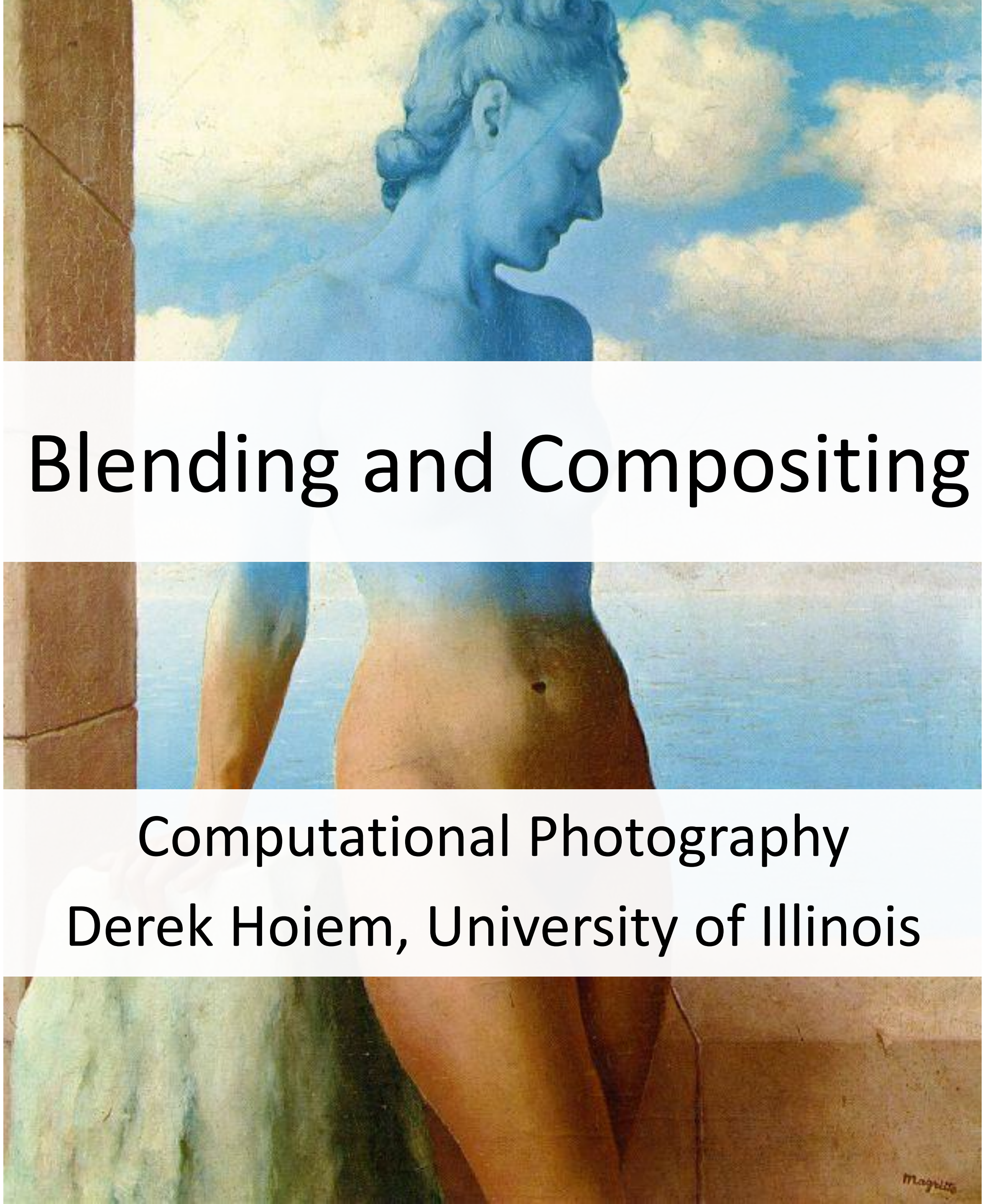


Blending and Compositing

Computational Photography

Derek Hoiem, University of Illinois

Project 1: issues

- Basic tips
  - Display/save Laplacian images using mat2gray or imagesc   (imshow is only for normal images)
  - Downsampling: use sigma ~= 2 for factor of 2

Result from Ryan Kuck

Color shift

More red (increase positive a channel values)

L*a*b* space

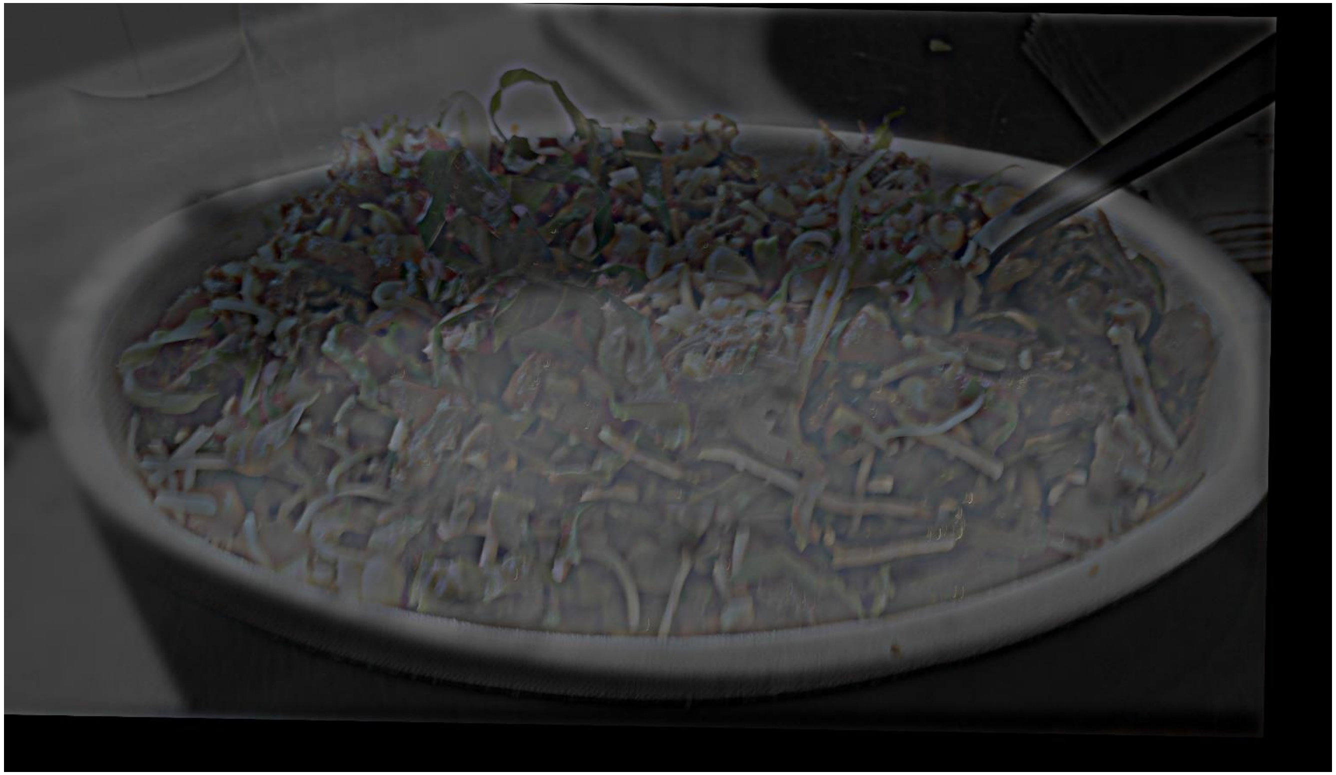
Less yellow (decrease positive b channel values)

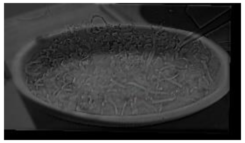
Project 1 Results

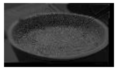
Incomplete list of great project pages

- Ulzee An: http://web.engr.illinois.edu/~ulzeean2/cs445/proj1/
  - great hybrid images and image pyramid results, good visualization
- Mahika Dubey: http://web.engr.illinois.edu/~dubey3/cs445/proj1/
  - good explanation of histogram equalization, good hybrid image results, image pyramids implemented successfully
- Yao-Tsung Hsu: http://web.engr.illinois.edu/~yhsu30/cs445/proj1/
  - good explanation of histogram equalization, good hybrid image results, image pyramids implemented successfully
- Amir Ibrahim: http://web.engr.illinois.edu/~aaelsay2/cs445/proj1/
  - good hybrid images and explanation of image enhancement techniques
- Harry Jian: http://web.engr.illinois.edu/~jian3/cs445/proj1/
  - interesting idea for hybrid images, good image pyramids
- Mariko Wakabayashi: http://web.engr.illinois.edu/~mwakaba2/cs445/proj1/
  - great hybrid image result and overall presentation of results
- Vivek Ramadoss: http://web.engr.illinois.edu/~ramados2/cs445/proj1/
  - another good hybrid image that works well + great zoom tool!

Hybrid results







Harry Jian

Mahika Dubey

Vivek Ramadoss

Last class: finding boundaries

- Intelligent scissors
  - Good boundary has a low-cost path from seed to cursor
  - Low cost = edge, high gradient, right orientation

- GrabCut
  - Good region is similar to foreground color model and dissimilar from background color
  - Good boundaries have a high gradient
  - Optimize over both

Take-home questions

1. What would be the result in “Intelligent Scissors” if all of the edge costs were set to 1?

2. How could you change boundary costs for graph cuts to work better for objects with many thin parts?

Last Class: cutting out objects

This Class

How do I put an object from one image into another?

Image Compositing

Some slides from Efros/Seitz

News Composites

http://www.guardian.co.uk/world/2010/sep/16/mubarak-doctored-red-carpet-picture

Original

"Enhanced" Version

News Composites

Original

“Enhanced” Version

Walski, LA Times, 2003

Three methods

1. Cut and paste

2. Laplacian pyramid blending

3. Poisson blending

Method 1: Cut and Paste

Method 1: Cut and Paste

Method:
- Segment using intelligent scissors
- Paste foreground pixels onto target region

Method 1: Cut and Paste

Problems:

- Small segmentation errors noticeable
- Pixels are too blocky
- Won’t work for semi-transparent materials

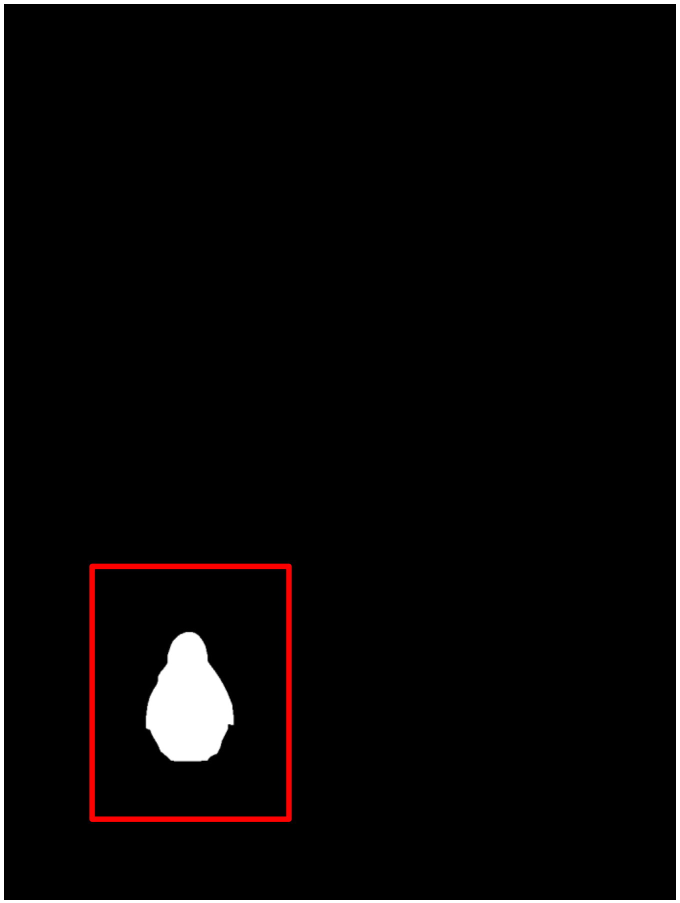
Feathering

Near object boundary pixel values come partly from foreground and partly from background

Method 1: Cut and Paste (with feathering)

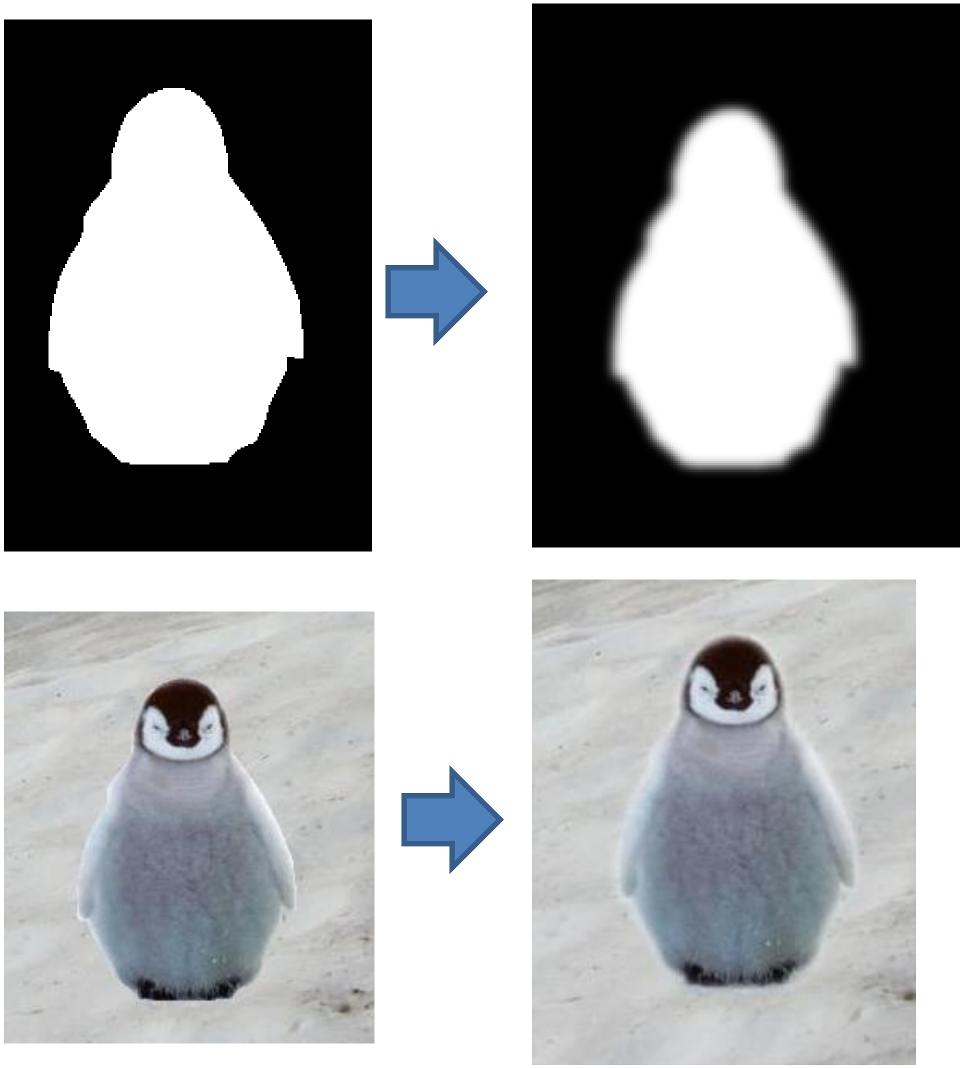
Alpha compositing

+



Output = foreground*mask + background*(1-mask)

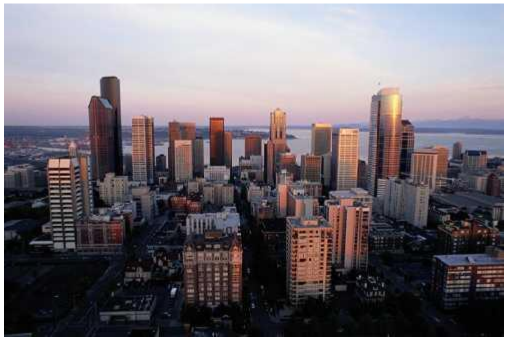
Alpha compositing with feathering



Output = foreground*mask + background*(1-mask)

Another example (without feathering)

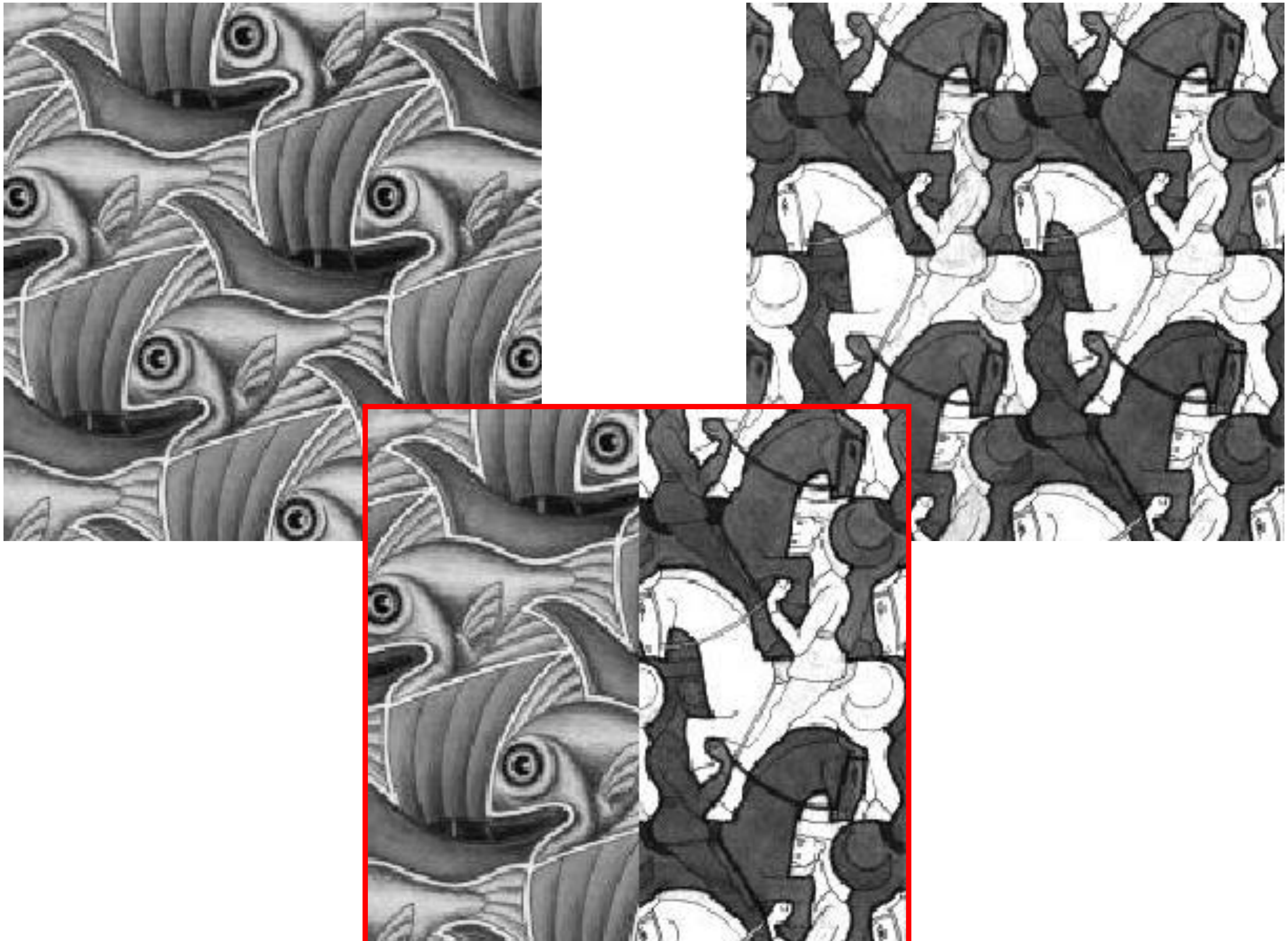
Mattes



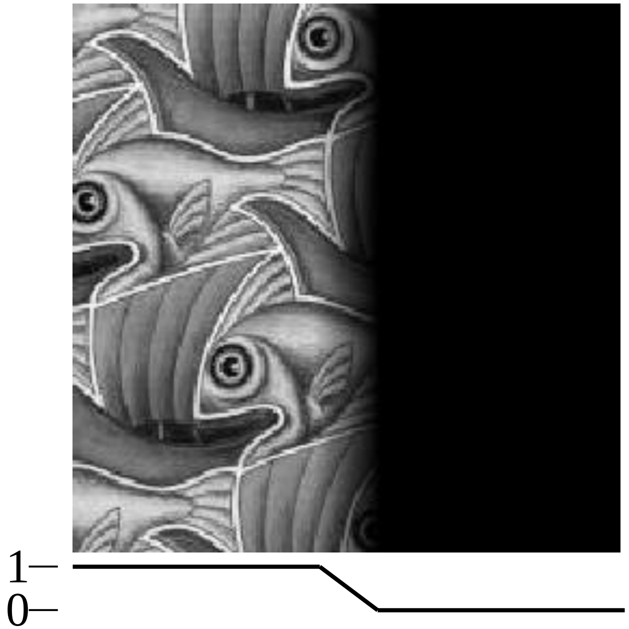
Composite

Composite by
David Dewey

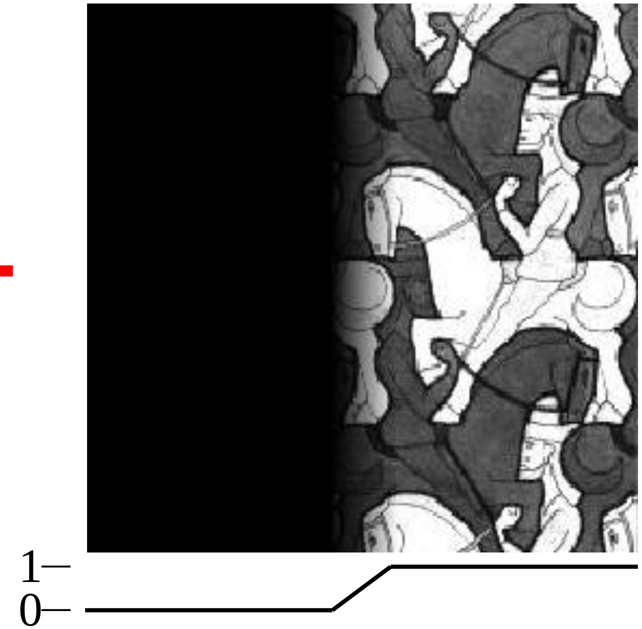
Proper blending is key



Alpha Blending / Feathering



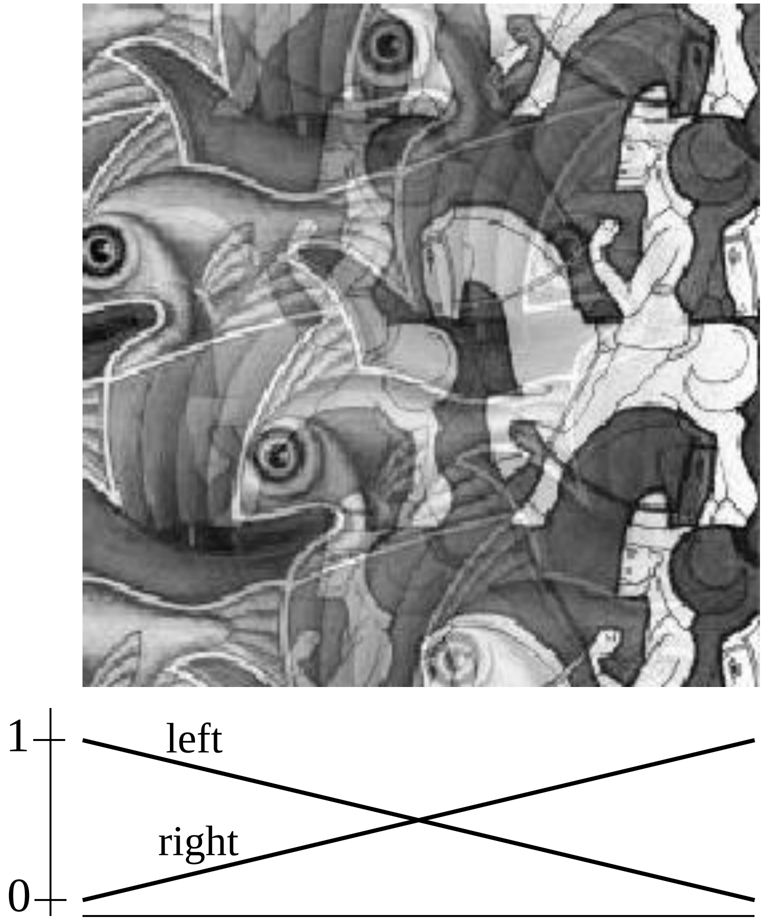
+

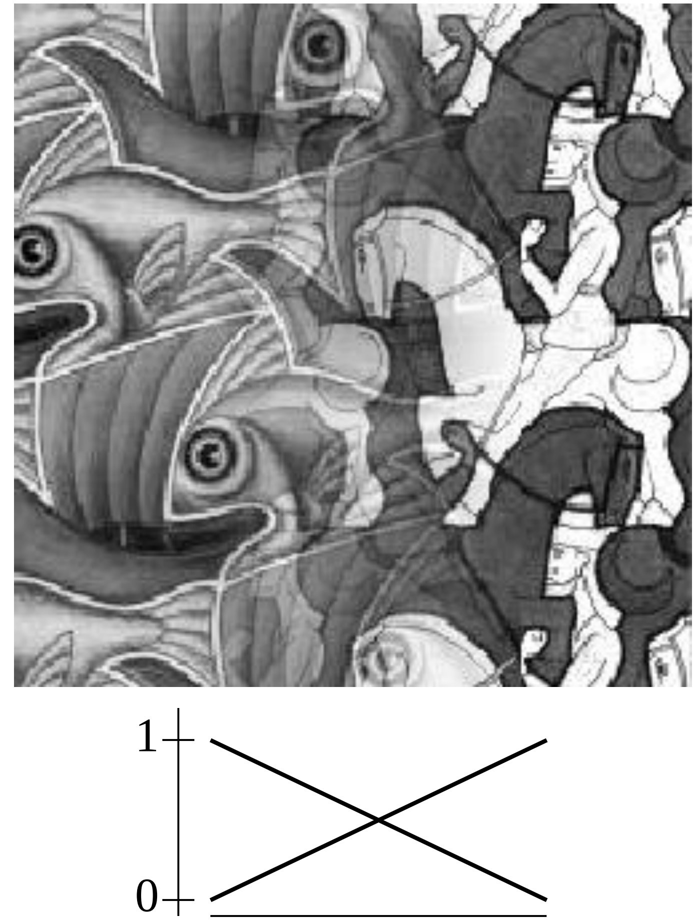


=

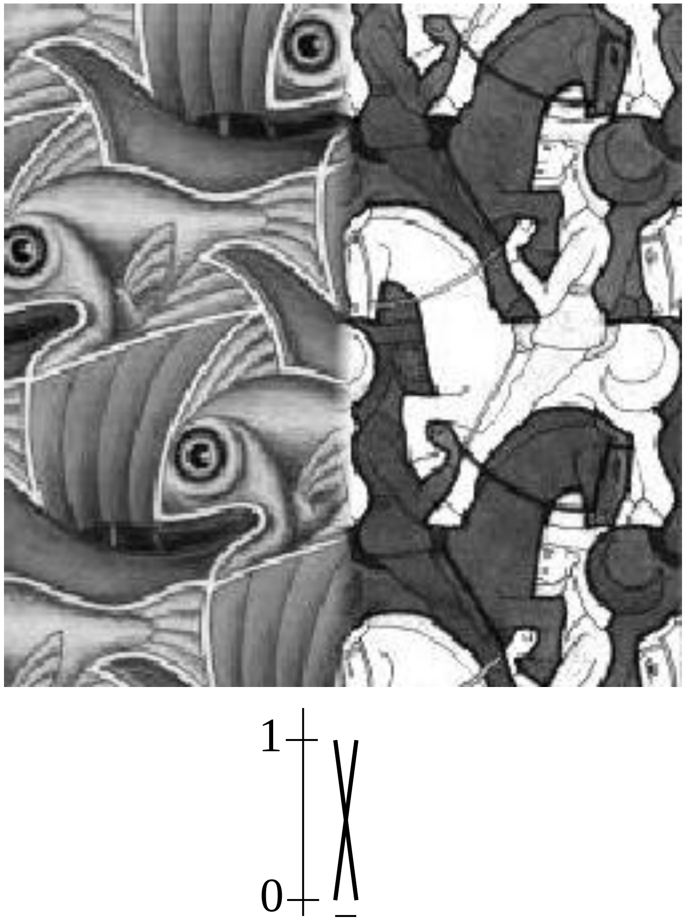
$$I_{blend} = \alpha I_{left} + (1-\alpha) I_{right}$$

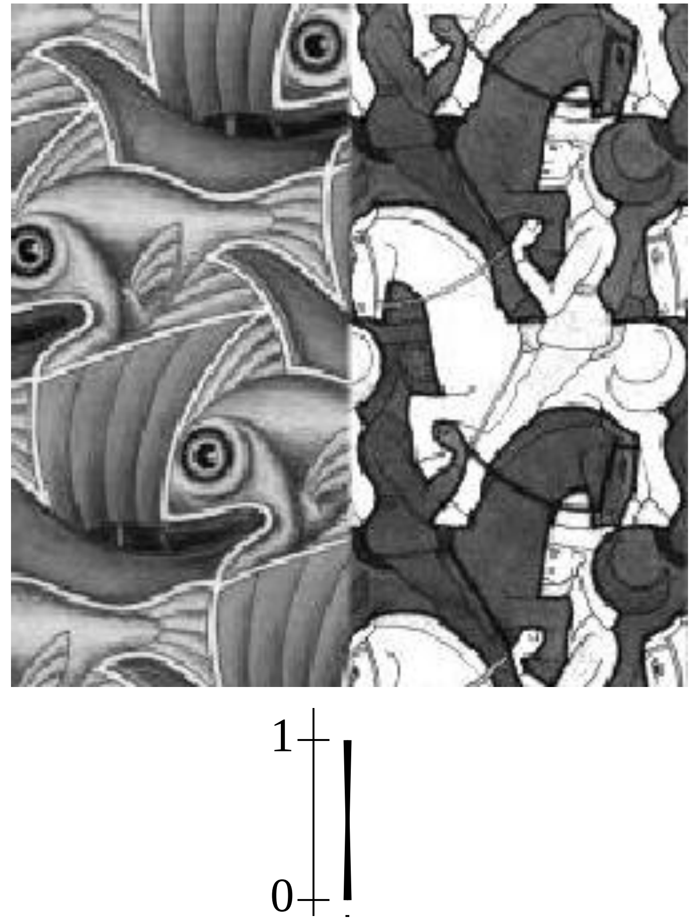
Effect of Window Size



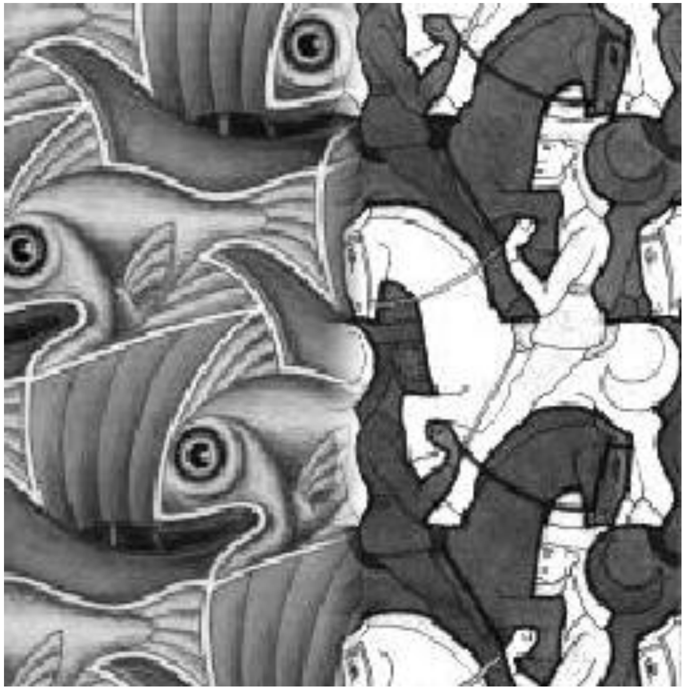


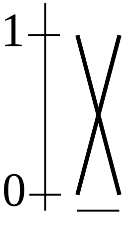
Effect of Window Size





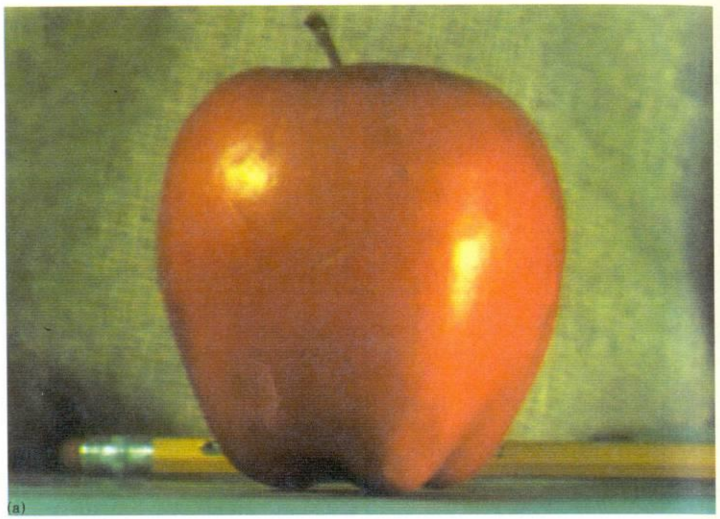
Good Window Size

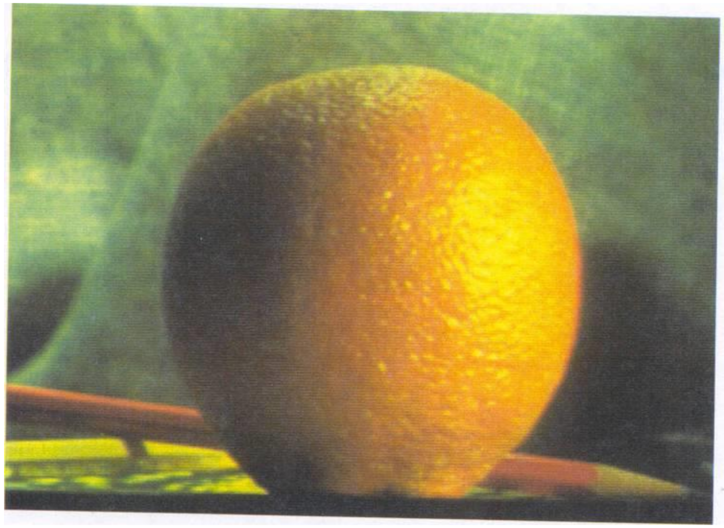


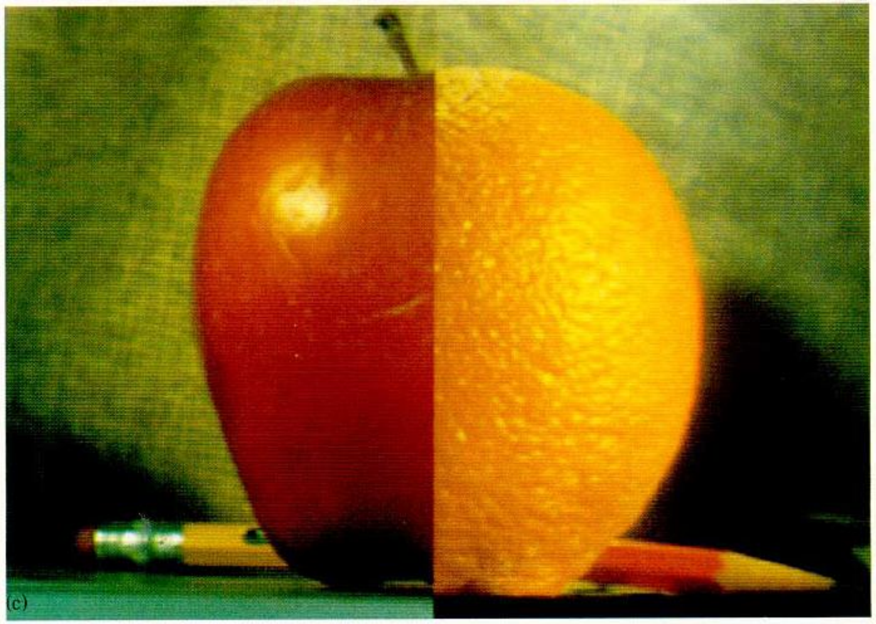


"Optimal" Window: smooth but not ghosted

How much should we blend?

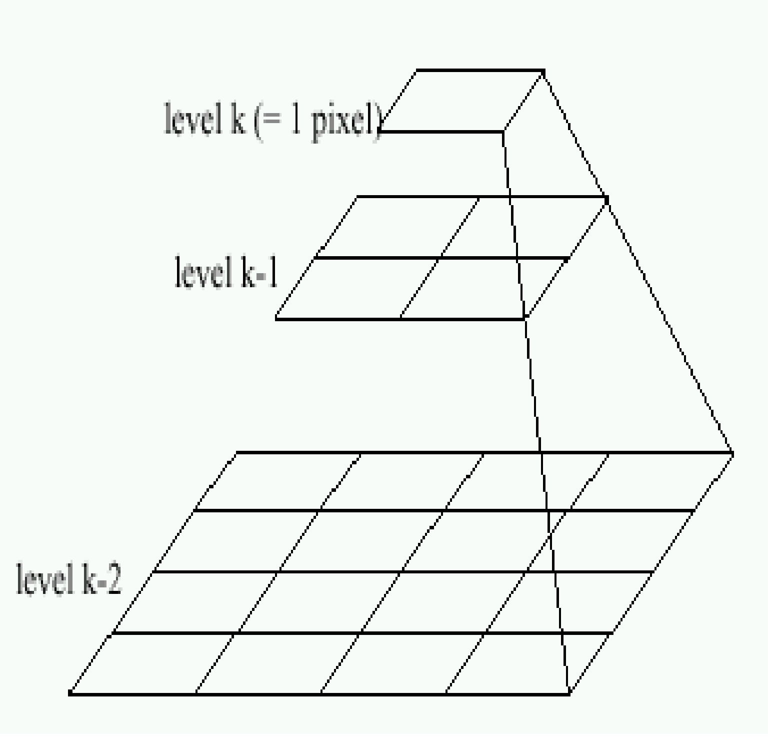


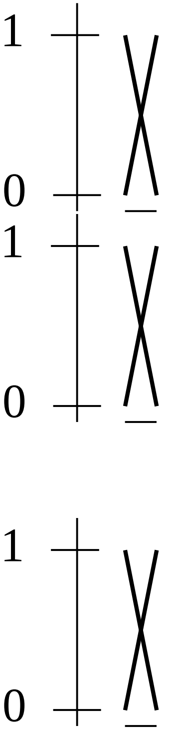


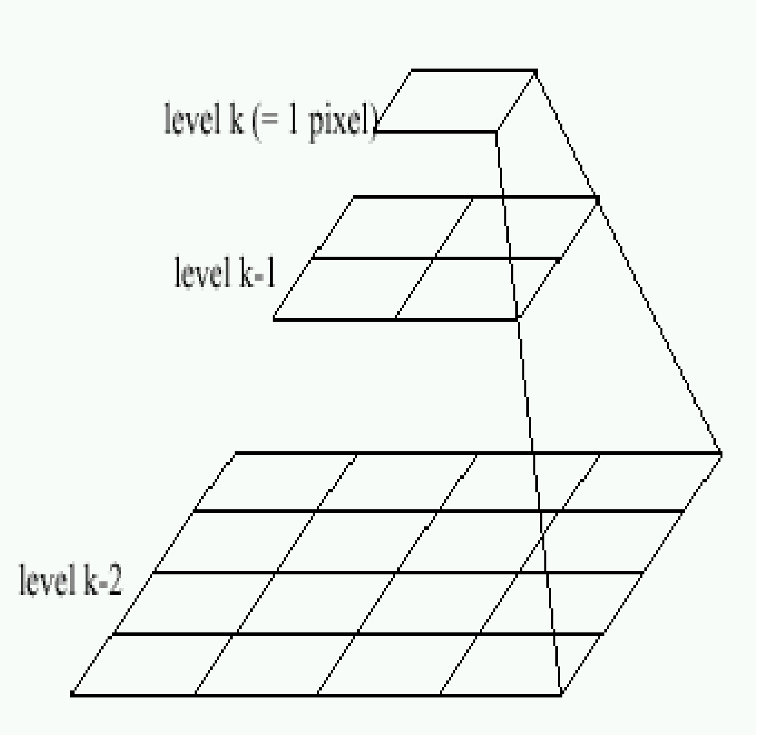


Method 2: Pyramid Blending

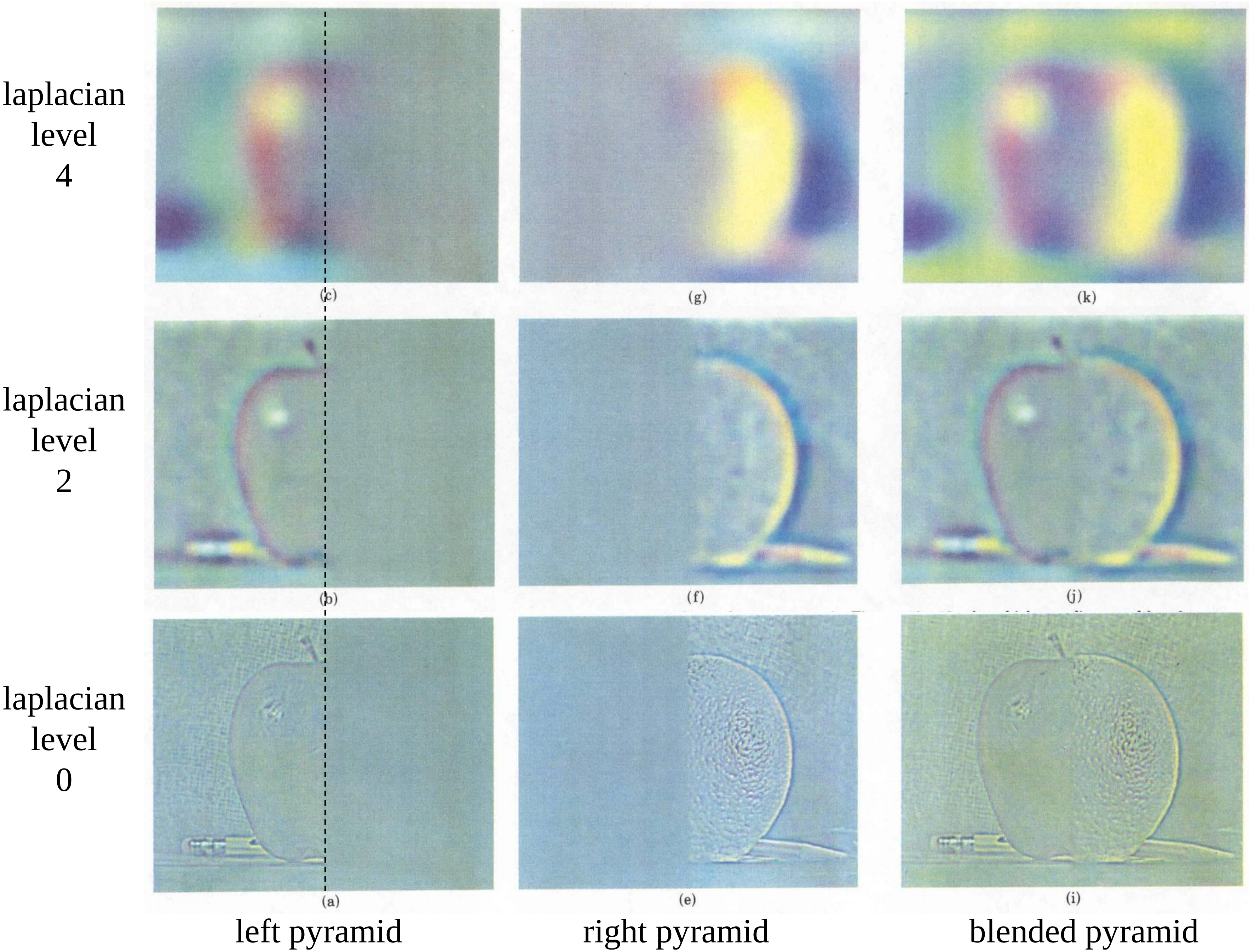
- At low frequencies, blend slowly
- At high frequencies, blend quickly





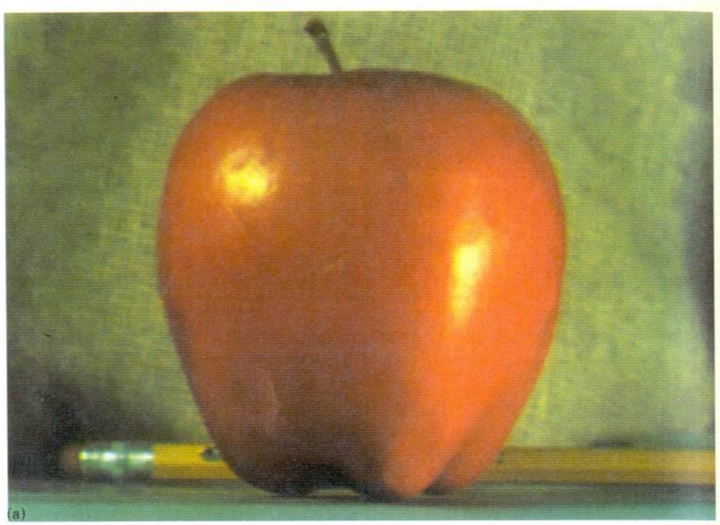


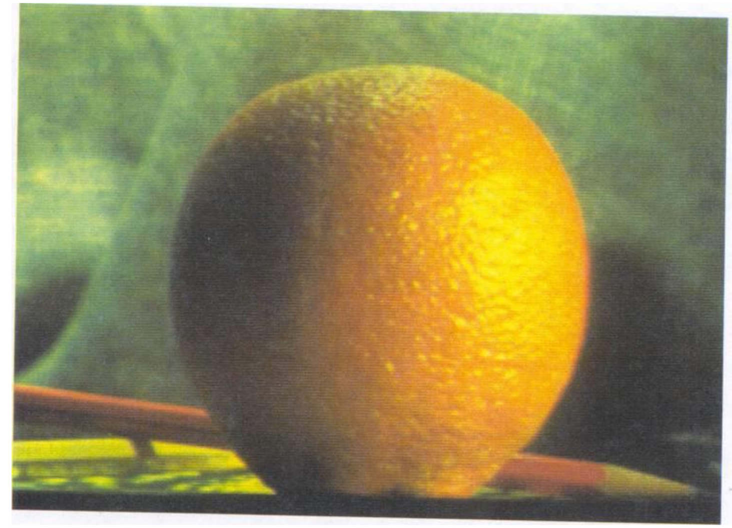
Left pyramid　　　　blend　　　　Right pyramid

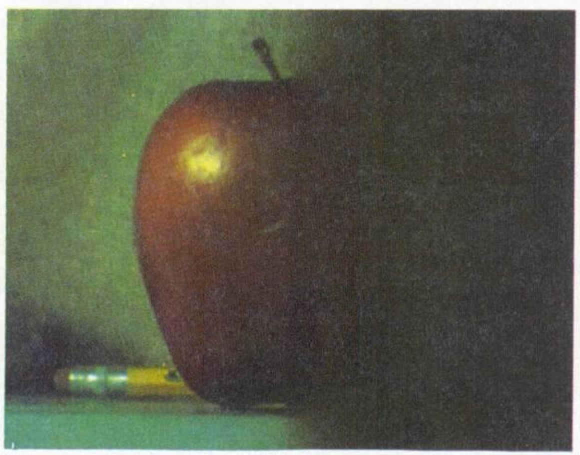


laplacian
level
4
laplacian
level
2
laplacian
level
0
(c)
(g)
(k)
(b)
(f)
(j)
(a)
(e)
(i)
left pyramid
right pyramid
blended pyramid

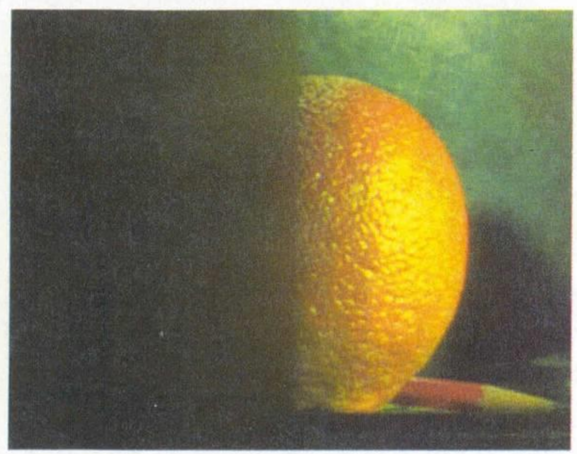
Method 2: Pyramid Blending



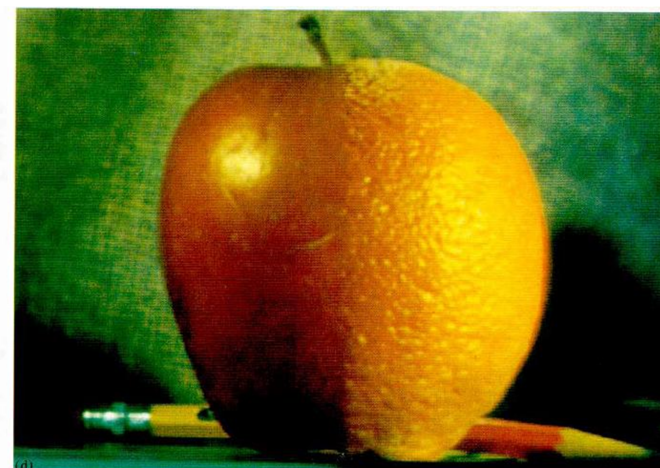




(d)



(h)



(l)

Burt and Adelson 1983

Laplacian Pyramid Blending

Implementation:

1. Build Laplacian pyramids for each image
2. Build a Gaussian pyramid of region mask
3. Blend each level of pyramid using region mask from the same level

$$L_{12}^{i} = L_{1}^{i} \cdot R^{i} + L_{2}^{i} \cdot (1 - R^{i})$$

Image 1 at level i of Laplacian pyramid

Pointwise multiply

Region mask at level i of Gaussian pyramid

4. Collapse the pyramid to get the final blended image

Burt and Adelson 1983

Simplification: Two-band Blending

- Brown & Lowe, 2003
  - Only use two bands: high freq. and low freq.
  - Blends low freq. smoothly

2-band Blending

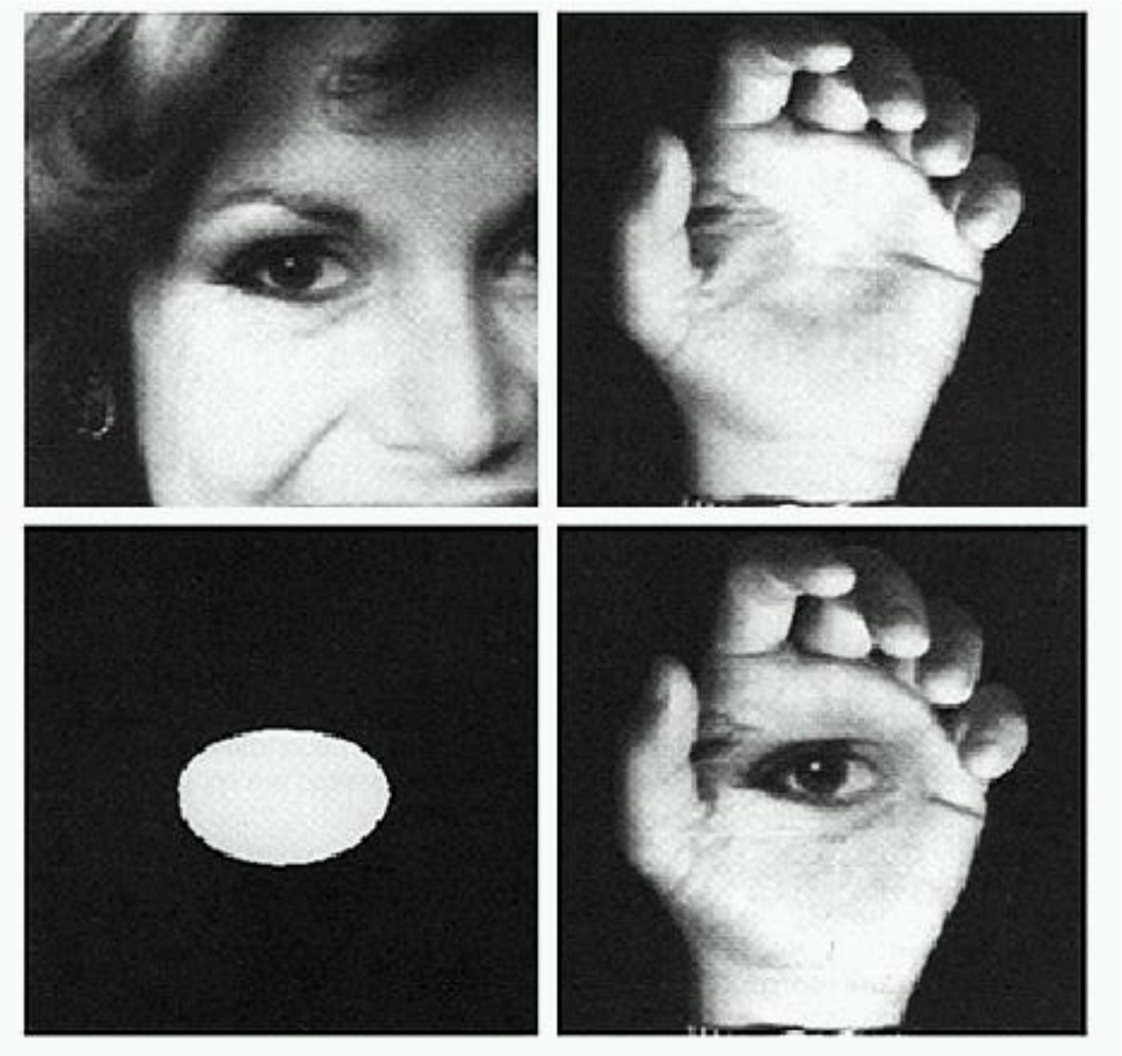
Low frequency

High frequency

Linear Blending

2-band Blending

Blending Regions



Related idea: Poisson Blending

A good blend should preserve gradients of source region without changing the background

Perez et al. 2003

Related idea: Poisson Blending

A good blend should preserve gradients of source region without changing the background

Project 3!

Perez et al. 2003

Method 3: Poisson Blending

A good blend should preserve gradients of source region without changing the background

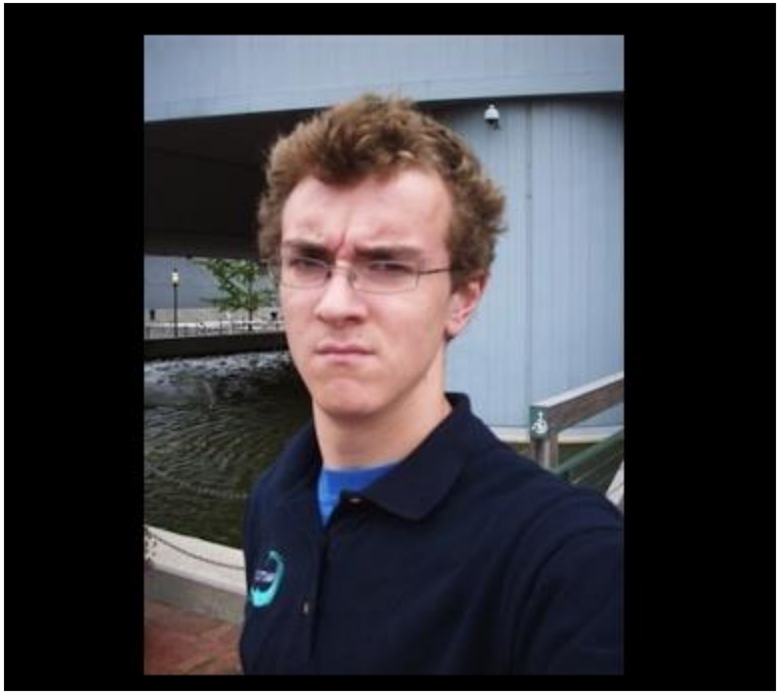
Treat pixels as variables to be solved

- Minimize squared difference between gradients of foreground region and gradients of target region
- Keep background pixels constant

$$\mathbf{v} = \underset{\mathbf{v}}{\operatorname{argmin}} \sum_{i \in S, j \in N_i \cap S} ((v_i - v_j) - (s_i - s_j))^2 + \sum_{i \in S, j \in N_i \cap \neg S} ((v_i - t_j) - (s_i - s_j))^2$$

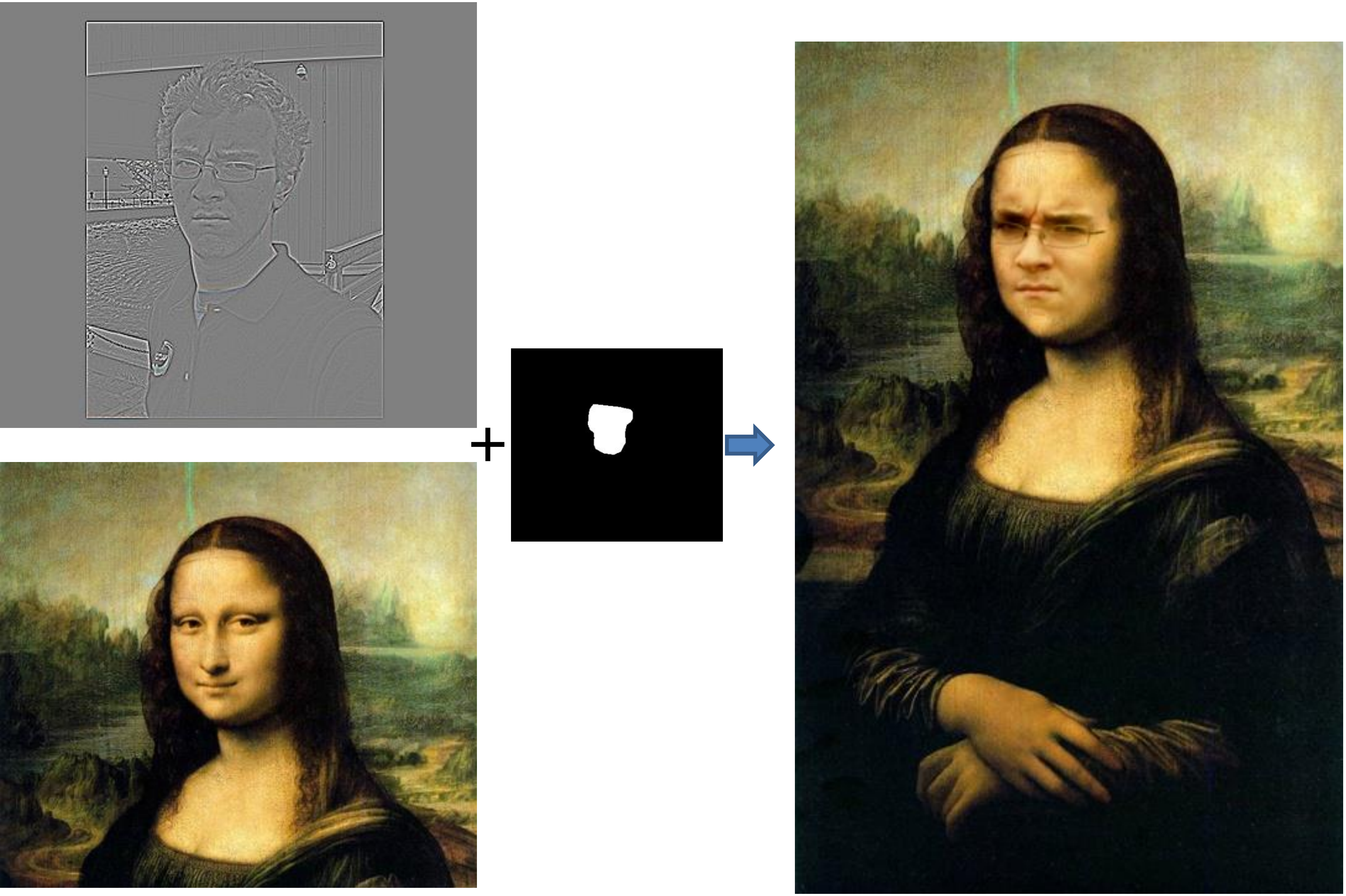
Perez et al. 2003

Example



Gradient Visualization

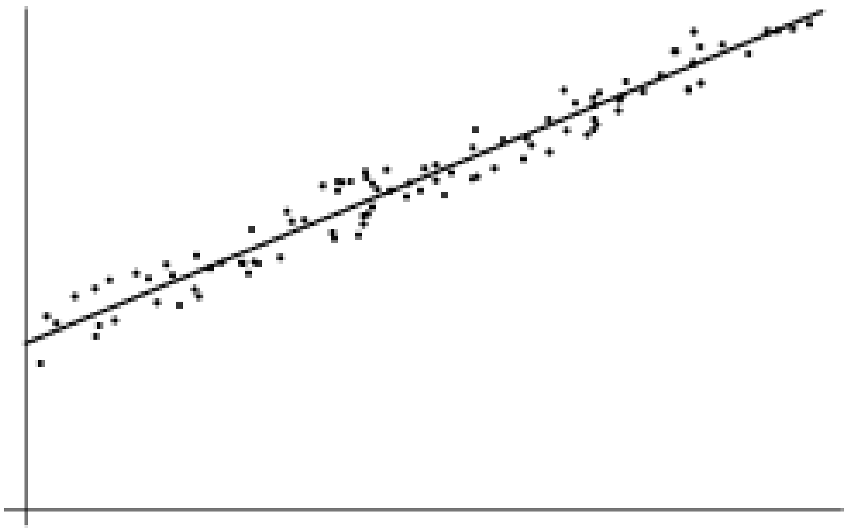
Source: Evan Wallace



Source: Evan Wallace

Gradient-domain editing

Creation of image = least squares problem in terms of: 1) pixel intensities; 2) differences of pixel intensities



Least Squares Line Fit in 2 Dimensions

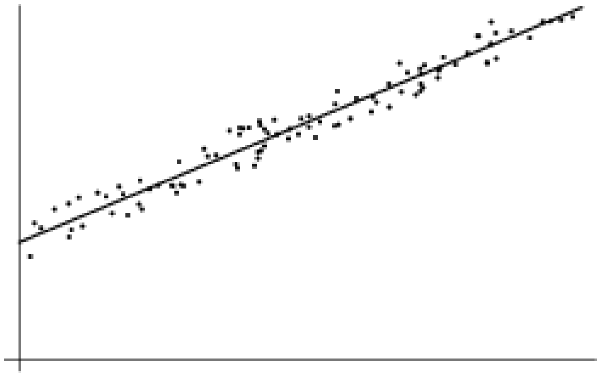
$$\hat{\mathbf{v}} = \arg\min_{\mathbf{v}} \sum_i \left(\mathbf{a}_i^T \mathbf{v} - b_i\right)^2$$

$$\hat{\mathbf{v}} = \arg\min_{\mathbf{v}} \left(\mathbf{A}\mathbf{v} - \mathbf{b}\right)^2$$

Use Matlab least-squares solvers for numerically stable solution with sparse A

Examples

1. Line-fitting: $y=mx+b$



Examples

2. Gradient domain processing

$$\mathbf{v} = \underset{\mathbf{v}}{\operatorname{argmin}} \sum_{i \in S, j \in N_i \cap S} ((v_i - v_j) - (s_i - s_j))^2 + \sum_{i \in S, j \in N_i \cap \neg S} ((v_i - t_j) - (s_i - s_j))^2$$

source image

1 **20**	5 **20**	9 **20**	13 **20**
2 **20**	6 **80**	10 **20**	14 **20**
3 **20**	7 **20**	11 **80**	15 **20**
4 **20**	8 **20**	12 **20**	16 **20**

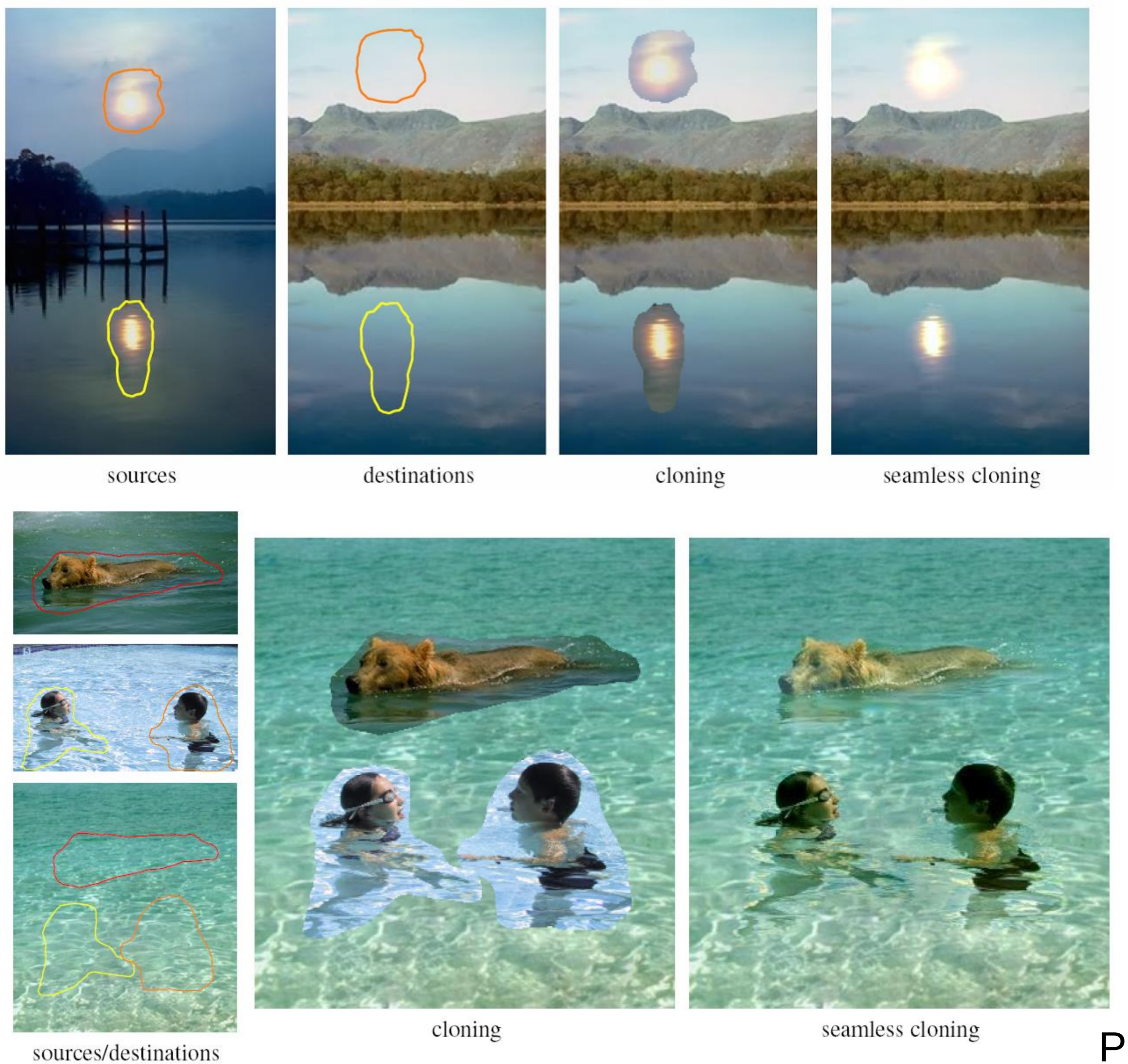
background image

1 **10**	5 **10**	9 **10**	13 **10**
2 **10**	6 **10**	10 **10**	14 **10**
3 **10**	7 **10**	11 **10**	15 **10**
4 **10**	8 **10**	12 **10**	16 **10**

target image

1 **10**	5 **10**	9 **10**	13 **10**
2 **10**	6 $\mathbf{v}_1$	10 $\mathbf{v}_3$	14 **10**
3 **10**	7 $\mathbf{v}_2$	11 $\mathbf{v}_4$	15 **10**
4 **10**	8 **10**	12 **10**	16 **10**

Other results



Perez et al. 2003

What do we lose?

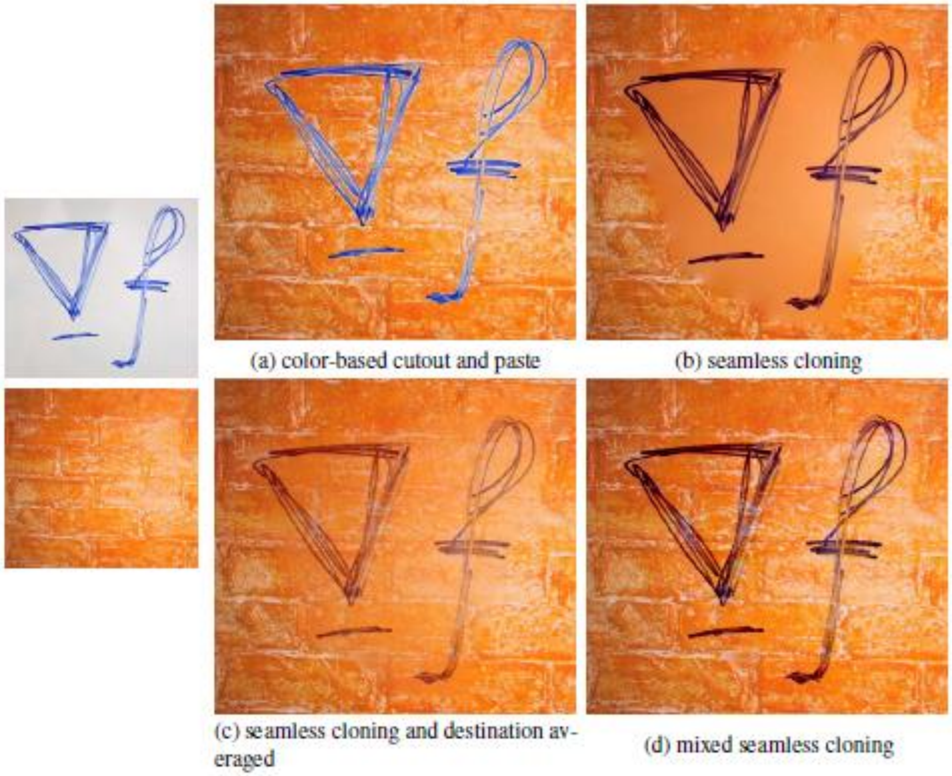
- Foreground color changes
- Background pixels in target region are replaced

sources/destinations — cloning — seamless cloning

Perez et al. 2003

Blending with Mixed Gradients

- Use foreground or background gradient with larger magnitude as the guiding gradient



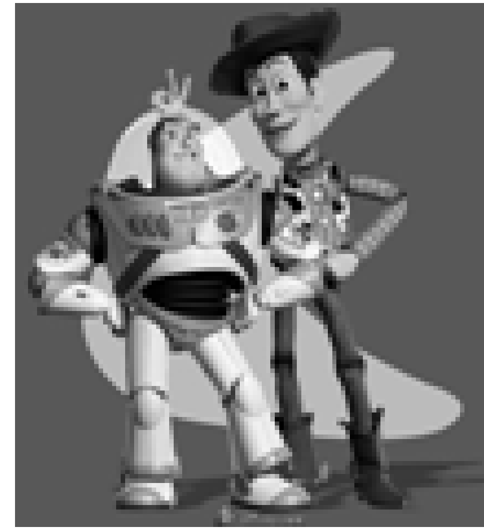
Perez et al. 2003

Project 3: Gradient Domain Editing

General concept: Solve for pixels of new image that satisfy constraints on the gradient and the intensity

- Constraints can be from one image (for filtering) or more (for blending)

Project 3: Reconstruction from Gradients



1. Preserve x-y gradients
2. Preserve intensity of one pixel

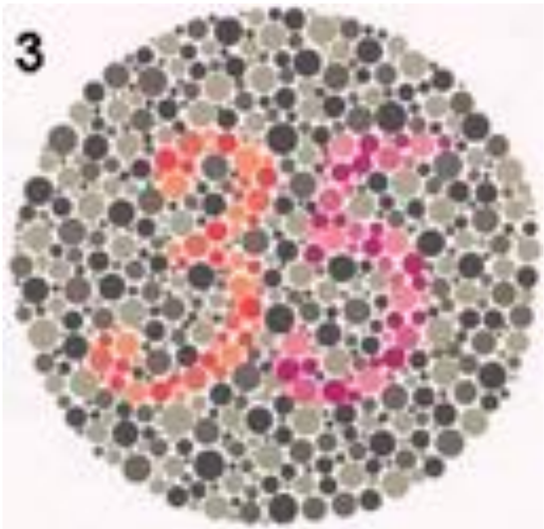
Source pixels: s

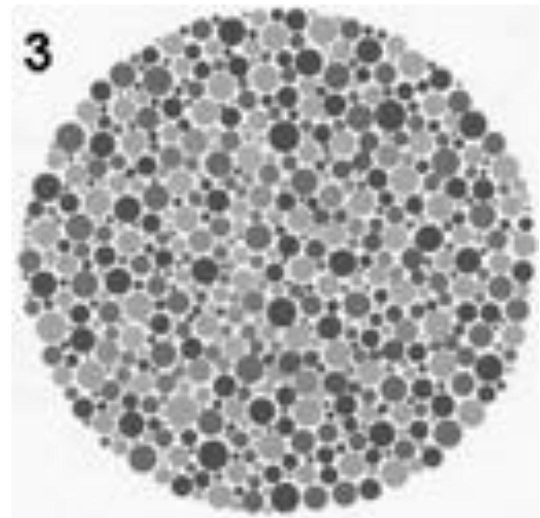
Variable pixels: v

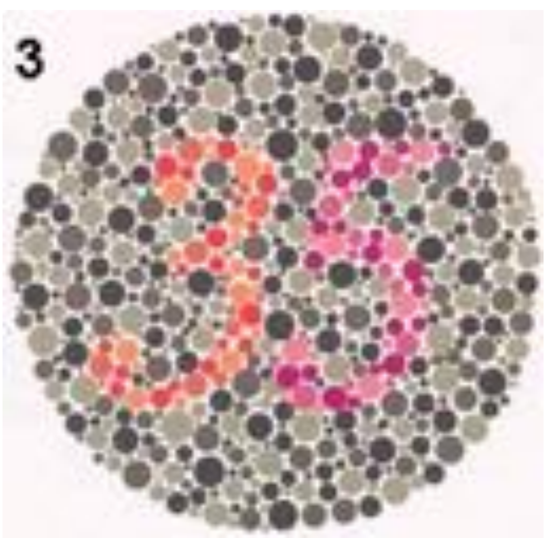
1. minimize (v(x+1,y)-v(x,y) - (s(x+1,y)-s(x,y))^2
2. minimize (v(x,y+1)-v(x,y) - (s(x,y+1)-s(x,y))^2
3. minimize (v(1,1)-s(1,1))^2

Project 3 (extra): Color2Gray

rgb2gray







Gradient-domain
editing

?

Project 3 (extra): NPR

- Preserve gradients on edges
  - e.g., get canny edges with edge(im, ‘canny’)
- Reduce gradients not on edges
- Preserve original intensity

Perez et al. 2003

Colorization using optimization

- Solve for uv channels such that similar intensities have similar colors

- Minimize squared color difference, weighted by intensity similarity

$$J(U) = \sum_{\mathbf{r}} \left(U(\mathbf{r}) - \sum_{\mathbf{s} \in N(\mathbf{r})} w_{\mathbf{rs}} U(\mathbf{s}) \right)^2$$

- Solve with sparse linear system of equations

http://www.cs.huji.ac.il/~yweiss/Colorization/

Things to remember

- Three ways to blend/composite
  1. Alpha compositing
     - Need nice cut (intelligent scissors)
     - Should **feather**
  2. Laplacian pyramid blending
     - **Smooth blending at low frequencies, sharp at high frequencies**
     - Usually used for stitching
  3. Gradient domain editing
     - Also called **Poisson Editing**
     - Explicit control over what to preserve
     - Changes foreground color (for better or worse)
     - Applicable for many things besides blending

Take-home questions

1) I am trying to blend this bear into this pool. What problems will I have if I use:
   a) Alpha compositing with feathering
   b) Laplacian pyramid blending
   c) Poisson editing?

Take-home questions

2) How would you make a sharpening filter using gradient domain processing? What are the constraints on the gradients and the intensities?

Next class

- Image warping: affine, projective, rotation, etc.