Image Stitching II

Linda Shapiro

CSE 455
RANSAC for Homography

Initial Matched Points
RANSAC for Homography

Final Matched Points
RANSAC for Homography
Image Blending

What’s wrong?
Feathering
Effect of window (ramp-width) size
Effect of window size
Good window size

“Optimal” window: smooth but not ghosted

- Doesn’t always work...

What can we do instead?
Pyramid blending

Create a Laplacian pyramid, blend each level

Forming a Gaussian Pyramid

• Start with the original image $G_0$
• Perform a local Gaussian weighted averaging function in a neighborhood about each pixel, sampling so that the result is a reduced image of half the size in each dimension.
• Do this all the way up the pyramid
  $G_l = \text{REDUCE}(G_{l-1})$
• Each level $l$ node will represent a weighted average of a subarray of level $l$. 
Making the Laplacians

- We want to subtract each level of the pyramid from the next lower one.
- But they are different sizes!
- In order to do the subtraction, we perform an interpolation process.
- We interpolate new samples between those of a given image to make it big enough to subtract.
- The operation is called EXPAND.
The Laplacian Pyramid

\[ L_i = G_i - \text{expand}(G_{i+1}) \]

Gaussian Pyramid

\( G_n \)
\( G_2 \)
\( G_1 \)
\( G_0 \)

Laplacian Pyramid

\( L_n = G_n \)
\( L_2 \)
\( L_1 \)
\( L_0 \)
To blend two images, we’ll combine two Laplacian pyramids.

Laplacian Pyramid LA

Laplacian Pyramid LS

to be filled in

Laplacian Pyramid LB
Forming the New Pyramid

- Laplacian pyramids LB and LB are constructed for images A and B, respectively.
- A third Laplacian pyramid LS is constructed by copying nodes from the left half of LA to the corresponding nodes of LS and nodes from the right half of LB to the right half of LS.
- Nodes along the center line are set equal to the average of corresponding LA and LB nodes.
Using the new Laplacian Pyramid

• Use the new Laplacian pyramid with the reverse of how it was created to create a Gaussian pyramid.

\[ G_i = L_i + \text{expand}(G_{i+1}) \]

• The lowest level of the new Gaussian pyramid gives the final result.
Laplacian level 4

(c) left pyramid

(g) right pyramid

(k) blended pyramid

Laplacian level 2

(b) left pyramid

(f) right pyramid

(j) blended pyramid

Laplacian level 0

(a) left pyramid

(e) right pyramid

(i) blended pyramid
Multiband blending (IJCV 2007)

1. Compute Laplacian pyramid of images and mask

2. Create blended image at each level of pyramid

3. Reconstruct complete image
Blending comparison (IJCV 2007)

(a) Linear blending

(b) Multi-band blending
Poisson Image Editing

For more info: Perez et al, SIGGRAPH 2003

http://research.microsoft.com/vision/cambridge/papers/perez_siggraph03.pdf
Encoding blend weights: \( I(x,y) = (\alpha R, \alpha G, \alpha B, \alpha) \)

color at \( p = \frac{(\alpha_1 R_1, \alpha_1 G_1, \alpha_1 B_1) + (\alpha_2 R_2, \alpha_2 G_2, \alpha_2 B_2) + (\alpha_3 R_3, \alpha_3 G_3, \alpha_3 B_3)}{\alpha_1 + \alpha_2 + \alpha_3} \)

Implement this in two steps:

1. accumulate: add up the (\( \alpha \) premultiplied) RGB values at each pixel
2. normalize: divide each pixel’s accumulated RGB by its \( \alpha \) value

Optional: see Blinn (CGA, 1994) for details:

http://ieeexplore.ieee.org/iel1/38/7531/00310740.pdf?isNumber=7531&prod=JNL&arnumber=310740&arSt=83&ared=87&arAuthor=Blinn%2C+J.F.
Choosing Seams: Where do we stitch?

- Easy method
  - Assign each pixel to image with nearest center
Choosing seams

• Easy method
  – Assign each pixel to image with nearest center
  – Create a mask:
  – Smooth boundaries ( "feathering"):
  – Composite
Choosing seams

- Better method: dynamic program to find seam along well-matched regions

Gain Compensation: Getting rid of artifacts

- Simple gain adjustment
  - Compute average RGB intensity of each image in overlapping region
  - Normalize intensities by ratio of averages
Recognizing Panoramas

Some of following material from Brown and Lowe 2003 talk
Recognizing Panoramas

Input: N images

1. Extract SIFT points, descriptors from all images

2. Find K-nearest neighbors for each point (K=4)

3. For each image
   a) Select M candidate matching images by counting matched keypoints (m=6)
   b) Solve homography $H_{ij}$ for each matched image
Recognizing Panoramas

Input: N images
1. Extract SIFT points, descriptors from all images
2. Find K-nearest neighbors for each point (K=4)
3. For each image
   a) Select M candidate matching images by counting matched keypoints (m=6)
   b) Solve homography $H_{ij}$ for each matched image
   c) Decide if match is valid ($n_i > 8 + 0.3 \cdot n_f$)
Recognizing Panoramas (cont.)

(now we have matched pairs of images)

4. Make a graph of matched pairs
    Find connected components of the graph
Finding the panoramas
Finding the panoramas
Recognizing Panoramas (cont.)

(now we have matched pairs of images)

4. Find connected components

5. For each connected component
   a) Solve for rotation and f
   b) Project to a surface (plane, cylinder, or sphere)
   c) Render with multiband blending
Finding the panoramas