Image Composition

COS 526
Princeton University

Modeled after lecture by Alexei Efros.
Slides by Efros, Durand, Freeman, Hays, Fergus, Lazebnik, Agarwala, Shamir, and Perez.

Image Blending

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

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

Slide credit: A. Efros

Image Composition

Laplacian pyramid blending
Graphcut seams
Poisson cloning

Image Blending

Without Blending

Slide credit: A. Efros
**Alpha Blending / Feathering**

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

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**Affect of Window Size**

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**Affect of Window Size**

Slide credit: A. Efros

**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\times size of smallest prominent feature

Natural to cast this in the **Fourier domain**
- largest frequency <= 2\times size of smallest frequency
- image frequency content should occupy one “octave” (power of two)

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**What if the Frequency Spread is Wide**

Idea (Burt and Adelson)
- Different window sizes for different frequencies

Method
- Decompose image into octaves (frequency bands)
- Feather each octave with appropriate window size
- Sum feathered octave images to reconstruct blended image

Slide credit: A. Efros
Laplacian Pyramid

Lowpass Images

Bandpass Images

Laplacian Pyramid Blending

Left pyramid

blend

Right pyramid

Laplacian Pyramid Blending

laplacian level 4

laplacian level 2

laplacian level 0

left pyramid

right pyramid

blended pyramid

Laplacian Pyramid Blending

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Problems with blending

Misaligned (moving) objects become ghosts

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Image Composition

Laplacian pyramid blending
Graph cut seams
Poisson cloning

Graph Cuts

General idea
• Single source image per segment (avoids blurring)
• Careful cut placement, plus optional blending (avoids seams)

Graph Cuts in Texture Synthesis

overlapping blocks  \rightarrow  vertical boundary

\begin{array}{c}
\text{overlap error} \\
\mathbf{2}
\end{array}

min. error boundary

Graph Cuts in Image Segmentation

Lazy Snapping
Interactive segmentation using graphcuts

Graph Cut Algorithm

Minimum cost cut can be computed in polynomial time
(max-flow/min-cut algorithms)

Boykov&Jolly, ICCV’01
Graph cuts in Image Retargeting

Seam Carving

Cropping  Seam Carving  Scaling  Shamir

Seam Carving

Shamir

Seam Carving

Shamir

Seam Carving

Shamir

Seam Carving

Shamir
Problem with graph cuts
What if colors/intensities are different?

Image Composition
Laplacian pyramid blending
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Gradient domain image editing
Motivation:
Human visual system is very sensitive to gradient
Gradient encode edges and local contrast quite well

Approach:
Edit in the gradient domain
Reconstruct image from gradient

Gradient domain image editing

Seamless Poisson cloning
Given vector field $\nu$ (pasted gradient), find the value of $f$ in unknown region that optimizes:
$$\min_f \int_{\Omega} |\nabla f - \nu|^2 \text{ with } f|_{\partial\Omega} = f^*|_{\partial\Omega}$$

Slide credit: F. Durand
Discrete Poisson solver

Minimize variational problem

\[ \min \int_{\Omega} |\nabla f - \nabla \tilde{f}|^2 \text{ with } f|_{\partial \Omega} = \tilde{f}|_{\partial \Omega} \]

\[ \min_{f} \sum_{(p,q) \in \Omega \times \Omega} (f_p - f_q - v_{pq})^2 \text{, with } f_p = f_q \text{, for all } p \in \partial \Omega \]

Rearrange and call \( N_p \) the neighbors of \( p \)

for all \( p \in \Omega \),

\[ |N_p| f_p - \sum_{q \in N_p} f_q = \sum_{q \in N_p} f_q' + \sum_{q \in N_p} v_{pq} \]

Big yet sparse linear system

Slide credit: F. Durand

Image Composition Results

Putting it all together

Compositing images

- Have a clever blending function
  - Feathering
  - Laplacian pyramid
  - Poisson cloning
- Choose the right pixels from each image
  - Graphcuts

Now, let’s put it all together:

- Photomontage [Agarwala et al. 2004]
- Scene Completion [Hayes et al. 2007]

Slide credit: A. Efros

Figure 2: Concealment. By importing seamlessly a piece of the background, complex objects, parts of objects, and undesirable artifacts can easily be hidden. In both examples, multiple strokes (not shown) were used.

Slide credit: A. Efros

Interactive Digital Photomontage

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

Slide credit: A. Efros
Interactive Digital Photomontage

Scene Completion Using Millions of Photographs

James Hays and Alexei A. Efros
SIGGRAPH 2007

Slides by J. Hays and A. Efros
Scene Matching for Image Completion
Data

2.3 Million unique images from Flickr groups and keyword searches.

The Algorithm

Input image → Scene Descriptor → Image Collection

20 completions
Context matching + blending
200 matches

Scene Matching

Scene Completion Result

Context Matching

… 200 total
Summary

Compositing images
- Have a clever blending function
  - Feathering
  - Laplacian pyramid
  - Poisson cloning
- Choose the right pixels from each image
  - Graphcuts

Applications:
- Interactive Digital Photomontage
- Scene completion from millions of images

Slide credit: A. Efros