Announcements

• Presentation schedule is out
• Project proposals due September 9th
  • Project goal and scope
  • Paper(s) you plan to implement, priority order
  • Resources (code on the web, tutorials, etc.)
  • Where you plan to get data
  • A couple of pages
Today: Image Completion

- Object removal by example-based inpainting
- Image completion with structure propagation
- Image completion using millions of photographs
Fundamental issue: Texture vs. structure
Recall: Hole Filling by Texture Synthesis

- The filling order is crucial
“Onion skin” filling order
Standard fill order: “onion skin”

Original image  Image with hole  Filling in “onion skin” order
Fill Order

• In what order should we fill the pixels?
  – choose pixels that have more neighbors filled
  – choose pixels that are continuations of lines/curves/edges
Image Completion by Example-Based Inpainting

A. Criminisi, P. Perez, and K. Toyama, CVPR 2003
Criminisi et al. Algorithm

- Assign each patch $p$ a priority value $P(p)$ that is a product of a confidence term $C(p)$ and data term $D(p)$:

$$P(p) = C(p)D(p)$$

**Confidence term:**

$$C(p) = \frac{\sum_{q \in \Psi_p \cap \Omega} C(q)}{|\Psi_p|}$$

**Data term:**

$$D(p) = \frac{|\nabla I_p^\perp \cdot n_p|}{\alpha}$$
Summary of algorithm

- Extract the initial fill front and priority values
- Repeat until no more unfilled pixels remain:
  - Find target patch with maximum priority
  - Find source patch that most closely matches the target patch
  - Paste source patch into target location
  - Update fill front and priority values
Inpainting Examples

http://research.microsoft.com/vision/cambridge/i3l/patchworks.htm
Inpainting Examples

http://research.microsoft.com/vision/cambridge/i3l/patchworks.htm
Object Removal

http://research.microsoft.com/vision/cambridge/i3l/patchworks.htm
Image Completion with Structure Propagation

J. Sun, L. Yuan, J. Jia, and H. Shum
SIGGRAPH 2005
Image Completion with Structure Propagation

• The method of Criminisi et al. does not ensure continuity of salient structures such as curves or junctions

• Missing structure is hard to recover automatically, but can be easily specified manually
  – That’s the difference between vision and graphics…
Example results
Comparison with Criminisi et al.
Example results
Comparison with Criminisi et al.
Example results
Comparison with Criminisi et al.
Scene Completion Using Millions of Photographs

James Hays and Alexei A. Efros
SIGGRAPH 2007

Slides by J. Hays and A. Efros
Efros and Leung result
Criminisi et al. result
Criminisi et al. result
Scene Matching for Image Completion
Data

2.3 Million unique images from Flickr groups and keyword searches.
Scene Completion Result
Scene Matching
Scene Descriptor

Gist scene descriptor (Oliva and Torralba 2001)
Scene Descriptor

Gist scene descriptor
(Oliva and Torralba 2001)
Scene Descriptor

Gist scene descriptor
(Oliva and Torralba 2001)
Context Matching
Result Ranking

We assign each of the 200 results a score which is the sum of:

- The scene matching distance
- The context matching distance (color + texture)
- The graph cut cost
... 200 scene matches
... 200 scene matches
... 200 scene matches
... 200 scene matches
Failures
Failures
Failures
Failures
Failures
Failures
Failures
Failures
Failures
Failures
Failures
Evaluation
Original Images

Criminisi et al.
Single result

Scene Completion
Each result selected from 20
Real Image. This image has not been manipulated

or

Fake Image. This image has been manipulated
User Study Results - 20 Participants

![Graph showing comparison between Criminisi et al., Our algorithm, and Real Photographs in terms of percentage of images marked as fake versus maximum response time (seconds).]
Image completion: Summary

• The key challenge is propagating the image “structure”

• Approaches:
  – For simple enough problems, the heuristic of extending existing edges (Criminisi et al.) is sufficient
  – For more complex problems, the user should provide the high-level structure information (Sun et al.)
  – Alternatively, high-level information should be obtained from a large database of scenes (Hays and Efros)
Project Idea: Image De-Fencing