COMP 790-096: Computational Photography



Basic Info

Instructor:

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Class webpage:

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Fundamental issue: Texture vs. structure



Recall: Hole Filling by Texture Synthesis



Boundary of the hole

• 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):

$$P(\mathbf{p}) = C(\mathbf{p})D(\mathbf{p})$$



Confidence term:

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

Data term:

$$D(\mathbf{p}) = \frac{|\boldsymbol{\nabla} I_{\mathbf{p}}^{\perp} \cdot \mathbf{n}_{\mathbf{p}}|}{\alpha}$$

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



Inpainting Examples



Inpainting Examples



Object Removal



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



oogle	P [™] allev	Search Images	Search the Web	Advanced Image Search
	Strict SafeSearch is on			Preferences

All image sizes Images Showing:

Results 1 - 20 of about 908,000 for alley [definition] with Safesearch on. (0.07 seconds)





Change Alley Aerial Plaza with its The Printer's Alley sign looking ... Looking west past Printers Alley. 679 x 450 - 469k - jpg 300 x 400 - 21k franklin.thefuntimesquide.com

×



679 x 450 - 464k - jpg franklin.thefuntimesguide.com



More Bubble Gum Alley photos can be ... 764 x 591 - 33k - gif www.locallinks.com



Gasoline Alley gang 692 x 430 - 177k - jpg newcritics.com



en.wikipedia.org

2007 Alley Loop Sponsors 300 x 453 - 51k - jpg www.cbnordic.org



Change Alley : interior 550 x 413 - 98k infopedia.nlb.gov.sg



Earl G. Alley ... 321 x 383 - 19k - jpg www.msstate.edu



Gun Alley 8.5x11 Full Color Ink Wash ... 390 x 301 - 14k - jpg www.rorschachentertainment.com



Grace Court Alley 732 x 549 - 98k - jpg www.bridgeandtunnelclub.com



Grace Court Alley 732 x 549 - 80k - jpg www.bridgeandtunnelclub.com



panoramic photo of Alligator Alley 4902 x 460 - 1048k - jpg sflwww.er.usgs.gov



Richard B. Alley 450 x 361 - 29k - gif www.ncdc.noaa.gov



Also, Chicken Alley is reported to

450 x 337 - 82k phidoux.typepad.com



Ego Alley 500 x 375 - 48k - jpg dc.about.com



2.3 Million unique images from Flickr groups and keyword searches.







Scene Completion Result

The Algorithm



Input image





Scene Descriptor



Image Collection



20 completions



Context matching + blending



200 matches

Scene Matching






Gist scene descriptor (Oliva and Torralba 2001)



Gist scene descriptor (Oliva and Torralba 2001)



Gist scene descriptor (Oliva and Torralba 2001)





... 200 total



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

Top 20 Results






































































































































































... 200 scene matches











































Evaluation





Original Images



Criminisi et al.

Single result

ÎI 1

Scene Completion

Each result selected from 20



Each result selected from 20





or

Fake Image. This image has been manipulated







User Study Results - 20 Participants



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



• Y. Liu, T. Belkina, J. Hays, and R. Lublinerman, <u>"Image De-Fencing,"</u> CVPR 2008