Scene Completion Using Millions of Photographs

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Since 1699, when French explorers landed at the great bend of the Mississippi River and celebrated the first New Year there in North America, New Orleans has brewed a fascinating melange of cultures. It was French, then Spanish, then French again, then sold to the United States. Through all these years, and even into the 1900s, others arrived from everywhere: Acadians (Cajuns), Africans, indige-

Diffusion Result

Hays and Efros, SIGGRAPH 2007
Efros and Leung result

Hays and Efros, SIGGRAPH 2007
Criminisi et al. result
Criminisi et al. result

Hays and Efros, SIGGRAPH 2007
Microsoft Digital Image Pro Smart erase result

Hays and Efros, SIGGRAPH 2007

Jian Sun, Lu Yuan, Jiaya Jia and Heung-Yeung Shum. 
Image Completion with Structure Propagation. SIGGRAPH 2005 

Hays and Efros, SIGGRAPH 2007
Jian Sun, Lu Yuan, Jiaya Jia and Heung-Yeung Shum. Image Completion with Structure Propagation. SIGGRAPH 2005
Scene Matching for Image Completion

Hays and Efros, SIGGRAPH 2007
Scene Completion result by Linda Fong
The Algorithm

Input image → Scene Descriptor → Image Collection

20 completions → Context matching + blending → 200 matches

Hays and Efros, SIGGRAPH 2007
Data

We downloaded **2.3 Million** unique images from Flickr groups and keyword searches.
Scene Matching
Scene Descriptor
Scene Descriptor

Gist scene descriptor
(Oliva and Torralba 2001)
Scene Descriptor

Gist scene descriptor
(Oliva and Torralba 2001)

Hays and Efros, SIGGRAPH 2007
Scene Descriptor

+ Gist scene descriptor

(Oliva and Torralba 2001)

Hays and Efros, SIGGRAPH 2007
Graph cut + Poisson blending
Result Ranking

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

1. The scene matching distance
2. The context matching distance (color + texture)
3. The graph cut cost

Hays and Efros, SIGGRAPH 2007
Top 20 Results
... 200 scene matches
Hays and Efros, SIGGRAPH 2007
… 200 scene matches

Hays and Efros, SIGGRAPH 2007
... 200 scene matches
... 200 scene matches

Hays and Efros, SIGGRAPH 2007
... 200 scene matches
... 200 scene matches
... 200 scene matches

Hays and Efros, SIGGRAPH 2007
Failures
Failures
Failures
Failures
Failures
Failures
Failures

Hays and Efros, SIGGRAPH 2007
Failures

Hays and Efros, SIGGRAPH 2007
Failures
Failures
Failures
Failures
Evaluation
Criminisi et al.          Scene Completion

Original Images

Criminisi et al.
Single result

Scene Completion
Each result selected from 20

Hays and Efros, SIGGRAPH 2007
Original Images

Criminisi et al.
Single result

Scene Completion
Each result selected from 20

Hays and Efros, SIGGRAPH 2007
Real Image. This image has not been manipulated

or

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

Criminisi et al.

Our algorithm

Real Photographs

Hays and Efros, SIGGRAPH 2007
Why does it work?
10 nearest neighbors from a collection of 20,000 images

Hays and Efros, SIGGRAPH 2007
10 nearest neighbors from a collection of 2 million images

Hays and Efros, SIGGRAPH 2007
Database of 70 Million 32x32 images

The Small Picture

Pixels

Image Collection

Pixels + Semantics

Hays and Efros, SIGGRAPH 2007
Expert-supplied Semantics

Hays and Efros, SIGGRAPH 2007
Hybrid Solution?

Hays and Efros, SIGGRAPH 2007
The Big Picture

Sky, Water, Hills, Beach, Sunny, mid-day

Brute-force Image Understanding

Hays and Efros, SIGGRAPH 2007