

CSCE 448/748 - Computational Photography

Image Analogies & Scene Completion

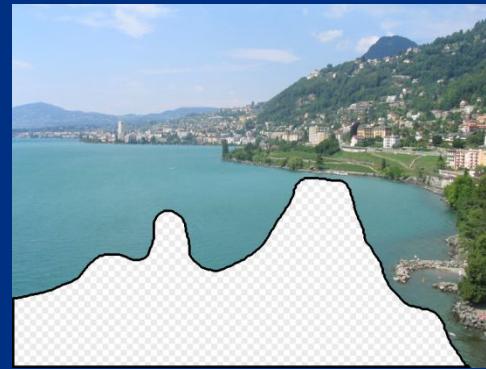
Nima Kalantari

Slides by Hertzmann et al. and Hays and Efros

Scene Completion Using Millions of Photographs



SIGGRAPH2007



James Hays and Alexei A. Efros

Carnegie Mellon University

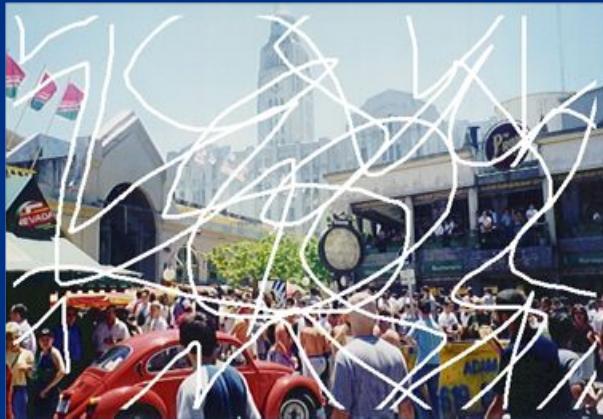




Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007

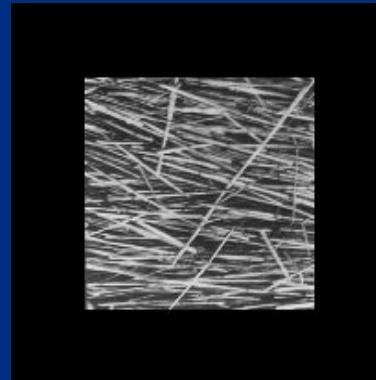
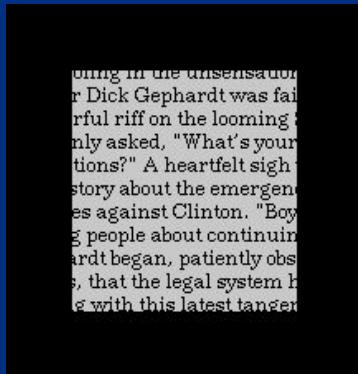


Bertalmio, Sapiro, Caselles, and Ballester.
Image Inpainting. SIGGRAPH 2000.

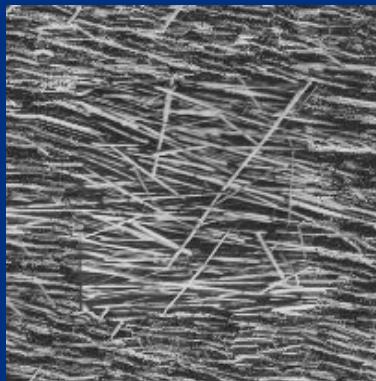


Diffusion Result

Hays and Efros, SIGGRAPH 2007



coming in the unsensational
r Dick Gephardt was fail-
rful riff on the looming
only asked, "What's your
tions?" A heartfelt sigh
story about the emergen-
es against Clinton. "Boys
g people about continuing
ardt began, patiently ob-
s, that the legal system ha-
g with this latest tangemem



Efros and Leung. Texture synthesis by
non-parametric sampling. ICCV 1999.



Efros and Leung result

Hays and Efros, SIGGRAPH 2007



Microsoft Digital Image Pro Smart erase result

Hays and Efros, SIGGRAPH 2007



Photoshop Content Aware Fill



Hays and Efros, SIGGRAPH 2007



Road

Scene Matching for Image Completion



Images

Showing: All image sizes ▾

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

franklin.thefuntimesguide.com

679 x 450 - 464k - jpg

franklin.thefuntimesguide.com

More Bubble Gum Alley photos

can be ...

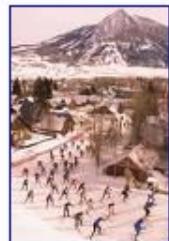
764 x 591 - 33k - gif

www.locallinks.com

Gasoline Alley gang

692 x 430 - 177k - jpg

newcritics.com



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

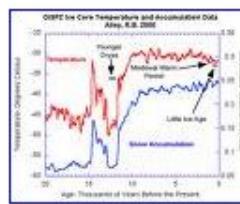


Grace Court Alley

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

Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007



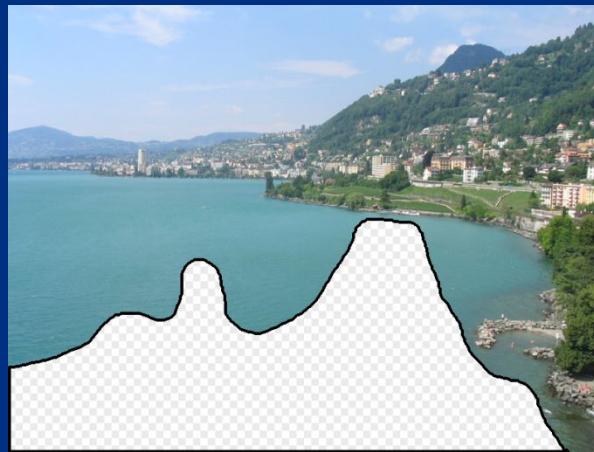
Scene Completion Result

Hays and Efros, SIGGRAPH 2007

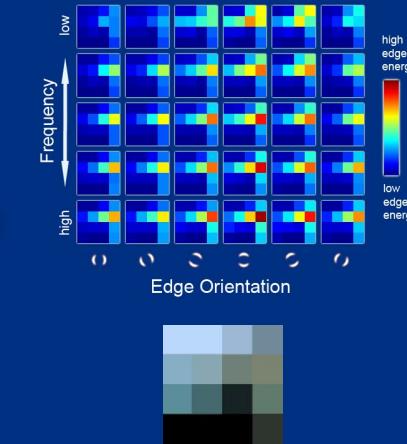


Scene Completion result by Linda Fong

The Algorithm



Input image



Scene Descriptor



Image Collection



20 completions



Context matching
+ blending



200 matches

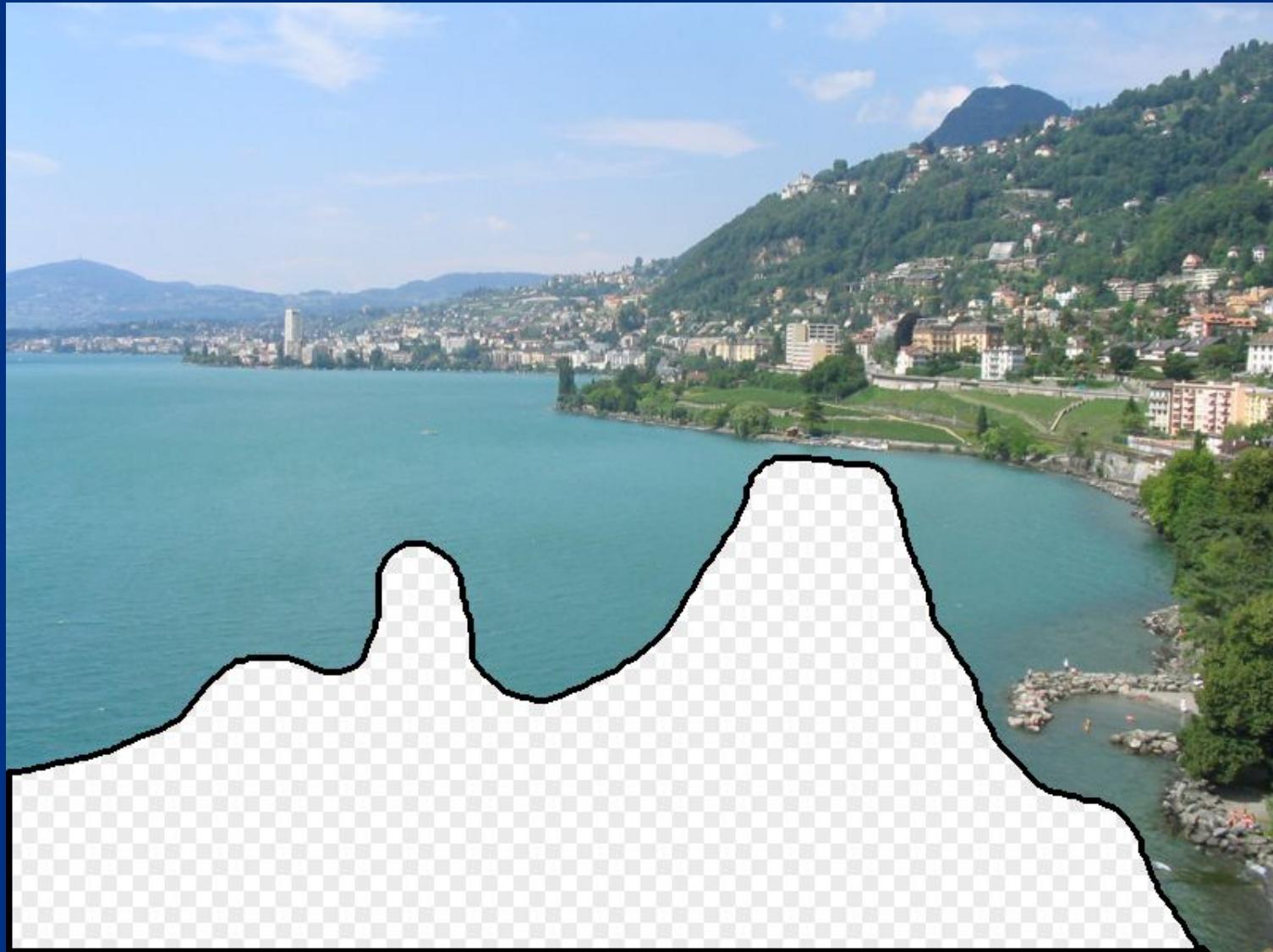
Hays and Efros, SIGGRAPH 2007

Data

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



Scene Matching



Demo : Rapid image understanding

By Aude Oliva

Instructions: 9 photographs will be shown for half a second each. Your task is to **memorize these pictures**



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba



Credit: Antonio Torralba

Memory Test

Which of the following pictures have you seen ?

**If you have seen the image
clap your hands once**

**If you have not seen the image
do nothing**



Have you seen this picture ?

Credit: Antonio Torralba



Credit: Antonio Torralba



Have you seen this picture ?

Credit: Antonio Torralba



Credit: Antonio Torralba



Have you seen this picture ?

Credit: Antonio Torralba



Credit: Antonio Torralba



Have you seen this picture ?

Credit: Antonio Torralba



Credit: Antonio Torralba



Have you seen this picture ?

Credit: Antonio Torralba



Credit: Antonio Torralba



Have you seen this picture ?

Credit: Antonio Torralba

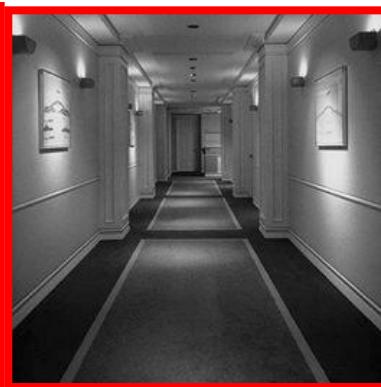


Credit: Antonio Torralba

You have seen these pictures



You were tested with these pictures



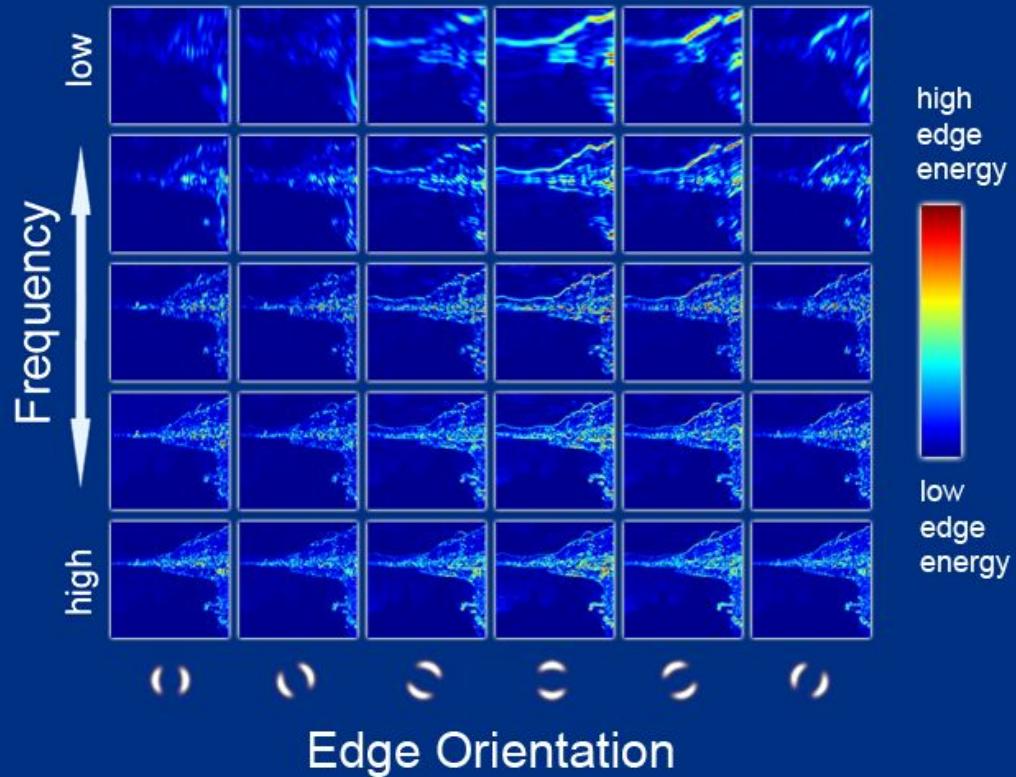
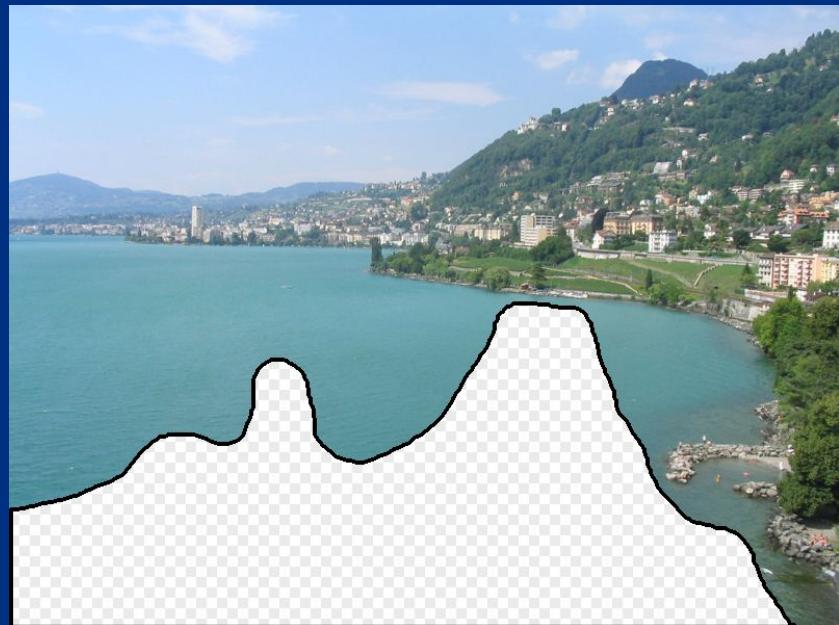
The gist of the scene

In a glance, we remember the meaning of an image and its global layout but some objects and details are forgotten

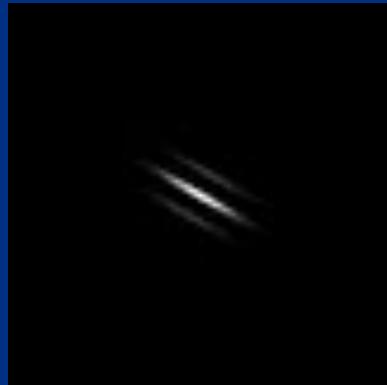


Credit: Antonio Torralba

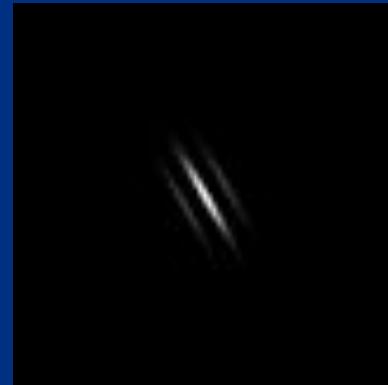
Scene Descriptor



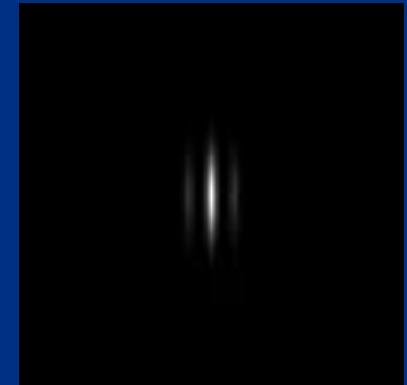
Filter kernels



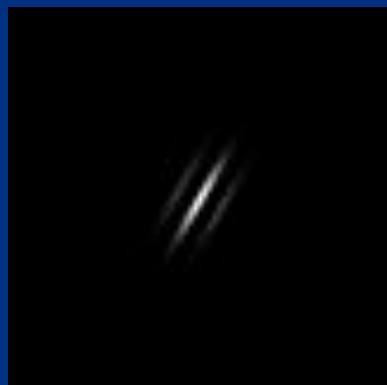
-60°



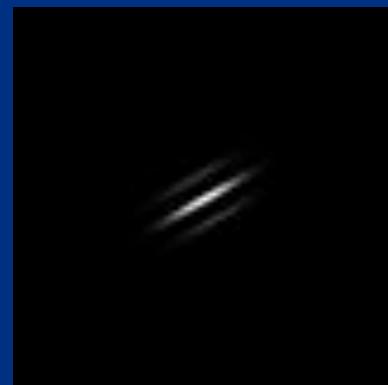
-30°



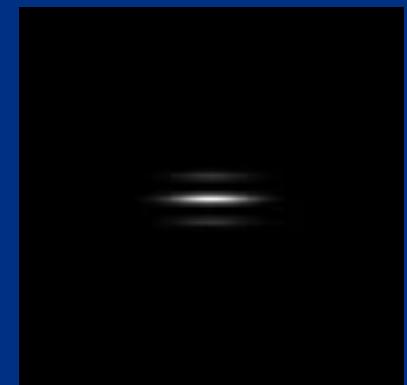
0°



30°

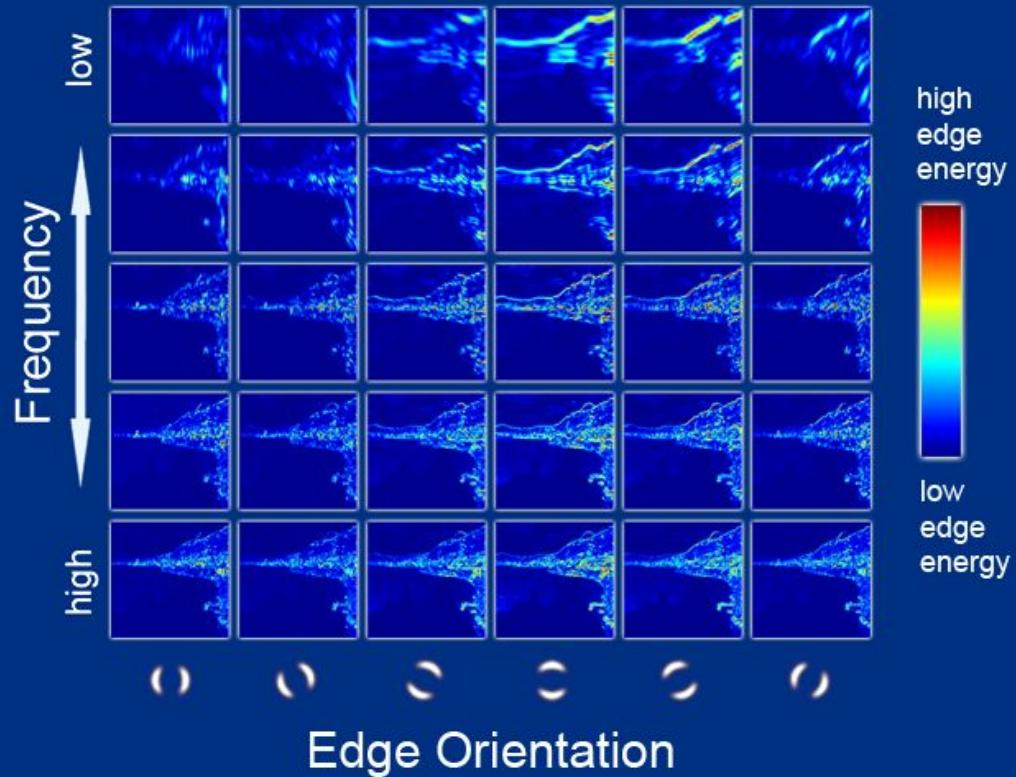
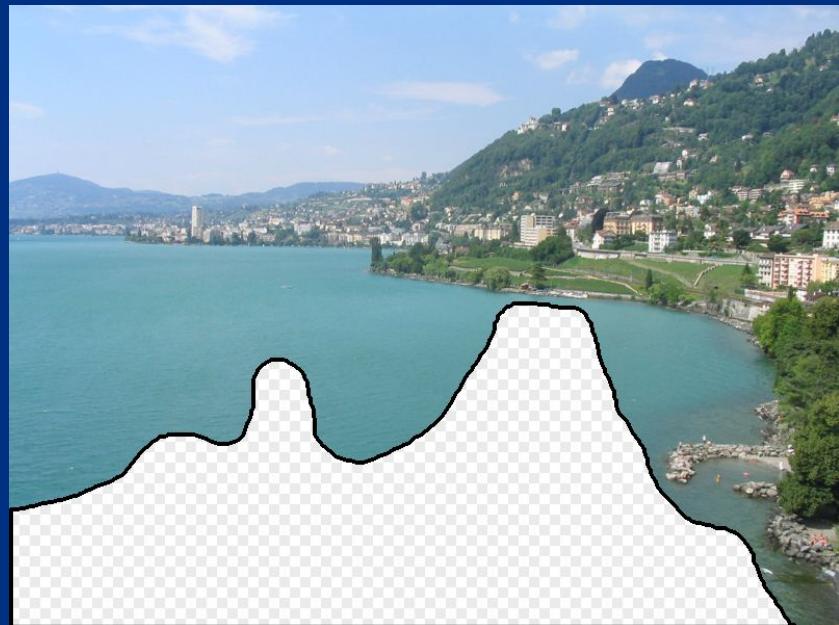


60°

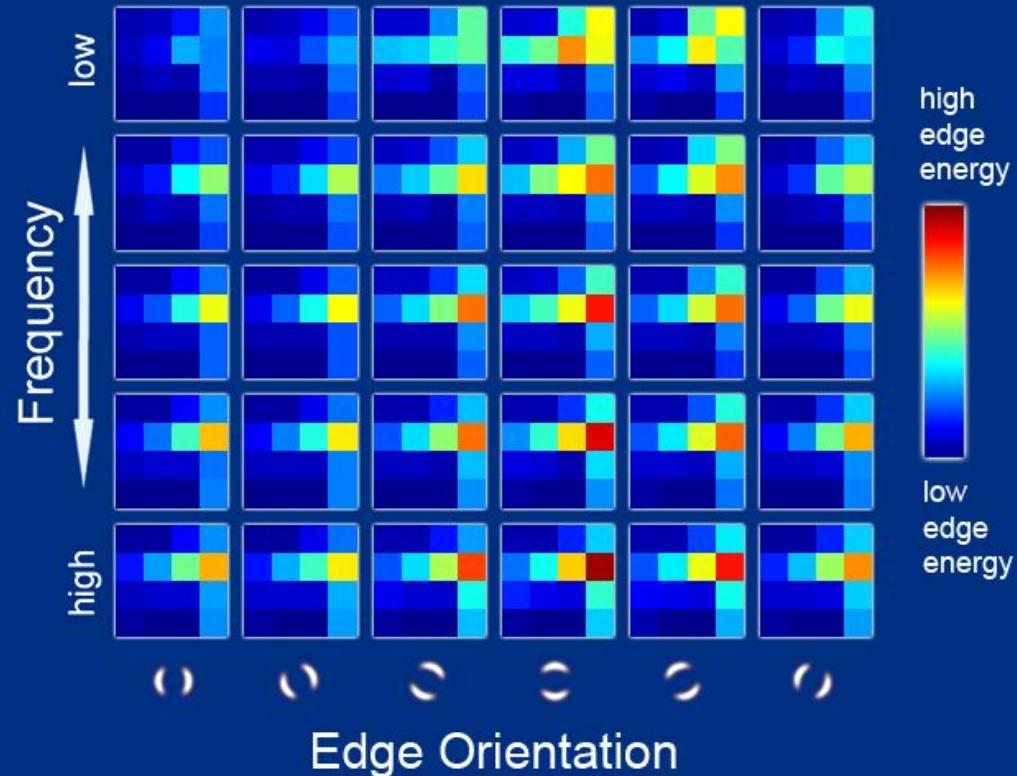
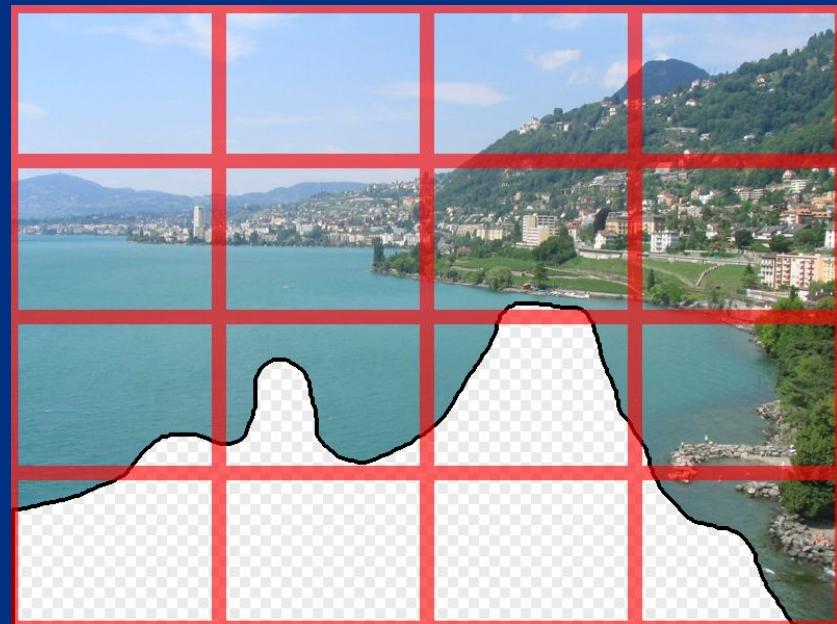


90°

Scene Descriptor



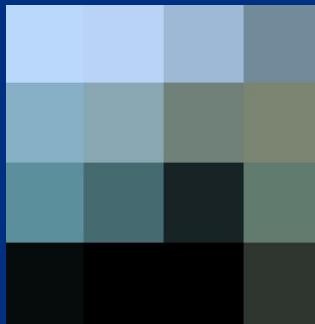
Scene Descriptor



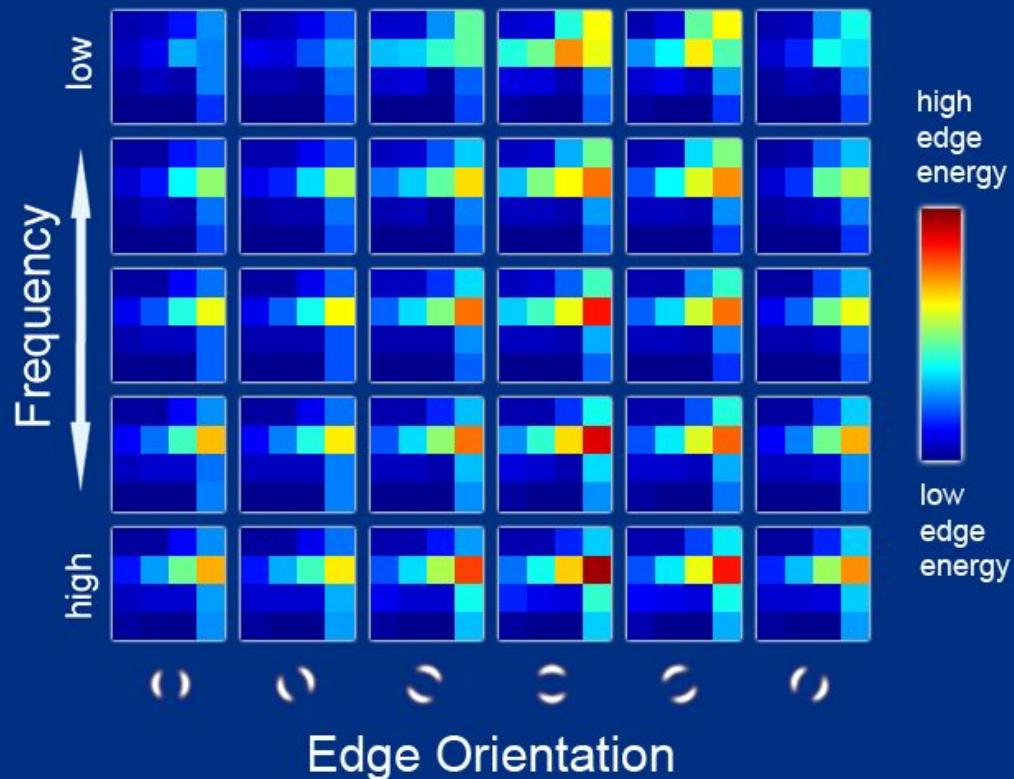
Gist scene descriptor
(Oliva and Torralba 2001)

Hays and Efros, SIGGRAPH 2007

Scene Descriptor



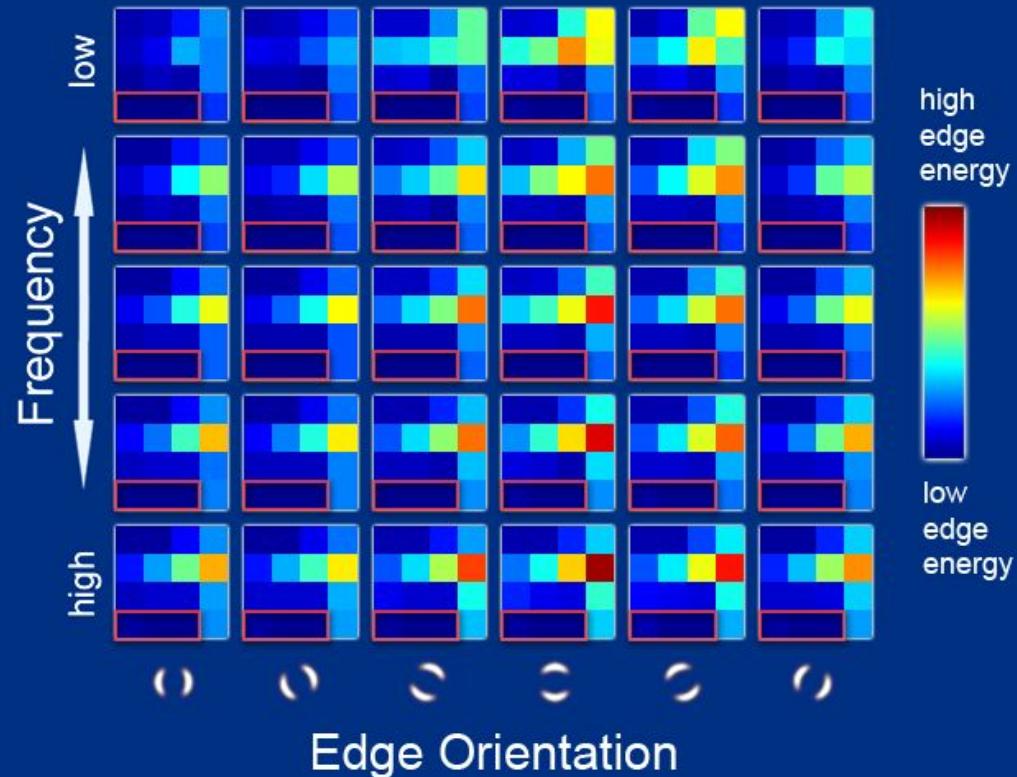
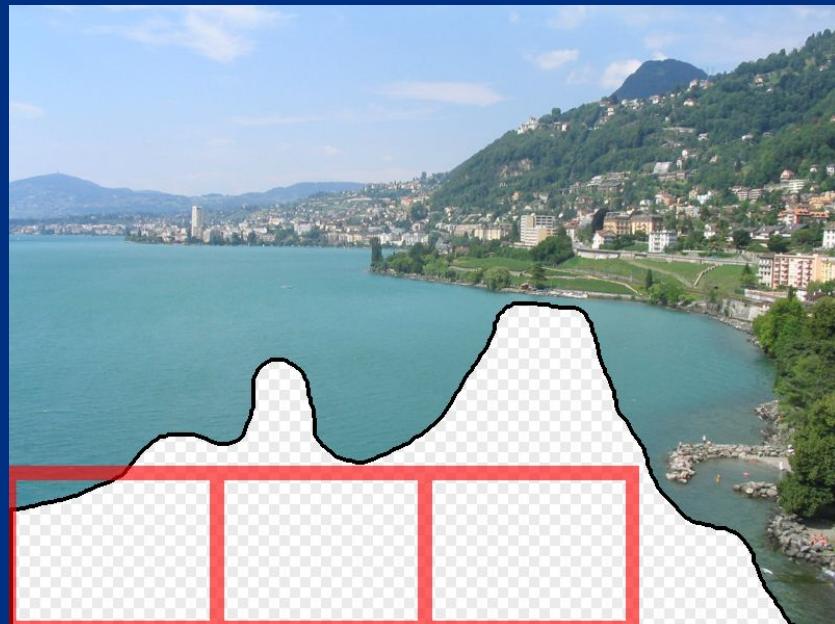
+



Gist scene descriptor
(Oliva and Torralba 2001)

Hays and Efros, SIGGRAPH 2007

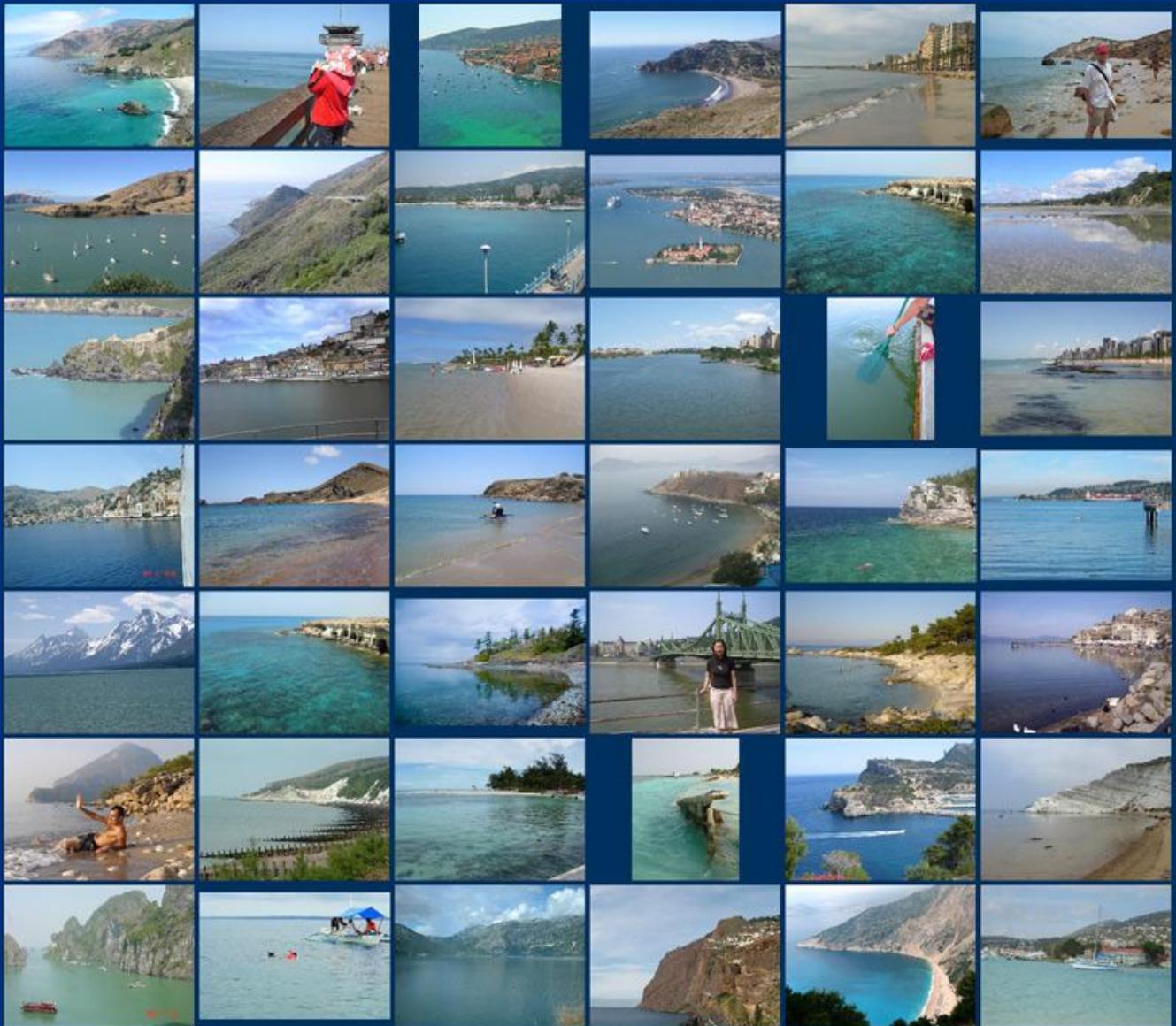
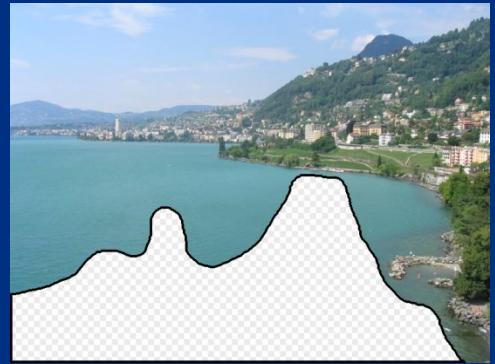
Scene Descriptor



Gist scene descriptor
(Oliva and Torralba 2001)

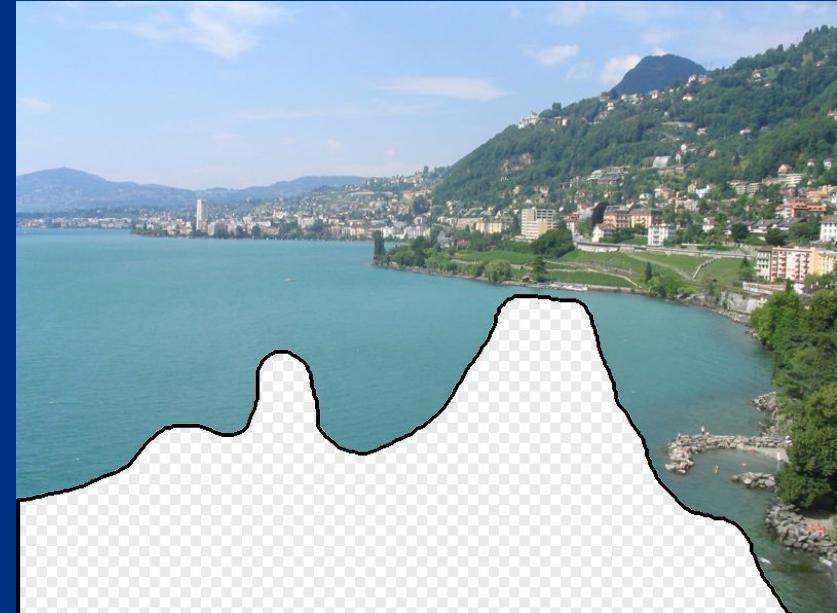
Hays and Efros, SIGGRAPH 2007





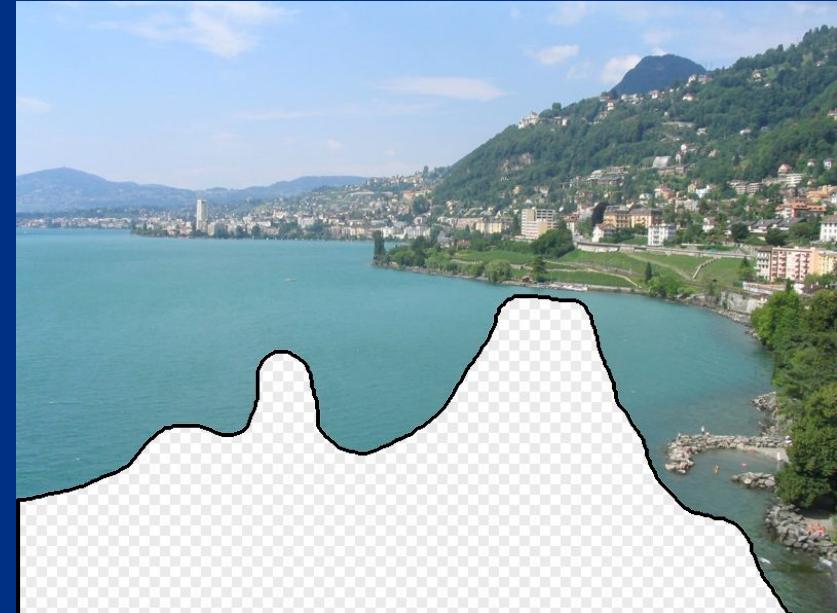
... 200 total

Context Matching





Context Matching



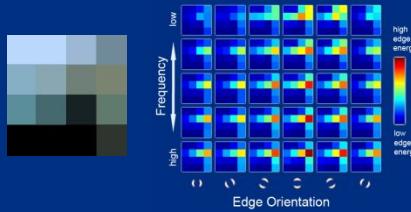


Graph cut + Poisson blending

Hays and Efros, SIGGRAPH 2007

Result Ranking

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



The scene matching distance



The context matching distance



The graph cut cost

Top 20 Results





Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007





Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007





Hays and Efros, SIGGRAPH 2007



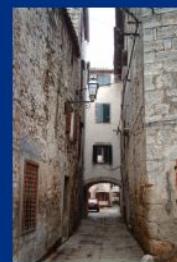
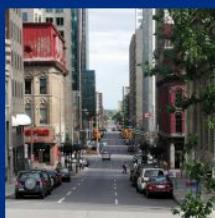
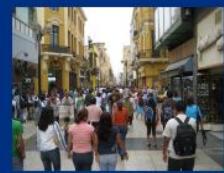
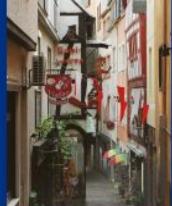
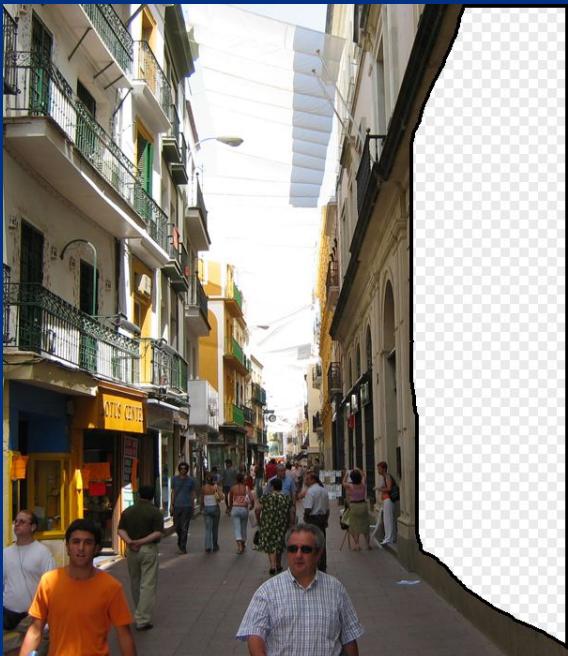
Hays and Efros, SIGGRAPH 2007



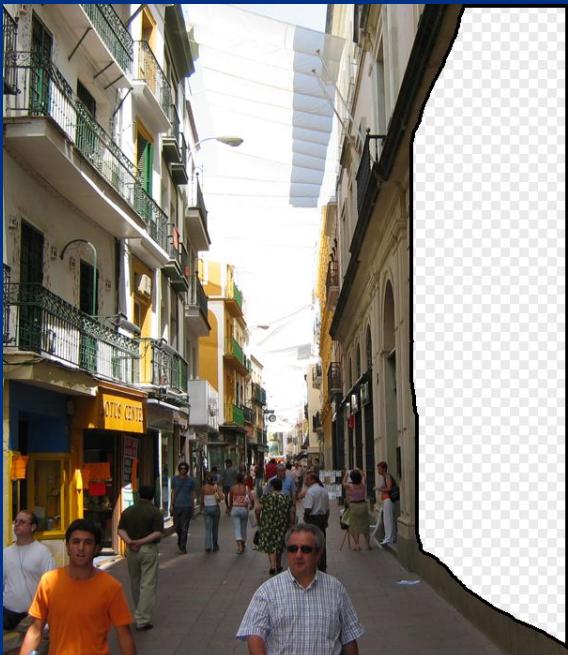
Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007



... 200 scene matches



... 200 scene matches

Hays and Efros, SIGGRAPH 2007

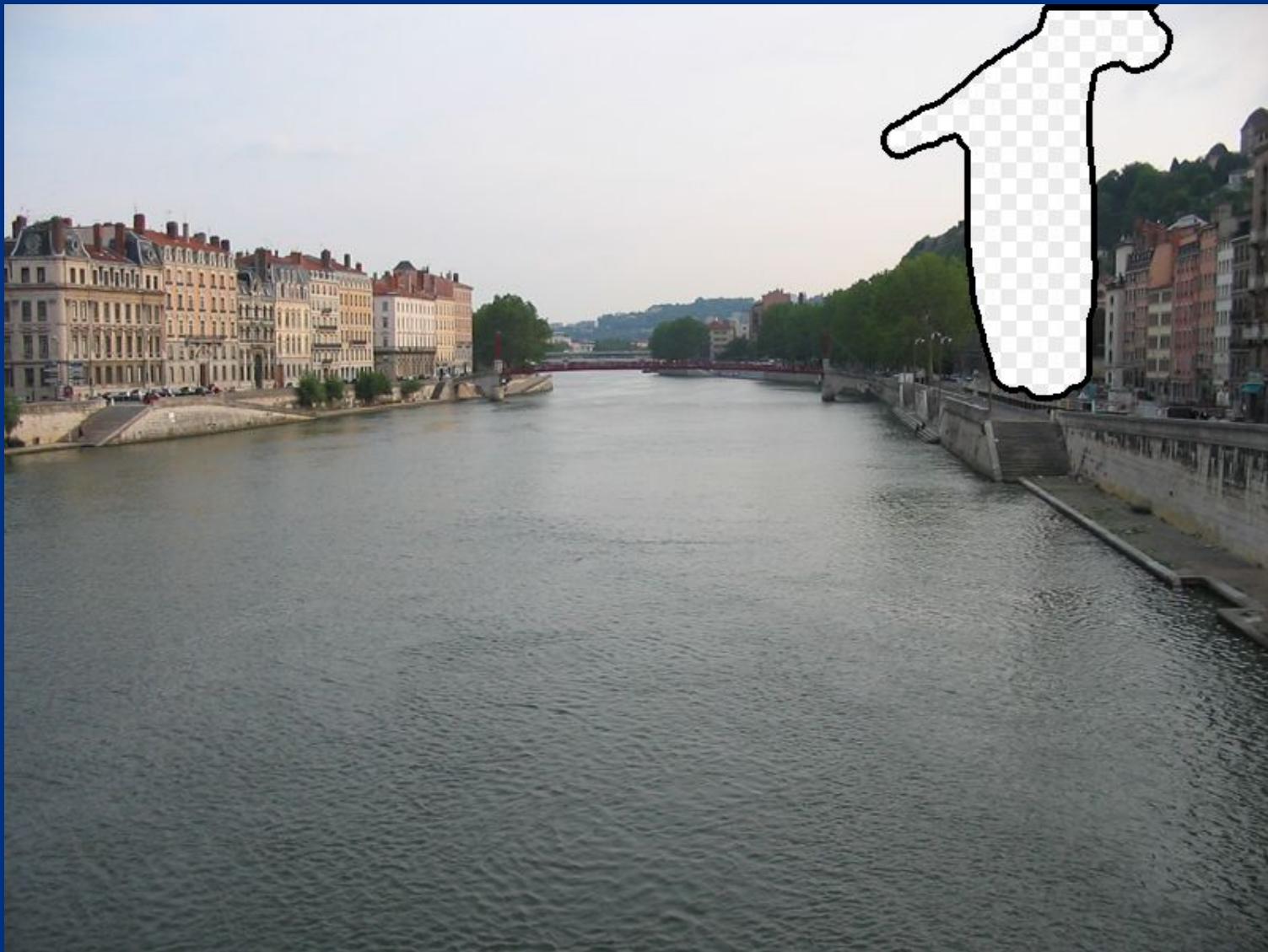


Hays and Efros, SIGGRAPH 2007

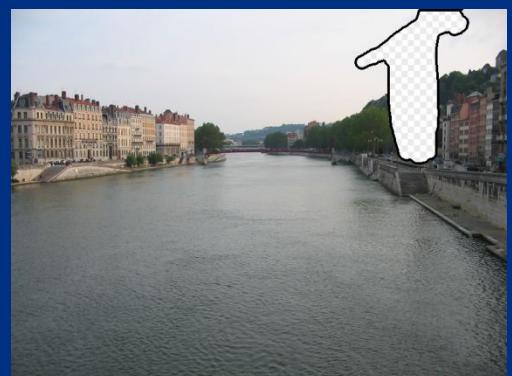


Hays and Efros, SIGGRAPH 2007

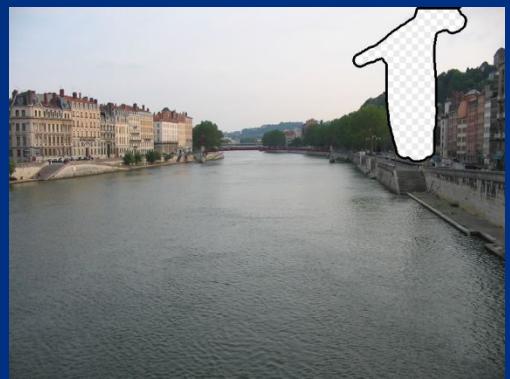




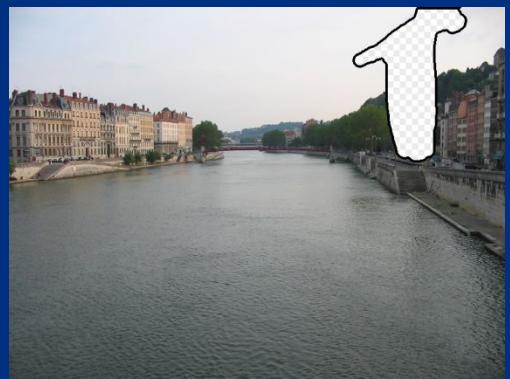




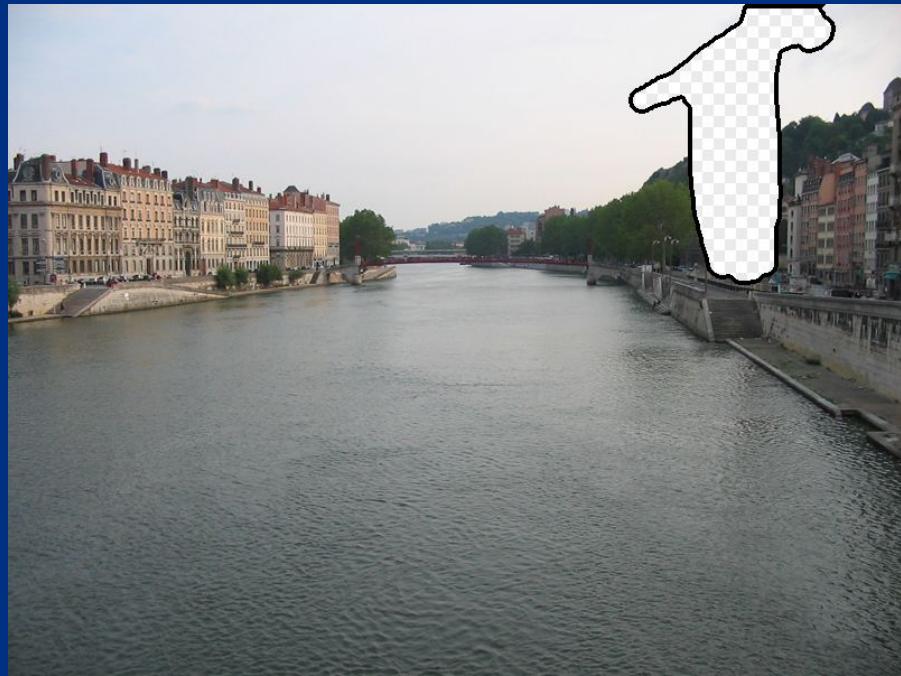
... 200 scene matches



... 200 scene matches



... 200 scene matches



Hays and Efros, SIGGRAPH 2007





Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007



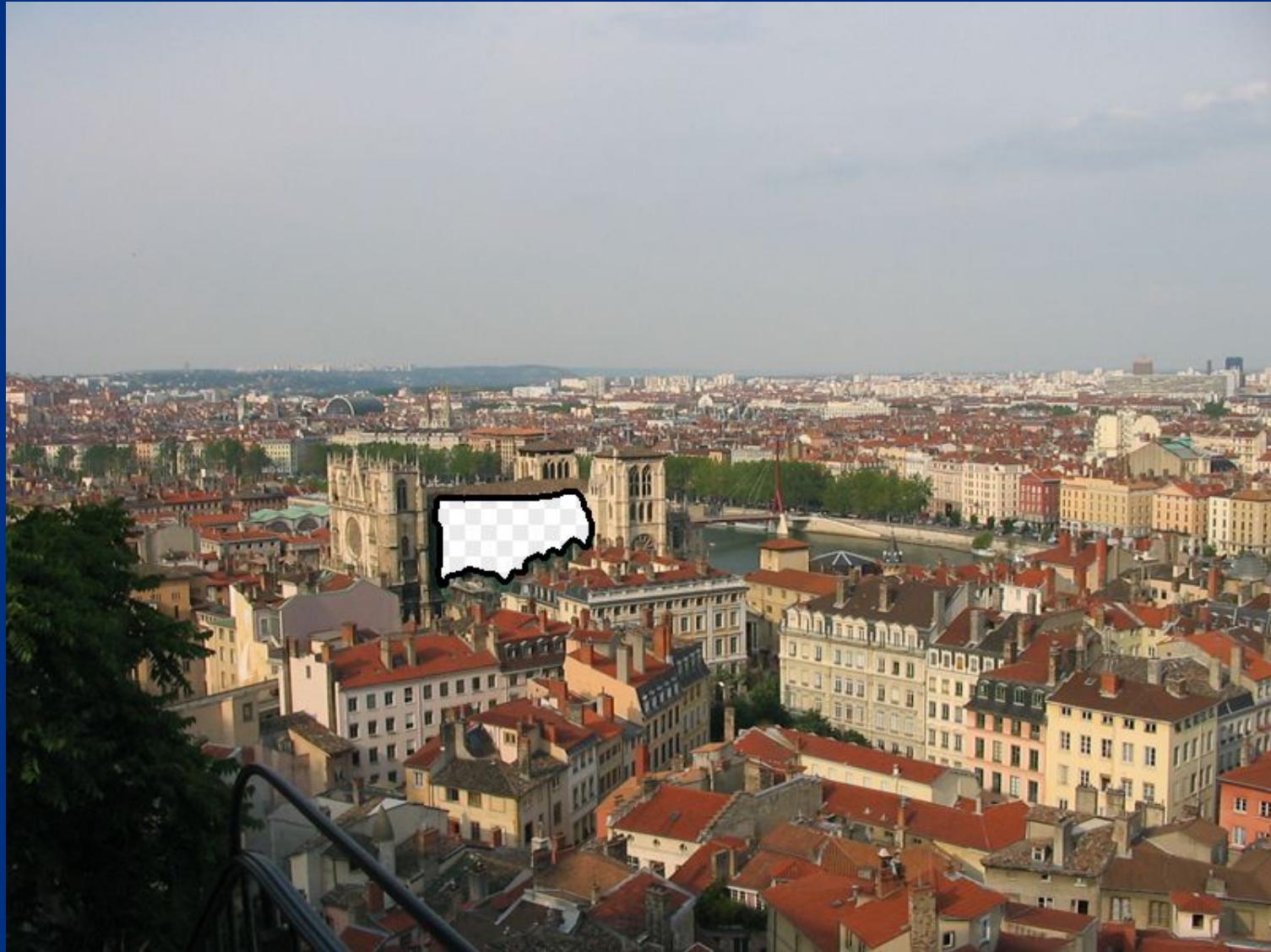


Hays and Efros, SIGGRAPH 2007



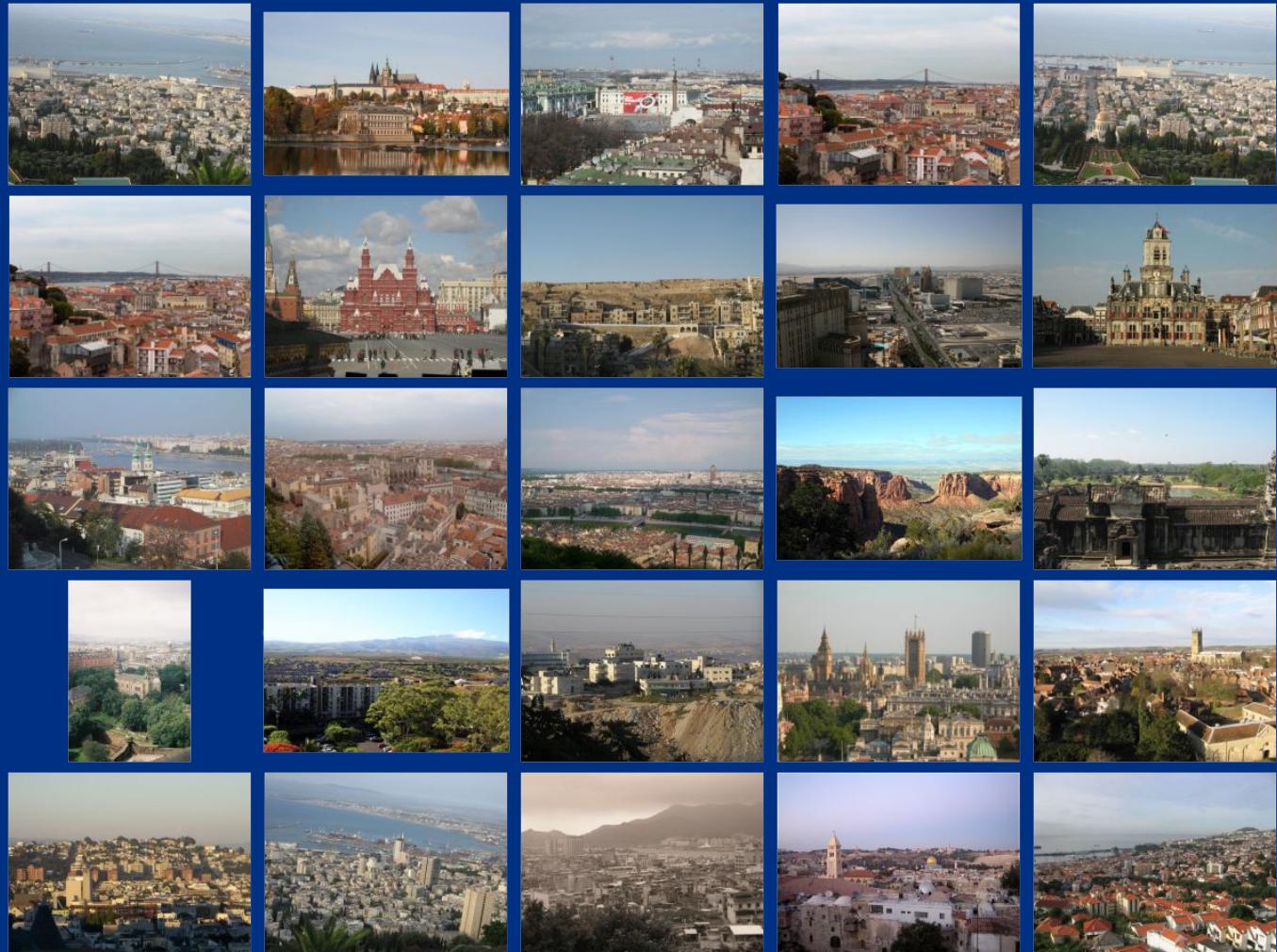
Hays and Efros, SIGGRAPH 2007



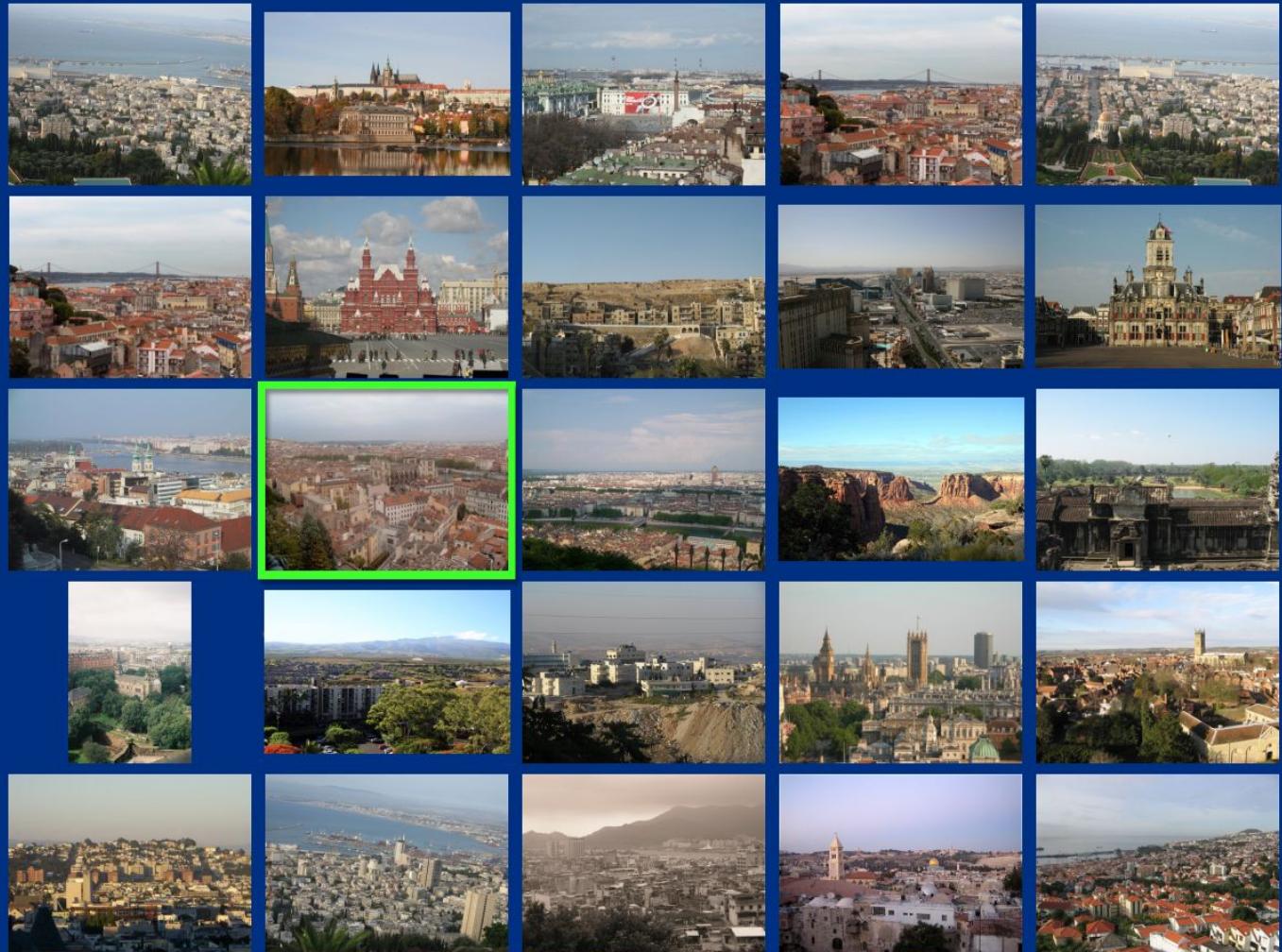


Hays and Efros, SIGGRAPH 2007

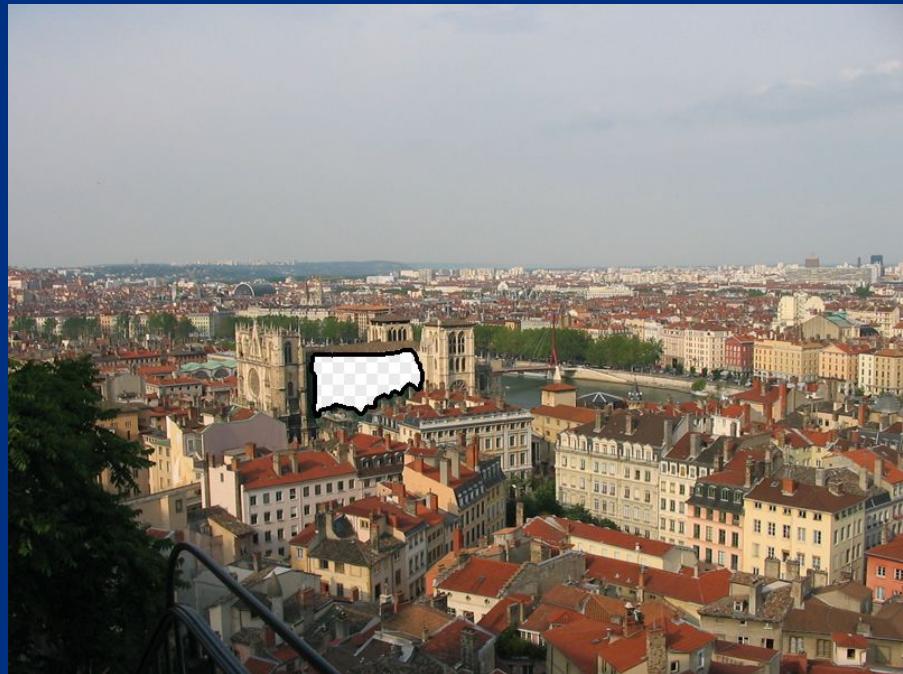




... 200 scene matches



... 200 scene matches



Hays and Efros, SIGGRAPH 2007



Hays and Efros, SIGGRAPH 2007

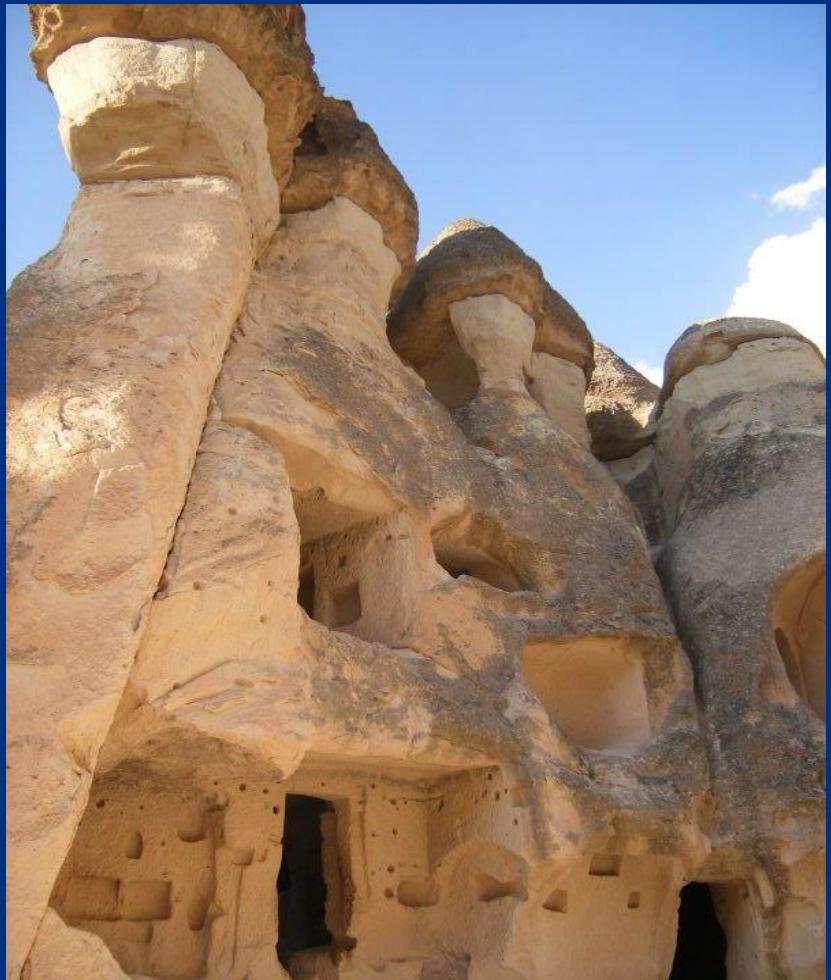
Failures



Failures



Failures



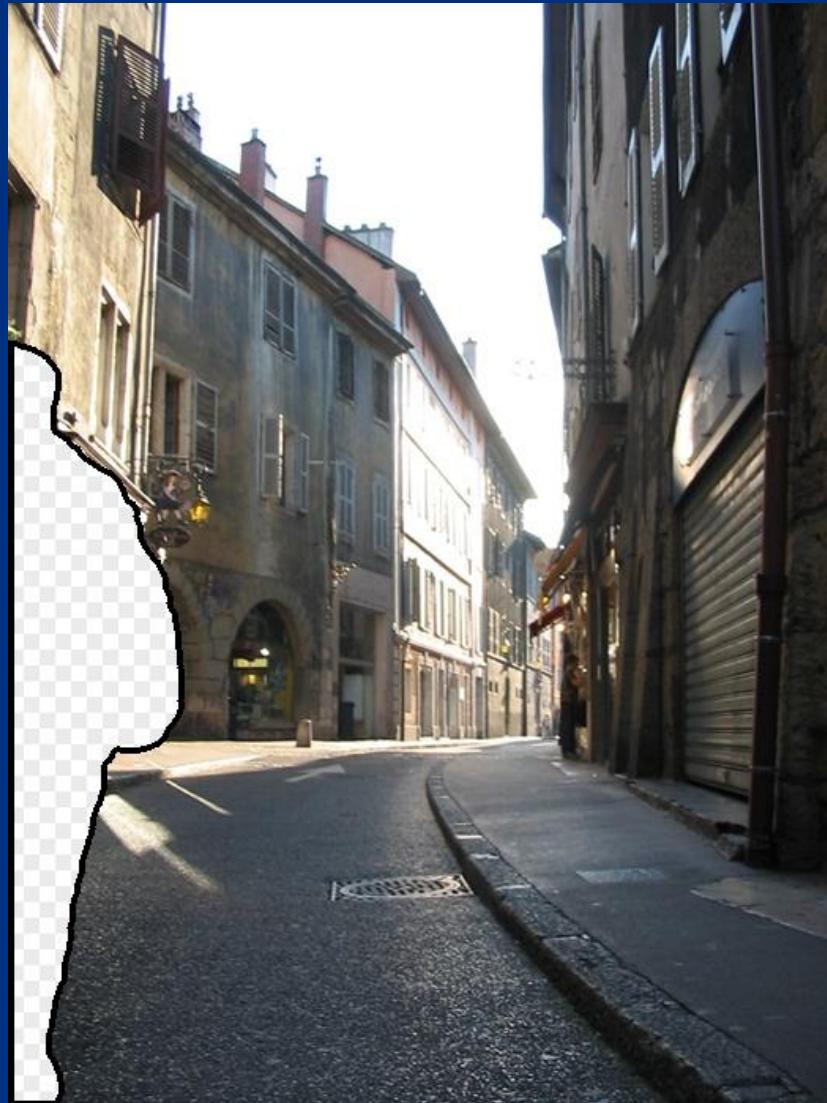
Failures



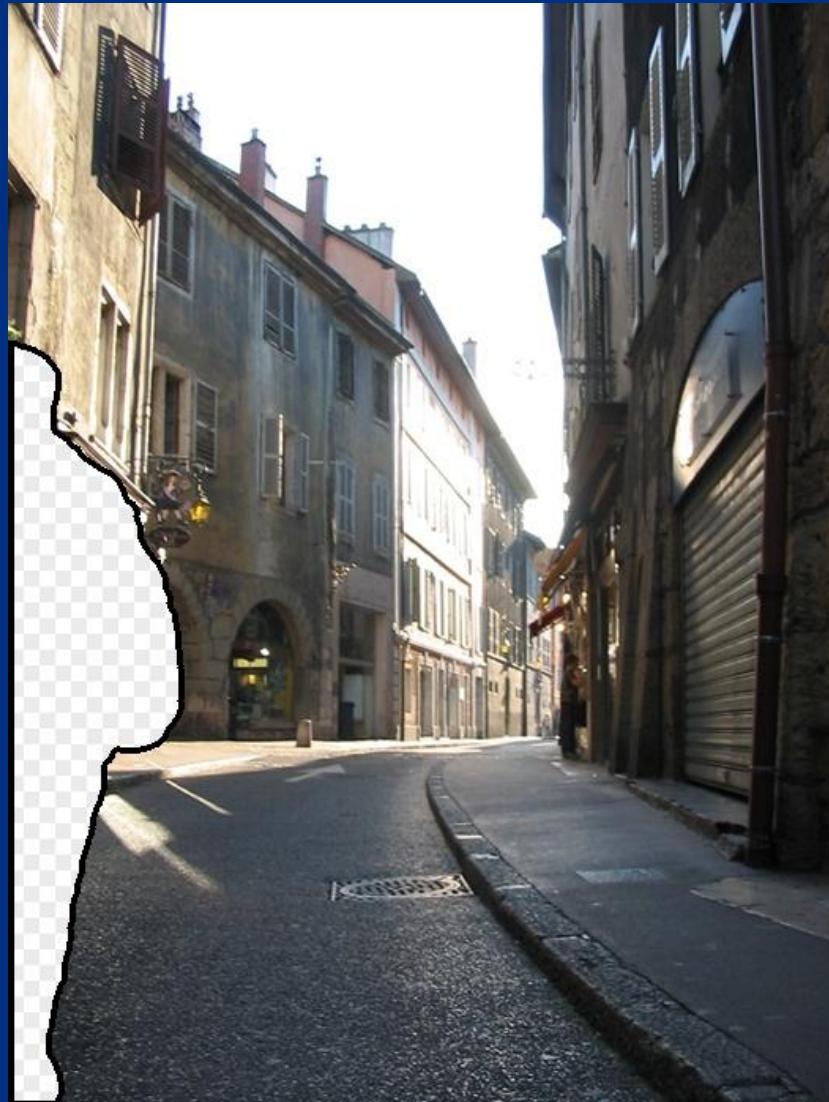
Failures



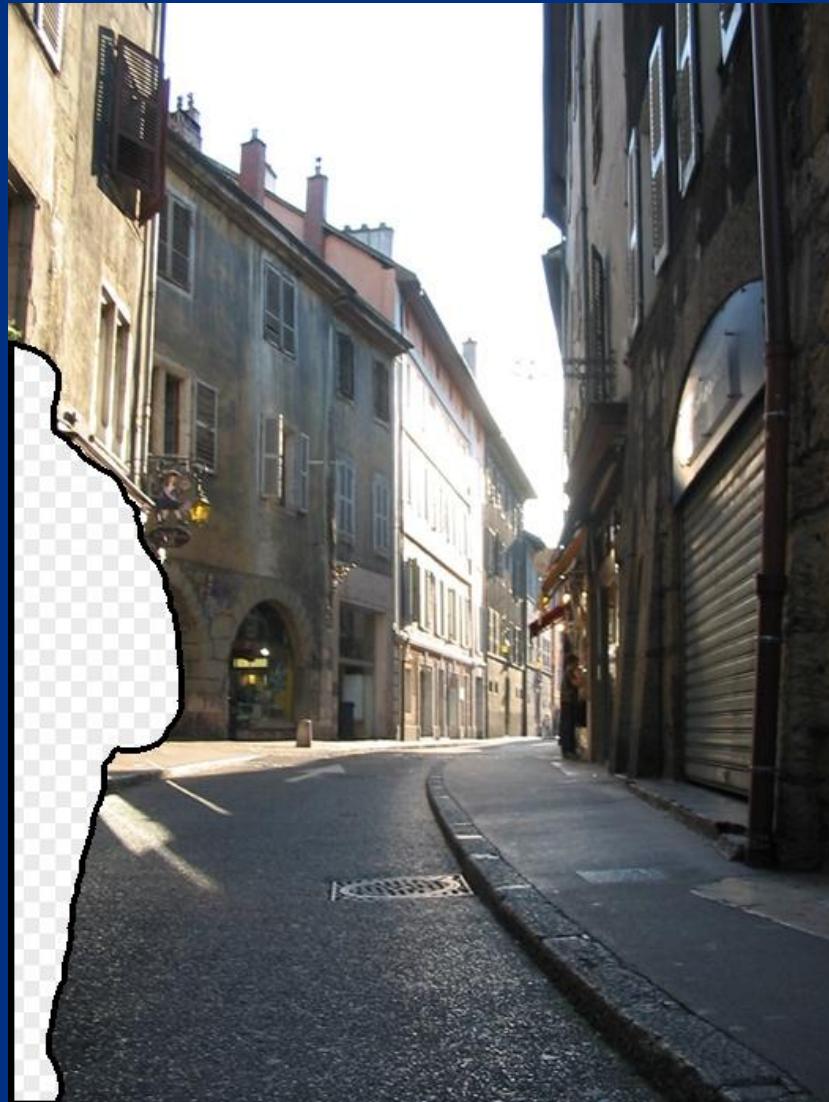
Failures



Failures



Failures



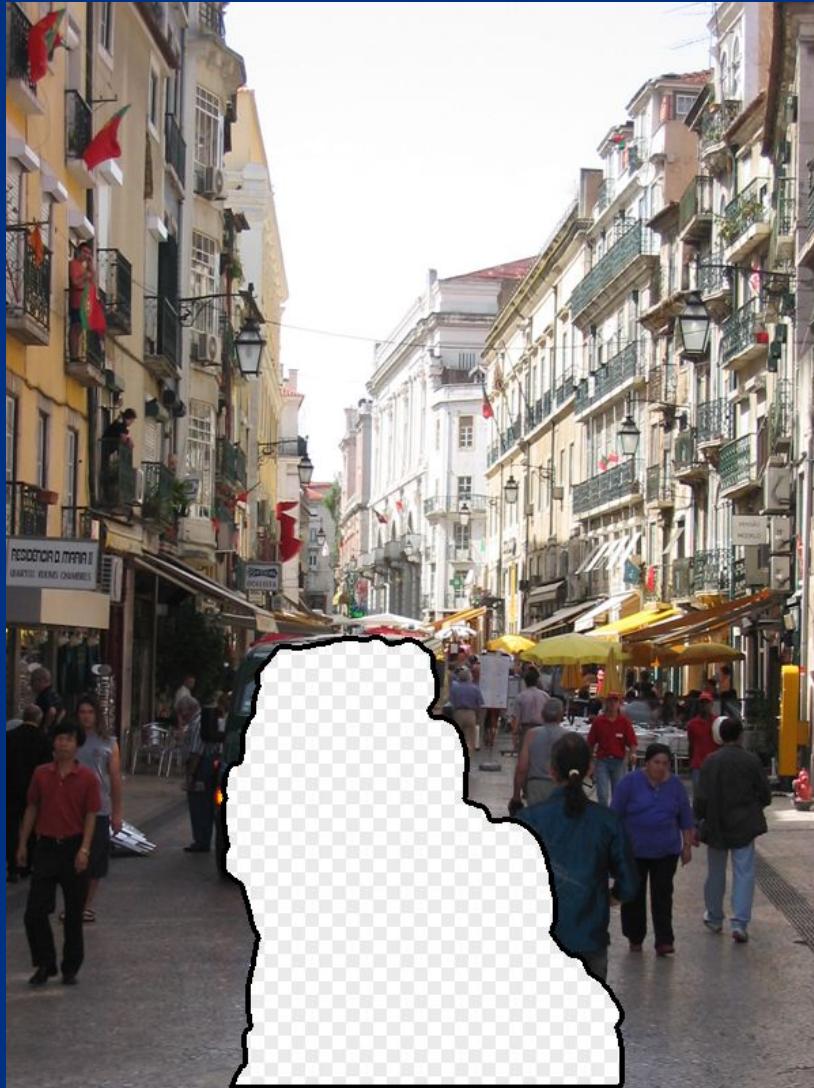
Failures



Failures



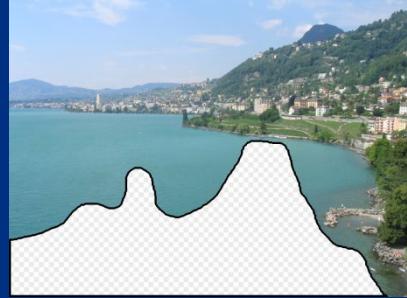
Failures

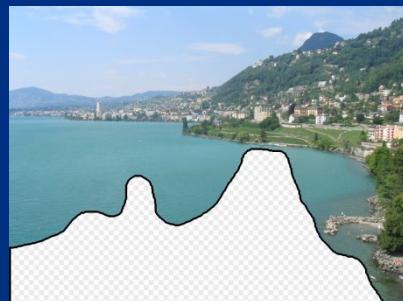
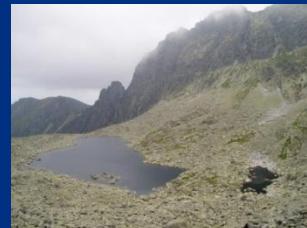


Failures



Why does it work?



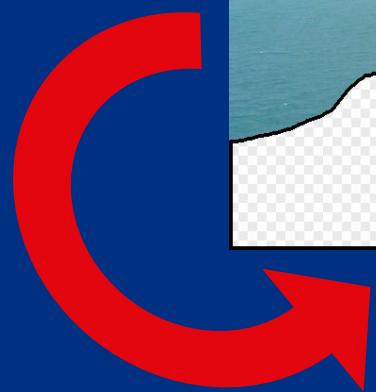


10 nearest neighbors from a collection of 20,000 images

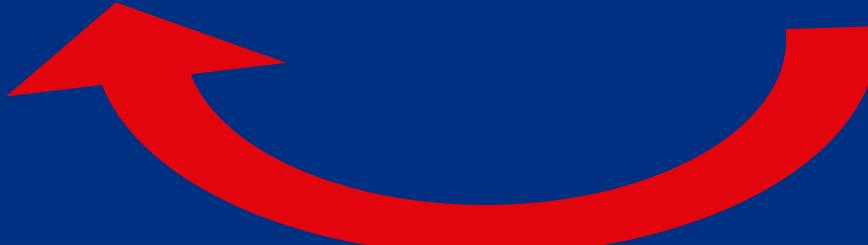
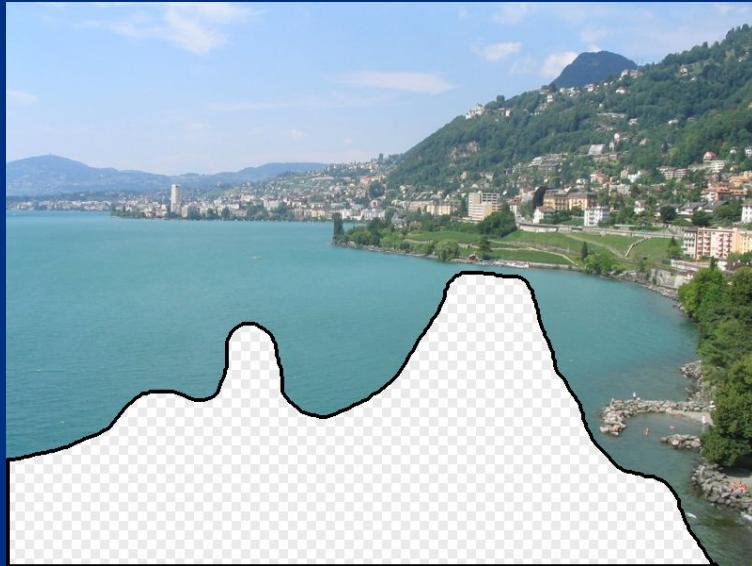


10 nearest neighbors from a collection of 2 million images

Discussion



Pixels



Pixels + Semantics

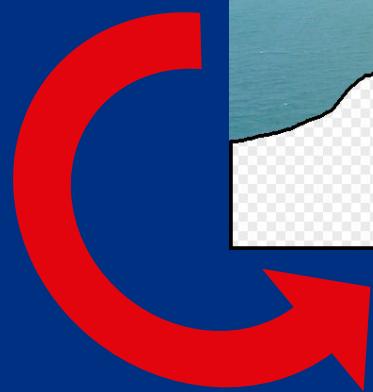


Image Collection

Expert-supplied Semantics



Hybrid Solution?



Pixels

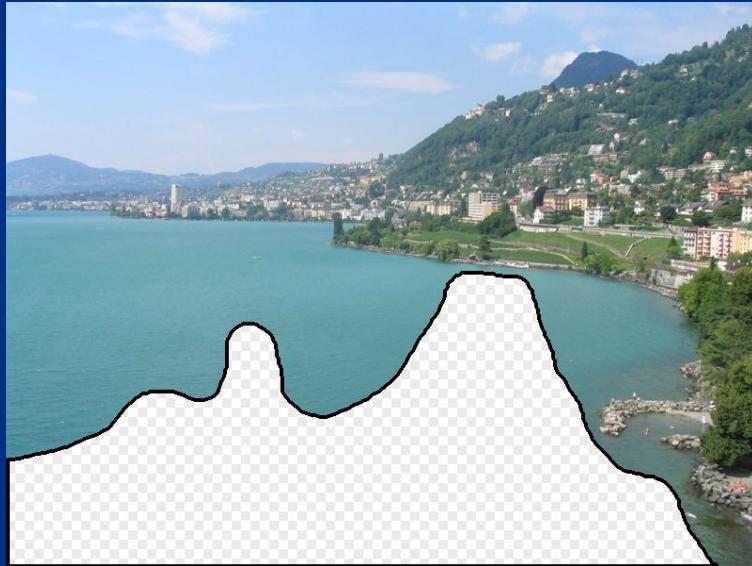


Image Collection

Semantics