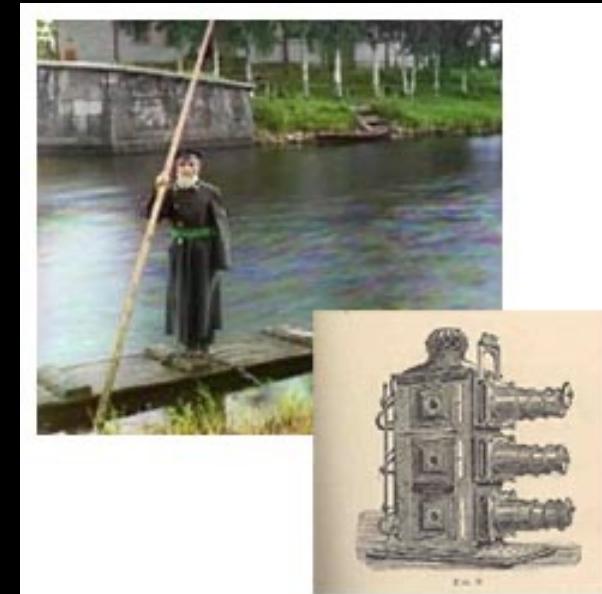
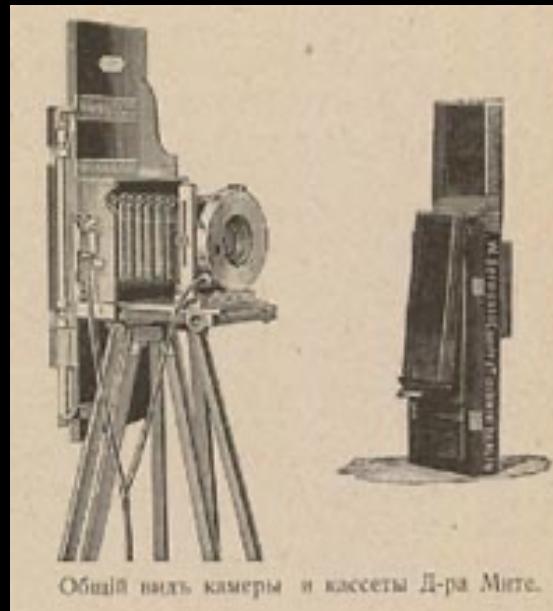


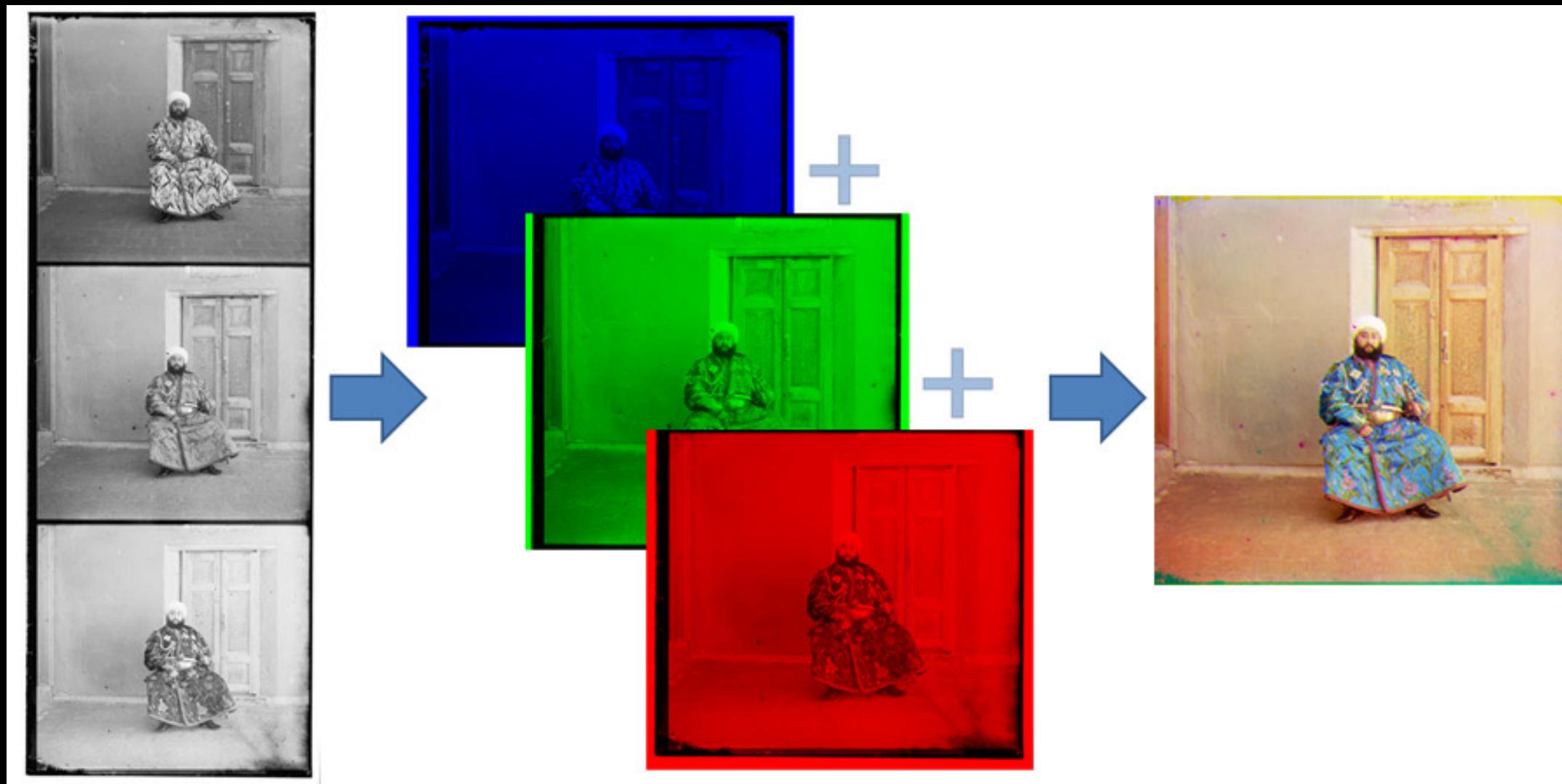
Programming Project #1

- Prokudin-Gorskii's Color Photography (1907)



Programming Project #1

- Align R, G, B images (Due 2/15/2022)



Programming Project #1

- How to compare R,G,B channels?
- No right answer
 - Sum of Squared Differences (SSD):

$$ssd(u, v) = \sum_{(x,y) \in N} [I(u+x, v+y) - P(x, y)]^2$$

- Normalized Correlation (NCC):

$$ncc(u, v) = \frac{\sum_{(x,y) \in N} [I(u+x, v+y) - \bar{I}] [P(x, y) - \bar{P}]}{\sqrt{\sum_{(x,y) \in N} [I(u+x, v+y) - \bar{I}]^2 \sum_{(x,y) \in N} [P(x, y) - \bar{P}]^2}}$$



Credit: Berkeley CS194-25



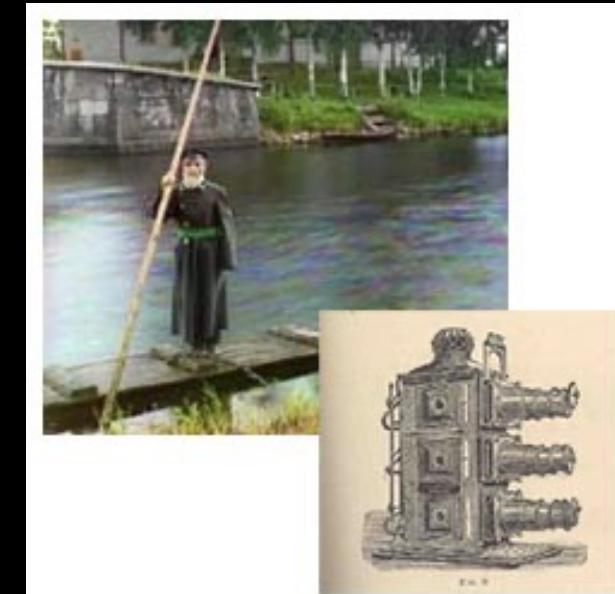
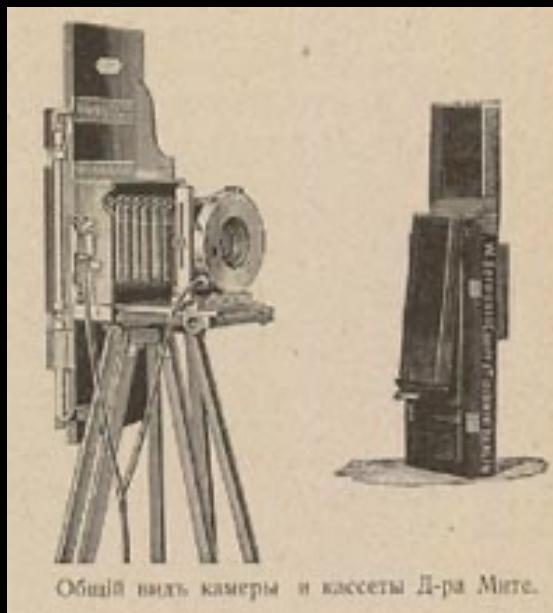
Data-Driven Graphics

Jun-Yan Zhu

16-726 Learning-based Image Synthesis, Spring 2023

Review: Global/Local warping

- Prokudin-Gorskii's Color Photography (1907)



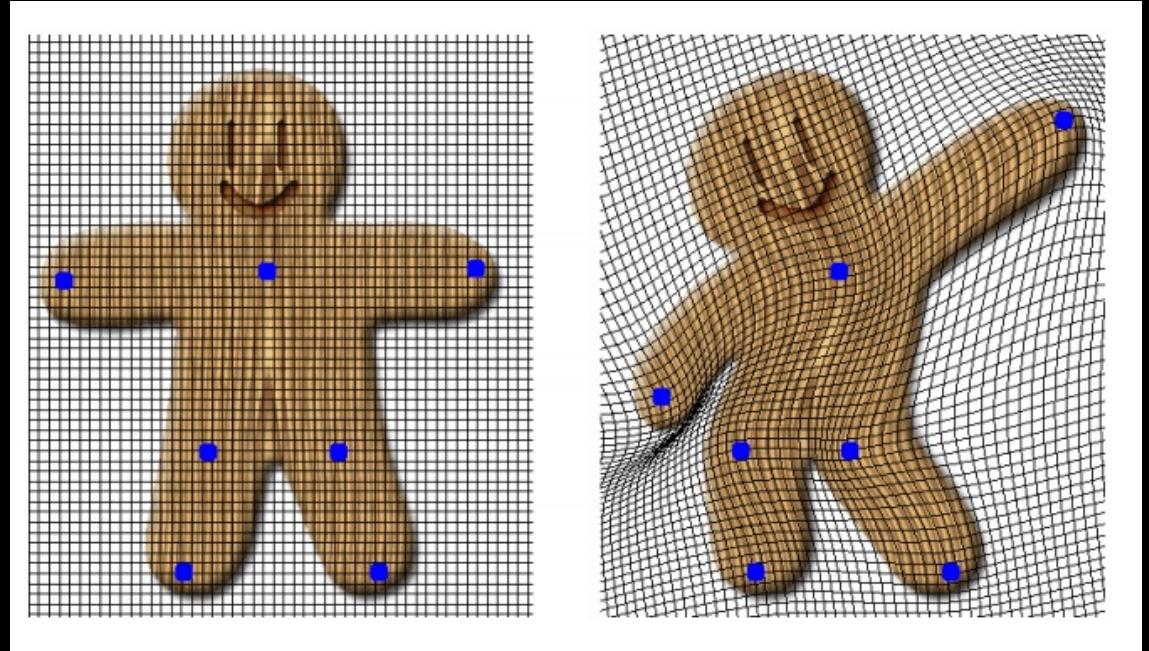
Review: Global/Local warping

Global vs. Local warping

- Parameter sharing

Dense vs. sparse warping

- Degree of freedom
- Interpolation vs. curve fitting?



Triangulation vs. Moving Least Squares

- Piece-wise function
- Spatially-varying objective functions



Data-Driven Graphics

Jun-Yan Zhu

16-726 Learning-based Image Synthesis, Spring 2023

Subject-specific Data



Photos of Coliseum



Portraits of Bill Clinton

Big Visual Data

flickr

6 billion images

YouTube

100 hours uploaded
per minute



3.5 trillion
photographs

the simple image sharer
imgur

1 billion images
served daily

facebook®

70 billion images

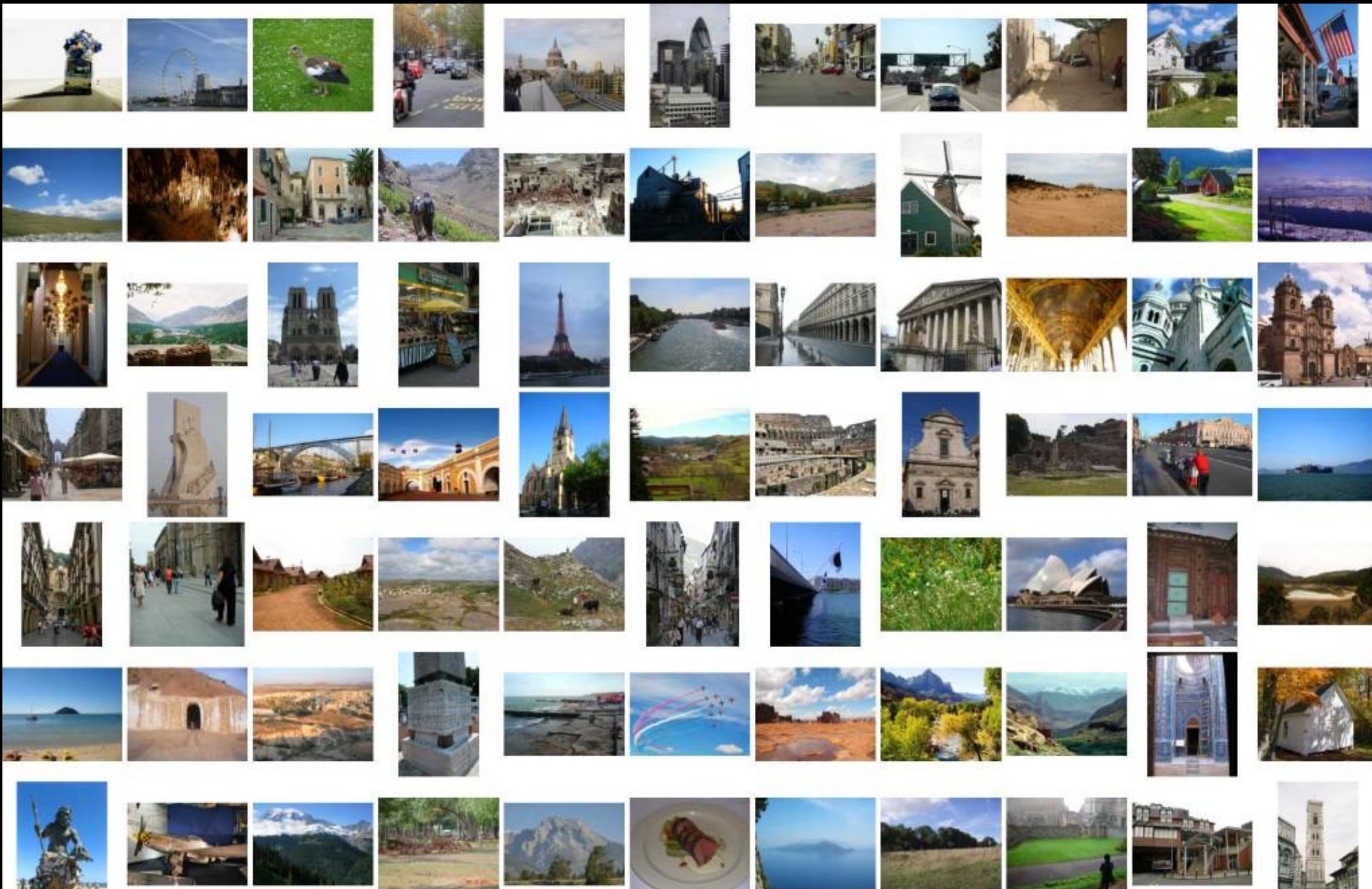
Too Big for Humans

Digital Dark Matter

Big issues

- What is out there on the Internet? How do we get it? What can we do with it?
- How do we compute distances between images?

Much of Captured World is “generic”



Generic Data



street scenes

Food plates



faces

pedestrians

The Internet as a Data Source

- Social Networking Sites (e.g., Facebook, Snapchat)
- Image Search Engines (e.g., Google, Bing)
- Photo Sharing Sites (e.g., Instagram, Flickr, Adobe Stock)
- Computer Vision Databases (e.g., ImageNet, Places, OpenImages)

Is Big Visual Data useful?

A motivating example...



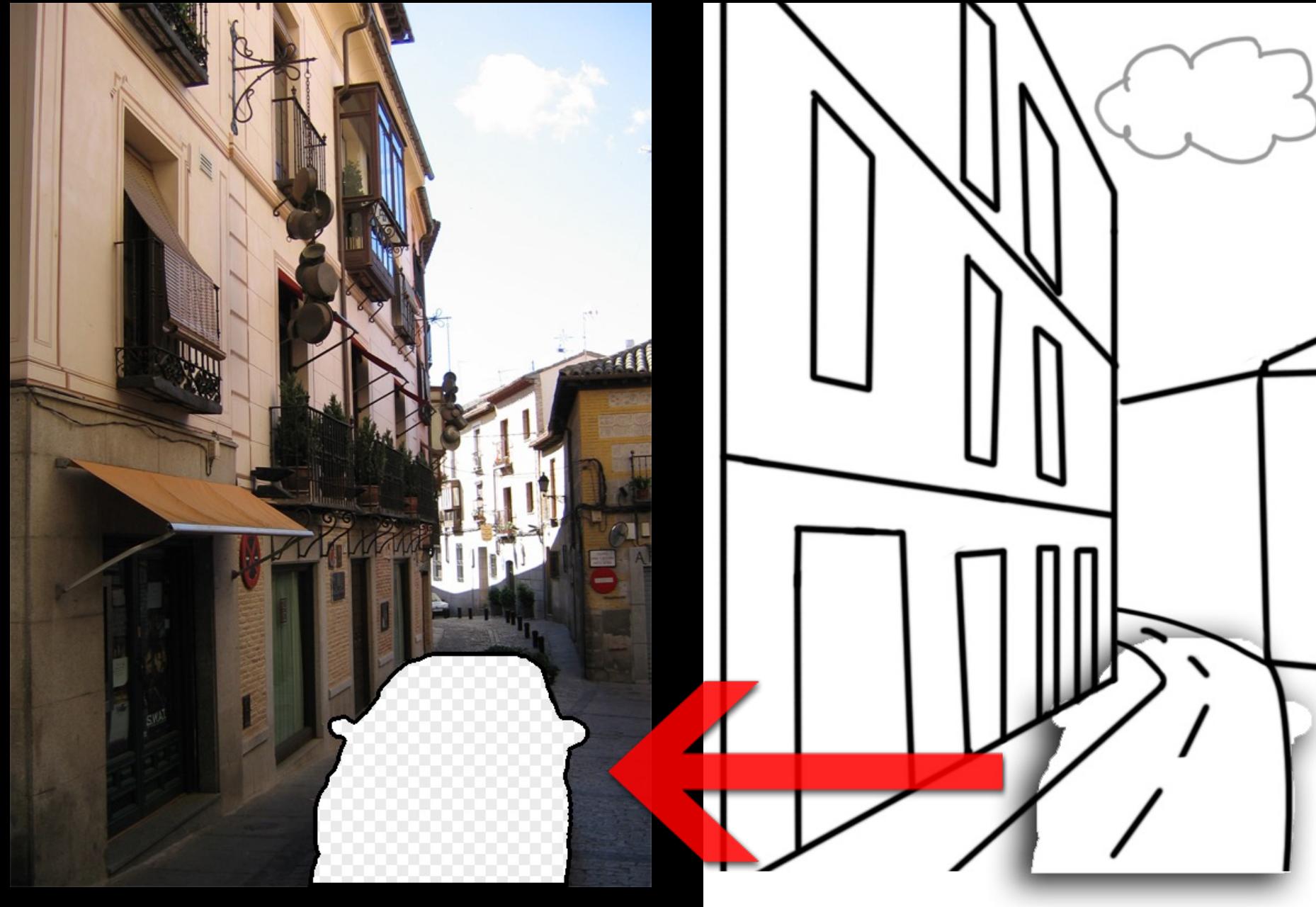








Scene Matching for Image Completion

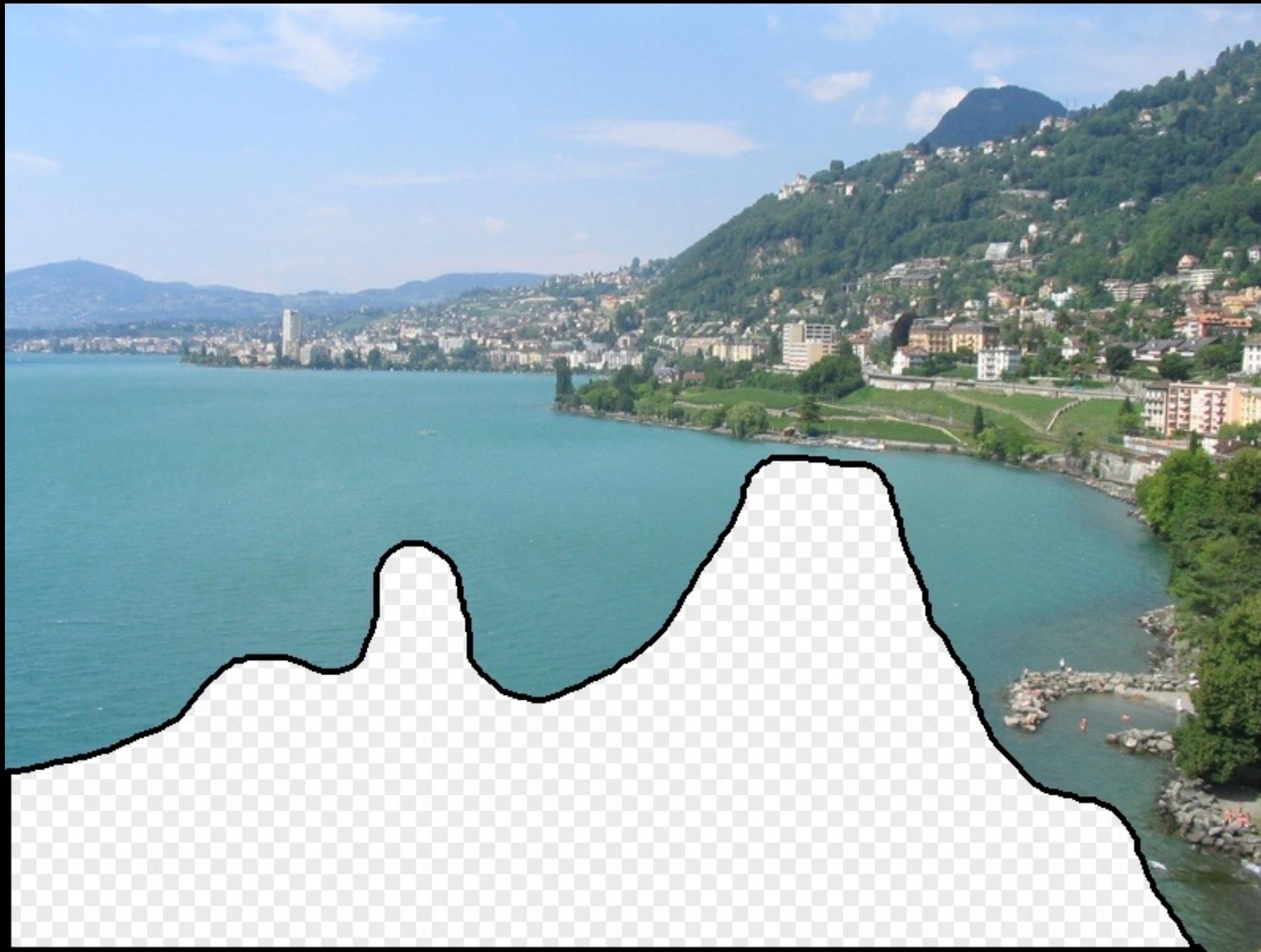




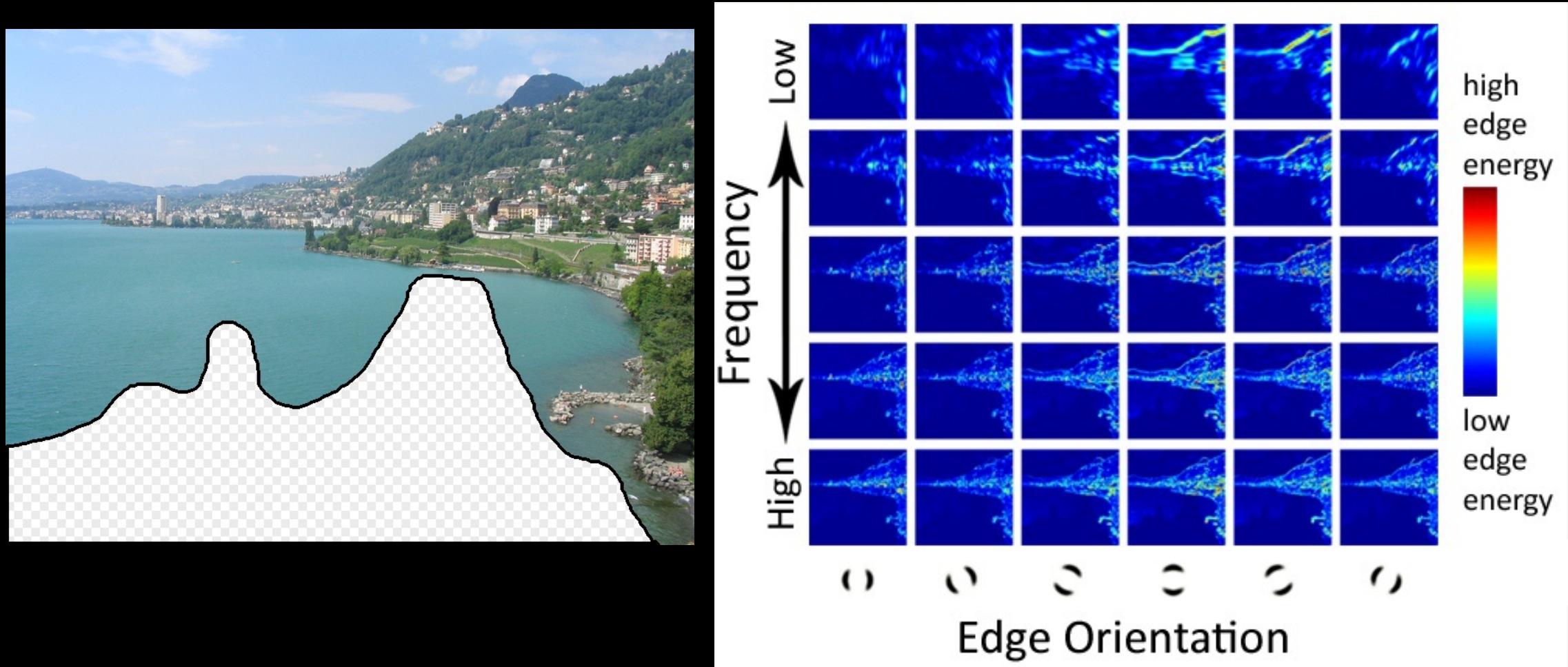
The Algorithm



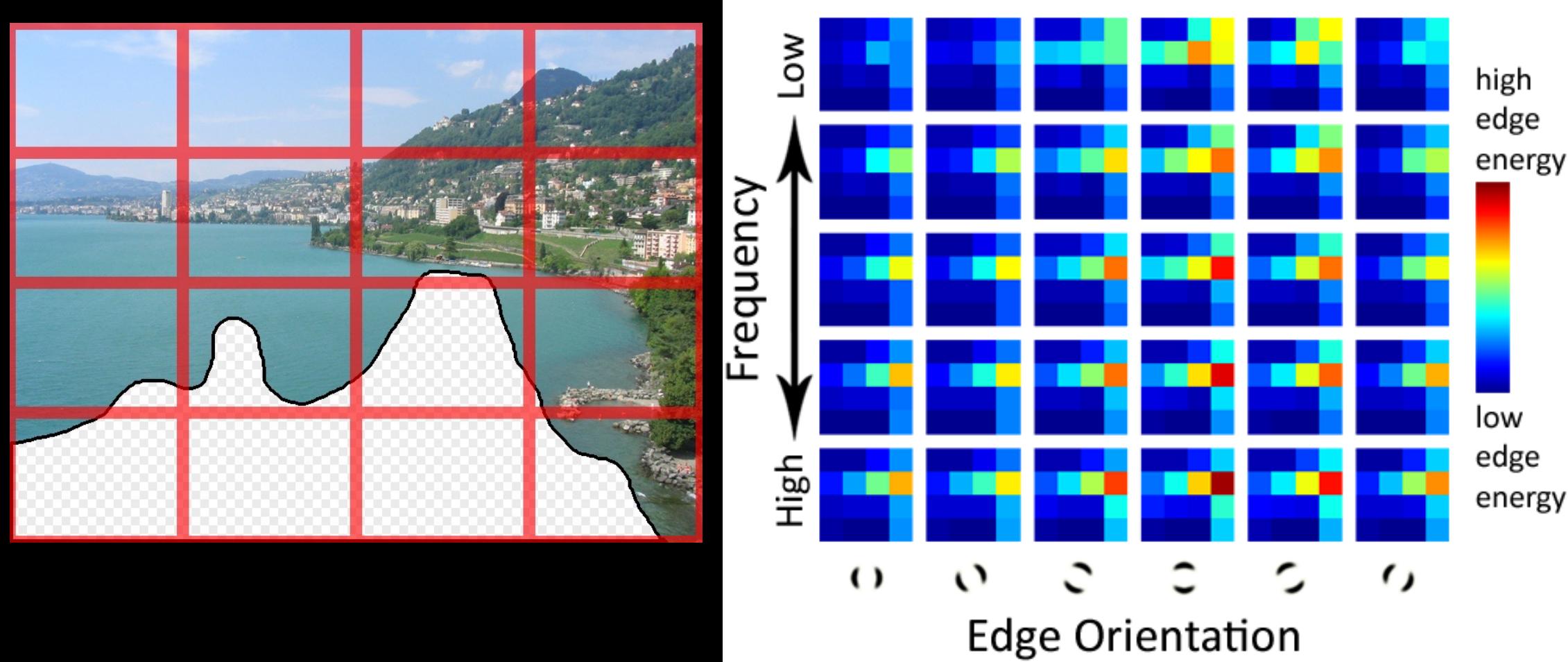
Scene Matching



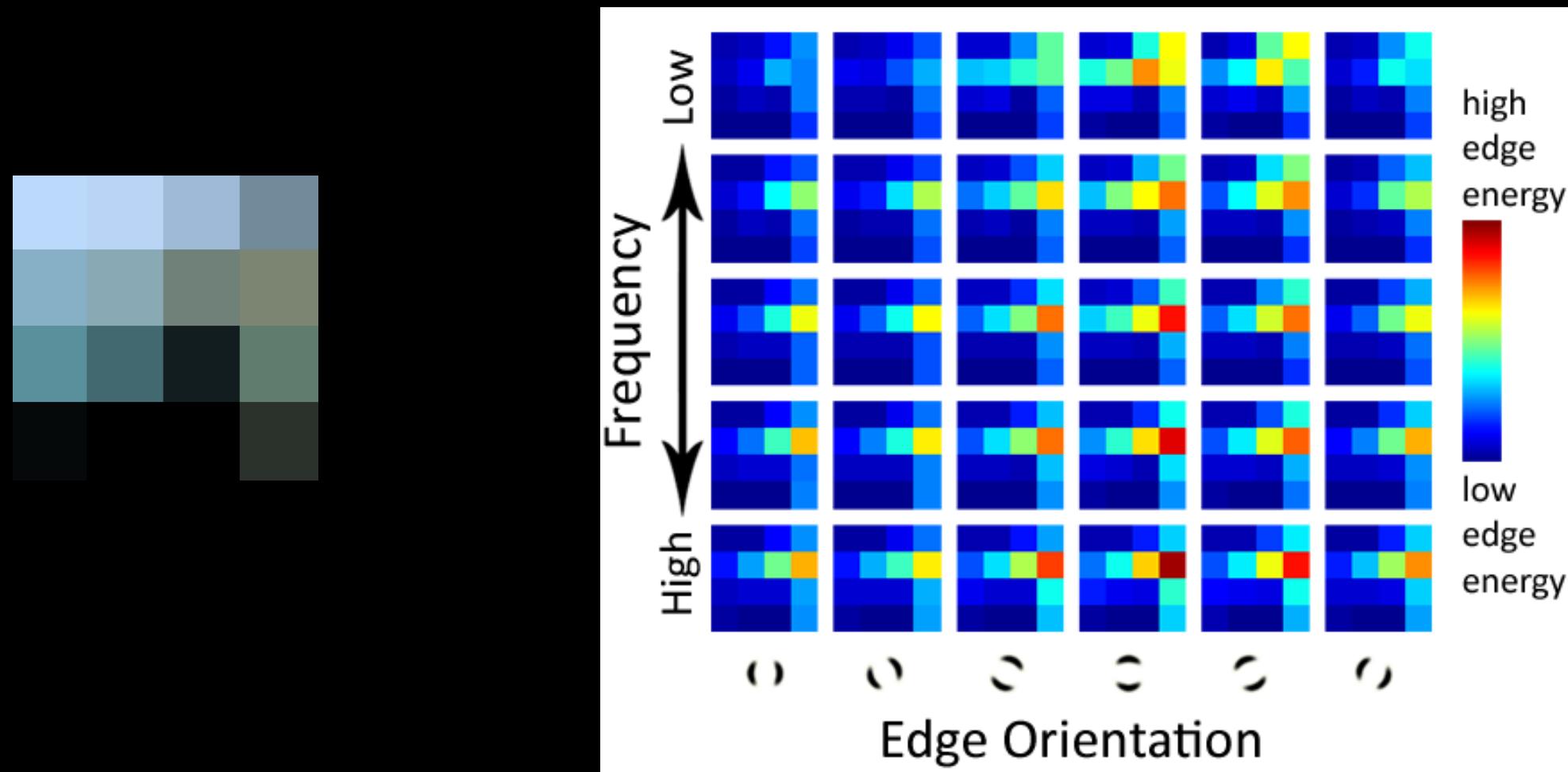
Scene Descriptor



Scene Descriptor

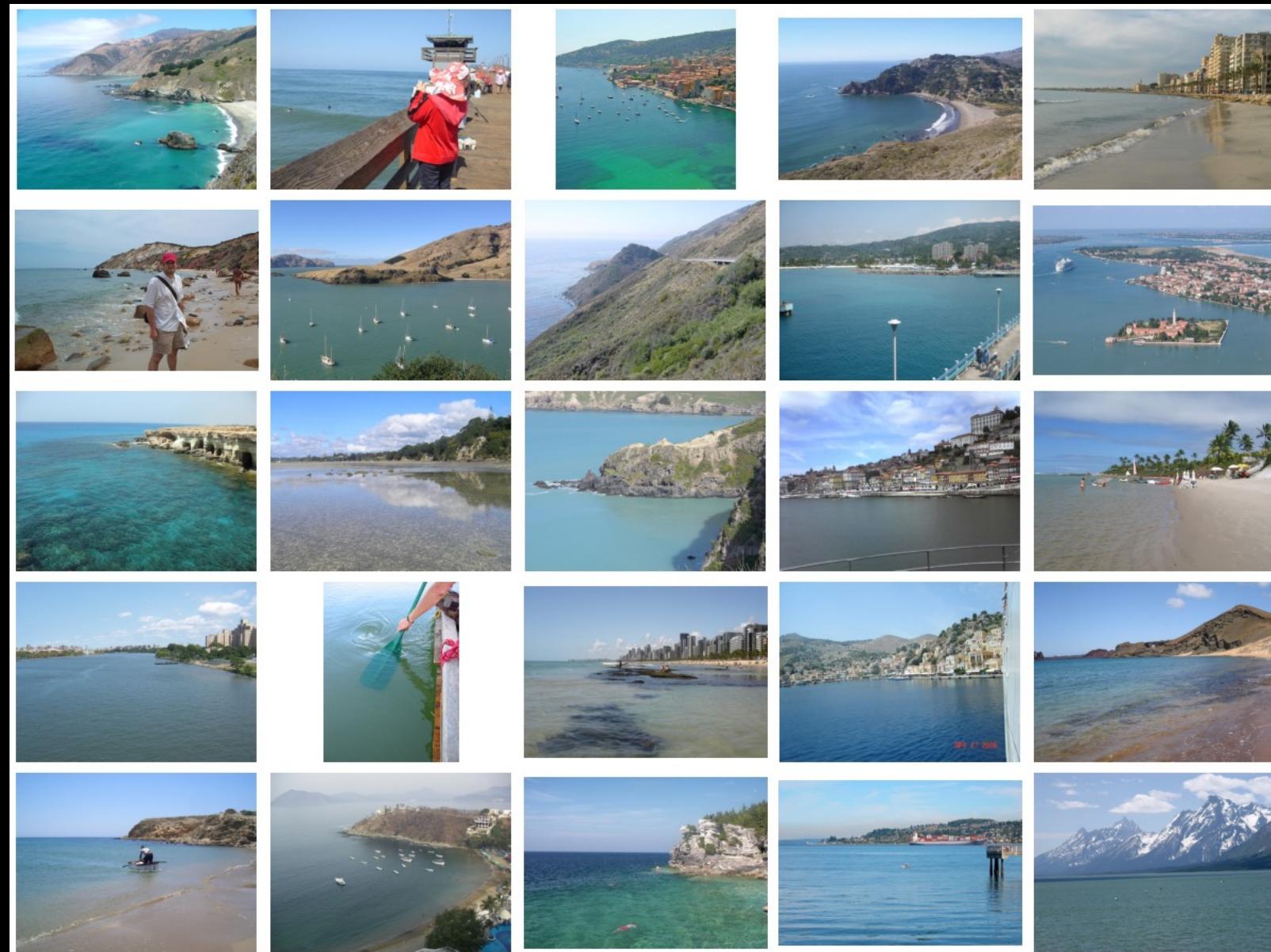
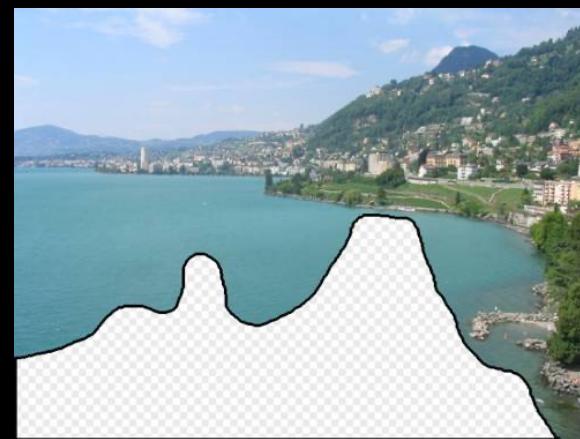


Scene Descriptor

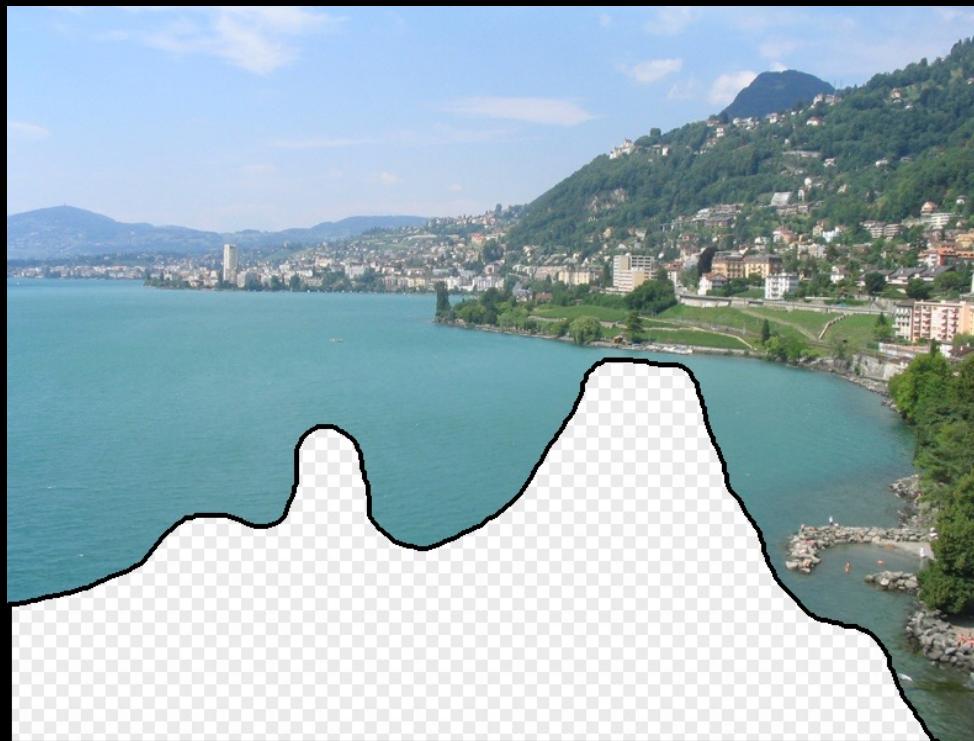


2 Million Flickr Images





Context Matching

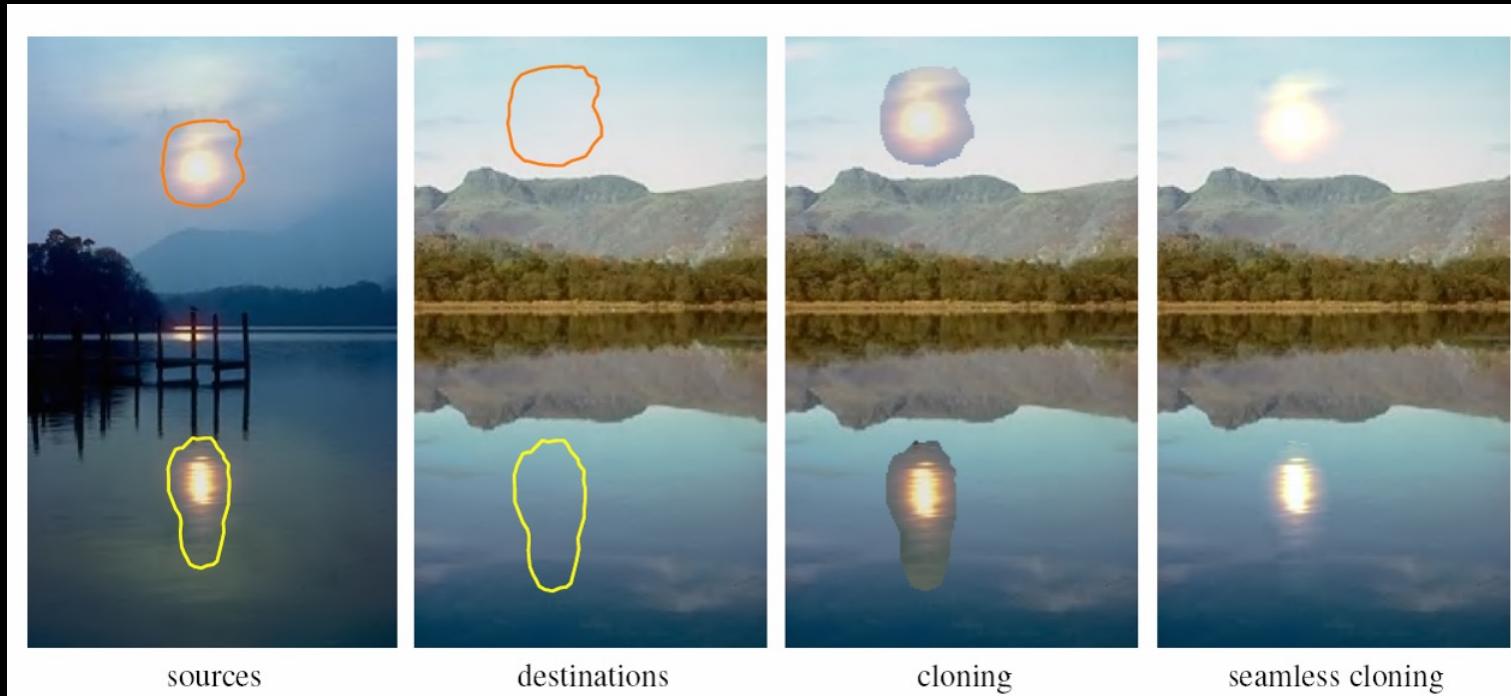




Graph cut + Poisson blending

Image Blending

Poisson Image Blending



More details in the later lectures.

More results

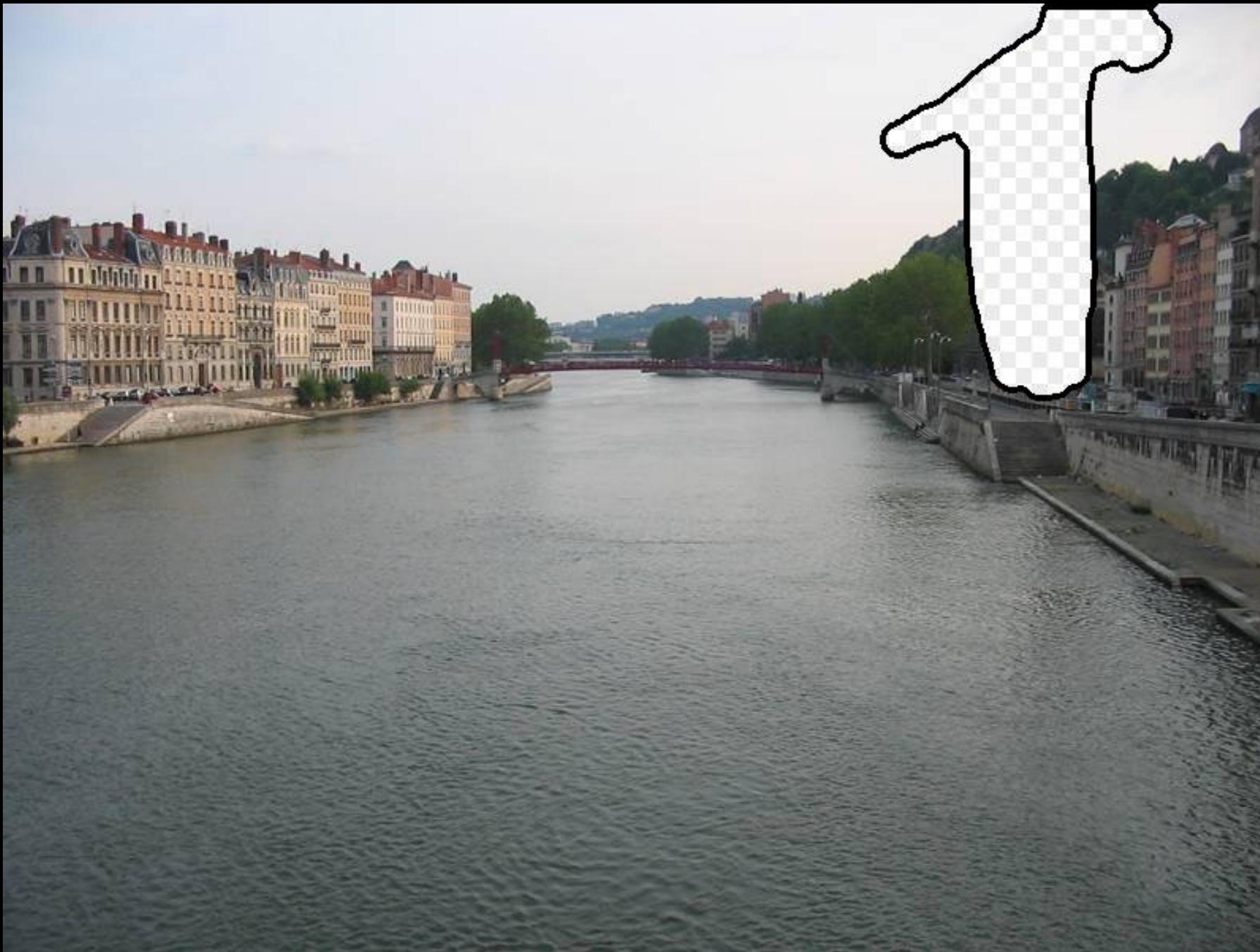




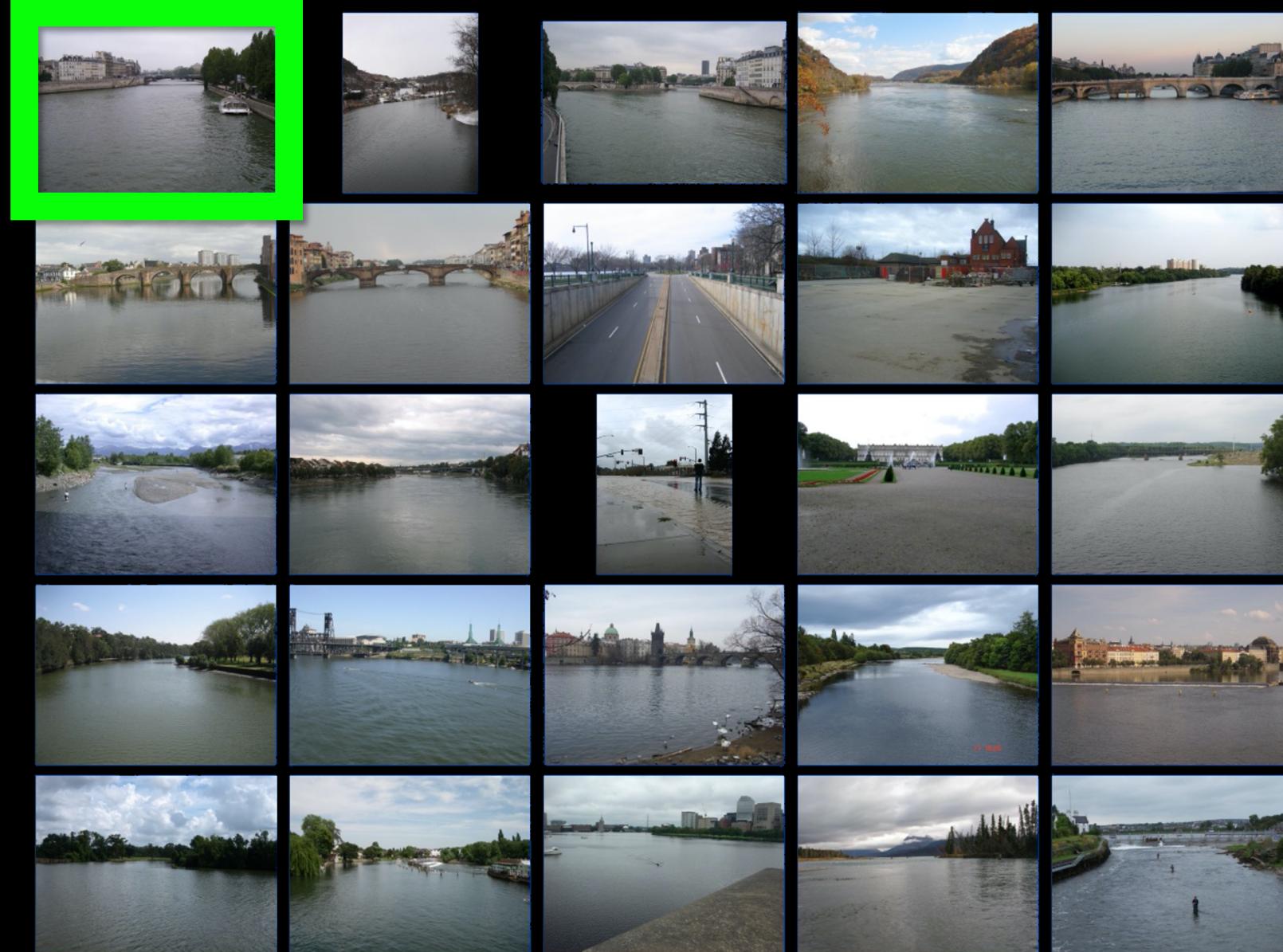
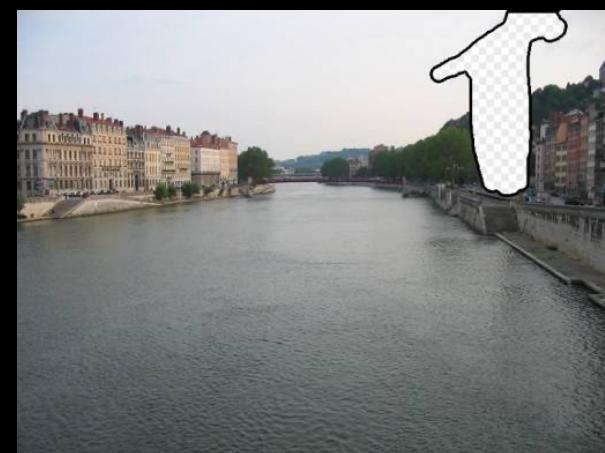
















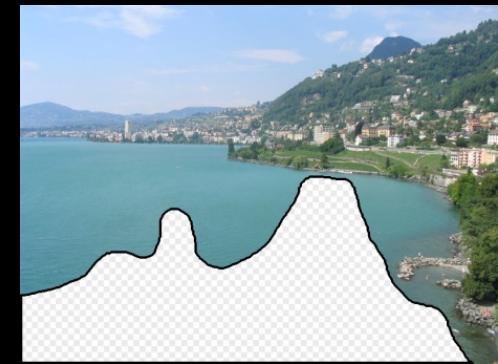


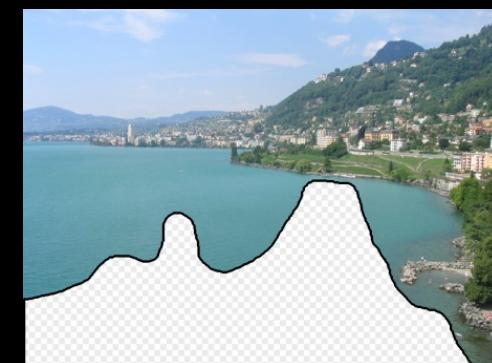


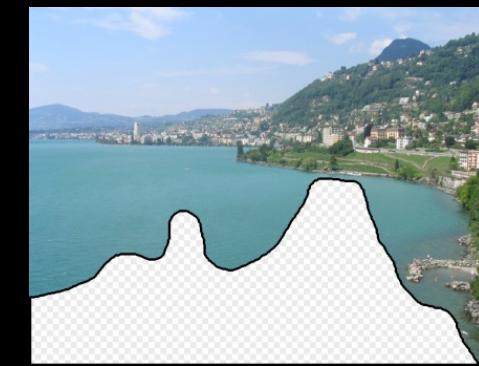




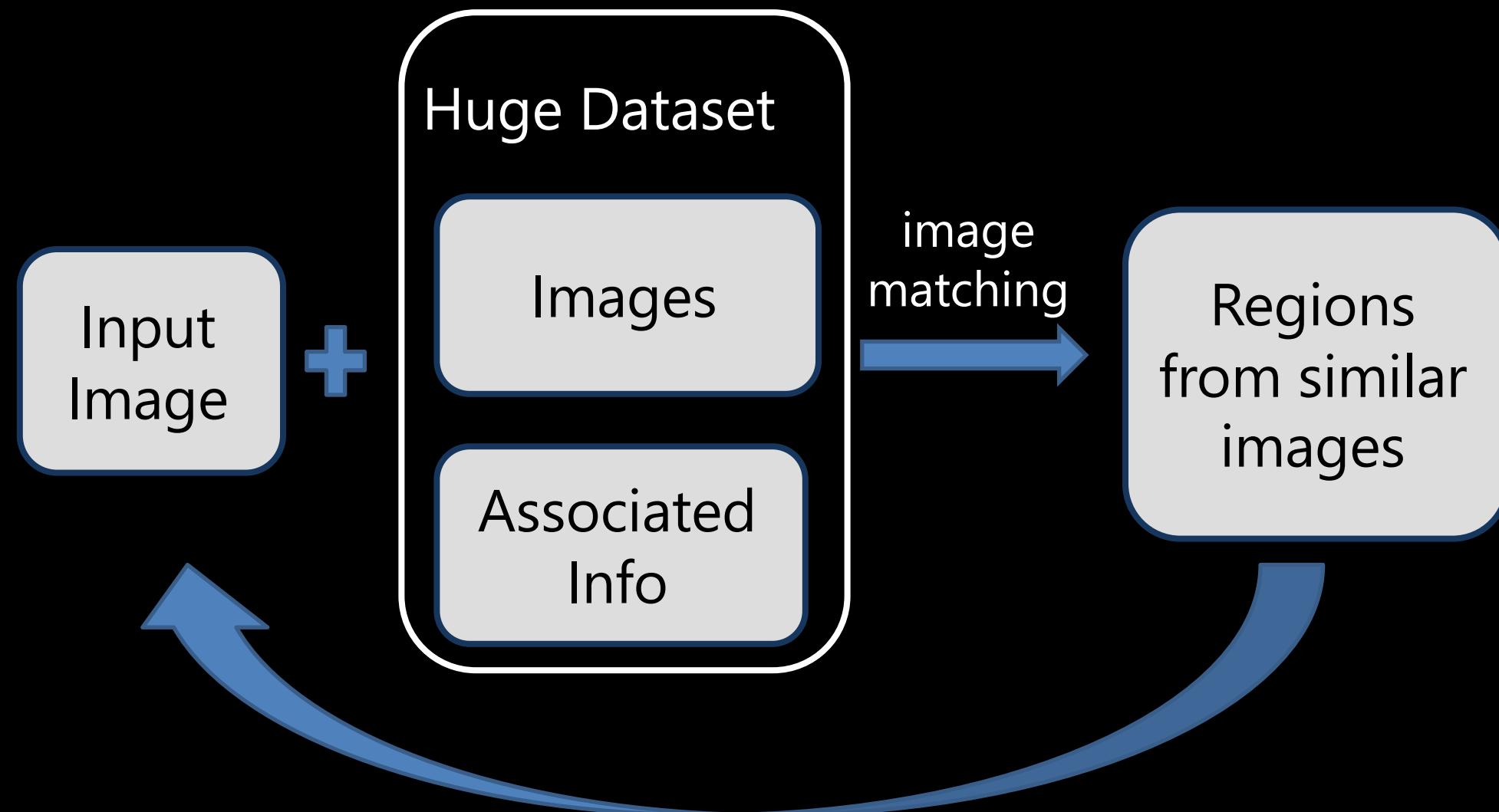
Why does it work?





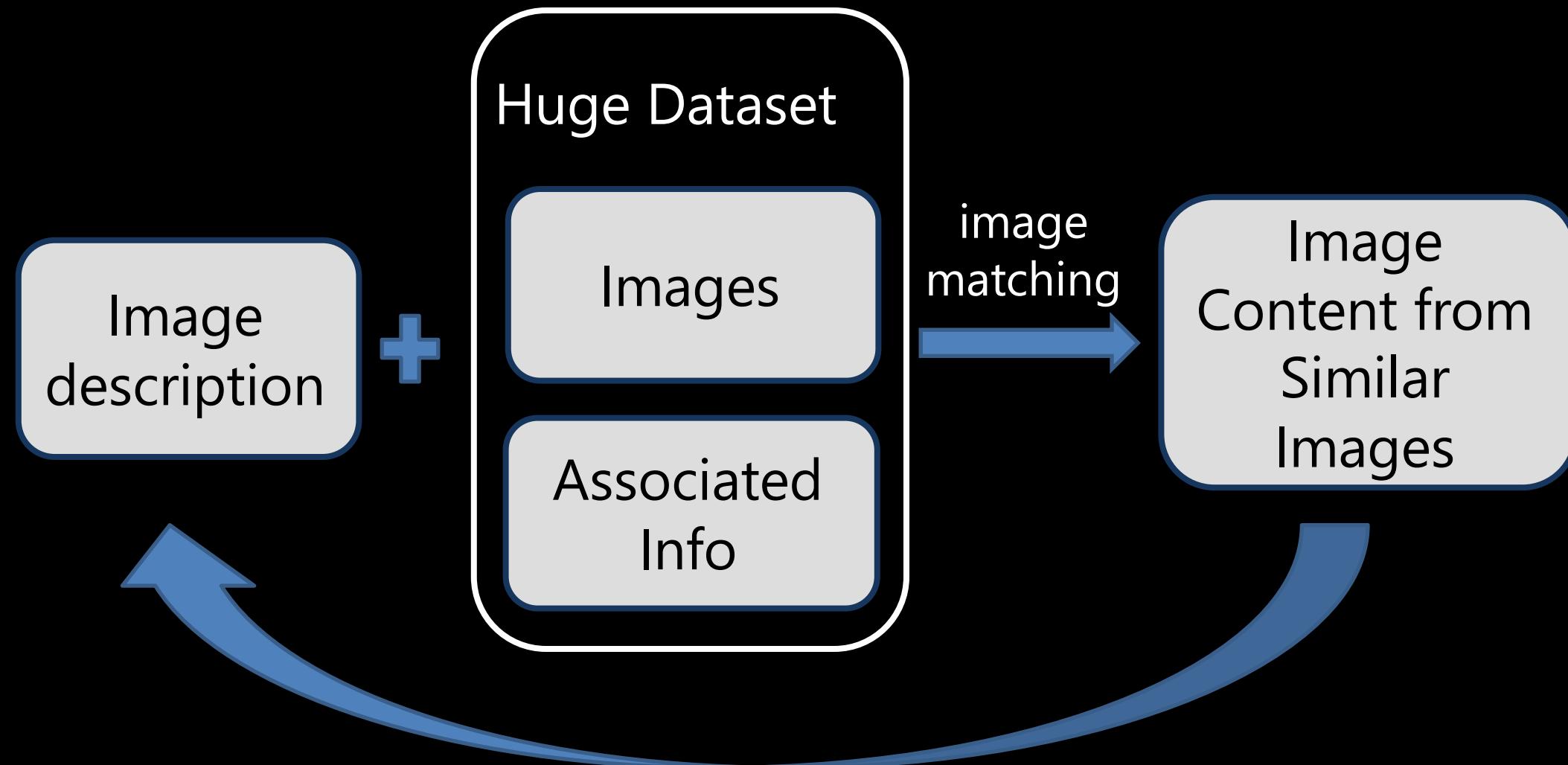


Recap: Using lots of data!



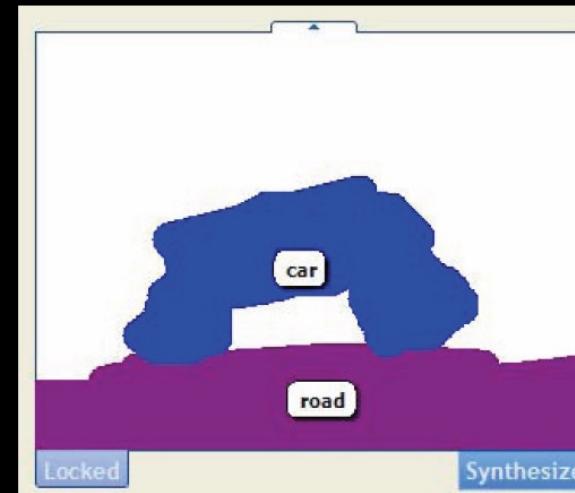
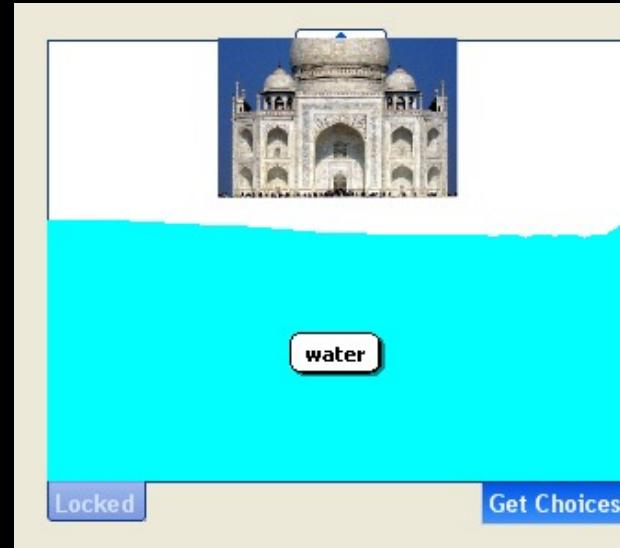
Trick: If you have enough images, the dataset will contain very similar images that you can find with simple matching methods.

Semantic Photo Synthesis



M. Johnson, G. Brostow, J. Shotton, O. A. c, and R. Cipolla, "Semantic Photo Synthesis," Computer Graphics Forum Journal (Eurographics 2006), vol. 25, no. 3, 2006.

Semantic Photo Synthesis [EG'06]



Johnson, Brostow, Shotton, Arandjelovic, Kwatra, and Cipolla. Eurographics 2006.

Semantic Photo Synthesis

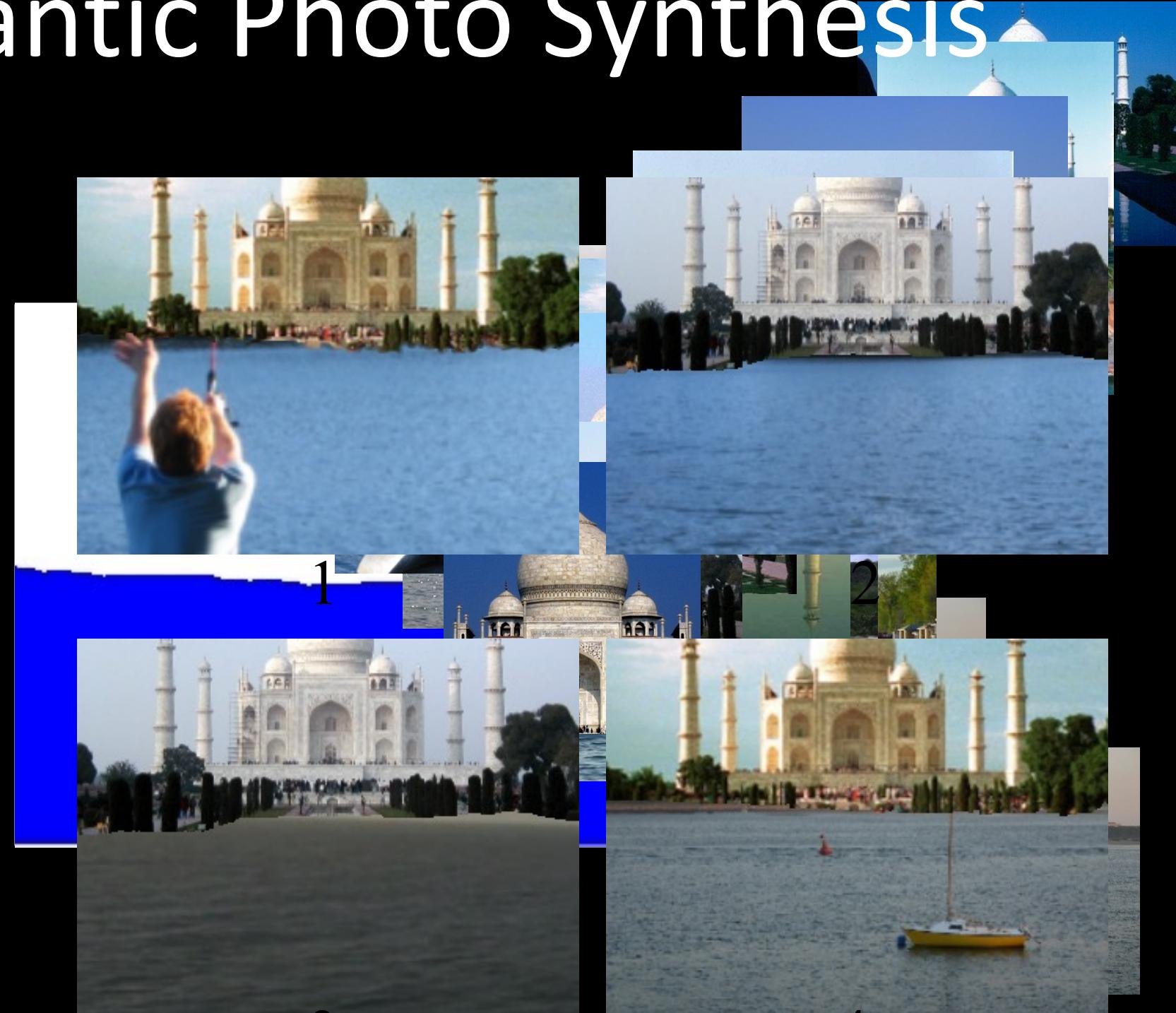


Photo Clip Art

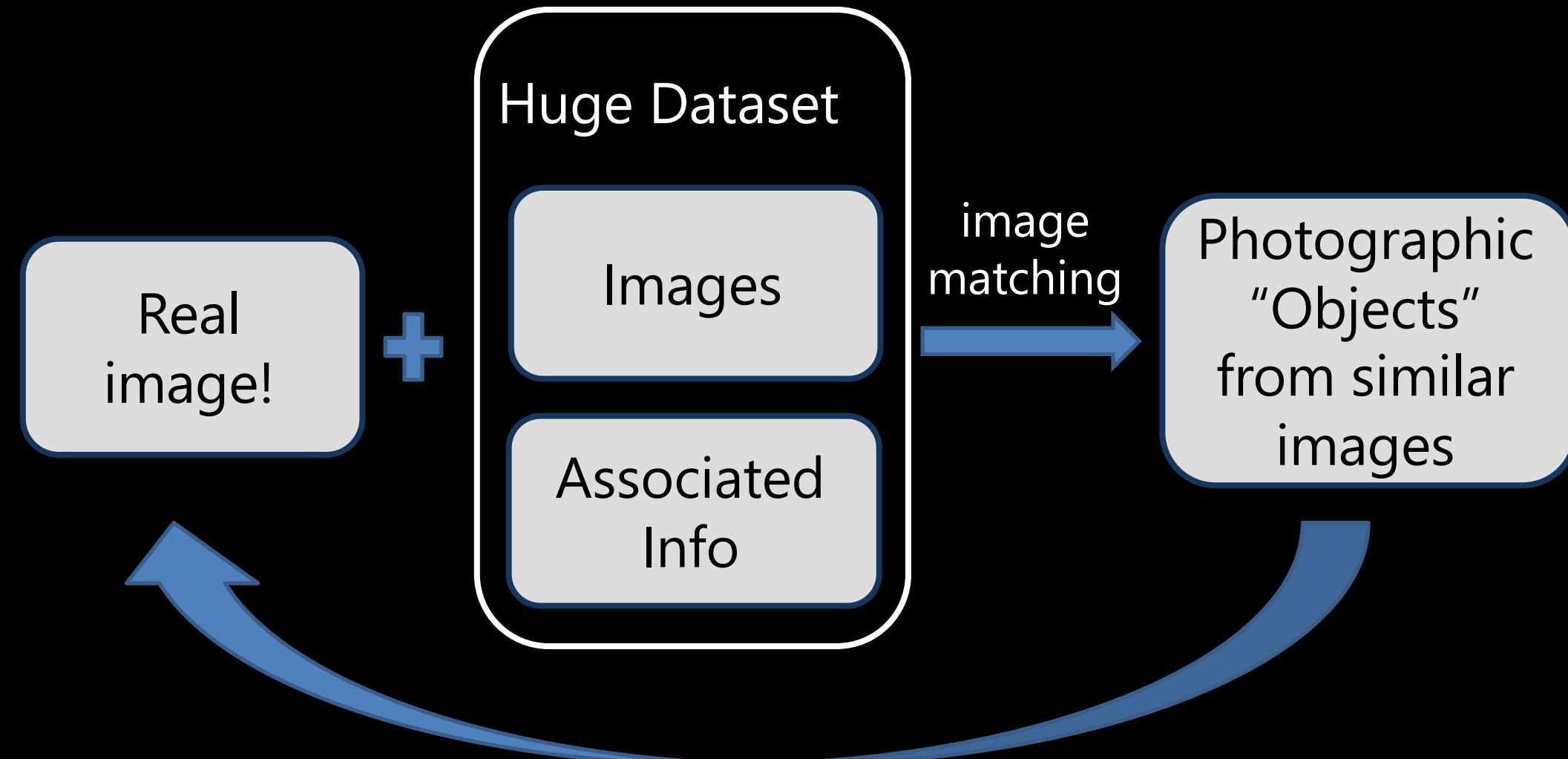


Photo Clip Art [SIGGRAPH 2007]

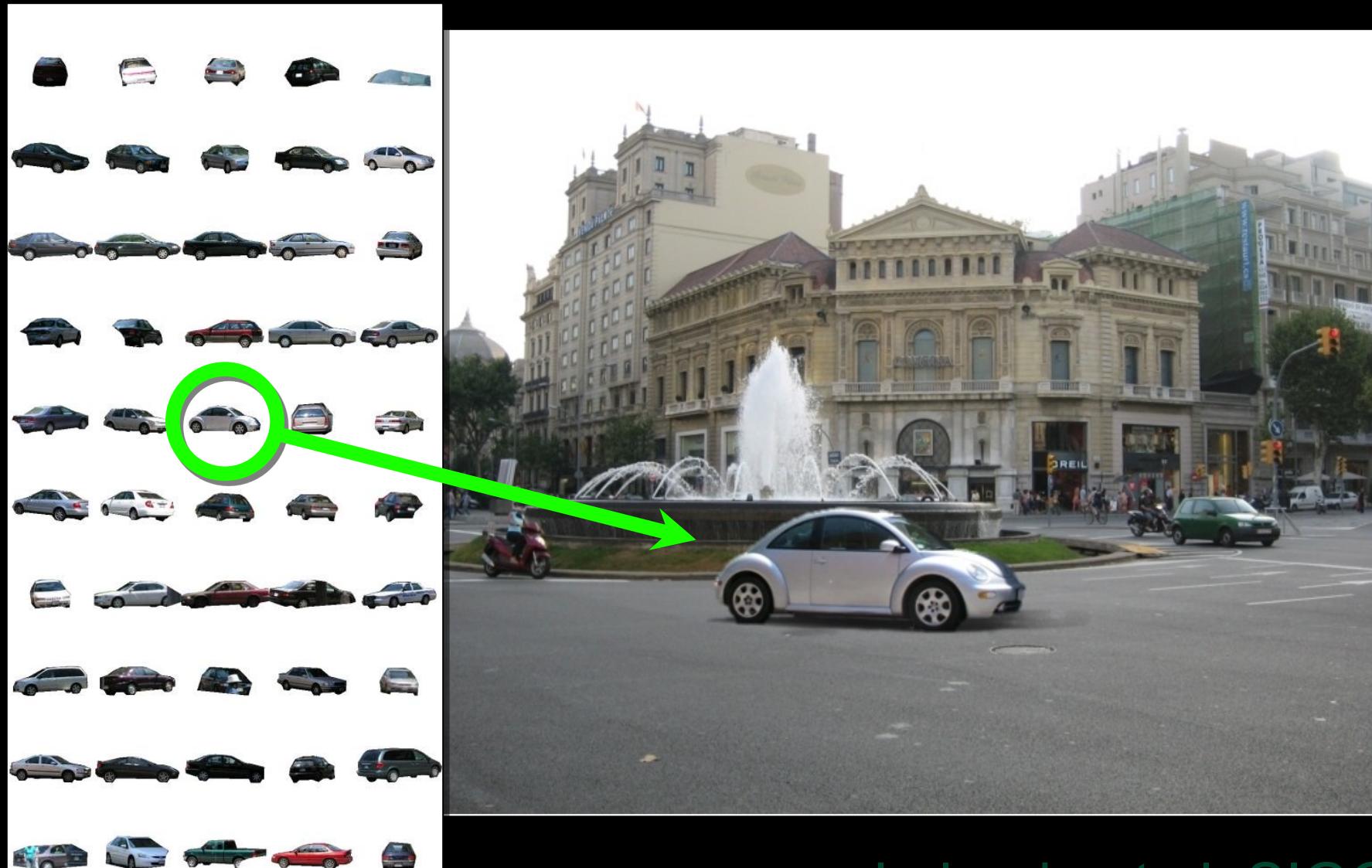
Inserting a single object -- still very hard!



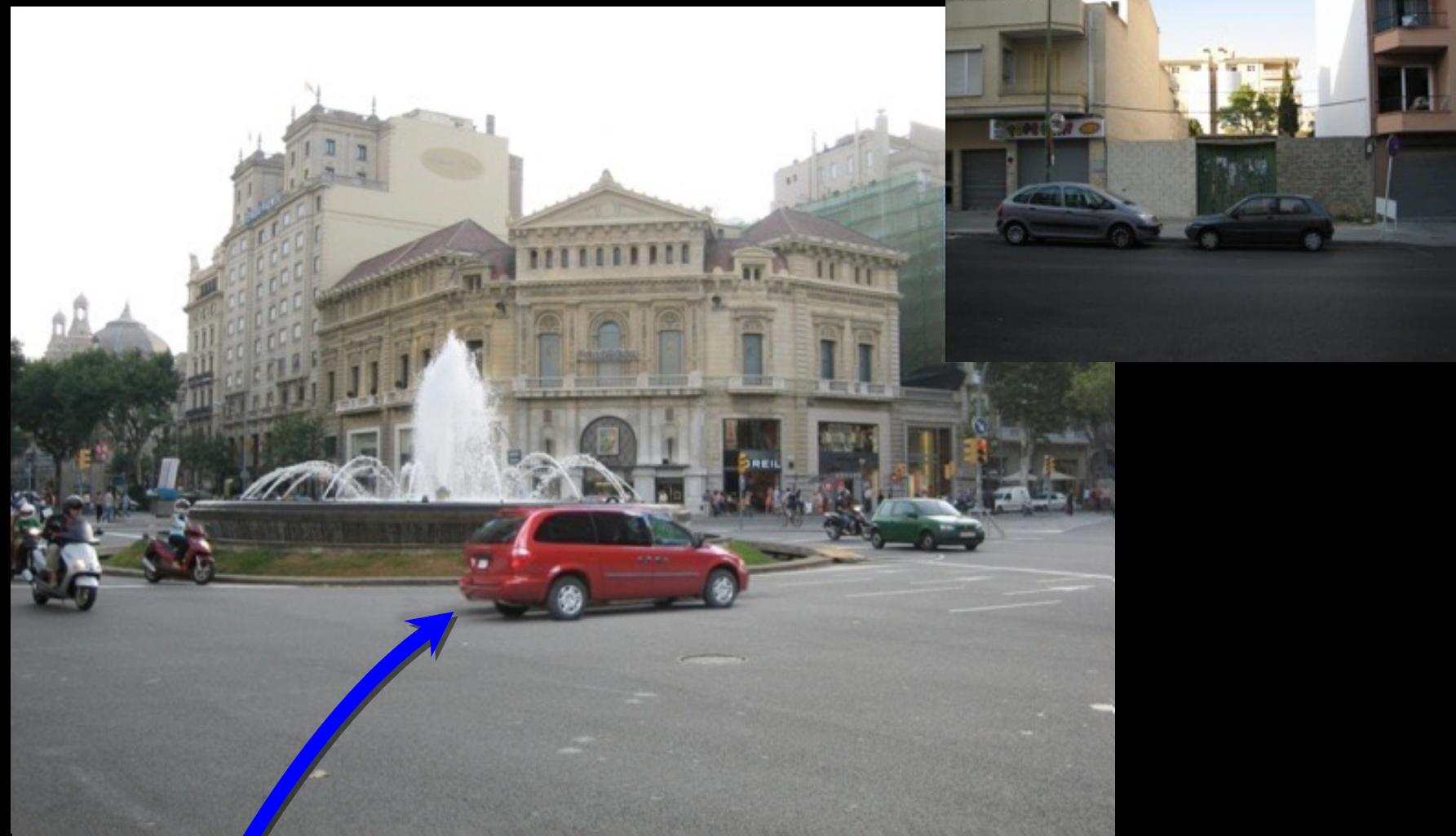
[Lalonde et al, SIGGRAPH 2007]

Photo Clip Art

Use database to find well-fitting object



Geometry is not enough



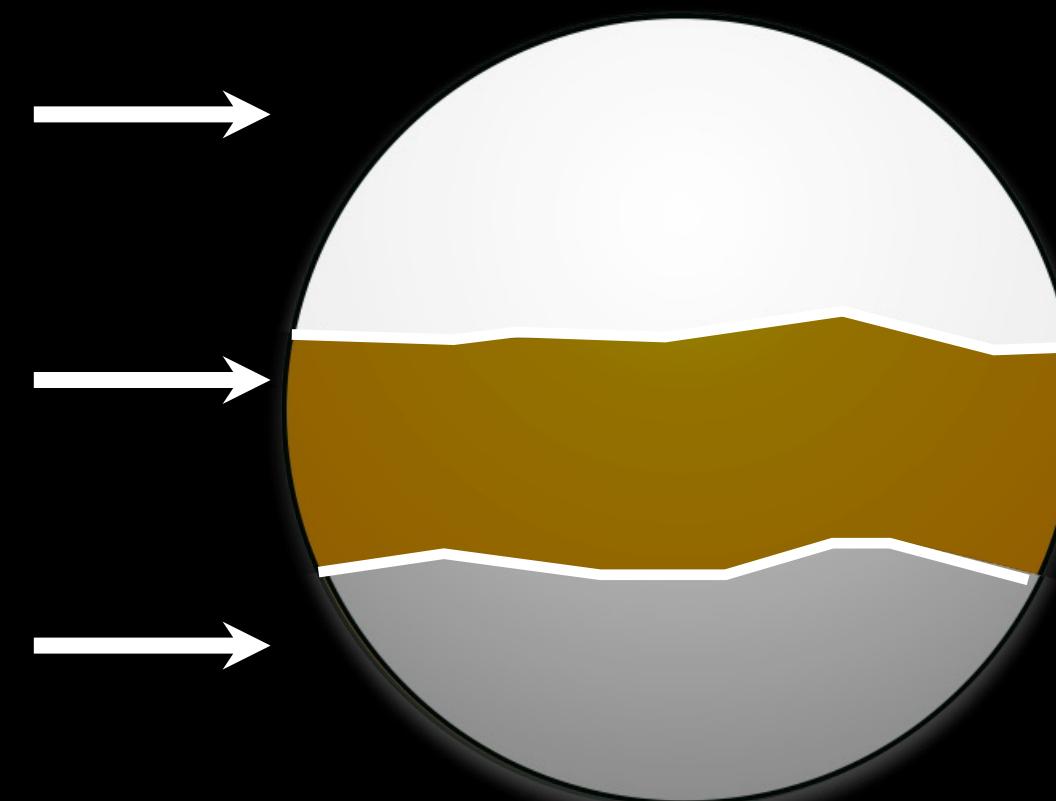
Illumination context

- Exact environment map is impossible
- Approximations [Khan et al., '06]

Database image



Environment map rough approximation



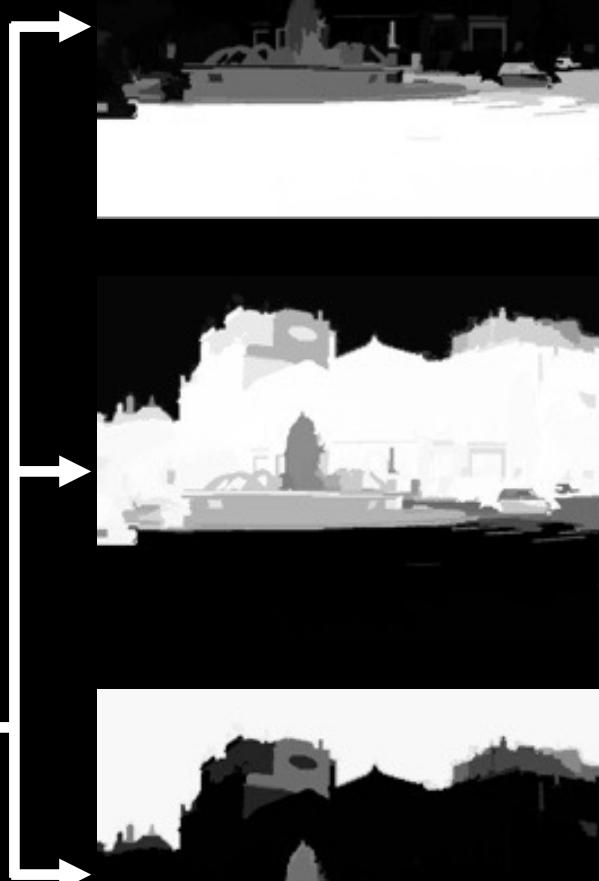
Illumination context

Database image

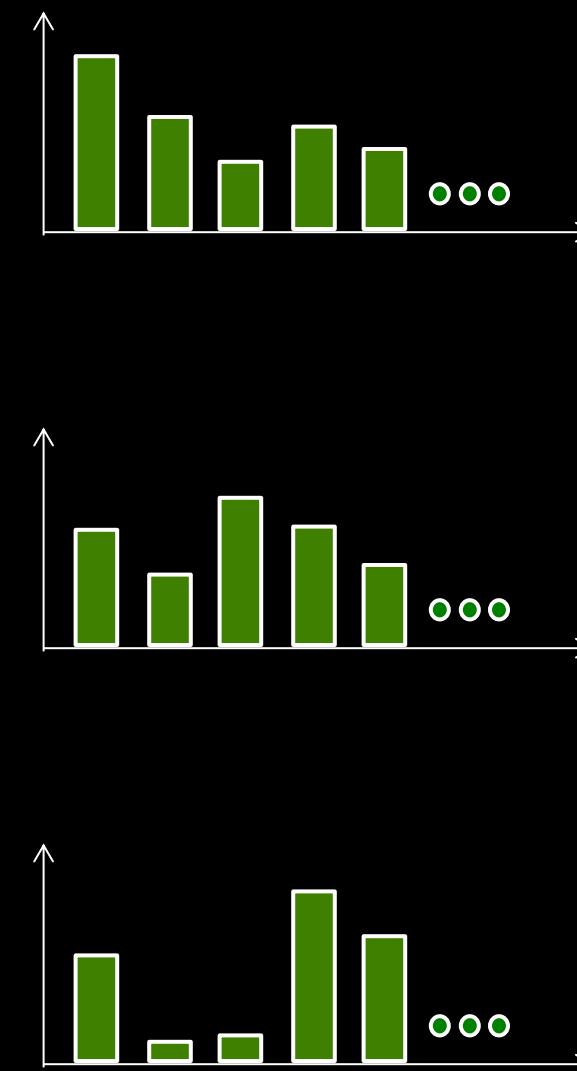


↓
Automatic Photo Popup
Hoiem et al., SIGGRAPH '05

$P(\text{pixel}|\text{class})$



CIE L*a*b* histograms



Illumination nearest-neighbors



Street accident



Bridge



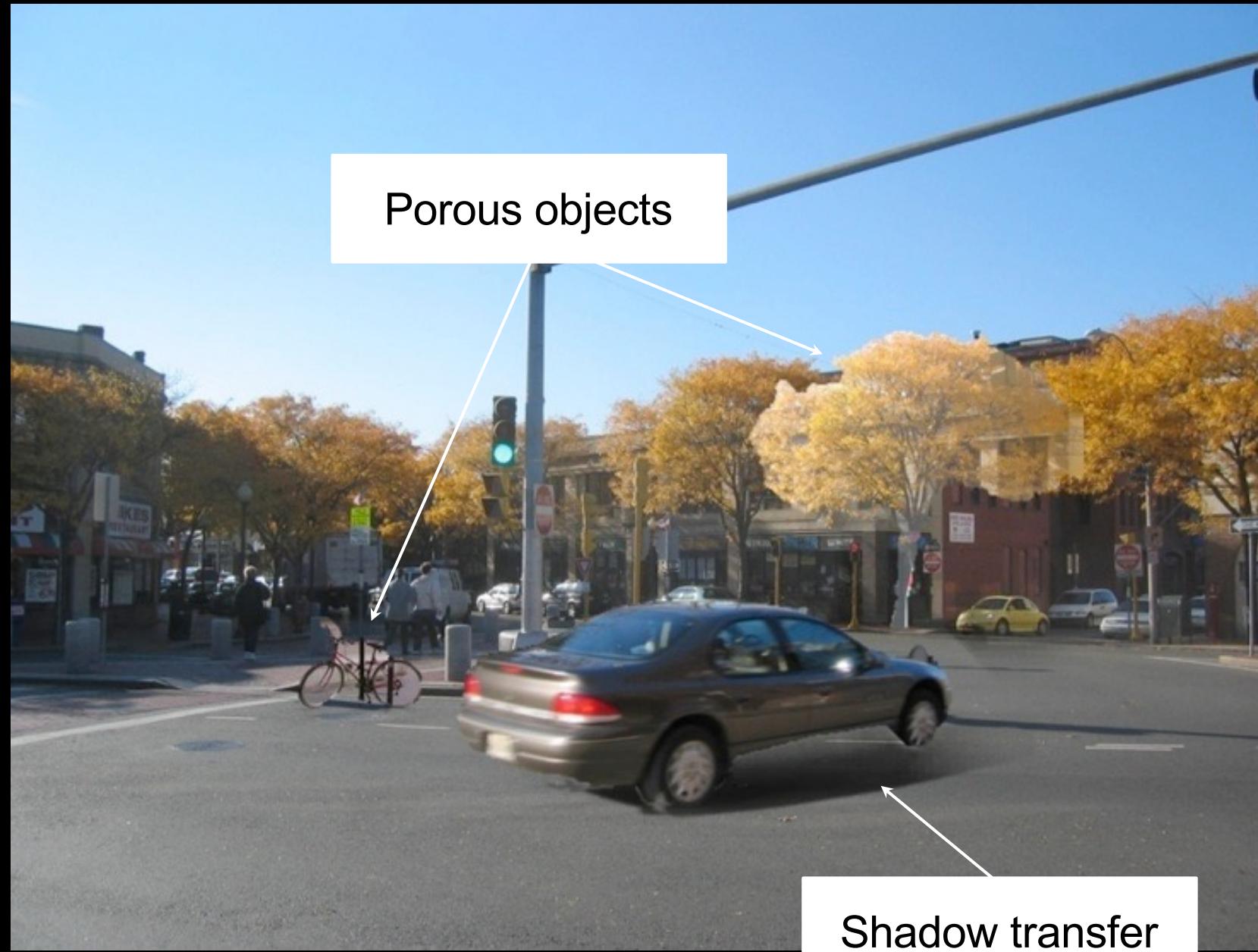
Painting



Alley



Failure cases



Failure cases



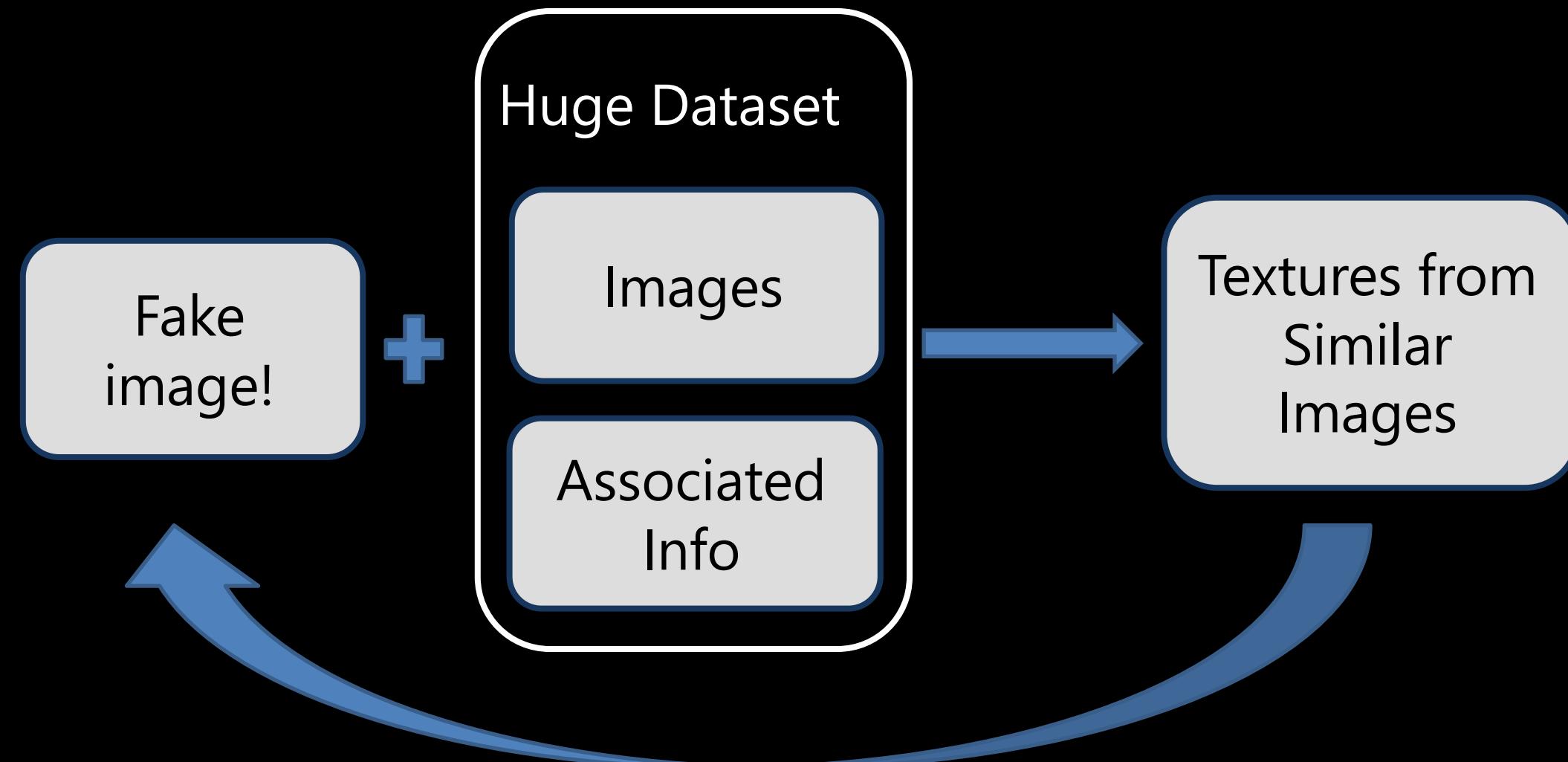
Review (Data-driven Graphics)

- How to find images given a user query?
 - Image Retrieval (Gist descriptor? Deep learning?)
 - Big data helps!
- How to combine images?
 - Image blending (Poisson Equation)

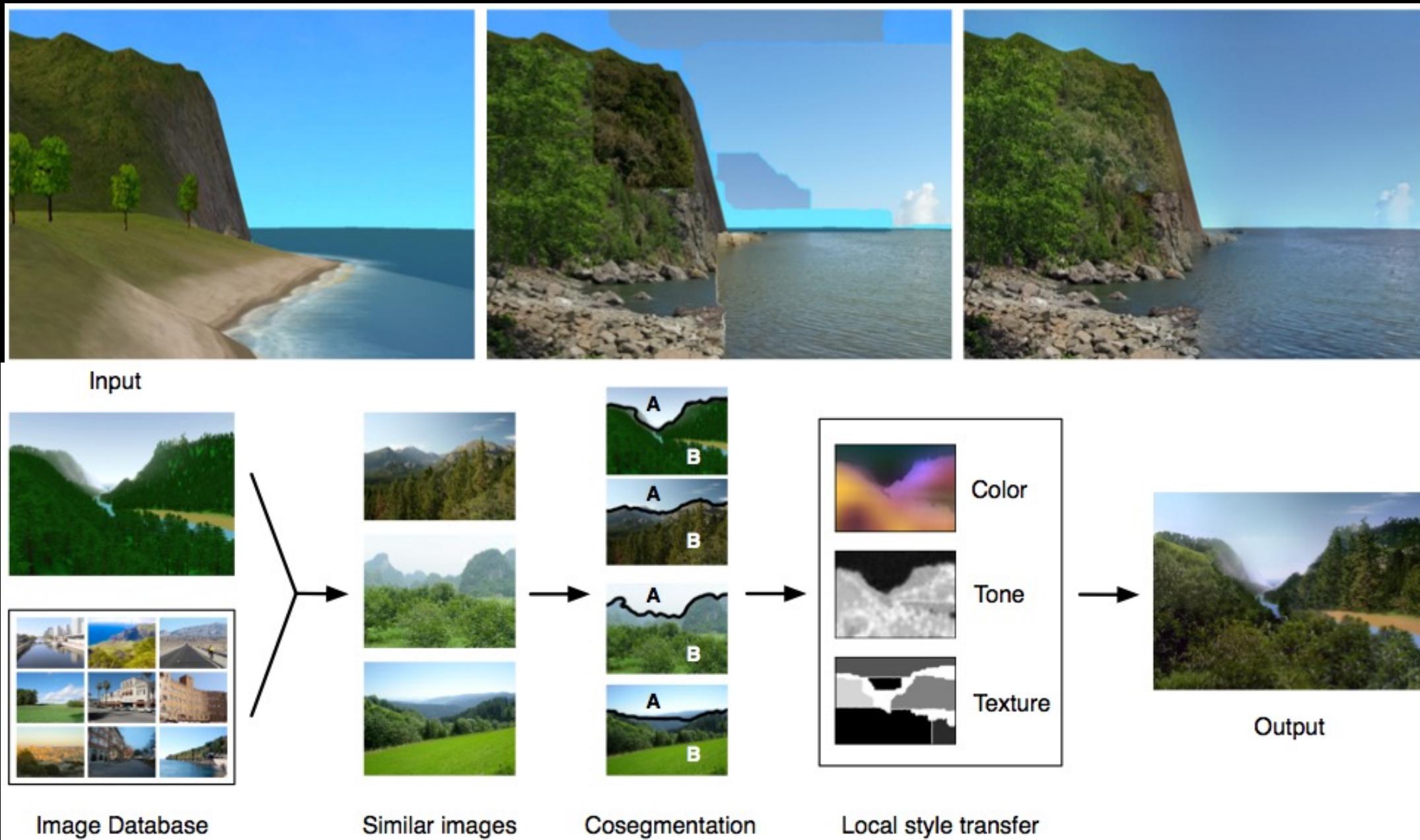
How to Combine Images?

- Image Blending/Compositing:
 - Each piece comes from a different image.
 - Need to hide the boundary

CG2Real

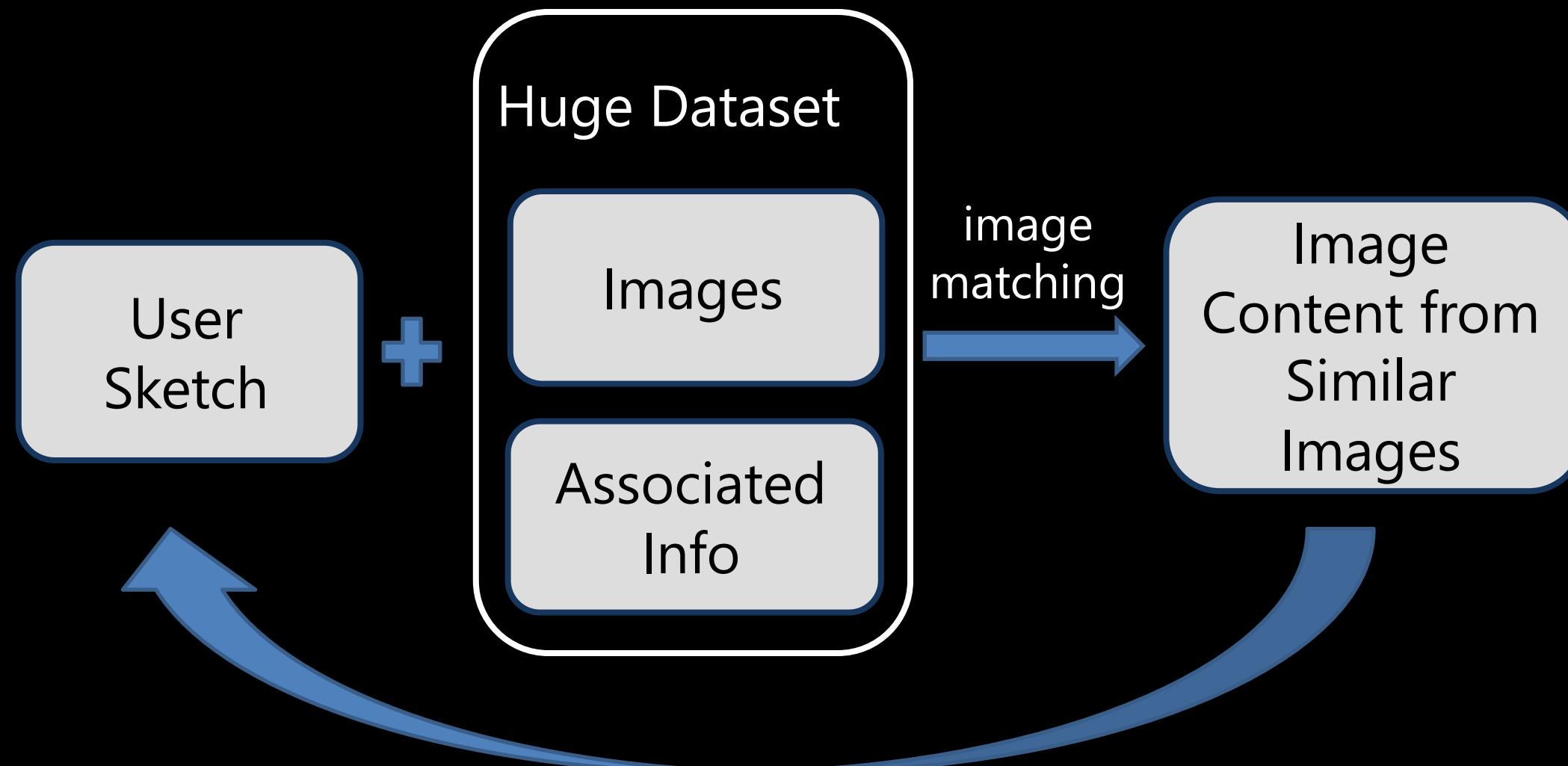


CG2Real



M. K. Johnson, K. Dale, S. Avidan, H. Pfister, W. T. Freeman, and W. Matusik, "CG2Real: Improving the realism of computer generated images using a large collection of photographs," IEEE TVCG, 2010.

Sketch2Photo



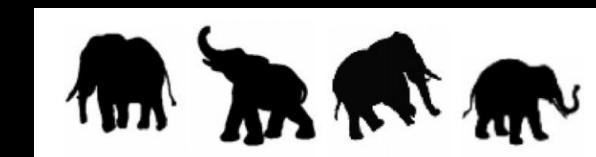
Sketch2Photo

Sketch-based image retrieval + image blending



Sketch2Photo: Internet Image Montage. Tao et al. SIGGRAPH Asia 2009.

Shape retrieval [Belongie et al. PAMI 2002]

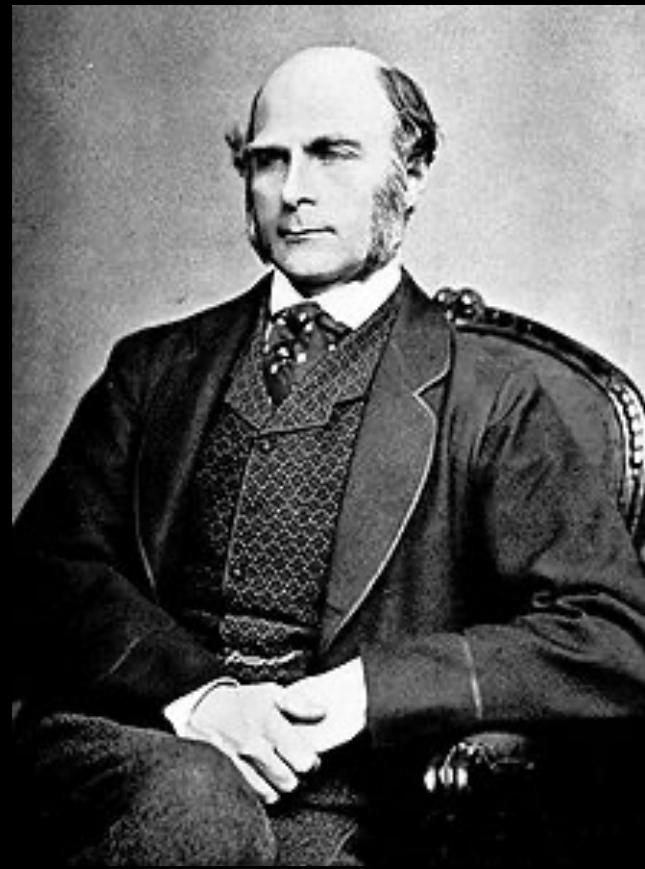


Only based on the extracted contour

How to Combine Images?

- Image Blending/Compositing:
 - Each piece comes from a different image.
 - Need to hide the boundary
- Image Averaging
 - Each pixel is a combination of multiple pixels from different images.
 - Special case: Cross-Dissolve (two images)

Image Averaging



Sir Francis Galton
1822-1911



[Galton, "Composite Portraits", Nature, 1878]

Average Images in Art



*“60 passagers de 2e classe
du metro, entre 9h et 11h”
(1985)*

Krzysztof Pruszkowski



*“Dynamism of a cyclist”
(2001)*

James Campbell



*“Spherical type gasholders”
(2004)*

Idris Khan

“100 Special Moments” (2004) by Jason Salavon



Newlyweds



Little Leaguer



Kids with Santa

Not so simple...



Jason Salavon
“*Kids with Santa*”



Google query result:
“*kids with Santa*”



Automatic Average

Why Difficult?



Google results

Visual Modes

Misaligned

“Object-Centric Averages” (2001) by Antonio Torralba



...



Manual Annotation and Alignment

Average Image

With Alignment



Google results

Visual Modes

Misaligned Aligned

With Alignment



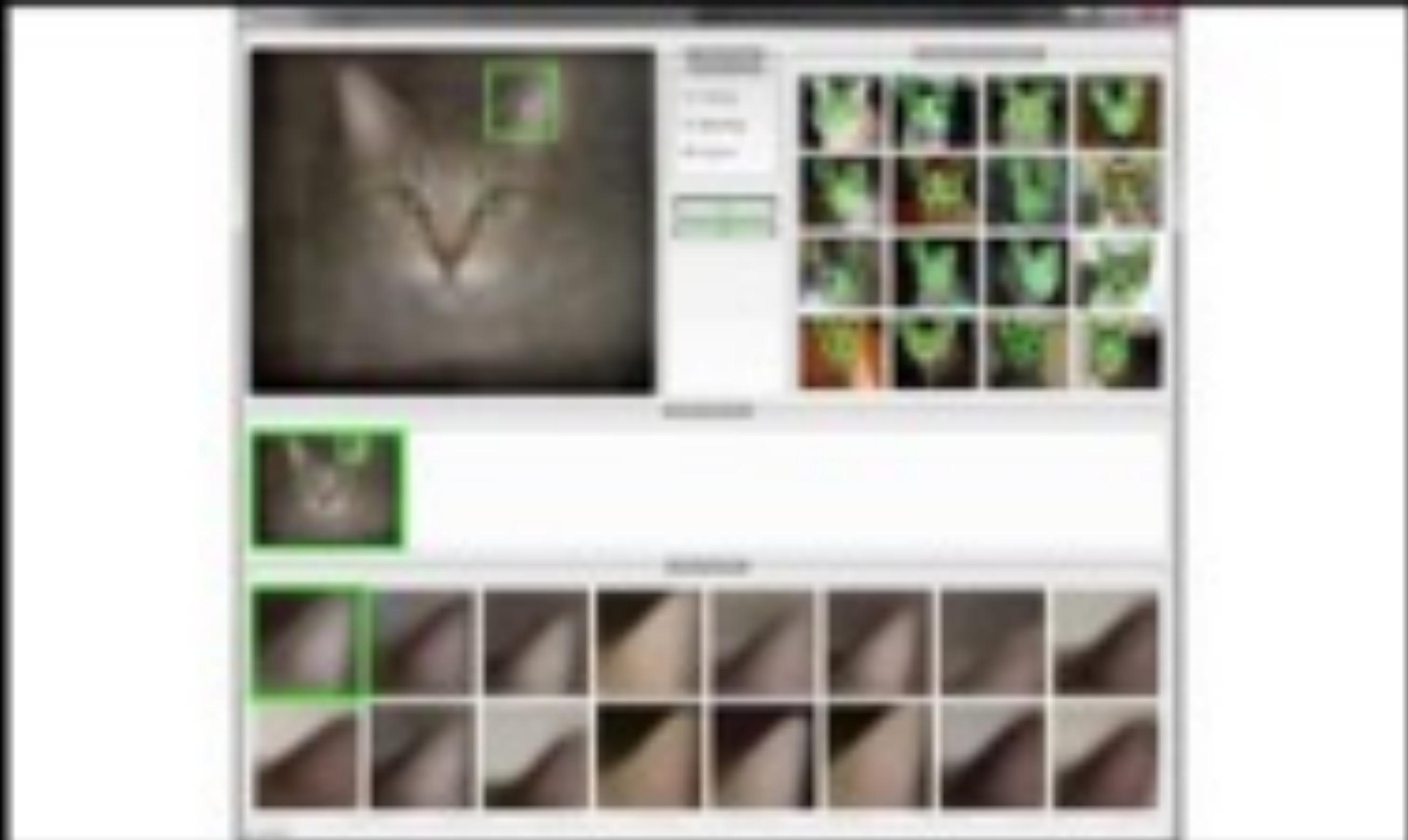
Google results

Visual Modes

Misaligned Aligned

Goal:

An interactive system to rapidly explore and align a large image collection using *image averaging*



Zhu, Lee, Efros. AverageExplorer: Interactive Exploration and Alignment of Visual Data Collections, SIGGARPH 2014.

Weighted Averages + View Alignment

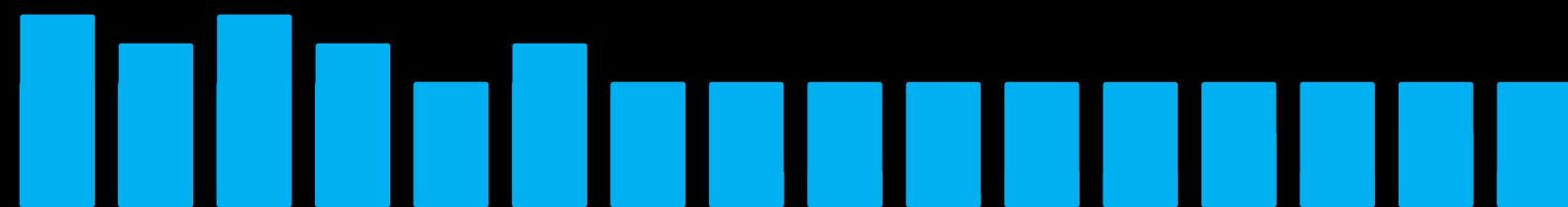


Image Weights $\{s_1 \cdots s_N\}$

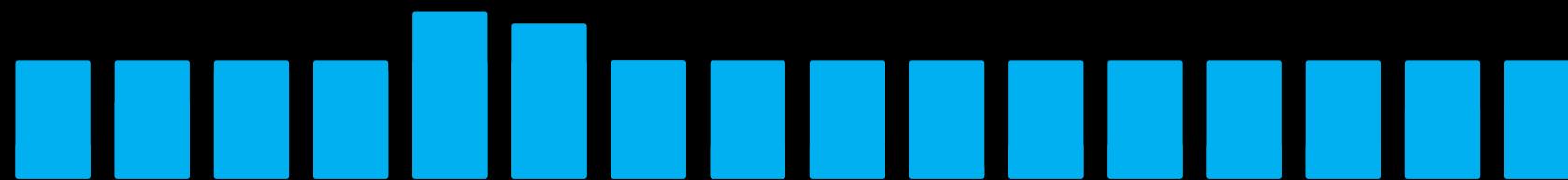
$$I_{avg} = \sum_{i=1}^N s_i I_i$$

Sketching Brush

Image Collection $\{I_1 \dots I_N\}_2$



Average

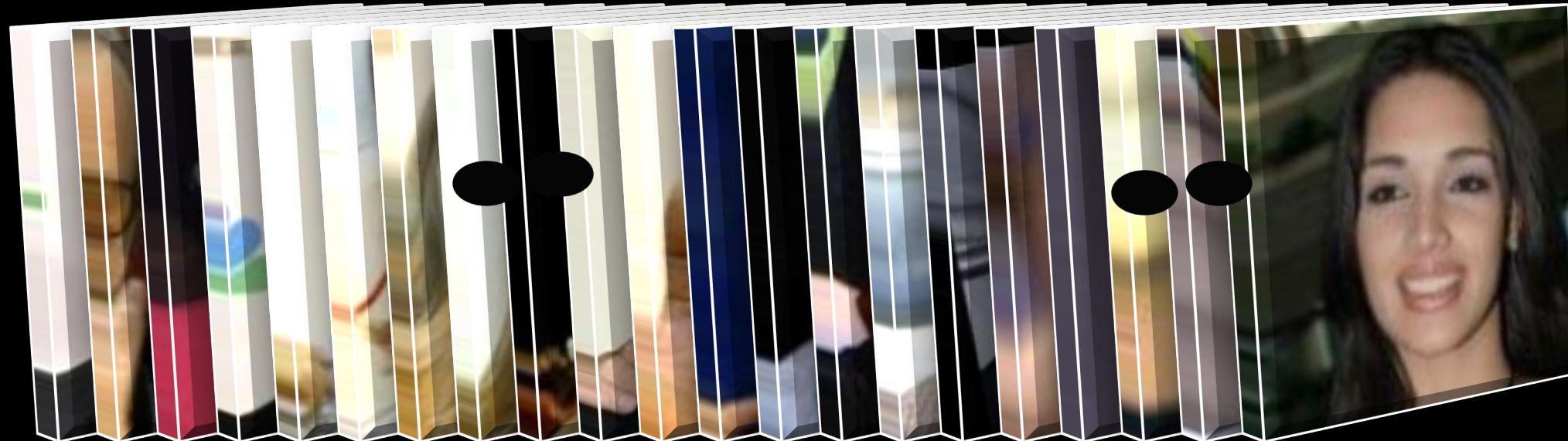


Weight $\rightarrow S_i + \text{similarity}(\text{sketch}, \text{image})$

Coloring Brush

Image Collection $\{I_1 \dots I_N\} I_2$

Average



Weight $\rightarrow S_i + similarity($, $\dots)$

Explorer Brush: Select a Local Mode

Local Visual Modes

N Image Batches



Visual
Mode
Discovery



$$S_i = S_i + \text{similarity}(\quad , \quad)$$

Mid-level
Discriminative Patch Discovery
[Doersch et al. 2012]

Weighted Averages + Alignment



Image Alignment

User Edit



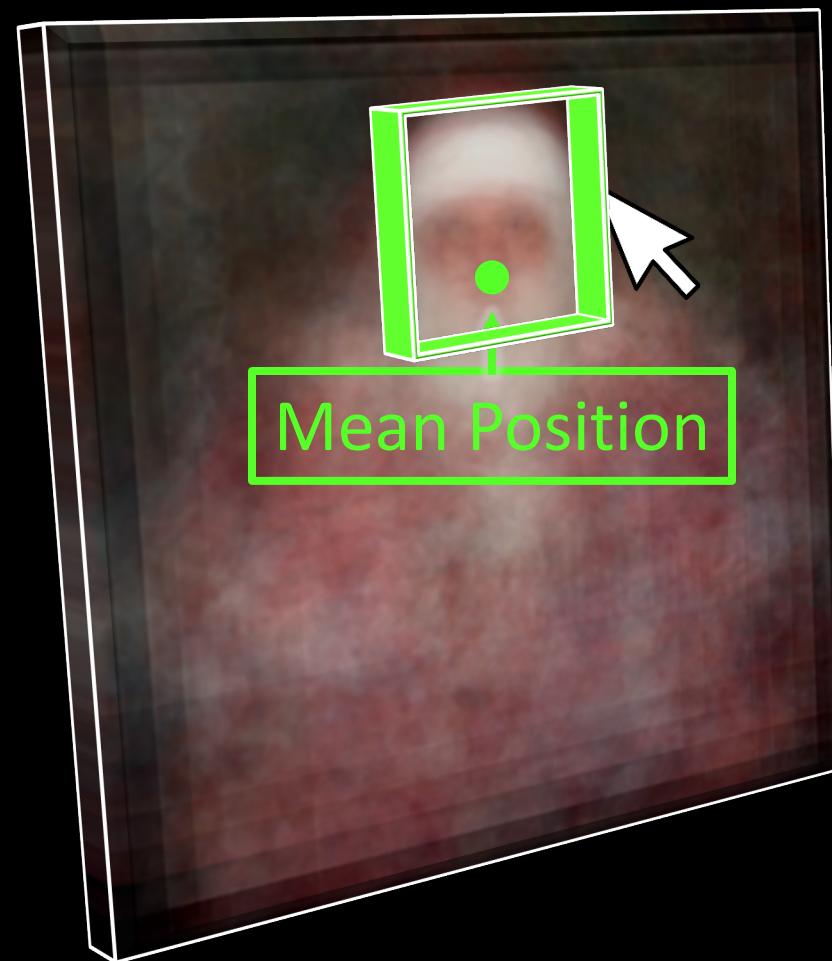
Image 1



Image 2



Average Image



Mean Position

Image Warping

User Edits



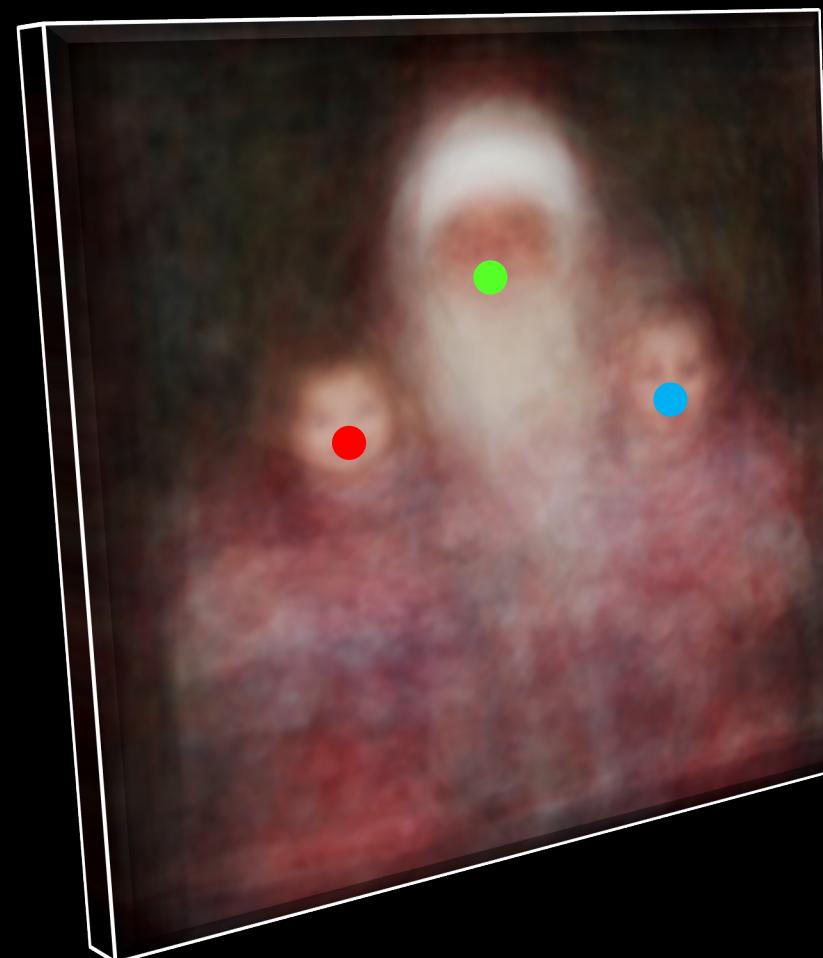
Image 1



Image 2



Average Image



Different Cat Breeds (Simple Average)



Abyssinian



Sphynx



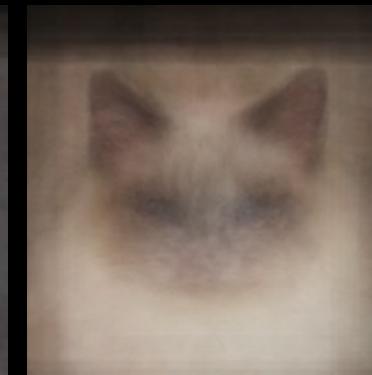
Birman



Bombay



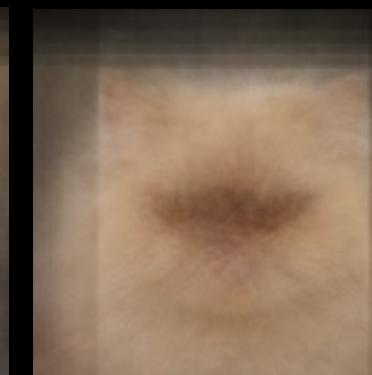
Egyptian
Mau



Ragdoll



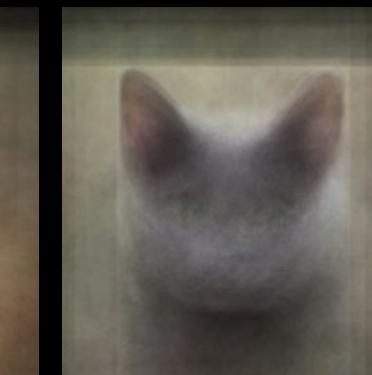
British
Shorthair



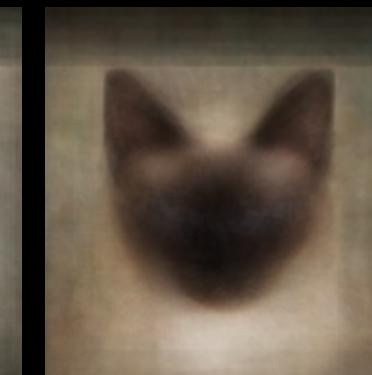
Persian



Maine
Coon



Russian
Blue



Siamese



Bengal

Different Cat Breeds (Our Result)



Abyssinian



Sphynx



Birman



Bombay



Egyptian
Mau



Ragdoll



British
Shorthair



Persian



Maine
Coon



Russian
Blue



Siamese

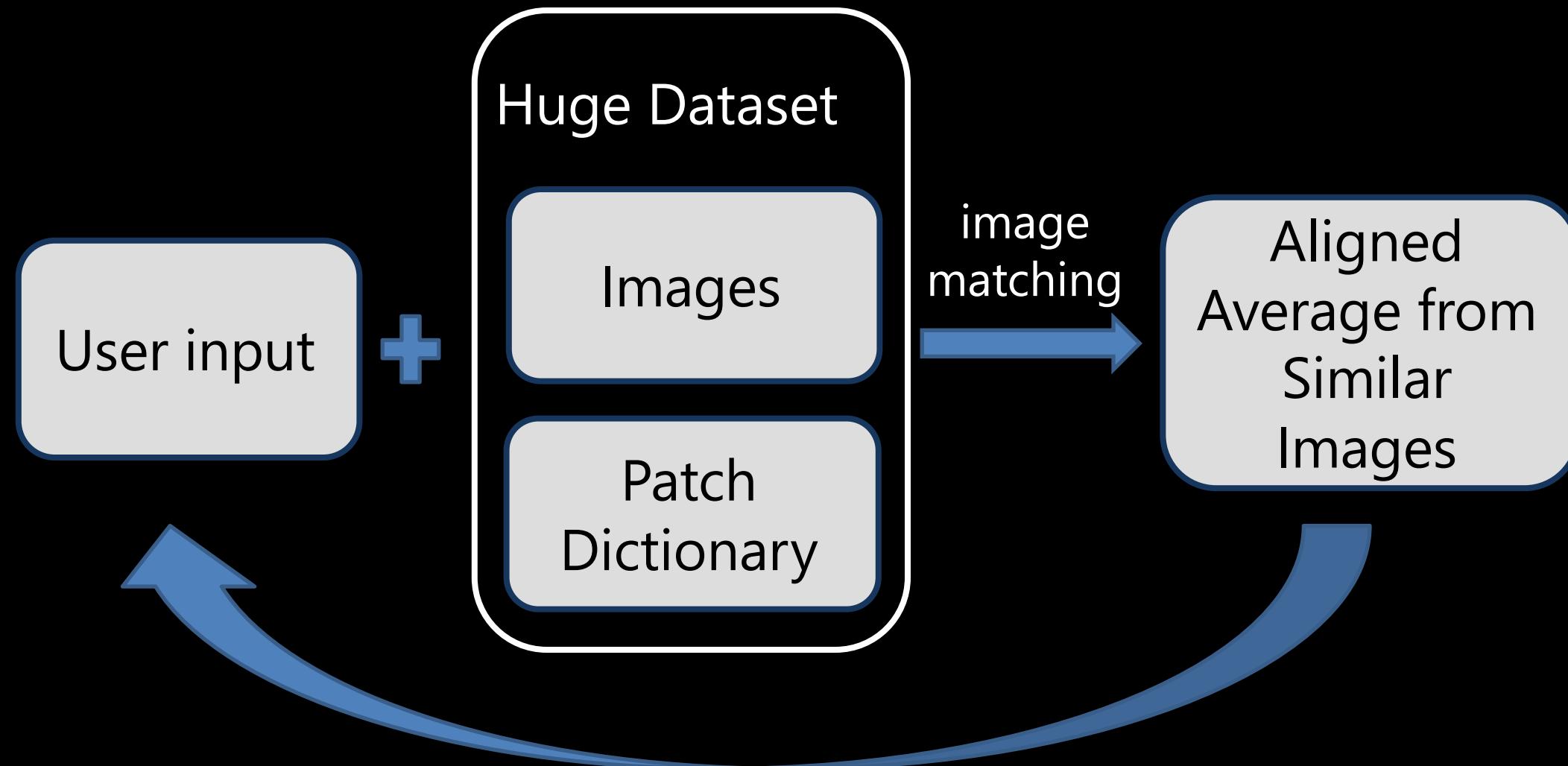


Bengal

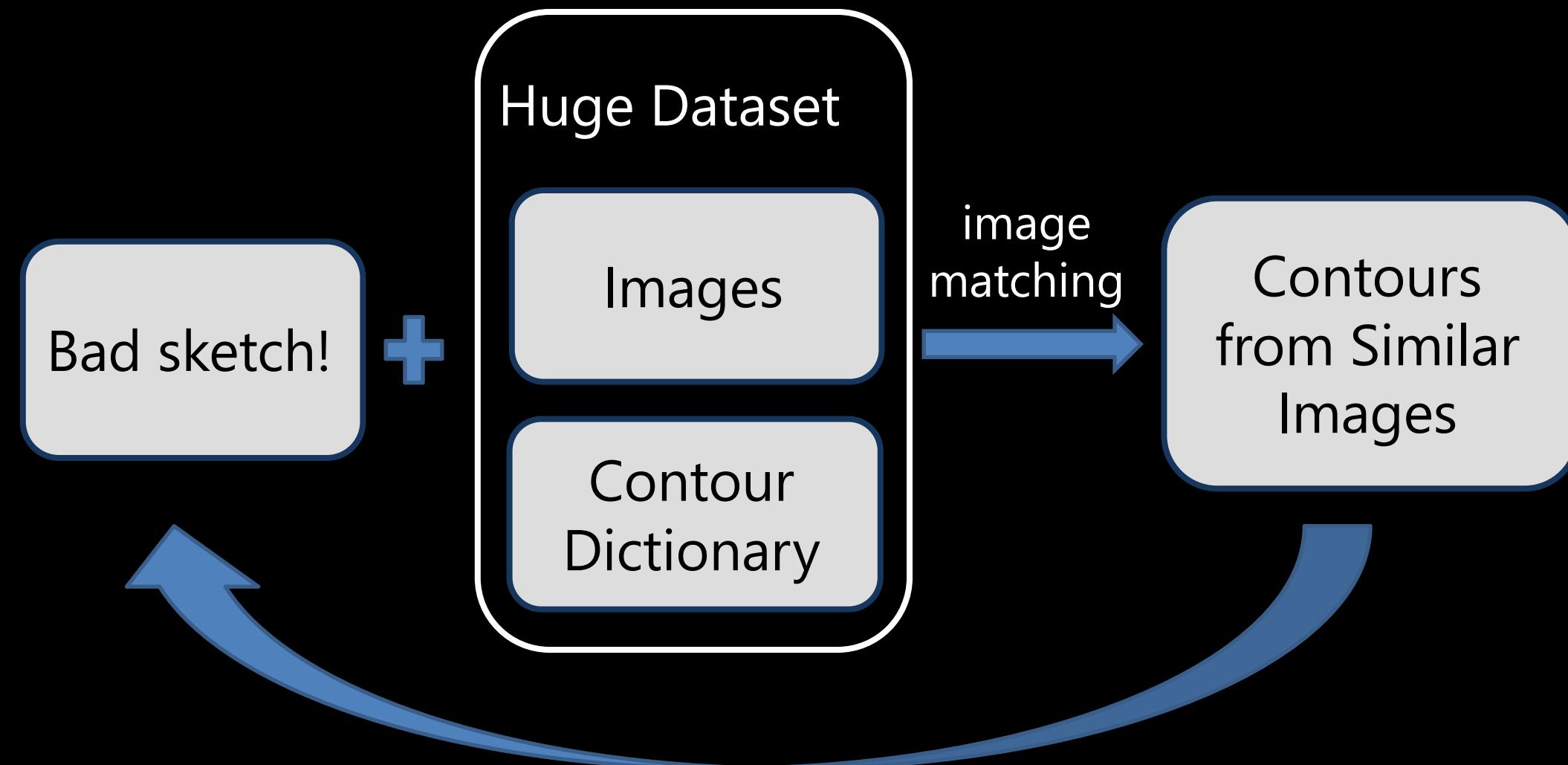
Application: Online shopping



AverageExplorer



ShadowDraw



Visible



Not visible

(Yellow)



The matches



Limitations

- Realism
 - Blending: locally realistic; globally not (need to handle and hide artifacts)
 - Averaging: globally realistic; locally not (results are blurry)
- Speed
 - Slow; might take minutes to hours for a user input.
 - Requires large-scale external databases.

How to Combine Images?

- Image Blending/Compositing:
 - Each piece comes from a different image.
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Limitations

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 - Slow for large-scale datasets.
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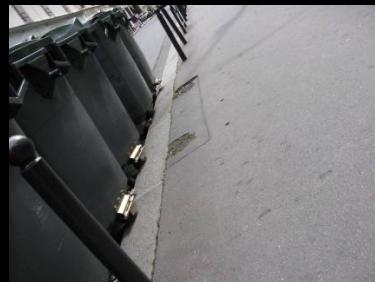
Dataset Bias

- Internet is a tremendous repository of visual data (Flickr, YouTube, Picassa, etc)
- But it's not random samples of visual world
- Many sources of bias:
 - Sampling bias
 - Photographer bias
 - Social bias

Flickr Paris



Real Paris



Real Notre Dame



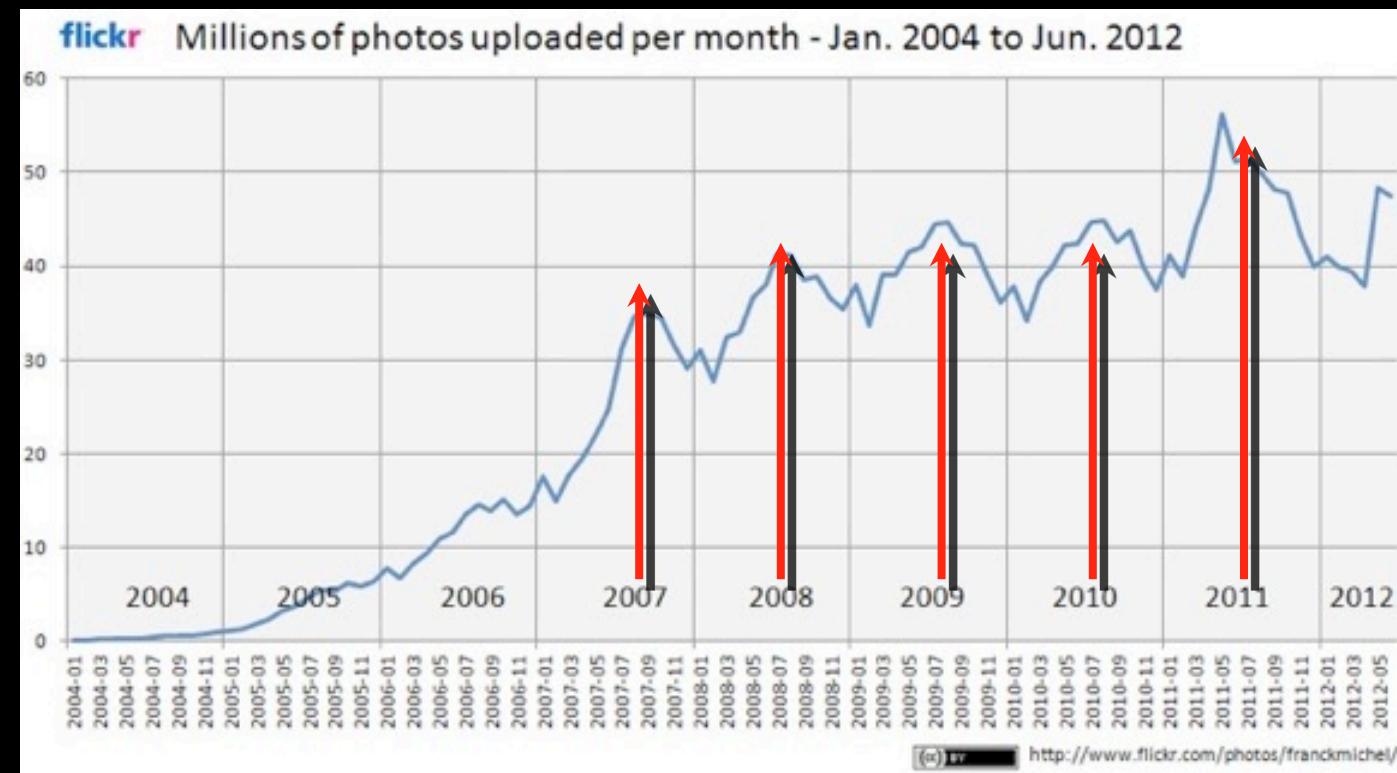
Sampling Bias

- People like to take pictures on vacation



Sampling Bias

- People like to take pictures on vacation



Photographer Bias

- People want their pictures to be recognizable and/or interesting



vs.



Photographer Bias

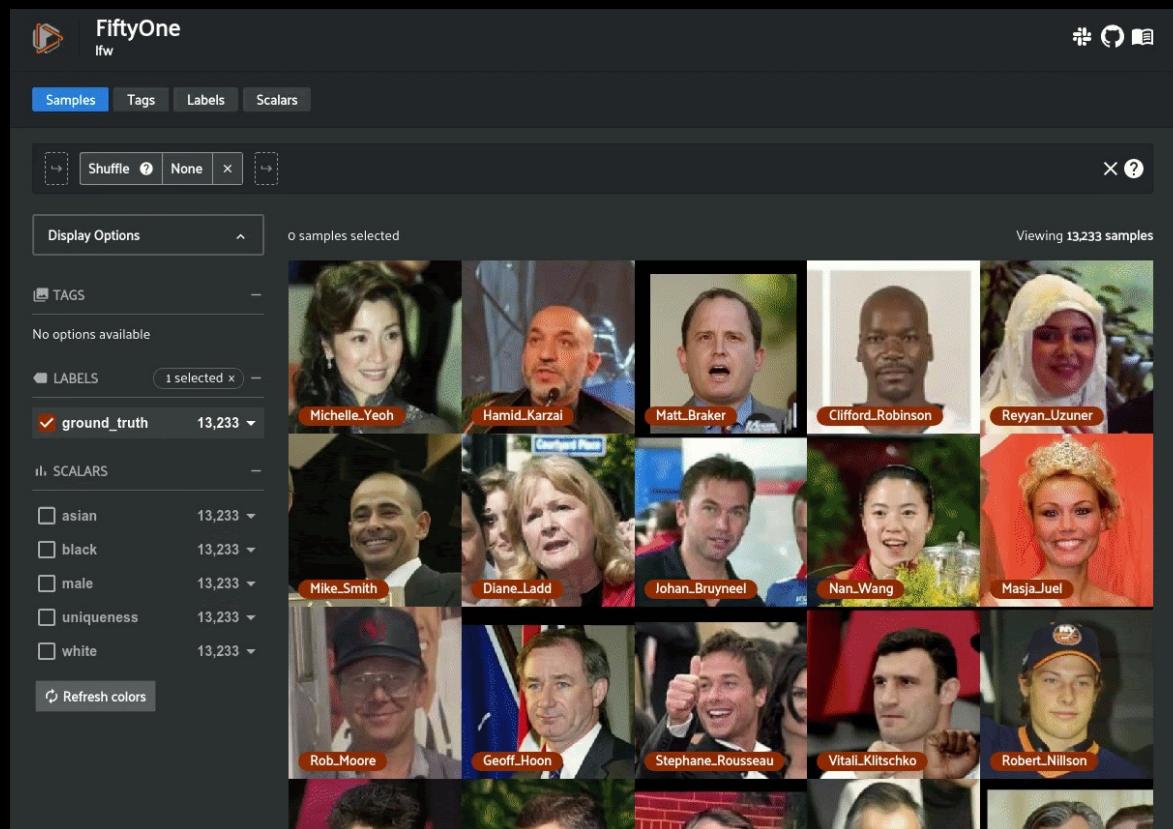
- People follow photographic conventions



vs.

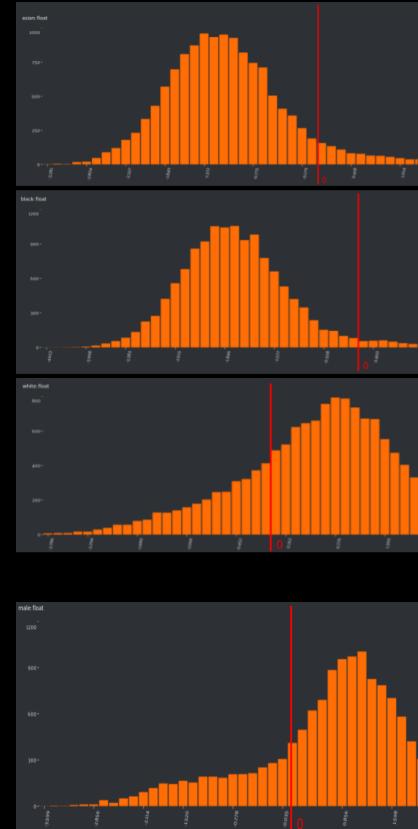


Social Bias



© Eric Hofesmann

Labeled Face in the Wild, 2007 (13,233 images)



Asian

Black

White

Male

George W. Bush: 500+ images
On average 2 images per person

Social Bias



Flickr-Faces-HQ Dataset (FFHQ), NVIDIA (70,000 images)

Reducing Dataset Bias

Reducing / Changing Bias



- Autonomous capture methods can reduce / change bias
 - But it won't go away completely
- Sometimes you can just pick your data to suit your problem, but not always...

Datasheet for Datasets

Motivation

- For what purpose was the dataset created?
- Who created the dataset?
- Who funded the creation of the dataset?
- ...

Collection Process

- Does the dataset identify any subpopulations?
- Is it possible to identify individuals?
- Does the dataset contain data that might be considered sensitive in any way?
- How was the data associated with each instance acquired?
- ...

Ethics and Societal Impact

- Were any ethical review processes conducted?
- Has an analysis of the potential impact of the dataset and its use on data subjects
- ...



THANK YOU!

16-726, SPRING 2023

[HTTPS://LEARNING-IMAGE-SYNTHESIS.GITHUB.IO/SP23/](https://learning-image-synthesis.github.io/SP23/)