Image Compositing & Morphing

Guest Lecture by Tom Funkhouser

COS 426, Spring 2015

Princeton University

Image Processing Operations I

- Luminance
  - Brightness
  - Contrast.
  - Gamma
  - Histogram equalization
- Color
  - Black & white
  - Saturation
  - White balance
- Linear filtering
  - Blur & sharpen
  - Edge detect
  - Convolution
- Non-linear filtering
  - Median
  - Bilateral filter
- Dithering
  - Quantization
  - Ordered dither
  - Floyd-Steinberg

Image Processing Operations II

- Transformation
  - Scale
  - Rotate
  - Warp

  } Last time

- Combining images
  - Composite
  - Morph
  - Computational photography

  } Today

Image Processing Operations II

- Transformation
  - Scale
  - Rotate
  - Warp
- Combining images
  - Composite
  - Morph
  - Computational photography

} Last time

} Today

Image Composition

Jurassic Park

Image Composition

- Issues:
  - Segmentation of image into layers/regions
  - Blend into single image seamlessly

Smith & Blinn`84

Image Composition

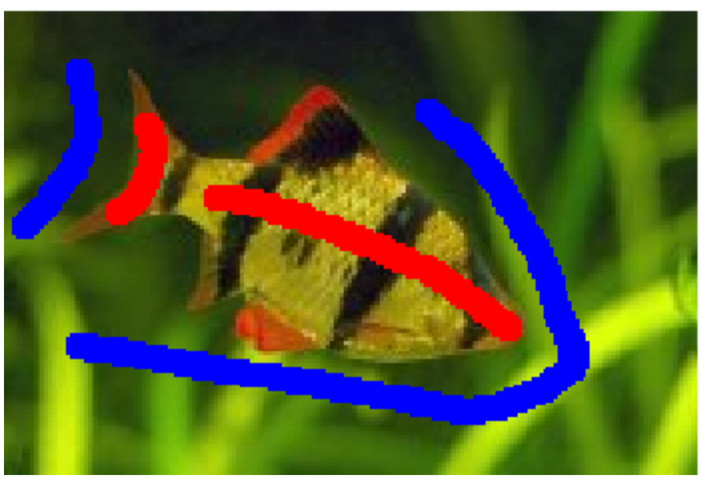
- Issues:
  - Segmentation of image into layers/regions
  - Blend into single image seamlessly

Image Segmentation

- Chroma keying (blue- or green-screen)
  - Photograph object in front of screen with known color

Image Segmentation

- Specify segmentation by hand
  - Purely manual: rotoscoping (draw matte, every frame)
  - Semi-automatic: graph min-cut (draw a few strokes)
    Separate image regions along minimal cuts (where edges measure differences between adjacent pixels)



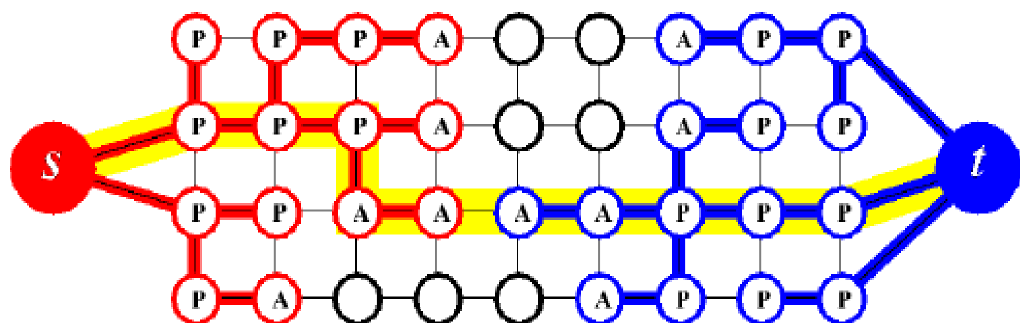


Image Segmentation

- Novel methods, e.g. flash matting

flash no flash matte composite

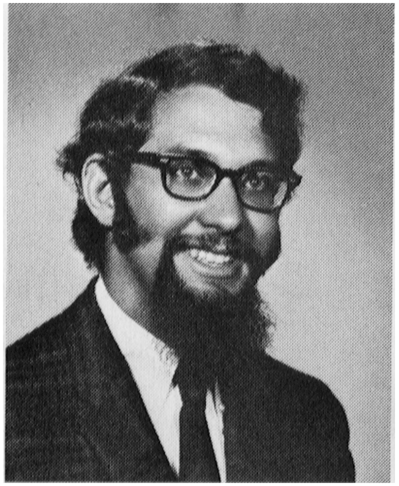
Sun et al., 2006

Image Composition

- Issues:
  - Segmentation of image into layers/regions
  - Blend into single image seamlessly

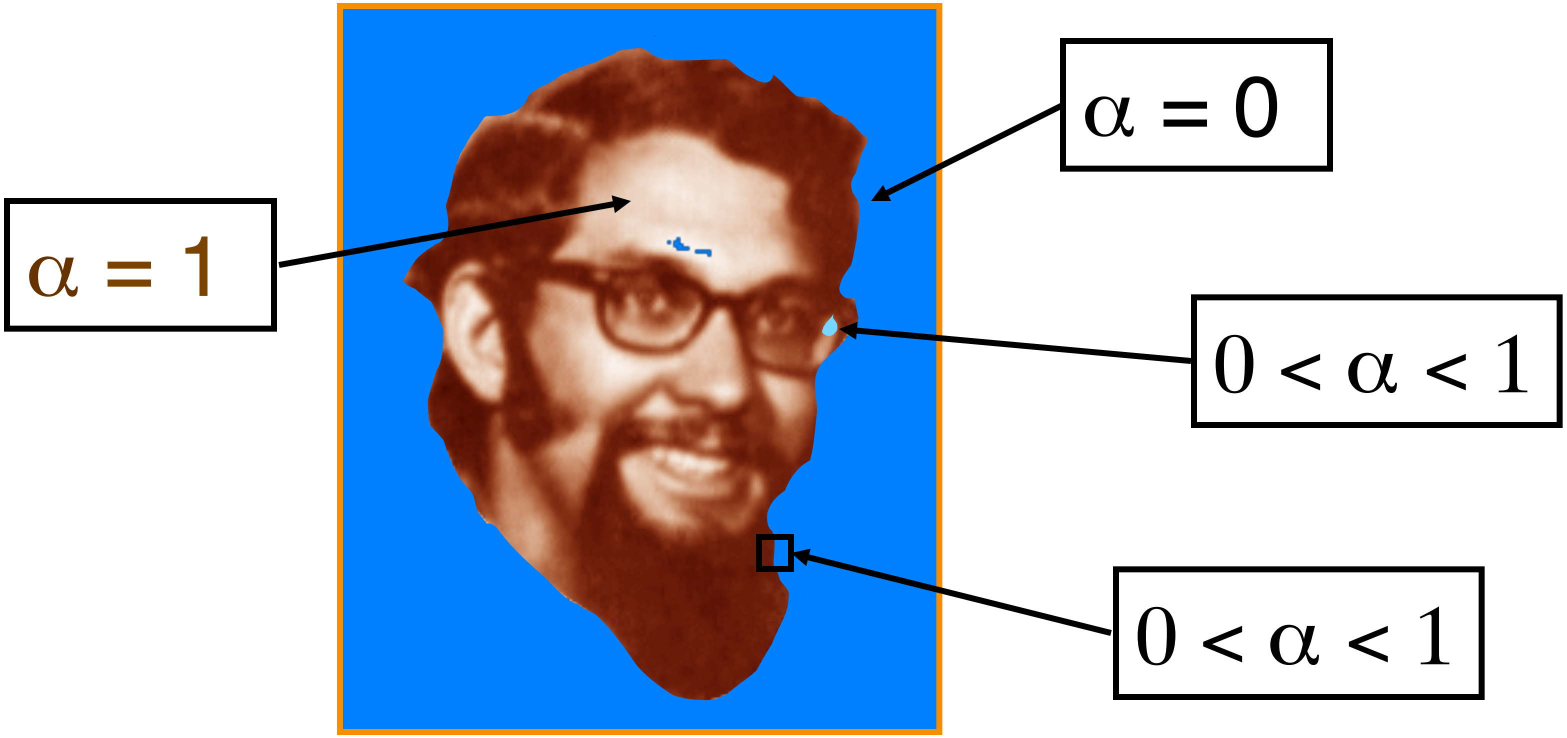
Image Blending

- Ingredients
  - Background image
  - Foreground image
- Goal
  - Put foreground over background seamlessly



Blending with Alpha Channel

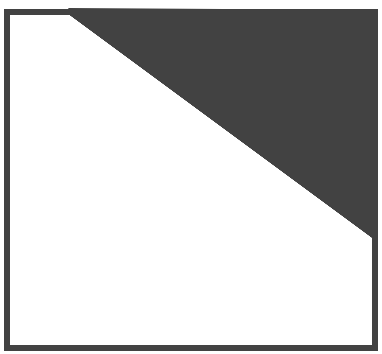
Alpha controls the linear interpolation of foreground and background pixels when elements are composited.



Blending with Alpha Channel

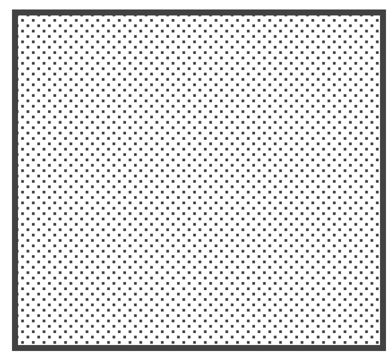
- Alpha encodes pixel coverage information
  - $\alpha = 0$: no coverage (or transparent)
  - $\alpha = 1$: full coverage (or opaque)
  - $0 < \alpha < 1$: partial coverage (or semi-transparent)

- Example: $\alpha = 0.3$



Partial Coverage

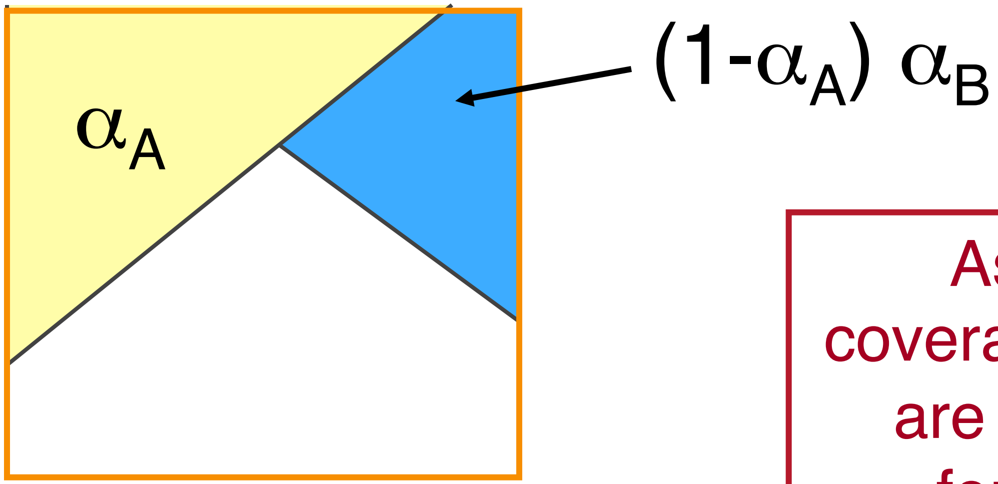
or



Semi-Transparent

Blending with Alpha Channel

- Example: C = A Over B
  - $C' = \alpha_A A + (1-\alpha_A)\,\alpha_B B$
  - $\alpha = \alpha_A + (1-\alpha_A)\,\alpha_B$

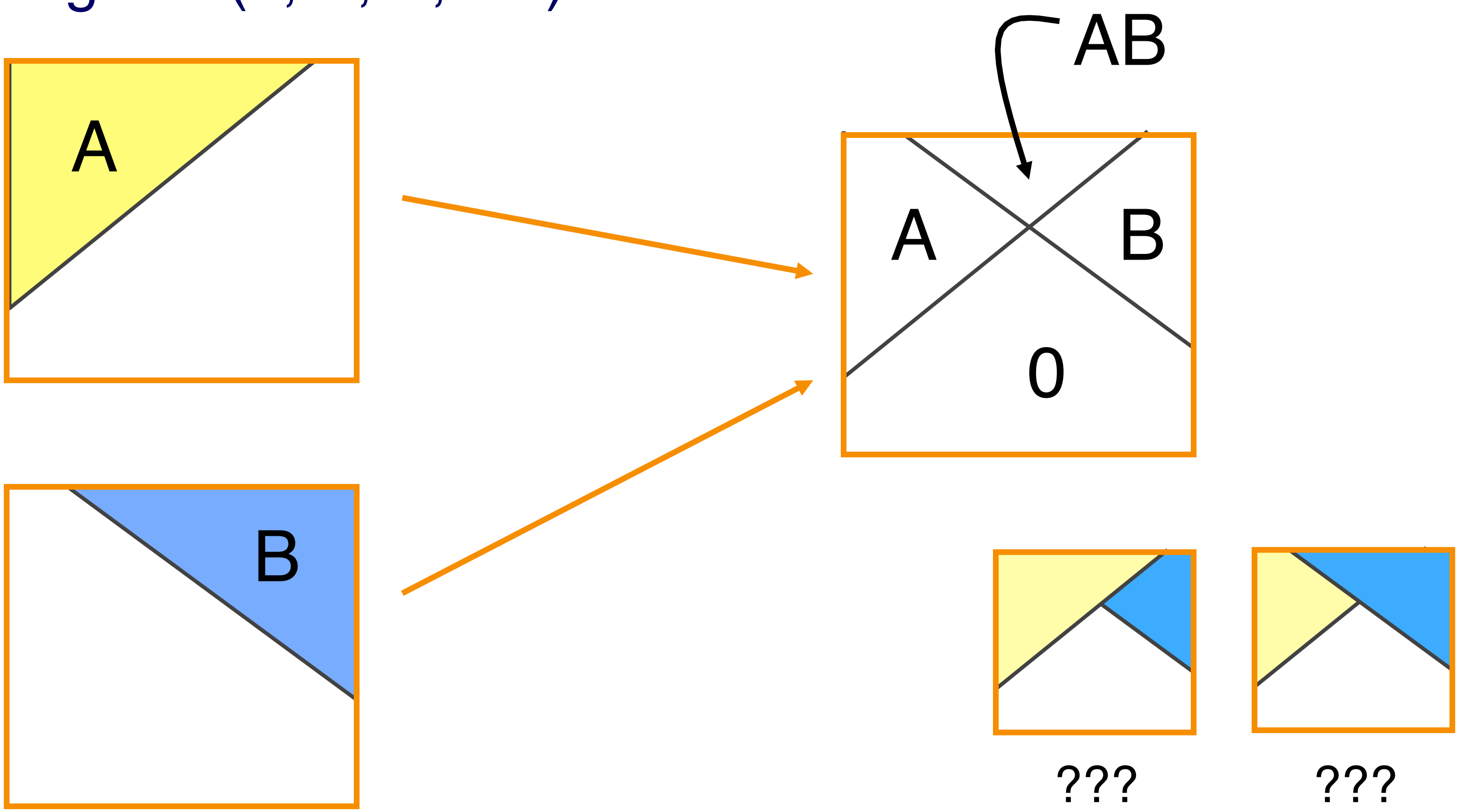


A over B

Assumption:
coverages of A and B
are uncorrelated
for each pixel

Other Composition Operations

- Ways to combine 2 partially covered pixels?
  - 3 possible colors (0, A, B)
  - 4 regions (0, A, B, AB)

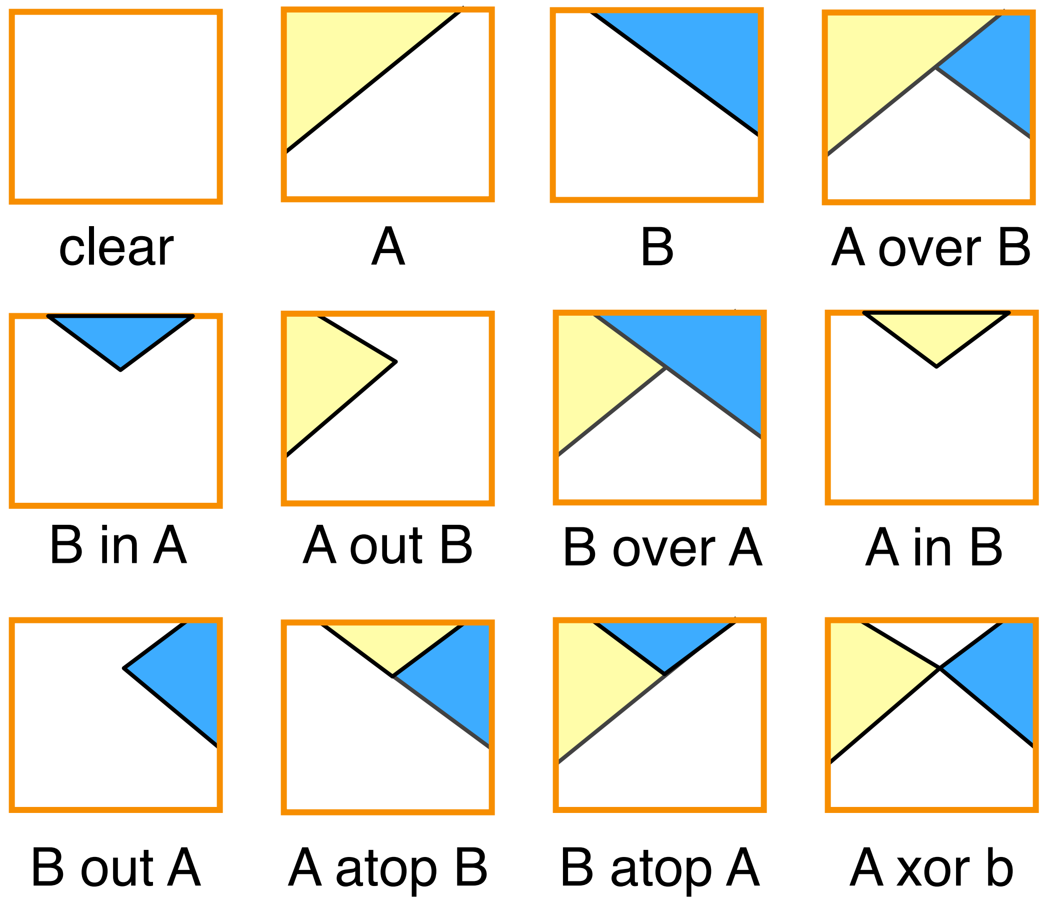


Other Composition Operations

Composition algebra – 12 combinations

$$C' = F_A \, \alpha_A A + F_B \, \alpha_B B$$

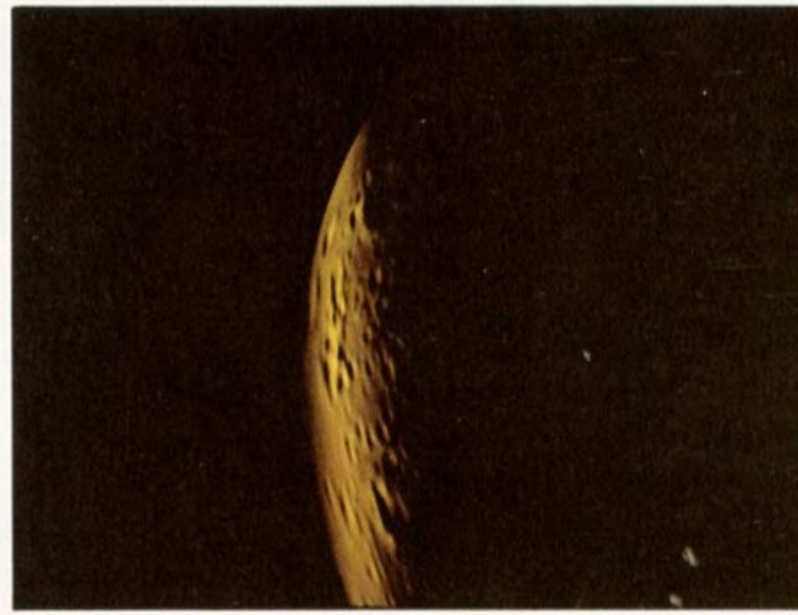
Operation	F_A	F_B
Clear	0	0
A	1	0
B	0	1
A over B	1	$1-\alpha_A$
B over A	$1-\alpha_B$	1
A in B	α_B	0
B in A	0	α_A
A out B	$1-\alpha_B$	0
B out A	0	$1-\alpha_A$
A atop B	α_B	$1-\alpha_A$
B atop A	$1-\alpha_B$	α_A
A xor B	$1-\alpha_B$	$1-\alpha_A$



Porter & Duff `84

Image Composition Example

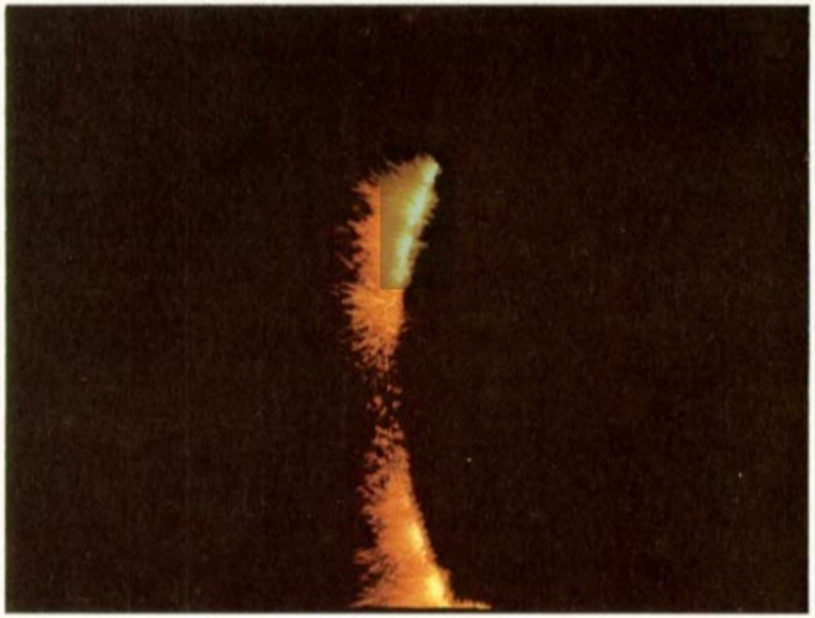
Stars

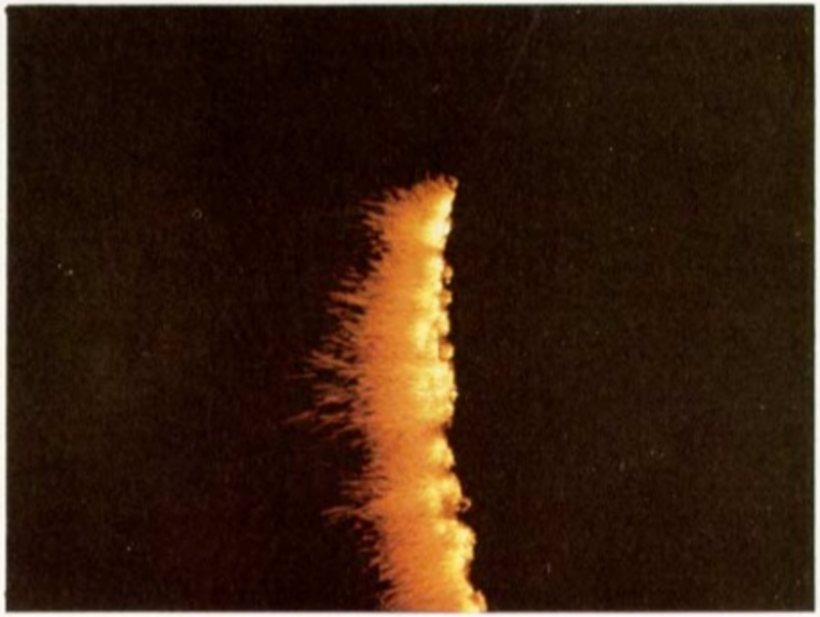


Planet

[Porter&Duff *Computer Graphics* 18:3 1984]

Image Composition Example

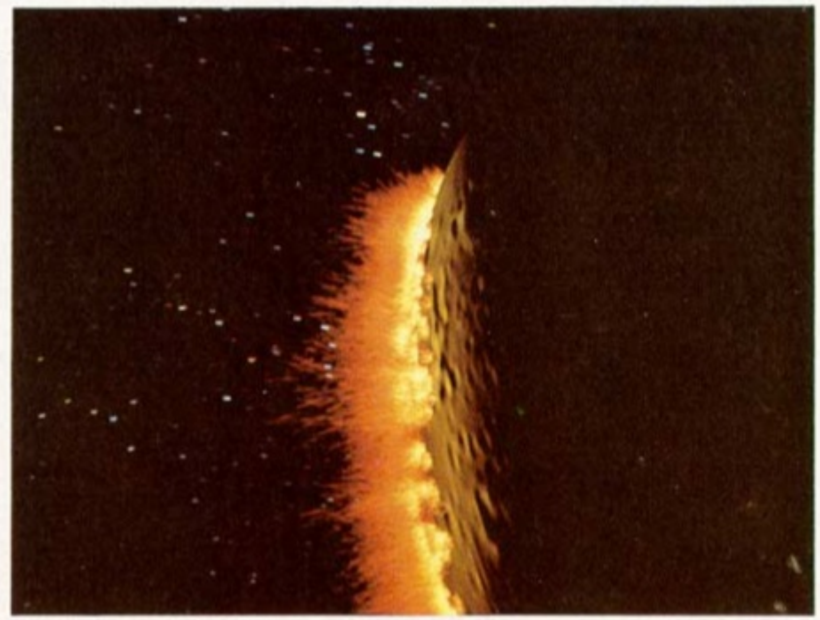

BFire


FFire

[Porter&Duff *Computer Graphics* 18:3 1984]

Image Composition Example

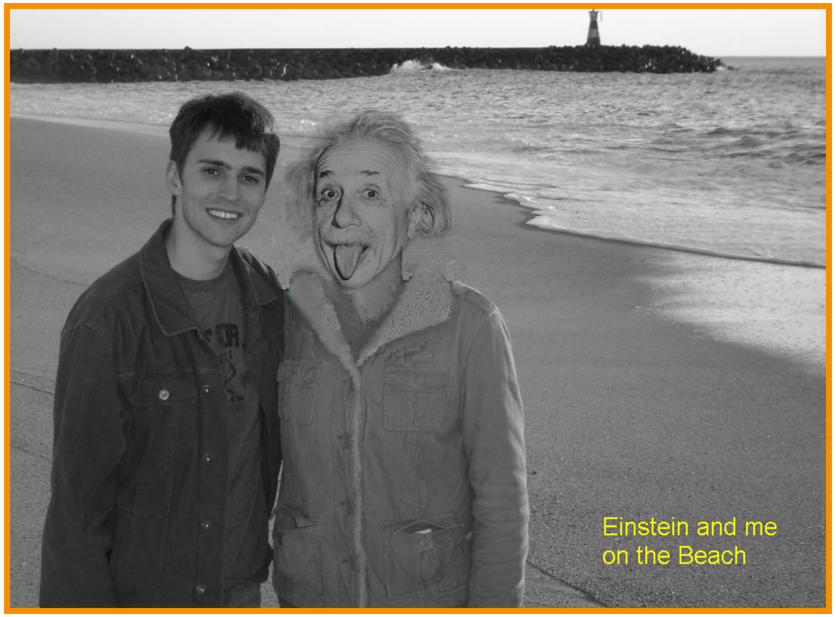
BFire **out** Planet



Composite

[Porter&Duff *Computer Graphics* 18:3 1984]

COS426 Examples



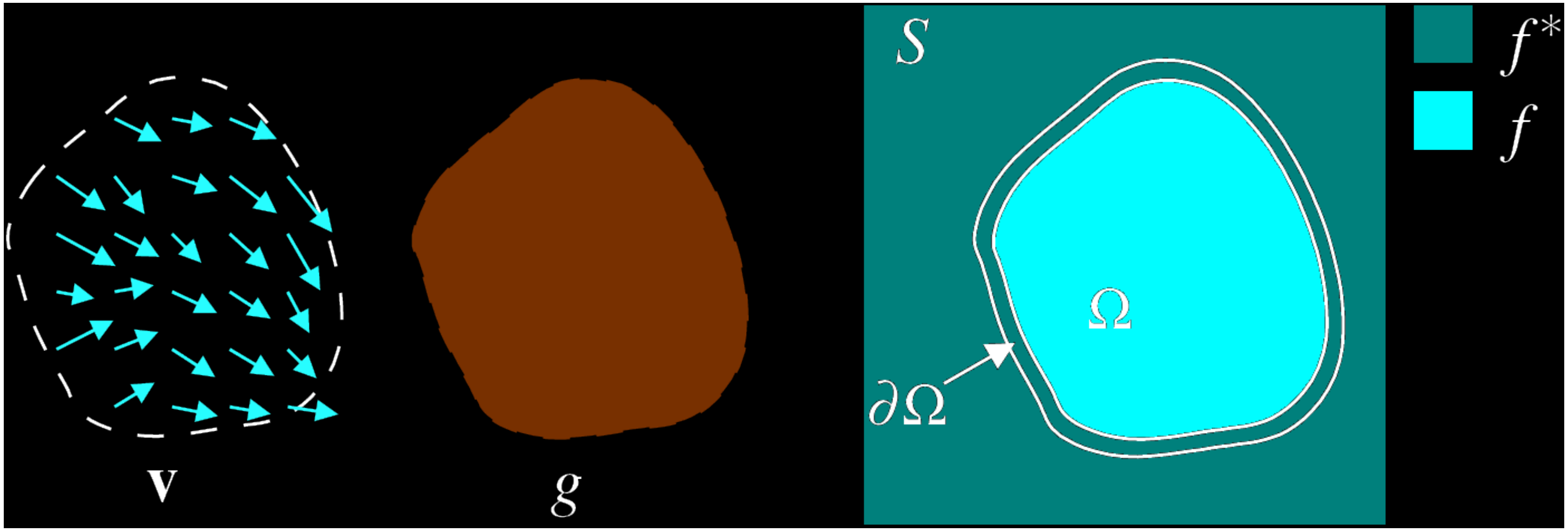
Darin Sleiter

Kenrick Kin

Poisson Image Blending

Beyond simple compositing

- Solve for image samples that follow gradients of source subject to boundary conditions imposed by dest

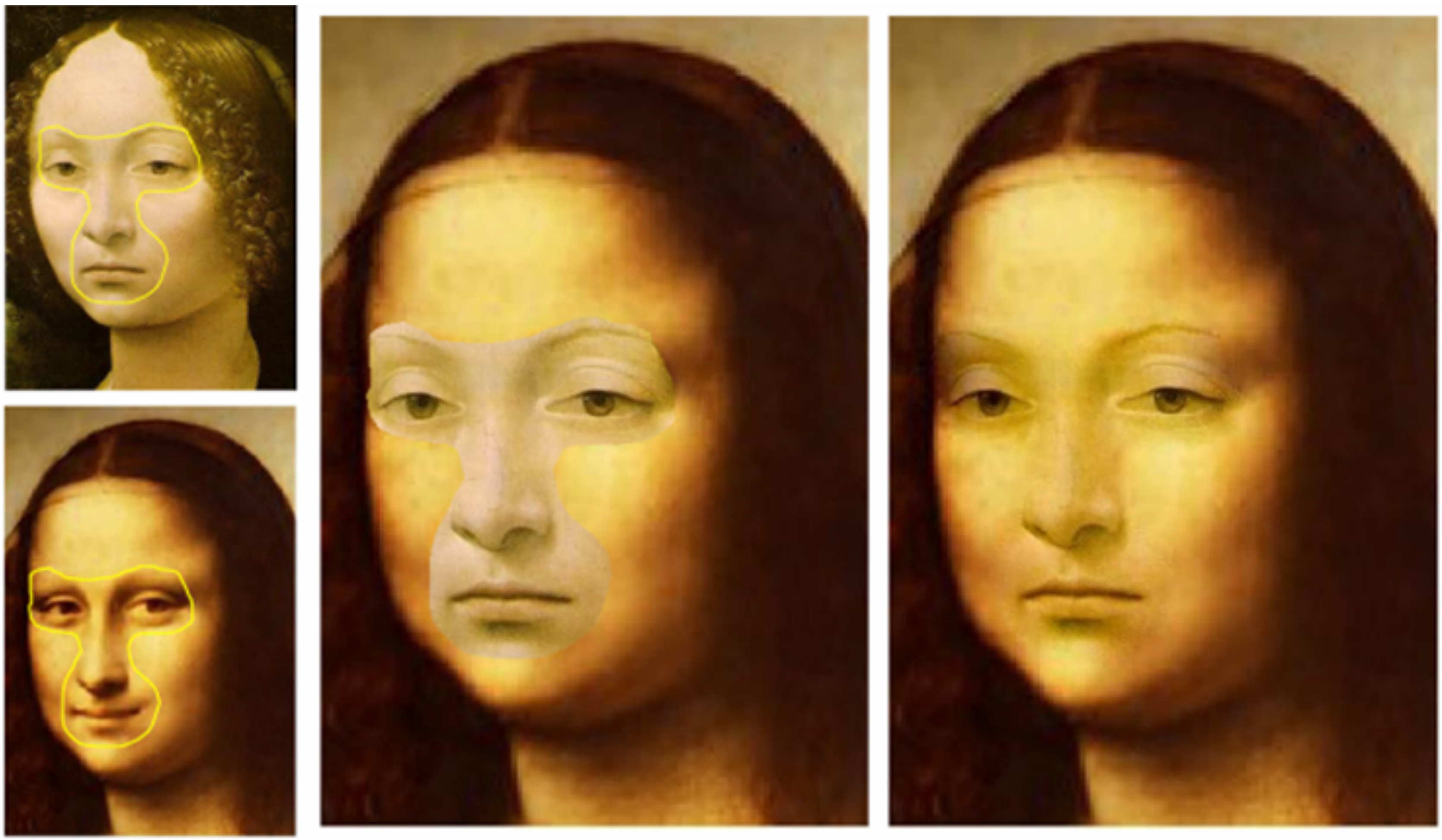


$$\begin{cases} \nabla^2 f = \nabla \cdot \mathbf{v} \\ f|_{\partial\Omega} = f^*|_{\partial\Omega} \end{cases}$$

Poisson Image Blending

sources destinations cloning seamless cloning

Poisson Image Blending



source/destination cloning seamless cloning

Poisson Image Blending

http://www.csie.ntu.edu.tw/~r00944002/CPHW2/result.htm

Digital Image Processing

- Changing intensity/color
  - Linear: scale, offset, etc.
  - Nonlinear: gamma, saturation, etc.
  - Add random noise
- Filtering over neighborhoods
  - Blur
  - Detect edges
  - Sharpen
  - Emboss
  - Median
- Moving image locations
  - Scale
  - Rotate
  - Warp
- Combining images
  - Composite
  - Morph
- Quantization
- Spatial / intensity tradeoff
  - Dithering

Image Morphing

- Animate transition between two images

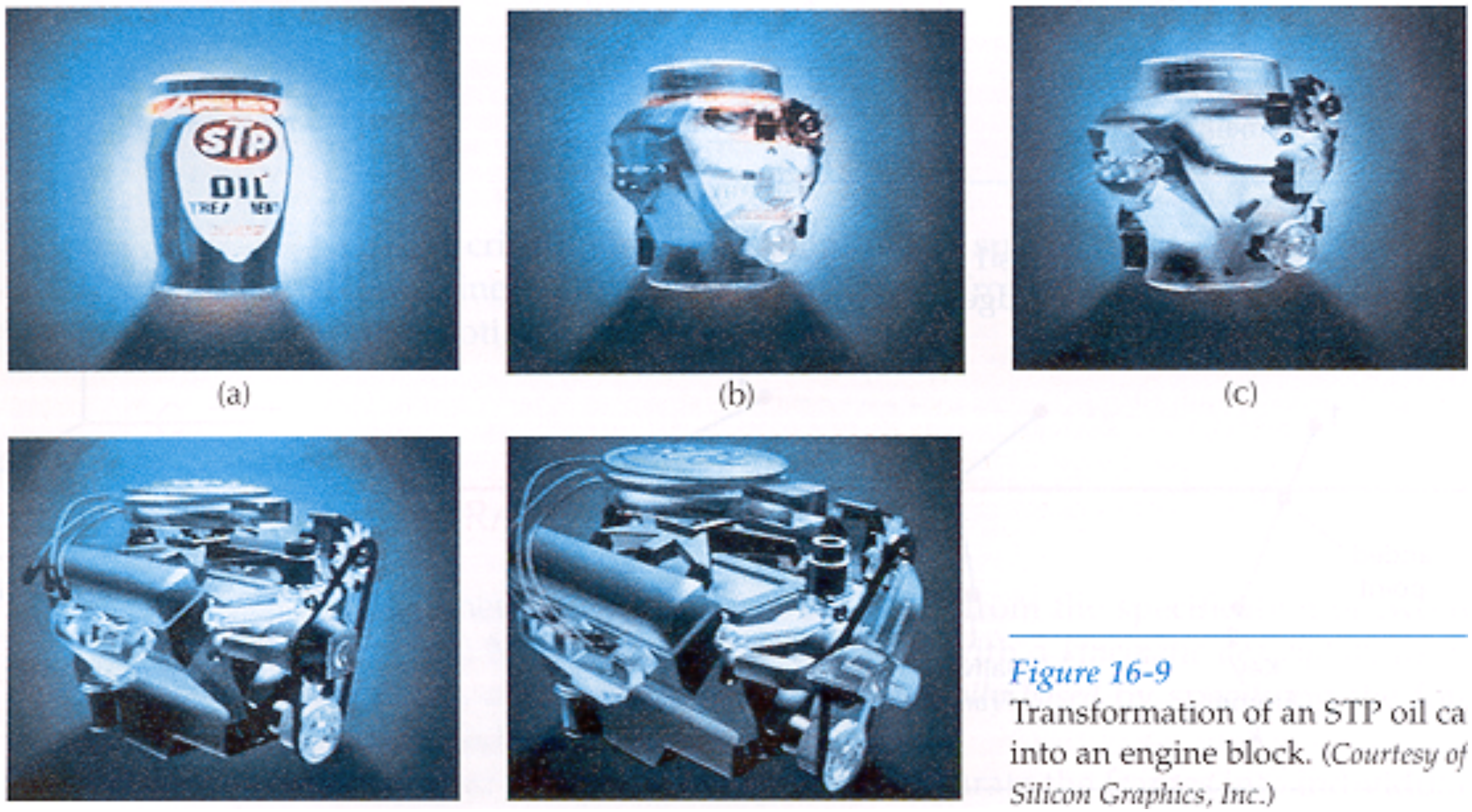


Figure 16-9
Transformation of an STP oil ca into an engine block. (*Courtesy of Silicon Graphics, Inc.*)

H&B Figure 16.9

Cross-Dissolving

- Blend images with “over” operator
  - alpha of bottom image is 1.0
  - alpha of top image varies from 0.0 to 1.0

$$\text{blend}(i,j) = (1-t)\,\text{src}(i,j) + t\,\text{dst}(i,j) \qquad (0 \le t \le 1)$$

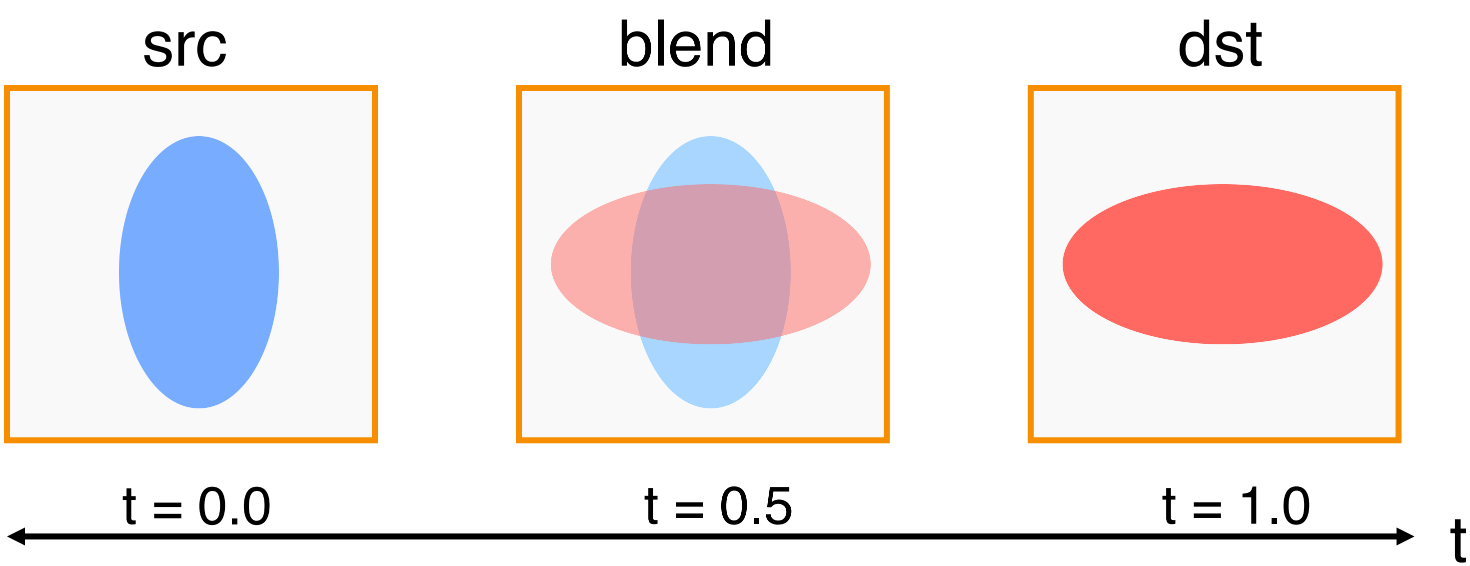
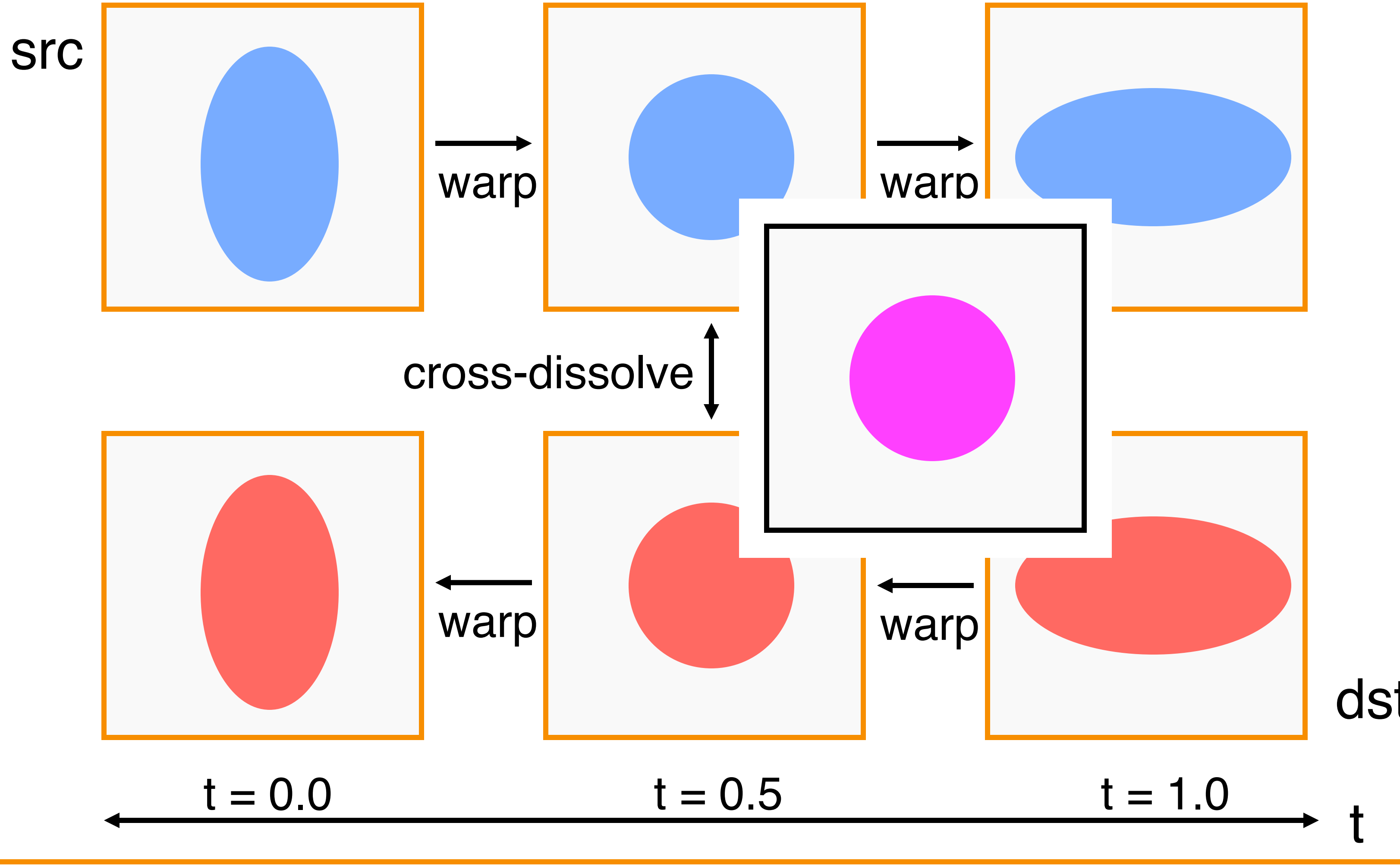
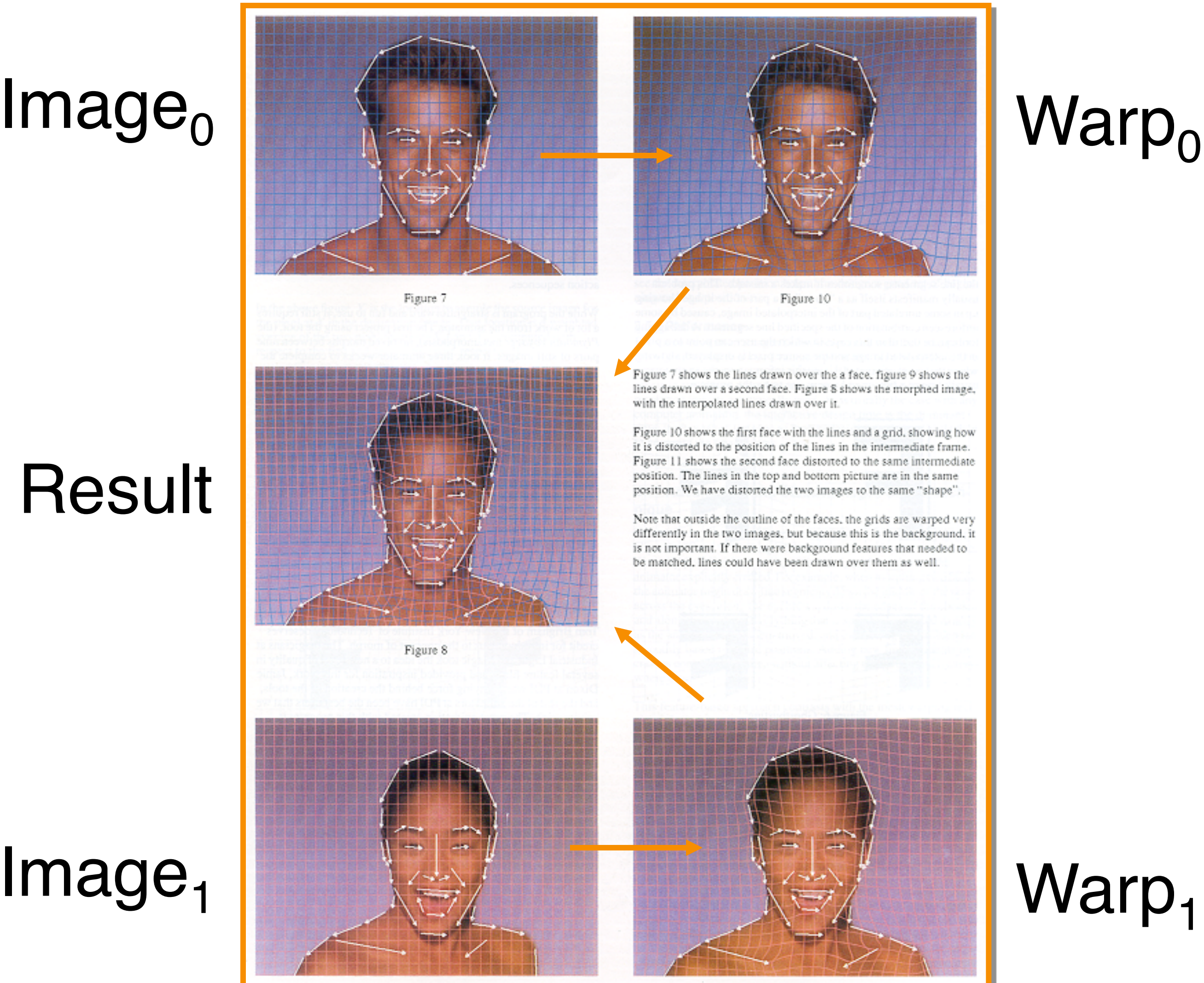


Image Morphing

- Combines warping and cross-dissolving



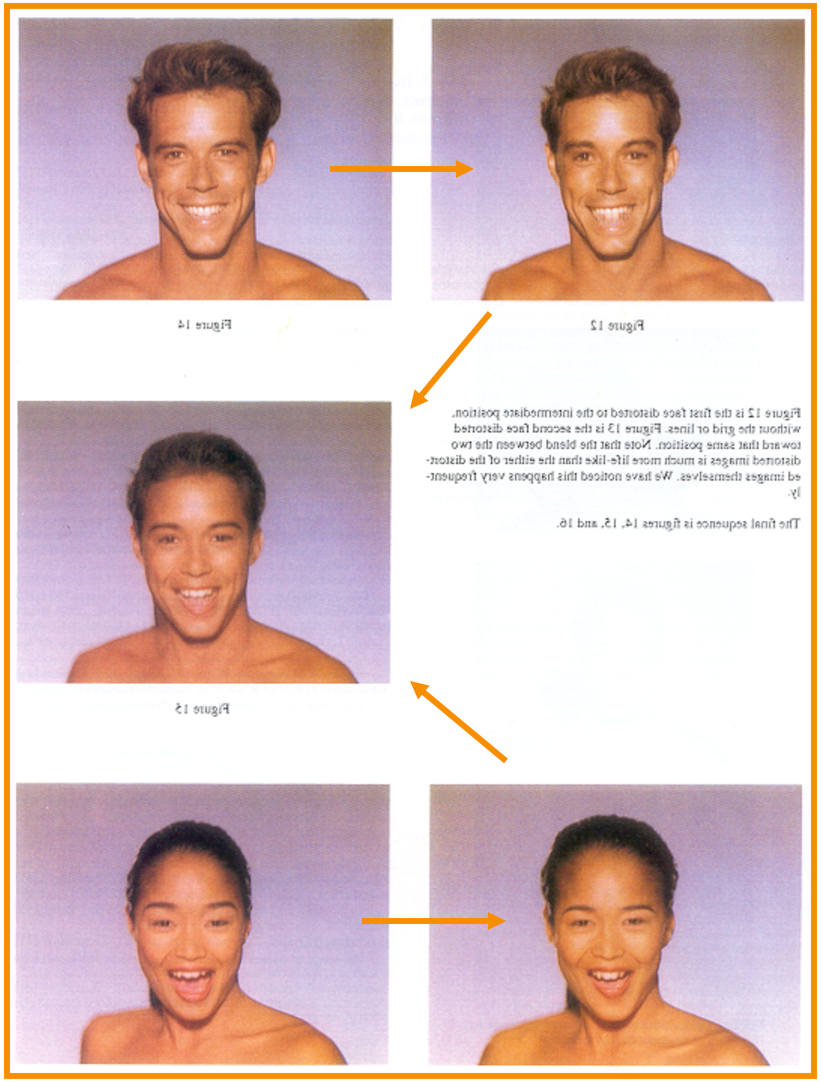
Beier & Neeley Example



Beier & Neeley Example

Image$_0$

Warp$_0$



Result

Image$_1$

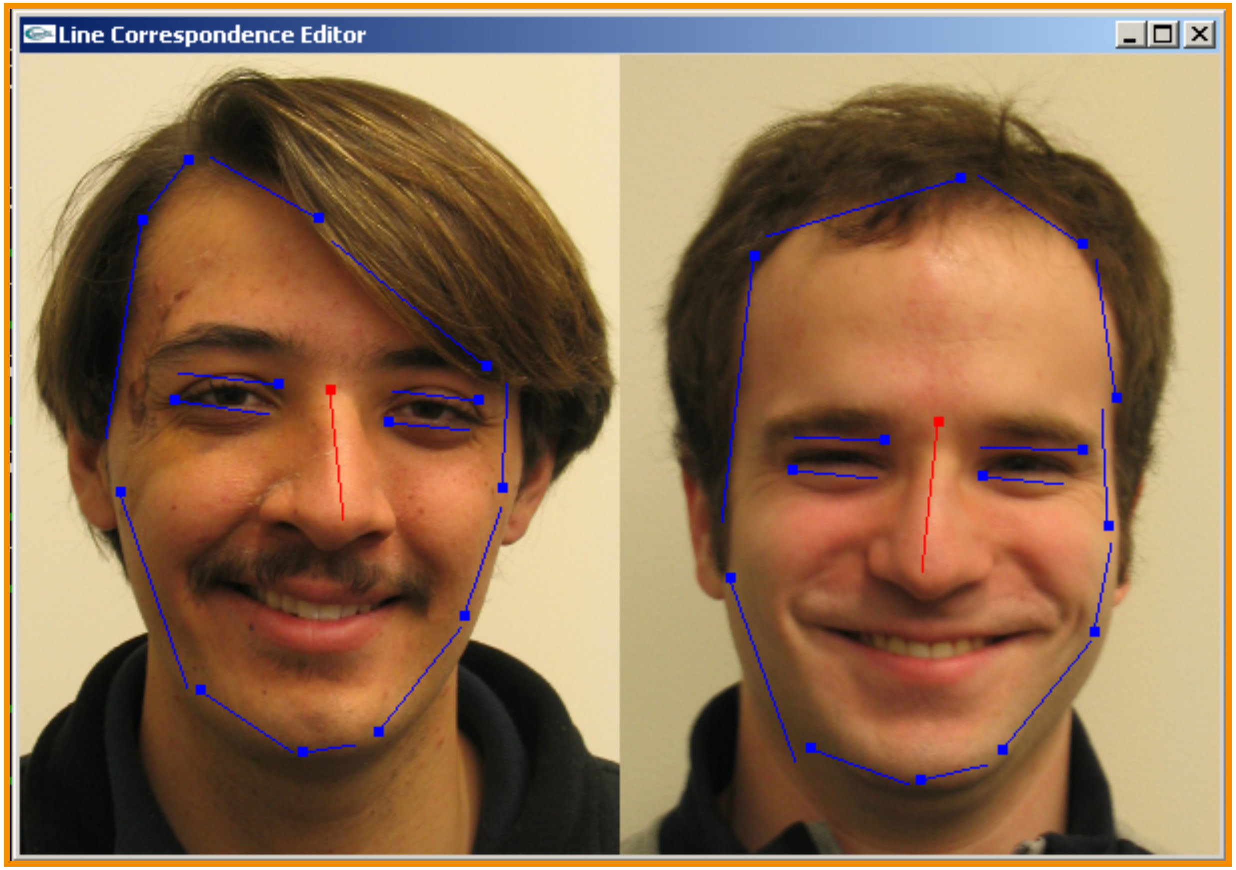
Warp$_1$

Beier & Neeley Example

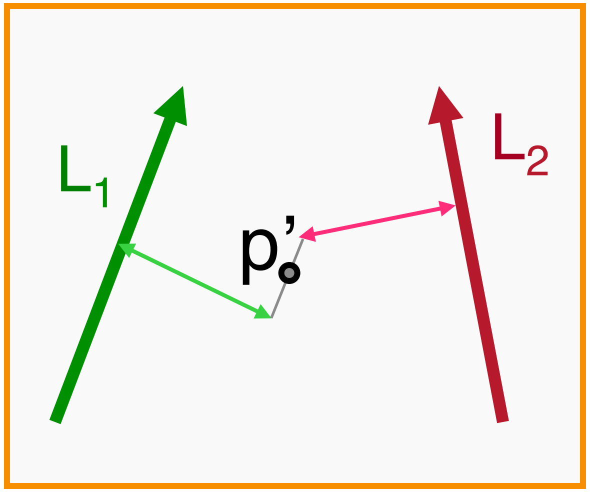
Black or White, Michael Jackson

Line Correspondence Mappings

- Beier & Neeley use pairs of lines to specify warp



Warping Pseudocode




```
WarpImage(Image, L'[…], L[…])
begin
    foreach destination pixel p do
        psum = (0,0)
        wsum = 0
        foreach line L[i] in destination do
            p'[i] = p transformed by (L[i],L'[i])
            psum = psum + p'[i] * weight[i]
            wsum += weight[i]
        end
        p' = psum / wsum
        Result(p) = Resample(p')
    end
end
```

Morphing Pseudocode

GenerateAnimation(Image$_0$, L$_0$[…], Image$_1$, L$_1$[…])
begin
    foreach intermediate frame time t do
        for i = 1 to number of line pairs do
            L[i] = line t-th of the way from L$_0$ [i] to L$_1$ [i]
        end
        Warp$_0$ = WarpImage(Image$_0$, L$_0$, L)
        Warp$_1$ = WarpImage(Image$_1$, L$_1$, L)
        foreach pixel p in FinalImage do
            Result(p) = (1-t) Warp$_0$ + t Warp$_1$

    end
end

COS426 Example

Amy Ousterhout

COS426 Examples

ckctwo

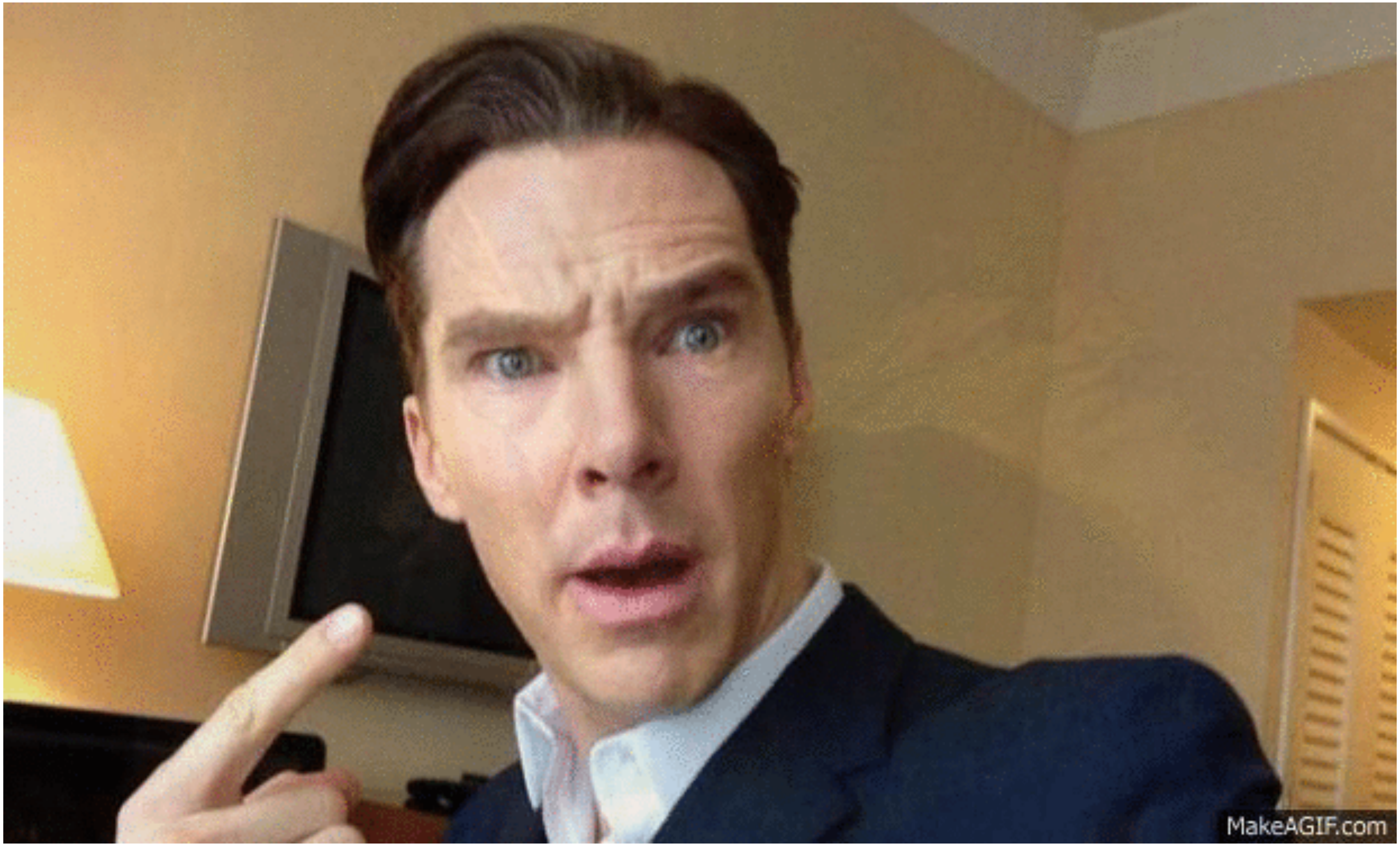
Jon Beyer

COS426 Examples from Last Year

Sam Payne

Matt Matl

COS426 Examples from Last Year



atran

Image Composition Applications

- *Computational photography*:
  enable new photographic effects that inherently use multiple images + computation + composition

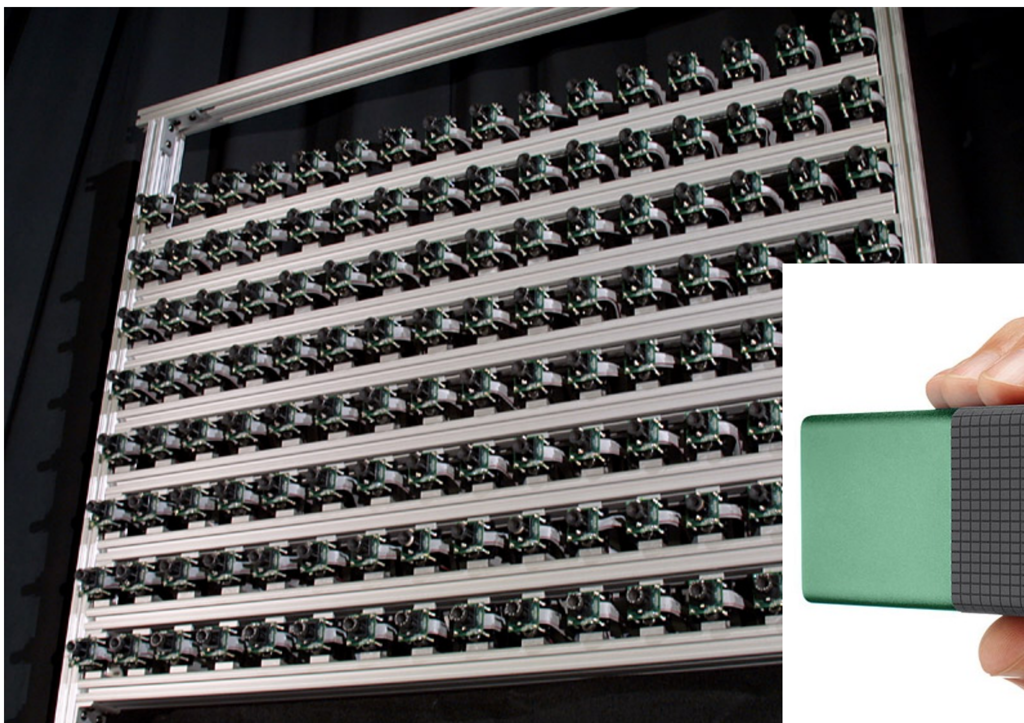
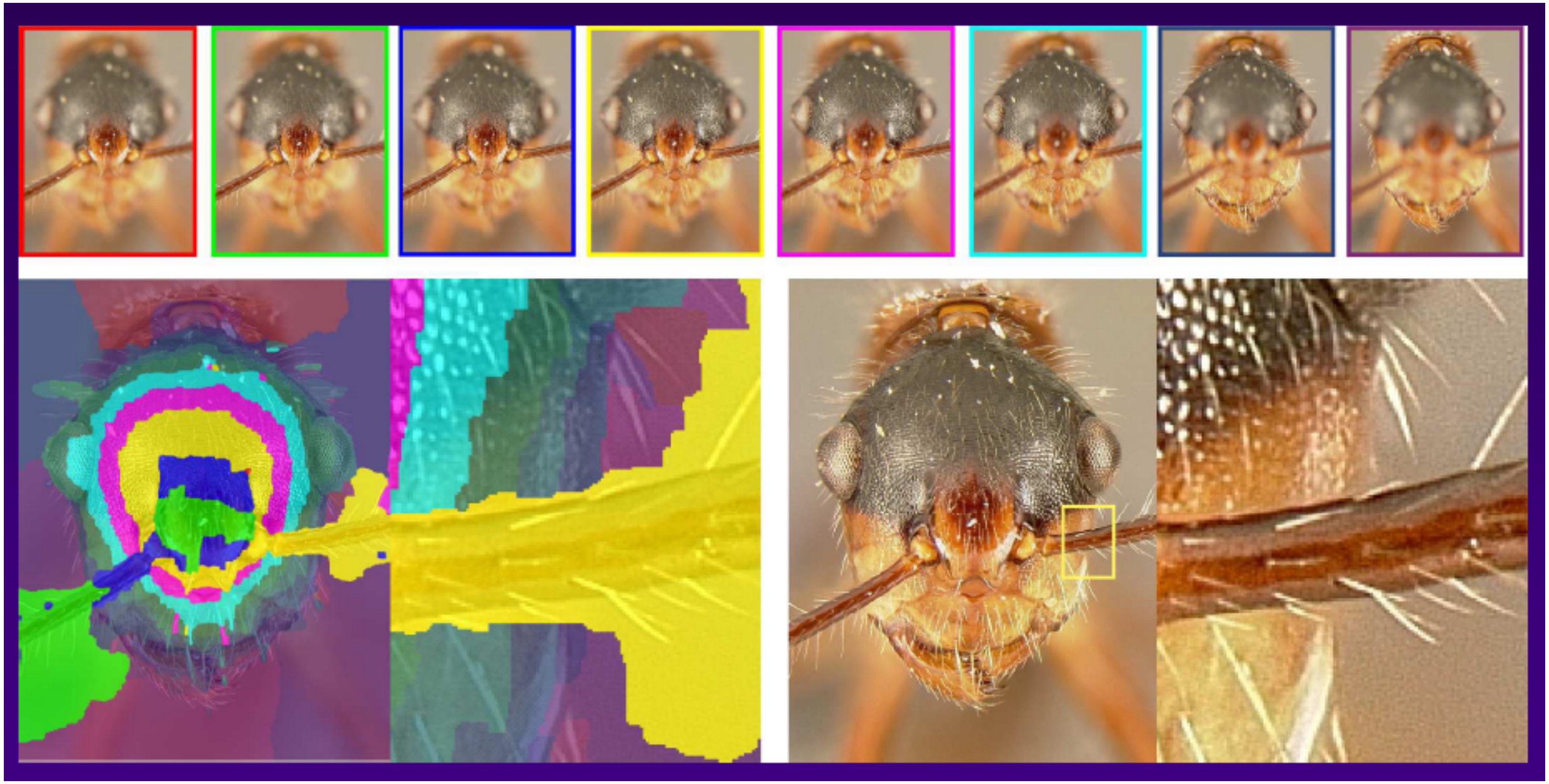


Image Composition Applications

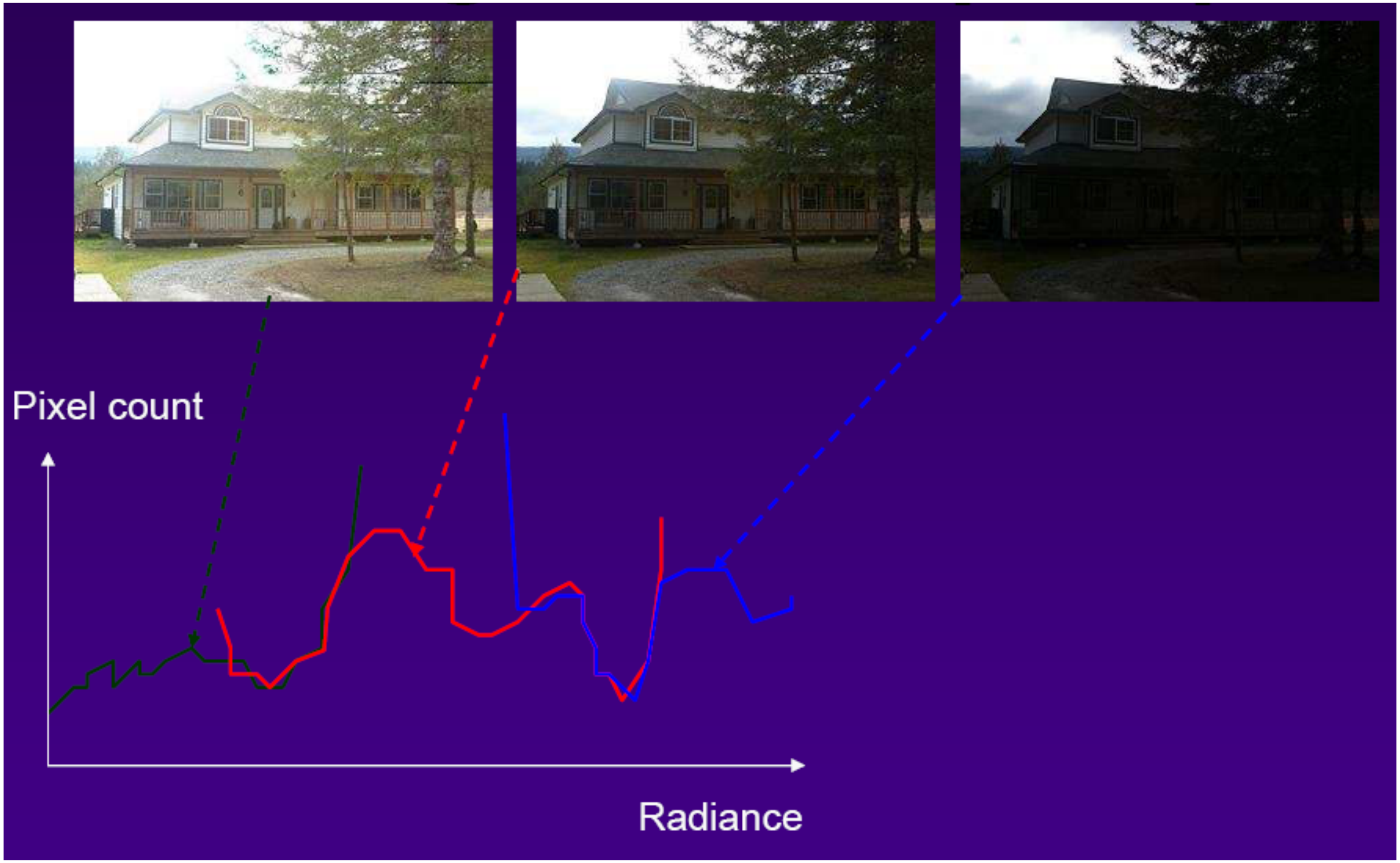
- Extended depth-of-field



[Michael Cohen]

Image Composition Applications

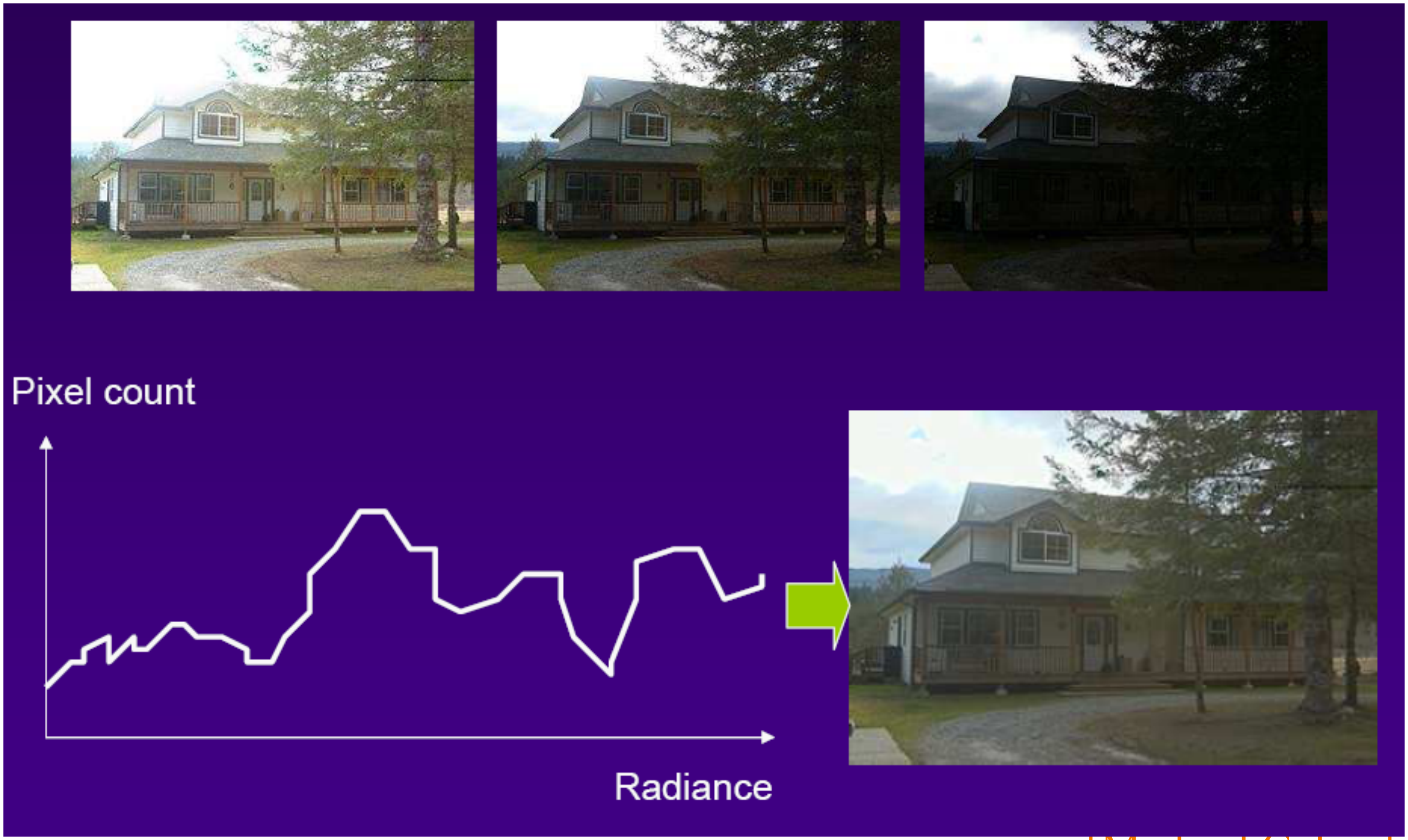
- High dynamic range images



[Michael Cohen]

Image Composition Applications

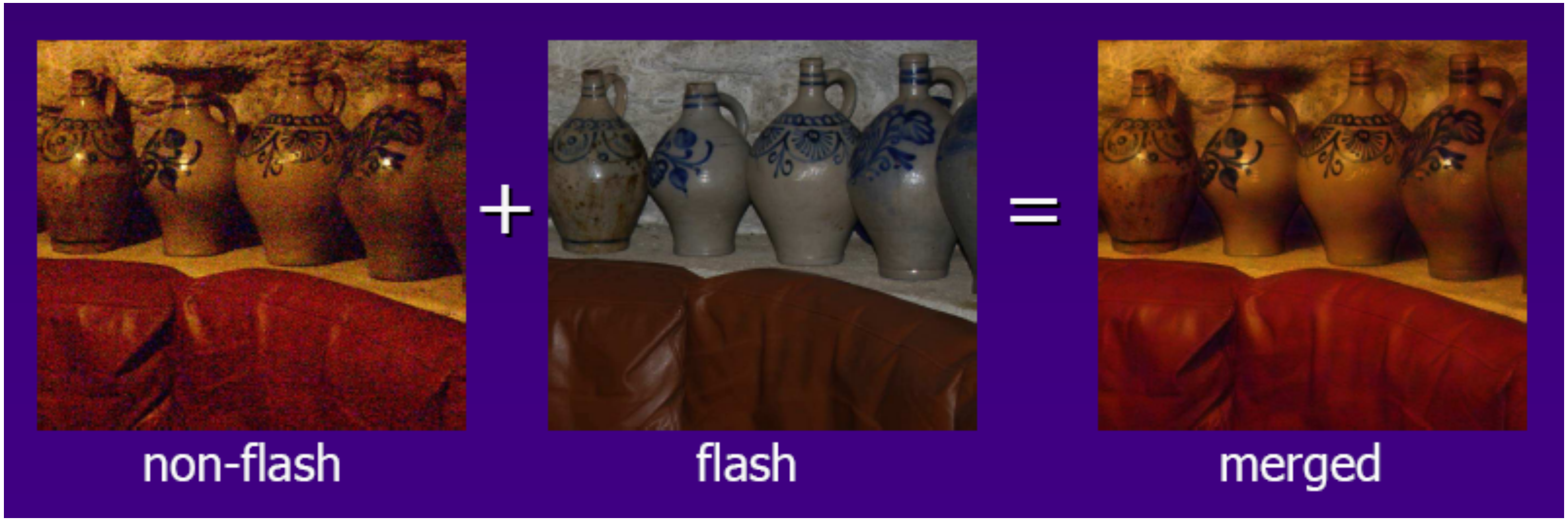
- High dynamic range images



[Michael Cohen]

Image Composition Applications

- Flash / No flash



[Michael Cohen]

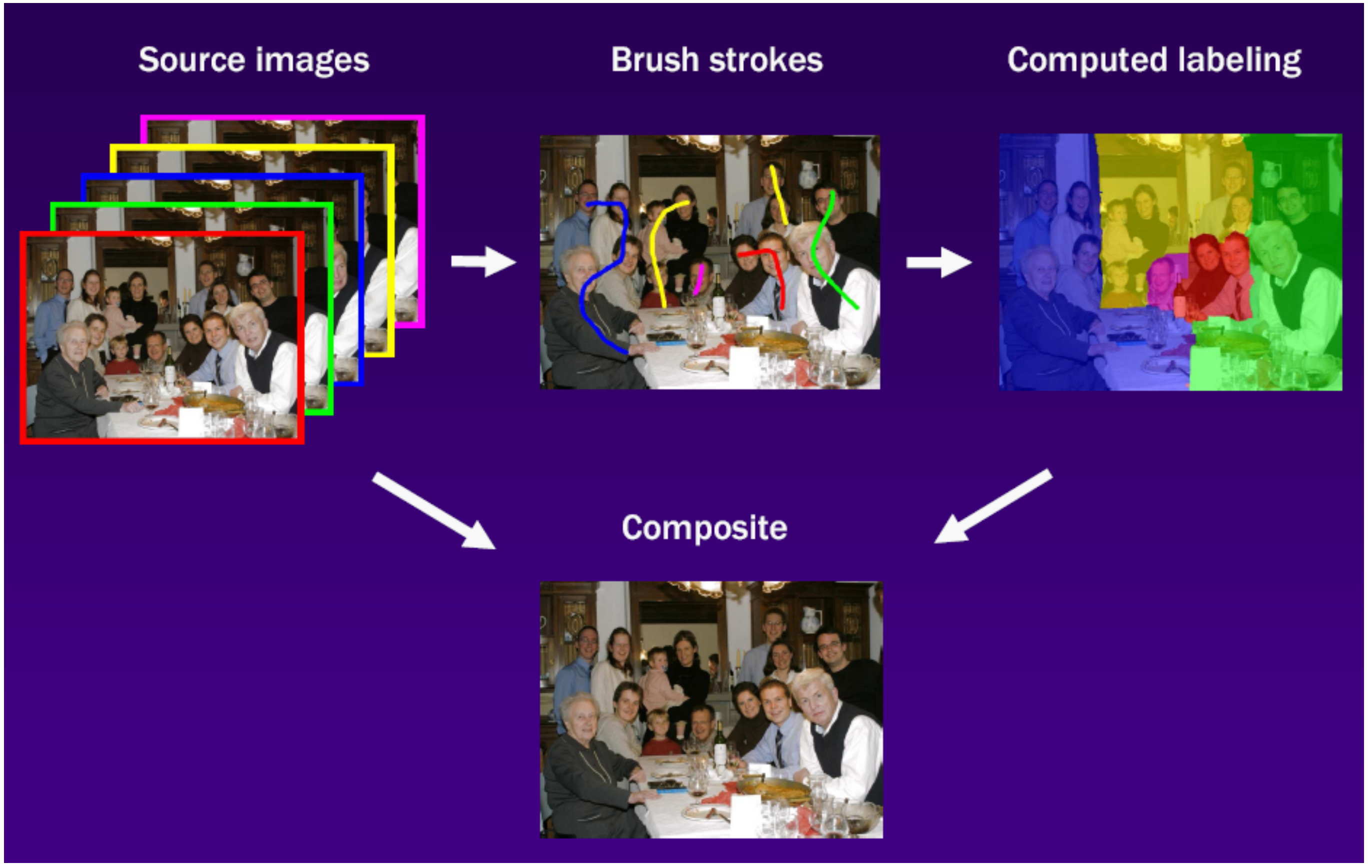
Image Composition Applications

- Stoboscopic images

[Michael Cohen]

Image Composition Applications

- Photo montage



[Michael Cohen]

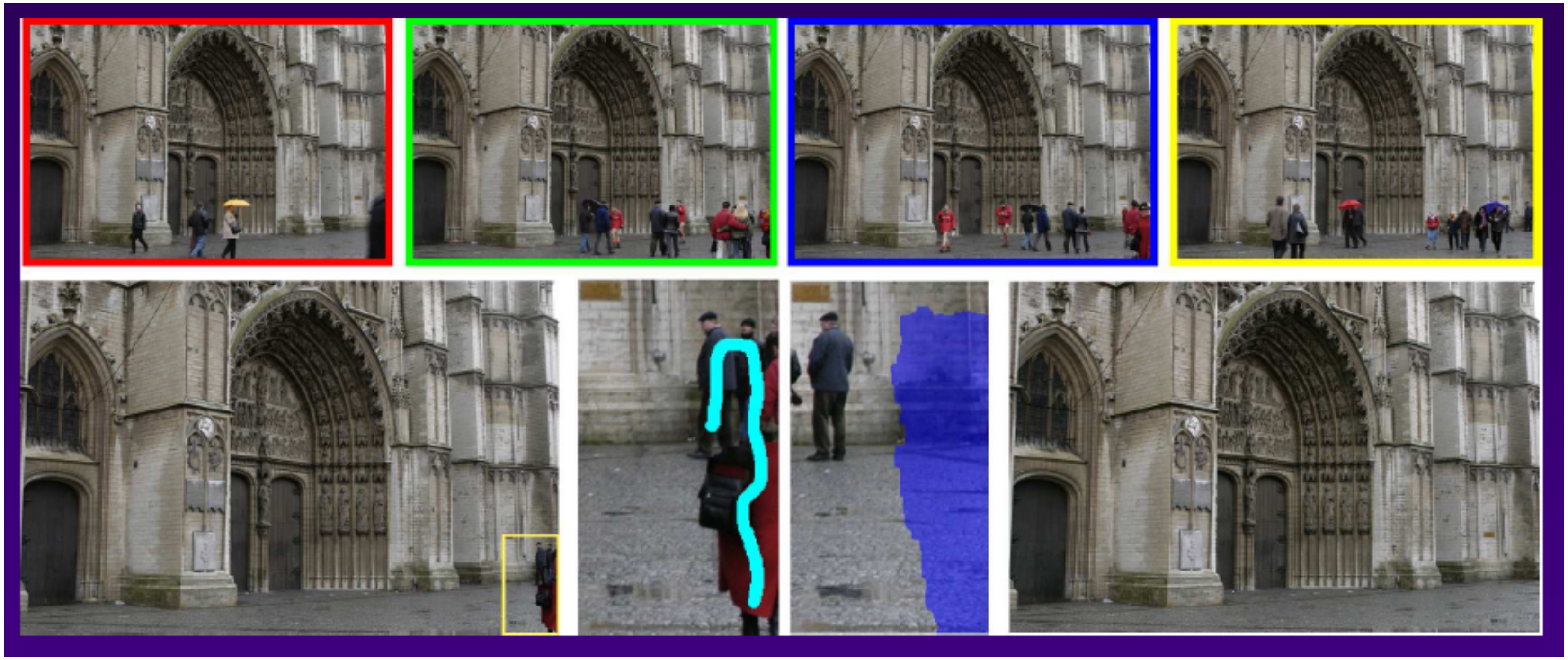
Image Composition Applications

- Photo montage

[Michael Cohen]

Image Composition Applications

- Removing people



[Michael Cohen]

Scene Completion Using Millions of Photographs

James Hays and Alexei A. Efros

SIGGRAPH 2007

Slides by J. Hays and A. Efros

Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Texture synthesis result

Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Image Completion

Hays et al. SIGGRAPH 07

Image Completion

2.3 Million unique images from Flickr

Hays et al. SIGGRAPH 07

Scene Completion Result

Hays et al. SIGGRAPH 07

Image Completion Algorithm

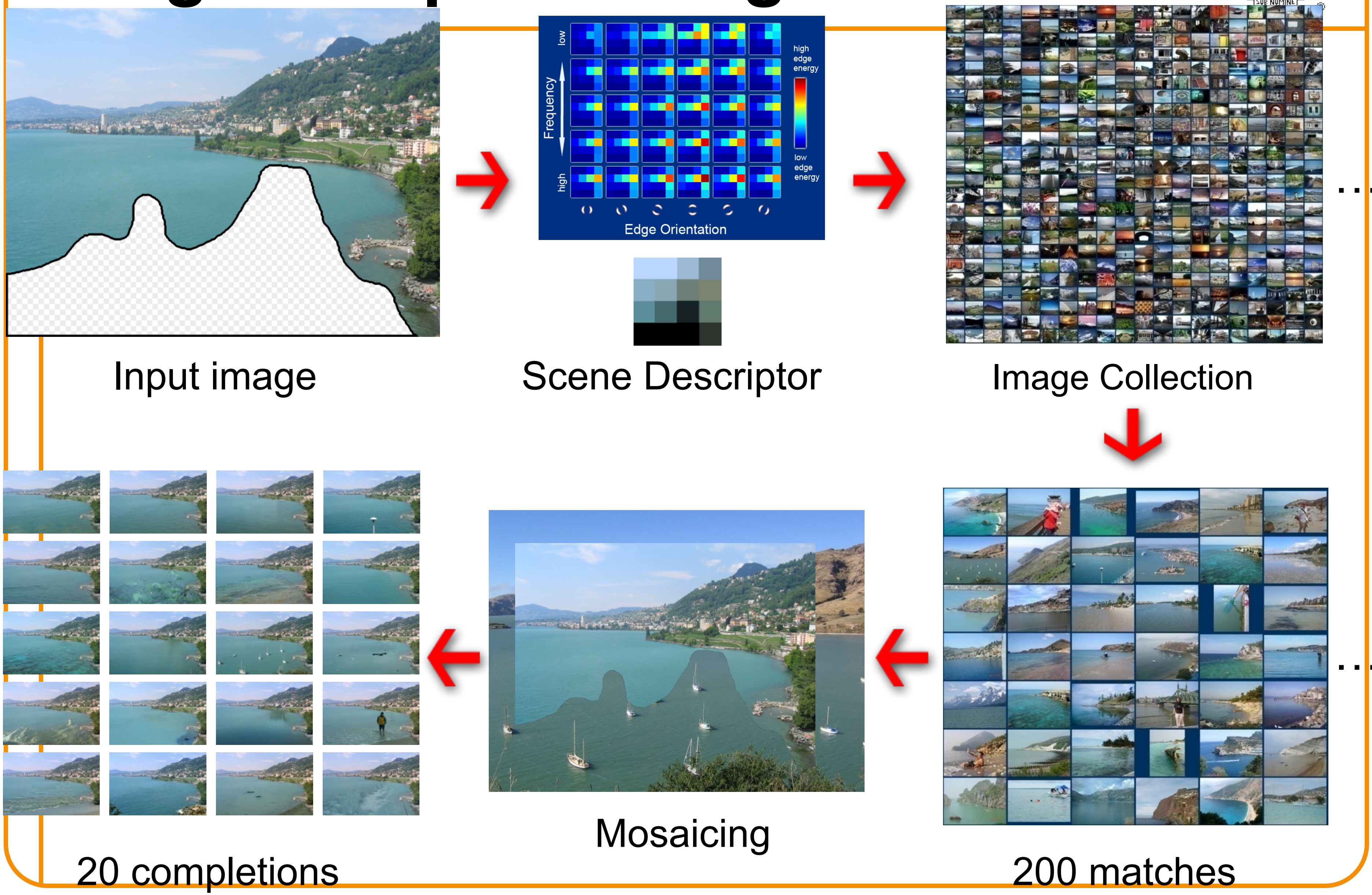
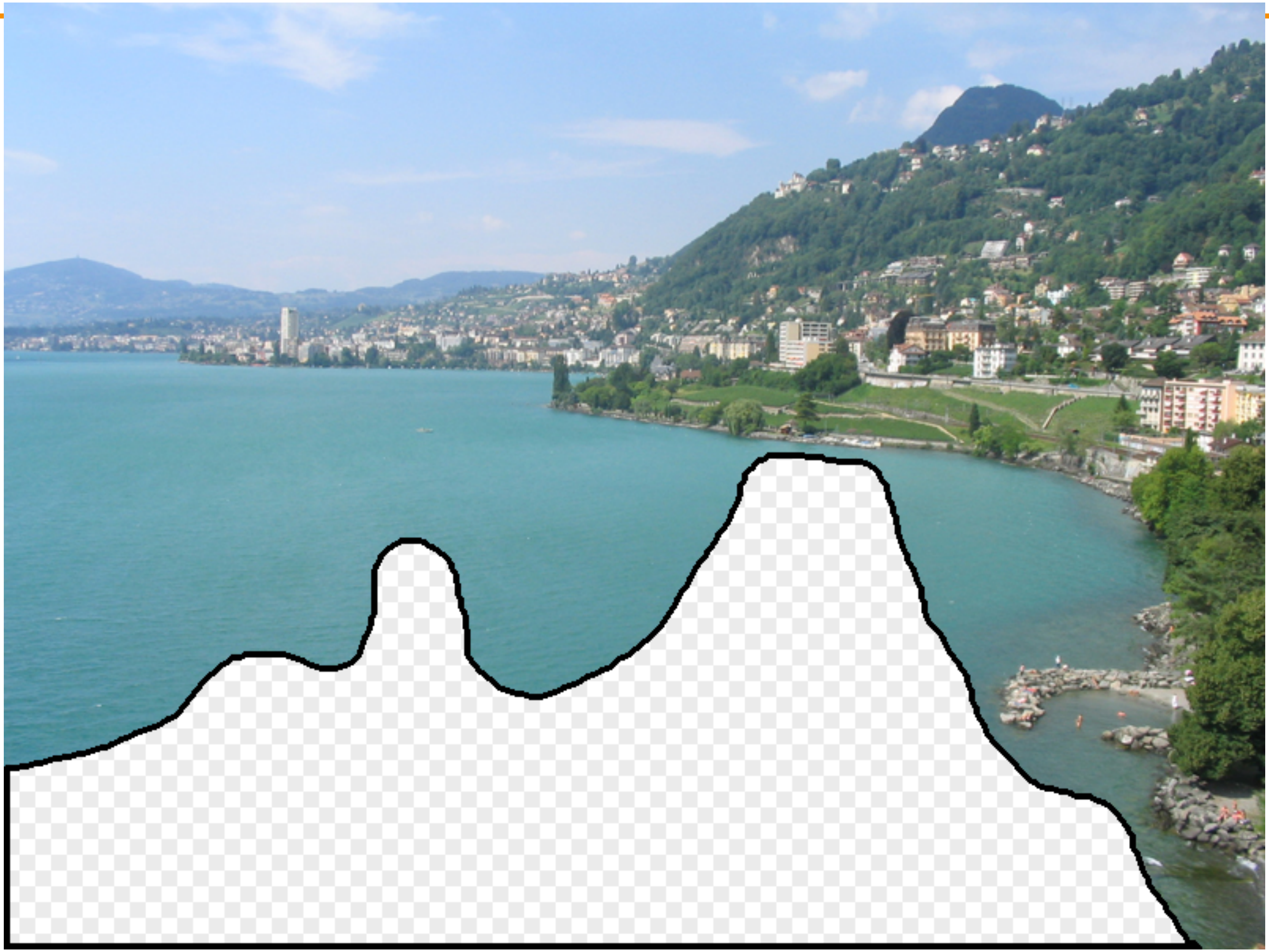
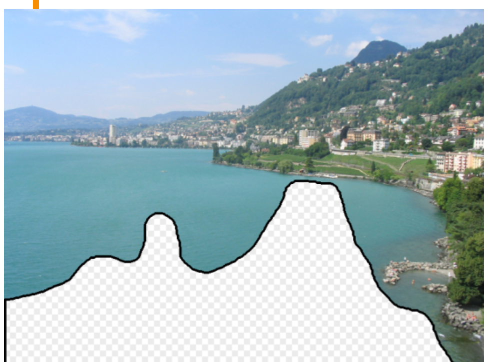
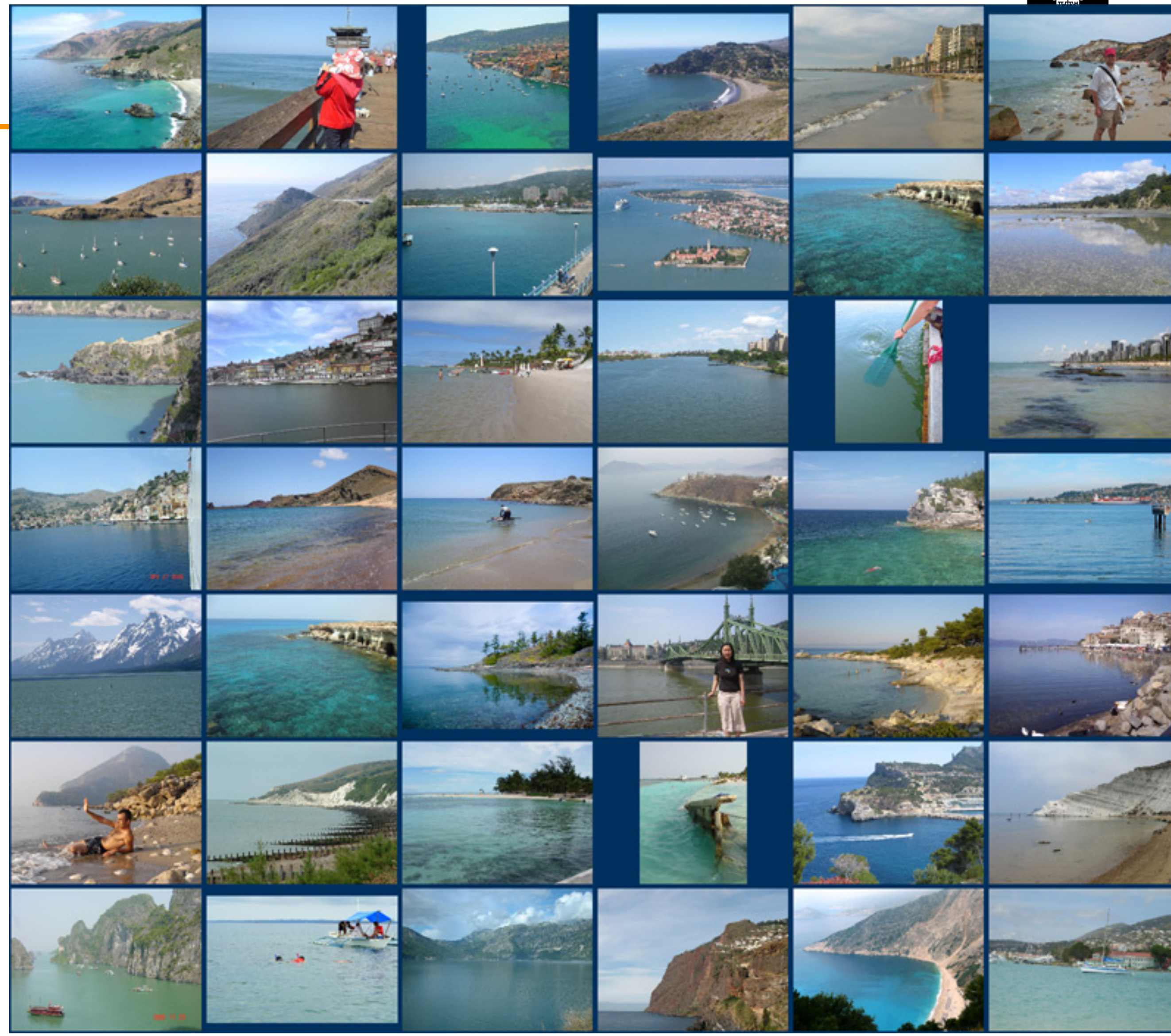


Image Completion



Hays et al. SIGGRAPH 07

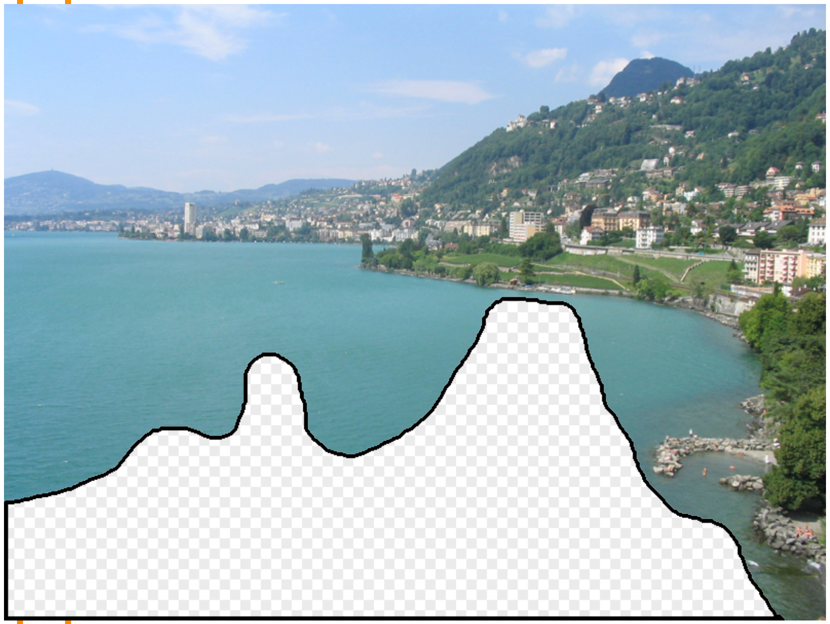




… 200 best matches

Hays et al. SIGGRAPH 07

Image Completion



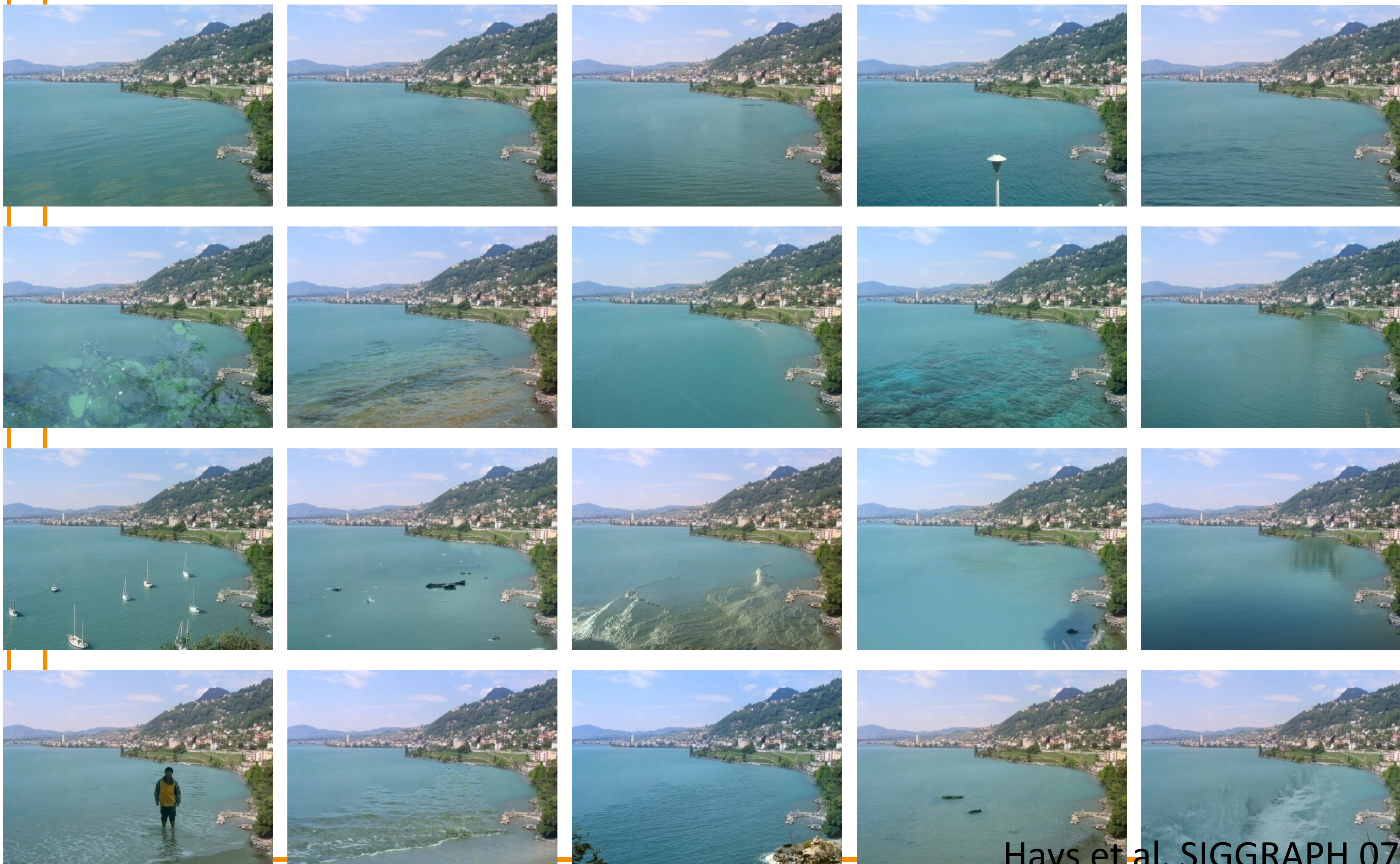
Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Image Completion Result

Hays et al. SIGGRAPH 07

Image Completion Results



Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

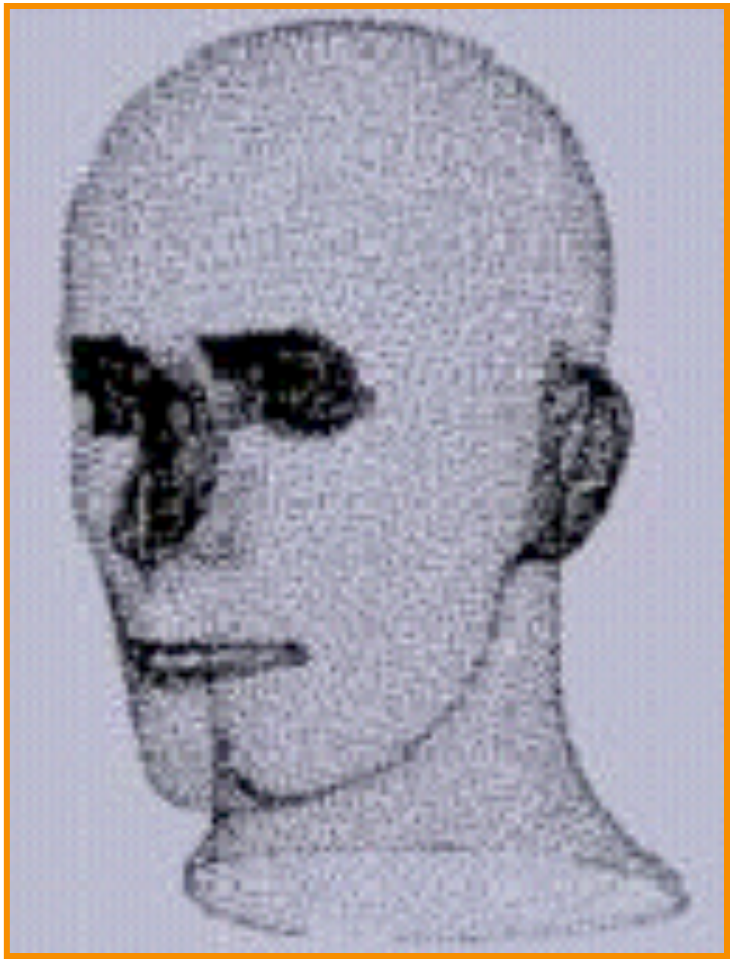
Hays et al. SIGGRAPH 07

Hays et al. SIGGRAPH 07

Summary

- Image compositing
  - Alpha channel
  - Porter-Duff compositing algebra
- Image morphing
  - Warping
  - Compositing
- Computational photography

Next Time: 3D Modeling



Hoppe