Background Subtraction and Matting

15-463: Computational Photography
Alexei Efros, CMU, Fall 2006

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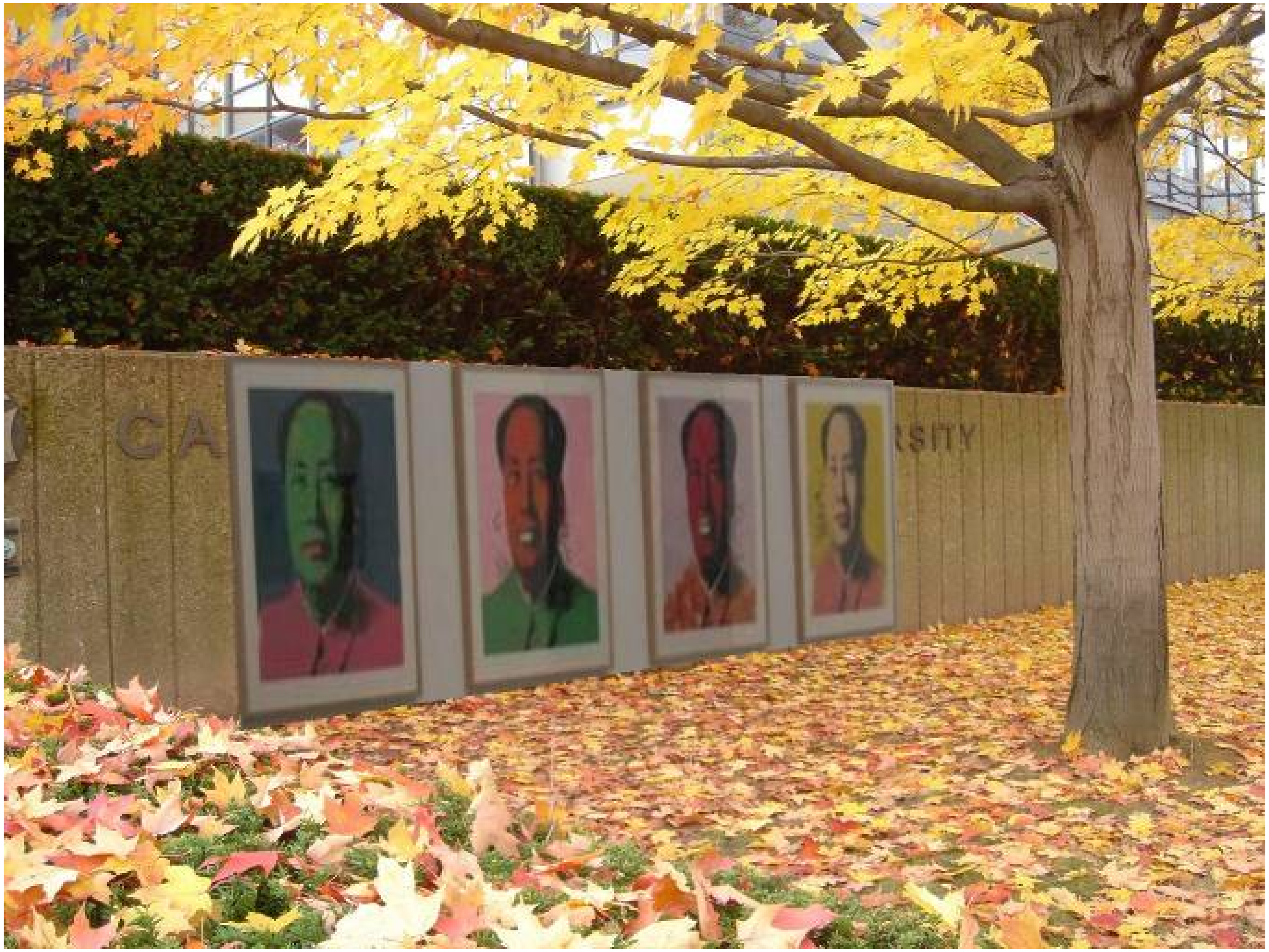
…if you don’t vote



Projects 3 highlights

Stephen Lin

ken2

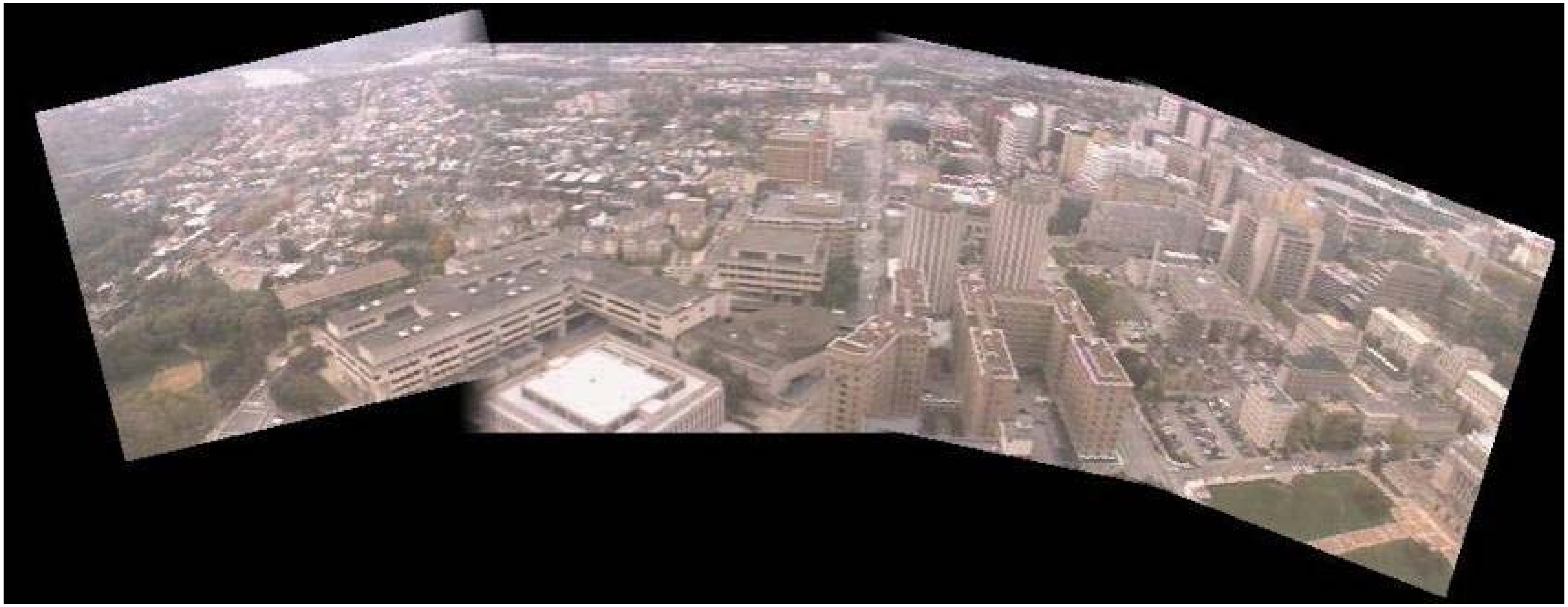
Chaz PRatt

Severin Hacker

Wei-Chen Chiu

Scott Shih-yu Wang

Faustinus Kevin Gozali

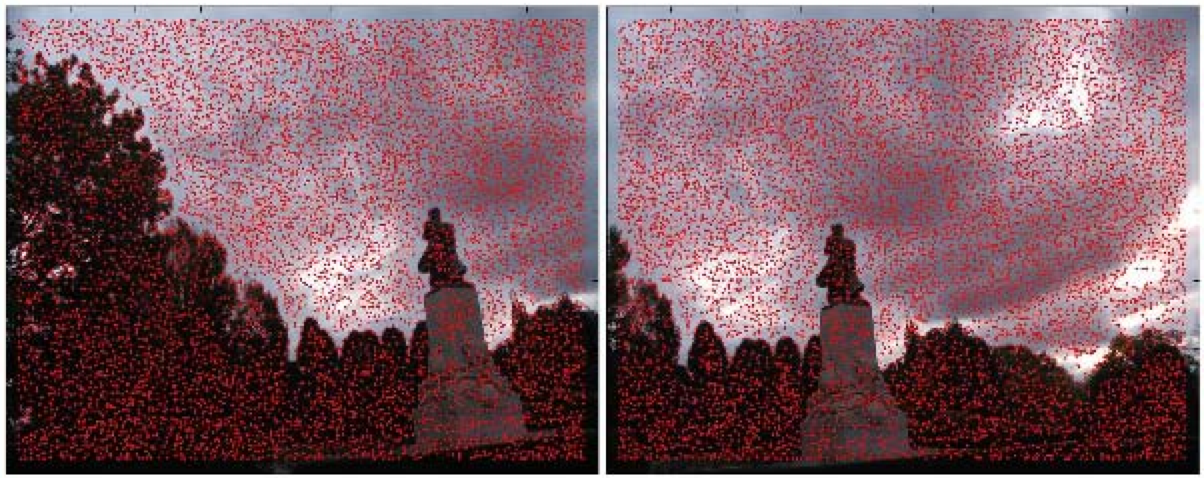


Charudatta Phatak

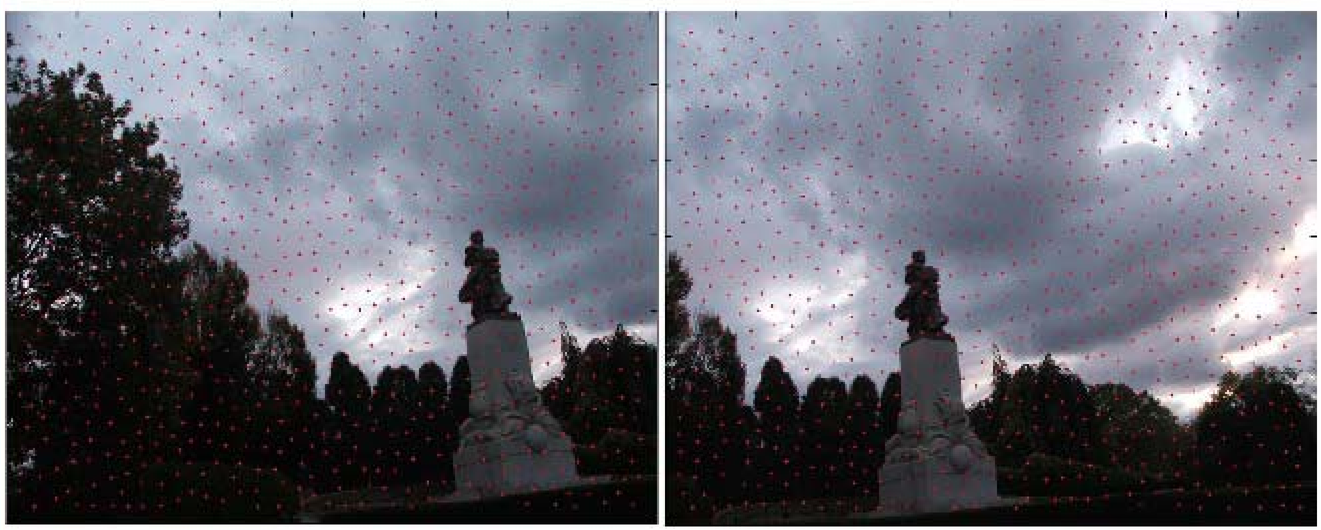
Stephen Lin

Project 4 highlights

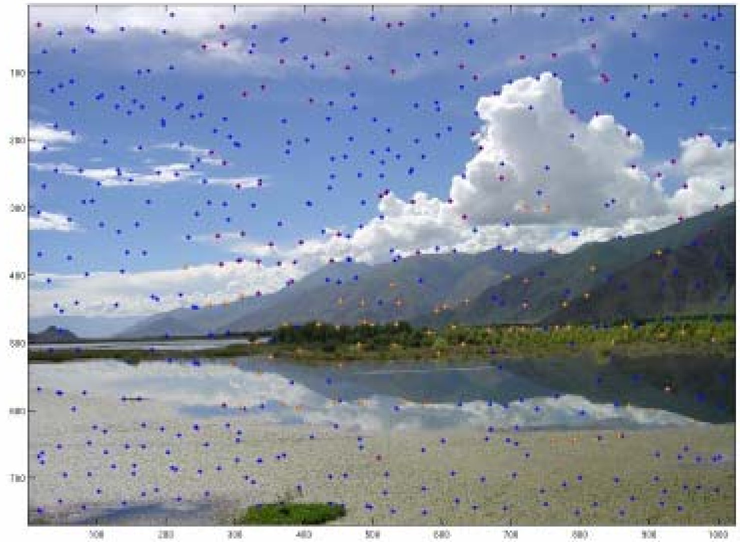
After Harris Corner Detector



After Adaptive Non-Maximal Suppression (radius = 20px)



Wei-Chen Chiu



sma1

sma1

Project 4 highlights

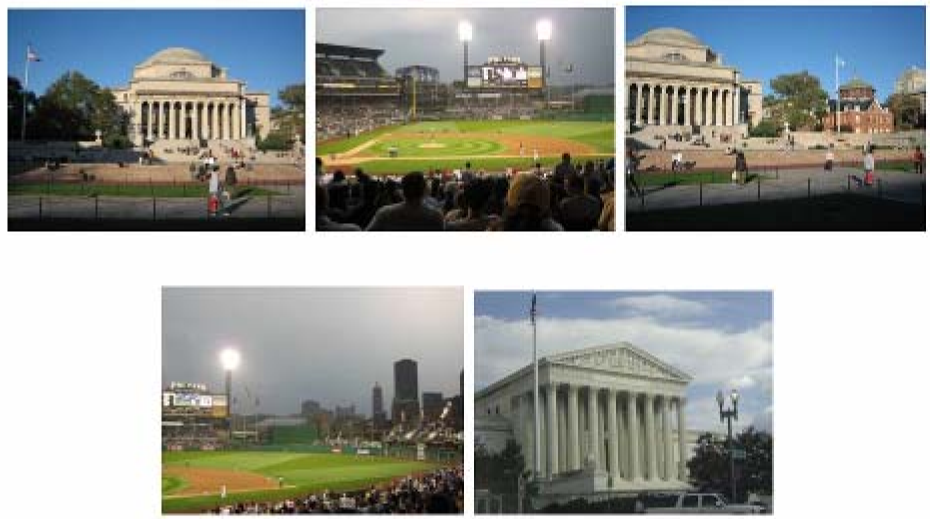


Figure 9: Input images in the order of input.

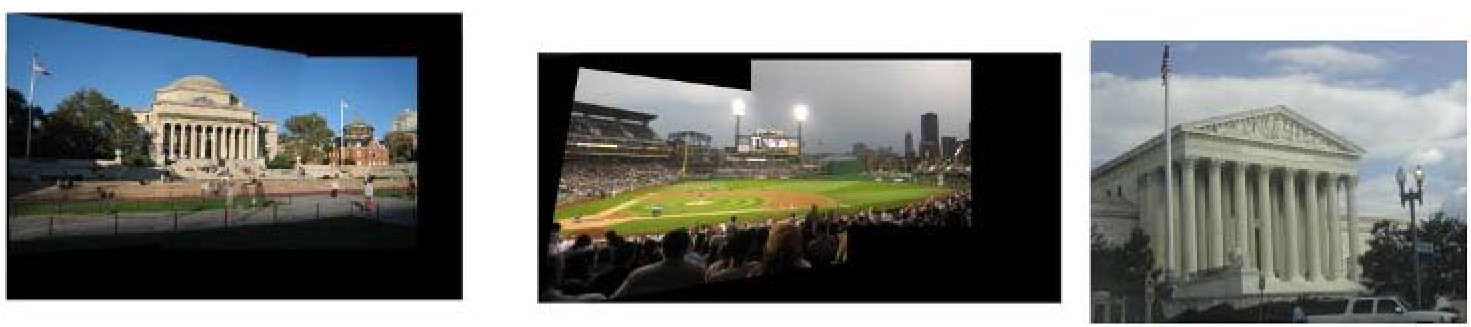


Figure 10: Output images.

Charudatta Phatak

Midterm on Thursday!

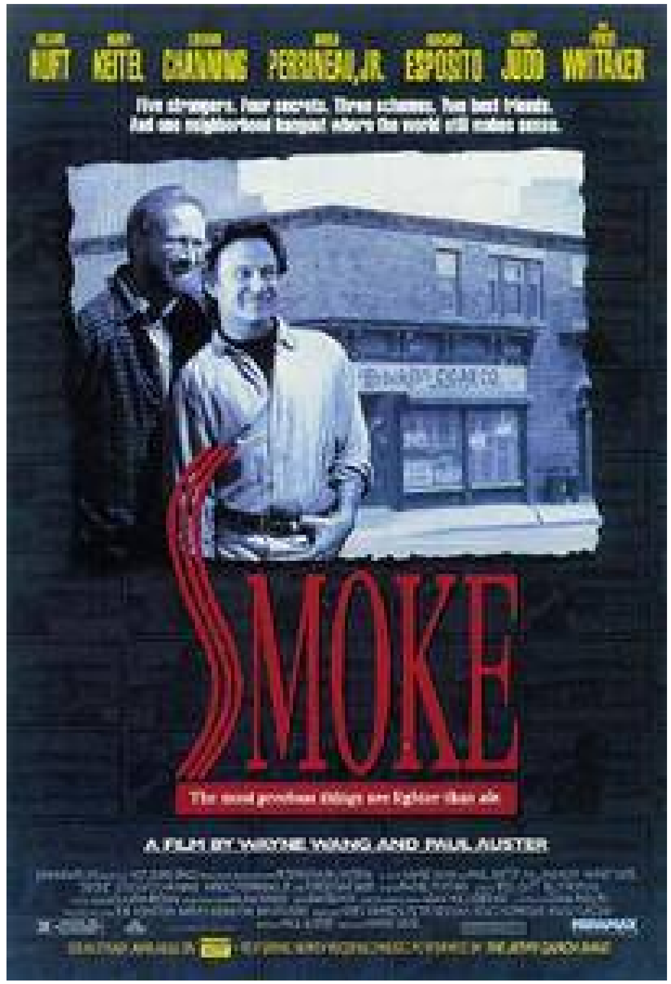
- 1.5 hours long
- Closed book, closed notes, closed laptops
- But can have a cheat sheet (2 pages, both sides)

- Will cover all material up to last week!

Midterm Review

- Cameras
  - Pin-hole model, camera “knobs”, perspective projection, other projections, etc.
- Capturing & modeling Light
  - Light perception, color, plenoptic function, Lumigraph/Lightfields
- Image Processing
  - Point processing, histograms, filtering, correlation, convolution, 2D Fourier transform, low-pass/band-pass/high-pass filtering, edge detection, Gaussian and laplacian pyramids, blending, etc.
- Image Warping and Morphing
  - 2D parametric transformations, homogeneous coordinates, degrees of freedom, forward/inverse warping, morphing, face modeling, PCA, etc.
- Mosaicing
  - Homographies, planar mosaics, cylindrical/spherical mosaics, degrees of freedom, direct alignment (optical flow), image features, RANSAC, etc.

“Smoke” (1996), the “photo album scene”



Moving in Time

Moving <u>only</u> in time, while not moving in space, has many advantages

- No need to find correspondences
- Can look at how each ray changes over time
- In science, always good to change just one variable at a time

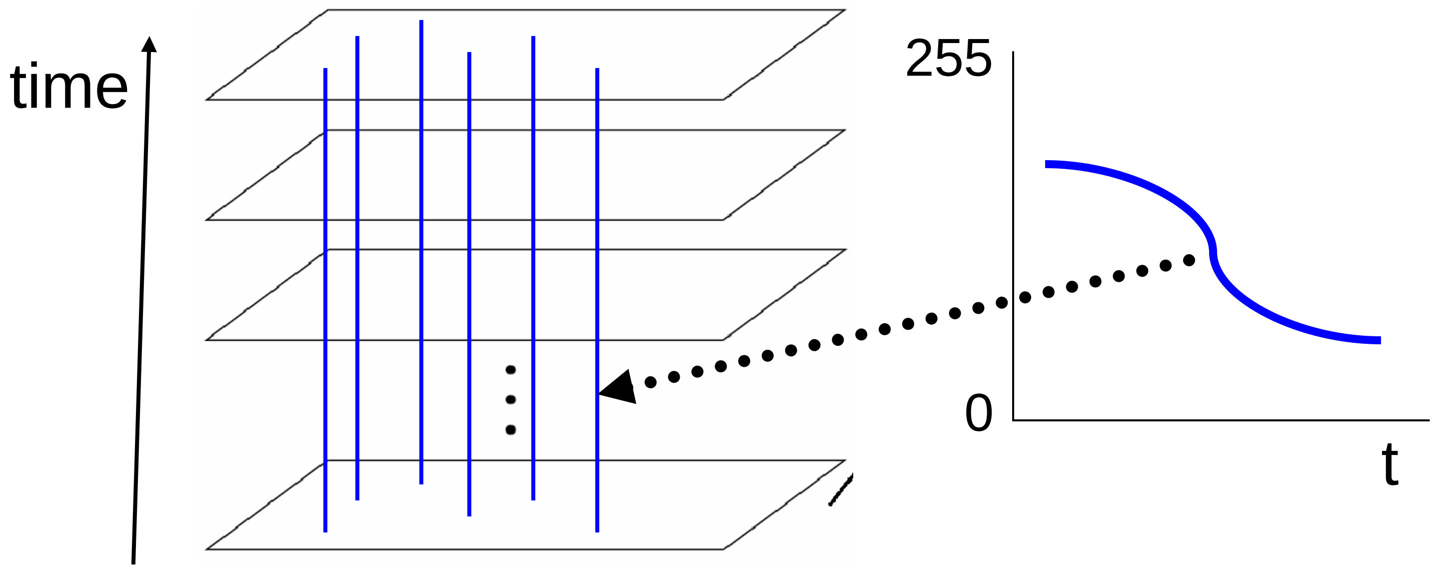
This approach has always interested artists (e.g. Monet)

Modern surveillance video camera is a great source of information

- There are now many such WebCams now, some running for several years!

Image Stack



As can look at video data as a spatio-temporal volume

- If camera is stationary, each line through time corresponds to a single ray in space
- We can look at how each ray behaves
- What are interesting things to ask?

Example

Getting the right pixels

Average image

Median Image

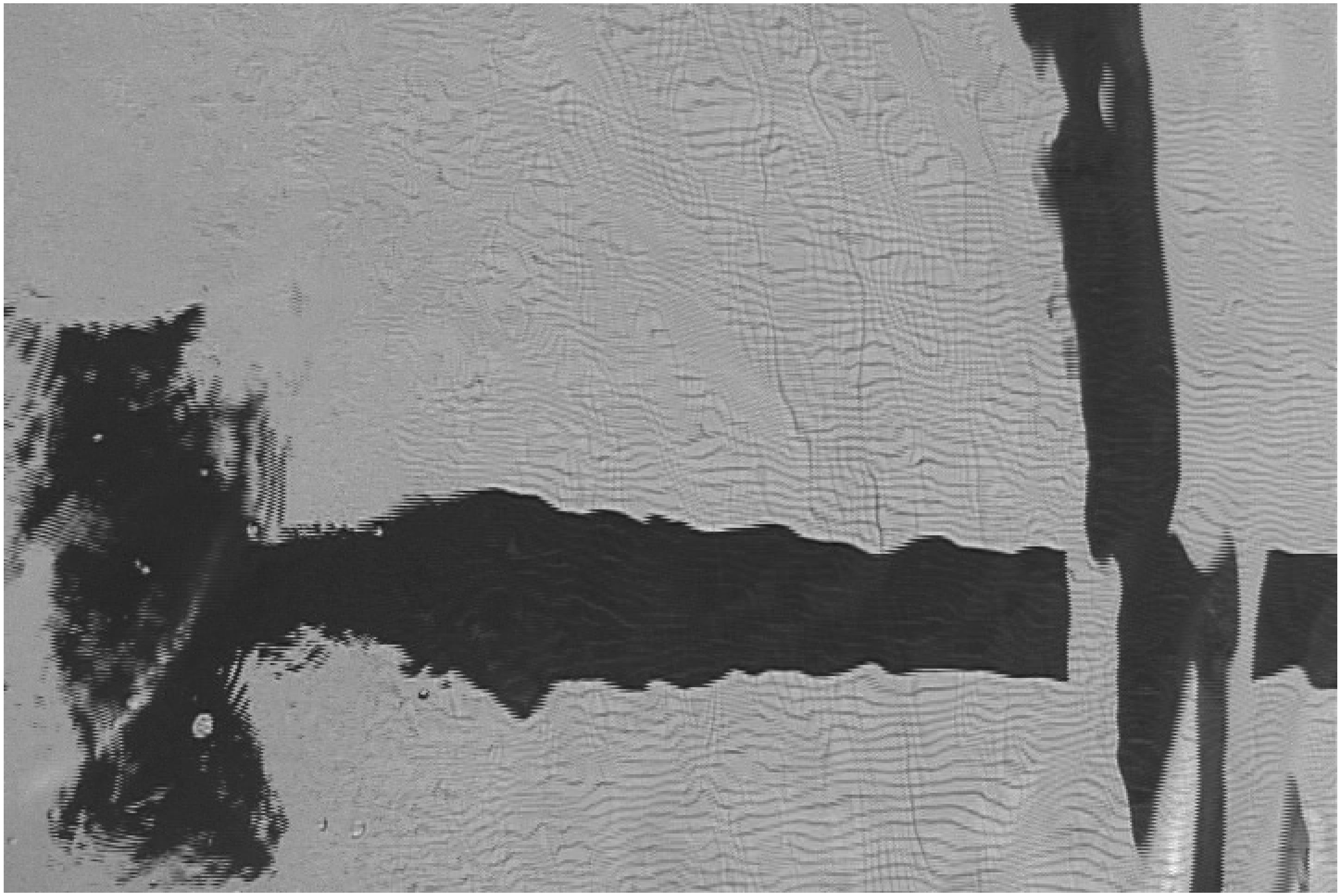
Webcams

http://sv.berkeley.edu/view/

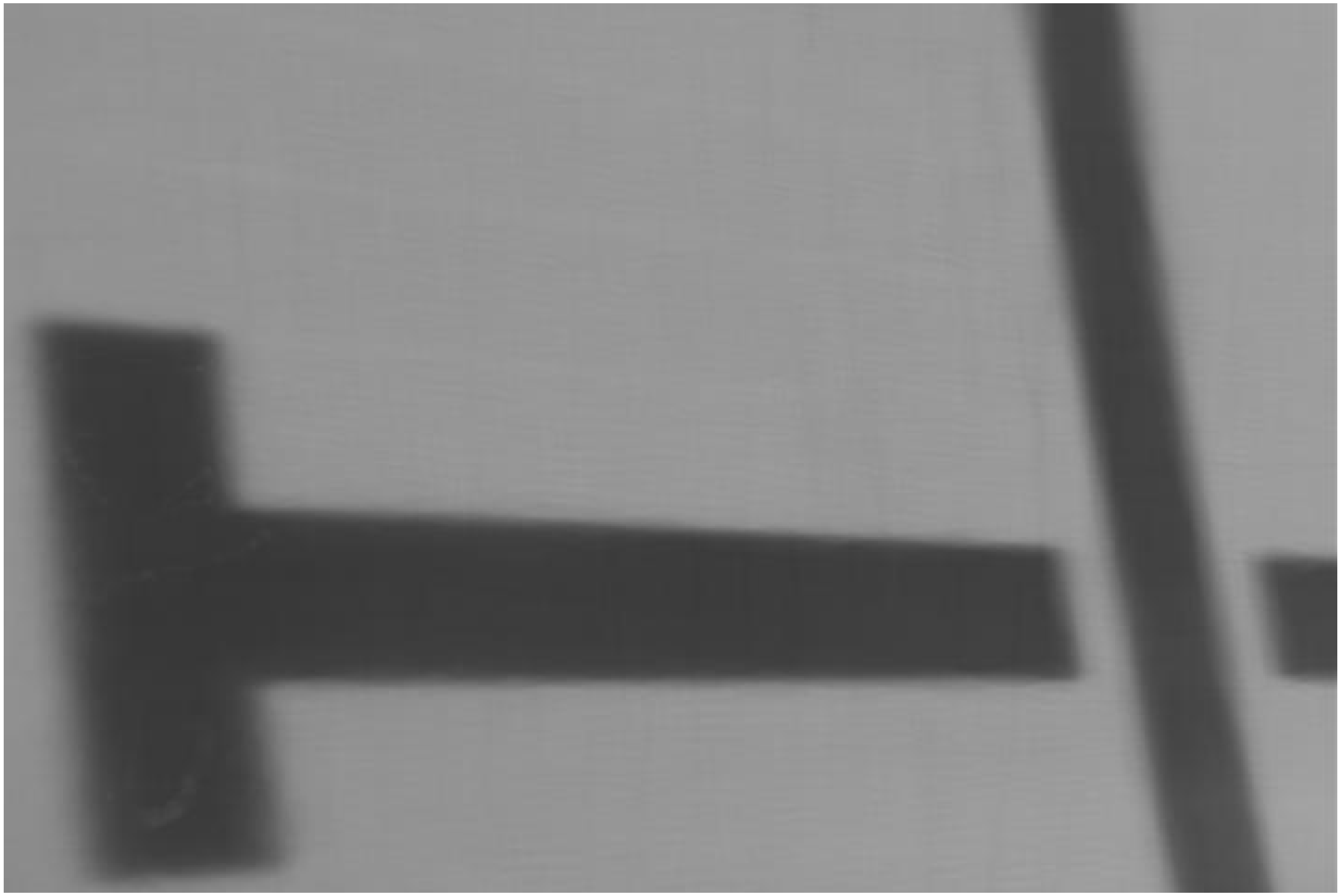
Lots of cool potential projects

- PCA, weather morphing, weather extrapolation, etc.

Input Video

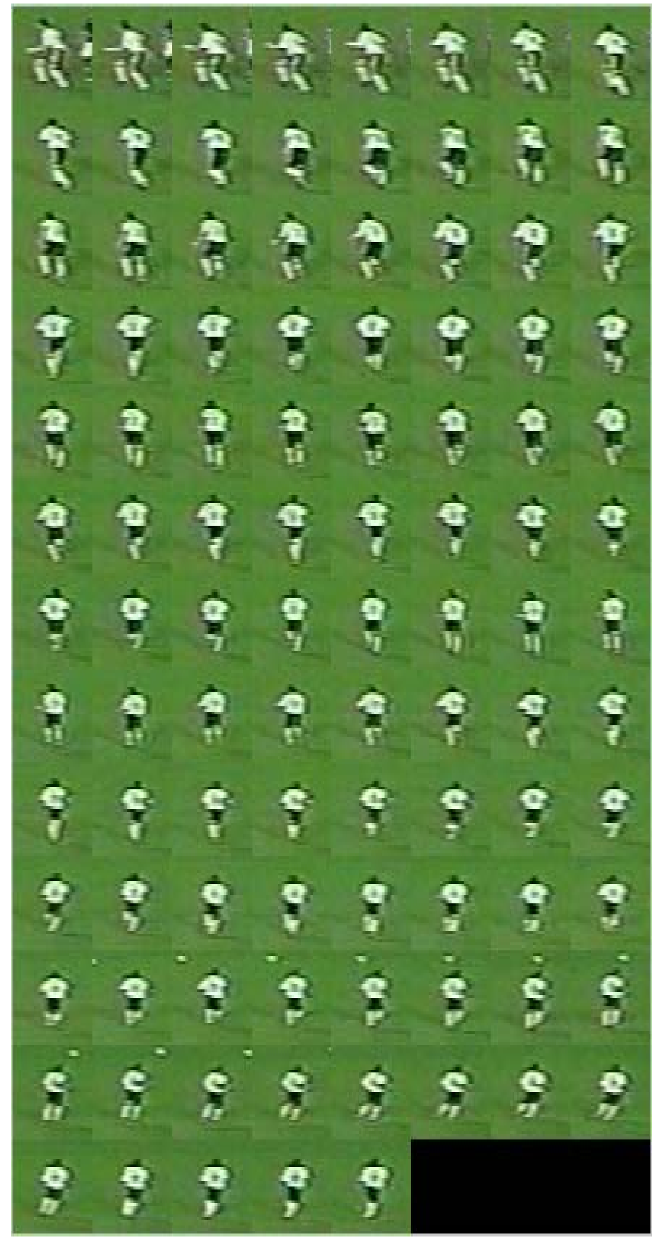


Average Image



What is happening?

Figure-centric Representation



Context-based Image Correction

Input sequence

3 closest frames

median images

Average/Median Image

What can we do with this?

Background Subtraction

-

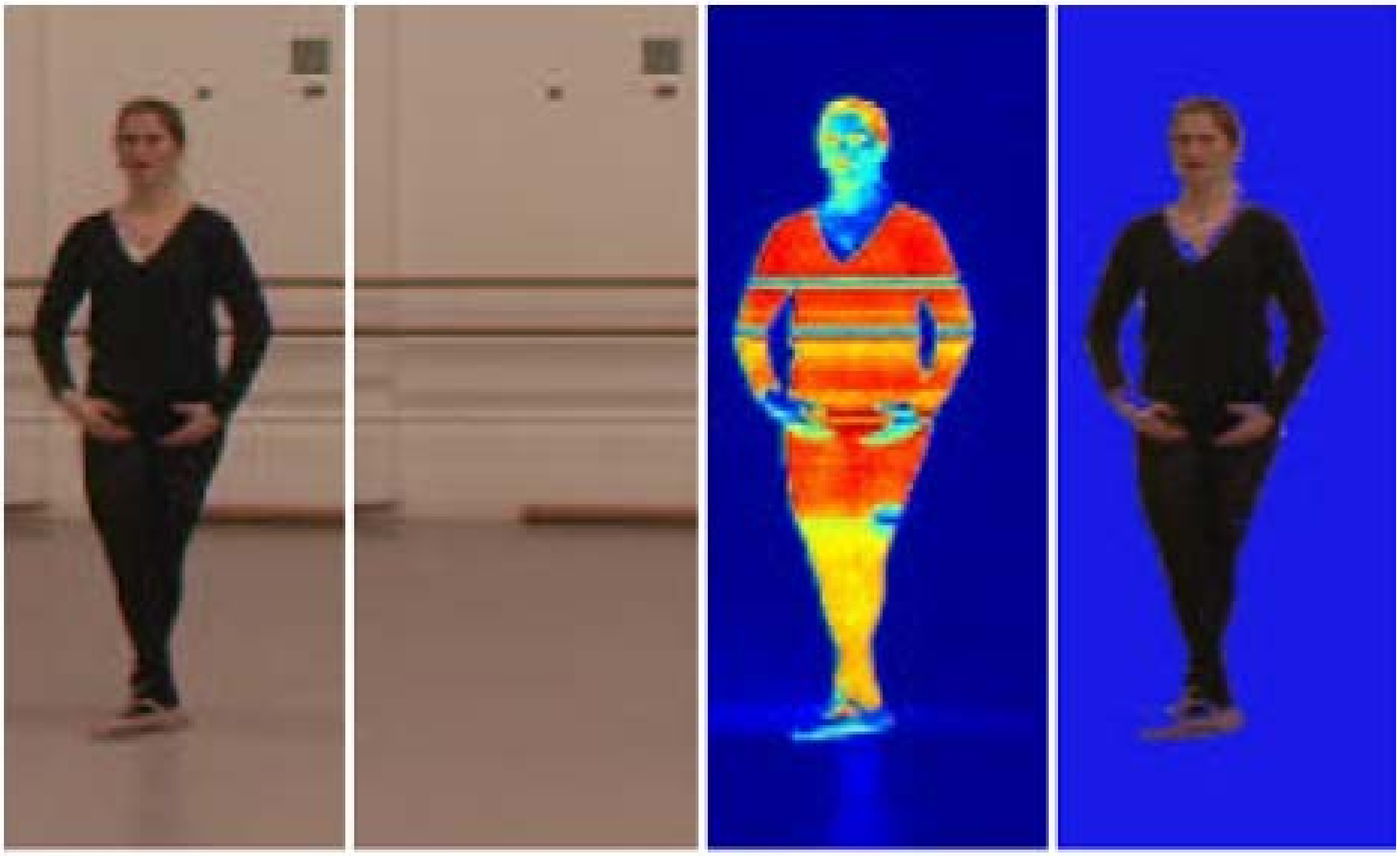
=

Crowd Synthesis (with Pooja Nath)

1. Do background subtraction in each frame
2. Find and record "blobs"
3. For synthesis, randomly sample the blobs, taking care not to overlap them

Background Subtraction

A largely unsolved problem…



One video frame | Estimated background | Difference Image | Thresholded Foreground on blue

How does Superman fly?

Super-human powers?

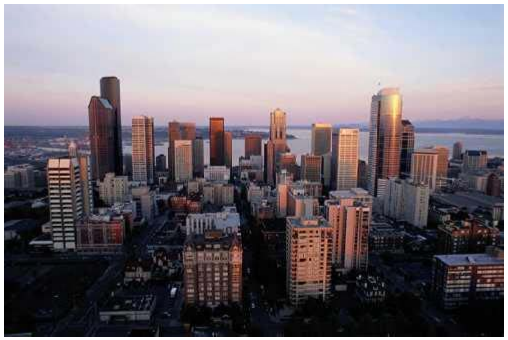
OR

Image Matting and Compositing?

Image Compositing

Compositing Procedure

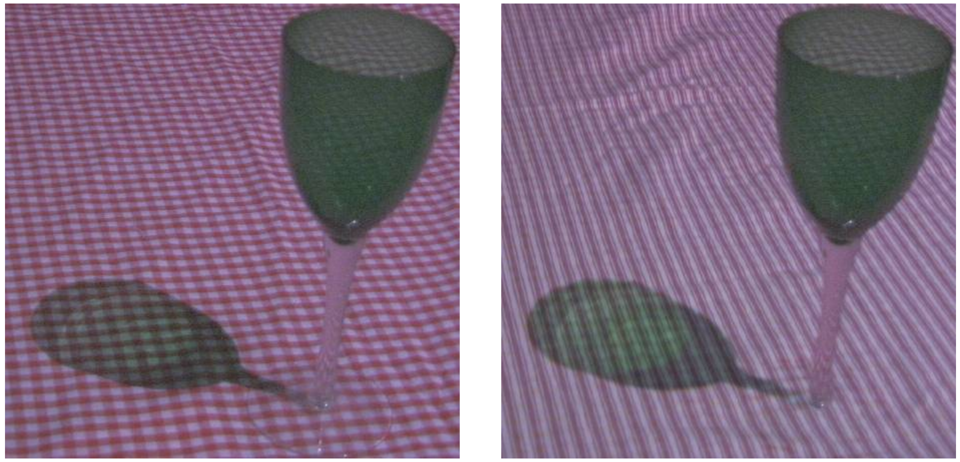
1. Extract Sprites (e.g using *Intelligent Scissors* in Photoshop)



2. Blend them into the composite (in the right order)

Composite by
David Dewey

Compositing: Two Issues



Semi-transparent objects

Pixels too large

Solution: alpha channel

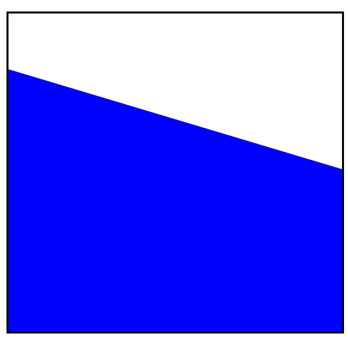
Add one more channel:

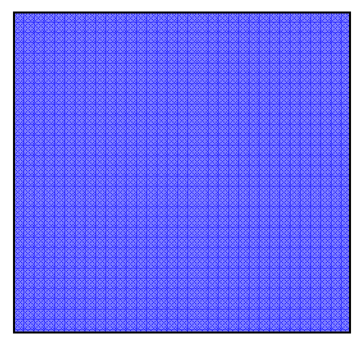
- Image(R,G,B,alpha) *Sprite!*

Encodes transparency (or pixel coverage):

- Alpha = 1: opaque object (complete coverage)
- Alpha = 0: transparent object (no coverage)
- 0<Alpha<1: semi-transparent (partial coverage)

Example: alpha = 0.7





Partial coverage or semi-transparency

Multiple Alpha Blending

So far we assumed that one image (background) is opaque.

If blending semi-transparent sprites (the “A over B” operation):

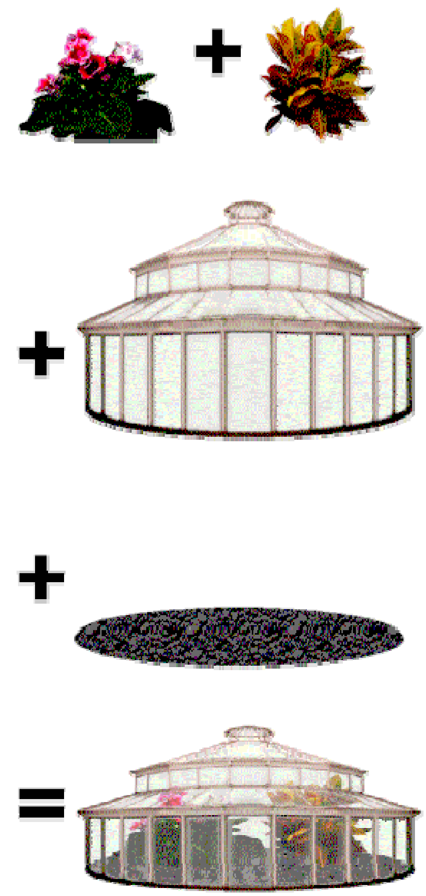
$$I_{comp} = \alpha_a I_a + (1-\alpha_a)\alpha_b I_b$$

$$\alpha_{comp} = \alpha_a + (1-\alpha_a)\alpha_b$$

Note: sometimes alpha is premultiplied: im(αR,αG,αB,α):

$$I_{comp} = I_a + (1-\alpha_a)I_b$$

(same for alpha!)



"Pulling a Matte"

Problem Definition:

- The separation of an image C into
  - A foreground object image C_o,
  - a background image C_b,
  - and an alpha matte α
- C_o and α can then be used to composite the foreground object into a different image

Hard problem

- Even if alpha is binary, this is hard to do automatically (background subtraction problem)
- For movies/TV, manual segmentation of each frame is infeasible
- Need to make a simplifying assumption…

Blue Screen

Blue Screen matting

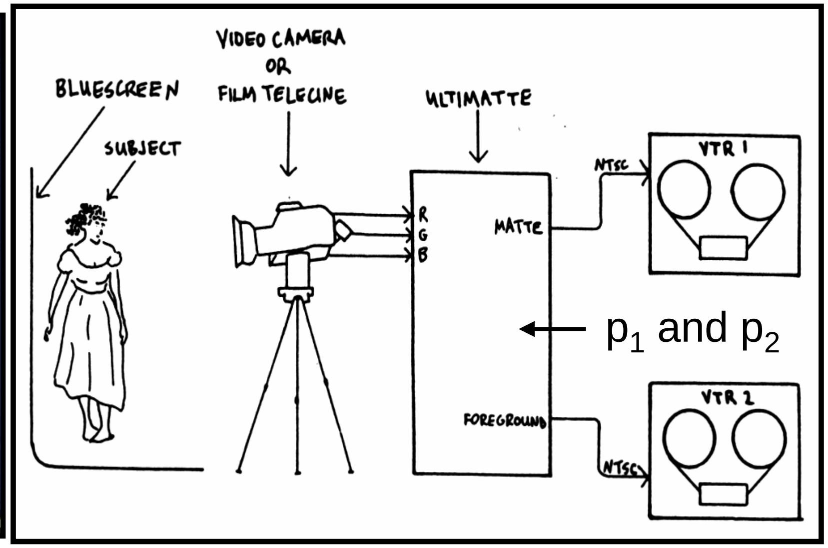
Most common form of matting in TV studios & movies

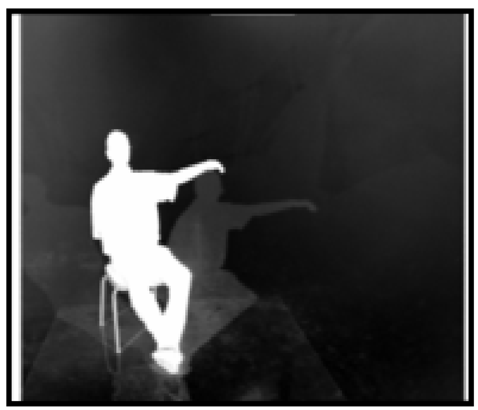
Petros Vlahos invented blue screen matting in the 50s. His Ultimatte® is still the most popular equipment. He won an Oscar for lifetime achievement.

A form of background subtraction:

- Need a known background
- Compute alpha as SSD(C,Cb) > threshold
  - Or use Vlahos' formula: $\alpha = 1\text{-}p_1(B\text{-}p_2G)$
- Hope that foreground object doesn't look like background
  - no blue ties!
- Why blue?
- Why uniform?

The Ultimatte





Blue screen for superman?

to be continued…