Computational Photography

Digital Visual Effects

Yung-Yu Chuang

with slides by Fredo Durand, Ramesh Raskar, Sylvain Paris, Soonmin Bae, Amit Agrawal, Ramesh Raskar

There are a lot of cameras around us

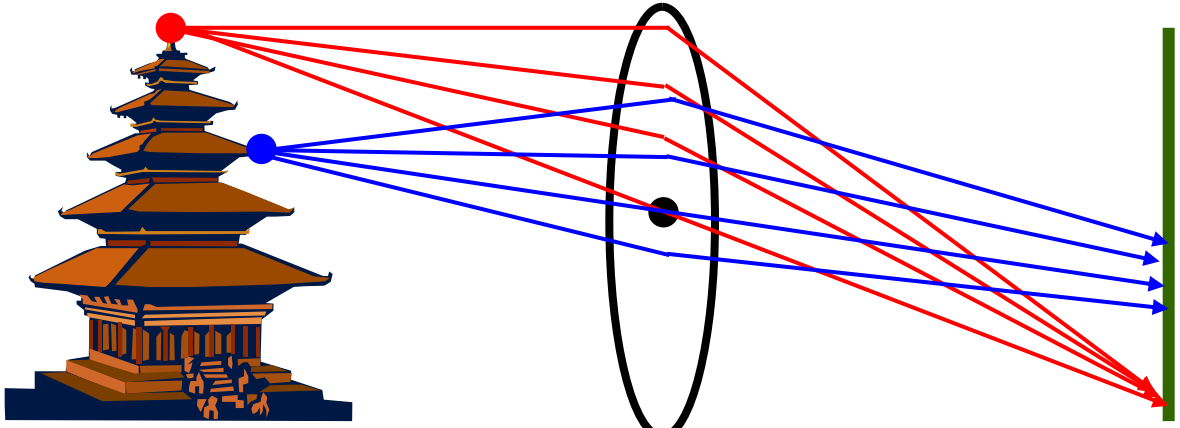
Photography in the mobile era

DigiVFX

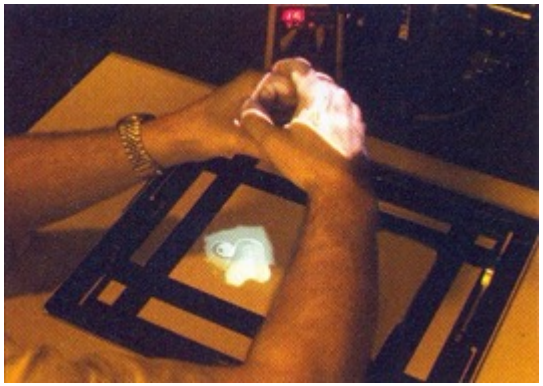
2005

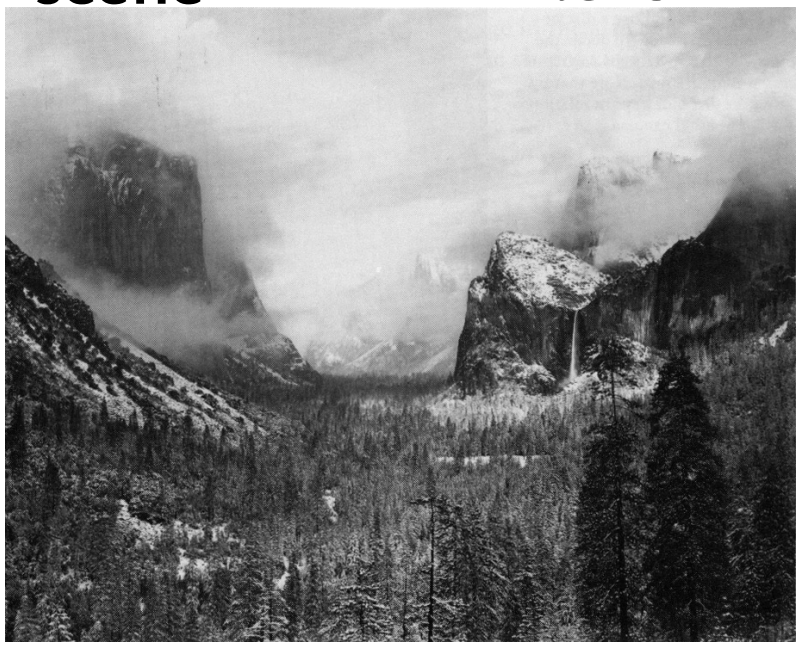
2013

Cameras

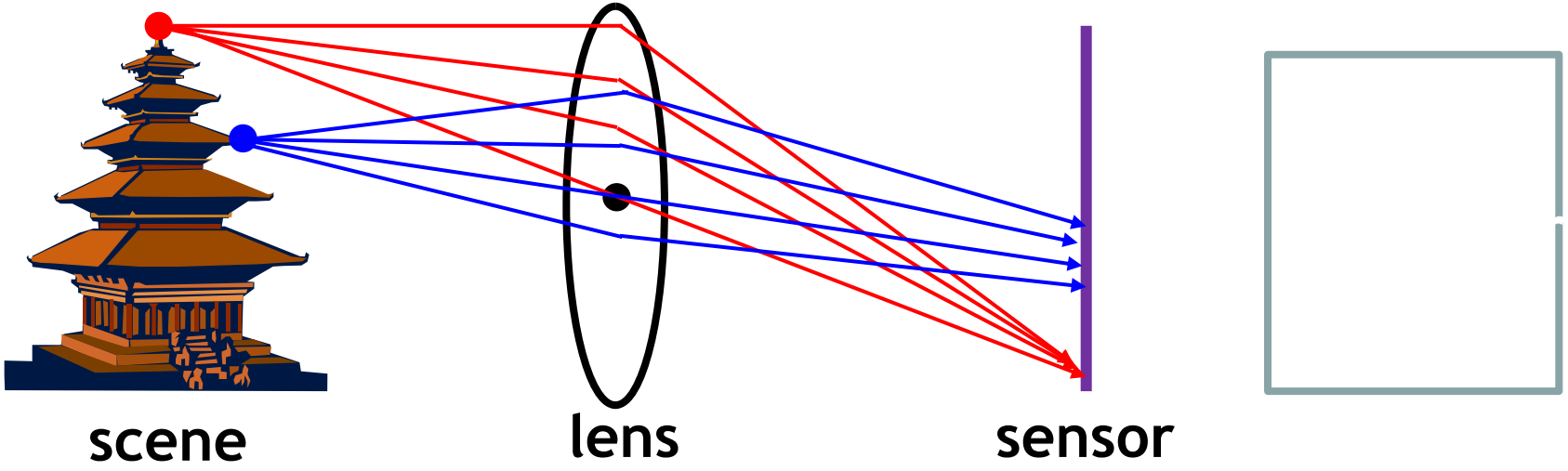


scene lens film





Digital cameras



- Cameras can only provide incomplete and imperfect records of the moments at the best.
- Computational photography: photographs are results of computation, rather than simply sensing.

Computational photography

DigiVFX

wikipedia:

Computational photography refers broadly to computational imaging techniques that enhance or extend the capabilities of digital photography. The output of these techniques is an ordinary photograph, but one that could not have been taken by a traditional camera.

What is computational photography

DigiVFX

- Convergence of image processing, computer vision, computer graphics and photography
- Digital photography:
  - Simply mimics traditional sensors and recording by digital technology
  - Involves only simple image processing
- Computational photography
  - More elaborate image manipulation, more computation
  - New types of media (panorama, 3D, etc.)
  - Camera design that take computation into account

Scope

DigiVFX

- We can’t yet set its precise definition. The following are scopes of what researchers are exploring in this field.
  - Record a richer visual experience
  - Overcome long-standing limitations of conventional cameras
  - Enable new classes of visual signal
  - Enable synthesis impossible photos

Computational photography

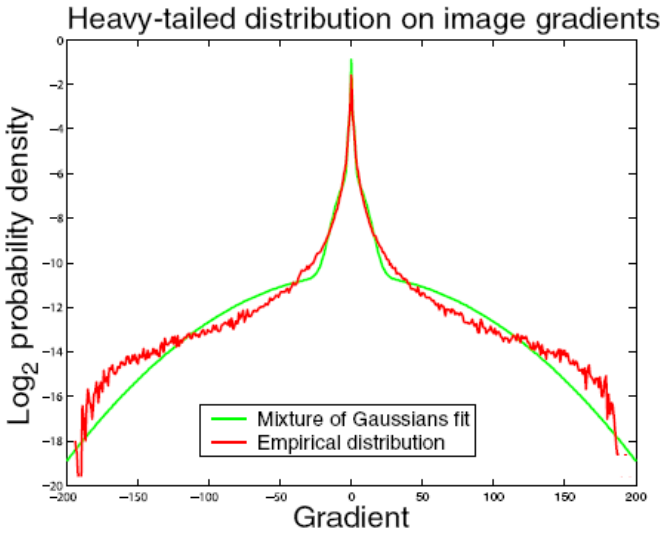
DigiVFX

Imperfect photographer

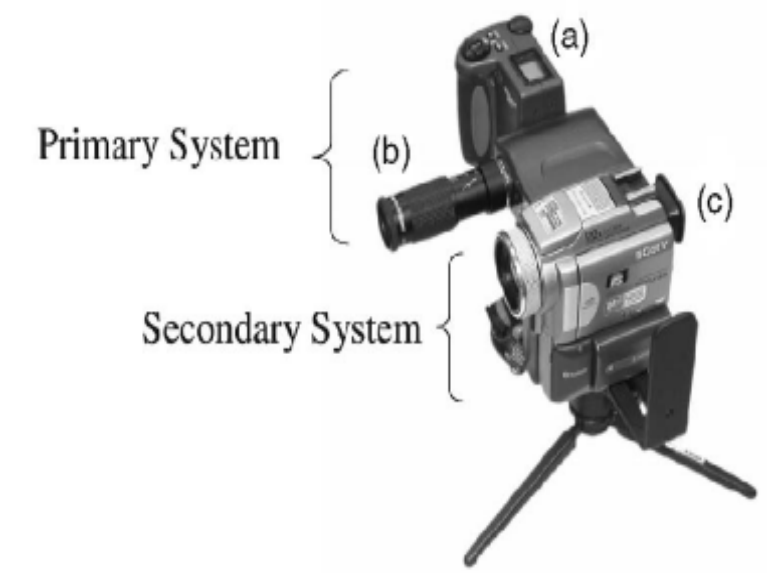
Deblurring

Deblurring

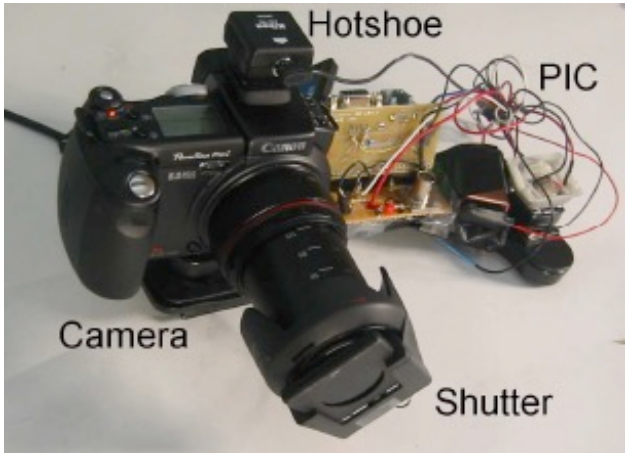
Deblurring

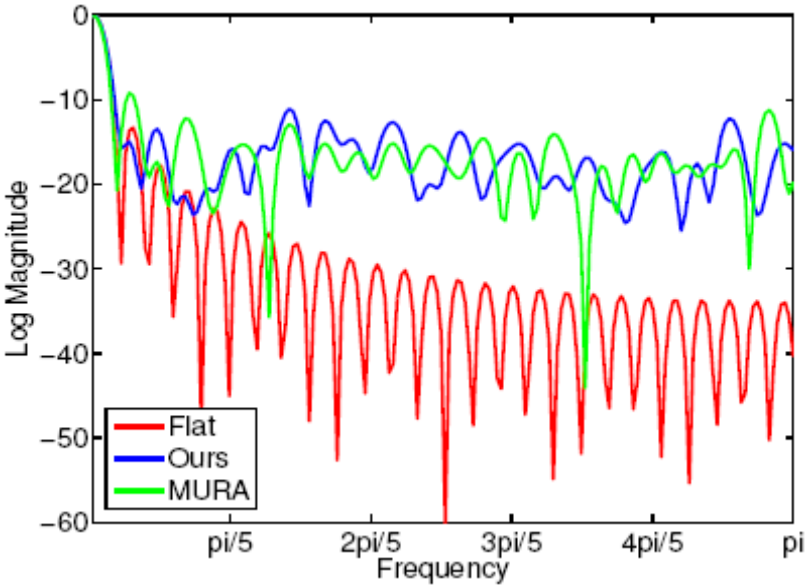

Heavy-tailed distribution on image gradients
Log2 probability density
Gradient
Mixture of Gaussians fit
Empirical distribution

Motion-Based Motion Deblurring



Deblurring


Hotshoe
PIC
Camera
Shutter


0
−10
−20
−30
−40
−50
−60
Log Magnitude
Flat
Ours
MURA
pi/5
2pi/5
3pi/5
4pi/5
pi
Frequency

Video stabilization

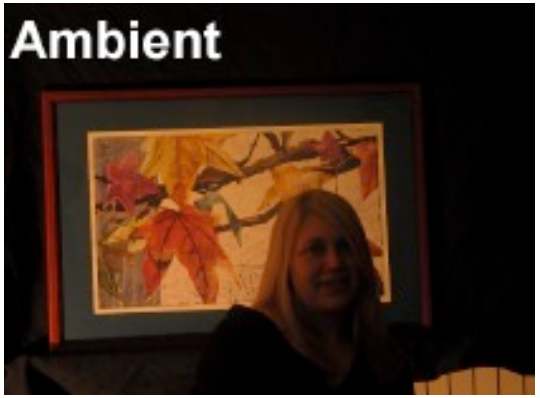
original video

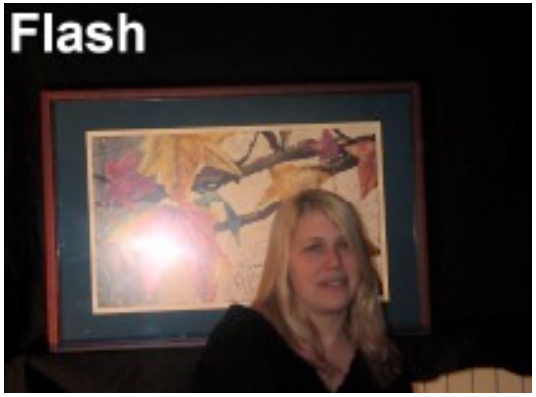
stabilized video

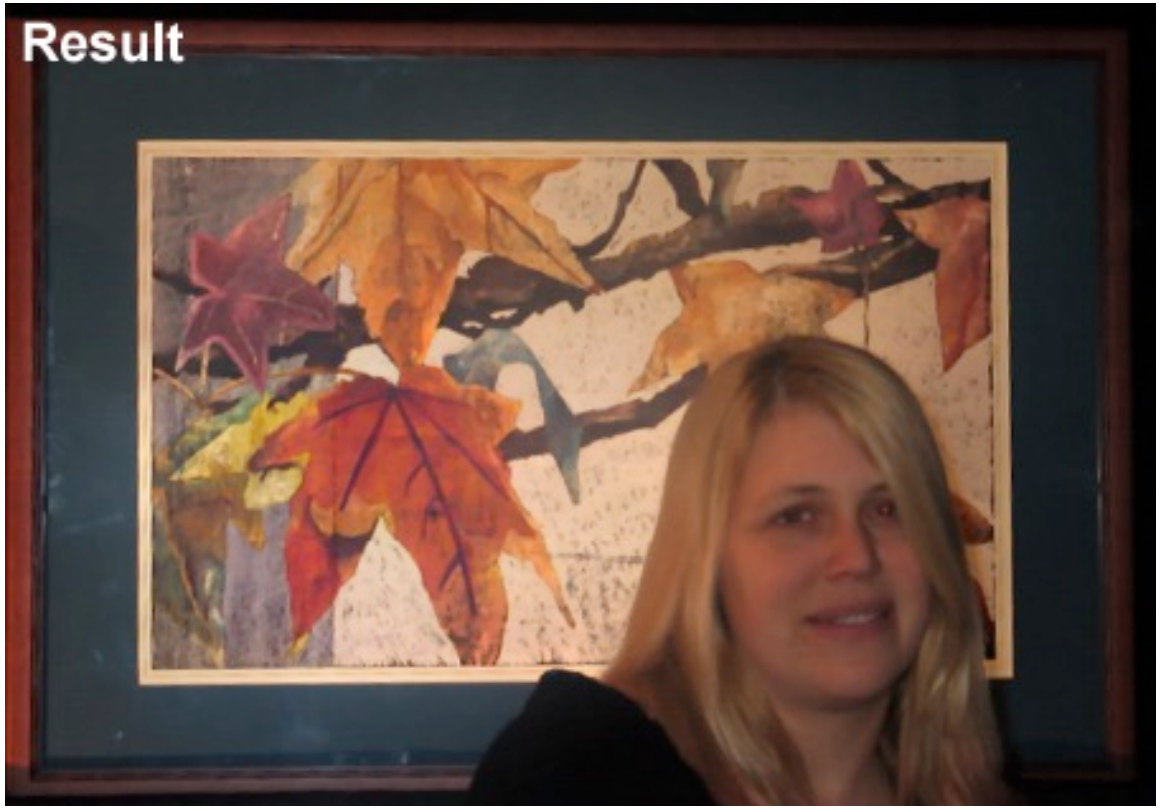
Imperfect scene

Flash photography

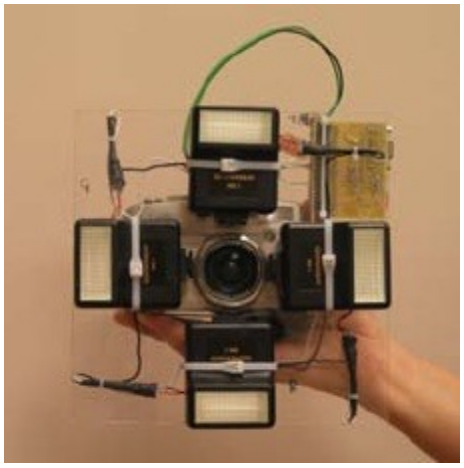
Flash photography







Flash photography



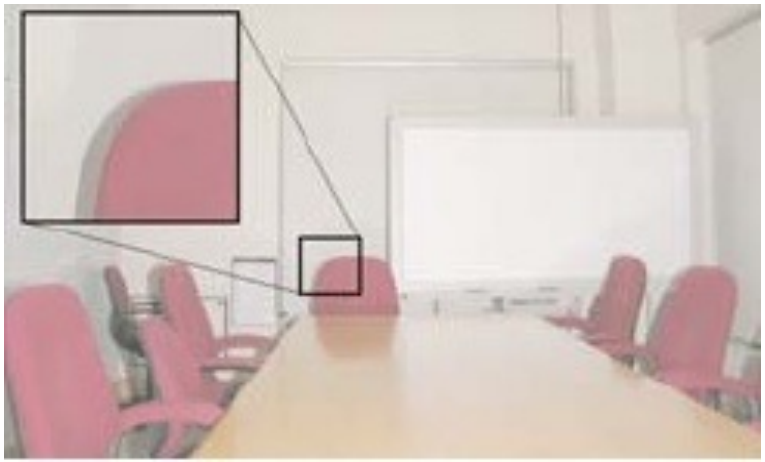


Image Inpainting

Image Inpainting

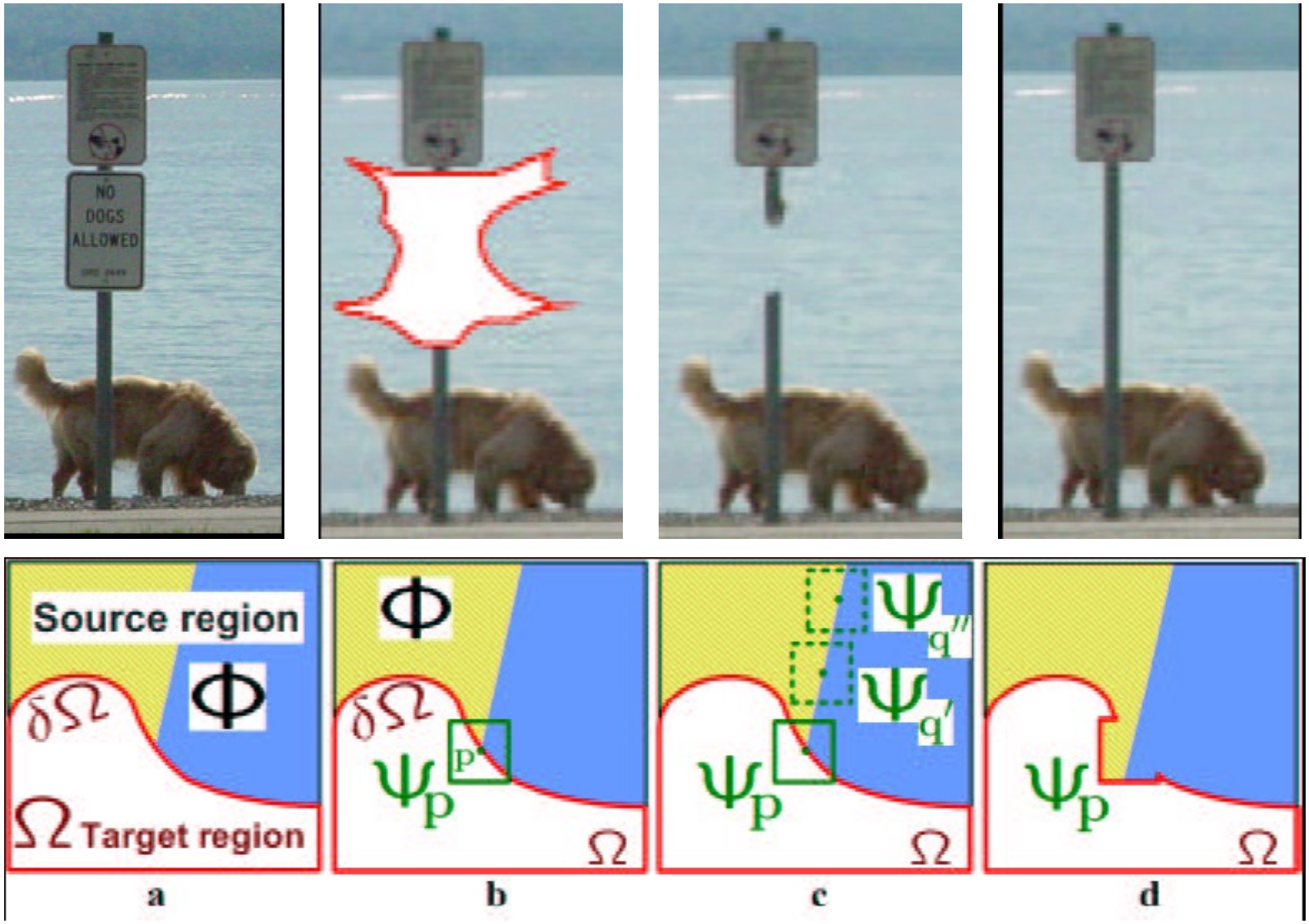
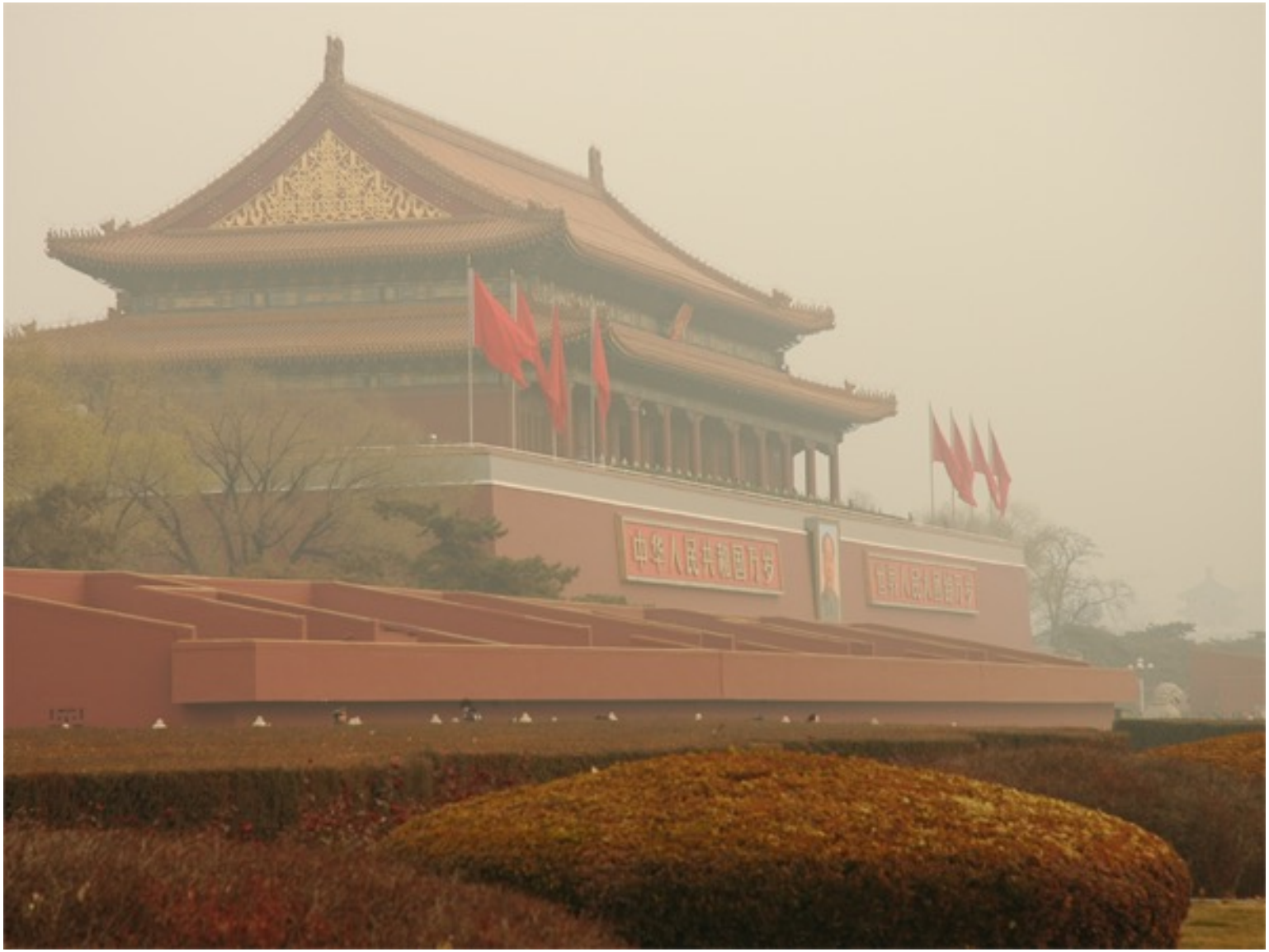
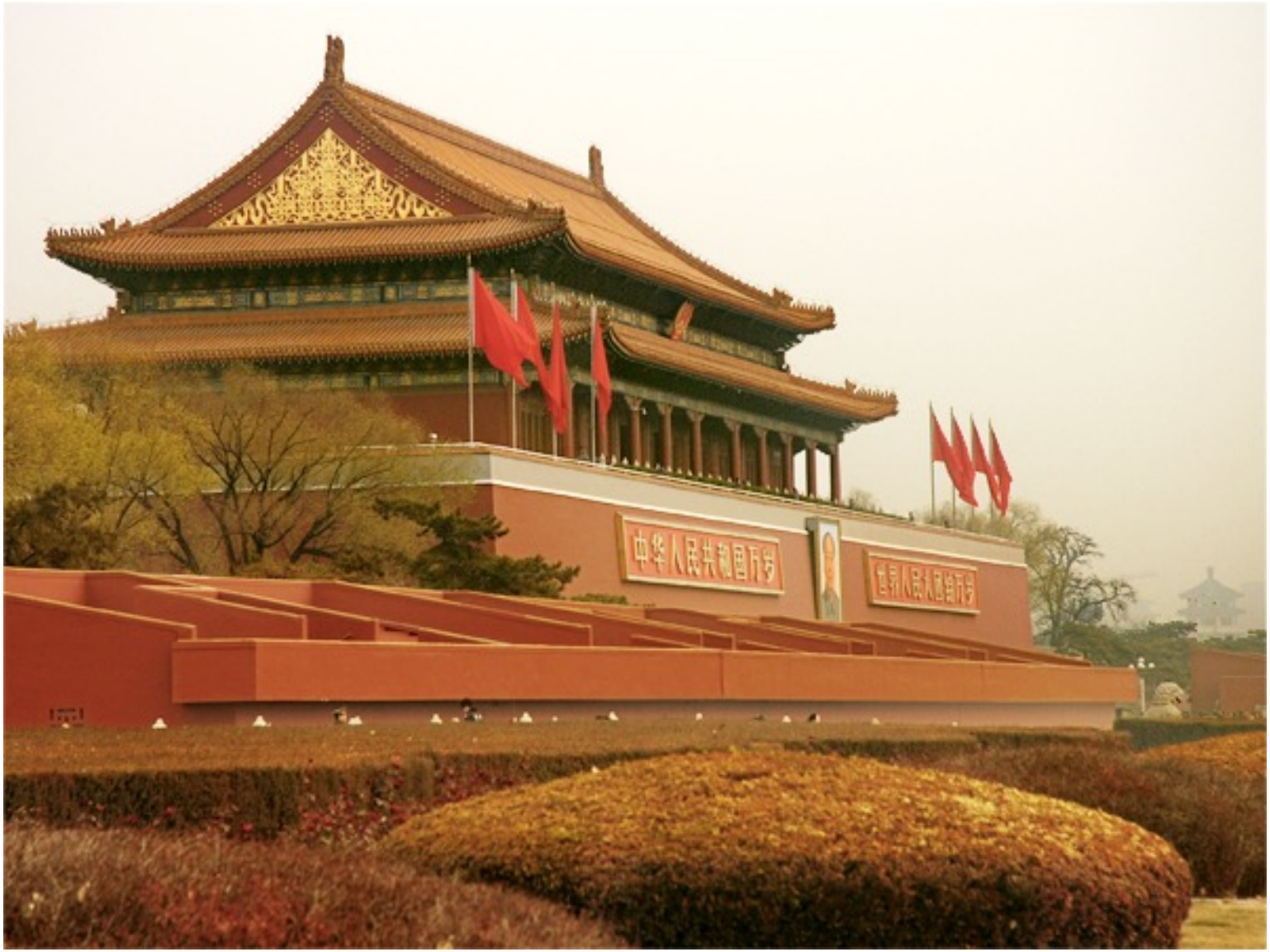


Image Inpainting

Dehazing



Dehazing



Sky replacement

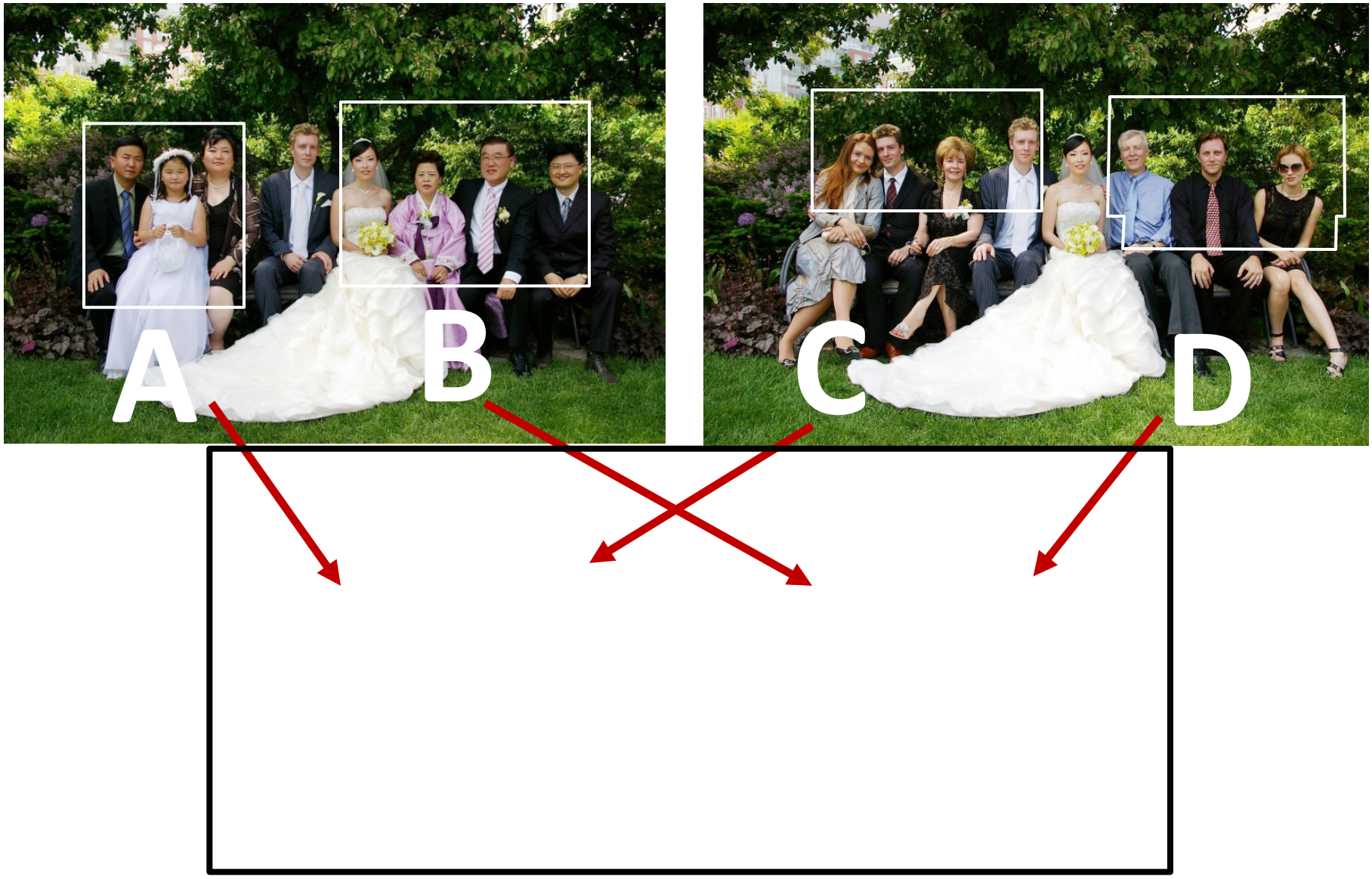
Sky replacement

Inpainting

Re-composition

Re-composition

Re-composition



Re-composition

Imperfect cameras

The problems with cameras

DigiVFX

Noise

real scene

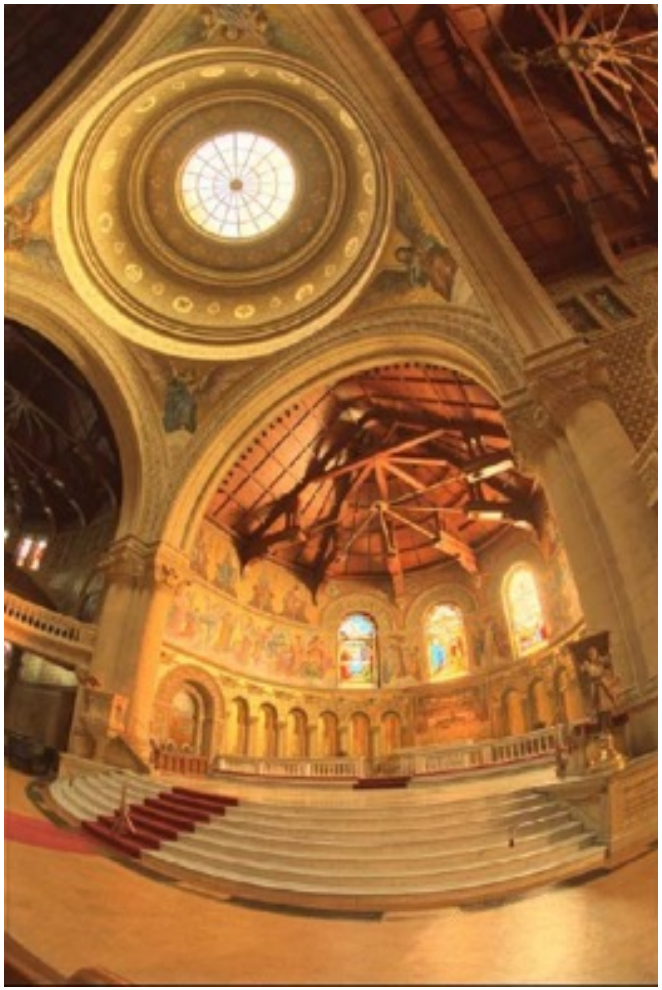
image

Resolution

real scene

image

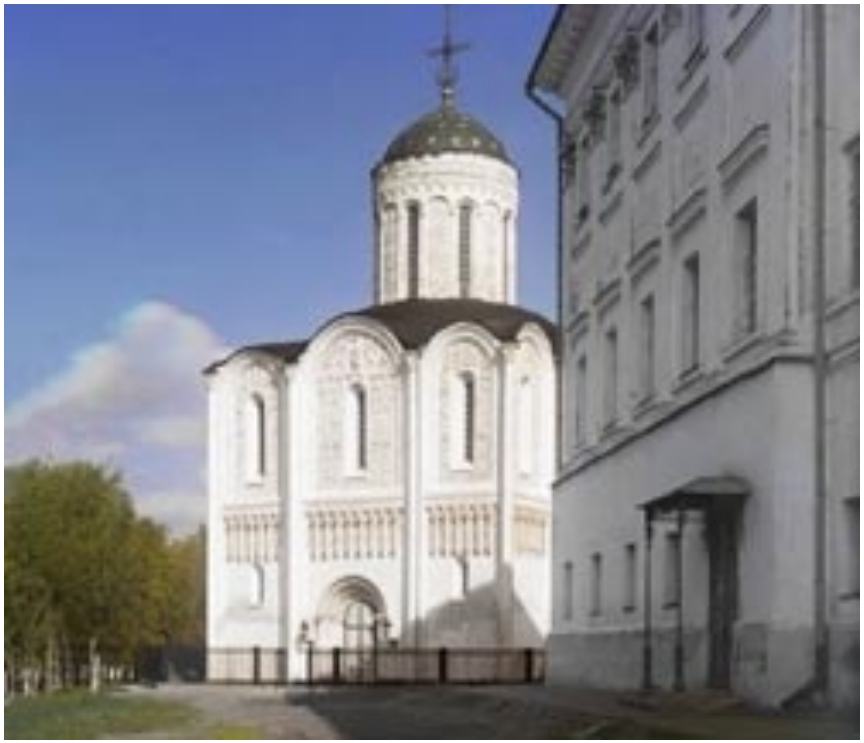
Dynamic range



real scene

image

Color

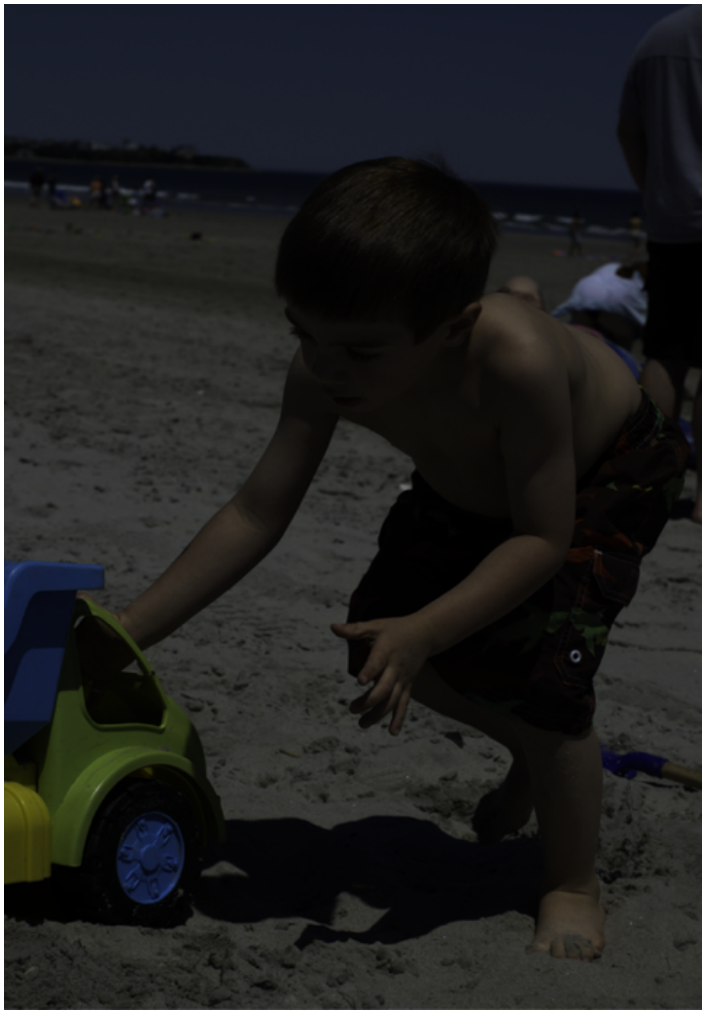


real scene

image

Non-linear response

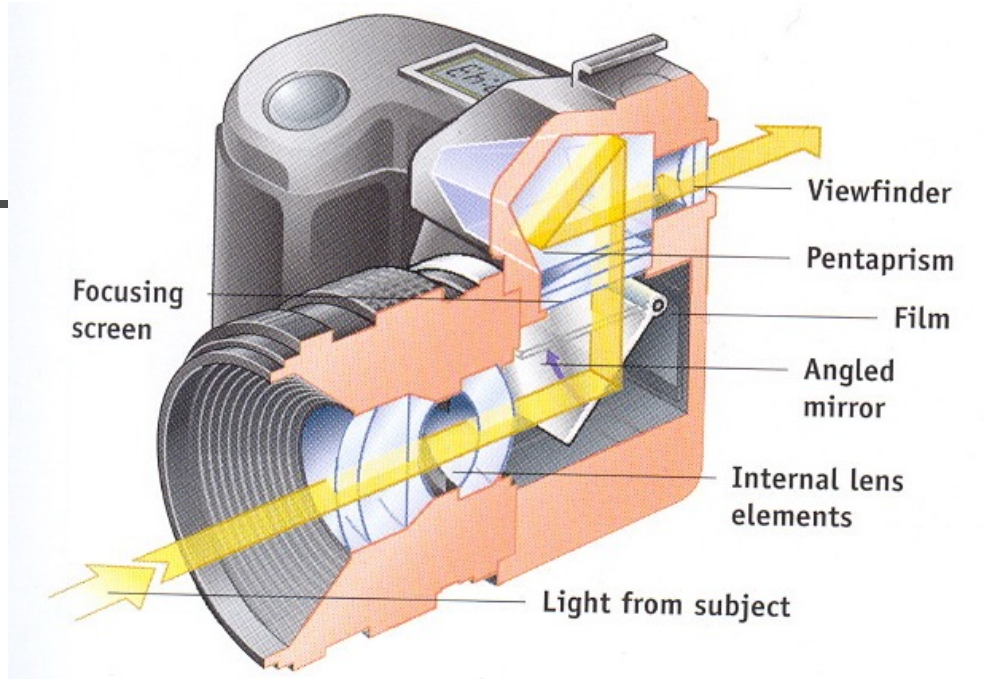
real scene

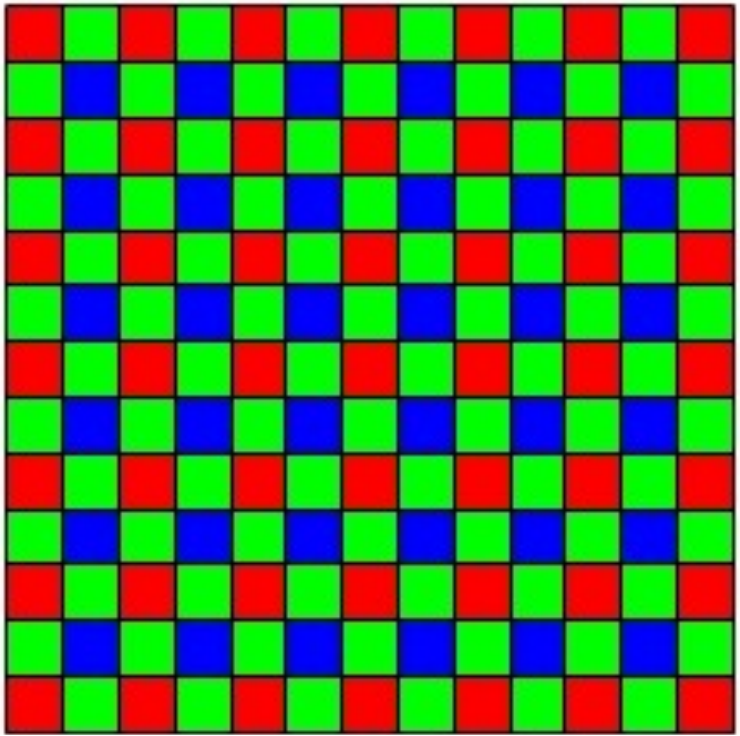


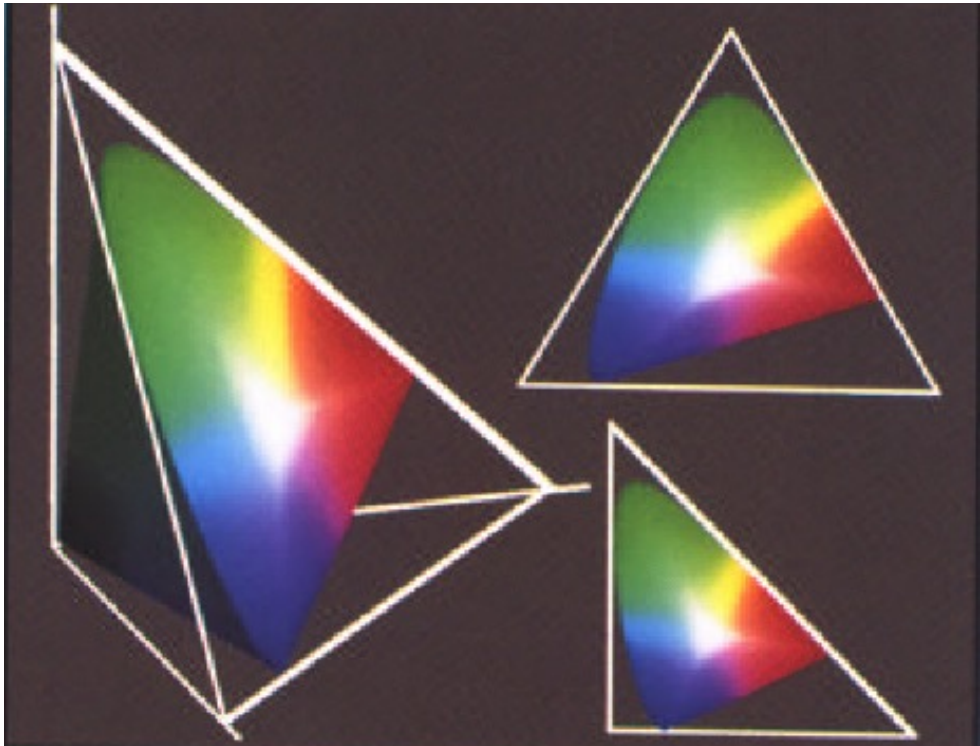
image

Cameras

- Image formation
- Color and color perception







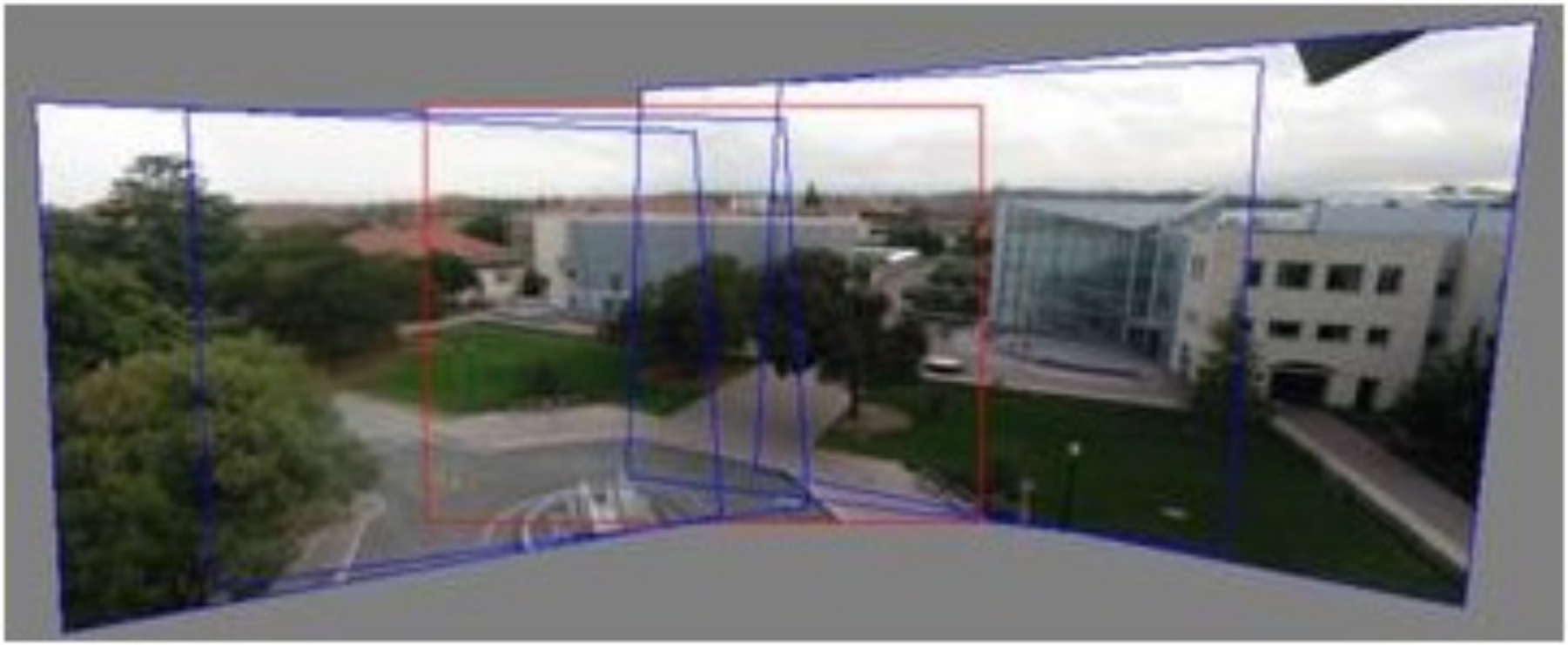
HDR

Exposure blending

Input sequence

Our composite result

Stitching



Retargeting

Retargeting

scaling

content-aware resizing

Vignette calibration

Vignette calibration

DigiVFX

Vignette calibration

De-noising

Super-resolution

original

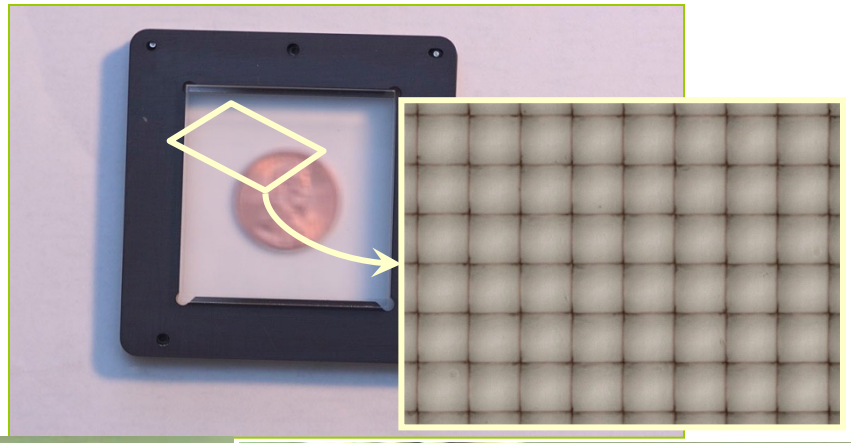
Super-resolution

bicubic

Super-resolution

ICCV 2010

Computational camera



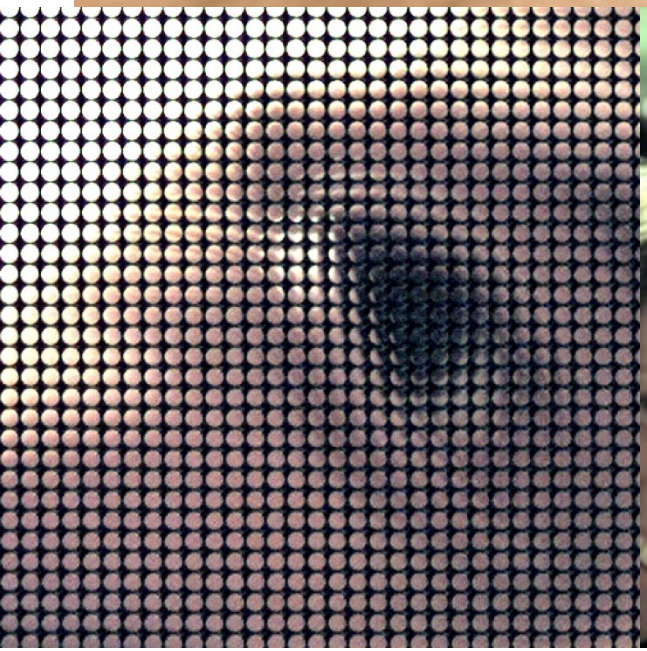
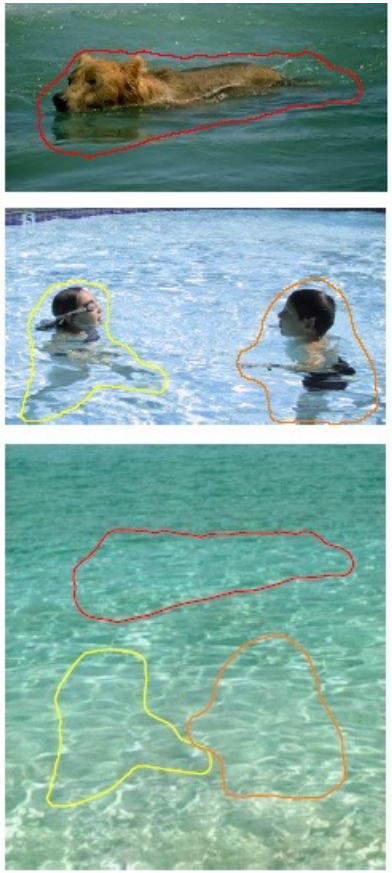


Image manipulation

- Gradient image manipulation



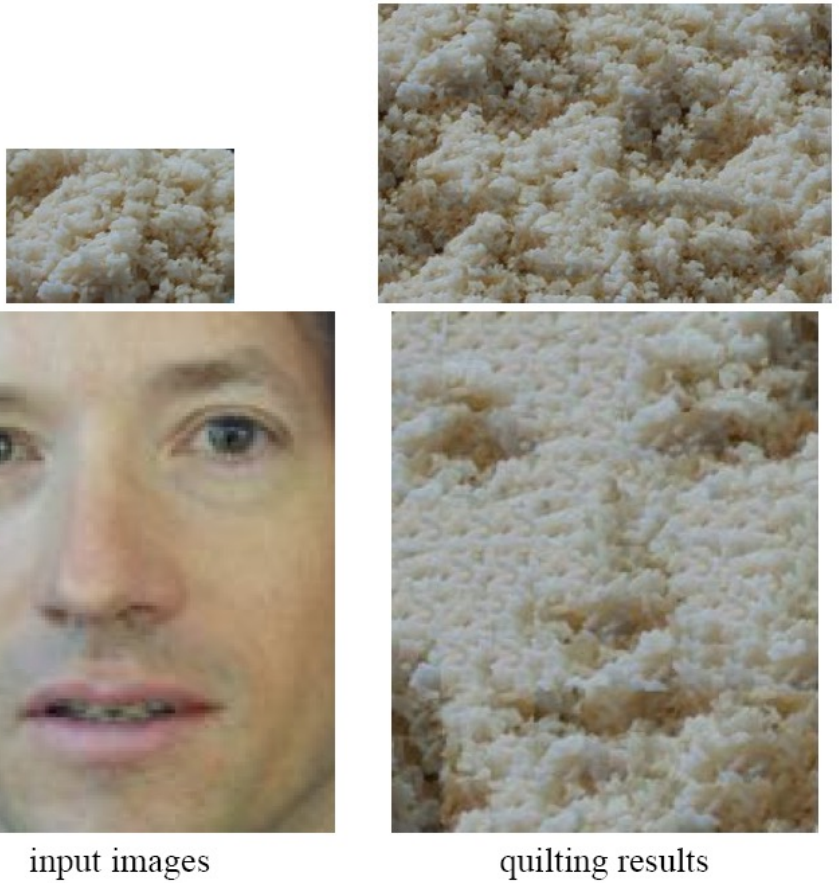
sources/destinations

cloning

seamless cloning

Image manipulation

- Non-parametric image synthesis, inpainting, analogies



input images quilting results

A A' B B'

Figure 1 An image analogy. Our problem is to compute a new "analogous" image B' that relates to B in "the same way" as A' relates to A. Here, A, A', and B are inputs to our algorithm, and B' is the output. The full-size images are shown in Figures 10 and 11.

Lazy snapping







Grab Cut

Tools

DigiVFX

- Graph cuts,
  - Segmentation and mosaicing
- Gradient domain operations,
  - Tone mapping, fusion and matting
- Bilateral filters,
  - Denoising, image enhancement
- Deep learning