



COS526: Advanced Computer Graphics




Tom Funkhouser
Fall 2012

Slides from Durand, Efron, Finkelstein, Freeman, Lazebnik, Rusinkiewicz, Seitz



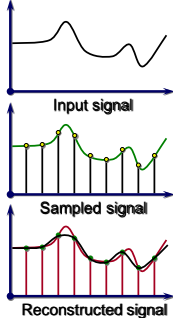
Background


- Image Processing
 - Basic signal processing
 - Filtering, resampling, warping, ...
- Rendering
 - Polygon rendering pipeline
 - Basic ray tracing
- Modeling
 - Basic 3D object representations
 - Polygonal meshes



Background

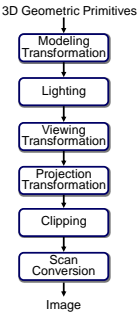
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CS526 Syllabus

- Computational Photography
 - Image composition
 - Texture synthesis
 - Image-based rendering
- Geometric Representations
 - Multiresolution meshes
 - Laplacian meshes
 - Point representations
- Global illumination
 - Photon mapping
 - Monte Carlo path tracing
 - Reflectance
- Other advanced topics
 - TBA



CS526 Syllabus

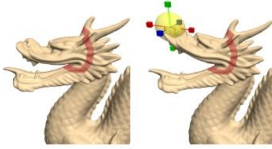


Computational Photography

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Geometric Representations

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Global illumination

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Sorkine

CS526 Syllabus



Computational Photography

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Geometric Representations

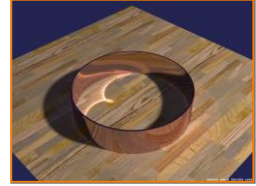
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Jensen

CS526 Syllabus



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Coursework

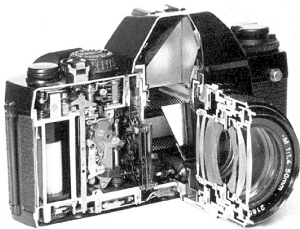


4 Short written exercises

3 Programming assignments

Final project

Computational Photography



What is Computational Photography



Definition 1: The use of computational techniques to overcome limitations of traditional photography

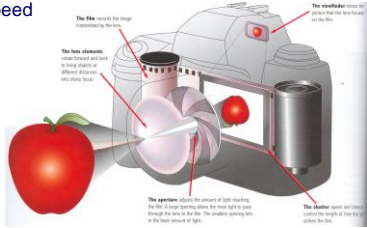
Slide by Lazebnik

Traditional Photography



Camera controls:

- Viewpoint
- Lens
- Shutter speed
- Aperture
- Sensor
- Flash

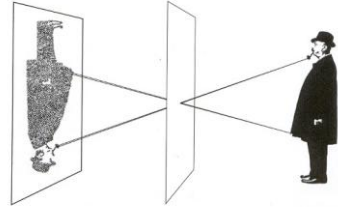


Slide by Freeman and Durand

Traditional Photography



Pin-hole camera:

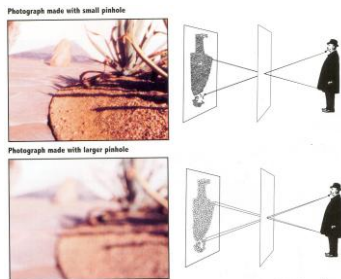


From Photography, London et al.

Traditional Photography



Pin-hole size?



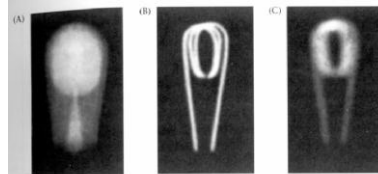
From Photography, London et al.

Traditional Photography



Pin-hole size?

- Smaller produces sharper image (up to limits of diffraction)
- Larger lets in more light



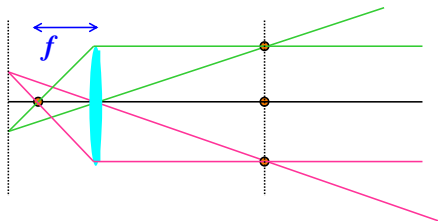
2.18 DIFFRACTION LIMITS THE QUALITY OF PINHOLE OPTICS. These three images of a bulb filament were made using pinholes with decreasing size. (A) When the pinhole is relatively large, the image rays are not properly converged, and the image is blurred. (B) Reducing the size of the pinhole improves the focus. (C) Reducing the size of the pinhole further worsens the focus, due to diffraction. From Rueschardt, 1958.

From Wandell

Traditional Photography



Lenses

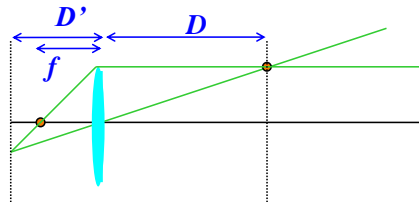


Slide by Freeman and Durand

Traditional Photography



Lenses



$$\frac{1}{D'} + \frac{1}{D} = \frac{1}{f}$$

Slide by Freeman and Durand

Traditional Photography



Lenses

- + More light
- + Sharp ...
- at one depth

Photograph made with small pinhole



To make this picture, the lens of a camera was replaced with a thin metal disk pierced by a tiny pinhole, equivalent in size to an aperture of f/162. Only a few rays of light from each point on the

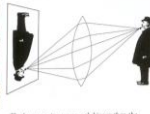


subject got through the tiny opening, producing a soft but acceptably clear photograph. Because of the small size of the pinhole, the exposure had to be 8 sec long.

Photograph made with lens



This time, using a simple convex lens with an f/16 aperture, the scene appeared sharper than the one taken with the smaller pinhole, and the exposure time was much shorter: only 1/100 sec.



The lens opening was much bigger than the pinhole, letting in far more light, but it focused the rays from each point on the subject precisely so that they were sharp on the film.
From Photography, London et al.

Limitations of traditional photography



Single depth of focus



Slide by Lazebnik

Limitations of traditional photography



Limited resolution

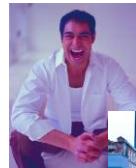


Slide by Lazebnik

Limitations of traditional photography



Bad color / no color

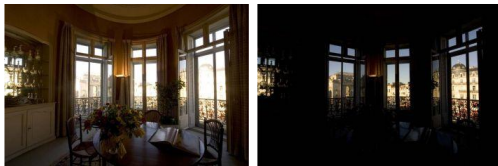


Slide by Lazebnik

Limitations of traditional photography



Limited dynamic range



Slide by Lazebnik

Limitations of traditional photography



Single viewpoint



NFL

Limitations of traditional photography

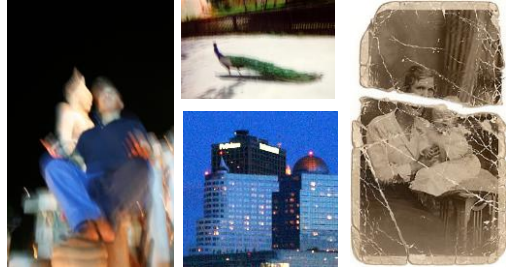
Static scene



Slide by Lazebnik

Limitations of traditional photography

Blur, camera shake, noise, damage



Slide by Lazebnik

Limitations of traditional photography

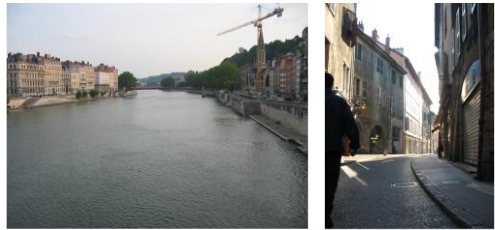
Unfortunate expressions



Slide by Lazebnik

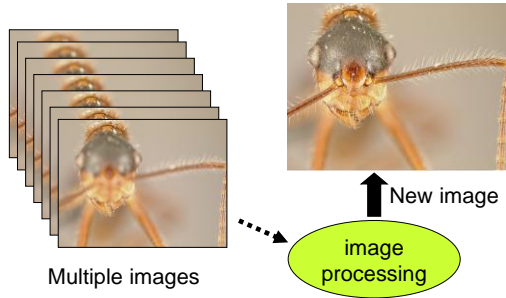
Limitations of traditional photography

Unwanted objects



Slide by Lazebnik

Computational Photography



Hasinoff et al. 2009

Computational Photography

Example: high-dynamic range



Debevec

Computational Photography



Example: deblurring



Fergus

Computational Photography



Example: super-resolution

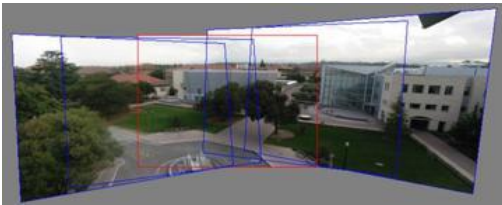


Hertzmann

Computational Photography



Example: creating panorama



Computational Photography



Example: gigapixel images



Kopf

Computational Photography



Example: color harmonization



Cohen-Or

Computational Photography



Example: background replacement



Computational Photography



Example: image completion



Sun

Computational Photography



Example: image completion

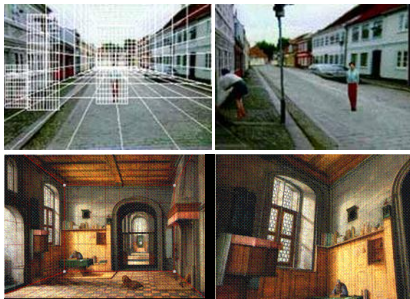


Efros

Computational Photography



Example: tour into the picture

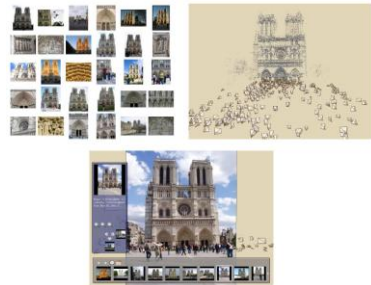


Horry

Computational Photography



Example: photo tourism



Snaveily

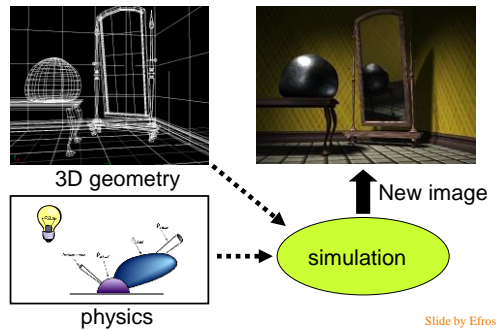
What is Computational Photography



Definition 2: the use of photographic imagery to overcome the limitations of computer graphics

Slide by Lazebnik

Traditional Computer Graphics



Slide by Efros

Limitations of Computer Graphics



Amazingly real ... but sterile, lifeless, *futuristic*

Slide by Efron

Limitations of Computer Graphics



Pavia, Italy

Slide by Efron

Limitations of Computer Graphics



River Cherwell, Oxford



Slide by Efron

Limitations of Computer Graphics



"Final Fantasy"

On the Tube, London



Slide by Efron

Limitations of Computer Graphics



Photo by Joaquin Rosales Gomez

"Final Fantasy"



Slide by Efron

Limitations of Computer Graphics



Virtual LA (SGI)

Photo of LA



Slide by Efron

Computational Photography



Computer Graphics



- + easy to manipulate objects/viewpoint
- hard to acquire/create
- hard to make realistic

Computational Photography

Realism
Manipulation
Ease of capture

Photography



- hard to manipulate objects/viewpoint
- + easy to acquire
- + instantly realistic

Slide by Efros

Next Time



Texture synthesis