



COS526: Advanced Computer Graphics



Tom Funkhouser Fall 2010

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



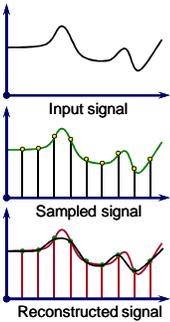
Background

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



Background

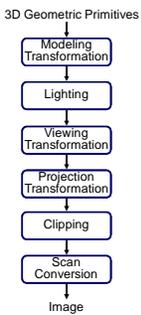
- Image Processing
 - Basic signal processing
 - Filtering, resampling, warping, ...
- Rendering
 - Polygon rendering pipeline
 - OpenGL
- Modeling
 - Basic 3D object representations
 - Polygonal meshes





Background

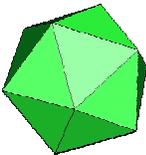
- Image Processing
 - Basic signal processing
 - Filtering, resampling, warping, ...
- Rendering
 - Polygon rendering pipeline
 - Ray tracing
- Modeling
 - Basic 3D object representations
 - Polygonal meshes





Background

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





CS526 Syllabus

- Computational Photography
 - Image composition
 - Texture synthesis
 - Image-based rendering
- Geometric Representations
 - Laplacian meshes
 - Multiresolution meshes
 - Point representations
- Shape Analysis
 - Matching
 - Segmentation
 - Deformation
- Global illumination
 - Reflectance
 - Simulating light transport

CS526 Syllabus



Computational Photography

- Image composition
- Texture synthesis
- Image-based rendering

Geometric Representations

- Laplacian meshes
- Multiresolution meshes
- Point representations

Shape Analysis

- Matching
- Segmentation
- Deformation

Global illumination

- Reflectance
- Simulating light transport



CS526 Syllabus



Computational Photography

- Image composition
- Texture synthesis
- Image-based rendering

Geometric Representations

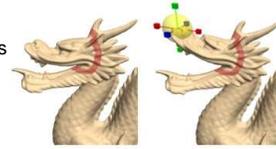
- Laplacian meshes
- Multiresolution meshes
- Point representations

Shape Analysis

- Matching
- Segmentation
- Deformation

Global illumination

- Reflectance
- Simulating light transport



Sorkine

CS526 Syllabus



Computational Photography

- Image composition
- Texture synthesis
- Image-based rendering

Geometric Representations

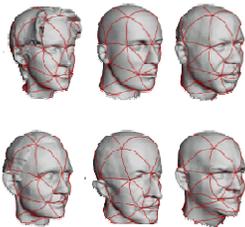
- Laplacian meshes
- Multiresolution meshes
- Point representations

Shape Analysis

- Matching
- Segmentation
- Deformation

Global illumination

- Reflectance
- Simulating light transport



Praun

CS526 Syllabus



Computational Photography

- Image composition
- Texture synthesis
- Image-based rendering

Geometric Representations

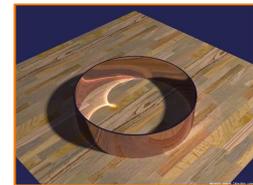
- Laplacian meshes
- Multiresolution meshes
- Point representations

Shape Analysis

- Matching
- Segmentation
- Deformation

Global illumination

- Reflectance
- Simulating light transport



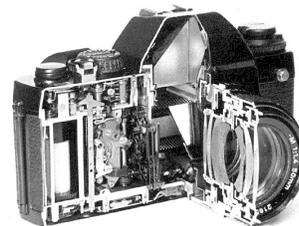
Jensen

Coursework



- 4 Short written exercises
- 3 Programming assignments
- Final project

Computational Photography

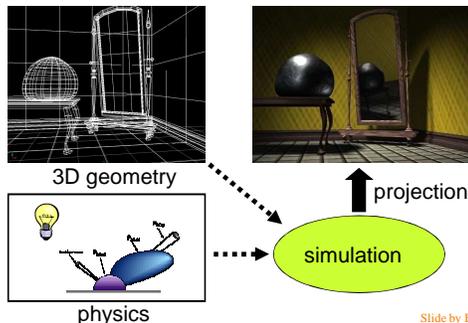


What is Computational Photography

Definition 1: the use of photographic imagery to create content for computer graphics

Slide by Lazebnik

Traditional Computer Graphics



Slide by Efros

State of the Art



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

Slide by Efros

The richness of our everyday world



Pavia, Italy

Slide by Efros

Beauty in complexity



Blue Mountains, Australia

Slide by Efros

Which parts are hard to model?



Slide by Efros

People

On the Tube, London

"Final Fantasy"

Slide by Efron

Faces / Hair

Photo by Joaquin Rosales Gomez

"Final Fantasy"

Slide by Efron

Urban Scenes

Photo of LA

Virtual LA (SGI)

Slide by Efron

Nature

River Cherwell, Oxford

Slide by Efron

Traditional Photography

- Camera controls:
 - Viewpoint
 - Lens
 - Shutter speed
 - Aperture
 - Sensor

Slide by Freeman and Durand

Traditional Photography

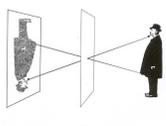
Pin-hole camera:

From Photography, London et al.

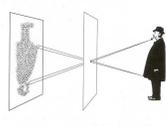
Traditional Photography

Pin-hole size?

Photograph made with small pinhole

Photograph made with larger pinhole

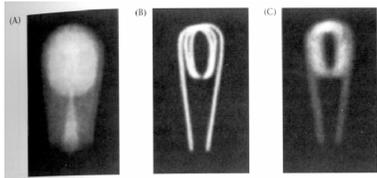



From Photography, London et al.

Traditional Photography

Pin-hole size?

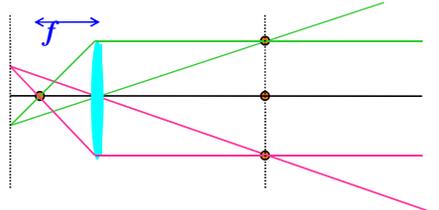
- Smaller produces sharper image (up to limits of diffraction)
- Larger lets in more light



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 Wandell

Traditional Photography

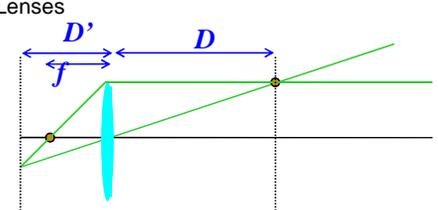
Lenses



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 6 sec. long.

Photograph made with lens

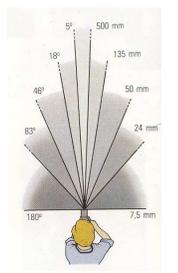


This time, using a simple convex lens with an f/16 aperture, the scene appeared sharper than the one taken with the smaller pinhole, and the exposure time was much shorter: only 1/100 sec.

From Photography, London et al.

Traditional Photography

Effect of different focal lengths



24mm



50mm



135mm



Limitations of traditional photography

Limited resolution



Slide by Lazebnik

Limitations of traditional photography

Single depth of focus



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

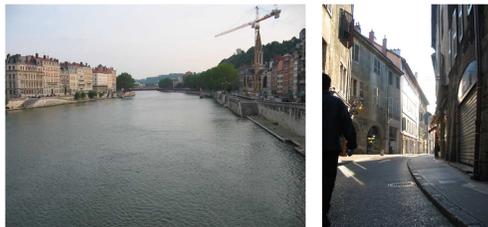
Unfortunate expressions



Slide by Lazebnik

Limitations of traditional photography

Unwanted objects



Slide by Lazebnik

The Realism Spectrum

Computer Graphics Computational Photography Photography



Realism
Manipulation
Ease of capture



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

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

Slide by Efros

What is Computational Photography

Definition 1: the use of photographic imagery to create graphics content

Definition 2: The use of computational techniques to overcome limitations of traditional photography

Slide by Lazebnik

Computational Photography

Example: high-dynamic range



Debevec

Computational Photography



Example: deblurring

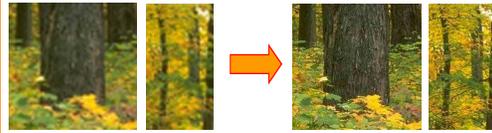


Fergus

Computational Photography



Example: super-resolution

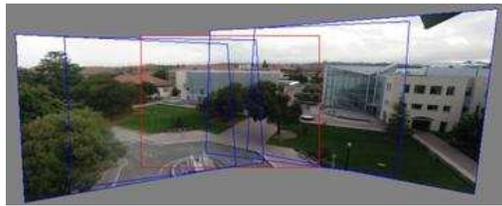


Hertzmann

Computational Photography



Example: creating panorama



Computational Photography



Example: gigapixel images



Kopf

Computational Photography



Example: color harmonization

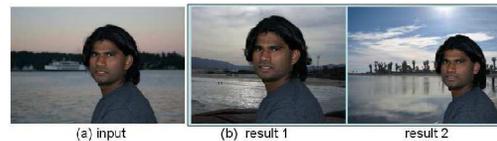


Cohen-Or

Computational Photography



Example: background replacement



Computational Photography



Example: image completion



Sun

Computational Photography



Example: image completion

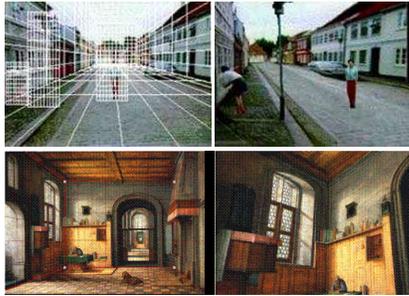


Efros

Computational Photography



Example: tour into the picture



Hory

Computational Photography



Example: photo tourism



Snavey

Next Time



Texture synthesis