CSC 4356
Interactive Computer Graphics
Lecture 25: Image-Based Rendering

Jinwei Ye

http://www.csc.lsu.edu/~jye/CSC4356/

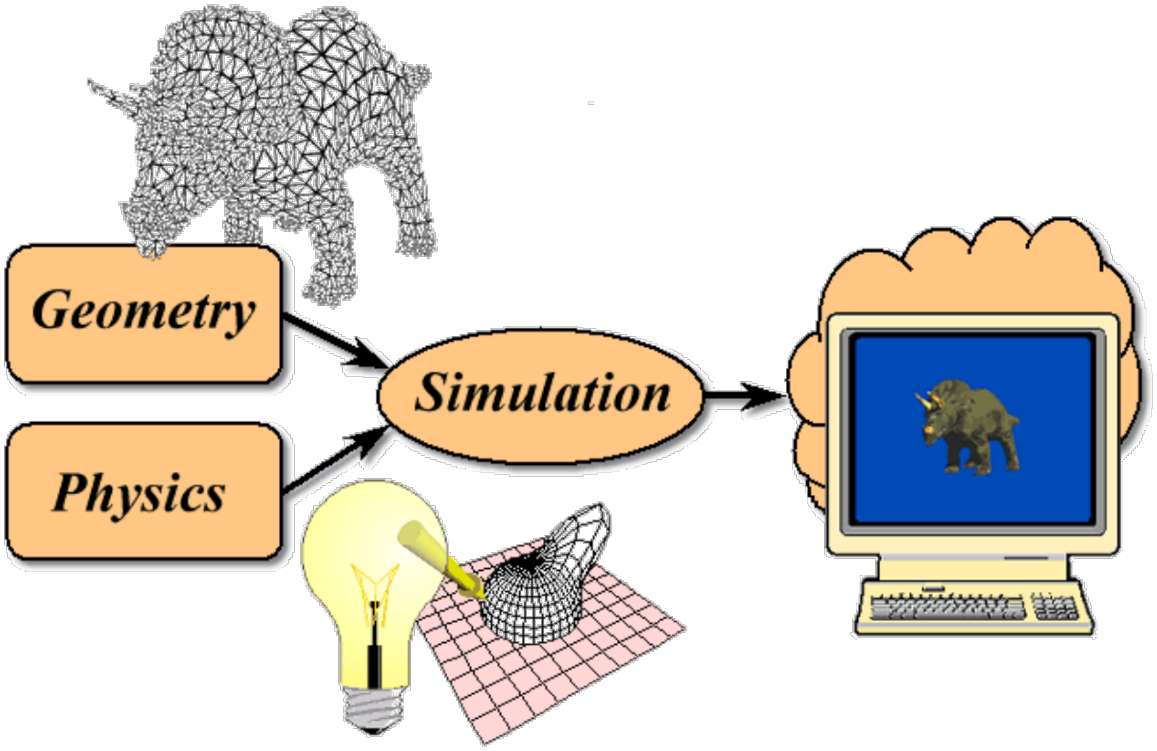
Tue & Thu: 10:30 - 11:50am
218 Tureaud Hall

From Previous Lectures

- Polygon-based rendering
- Ray tracing

Conventional 3-D Graphics

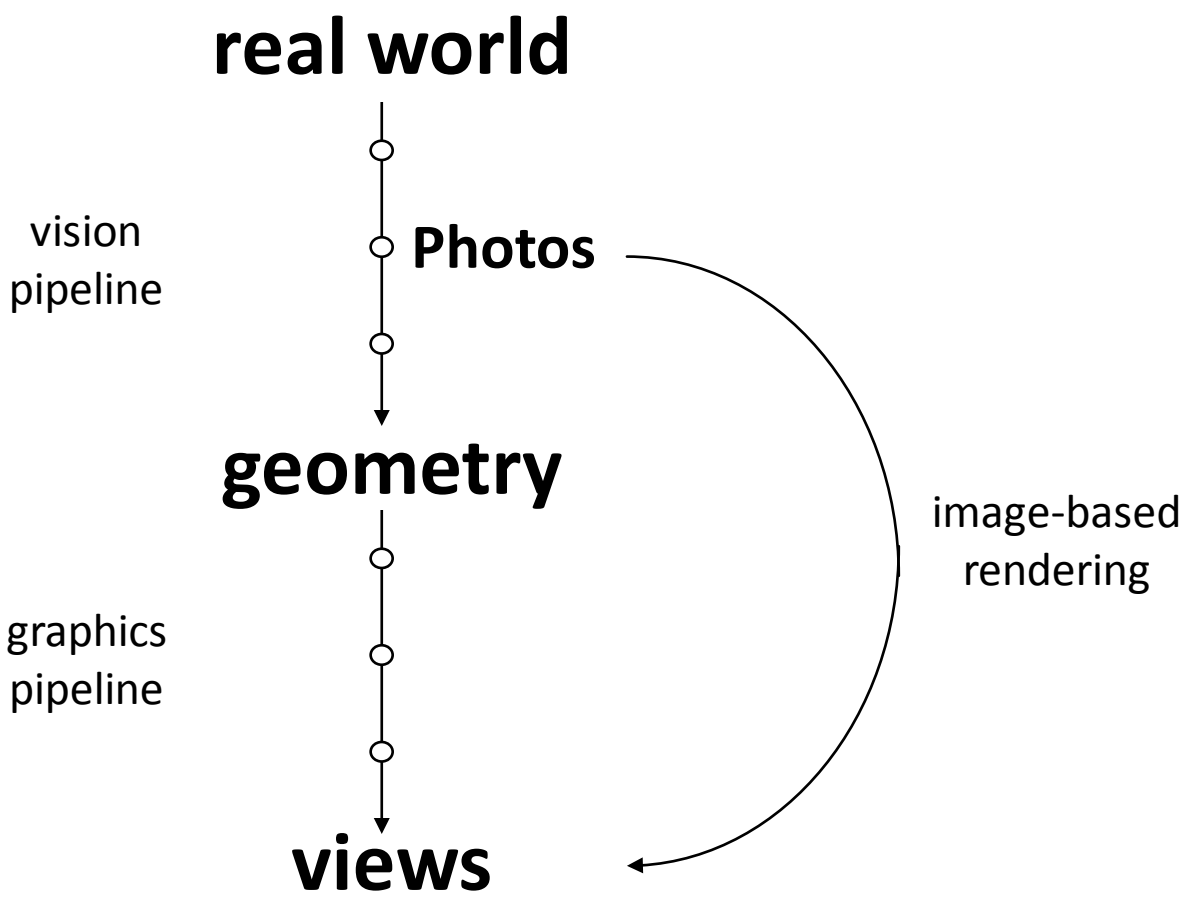
- Traditionally computer graphics treats rendering as a simulation problem



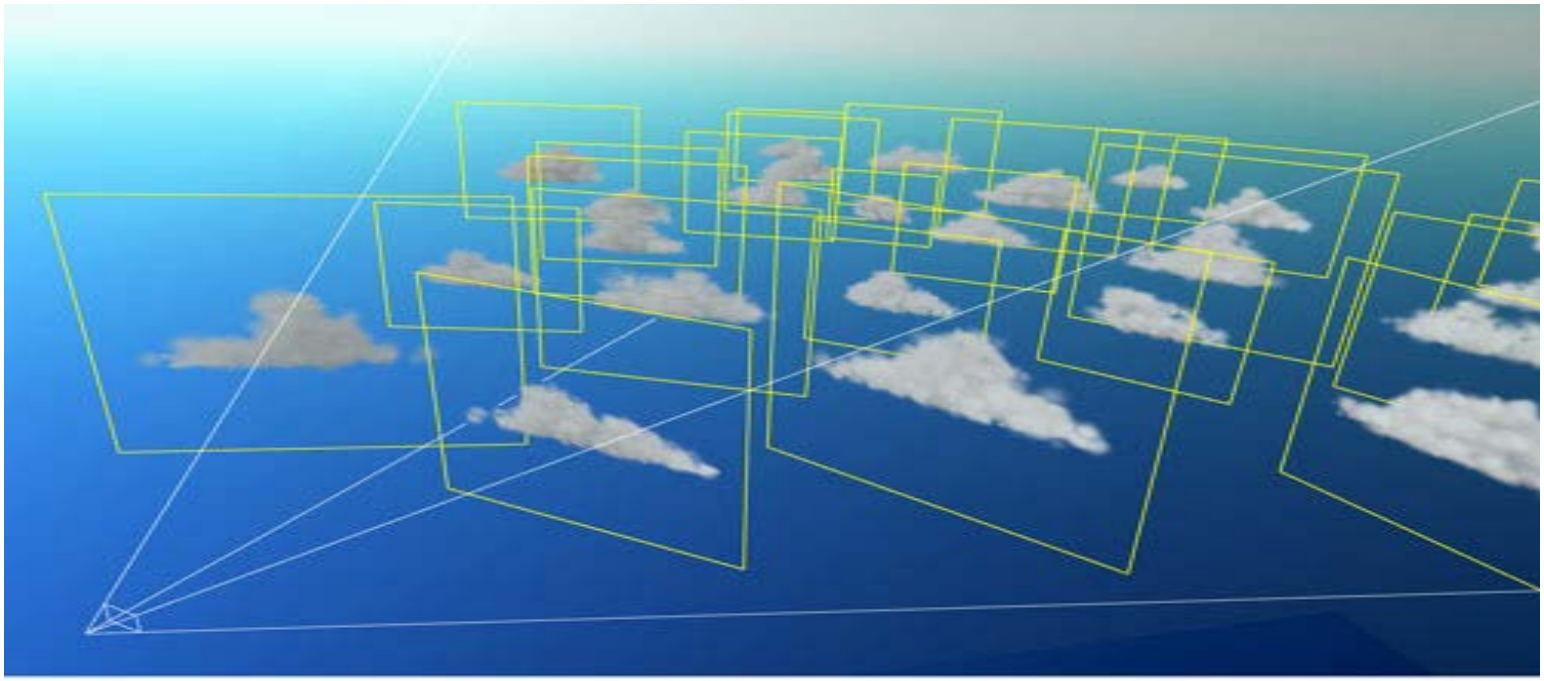
Motivation

- Modeling is expensive
  - complex geometry, reflectance, etc. hard to specify
  - realistic light transport is computationally intensive
- Results still have an artificial look
- Photos are realistic by definition
- Photos are easy to capture
- Why not just use photos directly?
  - a sampling problem instead of a simulation problem

Image-Based Rendering (IBR)



Simple Image-Based Rendering



Panoramas

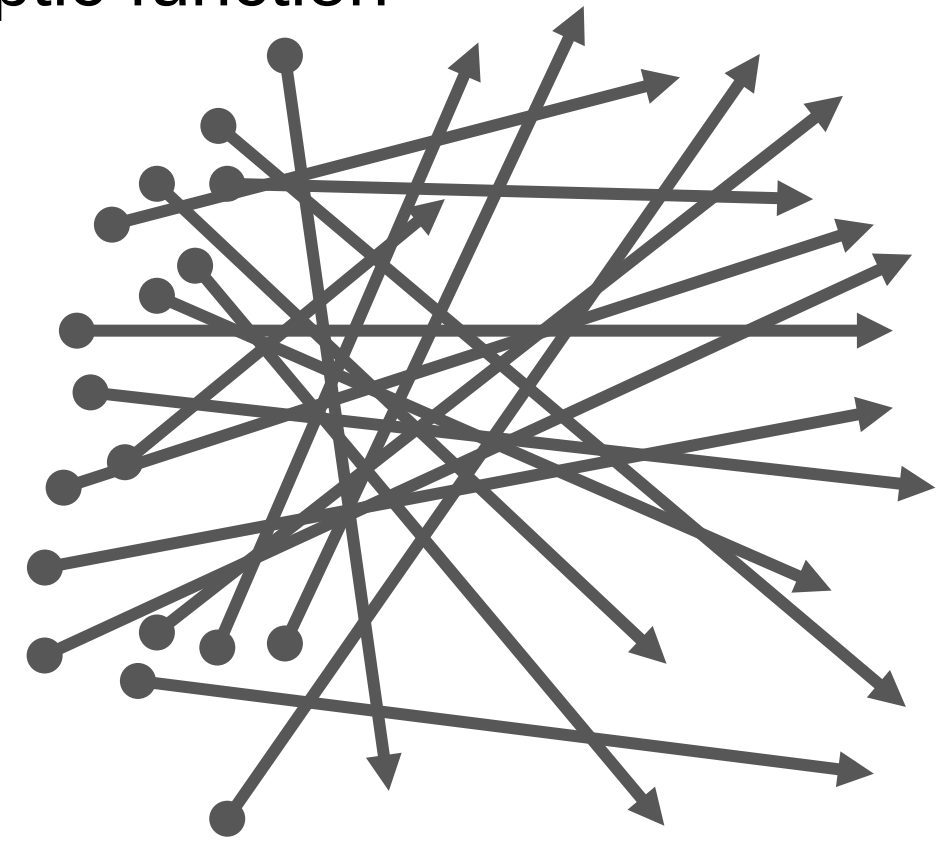
- Created by stitching together multiple images
  - one position, wide range of directions
  - Quicktime VR
    - interactive. User controls the gaze direction

Image-Based Rendering (IBR)

- Advantages
  - Modest computation compared to classical C.G.
  - Cost independent of scene complexity
  - Imagery from real or virtual scenes
- Limitations of pre-computation
  - Fixed look-from or look at point
  - Static scene geometry
  - Fixed lighting

Ray Space

- all possible rays
  - Plenoptic function



Plenoptic Function

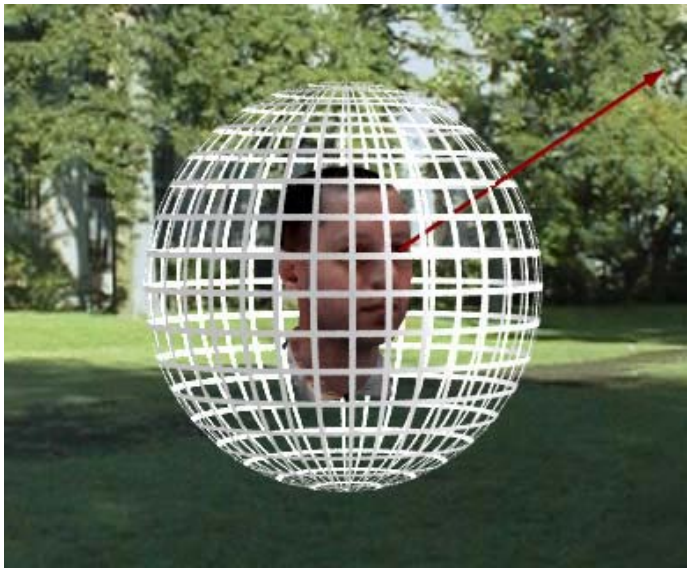
$$P(V_x, V_y, V_z, \theta, \phi, \lambda, t)$$

- Captures radiance
  - at a particular point in space (3D)
  - in a particular direction (2D)
  - at a particular wavelength (1D) -- color
  - at a particular time (1D)
- 7D function!

Plenoptic function

$$P(V_x, V_y, V_z, \theta, \phi)$$

- Simplifications
  - eliminate time
  - use only RGB
- Now only 5D
  - position
  - orientation

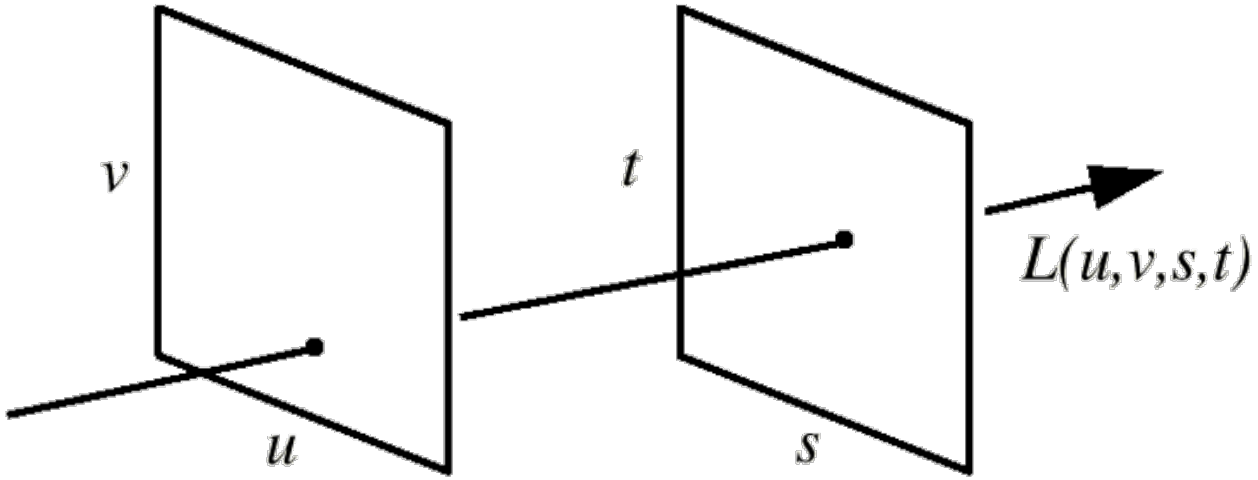


Plenoptic Function

- Many image-based rendering (IBR) approaches can be cast as sampling from and reconstructing the Plenoptic function
  - Note that the function is generally constant along segments of a line (assuming vacuum)

Light Fields (Two-Plane Parameterization)

- Reduce the Plenoptic function to 4D
- Exploits the fact that radiance doesn't change along a ray through empty space
- We need a way to parameterize rays



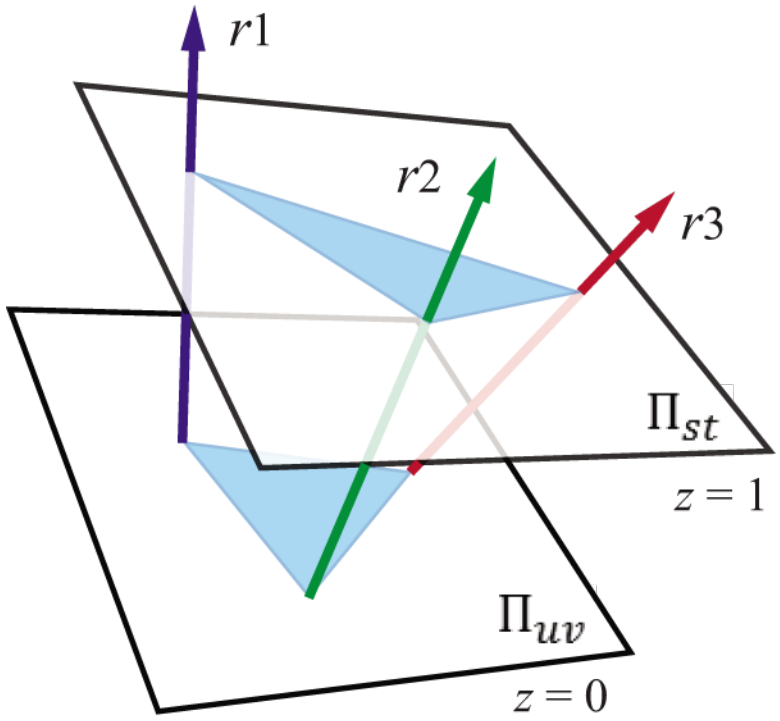
Two-Plane Parameterization(2PP)

- Parameterized over two parallel planes (2PP)
- Each ray maps to a 4D point [*u, v, s, t*]
- Relative 2PP

$$\vec{r} = \left[u, v, \sigma, \tau \right]$$

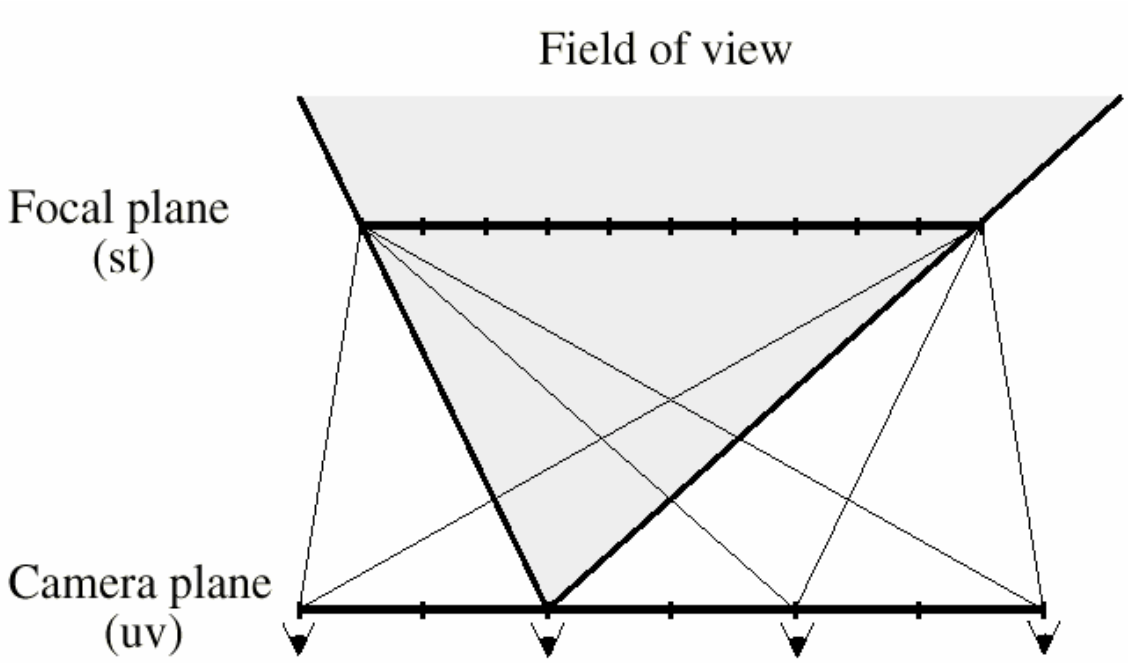
$$\sigma = s - u, \ \tau = t - v$$

- Ray direction: [*σ, τ, 1*]

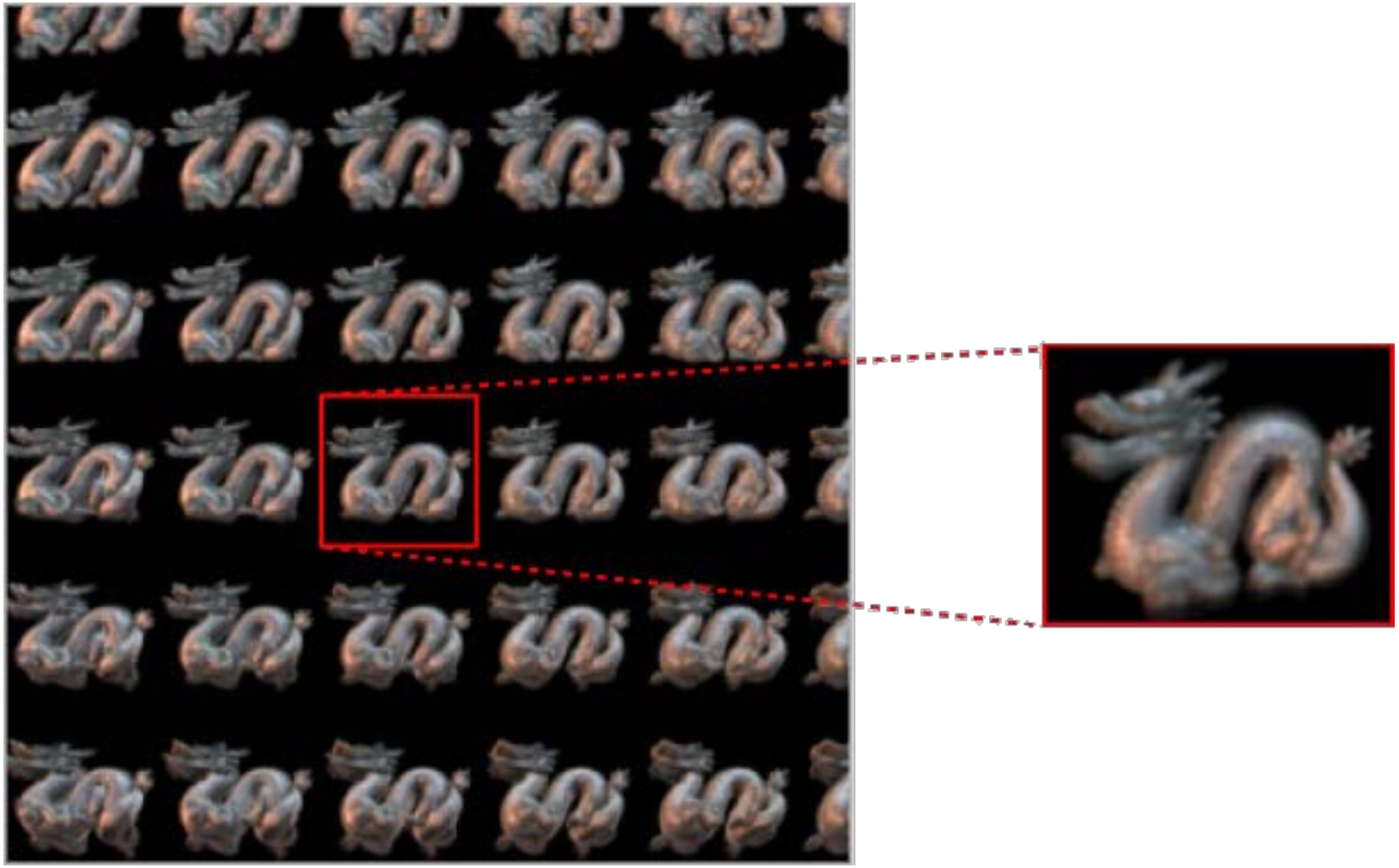


Creating a Light Field

- Synthetic light fields can be created from sheared perspective views

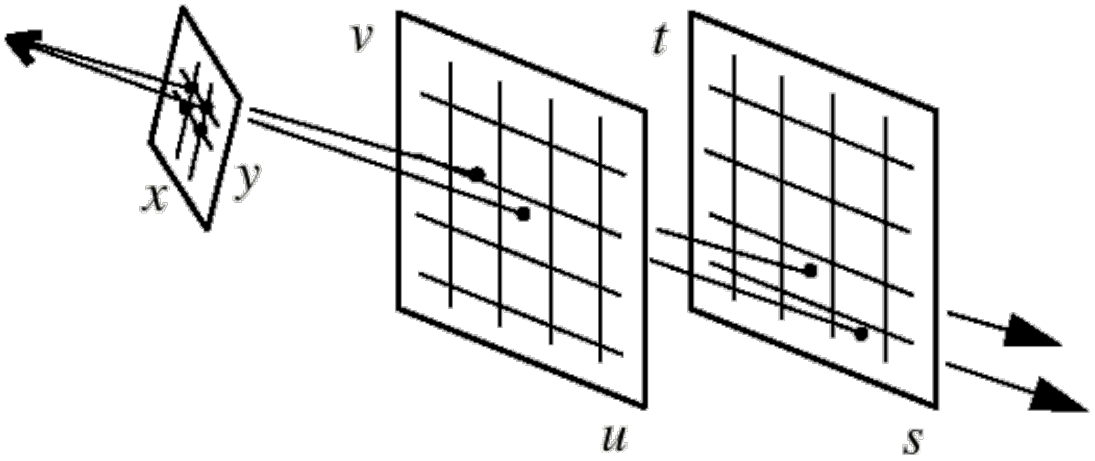


A light field is an array of images

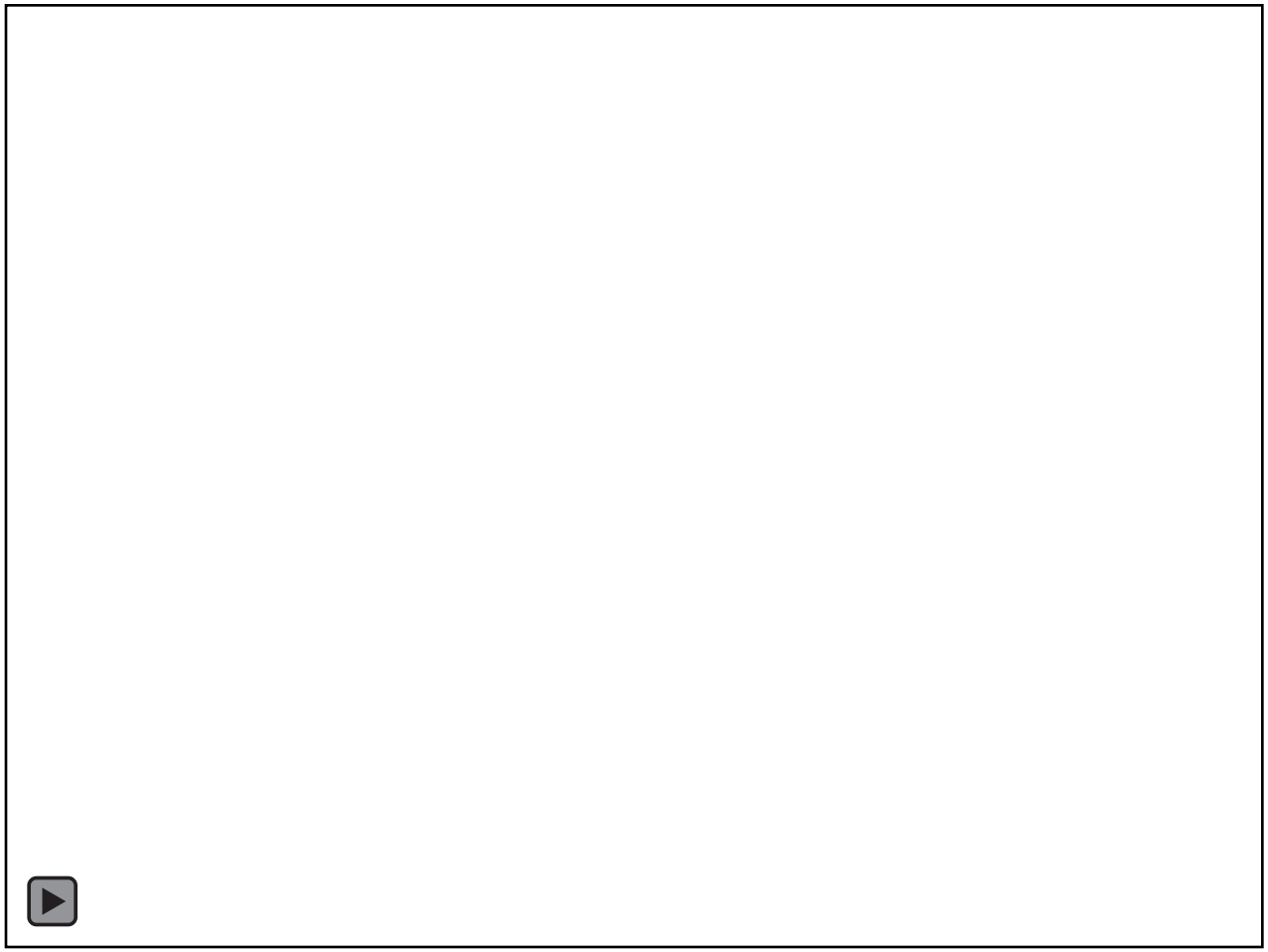


Resampling

- For each pixel
  - generate a ray
  - find the closest rays in the light field
  - return a combination of the radiance of those rays



Light Field Example



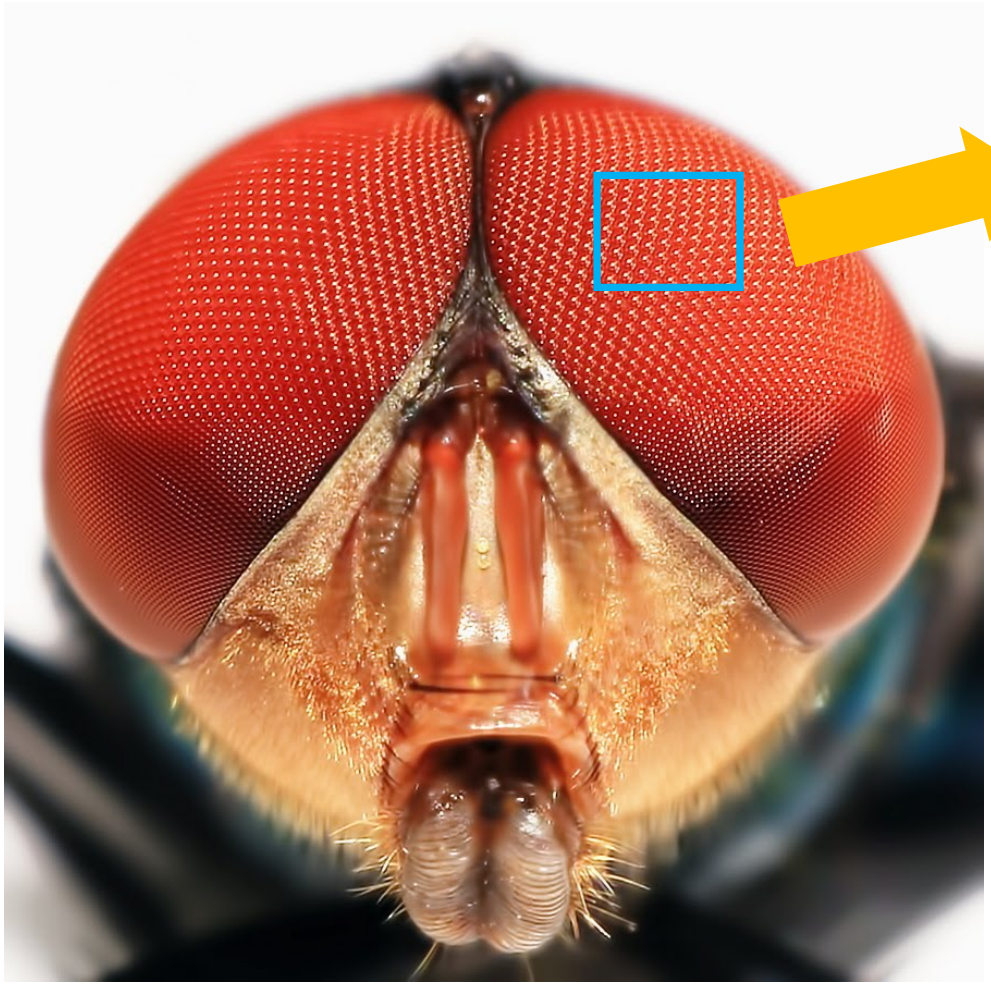
Capturing real-world light fields

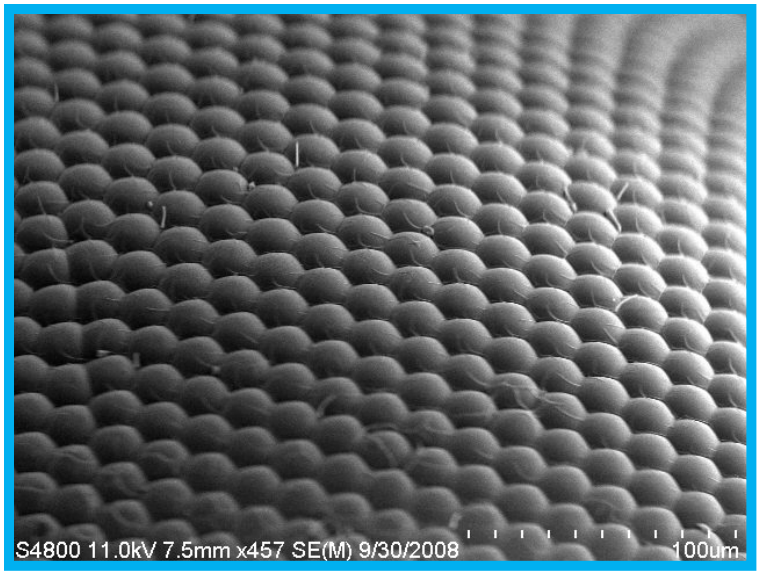
Stanford Multi-Camera Array

cameras closely packed
high-X imaging
synthetic aperture photography

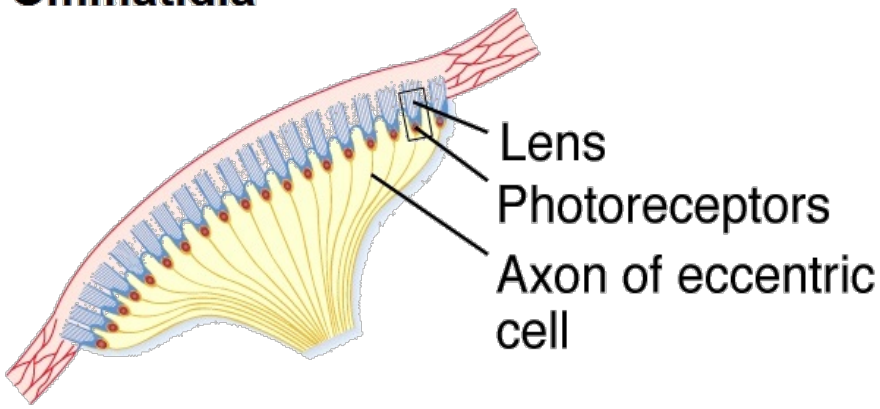
cameras widely spaced
video light fields
new computer vision algorithms

Compound Eye



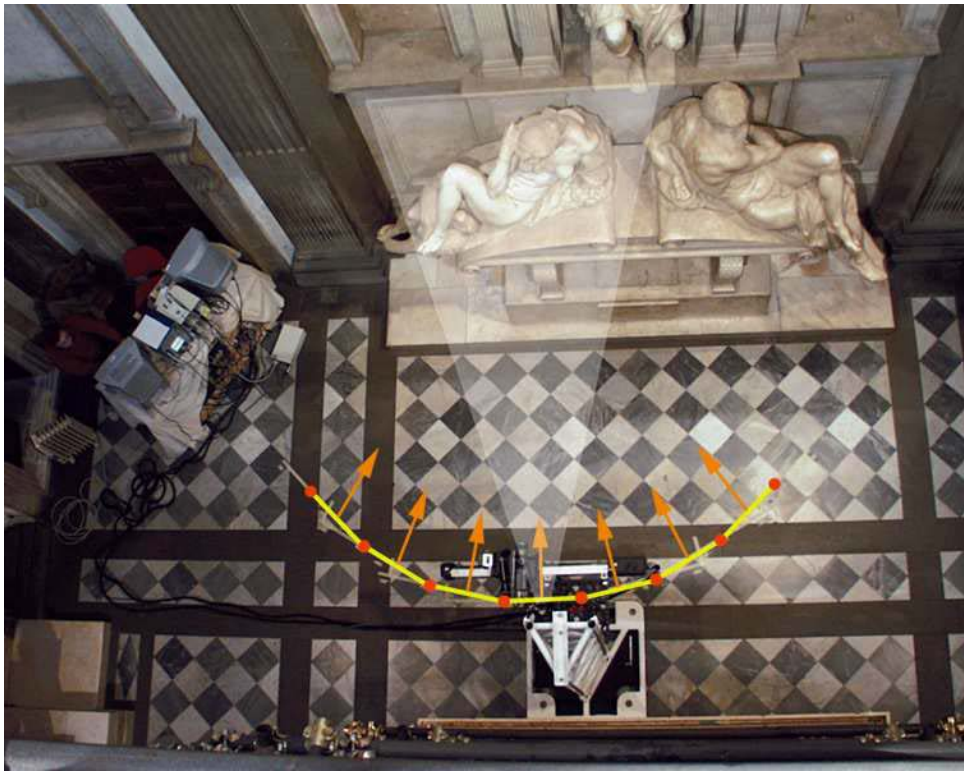


Ommatidia

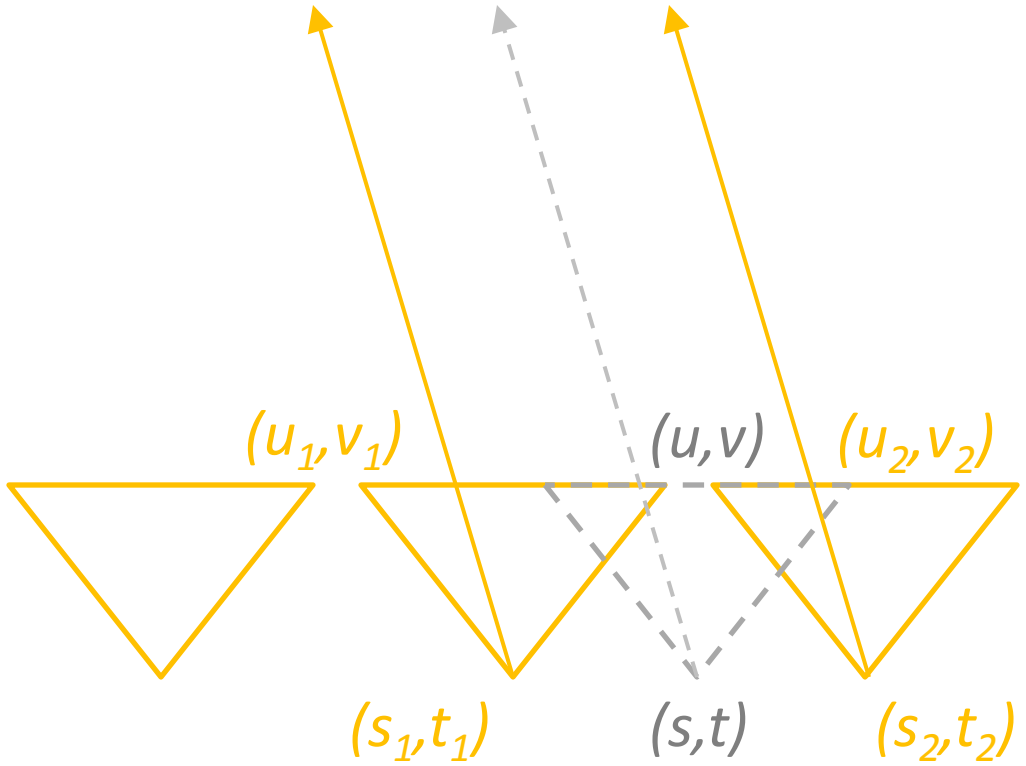


Complex Light Field Acquisition

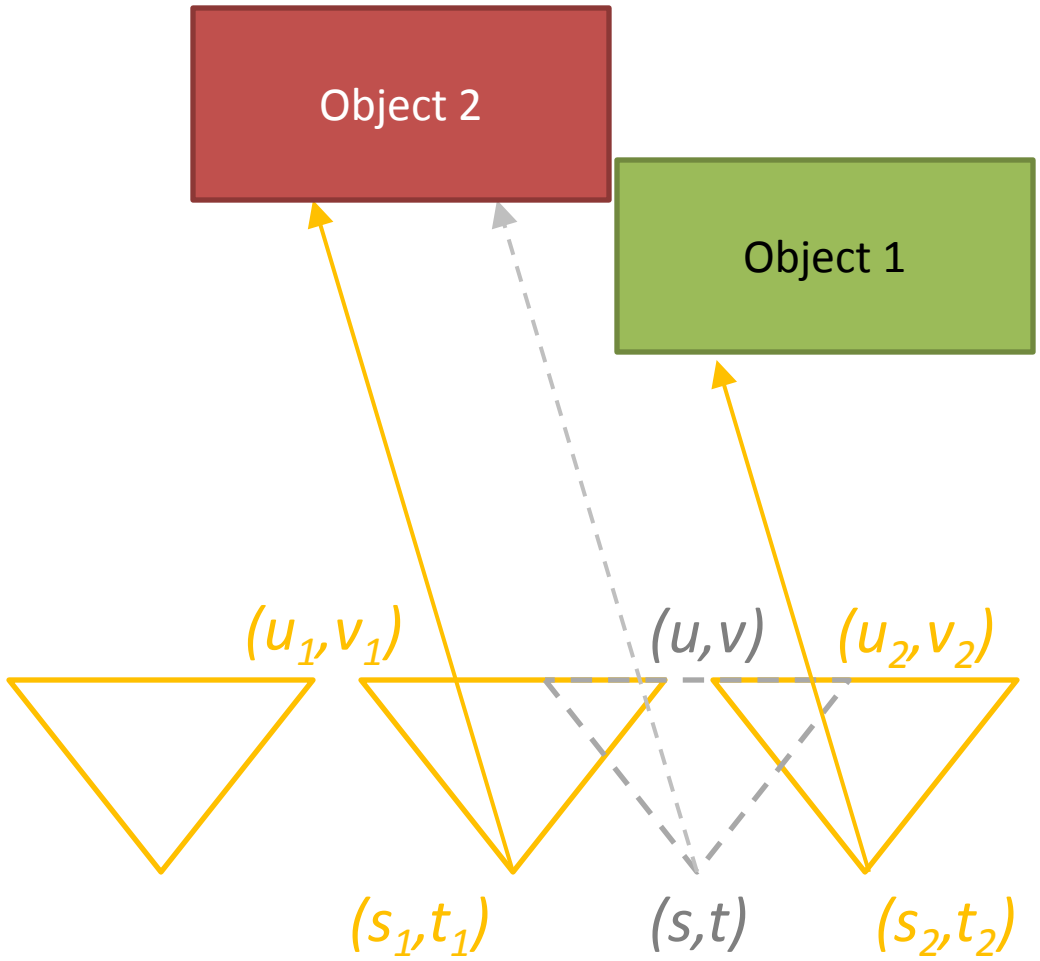
- Digital Michelangelo Project
  - Marc Levoy, Stanford University
  - Lightfield (“night”) assembled by Jon Shade



Aliasing in Light Field Rendering

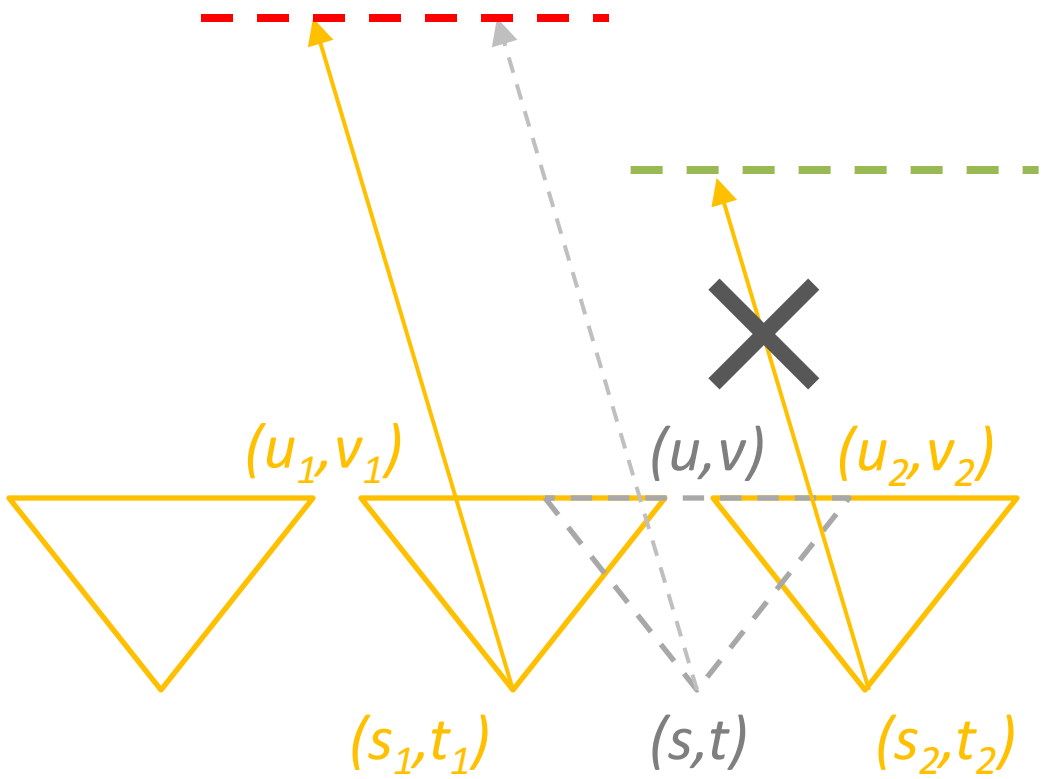


Aliasing in Light Field Rendering



Adding geometric information

- Can use rough depth information to improve rendering quality / reduce size



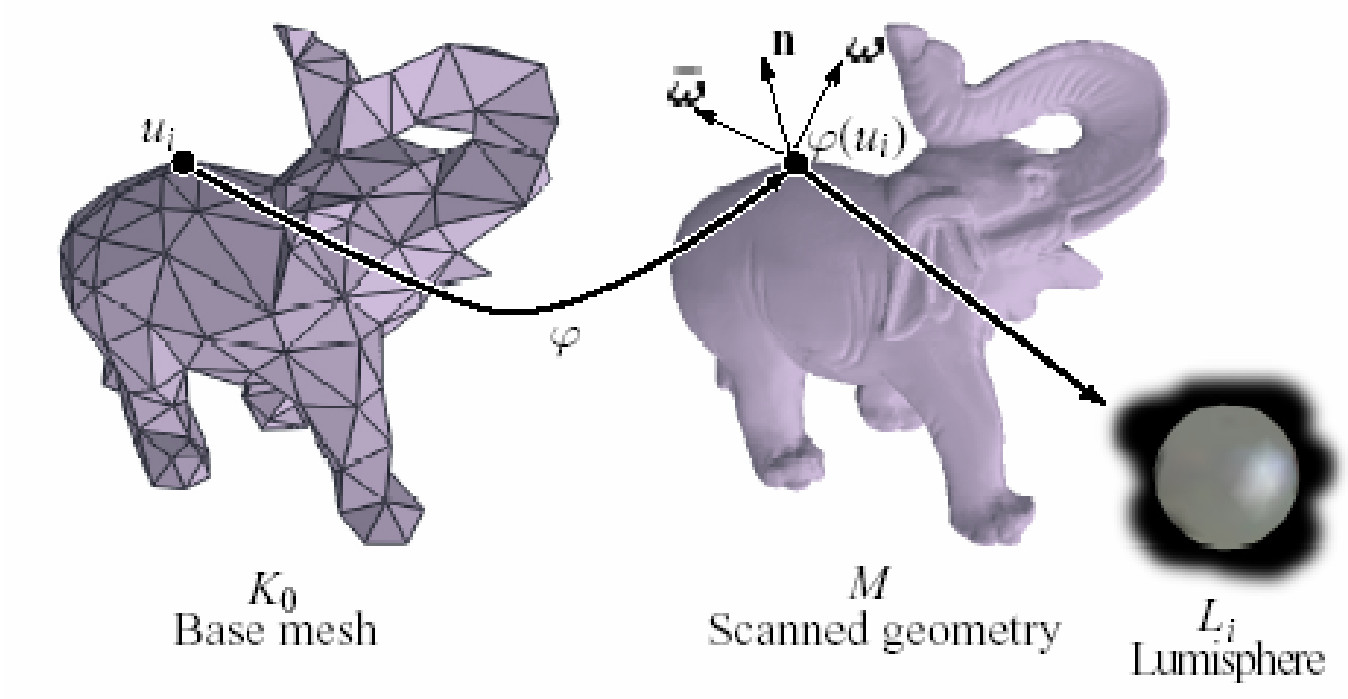
Light Field Rendering with Geometry

Without using geometry

Using approximate Geometry

Surface Light Fields

- Use a scanned model for geometry, but use light fields for reflectance



[Wood et al, SIGGRAPH 2000]

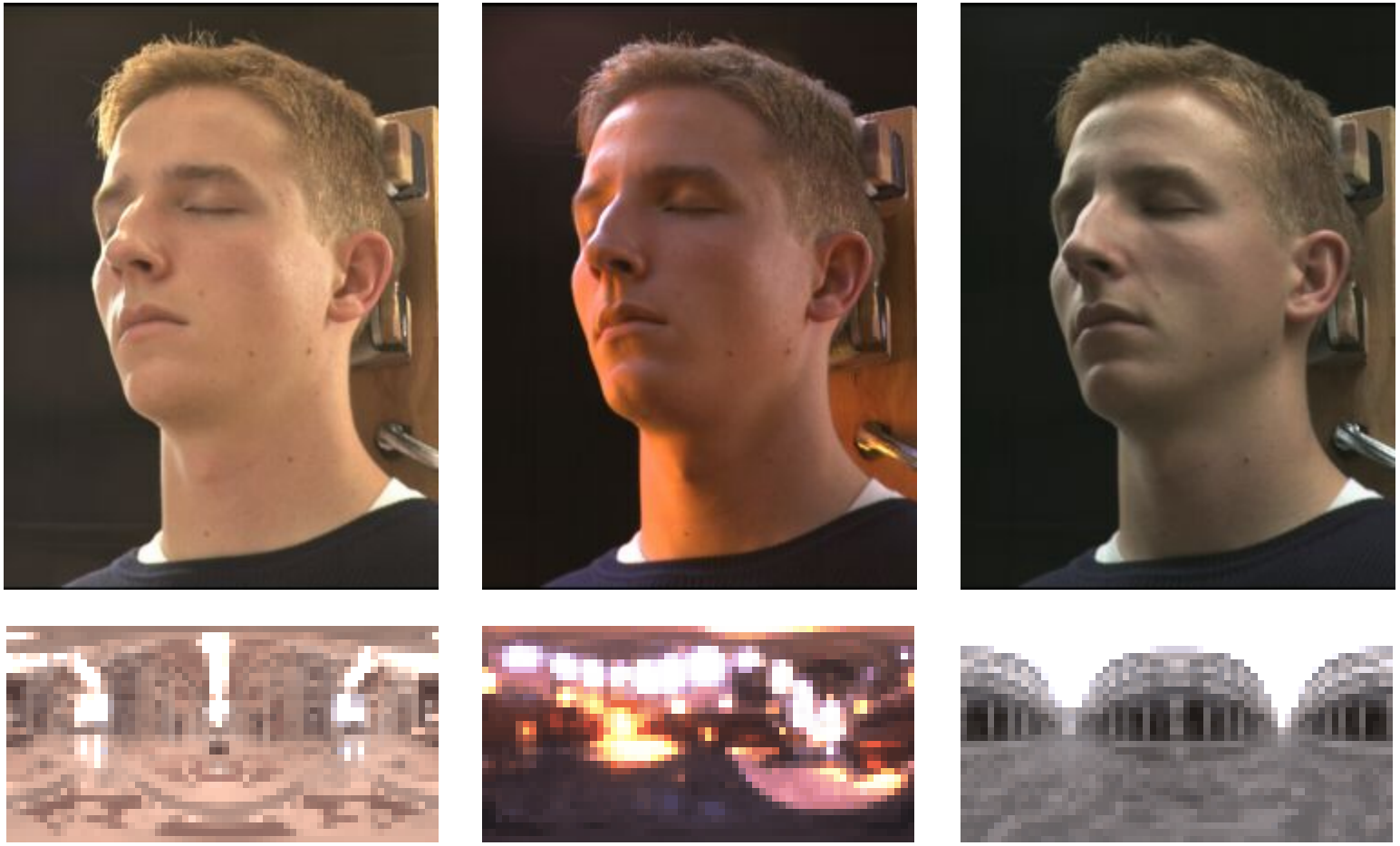
Surface Light Fields Example

Photos **Rendering**

Image-Based Rendering

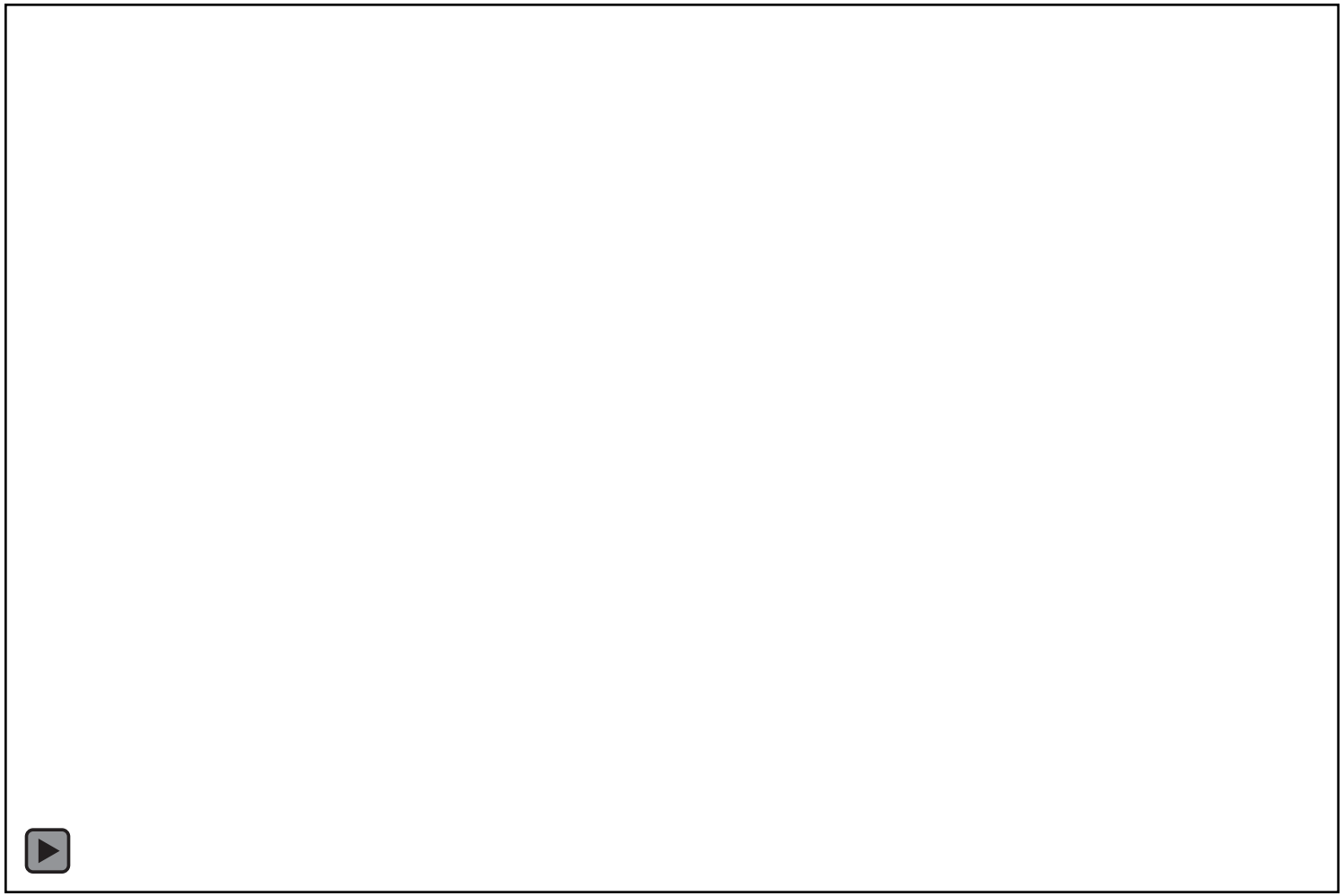
- Advantages
  - Modest computation compared to classical C.G.
  - Cost independent of scene complexity
  - Imagery from real or virtual scenes
- Limitations of pre-computation
  - Fixed look-from or look at point
  - Static scene geometry
  - Fixed lighting

Image-Based Relighting



[Debevec et al, SIGGRAPH 2000]

Light Stage



[Debevec et al, SIGGRAPH 2000]

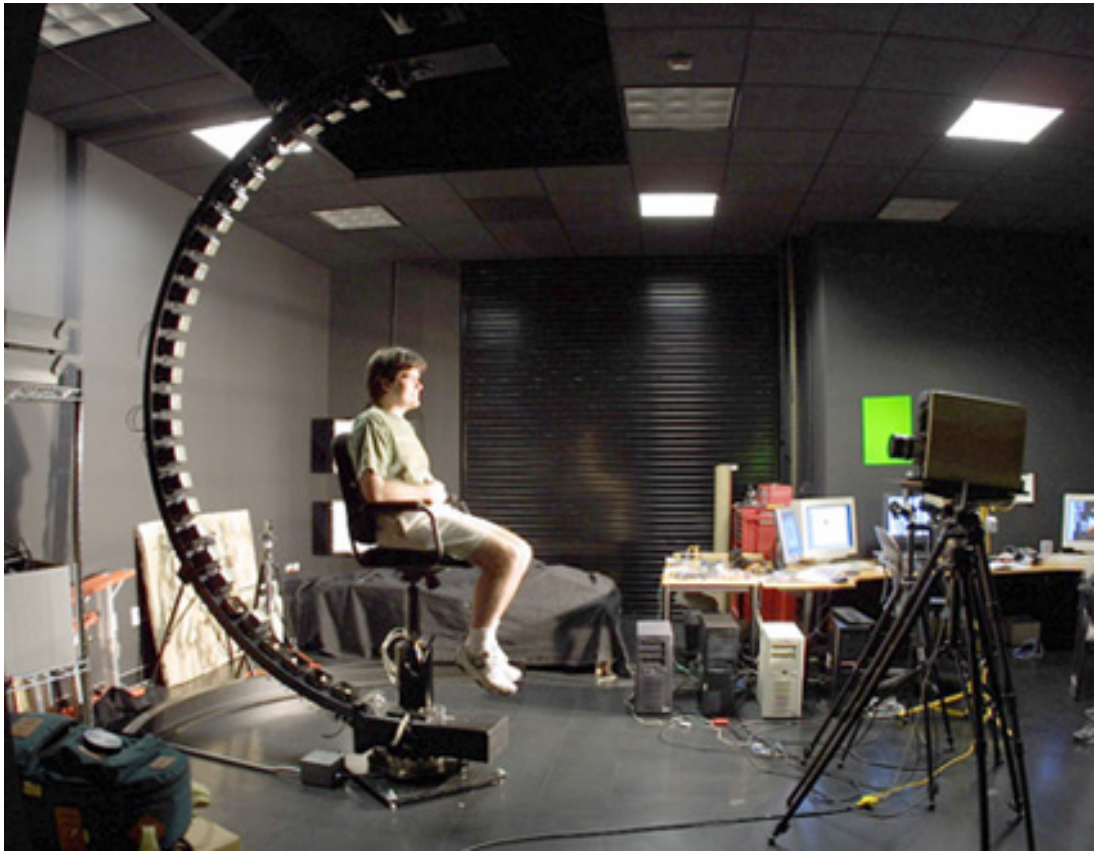
Light Stage Images

[Debevec et al, SIGGRAPH 2000]

Light Stage 1 & 2

Light Stage 1

[Debevec et al, 2000]



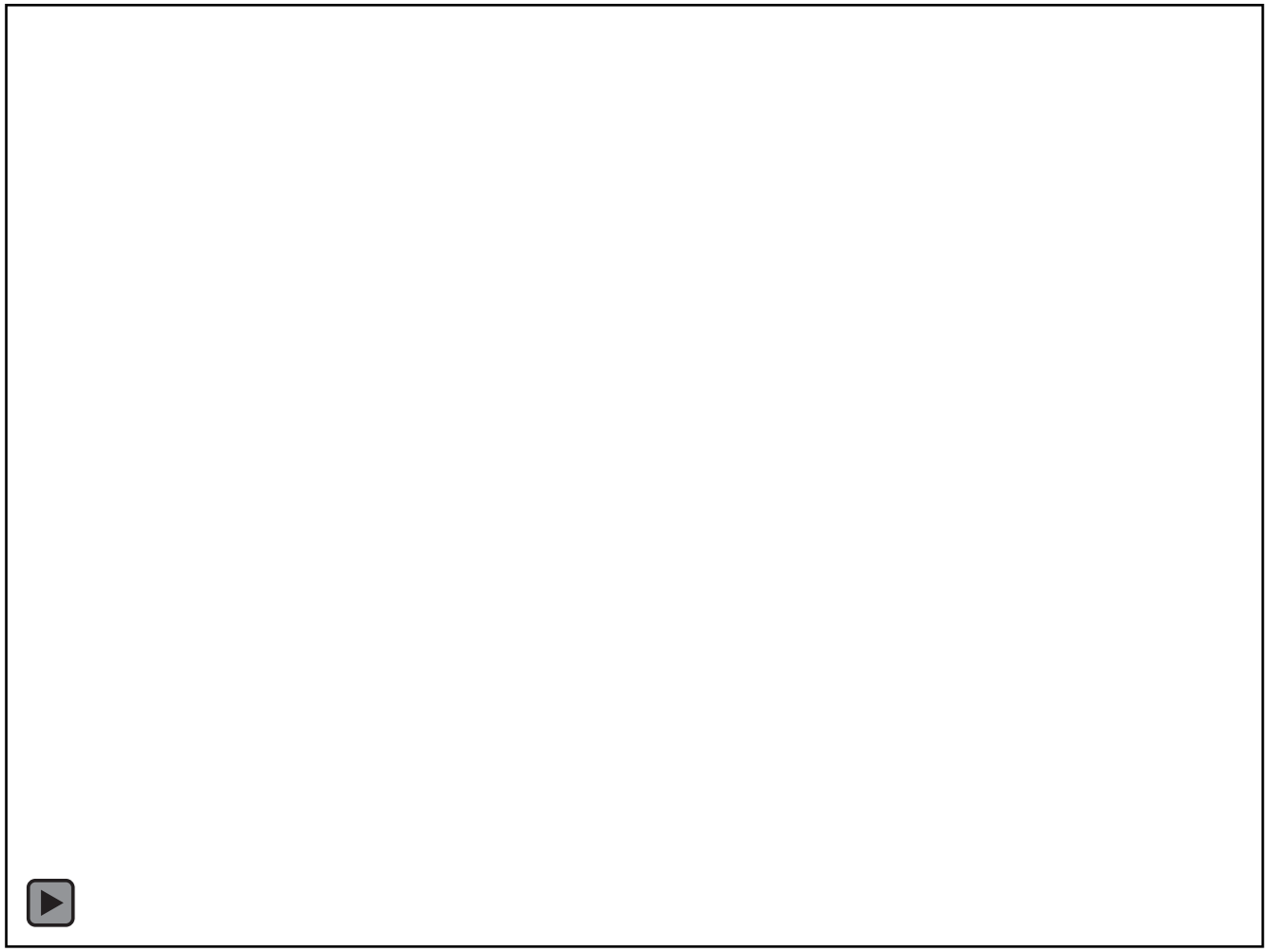
Light Stage 2

[Hawkins et al, 2001]

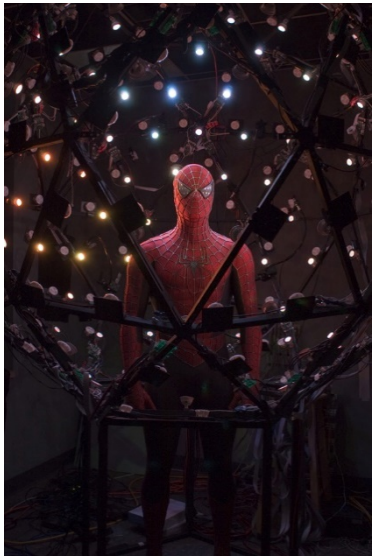
Light Stage 5

[Wenger et al, 2005]

Light Stage 5



Light Stage Example



The Spider-Man Chronicles: The Art and Making of Spider-Man 3

The Curious Case of Benjamin Button

Spider-Man 2

Avatar

Next Time…

- Final Review
- Final exam will be held on December 8 from 3:00-5:00pm
  - 218 Tureaud Hall
  - Question types similar to midterm

Course Evaluation

- Course evaluation is open until Dec 3
- Online: www.cae.lsu.edu/eval
- Our course ID is CSC 4356 001
- Please complete carefully
  - You will get 1 extra credit if you complete the course evaluation!