What is IBR?
(Part 2)

September 20, 2004
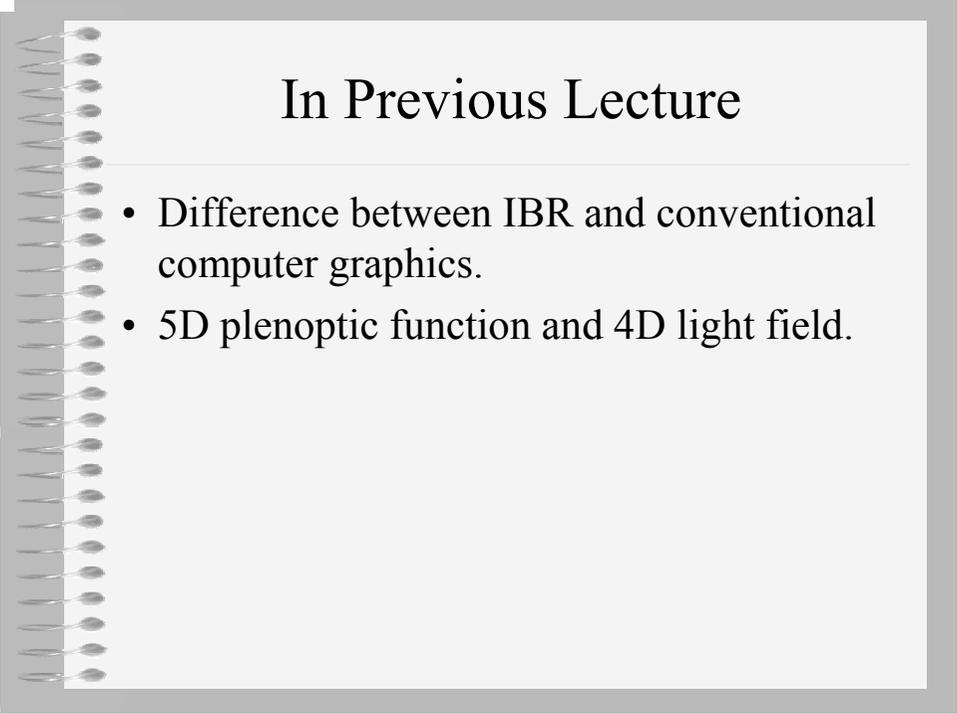
In Previous Lecture

- Difference between IBR and conventional computer graphics.
- 5D plenoptic function and 4D light field.

Conventional Computer Graphics

- Input: Geometry, Material Properties (Color, Reflectance,…etc.), Lighting.
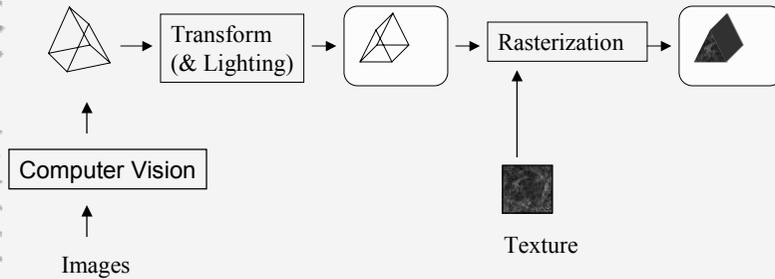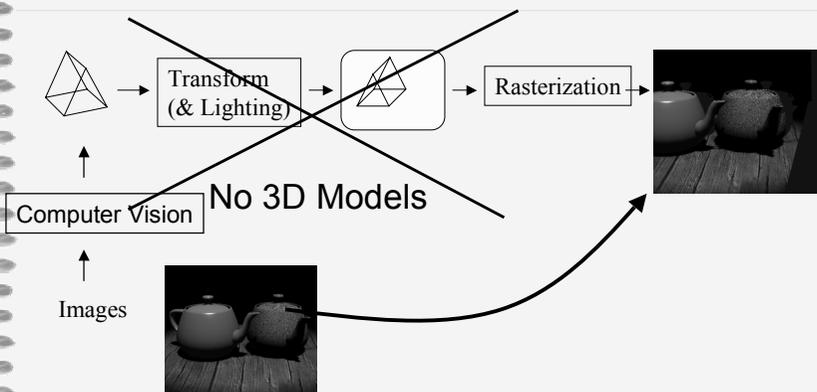- Rendering by transformation and rasterization.

Transform (& Lighting) → → Rasterization →
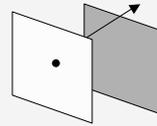
Computer Vision

Images

Texture

Image-Based Rendering

Transform (& Lighting) → → Rasterization →

Computer Vision

No 3D Models
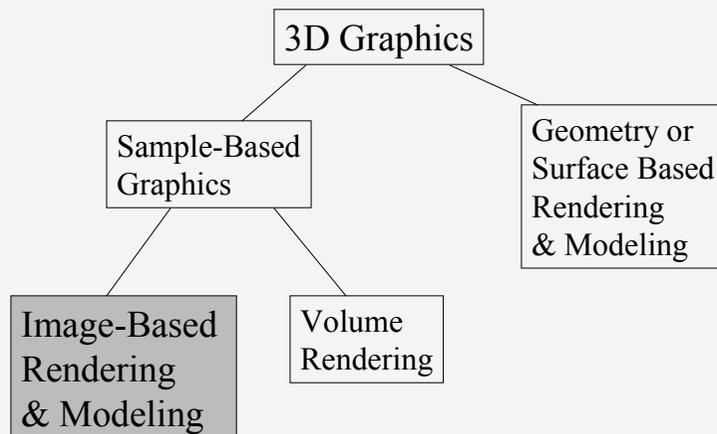
Images

Why is It Possible?

- 5D Plenoptic Function.
  - Color = $f(x, y, z, \theta, \phi)$
  - (x, y, z) defines the viewpoint.
  - (θ, ϕ) defines the view direction.

  Picture source: Leonard McMillan
- 4D Light Field/Lumigraph
  - Color = $f(u, v, s, t)$
  - (u, v) defines the viewpoint.
  - (s, t) defines the pixel coord.

Top Level Survey

```
                    3D Graphics
                   /          \
         Sample-Based      Geometry or
         Graphics         Surface Based
          /      \        Rendering
   Image-Based   Volume   & Modeling
   Rendering     Rendering
   & Modeling
```

IBR Survey

Image-Based
Rendering
& Modeling

Light Field Rendering
(or Lumigraph)
Stanford/Microsoft
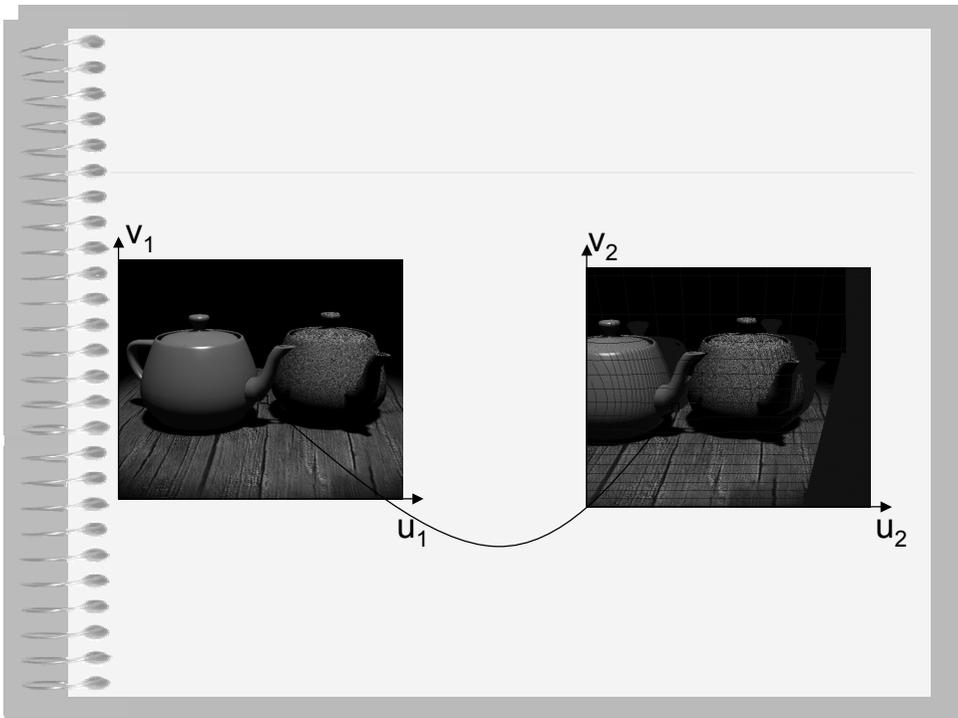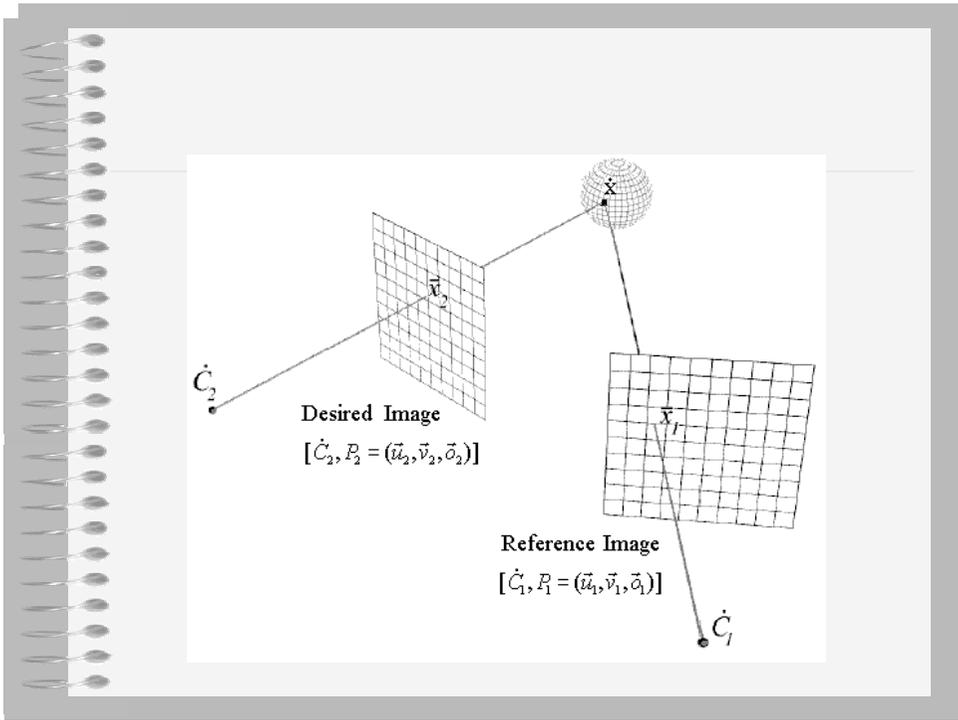
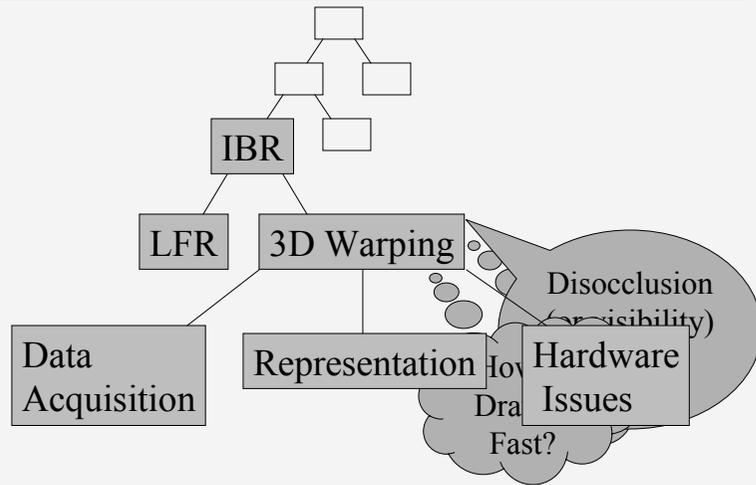3D Warping
(or Plenoptic Modeling)
UNC-Chapel Hill
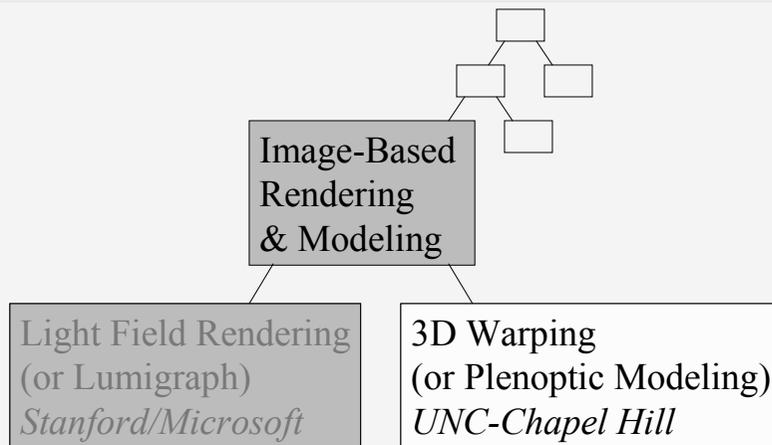
3D Image Warping

- Each pixel in the source images has coordinates (u_1, v_1), depth info δ_1, and color.
- Warping Equation is applied to each pixel

$$(u_2, v_2) = f(u_1, v_1, \delta_1)$$

$$= \left(\frac{a \times u_1 + b \times v_1 + c + d \times \delta_1}{i \times u_1 + j \times v_1 + k + l \times \delta_1} , \frac{e \times u_1 + f \times v_1 + g + h \times \delta_1}{i \times u_1 + j \times v_1 + k + l \times \delta_1} \right)$$

where variables *a* to *l* are fixed for the same view.

- Rendering Time = O(#pixels)

Desired Image

$[\dot{C}_2, P_2 = (\vec{u}_2, \vec{v}_2, \vec{o}_2)]$

Reference Image

$[\dot{C}_1, P_1 = (\vec{u}_1, \vec{v}_1, \vec{o}_1)]$

IBR Survey

IBR

LFR   3D Warping

Data Acquisition   Representation   Hardware Issues

Disocclusion (or visibility)

How Draw Fast?

Video

- LDI Tree

1 camera position   3 camera positions   9 camera positions

IBR Survey

Image-Based
Rendering
& Modeling

Light Field Rendering
(or Lumigraph)
Stanford/Microsoft

3D Warping
(or Plenoptic Modeling)
UNC-Chapel Hill

Light Field & Lumigraph

v

t

(u,v)

(s,t)

Ray(s,t,u,v)

s

u

4D

u

s

z

Ray(s,u)

2D
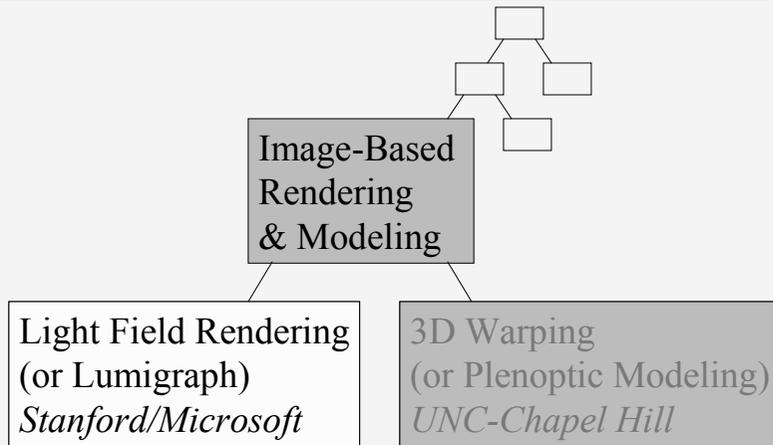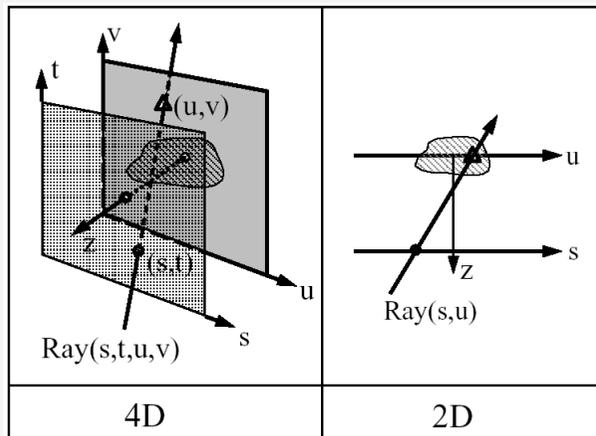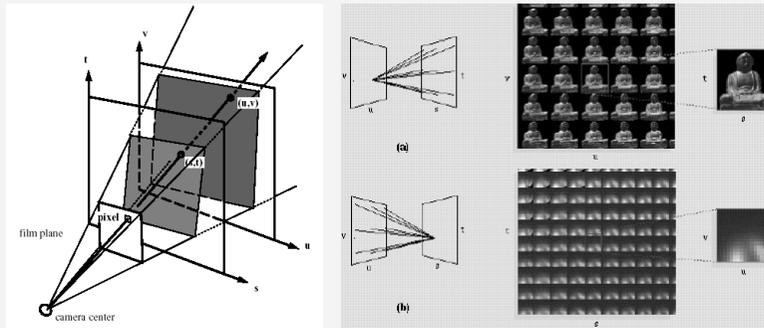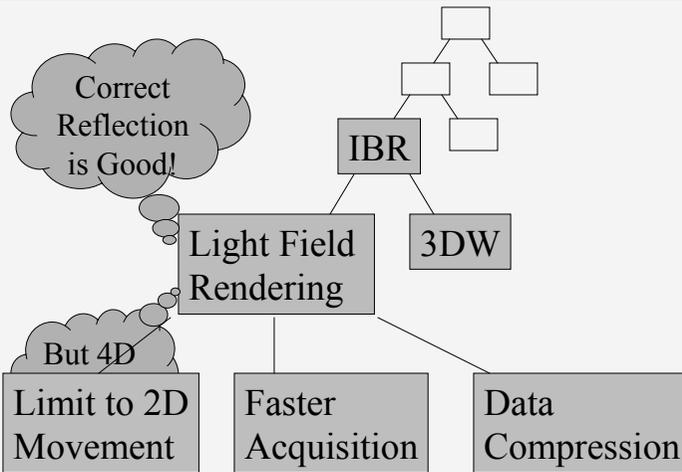
Images as 4D Samples

- Consider each image pixel a sample of 4D Light Field.

Does it Matter Where We Place the Planes?

- Yes!
- Depth correction in Lumigraphs:

IBR Survey

Correct Reflection is Good!

But 4D

IBR

3DW

Light Field Rendering

Limit to 2D Movement

Faster Acquisition

Data Compression

Light Field Related Works

- Concentric Mosaic [*Shum et al, SIGGRAPH 99*]
- Plenoptic Stitching [*Aliaga et al, SIGGRAPH 2001*]
- Surface Light Fields [*Wood et al, SIGGRAPH 2000*]
- Light Field Mappings [*Chen et al, SIGGRAPH 2002*]

Concentric Mosaic

- Hold a camera on a stick, then sweep a circle.
- Viewpoint is constrained on a 2D plane.
- Reducing the 4D light field to a 3D subspace.

Surface Light Field

- May be considered a compression scheme for light field data.
- 3D geometry required.

Light Field Mapping

**Light Field Mapping:
Hardware Accelerated Rendering
of Surface Light Fields**

Other Works

- Hybrid method (between geometry and IBR) by Paul Debevec