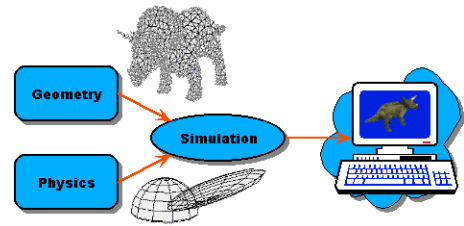


Image-Based Modeling and Rendering

Thomas Funkhouser
Princeton University
COS 426 Guest Lecture
Spring 2003

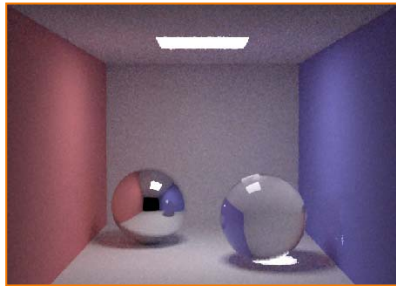


Traditional Computer Graphics



© EP 2003

When Does This Pipeline Work?

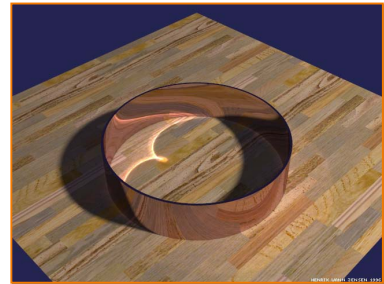


How would you model and render this scene?



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When Does This Pipeline Work?



How about this one?



© EP 2003

When Does This Pipeline Work?



.. and this one?



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When Does This Pipeline Work?



What about this one?



© EP 2003

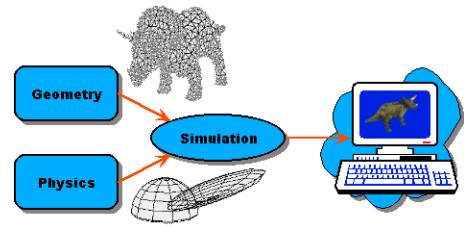
When Does This Pipeline Work?



How about this one?

©Crytek

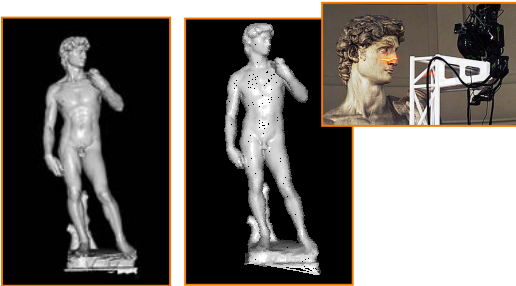
When Does This Pipeline Work?



When doesn't this pipeline work?

© EP Image

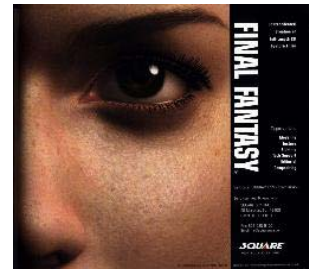
Geometric Modeling



It is hard to create 3D meshes for complex objects ...

©Crytek

Reflectance Modeling



It is hard to acquire good BRDFs for complex surfaces ...

© EP Image

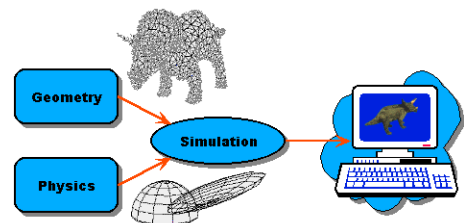
Light Transport Simulation



It is hard to compute all light paths for complex illumination ...

©Jhghghghgh

What Else Can We Do?



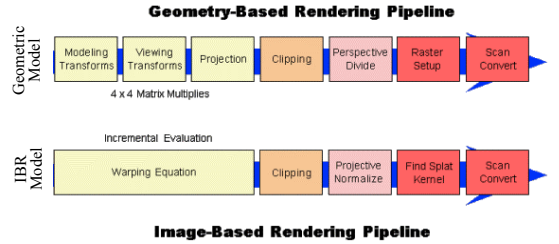
© EP Image

Image-Based Rendering (IBR)

- Model scene as set of reference images
- Render novel views by resampling pixels



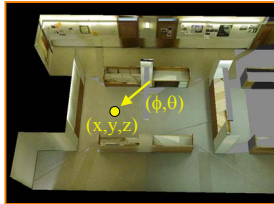
IBR Rendering Pipeline



© EPFL

Image-Based Representations

- Plenoptic function (7D):
 - Describes the radiance traveling along a ray
 - to/from any point (x, y, z) ,
 - in any direction (ϕ, θ) ,
 - at any frequency (λ) ,
 - at any time (t)



$F(x, y, z, \phi, \theta, \lambda, t)$

Image-Based Representations

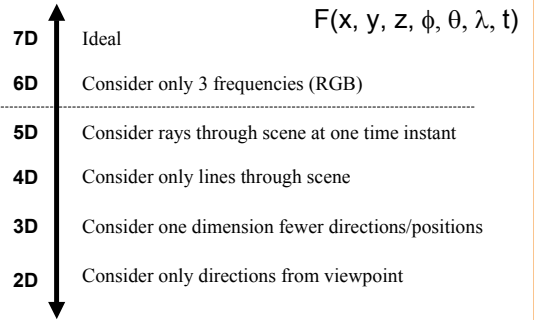


Image-Based Representations

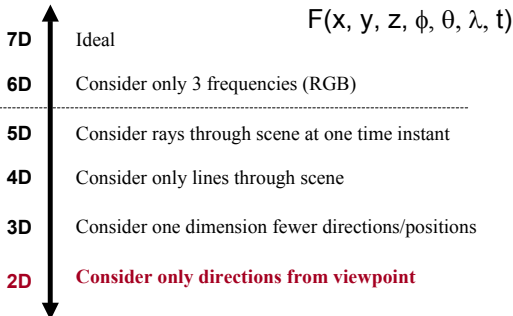


Image Panoramas



© EPFL

Image Panoramas



Image 1

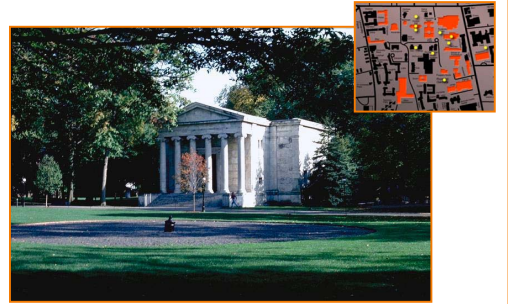
Image 2

Image 3



Kang 99

Image Panoramas



Virtual tours of Princeton

EBuz z q,

Image-Based Representations



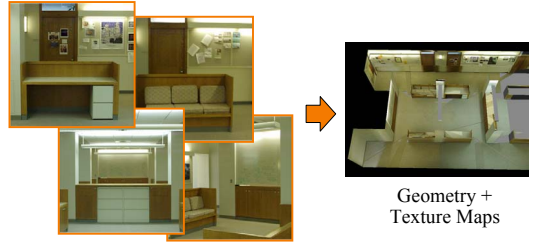
$$F(x, y, z, \phi, \theta, \lambda, t)$$

- 7D Ideal
- 6D Consider only 3 frequencies (RGB)
-
- 5D Consider rays through scene at one time instant
- 4D Consider only lines through scene
- 3D Consider one dimension fewer directions/positions
- 2D **Consider only positions on surfaces**

Texture Mapping



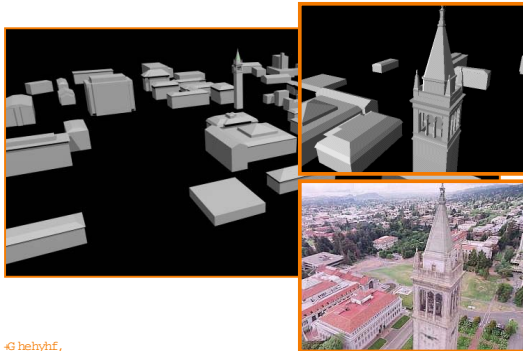
- Map photographs onto surfaces



Photographs

Geometry +
Texture Maps

Texture Mapping



© helvhtf,

Image-Based Representations



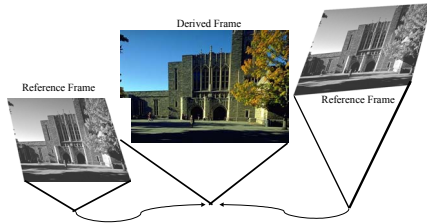
$$F(x, y, z, \phi, \theta, \lambda, t)$$

- 7D Ideal
- 6D Consider only 3 frequencies (RGB)
-
- 5D **Consider rays through scene at one time instant**
- 4D **Consider only lines through scene**
- 3D **Consider one dimension fewer directions/positions**
- 2D Consider only directions or positions on surfaces

View Interpolation



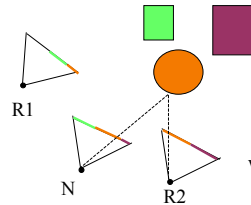
- Create novel images by resampling photographs
 - Reference images sample 5D plenoptic function



View Interpolation



- Method:
 - Warp nearby reference images to novel viewpoint
 - Blend warped images

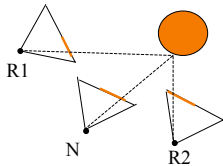


This is just a morph where the warp is defined by pixel correspondences!

View Interpolation



- How define warp for one view to another?
 - Use depth at pixel to project into scene, or ...



View Interpolation



- How define warp for one view to another?
 - Use depth at pixel to project into scene, or ...



View Interpolation



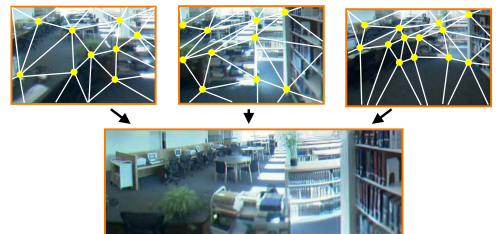
- How define warp for one view to another?
 - Use depth at pixel to project into scene, or ...
 - Use pixel correspondences



View Interpolation



- How define warp for one view to another?
 - Use depth at pixel to project into scene, or ...
 - Use pixel correspondences



View Interpolation



- Finding pixel correspondences
 - Coarse 3D model
 - Sparse image features
 - Depth at every pixel

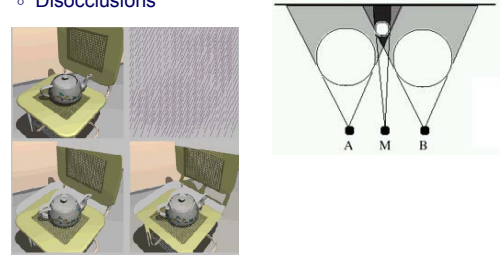


© 2004 Intel

View Interpolation



- Problems with view interpolation:
 - Changes in visibility
 - Disocclusions



© 2004 Intel

Disocclusions



- Partial solutions:
 - Fill holes by interpolating nearby pixels



© 2004 Intel

Disocclusions



- Partial solutions:
 - Fill holes by interpolating nearby pixels
 - Use more photographs



Lumigraph

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Image-Based Representations



7D	Ideal	$F(x, y, z, \phi, \theta, \lambda, t)$
6D	Consider only 3 frequencies (RGB)	
<hr/>		
5D	Consider rays through scene at one time instant	
4D	Consider only lines through scene	
3D	Consider one dimension fewer directions/positions	
2D	Consider only directions or positions on surfaces	

Light Field / Lumigraph



- If observer stays in free space, plenoptic function reduces to 4D
 - Exterior of the convex hull of an object
 - Interior of an environment

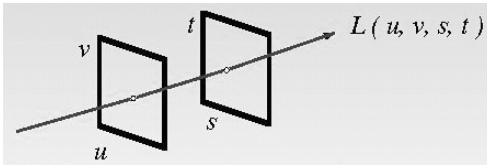
$$F(r, \alpha, \phi, \theta)$$



© 2004 Intel

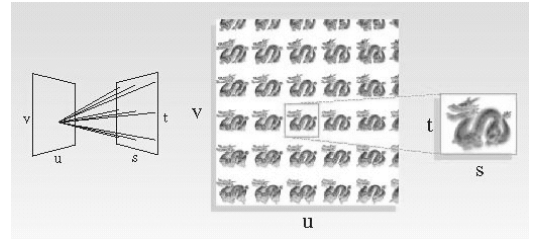
Representing a Light Field

- Two-plane parameterization (4D)



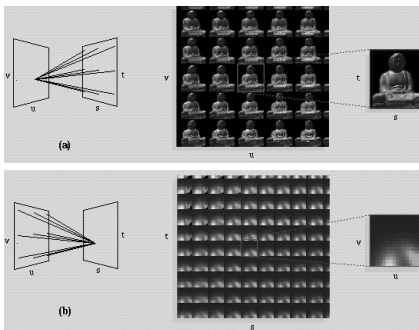
©byz | <9,

Representing a Light Field



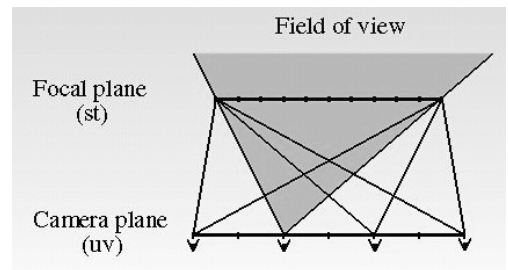
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Two Interpretations of a Light Field



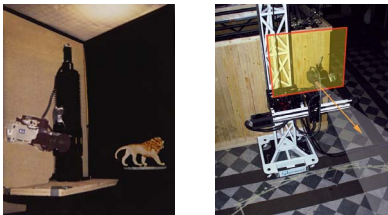
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Creating a Light Field



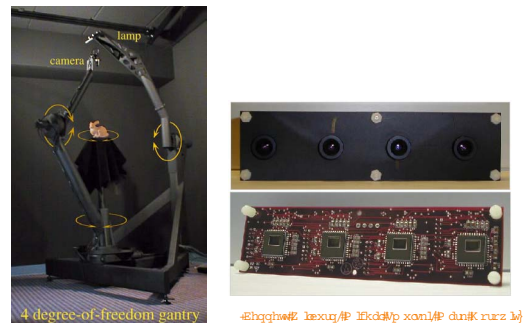
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Capturing a Light Field



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Capturing a Light Field



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Capturing a Light Field



©Ehqqhw#E Iæxuy/AP Iðkdl/p xoml/AP dln#K rzurz lð,

Capturing a Light Field

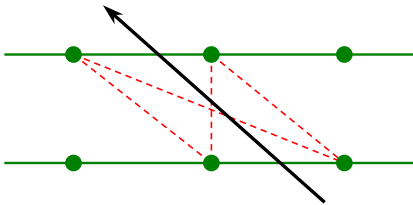


©Ehqqhw#E Iæxuy/AP Iðkdl/p xoml/AP dln#K rzurz lð,

Rendering a Light Field



- Resampling problem
 - Interpolation
 - Avoid aliasing



©J rzuduk9,

Rendering a Light Field



Video

©lhyz |) #K dæqukcdq,

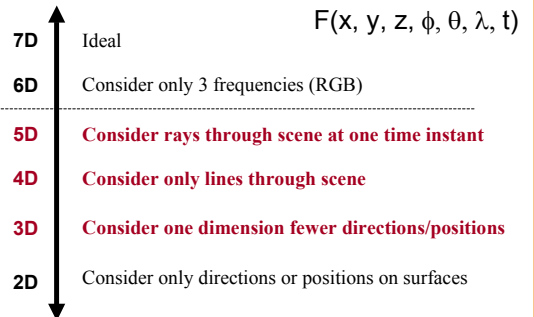
Rendering a Light Field



Demo

©lhyz |) #K dæqukcdq,

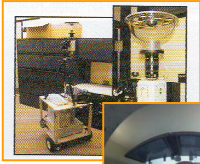
Other IBR Representations



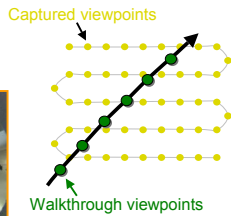
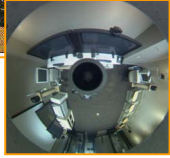
Sea of Images



- Dense sampling with hemispherical camera moving in environment on eye-height plane



Robotic Capture Device



(with Daniel Allaga)

IBR Trade-offs



- Advantages
 - Photorealistic - by definition
 - Do not have to create 3D detailed model
 - Do not have to do lighting simulation
 - Performance independent of scene
- Disadvantages
 - Real-world scenes only
 - Difficult for dynamic scenes
 - Difficult to change rendering parameters
 - Difficult for scenes with specularities, etc.
 - Limited range of viewpoints
 - Limited resolution

IBR Applications



- Historical Site Preservation
- Remote Education
- Virtual Tourism

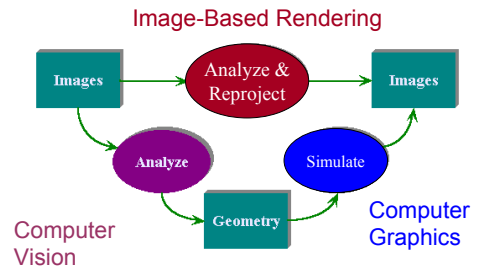


Frank Lloyd Wright
Fallingwater House, PA

Thomas Jefferson
Monticello, VA

Inside Independence Hall,
Philadelphia, PA

Future

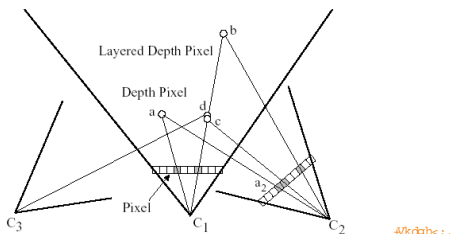


EP 1001

Layered Depth Images



- Multiple samples per pixel at different depths



4/10/2017