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Image-Based Rendering

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Princeton University
C0S 426, Fall 2001

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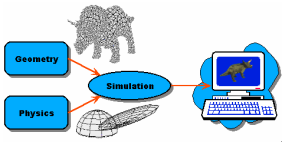
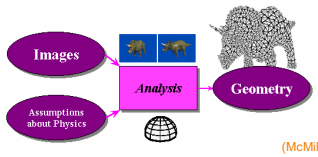
Traditional Approaches



Traditional Computer Graphics



Traditional Computer Vision

(McMillan)

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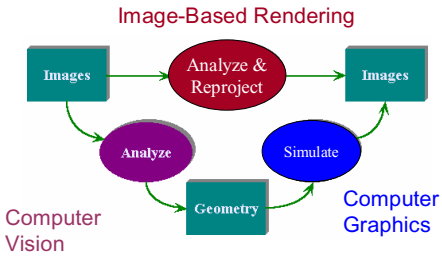
Image-Based Rendering (IBR)



(McMillan)

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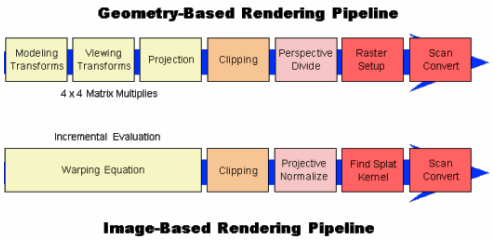
IBR Rendering Pipeline



(McMillan)

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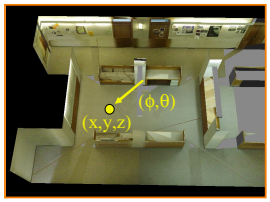
Image-Based Representations

- 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, ϕ, θ, λ, t)

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Image-Based Representations

F(x, y, z, ϕ, θ, λ, t)

7D	Ideal
6D	Consider only 3 frequencies (RGB)
5D	Consider only one time instant (static scene)
4D	Consider only viewpoints inside/outside scene
3D	Consider one dimension fewer directions/positions
2D	Consider viewpoints at finite set points or angles

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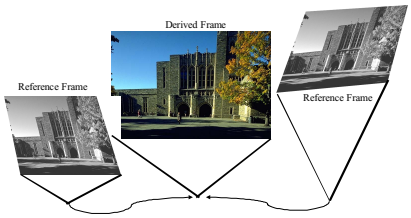
View Interpolation

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



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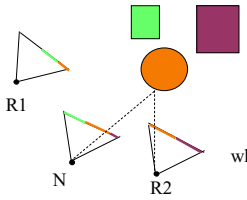
View Interpolation

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



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

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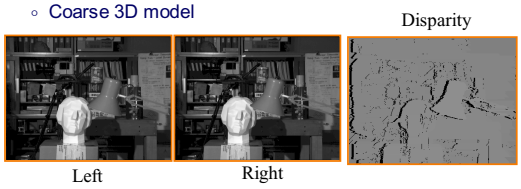
View Interpolation

- How find pixel correspondences:
  - Disparity
  - Sparse features
  - Depth at every pixel
  - Coarse 3D model



(Szeliski)

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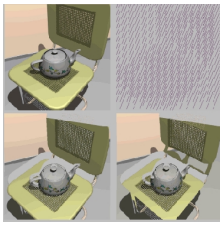
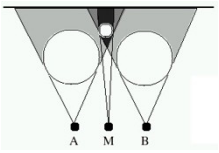
View Interpolation

- Problem:
  - Changes in visibility
  - Disocclusions





(McMillan)

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Disocclusions

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

(McMillan)

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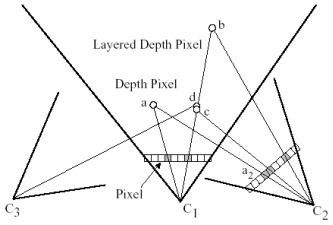
Disocclusions

- Better solutions (when possible):
  - Multiple samples per pixel at different depths



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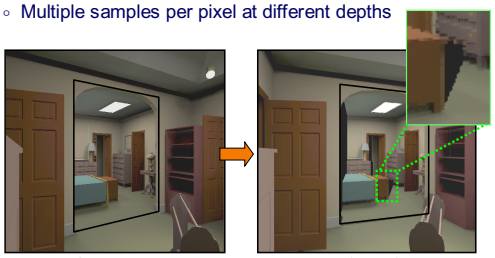
Disocclusions

- Better solutions (when possible):
  - Multiple samples per pixel at different depths



Reference Image Warped Depth Image

(Popescu)

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Disocclusions

- Better solutions (when possible):
  - Multiple samples per pixel at different depths

Reference Image Warped Layered Depth Image

(Popescu)

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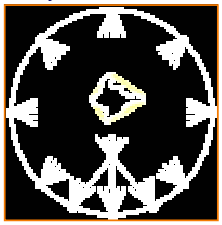
Light Field / Lumigraph

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

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



(Levoy96)

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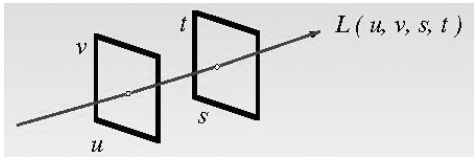
Representing a Light Field

- Two-plane parameterization (4D)



(Levoy96)

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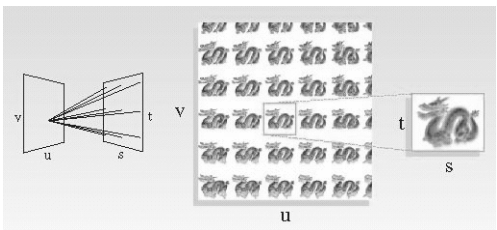
Representing a Light Field



(Levoy96)

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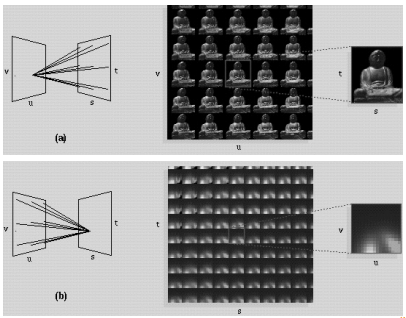
Two Interpretations of a Light Field



(Levoy96)

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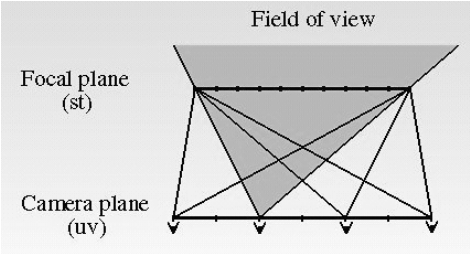
Creating a Light Field



(Levoy96)

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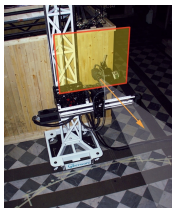
Capturing a Light Field



(Stanford University)

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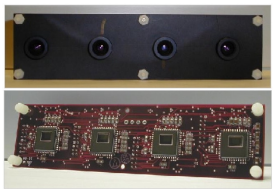
Capturing a Light Field



(Bennett Wilburn, Michal Smulski, Mark Horowitz)

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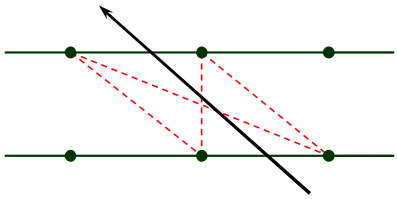
Rendering a Light Field

- Resampling problem
  - Interpolation
  - Avoid aliasing



(Gortler96)

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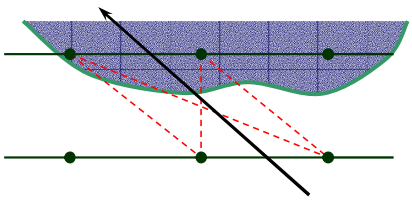
Rendering a Light Field

- Resampling with approximate geometry
  - Improves quality



(Gortler96)

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Rendering a Light Field

Without using geometry

Using approximate geometry

(Gortler96)

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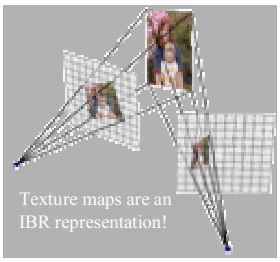
Other IBR Representations

- Texture maps
- Panorama
- Etc.



(McMillan)

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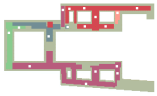
QuickTime VR

- Cylindrical panorama at certain points



Cylindrical Panorama

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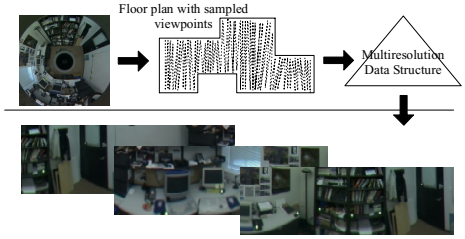
Sea of Images

- My current work with Dan Aliaga



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IBR Summary

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