Lightfields and Lumigraphs

CS635

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Image-Based Rendering (IBR)

• Built on the desire to bypass the (manual) modeling phase and directly produce the final visual results
  – Does not just place images on geometry
  – Does not try to reconstruct the geometry of the environment

(some slides courtesy of Voicu Popescu, Anselmo Lastra, and Marc Levoy)
Photographs

• We have tools that acquire and tools that display photographs at a convincing quality level
Image-Based Rendering (IBR)

• Built on the desire to bypass the (manual) modeling phase and directly produce the final visual results
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  – Does \textit{not} try to reconstruct the geometry of the environment

• How can we use images (of some kind) to “model” 3D objects and 3D environments?
Plenoptic Function

- $P(x, y, z, \phi, \varphi, \lambda, t)$

- 7D function to describe light intensity passing through every viewpoint, for every direction, for every wavelength, and for every time instant
Plenoptic Function

- “Holodeck” (Star Trek)
- Layered Depth Images [Shade98]
- 3D Image Warping [Max95, McMillan95, ...]
- View Interpolation [Chen93]
- Sea of Images [Aliaga01]
- Lightfield/Lumigraph [Levoy96, Gortler96]
- Plenoptic Stitching [Aliaga99]
- Concentric Mosaics [Shum99]
- Panoramic Images [Szeliski97, ...]
What is a “light ray through space”?
Light Ray Organization

- Surface-centric
- Viewpoint-centric
  or
- Inside-looking-out
- Outside-looking-in
Reducing Dimensions of the Plenoptic Function

- Use constant frequencies
- Use static environments
- Use open spaces
Light Ray Parameterization

- Random collection of rays
- Two slab representation \((s,t,u,v)\)
- Box representation
4D Lightfield / Lumigraph

• Demo
4D Lightfield / Lumigraph
4D Lightfield / Lumigraph
Discreet 4D Lightfield
Lightfield

- Set of images with COPs on regular grid
Lightfield

- Set of images of a point seen at various angles
Depth Correction of Rays
Depth Correction of Rays
Capture a dense set of photographs
Capturing a sparse set of photographs

acquisition stage

camera positions

blue screening
Filling in gaps using pull-push algorithm

- **Pull phase**
  - low res levels are created
  - gaps are shrunk

- **Push phase**
  - gaps at high res levels are filled using low res levels
Compression

• Large size uncompressed: 1.125GB
  – 32x32 (s, t) x 256x256 (u, v) x 6 faces x 3 B
• Compression
  – JPEG + MPEG (200:1 to 6MB)
  – or vector quantization + entropy encoding
Vector Quantization (VQ)

- **Principle**
  - codebook made of codewords
  - replace actual word with closest codeword

- **Implementation**
  - training on representative set of words to derive best codebook
  - compression: replacing word with index to closest codeword
  - decompression: retrieve indexed codeword from codebook
Lightfield compression using VQ
Acquiring a 4D Lightfield/Lumigraph

• Capture (many images)

• Organize into a \((s,t,u,v)\) parameterization
  – Do not “need” to resample the pixels
  – Use (linear) interpolation to extract an arbitrary ray/line
  – Optionally compress/decompress data
  – Interactively extract rays/lines to create a visual representation
Limitations of a Lightfield/Lumigraph

• What are they?
Limitations of a Lightfield/Lumigraph

- Resolution
- High storage requirement
- Difficult capture (?)
- No geometry
  - Cannot add new geometry and (easily) do occlusion and re-illumination