Capturing, Modeling, Rendering 3D Structures

Image-Based Rendering, Plenoptic Functions, Lightfields, and Lumigraphs

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

Photographs
- We have tools that acquire and tools that display photographs at a convincing quality level
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

How can we use images (of some kind) to "model" 3D objects and 3D environments?

**Image-Based Rendering (IBR)**
Plenoptic Function

- \( P(x, y, z, \phi, \psi, \lambda, t) \)
  - 7D function to describe light intensity passing through every viewpoint, for every direction, for every wavelength, and for every time instant

---

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

- Set of images with COPs on regular grid

Lightfield

- Set of images of a point seen at various angles
Depth Correction of Rays

Capture a dense set of photographs

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?

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