Light Fields

Light Fields

By Levoy and Hanrahan, SIGGRAPH 96

Representation for sampled plenoptic function

- stores data about visible light at various positions and directions

Created from set of images

Resamplings employ data from lots of different images

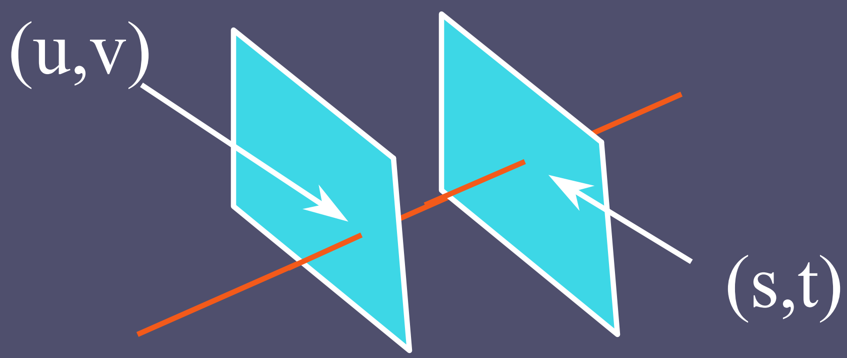
Light Field Dimensionality

Position and direction for each sample is a 5D space

For empty space (no occlusion), space reduced to 4D

- sample is constant along a line
- light field defined on 4D space of directed lines

Slab Representation



Define two parallel planes

- *uv*-plane and *st*-plane

Light field defined as L(*u*,*v*,*s*,*t*)

- (r,g,b) for each (*u*,*v*,*s*,*t*) tuple

Use multiple slabs to cover larger space

Sampling

Typically create regular sampling of uv- and st-planes

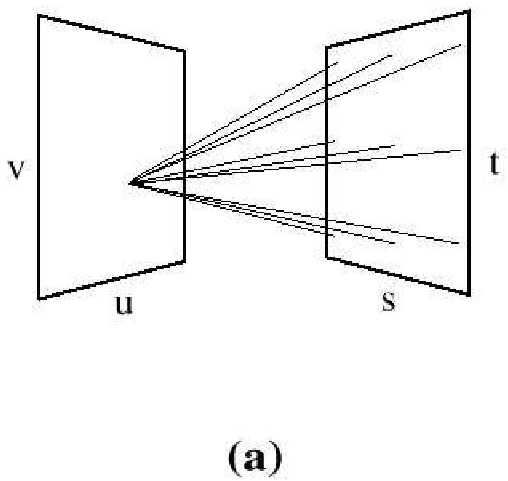
Place eye point at (u,v) on the uv-plane

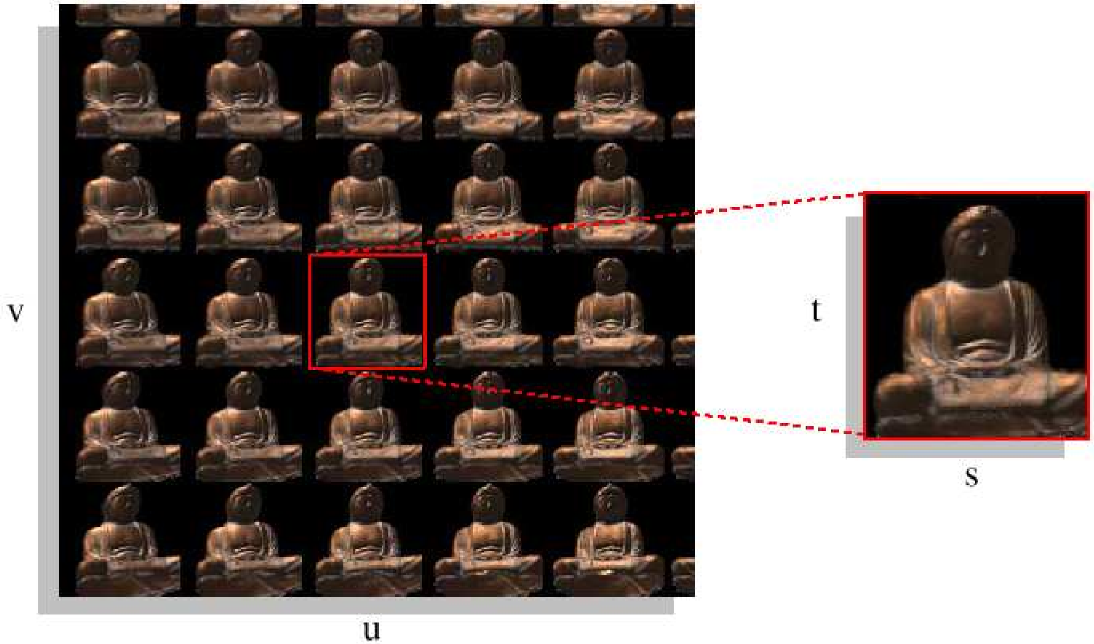
Generate image with each corresponding to a point on the st-plane

- each pixel for image (u,v) supplies sample (u,v,x,y)
- using skewed perspective matrix, (x,y) = (s,t)

Data looks like 2D array of 2D images

Visualization of Light Field





from Levoy and Hanrahan, “Light Field Rendering,” *Proceedings of SIGGRAPH 96*, page 34.

Generating Samples

Using rendered images

- Place eye at (u,v)
- Skew projection to cover proper (s,t) range
- Generate image

Using real photographs (looking inward)

- Computer-controlled camera on planar gantry
- Camara tilts to center on object
- (s,t) resampled from (x,y)
- Object platform (and lighting) rotates to capture different slabs

Stanford Light Field Gantry

from Levoy and Hanrahan, "Light Field Rendering," *Proceedings of SIGGRAPH 96*, page 36.

Resampling

Foreach pixel in the rendered image

- compute line coordinates (intersections with uv- and st-planes
- Apply nearest neighbor, bilinear, or quadralinear sampling to generate value of pixel from nearby lines in light field

Computing Line Parameters

Possible using ray/plane intersection

Faster using “texture mapping” to take advantage of plane coherence

- Store (u,v) coordinates in texture map
- Render uv-plane as textured rectangle
- Look up (u,v) coordinates for each pixel
- Repeat for (s,t) coordinates

Anti-aliasing

- Pre-filter data to remove aliases
- Integrate over range of eye points to filter (u,v)
- Apply lens aperture to filter (s,t)
- Filter size should be consistent with sample spacing

Compression

Light fields can be BIG (gigabytes)

Want to transmit over internet

Want to fit in memory

Need random access during reconstruction

Compression can be slow, decompression must be fast

Two Stage Compression/Decompression

- Lossy vector quantization (VQ) compression
  - Decompose data into small chunks, described as vector
  - Train with data to generate codebook (containing codewords to represent)
  - Store index of best codeword for each vector
- Lossless entropy coding (using gzip)

Decompression

Decompress entropy coding (gunzip) on loading to memory

- entropy coding doesn't allow random access

Decompress vector quantization (fast lookup) for each line sample on the fly

May compress 24:1 for VQ, 5:1 for gzip, total of 120:1

Live Demo (Stanford implementation)

Videos

- Levoy and Hanrahan. "Light Field Rendering." *Proceedings of SIGGRAPH 96.*
- Regan et al., "A Real-time, Low Latency Light Field Renderer", *Proceedings of SIGGRAPH 99*
- Wood et al., "Surface Light Fields for 3D Photography", *Proceedings of SIGGRAPH 2000*
- Isaksenm et al., "Dynamically Reparameterized Light Fields", *Proceedings of SIGGRAPH 2000*
  - Perhaps others from SIGGRAPH 2000
- (Sloan, Cohen, and Gortler. "Time Critical Lumigraph Rendering." *Proceedings of 1997 Symposium on Interactive 3D Graphics.)*