For CS291-J00,
These slides are slightly edited versions of those available at:
http://grail.cs.washington.edu/projects/slf/

Surface Light Fields for 3D Photography

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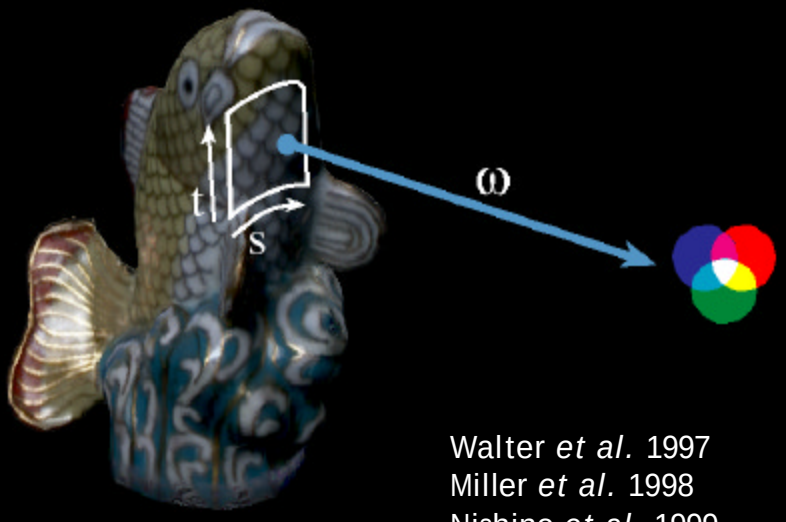
3D Photography

Goals
- Rendering and editing

Inputs
- Photographs and geometry

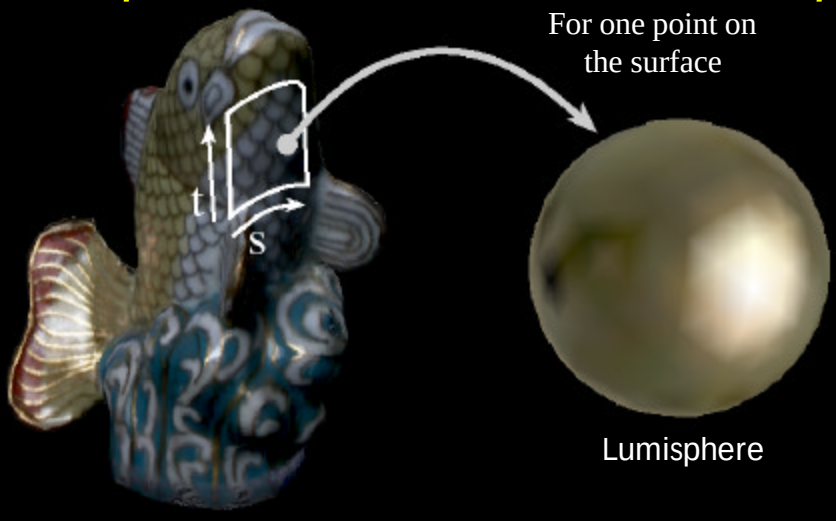
Requirements
- Estimation and compression

Surface light fields



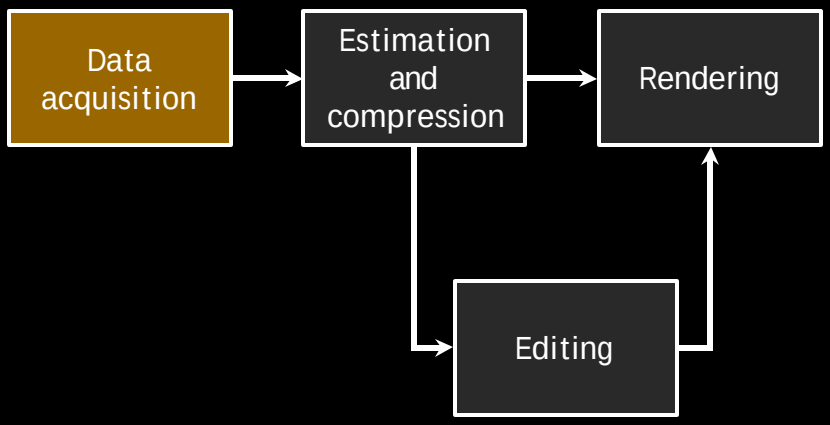
Walter *et al.* 1997
Miller *et al.* 1998
Nishino *et al.* 1999

Lumisphere-valued "texture" maps

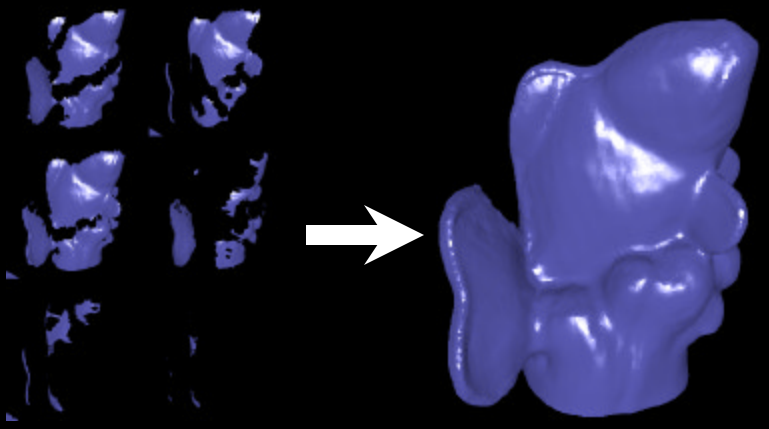


NOTE: Lighting remains fixed, and isn't contrllable

Overview



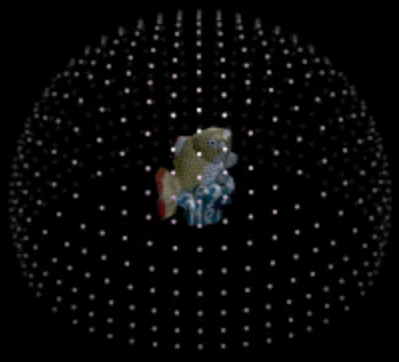
Scan and reconstruct geometry



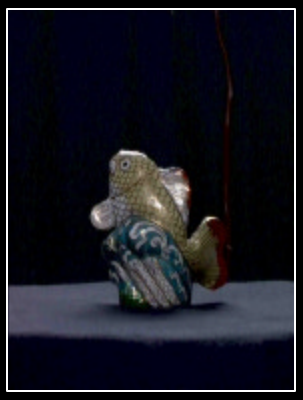
Range scans
(only a few shown . . .)

Reconstructed geometry

Take photographs

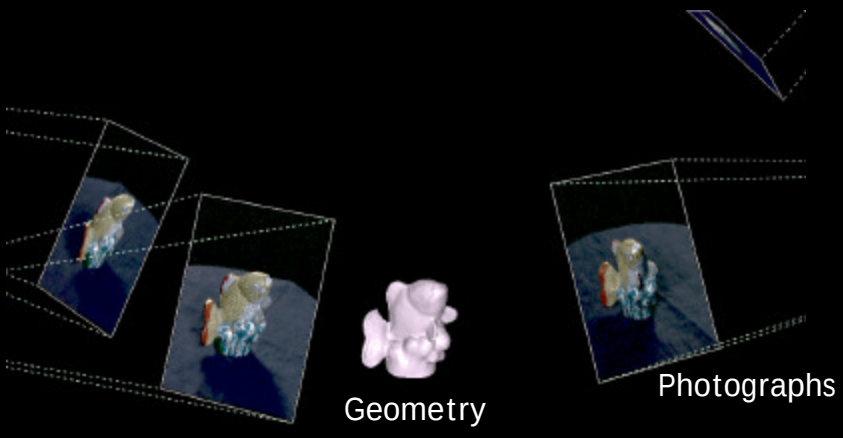


Camera positions



Photographs

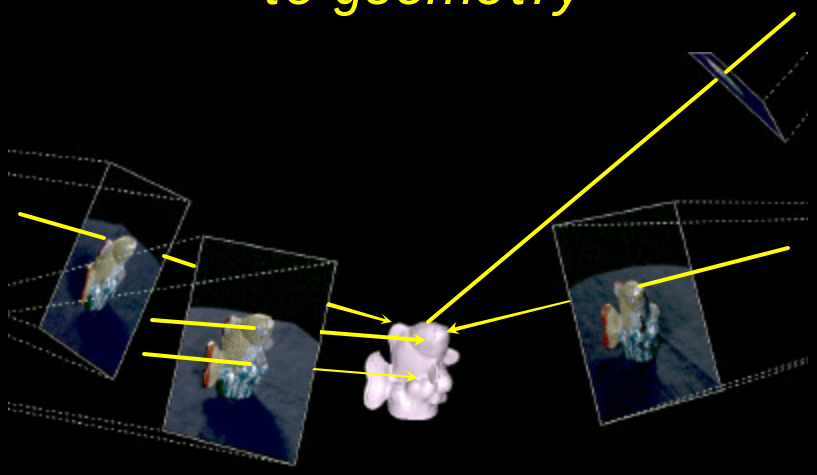
Register photographs to geometry



Geometry

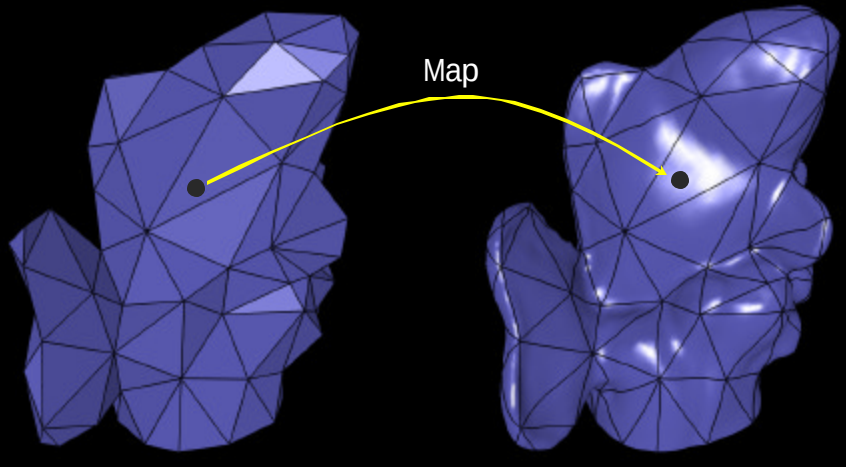
Photographs

Register photographs to geometry



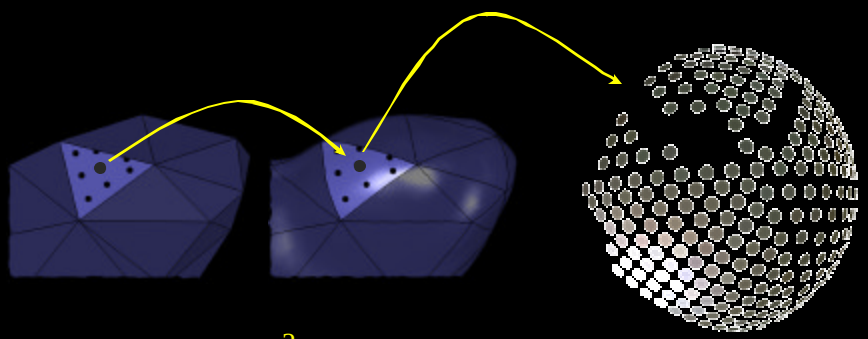
User selected correspondences (rays)

Parameterizing the geometry Atlas of Charts



$$L : K_0 \rightarrow M \subset \Re^3$$

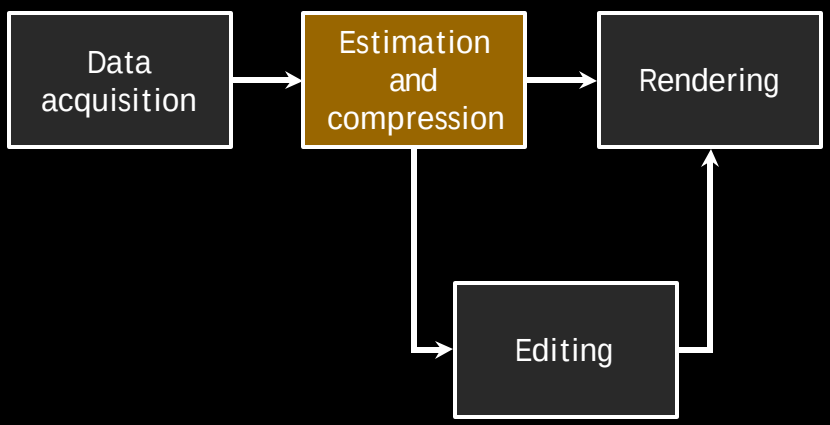
Assembling data lumispheres



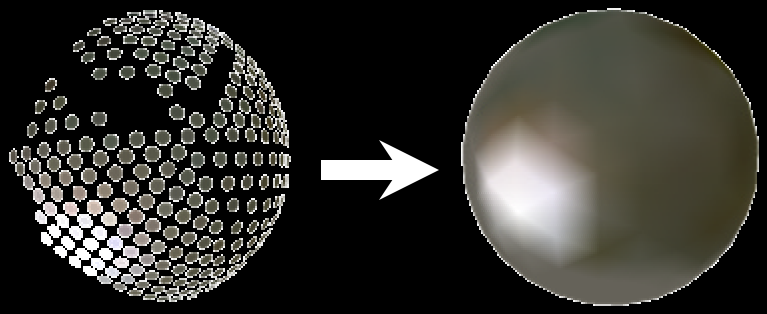
$L : K_0 \times S^2 \rightarrow RGB$

Data lumisphere

Overview



Pointwise fairing
Interpolation, filling in missing data



Data lumisphere

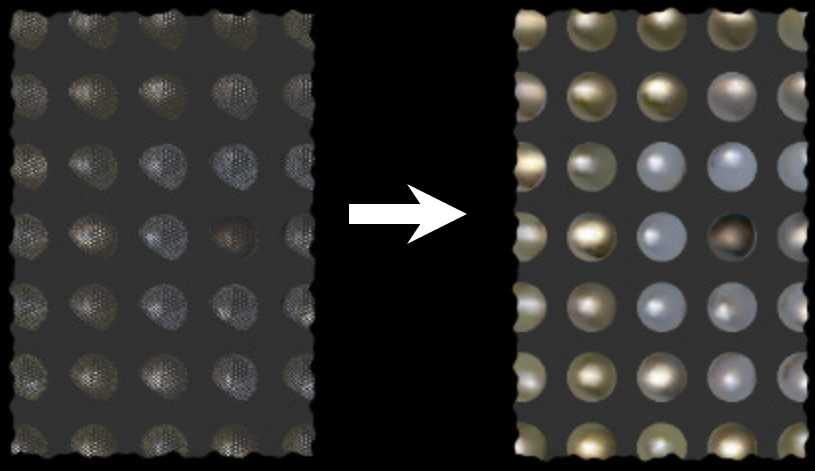
Faired lumisphere

Pointwise fairing results

Input photograph

Pointwise faired
(177 MB)

Pointwise fairing



Many input data lumispheres

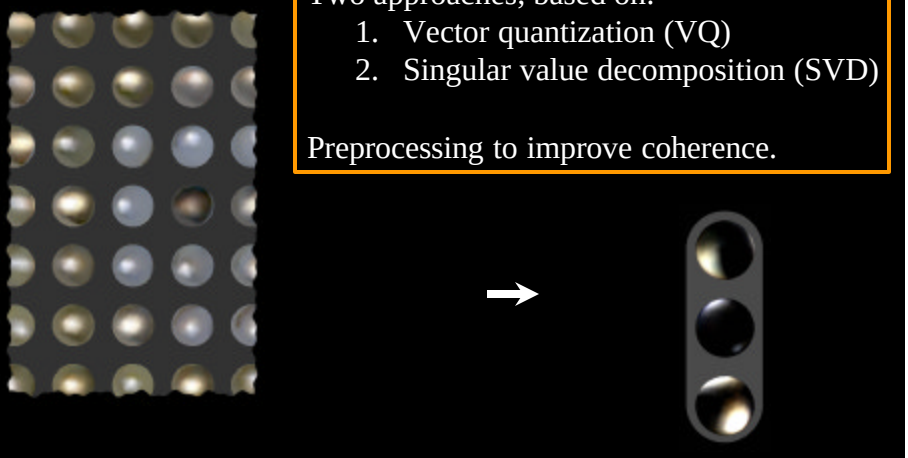
Many faired lumispheres

Compression

Two approaches, based on:

1. Vector quantization (VQ)
2. Singular value decomposition (SVD)

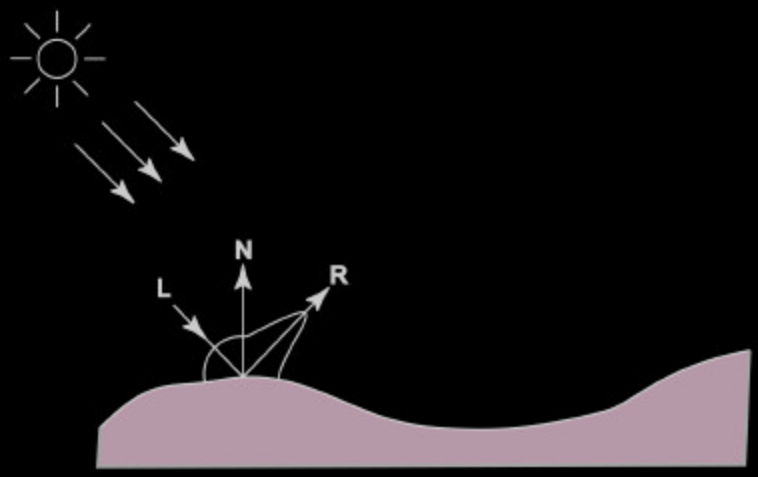
Preprocessing to improve coherence.



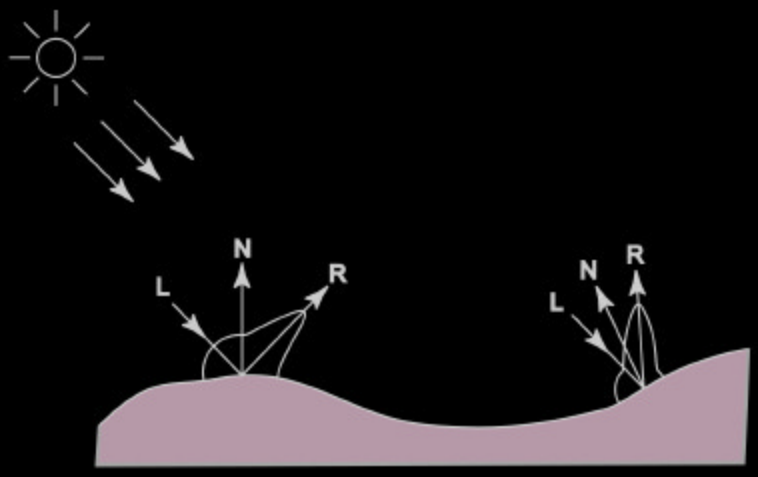
Many input data lumispheres

Small set of prototypes

Reflected reparameterization

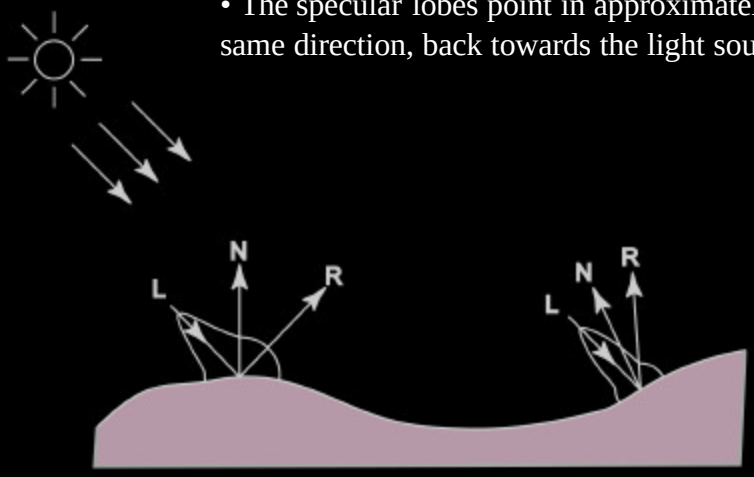


Reflected reparameterization

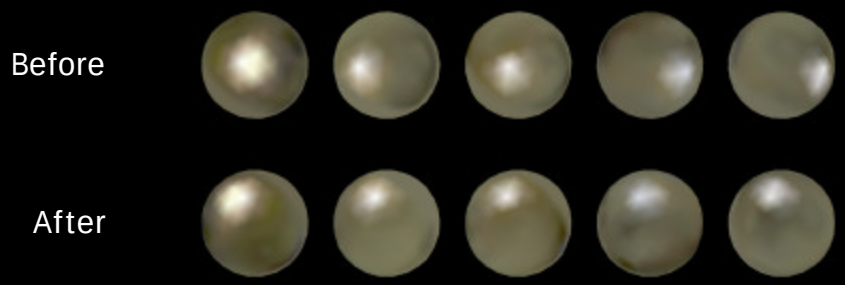


Reflection reparameterization

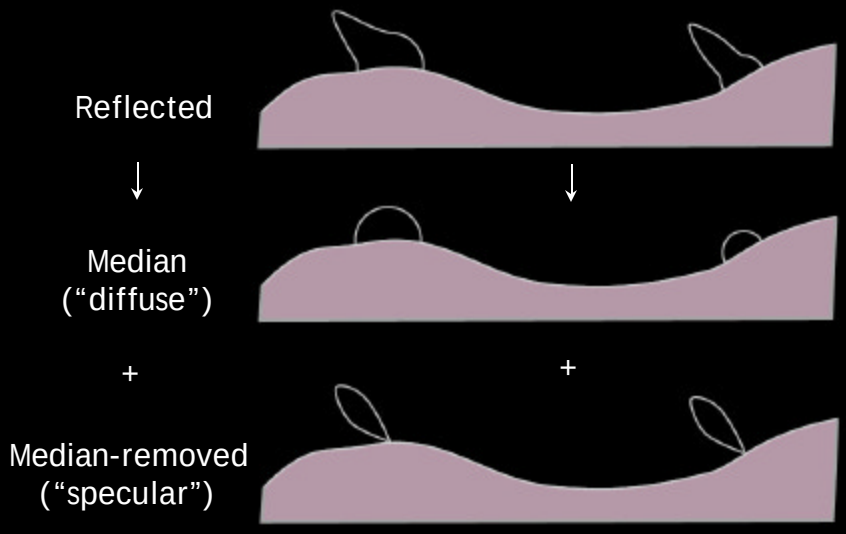
- Reflect the lumispheres through their normals
- The specular lobes point in approximately the same direction, back towards the light source.



Reflected reparameterization



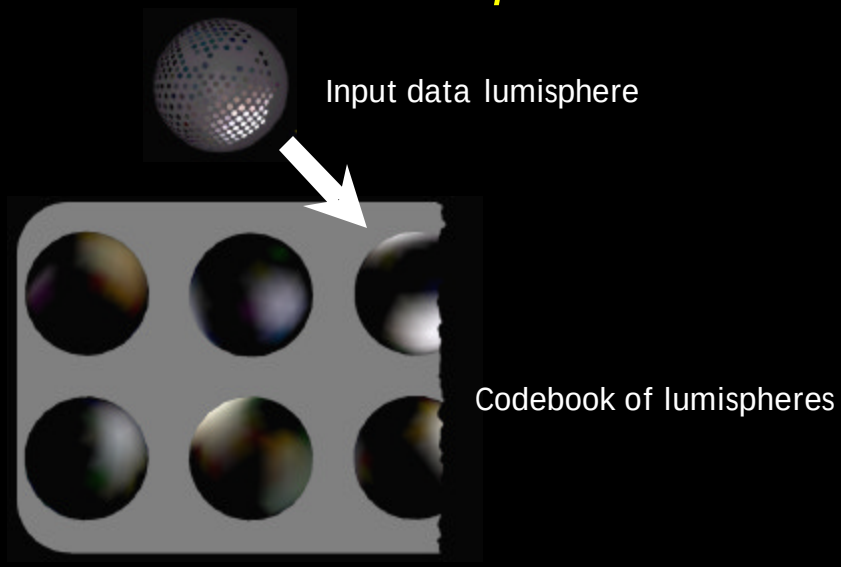
Median removal



Median removal

Median values | Residual "Specular" | Result

Function quantization based on vector quantization



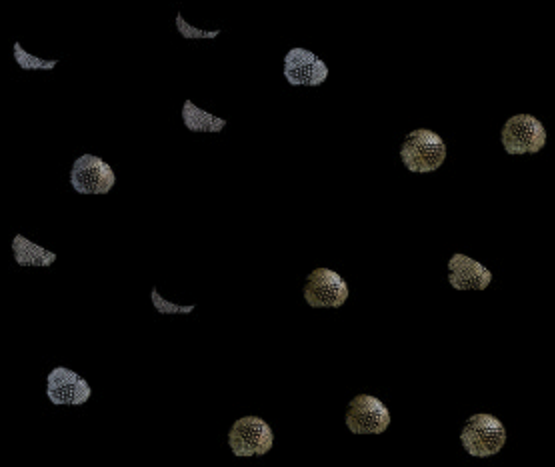
Construct codebook using Lloyd iteration

Iterate until convergence:

1. Assign all data lumispheres to closest codeword, forming clusters.
2. Compute new codeword for each cluster by “cluster-wise” fairing.

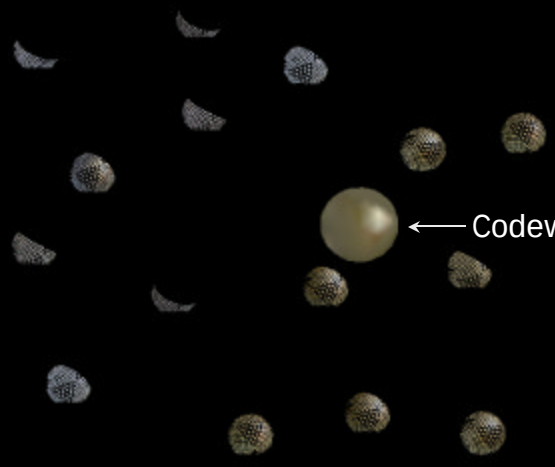
Then split all codewords and start over.

Lloyd iteration

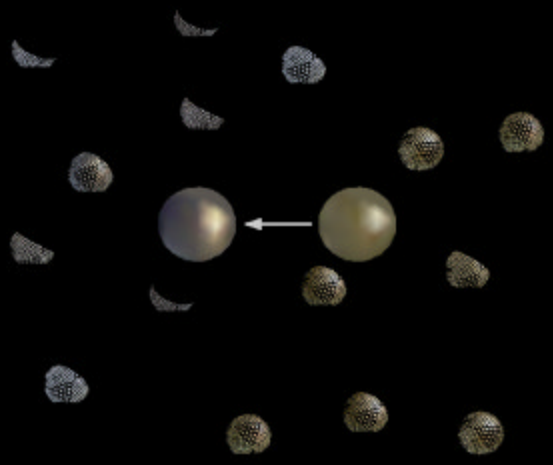


Input data lumispheres

Lloyd iteration

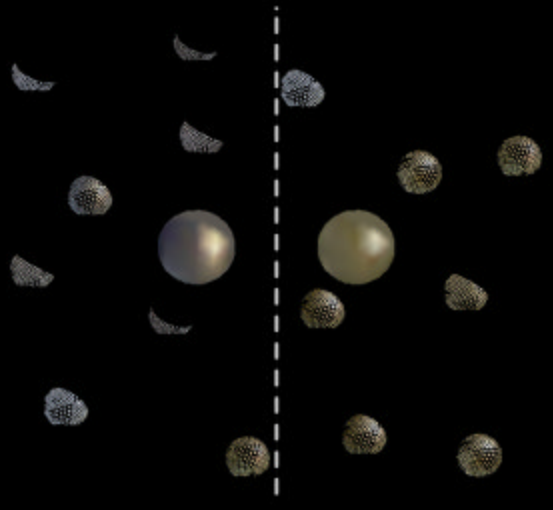


Lloyd iteration



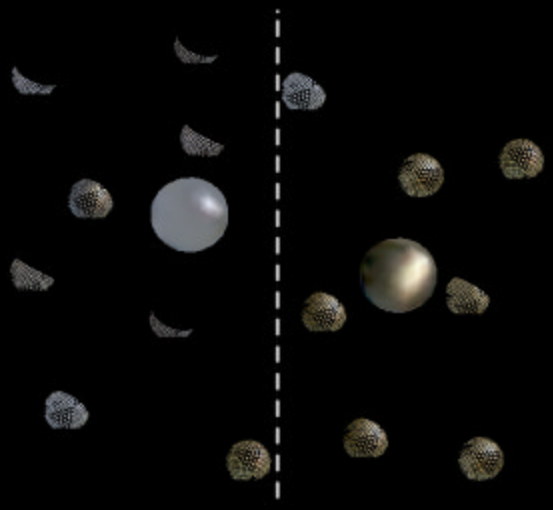
Perturb codewords to create larger codebook

Lloyd iteration



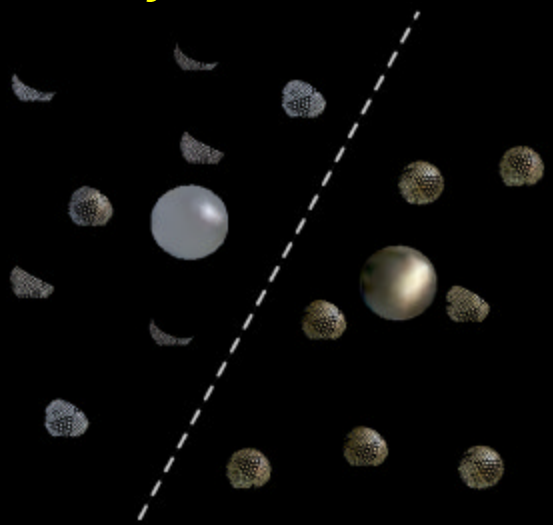
Form clusters around each codeword

Lloyd iteration



Optimize codewords based on clusters

Lloyd iteration



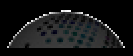
Create new clusters

Function quantization results

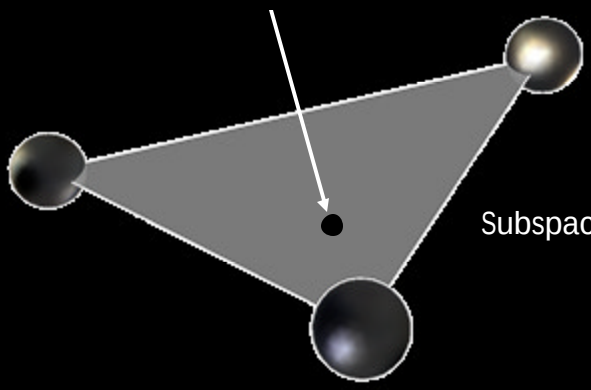
Input photograph

Function quantized
(1010 codewords, 2.6 MB)

Principal function analysis



Input data lumisphere



Prototype lumisphere

Subspace of lumispheres

Principal function analysis results

Input photograph

PFA compressed
(Order 5 - 2.5 MB)

Compression comparison

Pointwise fairing
(177 MB)

Function quantization
(2.6 MB)

Principal function
analysis (2.5 MB)

Qualitative comparison

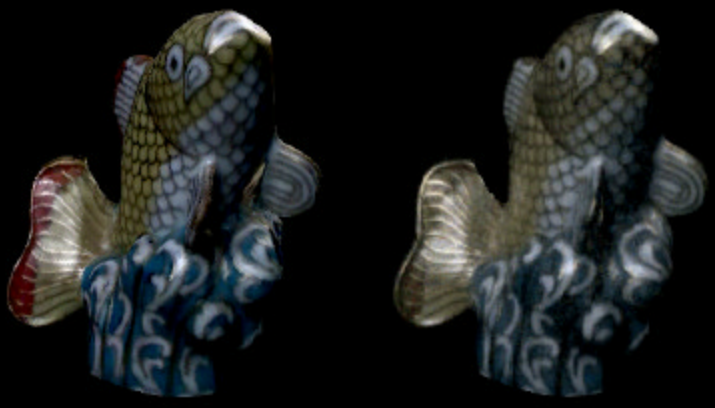
- PCA leads to smoother images
- Function quantization introduces artifacts such as jaggies on tail
- Function quantizatino better preserves colors in highlights and effects of inter-reflections

Comparison with 2-plane light field (uncompressed)

Pointwise-faired surface light field (177 MB)

Uncompressed lumigraph / light field (177 MB)

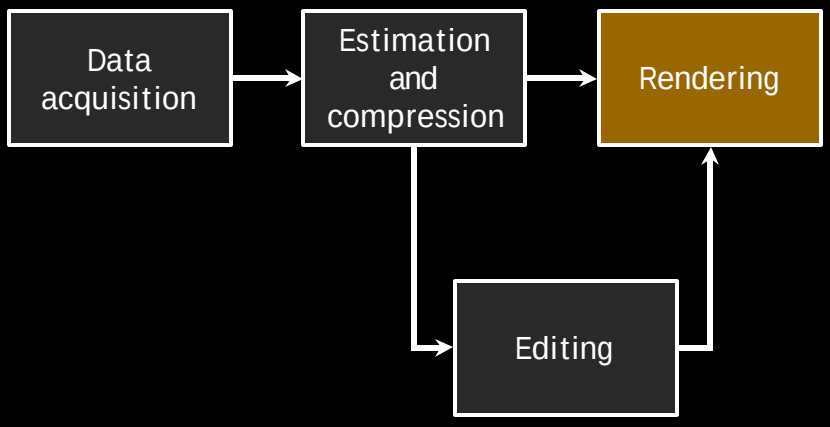
Comparison with 2-plane light field (compressed)



Compressed (PFA) surface light field (2.5 MB)

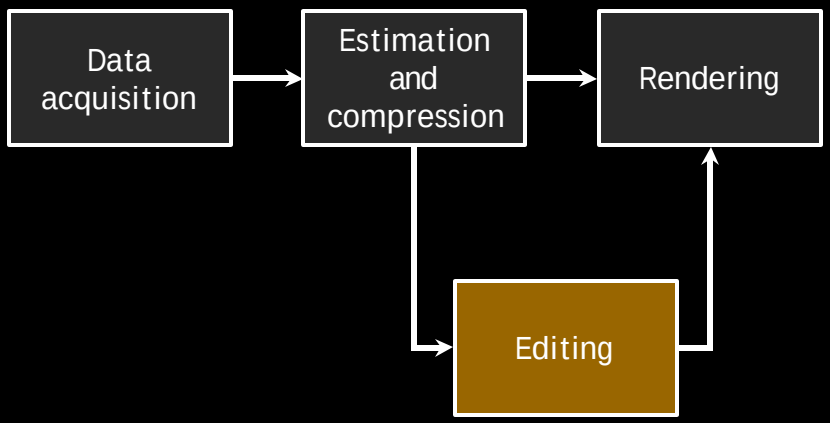
Vector-quantized lumigraph / light field (8.1 MB)

Overview



Interactive renderer screen capture

Overview



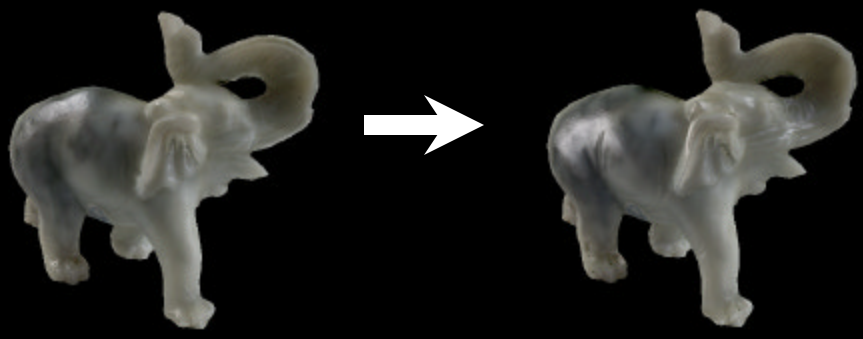
Lumisphere filtering

Simple bias function to the values in the lumisphere, making the specular lobes taller and narrower.

Original surface light field

Glossier coat

Rotating the Lighting by rotating the lumispheres…



Original surface light field

Rotated environment

Deformation

Original

Deformed

Deformation