GEOMETRY INDEPENDENT SURFACE LIGHT FIELDS FOR REAL TIME RENDERING OF PRECOMPUTED GLOBAL ILLUMINATION

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THE GOAL

- Real Time Rendering of globally illuminated scenes:

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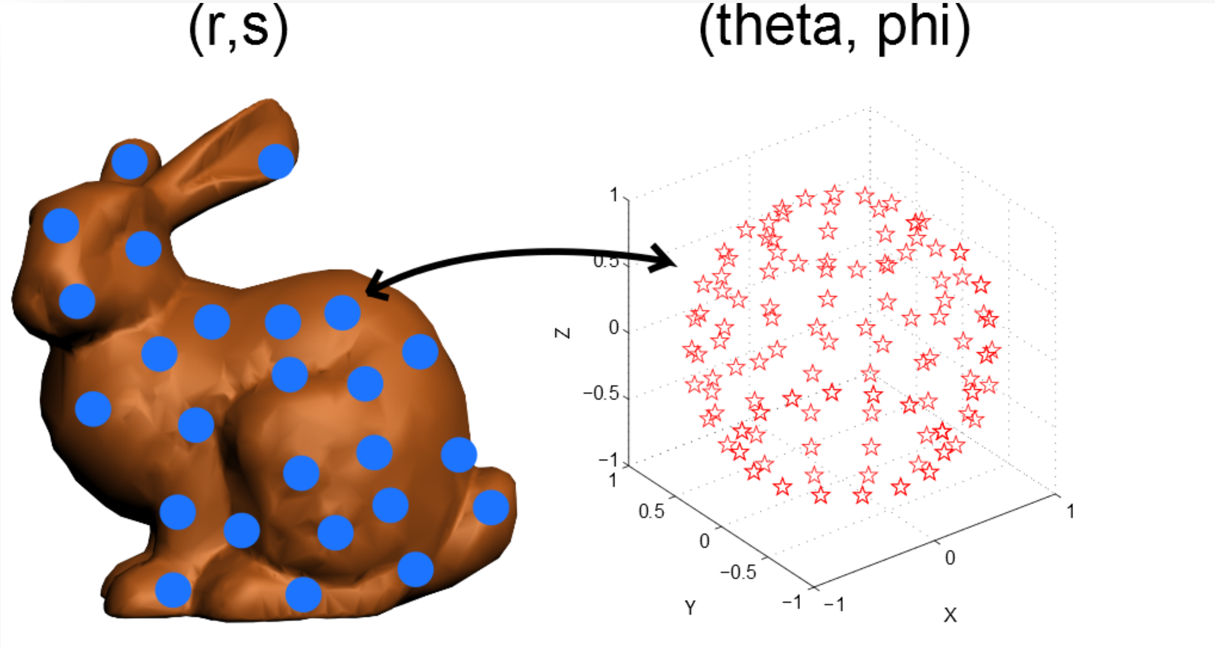
- Real Time Rendering of globally illuminated scenes:

- Assumptions:
  - Free viewpoint
  - Static scenes
  - Fixed lighting
  - All-frequency

BACKGROUND

- Surface Light Field (SLF): $f(r,s,\theta,\varphi)$



[MRP98]

CONTRIBUTIONS

- Geometry independent SLF
- Application of CPCA for SLF compression
- Real time rendering of CPCA compressed data
- A fast power iteration method

Method Overview

Data Generation

1. SLF function discretization
   1. Spatial sampling
   2. Angular sampling
2. Compute outgoing radiance
3. Store results in SLF Matrix *F*

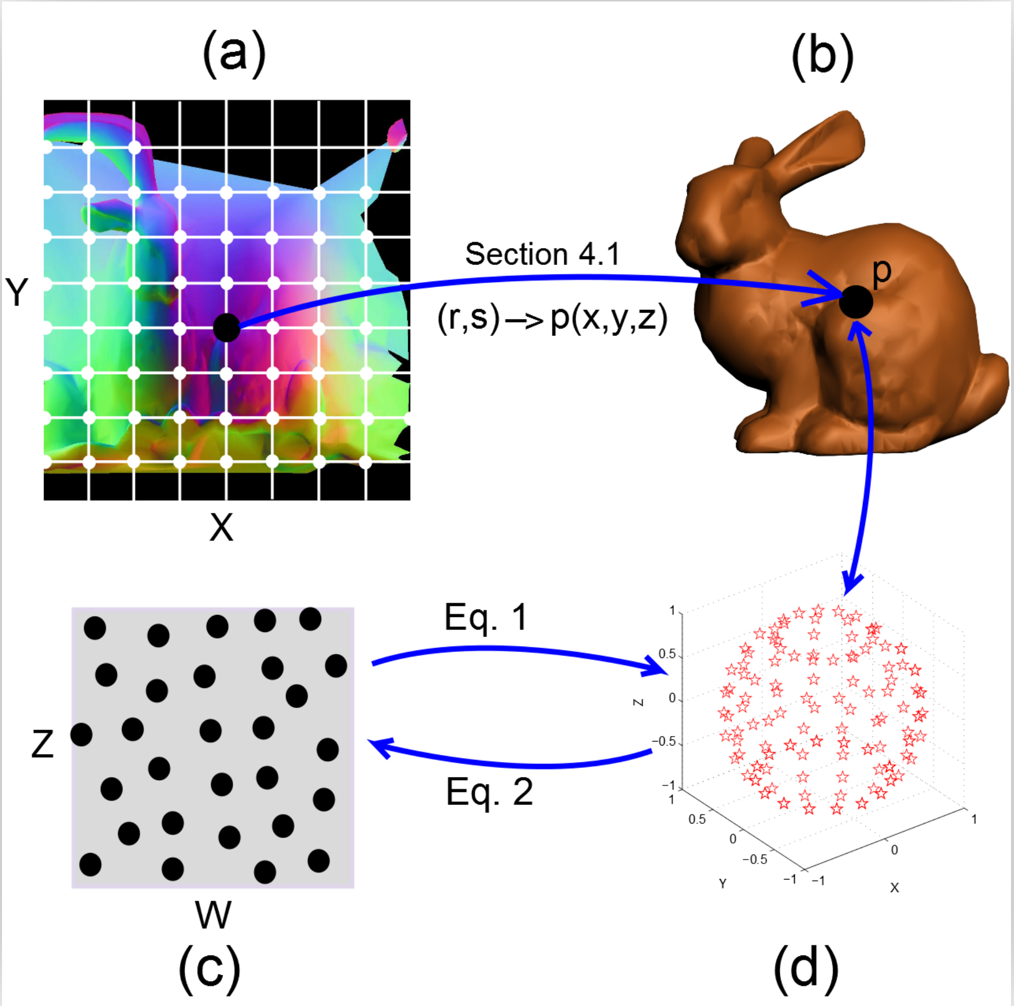
Compression (CPCA)

1. Cluster *F*
2. Apply PCA on each cluster

Rendering

1. For each ray/view direction
2. Find the corresponding surface point and direction
3. Fetch data and decode

Data Generation



DATA GENERATION

- The result is a m x n matrix:

$$F = \begin{bmatrix} f(r_1, s_1, \theta_1, \varphi_1) & . & . & . & f(r_1, s_1, \theta_Z, \varphi_W) \\ . & . & & & . \\ . & & . & & . \\ . & & & . & . \\ f(r_X, s_Y, \theta_1, \varphi_1) & . & . & . & f(r_X, s_Y, \theta_Z, \varphi_W) \end{bmatrix}$$

Compression

- Huge amount of data (typically +1.5GB per shape)
- What we need is a method with:
  - High compression ratio
  - Faithful reconstruction of data
  - Random access
- CPCA vs. PCA

Clustered Principal Component Analysis (CPCA)

1. Mean subtraction

$$G = [x_{p1} - \mu_{p2}, x_{p2} - \mu_{p1}, \ldots, x_{pm} - \mu_{pm}]^T$$

2. Clustering
3. PCA on clusters

$$G_i = U_i V_i^T$$

4. Surface and view maps

Clustered Principal Component Analysis (CPCA)

- We use power iteration for PCA
  - Calculate few terms (not full SVD)
  - Progressive
  - Low memory footprint
- Not efficient for CPCA
- Solution: Modified Power Iteration
- If $m > n$
  - *Compute eigenvectors and eigenvalues of* $A = F^T F$
- Else
  - *Compute eigenvectors and eigenvalues of* $A = F F^T$

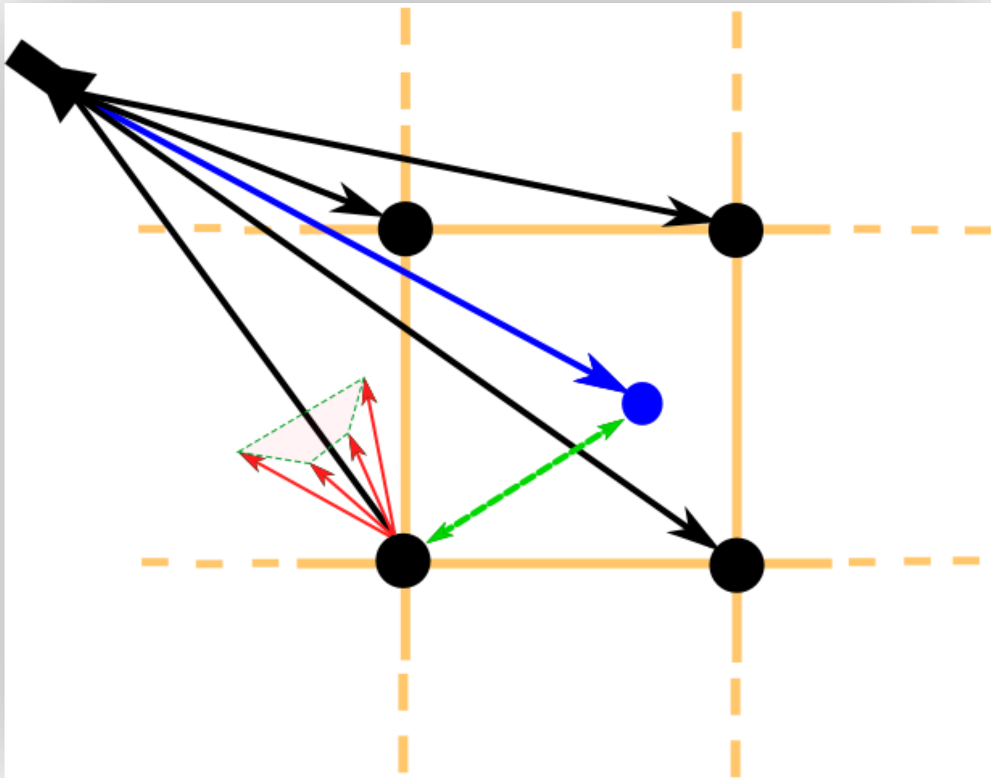
RENDERING

$$f(r,s,\theta,\varphi) \approx F[r,s,u,v] = \left(\sum_{j=1}^{k} U_i[\alpha, j] V_i[\beta, j]^T \right) + \mu[\alpha]$$

- Single pass rendering
- We have
  - Intersection point (and the texture coordinate of it)
  - View vector
- We need
  - Surface and view map addresses (α and β)

RENDERING

- Reconstruction and Interpolation

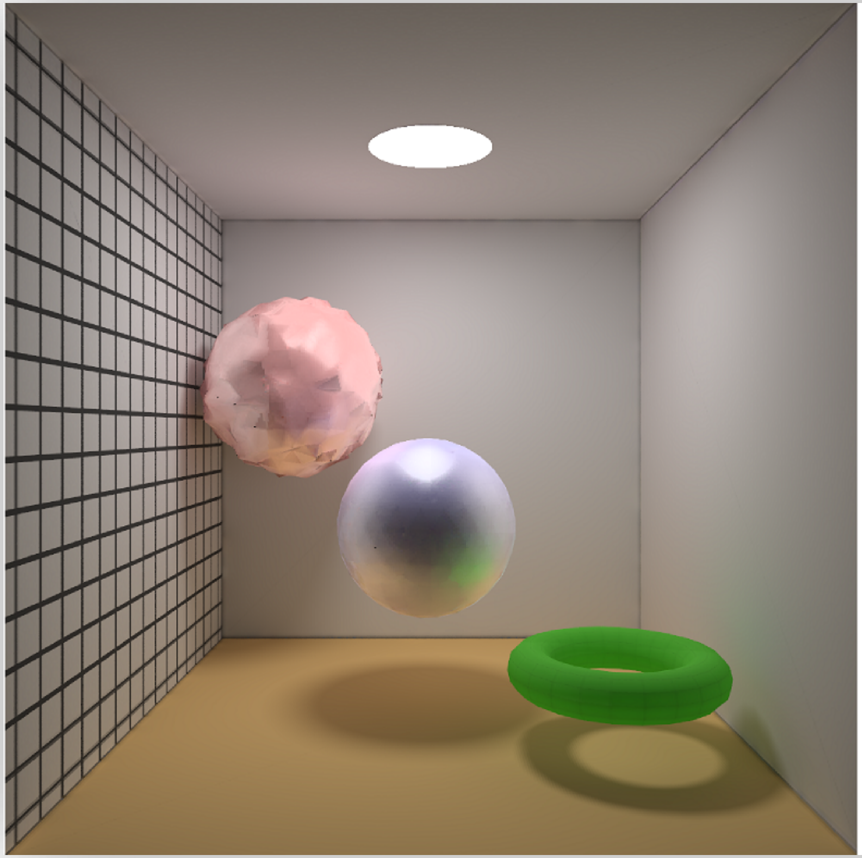


IMPLEMENTATION

- Data Generation
  - PBRT (as a renderer)
  - Different surface integrators can be used
- Compression
  - K-Means
  - Hand tuned PCA!
  - Guaranteed convergence
- Renderer
  - CPU based (PBRT)
  - GPU based (DirectX + HLSL)

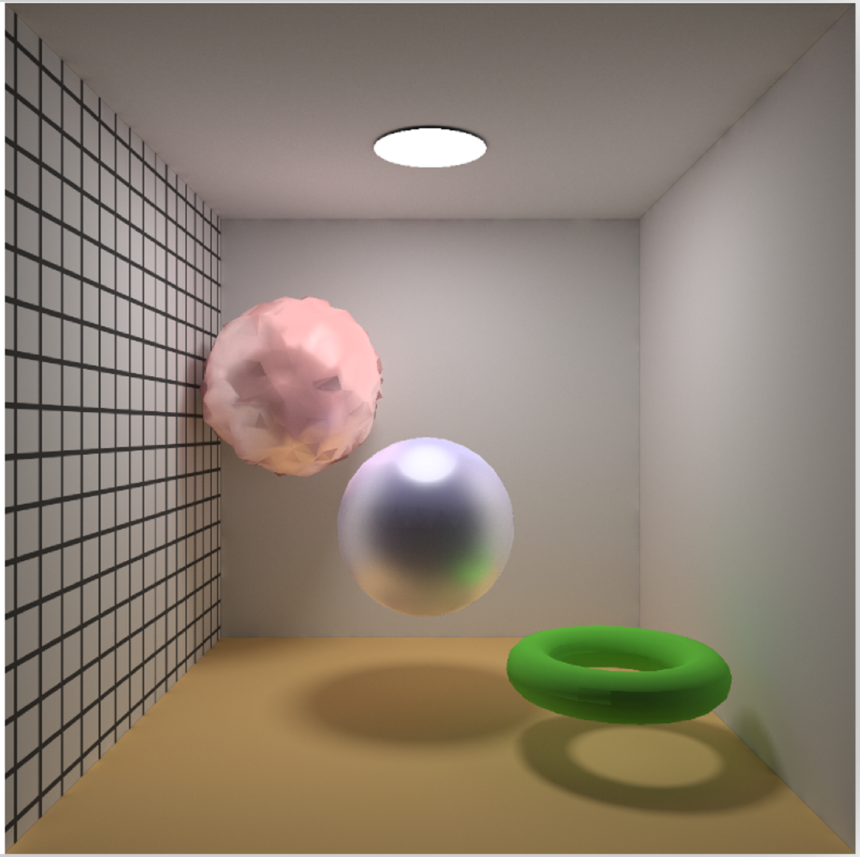
Results (CPU)

Our method



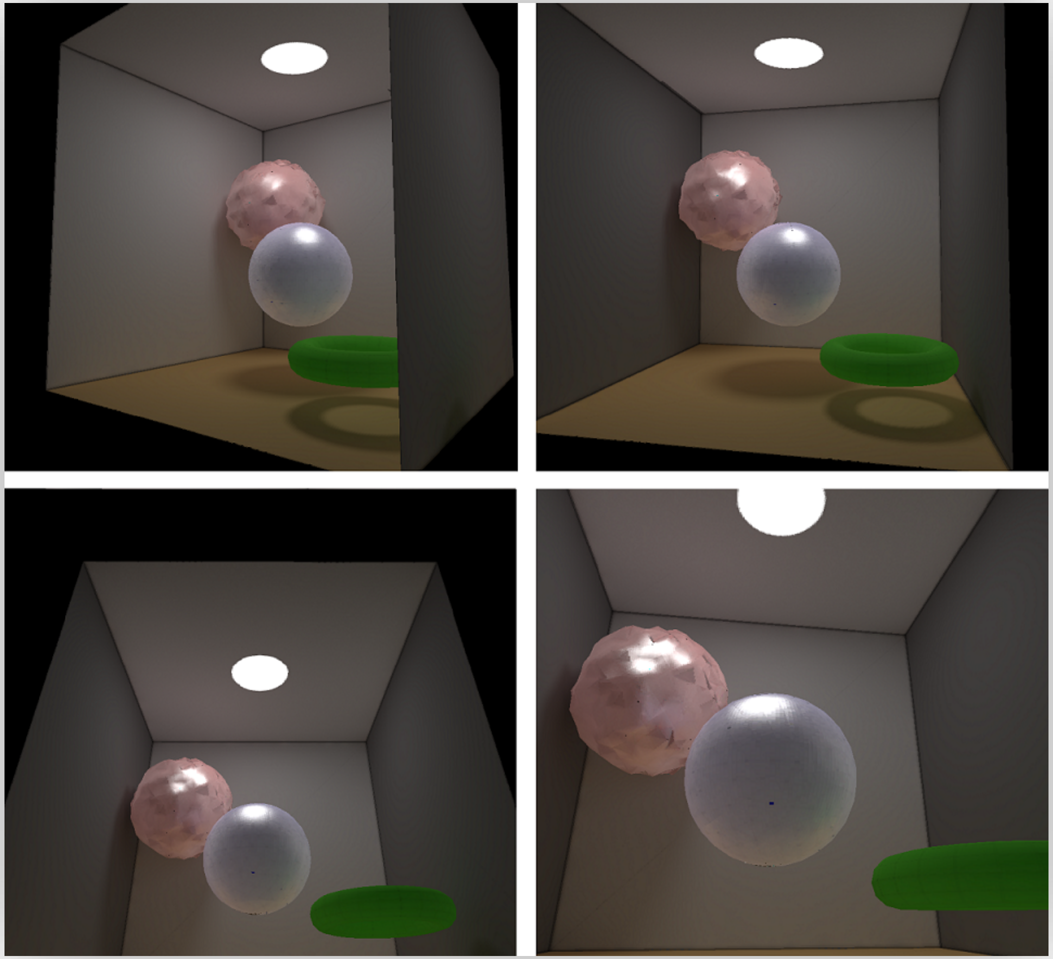
16.7 sec

Reference



202 min

RESULTS (GPU)



~120 Frames Per Second

THANK YOU

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