Restoring Illumination and View Dependent Data from Sparse Samples

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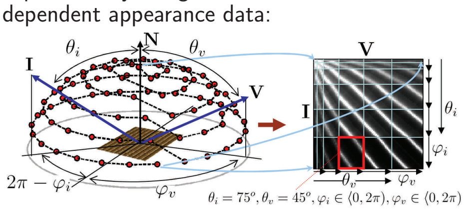
Abstract

Capturing appearance of material with respect to illumination and viewing directions is crucial to achieve realistic visual experience in virtual environments. The capturing process is time demanding or requires a specific shape of the captured material. Therefore, we propose a method of such a data reconstruction from very sparse measurements, whose placement allows for continuous and fast acquisition, from which can benefit future acquisition setups. The proposed approach shows a promising performance in terms of whole data-space reconstruction speed and visual quality.

Problem Definition

Realistic appearance of materials can be captured only using view- & illumination dependent appearance data:



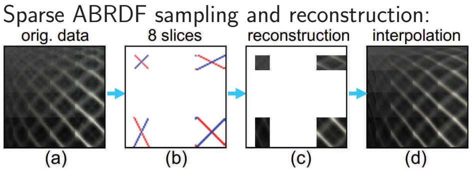
Standard approaches:

- uniform sampling → time demanding,
- or requires specific sample's shape.

Applicable appearance representations: BRDF, SVBRDF, Apparent BRDF, BTF.

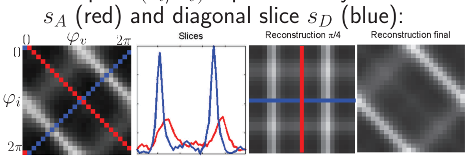
The Proposed Method

Sparse ABRDF sampling and reconstruction:



(b) using 8 continuous slices in 4 subspaces (fixed elevation angles),
(c) interpolation of missing data in subspaces,
(d) interpolation of missing subspaces (RBF).

- Subspace (θ_i/θ_v) represented by axial slice s_A (red) and diagonal slice s_D (blue):



$$s_A(\varphi_i) = B(\theta_i, \theta_v, \varphi_i, \varphi_v = \varphi_i + \alpha) \ ,$$
$$s_D(\varphi_v) = B(\theta_i, \theta_v, \varphi_i = 2\pi - \varphi_v + \alpha, \varphi_v) \ .$$

s_A rotation of the sample below fixed light and sensor (anisotropic behavior)
s_D mutually opposite movement of the light and sensor (specular highlights)

- Subspace reconstruction from the slices:

$$v(\varphi_i, \varphi_v) = s_A(\varphi_{i,R}) + s_D(\varphi_{v,R}) \ ,$$
$$\begin{bmatrix} \varphi_{i,R} \\ \varphi_{v,R} \end{bmatrix} = \begin{bmatrix} \cos\pi/4 & -\sin\pi/4 \\ \sin\pi/4 & \cos\pi/4 \end{bmatrix} \begin{bmatrix} \varphi_i \\ \varphi_v \end{bmatrix} \ .$$

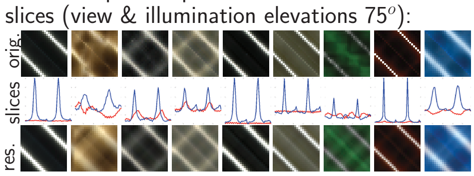
- Values normalization to original slices range:

$$\hat{B}(\theta_i, \theta_v, \varphi_i, \varphi_v) = v(\varphi_i, \varphi_v) \cdot (M - m) + m \ ,$$
$$m = \min(s_A \cup s_D) \qquad M = \max(s_A \cup s_D) \ ,$$

where: v is normalized to range [0,1].

Tests and Results

- Anisotropic subspaces reconstruction from slices (view & illumination elevations 75^o):

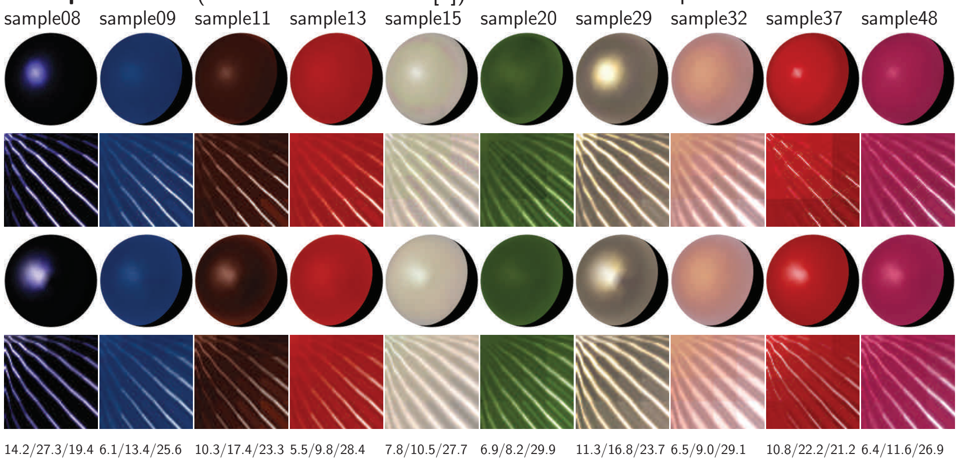


- experiments (below ↓): original ABRDF and its complete reconstruction using 204 samples (8 slices) + difference in CIE ΔE/RMSE/PSNR.

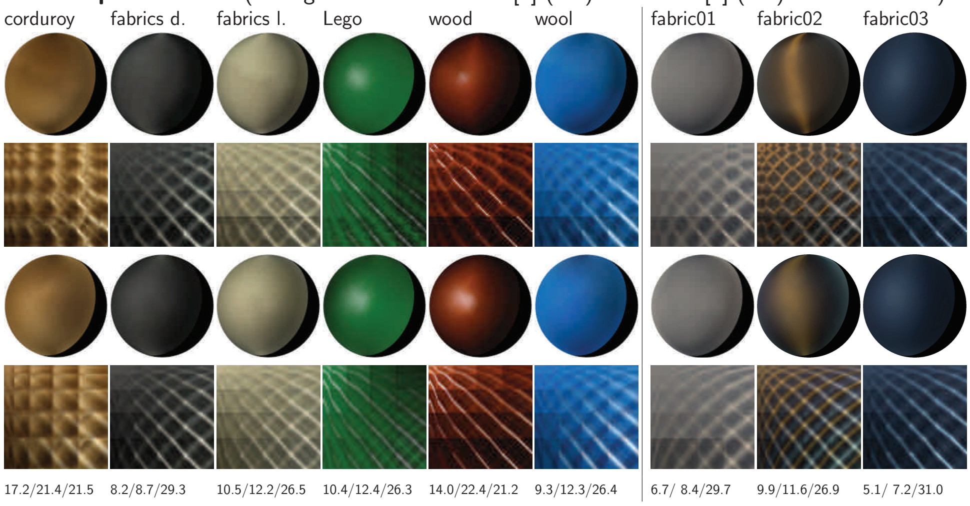
Method's Key Features

- fast ABRDF reconstruction from sparse samples (204 samples used) ≈ 1s,
- intuitive continuous sampling for fast measurement of slices,
- no input data restriction (anisotropic, non-reciprocal, HDR, specular),
- arbitrarily dense angular data modeling,
- contribution to future development of simple, inexpensive acquisition setups of illumination- & view-dependent data.

Isotropic BRDFs (MERL BRDF database [1]) - 10 of 55 tested samples



Anisotropic ABRDFs (averaged BTFs from UBO [2] (1-6) and UTIA [3] (7-9) BTF databases)



[1] http://www.merl.com/brdf/ [2] http://cg.cs.uni-bonn.de/en/projects/btfdbb/ [3] **http://btf.utia.cas.cz**

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