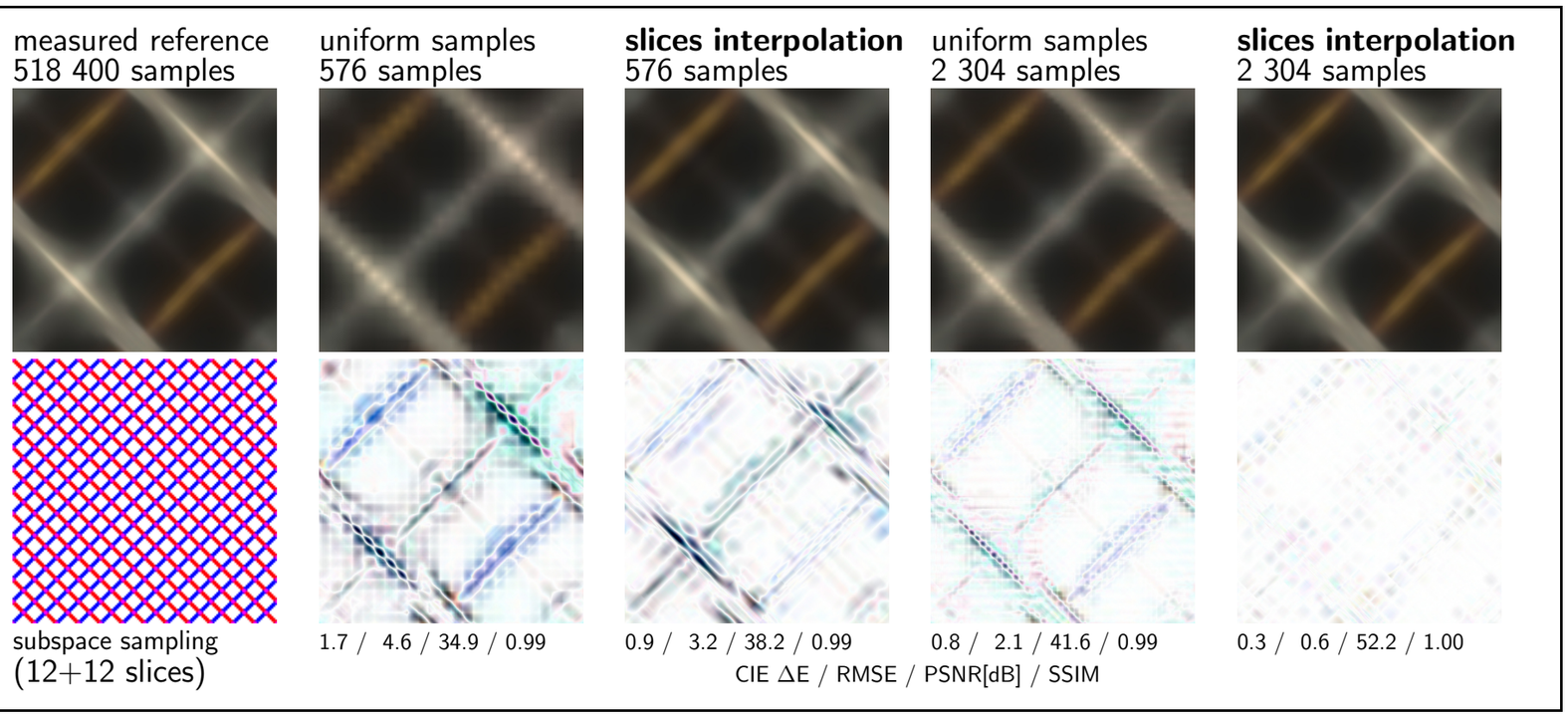
BRDF Slices: Accurate Adaptive Anisotropic Appearance Acquisition

Jiří Filip[1] **Radomír Vávra**[1] **Michal Haindl**[1] **Pavel Žid**[1] **Mikuláš Krupička**[1] **Vlastimil Havran**[2]

[1] Institute of Information Theory and Automation of the AS CR, Prague [2] Faculty of Electrical Engineering, Czech Technical University in Prague

{filipj,vavra,haindl,zid,krupimik}@utia.cas.cz, havran@fel.cvut.cz

We introduce unique publicly available dense anisotropic BRDF data measurements. We use this dense data as a reference for performance evaluation of the proposed BRDF sparse angular sampling and interpolation approach. The method is based on sampling of BRDF subspaces at fixed elevations by means of several adaptively-represented, uniformly distributed, perpendicular slices. Although our method requires only a sparse sampling of material, the interpolation provides a very accurate reconstruction, visually and computationally comparable to densely measured reference. Due to the simple slices measurement and method's robustness it allows for a highly accurate acquisition of BRDFs. This is considerably faster than standard uniform angular sampling and uses far less samples.

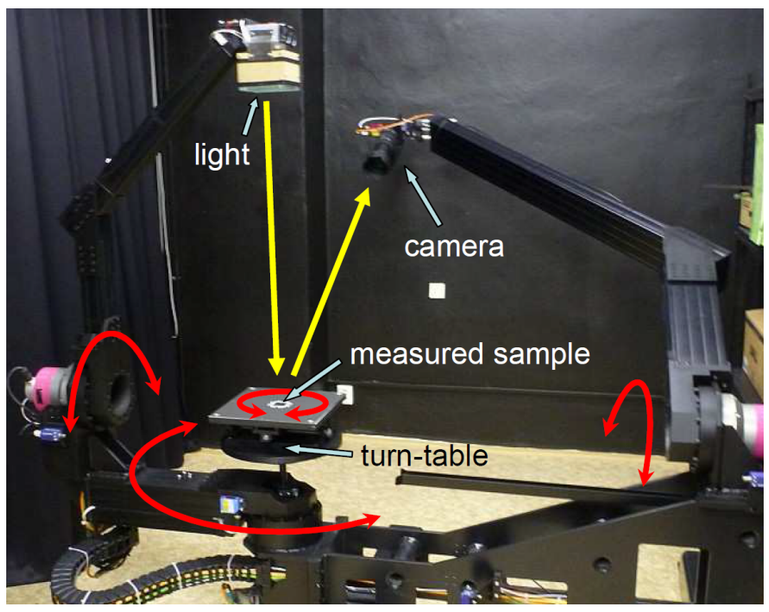


Motivation

Accurate anisotropic BRDF measurement:

- **Challenge**: time-demanding measurement (4 mechanical DOF)
- **Approach**: effective sparse/adaptive sampling + visually accurate reconstruction

Reference BRDF Measurement

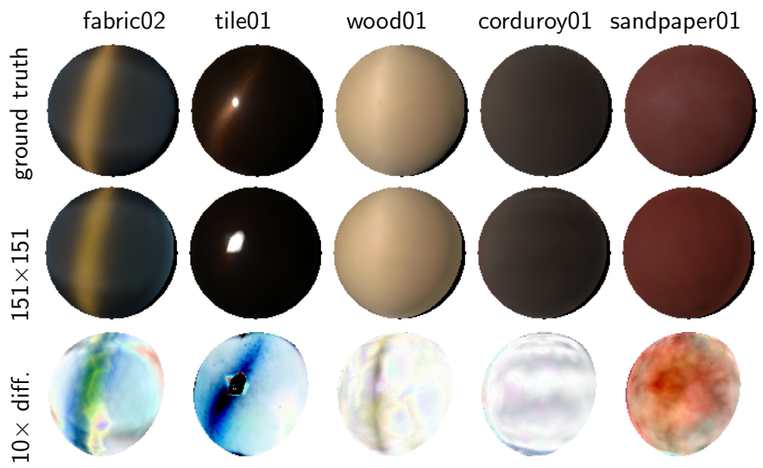


Novel gonioreflectometer measurement setup:

- arms positioning angular accuracy: $\pm 0.03^o$
- 16Mpix RGB camera (14bits) → 2m from sample
- HDR data: LED light intensity+multiple exposures
- Calibrations: initial mechanical positions, lighting non-uniformity, vignetting, colorimetric.

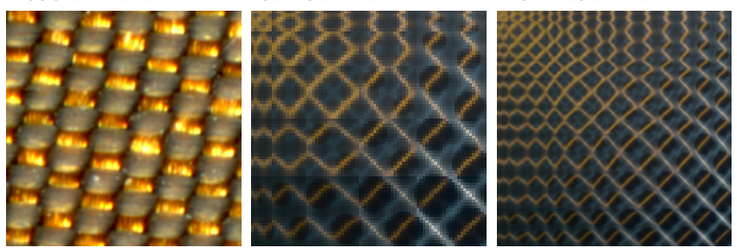
Uniform Sampling Evaluation

Uniform sampling in 81×81 (6 561 samples) or 151×151 (22 801 samples) is insufficient:



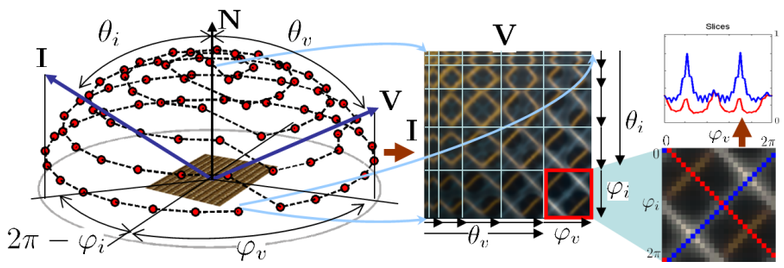
Reference Data Analysis

fabric material → strong anisotropic behavior

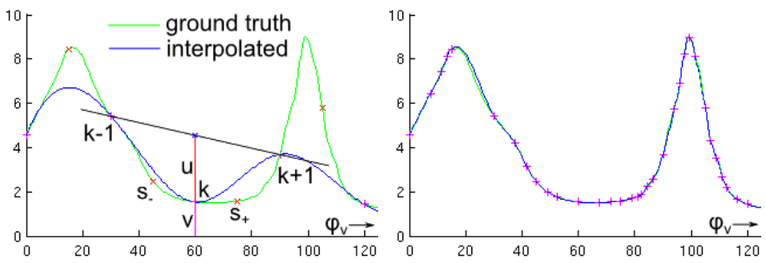


Interpolation from Sparse Samples

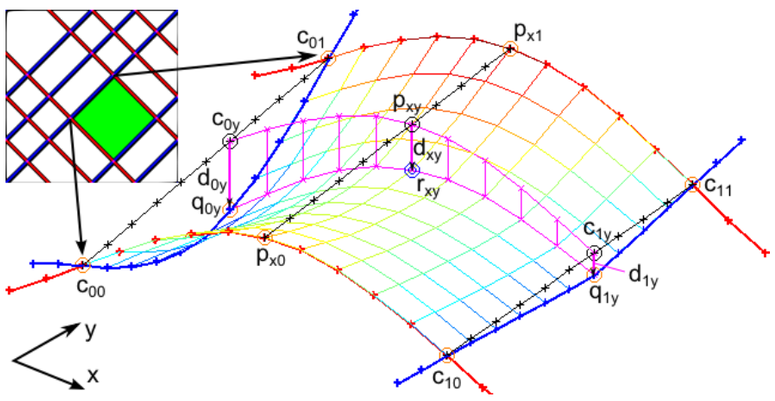
BRDF subspace measurement using 2 slices:



Adaptive Slice Sampling



Subspace Reconstruction from Slices



Linear interpolation along y axis:

$$p_{xy} = (1-y)\cdot p_{x0} + y \cdot p_{x1}$$
$$d_{0y} = q_{0y} - [(1-y)\cdot c_{00} + y \cdot c_{01}]$$
$$d_{1y} = q_{1y} - [(1-y)\cdot c_{10} + y \cdot c_{11}]$$

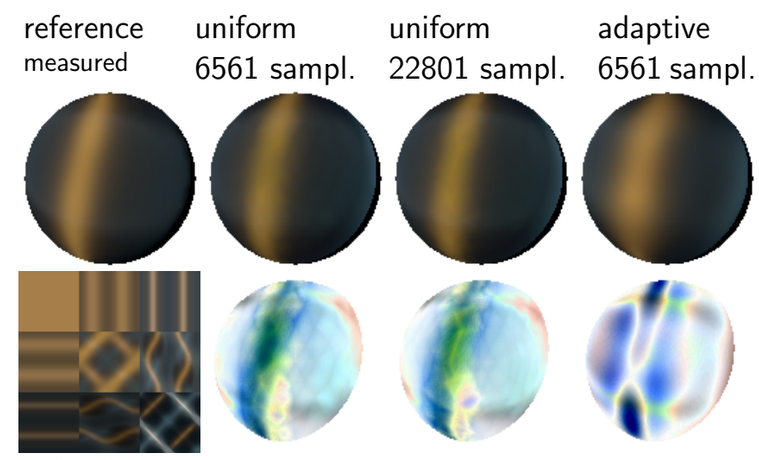
Linear interpolation along x axis:

$$d_{xy} = (1-x)\cdot d_{0y} + x \cdot d_{1y}$$

Reconstruction of value r_{xy} at point (x, y):

$$r_{xy} = max(p_{xy} + d_{xy}, min(p_{x0}, p_{x1}, q_{0y}, q_{1y}))$$

Results



Conclusions

- Sparse BRDF data representation and interpolation method → outperforms uniform sampling (in reconstruction quality using the same count of samples).
- Slices → fast, continuous acquisition at fixed elevations of camera/light → robust reconstruction of arbitrary missing values.
- Accuracy controllable by: number of slices + their adaptive sampling density (maximal allowed error).

UTIA BTF database **http://btf.utia.cas.cz**