Effective Acquisition of Dense Anisotropic BRDF

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The development of novel analytical BRDF models, as well as adaptive BRDF sampling approaches, rely on the appropriate BRDF measurement of real materials. The quality of measurements is even more critical when it comes to accurately representing anisotropic materials where the character of anisotropy is unknown. As currently there is a lack of dense yet noise-free BRDF anisotropic datasets, we introduce such unique measurements of three anisotropic fabric materials. We discuss a method of dense BRDF data acquisition, post-processing, missing values interpolation, and analyze properties of the datasets.

Motivation

Lack of dense reference BRDF measurements suitable for:

- development and evaluation of novel analytical anisotropic models
- evaluation of adaptive measurement techniques of anisotropic materials
- high-quality appearance rendering

Related Work

Analytical BRDF models:

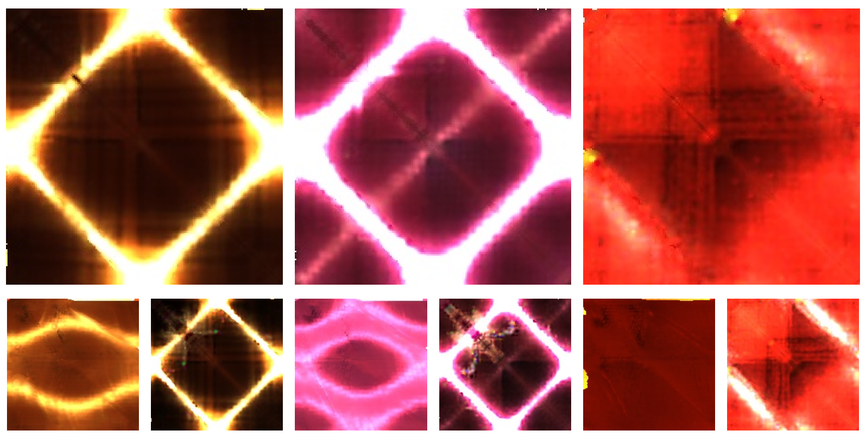
- pros: outliers suppression, no interpolation
- cons: unreliable fitting

BRDF measurement approaches:

- mirror-based approaches: low dynamic/angular range and accuracy
- image-based setups (material on sphere, cylinder): long acquisition, rather noisy.

Image-based BRDF measurements by [Ngan et al. EGSR06] after interpolation:

yellow satin *purple satin* *red velvet*



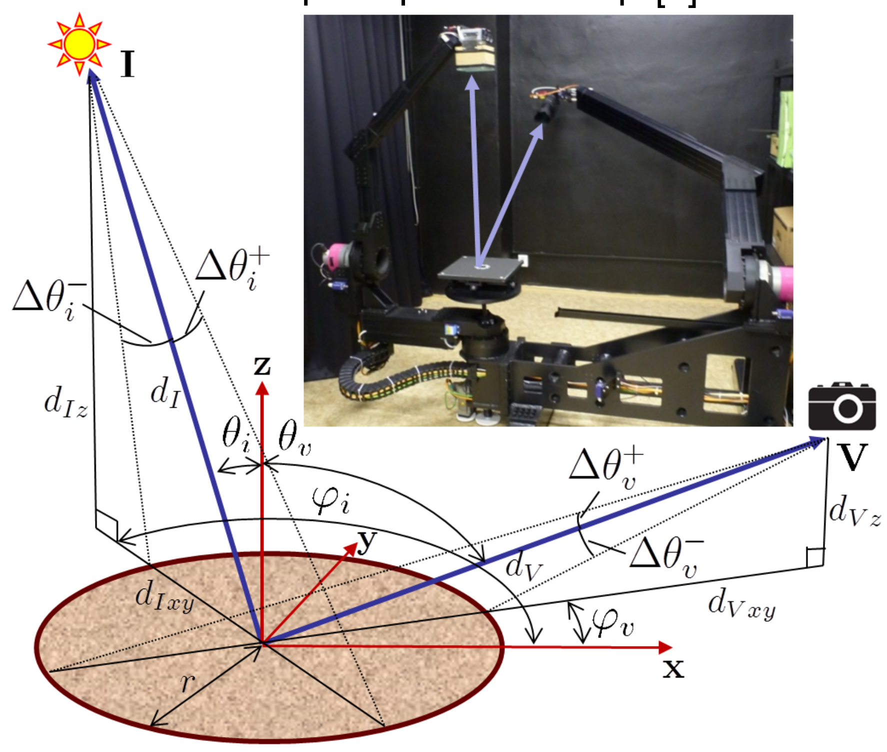
The Proposed Method

- viewing and illumination angles variations across the flat measured surface (radius r)
- surface of size comparable to its distance from light/camera (d)
- elevation angle variation (see scheme):

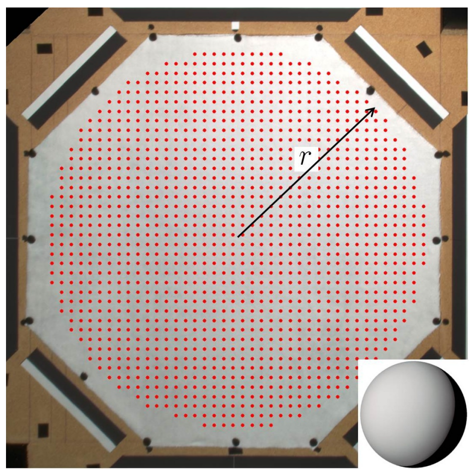
$$d_{xy} = d \cdot \sin\theta \qquad d_z = d \cdot \cos\theta$$

$$\Delta\theta^{+} = atan\left(\frac{d_{xy}+r}{d_z}\right) - \theta \qquad \Delta\theta^{-} = atan\left(\frac{d_{xy}-r}{d_z}\right) - \theta$$

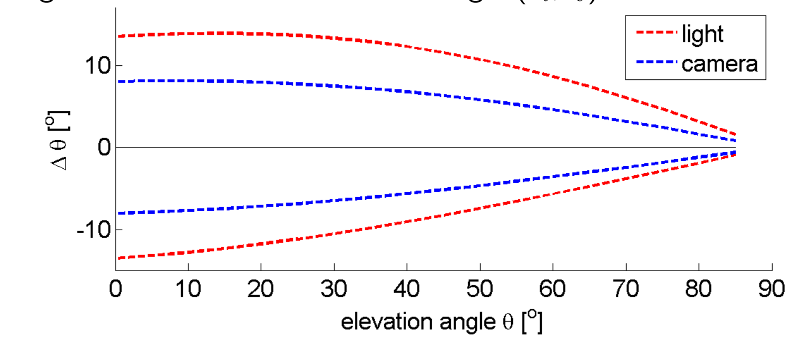
- Measurement principle and setup [1]



- uniform material sample r=0.3m,dI=1.1m,dV=1.8m
- image-based registration using marks around sample
- white velvet material (right) used for illumination non-uniformity compensation $I_F = I \cdot \frac{I_C}{I_R} \cdot \frac{1}{\cos\theta_i}$
- 8505 images captured → slight variations of angles → three million samples
- measurement time: 20 h



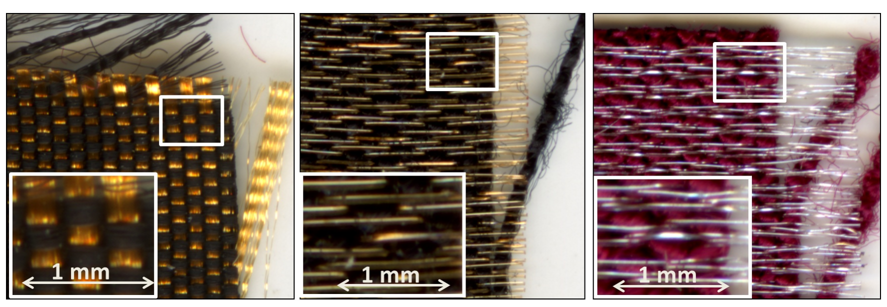
Range of effective span of illumination and view elevation angles as a function of elevation angle (θ_i,θ_v)



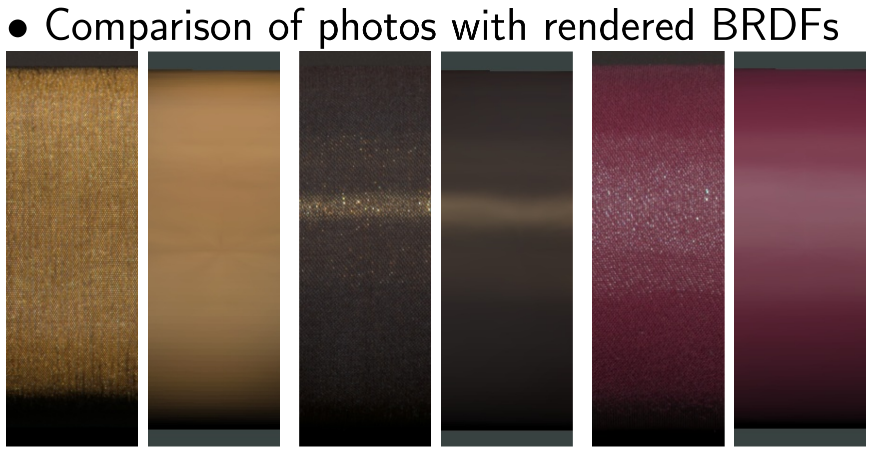
Tests and Results

- Detail structure of the measured materials.

fabric112 *fabric135* *fabric136*



- Comparison of photos with rendered BRDFs

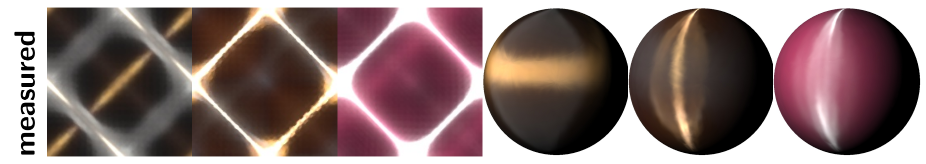


- Data publicly available (PNG, OpenEXR) at **http://btf.utia.cas.cz**

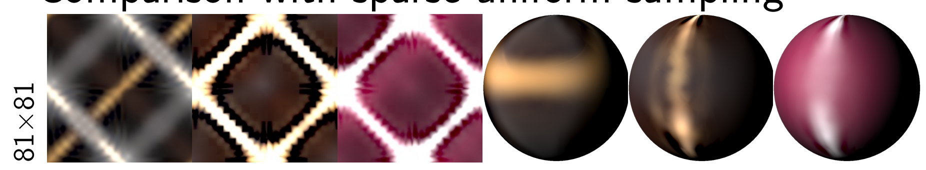
- Rendering of BRDFs in illum. environment

BRDF subspace interpolated at elevations $\theta_i/\theta_v = 74^o/74^o$ BRDF renderings on spheres (point light from top-left)

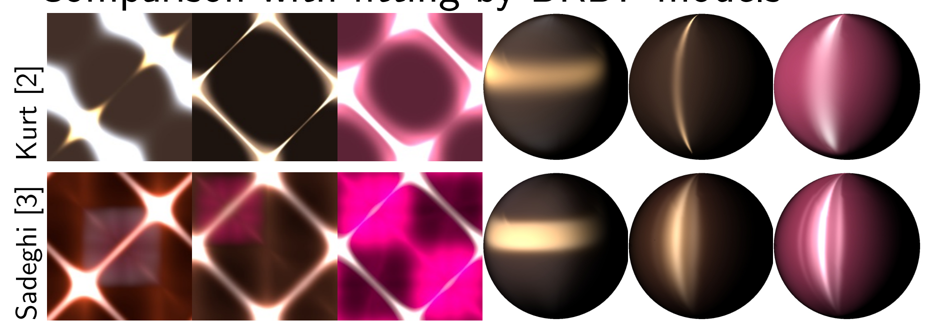
fabric112 *fabric135* *fabric136* *fabric112* *fabric135* *fabric136*



- Comparison with sparse uniform sampling

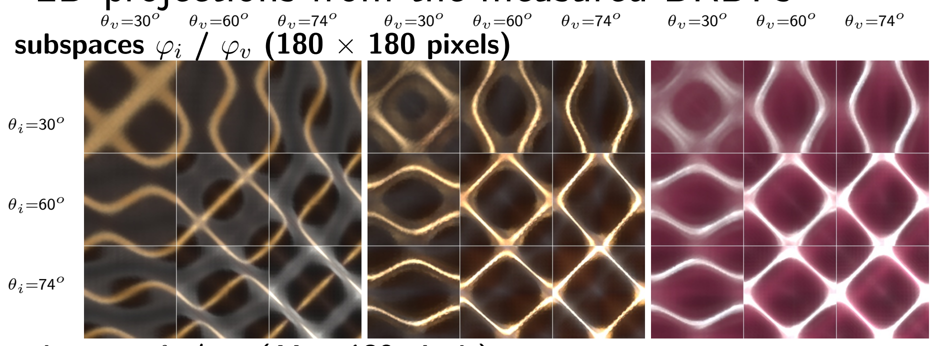


- Comparison with fitting by BRDF models

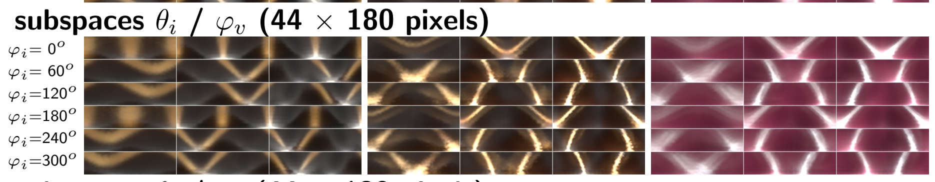


- 2D projections from the measured BRDFs

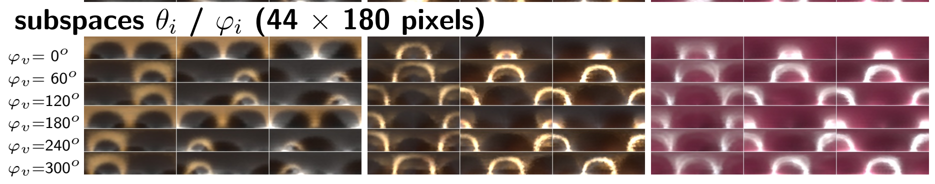
subspaces φ_i / φ_v (180 × 180 pixels)



subspaces θ_i / φ_v (44 × 180 pixels)



subspaces θ_i / φ_i (44 × 180 pixels)



Contributions

- combination of gonioreflectometer with image-based methododology
- unique BRDF data density – uniform angular step 2^o in all four dimensions
- benchmark BRDF measurements of three anisotropic materials

References

[1] J. Filip, R. Vavra, M. Haindl, P. Zid, M. Krupicka, and V. Havran, *BRDF slices: Accurate adaptive anisotropic appearance acquisition*, in CVPR 2013, pp. 43214326

[2] M. Kurt, L. Szirmay-Kalos, and J. Krivanek, *An anisotropic BRDF model for fitting and Monte Carlo rendering*, SIGGRAPH Comput. Graph., vol. 44, pp. 3:13:15, 2010.

[3] I. Sadeghi, O. Bisker, J. De Deken, and H. W. Jensen, *A practical microcylinder appearance model for cloth rendering*, ACM Trans. Graph., vol. 32, no. 2, pp. 14:114:12, 2013

ICPR 2014, Stockholm, Sweden