Reflectance Capture using Univariate Sampling of BRDFs

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Background

Direct BRDF measurement

- Pros: provide faithful rendition.
- Cons: specialized acquisition setups, large amount of images

Image-based method

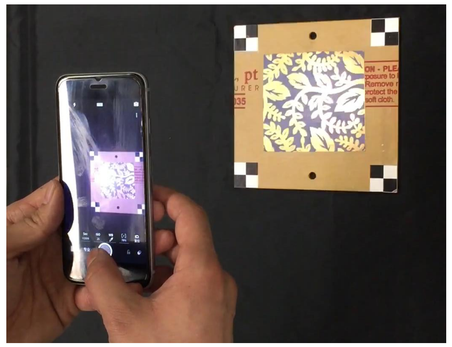
- Pros: High-quality estimation with commodity hardware.
- Cons: restricted setup, i.e. distant lighting, calibrated camera.

Optimal BRDF sampling

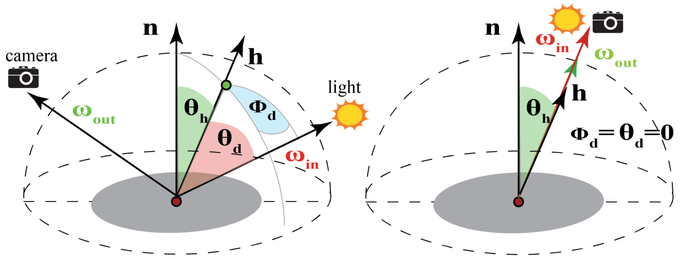
- Pros: small set of input images.
- Cons: calibrated camera and light sources.

Proposed setup

- A mobile setup to estimate the material BRDFs



- **Challenge**: mobile devices have co-located camera and light leading to a sparse sampling of the BRDF

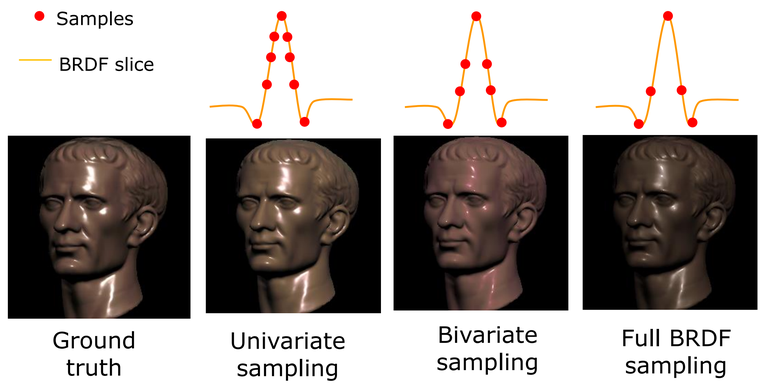


full BRDF sampling **collocated setup**

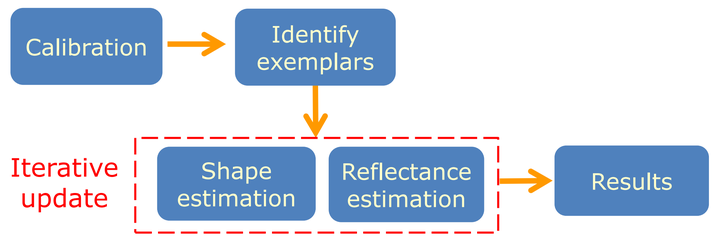
- Can we exploit 1-D "univariate" sampling of a 3-D isotropic BRDF to recover material reflectance?

Univariate sampling of isotropic BRDFs

- Assumption: near-planar scene with isotropic SV-BRDF
- Univariate sampling samples the specular lobe of the BRDF, which plays a major role in material appearance.
- Given a fixed number of samples, this leads to more accurate BRDF reconstruction.



Shape and reflectance estimation

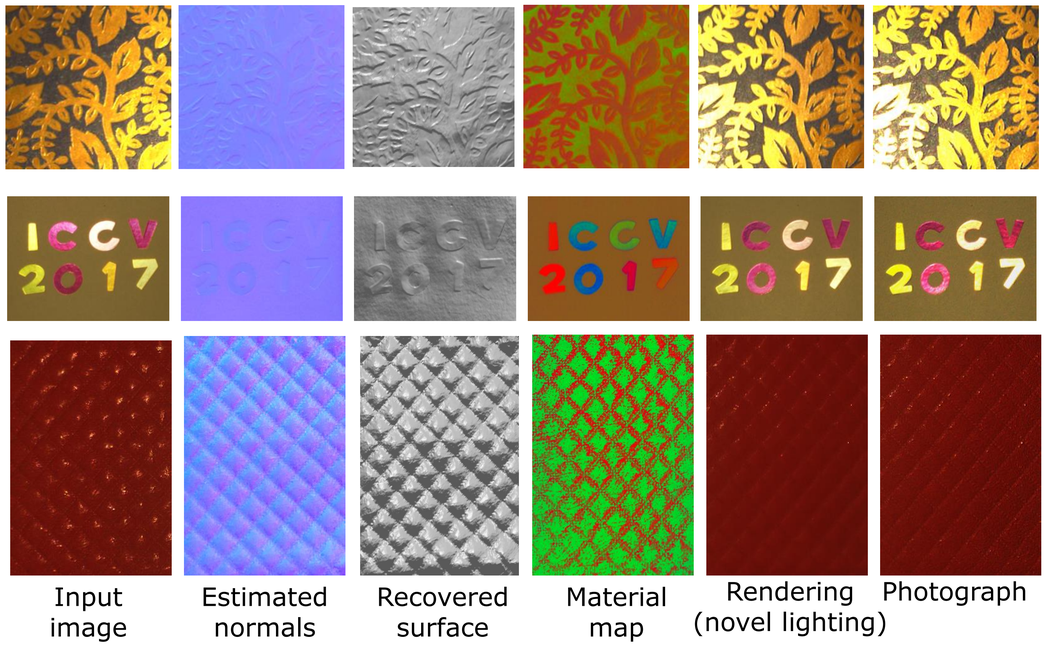


$$\{\hat{\mathbf{n}}_\mathbf{p},\ \hat{\mathbf{c}}_\mathbf{p}\} = \arg\min_{\{\mathbf{c}\geq 0,\mathbf{n}\}} \|\mathbf{I}_\mathbf{p} - B(\mathbf{n}, \mathbf{l}_\mathbf{p}, \mathbf{v}_\mathbf{p})\mathbf{c}\|_2^2$$

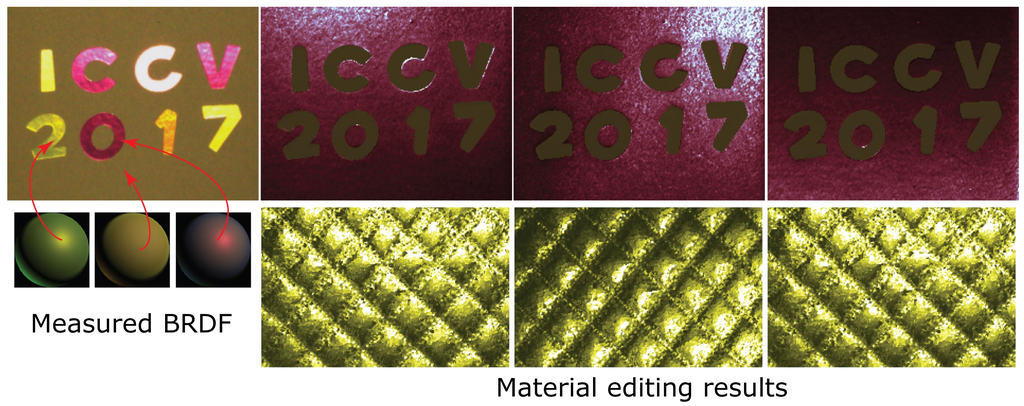
- $B(\mathbf{n}, \mathbf{l}_\mathbf{p}, \mathbf{v}_\mathbf{p})$: BRDF dictionary where each column is BRDF measurements of one material from MERL database
- Lighting/view directions $(\mathbf{l}_\mathbf{p}, \mathbf{v}_\mathbf{p})$ calibrated from images
- First, identify exemplars materials on sample by enforcing sparsity in BRDF coefficients
- Then, iteratively recover SVBRDF and normals by minimizing objective function:
  - Initialize with flat surface, update coefficients
  - Fix coefficients, update surface normals
- Complete BRDFs reconstructed by applying coefficients to BRDF dictionary

Results on iPhone 6s

Shape and reflectance estimation



Material editing



Material trait analysis