High-Resolution BTF Capture for delicate Materials

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Bidirectional Texture Functions are data-driven appearance models that can accurately reproduce the visual appearance of real-world materials. Practically, BTFs are stored as a stack of 2-dimensional textures that correspond to a material's appearance at a given set of light and view directions.
A typical BTF dataset contains up to tens of thousands of light-view combinations, which makes them tedious to acquire. Different BTF measurement setups have been proposed (ranging from camera arrays to mirror-based or kaleidoscopic systems), balancing hardware, acquisition time and computation costs in different ways. We present a custom system with unique properties, developed for a commercial project.

Our BTF acquisition device

Design

The device is located on vibration-isolating mounts in a dark room, and building materials are chosen such as to minimize stray light reflections. The system is designed to scan flat 10×10 cm material samples that the sample frame holds down.

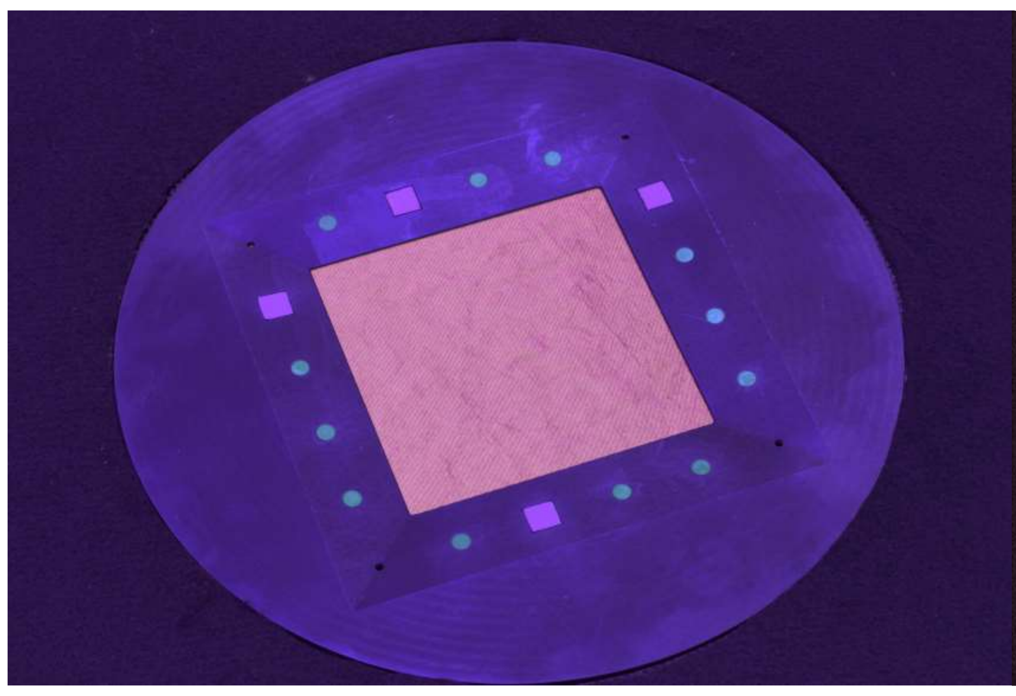
Two computer-controlled arms respectively carry a camera and a light source, and travel on a circular rail around a flat platform. Via inclination of the arms, the camera and light can reach any position on the hemisphere above the platform, down to 5 degrees elevation above the sample holder's plane.

- Canon EOS 5DS R 50-megapixel camera at 902 mm from the sample center
- Canon EF 100mm f/2.8L lens
- Smart Vision SXA30-WHI LED light source at 757 mm from the sample center
- Min. 5 degrees arc distance between LED and camera to avoid occluding the view

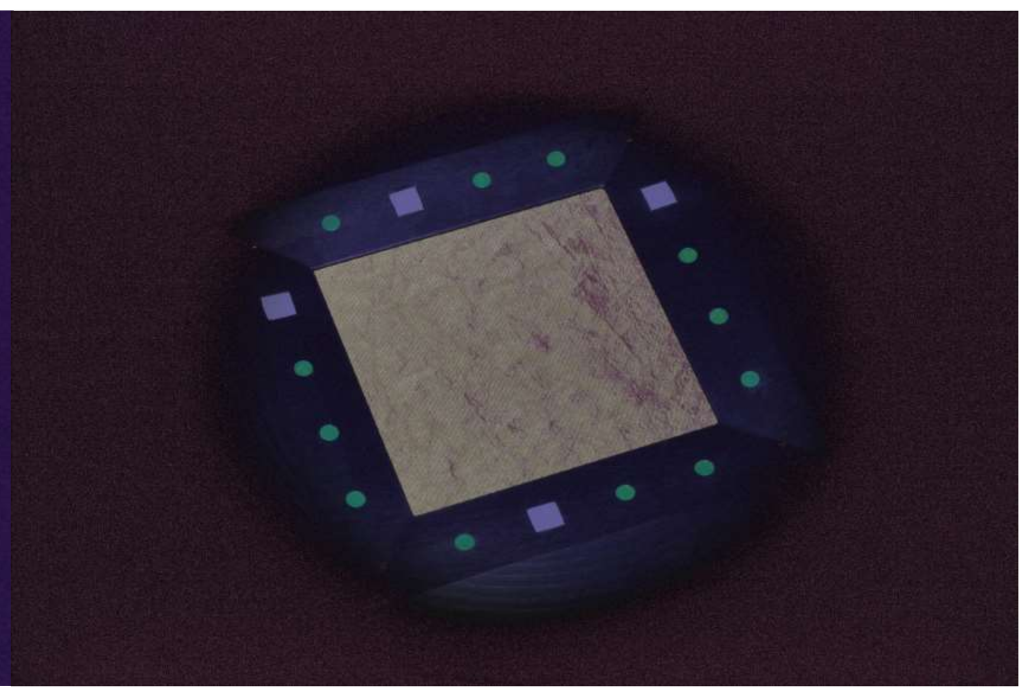
Acquisition

At every combination of light/camera positions, the system takes one image with programmable, diffuse ceiling lighting, one HDR measurement with the LED light and optionally one measurement in the dark, for situations where stray light might be expected. The ceiling light image is used to estimate the camera pose using the green targets. We separately also acquire photographs of a color checker, a Spectralon, and a checkerboard for intrinsic and radiometric calibration of the camera.

BTF datasets at an angular resolution of 40×40 view/light direction combinations take around 11 hours to acquire. Pixel resolution reaches up to 37 µm at orthogonal views.



With diffuse ceiling lighting

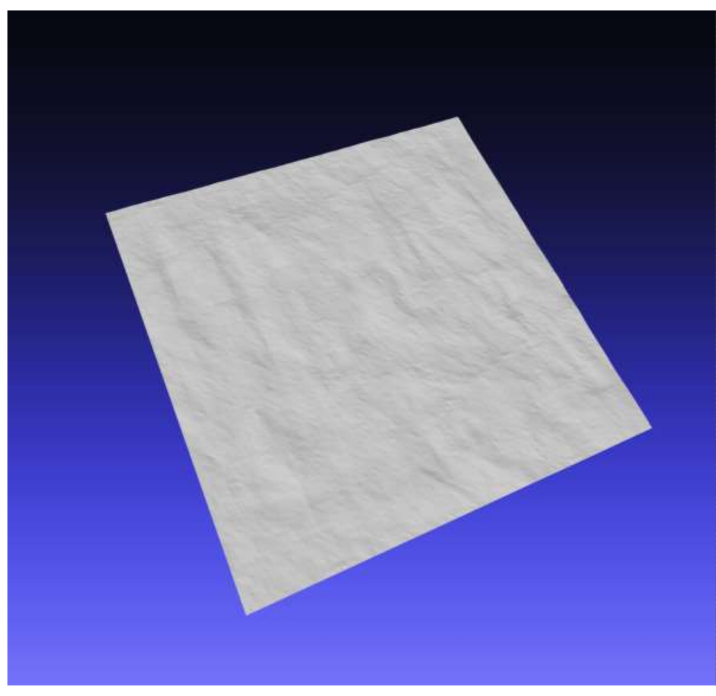


With directional LED lighting

Processing

Processing raw BTF data involves many calibration and rectification steps (HDR merging, radiometric calibration, camera intrinsics compensation, perspective unwarping).

Since the samples are not perfectly flat, we use the uniformly lit images to reconstruct a surface height field using a multi-view stereo algorithm. This surface proxy is then used to extract and unwarp the textures onto a square grid with minimal parallax (see below).



Estimated surface

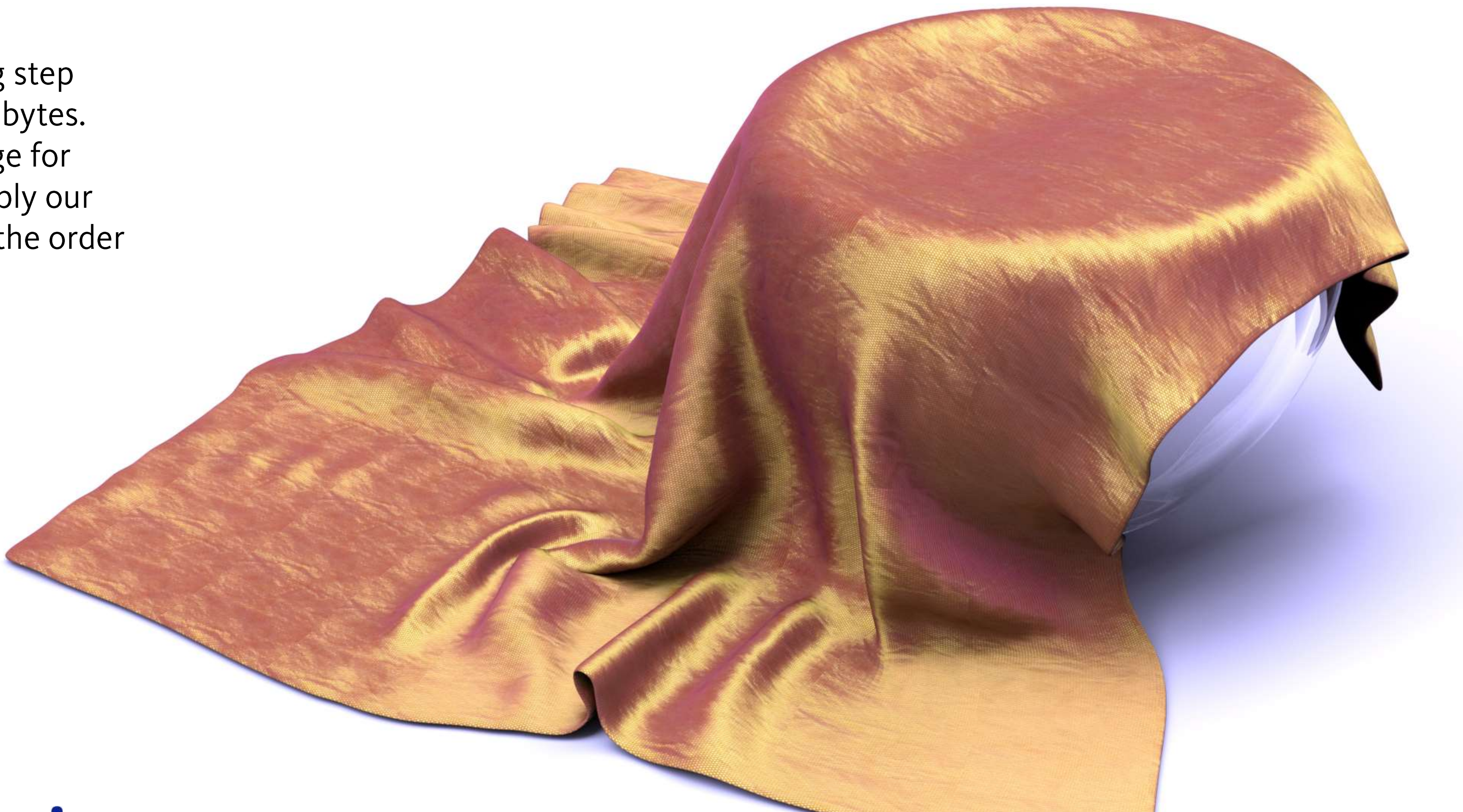
Final processed texture

Results

Raw BTF data is in the order of Terabytes. The processing step (texture extraction) reduces the size to the order of Gigabytes. Since the resulting dataset still takes up too much storage for easy transmission and practical rendering, we further apply our custom lossy compression scheme to reduce the size to the order of one Megabyte.

Future Work

Currently, the main limitation of the system is the low illumination, which explains the long acquisition times due to high shutter times. We can address this by increasing the ISO, however this in turn creates noisier measurements.
A stronger light source would allow quicker and clearer measurements and hence a denser sampling of the light and view hemispheres in the same duration.



Rendering in Mitsuba

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