Position-Free Monte Carlo Simulation for Arbitrary Layered BSDFs

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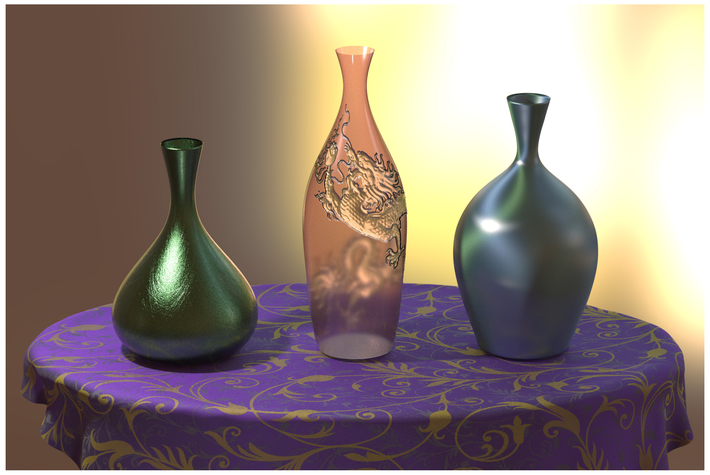
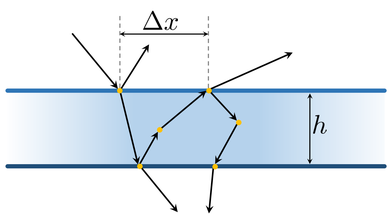
Introduction



In this paper, we introduced a new BSDF model to capture the appearance of layered materials. Inside the evaluation and sampling routines of the layered BSDF, we run a Monte Carlo simulation of light transport within flat slabs. This is substantially faster than explicitly constructing the layer geometry, but also allows constructing light transport paths that would not easily be available to a generic light transport algorithm, due to our new position-free path formulation.

Within this framework, we introduced unbiased Monte Carlo techniques analogous to a forward path tracer with next event estimation (NEE) and a fully bidirectional estimator. We demonstrated the capabilities of our solution on a number of examples, featuring multiple layers with surface and volumetric scattering, surface and phase function anisotropy, and spatial variation in all parameters. This leads to the first BSDF layering solution that offers unbiased accuracy and full flexibility in setting the layer properties.

Assumption

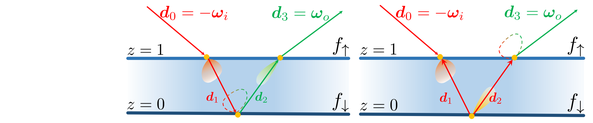


Small displacement assumption: Since the geometric thickness h of the layer is small, we assume the displacements (e.g., Δx) of light's entrance and departure locations can be neglected.

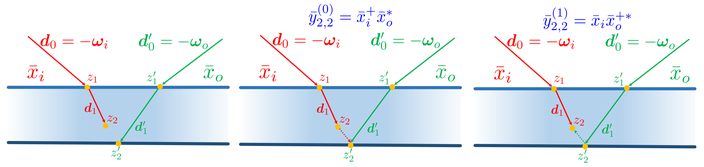
Methods

BSDF sampling: Forward path tracing in flat slab configuration

BSDF evaluation:

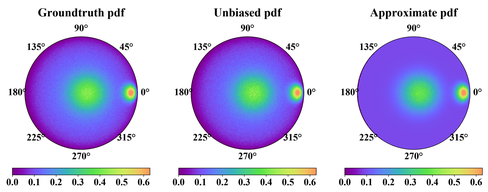


Unidirectional estimator



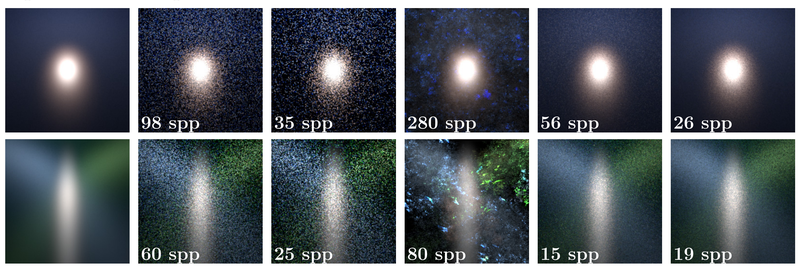
Bidirectional estimator

Pdf estimation:



Comparison

Equal-time comparison:

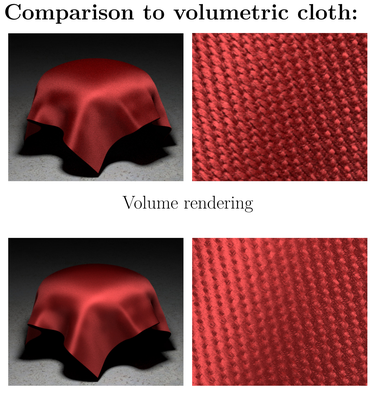


Reference PT BDPT MLT Our uni-dir Our bi-dir

Comparison to previous work:

Ours [Zeltner 2018] [Belcour 2018]

Comparison to volumetric cloth:



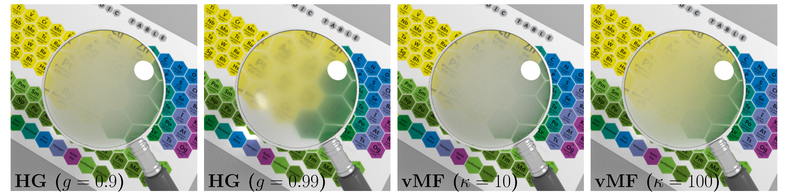
Volume rendering

Our BSDF + fiber-direction map

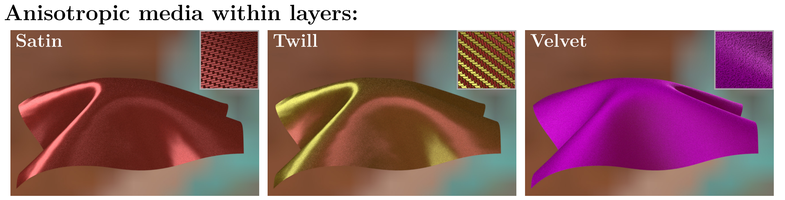
More results

Transmission (Spectrally varying optical densities):

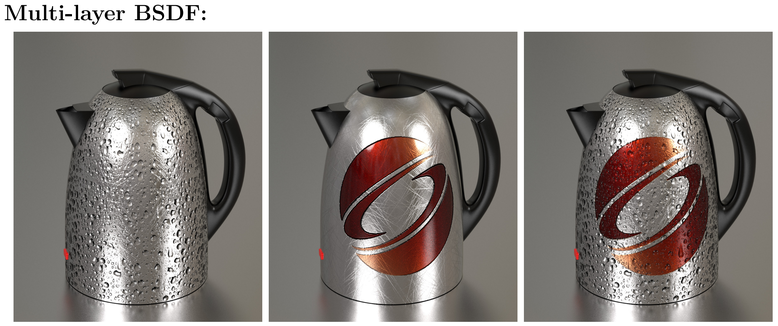
Transmission (Different phase function):



Anisotropic media within layers:



Multi-layer BSDF:



References

[1] Tizian Zeltner and Wenzel Jakob.
The layer laboratory: A calculus for additive and subtractive composition of anisotropic surface reflectance.
ACM Trans. Graph., 2018.

[2] Laurent Belcour.
Efficient rendering of layered materials using an atomic decomposition with statistical operators.
ACM Trans. Graph., 2018.