A Data-Driven BSDF Framework

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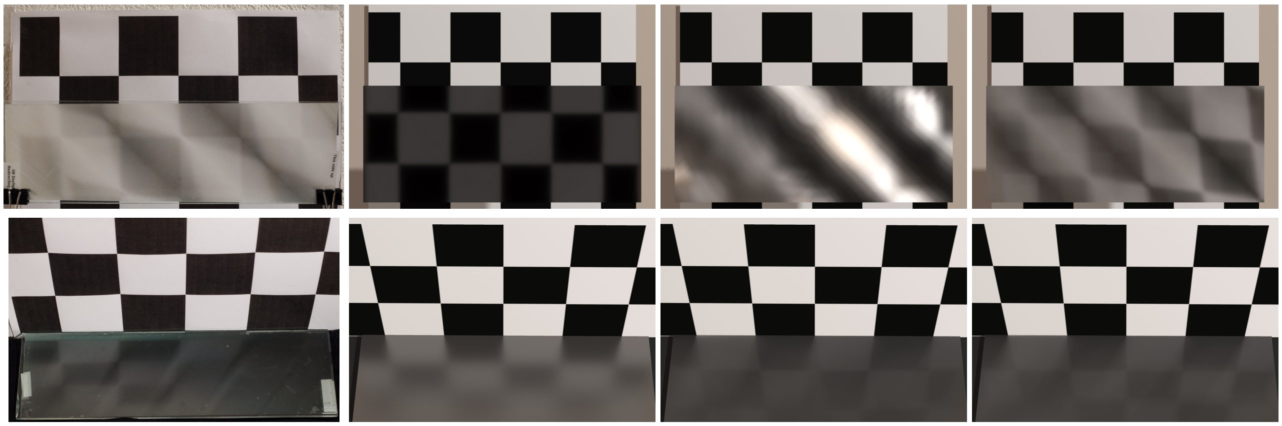

(a) Photograph (b) Walter et al.'s model (c) Linear interpolation (d) Our method

Figure 1: *We qualitatively validate our BSDF framework (d) using a measured BSDF and two photographs (a). This translucent material is a daylight redirecting film (by 3M), shown at normal incidence to show light transmission (top row) and grazing angle for specular reflection (bottom). We compare with Walter et al.'s [2007] BSDF model (b) and linear interpolation (c).*

Abstract

We present a data-driven Bidirectional Scattering Distribution Function (BSDF) representation and a model-free technique that preserves the integrity of the original data and interpolates reflection as well as transmission functions for arbitrary materials. Our interpolation technique employs Radial Basis Functions (RBFs), Radial Basis Systems (RBSs) and displacement techniques to track peaks in the distribution. The proposed data-driven BSDF representation can be used to render arbitrary BSDFs and includes an efficient Monte Carlo importance sampling scheme. We show that our data-driven BSDF framework can be used to represent measured BSDFs that are visually plausible and demonstrably accurate.

Keywords: BSDF, appearance modeling, data interpolation, global illumination, rendering.

Concepts: •**Computing methodologies** → **Rendering; Reflectance modeling; Modeling and simulation;**

1 Introduction

Optically thin, translucent materials are represented by Bidirectional Scattering Distribution Functions (BSDFs) in computer graphics. Although compact analytical BSDF models [Walter et al. 2007] for isotropic translucent materials exist, no comprehensive data-driven BSDF framework for both isotropic and anisotropic translucent materials has been presented. Such a BSDF framework is especially needed when material measurements do not fit the available analytical models. Making dense measurements is time consuming, particularly for anisotropic materials. Handling sparse measurements is a challenge since data-driven representations require dense measurements. In this work, we present a complete BSDF framework that reconstructs sparse measurements and represents arbitrary BSDFs. Our data-driven framework includes a tensor-tree BSDF representation [Ward et al. 2012] and an interpolation technique [Ward et al. 2014]. We compare our framework against ground truth and well-known representations, and show that our representation for measured BSDFs is accurate.

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2 Our Data-Driven BSDF Framework

Our Interpolation Technique: Our technique [Ward et al. 2014] handles sparse, irregular BSDF measurements in three stages. First, we fit a sum of Gaussian lobes to the reflected BSDFs for each incident direction. Since each Gaussian lobe is a RBF, we call our sum of Gaussian lobes a RBS. Second, we construct a spherical Delaunay triangulation of the incident directions. Third, we compute a transport plan for shifting RBS in the first vertex to RBS in the second vertex for each edge of the triangulation [Bonneel et al. 2011]. We also use a method similar to nested linear interpolation of the transport plan for interpolating inside the triangles of this mesh as well. This technique allows us to interpolate between sparse incident directions, arriving at a continuous, complete, smooth description of the BSDF over the entire $4D$ BSDF domain.

Our BSDF Representation: By using our interpolation, we generate $3D$ (i.e., rank-3 tensor) and $4D$ (i.e., rank-4 tensor) BSDF data for representing isotropic and anisotropic materials, respectively. Then, we represent this BSDF data using a "tensor tree" [Ward et al. 2012] which reproduces highly peaked data accurately and benefits from an efficient Monte Carlo importance sampling scheme. In this process, we use Shirley and Chiu's area-preserving map between our tensor-tree and the hemisphere, and a Hilbert traversal for efficient importance sampling. As seen in Figure 1, our data-driven framework represents measured BSDFs accurately.

Finally, we see our BSDF framework in a larger context for loading, interpolating, representing and rendering measured BSDF data.

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