Real-time Wavelength-Dependent Rendering Pipeline

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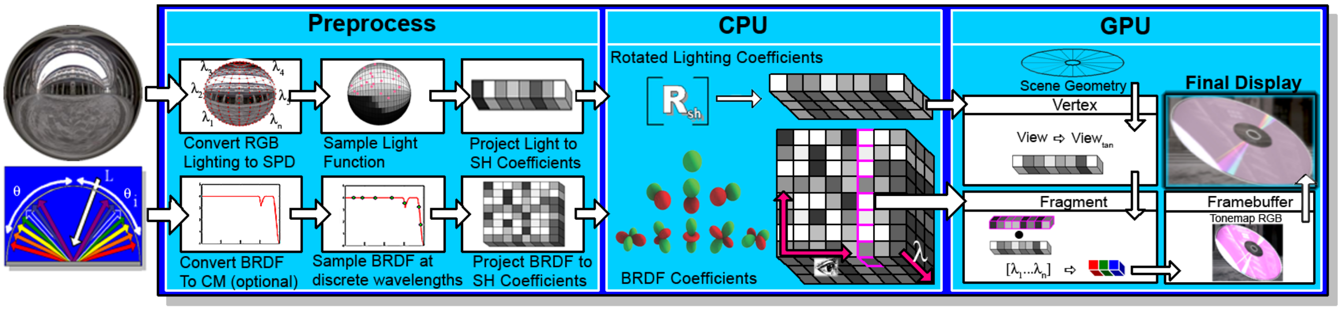

Figure 1: Input to the pipeline is a RGB lighting environment and wavelength-dependent BRDF. The input is preprocessed, transfered and rotated on the CPU, then rendered on the GPU.

1 Introduction

Iridescent colors such as diffraction, thin film interference, dispersive refraction and scattering are produced by wavelength-dependent Bi-directional Reflectance Distribution Functions (BRDFs). Due to expensive per-wavelength sampling required, rendering wavelength-dependent BRDFs have historically been restricted to offline rendering techniques or real-time techniques that use color ramps and simplified BRDFs. We present a generalized real-time pipeline for physically accurate wavelength dependent phenomena that is independent of sampling cost, uses a wavelength-based color, and supports High Dynamic Range (HDR). Our pipeline converts the lighting environment and BRDF to per-wavelength Spherical Harmonics (SH) coefficients, rotates and uploads them to the rendering framework, then interactively renders the lighting integral with traditional scene geometry.

2 Wavelength-dependent Pipeline

Our pipeline has three stages, preprocessing, transfer and rotation, and rendering. We preprocess lighting and BRDF information in the form of SH coefficients. At run time the SH coefficients are used in the rendering framework to calculate the lighting integral.

Preprocess: The first step of the preprocess stage is converting the lighting environments from RGB to a wavelength-based color representation. Each texel of the lighting environment (example in Fig. 1 uses a HDR light probe) is replaced with a Spectral Power Distribution. High frequency BRDFs, such as diffraction, additionally require conversion to the Composite Model wavelength representation for more compact storage of its narrow intensity spikes. Both the lighting and BRDF functions are then sampled. The final task of the preprocessing stage is to project the sampled lighting and BRDF functions to SH coefficients. SH coefficients are the final representation of the lighting and BRDF, where each color channel is encoded and subsequently uploaded to the rendering framework.

Rotation and Transfer: Prior to uploading the lighting coefficients to the rendering framework, rotation of the coefficients is performed in order to ensure they are in a consistent frame of reference with the BRDF coefficients.

Rendering: Our rendering stage consists of three discreet operations, which are modeled after traditional scene rendering operations and maps to vertex, fragment, and framebuffer operations. The vertex operation is unmodified from traditional rendering. It is primarily used for transferring appropriate scene data and lighting coefficients to the per fragment stage. In the fragment stage we calculate the lighting integral using the dot product of the lighting and view-dependent BRDF coefficients. The framebuffer operation completes the transition from wavelength color to a displayable format. The RGB color values from the fragment operation have a High Dynamic Range (unclamped) and thus a tonemapping operation is required to map them to a displayable range.

3 Results

Our pipeline is general enough to render most forms of wavelength-dependent iridescent color in real time. Figure 2 shows examples renderings of physically accurate diffraction and interference.

References

LINDSAY, C., AND AGU, E., 2005. Wavelength dependent rendering using spherical harmonics. in Proc. Eurographics, July.

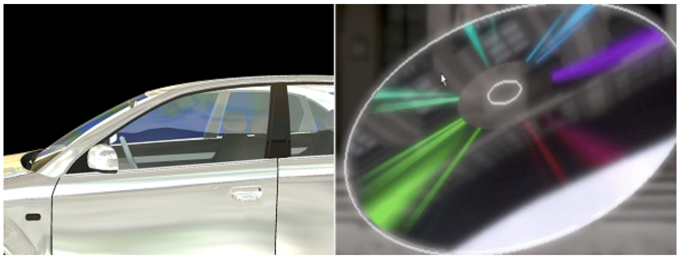

Figure 2: Interference (left), CDROM diffraction (right)

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