Towards a Physically Plausible Constrained Shader Graph System for Predictive Rendering

Ivo Pavlík[†], Alexander Wilkie[‡]

Charles University in Prague

Abstract

We present ongoing work on a modeling tool for Predictive Rendering based on the popular idea of shader graphs for description of object surfaces. To guarantee physical plausibility of the resulting materials, we use a restricted approach that only allows us to build the shader graphs by using physically safe surface models and physically safe manipulation operators. The tool also allows us to manipulate material properties – fluorescence and polarisation – which can affect object appearance, but are usually missing in other modeling toolsets. Since there is a rising demand for realism of the modelled material appearance among CG content creators, the concept of a restricted shader graph is also useful in the context of common photorealistic renderers.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—I.3.5 [Computer Graphics]: Physically based modeling—I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—

1. Introduction

Shading languages are powerful content creation tools that are in ubiquitous use within the mainstream realistic graphics industry. From the predictive rendering [Wil07] viewpoint, however, they provide the content creators with too much freedom, because the language constructs they can create are too hard to verify as being physically plausible. Shader graphs, on the other hand, represent a more high-level approach to the modeling process, as they restrict the user to combinations of pre-defined surface models, pattern-generation elements and other building blocks. They also prevent the user from using low-level functionality of shading languages to interfere with the rendering algorithms while still allowing creative content generation.

Since the shader graph approach hides some of the expressivity that can be potentially harmful in terms of physical plausibility, it is more appropriate for predictive rendering purposes than a full-fledged shading language. Contemporary shader graph modeling systems, however, are not designed with predictive rendering in mind. They do not guarantee physical plausibility of the resulting models and do not include manipulation of certain features which affect the appearance of materials, namely fluorescence and polarization. In this poster we present a modeling system which addresses these problems.

2. Physical Plausibility

There are two main ways of asserting the physical plausibility of a material described by a shader: to examine the material properties after they were modelled, or to restrict the toolset so that physically implausible materials cannot be created in the first place. The first approach is problematic because the tests are very time-consuming (e.g. checking many combinations of input and output ray directions would be necessary), complex (several physical properties have to be asserted), and not necessarily conclusive (e.g. there is an infinite number of possible input and output ray directions, so they cannot be fully examined). Moreover, even if such a test suite were possible to build and if it were to detect a problem, there is often no obvious way to fix an offending shader while retaining its intended functionality.

In this poster, we present our work on a modeling tool which is based on the restrictive approach: we allow the user

† e-mail: ivo.pavlik@gmail.com
‡ e-mail: wilkie@cgg.mff.cuni.cz

© The Eurographics Association 2013.

DOI: 10.2312/conf/EG2013/posters/001-002

delivered by EUROGRAPHICS DIGITAL LIBRARY www.eg.org diglib.eg.org

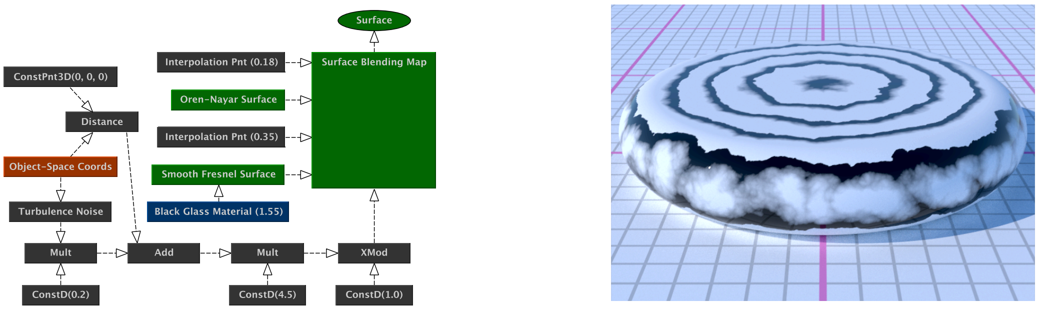

Figure 1: *A simple shader graph built using safe constructs blends between two basic surface models (Oren-Nayar and Fresnel on black glass material) according to a procedurally defined circular pattern and the resulting material rendered in our system.*

to only use safe building blocks and safe operations on them to build the shader graph. The user can choose from a set of pre-defined analytical surface models with physically plausible behaviour. These can be combined via safe blending operators into surface models with a more complex behaviour. We also provide tools for definition of textures which both surface models and their operators can be controlled by. An example of a simple safe shader graph and the resulting surface is shown in the Figure 1.

3. Material Properties

Our system is a hybrid that is capable of running as either a colourspace or a spectral renderer. The input data can be either synthetic values or measured colours or spectral data. In order to support polarisation and fluorescence, we must use special representations for both light and light attenuation. When polarisation support is activated, we represent each wavelength of light using a Stokes vector containing both light intensity and light polarisation state, while light attenuation of each wavelength is represented via a Mueller matrix that encodes attenuation and changes to polarisation state of incident light [Gol10]. To represent fluorescent behaviour, an energy re-radiation matrix has to be added to the internal light attenuation data structure when necessary.

Although more complicated internally, most of the non-standard technical details of our modeling system can be safely and conveniently hidden from the user. For example, the colour data can be entered in any possible form which the system permits (grayscale, various RGB and spectral modes) and are automatically converted into a representation needed for the selected colour mode of the rendering system before rendering. Fluorescent behaviour can be manipulated via colour parameters of surface models. Similarly polarisation, which is an intrinsic property of each particular surface model, can only be manipulated indirectly by the choice of a surface model and its parameters.

4. Current Progress

Our system is based on a library of materials that are known to be physically based, such as Torrance-Sparrow, Oren-Nayar, Smooth Fresnel, or He-Torrance-Sillion-Greenberg model. A linear blending operation and microfacet material layering [WW07] are available for the creation of more complex models. We already have implemented a significant subset of necessary tools for procedural patterns creation.

Currently the user can manipulate graphs via easy-to-operate Objective-C interface; however, it is possible to wrap the whole functionality into a usual graphical interface for more convenience in the future.

5. Conclusion and Future Work

Via our restricted graph modeling system, the user can safely model scenes for used in predictive rendering. They are guaranteed to be physically plausible with the additional possibility to manipulate fluorescence and polarisation behaviour. Moreover, since there is a rising demand for realism of the modelled material appearance among CG content creators, the concept of a restricted shader graph can also can be applicable in the context of the common photorealistic renderers.

In the future, we plan to extend our toolset with the ability to use measured image-based texture data to feed the material models. We also plan to investigate possibilities of adding user-defined surface models which will be guaranteed to be physically plausible and to explore the possibilities to assure that the resulting materials are not only physically plausible, but also manufacturable.

References

[Gol10] GOLDSTEIN D.: *Polarized Light, Third Edition*. Optical Engineering. Marcel Dekker, 2010. 2

[Wil07] WILKIE A.: *Predictive Image Synthesis*. PhD thesis, Technischen Universität Wien, 2007. 1

[WW07] WEIDLICH A., WILKIE A.: Arbitrarily layered microfacet surfaces. In *GRAPHITE 2007* (Dec. 2007), ACM. 2

© The Eurographics Association 2013.