Lighting and Rendering *Alice in Wonderland*

Adam Martinez Terrance Tornberg
Sony Pictures Imageworks

Introduction

Recent films such as *Cloudy with a Chance of Meatballs*, *2012* and *Alice in Wonderland* (*Alice*) have represented dramatic changes in the way Sony Pictures Imageworks produces imagery. We have moved away from the traditional biased, multi-pass rendering system to a largely single-pass, global illumination system incorporating modern ray-tracing and physically based shading techniques. We will discuss how these changes applied to our work on *Alice*, and look at specific examples from the film. Topics discussed will include: motivations behind moving to a physically based rendering system and how such motivations would ideally manifest, micro-facet illumination models, global illumination and layered materials. We will talk about the impact of these developments on our creative approach and lighting procedures in production, as well as some of the unintended consequences of these changes.

1. Historical Background

For projects as recent as *Watchmen*, Sony Pictures Imageworks employed a rendering system that does not natively account for global illumination effects. This system was heavily pass-dependant: shadows were depth-mapped, color bleeding came from point clouds, and reflection or environment occlusion was rendered in a separate pass, often in a separate renderer. Biased techniques such as shadow map and point cloud generation meant smaller sub-pipelines had to be developed and maintained. These techniques are largely phenomenological and physically inaccurate. Fidelity of the final result was subject to the quality of the passes that were generated previously. In addition, there was an enormous potential for version mismatches between separate passes. Over the long term, this means more passes and more time devoted to managing those passes.

1.1 Arnold Renderer

Imageworks' internal global illumination renderer, Arnold, was largely considered an experimental and utility renderer. The facility moved it into production as the primary renderer for *Cloudy with a Chance of Meatballs* and proved it could handle the volume of data required for a large project.

The decision to use Arnold on *Alice* was not taken lightly. This would mean a considerable commitment of development resources to author a pipeline to meet the needs of a large visual effects project. A massive educational effort also had to be undertaken as a lot of the practices from the previous system were no longer applicable.

2. Arnold in Wonderland

For *Alice*, there was a strong desire to leverage the power of the ray tracer to implement a physically based shading system, but also to expand the capabilities of the shading system during the look development stage. This coincided with a facility mandate to provide photo-realistic results out of the gate. Previously, realism was difficult to control, and maintain, in the face of creative demands. Supervisors wanted a system that would allow them to start the creative process sooner, and maintain a consistent level of realism.

We implemented three key techniques to meet these goals:

2.1 Shading

For *Alice* we began with a direct implementation of the BSDF and Monte-Carlo sampling functions as presented in [WALTER07]. This gave us out-of-the-box coherency between the direct specular highlights and traced glossy reflections and refractions. These physically plausible shading models provided users a very realistic look with limited parameterization. Our implementation also allowed us to easily deploy multiple importance sampling techniques to reduce noise in final images [VEACH97].

2.2 Material Layering

We created a generalized methodology for arbitrarily layering discrete materials. This afforded a previously unavailable level of flexibility and experimentation in the look development process. While material layering has been implemented in commercial applications for a long time, the potential for added computational expense makes it a rare occurrence in feature film production. Our approach allowed artists to create separate materials with entirely distinct settings, such as metal, paint, glass or dirt. Artists could then composite these materials in an intuitive manner while preserving consistent behavior and reducing computational overhead.

2.3 Workflow

Ray tracing and physically based shading techniques had a significant impact on the workflow of look development and shot lighting. A key distinction was turning away from the traditional composition of materials as a function of highlight size and shape. Instead, there was new emphasis on surface roughness and dielectric response. Look developers were constructing materials in a manner more consistent with the behavior of materials in the real world. Highlight size, shadow softness and diffuse illumination "wrap" were all functions of the area light source size, rather than a property of the material.

First takes of assets and shots had the full complement of shading effects out of the box. Color bleed, traced reflections, refractions and soft shadowed area lights with corresponding specular highlights were all part of the first render. Consistent material behavior meant that lighters focused on lighting to the sequence more than to the individual shot, allowing creative feedback to begin earlier.

3. REFERENCES

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