Path Tracing in Production Part 2: Making Movies

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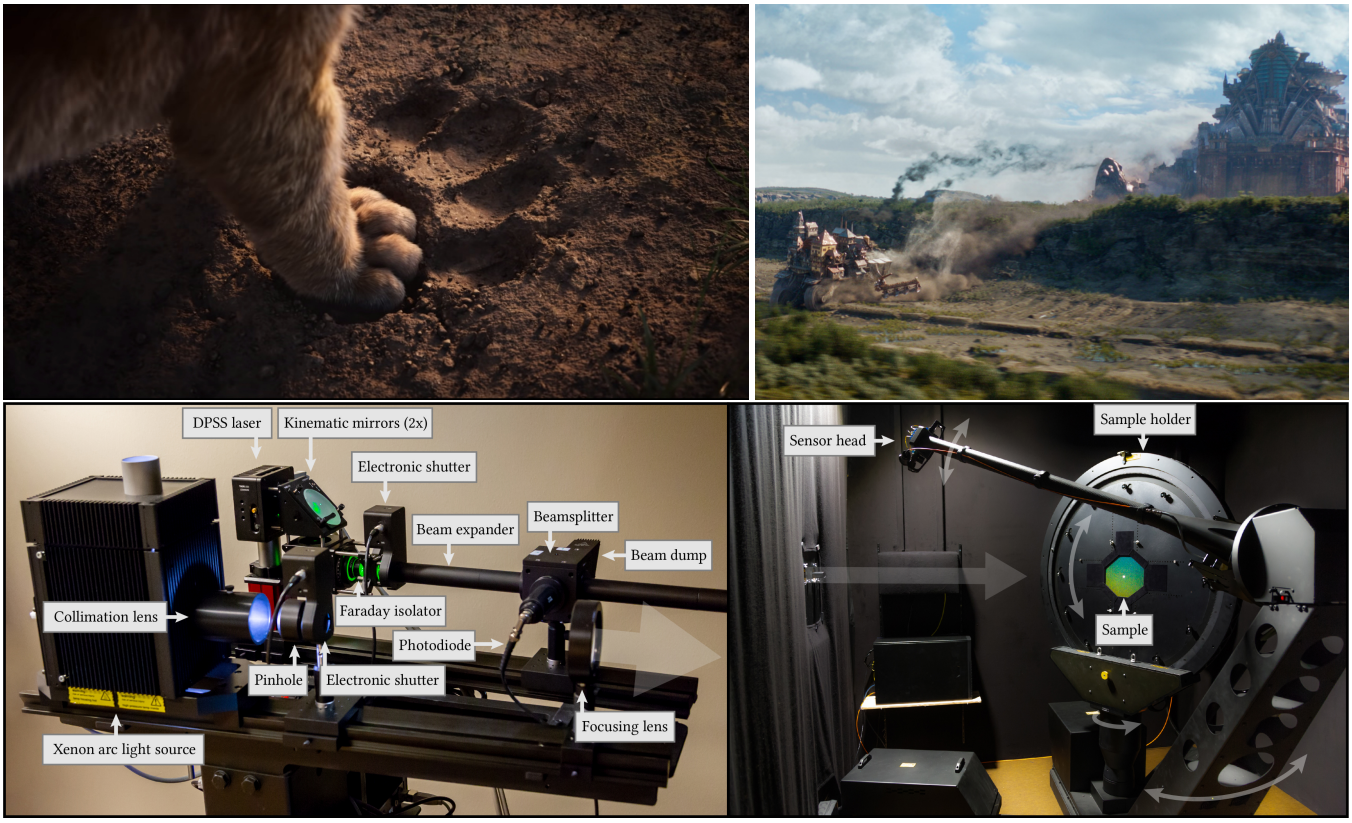

Figure 1: Top row: two images from recent movie productions, showcasing difficult light transport in fur and dust, as well as high geometric complexity, atmospherics and volumetric scattering. Left: *The Lion King*, image courtesy of MPC Film, ©2019 Disney. All rights reserved. Right: *Mortal Engines* ©2018 Universal Studios. All rights reserved. Bottom: Picture of *the machine* from *An Adaptive Parameterization for Efficient Material Acquisition and Rendering* by Jonathan Dupuy and Wenzel Jakob as appeared in *Transactions on Graphics (Proceedings of SIGGRAPH Asia 2018)*.

ABSTRACT

In the past few years the movie industry has switched over from stochastic rasterisation approaches to using physically based light transport simulation: path tracing in production has become ubiquitous across studios. The new approach came with undisputed advantages such as consistent lighting, progressive previews, and fresh code bases. But also abandoning 30 years of experience meant some hard cuts affecting all stages such as lighting, look development, geometric modelling, scene description formats, the way we schedule for multi-threading, just to name a few. This means there is a rich set of people involved and as an expert in one of the aspects it is easy to lose track of the big picture.

This is part II of a full-day course, and it focuses on a number of case studies from recent productions at different facilities, as well as recent development in material modeling and capturing. The

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presenters will will showcase practical efforts from recent shows spanning the range from photoreal to feature animation work, pointing out unexpected challenges encountered in new shows and unsolved problems as well as room for future work wherever appropriate.

This complements part I of the course, where context was provided for everybody interested in understanding the challenges behind writing renderers intended for movie production work, with a focus on new students and academic researchers.

KEYWORDS

path tracing, movie production

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1 "EVERYTHING THE LIGHT TOUCHES" – RENDERING *THE LION KING*

Rob Pieké

Not long after the success of *Disney*'s *The Jungle Book*, *MPC Film* began work on the retelling of another *Disney* classic: *The Lion King*. The mandate for this project was to bring realistic environments and documentary-style cinematography to the screen, requiring improvements across the board to our rendering-related technology, workflows and pipelines.

A large investment was made in revisiting the way we render fur. We drew inspiration from recent publications on fur shading, both from academic research and from other studios, generally involving looking at the components of hair at a microscopic level, and considering the main differences between long human hair and short animal fur. We overhauled our in-house shader to support longitudinal and azimuthal roughness - accentuating the cylindrical shape of hair strands - and introduced new shading lobes to simulate the scattering in a medulla core.

Rob will also touch upon other aspects of the full rendering environment such as matte painting vs. 3D geometry, deep compositing, as well as project management.

2 INTRODUCTION OF GPU PRODUCTION PATH TRACING AT DIGITAL DOMAIN

Hanzhi Tang

Starting in 2016 *Digital Domain* has been testing *GPU* rendering, trying to see how it would integrate into the production rendering pipeline smoothly. Starting from initial qualitative tests to widespread use on *Avengers: Infinity War* to final production renders on *Captain Marvel*, *Digital Domain* built a robust *GPU* rendering option that sits alongside the main CPU rendering pipeline. Hanzhi Tang will present the development challenges of both hardware and software that were encountered in this implementation of this new renderer.

3 CAPTURING AND RENDERING THE WORLD OF MATERIALS

Wenzel Jakob

One of the key ingredients of any realistic rendering system is a description of the way in which light interacts with objects, typically modeled via the *Bidirectional Reflectance Distribution Function* (BRDF). Unfortunately, real-world BRDF data remains extremely scarce due to the difficulty of acquiring it: a BRDF measurement requires scanning a four-dimensional domain at high resolution—an infeasibly time-consuming process.

In this talk, Wenzel will showcase the ongoing work at *EPFL* on assembling a large library of materials including metals, fabrics and organic substances like wood or plant leaves. The key idea to work around the curse of dimensionality is an adaptive parameterization, which automatically warps the 4D space so that most of the volume maps to "interesting" regions. Starting with a review of BRDF models and microfacet theory, Wenzel will explain the new model, as well as the optical measurement apparatus used to conduct the measurements.

4 PRODUCTION QUALITY MATERIALS

Andrea Weidlich

Recent film productions like *Mortal Engines* or *Alita: Battle Angle* exhibit an unprecedented visual richness that was unthinkable ten years ago. One key component to achieve this is a flexible but expressive material system that is capable of reproducing the complexity of real-world materials but is still simple enough so that it can be used on a large scale. Andrea will talk about material modeling in a production path tracer in general and the constraints that come about when artistically driven decisions meet a physically plausible world. She will demonstrate how a modern layer-based material system as it can be found in Weta Digital's in-house renderer Manuka influences design and look development decisions, and give examples of how it is used in production.