Rendering the darkness: Glimpse on *The LEGO Batman Movie*

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Figure 1: *The LEGO Batman Movie* rendered with *Glimpse*. ©Warner Bros Inc., The LEGO Corporation. All rights reserved.

ABSTRACT

The technical and creative challenges of *The LEGO Batman Movie* motivated many changes to rendering at *Animal Logic*. The project was the first feature animation to be entirely rendered with the studio's proprietary path-tracer, *Glimpse*. Brick-based modelling, animation and destruction techniques taken to the extents of Gotham City required extraordinary scalability and control. The desire to separate complexity from artistic intent led to the development of a novel material composition system. Lensing and lighting choices also drove technical development for efficient in-render lens distortion, depth-of-field effects and accelerated handling of thousands of city and interior lights.

CCS CONCEPTS

•Computing methodologies →Ray tracing;

KEYWORDS

ray tracing, instancing, depth of field, culling

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1 INTRODUCTION

To realize the world of *The LEGO Batman Movie* we made many improvements to the systems used to render *The LEGO Movie*[Baillet et al. 2014]. Gotham City at night is a huge and dark metropolis, filled with thousands of light sources. Artifacts and inefficiencies in compositing-based lens distortion and depth-of-field motivated us to capture these effects in-render. Previous experience and new requirements informed the development and use of our proprietary path tracer, *Glimpse*, to deliver the project.

2 GLIMPSE

Glimpse originated as an interactive lighting preview tool, which was extended to be a fast animation review renderer and indirect lighting ray-server during *The LEGO Movie*. We developed the remaining functionality for it to serve as a full production renderer, without sacrificing performance or interactivity. *Glimpse* now supports programmable shading, displacement, subdivision surfaces, curves and importance-sampled, emissive volumetrics. This general set of capabilities has made *Glimpse* our primary renderer for all projects, including non-*LEGO* based VFX projects.

3 SCENE SCALABILITY

The brick-based representation used for *The LEGO Movie*[Smith et al. 2014] was retained but applied to environments of much larger scale.

3.1 Scene Description

Glimpse employs an expressive hierarchical scene description and API for serialisation and interaction with custom editors and DCC tools such as *Maya*. Direct editing with sparse rendering updates are supported for fast interactive workflows. Edits may also be

Figure 2: Comparison of images rendered without (left) and with (right) our Energy Redistribution (ER) method. For equal render time, ER significantly reduces variance in defocused highlights. *San Miguel* scene ©Guillermo M. Leal Llaguno.

expressed as separate overrides to support referencing and pipeline workflows.

3.2 Building and Editing Gotham City

Using hierarchical instancing we exploit repetition at both the brick level and in aggregation (e.g. levels of buildings and entire buildings) for city environments. Our edit-aware instancing system automatically optimizes the scene to minimise duplication without requiring changes to the user-facing scene hierarchy. *Glimpse* provides a fast ray-traced viewport for Maya which allows direct manipulation of vast scenes in this efficient representation.

4 MATERIAL COMPOSITION

A novel, component-based material composition system enables concise shader definition, editing, and assignment in complex scenes. Materials are composed through hierarchical shading graph layering and parameter substitution. This separates scene complexity from artistic intent and maximizes shader reuse, e.g. in-situ effects such as a sparse layer of dust may be applied as a single high-level shader layer, independent of the geometry and shading structure of the affected objects.

5 LENS EFFECTS

Post-render lens effects used on previous projects suffered from artifacts, leading us to support efficient in-render lens effects in *Glimpse*.

5.1 Lens Model

The extremely wide, distorted lens characteristics chosen for this project led us to implement an in-render parametric lens model. This avoids over-rendering and excessive image filtering associated with post-render distortion. Our model also simulates optical defocus, avoiding shortcomings of post-render depth-of-field, such as edge artifacts and manual render layering.

5.2 Energy Redistribution Depth-of-Field

The look of *The LEGO Batman Movie* required shallow depth-of-field, shiny plastic, and small lights. This lead to many bright, out-of-focus highlights, which are notoriously hard to resolve with unidirectional path tracing. To render these effects, we implemented a novel technique inspired by Energy Redistribution Path Tracing[Cline et al. 2005]. In concert with adaptive sampling, we identify bright highlights found during conventional path tracing and project them onto the image through the defocused distorted lens mapping. Our method has significantly less variance than standard unidirectional path tracing, as shown in Figure 2.

6 LIGHT PLACEMENT AND CULLING

Our lighting artists typically placed thousands of lights to achieve the appearance of realistic lights integrated into a large *LEGO* scene comprising a metropolis. In addition, by leveraging the repetitive structure due to reuse of models and bricks, small light rigs matching the models in the scene were procedurally applied with variation. The result were scenes with over 20,000 lights causing long render times and increased noise. To remedy these issues, we added an adaptive light culling technique that cuts down the average number of evaluated lights based on location and direction of the lights as well as the materials of the bricks. With very minimal impact on the visual end result we were able to significantly reduce render times with just a few seconds overhead for the actual culling algorithm.

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