Automated light probes from capture to render for *Peter Rabbit*

Daniel Heckenberg
Animal Logic
danielh@al.com.au

Steve Agland
Animal Logic
stevea@al.com.au

Jean Pascal leBlanc
Animal Logic
jpascall@al.com.au

Raphael Barth
INDIECAM
raphael@indiecam.com

Figure 1: (a) Tone mapped HDR light probe image from the set of *Peter Rabbit*; (b) Customised *INDIECAM nakedEYE* camera

ABSTRACT

We created an efficient pipeline for automated, HDR light probes for the hybrid live-action / animated feature film *Peter Rabbit*. A specially developed "360°" spherical camera allows on-set acquisition at more positions and in less time than traditional techniques. Reduced capture time, drastically simplified stitching and a custom multiple-exposure raw to HDR process minimizes artefacts in the resulting images. A semi-automated system recovers clipped radiance in direct sunlight using surfaces with known properties. By recording capture location and orientation and combining with other scene data we produce automated rendering setups using the light probes for illumination and projection onto 3d render geometry.

CCS CONCEPTS

•Computing methodologies →Computer graphics;

KEYWORDS

light probes, HDRI, VFX automation

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1 INTRODUCTION

We pursued twin goals for our light probe pipeline. Beyond a workflow for lighting artists to finesse light probe maps for their shots, we used the probes for image-based lighting in automated review renders for upstream departments like layout and animation. We automated generation of maps, assignment to shots, matching to plate exposure and color, and orientation such that realistically-lit CG characters would be integrated into live action plates with minimal human intervention. This required consistent and automated on-set capture with sufficient metadata and exploiting certain tricks during ingest and processing.

2 ACQUISITION

To efficiently capture high quality light probes we used a custom "360°" spherical camera. Exposing full spherical images rather than multiple views taken at different times minimises stitching complexity and artefacts due to scene movement. It also reduces overall capture time. This allows for more light probes to be gathered, with less on-set disruption. In practice this means better spatial coverage and even the possibility of scene reconstruction through disparity. In situations outdoors or with changing lighting conditions, it affords more frequent light probe capture to better match shot takes.

2.1 Hardware Setup

Working with the manufacturer, we obtained a modified *nakedEYE* camera[INDIECAM 2016]. *INDIECAM* developed custom recording software to very quickly capture exposure-duration bracketed images in 12-bit raw DNG format. This camera (fig. 1) uses two synchronised sensors mounted back to back, each with a 250° fisheye lens. A separate recording unit controls the compact camera head and is in turn operated via a wireless iPad interface. We ruggedized the system for outdoor use and added reference targets in the form of the grey case and a color chart. An attached GPS unit allows position metadata to be embedded.

2.2 Camera Configuration

A single camera configuration was used for all outdoor takes for maximum efficiency of operation on-set. The compromise between total duration and exposure range chosen was 16 exposures, one stop apart, from 1/16000 to 2 seconds using 4 stop neutral density filters. This allowed reliable capture of light probes at different times of day and in different sky conditions with unclipped exposure except for the sun itself.

2.3 Capture Workflow

By avoiding any physical camera movement or operator interaction we were able to reduce capture time dramatically. Total duration of capture for the chosen configuration is under 14s, compared to our previous average of around two minutes using a DSLR and nodal tripod mount. The compact camera head and lack of any physical operation allowed light probes to be captured in positions that would have been impossible with traditional methods. This was particularly important to capture local lighting conditions in the positions our small CG rabbits occupy.

3 INGEST AND PROCESSING

The raw camera data is ingested in bulk and processed into renderer-ready HDR maps. This process is fully automated, primarily in The Foundry's *Nuke*, allowing reprocessing by an artist later if necessary.

3.1 Merging and Stitching

Raw DNG outputs from the *nakedEYE* were converted to *ACES* EXR with the raw sensor data preserved in an auxilliary channel. This was used in the HDR merging process to reliably filter out near-black and saturated ("clipped") pixels prior to demosaicing and color transformation. Equirectangular reprojection was also performed in a single operation to avoid repeated resampling.

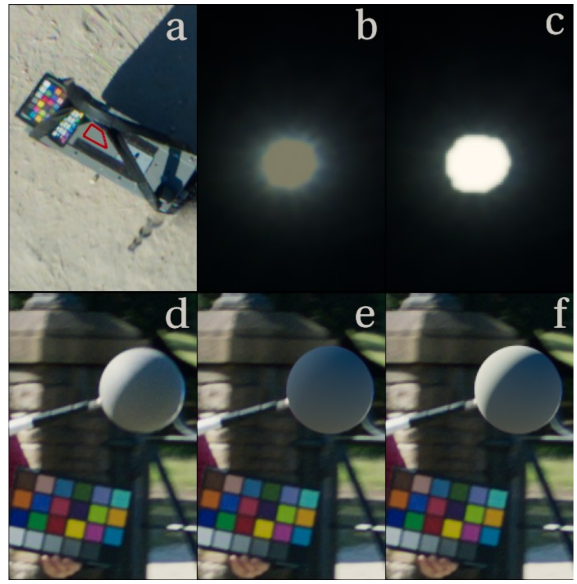

Figure 2: Sun recovery: (a) Radiance sampled from reference surface; (b) clipped sun (reduced 8 stops); (c) recovered sun; (d) reference sphere photo; (e) rendered sphere with clipped sun; (f) rendered sphere with recovered sun.

3.2 Sun Recovery

A technique similar to [Stumpfel 2004] was used to recover clipped images of the sun by exploiting the ubiquitous presence of the matte-grey case built to house the *nakedEYE.* It provided a reference surface with an assumed orientation, reflectance model and albedo. We measure the captured irradiance onto this surface by integrating over half the map. We compute the missing energy, which we add to clipped pixels, recovering direct sunlight irradiance (fig. 2).

4 USE IN RENDERING

Exposure and white balance values were recorded for both light probes and shot plates, allowing automated correction. We use the resulting maps in automated renders throughout the pipeline, both for direct image-based lighting, and for projecting along with the shot plate onto proxy geometry. This allows reviewing of work with a close-to-final look, even during layout and animation.

5 FUTURE WORK

We are pursuing more reliable position and orientation capture for set registration; depth map extraction from multiple captures at offset locations[Suter et al. 2016]; and automated separation of on-set light sources from the environment map.

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