A full HDR pipeline from acquisition to projection

Pedro Santos* Fraunhofer-IGD
Thomas Gierlinger† Fraunhofer-IGD
Rafael Huff‡ Fraunhofer-IGD
Martin Ritz§ Fraunhofer-IGD
André Stork¶ TU-Darmstadt

1 Introduction

In the real world, the ratio between full brightness of the sun and complete darkness is in the range of 2.000.000.000:1. However today's projection display technology is limited to contrast ratios of approximately 10.000:1. This hinders a convincing simulation and presentation of lighting effects in professional markets such as car styling, architecture and industrial design. At the same time, High Dynamic Range Imaging (HDRI) has been developed as a new field of research resulting in breakthroughs in image based lighting. What is missing today are interactive visualisation systems that fully support HDR material and light information from the acquisition stage right through the processing stage to the display stage. Current software systems do exist to simulate the effect of light sources in virtual scenes. However, they require specialist training, they are complex to use, they cannot operate in real-time, often requiring modification and recalibration. Current systems also do not support HDRI. This means that not only do they lack the ability to simulate real lighting conditions, e.g. the position and intensity of the sun, cloudcover, but also the behaviour of materials in various light conditions.

Figure 1: *Hybrid PRT+Raytracing, Spheron HDR acquisition, Barco HDR projector*

In this publication we present one of the first full HDR visualization systems (see Figure 1) starting with HDR material and light acquisition, providing a HDR light simulation and rendering pipeline and finally displaying maximum fidelity image quality with color gamut enhanced HDR projection technology to bring the total dynamic range to over 5.000.000:1. We demonstrate these capabilities in the fields of car design and architecture.

Figure 2: *PRT only; Raytracing only; Hybrid PRT+Raytracing*

*e-mail: pedro.santos@igd.fraunhofer.de
†e-mail:thomas.gierlinger@igd.fraunhofer.de
‡e-mail:rafael.huff@igd.fraunhofer.de
§e-mail:martin.ritz@igd.fraunhofer.de
¶e-mail:andre.stork@igd.fraunhofer.de

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2 Exposition

The aim in **HDR acquisition** is to further develop a HDR sensor that is used to measure BRDFs (material properties) and light fields (environment lights / light probes) that are used for physically based image synthesis. A HDR sensor and its dynamic range (DR) capabilities have been re-evaluated in the context of an experimental HDR goniometer and a full spherical HDR camera (in full production) in order to identify all opportunities to improve on the DR-performance of the two devices. First measurements of BRDFs and light fields have been performed and an interchange fileformat for the BRDF data has been defined.

The **rendering work** performed is concerned with physically based image synthesis utilizing measured material and light data. The goal is to generate realistic images for design review with a quality close to current off-line rendering systems but at higher speeds. To achieve this we developed the concept of Hybrid Rendering to fuse diffuse global illumination results generated using Precomputed Radiance Transfer (PRT) and specular effects generated by Ray Tracing (RT). Support for dynamic objects and local light sources is achieved by further development of the Precomputed Shadow Fields algorithm. Initial CPU-based implementations of all relevant algorithms are available. The concept of Hybrid Rendering using PRT+RT has been verified (see Figure 2). The method to produce 16-bit output for the HDR projector has been validated.

The **HDR projection technologies** are concerned with increasing the dynamic range, accuracy and color gamut of existing projectors. The expected increase in dynamic range to 5.000.000:1 using a combination of dimming systems has been validated [Vandenberghe 2008]. To enable communication of HDR image data from the image generator (rendering PC) to the projector, 16 bit gamma encoded input and the 23 bit equivalent processing path have been integrated into a projector. The (relative) accuracy of the proposed external spectrometer based color maintenance system was verified. For white point a maintenance accuracy of better than 0.005 in CIE 1931 x,y can be expected. In addition a 30% color gamut expansion over EBU is achievable on a projector at the expense of max. 15% of the light output.

3 Conclusion

This publication extends previously published work [Santos et al. 2009] by implementing one of the first full HDR pipelines from acquisition to projection for photo-realistic rendering. This work was funded in part by European research grant MAXIMUS FP7-ICT-1-217039.

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