HDR in the Living Room

Tania Pouli*, Ronan Boitard, Christel Chamaret, Mekides Abebe, Catherine Serré, David Touzé, Edouard François, Erik Reinhard
Technicolor, Cesson-Sévigné, France

Abstract

High dynamic range (HDR) imaging has been an active area of research in visual computing for more than a decade. HDR imaging technologies are concerned with the capture, processing, compression and display of content with a wider luminance range and offer a significant increase in visual quality. Despite that, HDR technologies have not yet penetrated the consumer market. We investigate the reasons behind this apparent resistance and discuss some solutions for dealing with the main aspects of an HDR imaging pipeline in a real world entertainment context.

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1 Introduction

High dynamic range (HDR) imaging offers an increased luminance and contrast range. Although conceptually simple, to achieve this, modifications are required at every step of the imaging pipeline (Fig. 1). In the last decade much research has been expended on HDR imaging, addressing many limitations of existing imaging pipelines [Reinhard et al. 2010], but focusing mostly on still imagery while ignoring video. Despite the increased visual quality that HDR can offer, adoption of HDR technologies in industry and entertainment has therefore been slow. Here, we investigate the reasons for this resistance to adoption and we propose solutions for a practical HDR video pipeline from an industry perspective.

2 HDR Video Pipeline

In all aspects of a video pipeline, both the visual quality and computational complexity need to be considered before adopting any algorithm. Although today's graphics hardware allows even complex algorithms to run in real-time, displays or set-top boxes are considerably more limited. Yet, this is the hardware to be considered to get HDR to the consumer. In the following, we consider capture and dynamic range management. Note that although compression is a crucial part of an imaging pipeline and HDR compression is currently an active area of research, we are not addressing it in this paper. We refer the reader to the work of Touzé et al. [2013] on adapting existing video codecs to HDR video for a practical compression solution.

Capture. HDR still images are traditionally captured by merging a set of different exposures. However, temporally segregating exposures is ill-suited for video and computational photography setups are unlikely to be adopted by film creators as the optical quality of such solutions is not as high as in professional film cameras. To that end, as part of the NEVEx collaborative project, we constructed a practical HDR capture setup. By adding a filter and a beam splitter to a modified stereo rig, we capture two different exposures synchronously, which, when combined, offer approximately 20 f-stops of range, with no temporal artefacts. At the same time, professional cameras can be used (e.g. Sony F65), giving directors creative flexibility.

*e-mail:tania.pouli@technicolor.com

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Figure 1: *The components necessary for an HDR imaging pipeline.*

Video Tonemapping. Tonemapping operators (TMOs) have only recently been extended to video. Many video solutions are still either too resource-hungry or not robust enough temporally for display-side use. We distinguish three main types of temporal artifacts often caused by video TMOs: flickering, short-term and long-term brightness artifacts. Global TMOs cope with flickering artifacts through temporal filtering, but cannot match the visual quality of TMOs based on edge-aware filters. At the same time, reducing temporal brightness artifacts may require pre-analysis of the content [Boitard et al. 2013]. Our method combines with any edge-aware TMO, and reduces temporal artifacts through modified adaptive motion-compensated temporal filtering (MCTF). It decomposes HDR frames of a defined temporal window into different frequency subbands. To prevent ghosting artifacts, the best suited temporal frequency subband is selected adaptively based on a distortion criterion. The computed adaptive temporal subband is then used to compute the base layer for any edge-aware TMO.

Reverse Tonemapping. Adoption of a new imaging pipeline is greatly facilitated if legacy content can be adapted to it. To prepare legacy content for an HDR display, its luminance information needs to be expanded. We propose a new method to achieve that for displays of varying peak luminance, while preserving the director's intent. Our solution is spatially varying and temporally stable. Each frame is processed in a single pass, requiring no user input or parameter setting other than knowledge of the display peak luminance. It is thus well suited for real-time, display side applications. To process each frame, a per-pixel exponent is computed using an edge-aware filtering process on the image. This is further reshaped according to the display capabilities to ensure that the mean luminance of the image is preserved, while highlights are expanded. Edge-aware processing is also used to ensure that small, high frequency details such as noise, banding or textures are not enhanced, while the overall contrast of the image is amplified.

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