D7.7 Open Access Document specifying guidelines on shooting for HDR production & distribution

Grant Agreement nr	761544
Project acronym	HDR4EU
Project start date (duration)	July 1st 2017 (36 months)
Document due:	30/06/2020
Actual delivery date	31/08/2020
Leader	UPF
Reply to	marcelo.bertalmio@upf.edu
Document status	Submission Version

Project funded by H2020 from the European Commission

Project ref. no.	761544
Project acronym	HDR4EU
Project full title	Enabling end-to-end HDR ecosystem
Document name	Open Access Document specifying guidelines on shooting for HDR production & distribution
Security (distribution level)	Public
Contractual date of delivery	30/06/2020
Actual date of delivery	31/08/2020
Deliverable name	D7.7 Open Access Document specifying guidelines on shooting for HDR production & distribution
Type	Report
Status & version	Submission Version
Number of pages	8
WP / Task responsible	WP7 / UPF
Other contributors	All partners
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Abstract	Practical insights gained by the project consortium throughout the process of developing HDR technology, testing products with artists, and producing content.
Keywords	HDR, SDR, Capture, Manipulation, Viewing, Distribution
Sent to peer reviewer	Yes
Peer review completed	Yes
Circulated to partners	Yes
Read by partners	Yes
Mgt. Board approval	No

Document History

Version and date	**Reason for Change**
1.0 01-06-2020	Document created by Trevor Canham
1.1 31-07-2020	Version with feedback from partners
1.2 31-08-2020	Revisions in response to review: final version submitted to Commission

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1 EXECUTIVE SUMMARY

HDR, or High Dynamic Range video, is an emerging format in the motion picture industry which is in the process of top to bottom adoption by technology manufacturers, standards bodies, artists, and viewers. In essence, the format allows for the display of images at a larger range of light levels (dynamic range) than was previously possible with legacy (Standard dynamic range, or SDR) display equipment (televisions, digital cinema projectors, etc.). While this may seem a trivial thing to change, initial experiments in HDR imaging showed that many of the assumptions (regarding perception) which SDR imaging technology is based on were broken by this increase in range. In the following document, we intend to share the practical insights gained by the project consortium throughout the process of developing HDR technology, testing products with artists, and producing content. It is our hope that these practical insights will aid filmmakers in learning how to use HDR technology effectively.

2 INTRODUCTION

HDR, or High Dynamic Range video, is an emerging format in the motion picture industry which is in the process of top to bottom adoption by technology manufacturers, standards bodies, artists/users, and viewers. In essence, the format allows for the display of images at a larger range of light levels (dynamic range) than was previously possible with legacy display equipment (televisions, digital cinema projectors, etc.) and their associated standards [1]. Increasing dynamic range not only increases the global perception of contrast (affecting the appearance of color in the image), but also that of local contrast, or the difference in light level between adjacent objects, which is more commonly identified as sharpness. In the same vein, a long list of interdependent perceptual factors are impacted by this seemingly simple adjustment. Because standard displays produce only a small fraction of the light levels we encounter in real scenes, the proportionality from one light level to the next must be distorted heavily to produce realistic images with them [2]. As the dynamic range parameter of our displays approaches that of the physical world (and is effectively allowed to be variable with HDR standards [3]), the nature of this distortion must change with it. Ultimately, this will be determined on an image by image basis by artists, given that they have the tools to effectively capture, manipulate, and display these images, as well as the interest and patronage of viewers. In this way, the development of the format is a cycle between all parties in the process.

Before the format can reach its full potential, though, individuals involved in each link in this cycle must answer the following questions: Why should the technology exist? What makes this technology truly novel? How can this technology be used in a way that is positively valuable to society? While these are still very open questions that will be determined by the path the industry collectively chooses moving forward, the HDR4EU project has allowed for a fruitful collective reflection on the current state of HDR technology, which we share in full detail in our collection of project deliverables, associated publications, and developed products.

While we cannot confidently answer the big questions above, we did encounter some valuable practical takeaways that individuals working with HDR can put to use. In the following guide, we intend to outline some of these which came to light while developing HDR technology, testing products with artists, and producing content. We hope that these insights will ease the transition for filmmakers who are new to HDR, although we acknowledge the best way to learn how to create excellent high dynamic range imagery is through hands-on experimentation. As has been the case with new imaging formats from the past, HDR opens the playing field for artists to create novel styles and looks. By this virtue, once we collectively have a stable and consistent ecosystem in which to create and enjoy HDR content, the artists will demonstrate through their images the full potential of the technology as an artistic medium.

3 IMAGE CAPTURE (Production)

The most important general recommendation that can be offered for shooting HDR content is to monitor the images at the dynamic range they will be distributed. While this may seem obvious, there always exists the temptation to use SDR monitoring equipment to more or less imagine how the images will translate in HDR. This approach can lead to unhappy surprises in the color grading process. To name a few, noise will increase visually as the dynamic range of images increases, motion judder will become more noticeable, and any over exposed or sensor clipped regions (e.g. practical lights) in the image become far more distracting in HDR, as they are pinned to the maximum light value. These artifacts can lead to great difficulty in the grading of HDR masters and can go unnoticed when monitoring in SDR. In addition to ensuring that acceptable imagery is being captured, monitoring in HDR can allow all production departments to do the best version of their work. For example, due to the increased local contrast (sharpness) that comes along with increasing global dynamic range, the appearance of skin, hair, pores, and makeup textures can be affected significantly. For this reason, it would be important to allow hair & makeup and art departments to monitor an HDR representation of the image as creative decisions are being made on set.

Shooting scenes which push the limits of the camera dynamic range on both ends (shadows and highlights) simultaneously can be particularly hard to balance in post. With the majority of grading tools currently available, it can be difficult to correct one end of the dynamic range without losing detail in the other. Care should be taken in lighting different regions (foreground and background, for example) as the relationship between these regions can have a powerful influence on where the viewer will focus on the image (as is the case with SDR, but like the other effects listed, is magnified in HDR). When shot properly, sparse specular highlights allow for particularly good HDR effects. Reflections of light sources on water (in daylight or nighttime), eyes, glitter or other specular (shiny) surfaces add new dimensionality to characters and scenes in HDR.

As an additional note, one must remember that while monitoring HDR, it is important to pay attention to the viewing environment the display is located (as with SDR). Bright lights and glare on the monitor can cause the appearance of contrast to decrease and for shadow detail to be obscured. While bright HDR images may appear to be less affected by changes in the viewing environment compared to images on dim SDR screens, its influence still cannot be ignored. A general recommendation would be to simulate the intended grading environment to the best of one's ability while on set.

One of the major questions that came up during the course of the project was the following: Since HDR and SDR are fundamentally different formats, artists will use them differently. However, in order to share the content with the largest amount of people, both HDR and SDR final versions will need to be produced. So the question is, which version should the DP intend to shoot the content for? To try to do something "in between" is impractical – it would result in a picture which is simultaneously compromising for both formats. Ultimately, the response is up to the director of photography (DP) who can choose what version should be prioritized. It is then the responsibility of the colorist to translate the image as best as possible to the secondary format.

4 IMAGE MANIPULATION (Post-production)

In order to have a discussion on how to go about mastering HDR images, which make use of accentuated areas of brightness and shadow to create a more immersive film viewing experience, one should first address how the perceptual processes of the viewer will react to this new range. While exploring the effects of varying global contrast and the average light level (ALL) of images [4], one will find that the human eye easily grows accustomed to any level of constant brightness, as long as there is time for adaptation. By this token, any images which do not use highlights sparingly risk looking more or less like SDR as the viewer will quickly adapt to the new contrast range. One should also remember that HDR highlights have the potential to be painful to viewers. Large transitions between ALL should be done conservatively and slowly to avoid making an uncomfortable and fatiguing visual experience. In our daily life we seamlessly transition between regions with vastly different absolute dynamic ranges. When the transition is truly intense it can catch our eye for a moment (e.g. opening a door or a curtain to the outdoors in a dimly lit room), but the level of discomfort this causes is quite temporary and goes mostly unnoticed. However, in real life we do not experience 'cuts' like we do in motion pictures, where our vision transitions instantaneously between different scenes. For this reason, colorists should keep an awareness of their state of adaptation in relation to the images, as to not master content which viewers find physically uncomfortable to watch.

Since the light levels in HDR images are distributed differently than SDR images, it stands to reason that the *lift, gamma, gain* controls which have been traditionally used in motion picture color correction will not react in the same way between formats. With SDR images, these controls could be used to roughly adjust highlight, mid-tone, and shadow regions of images. In essence, the feeling reported by many colorists in using them for HDR grading is that they are too ham-fisted, and do not always allow for the best use of the image. In the event that colorists feel they run into limits too quickly with their standard color correction workflow, they should look into alternative grading tools and image encoding formats which have been developed with HDR images in mind. These new tools should allow colorists to adjust images along consistent perceptual axes (e.g. brightness, hue, saturation, sharpness) and make HDR images appear in the way they direct, rather than the other way around – where colorists feel trapped into some "look" which they deem inherent to HDR because they cannot control the images in the way they are accustomed to.

With regard to one perceptual axis, that of saturation, HDR images pose an interesting new challenge. As the dynamic range of imagery is increased, certain surface colors may start to "pop" to the point where they appear to be brighter than the light source in the scene, giving the viewer the impression that the object is fluorescent (appears as if it is emitting light), which can be a jarring effect (e.g. a brightly colored bird should not appear as if it is emitting light, as we have an understanding that birds do not emit light). Colorists should be careful to control the saturation of object colors in a way that does not break these perceptual barriers and should be generally aware that HDR images may react with legacy tools to create unnatural visual experiences.

Another perceptual axis, sharpness, is intimately related to dynamic range. By increasing the global contrast of an image, one also increases the local contrast, or sharpness. Large increases in sharpness can result in unpleasant artifacts (blocky clipped highlights which are particularly obtrusive in the case of practical lights, noise, unnatural or overdetailed textures [e.g. skin, hair], etc.) To control these elements, colorists will need to familiarize themselves with new tools for selectively blurring and sharpening image regions, and equalizing textures throughout the images. Along a similar line, any glow/glare that either is artificially added in post-production to emphasize the brightness effect of an object or captured physically with the help of an optical filter can reduce the HDR effect by lowering the local contrast and increasing the average brightness level of the image, making highlights less pronounced.

5 IMAGE VIEWING, DISTRIBUTION (Delivery)

The different display technology options available at the moment (LCD, OLED, QLED, etc..) have widely varying performance [5]. Even among displays marketed to meet the same standards, different technologies can vary significantly in how they render images. Highlight and shadow rendering is often perceptibly different between the various technologies. Different display types have different properties of sharpness, or are normally observed at different viewing angles, which also make a large impact on the appearance of images. Display manufacturers include various image enhancement functions which operate under the hood, as a means to differentiate their products from the competition, increasing the variability in the rendering behavior of consumer displays. Finally, the environment surrounding the display and the individual properties of the viewer's visual system will have an impact on the degree to which image renderings are consistently conveyed throughout the production process and in delivering the final piece. These sources of variability are important to keep in mind when mastering content for delivery.

With regard to producing an SDR version of an HDR master or vice-versa, the average light level of an HDR image should be roughly the same as its SDR equivalent, just expanding the highlights and the shadows. Otherwise, if the average light level is scaled proportionally with the peak highlight, the HDR effect will be lost completely. The viewer will adapt to the image and it will appear roughly the same as it would on an SDR display. Care should be taken when using global up-conversion methods (SDR->HDR) as simply increasing the global dynamic range can result in accentuated compression artifacts and generally over-sharp images. Although artifacts would most likely be less noticeable in the opposite case (HDR->SDR), some skepticism should always be taken with global transformation methods as a satisfactory preservation of creative intent is quite dependent on the scene and the grade, and these tools are often not reactive to these parameters (by design). A proper solution proposed by Filmlight for this problem is that of allowing the colorist to grade an SDR and HDR version separately, such that two creative intent reference points are given, and then to use a simple blending scheme to produce images for screens which have a dynamic range that lies in between that of the SDR and HDR reference points. In this case, there is a specific, pixel-wise mapping transitioning between the two approved image states which can be used to produce masters at varying dynamic range levels. In effect, this blending could be accomplished by taking a weighted average between the image representations depending on the destination dynamic range.

6 CONCLUSION

HDR, or High Dynamic Range imaging, is an emerging format in the motion picture industry which is in the process of top to bottom adoption by technology manufacturers, standards bodies, artists/users, and viewers. Before the format can reach its full potential, though, individuals involved with each of these links must answer the following questions: Why should the technology exist? What makes this technology truly novel? How can this technology be used in a way that is positively valuable to society? While these are still very open questions that will be determined by the path the industry collectively chooses moving forward, the HDR4EU project has allowed for a fruitful collective reflection on the current state of HDR technology, which we share in full detail in our collection of project deliverables, associated publications, and developed products.

In the meantime, we present a collection of practical recommendations that individuals can use to improve their understanding of the HDR format and its associated technology ecosystem. We acknowledge, however, that the best way to learn how to create excellent high dynamic range imagery is through hands-on experimentation. Once we collectively have a stable and consistent ecosystem in which to create and enjoy HDR content, artists will demonstrate through their images the full potential of the technology as an artistic medium.

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