LYNXTechnik AG
Broadcast Television Equipment

Dynamic conversion during HDR/SDR parallel production

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Revision 1

Updated: March 2020

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Abstract

Today's HDR/SDR parallel productions still follow a similar workflow from that of SDR-only productions. In current workflows, it is not possible to perform "real HDR shading" to create dynamic and brilliant HDR content. In addition, SDR hardly benefits from increased recording quality. Within this article, we will discuss how dynamic conversion can help parallel HDR/SDR productions as well as the new workflows that can be supported.

Introduction

The number of HDR (High Dynamic Range) productions is slowly increasing, with distribution via OTT and classic broadcast playout. Even with these indicators, HDR is still a long way from being embraced by the global market. Plus, there are a variety of challenges that still exist within HDR productions today. One example is that the aspect of parallel creation of an equally professional HDR and SDR version (SDR = Standard Dynamic Range) is inadequate. Within this article, we discuss how this challenge can be addressed by using dynamic HDR/SDR converters, such as the LYNX Technik greenMachine HDR Evie (TM). Another challenge in HDR/SDR conversion is the adjustment of the color gamut. A standards-compliant HDR production according to ITU-R BT.2100 [5] also requires an extended color gamut, usually called Wide Color Gamut (WCG). When converting to an SDR signal according to ITU-R BT.709 [6], an adaptation to a smaller color gamut must be carried out. For more detailed information on these challenges and possible solutions, please refer to the reference list included in this document – see [7] and [8].

HDR test production in Valencia

To help us understand the challenges associated with an HDR production, it is worth taking a look at the history of HDR production. The first ground-breaking HDR test production was carried out in 2014 at the MotoGP in Valencia, Spain. The aim was to investigate the added value of HDR vs. SDR. For this purpose, two parallel productions were carried out, with corresponding duplication of the technical equipment (cameras, mixers, etc.) and personnel (image engineers, etc.). This production is especially known for its familiar photograph [1], which was taken during the event.

The photo shows the HDR and the SDR shaders both sitting in front of the control monitors in the OB van. While the SDR shader is looking at the images intently while turning the aperture, the HDR shader is relaxed and is more entertained by the action. A key advantage (as highlighted by this comparison) to HDR is that a large amount of aperture control required in SDR is not necessary with HDR. Of course, in an HDR production, adjustments may need to be made from time to time; but only when large brightness fluctuations occur. The second advantage of HDR is that it ensures that the minor brightness variations can be distributed to the home viewer and do not have to be suppressed in production. All of this ultimately helps to improve the viewer's immersive experience. The third advantage of HDR is that greater contrast range can be captured within one HDR exposure and therefore clipping occurs much later and less often compared to an SDR environment.

Current HDR/SDR productions and ITU-R BT.2408

The test production showed not only the advantages of HDR but also its disadvantages. In this showcase the two productions were performed parallel; without any synergy. Running parallel productions is not sustainable in the long run due to the complexity as well as the associated costs.

Therefore, in practice, the goal is to produce the SDR program from the HDR program without much effort. Currently, a static HDR/SDR conversion (down-conversion) is used for this purpose. This approach “cuts out” a defined luminance range from the HDR signal and applies on it the classic gamma curveHowever, concerning the aperture control, it is not possible to proceed as the HDR shader did during the test production since the variance of exposure would be too large. It is possible that the important image areas may fall into the fixed corridor that the static converter for SDR defines. However, this may also possibly not be the case and could quickly lead to under- or overexposure with information that would burn out or disappear in the shadows. The ITU-R BT.2408 ("Guidance for operational practices in HDR television production") [2] states:

"If the SDR production must not be compromised, both HDR and SDR cameras should be shaded using an SDR monitor fed via a down-converter. Whilst the HDR signals may not always exploit the full potential of the HDR production formats, the HDR pictures can still show significant improvement over SDR."

In other words, to control the aperture, the image is viewed on an SDR display after the static conversion takes place. But what does this procedure mean for the three advantages of the Valencia production explained above? On the one hand, everything remains the same with the aperture control. The shader must continue to constantly adjust the aperture to changing light conditions. This also means that the HDR image is cropped in its maximum luminance and variance. Although the above quote from ITU-R BT.2408 still talks about a significant improvement, the HDR image still falls short of its capabilities and allows little creative work with the brightness. The SDR image in turn hardly benefits from the increased recording quality, as a function similar to the current knee or gain function is used for conversion. Information outside the defined narrow brightness corridor continues to fall victim to clipping. In summary, almost all the advantages of the original HDR production were surrendered. On the other hand, this is also because until recently there were no alternatives to the static converters mentioned above.

To be able to adjust the aperture in HDR, a system is needed that adjusts the aperture or combines much more contrast range within an SDR image so that the aperture loses relevance. Compared to current solutions, the system must work dynamically based on the image content. The ITU-R BT.2408 states

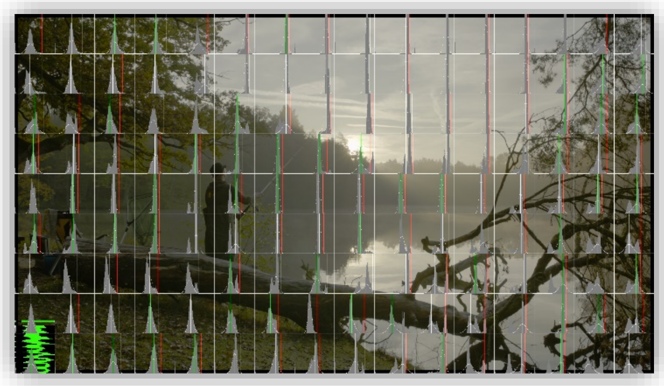
"As the exposure latitude of HDR images is far greater than SDR, a dynamic HDR to SDR converter may be required to deliver a satisfactory SDR output. A dynamic converter is designed to optimize the HDR to SDR tone mapping curve for any scene, thereby accommodating a wider range of exposures than might be possible with a fixed (or static) tone mapping curve."

Dynamic conversion

Dynamic conversion can be divided into two levels:

***Level 1**: The entire image is analyzed, and the transfer curve is adjusted based on the result of the analysis (global approach).* The entire image is analyzed, and the transfer curve is adjusted based on the result of the analysis (global approach). A compromise has to be made between contrast level and preserving as much information as possible. The flatter the image, the less detail is lost in the highlights and shadows. However flat images are not desirable, therefore the conversion algorithm must decide between what information is important and the level of gradation which is acceptable. *Within an HDR workflow, the real advantages are that a real HDR aperture control can be used with a correspondingly large variance in exposure.*

***Level 2**: The weighing decision described above can also be carried out separately on different areas of the image (sectional approach), so that lights and shadows are treated differently and can therefore, be adjusted to each other. Lights can be lowered, and shadows can be brightened without affecting each other. In other words, a steeper image impression can be achieved with the same contrast range of the scene [3][4]. Another key advantage is that the increased contrast range benefits the HDR image as well as the SDR image. It is possible to display almost all of the image information in SDR. The brilliance and strongly saturated colors remain the true unique selling proposition of HDR. This concept is comparable to a window-based color correction.*



For level 1 and 2 described above, it is always necessary to perform a suitable color gamut transformation as described in [8].

Workflows with dynamic conversion

The use of dynamic conversion results in several possible new workflows, which are explained below:

Option 1 (for use in an HDR/SDR production)

The first option (see Figure 1) is to use a dynamic HDR/SDR conversion after the HDR production to automatically create an SDR version without having to consider it in the production process. This method allows the image to be shaded and controlled by using an HDR monitor only. This workflow requires that the appropriate ITU-R BT.2100 [5] capable equipment is available, otherwise one can expect high investment costs. One should also take into account that the dynamic conversion should be performed on the Clean Feed signal, as the conversion curve is image content-related and could slightly distort the graphics. Since the graphics are usually rendered in SDR, they can be added to the Clean Feed signal after the dynamic conversion. For the HDR channel, a static SDR/HDR up-conversion of the graphics can be used. In addition to dynamic HDR/SDR conversion, an automatic color gamut transformation from BT.2100 (WCG) to BT.709 (Standard Color Gamut, SCG) needs to be performed as well.

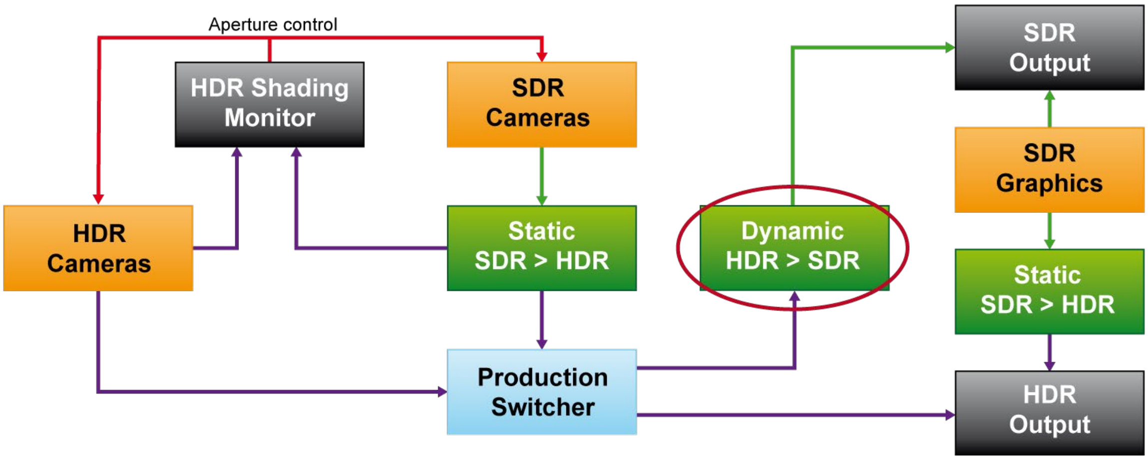


Figure 1 HDR/SDR production with dynamic conversion at output

Option 2 (for use in an HDR/SDR production)

Another option is that the dynamic conversion can take place directly behind each camera as an HDR/HDR conversion (see Figure 2). This will homogenize the image and enable static conversion at the output. Of course, the question arises why a dynamic conversion should be performed for HDR to HDR and what is meant by homogenization?

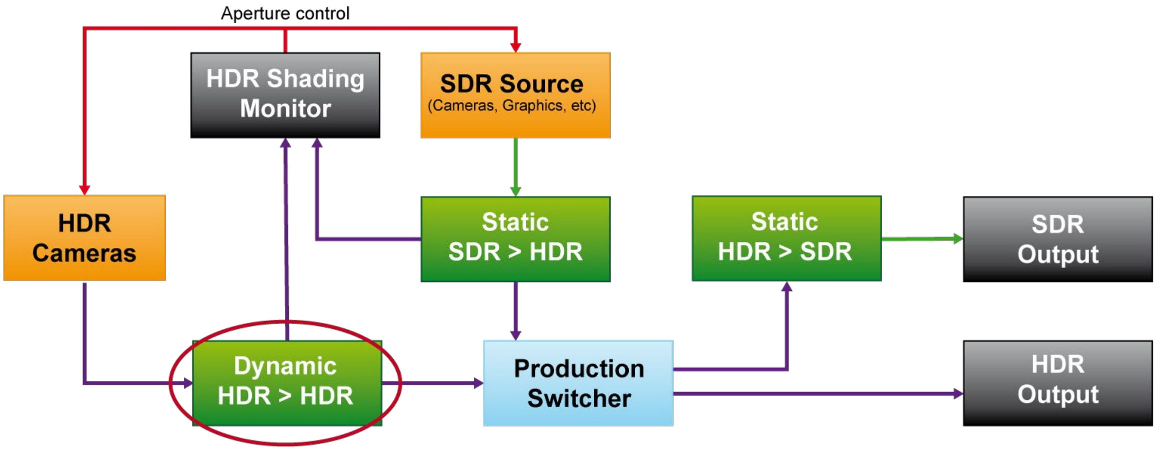


Figure 2 HDR/SDR production with dynamic conversion behind the camera

Figure 3 During an outdoor sports event, the presenter is standing under a tent. In the classic SDR (left) the presenter's face is therefore shown very dark. With the help of 12 kW brightening light (middle) an attempt is made to balance the lighting of the scene. Alternatively, dynamic conversion can be used (right). [Source: WDR/HSRM test production, with kind permission of Westdeutscher Rundfunk]

As an example, in the left picture above in Figure 3, the presenter is standing in front of a very bright background. This picture shows the scene in classic SDR, which limits the background to 100 cd/m^2. The clipping could probably be prevented by displaying the image in HDR. But how would this change the impression of the scene? The presenter, who is already relatively shadowed by darkness would not be significantly brightened in HDR, yet the background, since it is not limited, would reach much higher brightness values and would literally outshine her. It would be possible to display the scene on an HDR monitor; however, this would not make it more visually appealing. To enhance the image, lighting would still need to be used, as shown in the middle image in Figure 3. It becomes clear that HDR alone does not solve the problem of poorly lit scenes. To reduce the use of lighting and to obtain a more natural image, it is possible to use the sector-by-sector processing of dynamic conversion for HDR. The right-hand image in Figure 3 shows the same scene without the use of fill light but using a dynamic conversion. This compensates for the inhomogeneous lighting situation of the scene, which leads to the desired effect with HDR images. Furthermore, significantly more brightness values fall *into the SDR corridor. In this way, both signals, the optimized HDR signal and the optimal SDR signal (with the help of an additional simple static conversion), with a color gamut according to BT.709, can be generated at the output.*

Option 3 (for use in an SDR production)

The third option (see Figure 4) is not primarily about producing HDR, but rather about improving the SDR image and automating the production process to a higher degree. This option offers many broadcasters, who have little experience with HDR or have minimal HDR-capable equipment, the possibility to easily approach the concepts. Compared with the first two options, only the camera has to be exchanged for an HDR-compatible equivalent or the existing camera has to be retrofitted accordingly. Behind the camera, the HDR/SDR conversion including the necessary color space transformation for the color gamut adjustment is carried out, so that in the following processing chain (mixers, monitors, etc.) it is still possible to work with equipment that only interprets ITU-R BT.709 correctly.

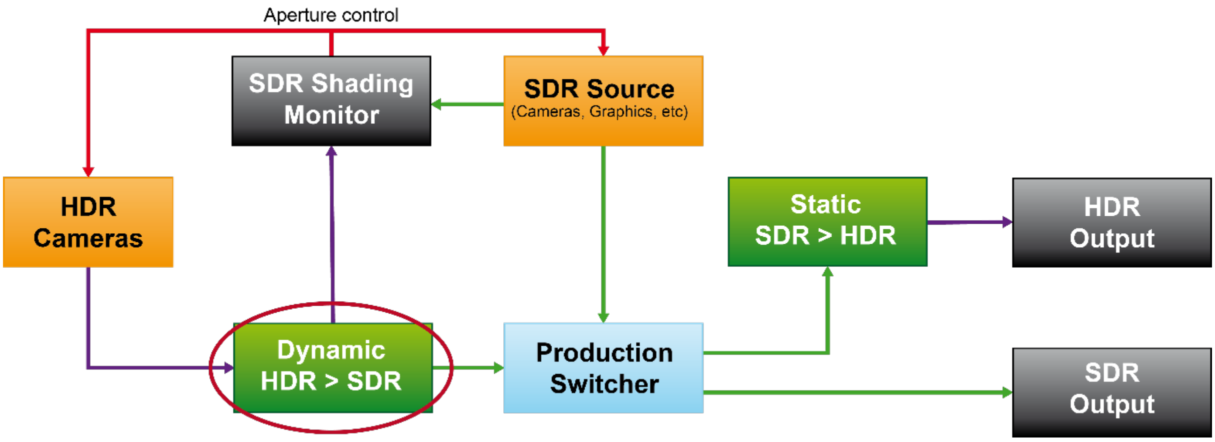


Figure 4 SDR production with HDR cameras and dynamic conversion

This workflow represents a low entry option compared to a complete conversion of all components. Nevertheless, it enables broadcasters to take advantage of HDR. On the one hand, it is immediately possible to send a higher contrast range and thus a better picture to every viewer. On the other hand, and equally relevant, the production effort can be reduced compared to the status quo. This is possible for two reasons: 1. the increased aperture range of the shot leads to a larger working area. This means that the image needs less readjustment and the actual exposure is more automated. 2. the use of fill light can be reduced, as shown above in Option 2. Due to the increased contrast range of the HDR-capable cameras, it is possible in this workflow to perform illumination to a certain extent in signal processing.

For future HDR productions, a dynamically converted SDR, with the help of a static SDR/HDR up-conversion, will allow much closer approximation to the original HDR impression as compared to the SDR image which is impaired by clipping. Thus, this option enables the storage of approximated HDR content in an SDR archive or allows HDR playback parallel to SDR playback. For example: simultaneous HDR live streaming application.

Conclusion

The current workflows for parallel HDR/SDR production are based on static HDR/SDR conversion. It has been shown that the quality gain of such a production is rather limited - especially in terms of the effort and investment involved. Both the HDR and SDR images fall short of their capabilities. In this context, dynamic conversion offers an unprecedented opportunity because on the one hand the *details in the lights and shadows is preserved in the SDR image and on the other hand a real dynamic adjustment can be made based on the HDR image.*

Furthermore, it was shown that a dynamic HDR/SDR converter is not only a new device in the workflow, it also influences the way a program or event is produced.

The above workflows use static converters in addition to the dynamic converters. For example: graphics should be routed via a static path.

Reference

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[3] Lenzen, L.: "HDR for legacy displays using Sectional Tone Mapping", Proceedings of the IBC conference 2016, Amsterdam, September 2016

[4] Lenzen, L., Hedtke, R., Christmann, M.: "HDR für alle Displays", Fernseh- und Kinotechnik (FKT), 72nd volume, issue 5/2018, pages 37-40

[5] ITU, "Recommendation ITU-R BT.2100-2 - Image Parameter Values for High Dynamic Range Television for Use in Production and International Programme Exchange"

[6] ITU, "Recommendation ITU-R BT.709-1 - Basic Parameter Values for the HDTV Standard for the Studio and for International Programme Exchange," 1993.

[7] Kutschbach, P.: " HDR – Farbraumtransformationen – Grundlagen", Fernseh- und Kinotechnik (FKT), 73rd volume, issue 10/2019, pages 40-44

[8] Kutschbach, P.: "HDR – Farbraumtransformationen – Transformationsalgorithmus", Fernseh- und Kinotechnik (FKT), Volume 73, Edition 11/2019, pages 36-41