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| *Title:* | **Usage of CRI for HDR video compression with dynamic range adaptation** | | |
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| *Author(s) or Contact(s):* | E. François,  F. Hiron,  P. Andrivon | Tel: Email: | [edouard.francois@technicolor.com](mailto:edouard.francois@technicolor.com) [franck.hiron@technicolor.com](mailto:franck.hiron@technicolor.com) [pierre.andrivon@technicolor.com](mailto:pierre.andrivon@technicolor.com) |
| *Source:* | Technicolor | | |

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# Abstract

This contribution presents results of experiments consisting in using CRI for Dynamic Range Adaptation (DRA) (a.k.a. reshaping) for HDR/WCG video compression efficiency. CRI was specified to perform content conversion from one colour volume to another one. CRI was also mentioned in 22nd and 23rd JCT-VC meetings as a relevant SEI message to perform DRA for improving coding efficiency of HDR10 signal, as achieved by the modified HDR Exploratory Test Model (ETM) presented in JCTVC-W0084. Experiments presented in the present contribution are based on the modified ETM of JCTVC-W0084, in which the DRA metadata are embedded in a CRI SEI message instead of PPS. Similar results to this modified ETM are reported. It is proposed to add a description of CRI SEI usage for DRA to the Annex A of document “Conversion and Coding Practices for HDR/WCG Video”, as an option to improve HDR coding efficiency.

# Introduction

Colour Remapping Information (CRI) is an SEI message that aims at enabling conversion of a reconstructed video content from one colour volume to another one. For example, CRI can be used in a post-processing step following the decoding stage to convert a decoded HDR video represented with BT.2020 primaries and SMPTE ST 2084 transfer function to an SDR video represented with BT.709 primaries and BT.709 transfer function ([JCTVC-Q0074](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/17_Valencia/wg11/JCTVC-Q0074-v4.zip)). CRI has also been investigated to perform dynamic range adaptation (DRA, also named reshaping) in order to improve coding efficiency of HDR content ([JCTVC-V0064](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/22_Geneva/wg11/JCTVC-V0064-v1.zip)). In the 23rd JCT-VC meeting, it has been concluded that the performance of the HDR Exploratory Test Model (ETM) can likely be reproduced using CRI. This contribution provides results showing that existing CRI SEI message can indeed be used for DRA, improving coding efficiency of HDR10 signal with the same performance as ETM.

It is proposed that a description of CRI SEI usage for DRA is added in Annex A of the document “Conversion and Coding Practices for HDR/WCG Video”.

# Experiments

The experiments reported in this contribution are based on the modified ETM software as proposed in [JCTVC-W0084](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0084-v2.zip), called here “**reference ETM**”. [JCTVC-W0084](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0084-v2.zip) proposes a DRA process aiming at improving the compression performance for HDR/WCG video. DRA is based on three reshaping functions, one for luma based on piece-wise polynomial model (PWP), with 8 portions, plus two ones for chroma based on piece-wise linear model (PWL), with 1 single portion. The parameters of these models are embedded in the PPS. The functions are typically implemented in the shape of 1D look-up-tables (*LUTDRAk*, for *k*=0, 1, 2). The synoptic of the pre-processing and post-processing is shown in Figure 1 and Figure 2. In order to fully benefit from the coding code-words range, the DRA process generates a Full Range (FR) signal. The inverse DRA process goes back to Legal Range (LR) HDR ST 2084 10-bit YCbCr signal. The conversion from full-to-legal range is managed internally by the inverse DRA.



Figure . Pre-processing synoptic of JCTVC-W0084.



Figure . Post-processing synoptic of JCTVC-W0084.

In the present experiments, the luma and chroma reshaping functions are all modeled by a PWL model, which parameters are embedded by a CRI SEI message.

For chroma, one linear portion is used. For luma, 9, 17 or 33 linear portion are tested instead of the 8 PWP pieces used in the initial ETM version. Apart from that, the way luma and chroma reshaping functions are derived is identical to the method used in [JCTVC-W0084](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0084-v2.zip). The modified HM as described in [JCTVC-W0084](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0084-v2.zip) is also used for the encoding (in particular the same chroma QP and luma deltaQP adjustments are used). The only difference is that the metadata are contained in a CRI SEI message, and the post-processing uses these CRI syntax elements to reconstruct the HDR signal from the decoded HDR reshaped signal. The modified synoptic of the pre-processing and encoding is shown in Figure 3. The corresponding solution is called here “**ETM with CRI**”.

**CRI is applied directly in 4:2:0**

The syntax of the CRI SEI message includes three parts: a first piece-wise linear function applied to each colour component (PreLUT), followed by a three-by-three matrix applied to the three resulting colour components, followed by a second piece-wise linear function applied to each resulting colour component (PostLUT). For DRA, only the three PreLUTs are used. The three-by-three matrix and the PostLUTs are not activated. Therefore the conversion process can directly apply to 4:2:0 signal, and no upsampling to 4:4:4 is required.

**Full and Legal range management**

Contrary to the ETM inverse reshaper process, the conversion from legal range to full range by the inverse DRA process is directly addressed by the CRI PreLUTs that apply in the inverse DRA process. The inverse DRA process is therefore not at all impacted. For 10-bit YCbCr signal, the LUTs are generated as follows:

For luma:

For chroma: *k*=1 or 2

where are the inverse of the Y, Cb, Cr DRA LUTs, respectively, generating a full range YCbCr signal (that is, so that ]).



Figure . Modified pre-processing synoptic using CRI for DRA.



Figure . Modified post-processing synoptic using CRI for DRA.

# Results

The software package of JCTVC-W0084, delivered in the context of HDR CE2 defined in 113th MPEG meeting (cf MPEG document [m37497](http://phenix.int-evry.fr/mpeg/doc_end_user/documents/113_Geneva/wg11/m37497-v2-m37497_CE2_Document_v3.zip)), has been used for the experiments. In HDRTools, the way the pre-processing DRA parameters are derived from the picture analysis is not changed. Code to manage the CRI parameters derivation has been added. It produces the CRI metadata embedded in a text file, in the adapted format for the CRI interface of the HM. The writing and reading code of the reshaping information in the SPS and PPS has been deactivated. CRI implementation in HM has not been modified.

We present in Table 1, Table 2 and Table 3 partial results with objective performance of the ETM with CRI, using 9, 17 or 33 PWL points for the luma reshaping function modeling, relatively to the reference ETM. In addition, in Table 4, the PSNR between the YCbCr reshaped HDR content between the reference ETM and the ETM with CRI are provided. It is observed that the impact of replacing the PWP 8 portions model by a PWL model with 9, 17 or 33 points is limited both for the reshaped signal, and for the reconstructed signal after compression and inverse reshaping. A gain in DE100 is even observed.

As in JCTVC-W0084, the number of different CRIs within one sequence is in most cases limited to 1. Only for GarageExit and ShowGirl, more than one CRI is needed (2 for GarageExit, 17 for ShowGirl). The cost of one CRI SEI message is of 510 bits, 766 bits and 1278 bits for 9, 17 and 33 PWL luma points (in all cases, 2 PWL points are used for each chroma component), respectively.

Table . ETM with CRI 9 points.



Table . ETM with CRI 17 points.



Table . ETM with CRI 33 points.



Table . PSNR\_YUV between reshaped versions from ETM without CRI, versus ETM with CRI.



# Conclusions

The results presented in this document confirm that the CRI SEI message is able to reproduce the behaviour of the ETM. CRI can be efficiently used as a reshaper metadata container, in view of improving compression efficiency. It is proposed that a description of CRI SEI usage for DRA is added in Annex A of the document “Conversion and Coding Practices for HDR/WCG Video”.

# Patent rights declaration(s)

**Technicolor may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**