|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  24th Meeting: Geneva, CH, 26 May – 1 June 2016 | Document: JCTVC-X0066 / m38469 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **Proposed text for usage of Colour Remapping Information (CRI) SEI message for Conversion and Coding Practices for HDR/WCG Video** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | E. François, F. Hiron, P. Andrivon (Technicolor) | Tel: Email: | [edouard.francois@technicolor.com](mailto:edouard.francois@technicolor.com) [pierre.andrivon@technicolor.com](mailto:pierre.andrivon@technicolor.com) |
| *Source:* | Technicolor | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

The Colour Remapping Information (CRI) SEI message was specified to perform content conversion from one colour volume to another one. CRI was also identified in 22nd and 23rd JCT-VC meetings as a possible relevant SEI message to perform dynamic range adaptation (DRA, a.k.a. reshaping) for improving coding efficiency of HDR10 signal. This contribution provides proposed text describing the usage of CRI for DRA, to be inserted in Annex A of JCT-VC document untitled “Conversion and Coding Practices for HDR/WCG Video”.

# Introduction

The Colour Remapping Information (CRI) is an SEI message that aims at enabling conversion of a video content from one colour volume to another one. For example, CRI can be used in a post-processing step following the decoding for display SDR backward compatibility, that is, to convert a decoded HDR video with BT.2020 primaries and SMPTE ST 2084 transfer function to an SDR video with BT.709 primaries and BT.1886 transfer function ([JCTVC-Q0074](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/17_Valencia/wg11/JCTVC-Q0074-v4.zip)). It has also been demonstrated that CRI can be used as a container for dynamic range adaptation (DRA, also named reshaping) in order to improve compression efficiency of HDR content ([JCTVC-V0064](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/22_Geneva/wg11/JCTVC-V0064-v1.zip), JCTVC-X0041).

The contribution proposes text describing the CRI and its possible usage for DRA, to be added in Annex A of document untitled “Conversion and Coding Practices for HDR/WCG Video”.

# Proposed added text to document “Conversion and Coding Practices for HDR/WCG Video”, Annex A

* 1. Colour Remapping information SEI message for Dynamic Range Adjustment
     1. Context

The colour remapping information (CRI) SEI message defined in HEVC conveys information that is used to remap decoded pictures from one colour volume to another one. The syntax of the CRI remapping model includes three parts: a first piece-wise linear function applied to each colour component (“Pre-LUT”), 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 (“Post-LUT”). Each one of these set of data is optional (for instance only the Pre-LUTs can apply, leading to the application of only one transfer function to each colour component of the input signal). A maximum of 33 pivot points per LUT are coded to specify the piece-wise linear functions.

The CRI SEI message also includes a syntax element colour\_remap\_id, that may be used to identify the purpose of the colour remapping information. For instance, colour\_remap\_id value may be used to indicate that the input of the remapping is the result of a first conversion process, such as conversion to YCbCr or GBR colour representation, or to enable cascading of different remapping processes.

* + 1. Dynamic range adjustment for HDR/WCG compression

HDR/WCG video compression can be improved by adjusting the distribution of the input codewords of the input encoder samples, using a dynamic range adjustment (DRA, a.k.a. reshaping) approach. The motivation of reshaping is based on the observation that an HDR10 signal (YCbCr 10-bit signal represented with ST 2084 transfer function and in BT.2020 container) does not, in general, fully exploit the codeword range of [0,1023]. The ST 2084 transfer function covers a linear-light range from 0 to 10,000 nits that can be much larger than the actual range of the HDR signal. Similarly, the actual colour gamut of the HDR signal can be noticeably lower than the BT.2020 colour gamut. And when the signal is represented in limited range, the foot-room and head-room values are not exploited. DRA aims at adaptively redistribute the codewords to reduce the impacts of quantization and therefore to get an improved texture sharpness and color restitution after compression.

* + - 1. Encoding and decoding processes

The encoding process using DRA is illustrated in Figure 1. DRA typically applies three transfer functions to the Y, Cb, and Cr components of the input HDR10 signal resulting in a full range reshaped signal. These functions are derived from the analysis of the signal properties and aim at better distributing the code values. The reshaped signal is then encoded, using an HEVC Main10 compliant encoder. The reshaping functions are typically implemented in the shape of 1D look-up-tables (*LUTDRAk*, for *k*=0, 1, 2), that directly apply to the HDR10 Y, Cb and Cr components.

The decoding process including the inverse DRA process is illustrated in Figure 2 After HEVC Main 10-compliant decoding, the decoded signal is post-processed to generate the HDR10 signal using the inverse DRA transfer functions. These functions are coded using the three Pre-LUTs of a CRI SEI message. The three-by-three matrix and the Post-LUTs are not activated. Therefore the conversion process can directly apply to 4:2:0 signal, without any chroma subsampling.



Figure 1. Pre-processing synoptic using CRI for DRA.



Figure 2. Post-processing synoptic using CRI for DRA.

* + - 1. Derivation of the reshaping parameters

An illustrative process of DRA/reshaping parameters derivation for purpose of HDR/WCG compression efficiency improvement is described in JCTVC documents [JCTVC-W0031](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0031-v1.zip) and [JCTVC-W0084](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/23_San%20Diego/wg11/JCTVC-W0084-v2.zip) [1], [2].

The steps for generating the DRA functions applied in the pre-processing are summarized as follows:

* Derivation of the forward DRA functions *fDRAc*, for *c*=0 (for luma), 1,2 (for chroma);
* Derivation of the inverse reshaping functions *invfDRAc*, for c=0,1,2;
* Modeling of the inverse reshaping functions *invfDRAc*, for c=0,1,2 by PWL models *Pre-LUTc*, and generation of corresponding look-up-tables *LUTDRAc*, with proper range management;
* Derivation of the inverse LUTs *invLUTDRAc* derived from *LUTDRAc*, for c=0,1,2;
* Reshaping using the forward DRA LUTs *invLUTDRAc*, for c=0,1,2;
* Coding of the PWL models of *Pre-LUTc*, for c=0,1,2.

In the post-processing, the steps are summarized as follows:

* Decoding of the PWL models *Pre-LUTc*, and generation of corresponding look-up-tables *LUTc*, for c=0,1,2;
* Inverse DRA by application of the CRI *Pre-LUTc*, for c=0,1,2
  + - 1. Full and limited range management

DRA converts a standard range HDR10 signal into a full range reshaped signal. The conversion from limited range to full range by the inverse DRA process is directly addressed by the CRI LUTs, derived from the Pre-LUTs. 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 ).

* + - 1. VUI and CRI settings

As the reshaped HDR signal is based on adaptive transfer functions not specified in the VUI transfer functions, it is recommended to set the VUI syntax element transfer\_characteristics to “Unspecified”. The syntax element video\_full\_range\_flag should be set to 1. The other syntax elements should not be modified compared to the settings used when DRA does not apply.

In the CRI message, the syntax elements colour\_remap\_transfer\_function should be set to 16 (ST 2084), and colour\_remap\_full\_range\_flag should be set to 0.

In summary, the following settings are recommended in the VUI:

* transfer\_characteristics set equal to “Unspecified”.
* colour\_primaries set equal to 9 (Rec BT.2020, non constant luminance).
* matrix\_coeffs set equal to 9.
* video\_full\_range\_flag set equal to 1.

In summary, the following settings are recommended in the CRI:

* colour\_remap\_video\_signal\_info\_present\_flag set equal to 1
* colour\_remap\_transfer\_function set to 16 (ST 2084).
* colour\_remap\_full\_range\_flag shall be set to 0.
* colour\_remap\_primaries shall be set to 9.
* colour\_remap\_matrix\_coefficients shall be set to 9.
* colour\_remap\_output\_bit\_depth shall be set to 10.

# Reference

[1] K. Minoo (Arris), T. Lu, P. Yin (Dolby), L. Kerofsky (InterDigital), D. Rusanovskyy (Qualcomm), E. Francois (Technicolor), Description of the reshaper parameters derivation process in ETM reference software, JCTVC document W0031, San Diego, USA, Feb. 2016

[2] T. Lu, F. Pu, P. Yin, T. Chen, W. Husak (Dolby), Y. He, L. Kerofsky, Y. Ye (InterDigital) HDR CE2: CE2.a-2, CE2.c, CE2.d and CE2.e-3, JCTVC document W0084, San Diego, USA, Feb. 2016

# 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).**