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Title:	**Evaluation of Chroma Subsampling for High Dynamic Range Video Compression**
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Author(s) or Contact(s): Ronan Boitard[1], Mahsa T. Pourazad[2,3], and Panos Nasiopoulos[1, 3]

Tel: (604) 827-4878
Email: rboitard.w@gmail.com
mahsa.pourazad@gmail.com
panos.p.n@ieee.org

Source: [1]University of British Columbia (UBC) , [2]TELUS Communications Inc., [3] The Institute for Computing, Information and Cognitive Systems (ICICS)

Abstract

This contribution evaluates the impact of chroma subsampling using two different downsampling filters using objective metric. Objective results show that distributing 4:4:4 is more efficient than its 4:2:0 counterpart for medium to high bit-rates. For low bit-rates, this increase in efficiency is reduced and in some cases even reversed.

1 Introduction

To distribute video content with the highest possible visual quality at a given bandwidth, broadcasters rely on several lossy processing steps, applied prior to distribution. Among them, chroma subsampling has been established since the early stages of digital video as a mandatory step of most distribution pipelines. Chroma subsampling is assumed to reduce bandwidth requirements with limited impact on video quality. However, with the deployment of emerging technologies such as High Dynamic Range (HDR) [1] and Wide Color Gamut (WCG) [2], this assumption may not hold anymore.

The rest of this paper is structured as follows: Section 2 assesses the impact of subsampling (when no compression is applied. In Section 3, we compare the compression efficiency of full (4:4:4) and sub (4:2:0) chroma sampling. Finally Section 6 concludes this paper.

2 Chroma Sampling Comparison

In our first experiment two different chroma samplings are considered: 4:2:0 MPEG and 4:2:0 Lanczos. 4:2:0 MPEG uses the filter defined in the Common Test Condition (CTC) with the luma adjustment method deactivated. 4:2:0 Lanczos is a 6-tap Lanczos filter (Matlab filter lanczos3). These chroma sampling schemes are applied on four HDR test video sequences. The results are then compared against 4:4:4 (not using downsampling and upsampling but still using SMPTE ST 2084 and HDR10) in terms of t-PSNR-Y and PSNR-DE0100 (see Table 1 and Table 2).

Table 1: Impact of downsampling on the luma channel in dB

tPSNR-Y in dB			
Sequence	4:4:4	4:2:0 Lanczos	4:2:0 MPEG
FireEater2	69.33	65.15	64.38
Market3	69.56	62.52	62.07
BalloonFestival	67.94	62.35	62.12
Tibul2	68.53	60.66	60.00

Table 2: Impact of chroma downsampling on the color accuracy in dB..

PSNR-DE0100 in dB			
Sequence	4:4:4	4:2:0 Lanczos	4:2:0 MPEG
FireEater2	52.32	48.80	48.42
Market3	42.11	36.88	36.76
BalloonFestival	45.36	40.46	40.62
Tibul2	49.66	45.92	45.61

3 Chroma Subsampling and Compression Efficiency

In our second experiment, we evaluate the combined distortion of chroma subsampling and video compression. To this end, we compressed six HDR sequences using HM 16.7 with Range-Extension (RExt) to enable full chroma sampling video coding. The main-RExt profile was used (a.k.a. **main12**). We used the CTC QPs.

Figs. 1 to 6 report the RD curves when tPSNR-XYZ and the PSNR-DE0100 metric are used for measuring the distortion. tPSNR-XYZ results show that full chroma sampling performs slightly better for high bit-rates. However, as the bit-rate decreases, the gain is reduced and for low bit- rates it becomes negative (see Figs. 5 and 6). Note that for comparison we also included the **anchor 3.2 results,** which are using **the main10 profile.** The anchor results are always below both other approaches.

The gain in color accuracy (PSNR-DE0100 metrics) seems less dependent on the bit-rate and is close to 1 dB for most of sequences. Only the FireEater2 sequence results (Fig. 1) have a limited gain in color accuracy, close to 0.5 dB. FireEater2 is mostly a dark sequence, which explains the lower impact of using full chroma sampling. Note that the more colorful the sequence is, the more impact full chroma sampling has (BalloonFestival results show an average gain of 2 dB, Fig 4). The anchor however outperforms both methods using the main 12 profile.

Finally, note that using a longer filter (6-tap 4:2:0 Lanczos versus 3-tap 4:2:0 MPEG) does not seem to improve the compression efficiency.

4 Conclusion

We evaluated the impact of chroma subsampling on the compression efficiency of HDR video content. We observed that using chroma subsampling always decreases the accuracy of color reproduction. Results obtained from the tPSNR-XYZ metric indicated that using chroma subsampling reduces the compression efficiency at medium to high bit-rates, while some gain can be achieved at low bit-rates. Our results also indicated that using a longer filter does not seem to increase compression efficiency.

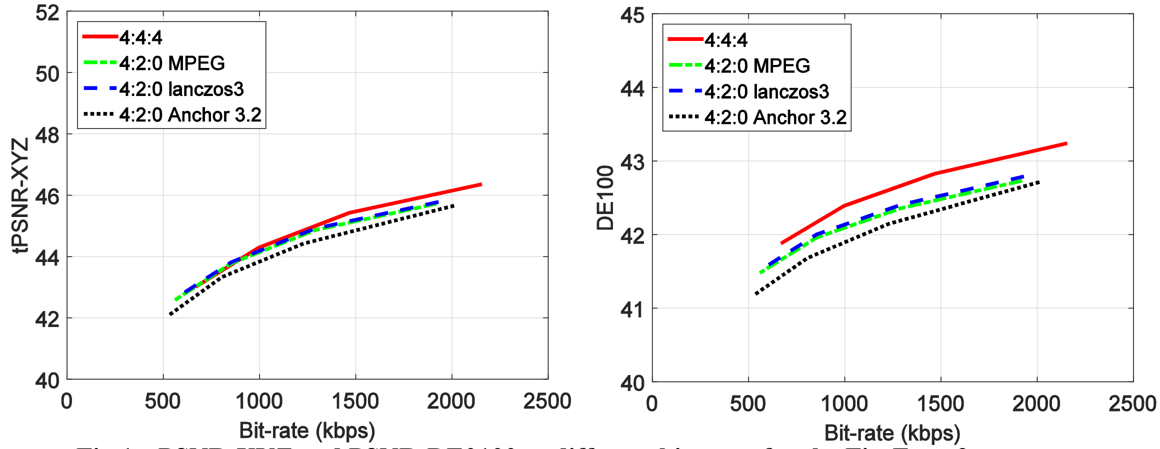

Fig 1: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the FireEater2 sequence.

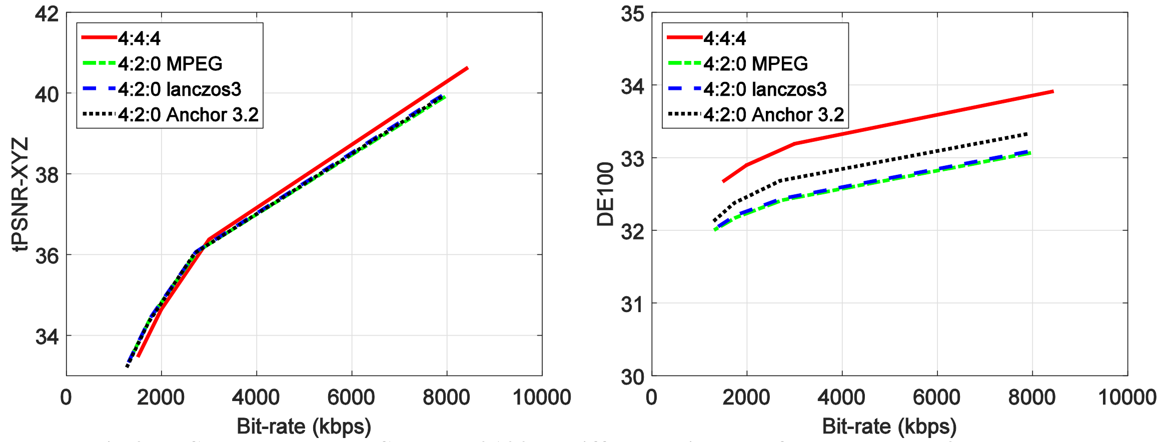

Fig 2: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the Market3 sequence.

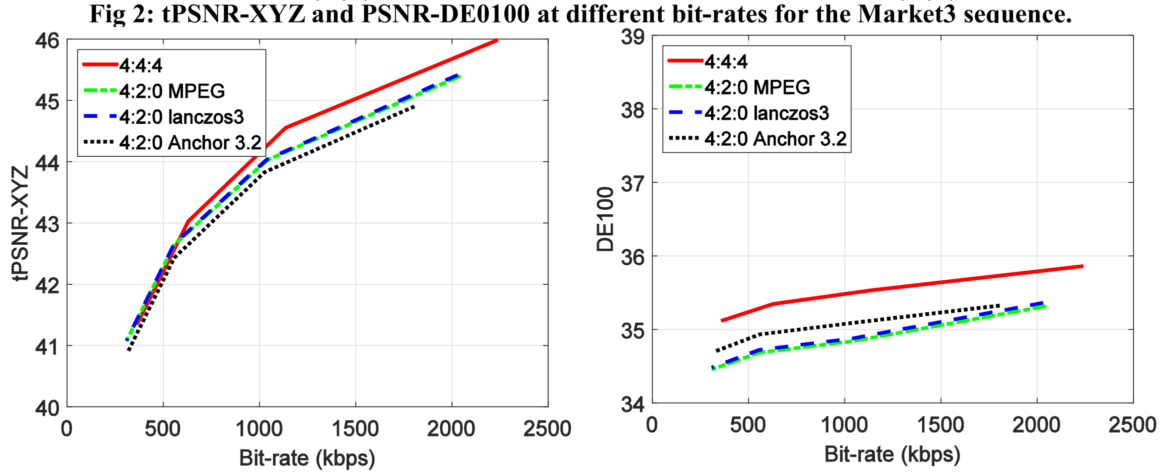

Fig 3: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the Sunrise sequence.

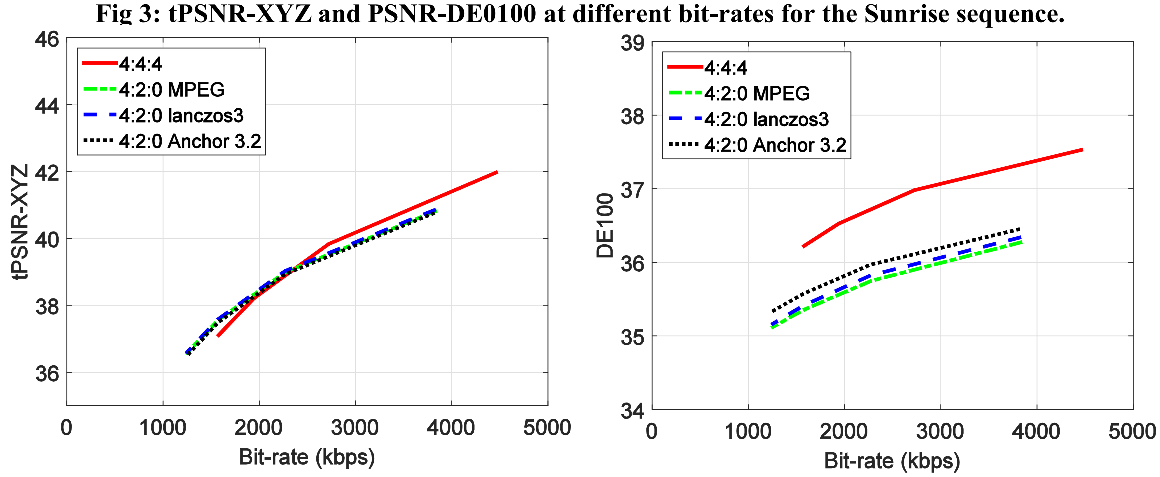

Fig 4: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the BallonFestival sequence.

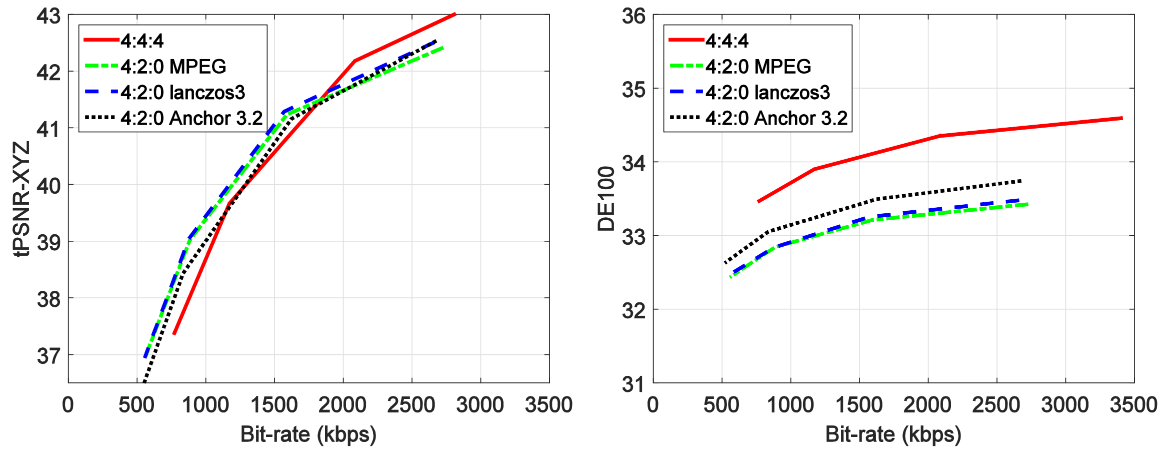

Fig 5: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the Starting sequence.

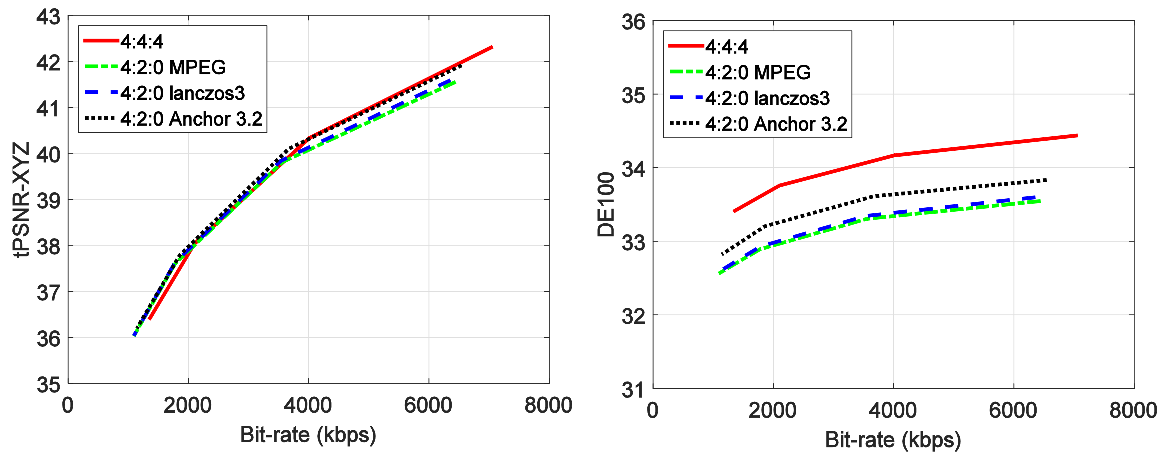

Fig 6: tPSNR-XYZ and PSNR-DE0100 at different bit-rates for the Hurdles sequence.

5 References

[1] Ronan Boitard, Mahsa T. Pourazad, Panos Nasiopoulos, and Jim Slevinsky, "Demystifying high-dynamic-range technology: A new evolution in digital media.," IEEE Consumer Electronics Magazine, vol. 4, no. 4, pp. 72– 86, oct 2015.

[2] C. Poynton, Jeroen Stessen, and Rutger Nijland, "Deploying wide color gamut and high dynamic range in hd and uhd," SMPTE Motion Imaging Journal, vol. 124, no. 3, pp. 37–49, apr 2015.

6 Patent rights declaration(s).

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