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| *Title:* | **On a 10-bit consumer-oriented profile in High Efficiency Video Coding (HEVC)** | | |
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| *Source:* | [NGcodec, BSkyB, NHK, DirecTV, SVT, Motorola Mobility, Technicolor, Ericsson, Thomson Video Networks, BBC, ST, ATEME, CISCO, RAI, ViXS Systems] | | |

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# Abstract

This joint contribution suggests that JCT-VC establishes a breakout group (BoG) in order to investigate the creation of an additional Profile to be included in a next version of the Text Specification Draft for High Efficiency Video Coding (HEVC) that would support both 8 and 10 bits bit-depth 4:2:0 content coding and that analyzes the feasibility of completing the work on this profile before on the release of professional extensions profiles.

Introduction

It is proposed to introduce a new profile to HEVC that supports the processing of both 8 and 10 bits bit-depth video content. The 8-bit step may help broadcast stakeholders to choose and ensure retro-compatibility of services. This new profile would extend the current Main Profile to support 10-bit content and maintaining the chroma support being only 4:2:0. Support for 10-bit bit-depth content would be the only proposed technical difference between the currently defined Main Profile and this new 10-bit Profile and this work would be done in isolation from other work to create additional professional profiles on HEVC related to 4:2:2/4:4:4, scalability, multiview tools etc. Indeed this profile would be considered as a consumer-oriented profile that would aim at easing UHDTV (i.e. with Rec. 2020 [1] parameters) advent and deployment.

On the importance of a new 10-bit profile

Support for 10-bit bit-depth is becoming very important in many mass market applications, especially related to 1080p HD and UHDTV[[1]](#footnote-2), including the following examples:

* The bit depth supported by the ITU-R BT. 2020 [1] recommendation on UHDTV is 10 or 12 bits (8 bits is not supported at the moment).
* Content producers are mastering and archiving 1080p HD content in 10-bit bit-depth.
* Support for 10-bit bit-depth is becoming available on consumer display systems. The larger physical size of UHDTV displays, coupled with the wider color gamut and higher dynamic ranges supported by them, may more readily expose the visual artifacts of 8-bit video content
* Nowadays, many consumer interfaces support 10-bit bit-depth (HDMI1.4a, DisplayPort support 12 bits at least)

Besides, most of the digital video workflow elements now support at least 10-bit, from the acquisition to the rendering ([5]). Furthermore, a number of broadcasters (some of them represented on this contribution) evaluating the creation of 1080p HD and UHDTV services have identified the need for a 10-bit profile being able to use HEVC for delivering UHDTV content. The current lack of a 10-bit profile in HEVC may delay the deployment of these services or will conduct to consider other compression formats. This has led to the creation of this contribution with the goal of accelerating its inclusion on the HEVC International Standard.

One of the goals of the JCT-VC is to promote the rapid acceptance of HEVC in the industry and minimize the barriers towards adopting the new format. Providing a basic 10-bit profile sooner will speed up acceptance by the broadcast industry and help to proliferate HEVC, more importantly in generalized HD 1080p services and UHDTV applications that are originally one of the main objectives of HEVC.

Technical Merits of supporting 10-bit bit-depth video content

It is well understood that some video artifacts are associated with the restriction of utilizing 8 bit bit-depth. The primary issue is described as banding or contouring, mostly in video sequences with shallow color changes. The following side-by-side comparisons illustrate the difference between 8-bit and 10-bit per component format. These are not HEVC-coded pictures, but generic examples showing the limitations of 8-bit bit-depth. The first picture is from a commercial TV advertisement, which supports the observation that the difference between 8 and 10 bits bit-depth is in the general consumer’s awareness. More examples, with pictures, can be found in the literature, e.g. [2].



Figure 1 – Banding illustration with 8-bit versus 10-bit



Figure 2 - Banding effect in the sky 10-bit versus 8-bit.

A second artifact that may be reduced by using 10-bit bit-depth is related to mosquito noise and similar visual distortions.

There is some evidence [3] using AVC that encoding at 10 bits does not necessarily require a higher bit rate than encoding at 8 bits, particularly at moderate compression ratios. This stems from the following observations:

* For a given PSNR, a 10-bit encoded video stream can be quantized more heavily than an 8-bit stream (due to the extra two bits of precision) while yielding the same final quality
* The potential usage of 10-bit precision in internal data paths (e.g. known as Internal Bit-Depth increase or IBDI) results in better prediction, smaller residuals and better overall visual experience

# Current state of 10 bits coding in the Text Specification Draft and Reference Software

From previous contributions submitted at previous JVT-VC meetings, including JCTVC-J0079 [4] and its predecessor JCT-VC-I0108 [5], it is indicated that the current HEVC Draft Text and Reference Software (as of HM7.0) successfully supports the coding of 10-bit video sequences. From JCTVC-J0079: “It is reported that no major issues have been identified for 8, 10 and 12 bit-depths for both HEVC Draft 7 d4 and HM7.0 (RA-HE and AI-HE).” Besides this contribution fixes bit-depth issues until 14-bit conducting to very coherent results between AVC and HEVC for 8, 10, 12 and 14 bits coding.

As part of the complete definition of this new profile, it would be required to consider if it is necessary to create new levels definitions or it is sufficient to use the current levels defined for the Main Profile of HEVC – although the authors of this proposal, for the time being, can not see any need of new Levels.

Rec. 2020 [1] (UHDTV) proposes same reference white and OETF as Rec. 709 (HDTV) however chromaticity coordinates are different as well as gamut that is wider for UHDTV. According to HEVC codec viewpoint this information is exposed informatively in the VUI as the codec internal mechanisms are signal colorimetry-agnostic per se. Besides, current Draft already mentions such colorimetry aspects, some slight enhancement may be proposed according to Rec. 2020 evolution [7].

Regarding 4:2:2/4:4:4 chroma format and beyond 10-bit bit-depth

This joint contribution does not recommend that either a 4:2:2 chroma format or bit-depths beyond 10 bits be supported in an extension profile at this time, but it does suggest that those extensions may be added at a later stage.

Although 4:2:2/4:4:4 chroma formats often have been coupled in the past with greater than 8-bit bit-depth when discussing enhanced video modes, those were mostly looking at professional applications and the creation and manipulation of video content. There is a new trend in the delivery of video content that is requesting 10 bits in isolation from 4:2:2/4:4:4 chroma formats and that does not associate them together.

This is mostly for the following reasons:

* There is a penalty in bit rates required for coding of 4:2:2 content as opposed to 4:2:0 [6]
* There is small perceived video quality improvements in most applications associated with the delivery of video content when using 4:2:2 or 4:4:4 for encoding.

It is proposed in this contribution that the support for bit-depths greater than 10 and 4:2:2 and 4:4:4 chroma formats be added as additional HEVC profiles at a later stage and not at the same time as the inclusion of this new 10-bit profile. The HEVC extensions currently under discussion include a number of proposed additions, including new tools for scalability and multiview, which are not necessary for a basic 10-bit profile that would be oriented for consumer applications like 1080p HD or UHDTV. The need for development and testing of those tools will risk delaying a basic 10-bit profile which, based on our experience with AVC, will only differ from the current HEVC Main Profile in bit-depth and would be much simpler to develop as beyond 8-bit bit-depth was thought from start in HEVC design (e.g. 10 bits sequences were added as test material as well as coding profiles (High Efficiency 10 bits) to ensure that HEVC extensions development would not be a burden.)

Suggested approach

The authors of this contribution suggest the following approach for the creation of a basic profile that supports 10-bit in the HEVC specification:

* Establish a BoG with the following mandates:
* Review all related inputs
* Review the current support for 10 bits on the current version of the Text Specification Draft and Reference Software
* Create a text that specifies the recommended changes related to this new Profile on the Text Specification Draft, if necessary
* Identify any technical issues to be considered within the current timeline, if necessary
* Review the text and make a recommendation on its adoption into the Text Specification Draft.
* Continue Ad Hoc Group discussions until the next meeting with the following mandates:
* Study and refine the Text Specification Draft changes related to this 10-bit Profile
* Study aspects of the technical design and software that need modification to support 10 bit bit-depth format
* Collect 10-bit bit-depth sequences for further evaluation and analyze the technical design
* Report the results and conclusions to the JCT-VC

Conclusion

Up to now in the HEVC development cycle, support for 10-bit bit-depth has been grouped together with 4:2:2, 4:4:4, and bit-depths beyond 10 bits as “professional” requirements that could be supported in a set of “professional” profiles to be defined later. It is our contention that due to the noticeable nature of artifacts (banding) visible with 8-bit coding, together with the increasing availability of 10-bit bit-depth production and consumer equipment, and an associated push by the industry to educate consumers on the benefits of 10-bit bit-depth content, as well as the fact that 10-bit bit-depth is currently required by the ITU specification for UHDTV applications, it is necessary to move a basic 10-bit profile from the “professional” category to the “consumer” category and preferably make it part of the initial HEVC specification as soon as possible to not brake 1080p HD and UHDTV services setting up.

References

[1] ITU-R BT.2020, “Parameter values for ultra-high definition television systems for production and international program exchange”, August 2012

[2] P. Larbier, “Keeping Video Quality Pristine throughout the Production Process: 4:2:2 10-bit AVC/H.264 encoding”, <http://x264.nl/x264/10bit_03-422_10_bit_pristine_video_quality.pdf>

[3] Pierre Larbier, “Using 10-bit AVC/H.264 Encoding with 4:2:2 for Broadcast Contribution”, 2010

[4] P. Andrivon, P. Bordes, P. Salmon, “AHG12: On beyond 8 bit-depth support in HEVC”, JCTVC-J0079, Stockholm, Sweden, Jul. 2012.

[5] P. Andrivon, P. Bordes, “High Bit Depth Considerations in HEVC”, JCTVC-I0108, Geneva, Switzerland, Apr. 2012.

[6] British Sky Broadcasting, “DVB TM-AVC0560: Comparison of Different Chroma Sampling Schemes for Video Broadcasting”, September 2012

[7] T. Suzuki , “Proposal to support UHDTV colorimetry”, JCTVC-J0577, Stockholm, Sweden, July 2012

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**NGcodec Inc does not have any current or pending patent rights relating to the technology described in this contribution.**

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1. One example of UHDTV is 3840x2160p, i.e. “QuadHD or 2160p”, UHDTV also defines 7680x4320p. [↑](#footnote-ref-2)