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| **ITU – Telecommunications Standardization Sector**STUDY GROUP 21 Question 6**Video Coding Experts Group (VCEG)**76th Meeting: 27 March – 4 April 2025, Teleconference | Document VCEG-BX13-v2 |

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| Question: | 6/21 (VCEG)  |
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| Title: | **Core experiment CE1-2 on improved deblocking in biomedical waveform coding** |
| Purpose: | Core experiment |

**Abstract**

This contribution reports objective and subjective results of core experiment CE1-2 on deblocking in H.BWC, initiated at the January 2025 VCEG meeting in Geneva, via BD-rate and examples of perceptual observations and comparisons, respectively. Relative to the technology proposed as part of Fraunhofer HHI’s CfP response (see VCEG-BW12), the changes to the deblocking method are:

* use of an own probability context in entropy coding of the block-wise deblocking parameter,
* modified (de)quantization strategy for parameter value ±1to minimize side information rate,
* adoption of deblocking in all trigonometric-transform coded blocks (previously not the case).

On the default *combined* configuration presets and on top of the current version1.0 of the H.BWC reference software, the following PRD based Bjøntegaard delta-rate results are reportedly observed when enabling the deblocking-only perceptual optimization via encoder option --*PerceptMode*=1:

* **ECG** data: BD-rate 3.16%, encoding time ratio 102.7%, decoding time ratio 95.8% (faster),
* **EMG** data: BD-rate 1.12%, encoding time ratio 100.7%, decoding time ratio 100.1% (same),
* **EEG** data: BD-rate 2.32%, encoding time ratio 100.7%, decoding time ratio 98.2% (faster).

Compared to the initial results reported in VCEG-BW12 on the objective effects of this technology on the coding efficiency (around10% loss in BD-rate), a considerable improvement can be noted. No change to the coding efficiency is observed in lossless codec operation since deblocking is not activated in this case. Comparative screenshots of waveforms and spectrograms with and without deblocking on biomedical signals are provided to illustrate the perceptual benefit of this proposal.

1. **Description of Changes**

Since the fundamental operation of HHI’s deblocking solution for H.BWC is described in detail in VCEG-BW12 [1], only the changes to this version of the technology are described in the following.

* **use of separate probability context** in entropy coding of block-wise deblocking parameter: When deblocking is active and a block is coded using a trigonometric transform, a quantized deblocking parameter is en/decoded after the quantized residual transform coefficients, using the same entropy coding method as for a zero-frequency (DC) transform coefficient. Unlike in prior versions, where the same probability context (value significance flag and range class) was used for the residual transform coefficients and deblocking parameter (reuse), the latter is now coded using a separate probability context, updated independently for this parameter.
* **modified (de)quantization strategy** for parameter value ±1to reduce side information rate: It was noticed that quantized deblocking parameter values of 1or –1, requiring only few bits during entropy coding, occur relatively infrequently. Hence, such values now serve as escape value for more likely corrective-curve parametrization, namely, flat or half-cosine correction.
* **adoption of deblocking in all blocks** coded using trigonometric transform (wasn’t the case): During the formation of the current H.BWC test model and reference software, code which did not exist during the time of Fraunhofer HHI’s CfP response was added. Since, currently, the new code is not equipped with deblocking capability but also applies trigonometric trans­formation to block signals, a respective extension of the deblocking functionality was added.

A block diagram of the overall deblocking architecture in the codec looks as follows (see also [1]):



1. **Performance Results**

The effect of enabling deblocking, via --*PerceptMode*=1, was assessed using PRD based BD-rate evaluation [3], with adoption of the default *combined...cfg* presets and the necessary code changes implemented on top of version1.0 of the H.BWC test model software [2]. The results are as follows in lossy codec mode (step-size >1; deblocking is not applied in lossless mode with step-size =1):

* **ECG** data: BD-rate 3.16%, encoding time ratio 102.7%, decoding time ratio 95.8% (faster),
* **EMG** data: BD-rate 1.12%, encoding time ratio 100.7%, decoding time ratio 100.1% (same),
* **EEG** data: BD-rate 2.32%, encoding time ratio 100.7%, decoding time ratio 98.2% (faster).

In summary, slight loss in objective coding efficiency is observed on all datasets, but the loss is an order of magnitude lower than that originally illustrated in [1], which was around10%. Moreover, a significant increase in encoder runtime is only observed on the ECG set where, at the same time, the decoder runtime decreases by 4% (most likely due to more use of the DST, which benefits from deblocking pre-/post-processing and is faster that a DCT). Decoding on EEG data also gets faster.

Detailed per-sequence results on the ECG, EMG, and EEG datasets are attached to this document.

1. **Visual Comparisons**

On the following page, screenshots of waveforms and spectrograms are provided to demonstrate the perceptual benefit of applying deblocking in the lossy coding of biomedical waveform signals.

It is kindly requested to adopt the described deblocking approach into the next H.BWC test model. Draft specification text can be provided in a relatively timely manner.

1. **References**

[1] C. Helmrich *et al.*, “Optimization of HHI’s CfP response for rate constrained or perceptual use cases,” *ITU-T document VCEG-BW12*, Kemer, Nov. 2024, *files with VCEG-BW12 in name*. 🌍: <https://www.itu.int/wftp3/av-arch/video-site/2411_Kem/>, missing page stored as a separate file

[2] VCEG, “Reference software for biomedical waveform data compression,” tag BWC-1.0. 🌍: <https://vcgit.hhi.fraunhofer.de/vceg-sw/bwc/-/tags>, presets *combined...cfg* in directory*bwc/cfg*

[3] J. Pfaff, C. Fersch, and Rapporteur Q6/21, “Common test conditions and evaluation procedures for H.BWC technical experiments,” *ITU-T document SG21-TD68/WP3*, Geneva, Jan. 2025. 🌍: <https://www.itu.int/wftp3/av-arch/video-site/2501_Gen/T25-SG21-TD-WP3-068-BWC-CTC.docx>

1. **Patent Rights Declaration**

**Fraunhofer 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 (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

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All of the illustrations below are from encodings at bit-rates of approximately1.72 bits per sample.

EEG waveform (unknown channel)



EMG waveform (channel 4 only)

EMG spectrograms (channels 3, 4)

