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| Question: | 6/21 (VCEG) |
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| Title: | **Report of CE-5** |
| Purpose: | Proposal |

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# Abstract

This document reports on the simulation results of CE-5.

# Technical overview of the CE

In this CE, besides being combined with the zero prediction mode as in CE-4, the LMS-prediction is also enabled to operate on the prediction residuals of the block-based prediction modes inter-channel prediction and block-matching prediction that are supported in the current H.BWC, version 2. For the coding of the DCT coefficients, only CABAC entropy coding is used. In the same way as in CE-4, two versions of CABAC entropy coding are tested: Either the CABAC version of the current H.BWC, version 2, or the CABAC version of the current H.BWC, version 2, but with the changes proposed in CE 3 enabled. Moreover, in the same way as in CE-4, both of these CABAC versions are tested in combination with three versions of quantization: Uniform scalar reconstruction quantization without entropy constraint quantization at the encoder, uniform scalar reconstruction quantization with entropy constraint quantization (rate-distortion optimized quantization) at the encoder and, finally, trellis coded quantization.

# Software version for CE-5

To generated the experimental results of CE-5, two software version were used. Software version SW-v1 was used to generate the results of CE-5-1-1, CE-5-2-1 and CE-5-3-1. The software SW-v1 is the same software as the software SW-v1 used to generate the results of CE-4-1-1, CE-4-2-1 and CE-4-3-1 as well as CE-4-4-1, CE-4-5-1 and CE-4-6-1, where different configuration-files were used for each of these CEs. Software version SW-v2 was used to generate the results of CE-5-1-2, CE-5-2-2 and CE-5-3-2. The software SW-v2 is the same software as the software SW-v2 used to generate the results of CE-4-1-2, CE-4-2-2 and CE-4-3-2 as well as CE-4-4-2, CE-4-5-2 and CE-4-6-2 where different configuration-files were used for each of these CEs.

# Simulation results

## Simulation results of CE-5-1-1

In CE-5-1-1, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-1-1 is the CABAC-entropy coding method of H.BWC, version 2. For quantization, a uniform scalar reconstruction quantizer is used. At the encoder, simple quantization without entropy constraints is invoked.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 8,09% | 8,09% | 43% | 119% |
| INCART (ECG) | -17,42% | -17,45% | 21% | 162% |
| CHBMIT (EEG) | 1,99% | 2,03% | 86% | 159% |
| NMR55 (EEG) | 9,05% | 11,83% | 21% | 106% |
| NMR57 (EEG) | 4,76% | 4,83% | 28% | 233% |
| Ozdemir (EMG) | 3,42% | 3,49% | 20% | 106% |
| **Overall**  | 1,65% | 2,14% | 37% | 147% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 10,41% | 10,41% | 42% | 114% |
| INCART (ECG) | 6,82% | 6,94% | 22% | 147% |
| CHBMIT (EEG) | 6,25% | 6,27% | 42% | 144% |
| NMR55 (EEG) | 10,19% | 13,49% | 23% | 118% |
| NMR57 (EEG) | 7,02% | 7,09% | 23% | 127% |
| Ozdemir (EMG) | 3,91% | 3,96% | 22% | 135% |
| **Overall**  | 7,43% | 8,03% | 29% | 131% |

## Simulation results of CE-5-1-2

In CE-5-1-2, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-1-2 is the CABAC-entropy coding method of H.BWC, version 2, where the proposed entropy coding modifications of CE-3 are enabled. For quantization, a uniform scalar reconstruction quantizer is used. At the encoder, simple quantization without entropy constraints is invoked.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 7,09% | 7,09% | 43% | 118% |
| INCART (ECG) | -17,94% | -17,95% | 21% | 159% |
| CHBMIT (EEG) | -1,93% | -1,89% | 87% | 156% |
| NMR55 (EEG) | 5,73% | 8,43% | 21% | 106% |
| NMR57 (EEG) | 1,99% | 2,06% | 28% | 228% |
| Ozdemir (EMG) | 1,12% | 1,20% | 21% | 104% |
| **Overall**  | -0,65% | -0,18% | 37% | 145% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 9,22% | 9,21% | 42% | 115% |
| INCART (ECG) | 5,96% | 6,08% | 22% | 144% |
| CHBMIT (EEG) | 2,41% | 2,43% | 42% | 140% |
| NMR55 (EEG) | 6,85% | 10,07% | 23% | 117% |
| NMR57 (EEG) | 4,87% | 4,94% | 23% | 123% |
| Ozdemir (EMG) | 1,61% | 1,67% | 22% | 130% |
| **Overall**  | 5,15% | 5,73% | 29% | 128% |

## Simulation results of CE-5-2-1

In CE-5-2-1, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-2-1 is the CABAC-entropy coding method of H.BWC, version 2. For quantization, a uniform scalar reconstruction quantizer is used. At the encoder, entropy constraint quantization (rate-distortion optimized quantization) is invoked.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 5,13% | 5,14% | 49% | 118% |
| INCART (ECG) | -20,10% | -20,21% | 23% | 160% |
| CHBMIT (EEG) | 0,95% | 0,90% | 101% | 157% |
| NMR55 (EEG) | 8,89% | 11,03% | 23% | 105% |
| NMR57 (EEG) | 3,60% | 3,52% | 30% | 228% |
| Ozdemir (EMG) | 3,35% | 3,18% | 23% | 106% |
| **Overall**  | 0,30% | 0,59% | 41% | 146% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 7,86% | 7,86% | 47% | 114% |
| INCART (ECG) | 4,79% | 4,91% | 24% | 145% |
| CHBMIT (EEG) | 5,63% | 5,60% | 49% | 142% |
| NMR55 (EEG) | 10,00% | 12,72% | 25% | 118% |
| NMR57 (EEG) | 6,34% | 6,31% | 28% | 125% |
| Ozdemir (EMG) | 3,90% | 3,67% | 25% | 133% |
| **Overall**  | 6,42% | 6,85% | 33% | 129% |

## Simulation results of CE-5-2-2

In CE-5-2-2, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-2-2 is the CABAC-entropy coding method of H.BWC, version 2, where the proposed entropy coding modifications of CE-3 are enabled. For quantization, a uniform scalar reconstruction quantizer is used. At the encoder, entropy constraint quantization (rate-distortion optimized quantization) is invoked.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 3,89% | 3,90% | 57% | 118% |
| INCART (ECG) | -20,52% | -20,60% | 27% | 161% |
| CHBMIT (EEG) | -4,01% | -4,02% | 117% | 158% |
| NMR55 (EEG) | 4,43% | 6,93% | 27% | 105% |
| NMR57 (EEG) | -0,10% | -0,08% | 32% | 227% |
| Ozdemir (EMG) | 0,22% | 0,26% | 27% | 96% |
| **Overall**  | -2,68% | -2,27% | 48% | 144% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 6,32% | 6,32% | 53% | 115% |
| INCART (ECG) | 3,84% | 3,97% | 28% | 143% |
| CHBMIT (EEG) | 1,00% | 1,01% | 55% | 139% |
| NMR55 (EEG) | 5,78% | 8,94% | 29% | 117% |
| NMR57 (EEG) | 3,43% | 3,51% | 32% | 122% |
| Ozdemir (EMG) | 0,74% | 0,75% | 29% | 129% |
| **Overall**  | 3,52% | 4,08% | 38% | 128% |

## Simulation results of CE-5-3-1

In CE-5-3-1, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-3-1 is the CABAC-entropy coding method of H.BWC, version 2. For quantization, trellis coded quantization with four states is used.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 1,47% | 1,47% | 74% | 118% |
| INCART (ECG) | -23,10% | -23,16% | 40% | 160% |
| CHBMIT (EEG) | -1,30% | -1,37% | 181% | 157% |
| NMR55 (EEG) | 7,14% | 8,93% | 39% | 106% |
| NMR57 (EEG) | 1,48% | 1,30% | 48% | 219% |
| Ozdemir (EMG) | 1,30% | 1,08% | 42% | 104% |
| **Overall**  | -2,17% | -1,96% | 71% | 144% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 4,42% | 4,43% | 65% | 114% |
| INCART (ECG) | 1,56% | 1,68% | 35% | 143% |
| CHBMIT (EEG) | 3,49% | 3,44% | 73% | 140% |
| NMR55 (EEG) | 8,12% | 10,41% | 36% | 117% |
| NMR57 (EEG) | 3,95% | 3,78% | 43% | 125% |
| Ozdemir (EMG) | 1,77% | 1,52% | 39% | 132% |
| **Overall**  | 3,89% | 4,21% | 49% | 128% |

## Simulation results of CE-5-3-2

In CE-5-3-2, the LMS-prediction mode is operated on the block-based prediction residuals for the zero-prediction mode, the block-matching prediction mode and the cross-channel prediction mode. The coding mode 0 is no longer present. The only entropy coding method used in CE-5-3-2 is the CABAC-entropy coding method method of H.BWC, version 2, where the proposed entropy coding modifications of CE-3 are enabled. For quantization, trellis coded quantization with four states is used.

The following results are reported for the CTC in the case of joint channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | -0,14% | -0,13% | 81% | 119% |
| INCART (ECG) | -23,66% | -23,71% | 56% | 205% |
| CHBMIT (EEG) | -7,97% | -7,97% | 193% | 201% |
| NMR55 (EEG) | 0,82% | 3,18% | 55% | 105% |
| NMR57 (EEG) | -4,30% | -4,28% | 66% | 300% |
| Ozdemir (EMG) | -3,04% | -2,98% | 58% | 131% |
| **Overall**  | -6,38% | -5,98% | 85% | 177% |

The following results are reported for the CTC in the case of independent channel coding:

|  |  |
| --- | --- |
|  | **Lossy Compression** |
|  | **Over BWC-2.1** |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | 2,60% | 2,61% | 71% | 115% |
| INCART (ECG) | 0,42% | 0,55% | 38% | 141% |
| CHBMIT (EEG) | -2,91% | -2,90% | 79% | 137% |
| NMR55 (EEG) | 2,01% | 4,87% | 40% | 117% |
| NMR57 (EEG) | -0,50% | -0,43% | 46% | 122% |
| Ozdemir (EMG) | -2,61% | -2,56% | 42% | 128% |
| **Overall**  | -0,17% | 0,36% | 53% | 127% |

# Proposed action following CE-4 and CE-5

It is proposed to adopt the changes incorporated into software SW-v2 into the next version of H.BWC. Thus, it is proposed that the current H.BWC:

* Supports LMS prediction on the prediction residual of the zero prediction, the block matching prediction and the cross channel prediction
* Only uses CABAC entropy coding for the DCT coefficients, in the version of the current H.BWC, but with the proposed changes of CE-3 enabled.

This means that, invoking the appropriate configuration-files, results as reported in CE-4-1-2, CE-4-2-2, CE-4-3-2, CE-4-4-2, CE-4-5-2 and CE-4-6-2 as well as CE-5-1-2, CE-5-2-2, and CE-5-3-2 can be obtained which all represent different tradeoffs between encoder runtime and compression efficiency.

# Patent rights declaration(s)

**Fraunhofer HHI 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).**

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