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| Question: | 6/21 (VCEG) | | |
| Source: | **Christian Helmrich, Sophie Pientka, Gabriel Hege, Heiner Kirchhoffer, Paul Haase, Heiko Schwarz, Jonathan Pfaff (Fraunhofer HHI)** | Email: | [christian.helmrich@hhi.fraunhofer.de](mailto:christian.helmrich@hhi.fraunhofer.de) |
| Title: | **Speedup of H.BWC reference software via pre-search and predictor optimization** | | |
| Purpose: | Proposal | | |

**Abstract**

The current version of the H.BWC reference software spends considerable processing time on the calculation of block prediction signals as well as on their RDO evaluation. Herein, we propose to accelerate the reference software by up to a factor of 11, with little loss in coding performance. On top of software engineering related improvements and avoidance of redundant or unnecessary cal­culations, our code acceleration work includes the following changes to the H.BWC software base:

* usage of an integer fast Walsh-Hadamard transform instead of a DCT in the pre-search stage,
* temporal¼ downsampling of waveform signals during the block prediction pre-search stage,
* temporal reuse of pre-search results or data for block *bc* in channel *c* in the next block *b* +1*c*,
* cross-channel reuse of pre-search results or data for *bc* in channel *c* in the next channel *bc* +1,
* cross-block-split reuse of pre-search results or data in different split depths or blocks (ECG).

On the default *combined* configuration presets, encoder as well as decoder speedups of more than 30% are observed,with at most1.8% loss in BD-rate performance (ECG dataset, less on other sets). In addition, a new *very fast* configuration preset, testing only two block-prediction methods (block matching and/or cross-channel prediction, with fallback to *Off*) during encoder RDO, is proposed.

1. **Description of Changes**

Aside from software engineering related improvements to the current version of the H.BWC refer­ence software [1], such as avoidance of unnecessary calculations of prediction signals (encoder or decoder) or RDO cost and reconstructed-signal information (encoder side), this proposal includes:

* usage of an integer fast Walsh-Hadamard transform instead of a DCT in the pre-search stage: the block matching (BM) and cross-channel (CC) block predictors apply a pre-search process in which multiple predictor configuration candidates are determined using transform-domain L1 norm calculations. Instead of a DCT-II for time-frequency transformation for this purpose, use of a fast, 32-bit (for16-bit input) integer Walsh-Hadamard transform (WHT) is proposed.
* temporal¼ downsampling of waveform signals during the block prediction pre-search stage: to lower the number of sample-wise calculations during the abovementioned pre-search step, it is proposed to apply intermediate downsampling, by a factor of 4, of the channel and block-wise waveform data during the search for optimal block-prediction configuration candidates.
* temporal reuse of pre-search results or data for block *bc* in channel *c* in the next block *b* +1*c*: it is proposed to adopt, in each new block *b* +1*c*, the decision for the cross-channel split depth1vs.0 (no split) from the decision made in the already encoded first block *b'c* of each frame.
* cross-channel reuse of pre-search results or data for *bc* in channel *c* in the next channel *bc* +1: same as above, but in channel instead of time direction (e. g., use same BM offset in ch.*c* +1).

1. **New Configuration File**

This contribution includes the proposal of a further encoder configuration preset file for ECG or EMG datasets,called *veryFastPresetECG.cfg*,which is fundamentally similar to the *combined...cfg* files already included in the H.BWC reference software repository [1] but targeted at lower encoder runtimes while keeping good coding efficiency. Its main differences to the *combined...cfg* files are:

* **block predictors**: only the block matching and cross-channel (linear-model) time-predictors are included in the RDO search. The changes to the H.BWC reference software encoder inc­lude an automatic fallback to block prediction bypass (*Off*) upon bad predictor performance.
* **other predictors**: only the frequency-domain (herein, DCT-domain) predictors are included in the RDO search. In lossless mode (QP = 0), simple delta or LPC predictors are also added.
* **predictor candidates**: for block prediction, reduced numbers of parametrization candidates (*BM/LMNumCandsFullRD*, obtained during the pre-search) are included in the RDO search.
* **trigonometric transform**: only the DCT-II is used for residual transformation, not the DST.

For EMG datasets, it is suggested to reduce the values of both ...SPLIT\_DEPTH... options by one.

1. **Performance Results**

The effect of enabling the abovementioned improvements was assessed using PRD based BD-rate evaluation [2], with adoption of the default *combined...cfg* presets [1]. Two encoder settings were evaluated: one with the default predictor configuration (using the *combined...cfg*) and one with the newly proposed configuration (using the *veryFastPresetECG.cfg* preset). The results are as follow:

* **default** [1] configuration, results measured over v1.0 of H.BWC in default configuration [1]:  
  *ECG*lossy BD1.79%, Enc **61.3**%, Dec 42.7%; lossless BD 99.79%, Enc **67.3**%, Dec 51.0%  
  *EMG* lossy BD –0.1%, Enc **73.7**%, Dec 89.9%; lossless BD100.04%, Enc **73.2**%, Dec 93.7%  
  In summary, encoder speedups between factors of1.49x and1.63x are achieved on ECG data. On the EMG dataset, speedup is less (1.36x,1.37x) but minor gain is achieved in lossy mode.
* ‘**very fast**’ configuration, results measured over v1.0 of H.BWC in default configuration [1]:  
  *ECG*lossy BD13.7%, Enc **24.9**%, Dec 47.8%; lossless BD102.46%, Enc **31.1**%, Dec 51.3%  
  *EMG*lossy BD 2.51%, Enc**10.5**%, Dec102.4%; lossless BD100.3%, Enc **8.95**%, Dec 82.7%  
  In summary, encoder speedups between factors of 4.02x and11.2x are achieved. The decoder runtime increase on the EMG dataset in lossy mode is the subject of an ongoing investigation.

Detailed per-sequence results on the ECG and EMG datasets and a software patch can be provided.

1. **References**

[1] 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*

[2] 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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