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| **INTERNATIONAL ORGANIZATION FOR STANDARDIZATION ORGANISATION INTERNATIONALE DE NORMALISATION ISO/IEC JTC 1/SC 29/WG 5 MPEG JOINT VIDEO EXPERTS TEAM WITH ITU-T SG 16** |
| **ISO/IEC JTC 1 / SC 29 / WG 5 N 310** |
| **Sapporo, JP – 12–19 July 2024** |
| |  |  | | --- | --- | | **Source:** | **Convenor (Jens-Rainer Ohm)** | | **Title:** | **Exploration experiment on enhanced compression beyond VVC capability (EE2)** | | **Type:** | **General** | | **Subtype:** | **Other** | | **Status:** | **Approved** | | **Date:** | **2024-08-22** | | **Expected Action:** | **Info** | | **Action due date:** | **N/A** | | **Pages:** | **21** (not including this cover page) | | **Email of convenor:** | **ohm @ ient . rwth-aachen . de** | | **Committee URL:** | **https://sd.iso.org/documents/ui/#!/browse/iso/iso-iec-jtc-1/iso-iec-jtc-1-sc-29/iso-iec-jtc-1-sc-29-wg-5** | |

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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  35th Meeting, Sapporo, JP, 12–19 July 2024 | Document: JVET-AI2024-v2 |

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| --- | --- | --- | --- |
| *Title:* | **Exploration Experiment on Enhanced Compression beyond VVC capability (EE2)** | | |
| *Status:* | Output document to JVET | | |
| *Purpose:* | EE description | | |
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| *Source:* | EE coordinators | | |

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# Abstract

This document describes Exploration Experiments (EEs) planned to be performed between 34th and 35th JVET meetings to evaluate enhanced compression tools beyond VVC capability.

# Introduction

EE focus is to evaluate individual coding technologies and their combinations. Contributions improving compression efficiency further is highly encouraged.

EE related discussions shall happen on JVET reflector.

EE tests should be implemented on top the ECM software, ECM-14.0 is used as an anchor in the tests.

Tests shall be performed according to the CTC described in JVET-AF2017.

TGM class tests is required for SCC tests and is optional otherwise.

For RPR tests, in addition to ECM CTC the tests are performed following JVET-Q2015, where only LB configuration is mandatory, and the sequences length is reduced to 5 seconds for all classes.

AI and RA test configurations are required for intra tool testing, while RA and LB test configurations are required for inter tool testing. LP configuration is optional. In LB and LP configurations, the sequences length is reduced to 5 seconds for all classes.

If encoder modification is included in EE tests, such encoder optimization, if applicable, introduced to the anchor should be tested.

# Timeline

**T1** = 3 weeks (August 9, 2024) after JVET meeting: ECM is released

**T2** = T1 + 1 week (August 16, 2024): EE description is finalized

**T3** = T2 + 2 weeks (August 30, 2024): Initial software release for EE tests

**T4** = JVET meeting start – 3 weeks (October 11, 2024): Software in EE branches is frozen

# List of tests

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tests** | **Tester** | **Cross-checker** |
| **1 Partitioning** | | | |
| 1.1a | Rectangular partitioning restrictions with normative solution | A. Tissier  (Xiaomi) |  |
| 1.1b | Rectangular partitioning restrictions with non normative solution | A. Tissier  (Xiaomi) |  |
| **2 Intra prediction** | | | |
| 2.1 | Matrix-based position dependent intra prediction for TIMD | Y. Kidani  (KDDI) |  |
| 2.2a | TIMD merge mode extension with BV improvement | J. Fu  (Peking Univ.)  Y.-J. Chang  (Qualcomm)  M. Abdoli  (Xiaomi) |  |
| 2.2b | Test 2.2a + DIMD merge mode (Intra merge mode extension with BV improvement) | J. Fu  (Peking Univ.)  Y.-J. Chang  (Qualcomm) |  |
| 2.3 | TIMD with enhanced block vectors deployment | K. Naser (InterDigital)  J. Fu (Peking Univ.) |  |
| 2.4 | Test 2.3 + BV merge list improvement | K. Naser (InterDigital) | D. Ruiz Coll (Ofinno) |
| 2.5 | TIMD merge mode | M. Abdoli  (Xiaomi)  Y.-J. Chang  (Qualcomm) | V. Rufitskiy  (TCL) |
| 2.6 | Additional TIMD mode with different cost metric | [D. Bugdayci Sansli](mailto:done.bugdayci_sansli@nokia.com)  (Nokia) |  |
| 2.7a | Disabling TIMD related combinations in normative way | Z. Fan  (Sharp) |  |
| 2.7b | Disabling TIMD related combinations in non-normative way | Z. Fan  (Sharp) |  |
| 2.7c | Test 2.7a + additional RDOs | Z. Fan  (Sharp) |  |
| 2.7d | Test 2.7b + additional RDOs | Z. Fan  (Sharp) |  |
| 2.8 | Combination of TIMD and intra merge related tests |  |  |
| 2.9 | DIMD with filtered-template | Z. Lv  (vivo) |  |
| 2.10a | Adaptive HoG for DIMD | S. Blasi  (Nokia) |  |
| 2.10b | Adaptive HoG without increased predictors | S. Blasi  (Nokia) |  |
| 2.10c | Adaptive HoG without scaling and increased predictors | S. Blasi  (Nokia) |  |
| 2.11 | DIMD with 2x2 edge operator applied to small blocks | A. Filippov  (TCL) |  |
| 2.12 | Non-adjacent DIMD mode derivation for TMRL intra mode candidate list construction | V. Rufitskiy  (TCL) |  |
| 2.13a | Test 2.11 + Test 2.10 | A. Filippov  (TCL)  S. Blasi (Nokia) |  |
| 2.13b | Test 2.11 + Test 2.9 | V. Rufitskiy  (TCL)  Z. Lv  (vivo) |  |
| 2.13c | Test 2.11 + Test 2.12 | V. Rufitskiy  (TCL) |  |
| 2.14 | High-level control of intra prediction methods | K.-Y. Kim  (WILUS) |  |
| 2.15a | Regression-based SGPM blending | X. Li  (Alibaba) |  |
| 2.15b | SGPM with PDP replacement | X. Li  (Alibaba) |  |
| 2.15c | Test 2.15a + Test 2.15b | X. Li  (Alibaba) |  |
| 2.16 | Unified reference area of IBC and IntraTMP | N. Zhang  (Bytedance) |  |
| 2.17 | Modified L-shape template in IntraTMP | J. Lee  (ETRI) | J.-K Lee  (Ofinno) |
| 2.18 | Chroma TMRL | H. Huang  (OPPO) |  |
| 2.19a | Multi-model EIP | L. Zhang  (OPPO) |  |
| 2.19b | Block vector guided EIP | Z. Xie  (OPPO) |  |
| 2.19c | Test 2.19a + Test 2.19b | L. Zhang  (OPPO) |  |
| 2.20 | Neural network-based intra prediction with DIMD mode derivation | S. Eadie  (Qualcomm) |  |
| 2.21 | Neural network-based intra prediction | T. Dumas  (InterDigital) |  |
| **3** **Inter prediction** | | | |
| 3.1 | Dual merge mode | R.-L. Liao  (Alibaba) |  |
| 3.2a | Regular inter AMVP list with more candidates | Z. Deng  (Bytedance) |  |
| 3.2b | Affine inter AMVP list with template matching | Z. Deng  (Bytedance) |  |
| 3.2c | Test 3.2a + Test 3.2b | Z. Deng  (Bytedance) |  |
| 3.3a | OBMC extension with intra prediction | D. Kim  (ETRI) | Y. Ahn (LGE) |
| 3.3b | Test 3.3a + DIMD with 2x2 edge operator | D. Kim  (ETRI) | Y. Ahn (LGE) |
| 3.3c | Test 3.3a + using intra prediction mode of neighbouring block | D. Kim  (ETRI) | J.-K Lee  (Ofinno) |
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| 3.4a | GPM mode extension (64 to 112 modes) | Y. Ahn  (LGE) |  |
| 3.4b | GPM mode extension with block shape dependency (64 to 80 modes) | K. Reuzé (InterDigital) |  |
| 3.4c | GPM mode extension with additional distances for hor/ver angles only (64 to 70 modes) | Y. Ahn  (LGE) |  |
| 3.4d | Test 3.4b not applied on IBC-GPM nor SGPM | K. Reuzé  (InterDigital) |  |
| 3.4e | GPM mode extension with block size adaptation | Y. Ahn  (LGE),  K. Reuzé  (InterDigital) |  |
| 3.5 | On POC conditions of BDOF | N. Yan  (Kwai) |  |
| 3.6 | GPM-affine with TM | Y. Wang  (Bytedance) |  |
| 3.7a | Sub-block merge mode extension with normative conditioning | F. Wang  (OPPO) |  |
| 3.7b | Sub-block merge mode extension with non-normative conditioning | F. Wang  (OPPO) |  |
| 3.8 | Sharp motion compensation filter extension | H. Huang  (Qualcomm) |  |
| 3.9a | Affine CPMV search for affine DMVR | J.-L. Lin  (Qualcomm) |  |
| 3.9b | High precision MV for affine motion compensation | J.-L. Lin  (Qualcomm) |  |
| 3.9c | Additional combined merge candidates | J.-L. Lin  (Qualcomm) |  |
| 3.9d | Test 3.9a + Test 3.9b +Test 3.9c | J.-L. Lin  (Qualcomm) |  |
| 3.10a | SATD-based reordering for intra coding | Y. Wang  (Bytedance) |  |
| 3.10b | SATD-based reordering for inter coding | Y. Wang  (Bytedance) |  |
| 3.10c | Test 3.10a + Test 3.10b | Y. Wang  (Bytedance) |  |
| 3.11a | Regression-based GPM with TM | K. Jia  (Alibaba) |  |
| 3.11b | Regression-based GPM with TM and MMVD | K. Jia  (Alibaba) |  |
| **4** **Transform and coefficients coding** | | | |
| 4.1 | NSPT kernels for non-regular intra modes | G. Verba  (Qualcomm) |  |
| 4.2a | Improved implicit MTS applied to ISP blocks (CTC) | C. Bonnineau  (InterDigital) |  |
| 4.2b | Improved implicit MTS applied to intra blocks (non-CTC) | C. Bonnineau  (InterDigital) |  |
| 4.3a | Corner subblocks for SBT | V. Seregin  (Qualcomm) |  |
| 4.3b | Corner and center subblocks for SBT | V. Seregin  (Qualcomm) |  |
| **5 In-loop filtering** | | | |
| 5.1a | Restriction of ALF coefficient values to form *m*\*2^*b* + Huffman-based coding | V. Shchukin  (Ericsson) |  |
| 5.1b | Restriction of ALF coefficient values to form *m*\*2^*b* + modified Golomb-Rice coding | V. Shchukin  (Ericsson) |  |
| 5.1c | Simulated annealing to derive ALF coefficients (encoder-only) | V. Shchukin  (Ericsson) |  |
| 5.1d | Test 5.1c + *m*\*2^*b* coefficient values restriction (encoder-only) | V. Shchukin  (Ericsson) |  |
| 5.1e | Test 5.1a + Test 5.1c | V. Shchukin  (Ericsson) |  |
| 5.2 | Using luma reconstruction signal for chroma ALF | C. Ma  (Kwai) |  |
| 5.3 | Extended usage of fixed-filters | W. Yin  (Bytedance) |  |
| 5.4a | Coding information based classification for online-filter of ALF | W. Yin  (Bytedance) |  |
| 5.4b | Coding information based classification for offline-filter of ALF | W. Yin  (Bytedance) |  |
| 5.4c | Test 5.4a + Test 5.4b | W. Yin  (Bytedance) |  |
| 5.5a | ALF joint optimization (encoder only) | H. Wang  (Qualcomm) |  |
| 5.5b | ALF joint optimization with reuse of ALF control information | H. Wang  (Qualcomm) |  |
| **6 Entropy coding** | | | |
| 6.1a | Context initialization retraining | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |  |
| 6.1b | Context bins coding is redistributed between context and EP coding | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |  |
| 6.1c | Bins coding is redistributed between context and EP coding | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |  |
| 6.2a | Bins redistribution between context, NEP and EP with no constraint on the number of arithmetic coded bins. | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |  |
| 6.2b | Bins redistribution between context, NEP and EP, with a constraint on the number of arithmetic coded bins (alpha=0.5) | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |  |
| 6.2c | Bins redistribution between context, NEP and EP, with a constraint on the number of arithmetic coded bins (alpha=1.0) | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |  |
| 6.2d | Context bin coding is redistributed between context and NEP | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |  |

# Tools description

## Partitioning

**Test 1.1: Rectangular partitioning restrictions (JVET-AI0261)**

This test has two aspects. First, it relaxes the maximum BT and TT sizes constraints, so that these split types will be applicable to 64x64 CUs in luma and 128x128 CUs in chroma. The second aspect limits the number of BT/TT splits for those MTT restricted blocks to only one split, i.e. a 64x64 CU in luma can only be split once by MTT and cannot become an MTT tree of depth > 1.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.1a | Rectangular partitioning restrictions with normative solution | A. Tissier  (Xiaomi) |
| 1.1b | Rectangular partitioning restrictions with non-normative solution | A. Tissier  (Xiaomi) |

## 2. Intra prediction

### Test 2.1: Matrix-based position dependent intra prediction for TIMD (JVET-AI0085)

This test studies a matrix-based position-dependent intra prediction (PDP) for template-based intra mode derivation (TIMD). PDP is newly adopted in ECM-13.0, which replaces part of the conventional intra prediction modes (IPMs) in the regular intra prediction with alternative IPMs using a matrix of weights defined for a block shape and IPMs. TIMD still uses conventional IPMs, so the performance when applying PDP for TIMD is investigated in this test.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.1 | Matrix-based position dependent intra prediction for TIMD | Y. Kidani  (KDDI) |

### Test 2.2: Intra merge mode extension with BV improvement (JVET-AI0224)

The block vector-based prediction is highly used for intra blocks in ECM. The Intra merge mode is the method constructing an intra candidate list by the intra modes that are used in intra-coded neighbouring blocks to predict a current coding block. This contribution further proposes using block vectors prediction to replace intra mode for Intra Merge Mode through template cost analysis.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.2a | TIMD merge mode extension with BV improvement | J. Fu  (Peking Univ.)  Y.-J. Chang  (Qualcomm)  M. Abdoli  (Xiaomi) |
| 2.2b | Test 2.2a + DIMD merge mode (Intra merge mode extension with BV improvement) | J. Fu  (Peking Univ.)Y.-J. Chang  (Qualcomm) |

**Test 2.3: TIMD with enhanced block vectors deployment (**[**JVET-AI0104**](https://jvet-experts.org/doc_end_user/current_document.php?id=14346)**)**

In ECM, in addition to IBC and IntraTMP modes, the block-vector-based prediction in ECM is further used in combination with directional prediction of SGPM and DIMD, where the merge candidates (adjacent and non-adjacent) are evaluated with the template cost to select the best block vector predictor to be combined with the directional modes.

In the test, BV combination with TIMD is evaluated. Any of the three fusion modes of TIMD can be replaced by a block-vector-based prediction from the merge candidates based on the template cost. Auto-relocated block vector candidates of IntraTMP are combined with DIMD and TIMD modes.

1. Allow TIMD with block vectors: When deriving the intra modes of TIMD (2 angular and 1 non-angular), the block vectors of the merge candidates of IntraTMP mode are also checked. If the template cost is smaller than any of the other modes, the mode is replaced by the block vector.
2. Use ARBVP merge list in DIMD and TIMD: The additional block vector candidates generated by ARBVP process are included in the merge list of DIMD and TIMD, in the same manner as in IntraTMP.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.3 | TIMD with enhanced block vectors deployment | K. Naser (InterDigital)  J. Fu (Peking Univ.) |

### Test 2.4: BV merge list improvement (JVET-AI0253)

For DIMD, SGPM and TIMD with BV based prediction, the BV list is generated from all the spatial merge candidates that contain BVs. Similar to IntraTMP merge BVs, where refinement of 11x11 window is performed, this test proposes a unified process for generating the BV merge list, including a clustering and refinement process for all merge BVs. The method can be described as follows (figure below):

1. Collecting all BV merge candidates from spatial neighbours.
2. Performing ARBVP process to generate additional merge candidates
3. Defining a refinement window around each BV from the merge list: This is shown by the dotted red lines in the figure
4. For all coinciding BVs, the same refinement window is used: as shown in the figure. Multiple BVs are coinciding in one area (shown in gray in the figure above). All these BVs are fused together, and a single refinement region is used.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.4 | Test 2.3 + BV merge list improvement | K. Naser  (InterDigital) |

### Test 2.5: TIMD merge mode (JVET-AI0110)

In ECM, TIMD prediction is derived by a fusion of up to 3 intra modes with the smallest SATD cost with the weights corresponding to the template cost. In this test, TIMD merge list of size 5 is constructed by adding TIMD information (prediction modes, fusion flag, fusion weights and wide-angle conditions of TIMD modes, MTS transform types) from adjacent and non-adjacent neighbouring blocks. TIMD candidates are sorted in the list based on SAD template cost. A flag is signalled to indicate the mode usage.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.5 | TIMD merge mode | M. Abdoli  (Xiaomi)  Y.-J. Chang  (Qualcomm) |

### Test 2.6: Additional TIMD mode with different cost metric (JVET-AI0113)

In this test, an additional TIMD based intra mode is introduced, where the cost metric used in the derivation of TIMD modes is changed from SATD to MR SAD, the number of template lines/columns around the current block are doubled to 4/8, and the list of TIMD candidate modes is modified to avoid redundancy with respect to the conventional TIMD mode.***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.6 | Additional TIMD mode with different cost metric | [D. Bugdayci Sansli](mailto:done.bugdayci_sansli@nokia.com)  (Nokia) |

### Test 2.7: Disabling the combination of TIMD-ISP and TIMD-MRL (JVET-AI0080)

This test disables TIMD-related combinations (TIMD-ISP and TIMD-MRL) to reduce encoding time by decreasing the number of RDOs. It also aims to achieve performance gains by utilizing the saved RDOs to other intra tools.

Test 2.7a, TIMD-related combinations will be disabled in a normative way. This change eliminates ineffective combinations, which can reduce encoding time by decreasing the number of RDOs.

Test 2.7b, similar to Test 2.7a, but achieved in a non-normative way.

Test 2.7c, based on Test 2.7a, this test aims to achieve gains by utilizing the saved RDOs in other intra tools.

Test 2.7d, based on Test 2.7b, this test aims to achieve gains by utilizing the saved RDOs in other intra tools.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.7a | Disabling TIMD related combinations in normative way | Z. Fan  (Sharp) |
| 2.7b | Disabling TIMD related combinations in non-normative way | Z. Fan  (Sharp) |
| 2.7c | Test 2.7a + additional RDOs | Z. Fan  (Sharp) |
| 2.7d | Test 2.7b + additional RDOs | Z. Fan  (Sharp) |

### Test 2.8: Combination of TIMD and intra merge related tests

This section summarizes combinations of TIMD and intra merge related tests.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
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### Test 2.9: DIMD with filtered-template (JVET-AI0125)

In this test, the reconstructed neighbour samples are filtered using a 3x3 filter before obtaining the gradient histogram. And then DIMD modes are derived from this filtered-template.

Compared to current DIMD, the template is modified. One additional row towards above side, and one additional column towards left side are extended if available. When there are un-available reconstructed samples, the unfiltered samples in adjacent row and column are used for gradient computation. In addition, the encoder optimization strategy is designed to reduce the encoding time.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.9 | DIMD with filtered-template | Z. Lv  (vivo) |

### Test 2.10: Adaptive HoG for DIMD (JVET-AI0106)

In this contribution, modifications to the computation of the Histogram of Gradient (HoG) for DIMD are proposed. Rather than using a fixed template, the DIMD process is modified so that an adaptive number of samples is considered, with the goal of filling the HoG until the total cumulative amplitude is greater or equal than a given threshold. When computing a given gradient for a reference sample, its amplitude may be scaled with a weight. Also, increased number of predictors is investigated.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.10a | Adaptive HoG for DIMD | S. Blasi  (Nokia) |
| 2.10b | Adaptive HoG without increased predictors | S. Blasi  (Nokia) |
| 2.10c | Adaptive HoG without scaling and increased predictors | S. Blasi  (Nokia) |

Test 2.11: DIMD with 2x2 edge operator applied to small blocks (JVET-AI0140)

In the test, 2x2 edge operator is applied to small blocks instead of 3x3 Sobel edge operator when calculating a Histogram of Gradients in the DIMD process. Modifications are introduced to the DIMD mode derivation process, when luma intra mode is determined. No changes to signaling and no additional encoder side passes are introduced.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.11 | DIMD with 2x2 edge operator applied to small blocks | A. Filippov  (TCL) |

Test 2.12: Non-adjacent DIMD mode derivation for TMRL intra mode candidate list construction (JVET-AI0148)

In the test, DIMD processing is reused to construct a TMRL candidate list. For this purpose, DIMD is applied to non-adjacent reference lines, i.e. HoG is calculated in the area determined by a reference line. This non-adjacent DIMD HoG derivation process is aimed at deriving angular modes by estimating gradients and, eventually, directionality within the reference area pointed out by a reference line.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.12 | Non-adjacent DIMD mode derivation for TMRL intra mode candidate list construction | V. Rufitskiy  (TCL) |

### Test 2.13: Combination of DIMD related tests

This section summarizes combinations of DIMD related tests.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.13a | Test 2.11 + Test 2.10 | A. Filippov  (TCL)  S. Blasi (Nokia) |
| 2.13b | Test 2.11 + Test 2.9 | V. Rufitskiy  (TCL)  Z. Lv  (vivo) |
| 2.13c | Test 2.11 + Test 2.12 | V. Rufitskiy  (TCL) |

### Test 2.14: High-level control of intra prediction methods (JVET-AI0101)

In this test, several methods (reference sample filtering, PDPC (and gradient PDPC), and intra prediction fusion) are not applied in the screen contents. The application of methods for screen content is controlled by individual SPS flags.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.14 | High-level control of intra prediction methods | K.-Y. Kim  (WILUS) |

### Test 2.15: Regression-based SGPM blending (JVET-AI0102)

In Test 2.15a, a regression-based SGPM blending method is tested. Each regression-based SGPM candidate contains two intra prediction modes and a blending matrix. The blending matrix is derived from the template and used to blend the two intra predictors.

In Test 2.15b, the PDP replacement method is extended to SGPM. The conventional intra prediction modes in SGPM can be replaced with PDP.

In Test 2.15c, the combination of Test 2.15a and Test 2.15b is tested.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.15a | Regression-based SGPM blending | X. Li  (Alibaba) |
| 2.15b | SGPM with PDP replacement | X. Li  (Alibaba) |
| 2.15c | Test 2.15a + Test 2.15b | X. Li  (Alibaba) |

**Test 2.16: Unified reference area of IBC and IntraTMP (JVET-AI0108)**

In this test, to unify the reference area of IBC and IntraTMP, the valid IBC reference area is extended to all the reconstructed areas in the picture.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.16 | Unified reference area of IBC and IntraTMP | N. Zhang  (Bytedance) |

**Test 2.17: Modified L-shape template in IntraTMP (JVET-AI0139)**

In this test, the L-shape template in IntraTMP is modified to exclude the top-left samples. This exclusion affects the calculation of SAD and MRSAD, as well as the parameter derivation process in FLM mode.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.17 | Modified L-shape template in IntraTMP | J. Lee  (ETRI) |

**Test 2.18: Chroma TMRL (JVET-AI0168)**

In this test, the TMRL mode is extended to chroma as a new chroma prediction mode. The process of this new chroma prediction mode is similar to TMRL. A candidate list that includes combinations of reference line and intra prediction mode is constructed and reordered. A flag and a list index are signaled to indicate which combination candidate is used to predict the current chroma block.

***List of tests to be performed***

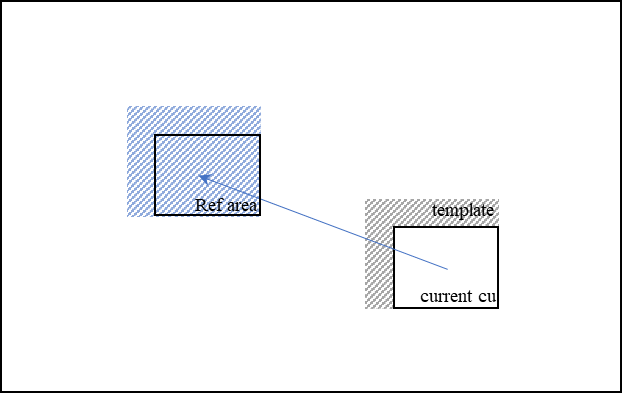
|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.18 | Chroma TMRL | H. Huang  (OPPO) |

**Test 2.19: Improvements on EIP (JVET-AI0167)**

In this test, two improvements to the EIP mode and their combination are tested.

In Test 2.19a, a multi-model EIP method is tested. In the method, the EIP training samples are classified into two groups, Group 1 and Group 2, and both groups of EIP training samples are used as training sets to derive two separate extrapolation filters, respectively. The classification process is based on the reference value of the EIP training sample and a threshold. An EIP training sample with reference <= threshold is classified into Group1, while an EIP training sample with reference > threshold is classified into Group2. The same classification rule is applied when predicting the current block.

In Test 2.19b, a block vector guided EIP method is tested. This method uses a block vector to determine the reference area for calculating the EIP filter parameters instead of directly using the adjacent spatial reference area. Then the current coding unit utilizes the calculated EIP filter parameters and neighbouring reconstructed samples to do the prediction. The reference area in the method is illustrated as in the figure:



In test 2.19c, the combination of test 2.19a and test 2.19b is tested.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.19a | Multi-model EIP | L. Zhang  (OPPO) |
| 2.19b | Block vector guided EIP | Z. Xie  (OPPO) |
| 2.19c | Test 2.19a + Test 2.19b | L. Zhang  (OPPO) |

**Test 2.20: Neural network-based intra prediction with DIMD mode derivation (JVET-AI0225)**

This test studies a low-complexity NN-based intra prediction mode with compact parameter matrices, using DIMD to derive the intra mode (e.g. for transform selection). These models use 16-bit integer inference, as implemented in the SADL library. This test will study further speed-ups/complexity reductions, such as MACs/pixel, context shape, parameter count and SIMD optimization.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.20 | Neural network-based intra prediction with DIMD mode derivation | S. Eadie  (Qualcomm) |

**Test 2.21: Neural network-based intra prediction (JVET-AI0201)**

This contribution proposes a new intra prediction mode based on a low complexity neural networks. It is built from the algorithm integrated into Neural Network Video Coding (NNVC) and described in JVET-AH2019. 16-bits integer is used for model coefficients, as implemented in SADL library.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.21 | Neural network-based intra prediction | T. Dumas  (InterDigital) |

## 3. Inter prediction

### Test 3.1: Dual merge mode (JVET-AI0109)

A dual merge mode which inherits two motion information from previous coded block is proposed. In this mode, a dual merge candidate list is constructed which derive motion information from neighbouring dual merge coded blocks or from others merge candidate list. Each dual merge candidate in the list has two motion information. The prediction for this mode is generated by averaging the two predictions which are separately predicted using the two motion information.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.1 | Dual merge mode | R.-L. Liao  (Alibaba) |

### Test 3.2: Inter AMVP list enhancements (JVET-AI0126)

In Test 3.2a, more candidates can be checked to construct the regular inter AMVP candidate list. The non-adjacent positions checking pattern from the existing merge mode in ECM is used to scan the predefined positions for regular inter AMVP candidates.

In Test 3.2b, the affine inter AMVP list construction can be enhanced by template matching. Template based reordering is applied to reorder the affine AMVP candidates in the affine AMVP candidate list.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.2a | Regular inter AMVP list with more candidates | Z. Deng  (Bytedance) |
| 3.2b | Affine inter AMVP list with template matching | Z. Deng  (Bytedance) |
| 3.2c | Test 3.2a + Test 3.2b | Z. Deng  (Bytedance) |

**Test 3.3: OBMC extension with intra prediction (JVET-AI0154)**

In OBMC of ECM-13.0, boundary pixels of the current block are refined using motion information of neighbouring block. However, boundary pixels adjacent to intra block are currently not refined because there is no motion information available for neighbouring intra block.

In this test, boundary pixels adjacent to intra block are blended using intra prediction block generated with the intra prediction mode derived by applying DIMD on the neighbouring reconstructed samples.

In Test 3.3a, OBMC extension with intra prediction is tested.

In Test 3.3b, DIMD with 2x2 edge operator is applied to derive intra prediction mode from the neighbouring reconstructed samples.

In Test 3.3c, instead of using DIMD-derived mode, intra prediction mode of neighbouring block is used to generate intra subblock.

In Test 3.3d, in addition to Test 3.3a, more neighbouring blocks are checked for available motion information to generate inter subblock.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.3a | OBMC extension with intra prediction | D. Kim  (ETRI) |
| 3.3b | Test 3.3a + DIMD with 2x2 edge operator | D. Kim  (ETRI) |
| 3.3c | Test 3.3a + using intra prediction mode of neighbouring block | D. Kim  (ETRI) |
| 3.3d | Test 3.3a + more neighbouring blocks are checked for available motion information to generate inter subblock | D. Kim  (ETRI) |

**Test 3.4: GPM mode extension (JVET-AI0063 and JVET-AI0067)**

In ECM, GPM supports 64 partitioning modes combined with 20 slope based angles and 4 distances.

In this test, the number of GPM partitioning modes is extended with the additional angles and distances. Especially, different numbers of total GPM extension modes will be studied to find the trade-off between encoding gain and complexity along with block shape and size adaptation.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.4a | GPM mode extension (64 to 112 modes) | Y. Ahn  (LGE) |
| 3.4b | GPM mode extension with block shape dependency (64 to 80 modes) | K. Reuzé  (InterDigital) |
| 3.4c | GPM mode extension with additional distances for hor/ver angles only (64 to 70 modes) | Y. Ahn  (LGE) |
| 3.4d | Test 3.4b not applied on IBC-GPM nor SGPM | K. Reuzé  (InterDigital) |
| 3.4e | GPM mode extension with block size adaptation | Y. Ahn  (LGE),  K. Reuzé  (InterDigital) |

**Test 3.5: Non-EE2: On POC conditions of BDOF ( JVET-AI0198)**

In ECM-13.0, the bi-directional optical flow (BDOF) tool is only applied to refine the prediction samples of the inter CUs with “true” bi-prediction, i.e., two reference pictures are from two different direction with regard to the current picture.

In this test , it is proposed to enable the BDOF for the bi-predictive CUs with both reference pictures from the same direction.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.5 | On POC conditions of BDOF | N. Yan  (Kwai ) |

**Test 3.6: GPM-affine with TM (JVET-AI0083)**

GPM-affine is combined with GPM-TM, in which an affine candidate is refined by template matching using the same method as in affine mode. A GPM sub-partition can be predicted by GPM-affine with GPM-TM or GPM-TM.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.6 | GPM-affine with TM | Y. Wang  (Bytedance) |

**Test 3.7: Sub-block merge mode extension (JVET-AI0169)**

In this test, the block size restriction for sub-block merge mode is modified to allow more CUs applicable for sub-block merge mode. The sub-block merge mode flag is signalled depending on whether the adjacent and non-adjacent neighbouring blocks have already been coded with sub-block merge mode or inter affine mode.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.7a | Sub-block merge mode extension with normative conditioning | F. Wang  (OPPO) |
| 3.7b | Sub-block merge mode extension with non-normative conditioning | F. Wang  (OPPO) |

**Test 3.8 Sharp motion compensation filter extension (JVET-AI0217)**

In this test, the sharp motion compensation filter for bi-prediction is extended to be applied in generating reference template in LIC, affine TM search, affine merge candidate reordering, et al.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.8 | Sharp motion compensation filter extension | H. Huang  (Qualcomm) |

**Test 3.9 Sub-block inter mode improvement (JVET-AI0218)**

In this test, the following modifications are performed.

First, a CPMV search process is added in the affine DMVR. For each control point, bilateral matching is independently performed for a block that centered by the control-points to derive the refined CPMVs. Then the refined CPMVs are used to derive the best set of CPMVs that minimize the bilateral matching cost of the current block.

Second, the per-pixel or subblock based motion vector in affine motion compensation is quantized to 1/64-pel precision instead of 1/16-pel one for motion compensation.

Third, additional candidates are added by combing the source MV with either TMVP or CMVP. The source MV is the MV used to derive TMVP or CMVP, which is a uni-directional MV. For example, if the source MV comes from the reference picture list 0, the list 0 MV of the TMVP or CMVP is replaced by this MV and the result is used as a new combined candidate in both regular merge candidate list and subblock candidate list.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.9a | Affine CPMV search for affine DMVR | J.-L. Lin  (Qualcomm) |
| 3.9b | High precision MV for affine motion compensation | J.-L. Lin  (Qualcomm) |
| 3.9c | Additional combined merge candidates | J.-L. Lin  (Qualcomm) |
| 3.9d | Test 3.9a + Test 3.9b + Test 3.9c | J.-L. Lin  (Qualcomm) |

**Test 3.10: SATD-based reordering (JVET-AI0114)**

In this test, SATD is calculated as the template cost in the reordering process. In Test 3.10a, SATD-based reordering is used for intra coding, such as reordering in TMRL and EIP, and ARMC for IBC. In Test 3.10b, SATD-based reordering is used for inter coding, such as ARMC, template matching based BCW index derivation for merge mode. Test 3.10c is the combination of Test 3.10a and Test 3.10b.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.10a | SATD-based reordering for intra coding | Y. Wang  (Bytedance) |
| 3.10b | SATD-based reordering for inter coding | Y. Wang  (Bytedance) |
| 3.10c | Test 3.10a + Test 3.10b | Y. Wang  (Bytedance) |

**Test 3.11: Regression-based GPM extension (JVET-AI0115)**

The regression-based GPM is extended by applying TM-based motion vector refinement and MMVD refinement. Two tests are conducted to investigate the performance impact of these two elements. In test 3.11a, TM-based motion vector refinement is applied to refine the motion vectors of two partitions of regression-based GPM. And in the test 3.11b, both TM-based motion vector and MMVD is applied to refine motion vectors of the two partitions of regression-based GPM.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.11a | Regression-based GPM with TM | K. Jia  (Alibaba) |
| 3.11b | Regression-based GPM with TM and MMVD | K. Jia  (Alibaba) |

## 4. Transform and coefficients coding

### Test 4.1: NSPT for non-regular intra modes (JVET-AI0255)

ECM uses NSPT kernels which are block-shape and intra direction dependent as a non-separable transform. In this test, an additional set of NSPT kernels (block shape and intra direction dependent as ECM) are introduced for non-regular intra modes. The memory requirement for additional kernels will be provided.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 4.1 | NSPT for non-regular intra modes | G. Verba  (Qualcomm) |

**Test 4.2:  Improved implicit MTS (JVET-AI0223)**

In the ECM, implicit MTS uses the size of the current block to derive a primary transform pair based on DCT2 and DST7 separable transforms. In this test, it is proposed to introduce the other ECM-13.0 primary transforms used by intra explicit MTS to implicit MTS. It is also proposed to make implicit MTS dependent on the intra mode and the TU size. This test considers both CTC and non-CTC configuration settings.

In test 4.2a, the proposed implicit MTS method is only applied to ISP blocks following CTC configuration settings.

In test 4.2b, the proposed implicit MTS method is applied to more intra modes using non-CTC configuration settings. The following configuration settings are used (MTSImplicit=1, MTS=0).

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 4.2a | Improved implicit MTS applied to ISP blocks (CTC) | C. Bonnineau (InterDigital) |
| 4.2b | Improved implicit MTS applied to intra blocks (non-CTC) | C. Bonnineau (InterDigital) |

**Test 4.3: Corner and center subblocks for SBT (JVET-AI0282)**

In this test, corner and center subblocks are added to SBT, the size of those subblocks is with/2 x height/2 and width/4 x height/4, where width and height are the transform block dimensions. A choice of subblock having non-zero residual is signalled for corner subblocks, while center subblock can only have non-zero residual. Transform kernels are implicitly derived, DCT-8 and DST-7 combination is used for corner subblocks and DST-1 is used for the center, DCT-2 transform kernel will be also tested.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 4.3a | Corner subblocks for SBT | V. Seregin  (Qualcomm) |
| 4.3b | Corner and center subblocks for SBT | V. Seregin  (Qualcomm) |

## 5. In-loop filtering

**Test 5.1: Adaptive mantissa precision for ALF Coefficients (JVET-AI0081)**

In this test, allowed values of ALF coefficient are restricted to the elements of set {*m*\*2^*b*}, where *m* lies in {-1, 0, 1} or {-3, -2, -1, 0, 1, 2, 3}, and *b* is a non-negative integer. The coefficients are derived using a simulated annealing approach and signalled into APS using Huffman coding. The full combination of all modifications is included into Test 5.1e. In Tests 5.1a-5.1d, the proposed modifications are tested individually or jointly.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.1a | Restriction of ALF coefficient values to form *m*\*2^*b* + Huffman-based coding | V. Shchukin  (Ericsson) |
| 5.1b | Restriction of ALF coefficient values to form *m*\*2^*b* + modified Golomb-Rice coding | V. Shchukin  (Ericsson) |
| 5.1c | Simulated annealing to derive ALF coefficients (encoder-only) | V. Shchukin  (Ericsson) |
| 5.1d | Test 5.1c + *m*\*2^*b* coefficient values restriction (encoder-only) | V. Shchukin  (Ericsson) |
| 5.1e | Test 5.1a + Test 5.1c | V. Shchukin  (Ericsson) |

**Test 5.2: Using luma reconstruction signal for chroma ALF (JVET-AI0200)**

In this test, chroma ALF with using luma reconstruction signal as input is tested. Specifically, besides the existing reconstructed chroma samples, additional filter taps are introduced and applied to the reconstructed luma samples in the chroma ALF process.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.2 | Using luma reconstruction signal for chroma ALF | C. Ma  (Kwai) |

**Test 5.3: Extended usage of fixed-filters (JVET-AI0135)**

In this test, the extended usage of fixed-filters is proposed. Considering the fixed-filters of ALF are well-designed and already stored at both encoder and decoder. The proposed method reuses the fixed-filters of ALF after DBF to refine the reconstruction at that stage. The output of the proposed method is utilized as the input for the later stages, such as BF/SAO/CCSAO. The filter coefficients and filtering logic of the fixed-filters are directly reused. The ALF process is kept unchanged, including both online-filtering and offline-filtering. The proposed method signals one slice level flag to achieve on/off control.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.3 | Extended usage of fixed-filters | W. Yin  (Bytedance) |

**Test 5.4: Coding information based classification for ALF (JVET-AI0152)**

In this test, the coding information based classification for ALF is proposed, towards both online-filter and offline-filter.

In test 5.4a, for the online filter of ALF, each 2x2 unit is classified into 2 boundary levels according to the partitioning information. For a 2x2 unit, it is classified into boundary level 1 if it is located at a block boundary, and into boundary level 0 if it is not. The class number of the existing classifier is reduced from 25 to 12. These 12 classes are further combined with the proposed 2 boundary levels to generate final 12x2 = 24 classes for each classifier.

In test 5.4b, for the offline filter of ALF, each 2x2 unit is classified into 2 boundary level in the same way as the online-filter classification. Besides, each 2x2 unit is classified into 2 residual levels based on a predefined threshold. The generated offline-filter-offset is adjusted based on the boundary level and residual level accordingly.

In test 5.4c, the combination of test 5.4a and test 5.4b is tested.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.4a | Coding information based classification for online-filter of ALF | W. Yin  (Bytedance) |
| 5.4b | Coding information based classification for offline-filter of ALF | W. Yin  (Bytedance) |
| 5.4c | Test 5.4a + Test 5.4b | W. Yin  (Bytedance) |

**Test 5.5:  Reuse of ALF control information (JVET-AI0280)**

ECM signals ALF control information, including on/off flags and filter usage information, at both picture and CTU levels. In this test, ALF control information is reused at both picture and CTU levels from the previously encoded picture, and if it is reused then the signalling of that information is skipped. At encoder, ALF filter is derived for a group of pictures jointly. The latency of the proposed method will be analyzed.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.5a | ALF joint optimization (encoder only) | H. Wang  (Qualcomm) |
| 5.5b | ALF joint optimization with reuse of ALF control information | H. Wang  (Qualcomm) |

## 6. Entropy coding

**Test 6.1: CABAC retraining and bin redistribution between CABAC and EP (JVET-AI0342, JVET-AI0343)**

In Test 6.1a, all the context initialization is retrained.

In test 6.1b, contexts are retrained that they can stay as context coded or being converted to EP coding, e.g. context bins go to context or EP bins.

In Test 6.1c, all the existing contexts and EP bins are retrained that they can be either context or EP coded as the result., e.g. context and EP bins go to context or EP bins.

In the tests, the number of contexts set to be coded using CABAC engine and coded as EP should be reported along with associated bin rates. Number of bins coded with context and EP coding for CTC bitstreams to be provided.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 6.1a | Context initialization retraining | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |
| 6.1b | Context bins coding is redistributed between context and EP coding | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |
| 6.1c | Bins coding is redistributed between context and EP coding | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |

**Test 6.2: Study of entropy coding extension (JVET-AI0343)**

In this test, Non-Equal-Probable (NEP) bin coding mode is introduced, it is a context coding but without the context update. Bins are redistributed between context, NEP, and EP coded bins.

In the tests, a constraint on the total number of arithmetic coded bins is set as follows.

* Let *nb\_contexts* be the number of context-coded bins in ECM.
* Let *nb\_nep* be the number of NEP coded bins in proposed test.
* Let *nb\_cabac* be the number of CABAC coded bins in proposed test.
* In this test, bins are distributed under the following constraint:

( *nb\_cabac* + *alpha \* nb\_nep* )   *nb\_contexts*

* Where alpha is set to 0.5 or 1.0, to reflect the intent of NEP which is an arithmetic-coded bin with reduced complexity w.r.t. context coding.

Number of bins coded with context, NEP and EP coding for CTC bitstreams to be provided.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 6.2a | Bins redistribution between context, NEP and EP with no constraint on the number of arithmetic coded bins. | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |
| 6.2b | Bins redistribution between context, NEP and EP, with a constraint on the number of arithmetic coded bins (alpha=0.5) | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |
| 6.2c | Bins redistribution between context, NEP and EP, with a constraint on the number of arithmetic coded bins (alpha=1.0) | F. Galpin  (InterDigital)  P. Nikitin  (Qualcomm) |
| 6.2d | Context bin coding is redistributed between context and NEP | P. Nikitin  (Qualcomm)  F. Galpin  (InterDigital) |