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| *Title:* | SCE3: Results of test 3.6 on Generalized Residual Prediction with shorter-tap MC filter | | |
| *Status:* | Input Document to JCT-VC | | |
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# Abstract

This contribution reports coding efficiency and complexity assessment results of SCE3.6: Generalized Residual Prediction with shorter-tap interpolation filter, where 2 or 4 tap filter is used depending on the slice type and colour component. The method is the same as JCTVC-L0265 and implemented on SHM1.0 with TE3 4.6.3(JCTVC-L0038) software. It is reported that the BD-rate (EL+BL) changes compared to SHM1.0 are -2.1%, -3.3%, -1.8%, -2.5%, -3.7%, -2.2%, -3.3%, -4.6% and -3.0% for RA 2x, RA 1.5x, RA SNR, LP 2x, LP 1.5x, LP SNR , LB 2x, LB 1.5x and LB SNR cases respectively.

# Introduction

Originally GRP uses 8 tap for luma and 4 tap for chroma but it was recognized complex in the last meeting. Our former work, JCTVC-L0265 [5], revealed that the use of shorter-tap filter can retain or improve coding efficiency, thus CE study was recommended.

In the established CE, SCE3, shorter-tap MC filter and other simplified methods on GRP have been studied. Most of them apply shorter-tap MC filter to create motion-compensated up-sampled base-layer reconstruction and/or motion-compensated enhancement-layer prediction for GRP.

This contribution reports the results of test 3.6, where 2 or 4 tap filter is used depending on the slice type and colour component.

# Generalized Residual Prediction

The GRP implementation of this proposal is summarized as follows:

* Generate residual by subtracting base layer MC result with the enhancement layer motion parameters from base layer reconstruction.
* Add the regular prediction and the weighted generated residual (predicted residual) to get final prediction
* Signal the weight (0, 0.5 or 1) on PU level

Basically, the GRP for uni-prediction and bi-prediction are formulated as follows:

[GRP for uni-prediction]

PREDEL = **MC1**[REFEL, MVEL,LX] + W\*{**UP1**{RECBL} – **MC2**[ **UP2**{REFBL} , MVEL,LX ] } -(eq.1)

[GRP for bi-prediction]

PREDEL= ( **MC1**[REFEL,MVEL,L0]+**MC1**[REFEL,MVEL,L1])/2

**+ W\***{**UP1**{RECBL}–(**MC2**[ **UP2**{REFBL} , MVEL,L0 ] + **MC2**[ **UP2**{REFBL} , MVEL,L1 ])/2 } -(eq.2)

where, the above terms are defined as follows:

* PREDEL is the prediction signal of the enhancement layer
* REFEL and REFBL are the temporal reference signals in the Enhancement and Base layers
* RECBL is the base layer reconstructed signal corresponding to the current enhancement layer block
* MVEL,LX is the EL motion vector selected from the EL reference picture list X
* UPx{.} is the up-sampling operator x
* MCx[I,MV] is the motion compensation operator x of the current block using I as reference picture and MV for the motion vector.
* W is the weighted value for predicted residuals

# Proposed method

In our proposal, the interpolation filters for up-sampled base-layer reconstruction (**MC2** in eq. 1 and 2) are selected depending on the slice type and colour component as shown Table 1. The interpolation filters for enhancement-layer (**MC1**) and up-sample filters (**UP1**/ **UP2**) in eq. 1 and 2 are the same as SHM1.0.

Table.1: Interpolation filter selection for each slice type

|  |  |  |
| --- | --- | --- |
| Slice type | Interpolation filter | |
| Luma | Chroma |
| P-slice | 4-tap DCT-IF | 2-tap (bilinear) |
| B-slice | 2-tap (bilinear) | 2-tap (bilinear) |

Table 2, 3 and 4 show the coefficients for each interpolation filter. Note that 4-tap filter for luma in Table 2 is the same as 4-tap DCT-IF for chroma in HEVC.

Table.2: Interpolation filter for luma in the case of P-slice

|  |  |
| --- | --- |
| Phase offset | Filter coefficients |
| 0/4 | [ 0, 64, 0, 0 ] // 64 |
| 1/4 | [-4, 54, 16, -2 ] // 64 |
| 2/4 | [-4, 36, 36, -4 ] // 64 |
| 3/4 | [-2, 16, 54, -4 ] // 64 |

Table.3: Interpolation filter for luma in the case of B-slice

|  |  |
| --- | --- |
| Phase offset | Filter coefficients |
| 0/4 | [ 64, 0 ] // 64 |
| 1/4 | [48, 16] // 64 |
| 2/4 | [32, 32] // 64 |
| 3/4 | [16, 48] // 64 |

Table.4: Interpolation filter for chroma in the case of P/B-slice

|  |  |
| --- | --- |
| Phase offset | Filter coefficients |
| 0/8 | [ 64, 0 ] // 64 |
| 1/8 | [ 56, 8 ] // 64 |
| 2/8 | [ 48, 16] // 64 |
| 3/8 | [ 40, 24] // 64 |
| 4/8 | [ 32, 32] // 64 |
| 5/8 | [ 24, 40] // 64 |
| 6/8 | [ 16, 48] // 64 |
| 7/8 | [ 8, 56] // 64 |

# Experimental results

The proposed method is implemented on SHM1.0 with TE3 4.6.3[1] software and evaluation is done based on the test condition described in SCE3 document [4].

BD-rate results are provided in the three following attached files:

* + JCTVC-M0074\_BDRate\_SCE3.6\_v3.xls: results of the proposed method compared to SHM1.0
  + JCTVC-M0074\_BDRate\_SCE3.6\_v3\_wo\_simpl.xls: results of the GRP without JCTVC-L0265 (the same as TE3 4.6.3[1]) compared to SHM1.0. ( additional tests )
  + JCTVC-M0074\_BDRate\_SCE3.6\_v3\_vs\_SCE3.6\_wo\_simpl.xls: results of the proposed method compared to the GRP without JCTVC-L0265 (the same as TE3 4.6.3[1]) ( as additional tests )

Complexity analysis is done according to the methodology described in JCTVC-L0440 and the results are provided in the three following attached files:

* + JCTVC-M0074\_ComplexityAnalysis\_SCE3.6\_v3\_BSLICE.xls: complexity assessment data for B-Slice cases of the proposed method
  + JCTVC-M0074\_ComplexityAnalysis\_SCE3.6\_v3\_PSLICE.xls: complexity assessment data for P-Slice cases of the proposed method
  + JCTVC-M0074\_ComplexityAnalysis\_SCE3.6\_v3\_wo\_simpl.xls: complexity assessment data for the GRP without JCTVC-L0265 (the same as TE3 4.6.3[1]) ( as additional tests )

Table 5 and 6 show the coding performance and complexity information of the proposal compared to SHM1.0 respectively.

As an additional test, we also evaluated the GRP without JCTVC-L0265 [5], that is the same as TE3 4.6.3[1] to compared to SCE3.6. Table 7 and 8 show the coding efficiency and complexity information of GRP without JCTVC-L0265. Table 9 shows the coding efficiency of the proposal compared to the GRP without JCTVC-L0265.

Table 10 shows the worst case complexity assessment of the proposed method and the GRP without JCTVC-L0265 (the same as TE3 4.6.3[1]).

It is observed that the proposed method can reduce the worst case of complexity on Mult, Adds, MemBand(2D:4x2) and MemBand(2D:8x2) without significant coding loss compared to the GRP without JCTVC-L0265 (the same as TE3 4.6.3 [1]).

Table 5: Coding performance of the proposal (ref. SHM1.0)



Table 6: Complexity information of the proposal (ref. SHM1.0)



Table 7: Coding performance of the GRP without JCTVC-L0265 (ref. SHM1.0)   
(additional results)



Table 8: Complexity information of the GRP without JCTVC-L0265 (ref. SHM1.0)  
(additional results)



Table 9: Coding performance of the proposal (ref. the GRP without JCTVC-L0265)  
(additional results)



Table 10: Worst case complexity assessment

|  |  |  |  |
| --- | --- | --- | --- |
|  | **SCE3.6  B-Slice case** | **SCE3.6  P-Slice case** | **GRP without JCTVC-L0265** |
| **Mult** | 269% | 168% | 350% |
| **Adds** | 266% | 167% | 355% |
| **MemBand(2D:4x2)** | 296% | 238% | 350% |
| **MemBand(2D:8x2)** | 302% | 233% | 350% |
| **Number of Ref Frames** | 180% | 180% | 180% |
| **Tables Size** | 121% | 121% | 100% |

# Conclusion

This contribution reports coding efficiency and complexity assessment results of SCE3.6: Generalized Residual Prediction with shorter-tap interpolation filter, where 2 or 4 tap filter is used depending on the slice type and colour component. The method is the same as JCTVC-L0265 and implemented on SHM1.0 with TE3 4.6.3(JCTVC-L0038) software. It is reported that the BD-rate (EL+BL) changes compared to SHM1.0 are -2.1%, -3.3%, -1.8%, -2.5%, -3.7%, -2.2%, -3.3%, -4.6% and -3.0% for RA 2x, RA 1.5x, RA SNR, LP 2x, LP 1.5x, LP SNR , LB 2x, LB 1.5x and LB SNR cases respectively. It is proposed to adopt this method into the next SHM.

# Reference

1. J. Lainema, K. Ugur, “TE3: Results of test 4.6.3 on base enhanced motion compensated prediction”, JCTVC-L0038, Geneva, Switzerland, 14–23 Jan. 2013.
2. X. Li, J. Chen, K. Rapaka, M. Karczewicz, “TE3: Results of Test 4.6.2.1 on Generalized Residual Prediction”, JCTVC-L0078, Geneva, Switzerland, 14–23 Jan. 2013.

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2. X. Li, et.al, “Description of Tool Experiment SCE3: Combined Inter and Inter-Layer Prediction in SHVC,” JCTVC-L1103, Geneva, CH, Jan. 2013.

1. [T. Tsukuba](mailto:tsukuba.takeshi@sharp.co.jp), T. Yamamoto, T. Ikai, “On interpolation filter for Generalized Residual Prediction”, JCTVC-L0265, Geneva, Switzerland, 14–23 Jan. 2013.

# Patent rights declaration(s)

**SHARP Corporation 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).**