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| *Title:* | **Non-SCE3: Simplified Generalized Residual Prediction** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This document reports additional results of generalized residual prediction (GRP). To further reduce the bandwidth requirement of GRP, two variants, i.e., GRP with 3-tap up-sampling/smoothing filter and GRP with further constraint on block size, are proposed. It is reported that the computational complexity (in terms of the numbers of multiplications and additions) and memory access of GRP decoding module in the worst case is kept lower than that of motion compensation module in HEVC single layer decoding according to AHG17 template. The average luma BD-rate reduction (the average of RA cases, LD-P cases, and LD-B cases) is reported as 2.0%, 5.3%, and 3.1% for GRP with 3-tap filter and 2.0%, 5.3%, and 3.1% for GRP with additional block size constraint, respectively.

# Introduction

Generalized residual prediction was proposed in [1][2][3][4] to improve the coding efficiency of SHVC. It uses previously coded base layer and enhancement layer pictures to predict the current enhancement layer picture.

In [8], GRP with reduced decoding complexity was proposed. In this proposal, the decoding bandwidth requirement is further reduced by shorter up-sampling/smoothing filter and additional constraint on block size.

# Technical details

To further reduce decoding complexity of GRP, two simplification methods, i.e., 3-tap GRP up-sampling/smoothing filter and additional constraint on block size, are proposed on top of test case 2 of [8] in this section.

## 3-tap GRP up-sampling/smoothing filter

In test case 2 of [8], 4-tap up-sampling/smoothing filter was proposed for GRP mode. In this proposal, a 3-tap filter as shown in Table 1 is proposed to replace the 4-tap one for further complexity reduction.

Table 1 3-tap up-sampling/smoothing filter for GRP mode (for both luma and chroma)

|  |  |  |  |
| --- | --- | --- | --- |
| Phase | Filter coefficients | | |
| 0/16 | 9 | 46 | 9 |
| 1/16 | 7 | 45 | 12 |
| 2/16 | 5 | 45 | 14 |
| 3/16 | 3 | 44 | 17 |
| 4/16 | 2 | 42 | 20 |
| 5/16 | 1 | 40 | 23 |
| 6/16 | 0 | 38 | 26 |
| 7/16 | 0 | 35 | 29 |
| 8/16 | 0 | 32 | 32 |
| 9/16 | 0 | 29 | 35 |
| 10/16 | 1 | 26 | 37 |
| 11/16 | 1 | 23 | 40 |
| 12/16 | 2 | 20 | 42 |
| 13/16 | 3 | 17 | 44 |
| 14/16 | 3 | 15 | 46 |
| 15/16 | 4 | 12 | 48 |

## Additional Constraint on block size

To reduce computational complexity and memory access, the block size of GRP mode was constrained in test case 2 of [8] as follows.

* GRP mode can only be applied to PUs no smaller than 8x8.
* In bi-directional prediction, GRP mode can only be applied to PUs larger than 16x16.

In this proposal, it is further constrained that GRP cannot be applied to 4x16 or 16x4 PUs in uni-directional prediction.

# Test Results

In this section, the two GRP simplification methods are experimentally verified based on the test case 2 in [8] (defined in Table 2). Simulation results and complexity information are summarized in Table 3. Please refer to attached excel files for details.

Table 2 Configurations of test cases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | GRP weighting modes | Bi-linear interpolation | GRP up-sampling/ smoothing | Common GRP block size constraint | No GRP for  chroma | No GRP filtering in  SNR | Additional ME |
| Test case 2 [8] | 0, res-0.5, 1, diff-0.5 | Y | Y | Uni: 8x8  Bi: 16x16 | N | N | N |

Table 3 Simulation results and complexity information

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Case | Conf | Y | U | V | EncT | DecT | 8b/8b | 64b/256b | 64b/512b | Mults | Adds |
| 3-tap filter | RA | -2.0% | -3.6% | -3.8% | 114% | 122% | 118% | 115% | 116% | 108% | 105% |
| LD-P | -5.3% | -5.5% | -4.9% | 120% | 123% | 135% | 130% | 131% | 117% | 110% |
| LD-B | -3.0% | -4.5% | -4.4% | 111% | 121% | 126% | 122% | 123% | 112% | 107% |
| **Aver** | **-3.4%** | **-4.5%** | **-4.4%** | **115%** | **122%** | **126%** | **122%** | **123%** | **112%** | **107%** |
| No 4x16 or16x4 uni-pred | RA | -2.0% | -3.7% | -3.9% | 113% | 121% | 120% | 120% | 120% | 114% | 111% |
| LD-P | -5.3% | -5.6% | -5.0% | 115% | 120% | 140% | 143% | 143% | 130% | 125% |
| LD-B | -3.1% | -4.6% | -4.5% | 107% | 119% | 130% | 130% | 130% | 121% | 117% |
| **Aver** | **-3.5%** | **-4.6%** | **-4.5%** | **112%** | **120%** | **130%** | **131%** | **131%** | **121%** | **118%** |

When compared to the coding performance of test case 2 in [8], marginal coding loss (less than 0.1% luma BD rate on average) was introduced by the two simplification methods while the decoding complexity is further reduced.

As shown in Table 4 with the two simplifications, the computational complexity and memory access of GRP decoding module in the worst case is kept lower than that of motion compensation module in HEVC single layer decoding according to the AHG17 template [7].

Table 4 Complexity of the proposed tool in the worst case

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test case | Mul | Adds | MemBand (4x2) | MemBand (8x2) | Ref num in pred | Additional picture buffer | Size of lookup table |
| 3-tap filter | 61% | 49% | 98% | 96% | 180% | 0% | 138% |
| No 4x16 or16x4 uni-pred | 76% | 67% | 98% | 91% | 180% | 0% | 146% |

# Conclusions

In this proposal, generalized residual prediction proposed in [8] is further simplified. The computational complexity (in terms of the numbers of multiplications and additions) and memory access of GRP decoding module in the worst case is kept lower than that of motion compensation module of HEVC single layer decoding. It is suggested to adopt GRP into SHVC and reference software.

# References

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# Patent rights declaration(s)

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