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| *Title:* | **Parametric Adaptive Loop Filter** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This document provides a brief description and results of Parametric Adaptive Loop Filter which was introduced as a low complexity alternative to conventional ALF techniques [JCTVC-D270]. In this approach, a set of fixed filters is used instead of the traditional online-trained Weiner filters. The encoder chooses the best (in RD sense) filter for a Coding Unit (CU) and transmits the index of the filter in the bit stream to the decoder. The selection of the best filter at the encoder requires only a single-pass processing for each Large CU (LCU), therefore, reducing the encoder delay significantly compared to traditional ALF approaches which require multi-pass processing. On average, using this technique, 1.9%, 4.1%, and 3.4% gain compared to HM 2.0 anchors could be achieved for Low Complexity (LC) Intra, low delay, and random access, respectively.

# Algorithm description

In contrast to most conventional ALF schemes, Parametric ALF (PALF), uses fixed filters and single-pass, LCU-level optimization to find the best filters at the encoder. In other words, once an LCU is reconstructed at the encoder and de-blocking filter is applied, the PALF process can start immediately to find an optimized set of filters for that LCU. No further processing for that LCU will be required once the filter indices are obtained. Therefore, the encoder can write the filter indices into the bit stream and start processing the next LCU as it becomes available at the encoder. A more detailed description of PALF can be found in [JCTVC-D270]. On-line training of filter coefficients, however, usually requires multi-pass processing of the reconstructed pixel values and auto- and cross-correlation statistics. Furthermore, variable filter coefficients make the hardware implementation of ALF much more costly compared to fixed filters.

## Direction-based filter shapes

Traditionally, ALF filters have rectangular shapes. However, both for reducing the overhead due to coefficients and speeding up filtering operations, different filter shapes, such as diamond, have also been proposed. Nevertheless, the shape of the filters is typically independent from the classification that is done on the images on which these filters are being applied. These classifications may include a local activity measure, image gradients, or even direction. In this contribution, we propose to also vary the filter shapes based on the class of pixels the filter is trained on. More specifically, for our fixed PALF filters which are identified by direction and bandwidth, we introduce different filter shapes based on direction. All filter shapes are derived (carved out) from a base-shape, which in this case is an NxN rectangular shape. Since most significant filter coefficients are concentrated along the direction of the filter, we assume that the support of the filter perpendicular to the direction is less than that along the direction. As an example, we demonstrate the concept for a direction (vertical right). Figure 1 shows the rectangular 9x9 base shape and region where non-zero filter coefficients are assumed to be (N=9, M=5). Note that due to the center symmetry not always the pixel location that is closest to the actual line can be selected.



Figure 1. Location of nonzero filter coefficients for filter direction . Highlighted blue area indicated nonzero coefficients.

# Results

The proposed algorithm was implemented into the HM software 2.0. Test conditions are as defined in Core Experiment 8 and the results are compared with the original HM 2.0 software. We also compare the results with the ALF that is built in HM 2.0. There are 32 fixed filters for luma with a base shape of 9x9 rectangle and 32 filters for chroma with a base shape of 7x7 rectangle. Number of nonzero elements for luma and chroma filters are 23 and 17, respectively. A 14-bit precision is used to describe the filter coefficients. Table 1, Table 2, and Table 3 show the performance of PALF in direct comparison with the ALF implemented in HM 2.0 (referred to as QALF).

Table . Comparison of HM 2.0 ALF and PALF for Intra LoCo.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | QALF | | | PALF | | | Difference (negative = gain) | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -6.5 | -1.9 | -1.6 | -3.4 | -1.1 | -0.9 | 3.1 | 0.8 | 0.7 |
| Class B | -3.0 | -2.9 | -2.4 | -1.6 | -1.9 | -2.3 | 1.4 | 1.0 | 0.1 |
| Class C | -2.7 | -2.9 | -4.1 | -1.6 | -1.7 | -2.9 | 1.1 | 1.2 | 1.2 |
| Class D | -1.5 | -2.7 | -3.3 | -0.7 | -1.1 | -1.5 | 0.7 | 1.7 | 1.8 |
| Class E | -4.8 | -5.6 | -5.9 | -2.7 | -3.3 | -3.7 | 2.1 | 2.3 | 2.2 |
| All | -3.6 | -3.1 | -3.3 | -1.9 | -1.8 | -2.2 | 1.7 | 1.3 | 1.1 |
| Enc Time[%] | 159% | | | 131% | | | -28% | | |
| Dec Time[%] | 208% | | | 153% | | | -54% | | |

Table . Compasison of HM 2.0 ALF and PALF for Low Delat LoCo.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | QALF | | | PALF | | | Difference (negative = gain) | | |
|  | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A |  |  |  |  |  |  |  |  |  |
| Class B | -5.5 | -1.2 | -1.2 | -5.1 | -6.7 | -6.1 | 0.3 | -5.5 | -4.9 |
| Class C | -3.7 | 0.2 | 0.2 | -3.8 | -3.8 | -5.8 | -0.1 | -4.0 | -6.0 |
| Class D | -2.1 | 0.1 | 0.1 | -2.9 | -1.4 | -1.5 | -0.8 | -1.5 | -1.6 |
| Class E | -5.4 | -7.1 | -7.1 | -4.5 | -11.6 | -9.5 | 0.9 | -4.5 | -2.4 |
| All | -4.2 | -1.6 | -1.6 | -4.1 | -5.6 | -5.5 | 0.1 | -3.9 | -3.9 |
| Enc Time[%] | 106% | | | 104% | | | -2% | | |
| Dec Time[%] | 166% | | | 121% | | | -45% | | |

Table . Comparison of HM 2.0 ALF and PALF for Random Access Loco.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | QALF |  |  | PALF |  | Difference (negative = gain) | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |  |  |  |
| Class A | -8.6 | -4.0 | -4.3 | -5.3 | -4.0 | -4.3 | 3.4 | 0.0 | 0.0 |
| Class B | -5.3 | -2.2 | -0.2 | -3.8 | -4.0 | -2.9 | 1.5 | -1.8 | -2.7 |
| Class C | -3.1 | 0.4 | -1.1 | -2.4 | -1.4 | -1.1 | 0.7 | -1.8 | 0.0 |
| Class D | -2.4 | 0.1 | 0.2 | -2.1 | -0.1 | -0.1 | 0.3 | -0.2 | -0.3 |
| Class E |  |  |  |  |  |  |  |  |  |
| All | -4.9 | -1.5 | -1.3 | -3.4 | -2.5 | -2.5 | 1.5 | -1.0 | -1.2 |
| Enc Time[%] | 108% | | | 106% | | | -2% | | |
| Dec Time[%] | 169% | | | 122% | | | -47% | | |

# Patent rights declaration(s)

**Sony Corp. may have IPR 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).**

# References

1. Peng Yin, Tourapis A.M., Boyce J., “Localized Weighted Prediction for Video Coding,” IEEE International Symposium on Circuits and systems,　ISCAS 2005.