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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  15th Meeting: Geneva, CH, 23 Oct. – 1 Nov. 2013 | Document: JCTVC-O0181\_r2 |

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| *Title:* | **Non-RCE3: Implicit derivation for adaptively turning filtering off in intra prediction** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes implicit derivation methods for adaptively turning off a set of filters used for intra prediction. These include the interpolation filter, intra smoothing filters and the horizontal and vertical gradient filters. In the proposed schemes, the decision is made based solely on the transform\_skip\_flag for a TU or in conjunction with the reference samples used for intra prediction. Simulation results reportedly show that the proposed scheme achieves coding gains in YUV and RGB screen content sequence classes and incurs no loss in natural videos and RExt sequences.

# Introduction

Figure 1 shows the reference samples used for intra prediction for a 4×4 block. Mode-dependent intra smoothing and bi-linear filtering may be used to filter the reference samples depending on the block size and intra prediction mode. In addition, gradient filtering may be used for horizontal and vertical intra modes and DC prediction filtering may be used for DC mode. Similarly bi-linear interpolation is used in angular intra prediction process.

Screen content and non-camera generated videos may contain synthetic contents with sharp edges along object boundaries and characters. For such content, different kinds of filtering described above may be undesirable. In [1], it was proposed to use nearest neighbor interpolation instead of bi-linear interpolation for angular prediction for certain angles.

We propose a method to adaptively disable some of the filtering used in the intra prediction process using an implicit criterion. The criterion is based on the reference samples and/or the transform\_skip\_flag for a TU. Experimental results are presented to show that the implicit method provides BD-rate gains for F, SC YUV, SC RGB classes without incurring losses for other classes.

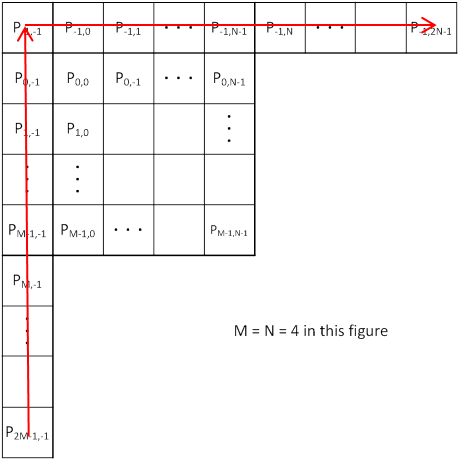


Figure 1: Reference samples of a 4×4 block for HEVC intra prediction

# Proposed method

The proposed derivation of the disable filtering flag to switch off filters in the intra prediction process is provided in subsection 2.1. If the disable filtering flag is 0, the filtering as in the current HEVC Range extension specification is performed.

## Implicit derivation of a disabling filter flag

## Method 1

1. If the transform\_skip\_flag is 0, the disable filtering flag is set to 0, and the derivation process is terminated. Otherwise (if the transform\_skip\_flag is 1), the following applies:
2. Apply a [1, -2, 1] FIR filter to the reference samples from the bottom-left position to the top-right position (i.e., along the red path) in Figure 1.
3. If a filtered value greater than a threshold is found, the disabling flag is set to 1, and the derivation process is terminated. The threshold is set to (1<<(bitdepth-2)+ 1<<(bitdepth-4))
4. Otherwise the disable filtering flag is set to 0.

**Method 2**

1. If the transform\_skip\_flag is 0, the disable filtering flag is set to 0, and the derivation process is terminated.
2. If the transform\_skip\_flag is 0, the disable filtering flag is set to 0, and the derivation process is terminated.
3. Otherwise, the disable filtering flag is set to 1.

The disable filtering flag controls MDIS, bi-linear interpolation, and gradient filtering applied to horizontal and vertical intra prediction modes. When bi-linear interpolation is disabled, nearest neighbor interpolation as described in [1] is used.

# Experimental results

Experimental results for the proposed methods are presented in this section with lossy and lossless configuration under AHG8 test sequences and conditions. The anchor is AHG8 anchor based on HM12.0RExt-4.1 software.

## Method 1: Using transform\_skip\_flag + FIR filtering for implicit derivation (4x4 block only)



Table 1: Lossy coding results for Method 1 applied to blocks of size 4×4. Anchor is HM12.0+RExt4.1.

## Method 2: Using only transform\_skip\_flag (4x4 blocks only)



Table 2: Lossy coding results for Method 2 applied to blocks of size 4×4. Anchor is HM12.0+RExt4.1.

## Lossless coding

In the results of this subsection, the disable filter flag for method 1 is derived using the same derivation procedure in Section 2.1, and applied to a 4x4 TU. Instead of the transform\_skip\_flag, the cu\_transquant\_bypass\_flag is used. For lossless coding for all blocks, the cu\_transquant\_bypass\_flag is 1. Thus, Table 3 shows the results when only the FIR filter is used as the decision criteria. We show results for the “All Intra” configuration. More details can be found in the accompanying excel files. Method 2 is not applied in the lossless case. This is because for lossless coding, the cu\_transquant\_bypass\_flag is 1 for all the blocks. Thus it can not be used as a criterion for selection of nearest neighbor interpolation or bilinear interpolation.



Table 3: Lossless coding results for Method 1 applied to blocks of size 4x4. Anchor is HM12.0+RExt4.1.

# Conclusion

This contribution proposes implicit derivation methods for adaptively turning off a set of filters used for intra prediction. These include the interpolation filter, intra smoothing filters and the horizontal and vertical gradient filters. In the proposed schemes, the decision is made based solely on the transform\_skip\_flag for the TU or in conjunction with reference samples used for intra prediction. Simulation results show that the proposed scheme achieves a coding gain in YUV and RGB screen content sequence classes and incurs no loss for natural videos and RExt sequences.

# Working Draft text

Proposed changes in yellow are in Section **8.4.4.2.3 Filtering process of neighbouring samples of JCTVC-N1005\_v3 as below:**

**Method 1:**

Inputs to this process are:

– the neighbouring samples p[ x ][ y ], with x = −1, y = −1..nTbS \* 2 − 1 and x = 0..nTbS \* 2 − 1, y = −1,

– a variable nTbS specifying the transform block size.

Outputs of this process are the filtered samples pF[ x ][ y ], with x = −1, y = −1..nTbS \* 2 − 1 and x = 0..nTbS \* 2 − 1, y = −1, and a flag DisableFilterFlag specifying to disable filters in intra prediction.

DisableFilterFlag is set to (transform\_skip\_flag[xTbCmp][ yTbCmp] || cu\_transquant\_bypass\_flag) && (nTbs < 8)

- If DisableFilterFlag is equal to 1, the following filtering is applied to modify DisableFilterFlag.

- DisableFilterFlag is set equal to 0.

- the filtered sample values pFIR[ x ][ y ] with x = −1, y = nTbS \* 2 − 1 .. -1 and x = 0..nTbS \* 2 − 1, y = −1 are derived as follows:

pFIR [ −1 ][ y ] = ( p[ −1 ][ y + 1 ] + 2 \* p[ −1 ][ y ] + p[ −1 ][ y − 1 ] )  for y = nTbS \* 2 – 1..0

pFIR [ −1 ][ −1 ] = ( p[ −1 ][ 0 ] + 2 \* p[ −1 ][ −1 ] + p[ 0 ][ −1 ]

pFIR [ x ][ −1 ] = ( p[ x − 1 ][ −1 ] + 2 \* p[ x ][ −1 ] + p[ x + 1 ][ −1 ] )  for x = 0..nTbS \* 2 – 1-

- If any filtered value in pFIR[ x ] [ y ] is greater than (1<<(bitdepth-2) + 1<<(bitdepth-4)), DisableFilterFlag is set equal to 1.

...

* The variable filterFlag is derived as follows:
* If minDistVerHor is greater than intraHorVerDistThres[ nTbS ], filterFlag is set equal to ~~1~~ !DisableFilterFlag.
* Otherwise, filterFlag is set equal to 0.

**Table 8‑4 – Specification of intraHorVerDistThres[ nTbS ] for various transform block sizes**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **nTbS = 8** | **nTbS = 16** | **nTbS = 32** |
| **intraHorVerDistThres[ nTbS ]** | 7 | 1 | 0 |

**8.4.4.2.6 Specification of intra prediction mode in the range of INTRA\_ANGULAR2.. INTRA\_ANGULAR34**

...

The values of the prediction samples predSamples[ x ][ y ], with x, y = 0..nTbS − 1 are derived as follows:

– If predModeIntra is equal or greater than 18, the following ordered steps apply:

1. The reference sample array ref[ x ] is specified as follows:

* The following applies:

ref[ x ] = p[ −1 + x ][ −1 ], with x = 0..nTbS (8‑47)

* If intraPredAngle is less than 0, the main reference sample array is extended as follows:
* When ( nTbS \* intraPredAngle )  >>  5 is less than −1,

ref[ x ] = p[ −1 ][ −1 + ( ( x \* invAngle + 128 )  >>  8 ) ],  
 with x = −1..( nTbS \* intraPredAngle )  >>  5 (8‑48)

* Otherwise,

ref[ x ] = p[ −1 + x ][ −1 ], with x = nTbS + 1..2 \* nTbS (8‑49)

1. The values of the prediction samples predSamples[ x ][ y ], with x, y = 0..nTbS − 1 are derived as follows:
   1. The index variable iIdx and the multiplication factor iFact are derived as follows:

iIdx = ( ( y + 1 ) \* intraPredAngle )  >>  5 (8‑50)

iFact = ( ( y + 1 ) \* intraPredAngle ) & 31 (8‑51)

* 1. Depending on the value of iFact, the following applies:
* If iFact is not equal to 0, the value of the prediction samples predSamples[ x ][ y ] is derived as follows:
* If (DisableFilterFlag)

If (iFact<16)

predSamples[ x ][ y ] = ref[ y + iIdx + 1 ]

Otherwise

predSamples[ x ][ y ] = ref[ y + iIdx + 2 ]

predSamples[ x ][ y ] =   
 ( ( 32 − iFact ) \* ref[ x + iIdx + 1 ] + iFact \* ref[ x + iIdx + 2 ] + 16 )  >>  5 (8‑52)

* Otherwise, the value of the prediction samples predSamples[ x ][ y ] is derived as follows:

predSamples[ x ][ y ] = ref[ x + iIdx + 1 ] (8‑53)

* 1. When predModeIntra is equal to 26 (vertical), cIdx is equal to 0, nTbS is less than 32, DisableFilterFlag is equal to 0, and cu\_transquant\_bypass\_flag is equal to 0, the following filtering applies with x = 0, y = 0..nTbS − 1:

predSamples[ x ][ y ] = Clip1Y( p[ x ][ −1 ] + ( ( p[ −1 ][ y ] − p[ −1 ][ −1 ] )  >>  1 ) ) (8‑54)

– Otherwise (predModeIntra is less than 18), the following ordered steps apply:

1. The reference sample array ref[ x ] is specified as follows:

* The following applies:

ref[ x ] = p[ −1 ][ −1 + x ], with x = 0..nTbS (8‑55)

* If intraPredAngle is less than 0, the main reference sample array is extended as follows:
* When ( nTbS \* intraPredAngle )  >>  5 is less than −1,

ref[ x ] = p[ −1 + ( ( x \* invAngle + 128 )  >>  8 ) ][ −1 ],  
 with x = −1..( nTbS \* intraPredAngle )  >>  5 (8‑56)

* Otherwise,

ref[ x ] = p[ −1 ][ −1 + x ], with x = nTbS + 1..2 \* nTbS (8‑57)

1. The values of the prediction samples predSamples[ x ][ y ], with x, y = 0..nTbS − 1 are derived as follows:
2. The index variable iIdx and the multiplication factor iFact are derived as follows:

iIdx = ( ( x + 1 ) \* intraPredAngle )  >>  5 (8‑58)

iFact = ( ( x + 1 ) \* intraPredAngle ) & 31 (8‑59)

1. Depending on the value of iFact, the following applies:

* If iFact is not equal to 0, the value of the prediction samples predSamples[ x ][ y ] is derived as follows:

If (DisableFilterFlag)

If (iFact<16)

predSamples[ x ][ y ] = ref[ y + iIdx + 1 ]

Otherwise

predSamples[ x ][ y ] = ref[ y + iIdx + 2 ]

predSamples[ x ][ y ] =   
 ( ( 32 − iFact ) \* ref[ y + iIdx + 1 ] + iFact \* ref[ y + iIdx + 2 ] + 16 )  >>  5 (8‑60)

* Otherwise, the value of the prediction samples predSamples[ x ][ y ] is derived as follows:

predSamples[ x ][ y ] = ref[ y + iIdx + 1 ] (8‑61)

1. When predModeIntra is equal to 10 (horizontal), cIdx is equal to 0, nTbS is less than 32, DisableFilterFlag is equal to 0, and cu\_transquant\_bypass\_flag is equal to 0, the following filtering applies with x = 0..nTbS − 1, y = 0:

predSamples[ x ][ y ] = Clip1Y( p[ −1 ][ y ] + ( ( p[ x ][ −1 ] − p[ −1 ][ −1 ] )  >>  1 ) ) (8‑62)

# References

1. H. Chen, A. Saxena, F. Fernandes, “Non-RCE2: Enhanced angular intra prediction for screen content coding,” JCTVC-N0183, Vienna, Austria, Aug. 2013.

# Patent rights declaration(s)

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