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CE9-related: Simplification of BDOF JVET-N0147

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- In BDOPF, 4x4 predicted pixels are generated by using 6x6 pixels in which one pixel surrounding 4x4 are overlapped.
- In this contribution, a simplification by changing from 6x6 to 4x4 is proposed.
- As experimental results, 1% of encoding time, 2% of decoding time improvement and 0.06% loss.
- JVET-N0152 (Ericsson) is the same as this proposal independently.

• Change from 6x6 to 4x4 and remove clippings

8.5.7.4 Bidirectional optical flow prediction process

– For $x = x_{Sb} - 1..x_{Sb} + 4$, $y = y_{Sb} - 1..y_{Sb} + 4$, the following ordered steps apply:

1. The locations (hx , vy) for each of the corresponding sample locations (x , y) inside the prediction sample arrays are derived as follows:

$$hx = \text{Clip3}(1, nCbW, x) \quad (8-853)$$

$$vy = \text{Clip3}(1, nCbH, y) \quad (8-854)$$

– The variables $sGx2$, $sGy2$, $sGxGy$, $sGxdl$ and $sGydl$ are derived as follows:

$$sGx2 = \sum_i \sum_j (\text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{tempH}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = -1..4 \quad (8-862)$$

$$sGy2 = \sum_i \sum_j (\text{tempV}[x_{Sb} + i][y_{Sb} + j] * \text{tempV}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = -1..4 \quad (8-863)$$

$$sGxGy = \sum_i \sum_j (\text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{tempV}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = -1..4 \quad (8-864)$$

$$sGxdl = \sum_i \sum_j (- \text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{diff}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = -1..4 \quad (8-865)$$

$$sGydl = \sum_i \sum_j (- \text{tempV}[x_{Sb} + i][y_{Sb} + j] * \text{diff}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = -1..4 \quad (8-866)$$



8.3.6.4 Bidirectional optical flow prediction process

– For $x = x_{Sb}..x_{Sb} + 3$, $y = y_{Sb}..y_{Sb} + 3$, the following ordered steps apply:

1. The locations (hx , vy) for each of the corresponding sample locations (x , y) inside the prediction sample arrays are derived as follows:

$$hx = \text{Clip3}(1, nCbW, x) \quad (8-853)$$

$$vy = \text{Clip3}(1, nCbH, y) \quad (8-854)$$

The variables $sGx2$, $sGy2$, $sGxGy$, $sGxdl$ and $sGydl$ are derived as follows:

$$sGx2 = \sum_i \sum_j (\text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{tempH}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = 0..3 \quad (8-862)$$

$$sGy2 = \sum_i \sum_j (\text{tempV}[x_{Sb} + i][y_{Sb} + j] * \text{tempV}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = 0..3 \quad (8-863)$$

$$sGxGy = \sum_i \sum_j (\text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{tempV}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = 0..3 \quad (8-864)$$

$$sGxdl = \sum_i \sum_j (- \text{tempH}[x_{Sb} + i][y_{Sb} + j] * \text{diff}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = 0..3 \quad (8-865)$$

$$sGydl = \sum_i \sum_j (- \text{tempV}[x_{Sb} + i][y_{Sb} + j] * \text{diff}[x_{Sb} + i][y_{Sb} + j]) \text{ with } i, j = 0..3 \quad (8-866)$$

- Change shift values for increasing internal bit precision
 - Keep 32-bit operations

8.5.7.4 Bidirectional optical flow prediction process

Variables bitDepth, shift1, shift2, shift3, shift4, offset4, and mvRefineThres are derived as follows:

The variable bitDepth is set equal to BitDepth_Y .

The variable shift1 is set to equal to $\text{Max}(2, 14 - \text{bitDepth})$.

The variable shift2 is set to equal to $\text{Max}(8, \text{bitDepth} - 4)$.

The variable shift3 is set to equal to $\text{Max}(5, \text{bitDepth} - 7)$.



8.5.7.4 Bidirectional optical flow prediction process

Variables bitDepth, shift1, shift2, shift3, shift4, offset4, and mvRefineThres are derived as follows:

The variable bitDepth is set equal to BitDepth_Y .

The variable shift1 is set to equal to $\text{Max}(2, 14 - \text{bitDepth})$.

The variable shift2 is set to equal to $\text{Max}(7, \text{bitDepth} - 5)$.

The variable shift3 is set to equal to $\text{Max}(4, \text{bitDepth} - 8)$.

- 1% of encoding time and 2% decoding time were improved.
- Loss was 0.06% on average.

	Random Access Main 10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.05%	0.05%	-0.02%	99%	98%
Class A2	0.08%	0.04%	0.02%	99%	98%
Class B	0.08%	0.07%	0.03%	100%	98%
Class C	0.05%	-0.01%	-0.08%	99%	97%
Class E					
Overall	0.06%	0.04%	-0.01%	99%	98%
Class D	0.01%	-0.05%	-0.06%	99%	97%
Class F	0.00%	-0.03%	-0.02%	99%	99%

- In this contribution, we have proposed a simplification of BDOF.
 - By changing from 6x6 to 4x4, it can be realized with less than half of the processing for BDOF.
- As experimental results, loss was 0.06% on average.
- Recommend to fix this change to WD and VTM software.
- Thank Ruoyang (Ericsson, JVET-N0673) for cross-checking.

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- Disable CU base (1st) early termination
- Enable 4x4 (2nd) early termination

	Random Access Main 10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.00%	0.02%	0.02%	100%	104%
Class A2	-0.02%	0.02%	0.03%	100%	104%
Class B	0.01%	0.00%	0.01%	100%	104%
Class C	0.00%	-0.05%	-0.02%	100%	102%
Class E					
Overall	0.00%	-0.01%	0.01%	100%	103%
Class D	0.00%	0.00%	-0.03%	100%	101%
Class F	0.00%	0.00%	0.01%	101%	110%

- Disable CU base (1st) early termination
- 3% of decoding time were improved from reference scheme.
- Loss was 0.06% on average.

	Random Access Main 10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.05%	0.05%	0.03%	100%	101%
Class A2	0.06%	0.03%	0.01%	100%	101%
Class B	0.08%	0.03%	0.03%	100%	101%
Class C	0.05%	0.01%	-0.09%	100%	99%
Class E					
Overall	0.06%	0.03%	-0.01%	100%	100%
Class D	0.01%	-0.08%	-0.09%	100%	98%
Class F	0.00%	-0.03%	-0.03%	100%	105%