JVET-P0153
CE4-related: Overlapped block optical flow (OBOF)

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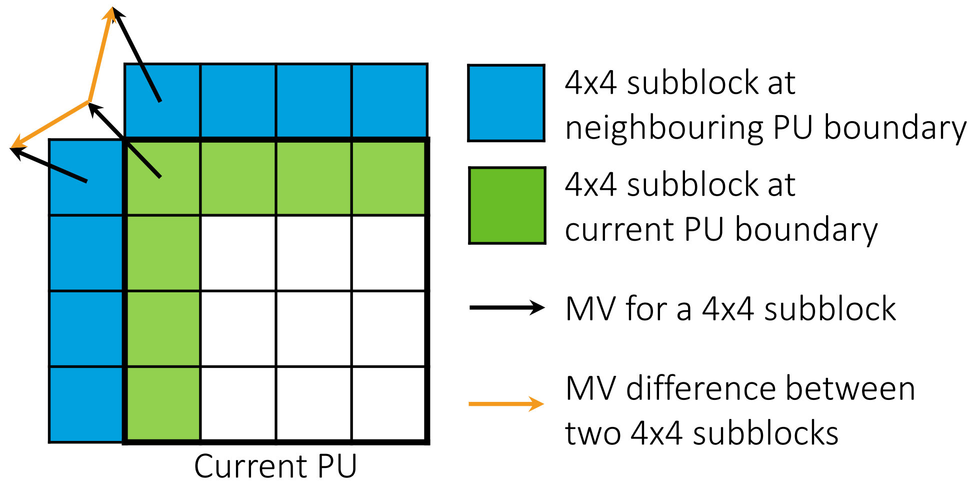
Overall Summary

- Extend the prediction refinement with optical flow process to the above and left boundaries of inter coding blocks
  - Reuses most parts of processes in BDOF and PROF
  - Only changes the sample-level MV offset to be the MV differences between the current block and neighbouring blocks

	Over VTM-6.0 (%)		Y	U	V	EncT	DecT
1	OBOF	RA	-0.09	-0.02	-0.09	107%	108%
		LB	-0.31	-0.23	-0.27	108%	111%

Introduction

- Prediction refinement by optical flow for above and left boundaries of inter coding blocks
  - Reduce motion discontinuities among inter coding block boundaries
  - Without extra memory bandwidth of reference samples as required in OBMC
  - Extension of existing optical flow tools
    - PROF which only applies to affine CUs
    - BDOF which only applies to true bi-prediction CUs



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Proposed Method

- Step 1: Generate sample prediction $I(i,j)$
  - Perform MC for one PU with one prediction sample padding on each side of the MC block for the gradient calculation
  - Same as BDOF
- Step 2: Calculate spatial gradients $g_x(i,j)$ and $g_y(i,j)$
  - Calculated using a 3-tap filter [-1, 0, 1] at each sample location
  - Same as PROF and BDOF
- **Step 3: Calculate sample level MV offset $\boldsymbol{\Delta v(i,j)}$**
- Step 4: Apply optical flow equation
  - $\Delta I(i,j) = g_x(i,j) * \Delta v_x(i,j) + g_y(i,j) * \Delta v_y(i,j)$
  - $I'(i,j) = I(i,j) + \Delta I(i,j)$
  - Same as PROF and BDOF

Proposed Method

- Step 3: Calculate sample-level MV offset $\Delta v(i,j)$
- Calculate MV difference
  - If neighbouring MV is not available or if the difference of MV is larger than a threshold, then the difference of MV is forced to zero
  - $$\begin{cases} MV_{Adiff}(i) = MV_{nei}(i,-1) - MV_{cur} \\ MV_{Ldiff}(j) = MV_{nei}(-1,j) - MV_{cur} \end{cases}$$
- Apply weighting

$$n = \min(32, \min(PU\ height, PU\ width) \gg 1)$$

  - $$\begin{cases} \Delta va(i,j) = w_n(j) * MV_{Adiff}(i) \\ \Delta vl(i,j) = w_n(i) * MV_{Ldiff}(j) \end{cases}$$

$$\begin{cases} w_n(i) = \frac{n-i}{n}, if\ i < n \\ w_n(i) = 0, otherwise \end{cases}$$

- Combine two sample-level MV offsets
  - Precision and range of sample-level MV offset are aligned to BDOF which are 1/64 precision and in the range from -32 to 31
  - $\Delta v(i,j) = \Delta va(i,j) + \Delta vl(i,j)$

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Proposed Method

- Applied condition
  - Translational uni-prediction
  - Translational bi-prediction with CU level weights index
  - Translational bi-prediction with equal weight
  - TPM
  - All 8x8 subblocks in SbTMVP
  - Bi-prediction with only BDOF enabled

Simulation Results

- Proposed OBOF
- SIMD is not yet applied to sample-level MV offset calculation
  - Runtimes can be further reduced by SIMD

	Random access Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	-0.05%	0.01%	-0.07%	106%	109%
Class A2	-0.03%	0.02%	-0.06%	106%	109%
Class B	-0.10%	0.07%	-0.02%	108%	108%
Class C	-0.15%	-0.18%	-0.20%	107%	108%
Class E					
Overall	-0.09%	-0.02%	-0.09%	107%	108%
Class D	-0.20%	-0.05%	-0.21%	107%	108%
Class F	-0.03%	-0.05%	-0.05%	106%	115%

	Low delay B Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.19%	-0.32%	-0.27%	108%	108%
Class C	-0.24%	-0.41%	-0.03%	108%	108%
Class E	-0.60%	0.16%	-0.61%	110%	118%
Overall	-0.31%	-0.23%	-0.27%	108%	111%
Class D	-0.38%	-0.01%	0.13%	108%	108%
Class F	0.07%	0.01%	0.42%	107%	115%

Conclusions

- OBOF is an extension of the existing optical flow tools in VVC
  - Only different sample-based MV offset calculation method
  - Reuse most parts of BDOF and PROF designs
    - Boundary padding, gradient calculation and sample refinement calculation
  - Coding tool for BDOF is not applicable, e.g., low delay cases
  - Alternative coding tool with less complexity compared with BDOF
- Thanks to ETRI for cross-checking