

JVET-J0012

SDR and HDR video coding technology proposal by Ericsson and Nokia

Rickard Sjöberg, Kenneth Andersson, Ruoyang Yu,
Zhi Zhang, Per Wennersten
Ericsson

Jani Lainema, Antti Hallapuro, Alireza Aminlou,
Miska Hannuksela, Ramin Ghaznavi-Youvalari,
Justin Ridge
Nokia

Proposal philosophy and summary

- The CfP evaluation procedure contains subjective testing and therefore we wanted a clean measure of subjective performance between the proposal and the anchor
- We therefore based our proposal on JEM 7.0
- No encoder optimizations such as changes to structure of reference pictures, QP settings or lambda usage
- We also focused on keeping the complexity low
- The BD-rate impacts over JEM 7.0 for SDR RA and LD are -0.90% and -0.17%, respectively
- For HDR, a BD-rate impact of -0.9% over the JEM anchor is reported
- Encoder runtimes compared to JEM 7.0 are 103%, 99% and 103% for SDR RA, SDR LD and HDR
- Decoder runtimes for the same configurations are 98%, 95% and 99%, respectively

Subjective quality

- The proposal contains several tools that aim at improving the subjective quality rather than providing BDR improvements.
- The JVET-J0012 Word document contains several still picture examples showing claimed subjective improvements such as less blocking artifacts, please take a look.
- The next slide shows an example (using a bright picture)
- We plan to make the software source code available

Subjective performance example - FoodMarket



JEM 7.0



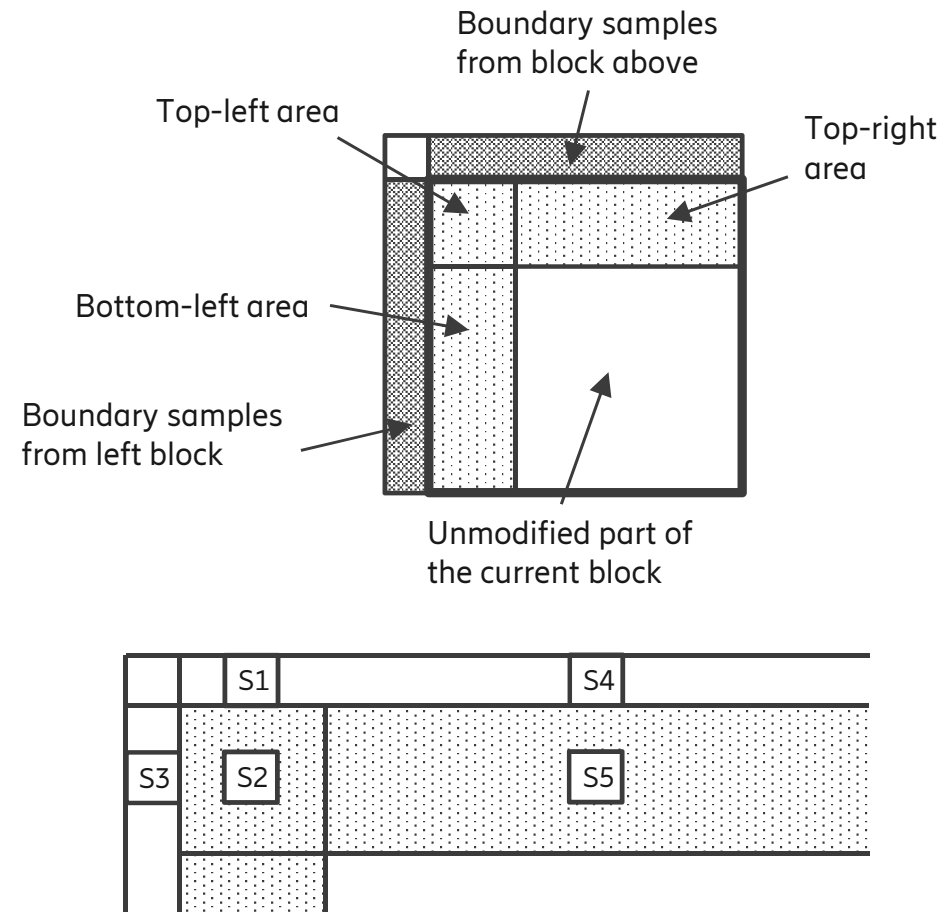
Proposal

List of proposed tools

- 8 tools with favorable compression/coding efficiency trade-off
 1. Multiple boundary filtering for planar and DC mode
 2. Motion vector look back
 3. Motion vector prediction between lists
 4. Motion vector difference sign data hiding
 5. Restricted OBMC
 6. In-loop deblocking filter
 7. Wide-angle intra prediction
 8. Affine flexing

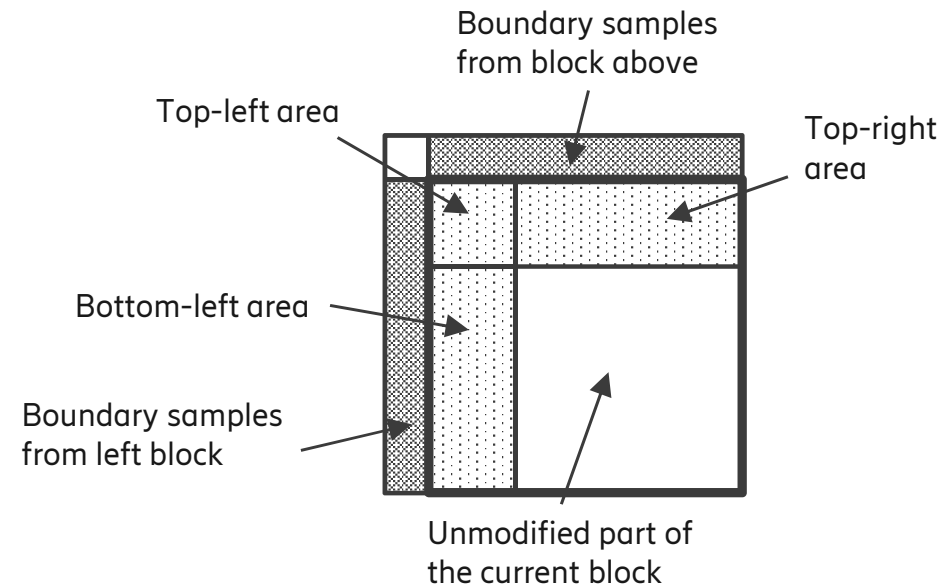
Multiple boundary filtering for planar and DC mode

- The concept with MBF is to make a better alignment of the intra predicted block with the samples of neighboring blocks
- In the top-right area and the bottom-left area the predicted samples are modified by a weighted average of the predicted sample (S5) and one adjacent sample (S4)
- In the top-left area the predicted samples are modified by a weighted average of the predicted sample (S2) and one sample (S3) to the left.
- The weights used to average decays with distance from the boundary and gives a smooth transition to the neighbors.



Multiple boundary filtering for planar and DC mode

- Planar mode
 - PDPC planar is replaced by a planar mode using MBF which filters 2 or 4 columns and rows of a block depending on block size
 - The reference sample filtering approach from PDPC planar is still used.
- DC mode
 - The one sample boundary smoothing for the DC mode in JEM 7.0 is proposed to be replaced by MBF
 - The length of the filter is determined by the size (minimum of width and height of the block) and the use of non-separable transforms (NSST) as indicated in the table



size	filter length NSST used	filter length NSST not used
32	15	7
16	7	7
8	4	1
4	2	1

Subjective improvements of MBF filtering



JEM 7.0 (PDPC planar)



JEM 7.0 with MBF for planar (proposal)

Multiple boundary filtering for planar and DC mode

- Results shows a small subjective and objective improvement at similar encoding and decoding time.

	"tool-off" test results				
	BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec
SDR RA	0.1%	0.5%	0.2%	100%*	99%*
SDR LD	0.0%	0.3%	0.9%	101%*	101%*

	"tool-off" test results					
	BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.3%	0.1%	0.1%	0.1%	96%*	100%*

*Encoding and decoding time computed on same compute cluster but not same machine

Multiple boundary filtering for planar and DC mode

— Results MBF DC mode

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.1%	0.4%	0.2%	98%*	100%*	-0.1%	-0.2%	-0.3%	100%	100%
SDR LD	0.0%	-0.1%	0.7%	100%	100%	-0.0%	0.0%	-1.0%	100%	99%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.1%	0.1%	0.1%	0.1%	97%*	102%*	-0.3%	-0.1%	-0.1%	-0.1%	98%*	102%*

*Encoding and decoding time computed on same compute cluster but not same machine

Multiple boundary filtering for planar and DC mode

— Results MBF planar mode

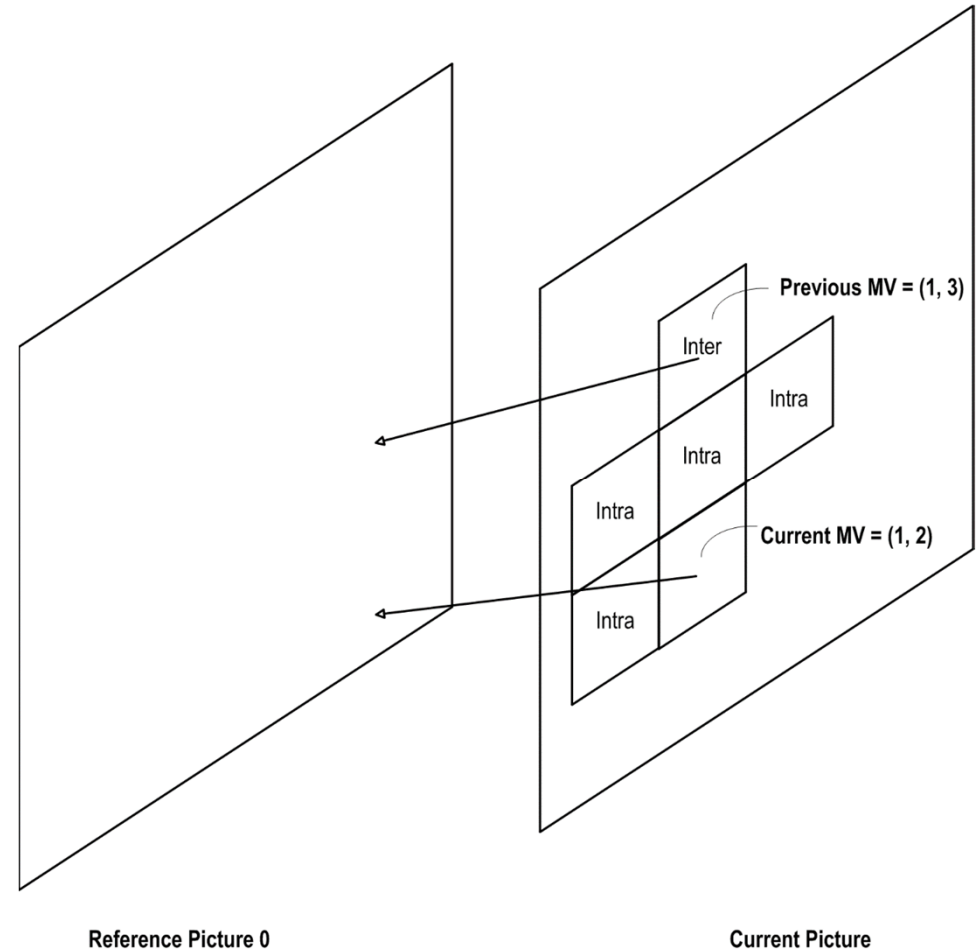
	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.0%	0.2%	-0.0%	99%*	102%*	0.0%	0.1%	-0.1%	100%	100%
SDR LD	0.0%	0.3%	0.8%	100%	101%	0.0%	0.3%	0.4%	101%	98%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.1%	0.0%	0.0%	0.0%	97%*	102%*	0.0%	0.0%	0.0%	0.0%	99%*	101%*

*Encoding and decoding time computed on same compute cluster but not same machine

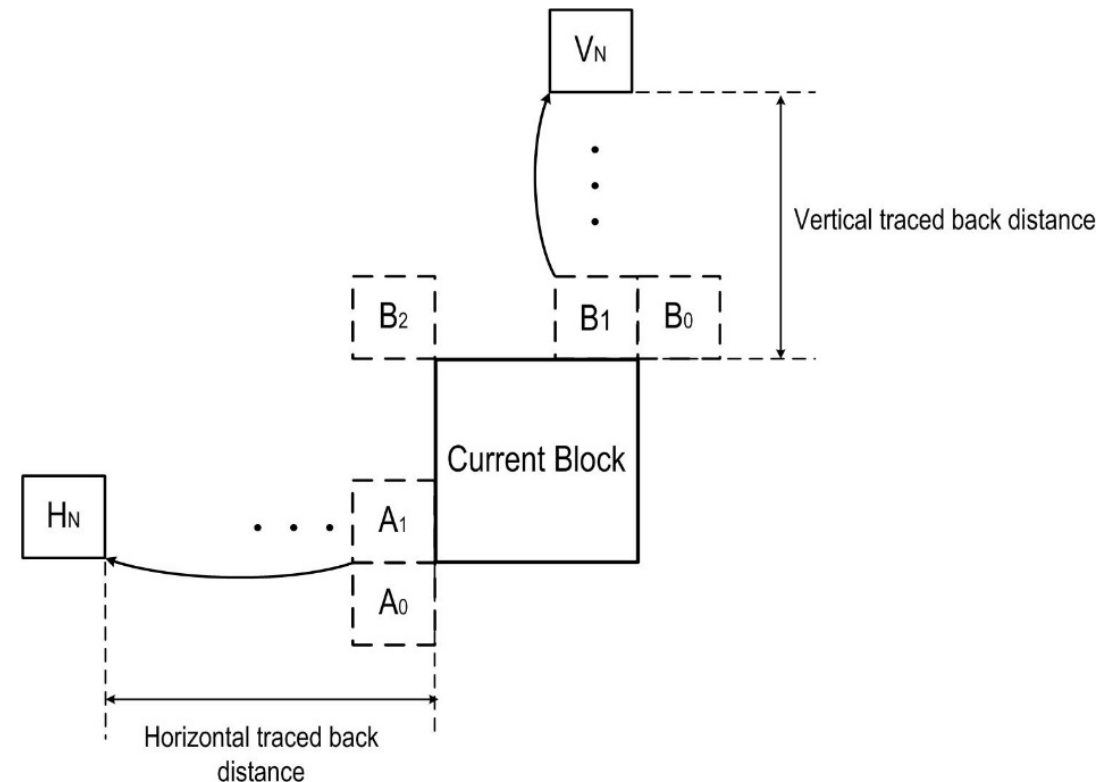
Motion vector look back

- If the current block is Inter coded and the surrounding blocks are all Intra coded, then there are no spatially neighboring motion vectors to use for prediction
- It may still be the case that there are good MV predictors further away from the current block
- What we propose is to modify the merge candidate list generation .
 - Besides use of merge mode, the merge candidates are part of the start candidates for FRUC



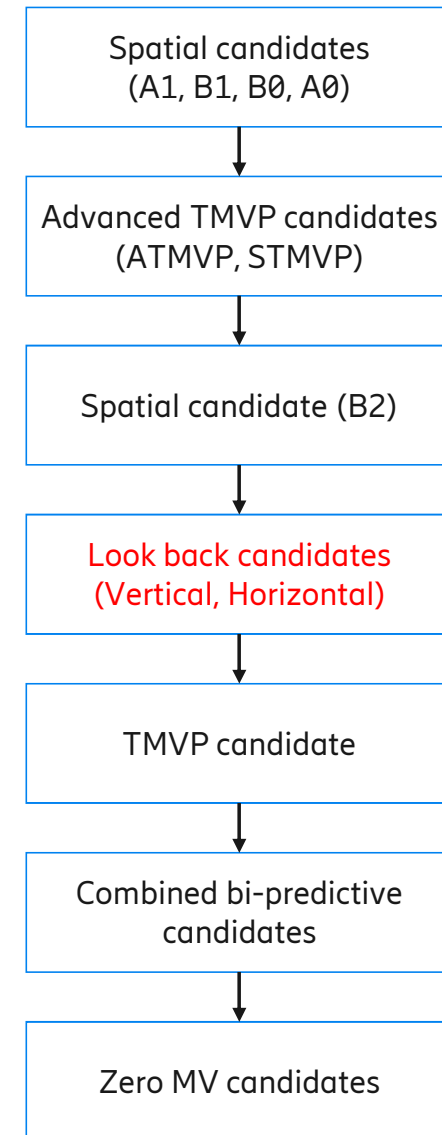
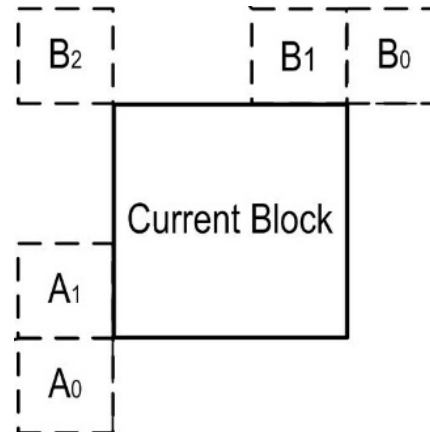
Motion vector look back

- Our proposed solution is to allow neighboring blocks further away to be used for prediction
- To keep the complexity at a minimum, we check the neighboring blocks at a maximum distance of 1 CTU.
- First, the closest vertically neighboring block is added
- Then the closest horizontally neighboring block is added



Motion vector look back

- The added candidates are added before the TMVP candidate in the merge candidate list
- New candidates are only added if there are less than 4 spatial candidates added.
Less than 4 of A_1, B_1, B_0, A_0, B_2 that is.



Motion vector look back

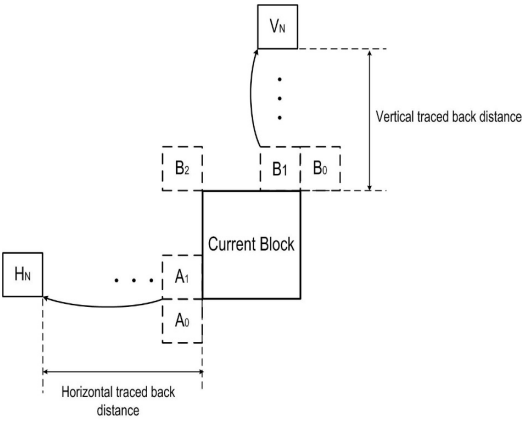
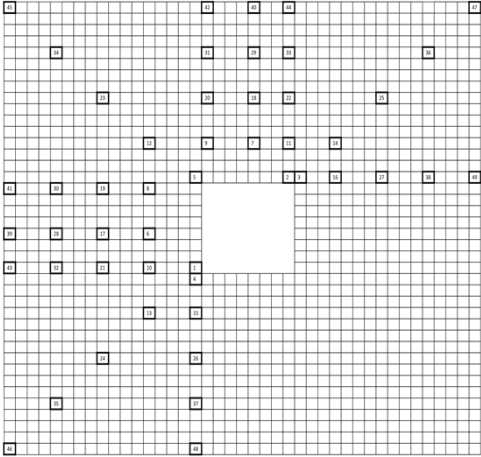
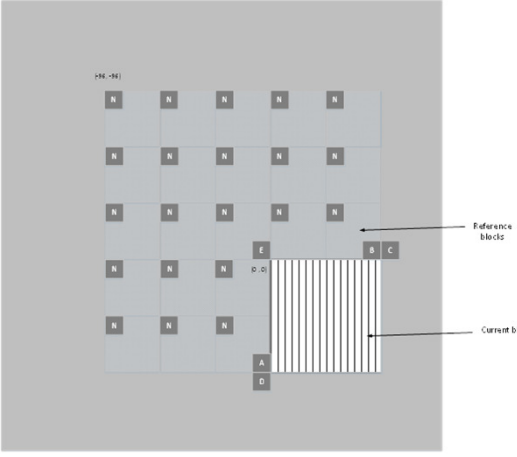
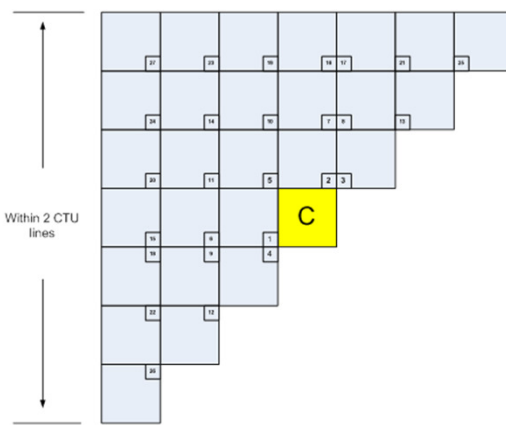
— Results show -0.3% luma BDR for RA at low complexity impact

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.3%	0.4%	0.5%	100%*	100%*	-0.3%	-0.3%	-0.5%	100%	100%
SDR LD	0.1%	0.5%	0.3%	101%	100%	-0.1%	0.5%	-0.1%	100%	101%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.4%	0.3%	0.3%	0.3%	98%*	99%*	-0.4%	-0.3%	-0.3%	-0.3%	97%*	100%*

*Encoding and decoding time computed on same compute cluster but not same machine

Other proposals similar to motion vector look back

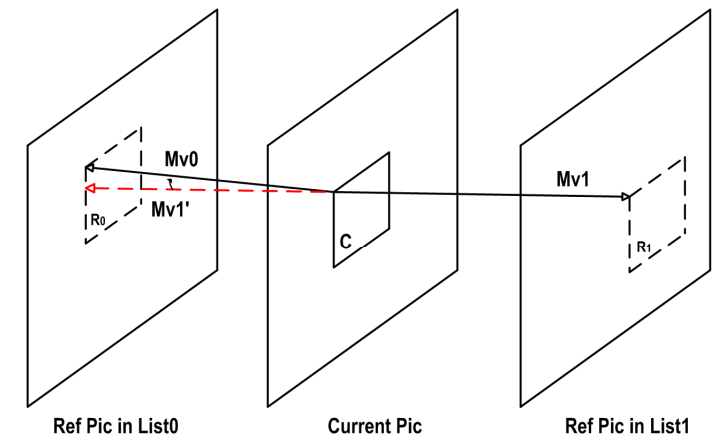
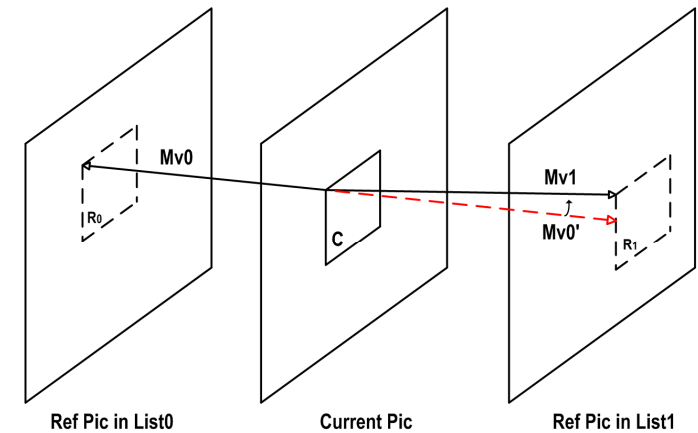
MV look back J0012 (Ericsson, Nokia)	J0021(Qualcomm, Technicolor)	J0029(Tencent) J0058 (modified J0029)	J0059 (Hisilicon)
 The diagram illustrates the MV look back mechanism. A 'Current Block' is shown with a horizontal traced back distance to a sequence of reference blocks $A_0, A_1, \dots, A_N$ and a vertical traced back distance to a sequence of reference blocks $B_0, B_1, \dots, B_N$. The horizontal distance is labeled 'Horizontal traced back distance' and the vertical distance is labeled 'Vertical traced back distance'.	 The diagram shows a 16x16 grid of blocks. Each block contains a small square representing a motion vector. A central 4x4 area of the grid is highlighted in white, indicating a specific region of interest or a different type of block.	 The diagram shows a grid of blocks. A central 4x4 area is highlighted in white. To the right of this area, a vertical strip of blocks is labeled 'Current block'. Above this strip, a horizontal strip of blocks is labeled 'Reference blocks'. The blocks are labeled with letters A, B, C, D, E, and a small 'C' is also visible.	 The diagram shows a grid of blocks. A central 4x4 area is highlighted in white. To the right of this area, a vertical strip of blocks is labeled 'Current block'. Above this strip, a horizontal strip of blocks is labeled 'Reference blocks'. The blocks are labeled with letters A, B, C, D, E, and a small 'C' is also visible. A vertical arrow on the left indicates 'Within 2 CTU lines'.

Proposed Motion vector look back CE

- We propose that a core experiment is run until the next meeting with technology from the following proposals
 - JVET-J0012 (Ericsson/Nokia)
 - JVET-J0021 (Qualcomm/Technicolor)
 - JVET-J0029 (Tencent)
 - JVET-J0058 (Tencent)
 - JVET-J0059 (HiSilicon)
- Proposed CE name: “Non-neighboring spatial merge MV candidates”
- Properties to test:
 - SDR and HDR BDR compression performance
 - Computational complexity

Motion vector prediction between lists

- Motion vector prediction between list exploits correlation between the two motion vectors when the current block is bi-predictively coded using the AMVP mode
- MV reconstruction is then done as follows:
 - If the L1 candidate list does not contain a scaled candidate
 - Reconstruct the L1 MV as MV1
 - If the L0 candidate list contains a scaled candidate
 - Replace the first scaled candidate in L0 with a scaled MV1
 - Otherwise
 - Reconstruct the L0 MV as MV0
 - If the L1 candidate list contains a scaled candidate
 - Replace the first scaled candidate in L1 with a scaled MV0
- (A FRUC candidate is counted as a non-scaled candidate)



Motion vector prediction between lists

— Results show -0.2% luma BDR for RA at low complexity impact

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.2%	0.1%	0.1%	94%*	100%*	-0.2%	-0.1%	-0.1%	104%	100%
SDR LD	0.0%	0.0%	0.0%	100%	100%	0.0%	0.0%	0.1%	100%	99%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.2%	0.1%	0.1%	0.1%	93%*	100%*	-0.2%	-0.1%	-0.1%	-0.1%	101%*	102%*

*Encoding and decoding time computed on same compute cluster but not same machine

Motion vector difference sign data hiding

- The sign of the x component of the MVD is proposed to be derived as follows when MVD is signaled in quarter-pel resolution:

$$AbsSum = Magnitude(x) + Magnitude(y) + RefPicIdx$$

$$Sign(x) = AbsSum \& 1$$

- *Magnitude* represents the value of the MVD magnitude.
- *RefPicIdx* represents the value of the reference picture index.
- The tool is turned off when full-pel MVD is used

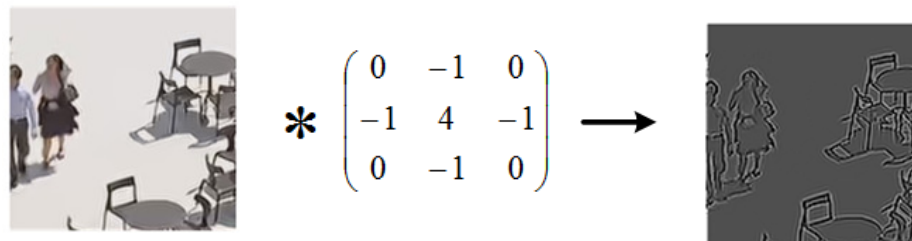
Motion vector difference sign data hiding

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.1%	0.1%	0.1%	99%*	99%*	0.0%	0.1%	0.0%	100%	100%
SDR LD	0.1%	0.2%	-0.0%	98%	100%	-0.1%	0.8%	0.2%	102%	100%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	-0.1%	0.0%	0.0%	0.0%	96%*	100%*	-0.1%	0.0%	0.0%	0.0%	98%*	100%*

*Encoding and decoding time computed on same compute cluster but not same machine

Restricted OBMC



Part 1:

- A 2D spatial Laplacian activity for luma samples of the prediction block is calculated to measure the edge activity as follows

$$La = \frac{\sum_{i=1}^{M-1} \sum_{j=1}^{N-1} |4 * P_{i,j} - P_{i-1,j} - P_{i+1,j} - P_{i,j-1} - P_{i,j+1}|}{(M-2) * (N-2)}, \text{ } P_{i,j} \text{ is the sample value for sample at (i,j)}$$

- OBMC is then disabled if La is lower than a threshold $T = K \ll (\text{bitDepth}-8)$, where K depends on QP:

QP	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30
K	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	2	4	4	4
QP	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8
K	4	6	6	8	8	10	12	14	14	16	16	16	16	16	32	32	32	32	32	32	32	32
QP	7	6	5	4	3	2	1	0														
K	32	32	32	32	32	32	32	32														

Restricted OBMC

Part 2:

- For a current sub-PU, its local illumination (LIC) flag is compared with the LIC flags of neighboring sub-PU.
- When the LIC flags are different, the MV of that neighboring sub-PU will not be used for OBMC of the current sub-PU.
- It should be noted that the restricted OBMC is enabled only when the OBMC flag of the current block is implicitly derived to be equal to 1
 - The current block is either coded with merge flag equal to 1 or has a size larger than 256 luma samples

Restricted OBMC

- Around 2% speed-up on both encoder and decoder without significant BDR impact

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.0%	0.0%	0.0%	102%	101%	0.0%	0.1%	0.1%	99%	98%
SDR LD	0.0%	0.1%	0.1%	102%	102%	0.1%	1.0%	1.0%	98%	97%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	-0.1%	0.0%	0.0%	0.0%	99%*	102%*	0.1%	0.0%	0.0%	0.0%	96%*	99%*

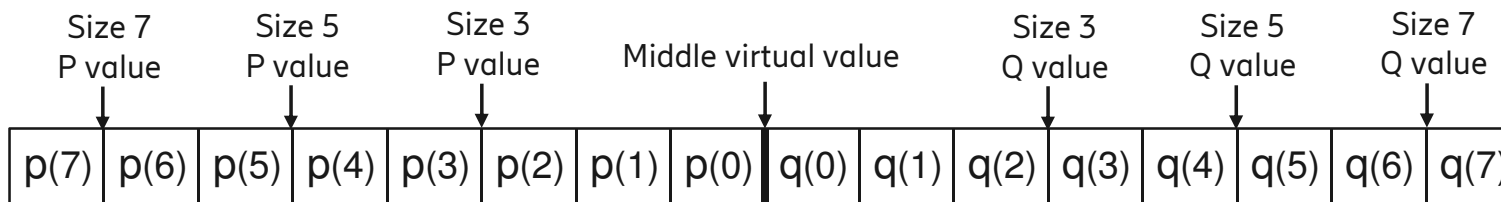
*Encoding and decoding time computed on same compute cluster but not same machine

In-loop deblocking filter

- A number of deblocking modifications are proposed
 1. Longer deblocking filters for luma, up to 7 samples on each side of the boundary
 2. Adding deblocking of luma sub-CU boundaries
 3. Deblock LIC block boundaries for luma and chroma
 4. Deblock inside chroma blocks that are predicted from luma
 5. A parallel-friendly deblocking design
- There are still pictures in the document showing effects of individual modifications

Longer deblocking filter for luma

- HEVC and JEM currently filter up to 3 samples on each side of a block boundary
- This seem insufficient for high spatial resolution video such as 2160p
- We propose addition of strong filters capable of filtering 3, 5 and 7 luma samples on each side
 - The filter consist of replacing decoded sample values by values linearly interpolated from one Middle virtual value and one virtual block P or block Q value



Longer deblocking filter for luma

- The block P and block Q virtual values are calculated as the average of the closest neighboring sample values: $(a+b+1) \gg 1$
- The Middle virtual value is calculated as a weighted average of sample values

$$Middle = \left(\sum_{k=0}^8 (w(k) \cdot (p(k) + q(k))) + 8 \right) \gg 4$$

k	7	6	5	4	3	2	1	0	0	1	2	3	4	5	6	7
Sample value	p(7)	p(6)	p(5)	p(4)	p(3)	p(2)	p(1)	p(0)	q(0)	q(1)	q(2)	q(3)	q(4)	q(5)	q(6)	q(7)
Weights (w) size 3	0	0	0	0	0	2	3	3	3	3	2	0	0	0	0	0
Weights (w) size 5	0	0	0	0	1	1	3	3	3	3	1	1	0	0	0	0
Weights (w) size 7	0	1	1	1	1	1	1	2	2	1	1	1	1	1	1	0

Longer deblocking filter for luma

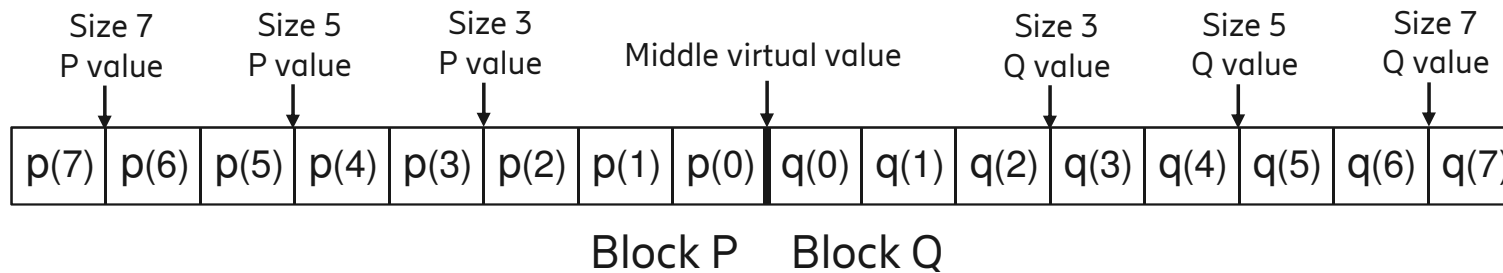
- Block boundary samples are then replaced by the $p_i'(x)$ and $q_i'(x)$ as follows:

$$p_i'(x) = (f(x) * \text{Middle} + (64 - f(x)) * P + 32) \gg 6, \text{ clipped to } \pm tc$$

$$q_i'(x) = (f(x) * \text{Middle} + (64 - f(x)) * Q + 32) \gg 6, \text{ clipped to } \pm tc$$

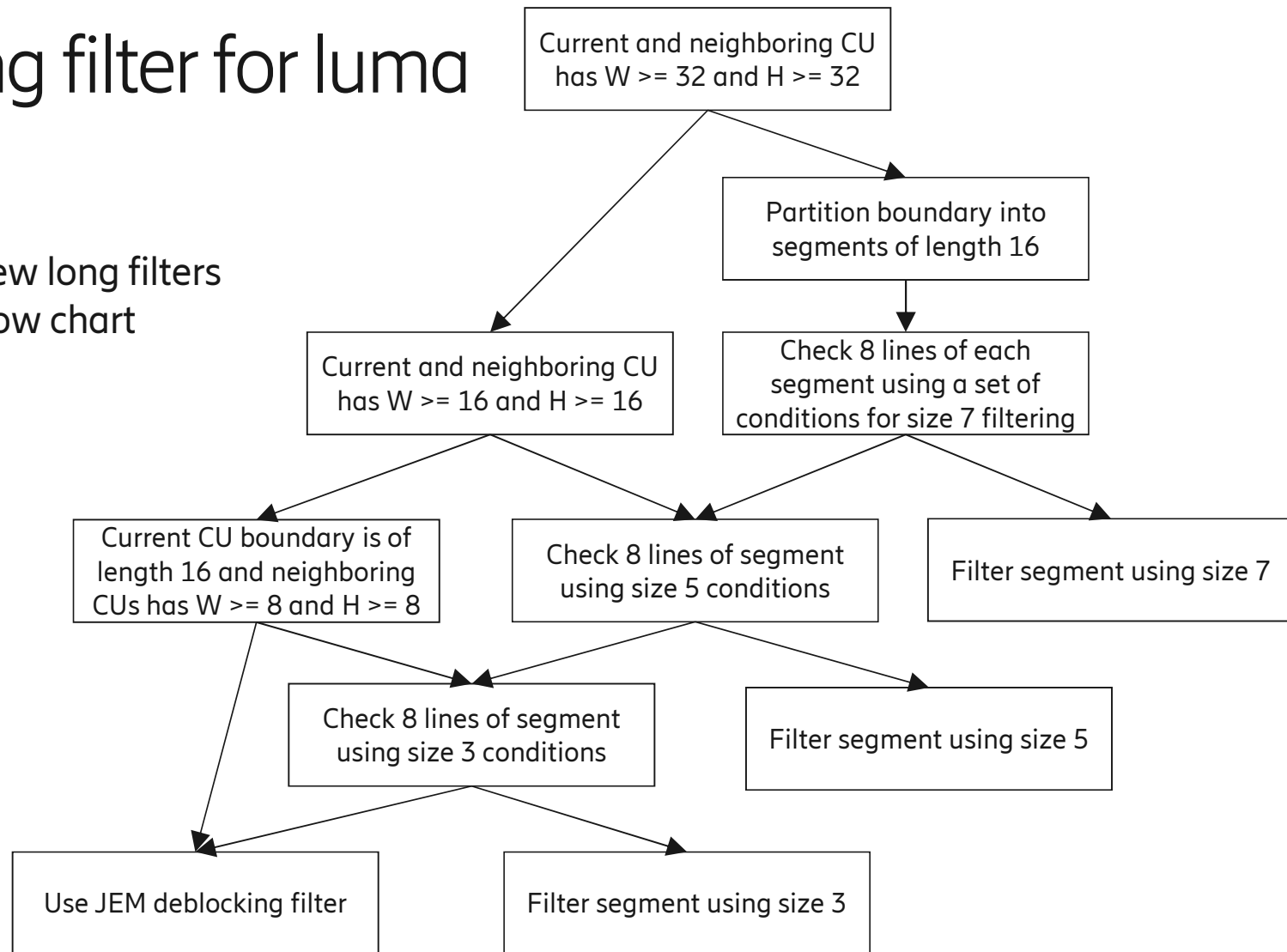
- where $f(x)$ are values for linear interpolation

size	$f(x)$
3	{53,32,11}
5	{58,45,32,19,6}
7	{59,50,41,32,23,14,5}



Longer deblocking filter for luma

- The filter decisions for the new long filters are done according to this flow chart



Longer deblocking filter for luma

Size	Conditions for each of the 8 lines of a 16 sample segment
7	$\text{HEVC}_{\text{strongweak}} \&\& (p(0) - 2p(2) + p(4) + q(0) - 2q(2) + q(4)) < 3\beta/32 \&\&$ $(p(0) - p(2) - p(3) + p(5) + q(0) - q(2) - q(3) + q(5)) < 3\beta/32 \&\&$ $(p(0) - 2p(3) + p(6) + q(0) - 2q(3) + q(6)) < 3\beta/32 \&\&$ $(p(0) - p(3) - p(4) + p(7) + q(0) - q(3) - q(4) + q(7)) < 3\beta/32$
5	$\text{HEVC}_{\text{strongweak}} \&\& (p(0) - p(4) + q(0) - q(4)) < \beta/8 \&\&$ $(p(0) - p(5) + q(0) - q(5)) < \beta/8$
3	$\text{HEVC}_{\text{strongweak}} \&\& (p(0) - p(1) - p(2) + p(3) + q(0) - q(1) - q(2) + q(3)) < 3\beta/32$
0-3	HEVC filter and decisions apply but reducing maximum filter length to half the minimum of the distance between current and neighboring CU boundaries

p(7)	p(6)	p(5)	p(4)	p(3)	p(2)	p(1)	p(0)	q(0)	q(1)	q(2)	q(3)	q(4)	q(5)	q(6)	q(7)
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Block P Block Q

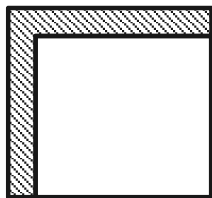
Adding deblocking of luma sub-CU boundaries

- Sub-PU boundaries can result from FRUC, MV prediction or AFFINE
 - Those are currently not deblocked in JEM 7.0
- We propose to set the boundary strength equal to 1 for a sub-PU boundary if any of the following conditions is true:
 1. If any of the absolute value differences between motion vector components for the two sides of the sub-PU boundary exceeds the JEM threshold
 2. If different reference pictures are used for the two sides of the sub-PU boundary
 3. If one side of the sub-PU boundary uses uni-directional prediction and the other uses bi-prediction

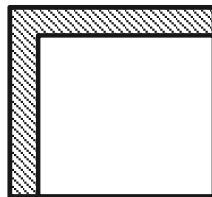
Deblock LIC block boundaries for luma and chroma

- Local illumination compensation (LIC) scales or offsets the prediction block which can cause discontinuities across blocks.
- We propose that if any of the two blocks of a block boundary uses LIC, the current JEM deblocking filter is applied with boundary strength set to 1 for luma and 2 for chroma.

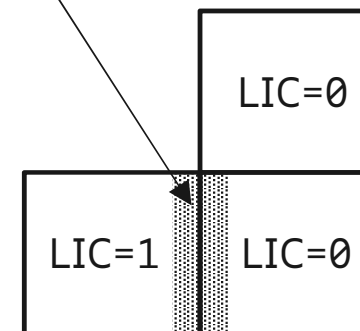
Reference block



Current block



Filtering is performed
where LIC is used



Deblock inside chroma blocks that are predicted from luma

- Luma and chroma are coded with separate coding structures for intra slices which may cause internal boundaries in chroma blocks that has been predicted from luma using cross-component prediction.
- We propose to deblock any such internal chroma boundary using strength 1 for which the corresponding luma boundary strength is larger than 0
- The filtering is performed at an 8 sample grid, same chroma grid size as JEM

A parallel-friendly deblocking design

- HEVC
 - Deblocking is done on a grid size of 8 for luma and 4 for chroma
 - All boundaries (TUs and PUs, luma and chroma) can be deblocked in parallel
- JEM
 - Deblocking is done on a grid size of 4 for luma and 8 for chroma
 - Luma boundaries cannot be deblocked in parallel since the filter may read 4 and modify 3 samples on each side which can lead to recursion
- Our proposal
 - Deblocking is done on a grid size of 4 for luma and 8 for chroma
 - All boundaries can be deblocked in parallel with the exception of sub-CU boundaries. Those needs to be deblocked before the CU boundaries
 - The parallelism is achieved by disallowing filter sizes that leads to recursion
 - The reason for the sub-CU exception is subjective quality improvements

In-loop deblocking filter

- Gives large benefit in subjective quality at a small BDR impact and around 1.5% increase of decoding time

	"tool-off" test results					"tool-on" test results				
	BD-rate			Runtime		BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec	Y	Cb	Cr	Enc	Dec
SDR RA	0.1%	0.1%	0.2%	100%	98%	0.0%	0.0%	-0.2%	100%	101%
SDR LD	0.0%	0.5%	0.8%	100%	98%	0.1%	0.2%	-1.3%	100%	102%

	"tool-off" test results						"tool-on" test results					
	BD-rate				Runtime		BD-rate				Runtime	
	DE100	PSNRL100	wPsnrY	Y	Enc	Dec	DE100	PSNRL100	wPsnrY	Y	Enc	Dec
HDR	0.0%	0.0%	0.0%	0.0%	98%*	98%*	0.1%	0.1%	0.0%	0.0%	98%*	102%*

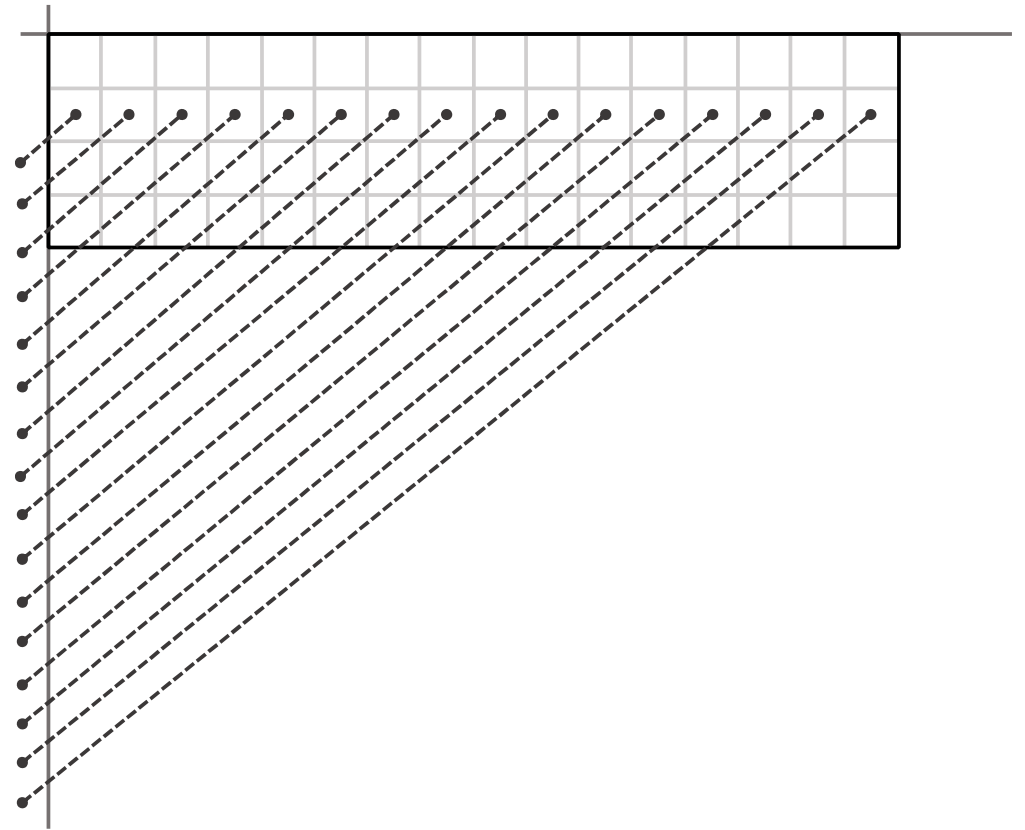
*Encoding and decoding time computed on same compute cluster but not same machine

Proposed Deblocking CE

- Other proposals that also use longer deblocking filters
 - JVET-J0016 KDDI, JVET-J0018 Mediatek , JVET-J0021 Qualcomm, JVET-J0024/25 Samsung, Huawei, GoPro, Hisilicon, JVET-J0028 Sony,
 - Also a contribution in JVET-J0056 Qualcomm but this is different concept more similar to ALF than pure deblocking
- Other proposals that also filter LIC boundaries
 - JVET-J0020 Panasonic
- Other proposals also claim parallel friendliness
- We propose that a core experiment is run until the next meeting with technology from above proposals
 - Proposed CE name: “Deblocking”
 - Properties to test: Subjective quality and BDR impact

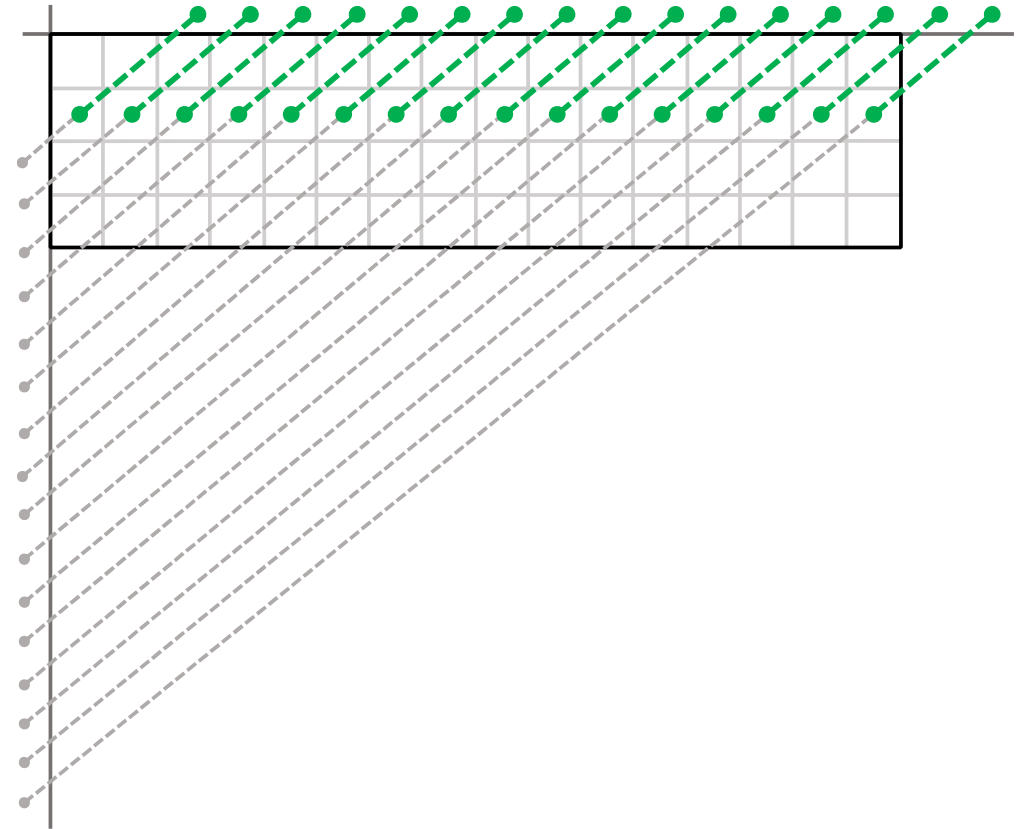
Wide-angle intra prediction

- In angular intra prediction the reference samples for non-square blocks can be far from the target samples...



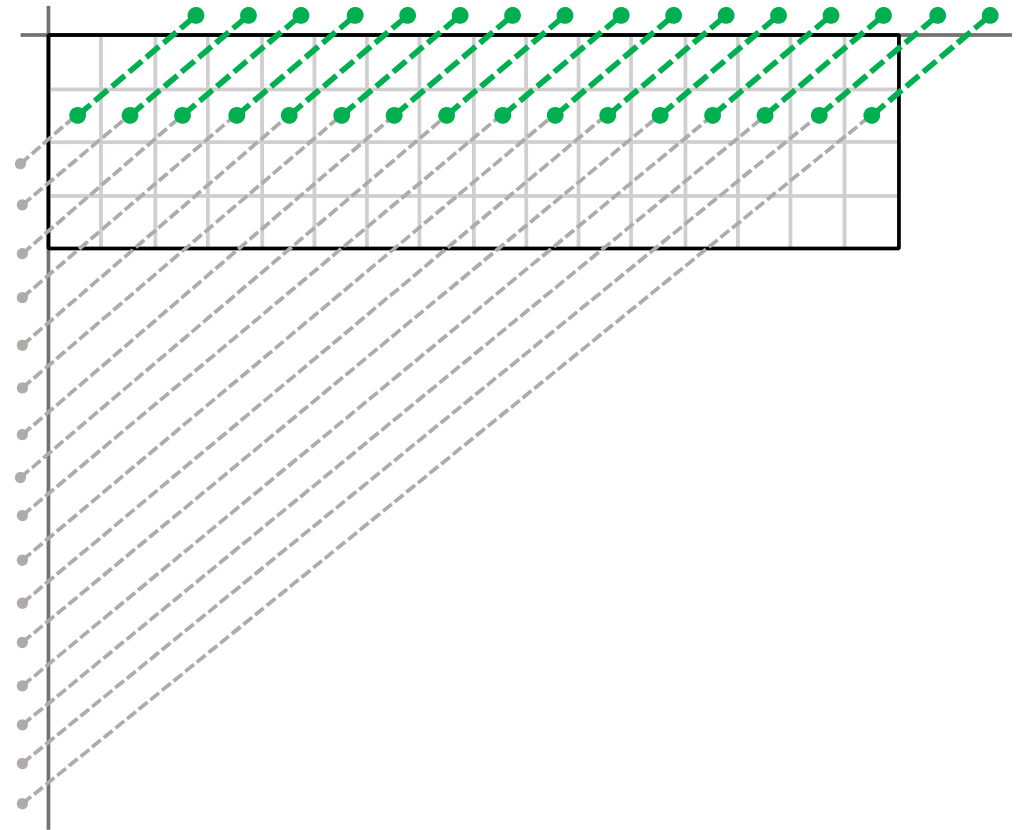
Wide-angle intra prediction

- In angular intra prediction the reference samples for non-square blocks can be far from the target samples...
- However, similar directional structure can be generated using closer samples on “side reference” with angle $> 45^\circ$



Wide-angle intra prediction

- If prediction is from the “narrow side” of non-square block and close to 45 degrees, signal if using
 - Indicated prediction direction
 - Wide-angle prediction from side reference with inverse angle
- Applied to 10 directions closest to 45 degrees in the case of JEM 7.0
- No extra full RDO checks in the encoder (new directions evaluated during the fast initial search)



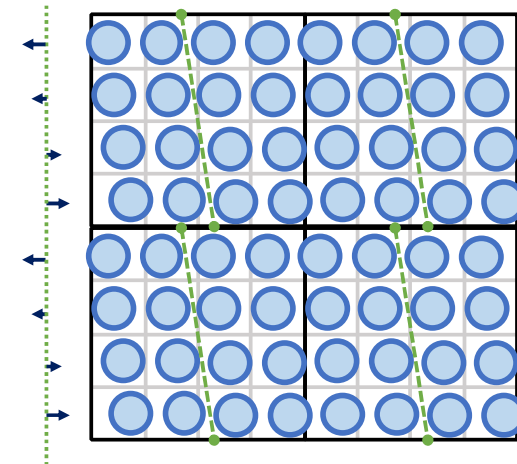
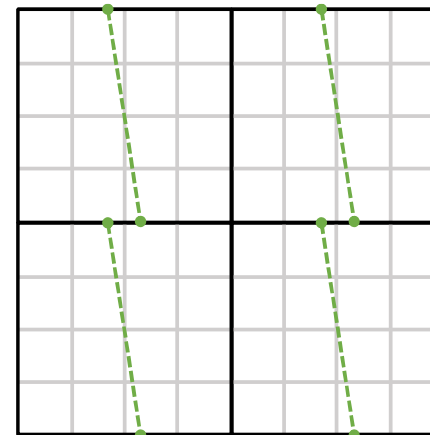
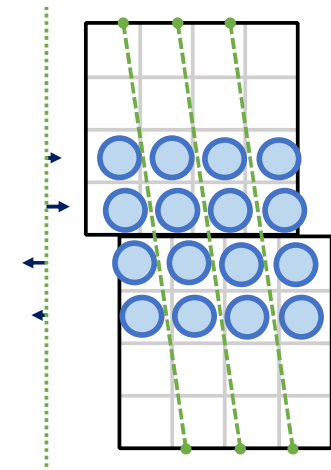
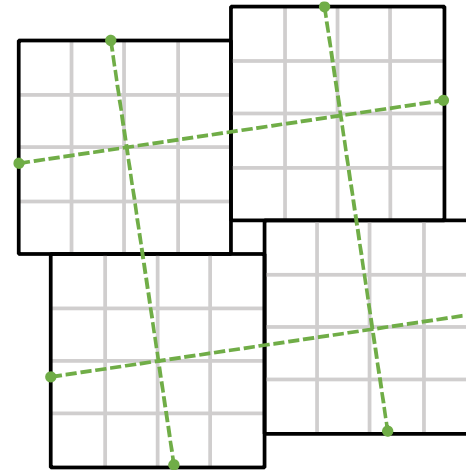
Wide-angle intra prediction

- Using All Intra configuration of CTC the luma gain is -0.25%
- Small runtime impact
- Potential further improvements
 - Interpolation filter strength
 - Bi-prediction
 - Transform selection
 - Implicit signaling

CTC results (AI)					
	BD-rate			Runtime	
	Y	Cb	Cr	Enc	Dec
WIDEANG	-0.25%	-0.20%	-0.50%	104%	101%

Affine flexing

- Recreates the sample based nature of affine motion with block/line based operations
- Resamples the predicted affine block compensating the motion difference on horizontal and vertical sub-PU boundaries
 - Lateral for rotating
 - Perpendicular for zooming
- Switches OBMC off for affine blocks
 - Memory bandwidth of “normal” motion compensation



Affine flexing

- Results on affine sequences indicate that affine flexing is
 - More effective than OBMC
 - Significantly lower complexity
- Implementation detail:
 - Applied to luma only
 - Padding samples outside the block
 - KTA 64 position interpolation
 - Only applied in the final motion compensation in the encoder

Affine sequences (*)					
	BD-rate			Runtime	
JEM 7.0	Y	Cb	Cr	Enc	Dec
OBMC off	-1.49%	-0.99%	-0.72%	102%	102%
OBMC on	-0.07%	-0.01%	0.10%	99%	86%

(*) CatRobot, Cactus, Jets, SpinCalendar, TractorZoom, Station2, ShieldsZoom, BlueSky

Objective results – SDR vs HM

Constraint Set 1						
Over HM16.16						
	BD- rate(Y)	BD- rate(U)	BD- rate(V)	BD- PSNR(Y)	BD- PSNR(U)	BD- PSNR(V)
FoodMarket4	-33.92%	-44.27%	-47.54%	1.69	1.29	1.50
CatRobot1	-39.72%	-52.57%	-46.02%	1.56	0.96	1.30
DaylightRoad2	-40.80%	-57.53%	-41.70%	1.14	1.24	0.77
ParkRunning3	-31.87%	-26.36%	-28.75%	1.02	0.45	0.41
Campfire	-34.74%	-34.70%	-49.92%	1.02	1.29	1.53
BQTerrace	-31.05%	-45.71%	-55.15%	0.93	0.83	1.04
RitualDance	-28.08%	-37.99%	-41.74%	1.50	1.09	1.37
MarketPlace	-29.58%	-47.91%	-44.49%	1.04	0.84	0.81
BasketballDrive	-31.92%	-46.36%	-44.03%	1.15	1.03	1.33
Cactus	-35.63%	-45.76%	-41.68%	1.47	0.73	1.08
Average SDR-A	-36.21%	-43.09%	-42.79%	1.29	1.04	1.10
Average SDR-B	-31.25%	-44.75%	-45.42%	1.22	0.91	1.13
Average all	-33.73%	-43.92%	-44.10%	1.25	0.98	1.12
Enc Time[%]	777%					
Dec Time[%]	777%					

Objective results – SDR vs HM

	Constraint Set 2					
	Over HM16.16					
	BD- rate(Y)	BD- rate(U)	BD- rate(V)	BD- PSNR(Y)	BD- PSNR(U)	BD- PSNR(V)
BQTerrace	-26.47%	-46.77%	-53.21%	0.79	0.55	0.64
RitualDance	-21.98%	-35.31%	-36.47%	1.12	0.85	1.01
MarketPlace	-20.76%	-43.02%	-41.04%	0.66	0.56	0.59
BasketballDrive	-25.56%	-46.15%	-44.39%	0.96	0.99	1.31
Cactus	-28.51%	-42.98%	-40.56%	1.14	0.62	0.91
Average SDR-B	-24.66%	-42.85%	-43.13%	0.93	0.72	0.89
Enc Time[%]	828%					
Dec Time[%]	582%					

Objective results – SDR vs JEM

Constraint Set 1						
Over JEM 7.0						
	BD- rate(Y)	BD- rate(U)	BD- rate(V)	BD- PSNR(Y)	BD- PSNR(U)	BD- PSNR(V)
FoodMarket4	-0.94%	-1.16%	-1.41%	0.04	0.02	0.03
CatRobot1	-0.76%	-0.98%	-0.77%	0.02	0.01	0.01
DaylightRoad2	-0.86%	-0.95%	-0.97%	0.02	0.01	0.01
ParkRunning3	-1.11%	-1.65%	-1.90%	0.03	0.02	0.02
Campfire	-0.59%	-0.16%	-0.74%	0.01	0.01	0.01
BQTerrace	-1.02%	-1.03%	-1.47%	0.02	0.01	0.02
RitualDance	-1.05%	-1.68%	-2.01%	0.05	0.03	0.05
MarketPlace	-0.56%	-1.15%	-0.14%	0.02	0.01	0.00
BasketballDrive	-1.10%	-1.71%	-1.17%	0.03	0.02	0.03
Cactus	-1.00%	-0.98%	-0.92%	0.03	0.01	0.02
Average SDR-A	-0.85%	-0.98%	-1.16%	0.02	0.01	0.02
Average SDR-B	-0.95%	-1.31%	-1.14%	0.03	0.02	0.02
Average all	-0.90%	-1.14%	-1.15%	0.03	0.02	0.02
Enc Time[%]	103%					
Dec Time[%]	98%					

Objective results – SDR vs JEM

Constraint Set 2						
Over JEM 7.0						
	BD- rate(Y)	BD- rate(U)	BD- rate(V)	BD- PSNR(Y)	BD- PSNR(U)	BD- PSNR(V)
BQTerrace	-0.27%	1.57%	-4.74%	0.01	-0.01	0.03
RitualDance	-0.36%	-1.51%	-1.51%	0.02	0.03	0.03
MarketPlace	-0.08%	-0.62%	-0.63%	0.00	0.01	0.01
BasketballDrive	0.14%	-0.70%	-0.92%	0.00	0.01	0.02
Cactus	-0.30%	-1.13%	-1.86%	0.01	0.01	0.03
Average SDR-B	-0.17%	-0.48%	-1.93%	0.01	0.01	0.02
Enc Time[%]	99%					
Dec Time[%]	95%					

Objective results – HDR vs HM

	BD-rate							
	DE100	PSNRL100	wPsnrY	wPsnrU	wPsnrV	psnrY	psnrU	psnrV
DayStreet	-58.2%	-36.7%	-35.4%	-55.6%	-68.3%	-34.5%	-54.1%	-66.4%
PeopleInShoppingC	-50.1%	-29.9%	-28.8%	-58.5%	-54.4%	-28.6%	-56.2%	-53.9%
SunsetBeach	-55.4%	-26.7%	-21.5%	-81.2%	-79.0%	-22.4%	-76.4%	-79.6%
Market	-40.2%	-24.7%	-25.3%	-46.7%	-44.9%	-23.7%	-39.6%	-36.2%
ShowGirl2	-29.5%	-26.9%	-28.2%	-62.4%	-33.7%	-26.4%	-59.6%	-29.7%
Hurdles	-49.4%	-35.0%	-34.1%	-59.9%	-55.6%	-31.4%	-54.8%	-51.2%
Starting	-34.4%	-30.8%	-30.3%	-34.2%	-37.7%	-28.7%	-31.9%	-23.7%
Cosmos1	-31.8%	-25.1%	-25.2%	-67.4%	-79.6%	-23.8%	-66.8%	-79.6%
Average HDR-A	-54.6%	-31.1%	-28.6%	-65.1%	-67.3%	-28.5%	-62.2%	-66.7%
Average HDR-B	-37.1%	-28.5%	-28.6%	-54.1%	-50.3%	-26.8%	-50.5%	-44.1%
Average all	-43.6%	-29.5%	-28.6%	-58.2%	-56.6%	-27.4%	-54.9%	-52.5%
Enc Time[%]	610%							
Dec Time[%]	827%							

Objective results – HDR vs JEM

	BD-rate							
	DE100	PSNRL100	wPsnrY	wPsnrU	wPsnrV	psnrY	psnrU	psnrV
DayStreet	-0.5%	-0.5%	-0.4%	-0.5%	-1.0%	-0.6%	-0.5%	-0.8%
PeopleInShoppingC	-0.7%	-0.6%	-0.6%	-0.7%	-0.7%	-0.6%	-0.8%	-0.7%
SunsetBeach	-0.2%	-0.7%	-0.5%	0.2%	-0.3%	-0.5%	0.1%	-0.4%
Market	-0.9%	-0.4%	-0.3%	-1.1%	-1.9%	-0.3%	-1.0%	-1.3%
ShowGirl2	-2.7%	-0.7%	-1.0%	-4.3%	-5.6%	-1.0%	-5.3%	-5.9%
Hurdles	-0.1%	-0.5%	-0.8%	-0.8%	-0.7%	-0.9%	-0.5%	-0.5%
Starting	-0.5%	0.0%	0.0%	0.1%	-1.2%	0.0%	0.0%	-0.9%
Cosmos1	-1.9%	-1.3%	-1.4%	-2.8%	-4.2%	-1.4%	-2.5%	-3.2%
Average HDR-A	-0.5%	-0.6%	-0.5%	-0.3%	-0.7%	-0.5%	-0.4%	-0.7%
Average HDR-B	-1.2%	-0.6%	-0.7%	-1.8%	-2.7%	-0.7%	-1.9%	-2.3%
Average all	-0.9%	-0.6%	-0.6%	-1.2%	-2.0%	-0.7%	-1.3%	-1.7%
Enc Time[%]	103%							
Dec Time[%]	99%							

Conclusion

- Introduced new tools with favorable compression/coding efficiency trade-off
- Consider the tools for the first test model and include those in potential tool/core experiments