JCTVC-F247 CE3: DCT derived interpolation filter test by Samsung

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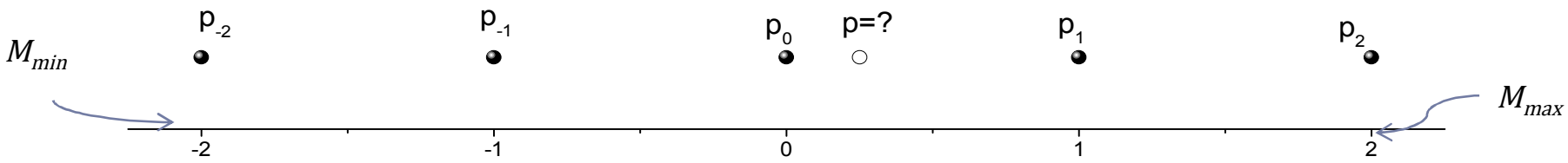
Filter coefficients generation



$$D_{lk} = \frac{2}{Size} cos\left(\frac{\pi k(l+(M_{min}+M_{max})/2+Size/2)}{Size}\right); M_{min} \leq l \leq M_{max}; 0 \leq k \leq Size-1$$

$$W_k = cos\left(\frac{\pi k(\propto+Size/2)}{Size}\right); 0 \leq k \leq Size-1$$

$$Filter_l(\propto) = cos\left(\pi\frac{l-\propto}{N-1}\right) * \sum_{k=0}^{Size-1} W_k D_{lk}$$

- Valid for both odd and even filter length
- Smoothing effect is controlled by window size N

DCTIF: 7(Q)+6(H)

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	0,0	-0,3	-0,2	-0,2	0,0	0,1
Class B	0,0	-0,1	0,0	0,0	0,1	0,0
Class C	0,1	0,1	0,1	0,2	0,1	0,1
Class D	0,1	0,1	0,1	0,5	0,2	0,3
Overall	**0,0**	**-0,1**	**0,0**	**0,1**	**0,1**	**0,1**
Mult[%]	87%			86%		
Adds[%]	84%			84%		
MemBand[%]	96%			96%		
	Low delay B HE			Low delay B LC		
Class B	0,0	0,1	0,1	-0,4	-0,3	-0,6
Class C	0,2	0,0	0,1	0,2	0,1	0,1
Class D	0,5	0,3	0,4	0,8	0,4	0,6
Class E	-0,2	-0,7	-0,4	-1,0	-0,8	-0,7
Overall	**0,2**	**0,0**	**0,1**	**-0,1**	**-0,1**	**-0,1**
Mult[%]	86%			85%		
Adds[%]	83%			83%		
MemBand[%]	96%			95%		
	Low delay P HE			Low delay P LC		
Class B	0,2	0,1	-0,1	-0,8	-0,2	0,1
Class C	0,6	0,5	0,3	0,2	0,3	0,3
Class D	1,2	1,1	0,6	1,0	0,8	0,6
Class E	0,0	0,1	-0,5	-1,8	-1,1	-1,0
Overall	**0,5**	**0,4**	**0,1**	**-0,3**	**0,0**	**0,1**
Mult[%]	85%			84%		
Adds[%]	83%			82%		
MemBand[%]	95%			95%		

Statistics	**Y**	**U**	**V**
Avg 6 cases:	**0.07**	**0.06**	**0.04**
Min	-3,52	-1,70	-2,12
Max	3,04	3,21	2,48
Mult	85%		
Adds	83%		
MemBand	95%		
WC Memory BW	**83%**		

7(Q)+6(H) filter (symmetric):
Q: {-2, 5, -11, 58, 18, -6, 2,}
H: {2, -9, 39, 39, -9, 2}

Conclusion:
- avg 16% computations reduction
- avg 5% memory BW reduction
- WC 17% memory BW reduction
- only 0.07% performance drop
- no need to change chroma filter

Complexity compare to AVC

	DCTIF 7(Q)+6(H)			AVC filter		
	Mults	Adds	Neighbor	Mults	Adds	Neighbor
½-pel	6	5	6	6	5	6
¼-pel	7	6	7	6	5+1	6

- Computational complexity of DCTIF 7(Q)+6(H) approaches to AVC filter
- Average number of neighbor pixels to access is ~5% higher (based on statistics)

Compare to 7(Q)+6(H) form Motorola

Statistics			
	Y	U	V
Avg 6 cases:	**0.07**	**0.06**	**0.04**
Min	-3,52	-1,70	-2,12
Max	3,04	3,21	2,48
Mult	85%		
Adds	83%		
MemBand	95%		
WC Memory BW	**83%**		

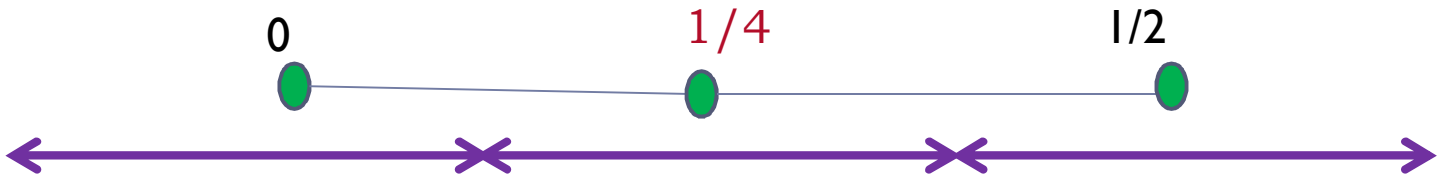
Statistics			
	Y	U	V
Avg 6 cases:	**0,05**	**0,77**	**0,87**
Min	-7,81	-4,91	-2,68
Max	8,45	11,54	12,23
Mult	93%		
Adds	91%		
MemBand	97%		
WC Memory BW	**83%**		

Asymmetry of "1/4-pel" leads to

- 8% more computations
- 2% memory BW increment
- only 0.02% performance improvement
- 0.8% chroma drop
- need to change chroma filter

¼ or α≠ ¼ ?

Hit ratio for α=3/16: "0" = 3/16,"1/4" = ¼, : "1/2" = 5/16,"3/4" = ¼,

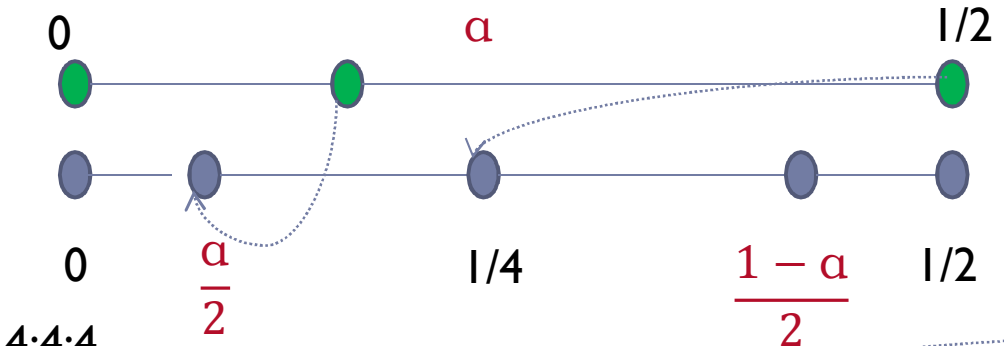


Hit ratio: "0" = ¼,"1/4" = ¼, : "1/2" = ¼,"3/4" = ¼,

Attraction area of integer pel positions in MC is much smaller if asymmetrica l filter with α < 1/4 is used → hit-ration of integer pel MC is lower
For α=3/16 reduction of integer pel positions number should be ~1/16 (6%)

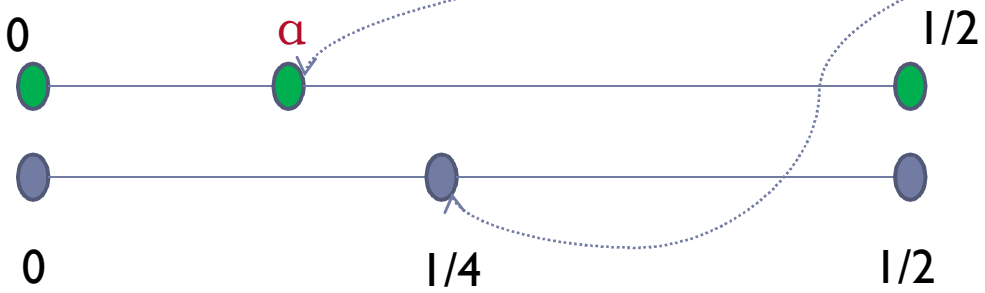
¼ or α≠ ¼ ?

4:2:0



phase shift synchronized for points with the same MV

4:4:4



the same MV but differ ent phase shift!

If α=1/4 Luma & Chroma IF are synchronized both in 4:2:0 and other sampling modes

Otherwise Chroma filter synchronized with Luma in 4:2:0 cannot be applied for other sampling modes.

From CE3 BoG test results summary

	7q8h F-599 Motorola	7q6h F-247 Samsung
Avg BD-rate Luma	**-0.48%**	**0.07%**
Avg BD-rate Chroma	0.12%	0.05%
Min	-5.9%	-3.5%
Max	2.0%	3.0%
Avg Mults	101%	85%
Avg Adds	99%	83%
Avg MemBand	100%	95%
WorstCase MemoryBand	100%	83%

Conclusion

- Modify the complexity measurement in CE3:
  - Mandatory report for the worst memory band-width and complexity case
  - Mandatory of average memory band-width and complexity
  - Actual number of operations according to hit-ratio of each filter
  - Chroma MC operations count should be included
- Based on test results:
  - only 0.07% average performance drop
  - 16% less average number of computations
  - 5% less average memory band-width
  - 17% reduction of memory band-width in the worst case

we propose to adopt proposed 7(Q) + 6 (H) solid (non-switch) Luma interpolation filter for next version of HM s/w and WD