

A STUDY OF PRIMARY TRANSFORMS (JVET-M0046)



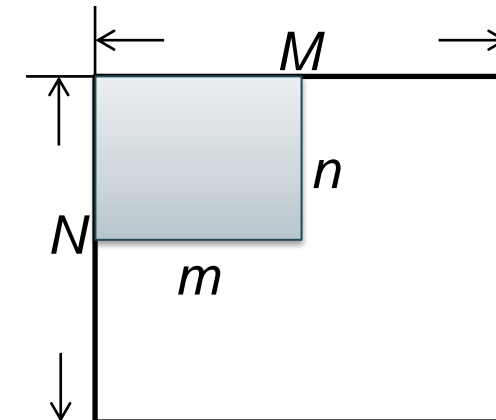
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Problem Statement

- A 32x32/32x16/16x32 DST7/DCT8 based TU significantly exceeds the computational complexity of a 64x64/64x32/32x64/32x32 DCT2 based TU
 - 32-/64-point DCT2: 40 muls/coef => 64 muls/cycle for 4K@60 video
 - 32-point DST7/DCT8: 64 muls/coef => 128 muls/cycle for 4K@60 video
- Potential solutions for cost reduction
 - Remove 32-point DST7/DCT8
 - Keep non-zero transform coefficients only in the top-left 16x16 region of a 32x32/32x16/16x32 DST7/DCT8 based TU

	M	N	m	n	number of multiplications per coefficient (direct matrix multiply)	number of multiplications per coefficient (half butterfly)
DCT2	TU size M*N, and keep the top-left m*n non-zero coefficients					
	64	64	32	32	48	30
	64	32	32	32	48	30
	32	64	32	32	64	40
	32	32	32	32	64	40
DST7/DCT8	TU size M*N, and keep the top-left m*n non-zero coefficients					
	32	32	32	32	64	
	32	16	32	16	48	
	16	32	16	32	48	
	32	32	16	16	24	
	32	16	16	16	24	
	16	32	16	16	32	



Experimental Results

- Tests carried out
 - Test 1: VTM3.0 plus enabling the MTS in both the intra- and inter-coded CUs (the 2nd anchor).
 - Test 2: disabling 32-point DST7/DCT8 and enabling the MTS in intra-coded CUs only.
 - Test 3: disabling 32-point DST7/DCT8 and enabling the MTS in both intra- and inter-coded CUs.
 - Test 4: keeping the non-zero transform coefficients only in top-left 16x16 region of a 32x32/32x16/16x32 DST7/DCT8 based TU, and enabling the MTS in intra-coded CUs only.
 - Test 5: keeping the non-zero transform coefficients only in top-left 16x16 region of a 32x32/32x16/16x32 DST7/DCT8 based TU, and enabling the MTS in both intra- and inter-coded CUs.
- Summary results

		All Intra Main10			Random Access Main 10			Low delay B Main10			Low delay P Main10		
Tested	Reference	Y	U	V	Y	U	V	Y	U	V	Y	U	V
2nd anchor	VTM3.0	0.00%	0.00%	0.00%	-0.37%	0.55%	0.56%	-0.54%	0.91%	1.10%	-0.59%	1.03%	1.16%
Test 2	VTM3.0	0.55%	0.62%	0.63%	0.32%	0.62%	0.68%	0.12%	0.49%	0.16%	0.09%	0.54%	0.23%
Test 3	2nd anchor	0.55%	0.62%	0.63%	0.45%	0.43%	0.44%	0.35%	0.15%	-0.10%	0.30%	0.23%	-0.21%
Test 4	VTM3.0	0.12%	0.05%	0.02%	0.04%	0.05%	0.08%	0.02%	0.08%	0.00%	-0.02%	0.33%	-0.21%
Test 5	2nd anchor	0.12%	0.05%	0.02%	0.05%	0.01%	0.10%	0.14%	0.10%	-0.05%	0.12%	0.05%	-0.22%

Spec Text Changes

Replace

The variables nonZeroW and nonZeroH are derived as follows:

$$\text{nonZeroW} = \text{Min}(\text{nTbW}, 32) \quad (8-564)$$

$$\text{nonZeroH} = \text{Min}(\text{nTbH}, 32) \quad (8-565)$$

with

The variable nonZeroW is derived as follows:

- If trTypeHor is equal to 0

$$\text{nonZeroW} = \text{Min}(\text{nTbW}, 32) \quad (8-564)$$

- Otherwise, if trTypeHor is equal to 1 or 2

$$\text{nonZeroW} = \text{Min}(\text{nTbW}, 16) \quad (8-565)$$

The variable nonZeroH is derived as follows:

- If trTypeVer is equal to 0,

$$\text{nonZeroH} = \text{Min}(\text{nTbH}, 32) \quad (8-566)$$

- Otherwise, if trTypeVer is equal to 1 or 2

$$\text{nonZeroH} = \text{Min}(\text{nTbH}, 16) \quad (8-567)$$

Recommendation

- To bring the implementation cost of 32-point DST7/DCT8 to a reasonable level, it is recommended to keep non-zero transform coefficients in the top-left 16x16 region only in the 32x32/32x16/16x32 DS7/DCT8 based transform units.

Thanks to InterDigital for cross-check