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On secondary transforms for intra prediction residual JCTVC-F554

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Overview

- ❑ Mode-Dependent DCT/DST for 4x4 Luma blocks JCTVC-E125 by Saxena & Fernandes adopted in Geneva meeting
- ❑ Currently in HM 3.0 :At block sizes 4x4 : DCT or DST is used.
- ❑ For 8x8 blocks and higher : Only DCT.
- ❑ Similar concept to CE 7: JCTVC-F224 on mode-dependent secondary transforms by Panasonic

Alternate/Additional Transforms for Sizes 8x8 and higher

- Additional primary transforms at sizes 16x16 and 32x32 too costly
- Require secondary transforms of sizes 4x4 or 8x8
- Desired : Fast implementation preferable

8x8 Mode-Dependent Secondary Transform (MD-ST)

- Change in HM 3.0
- Apply mode-dependent DCT/8x8 MD-ST at sizes 8x8, 16x16 and 32x32

A =

122	-37	-8	-3	-2	-1	-1	0
34	118	-33	-10	-5	-3	-1	-1
-15	-27	-122	24	8	4	2	1
8	13	19	124	-16	-6	-3	-1
-5	-7	-9	-14	-126	11	4	2
3	4	5	6	10	127	-7	-2
2	2	3	3	4	6	128	-4
1	1	1	1	2	2	4	128

← Small numbers:

- ❑ Derived analytically using concepts in JCTVC-C108 (Saxena & Fernandes, Samsung) and JCTVC-D151 (Shibahara & Nishi, Panasonic)

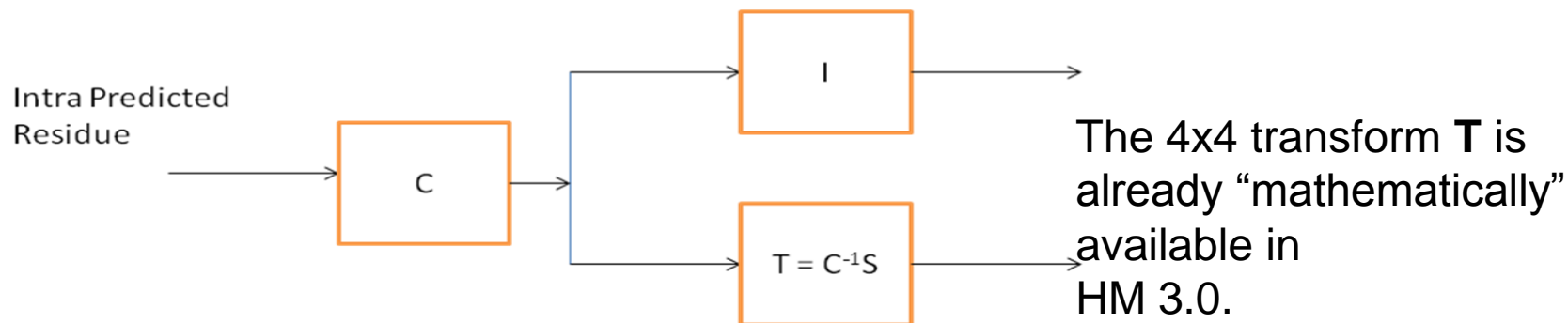
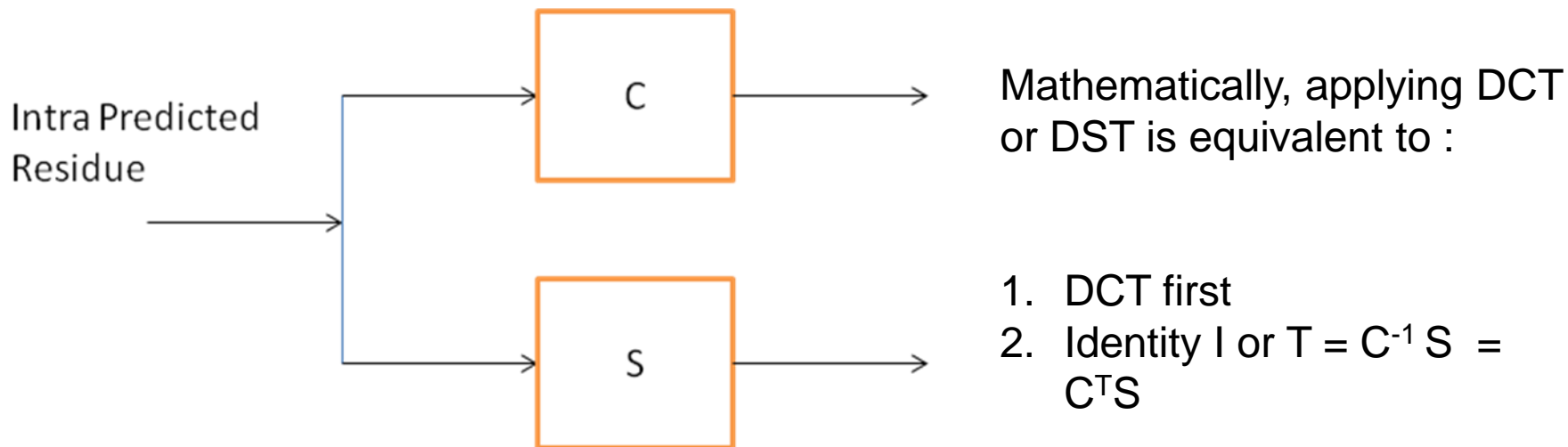
Results for 8x8 MD-ST

	Anchor	Proposed Scheme	Cross-Checker
1.	HM 3.0	8x8 MD-ST	Panasonic (JCTVC-F680)

	All Intra HE			All Intra LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.7	-0.5	-0.7	-0.5	-0.9	-1.2
Class B	-0.7	-0.8	-0.8	-0.4	-1.0	-1.0
Class C	-0.4	-0.6	-0.6	-0.4	-0.7	-0.7
Class D	-0.2	-0.4	-0.4	-0.3	-0.4	-0.4
Class E	-0.9	-1.2	-1.2	-0.7	-1.1	-1.3
All	-0.6	-0.7	-0.7	-0.5	-0.8	-0.9
Enc Time[%]	102%			103%		
Dec Time[%]	102%			103%		

	Random access HE			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.5	-0.2	-0.5	-0.3	-0.3	-0.6
Class B	-0.5	-0.5	-0.2	-0.3	-0.5	-0.6
Class C	-0.3	-0.1	-0.4	-0.3	-0.5	-0.5
Class D	-0.1	0.0	-0.3	-0.2	-0.3	-0.2
Class E						
All	-0.3	-0.2	-0.4	-0.3	-0.4	-0.5
Enc Time[%]	100%			100%		
Dec Time[%]	99%			100%		

Relationship between Primary Alternate Transform and Secondary Transform



I is Identity matrix. $T = C^{-1}S$ is a secondary transform

Low-Complexity 4x4 MD-ST

- ❑ Re-use $T = C^{-1} S = C^T S$ of size 4x4 to blocks 8x8 and higher.
- ❑ No new Transform Core
- ❑ Example at Size 32x32
 - ❑ Apply forward DCT of size 32x32
 - ❑ Apply Secondary transform $T = C^T S$ for top 4x4 part of 32x32 block.

Results for 4x4 MD-ST (**No new transform cores**)

	All Intra HE			All Intra LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.4	-0.2	-0.2	-0.3	-0.4	-0.5
Class B	-0.4	-0.3	-0.3	-0.2	-0.5	-0.5
Class C	-0.2	-0.4	-0.4	-0.3	-0.4	-0.4
Class D	-0.1	-0.3	-0.3	-0.1	-0.3	-0.3
Class E	-0.6	-0.8	-0.8	-0.5	-0.8	-0.9
All	-0.4	-0.4	-0.4	-0.3	-0.5	-0.5
Enc Time[%]	101%			101%		
Dec Time[%]	102%			102%		

	Random access HE			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.4	0.0	-0.6	-0.2	-0.3	-0.1
Class B	-0.3	-0.2	-0.1	-0.2	-0.2	-0.3
Class C	-0.2	-0.1	-0.4	-0.2	-0.3	-0.3
Class D	-0.2	-0.3	-0.4	-0.2	-0.4	-0.4
Class E						
All	-0.3	-0.2	-0.4	-0.2	-0.3	-0.3
Enc Time[%]	100%			100%		
Dec Time[%]	100%			101%		

Cross-Checkers : Panasonic : JCTVC-F680; Sony : JCTVC F 716

Fast 4x4 MD-ST

- ❑ DCT and DST in HM 3.0 have fast implementations.
- ❑ Even faster implementations for DST being proposed in F-283, F-153 with 5 or 4 multiplications instead of 8 mults in HM 3.0.
- ❑ By using “Faster” implementations for DST, the number of mults for the transform is **88 or 80** for a 4x4 block depending on F-283 or F-153 implementation (4x4 DCT: 48 mults; DST : 40 or 32 mults)
- ❑ **Full matrix mult requires 128 mults.**
- ❑ **No new transform cores**

Conclusions

- ❑ 8x8MD-ST gains 0.6/0.5/0.3/0.3 Intra HE/LC/RA-HE/RA-LC
- ❑ 4x4MD-ST gains 0.4/0.3/0.3/0.2 Intra HE/LC/RA-HE/RA-LC
- ❑ 4x4 MD-ST: No additional transform core
- ❑ 4x4 MD-ST has fast implementation as compared to matrix multiplication.
- ❑ **Recommend to adopt mode-dependent DCT/MD-ST in HM 3.0**

Complexity for 4x4 MD-ST and 8x8 MD-ST

Trans-form Size	Operation Counts					
		HM3 (DCT)	HM3 (DST)	Tool 1/2 in CE 7	Tool 3 (F224) MD – ST 4x4	F-554 MD-ST 8x8/4x4 (Fast)
New Transform Core		NA	NA	Yes	Yes	Yes No
4x4	Mults	48	64			
8x8	Adds	96	120			
	Shifts	32	32			
16x16	Mults	352		1024	+128	+528 +112 (96)
	Adds	576		1024	+256	1136 +344(336)
	Shifts	128		128	+32	432 +64
	Mults	3752			+128	+528 +112 (96)
32x32	Adds	3712			+256	1136 +280(272)
	Shifts	512			+32	432 +64
	Mults	21888			+128	+528 +112 (96)
	Adds	25856			+256	1136 +280(272)
	Shifts	2048			+32	432 +64

Results with SDIP: 8x8 MD-ST

Proposed 8x8 MD-ST gives additional gains with SDIP when applied on rectangular blocks as well.

Anchor : SDIP + DST4x4 Harmonized.

Proposed : SDIP + DST4x4 Harmonized + 8x8 MD-ST Harmonized

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	-0.8	-0.4	-0.6	-0.6	-0.9	-1.1
Class B	-0.9	-1.0	-0.8	-0.7	-1.0	-1.0
Class C	-0.5	-0.6	-0.6	-0.5	-0.6	-0.6
Class D	-0.3	-0.4	-0.4	-0.4	-0.5	-0.4
Class E	-1.2	-0.9	-0.9	-1.1	-0.8	-0.9
Overall	-0.7	-0.7	-0.7	-0.7	-0.7	-0.8
Enc Time[%]	101%			103%		
Dec Time[%]	103%			103%		

Results with SDIP: 4x4 MD-ST

Proposed 4x4 MD-ST gives additional gains with SDIP when applied on rectangular blocks as well.

Anchor : SDIP + DST4x4 Harmonized.

Proposed : SDIP + DST4x4 Harmonized + 4x4 MD-ST Harmonized

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	-0.4	-0.2	-0.2	-0.4	-0.4	-0.5
Class B	-0.6	-0.5	-0.4	-0.5	-0.5	-0.5
Class C	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4
Class D	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Class E	-0.9	-0.7	-0.7	-0.8	-0.5	-0.7
Overall	-0.5	-0.4	-0.4	-0.4	-0.4	-0.5
Enc Time[%]	101%			103%		
Dec Time[%]	101%			102%		