

JCTVC-C080

# TE7: One-Dimensional Directional Unified Transform

*Akiyuki Tanizawa*  
*Jun Yamaguchi*  
*Taichiro Shiodera*  
*Takeshi Chujoh*  
*Tomoo Yamakage*

Toshiba Corporation

# Summary

---

- **TE7: MDDT simplification**

- 1DDUT (1 Dimensional Directional Unified Transform)
  - Only two 1D transform matrices
  - 88% reduction of 1D transform matrices against to MDDT

- **Experimental results**

- BD-rate gain compared with TE12 anchor (MDDT on)
  - I slice only : 0.07% (HE)
  - Random access : 0.03% (HE)
- Encoding time and decoding time
  - Almost same as the anchor

# One-Dimensional Directional Unified Transform (1DDUT)

- **4/8-point 1 Dimensional Directional Unified Transform**

- Two 1D transform matrices (Type A and B)
  - Type A: DCT
  - Type B: Pre-determined directional transform matrix based on KLT
- Selecting four combinations of 1D transform matrices (AA, AB, BA, BB) each prediction mode
- Applied for block sizes of 4x4 and 8x8 (same as MDDT)

Transform Index	1 <sup>st</sup> 1D Transform	2 <sup>nd</sup> 1D Transform
0	B	A
1	A	B
2	A	A
3	B	B

- **Adaptive Coefficient Scan (ACS)**

- Adaptive 2D-1D coefficient scan for each prediction mode (same as MDDT)

# Training of transform matrix based on KLT

---

The training steps as follows;

- 1) The prediction error are collected by encoding test sequences using DCT for prediction mode 0
- 2) Design a vertical transform matrix using SVD (Singular Value Decomposition)

Test sequences	Resolution
Tennis, ChristmasTree	1920x1080
Flowervase, keiba, Mobisode2	832x480
Flowervase, keiba, Mobisode2	416x240

# Proposed transform matrix

- Type A and B for 4x4 block

$$A_{N=4} = \begin{bmatrix} 64 & 64 & 64 & 64 \\ 84 & 35 & -35 & -84 \\ 65 & -64 & -64 & 64 \\ 35 & -84 & 84 & -35 \end{bmatrix}, \quad B_{N=4} = \begin{bmatrix} 40 & 60 & 73 & 76 \\ 75 & 64 & -10 & -81 \\ -79 & 32 & 77 & -57 \\ 54 & -87 & 71 & -27 \end{bmatrix}$$

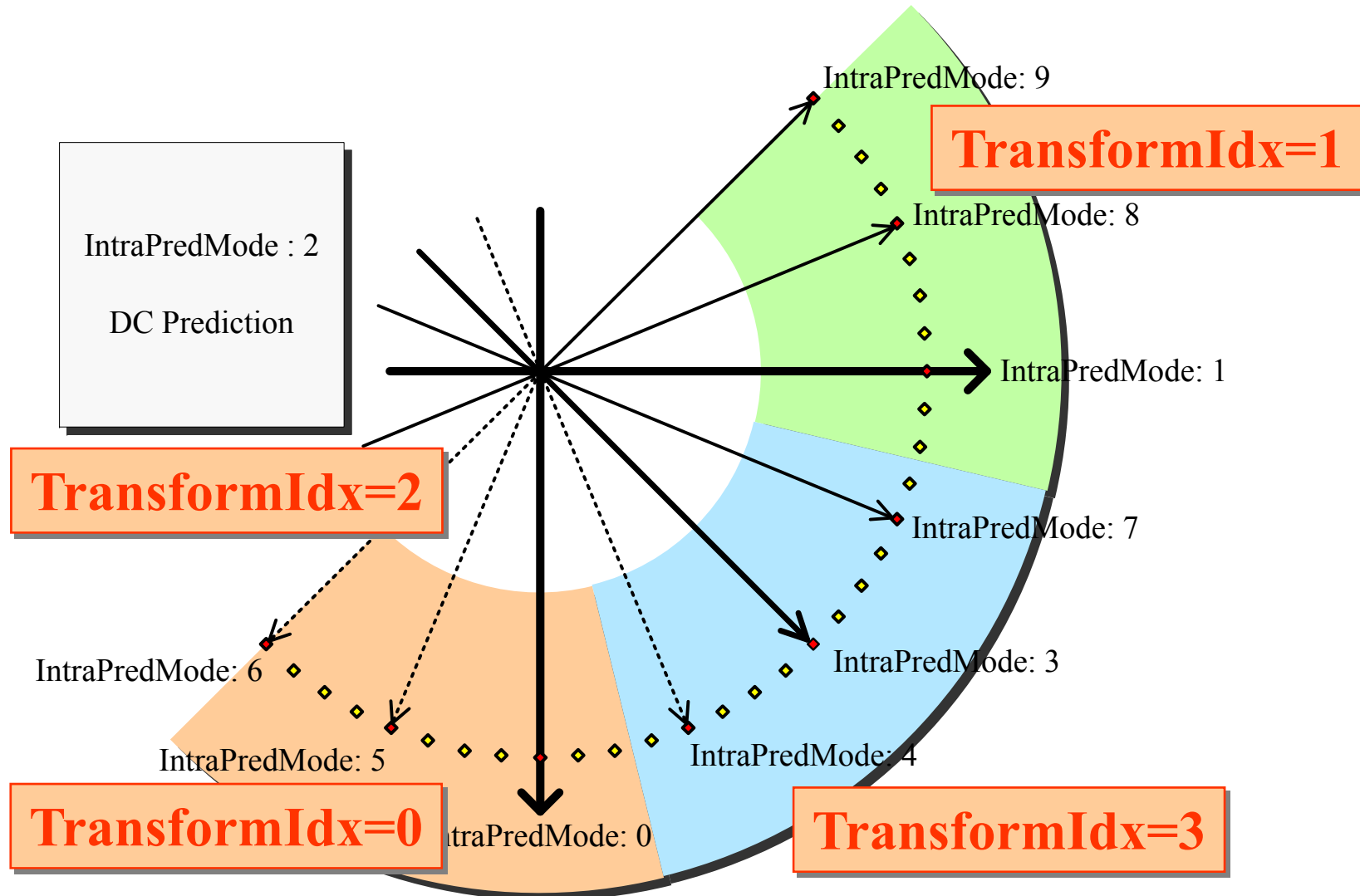
- Type A and B for 8x8 block

$$A_{N=8} = \begin{bmatrix} 45 & 45 & 45 & 45 & 45 & 45 & 45 & 45 \\ 63 & 53 & 36 & 12 & -12 & -36 & -53 & -63 \\ 59 & 24 & -24 & -59 & -59 & -24 & 24 & 59 \\ 53 & -12 & -63 & -36 & 36 & 63 & 12 & -53 \\ 45 & -45 & -45 & 45 & 45 & -45 & -45 & 45 \\ 36 & -63 & 12 & 53 & -53 & -12 & 63 & -36 \\ 24 & -59 & 59 & -24 & -24 & 59 & -59 & 24 \\ 12 & -36 & 53 & -63 & 63 & -53 & 36 & -12 \end{bmatrix}, \quad B_{N=8} = \begin{bmatrix} 17 & 27 & 35 & 44 & 51 & 55 & 57 & 57 \\ 38 & 56 & 60 & 45 & 16 & -20 & -46 & -58 \\ -49 & -55 & -19 & 38 & 66 & 38 & -18 & -55 \\ 59 & 28 & -40 & -56 & 12 & 63 & 20 & -54 \\ 61 & -9 & -63 & 17 & 54 & -35 & -47 & 44 \\ 53 & -50 & -15 & 61 & -39 & -24 & 62 & -34 \\ 42 & -63 & 45 & -4 & -35 & 59 & -57 & 24 \\ 23 & -46 & 58 & -62 & 57 & -47 & 30 & -10 \end{bmatrix}$$

The transform matrices of type A are identical to DCT's ones.

# Integration of UIP and 1DDUT

- UIP has 33 directional predictions and DC prediction.



# IntraPredMode and TransformIdx

IntraPredMode [ puParIdx ]	IntraPredType [ puParIdx ]	IntraPredAngleID [ puParIdx ]	TransformIdx [ puParIdx ]
0	Intra_Vertical	0	0
1	Intra_Horizontal	0	1
2	Intra_DC	-	2
3	Intra_Vertical	-8	3
4	Intra_Vertical	-4	3
5	Intra_Vertical	4	0
6	Intra_Vertical	8	0
7	Intra_Horizontal	-4	3
8	Intra_Horizontal	4	1
9	Intra_Horizontal	8	1
10	Intra_Vertical	-6	3
11	Intra_Vertical	-2	0
12	Intra_Vertical	2	0
13	Intra_Vertical	6	0
14	Intra_Horizontal	-6	3
15	Intra_Horizontal	-2	1
16	Intra_Horizontal	2	1

IntraPredMode [ puParIdx ]	IntraPredType [ puParIdx ]	IntraPredAngleID [ puParIdx ]	TransformIdx [ puParIdx ]
17	Intra_Horizontal	6	1
18	Intra_Vertical	-7	3
19	Intra_Vertical	-5	3
20	Intra_Vertical	-3	3
21	Intra_Vertical	-1	0
22	Intra_Vertical	1	0
23	Intra_Vertical	3	0
24	Intra_Vertical	5	0
25	Intra_Vertical	7	0
26	Intra_Horizontal	-7	3
27	Intra_Horizontal	-5	3
28	Intra_Horizontal	-3	3
29	Intra_Horizontal	-1	1
30	Intra_Horizontal	1	1
31	Intra_Horizontal	3	1
32	Intra_Horizontal	5	1
33	Intra_Horizontal	7	1

Transform Index is mapped to IntraPredMode Table for UIP.

# Experimental Conditions

---

- TMuC software version 0.7.1  
(Default configuration can get the same results as TMuC version 0.7)
- Proposed 1DDUT:
  - MDDT is replaced to 1DDUT.
  - 1DDUT is applied for only 4x4/8x8.
- Test conditions are followed on TE12 common conditions completely (JCTVC-B300).
- Coding structures are based on TE7 condition:
  - I slice only coding structure, High efficiency
  - Random access coding structure, High efficiency

# Experimental results

\*Negative value means gain

	Intra slice only			Random Access		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.01	-0.02	-0.06	0.02	-0.04	0.00
Class B	-0.01	-0.06	-0.07	-0.03	-0.12	0.00
Class C	-0.14	-0.10	-0.07	-0.04	-0.08	0.00
Class D	-0.08	-0.04	-0.09	-0.03	-0.01	0.00
Class E	-0.10	0.04	0.09	N/A	N/A	N/A
All	-0.07	-0.04	-0.05	-0.03	-0.07	0.00
<b>Enc Time[%]</b>	<b>99%</b>			<b>100%</b>		
<b>Dec Time[%]</b>	<b>100%</b>			<b>100%</b>		

- The BD-rate of 1DDUT is slightly better than the anchor.
- The encoding time and the decoding time is almost same as the anchor.

# Conclusion

---

- **Experimental results of 1DDUT for TE7**
  - BD-rate gain of 1DDUT compared with common anchor
    - I slice only : 0.07% (HE)
    - Random access : 0.03% (HE)
  - Encoding time and decoding time
    - Almost same as the anchor
  - 1DDUT can reduce 88% of transform matrices against to MDDT

---

**TOSHIBA**  
**Leading Innovation >>>**