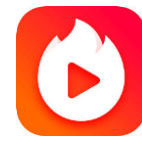


# JVET-P0379

## NON-CE6: A UNIFIED ZERO-OUT RANGE FOR 4X4 LFNST

Kui Fan, Li Zhang, Kai Zhang, Yue Wang



# Proposed

## ■ Zero-out ranges in the current LFNST design

Size	LFNST Size	Zero-out range
4×4	4×4	8
4×M/M×4 (M>4)	4×4	16
8×8	8×8	8
M×N (M>8, N>8)	8×8	16

## ■ Zero-out ranges in the proposed method

Size	LFNST Size	Zero-out range
4×4	4×4	8
4×M/M×4 (M>4)	4×4	8
8×8	8×8	8
M×N (M>8, N>8)	8×8	16

# Experimental results

## ■ Proposed method vs. VTM-6.0

	All Intra Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	-0.01%	0.12%	0.02%	101%	98%
Class A2	-0.01%	0.14%	0.13%	100%	99%
Class B	0.03%	0.10%	0.03%	101%	100%
Class C	0.04%	0.03%	0.15%	99%	101%
Class E	0.07%	0.13%	0.09%	100%	107%
<b>Overall</b>	0.03%	0.10%	0.08%	100%	101%
Class D	0.00%	0.24%	0.08%	98%	102%
Class F	0.04%	0.09%	0.09%	99%	100%

	Random access Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	0.01%	0.06%	0.06%	101%	100%
Class A2	0.03%	0.06%	0.07%	101%	99%
Class B	-0.01%	0.15%	0.00%	101%	102%
Class C	0.01%	0.13%	0.15%	100%	101%
Class E					
<b>Overall</b>	0.01%	0.11%	0.07%	101%	101%
Class D	-0.03%	0.00%	0.15%	100%	105%
Class F	-0.02%	-0.01%	-0.01%	99%	99%

CTC results

	All Intra Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	0.00%	0.11%	0.10%	98%	100%
Class A2	0.01%	-0.01%	0.00%	97%	100%
Class B	0.02%	0.01%	0.02%	97%	100%
Class C	0.01%	-0.02%	0.05%	97%	104%
Class E	0.10%	0.07%	0.06%	97%	100%
<b>Overall</b>	0.03%	0.03%	0.04%	97%	101%
Class D	0.01%	-0.01%	0.02%	97%	104%
Class F	0.01%	0.00%	0.02%	98%	102%

Low QP results

# Experimental results

- Proposed method with retrained 4×4 LFNST matrices in JVET-P0566 vs. VTM-6.0

	All Intra Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	-0.02%	0.05%	0.07%	101%	99%
Class A2	-0.03%	0.13%	0.16%	100%	101%
Class B	0.00%	0.15%	0.08%	99%	100%
Class C	-0.01%	-0.04%	0.11%	99%	102%
Class E	0.01%	0.04%	-0.05%	100%	102%
<b>Overall</b>	-0.01%	0.07%	0.08%	100%	101%
Class D	-0.03%	0.13%	-0.12%	98%	97%
Class F	0.00%	0.05%	0.07%	100%	106%

	Random access Main10				
	Over VTM-6.0				
	Y	U	V	EncT	DecT
Class A1	0.00%	0.04%	0.01%	100%	100%
Class A2	-0.01%	0.19%	0.11%	100%	100%
Class B	0.00%	0.15%	-0.06%	100%	101%
Class C	-0.02%	0.12%	-0.10%	100%	97%
Class E					
<b>Overall</b>	-0.01%	0.12%	-0.02%	100%	100%
Class D	-0.04%	-0.34%	-0.04%	100%	99%
Class F	-0.04%	0.08%	0.11%	101%	100%

CTC results

# Benefits of the proposed method

## ■ Multiplication number per sample

- The worst cases for  $4 \times N$  and  $N \times 4$  ( $N > 4$ ) is reduced by **50%**.

Block size	Current LFNST	Proposed
$4 \times 4$	$8 \times 16 / 16 = 8$	$8 \times 16 / 16 = 8$
$4 \times 8$ / $8 \times 4$	$16 \times 16 / 32 = 8$	$8 \times 16 / 32 = \mathbf{4}$
$4 \times N$ / $N \times 4$ ( $N > 8$ )	$16 \times 16 / (4 \times N) = 64 / N$	$8 \times 16 / (4 \times N) = \mathbf{32 / N}$
$8 \times 8$	$8 \times 48 / 64 = 6$	...
$8 \times N$ ( $N > 8$ )	$16 \times 48 / (8 \times N) = 96 / N$	...

- The required multiplication operations for LFNST for  $4 \times N$  and  $N \times 4$  ( $N > 4$ ) blocks is reduced by **50%**.

## ■ Memory cost of $4 \times 4$ LFNST

- The memory cost of  $4 \times 4$  LFNST matrices is reduced by **50%**.

	Transform matrix size	Number of matrices	Memory cost (Byte)
Current LFNST	$16 \times 16$	8	2048
Proposed	$8 \times 16$	8	<b>1024</b>

# Conclusions

- Benefits of the proposed method
  - *The worst case of multiplication number for LFNST 4x4 is alleviated.*
  - *The required multiplication operations for  $4 \times N$  and  $N \times 4$  ( $N > 4$ ) blocks is reduced by 50%.*
  - *The memory cost of  $4 \times 4$  LFNST matrices is reduced by 50%.*
- BD-rate changes are negligible
  - AI: 0.03%/0.10%/0.08%
  - RA: 0.01%/0.11%/0.07%
  - AI (Low QP): 0.03%/0.03%/0.04%
- Recommendation: to adopt this method in the next VVC WD and VTM software.
- Thanks Panasonic for cross-checking our proposal [JVET-P0696](#)