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shaping tomorrow with you

JVET-K0145
Non-CE1:On Transform Unit Partition-Uniform Transform Unit Structure

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Introduction

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- In VTM1, a quadtree with nested multi-type tree using binary and ternary splits coding block structure is introduced.
  - Flexible CU shapes (width and height).
  - In most cases, prediction and transform at CU level.
  - When W/H of CU is larger than max TU size, TU partitioning occurs.
- In HEVC, CU can be split into TUs in Quad-tree structure. And it has been proved that TU partitioning has gain.
- It seems that HEVC-like TU partitioning can not be applied directly to VTM1 due to non-square CU.

- This contribution proposes a simple TU partition scheme.

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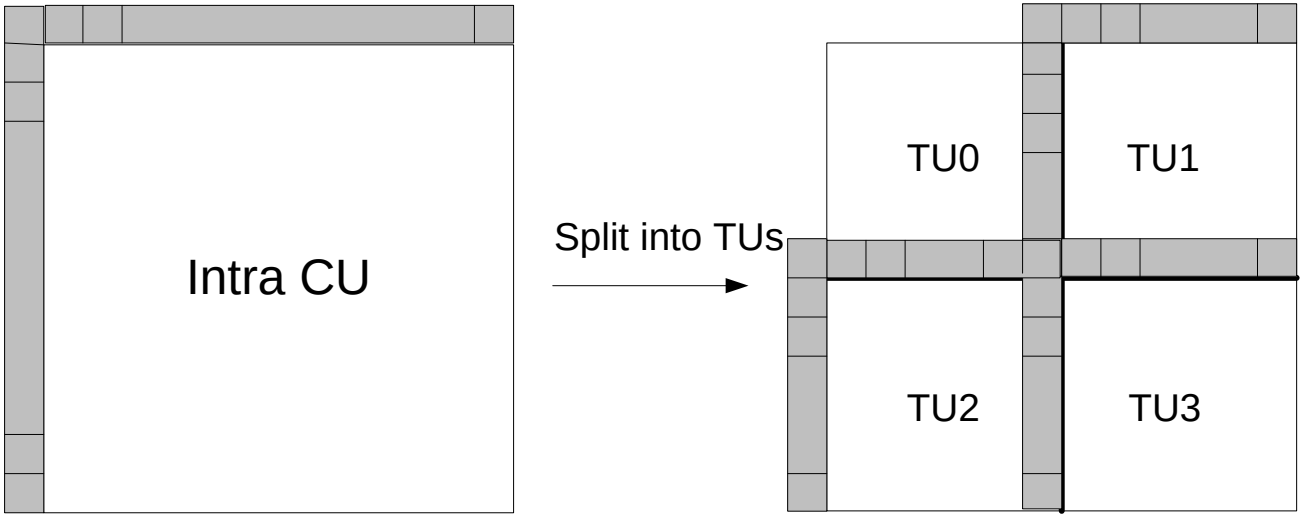
Motivation

- In HEVC and VTM1, Intra prediction is performed on TU basis. If a CU is split into TUs, more accurate intra prediction can be obtained.



The area of TU1, TU2 and TU3 has more accurate prediction

- Try to see the performance provided by Luma and Chroma using different block structure.
  - To use same CU partition and different TU partition is a way to make Luma and Chroma have different block structure.

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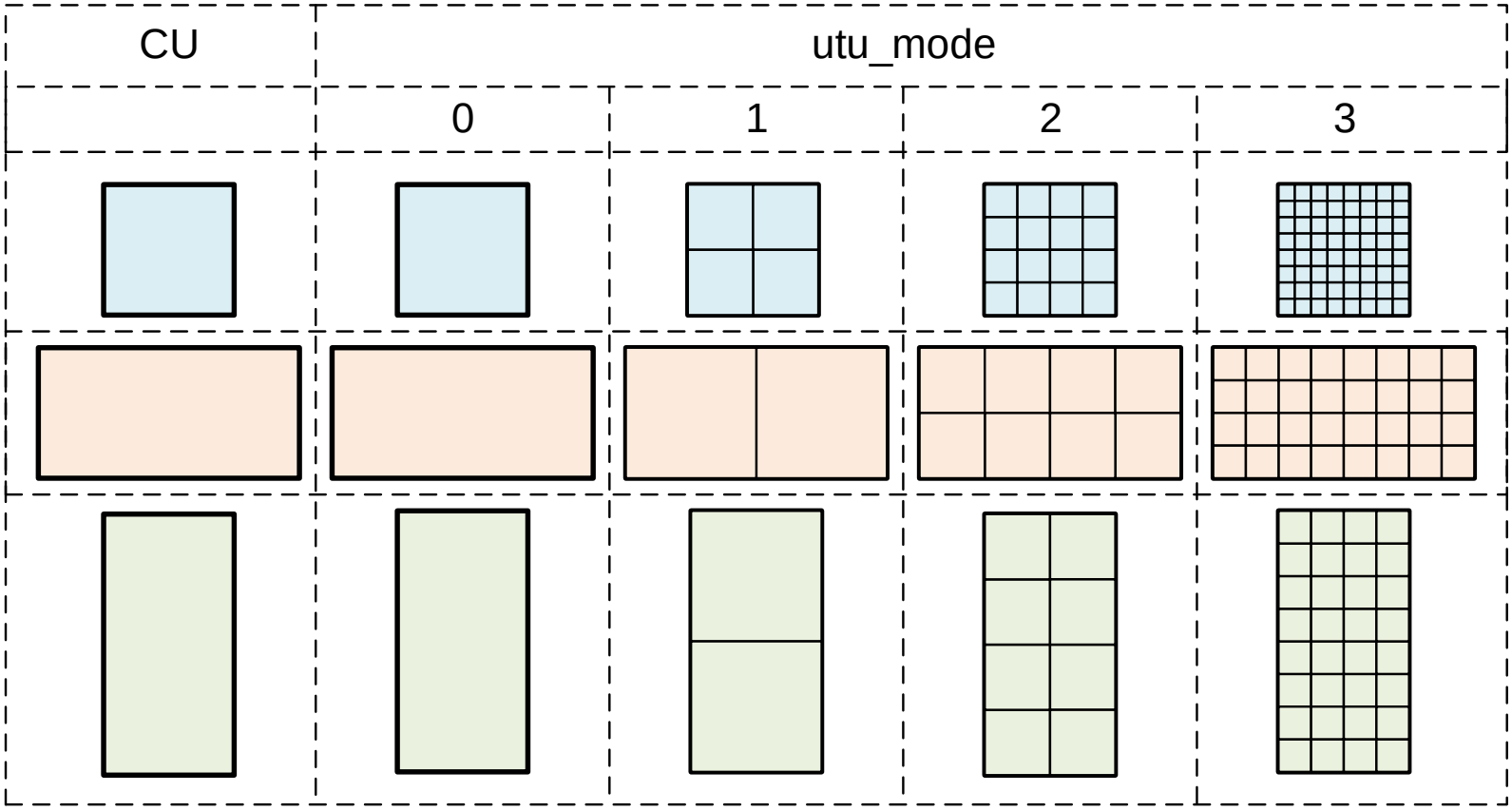
Proposal

- CU can be partitioned into TUs uniformly.
  - Each TU has same size and in square shape.
  - A syntax element **utu_mode** indicates the level of partitioning
  - Only for intra CU of I-slice.



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Handling of utu_mode

- Entropy coding
  - All bins are coded in bypass mode.
- CU size dependency
  - Maximum value is set so that TU size is always equal to or larger than 4x4 (Luma) or 2x2 (Chroma)

CU size	Bin string of utu_mode			
	0	1	2	3
4x4	N/A	N/A	N/A	N/A
64x4, 4x64, 4x32, 32x4,16x4, 4x16, 8x8, 8x4, 4x8	0	1	N/A	N/A
64x8, 8x64, 32x8, 8x32, 16x16, 16x8, 8x16	0	10	11	N/A
Other	0	10	110	111

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Summary of tests

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			Test 1	Test 2.1	Test 2.2	Test 2.3
Conditions	Luma and chroma		√			
	Luma only			√	√	√
	utu_mode = [0, 3]		√	√		
	utu_mode = [0, 2]				√	
	utu_mode = [0, 1]					√
Results (AI)	BD-Rate saving	Y	0.51%	0.65%	0.65%	0.58%
		U	0.04%	1.26%	1.26%	1.06%
		V	0.05%	1.50%	1.49%	1.27%
	Encoding time		221%	210%	190%	156%
	Decoding time		104%	113%	111%	110%

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Result of Test 1

- Luma and chroma share a UTU structure
- Range of utu_mode is [0, 3].

	Over VTM-1.0, AI				
	Y	U	V	EncT	DecT
Class A1	-0.35%	0.84%	0.75%	222%	104%
Class A2	-0.40%	0.55%	0.27%	223%	104%
Class B	-0.44%	-0.19%	-0.11%	228%	104%
Class C	-0.73%	-0.55%	-0.44%	222%	106%
Class E	-0.61%	-0.58%	-0.56%	207%	102%
Overall	-0.51%	-0.04%	-0.05%	221%	104%
Class D	-0.54%	-0.41%	-0.49%	184%	107%

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Result of Test 2.1

- Luma only
- Range of utu_mode is [0, 3].

	Over VTM-1.0, AI				
	Y	U	V	EncT	DecT
Class A1	-0.50%	-0.14%	-0.12%	212%	112%
Class A2	-0.53%	-0.93%	-0.60%	212%	113%
Class B	-0.60%	-1.22%	-1.97%	217%	112%
Class C	-0.91%	-1.68%	-2.02%	201%	115%
Class E	-0.67%	-2.21%	-2.33%	210%	111%
Overall	-0.65%	-1.26%	-1.50%	210%	113%
Class D	-0.69%	-1.58%	-1.75%	194%	114%

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Result of Test 2.2

- Luma only
- Range of utu_mode is [0, 2].

	Over VTM-1.0, AI				
	Y	U	V	EncT	DecT
Class A1	-0.48%	-0.18%	-0.08%	199%	110%
Class A2	-0.52%	-0.95%	-0.58%	199%	111%
Class B	-0.60%	-1.28%	-1.97%	200%	111%
Class C	-0.91%	-1.58%	-1.98%	174%	114%
Class E	-0.69%	-2.19%	-2.33%	176%	108%
Overall	-0.65%	-1.26%	-1.49%	190%	111%
Class D	-0.69%	-1.59%	-1.75%	145%	113%

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Result of Test 2.3

- Luma only
- Range of utu_mode is [0, 1].

	Over VTM-1.0, AI				
	Y	U	V	EncT	DecT
Class A1	-0.41%	-0.13%	-0.14%	161%	109%
Class A2	-0.45%	-0.77%	-0.49%	162%	110%
Class B	-0.52%	-1.10%	-1.59%	165%	110%
Class C	-0.82%	-1.36%	-1.76%	145%	113%
Class E	-0.63%	-1.83%	-1.99%	146%	108%
Overall	-0.58%	-1.06%	-1.27%	156%	110%
Class D	-0.68%	-1.51%	-1.71%	132%	113%

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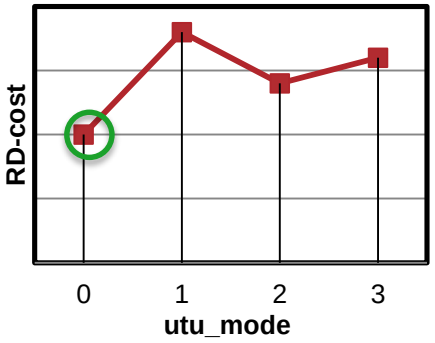
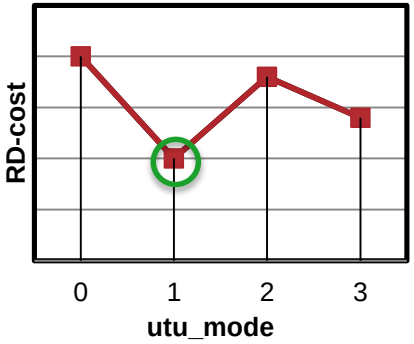
Speed up scheme (1/2)

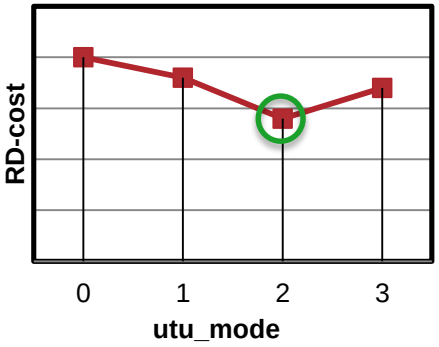
- Method 1: Early termination of utu_mode loop
  - The utu_mode loop will be terminated once RD-cost becomes worse.



Case 1
No checking for
utu_mode = 2 or 3



Case 2
No checking for
utu_mode = 3



Case 3
All utu_mode
is checked

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Speed up scheme (2/2)

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- Method 2: Fast decision of pred_mode candidate
  - In cycles of utu_mode = 2 and 3, only check the best pred_mode in cycles utu_mode = 0 and 1 .

```
CheckUTUSBestMode() {
        for (utu_mode =0; utu_mode<3; utu_mode++)
            if (utu_mode ≤1)
                while (pred_mode in full_mode_list)
                    CheckRdCost(pred_mode);
                    if (utu_mode == 1)
                        pred_mode_candidate = best_pred_mode;
            else
                CheckRdCost(pred_mode_candidate);
    }
```


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Summary of speed-up tests

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- Only first 40 frames are encoded.

			Test 2.1	Test 2.1a	Test 2.1b	Test 2.1c
Conditions	Early termination			√		√
	Fast decision				√	√
Results (AI)	BD-Rate saving	Y	0.67%	0.61%	0.65%	0.59%
		U	1.22%	1.06%	1.08%	1.11%
		V	1.31%	1.13%	1.24%	1.20%
	Encoding time		215%	179%	182%	175%

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Result of Test 2.1a

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- Early termination

	Over VTM-1.0, AI			
	Y	U	V	EncT
Class A1	-0.48%	-0.13%	-0.15%	172%
Class A2	-0.50%	-0.85%	-0.53%	175%
Class B	-0.51%	-0.92%	-1.30%	179%
Class C	-0.85%	-1.54%	-1.85%	190%
Class E	-0.70%	-1.79%	-1.49%	177%
Overall	-0.61%	-1.06%	-1.13%	179%
Class D	-0.66%	-1.77%	-2.28%	193%

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Result of Test 2.1b

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- Fast mode decision

	Over VTM-1.0, AI			
	Y	U	V	EncT
Class A1	-0.53%	-0.17%	0.07%	181%
Class A2	-0.54%	-0.95%	-0.59%	179%
Class B	-0.51%	-0.73%	-1.50%	183%
Class C	-0.94%	-1.58%	-1.92%	185%
Class E	-0.70%	-2.01%	-1.87%	182%
Overall	-0.65%	-1.08%	-1.24%	182%
Class D	-0.71%	-1.28%	-2.06%	184%

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Result of Test 2.1c

- Early termination
- Fast mode decision

	Over VTM-1.0, AI			
	Y	U	V	EncT
Class A1	-0.48%	-0.21%	-0.09%	170%
Class A2	-0.48%	-0.88%	-0.55%	172%
Class B	-0.48%	-1.07%	-1.41%	175%
Class C	-0.86%	-1.39%	-1.89%	180%
Class E	-0.66%	-1.93%	-1.68%	175%
Overall	-0.59%	-1.11%	-1.20%	175%
Class D	-0.70%	-1.83%	-2.04%	181%

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Conclusion

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- Uniform TU partitioning is proposed.
  - Bitrate saving is 0.65% (Luma) in Test 2.1
- Current encoder complexity is still high.
  - 175% in Test 2.1c
  - We believe complexity can be reduced by optimizing implementation and introducing another speed-up schemes.
- Suggest to further study of TU partitioning.
- Thanks cross-checking of ITRI.

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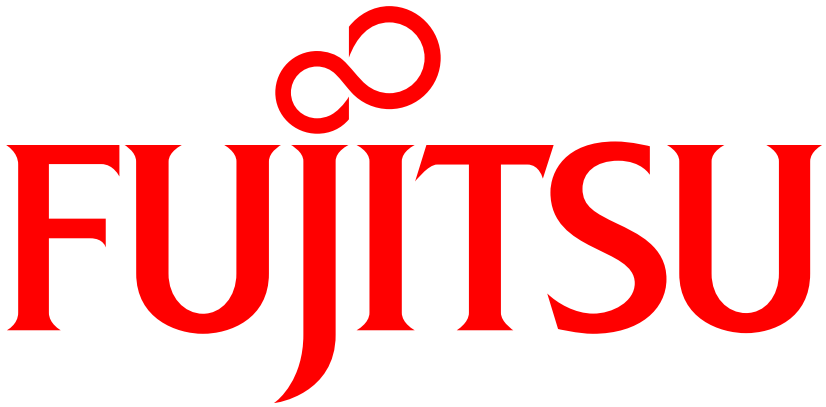

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