

CE5: Efficient coefficient coding method for 16x16 and 32x32 transforms in LCEC mode

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Introduction

❖ Current TMuC design

- The coefficient coding engine proposed by Tandberg, Ericsson, and Nokia (TEN) is used in LCEC mode [1], [2].
- TEN's engine encodes **up to 64 coefficients** even when transform size is larger than 8x8.
 - The remaining high frequency coefficients are truncated to 0.

❖ Motivation

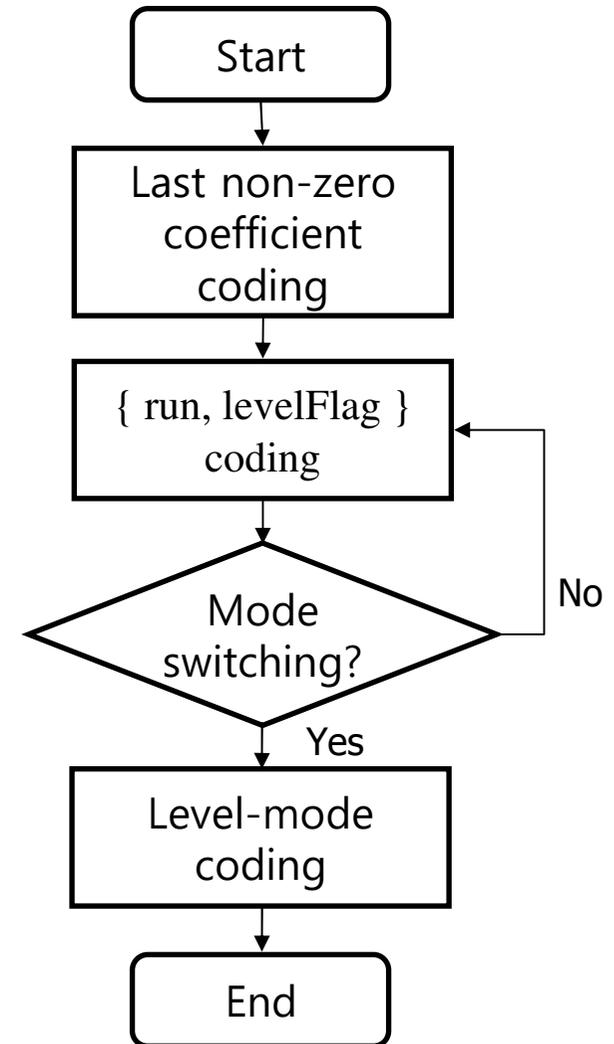
- The truncation of high frequency coefficients without any rate-distortion consideration can lead to the decrease in the overall coding efficiency.
- The current design is not consistent with high coding efficiency configuration where all the coefficients are coded using CABAC.

❖ Goal of this proposal

- This proposal is Samsung's response to CE5 on LCEC improvement.
- To propose an **efficient coefficient coding method for 16x16 and 32x32 transforms in LCEC mode** by simply extending the existing TEN's engine.

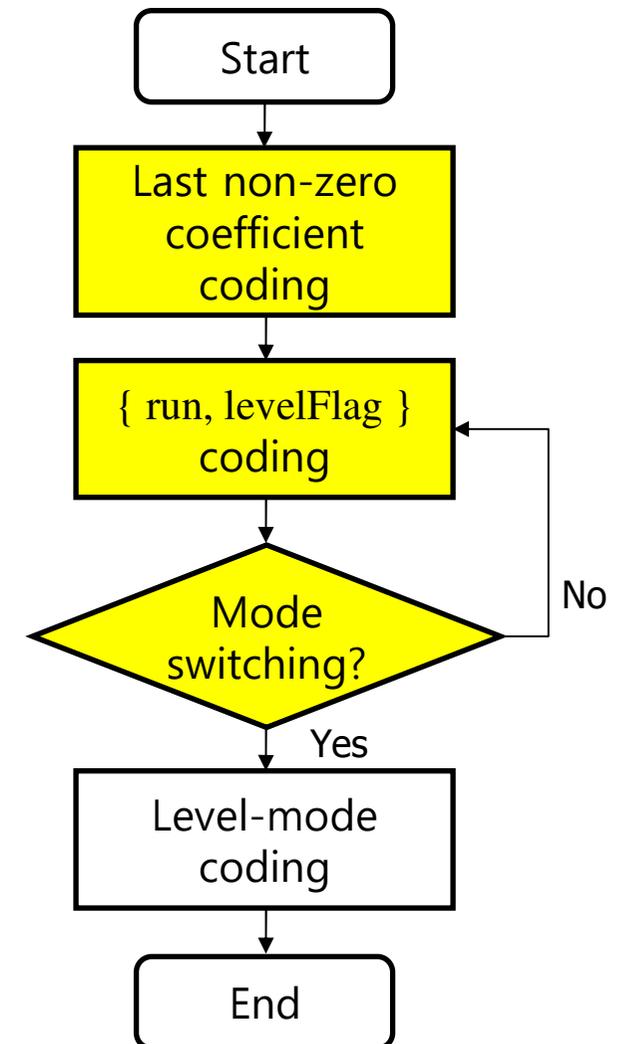
Coefficients coding of LCEC

- ❖ Mapping table is used to generate codewords for the combined coding of the following pairs:
 - { last non-zero coefficient position, levelFlag }
 - { zero-run, levelFlag }
 - levelFlag = level > 1
- ❖ VLC mapping table size of 8x8 transform
 - For example, the table for {Run, levelFlag} pair contains up to 127 elements at each maxRun (0~63) position.
- ❖ New and large mapping tables are necessary for the coefficient coding in 16x16 and 32x32 transforms considering natural extension.



Samsung's proposal in JCTVC-C210

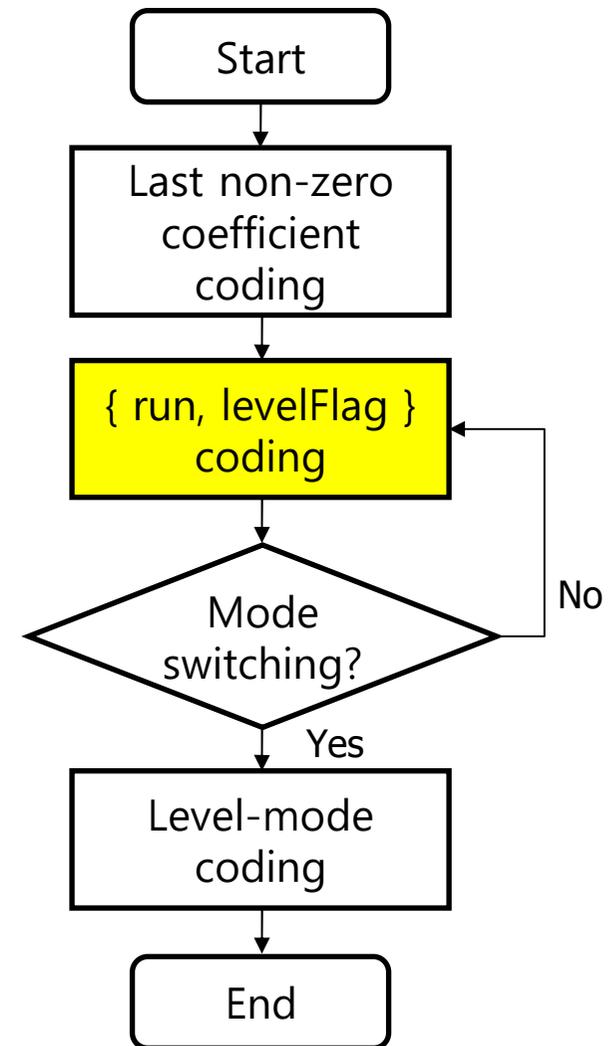
- ❖ Natural extension of TEN's method to 16x16 coefficients coding with new mapping tables
- ❖ Algorithm description
 - Proposed in the last meeting: JCTVC-C210 [3]
 - No changes in the coefficient coding of 4x4 and 8x8 transforms (exactly the same as TEN's method).
 - TEN's coefficient coding method is extended to 16x16 transform.
 - No changes in encoding/decoding process
 - A few new tables and threshold values are introduced to deal with large transforms.
 - The coefficient coding is further extended to 32x32 and 64x64 transforms without introducing additional tables.



Simplified extension to large TU

- ❖ Extension to 16x16 coefficients without additional mapping tables
- ❖ Algorithm description for 16x16 coefficients coding
 - Mapping table of 8x8 block and same coding method is re-used for most elements coding for 16x16 coefficients
 - Only the run-mode coding is slightly modified as follows, since TEN's method can't cover the zero-run longer than 63.

- 1) If $run \leq 63$
 - a. Encode pair $\{run, levelFlag\}$ using the same method of 8x8 transform
- 2) Else
 - a. Encode pair $\{run, levelFlag\}$ by using the escape codes (127 for $levelFlag=0$ and 128 for $levelFlag=1$).
 - b. Encode the remaining run ($run-64$).



Experimental results (1/2)

❖ Performance of the natural extension with additional tables

- 16x16 partial coefficient coding method has been implemented on the top of TMuC0.9.
- TEN's method is extended to 16x16 transform.
- When TU size is 32x32 (maximum size), only the coefficients from 16x16 low-frequency band are coded using the proposed method.

| Config. Class | Intra LoCo | | | Random access LoCo | | | Low delay LoCo | | |
|------------------|-------------|-------------|-------------|--------------------|------------|-------------|----------------|------------|------------|
| | Y | U | V | Y | U | V | Y | U | V |
| Class A | -2.5 | -1.0 | -1.4 | -0.9 | 0.4 | -0.1 | | | |
| Class B | -2.1 | -1.3 | -1.7 | -1.4 | 0.1 | -0.3 | 0.1 | 2.4 | 1.9 |
| Class C | -0.6 | -0.4 | -0.6 | -0.5 | 0.0 | 0.0 | 0.1 | 1.0 | 1.1 |
| Class D | -0.5 | -0.5 | -0.8 | -0.3 | -0.3 | -0.3 | 0.0 | 0.8 | 0.5 |
| Class E | -1.9 | -2.2 | -1.9 | | | | 1.1 | 3.3 | 1.8 |
| Average | -1.4 | -1.0 | -1.3 | -0.8 | 0.0 | -0.2 | 0.3 | 1.8 | 1.3 |
| Enc Time | 116% | | | 114% | | | 105% | | |
| Dec Time | 101% | | | 108% | | | 98% | | |

Experimental results (2/2)

❖ Performance of the simplified method without additional table

- Similar gain is achieved without any additional table or on-flying code-word generation method
- Performance improvement in all configurations, especially, considerable coding gain in intra configuration.
- The proposed method is more effective for high-resolution sequences.
- The encoder time increases due to the RDOQ, since now more number of coefficients should be dealt with the RDOQ. This can be alleviated by applying a simple RDOQ speedup method, e.g. [6].

| Config. Class | Intra LoCo | | | Random access LoCo | | | Low delay LoCo | | |
|------------------|-------------|-------------|-------------|--------------------|------------|------------|----------------|------------|------------|
| | Y | U | V | Y | U | V | Y | U | V |
| Class A | -1.8 | -0.3 | -0.7 | -0.7 | 0.6 | 0.2 | | | |
| Class B | -1.5 | -0.5 | -0.9 | -0.8 | 0.2 | 0.0 | -0.5 | 0.4 | 0.1 |
| Class C | -0.5 | -0.2 | -0.4 | -0.2 | 0.2 | 0.0 | 0.0 | 0.2 | 0.2 |
| Class D | -0.4 | -0.4 | -0.6 | -0.2 | -0.3 | -0.2 | -0.2 | 0.4 | 0.0 |
| Class E | -1.5 | -1.7 | -1.5 | | | | -0.1 | 1.0 | 1.1 |
| Average | -1.1 | -0.6 | -0.8 | -0.5 | 0.1 | 0.0 | -0.2 | 0.5 | 0.3 |
| Enc Time | 112% | | | 108% | | | 107% | | |
| Dec Time | 99% | | | 101% | | | 100% | | |

Conclusion

- ❖ In this proposal, an efficient coefficient coding method for 16x16 and 32x32 transforms in LCEC mode is proposed.
 - 16x16 low frequency is coded for 32x32 transform
- ❖ We recommend adopting the proposed method (with simplified extension) in the HM due to the following reasons.
 - Simple and straightforward extension of current HM LCEC method
 - The current VLC tables and code-word generation method is used for all TU sizes
 - One additional condition check of Run-length (≥ 64) for large TU .
 - The proposed method provides the coding gain without noticeable complexity increase.
 - The proposed method will make the HM design more consistent.
 - One coding method for the coefficients of TUs from both inter and intra PUs.
 - Consistency with the proposals on partial frequency transform can be considered [4], [5] to make identical 16x16 partial frequency coding for both HE and LC configuration.

References

- [1] K. Ugur, K. R. Andersson, and A. Fuldseth, "Description of video coding technology proposal by Tandberg, Nokia, Ericsson," JCTVC-A119, Dresden, Germany, Apr. 2010.
- [2] T. Wiegand, W.-J. Han, J.-R. Ohm, and G. J. Sullivan, "High Efficiency Video Coding (HEVC) text specification Working Draft 1," JCTVC-C403, Guangzhou, China, Oct. 2010.
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- [4] J. Sole, R. Joshi, M. Karczewicz, Y.-M. Hong, M.-S. Cheon, and I.-K. Kim, "Low complexity 32x32 transform by partial frequency transform," JCTVC-D257, Daegu, Korea, Jan. 2011.
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