RCE2: Test 1 – Residual DPCM (RDPCM) for HEVC lossless coding

Sunil Lee, Il-Koo Kim, and Chanyul Kim
(Samsung Electronics Co., Ltd.)

April 21, 2013

Contents

Inspire the World, Create the Future

I Introduction

II Algorithm Description

III Test Results

IV Conclusion

Introduction

RCE2

- At the last JCT-VC meeting in Geneva, it was agreed to set up HEVC range extension core experiment 2 on intra prediction for lossless coding (RCE2).
- The common software and test condition are defined for RCE2.
- 4 methods from L0117 (Samsung), L0161 (Siemens), L0176 (TI), and K0157 (I2R), one variant of L0176, and their combinations are tested in RCE2.

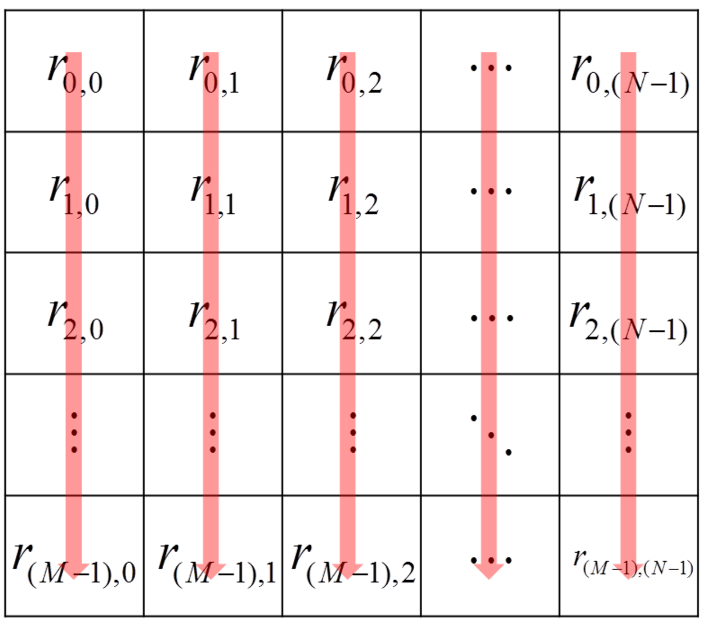
Residual DPCM

- The residual DPCM (DPCM) for HEVC lossless coding was proposed at the last Geneva meeting by Samsung (JCTVC-L0117).
- A simple DPCM is applied to the residual samples of intra-predicted PUs, when the intra prediction mode is either vertical or horizontal.
- The proposed method does not suffer from the throughput problem of sample-based prediction methods.
- The proposed coding tool is a part of H.264/AVC standard (8.5.15).

Algorithm description (1/3)

- The RDPCM is invoked when *cu_transquant_bypass_flag* is equal to 1, the prediction mode is intra, and the applicable intra prediction mode is equal to either vertical or horizontal mode.

Vertical mode



- Encoding

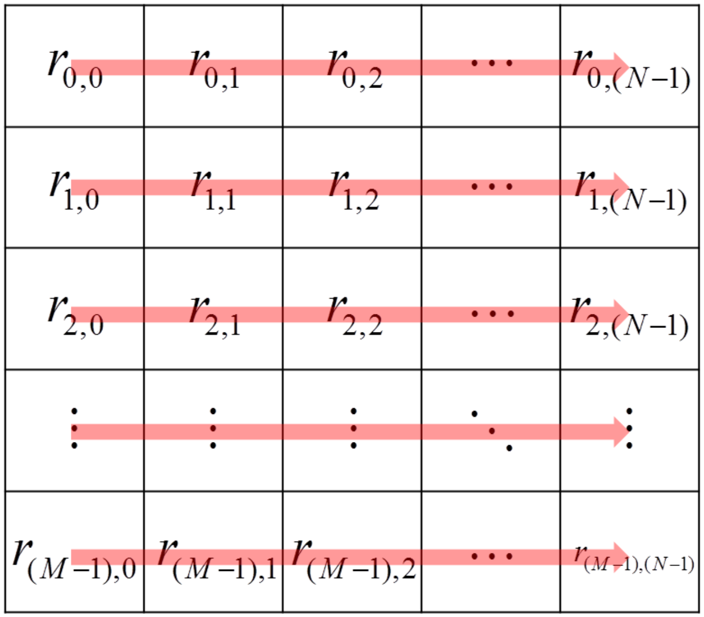
$$\tilde{r}_{i,j} = \begin{cases} r_{i,j} & , i = 0,\ j = 0..(N-1) \\ r_{i,j} - r_{(i-1),j} & , i = 1..(M-1),\ j = 0..(N-1) \end{cases}$$

- Decoding

$$r_{i,j} = \sum_{k=0}^{i} \tilde{r}_{k,j} \quad , i = 0..(M-1),\ j = 0..(N-1)$$

Algorithm description (2/3)

Horizontal mode



- Encoding

$$\tilde{r}_{i,j} = \begin{cases} r_{i,j} & , i = 0..(M-1),\ j = 0 \\ r_{i,j} - r_{(i-1),j} & , i = 0..(M-1),\ j = 1..(N-1) \end{cases}$$

- Decoding

$$r_{i,j} = \sum_{k=0}^{j} \tilde{r}_{i,k} \quad , i = 0..(M-1),\ j = 0..(N-1)$$

- The reconstruction of the current residual sample does not depend on the availability of the previous residual sample.
- The proposed method is exactly the same as "Intra residual transform-bypass decoding process" specified in 8.5.15 of H.264/AVC standard specification.

Algorithm description (3/3)

Encoder improvement

- The benefit of the RDPCM is not taken into account when intra prediction modes to be evaluated using the full RD optimization are selected by the fast encoding method of HM.
- In this non-normative encoder-only change, the encoder is forced to test horizontal and vertical mode using the full RD optimization.

Differences from SAP_HV

- The SAP_HV (a variant of SAP evaluated in Test 4) is mathematically identical to the RDPCM, however the following two differences lead to the different coded results.

1) The edge filtering specified in Section 8.4.4.2.6 of HEVC range extension draft text is disabled in the SAP.
2) The encoder behavior is different as pointed out in the motivation for the encoder improvement of the RDPCM.

Test results (1/5)

Test 1.1

- Tested: RDPCM as proposed in JCTVC-L0117.
- RDPCM is a simple yet effective coding tool for lossless coding.

	AI	RA	LDB
Class F	-9.3%	-5.7%	-4.6%
Class B	-4.5%	-0.9%	-0.6%
SC (GBR)	-11.1%	-7.7%	-7.1%
RangeExt	-2.8%	-0.7%	-0.6%
Overall (w/o SC)	**-5.7%**	**-2.7%**	**-2.2%**
Overall (w/ SC)	**-8.4%**	**-5.2%**	**-4.6%**
Enc Time[%]	101%	100%	100%
Dec Time[%]	98%	102%	98%

Test results (2/5)

Test 1.2

- Tested: RDPCM with non-normative encoder-only change.
- Its additional coding gain is 0.6% in AI, 0.4% in RA, and 0.4% in LDB.

	AI	RA	LDB
Class F	-9.9%	-6.0%	-4.8%
Class B	-4.8%	-0.9%	-0.7%
SC (GBR)	-12.0%	-8.3%	-7.7%
RangeExt	-3.0%	-0.7%	-0.6%
Overall (w/o SC)	**-6.1%**	**-2.9%**	**-2.3%**
Overall (w/ SC)	**-9.0%**	**-5.6%**	**-5.0%**
Enc Time[%]	105%	101%	101%
Dec Time[%]	96%	101%	101%

Test results (3/5)

Test 1.3

- Tested: RDPCM without edge filtering.
- Some coding gain for SC, but almost no gain or small loss for non-SC.

	AI	RA	LDB
Class F	-9.4%	-5.8%	-4.7%
Class B	-4.0%	-0.8%	-0.6%
SC (GBR)	-11.6%	-8.0%	-7.6%
RangeExt	-2.6%	-0.6%	-0.6%
Overall (w/o SC)	**-5.6%**	**-2.7%**	**-2.2%**
Overall (w/ SC)	**-8.6%**	**-5.4%**	**-4.9%**
Enc Time[%]	100%	100%	100%
Dec Time[%]	95%	100%	99%

Test results (4/5)

Test 1.4

- Tested: RDPCM with encoder improvement and without edge filtering.
- The combined effect of Test 1.2 and 1.3 to the RDPCM.

	AI	RA	LDB
Class F	-10.2%	-6.2%	-4.9%
Class B	-4.4%	-0.9%	-0.6%
SC (GBR)	-12.6%	-9.0%	-8.3%
RangeExt	-2.9%	-0.7%	-0.6%
Overall (w/o SC)	**-6.1%**	**-2.9%**	**-2.4%**
Overall (w/ SC)	**-9.4%**	**-6.0%**	**-5.3%**
Enc Time[%]	105%	101%	101%
Dec Time[%]	95%	102%	101%

Test results (5/5)

Throughput

- The encoder can be fully parallelized since original pixel values are identical to reconstructed pixel values in lossless coding.
- The decoder can be fully parallelized either, since the reconstruction of the current residual sample does not depend on the availability of the previous residual sample.

Number of operations

- When the block size is (nT)x(nT), the number of operations required to reconstruct one pixel value is as follows.

Decoding throughput	Number of operations
(nT)x(nT) pixels	(nT+1)/2 additions on avearge
(nT) pixels	1 addition

Conclusion

- The test results of RCE2 Test 1 on the RDPCM for HEVC lossless coding are reported.
- Based on the test results, it is suggested to adopt the RDPCM into the next version of the text and the test model of HEVC range extension.
  1) The significant coding gain is provided.
  2) Both encoder and decoder can be fully parallelized.
  3) It is a proven coding tool from H.264/AVC, which is specified in Section 8.5.15 of the standard specification.
- It is also suggested that the edge filtering of HEVC range extension is kept as it is, and its effect to the coding efficiency of HEVC lossless coding needs to be separately studied further.

Inspire the World, Create the Future

THANK YOU