AHG5: Recommended profiling of range extension coding tools

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Contents

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Introduction

- At the 14th JCT-VC meeting in Vienna, five profiles for HEVC range extensions were defined – Main 12, Main 4:2:2 10/12, and Main 4:4:4 10/12.
- At the 15th JCT-VC meeting in Geneva, the profiling of range extension coding tools was discussed and it was agreed to exclude the tools effective only for screen content coding (SCC) from Main 12 and Main 4:2:2 10/12.
- At the 16th JCT-VC meeting in San Jose, it was agreed to add a 4:4:4 16bit all-intra profile (with a coding tool called CABAC bit alignment dedicated to this profile), but consideration of other issues relating to 4:4:4 profiles was deferred until the 17th JCT-VC (108th MPEG) meeting.
- We suggest that profiling of range extension coding tools should use a similar evidence-based decision process to that used for HEVC v1, based on an evaluation under the range extension common test conditions.

Test set-up

- Test conditions: HEVC range extension CTC
- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0 without each coding tool
  1) Implicit RDPCM
  2) Explicit RDPCM
  3) Residual rotation
  4) Single context model for significance map coding in TS block
  5) Intra block copy
  6) Golomb-Rice parameter adaptation
  7) Cross component de-correlation
  8) CU-adaptive chroma QP offset
  9) CABAC bit alignment

Test results (Overall, AHG5)

Coding tools	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
Implicit RDPCM	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	99%	99%	99%	99%	99%	99%	99%
	100%	99%	99%	100%	100%	98%	98%
Explicit RDPCM	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	95%	95%	96%	87%	89%	89%	90%
	99%	99%	99%	100%	100%	99%	98%
Residual rotation	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**
	100%	100%	100%	99%	99%	99%	99%
	99%	99%	99%	98%	99%	98%	97%
Single ctx for sigmap in TS	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**
	99%	99%	99%	99%	99%	99%	99%
	99%	99%	99%	99%	100%	99%	98%
Intra block copy	0.5%	0.3%	0.2%	0.3%	0.1%	0.1%	0.1%
	44%	40%	40%	91%	87%	91%	87%
	100%	100%	99%	100%	99%	98%	98%
Golomb-Rice param. adaptation	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	99%	99%	99%	99%	99%	99%	99%
	99%	99%	99%	100%	99%	99%	98%
Cross comp. de-correlation	**9.0%**	**7.2%**	**5.3%**	**6.4%**	**5.1%**	**5.4%**	**4.4%**
	94%	93%	92%	95%	93%	95%	93%
	101%	101%	101%	101%	100%	99%	99%

Test results for YCbCr 4:4:4 SC (AHG8, Lossy)

Coding tools	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
Implicit RDPCM	**0.5%**	**0.5%**	**0.5%**	**0.4%**	**0.3%**	**0.0%**	**-0.1%**
	100%	100%	100%	99%	100%	100%	100%
	99%	100%	100%	99%	98%	99%	99%
Explicit RDPCM	**0.6%**	**0.5%**	**0.5%**	**0.3%**	**0.2%**	**0.1%**	**0.1%**
	97%	97%	97%	87%	88%	89%	90%
	100%	100%	100%	99%	98%	99%	99%
Residual rotation	**0.3%**	**0.3%**	**0.2%**	**0.4%**	**0.3%**	**0.1%**	**0.0%**
	100%	100%	100%	100%	100%	100%	100%
	99%	99%	100%	99%	99%	99%	99%
Single ctx for sigmap in TS	**0.5%**	**0.5%**	**0.6%**	**0.7%**	**0.8%**	**0.5%**	**0.5%**
	100%	100%	100%	100%	100%	100%	100%
	99%	100%	100%	99%	99%	98%	99%
Intra block copy	**48.9%**	**48.6%**	**46.6%**	**37.1%**	**37.3%**	**22.5%**	**24.6%**
	57%	55%	55%	95%	94%	96%	95%
	113%	114%	114%	101%	100%	100%	100%
Golomb-Rice param. adaptation	**0.3%**	**0.7%**	**1.2%**	**0.3%**	**0.6%**	**0.1%**	**0.3%**
	100%	100%	100%	100%	100%	100%	100%
	100%	100%	100%	99%	98%	99%	99%
Cross comp. de-correlation	**4.3%**	**4.5%**	**4.1%**	**3.6%**	**3.9%**	**2.9%**	**3.4%**
	96%	95%	94%	97%	96%	97%	96%
	101%	102%	102%	99%	99%	100%	99%

Test results for YCbCr 4:4:4 SC (AHG8, Lossles

Coding tools	AI	RA	LB
Implicit RDPCM	**6.6%**	**3.7%**	**2.9%**
	102%	100%	100%
	102%	99%	100%
Explicit RDPCM	**0.9%**	**3.0%**	**4.5%**
	98%	93%	94%
	100%	100%	102%
Residual rotation	**0.3%**	**0.1%**	**0.1%**
	100%	100%	100%
	100%	98%	101%
Single ctx for sigmap in TS	**0.6%**	**0.2%**	**0.4%**
	104%	104%	103%
	102%	101%	103%
Intra block copy	**31.8%**	**25.2%**	**20.3%**
	49%	90%	91%
	111%	102%	102%
Golomb-Rice param. adaptation	**3.7%**	**3.2%**	**3.2%**
	101%	100%	100%
	101%	99%	102%
Cross comp. de-correlation	**2.4%**	**2.1%**	**2.2%**
	95%	96%	97%
	103%	100%	102%

Test results (Overall, AHG18, Lossy)

Coding tools	AI-16bit	AI-12bit	LB-16bit	LB-12bit
Implicit RDPCM	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	100%	100%	100%	100%
	100%	100%	101%	100%
Explicit RDPCM	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	97%	96%	96%	95%
	100%	100%	100%	101%
Residual rotation	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	100%	100%	100%	100%
	100%	100%	99%	100%
Single ctx for sigmap in TS	**0.0%**	**0.0%**	**0.0%**	**0.1%**
	100%	100%	99%	99%
	100%	100%	99%	99%
Intra block copy	**0.1%**	**0.1%**	**0.0%**	**0.0%**
	38%	41%	82%	85%
	100%	100%	101%	100%
Golomb-Rice param. adaptation	**9.9%**	**0.9%**	**6.4%**	**0.5%**
	105%	101%	104%	101%
	112%	102%	108%	101%
Cross comp. de-correlation	**7.5%**	**17.6%**	**10.5%**	**19.8%**
	89%	90%	85%	89%
	103%	104%	105%	104%

Test results (Overall, AHG18, Lossless)

Coding tools	AI-16bit	AI-12bit	LB-16bit	LB-12bit
Implicit RDPCM	**2.4%**	**3.2%**	**0.4%**	**0.5%**
	103%	107%	101%	101%
	106%	105%	101%	102%
Explicit RDPCM	**0.0%**	**0.0%**	**1.2%**	**1.8%**
	101%	98%	95%	95%
	101%	100%	104%	105%
Residual rotation	**0.2%**	**0.4%**	**0.0%**	**0.1%**
	102%	101%	101%	101%
	101%	100%	100%	101%
Single ctx for sigmap in TS	**0.1%**	**0.2%**	**0.1%**	**0.2%**
	107%	105%	106%	107%
	103%	104%	102%	104%
Intra block copy	**0.0%**	**0.1%**	**0.0%**	**0.0%**
	101%	45%	101%	93%
	100%	100%	101%	103%
Golomb-Rice param. adaptation	**28.5%**	**6.5%**	**22.2%**	**4.5%**
	103%	108%	103%	103%
	110%	128%	112%	110%
Cross comp. de-correlation	**3.5%**	**5.9%**	**3.6%**	**5.2%**
	90%	95%	90%	92%
	103%	104%	104%	105%

Observations from the test results

- The range extension coding tools, only except cross component de-correlation, are not effective at all for camera-captured video sequences in AHG5 CTC.
- The coding gain of the range extension coding tools, except intra block copy and cross component de-correlation, is low even for SC in AHG8 CTC (lossy), mostly less than 1% on average.
- Intra block copy provides the significant coding gain for SC at the expense of the encoding complexity.
- The coding gain of residual rotation and single context model for sigmap coding in TS blocks is still marginal for SC even in AHG8 CTC (lossless), less than 1%.
- The other range extension coding tools provide good coding gain for SC in AHG8 CTC (lossless), but the coding gain of intra block copy decreases in lossless coding configuration.
- Golomb-Rice parameter is mainly effective for high bit-depth (>12bits), in which the level of transform coefficients is high.

Profiling based on the agreement so far

- Mapping of coding tools onto agreed Main profiles
- Still picture profiles are not shown here.

Range extension coding tools	Main 12	Main 4:2:2		Main 4:4:4			Main 4:4:4 All-Intra 16
		10	12	8	10	12	
Implicit RDPCM	✗	✗	✗	✓	✓	✓	✓
Explicit RDPCM	✗	✗	✗	✓	✓	✓	✓
Residual rotation	✗	✗	✗	✓	✓	✓	✓
Single ctx for TS	✗	✗	✗	✓	✓	✓	✓
Intra block copy	✗	✗	✗	✗	✗	✗	✗
Rice parm. adapt.	✗	✗	✗	✓	✓	✓	✓
Cross comp. de-cor.	✗	✗	✗	✓	✓	✓	✓
CU chroma QP offset	✗	✗	✗	✓	✓	✓	✓
CABAC bit alignment	✗	✗	✗	✗	✗	✗	✗

Conclusion

- The profiling of range extension coding tools should use a similar evidence-based decision process to that which was used for HEVC v1, based on testing under the range extension common test conditions.
- Test results show that cross component de-correlation is the only additional coding tool in the draft RExt text that provides a beneficial trade-off between performance and complexity with generic video content
- There is an immediate market requirement for HEVC range extensions which fulfill the stated purpose of Amd 1: to support high fidelity video signals in the high end consumer and professional environment.
- It is proposed that separate 4:4:4 profiles for screen content should be developed, in coordination with the SCC CfP evaluation at this meeting.
- It would be appropriate to include all of the additional coding tools in the draft RExt text in the initial test model for this new activity.

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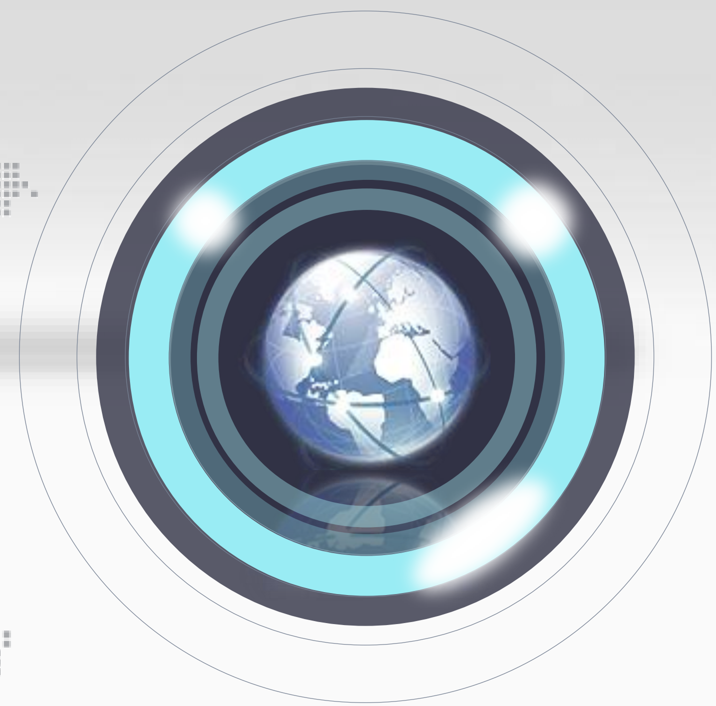
THANK YOU



References

1. M. Zhou, M. Budagavi, "RCE2: Experimental results on Test 3 and Test 4," JCTVC-M0056, Apr. 2013.
2. R. Joshi, J. Sole, M. Karczewicz, "RCE2 subtest C.2: Extension of residual DPCM to lossy coding," JCTVC-N0052, Jul. 2013.
3. M. Naccari, M. Mrak, "RCE2: Experimental results for Test C.1," JCTVC-N0074, Jul. 2013.
4. D. He, J. Wang, G. Martin-Cocher, "Rotation of Residual Block for Transform Skipping," JCTVC-J0093, Jun. 2012.
5. T. Tsukuba, T. Yamamoto, "Constant coefficient context for intra transform skipping," JCTVC-J0069, Jun. 2012.
6. C. Pang, J. Sole, L. Guo, M. Karczewicz, R. Joshi, "Non-RCE3: Intra Motion Compensation with 2-D MVs," JCTVC-N0256, Jul. 2013.
7. M. Karczewicz, L. Guo, J. Sole, R. Joshi, K. Sharman, N. Saunders, J. Gamei, "RCE2: Results of Test 1 on Rice Parameter Initialization," JCTVC-P0199, Jan. 2014.
8. W. Pu, W.-S. Kim, J. Chen, J. Sole, M. Karczewicz, "RCE1: Descriptions and Results for Experiments 1, 2, 3, and 4," JCTVC-O0202, Oct. 2013.
9. D. Flynn, N. Nguyen, D. He, A. Tourapis, G. Cote, D. Singer, "RExt: CU-adaptive chroma QP offsets," JCTVC-O0044, Oct. 2013.
10. K. Sharman, N. Saunders, J. Gamei, "RCE1: Results for tests B1, B2 and B3a," JCTVC-P0060, Jan. 2014.
11. C. Rosewarne, K. Sharman, D. Flynn, "Common test conditions and software reference configurations for HEVC range extensions," JCTVC-P1006, Jan. 2014.
12. S. Lee, E. Alshina, C. Kim, K. McCann, "AHG5 and AHG8: Recommended profiling of range extension coding tools", JCTVC-O0144, Oct. 2013.
13. S. Lee, E. Alshina, C. Kim, K. McCann, "AHG5: Recommended profiling of range extension coding tools," JCTVC-P0106, Jan. 2014.
14. T.-S. Chang, R.-L. Liao, C.-C. Chen, W.-H. Peng, H.-M. Hang, C.-L. Lin, F.-D. Jou, C. Pang, J. Sole, L. Guo, M. Karczewicz, "RCE3: Results of Subtest D.2 on Nx2N/2NxN/NxN Intra Block Copy," JCTVC-P0180, Jan. 2014.
15. MPEG Video and JCT-VC, "Request for ISO/IEC 23008-2:201X/Amd.1", ISO/IEC document JTC1/SC29/WG11/N13344, Jan. 2013.

Test 1: Implicit RDPCM off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, implicit RDPCM off
- Literally no gain for camera-captured test sequences in AHG5 CTC

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Overall	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Enc Time[%]	99%	99%	99%	99%	99%	99%	99%
Dec Time[%]	100%	99%	99%	100%	100%	98%	98%

Test 2: Explicit RDPCM off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, explicit RDPCM off
- Almost no gain for camera-captured test sequences in AHG5 CTC

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:2:2	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
Overall	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Enc Time[%]	95%	95%	96%	87%	89%	89%	90%
Dec Time[%]	99%	99%	99%	100%	100%	99%	98%

Test 3: Residual rotation off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, residual rotation off
- Almost no gain for camera-captured test sequences in AHG5 CTC

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
YCbCr 4:4:4	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
YCbCr 4:2:2	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%
Overall	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**
Enc Time[%]	100%	100%	100%	99%	99%	99%	99%
Dec Time[%]	99%	99%	99%	98%	99%	98%	97%

Test 4: Single ctx for sigmap in TS off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, single context model for the significance flag coding in TS block
- Almost no gain for camera-captured test sequences in AHG5 CTC

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%
YCbCr 4:4:4	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
YCbCr 4:2:2	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%
Overall	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**
Enc Time[%]	99%	99%	99%	99%	99%	99%	99%
Dec Time[%]	99%	99%	99%	99%	100%	99%	98%

Test 5: Intra block copy off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, intra block copy off
- Small coding gain at the cost of significant increase in encoder complexity

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.7%	0.4%	0.2%	0.5%	0.2%	0.3%	0.1%
YCbCr 4:4:4	0.5%	0.3%	0.2%	0.2%	0.2%	0.0%	0.1%
YCbCr 4:2:2	0.4%	0.3%	0.2%	0.2%	0.1%	0.0%	0.0%
Overall	**0.5%**	**0.3%**	**0.2%**	**0.3%**	**0.1%**	**0.1%**	**0.1%**
Enc Time[%]	44%	40%	40%	91%	87%	91%	87%
Dec Time[%]	100%	100%	99%	100%	99%	98%	98%

Test 6: Rice parameter adaptation off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, Golomb-Rice parameter adaptation off
- Literally no gain for camera-captured test sequences in AHG5 CTC

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YCbCr 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Overall	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Enc Time[%]	99%	99%	99%	99%	99%	99%	99%
Dec Time[%]	99%	99%	99%	100%	99%	99%	98%

Test 7: Cross component de-correlation off

- Anchor: HM13.0-RExt6.0
- Tested results: HM13.0-RExt6.0, cross component de-correlation off
- The only range extension coding tool which provides a beneficial trade-off between performance and complexity with generic video sequences.

BD-rate Y	AI-MT	AI-HT	AI-SHT	RA-MT	RA-HT	LB-MT	LB-HT
RGB 4:4:4	25.6%	19.6%	13.9%	18.6%	14.4%	16.1%	12.5%
YCbCr 4:4:4	1.5%	1.9%	2.1%	0.6%	1.0%	0.2%	0.7%
YCbCr 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Overall	**9.0%**	**7.2%**	**5.3%**	**6.4%**	**5.1%**	**5.4%**	**4.4%**
Enc Time[%]	94%	93%	92%	95%	93%	95%	93%
Dec Time[%]	101%	101%	101%	101%	100%	99%	99%