

JVET-AG0071 Informal Subjective Evaluation of Low Complexity Enhancement Video Codec (LCEVC) with VVC on SDR UHD (4K) Content

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Introduction

- The official report on formal assessment of LCEVC (Verification Tests Report, N0076), contains LCEVC evaluation results with SDR content only
- Among others, it contains UHD (4K) content coded with LCEVC+VVC (VTM-11) with following bitrates:
 - Marathon: ranging between 1.5 Mbps and 7.6 Mbps and LCEVC refinement between 0.17% and 0.89%
 - **MountainBay2**: ranging between 260 kbps and 1.5 Mbps and LCEVC refinement between 0.5% and 4.5%
 - DrivingPOVLogo: ranging between 1.2 Mbps and 7.7 Mbps and LCEVC refinement between 10.7% and 19.7%
 - **BoxeLogo**: encoded with bitrates range: 586 kbps to 1.6 Mbps and LCEVC refinement between 19.7% and 22.3%

LCEVC+VVC Objective Results

- Test1. H.266/VVC: VTM-19.0 (single layer encoding of 4K content with QP=22, 27, 32, 37)
- Test2. H.266/VVC + LCEVC: VTM-19.0 (1080p base encoder) + LTM-5.4.1 (4K enhancement layer encoder)

Sequence	RA, over VTM-19.0			
	PSNR_Y	PSNR_Cb	PSNR_Cr	PSNR_YCbCr
Tango2	-0.11%	-2.30%	9.29%	1.24%
FoodMarket4	6.03%	4.99%	5.31%	5.87%
Campfire	32.66%	156.97%	59.76%	52.80%
CatRobot	49.23%	49.91%	80.22%	53.49%
DaylightRoad2	86.81%	17.06%	48.41%	67.43%
ParkRunning3	14.95%	370.64%	220.60%	33.05%
Overall	31.59%	99.55%	70.60%	35.65%

LCEVC+VVC Objective Results

- Test3. H.266/VVC: for Campfire replace QP22 (46.14 Mbps) with QP25 (17.72 Mbps); for ParkRunning3 replace QP22 (97.29 Mbps) and QP27 (39.19 Mbps) with QP35 (11.00 Mbps) and QP40 (4.66 Mbps)
- Test4. H.266/VVC + LCEVC: find the closest match to the corresponding new QP points of Test3.

Sequence	RA, over VTM-19.0			
	PSNR_Y	PSNR_Cb	PSNR_Cr	PSND_YCbCr
Tango2	-0.11%	-2.30%	9.29%	1.24%
FoodMarket4	6.03%	4.99%	5.31%	5.87%
Campfire	12.11%	107.66%	41.39%	28.03%
CatRobot	49.23%	49.91%	80.22%	53.49%
DaylightRoad2	86.81%	17.06%	48.41%	67.43%
ParkRunning3	-3.06%	154.88%	49.57%	5.88%
Overall	25.17%	55.37%	39.03%	26.99%

LCEVC+VVC Objective Results

- Test3. H.266/VVC: for Campfire replace QP22 (46.14 Mbps) with QP25 (17.72 Mbps); for ParkRunning3 replace QP22 (97.29 Mbps) and QP27 (39.19 Mbps) with QP35 (11.00 Mbps) and QP40 (4.66 Mbps)
- Test4. H.266/VVC + LCEVC: find the closest match to the corresponding new QP points of Test3.

RA, over VTM-19.0			
Sequence	VMAF	Sequence	VMAF
Tango2	39.25%	CatRobot	92.31%
FoodMarket4	20.18%	DaylightRoad2	85.72%
Campfire	18.26%	ParkRunning3	3.43%
Overall	43.19%		

LCEVC+VVC Subjective Evaluation – Test Setup(1)

- Goal: compare visual quality of sequences coded with LCEVC when used with VVC at extended bitrate range
- Sequences and TPs used:

Sequence	Bitrate, kbps			
	VTM-19/0 / LTM-5.4.1 + VTM-19.0			
	TP1	TP2	TP3	TP4
Tango2	15782.42/14037.77	6691.40/6253.37	1955.98/1859.26	1858.15/1859.26
FoodMarket4	14299.10/13048.51	7244.36/7572.08	2025.59/1935.47	1932.38/1935.47
Campfire	12166.24/12206.41	6593.15/6101.85	3494.37/3321.34	3221.33/3321.34
CatRobot	16566.97/15159.76	7836.80/8323.48	2134.32/2091.01	2073.31/2091.01
DaylightRoad2	20763.04/17120.03	8042.71/8570.71	2037.04/1997.71	1972.72/1997.71
ParkRunning3	17375.88/16913.40	10999.65/10021.34	4659.57/4204.92	4177.13/4204.92

- In cases of very low bitrates, (TP3) it is suggested to replace the 4K sequence with 1080p version of the same sequence coded by VVC at matching bitrate (TP4).
 - sequences at UHD resolution (3840×2160), downsampled to 1920×1080 using the TAppDownConvertStatic tool from the SHM repository
 - downsampled sequences coded with VTM-19.0, and then upsampled using the VVC upscaling filters
 - upsampled videos are then compared with the LCEVC encodings of TP3

LCEVC+VVC Subjective Evaluation – Test Setup(2)

- 51 viewers, aging between 24 and 34 years old, 28 male, 23 female
- Each session had three people viewing the content, resulting in total 17 viewing sessions
- The subjective test carried out according to the recommendations ITU-R BT.500-15
- The assignment of sequences and tests is randomized and not revealed to the test subjects
- TV used: Samsung 65” QLED TV (QA65Q70TAW)
- Distance between TV and viewers set at $1.5 * H$, (height of the TV screen)

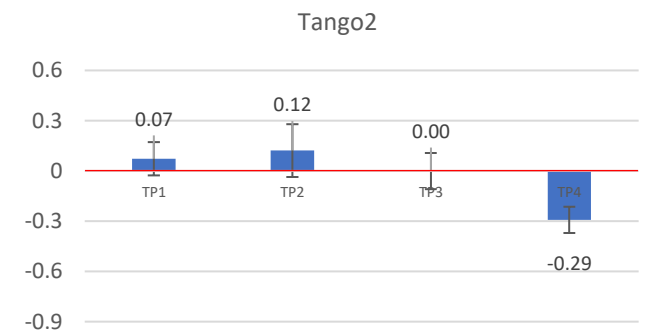
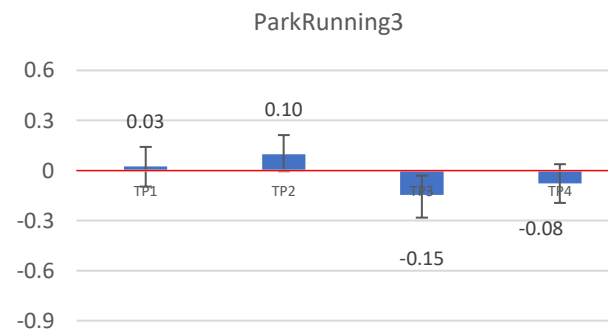
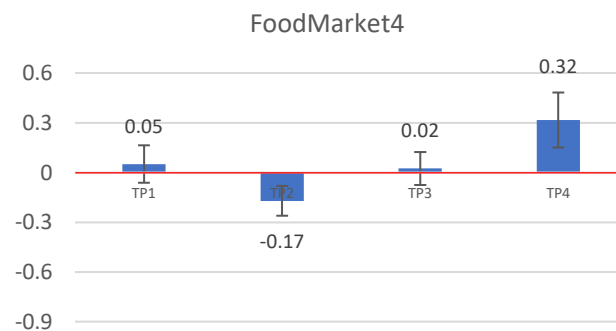
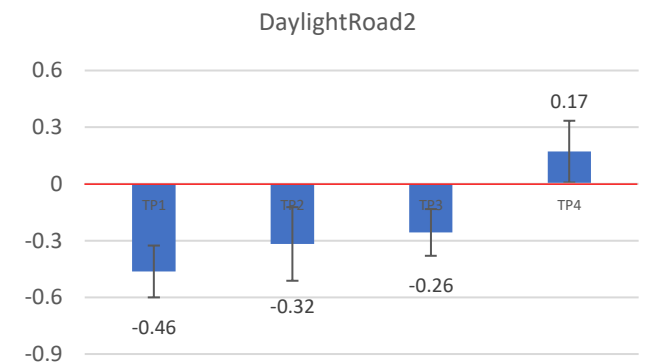
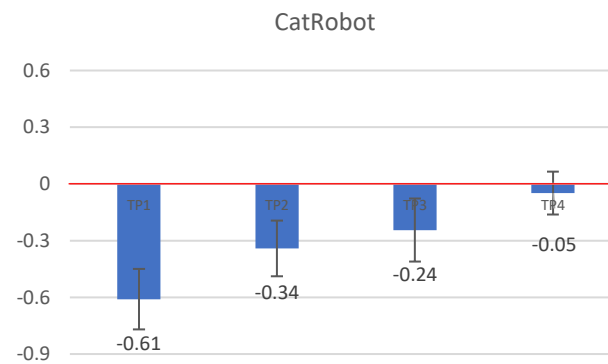
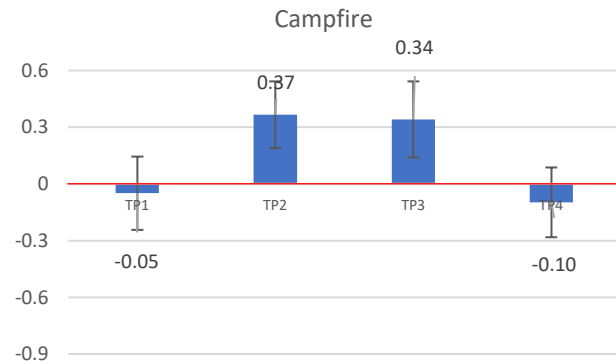
LCEVC+VVC Subjective Evaluation – Test Setup(3)

- Two coded sequences (using VTM-19.0 and LTM-4.5.1+VTM-19.0) at matching bitrates demonstrated to the viewers
 - Viewers compared the visual quality of the UHD or upscaled version encoded with VTM-19.0 to the visual quality of the LTM-5.4.1+VTM-19.0 version at matching rates.
- Original uncompressed content not used in this evaluation
- Test subjects asked to evaluate the quality of two reconstructed videos relative to each other, according to the viewers' personal preference
- The test subjects are asked to provide relative score of the visual quality of reconstructed video sequences presented in each test cell as follows:
 - "A much better than B"
 - "A better than B"
 - "A same as B"
 - "B better than A"
 - "B much better than A"

LCEVC+VVC Subjective Evaluation – Test Results (1)

- The votes of participants voting the two original sequences being very different not regarded in the final evaluation; 8 single votes excluded as obvious outliers
- The MOS and the 95% confidence intervals calculated for each TP of each sequence
- Resulting MOS value of zero indicates that VTM-19.0 and LTM-5.4.1+VTM-19.0 were rated to have the same visual quality, a positive number indicates a visual benefit for LTM-5.4.1+VTM-19.0, a negative number indicates the visual benefit of VTM-19.0

LCEVC+VVC Subjective Evaluation – Test Results (2)



Resulting MOS value of zero indicates that VTM-19.0 and LTM-5.4.1+VTM-19.0 were rated to have the same visual quality, a positive number indicates a visual benefit for LTM-5.4.1+VTM-19.0, a negative number indicates the visual benefit of VTM-19.0

Conclusions

- This contribution presents informal evaluation results of LCEVC reference implementation in combination with VVC reference encoder implementation
- Overall, no clear visual benefit was observed for LCEVC when used with VVC at various bitrates of an extended bitrate range, in both subjective evaluation and objective evaluation
- Moreover, at lower bitrates, using simple downscaling and upscaling of the coded results can easily provide visual quality similar to or better than LCEVC.
- Considering the demonstrated objective losses at the extended bitrate ranges, and no clear subjective benefit of LCEVC when combined with VVC, it is proposed to perform additional formal evaluation of LCEVC for UHD content coded at extended bitrate ranges, which are more reasonable for UHD content, and are not covered by LCEVC verification tests, N0076
- NOT criticizing N0076 VT Report, but asking to test LCEVC at extended bitrate ranges

Backup Slides

Table of results for SDR UHD sequences (VVC)

Sequence	full-VTM				half-VTM				LTM+VTM				
	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	% of LCEVC
Marathon	30	9256.35	7.97	0.25	26	7580.79	7.04	0.30	26	7599.06	7.97	0.27	0.24
	34	5362.65	6.63	0.33	29	4762.11	5.58	0.22	29	4770.36	6.64	0.30	0.17
	38	3100.83	4.83	0.36	32	2997.54	4.38	0.38	32	3005.76	5.42	0.28	0.27
	42	1777.83	3.02	0.38	36	1673.64	2.25	0.30	36	1688.61	3.61	0.31	0.89
MountainBay2	34	1672.14	6.63	0.26	29	1498.41	6.26	0.29	29	1505.88	6.79	0.42	0.50
	38	860.58	5.61	0.35	33	777.09	5.05	0.27	33	786.03	5.75	0.27	1.14
	42	442.47	3.71	0.34	37	408.30	3.49	0.29	37	419.37	4.21	0.24	2.64
	46	226.91	1.79	0.37	40	248.70	2.03	0.22	40	260.34	2.50	0.26	4.47
DrivingPOVLogo	28	9413.40	8.66	0.30	24	6850.98	7.49	0.29	24	7675.50	8.79	0.26	10.74
	32	5073.78	7.78	0.24	27	4279.14	6.13	0.29	27	4915.26	7.91	0.29	12.94
	38	2218.44	5.88	0.28	33	1712.58	4.63	0.28	33	2078.94	5.97	0.21	17.62
	42	1311.42	4.57	0.28	37	993.90	3.66	0.26	37	1209.36	4.63	0.31	17.82
BoxeLogo	30	1996.44	7.29	0.35	27	1286.34	5.08	0.40	27	1603.74	7.67	0.46	19.79
	34	1326.42	6.28	0.34	30	917.16	4.38	0.29	30	1172.64	6.42	0.22	21.79
	38	908.58	4.91	0.24	32	742.80	3.88	0.25	32	939.84	5.67	0.27	20.97
	42	632.04	3.92	0.39	37	455.46	2.62	0.24	37	586.32	4.34	0.26	22.32

Table of results for SDR UHD sequences (ETM)

Sequence	full-VTM				half-ETM				LTM+ETM				
	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	% of LCEVC
CatRobot	28	7829	7.86	0.39	23	7203	6.94	0.46	23	7232.94	7.97	0.36	0.41
	36	2627	6.03	0.38	30	2657.76	5.13	0.21	30	2670.78	6.18	0.34	0.49
	40	1594	4.06	0.32	34	1555.98	3.63	0.17	34	1569.6	5.22	0.3	0.87
	44	999	2.28	0.25	38	905.16	2	0.26	38	922.38	2.91	0.21	1.87
DrivingPOVLogo	28	11217	8.11	0.26	23	9996.7	7.17	0.27	23	10942.2	7.94	0.24	8.64
	32	5880	6.78	0.41	27	5072.04	5.33	0.21	27	5720.34	6.94	0.32	11.33
	38	2511	4.72	0.2	32	2392.44	3.72	0.33	32	2761.98	5.5	0.23	13.38
	42	1483	3.33	0.54	36	1354.8	2.06	0.35	36	1513.74	4.22	0.28	10.50
BarScene	28	2614	8.11	0.34	23	1954.26	6.53	0.3	23	1979.7	7.71	0.37	1.29
	36	595	6.18	0.36	31	516.6	5.06	0.25	31	529.56	6.56	0.37	2.45
	40	368	4.22	0.28	34	355.38	3.94	0.22	34	368.4	5.33	0.35	3.53
	44	239	1.89	0.36	38	218.22	2.33	0.33	38	231.42	3.22	0.3	5.70
BoxeLogo	28	2853	7.17	0.38	24	2216.16	5.89	0.33	24	2619.24	7.22	0.32	15.39
	32	1796	6.17	0.46	27	1512.3	5.06	0.28	27	1823.52	6.56	0.34	17.07
	38	975	4.11	0.33	32	870.18	3.94	0.41	32	1072.38	5.33	0.3	18.86
	42	664	1.72	0.29	36	575.58	2.33	0.26	36	698.76	3.22	0.32	17.63

Table of results for SDR UHD sequences (JM)

Sequence	full-VTM				half-JM				LTM+JM				
	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	% of LCEVC
CatRobot	27	15544.26	7.65	0.31	23	10549.13	6.62	0.24	23	10620.9	7.35	0.24	0.68
	32	8207.94	5.12	0.44	28	5328.52	4.73	0.31	28	5359.38	5.77	0.24	0.58
	37	4677.54	3.53	0.24	33	2836.47	3.38	0.26	33	2883.36	3.82	0.27	1.63
	42	2696.16	2.08	0.32	37	1735.31	2.63	0.38	37	1834.08	3.01	0.27	5.39
LupoPuppet	30	11802.85	6.92	0.27	26	7253.05	6.63	0.3	26	7284.9	7.48	0.3	0.44
	34	7243.2	5.03	0.37	29	4673.85	5.15	0.19	29	4694.9	6.12	0.46	0.45
	38	4695.95	3.12	0.43	33	2691.1	3.52	0.28	33	2732.7	4.23	0.34	1.52
	42	3090.75	2.02	0.33	37	1654.25	2.04	0.25	37	1722.8	2.95	0.39	3.98
DrivingPOV	28	17165.46	6.75	0.27	24	11552.58	5.32	0.26	24	12248.78	6.73	0.42	5.68
	32	9502.2	4.82	0.25	28	6158.82	3.93	0.28	28	6779.34	5.04	0.2	9.15
	36	5767.26	3.72	0.25	31	4029.72	2.78	0.42	31	4517.04	3.68	0.24	10.79
	42	3628.44	2.54	0.28	35	2386.8	2.22	0.4	35	2738.34	3.07	0.35	12.84
BoxeLogo	30	7664.7	6.82	0.22	24	4159.14	5.73	0.36	24	4522.26	7.23	0.26	8.03
	34	4649.76	4.33	0.3	28	2726.88	4.31	0.34	28	3005.34	6.04	0.27	9.27
	38	3449.92	2.44	0.39	31	2056.08	3.52	0.37	31	2296.86	5.12	0.34	10.48
	42	2492.52	0.55	0.41	34	1588.8	2.33	0.42	34	1788.42	4.24	0.29	11.16

Table of results for SDR UHD sequences (HM)

Sequence	full-VTM				half-HM				LTM+HM				
	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	QP	bitrate	MOS	CI	% of LCEVC
CatRobot	27	10803.96	7.65	0.29	23	8252.52	6.82	0.38	23	8346.96	7.82	0.27	1.13
	32	5453.52	6.27	0.44	27	4675.38	5.63	0.44	27	4712.64	6.93	0.33	0.79
	37	2960.58	4.65	0.41	32	2432.94	3.81	0.43	32	2483.34	5.82	0.44	2.03
	42	1651.9	2.94	0.33	36	1455.66	2.38	0.35	36	1568.34	4.74	0.34	7.18
LupoPuppet	30	8552.7	7.55	0.44	25	6531.25	7.25	0.47	25	6589.8	8.31	0.31	0.89
	34	4646.94	5.83	0.37	29	3376.65	5.28	0.29	29	3515.45	6.12	0.33	3.95
	38	2610.12	4.02	0.49	32	2042.5	3.63	0.3	32	2242.45	4.53	0.3	8.92
	42	1504.38	2.73	0.38	36	1104.55	2.63	0.33	36	1449.1	3.51	0.3	23.78
DrivingPOV	28	12624.66	8.01	0.6	24	9477.84	6.91	0.46	24	10300.68	8.43	0.36	7.99
	32	6697.32	5.92	0.34	28	4912.68	4.92	0.37	28	5537.52	6.12	0.4	11.28
	38	2927.7	4.05	0.36	33	2377.2	3.12	0.46	33	2767.86	4.81	0.28	14.11
	42	1769.34	3.02	0.45	36	1583.7	2.11	0.24	36	1812.36	3.43	0.29	12.62
BoxeLogo	30	2682.48	7.53	0.41	25	2239.38	6.53	0.19	25	2601.54	7.91	0.41	13.92
	34	1783.86	5.71	0.52	29	1390.26	4.18	0.26	29	1672.74	6.73	0.47	16.89
	38	1216.14	3.77	0.28	33	908.82	2.33	0.39	33	1115.34	4.68	0.4	18.52
	42	844.98	2.18	0.48	37	615.3	1.39	0.21	37	753.54	3.12	0.34	18.35