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Title: **TE3 - Cross-check results of Local Intensity Compensation tool from Mitsubishi Electric**

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Purpose: [Report on Subtest 3 Local Intensity Compensation tool of Tool Experiment 3: Inter Prediction in HEVC]

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Abstract

The contribution presents experimental results on coding efficiency and computational complexity for Local Intensity Compensation (LIC) tool proposed by Mitsubishi Electric [1]. Experiments were done in the context of Subtest 3: Multi-hypothesis inter prediction defined in Tool Experiment 3: Inter Prediction in HEVC [4]. The aim of experiments was to cross check the results obtained by authors of the method (Mitsubishi Electric).

1 Introduction – short review of LIC tool

Local Intensity Compensation technique was presented in [1] in detail. The main idea behind the method is to predict the current image block with some number of reference blocks, where the reference blocks can be arbitrary weighted. The method also assumes adding the offset to such obtained weighted prediction. The idea of the method was presented in Fig. 1.

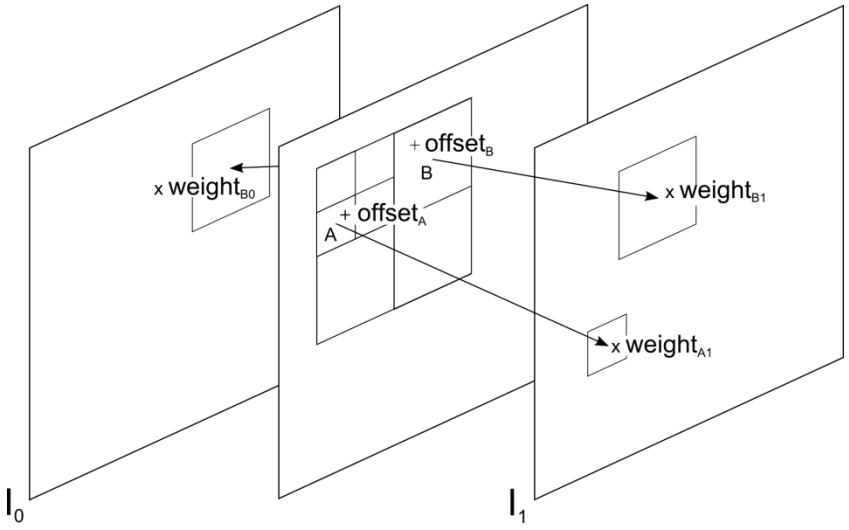

Figure 1. The idea of Local Intensity Compensation technique [source: 4]

In more detail, the LIC operation can be formulated as:

$$\mathbf{Bp} = o + w_0\mathbf{Bc}_0 + \ldots + w_n\mathbf{Bc}_n + \ldots + w_N\mathbf{Bc}_N ,$$

where **Bp** is the current block prediction, $\mathbf{Bc}_n$ is n-th reference block, o is offset and w_n is the weight associated with block $\mathbf{Bc}_n$. N relates to the number of reference blocks. The method was defined to operate at the prediction unit (PU) level, where for each block unit in a partition a different set of parameters can be derived and transmitted to the decoder. Parameters are calculated by minimization of a cost function.

2 Methodology of experiments

The experiments have been aimed at testing the coding efficiency of Local Intensity Compensation (LIC) tool [1] in the framework of TMuC software [3]. The computational complexity of video encoder and video decoder with LIC tool were also tested. Experiments were done under test conditions presented in the document of Tool Experiment 3 [4] (test sequences as defined in the CfP document [2] were used, original and the modified TMuC software with LIC tool was evaluated, video encoders were set up with configuration files provided by the TMuC software group [3]).

PUT received the software of modified TMuC with LIC tool from Mitsubishi Electric. The source code was analyzed. Experiments were done with 0.7.1 version of TMuC software. Both the original and the modified TMuC codecs were built from source code with Microsoft Visual Studio 2005 Professional Edition under the Windows 7 64-bit operation system. The compression performance and computational complexity tests were carried out on machines with parameters:

- Computer 1: Core 2 Duo E6600 (2.4GHz), 4GB of RAM, Windows 7 64-bit;
- Computer 2: QuadCore Intel Core i7 920, 2.833 GHz, 12GB of RAM, Windows Vista 7 ultimate.

In each experiment the bitrate, Y PSNR, U PSNR, V PSNR for encoded sequences were reported. Additionally, encoding and decoding times were reported. Obtained results were presented in next sections.

3 Experimental results on coding efficiency

In this section, results on compression performance of LIC tool were presented. Due to the time constraints, experiments were done only for ‘lowdelay_loco’ and ‘randomaccess_loco’ encoder configurations. Detailed results were presented in Table1 and Table 2.

Table 1. Experimental results for Random Access Low Complexity scenario.

			TMuC 0.7 reference				TMuC 0.7.1 + LIC, PUT						
		QPISlice	kbps	Y psnr	U psnr	V psnr	kbps	Y psnr	U psnr	V psnr	BD-rate Y	BD-rate U	BD-rate V
Class B 1080p	S03 Kimono	22	5366.10	41.43	43.26	44.88	5416.54	41.42	43.26	44.88	2.1	1.4	1.5
		27	2519.12	39.51	41.95	43.22	2547.07	39.49	41.95	43.21			
		32	1293.52	37.20	40.71	41.90	1311.51	37.16	40.71	41.90			
		37	714.06	34.87	39.58	40.90	727.27	34.82	39.57	40.89			
	S04 ParkScene	22	8723.53	39.77	41.94	43.22	8746.50	39.78	41.94	43.22	0.9	0.6	0.7
		27	3864.87	37.27	40.19	41.31	3882.70	37.27	40.19	41.31			
		32	1856.75	34.76	38.61	39.86	1870.35	34.74	38.62	39.86			
		37	919.32	32.32	37.15	38.82	930.51	32.30	37.15	38.81			
	S05 Cactus	22	19885.80	38.28	39.89	43.27	19938.74	38.28	39.89	43.27	1.0	1.2	1.1
		27	6792.18	36.71	38.99	41.62	6843.32	36.72	38.99	41.61			
		32	3341.44	34.81	38.12	39.97	3376.03	34.81	38.12	39.97			
		37	1802.75	32.65	37.08	38.26	1829.66	32.63	37.07	38.25			
	S06 BasketballDrive	22	18611.86	38.94	43.55	44.61	18636.61	38.94	43.55	44.60	1.0	1.1	1.0
		27	6975.67	37.25	42.27	42.58	7007.80	37.25	42.27	42.57			
		32	3395.80	35.39	40.91	40.53	3423.07	35.38	40.90	40.52			
		37	1871.98	33.43	39.52	38.56	1893.94	33.39	39.48	38.52			
	S07 BQTerrace	22	38240.30	37.00	41.73	43.84	38211.71	37.00	41.73	43.84	0.3	0.6	0.7
		27	8164.67	35.03	40.49	42.82	8165.69	35.04	40.49	42.82			
		32	2948.78	33.60	39.32	41.88	2965.60	33.60	39.32	41.89			
		37	1443.77	31.73	38.25	41.01	1467.95	31.73	38.25	41.00			
Class C WVGA	S08 BasketballDrill	22	4020.52	39.98	42.56	42.87	4040.15	40.00	42.58	42.89	0.6	0.7	0.4
		27	1941.75	36.88	40.09	39.99	1953.28	36.89	40.10	40.00			
		32	958.21	34.05	37.84	37.45	964.81	34.05	37.83	37.46			
		37	502.32	31.60	35.84	35.19	506.04	31.58	35.80	35.18			
	S09 BQMall	22	4290.70	39.92	43.19	44.55	4293.56	39.92	43.19	44.55	0.5	0.4	0.6
		27	2035.25	37.33	41.35	42.43	2040.30	37.34	41.35	42.43			
		32	1045.04	34.60	39.57	40.44	1049.19	34.59	39.57	40.43			
		37	565.56	31.89	37.85	38.59	569.75	31.86	37.85	38.58			
	S10 PartyScene	22	8472.65	37.57	40.75	41.66	8464.16	37.58	40.74	41.66	0.1	0.2	0.3
		27	3754.23	33.97	38.27	39.15	3761.11	33.99	38.27	39.15			
		32	1730.89	30.95	36.36	37.16	1738.24	30.95	36.37	37.17			
		37	805.56	28.20	34.71	35.45	812.55	28.19	34.71	35.44			
	S11 RaceHorses	22	5210.73	38.70	40.95	42.45	5219.91	38.70	40.95	42.46	0.6	0.6	1.0
		27	2266.90	35.54	38.64	40.27	2273.14	35.53	38.64	40.26			
		32	1072.22	32.70	36.65	38.33	1074.95	32.68	36.64	38.30			
		37	522.05	30.13	34.88	36.48	523.80	30.08	34.85	36.45			
Class D WQVGA	S12 BasketballPass	22	1703.07	40.28	43.46	42.49	1707.68	40.29	43.47	42.50	0.6	0.3	0.4
		27	857.25	36.56	40.93	39.45	860.06	36.56	40.93	39.45			
		32	432.31	33.29	38.75	36.87	433.58	33.27	38.74	36.87			
		37	228.54	30.55	36.71	34.68	228.64	30.50	36.71	34.66			
	S13 BQSquare	22	2296.51	37.20	42.37	43.24	2298.52	37.20	42.37	43.23	0.2	0.5	0.4
		27	866.51	33.53	40.57	41.35	868.21	33.54	40.56	41.35			
		32	376.38	30.75	39.17	39.81	377.74	30.75	39.17	39.80			
		37	195.24	28.31	38.00	38.42	196.87	28.30	38.00	38.44			
	S14 BlowingBubbles	22	1947.11	37.72	40.72	41.52	1948.56	37.72	40.72	41.53	0.4	0.1	0.4
		27	883.99	34.30	38.21	38.92	885.88	34.30	38.22	38.93			
		32	414.29	31.22	36.14	36.81	416.45	31.22	36.15	36.80			
		37	196.90	28.44	34.29	34.89	198.74	28.43	34.30	34.88			
	S15 RaceHorses	22	1362.82	39.04	40.91	42.04	1364.77	39.04	40.91	42.04	0.5	0.2	0.0
		27	672.04	35.36	38.23	39.44	673.25	35.35	38.23	39.46			
		32	329.67	32.05	36.09	37.24	330.01	32.02	36.09	37.23			
		37	164.69	29.34	34.20	35.22	164.37	29.28	34.18	35.21			
	Class B										1.1	1.0	1.0
	Class C										0.4	0.5	0.6
	Class D										0.4	0.3	0.3
	All										0.6	0.6	0.6

Table 2. Experimental results for Low Delay Low Complexity scenario.

			TMuC 0.7.1 reference, PUT				TMuC 0.7.1 + LIC, PUT						
		QPISlice	kbps	Y psnr	U psnr	V psnr	kbps	Y psnr	U psnr	V psnr	BD-rate Y	BD-rate U	BD-rate V
Class B 1080p	S03 Kimono	22	6530.46	41.64	43.11	44.41	6604.71	41.62	43.11	44.40	2.4	2.1	2.0
		27	3280.88	39.78	41.47	42.55	3326.95	39.76	41.46	42.55			
		32	1715.23	37.51	39.96	41.14	1745.55	37.47	39.94	41.12			
		37	876.77	34.91	38.63	40.13	894.35	34.87	38.61	40.11			
	S04 ParkScene	22	11168.25	39.79	41.66	42.50	11182.72	39.78	41.66	42.50	0.7	0.7	0.8
		27	4648.12	36.77	39.34	40.36	4665.92	36.77	39.34	40.36			
		32	1968.23	33.90	37.39	38.96	1981.33	33.89	37.38	38.96			
		37	851.00	31.26	35.86	38.06	860.63	31.26	35.86	38.05			
	S05 Cactus	22	26414.84	38.75	40.18	42.96	26464.08	38.76	40.18	42.96	0.2	1.3	1.2
		27	8728.81	36.60	38.64	40.81	8776.52	36.62	38.64	40.81			
		32	4097.07	34.40	37.44	38.78	4141.44	34.41	37.42	38.76			
		37	1989.45	31.99	36.13	36.66	2023.06	32.02	36.12	36.63			
	S06 BasketballDrive	22	25613.44	39.46	43.48	44.61	25627.51	39.47	43.49	44.61	0.8	0.8	0.8
		27	9890.24	37.59	41.91	42.38	9934.22	37.60	41.92	42.38			
		32	4872.79	35.75	40.29	40.12	4919.59	35.74	40.28	40.11			
		37	2495.04	33.57	38.67	37.87	2533.80	33.56	38.65	37.86			
	S07 BQTerrace	22	67650.18	38.45	41.55	43.35	67556.68	38.45	41.55	43.37	-0.5	0.2	-0.8
		27	12530.48	35.37	39.86	42.22	12486.38	35.37	39.86	42.23			
		32	3717.85	33.01	38.37	41.09	3687.57	33.01	38.36	41.09			
		37	1438.59	30.45	37.19	40.08	1445.99	30.45	37.17	40.07			
Class C WVGA	S08 BasketballDrill	22	5055.28	39.52	41.92	42.19	5062.91	39.54	41.92	42.19	0.1	1.2	1.0
		27	2573.71	36.52	39.07	39.07	2589.41	36.55	39.07	39.06			
		32	1295.46	33.80	36.54	36.24	1313.28	33.84	36.52	36.25			
		37	643.83	31.22	34.27	33.69	656.37	31.24	34.26	33.70			
	S09 BQMall	22	5763.20	40.06	42.64	43.86	5752.94	40.06	42.64	43.85	0.1	0.4	0.3
		27	2743.20	37.11	40.39	41.43	2739.50	37.11	40.39	41.42			
		32	1352.22	34.09	38.31	39.21	1355.48	34.09	38.30	39.21			
		37	673.90	31.09	36.36	37.12	680.00	31.10	36.32	37.10			
	S10 PartyScene	22	13599.32	38.22	40.23	40.90	13587.48	38.23	40.23	40.90	0.0	0.2	0.0
		27	6446.01	34.27	37.44	38.09	6442.40	34.28	37.44	38.08			
		32	2731.20	30.52	35.14	35.79	2732.26	30.52	35.14	35.80			
		37	1031.94	27.11	33.08	33.74	1036.45	27.11	33.07	33.74			
	S11 RaceHorses	22	7335.98	40.19	41.43	42.68	7348.36	40.19	41.43	42.68	0.5	0.4	0.4
		27	3395.89	36.95	38.68	40.31	3404.32	36.95	38.68	40.31			
		32	1531.68	33.75	36.37	38.04	1541.44	33.75	36.38	38.05			
		37	667.27	30.56	34.27	35.76	673.09	30.55	34.25	35.76			
Class D WQVGA	S12 BasketballPass	22	2222.19	40.78	43.26	42.86	2224.49	40.77	43.26	42.86	0.7	-0.1	0.4
		27	1213.92	37.34	40.47	39.79	1218.27	37.34	40.48	39.78			
		32	629.35	34.09	37.97	36.90	634.17	34.08	38.03	36.92			
		37	311.51	31.11	35.74	34.13	315.38	31.09	35.75	34.14			
	S13 BQSquare	22	4091.56	38.28	41.43	42.30	4096.68	38.29	41.44	42.31	-0.2	0.2	-0.1
		27	1906.05	34.24	39.39	40.07	1904.10	34.23	39.39	40.06			
		32	787.44	30.56	38.07	38.37	785.33	30.57	38.05	38.37			
		37	257.88	26.93	37.06	36.86	256.84	26.93	37.05	36.84			
	S14 BlowingBubbles	22	2918.92	38.00	39.92	40.38	2918.08	38.00	39.92	40.38	0.2	0.3	0.2
		27	1325.56	34.01	37.07	37.51	1327.05	34.01	37.07	37.50			
		32	557.09	30.38	34.65	35.07	557.98	30.38	34.64	35.07			
		37	218.57	27.25	32.47	32.96	219.70	27.24	32.46	32.96			
	S15 RaceHorses	22	1783.61	40.00	41.13	42.22	1786.31	40.00	41.13	42.22	0.6	0.3	0.4
		27	921.85	36.28	38.26	39.43	925.01	36.28	38.26	39.44			
		32	453.24	32.79	35.71	36.80	455.57	32.78	35.71	36.79			
		37	208.76	29.79	33.24	34.19	210.28	29.77	33.25	34.20			
ClassE 720p	S16 Vidyo1	22	2807.38	43.21	46.29	47.19	2800.85	43.20	46.29	47.19	0.9	1.6	1.9
		27	1120.09	40.76	44.85	45.41	1119.78	40.76	44.84	45.39			
		32	570.77	38.05	43.29	43.58	577.95	38.05	43.26	43.54			
		37	336.56	35.20	41.79	41.73	347.34	35.21	41.75	41.69			
	S17 Vidyo3	22	3878.70	43.05	47.82	46.92	3844.36	43.07	47.82	46.90	-1.2	0.8	2.4
		27	1422.89	40.40	46.59	44.83	1405.57	40.46	46.59	44.76			
		32	692.82	37.45	45.46	43.06	700.61	37.53	45.44	42.99			
		37	394.54	34.35	44.09	41.59	405.34	34.43	44.05	41.58			
	S18 Vidyo4	22	3313.72	43.01	47.59	47.75	3304.95	43.01	47.58	47.75	1.4	2.5	1.7
		27	1116.55	40.37	45.78	45.75	1119.99	40.36	45.75	45.72			
		32	531.09	37.65	43.95	43.54	538.94	37.62	43.89	43.54			
		37	315.02	34.93	42.21	41.43	327.24	34.94	42.17	41.40			
	Class B										0.7	1.0	0.8
	Class C										0.2	0.5	0.4
	Class D										0.3	0.2	0.2
	Class E										0.4	1.7	2.0
	All										0.4	0.8	0.8

The results were compared with results obtained by Mitsubishi Electric. The conclusion is that presented results match the results of Mitsubishi Electric.

4 Experimental results on computational complexity

This section presents results on complexity of video codec with and without LIC tool. Only results for class D encoded in 'lowdelay_loco' and 'randomaccess_loco' scenarios were reported. For other cases, due to the time constraints experiments were carried out by running the number of encoders that exceeded total number of processor cores. These results would not be reliable, so were not presented in the document. Computational complexity results for class D for 'lowdelay_loco' and 'randomaccess_loco' encoder configurations were presented in Table 3.

Table 3. Complexity of TMuC codec with LIC tool.

			TMuC 0.7.1 reference, PUT				TMuC 0.7.1 + LIC, PUT				
		QPISlice	Enc T [s]	Dec T [s]	Enc T [h]		Enc T	Dec T [s]	Enc T [h]	Enc. complexity increase [%]	Dec. complexity increase [%]
Class D WQVGA	S12 BasketballPass	22	9332.72	25.80	2.59		9920.30	26.70	2.76	6.30	3.48
		27	8620.00	26.40	2.39		9253.16	25.39	2.57	7.35	-3.83
		32	8038.90	24.68	2.23		8657.63	24.64	2.40	7.70	-0.15
		37	7492.14	23.91	2.08		7997.44	24.24	2.22	6.74	1.38
	S13 BQSquare	22	10881.69	31.94	3.02		11402.28	32.11	3.17	4.78	0.54
		27	9850.29	30.66	2.74		10358.28	30.12	2.88	5.16	-1.74
		32	8841.11	28.88	2.46		9308.20	29.49	2.59	5.28	2.13
		37	7660.26	27.83	2.13		8342.11	29.13	2.32	8.90	4.66
	S14 BlowingBubbles	22	9203.23	26.72	2.56		9692.95	27.67	2.69	5.32	3.55
		27	8267.14	25.27	2.30		8707.05	26.42	2.42	5.32	4.57
		32	7332.58	24.33	2.04		7871.85	24.43	2.19	7.35	0.38
		37	6511.33	22.62	1.81		6999.84	22.32	1.94	7.50	-1.31
	S15 RaceHorses	22	6169.89	16.26	1.71		6488.33	16.57	1.80	5.16	1.90
		27	5617.93	15.42	1.56		6014.76	16.13	1.67	7.06	4.59
		32	5185.66	14.74	1.44		5492.29	14.82	1.53	5.91	0.54
		37	4780.03	14.49	1.33		5141.72	14.40	1.43	7.57	-0.62
	Average									6.46	1.25

5 Conclusions

In general, application of LIC tool in TMuC leads to increase the BD-rate Y metrics ('randomaccess_loco': 1.1; 0.4; 0.4 on average for class B, C, D respectively, 'lowdelay_loco': 0.2; 0.3; 0.4 on average for class C, D, E respectively). The obtained results match the results of Mitsubishi Electric. Application of LIC technique increases complexity of TMuC encoder by 6.5% and complexity of TMuC decoder by 1.25%.

6 Patent rights declaration(s)

Poznań University of Technology may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).

7 References

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