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Author **Krzysztof Wegner, Tomasz Grajek, Jakub Stankowski, Damian Karwowski, Krzysztof Klimaszewski, Olgierd Stankiewicz, Marek Domański**

1. Introduction

This document reports continuation of the research presented in the document M39528 (116 MPEG meeting in Changdu, China, October 2016) [1].

In M39528 we described homogenous HEVC video transcoding, which performs transrating of the source HEVC bitstream by removing (setting to zero) some of higher frequency transform coefficient(s) in the Transform Unit (TU) blocks. We also briefly described mainly used solutions for HEVC video transcoding including cascaded pixel domain transcoder (CPDT). And finally, we gave technical details of our HEVC transcoder together with a limited set of experimental results showing its performance and computational complexity.

Here we will present supplementary results of much wider experiments than those presented in M39528 document.

The aim of this document is to bring attention of MPEG experts on real possibilities of fast transrating of HEVC encoded bitstreams, and to give numerical data reflecting the complexity of the task and the expected quality loses and drift.

2. Proposed Homogenous Transcoder - survey

The main idea of the proposed transcoder (transrater) is the same as the transcoder presented in the work [3]. In the case of the cited work transcoding method was used for AVC video compression technology. In this document the idea of transcoding has been explored for the HEVC technique, for which the transcoder (transrater) removes less significant non-zero transform coefficients from the bitstream (i.e we are setting to zero some of higher frequency transform coefficient(s) in the Transform Unit). Such an approach, compared with CPDT, is much easier, with less computational power, especially when considered in the scenario of a moderate reduction of bitrate. In other words, instead of full decoding and reconstructing video samples, and then re-encoding them again, we simply remove less significant quantized transform coefficient from the source bitstream, and thus creating the target one. We are removing as many transform coefficient as it is required to meet the target bitrate.

In the presented results we are starting with the least significant transform coefficients (high frequency ones), that have been quantized to 1. Such '1' coefficients do not contribute much to the overall image quality, and their removal will not degrade image much. In previous document we presented results for the case that only ONE coefficient of value equal to 1 could be removed. In this document we extend this rule – i.e. more than one (2, 3, 4 etc.) '1' coefficients may be removed in a TU block.

Of course, the described method is not restricted to removal of those particular coefficients, but in principle, any transform coefficient, even those with larger values, can be removed, as long as its removal will not contribute much to image degradation.

For details about processing pipeline of the proposed transcoder and coefficient removing strategy, readers are encouraged to refer to our previous document M39528 [1].

3. Methodology of the experiments

For the test purposes we have implemented our method on top of HTM version 13.0. The prepared software enables the following:

1. Decoding of all syntax elements which are contained in the HEVC data stream without decompressing them and reconstructing the samples.
2. Analysis of decoded quantized transform coefficients and removal of the selected coefficients. After removing the selected coefficients the software adjusts the values of some of other syntax elements if needed (e.g. value of CBF flag must be changed when removing all non-zero transform coefficients in a TU block).
3. Entropy re-encoding of the modified set of syntax elements.

Parameters of the proposed transcoder have been evaluated when performing a series of experiments. The goal was to assess the possibility of bitrate reduction and the loss of video quality when transrating HEVC encoded bitstreams under the assumed scenario of transform coefficients removing. The experiments were performed according to "common test conditions" (CTC) [2]. Both B and C classes of test video sequences were used, which were encoded with the HM 13.0 reference software configured according to CTC. The encoding of sequences has been performed for values of QP = 20, 25, 30, 35, 40, 45, 50. The encoded data streams, obtained in this way, were then feed to transcoding, which was realized with transrating of streams.

For both the first video encoding as well as in the case of encoded bitstream transcoding we collect bitrate of the encoded data streams together with quality of the encoded material. In each case, quality of the encoded video has been expressed as a PSNR calculated between the original and reconstructed video.

To present results in a more compact way, the PSNR difference (ΔPSNR) were calculated. The ΔPSNR is defined as the difference between the quality of the transcoded video and the quality of the original material that could potentially be encoded with the use of HEVC at the same bitrate as the transcoded one (see Figure 1).

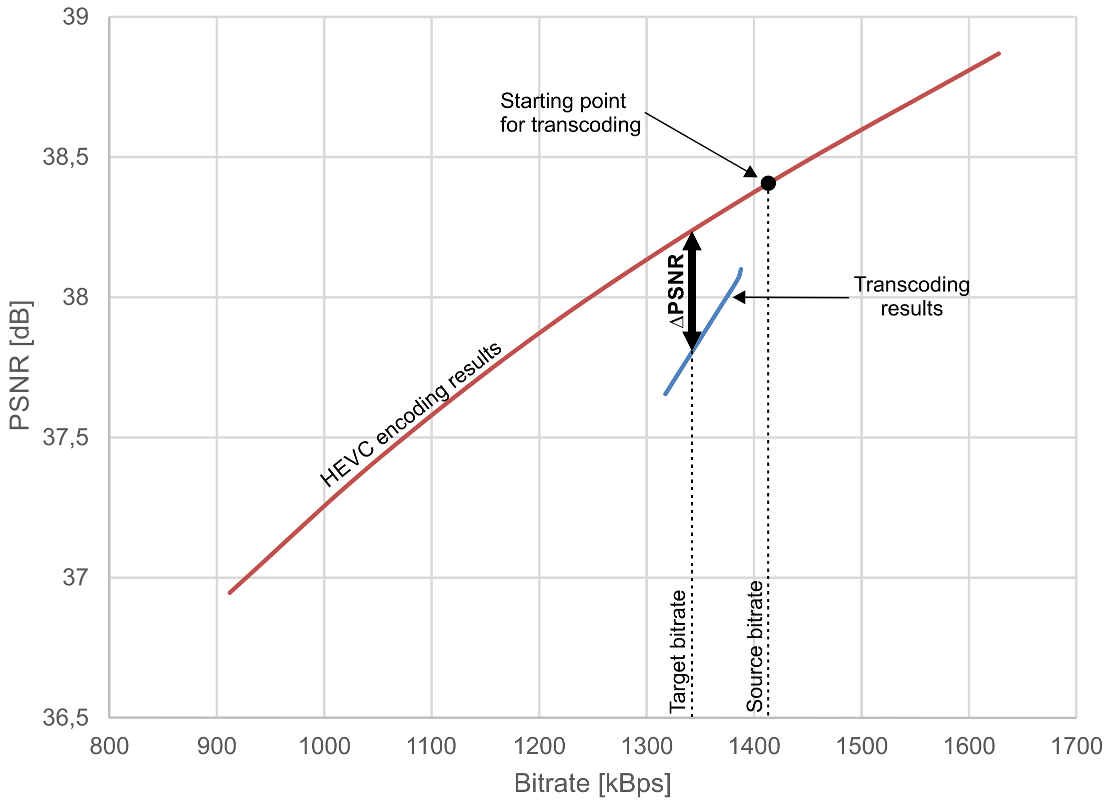


Figure 1. The way of determining ΔPSNR in the homogenous HEVC transcoder.

4. Performance of the proposed transcoder – results

In Figure 2 results for exemplary sequence has been presented. As can be seen from the results of Table 1 and Table 2, removing of up to one transform coefficient of value 1 (in each block of TU) leads to a small reduction of bitrate (1% in average) with an average loss of video quality by 0.25 dB and 0.47 dB for B and C classes respectively. Increasing number of removed ‘1’ coefficients to 2 leads to 2% bitrate reduction with quality loss about 0.27 dB and 0.50 dB for B and C classes respectively. Further increasing the number of removed ‘1’s (up to 16 in TU) results in up to 10% bitrate reduction with quality loss about 0.47 dB and 0.53 dB.

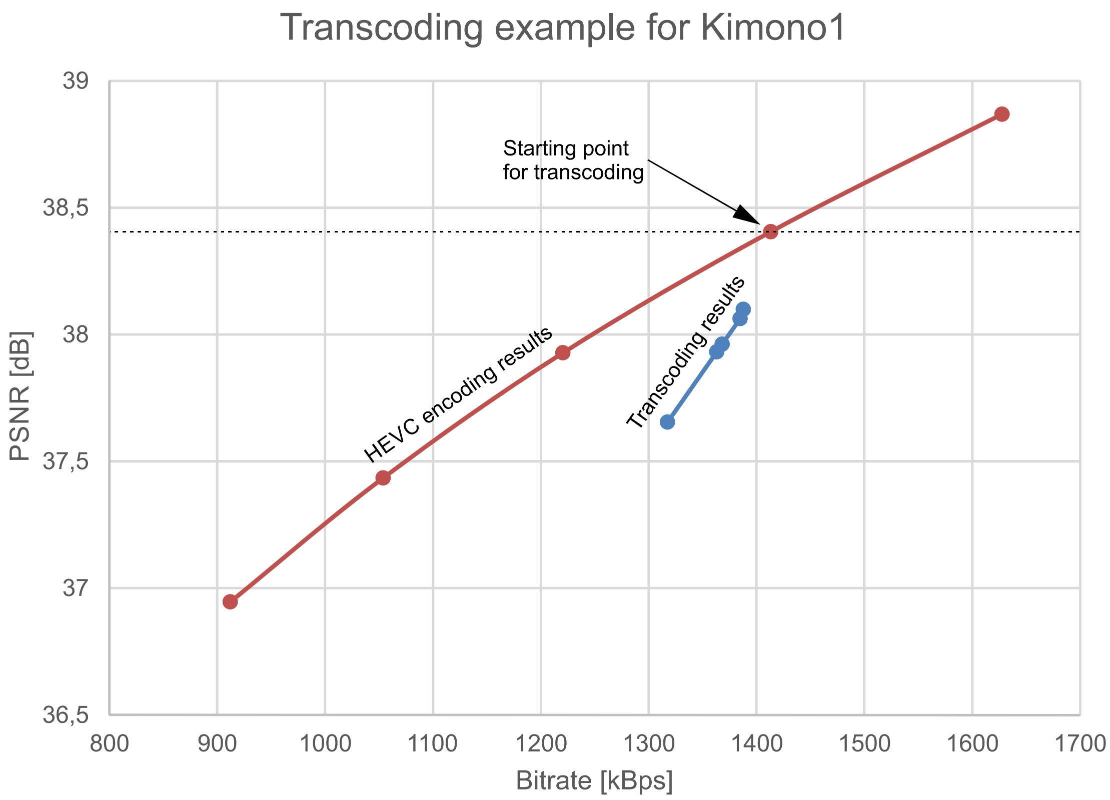
Table 1. Results of bitstreams transcoding for 5 different scenarios of removing transform coefficient of value equal to 1 within each of TU. Results for the B class of test sequences.

Sequence	QP	Bitrate ratio (Target bitrate/Source bitrate)					ΔPSNR [dB]				
		Removing up to 1 coeff	Removing up to 2 coeffs	Removing up to 3 coeffs	Removing up to 4 coeffs	Removing up to 16 coeffs	Removing up to 1 coeff	Removing up to 2 coeffs	Removing up to 3 coeffs	Removing up to 4 coeffs	Removing up to 16 coeffs
Kimono1	20	0.980	0.977	0.965	0.961	0.923	0.02	0.24	0.09	0.11	0.37
	25	0.983	0.978	0.967	0.962	0.924	1.15	1.13	1.21	3.50	1.48
	30	0.982	0.980	0.968	0.965	0.932	0.25	0.28	0.34	0.36	0.52
	35	0.983	0.981	0.971	0.968	0.946	0.49	0.51	0.56	0.57	0.68
	40	0.985	0.983	0.974	0.974	0.958	0.20	0.22	0.34	0.34	0.46
	45	0.987	0.986	0.981	0.979	0.975	0.27	0.28	0.32	0.35	0.37
	50	0.992	0.991	0.990	0.989	0.989	0.09	0.09	0.10	0.10	0.11
ParkScene	20	0.962	0.956	0.936	0.931	0.891	-0.14	-0.11	-0.07	-0.06	0.01
	25	0.974	0.969	0.957	0.954	0.931	0.03	0.05	0.08	0.09	0.15
	30	0.983	0.979	0.972	0.972	0.957	0.28	0.30	0.33	0.33	0.40
	35	0.988	0.985	0.980	0.978	0.970	1.28	-0.13	-0.11	-0.11	-0.09
	40	0.990	0.988	0.984	0.983	0.978	2.07	2.07	1.23	2.08	2.09
	45	0.991	0.990	0.987	0.986	0.983	0.15	0.15	0.16	0.16	0.17
	50	0.993	0.992	0.990	0.990	0.987	0.09	0.09	0.10	0.10	0.10
Cactus	30	0.991	0.989	0.985	0.984	0.975	0.16	0.17	0.19	0.19	0.24
	35	0.993	0.992	0.989	0.988	0.983	0.13	0.13	0.15	0.15	0.18
	40	0.994	0.993	0.991	0.990	0.987	0.28	0.28	0.30	0.30	0.36
	45	0.995	0.994	0.993	0.993	0.991	0.10	0.11	0.11	0.11	0.12
	50	0.996	0.996	0.995	0.995	0.995	0.07	0.07	0.08	0.08	0.08
BQTerrace	20	0.967	0.957	0.935	0.923	0.825	0.22	0.13	0.58	0.46	0.95
	25	0.949	0.933	0.907	0.893	0.818	-0.22	-0.18	1.07	-0.06	0.13
	30	0.967	0.957	0.944	0.938	0.913	0.31	0.66	0.69	0.40	0.69
	35	0.987	0.983	0.978	0.978	0.967	0.24	0.25	0.26	0.26	0.29
	40	0.993	0.991	0.989	0.987	0.983	0.16	0.17	0.18	0.18	0.19
	45	0.995	0.993	0.991	0.990	0.988	0.04	0.05	0.06	0.06	0.06
	50	0.996	0.995	0.994	0.993	0.992	0.21	0.21	0.21	0.22	0.22
Basketball Drive	20	0.986	0.981	0.973	0.969	0.947	0.02	0.04	0.06	0.07	0.40
	25	0.991	0.988	0.984	0.984	0.969	-0.09	-0.10	-0.08	-0.08	0.03
	30	0.994	0.992	0.989	0.987	0.980	0.46	-0.03	0.00	0.00	0.05
	35	0.995	0.993	0.991	0.990	0.986	0.17	0.18	0.26	0.27	0.22
	40	0.996	0.995	0.993	0.992	0.989	0.09	0.10	0.11	0.13	0.31
	45	0.997	0.995	0.994	0.994	0.992	0.25	0.26	0.27	0.27	0.29
	50	0.998	0.997	0.997	0.997	0.995	0.20	0.20	0.21	0.21	0.21

Table 2. Results of bitstreams transcoding for 5 different scenarios of removing transform coefficient of value equal to 1 within each of TU. Results for the C class of test sequences.

Sequence	QP	Bitrate ratio (Target bitrate/Source bitrate)					ΔPSNR [dB]				
		Removing up to 1 coeff	Removing up to 2 coeffs	Removing up to 3 coeffs	Removing up to 4 coeffs	Removing up to 16 coeffs	Removing up to 1 coeff	Removing up to 2 coeffs	Removing up to 3 coeffs	Removing up to 4 coeffs	Removing up to 16 coeffs
RaceHorse	20	0.981	0.981	0.968	0.965	0.938	0.27	0.29	0.43	0.45	0.63
	25	0.987	0.985	0.978	0.976	0.963	3.53	0.90	1.20	0.96	1.35
	30	0.994	0.993	0.990	0.990	0.986	0.06	0.07	0.09	0.09	0.11
	35	0.996	0.995	0.994	0.994	0.992	1.05	0.10	1.06	1.06	1.07
	40	0.997	0.997	0.996	0.996	0.995	0.03	0.03	0.04	0.04	0.04
	45	0.998	0.997	0.997	0.997	0.996	0.07	0.07	0.07	0.07	0.08
	50	0.998	0.997	0.997	0.997	0.996	0.03	0.04	0.04	0.04	0.05
BQMail	20	0.972	0.968	0.954	0.950	0.925	1.58	1.71	2.47	0.65	2.48
	25	0.983	0.980	0.973	0.971	0.959	0.16	0.18	0.23	0.25	0.32
	30	0.990	0.988	0.985	0.985	0.978	0.03	0.05	0.07	0.07	0.30
	35	0.994	0.993	0.991	0.990	0.987	0.10	0.11	0.12	0.13	0.15
	40	0.996	0.995	0.994	0.993	0.991	0.74	0.93	0.93	0.77	0.95
	45	0.996	0.995	0.994	0.994	0.992	0.10	0.11	0.12	0.12	0.13
	50	0.996	0.995	0.994	0.994	0.992	0.17	0.18	0.19	0.20	0.20
PartyScene	20	0.955	0.949	0.920	0.920	0.859	0.89	0.94	1.29	1.29	1.56
	25	0.970	0.965	0.947	0.942	0.914	0.39	0.44	0.60	0.63	0.80
	30	0.980	0.977	0.968	0.965	0.954	0.18	0.20	0.26	0.28	0.34
	35	0.988	0.986	0.981	0.980	0.975	1.19	1.18	1.22	1.15	1.25
	40	0.993	0.992	0.990	0.989	0.985	0.02	0.03	0.03	0.03	0.03
	45	0.995	0.994	0.992	0.992	0.989	0.68	0.68	0.68	0.68	0.06
	50	0.995	0.995	0.993	0.993	0.991	0.02	0.03	0.03	0.03	0.03
BasketballDrill	20	0.983	0.980	0.971	0.969	0.953	0.17	0.61	0.75	0.30	0.99
	25	0.989	0.988	0.983	0.981	0.974	0.06	0.08	0.11	0.21	0.17
	30	0.993	0.992	0.989	0.988	0.984	1.14	1.16	1.20	1.18	1.10
	35	0.995	0.994	0.992	0.992	0.990	0.27	0.27	0.28	0.28	0.29
	40	0.997	0.996	0.995	0.995	0.994	0.07	0.07	0.07	0.08	0.08
	45	0.998	0.997	0.996	0.996	0.996	0.11	0.11	0.12	0.12	0.12
	50	0.998	0.997	0.997	0.996	0.996	0.05	0.05	0.06	0.06	0.06

Figure 2. Transcoding results for exemplary sequence.



5. Conclusions

Removing of selected non-zero transform coefficients in HEVC enables low or moderate bitrate reduction of encoded data stream under reasonable loss of video quality. Comparing to CPDT transcoder the proposed transcoder is characterized by significantly lower computational complexity due to performing the following steps only:

1. Entropy decoding of syntax elements contained in the encoded data stream.
2. Analysis of decoded transform coefficients and removal of selected ones. Control of the correctness of values of all the syntax elements.
3. Entropy coding of the modified set of syntax elements.

In the next stage of our research we will investigate possibility of removing coefficients with magnitude greater than 1 and introduce the adaptability of the algorithm in order to adjust coefficients removing strategy to the encoded video.

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6. References

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