High Efficient Video Coding (HEVC) performance analysis for different configurations in main profile

Zoran M. Miličević, Zoran S. Bojković

***Abstract*—**This paper seeks to provide performance analysis for High Efficient Video Coding (HEVC) HM-16.6 reference coder for different resolution test sequences and picture structures. Two test sequences (resolutions) i.e., PeopleonStreet (2560x1600) and ParkScene (1920x1080) are considered. The HEVC coder is tested for the fixed Quantization Parameter (QP) value in intra, lowdelay and randomaccess configurations, with Main profile when I, P and B pictures are processed in I and IBBB formats, respectively. Two different configurations *encoder_intra_main* and *encoder_randomacces_main* are tested. Comparisons were performed with respect to the change of Signal-to-Noise Ratio (SNR), the change of data bit-rate and the change of encoding time saving, respectively. Simulation results have shown differences in SNR values for luma component of picture. Beside objective results, subjective video assessments for all tested sequences are presented, too.

***Keywords*—**Bit-rate, encoding time saving, HEVC test model (HM), signal-to-noise ratio (SNR).

I. Introduction

To cope with growing market demands for higher video resolution and a dominance video content in the Internet traffic that lead to increased bandwidth demands and data storage requirements, H.264/Advanced Video Coding (AVC) and High Efficient Video Coding (HEVC) standards are based on advanced methods to achieve higher compression rate, while retaining required video quality. Due to an increasing in computing complexity, this compression efficiency is hard to be achieved in real time. In the H.264/AVC standard [1], the current frame is divided into multiple 16x16 (pixel) macroblocks (MBs) which are encoded using either intra or inter-prediction mode. HEVC is developed by Joint Collaborative Team of Video Coding (JCT-VC) which has been jointly established by ISO/IEC Motion Picture Expert Group (MPEG) and ITU-T Video Coding Expert Group (VCEG). The high-level syntax architecture used in H.264/AVC standard has generally been retained, while including the following features [2]: Parameter set structure, network abstraction layer (NAL) unit syntax structure, slices, supplemental enhancement information (SEI) and video usability information (VUI) metadata. Three new features (tiles, wavefront parallel processing and dependent slice segments) are introduced in the HEVC standard to enhance the parallel processing capability or modify the structuring of slice data for the purposes of packetization.

The main goal of the HEVC standard is to significantly improve the compression ration up to 50% compared to earlier techniques such as H.264/AVC. In other words, HEVC can support up to 50% bit-rate reduction for equal perceptual video quality. The scope of the standard includes defining the semantic meaning of the syntax elements and a decoding process.

While maintaining the coding efficiency of HEVC, it is desirable to optimize the encoding process for computational complexity reduction. HEVC employs a coding unit (CU), prediction unit (PU) and transform unit based on the quadtree coding tree unit (CTU) structure to improve coding efficiency. The computational complexity increases quality because the rate distortion optimization process should be performed for all CUs, PUs and TUs to obtain the optimal CTU portion. The quadtree structure coding unit (CU) is adopted in HEVC.

The main steps of HEVC technical development are organized in the following time-line phases:

- The HEVC first base specification finalized in 2013.
- Format range extension (RExt), Scalable video coding (SHVC) and Multi-view video coding (MV-HEVC) extensions finalized in 2014.
- 3D video coding (3D-HEVC) extension finalized in 2015.
- Screen Content Coding (SCC) extensions will be included in the fourth version of HEVC, while it is expected to be finalized in 2016.

The first tree developments mainly targeted compression performance for consumer and professional uses, SHVC and MV/3D video coding have provided additional functionality such as variable-rate access at the bitstream level and support for multiple camera inputs in combination with efficient compression. After finalization of HEVC base specification, JCT-VC continued to work on extensions.

Format Range Extension (RExt) provides tools to support 4:0:0, 4:2:2 and 4:4:4 color spaces and additional bit depth. RExt is included in the second version of HEVC, which has been finalized in October 2014. Already during the initial phase of HEVC, multi-layer extensions were planned and the

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proper hooks were included into the base specification. The scalability extension of HEVC (SHEVC) provides support for spatial, SNR and color gamut scalability. It has been designed as a high-level syntax only extension to allow reuse of existing decoder components. SHVC is included in the second version of HEVC. The JCT-3V was established to work on multiview and 3D video coding extensions of HEVC and other video coding standards. The multiview extension of HEVC (MV-HEVC) provides support for coding multiple views with inter-layer prediction. It was designed as a high-level syntax only extension to allow reuse of existing decoder components. The 3D extension of HEVC (3D-HEVC) provides increased coding efficiency by joint coding of texture and depth for advanced 3D displays. 3D-HEVC is included in the third version of HEVC.

II. HEVC Test Model (HM)

During the HEVC standardization process, the JCT-VC also developed a reference Software HEVC test model (HM). The aim of the reference software was to provide a basis upon which to conduct experiments in order to determine coding performance. In HM, pictures are first divided into slices, while slices are divided into sequence of treeblocks. A treeblock is a square block (64x64 pixels) of luma samples together with two corresponding blocks of chroma samples. The coding unit (CU) is a basic unit of the splitting region used for inter/intra predictions. The CU concept allows treeblock recursive splitting into four equally sized blocks. This process generates a content-adaptive coding tree structure comprised of CU that may be as large as a tree block as small as 8x8 pixels. The prediction (PU) is the basic unit used for caring the information related to the prediction processes. During the HEVC standardization, the HEVC test model reference software adopted same fast encoding algorithm [3]-[5].

III. Experimental Results and Discussion

In an attempt to continue with performance of different versions HM test model software during different test conditions [6], [7], experimental results will be presented for HEVC HM-16.6 encoder. Experiments are conducted under the following conditions. First of all, different configurations in Main profile were used. Then, two values of Levels: 4.0 and 5.0, I pictures, hierarchical B pictures, period of I-pictures: only first, Hadamard transform was used, MV search range was 64, sample adaptive offset (SAO), asymmetric motion partitions (AMP) and rate-distortion-optimized quantization (RDOQ) were enabled, too. Also, Group of Picture (GOP) with length 1, 4 and 8 in I, as well as IBBB format was used. Experiments were carried out on the tested sequences with fixed quantization parameter value 32, because it is approximately average value in reference software setup configuration.

Two different configurations are tested as follows: *encoder_intra_main* and *encoder_randomacces_main*. All processed configurations adopt to Main profile.

In the experiments two test sequences with different resolution and frame rates are selected. The first 50 frames of test sequences ParkScene and PeopleOnStreet were used. ParkScene in Full High Definition (full HD) resolution (1920x1080 pixels) belongs to class B, while the test sequence PeopleOnStreet in resolution 2560x1600 pixels belongs to class A. All the test videos are in YUV 4:2:0 format and progressive. Also, signal-to-noise ratio (SNR) values for all component of pictures luma (Y) and both croma (Cb and Cr) are measured. The results of SNR are represented only for Y because human visual system is more sensitive to luma then to chroma components of pictures. Comparisons were performed with respect to the change of Signal-to-Noise Ratio (SNR), the change of data bit-rate (Bit-rate), and the change of encoding time saving (Time), respectively.

Table I shows, based on our own simulation results, the performance of the reference codec for all tested configurations when I and B pictures were processed in I format and IBBB format, respectively, for QP=32, as previously stated.

Table I: Experimental results when HM-16.6 is tested in Main profile and different picture formats.

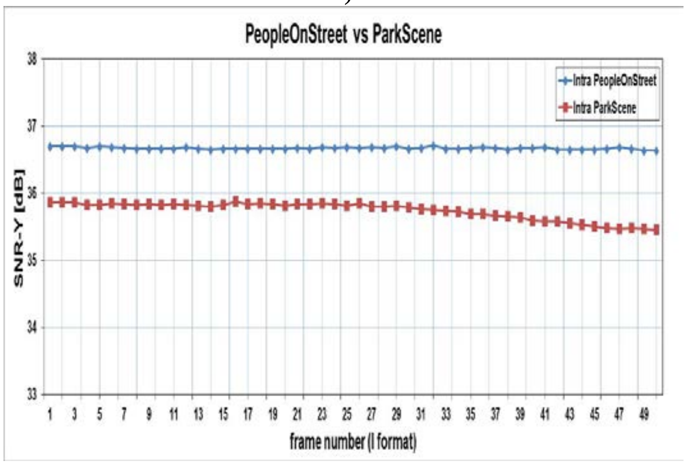
Test sequences (resolution)	Profile	SNR-Y (dB)	Bit-rate (kbps)	Time saving (sec)
	Main			
PeopleOnStreet (2560x1600)	Intra	36,68	34344,13	2812,88
	Randomaccess	34,26	8423,94	9832,52
ParkScene (1920x1080)	Intra	35,74	14154,24	1401,00
	Randomaccess	34,94	1591,61	4218,83
Results	Intra	2,55	58,79	50,19
	Randomaccess	-1,99	81,11	57,09

For both test sequences there are similar values of the SNR for luma component of picture by HEVC codec. Small difference is only for intra configuration for test sequence PeopleOnStreet.

On the other hand, when both test sequences are tested and compared in different configurations and picture formats, bits rate of test sequence PeopleOnStreet is increased approximately 59% for the intra configuration, while for the randomaccess configurations it is little bit over 81%. However, the encoding time saving is increased 50% for the intra configuration in comparison with ParkScene test sequence. Also, for the randomaccess it is 57%.

SNR curves for PeopleOnStreet vs ParkScene test sequences are depicted in Fig. 1 (A and B). The SNR-YUV is plotted as a function of the frame number for all tested configurations in different picture formats. For both processed test sequences, SNR shows on objective way similarity.

A)



B)

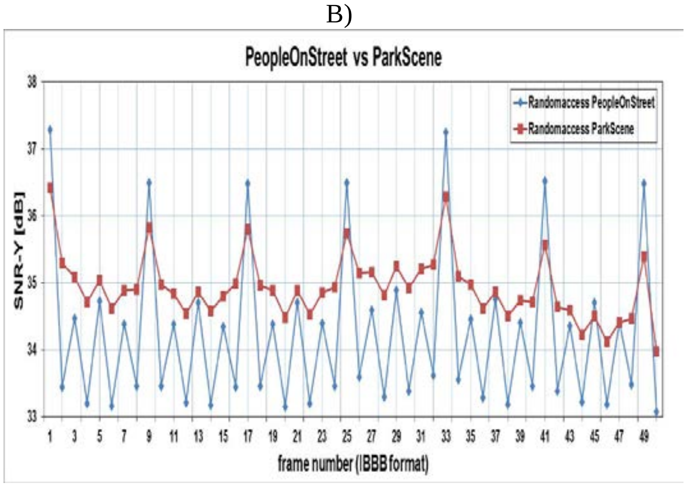
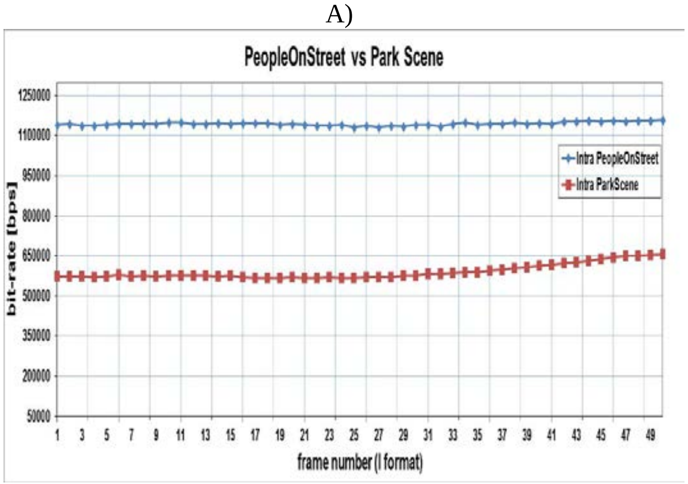


Fig. 1. SNR curves for PeopleOnStreet vs. ParkScene test sequences when different configurations in different picture formats are processed in HM-16.6 reference software.

Bit-rate savings curves for both typical tested sequences are depicted in Fig. 2 (A and B) and for the intra and randomaccess configurations, respectively. There exist the bit rate differences between all the HEVC tested configurations and picture formats, as well as bit-rate trends, as it has been shown in Table 1.

A)



B)

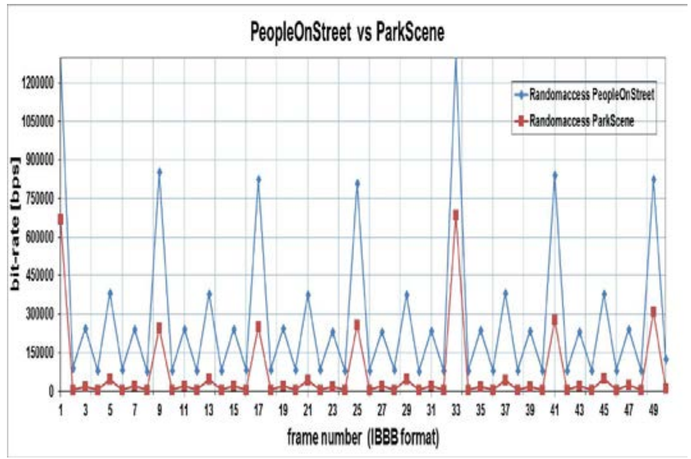


Fig. 2. Bit-rate curves for PeopleOnStreet vs. ParkScene test sequences when different configurations (intra and randomaccess) in different picture formats are processed in HM-16.6 reference software.

Beside objective analysis the potential of HEVC engine for two different resolution test sequences, it is necessary to analysis subjective video quality, too. Fig. 3 (A and B) shows HEVC HM-16.6 in all HEVC tested configurations and picture formats for subjective video assessment, when both test sequences processed by YUV player, respectively.

A)

B)

Fig. 3. HEVC subjective video assessment for PeopleOnStreet and ParkScene test sequence when different configurations in different picture formats are processed in HM-16.6 reference software.

IV. Conclusion

From the experimental results, the following observations are provided. HEVC standard HM-16.6 in intra and randomaccess configurations of encoder have many challenges when SNR, bit-rate and encoding time saving are measured for different resolution test sequences when I and B pictures were used in I and IBBB format, respectively, for QP=32. For both test sequences (resolutions): PeopleonStreet (2500x1600) and ParkScene (1920x1080), there are similar values of SNR. Small difference is only for intra configuration for test sequence PeopleonStreet. Bit-rate of test sequence People on Street is increased approximately 59% for intra configuration, while for random access configurations it is 81%. As for the encoding time saving, it is increased 50% for the intra configuration in comparison with ParkScene test sequence. For the random access it is 57%.

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