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Influence of Bit Depth on Objective Video Quality Assessment for High Resolutions

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Abstract

This paper deals with the influence of bit depth on the objective quality assessment. All tests were conducted on eight video sequences, while each one has different spatial and temporal information; 8-bit and 10-bit bit depths were used; analysed videos were in full and ultra HD resolutions, and coding efficiency of H.264 and H.265 was compared. The metrics PSNR and SSIM for evaluation of objective video quality were used.

Keywords: bit depth, H.264/AVC, H.265/HEVC, objective assessment, PSNR, SSIM

1. Introduction

In recent years, the level of video multimedia services has increased rapidly. This evolution was allowed by increase of bandwidth of communication networks. Despite the fact that the capacity of certain network access technologies is up to hundreds or thousands of megabits per second (depending on the type of technology), the video compression is still hot and a current topic.

The rest of the paper is divided as follows. In the first part, the short characteristic of H.264 and H.265 compression standards is written. The second part describes briefly objective metrics used in our experiments. In the last part, the measurements and experimental results are described.

2. State of the art

Even if in papers [1–3] the coding efficiency comparison of well-known and most used compression standards as H.264/AVC, H.265/HEVC and VP9 using objective metrics has been

researched, in this paper, only sequences in HD and full HD resolutions were compared, objective quality assessment for ultra HD resolution was missing. In papers [4–8], the objective quality assessment of the newest compression standards as H.265/HEVC and VP9 has been examined, but the reference and still the most used compression standard H.264 was not taken into account. In papers [9–11], only the quality of multimedia services has been explored. In all mentioned papers [1–11], the influence of bit depth for objective quality assessment was not analysed. Therefore the aim of this paper is to determine coding efficiency of H.264 and H.265 compression standards for FHD and UHD resolutions depending on content of sequence and 8- and 10-bit bit depth using objective metrics.

3. H.264/AVC and H.265/HEVC compression standards

H.264/AVC is still one of the most used compression standards. It has been developed and designed for a wide range of multimedia services and video applications. The range of use is from video for cell phones through web applications to TV broadcasting (HDTV). H.264/AVC also defines profiles and levels, but only three profiles are currently defined: baseline, main and extended [12].

The High Efficiency Video Coding known as HEVC/H.265 is a recent video project of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) standardization organizations, and this collaboration is known as the Joint Collaborative Team on Video Coding (JCT-VC). H.265 has been developed in January 2013, and it is direct successor to H.264/AVC standards. The basic structure stays the same like as in H.264; it contains many incremental improvements which make him more effective [13].

4. Objective video quality assessment methods

The video quality assessment is commonly divided into the two groups—objective and subjective assessments.

The subjective evaluation is based on assessments by the observers—assessors score the video quality in appropriate scale. An advantage of this way is the result accuracy (determine exactly end recipient of video information); drawbacks of this method are that it is very time-consuming and for evaluation, many people are needed (in accordance with ITU-R BT.500-13, minimum of 15 observers for each test are needed).

Vice versa, the objective quality assessment is executed by computers that allow quick evaluation in all the time, and it is not limited by the assessment duration and times of repetition. From the mentioned reason, the objective assessment is mainly used. It consists of the use of computational methods which produce values that score the video quality. The big advantage of this type of assessment is the repeatability. Nowadays many objective metrics exist. Mostly used are peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM).
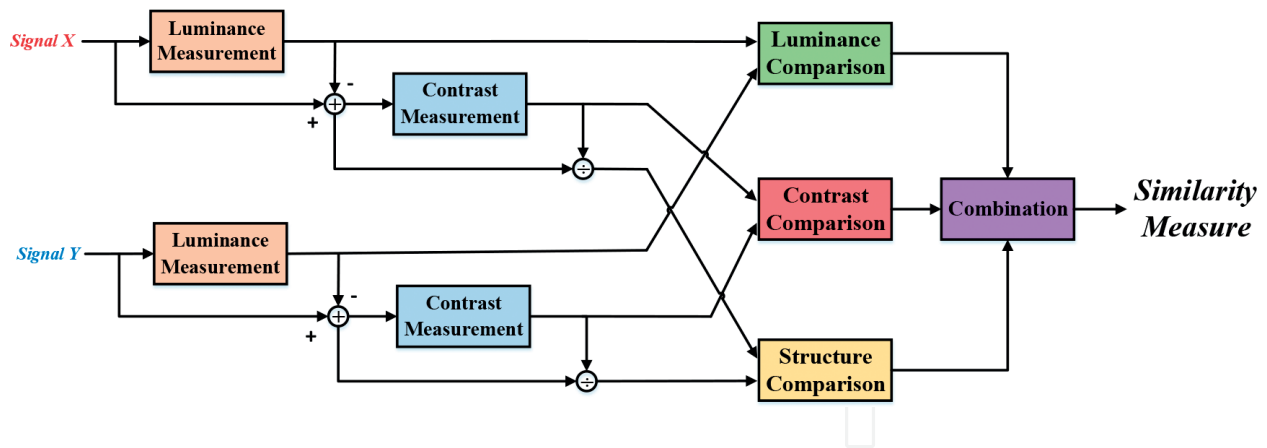
Figure 1. Block diagram of SSIM metric.

The PSNR is the oldest objective metric and considering its simplicity and computing speed still one of the most used. It is defined in [14]. The PSNR belongs to pixel-based metrics. The value of PSNR is derived from mean square error (MSE) and defined as:

$$\text{PSNR} = 10 \cdot \log\frac{I^2}{\text{MSE}} = 10 \cdot \log\frac{I^2}{\left(\frac{1}{TXY}\sum_t\sum_x\sum_y [x_0(x,y,t) - x_r(x,y,t)]^2\right)}[\text{dB}],$$

where x_0 and x_r are two consecutive frames of sequence, $X.Y$ is the size of frame in pixels, T is the count of frames in the sequence and I is maximum value that a pixel can take. The value I is defined by bit depth as follows:

$$I = 2^b - 1,$$

where b is the bit depth.

The SSIM metric uses the structural distortion measurement instead of the error one. It measures three components—the luminance, the contrast and the structural similarity—and combines them into one final value which determines the quality of the test sequence (**Figure 1**).

SSIM metric reaches a very good correlation with subjective perception [15]. The results are given in interval [0-1] where 0 represents the worst and 1 the best quality.

5. Measurement procedure

In this experiment, eight video test sequences are used. The sequences are part of database [16]. The next paragraphs contain short description of used sequences.

- **Bund nightscape**—city night shot. The scene is time lapsed; the dynamic segments of scene are moving cars and walkers on the curb; static segments are represented by urban buildings. The camera captures scene from static position (**Figure 2**).

- **Campfire party**—night scene close the fire. In the front of the image, there is flaming bonfire (the fast change of temporal and luminance information). In the background of the image, there is a group of slightly static people. At the end of the sequence, the camera zooms on the group of people (**Figure 3**).

- **Construction field**—shot on the construction site, where the static background is represented by buildings under construction, dynamic objects are represented by construction vehicles (excavator) and walking workers. The slow-motion scene is captured statically (**Figure 4**).

- **Fountains**—the daily shot on the city fountain. The foreground consists of squirting water (a lot of edges in the picture); the background is static formed by trees and the buildings. The capturing is static, scene with low dynamic of motion (**Figure 5**).

- **Marathon**—marathon competition. The runners are multiple moving objects with moderate dynamic; the background is a static road. The camera capturing is static from high point of view (**Figure 6**).

- **Runners**—the running challenge, but in contrast to "marathon scene", there are fewer runners. The camera is static, located in the front of the runners slightly angled to the side (higher spatial information). Scene is relatively dynamic (**Figure 7**).

- **Tall buildings**—the shot on the modern city. The static objects are skyscrapers, river and the urban infrastructure; the slow-motion objects are represented by city traffic. The camera is moving slowly form the left to the right side. The scene is characteristic with the change of spatial and temporal information (**Figure 8**).

- **Wood**—the forest scenery. The shot on the trees in the forest (captured objects are static). The motion of the camera is from the left to the right side, and the motion is accelerating in the sequence. Relatively high value of the spatial and temporal information (**Figure 9**).
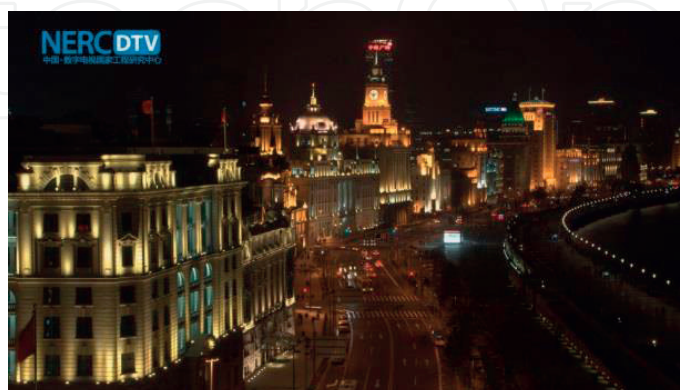
Figure 2. Bund nightscape.

Figure 3. Campfire party.

Figure 4. Construction field.

Figure 5. Fountains.

Generally, the compression difficulty is directly related to the spatial and temporal informa-
tion of a sequence. Regarding [17], the spatial information (SI) and temporal information (TI)
using the Mitsu tool [18] was calculated. According to results the spatial-temporal informa-
tion plane was drawn (**Figure 10**).

Figure 6. Marathon.
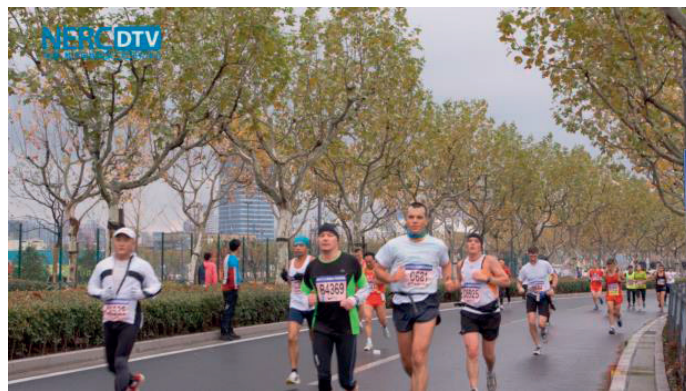

Figure 7. Runners.

Figure 8. Tall buildings.

According to [17], eight test sequences were used in a test.

All sequences were uncompressed in *.yuv format, in UHD resolution (3840 × 2160 px). The aspect ratio of all sequence was 16:9, framerate was 30fps (frames per second) and used chroma subsampling was 4:4:4. The length of these sequences was 300 frames, that is, 10 s.
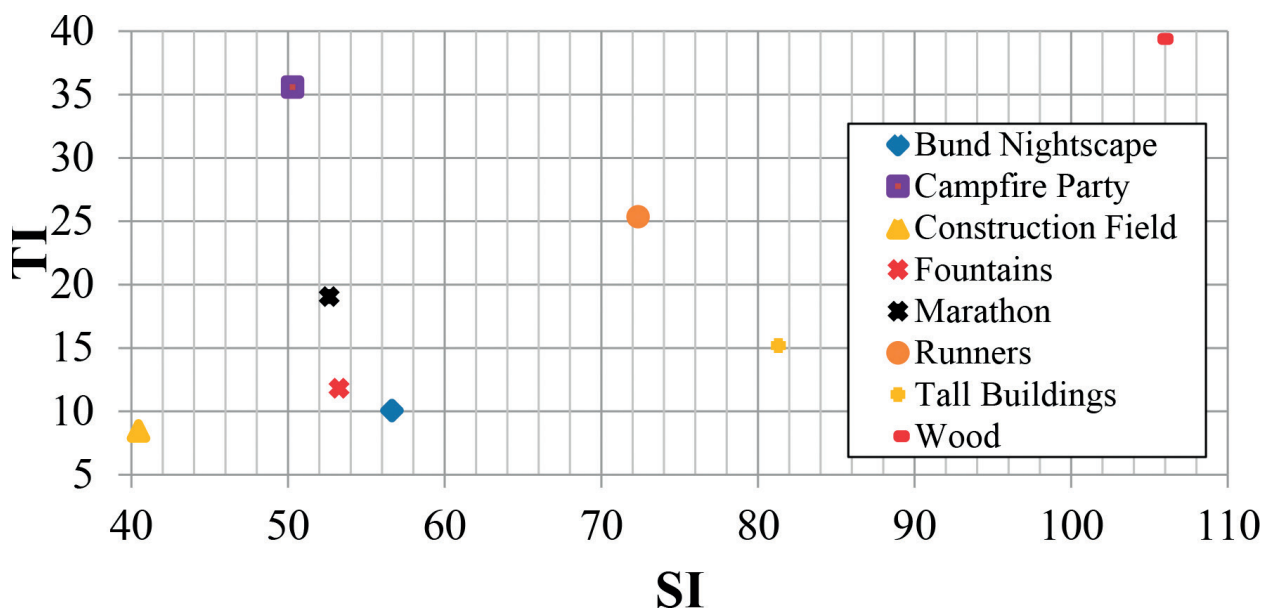
Figure 9. Wood.

Figure 10. Spatial-temporal information of test sequences.

The measurement procedure consists of four steps:

1. First, all sequences were downloaded from [16] in the uncompressed format (*.yuv) and used as the reference ones.

2. Afterwards, they were encoded to both H.264/AVC and H.265/HEVC compression standards using the FFmpeg and x264/x265 tool [19–21]. The target bitrates were 1, 3, 5, 10 and 15 Mbps; bit depth 8 and 10 bits for FHD and UHD, chroma subsampling 4:2:0 were used. GOP size was set to M = 3 and N = 15.

3. Then, the sequences were decoded using the same tool back to the format *.yuv.

4. Finally, the quality between these sequences and the reference (uncompressed) one was compared and evaluated. This was done using the MSU Measuring Tool Pro version 3.0 [22]. PSNR and SSIM objective metrics for the measurements were used.
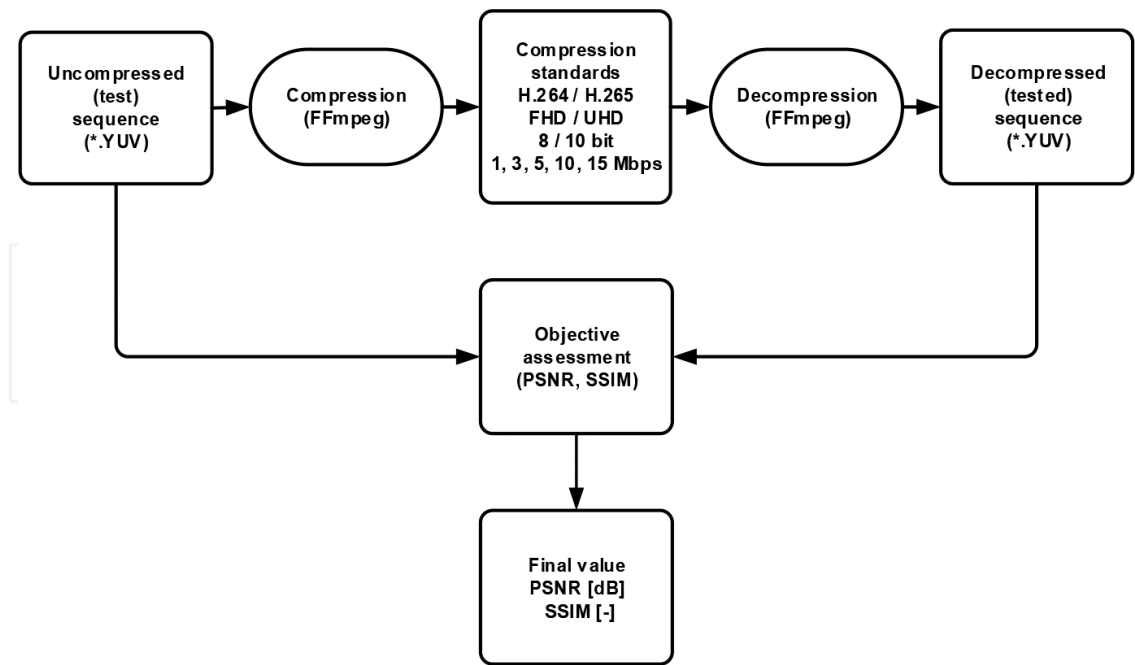
Figure 11. The whole procedure of measurement and evaluation the impact of both compression standards on the video quality.

The whole procedure of measurement and evaluation is represented in **Figure 11**.

6. Experimental results

All experiments using eight abovementioned video test sequences with different codecs, video resolutions, bitrates and bit depths were performed. The list of all parameters is in **Table 1**.

For every combination of test parameters, the value of PSNR and SSIM was computed. The obtained dataset consists of 320 values of PSNR and SSIM. Because the obtained number of results is massive, only the presented parameters are published:

- The **PSNR** difference between H.264 and 265 codec: $PSNR_{H.265} - PSNR_{H.264}$
- The **relative** SSIM difference between H.264 and 265 codec: $\dfrac{SSIM_{H.265} - SSIM_{H.264}}{SSIM_{H.264}}$
- The **PSNR** difference between 10- and 8-bit bit depth: $PSNR_{10bit} - PSNR_{8bit}$
- The **relative** SSIM difference between 10- and 8-bit bit depth: $\dfrac{SSIM_{10bit} - SSIM_{8bit}}{SSIM_{8bit}}$

In the first part, the **full HD** video sequences were analysed.

Tables 2–5 and **Figure 13** show the difference between codecs. The last column of tables contains average values computed for specific bitrate. **Figure 12** shows coding efficiency comparison of H.264 and H.265 in full HD with 8-bit bit depth (left) and with 10-bit bit depth (right).

Parameter	Values
Video test sequence	Bund nightscape, Campfire party, Construction field, Fountains, Marathon, Runners, Tall buildings, Wood
Codec	H.264, H.265
Video resolution	Full HD (FDH), ultra HD (UHD)
Bitrate (Mbps)	1, 3, 5, 10, 15
Bit depth (bit)	8, 10

Table 1. The list of parameter settings of performed experiments.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	1.54	2.67	1.89	0.85	1.55	1.46	2.21	1.91	1.76
3	1.36	1.58	1.64	0.41	0.84	0.99	1.84	1.29	1.24
5	1.22	1.20	1.30	0.28	0.64	0.80	1.59	1.04	1.01
10	1.07	0.92	0.99	0.13	0.40	0.45	1.29	0.87	0.77
15	0.86	0.78	0.97	0.06	0.29	0.31	1.20	0.77	0.66

Table 2. PSNR difference between H.264 and 265 codecs for FHD and 8-bit bit depth.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	1.45	5.47	3.19	3.19	5.87	13.78	9.24	8.13	1.45
3	0.44	2.58	0.93	1.18	1.22	2.76	2.52	1.78	0.44
5	0.25	1.44	0.50	0.85	0.55	1.16	1.12	0.71	0.25
10	0.27	0.78	0.30	0.47	0.18	0.24	0.35	0.15	0.27
15	0.17	0.57	0.29	0.31	0.14	0.07	0.25	0.07	0.17

Table 3. Relative SSIM difference between H.264 and 265 codecs for FHD and 8-bit bit depth.

The relative SSIM difference between H.264 and H.265 compression standard is more significant for low bitrates in full HD resolution (**Figure 13**). For 8-bit bit depth, the value is very close for bitrates 10 Mbps and higher. If the 10-bit bit depth is used, the value of relative SSIM is different for scenes Fountains and Campfire Party for bitrate 5 Mbps and higher. The trend of relative SSIM is similar for 8- and 10-bit bit depth, but the values for 8-bit bit depth are slightly higher for lower bitrates.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	1.82	2.32	1.65	0.71	1.87	1.48	2.09	1.94	1.73
3	1.74	2.00	1.39	0.79	1.14	0.99	2.10	1.77	1.49
5	1.60	1.72	1.14	0.82	0.93	0.83	1.85	1.64	1.32
10	1.32	1.43	0.78	0.61	0.58	0.60	1.49	1.40	1.03
15	0.99	1.19	0.73	0.64	0.44	0.47	1.36	1.33	0.89

Table 4. PSNR difference between H.264 and 265 codecs for FHD and 10-bit bit depth.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	1.47	5.93	2.64	2.45	7.81	12.19	8.35	8.03	1.47
3	0.48	3.69	0.71	1.99	1.68	2.32	2.64	2.28	0.48
5	0.28	2.33	0.37	1.81	0.85	1.03	1.22	1.12	0.28
10	0.14	1.22	0.14	1.46	0.26	0.30	0.42	0.36	0.14
15	0.10	0.78	0.13	1.30	0.16	0.14	0.24	0.18	0.10

Table 5. Relative SSIM difference between H.264 and 265 codecs for FHD and 10-bit bit depth.
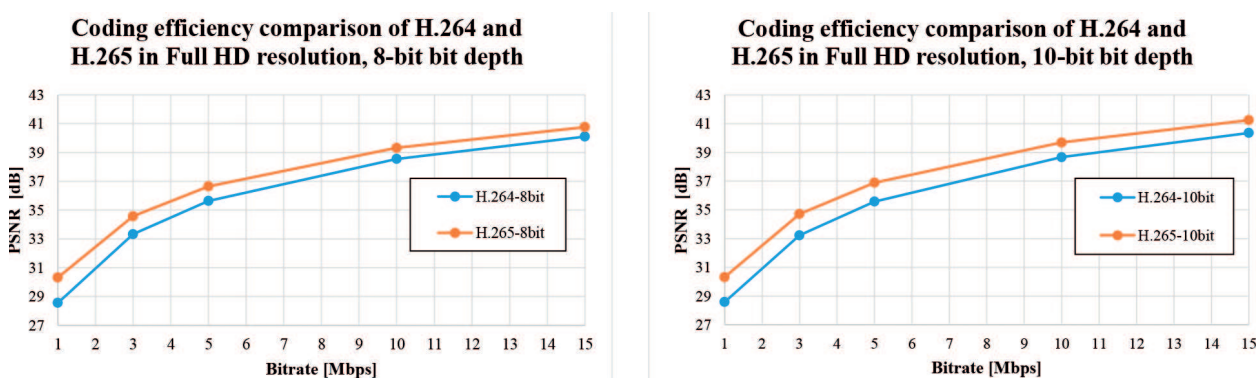
Figure 12. Coding performance comparison of H.264 and H.265 for full HD resolution, 8- and 10-bit bit depth (PSNR metric).

Tables 6–9 show the metrics for different bitrates and scenes. **Tables 6** and **8** show results for codec H.264 and **Tables 7** and **9** for H.265, respectively. The positive values in the table are marked with red colour. The positive value indicates that 10-bit bit depth outperforms 8-bit bit depth in FHD video sequence.
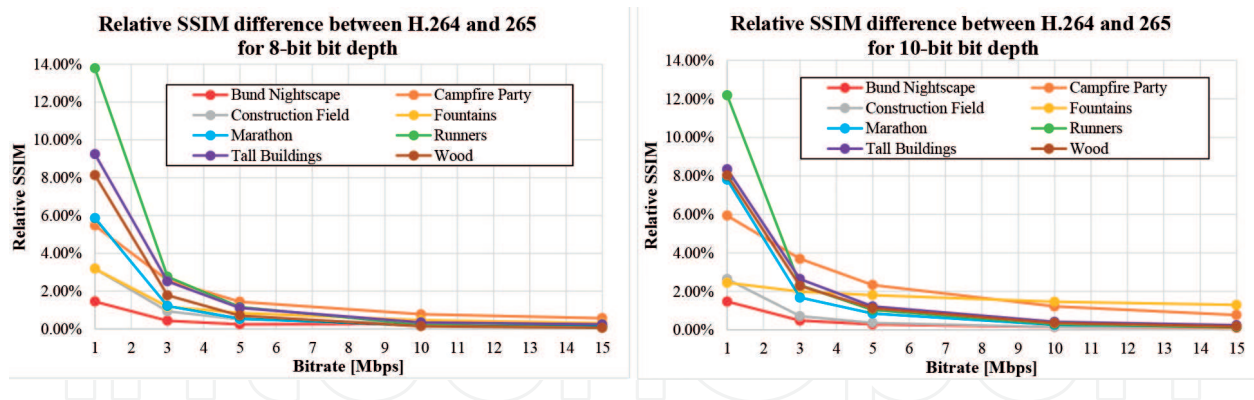
Figure 13. Relative SSIM difference between H.264 and H.265 compression standards for 8-bit (left) and 10-bit bit depth (right) in FHD.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	−0.36	0.22	0.21	0.39	−0.29	0.03	0.05	−0.07	0.02
3	−0.26	−0.43	0.38	−0.01	−0.08	0.08	−0.08	−0.40	−0.10
5	−0.04	−0.34	0.55	−0.12	−0.03	0.03	−0.02	−0.46	−0.05
10	0.62	−0.24	0.86	−0.05	0.00	−0.02	0.09	−0.30	0.12
15	1.17	−0.07	1.02	−0.16	0.07	0.03	0.21	−0.22	0.26

Note: The 10-bit bit depth outperforms 8-bit only 17 times.

Table 6. PSNR difference between 10- and 8-bit bit depths for H.264—FHD.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	−0.08	−0.14	−0.03	0.25	0.03	0.05	−0.07	−0.03	0.00
3	0.11	−0.02	0.13	0.36	0.22	0.07	0.18	0.07	0.14
5	0.34	0.18	0.39	0.42	0.26	0.06	0.24	0.14	0.25
10	0.87	0.27	0.64	0.43	0.18	0.13	0.30	0.23	0.38
15	1.29	0.34	0.78	0.42	0.21	0.19	0.37	0.34	0.49

Note: The 10-bit bit depth outperforms 8-bit 34 times.

Table 7. PSNR difference between 10- and 8-bit bit depths for H.265—FHD.

From **Table 6**, we can state that the best result of PSNR difference of FHD indicates sequences Construction field and Runners (scenes with slow dynamic); the worst result is in the scene Wood, which contains the most spatial and temporal information. Average enhancement with 10-bit bit depth is only 0.05 dB. Commonly, quality enhancement coefficient strongly depends on content of test sequence.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	−0.12	−0.4	0.51	1.67	−1.32	1.20	0.26	−0.50	0.16
3	0.13	−0.93	0.38	0.02	0.04	0.39	0.00	−0.68	−0.08
5	0.22	−0.60	0.37	−0.22	0.16	0.04	0.03	−0.46	−0.06
10	0.43	−0.20	0.42	−0.44	0.18	−0.12	0.00	−0.22	0.01
15	0.39	0.03	0.42	−0.57	0.23	−0.11	0.05	−0.13	0.04

Note: The 10-bit bit depth outperforms 8-bit 23 times.

Table 8. Relative SSIM difference between 10- and 8-bit bit depths for H.264—FHD.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	−0.10	0.02	−0.02	0.94	0.49	−0.22	−0.56	−0.60	0.00
3	0.18	0.14	0.16	0.82	0.50	−0.05	0.12	−0.19	0.21
5	0.25	0.27	0.24	0.73	0.46	−0.08	0.14	−0.05	0.24
10	0.30	0.24	0.26	0.54	0.26	−0.05	0.07	−0.01	0.20
15	0.33	0.23	0.27	0.41	0.25	−0.05	0.04	−0.02	0.18

Note: The 10-bit bit depth outperforms 8-bit 27 times.

Table 9. Relative SSIM difference between 10- and 8-bit bit depth for H.265—FHD.

Table 7 shows influence of 10-bit bit depth for H.265 compression standard. If we compare **Table 7** with **Table 6**, we can state that efficiency of H.265 with 10-bit bit depth is rapidly higher than (even the 34 positive cases). In the rest of cases, negative difference is very small and not significant. It leads to the conclusion that encoded videos are suitable for practical implementation.

Table 8 indicates slightly better results in comparison with **Table 6**; probably this result will better correlate with evaluations from subjective video quality assessment. This table indicates that the relative quality enhancement with 10-bit depth for H.264 and FHD resolution is in 23 cases. It leads to conclusion that efficiency of mentioned compression standard with 10-bit bit depth is low and not appropriate for practical applications.

Table 9 shows relative SSIM differences between 8-bit and 10-bit bit depths for H.265 in full HD resolution. The reference chosen was 8-bit bit depth. In all sequences 10-bit bit depth outperformed 8-bit; exemptions are only sequences Runners and Wood, which indicate high level of spatial information, but nevertheless the negative differences are so small—close to zero.

Figure 14 complexly summarizes results from **Tables 6–9**. Values of PSNR difference are on the left vertical axis; the right axis shows results with relative differences from the SSIM metric. Horizontal axis represents used bitrate.
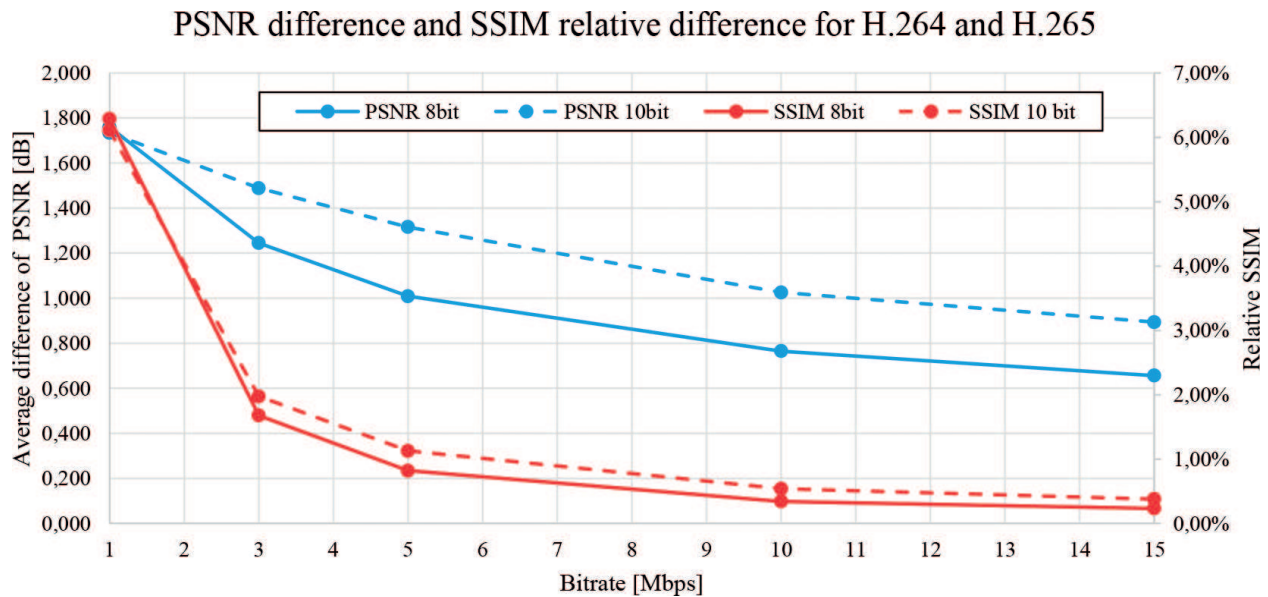
Figure 14. The PSNR difference and SSIM relative difference for FHD resolution, H.264 and H.265 compression standards and for different bitrates.

From **Tables 6–9** and **Figure 11**, we can state that 10-bit bit depth for H.264 in full HD resolution is not significant (only nearly half cases that quality increased); for H.265 the increase of quality is higher and should be a good choice for practical application.

In the next part, the **ultra HD** video sequences were analysed.

Tables 10–14 show the difference between codecs. The last column of tables contains average values computed for specific bitrate.

The relative SSIM difference between H.264 and H.265 compression standards is more significant for low bitrates (**Figure 15**). For 8-bit bit depth, the value is very close for bitrates 10 Mbps and higher. If we compare results from **Figures 13** and **15**, we can state that better results in percentage of SSIM should be achieved with UHD resolution.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire Party (dB)	Construction Field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall Buildings (dB)	Wood (dB)	AVG (dB)
1	2.43	2.08	2.85	0.69	2.33	2.20	3.32	4.71	2.58
3	1.71	3.05	1.68	0.64	2.31	2.22	2.86	3.08	2.19
5	1.38	2.57	1.16	0.67	1.66	1.68	2.42	2.45	1.75
10	0.83	1.23	0.52	0.44	0.78	0.87	1.86	1.64	1.02
15	0.51	0.86	0.44	0.41	0.56	0.61	1.43	1.37	0.77

Table 10. PSNR difference between H.264 and 265 codecs for UHD and 8-bit bit depth.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	3.24	3.41	5.33	1.42	3.92	7.56	16.96	18.58	7.55
3	1.08	4.37	2.30	0.53	5.17	11.07	8.45	8.82	5.22
5	0.67	3.64	1.39	0.88	3.04	6.45	5.01	4.50	3.20
10	0.30	1.75	0.56	0.59	1.23	2.05	2.27	1.56	1.29
15	0.17	1.29	0.55	0.64	0.90	1.06	1.23	0.92	0.85

Table 11. Relative SSIM difference between H.264 and 265 codecs for UHD and 8-bit bit depth.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	2.86	12.78	2.49	0.72	4.32	3.40	3.19	8.95	4.84
3	1.81	3.26	1.38	0.88	2.40	2.21	2.28	2.65	2.11
5	1.48	2.71	0.85	0.79	1.70	1.76	2.31	1.95	1.69
10	0.89	2.02	1.08	0.77	1.17	1.35	1.90	1.54	1.34
15	0.34	1.43	0.23	0.85	0.88	1.08	1.49	1.32	0.95

Table 12. PSNR difference between H.264 and 265 codecs for UHD and 10-bit bit depth.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall Buildings (%)	Wood (%)	AVG (%)
1	3.91	14.17	4.74	2.01	6.71	16.34	17.11	22.06	10.88
3	1.14	5.67	1.98	1.94	5.66	10.51	6.37	7.22	5.06
5	0.70	4.02	1.03	1.77	3.37	6.73	4.63	3.45	3.21
10	0.31	3.20	1.13	1.65	1.97	3.35	2.23	1.58	1.93
15	0.11	2.28	0.24	1.70	1.46	2.02	1.26	0.98	1.26

Table 13. Relative SSIM difference between H.264 and 265 codec for UHD and 10-bit bit depth.

Tables 14–17 show the metrics for different bitrates and scenes. **Tables 14** and **16** show results for codec H.264 and **Tables 15** and **17** for H.265, respectively. The positive values in the table are marked with red colour. The positive value indicates that 10-bit bit depth outperforms 8-bit in UHD video sequence.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	−0.15	−8.63	0.32	0.20	−1.24	−0.39	−0.18	−4.00	−1.76
3	0.14	−0.33	0.28	−0.02	0.07	0.08	0.39	0.11	0.09
5	0.22	−0.26	0.31	0.12	0.14	0.03	0.03	0.31	0.11
10	0.31	−0.61	−0.51	0.03	−0.05	−0.24	0.03	0.00	−0.13
15	0.36	−0.37	0.27	−0.04	−0.02	−0.22	0.06	0.01	0.01

Note: The 10-bit bit depth outperforms 8-bit only 22 times.

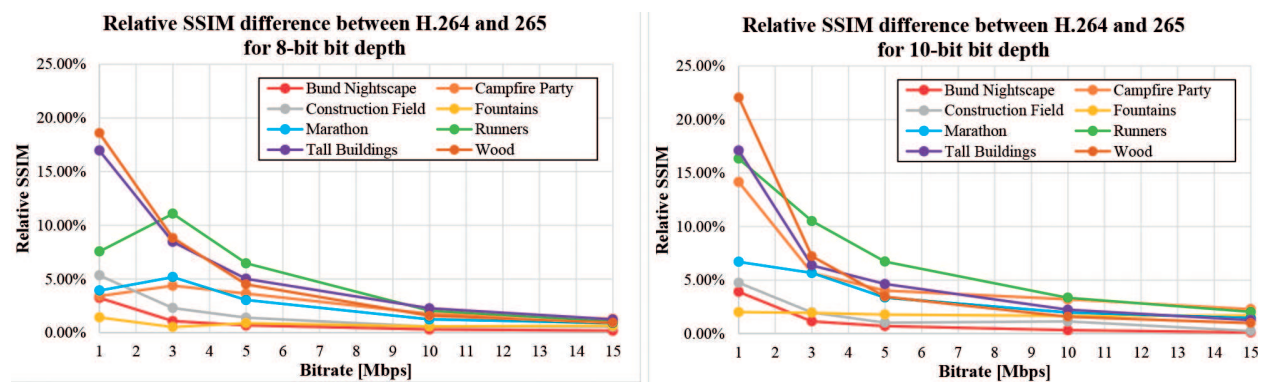Table 14. PSNR difference between 10- and 8-bit bit depths for H.264—UHD.

Figure 15. Relative SSIM difference between H.264 and H.265 compression standards for 8-bit and 10-bit bit depths and UHD.

Bitrate (Mbps)	Bund nightscape (dB)	Campfire party (dB)	Construction field (dB)	Fountains (dB)	Marathon (dB)	Runners (dB)	Tall buildings (dB)	Wood (dB)	AVG (dB)
1	0.27	2.08	−0.04	0.22	0.75	0.81	−0.32	0.24	0.50
3	0.24	−0.13	−0.01	0.21	0.15	0.07	−0.19	−0.32	0.00
5	0.32	−0.12	0.01	0.24	0.18	0.12	−0.08	−0.19	0.06
10	0.37	0.18	0.06	0.35	0.33	0.23	0.07	−0.10	0.19
15	0.19	0.20	0.06	0.40	0.30	0.25	0.11	−0.04	0.18

Note: The 10-bit bit depth outperforms 8-bit 29 times.

Table 15. PSNR difference between 10- and 8-bit bit depths for H.265—UHD.

From **Tables 14–17** and **Figure 16**, we can state that 10-bit bit depth with H.264 compression standard in UHD resolution is not appropriate; vice versa H.265 with 10-bit bit depth indicates quality increment in UHD resolution.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	−0.08	−7.08	0.73	0.30	−0.07	−2.53	−1.43	−1.19	−1.42
3	0.29	−1.09	0.50	−0.03	0.54	0.74	1.49	0.43	0.36
5	0.31	−0.22	0.49	0.25	0.58	0.37	0.23	0.69	0.34
10	0.32	−0.83	−0.44	0.02	0.08	−0.57	0.16	0.05	−0.15
15	0.34	−0.50	0.43	−0.08	0.12	−0.43	0.12	0.07	0.01

Note: The 10-bit bit depth outperforms 8-bit 25 times.

Table 16. Relative SSIM difference between 10- and 8-bit bit depths for H.264—UHD.

Bitrate (Mbps)	Bund nightscape (%)	Campfire party (%)	Construction field (%)	Fountains (%)	Marathon (%)	Runners (%)	Tall buildings (%)	Wood (%)	AVG (%)
1	0.56	2.59	0.17	0.88	2.60	5.43	−1.31	1.70	1.58
3	0.35	0.15	0.18	1.38	1.01	0.23	−0.46	−1.05	0.22
5	0.34	0.14	0.13	1.13	0.90	0.63	−0.14	−0.32	0.35
10	0.33	0.58	0.13	1.08	0.82	0.69	0.12	0.06	0.48
15	0.28	0.47	0.11	0.97	0.68	0.52	0.15	0.13	0.41

Note: The 10-bit bit depth outperforms 8-bit 35 times.

Table 17. Relative SSIM difference between 10- and 8-bit bit depths for H.265—UHD.
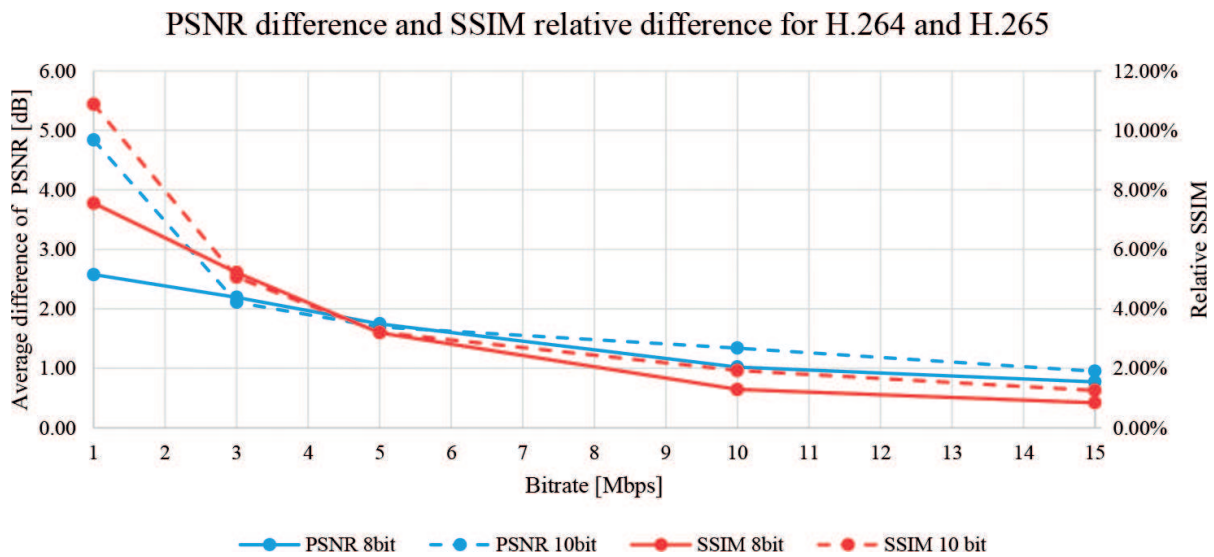

Figure 16. The PSNR difference and SSIM relative difference for UHD resolution, H.264 and H.265 compression standards and for different bitrates.

We can also state that H.265 with 10-bit bit depth is more appropriate with ultra HD resolution than full HD (more significant quality increment). The biggest efficiency H.265 indicates in low bitrates (from 1 to 3 Mbps).

According to the experimental results and graphs, several conclusions can be pronounced:

1. The quality of both compression standards rises logarithmically with increasing bitrate—in low bitrates the quality grows faster than in high bitrates (**Figure 12**).

2. By comparing both codecs, it can be generally said that the bigger difference in quality is in lower bitrates—with increasing bitrate the quality of H.264/AVC codec approaches the H.265/HEVC codec (**Figure 16**).

3. The coding efficiency of H.265/HEVC standard is more visible in UHD resolution.

4. The effectiveness of compression depends on the types of test sequences.

7. Conclusion

In this paper the impact of H.265/HEVC and H.264/AVC compression standards and bit depth on the video quality for high resolutions using objective metrics and determining their efficiency was presented. The assessment was done for eight types of sequences with full HD and ultra HD resolutions depending on the content. The experimental results showed that H.265/HEVC codec yields better compression efficiency than H.264/AVC and 10-bit bit depth significantly increment video quality in combination with H.265/HEVC. The bigger difference in quality is in lower bitrates—with increasing bitrate, the quality of H.264/AVC codec approaches the H.265/HEVC codec. The coding efficiency of H.265/HEVC standard is more visible in UHD resolution.

Acknowledgements

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