MSU Codec Comparison 2017

Part II: 4K Content, Objective Evaluation

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Free version

Codecs:

H.265

- Kingsoft HEVC Encoder
- nj265

Non H.265

- nj264
- x264

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- Nanjing Yunyan
- Kingsoft

The Video Group would also like to thank these companies for their help and technical support during the tests.

2 OVERVIEW

2.1 Sequences

	Sequence	Number of frames	Frame rate	Resolution
1.	Bay	432	24	3840×2160
2.	Blue Lagoon	986	30	3840×2160
3.	Disneyland	317	24	3840×2160
4.	Driving	1747	24	4096×2160
5.	Flight	1000	25	3840×2160
6.	Highfields	1383	25	3840×2160
7.	Little Girl	1531	30	4096×2160
8.	Outdoor Party	1183	30	3840×2160
9.	Waterfalls	994	30	3840×2160
10.	Weekend Warrior	849	30	3840×2160

TABLE 1: Summary of video sequences

Brief descriptions of the sequences used in our comparison are given in Table 1. More detailed descriptions of these sequences can be found in Appendix A.

2.2 Codecs

	Codec	Developer	Version
1.	Kingsoft HEVC Encoder	Kingsoft	V2.6.1.3
2.	nj264	Nanjing Yunyan Email: jtwen@tsinghua.edu.cn	V1.0
3.	nj265	Nanjing Yunyan Email: jtwen@tsinghua.edu.cn	V1.0
4.	x264	x264 Developer Team	r2833 df79067

TABLE 2: Short codecs' descriptions

Brief descriptions of the codecs used in our comparison are given in Table 2. x264 was used as a good quality AVC reference codec for comparison purposes. Detailed descriptions of all codecs used in our comparison can be found in Appendix C.

3 OBJECTIVES AND TESTING RULES

In this report we compare encoding quality of recently emerged HEVC encoders and encoders of other standards using objective assessment methods. 31 video sequences with 1080p resolution were used to evaluate performance of codecs under comparison. To choose these sequences we analyzed 512,000 video sequences and selected representative set (the detailed description of selection process is given in Appendix B).

Our comparison consists of three parts corresponding to various encoders' use cases: Fast encoding, Universal encoding, Ripping encoding. For each use case encoder developers had an option to provide encoding parameters to be used in our tests. If no parameters were provided, we either used the same parameters as were used in prior study or, if no prior parameters were available, did our best effort to choose good parameters ourselves. Nevertheless, the chosen parameters had to satisfy minimum speed requirements of 60 FPS. Computer with the following configuration was used to run codecs under comparison: Core i7 6700K (Skylake) @ 4Ghz, RAM 8 GB, Windows 8.1. For objective quality measurements we used YUV-SSIM quality metric (see Appendix E.1).

4 RD CURVES

Next figures show RD curves for ten video sequences. Kingsoft encoder has the best mean quality score at all the sequences. Moreover, one can notice that encoding quality strongly depends on video sequence — while the top SSIM score achieved at Bay sequence at lowest bitrate is 0.94, the top score achieved at Flight sequence at the highest bitrate is only 0.92.

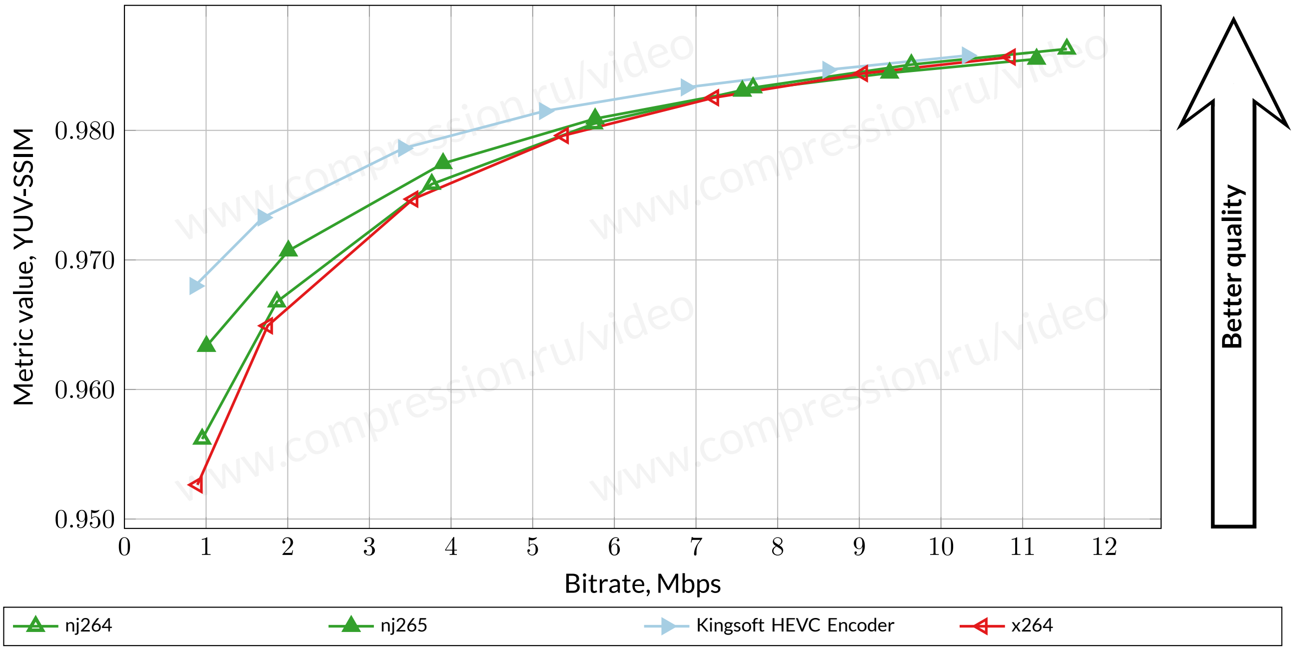


FIGURE 1: Bitrate/quality—use case “4K Encoding,” Blue Lagoon sequence, YUV-SSIM metric

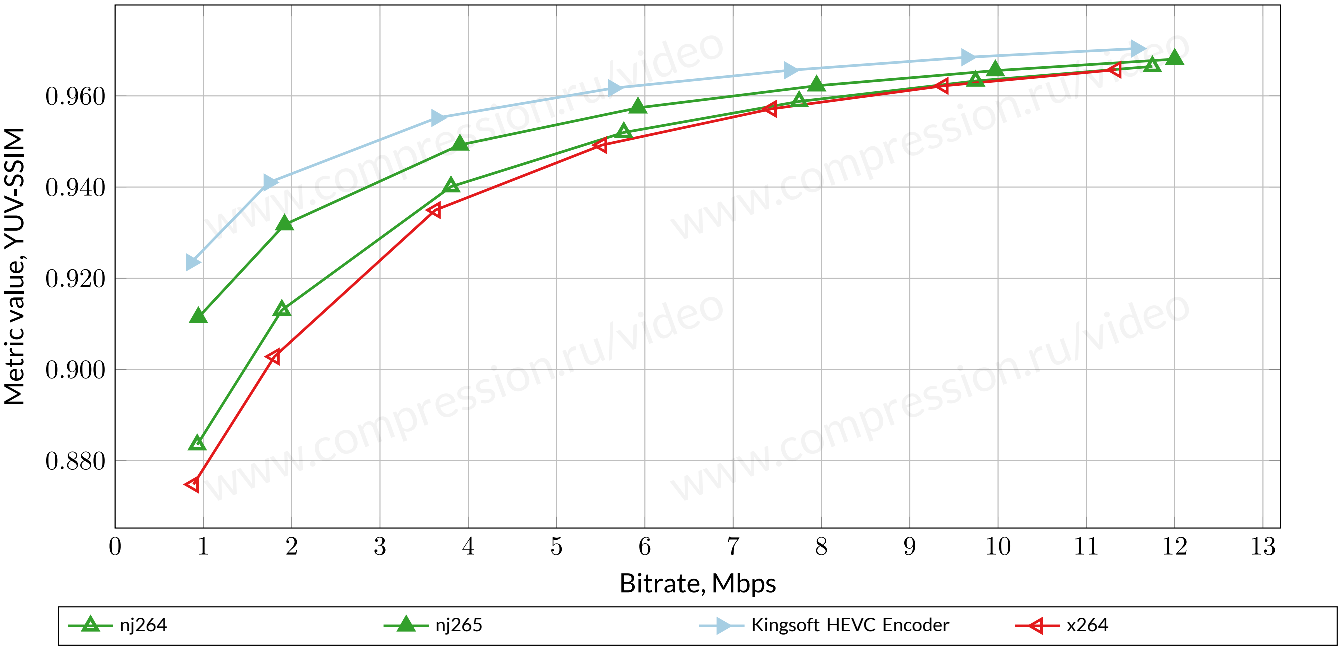


FIGURE 2: Bitrate/quality—use case "4K Encoding," Waterfalls sequence, YUV-SSIM metric

5 ENCODING SPEED

Figures below show difference in encoding speed among participating codecs. In these figures (as in previous section), different codecs take the first place at different sequences. Therefore, we can identify the leader based only on the mean speed scores. In this nomination, the first place goes to Kingsoft. Nevertheless, Kingsoft is not the absolute winner: for example, x264 is 6% faster than Kingsoft at High Fields and 2% faster at Outdoor Party sequences.

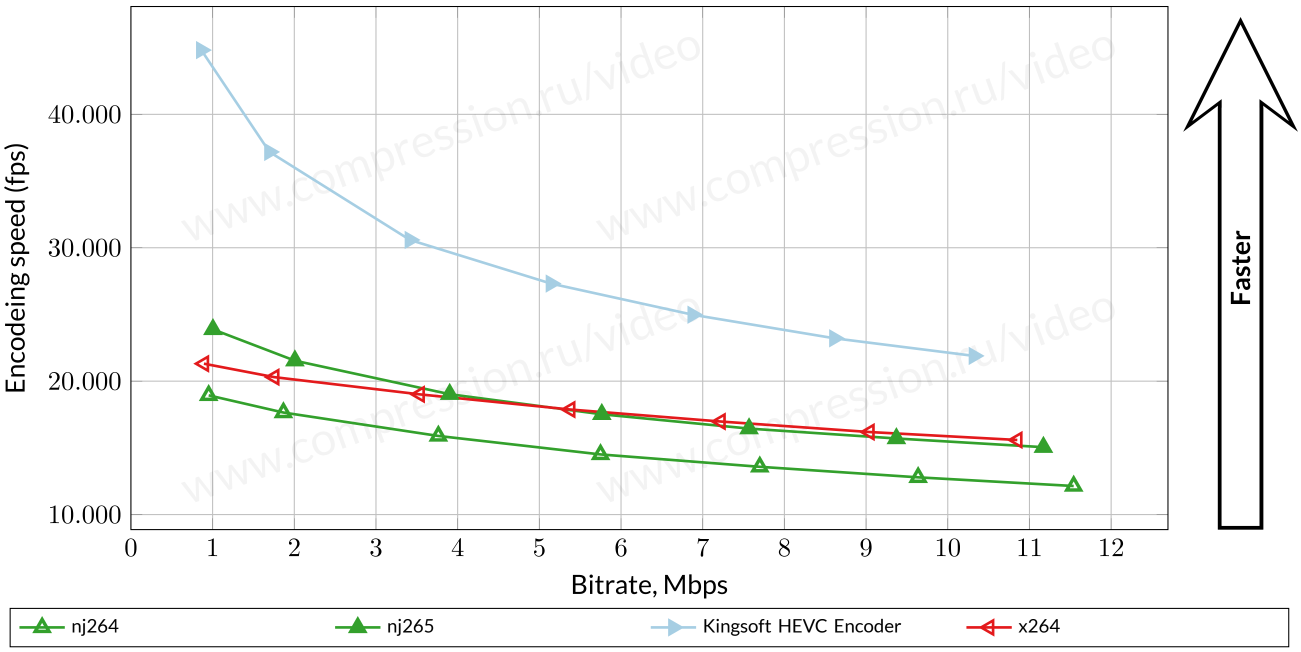


FIGURE 3: Encoding speed—use case "4K Encoding," Blue Lagoon sequence

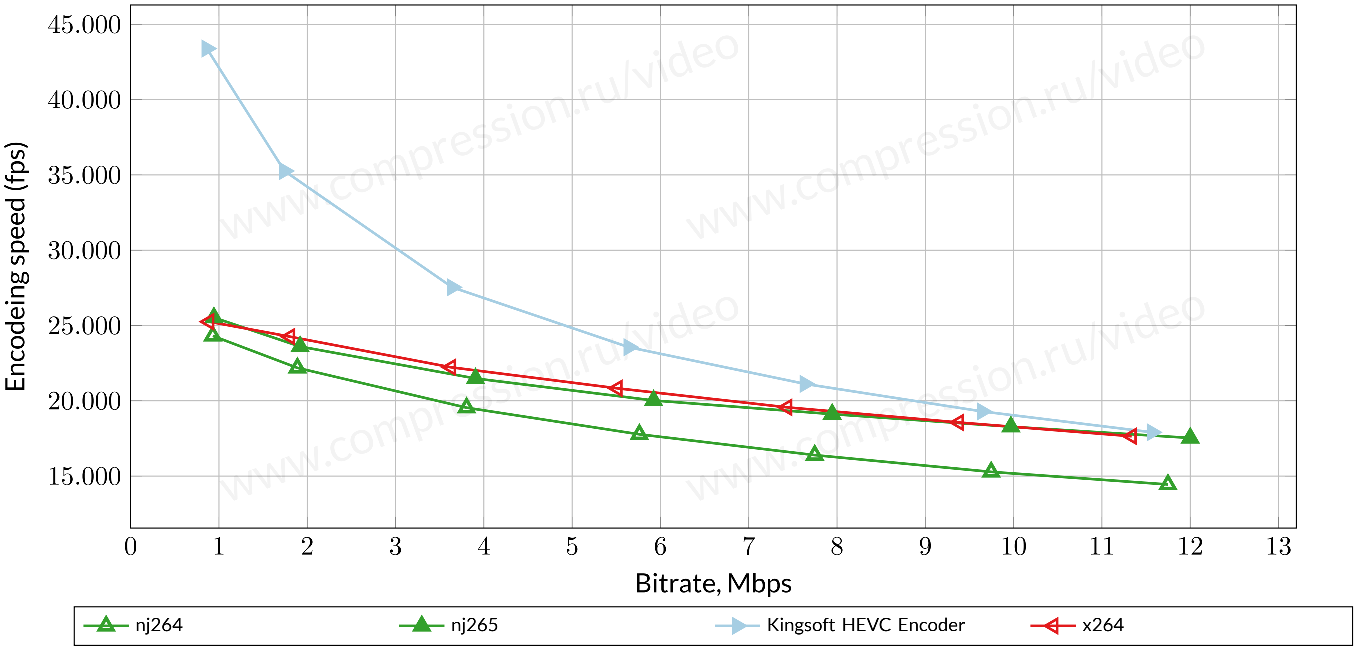


FIGURE 4: Encoding speed—use case “4K Encoding,” Waterfalls sequence

6 SPEED/QUALITY TRADE-OFF

Detailed descriptions of the speed/quality trade-off graphs can be found in Appendix D. Sometimes, codec results are not present in the particular graph owing to the codec's extremely poor performance (i.e. the codec's RD curve has no intersection with the reference's RD curve).
The speed/quality trade-off graphs show both relative quality and speed scores of encoders under comparison. Since x264 was chosen as reference codec in our comparison, we normalized all scores using x264 scores.

There is only one Pareto optimal encoder in terms of mean speed and quality scores for all the sequences — Kingsoft HEVC encoder. "Pareto optimal" encoder means there is no encoder faster and better than it in this test (at average for all the sequences). For two sequences: High Fields and Outdoor party x264 encoder is among Pareto optimal encoders (with Kingsoft encoder).

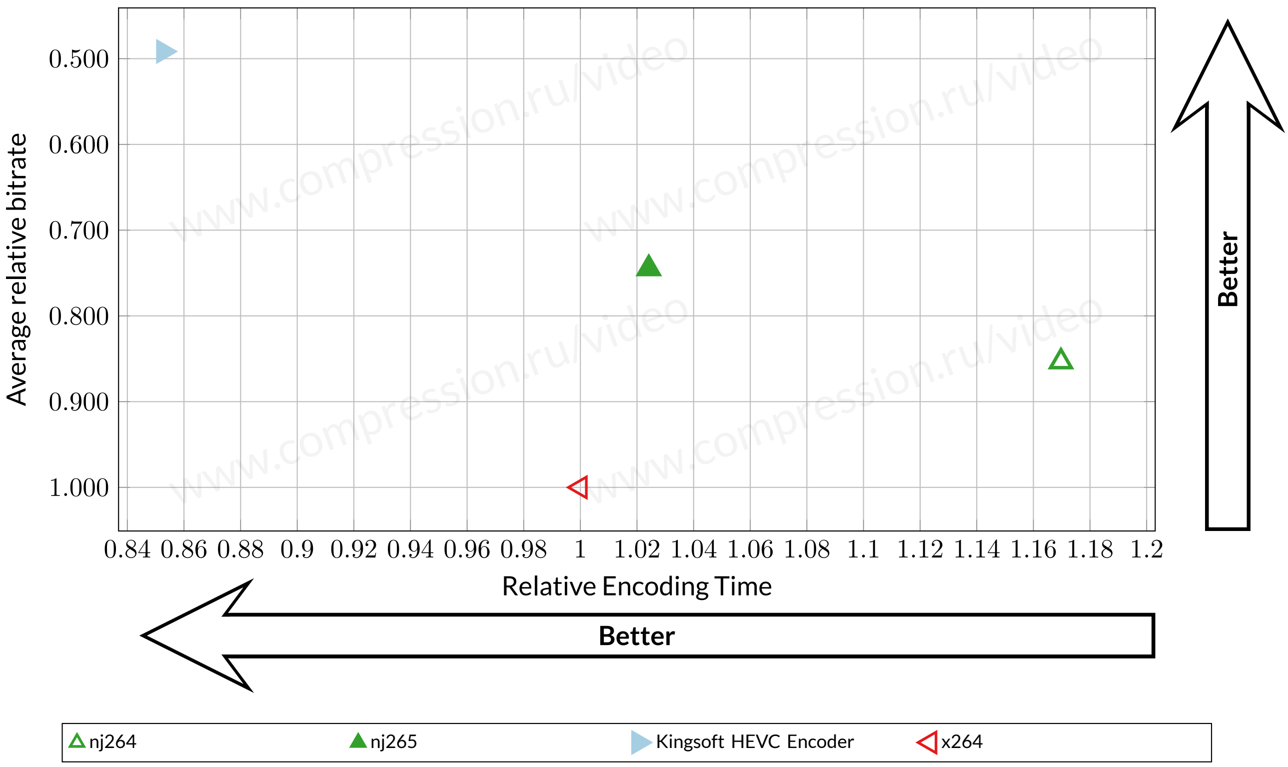


FIGURE 5: Speed/quality trade-off—use case "4K Encoding," all sequences, YUV-SSIM metric

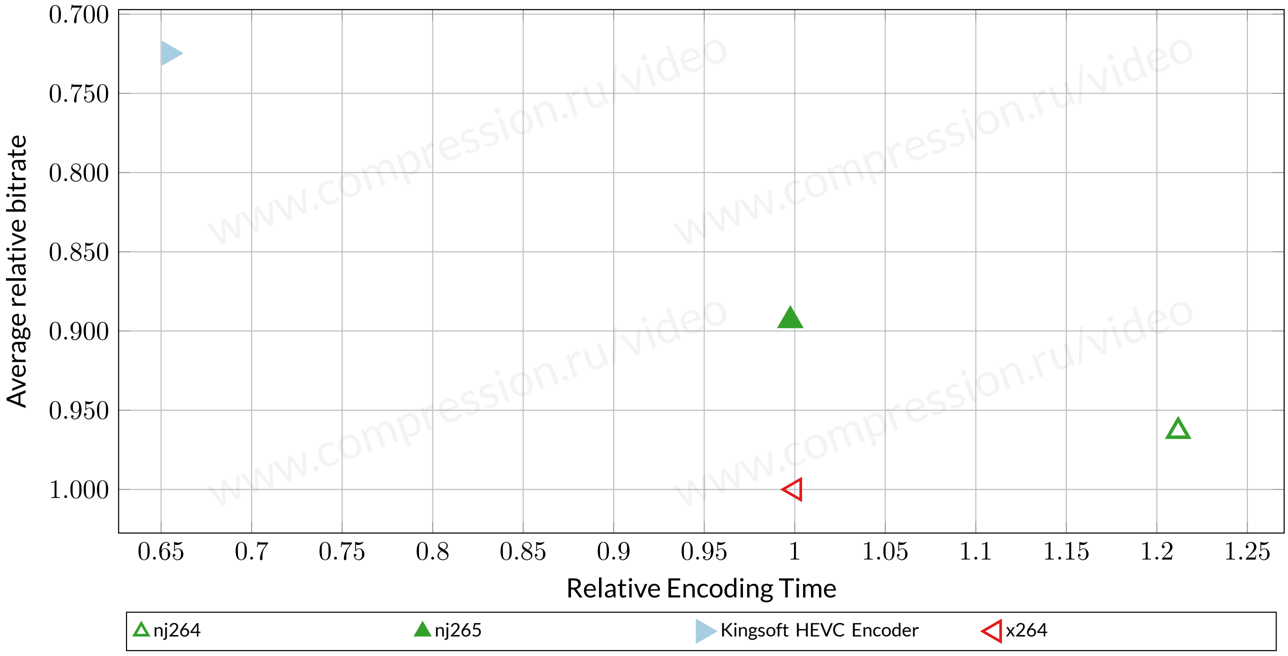


FIGURE 6: Speed/quality trade-off—use case "4K Encoding," Blue Lagoon sequence, YUV-SSIM metric

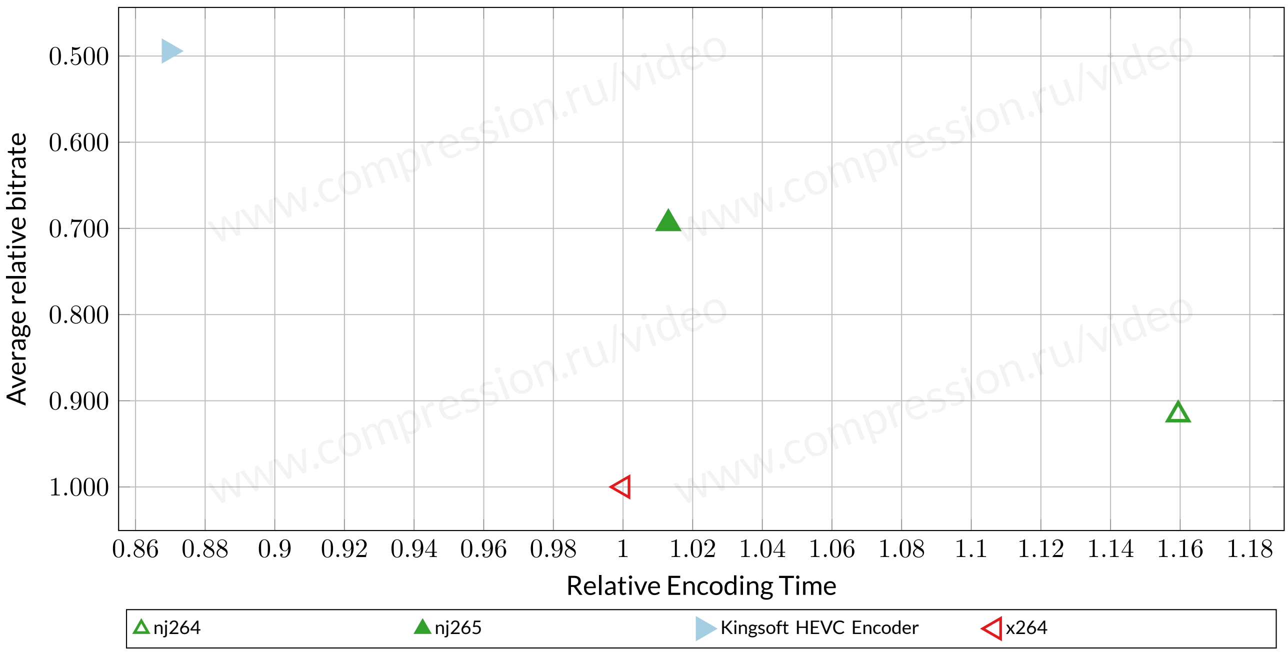


FIGURE 7: Speed/quality trade-off—use case "4K Encoding," Waterfalls sequence, YUV-SSIM metric

7 BITRATE HANDLING

The plots below show how accurately encoded stream's real bitrate matches bitrate requested by a user. Almost all encoders handle bitrate well, but there are issues for some encoders at some sequences, e.g. Kingsoft shows not ideal bitrate handling at many sequences: slightly undershoots target bitrates especially at low bitrates (Little girl and Bay sequences); x264 has great difficulties at high bitrates in the Disneyland sequence (strong overshooting).

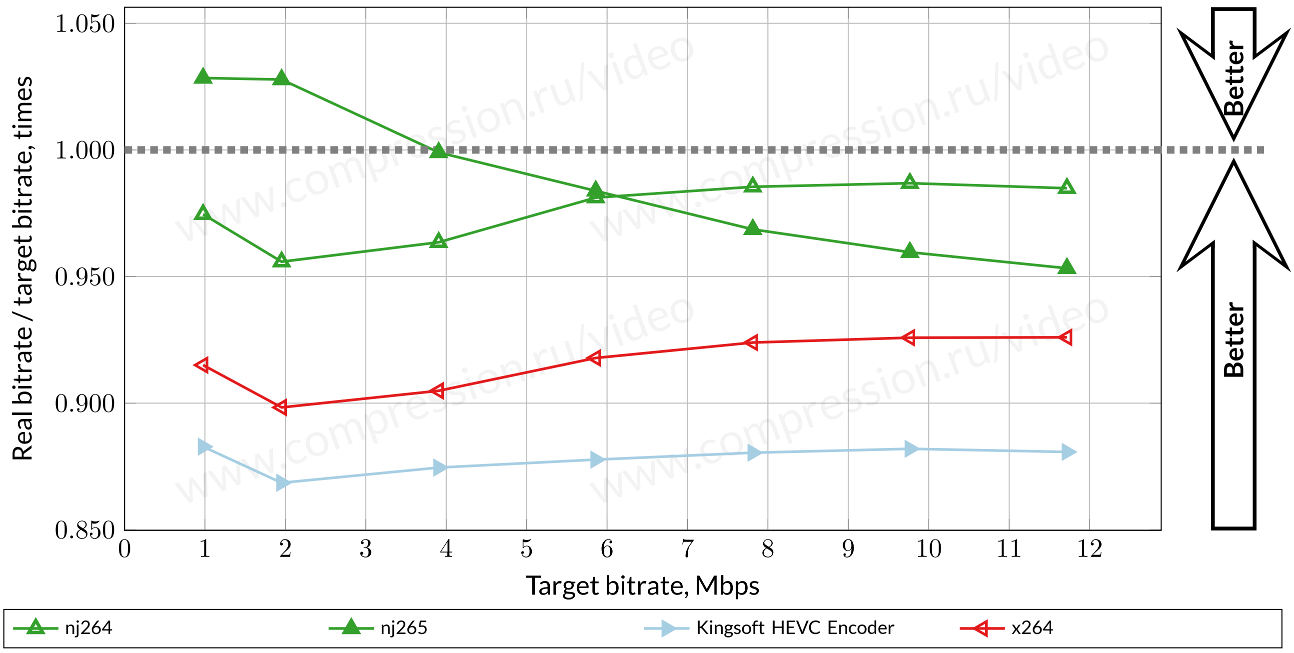


FIGURE 8: Bitrate handling—use case "4K Encoding," Blue Lagoon sequence

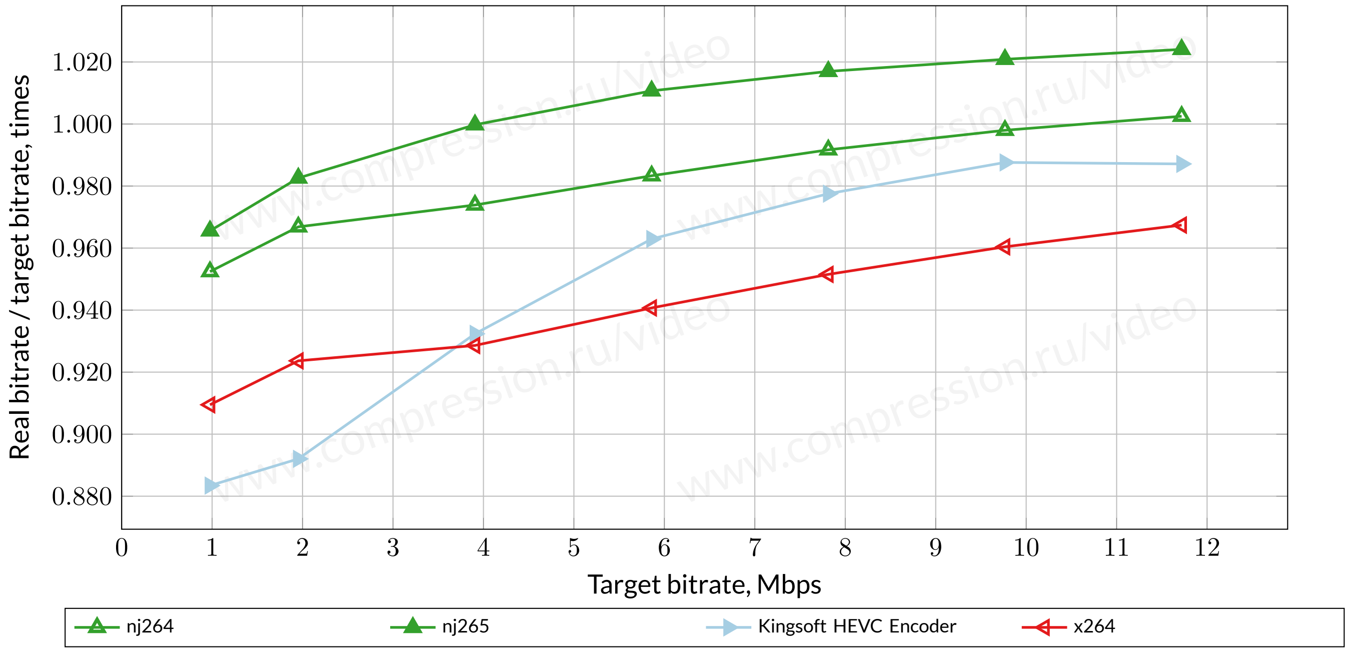


FIGURE 9: Bitrate handling—use case "4K Encoding," Waterfalls sequence

8 RELATIVE QUALITY ANALYSIS

	nj264	nj265	Kingsoft HEVC Encoder	x264
nj264	100%	88%	60%	117%
nj265	115%	100%	67%	134%
Kingsoft HEVC Encoder	172%	152%	100%	203%
x264	88%	79%	55%	100%

TABLE 3: Average bitrate ratio for a fixed quality—use case "4K Encoding," YUV-SSIM metric

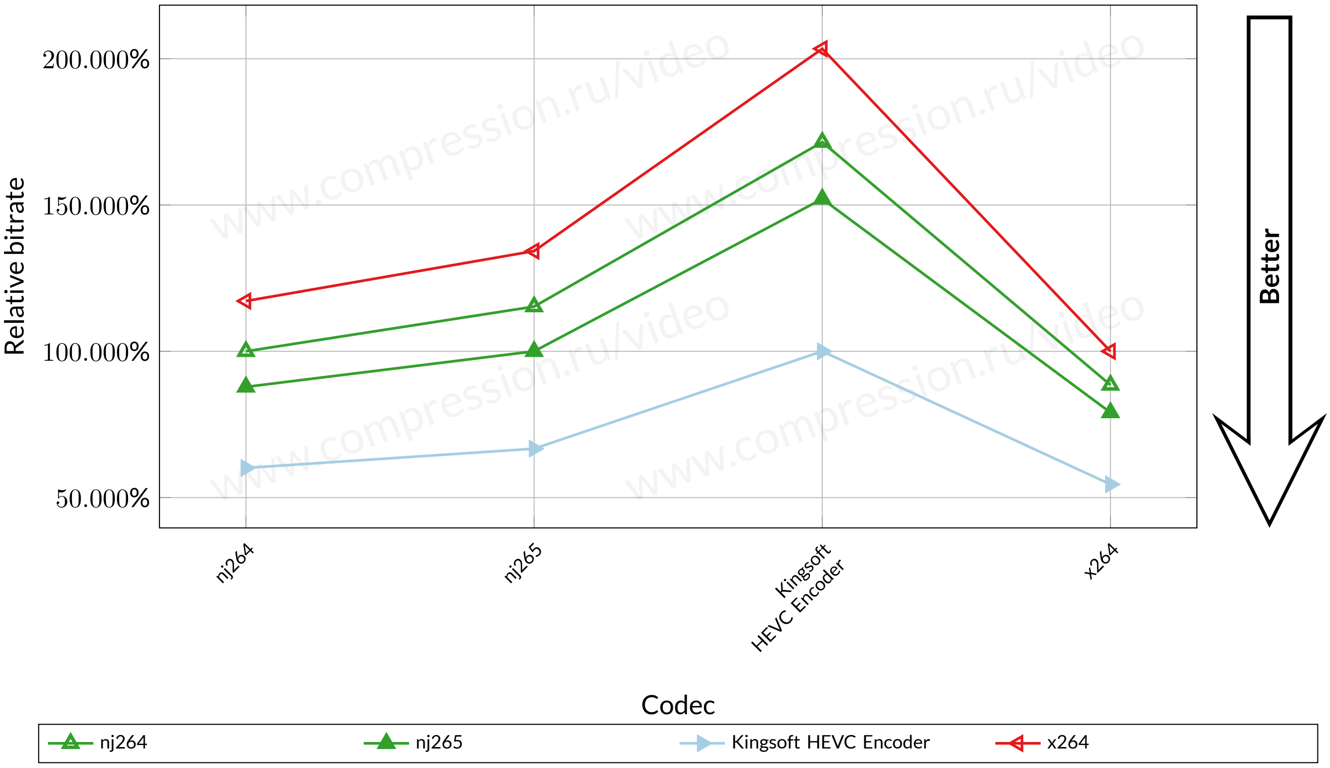


FIGURE 10: Average bitrate ratio for a fixed quality—use case "4K Encoding," YUV-SSIM metric

9 CONCLUSION

According to quality scores, the codecs can be ordered in the following way:

- Kingsoft HEVC encoder is in the first place
- nj265 is in the second place
- nj264 is in the third place.

Tested encoders have high quality value variance (55-100%) at tested 4K sequences. Below we show the plot illustrating speed/quality relation of all presets used in our comparison. x264 with "veryslow" preset was chosen as the reference point. Each line on the plot corresponds to encoder and each point on the line corresponds to preset. Along x-axis we put mean speed of encoder's preset on our test dataset. Position along y-axis is determined by preset's bitrate relative to reference (i.e. how much or less bits encoder needs to gain same quality as reference). Detailed description of relative bitrate computation can be found in Appendix D.4.

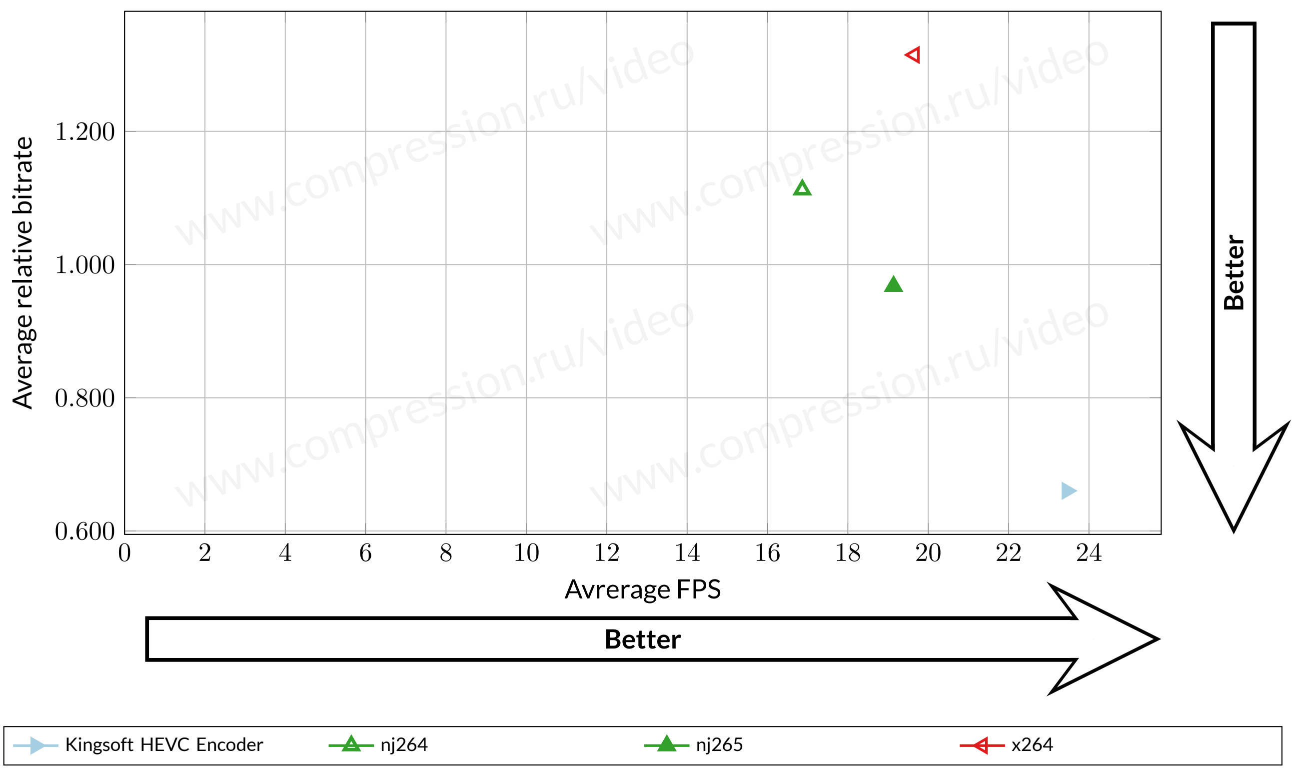


FIGURE 11: Average bitrate ratio and speed for various presets—YUV-SSIM metric.

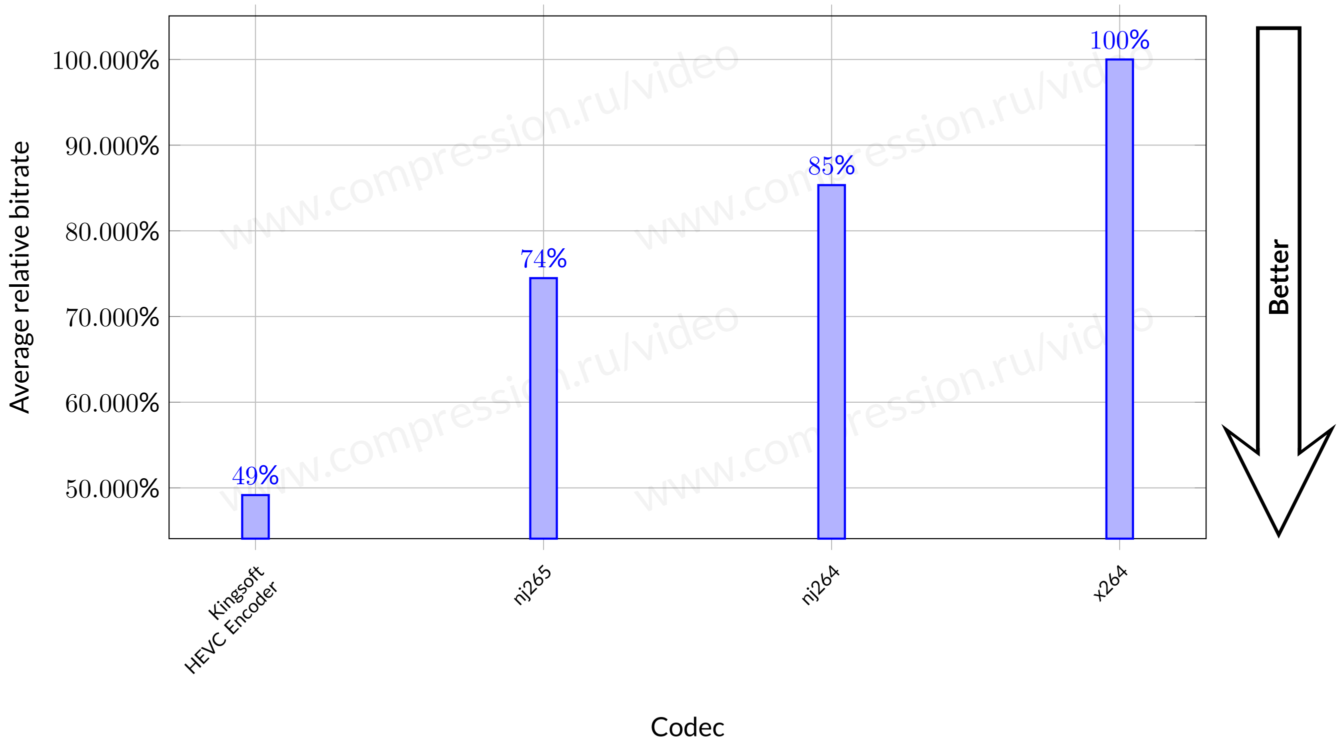


FIGURE 12: Average bitrate ratio for a fixed quality—use case "4K Encoding," YUV-SSIM metric.

A SEQUENCES

A.1 “Bay”

Sequence title	Bay
Resolution	3840×2160
Number of frames	432
Color space	YV12
Frames per second	24
Source	https://vimeo.com/169763926#t=0
Bitrate	90.891 Mbps

The video contains general view of the foggy bay. The camera moves slowly.

FIGURE 13: Bay sequence, frame 24

A.2 "Blue Lagoon"

Sequence title	Blue Lagoon
Resolution	3840×2160
Number of frames	986
Color space	YV12
Frames per second	30
Source	https://vimeo.com/189872577#t=300
Bitrate	61.8 Mbps

Footage of a young couple in an open pond with hot water. There is a time lapse at the end of the video.

FIGURE 14: Blue Lagoon sequence, frame 30

A.3 "Disneyland"

Sequence title	Disneyland
Resolution	3840×2160
Number of frames	317
Color space	YV12
Frames per second	24
Source	https://vimeo.com/152119430#t=0
Bitrate	430.225 Mbps

Time lapse of Disneyland castle located in a park with people. Camera slowly zooms in.

FIGURE 15: Disneyland sequence, frame 24

A.4 “Driving”

Sequence title	Driving
Resolution	4096×2160
Number of frames	1747
Color space	YV12
Frames per second	24

The camera is set on the car rapidly moving on Mulholland Drive in the evening.

FIGURE 16: Driving sequence, frame 24

A.5 "Flight"

Sequence title	Flight
Resolution	3840×2160
Number of frames	1000
Color space	YV12
Frames per second	25
Bitrate	50.2 Mbps

A quadrocopter shooting views of the forest and some houses on the hill.

FIGURE 17: Flight sequence, frame 25

A.6 "Highfields"

Sequence title	Highfields
Resolution	3840×2160
Number of frames	1383
Color space	YV12
Frames per second	25
Source	https://vimeo.com/202040059#t=40
Bitrate	99.168 Mbps

Footage about a cottage village with a demonstration of leisure activities and outdoor views. The video contains subtitles.

FIGURE 18: Highfields sequence, frame 25

A.7 “Little Girl”

Sequence title	Little Girl
Resolution	4096×2160
Number of frames	1531
Color space	YV12
Frames per second	30

A little girl is playing with toy blocks. The camera slowly moves to the left.

FIGURE 19: Little Girl sequence, frame 30

A.8 “Outdoor Party”

Sequence title	Outdoor Party
Resolution	3840×2160
Number of frames	1183
Color space	YV12
Frames per second	30
Bitrate	385.669 Mbps

Children relax on a grass in a park. Camera shakes a bit.

FIGURE 20: Outdoor Party sequence, frame 30

A.9 “Waterfalls”

Sequence title	Waterfalls
Resolution	3840×2160
Number of frames	994
Color space	YV12
Frames per second	30
Source	https://vimeo.com/189872577#t=165
Bitrate	61.8 Mbps

The waterfall is shot by static and moving cameras. A lot of moving water and fumes.

FIGURE 21: Waterfalls sequence, frame 30

A.10 "Weekend Warrior"

Sequence title	Weekend Warrior
Resolution	3840×2160
Number of frames	849
Color space	YV12
Frames per second	30
Source	https://vimeo.com/149249671#t=70
Bitrate	120 Mbps

At the beginning of the video, a man is shot from a moving motorcycle. Then he climbs on the old brick building.

FIGURE 22: Weekend Warrior sequence, frame 30

B SEQUENCES SELECTION

In "MSU Video Codecs Comparison 2016" we introduced a new technique for test dataset sequences' selection. This technique was designed to create dataset containing representative set of sequences that encoders are facing in everyday life. In this report we use the same methodology for video sequences selection, but we have dramatically updated video database from which we sample videos for encoders' comparison.

We analyzed over 512,000 videos hosted at Vimeo looking for 4K and FullHD videos with high bitrates (50 Mbps was selected as a lower bitrate boundary). This enabled us to find and download, 662 new 4K videos and 1993 new FullHD videos. The bitrate distributions for previous year dataset and updated dataset are shown in Figure 23.

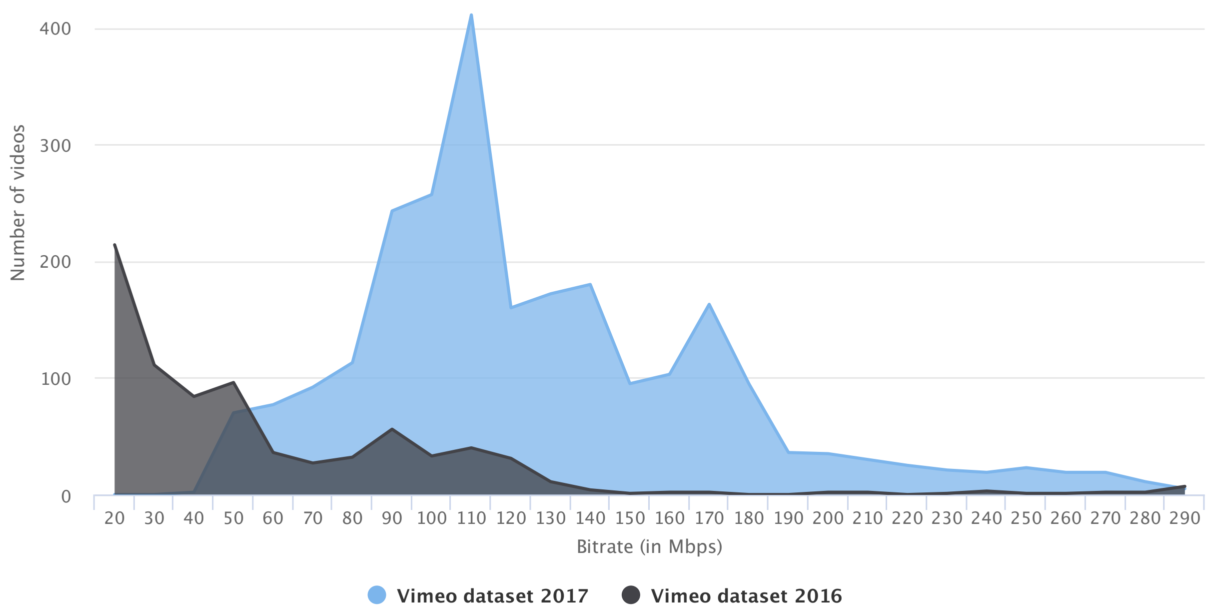


FIGURE 23: Bitrate distributions for videos dataset

For 4K Appendix we use only 4K videos from downloaded collection. All videos were cut at scene change points to samples, with 1000 frames approximate length. We also used 2900 samples from "MSU Video Codecs Comparison 2016". Thus, our 4K samples database for this year consisted of 4638 items.

To evaluate spatial and temporal complexity we encoded all samples using x264 encoder with constant quantization parameter (QP). For all samples temporal and spatial complexity were calculated. We define spatial complexity as average size of I-frame normalized by sample's uncompressed frame size. Temporal complexity is defined as average size of P-frame divided by average size of I-frame.[1] Distribution of obtained samples compared to samples from previous codec comparison is shown in Figure 24.

[1] C. Chen et. al., "A Subjective Study for the Design of Multi-resolution ABR Video Streams with the VP9 Codec," 2016.

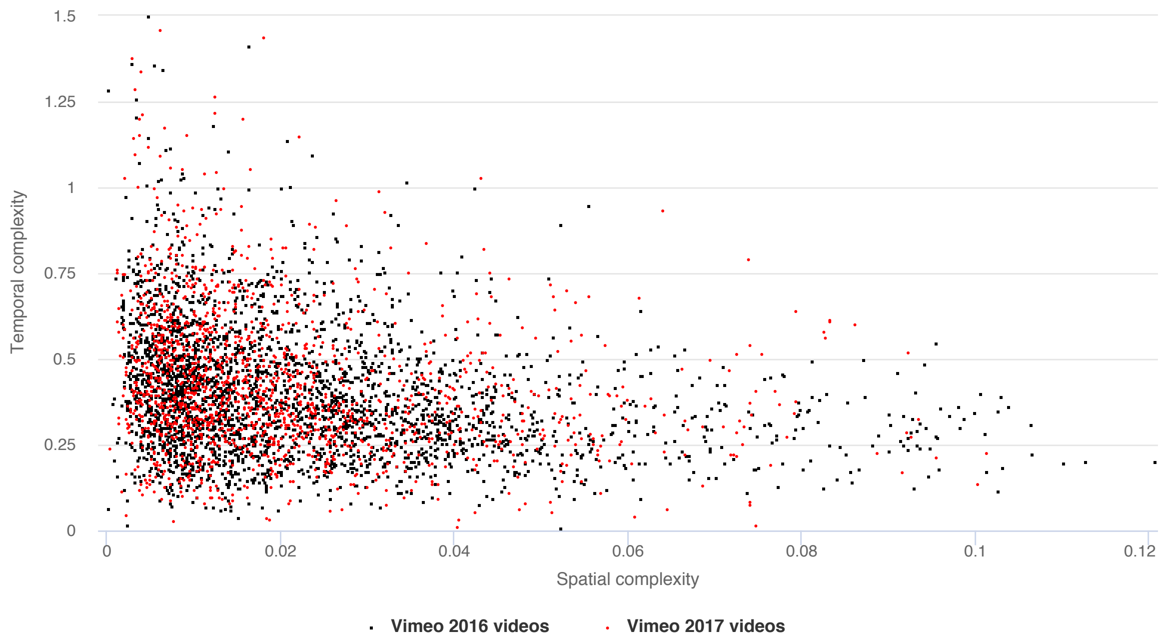


FIGURE 24: Distribution of obtained samples

Figure 24 reveals that new samples have similar distribution to samples from "MSU Video Codecs Comparison 2016". In order to prepare dataset we used the following process.

We divided the video database into 10 clusters with K-Means. To avoid complete update of sequences list, sequences from last year's 4K dataset were given 35 times higher weight compared to other sequences. For each cluster we selected the video sequence closest to its center that has a license enabling derivatives and commercial usage. The clusters' boundaries and chosen sequences are shown at Figure 25.

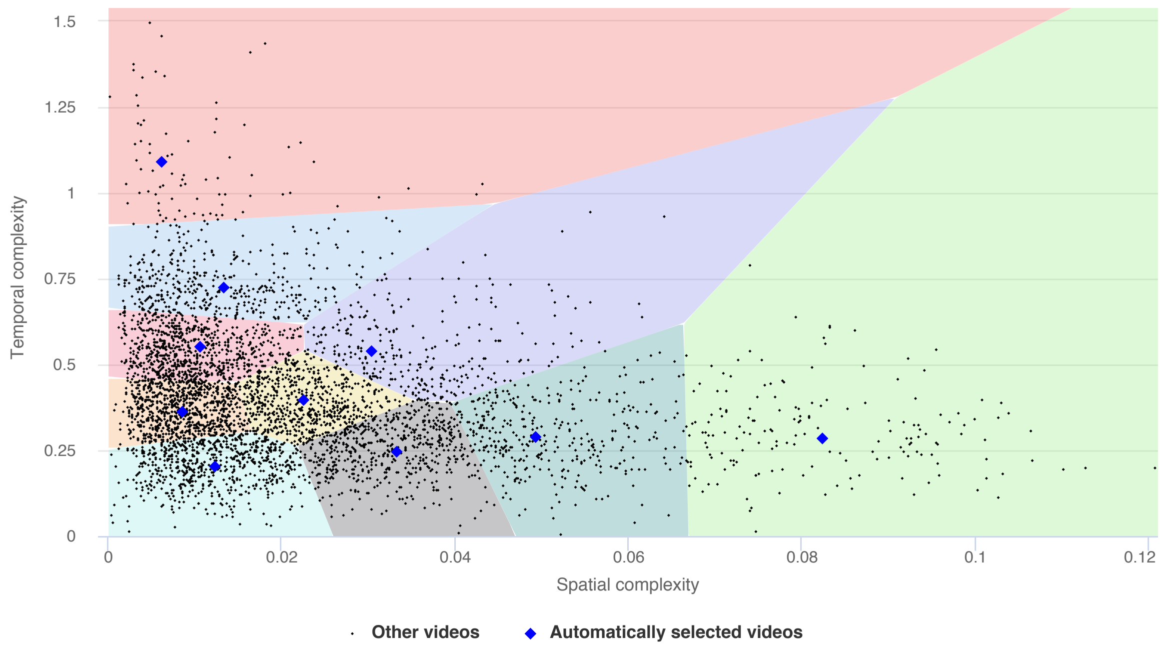


FIGURE 25: Segmentation of the samples

At Figure 26 we show correspondence of sequences from prior dataset to newly selected clusters. As can be seen from the figure, there are some clusters not covered by videos from old dataset.

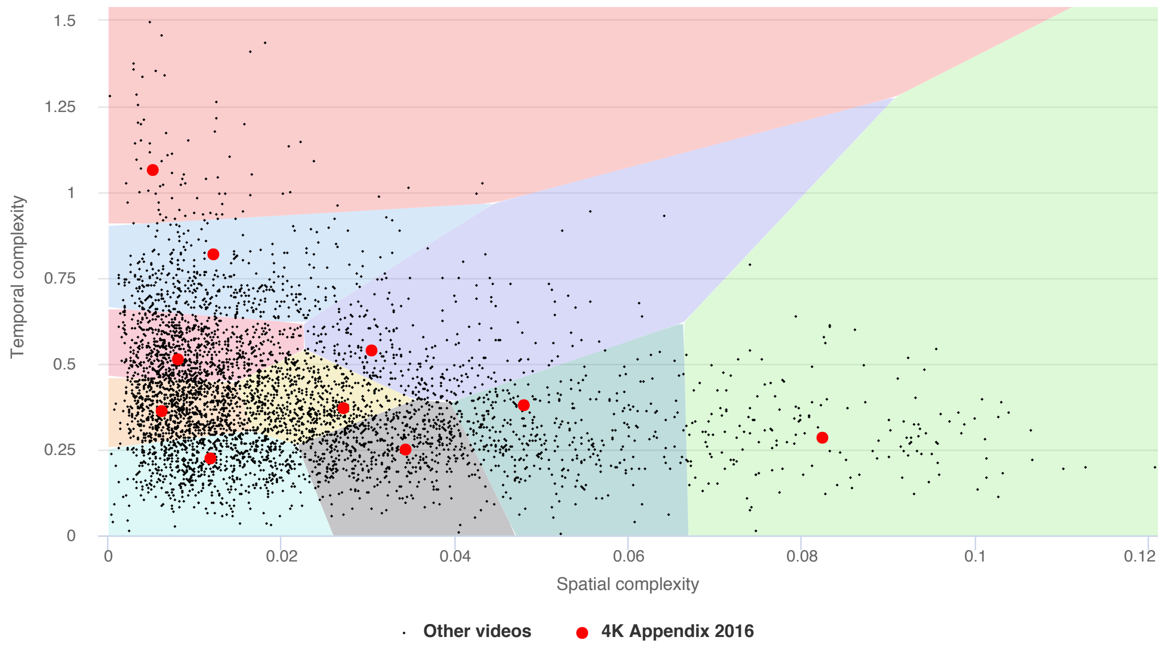


FIGURE 26: Segmentation of the samples compared to old dataset

Some of automatically chosen samples contain company names or have another copyright issues, so we replaced that samples with other samples in that clusters with suitable license. Figure 27 illustrates applied adjustments.

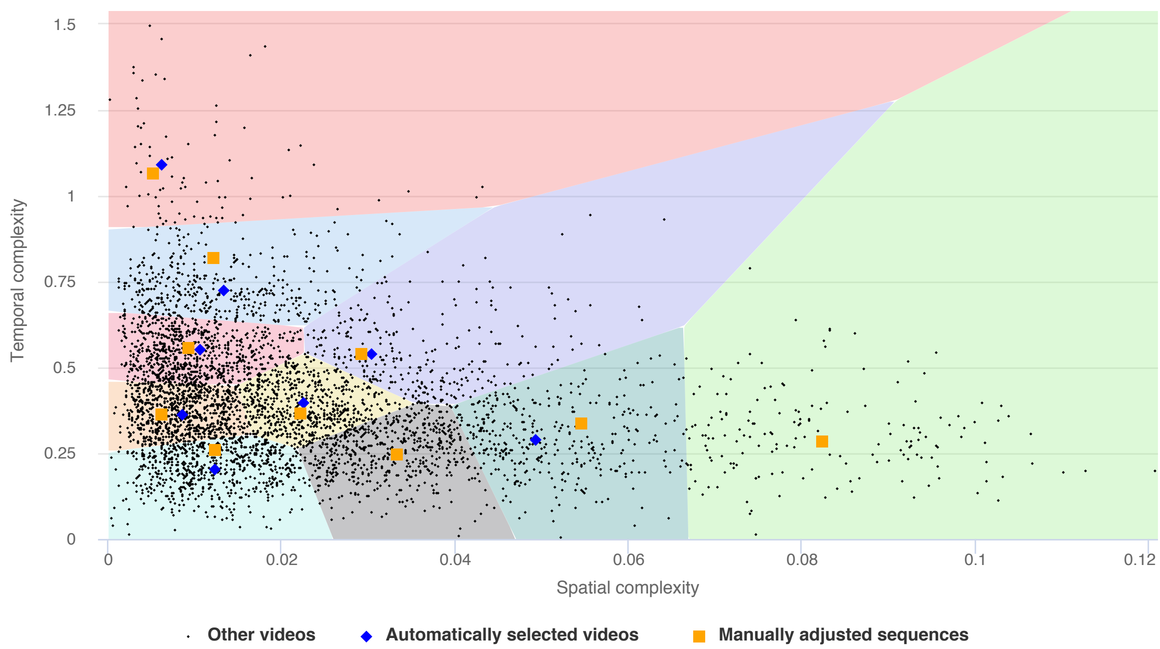


FIGURE 27: Adjustments to test dataset

Figure 28 shows final distribution of sequences in the dataset used in this report.

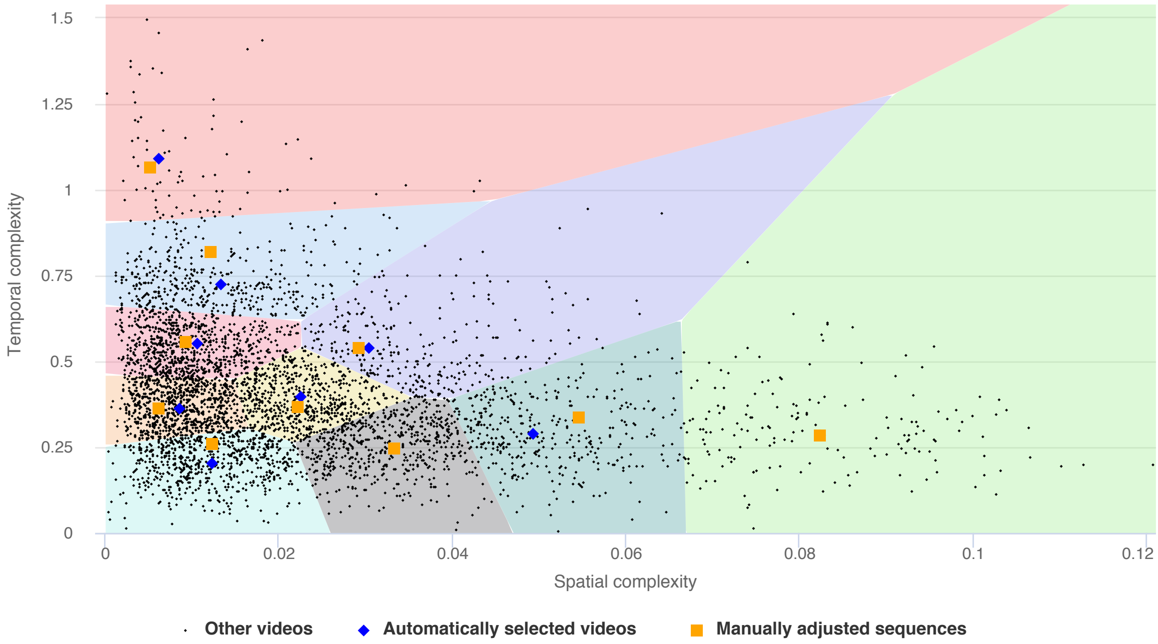


FIGURE 28: Distribution of sequences in final dataset

New dataset consists of 10 video sequences: 4 videos from old dataset, and 6 new videos from Vimeo. 6 sequences from old dataset were excluded. Median bitrate of all sequences in the final dataset is 109.584 Mbps. The complete list of sequences from new dataset can be found in Appendix A.

C CODECS

C.1 x264

Encoder title	x264
Version	r2833 df79067
Developed by	x264 Developer Team

Preset name	Encoder parameters
Reference	`x264 --tune ssim --preset veryslow --bitrate %BITRATE_KBPS% %SOURCE_FILE% -o %TARGET_FILE% --input-res %WIDTH%x%HEIGHT% --fps %FPS%`
4K	`x264 --preset fast --keyint infinite --tune ssim --bitrate %BITRATE_KBPS% %SOURCE_FILE% --input-res %WIDTH%x%HEIGHT% --fps %FPS% -o %TARGET_FILE%`

C.2 nj264

Encoder title	nj264
Version	V1.0
Developed by	Nanjing Yunyan

The encoder is recipient of the Frost & Sullivan 2016 Global Enabling Technology Leadership of the Year Award for AVC Video Encoding.

Preset name	Encoder parameters
4K	`nj264.exe -s %WIDTH%x%HEIGHT% -framerate %FPS% -i %SOURCE_FILE% -c:v libnj264 -nj264-params bitrate=%BITRATE_KBPS% -f h264 -y %TARGET_FILE%`

C.3 nj265

Encoder title	nj265
Version	V1.0
Developed by	Nanjing Yunyan

Preset name	Encoder parameters
4K	`nj265.exe -s %WIDTH%x%HEIGHT% -framerate %FPS% -i %SOURCE_FILE% -c:v libnj265 -nj265-params bitrate=%BITRATE_KBPS% -f hevc -y %TARGET_FILE%`

C.4 KS265

Encoder title	Kingsoft Encoder
Version	V2.6.1.3
Developed by	Kingsoft

Preset name	Encoder parameters
4K	`AppEncoder_x64.exe -i %SOURCE_FILE% -wdt %WIDTH% -hgt %HEIGHT% -fr %FPS% -br %BITRATE_KBPS% -b %TARGET_FILE% -preset slow -rc 1 -me 1 -rdoq 0`

D FIGURES EXPLANATION

The main charts in this comparison are classical RD curves (quality/bitrate graphs) and relative bitrate/relative time charts. Additionally, bitrate handling charts (ratio of real and target bitrates) and per-frame quality charts were also used.

D.1 RD Curves

These charts show variation in codec quality by bitrate or file size. For this metric, a higher curve presumably indicates better quality.

D.2 Relative Bitrate/Relative Time Charts

Relative bitrate/relative time charts show the dependence on relative encoding time of the average bitrate for a fixed quality output. The Y-axis shows the ratio of the bitrate of the codec under test to that of the reference codec for a fixed quality. A lower value (that is, the higher the value is on the graph) indicates a better-performing codec. For example, a value of 0.7 means that codec under test can encode the sequence under test in a file that is 30% smaller than that encoded by the reference codec.

The X-axis shows the relative encoding time for the codec under test. Larger values indicate a slower codec. For example, a value of 2.5 means that the codec under test works 2.5 times slower, on average, than the reference codec.

D.3 Graph Example

Figure 29 shows a case where these graphs can be useful. In the top left graph, it is apparent that the “Green” codec encodes with significantly better quality than the “Black” codec. On the other hand, the top right graph shows that the “Green” codec is slightly slower. Relative bitrate/relative time graphs can be useful in precisely these situations: it is clearly visible in the bottom graph that one of the codecs is slower, but yields higher visual quality, and that the other codec is faster, but yields lower visual quality.

As a result of these advantages, relative bitrate/relative time graphs are used frequently in this report since they assist in the evaluation of the codecs in the test set, especially when number of codecs is large.

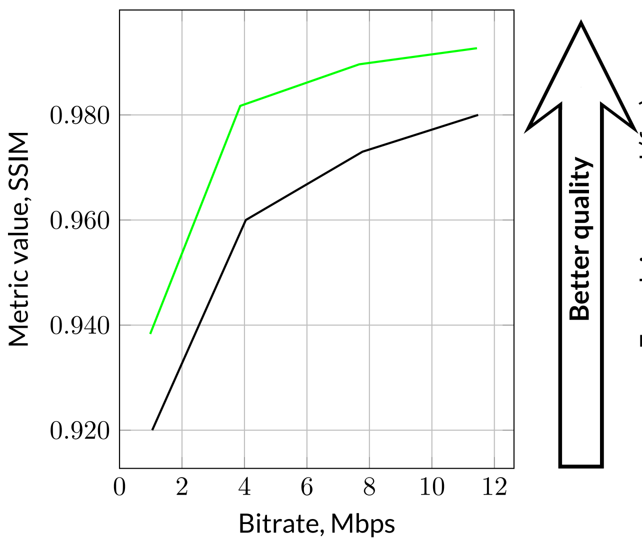
A more detailed description of the preparation of these graphs is given below.

D.4 Bitrates Ratio with the Same Quality

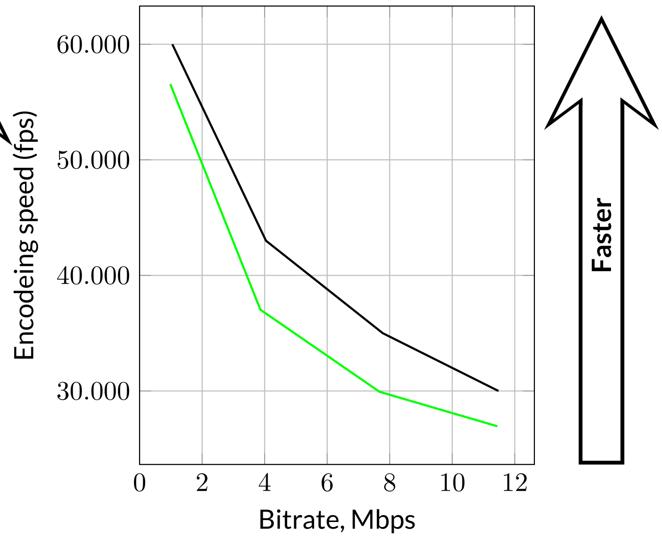
The first step in computing the average bitrate ratio for a fixed quality is inversion of the axes of the bitrate/quality graph (see Figure 30b). All further computations are performed using the inverted graph.

The second step involves averaging the interval over which the quality axis is chosen. Averaging is performed only over those segments for which there are results for both codecs. This limitation is due to the difficulty of developing extrapolation methods for classic RD curves; nevertheless, for interpolation of RD curves, even linear methods are acceptable.

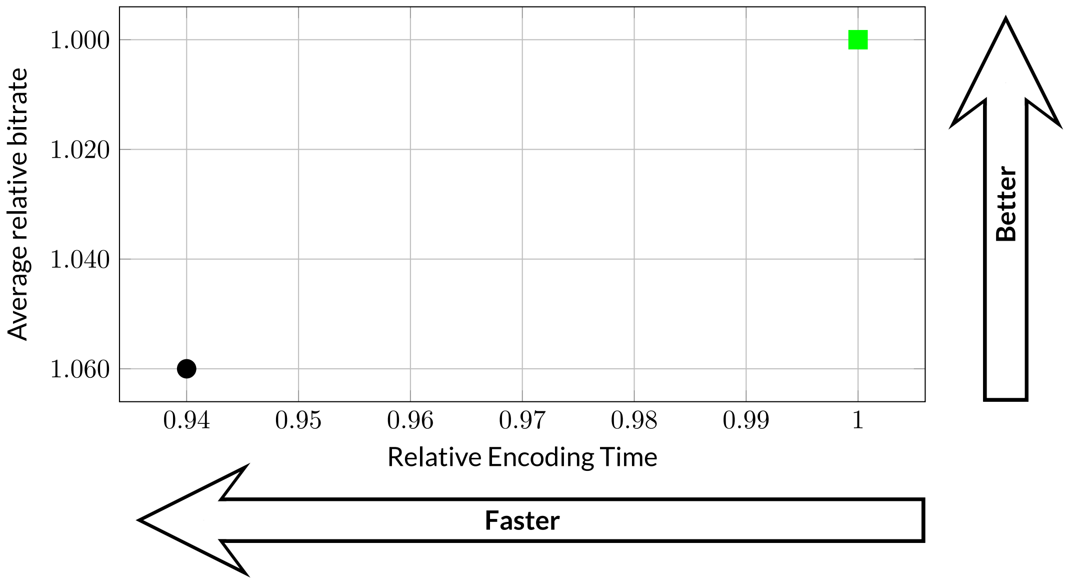
The final step is calculation of the area under the curves in the chosen interpolation segment and determination of their ratio (see Figure 30c). This result is an average bitrate ratio for a fixed quality for the two codecs. If



(a) RD curve. “Green” codec is better!

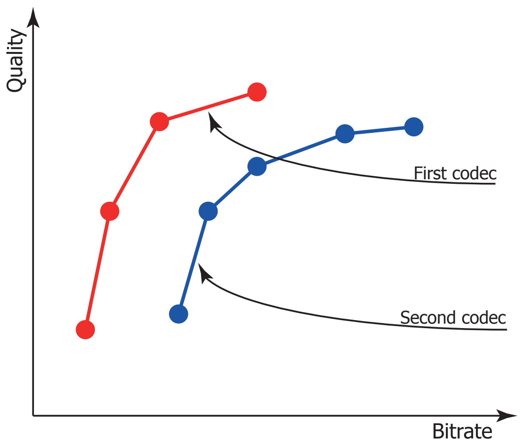


(b) Encoding speed (frames per second). “Green” codec is slower!

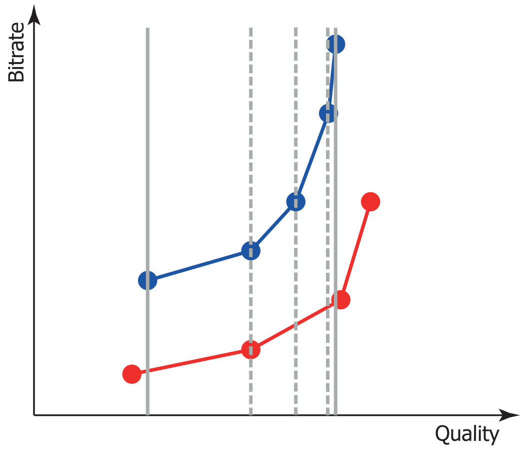


(c) Integral situation with codecs. This plot shows the situation more clearly

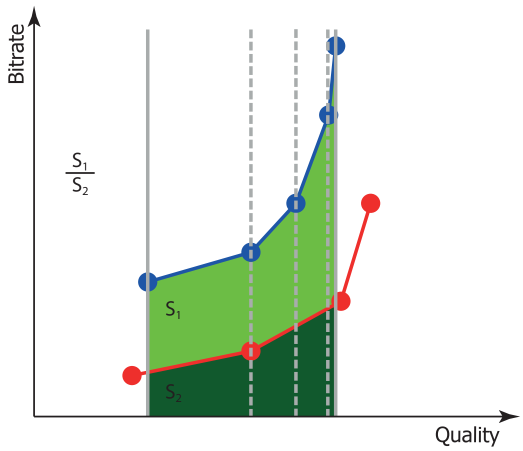
FIGURE 29: Speed/Quality trade-off example



(a) Source RD curves



(b) Axes' inversion and averaging interval choosing



(c) Areas under curves ratio

FIGURE 30: Average bitrate ratio computation

more than two codecs are considered, then one of them is defined as a reference codec and the quality of others is compared to that of the reference.

D.5 Relative Quality Analysis

While most figures in this report provide codec scores relative to reference encoder (i.e. x264) the "Relative Quality Analysis" sections show bitrate ratio with fixed quality (see Section D.4) score for each codec pair. This might be useful if one is interested in comparison of codec A relative to codec B only.

Below we show simplified example of "Average bitrate ratio for a fixed quality" table for two codecs only:

	A	B
A	100% ☺	75% ☹
B	134% ☹	100% ☺

TABLE 5: Example of average bitrate ratio for a fixed quality table

Let's consider column "B" row "A" of the table containing value 75% this should be read in the following way: average bitrate for a fixed quality of codec B is 75% less relative to codec A. The icon in the cell depicts confidence of this estimate. If projections of codecs' RD curves on quality axis (see Figure 30) have relatively large common area you will see happy icon. If size of this intersection is small and thus bitrate score can't be computed reliably the sad icon will be shown.

"Average bitrate ratio for a fixed quality" plots are visualizations of these tables. Each line in such plot depicts values from one column of corresponding table.

E OBJECTIVE QUALITY METRICS DESCRIPTION

E.1 SSIM (Structural SIMilarity)

YUV-SSIM objective quality metric was used in this report to assess quality of encoded video sequences. We compute YUV-SSIM as weighed average of SSIM values computed for each channel individualy (Y-SSIM, U-SSIM, V-SSIM):

$$\text{YUV-SSIM} = \frac{4\,\text{Y-SSIM} + \text{U-SSIM} + \text{V-SSIM}}{6}. \tag{1}$$

Brief description of SSIM metric computation is given below.

E.1.1 Brief Description

The original paper on the SSIM metric was published by Wang, et al.[2] The paper can be found at http://ieeexplore.ieee.org/iel5/83/28667/01284395.pdf. The SSIM author homepage is found at http://www.cns.nyu.edu/~lcv/ssim/

The scheme of SSIM calculation can be presented as follows. The main idea that underlies the structural similarity (SSIM) index is comparison of the distortion of three image components:

- Luminance
- Contrast
- Structure

The final formula, after combining these comparisons, is the following:

$$\textbf{SSIM}(x, y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x + \mu_y + C_1)(\sigma_x + \sigma_y + C_2)}, \tag{2}$$

where

$$\mu_x = \sum_{i=1}^{N} \omega_i x_i, \tag{3}$$

$$\sigma_x = \sqrt{\sum_{i=1}^{N} \omega_i (x_i - \mu_x)}, \tag{4}$$

$$\sigma_{xy} = \sum_{i=1}^{N} \omega_i (x_i - \mu_x)(y_i - \mu_y). \tag{5}$$

Finally, $C_1 = (K_1 L)^2$ and $C_2 = (K_2 L)^2$, where L is the dynamic range of the pixel values (e.g. 255 for 8-bit grayscale images), and $K1, K2 \ll 1$.

The values $K_1 = 0.01$ and $K_2 = 0.03$ were used for the comparison presented in this report, and the matrix filled with a value "1" in each position to form a filter for the result map.

For the implementation used in this comparison, one SSIM value corresponds to two sequences. The value is in the range $[-1, 1]$, with higher values being more desirable (a value of 1 corresponds to identical frames). One of

[2] Zhou Wang, Alan Conrad Bovik, Hamid Rahim Sheikh and Eero P. Simoncelli, "Image Quality Assessment: From Error Visibility to Structural Similarity," IEEE Transactions on Image Processing, Vol. 13, No. 4, April 2004.

the advantages of the SSIM metric is that it better represents human visual perception than does PSNR. SSIM is more complex, however, and takes more time to calculate.

E.1.2 Examples

Figure 31 shows the example of an SSIM result for an original and processed (compressed with lossy compression) image. The resulting value of 0.9 demonstrates that the two images are very similar.

(a) Original (b) Compressed (c) SSIM

FIGURE 31: SSIM example for compressed image

Figure 32 depicts various distortions applied to original image and Figure 33 shows SSIM values for these distortions.

(a) Original image

(b) Image with added noise

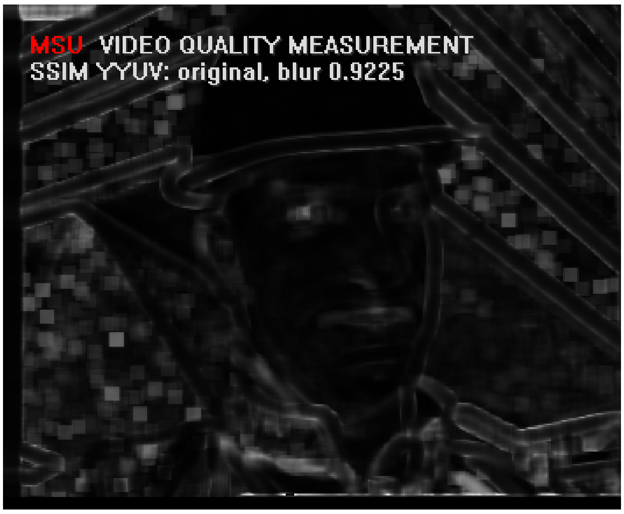
(c) Blurred image

(d) Sharpen image

FIGURE 32: Examples of processed images

(a) SSIM map for original image, **SSIM** $= 1$

(b) SSIM map for noisy image, **SSIM** $= 0.552119$



(c) SSIM map for blurred image, **SSIM** $= 0.9225$

(d) SSIM map for sharpen image, **SSIM** $= 0.958917$

FIGURE 33: SSIM values for original and processed images

F ABOUT THE GRAPHICS & MEDIA LAB VIDEO GROUP

The Graphics & Media Lab Video Group is part of the Computer Science Department of Moscow State University. The Graphics Group began at the end of 1980's, and the Graphics & Media Lab was officially founded in 1998. The main research avenues of the lab include areas of computer graphics, computer vision and media processing (audio, image and video). A number of patents have been acquired based on the lab's research, and other results have been presented in various publications.

The main research avenues of the Graphics & Media Lab Video Group are video processing (pre- and post-, as well as video analysis filters) and video compression (codec testing and tuning, quality metric research and codec development).

The main achievements of the Video Group in the area of video processing include:

- High-quality industrial filters for format conversion, including high-quality deinterlacing, high-quality frame rate conversion, new, fast practical super resolution and other processing tools.
- Methods for modern television sets, such as a large family of up-sampling methods, smart brightness and contrast control, smart sharpening and more.
- Artifact removal methods, including a family of denoising methods, flicking removal, video stabilization with frame edge restoration, and scratch, spot and drop-out removal.
- Application-specific methods such as subtitle removal, construction of panorama images from video, video to high-quality photo conversion, video watermarking, video segmentation and practical fast video deblur.

The main achievements of the Video Group in the area of video compression include:

- Well-known public comparisons of JPEG, JPEG-2000 and MPEG-2 decoders, as well as MPEG-4 and annual H.264 codec testing; codec testing for weak and strong points, along with bug reports and codec tuning recommendations.
- Video quality metric research; the MSU Video Quality Measurement Tool and MSU Perceptual Video Quality Tool are publicly available.
- Internal research and contracts for modern video compression and publication of MSU Lossless Video Codec and MSU Screen Capture Video Codec; these codecs have one of the highest available compression ratios.

The Video Group has also worked for many years with companies like Intel, Samsung and RealNetworks.

In addition, the Video Group is continually seeking collaboration with other companies in the areas of video processing and video compression.

E-mail: `video@graphics.cs.msu.ru`

G LIST OF MINARY FIXES

We are sorry for mistakes and formatting defects in the release version of our report. This year we used new version of report generation system, that caused some inaccuracies passed while manual report checking. In this report version the following mistakes were corrected:

1. x265 codec version was unified and corrected in all mentions and report parts. Before this changes, some of the x265 mentions included an old (1.9+169-e5b5bdc3c154) version. This happened due to cut&paste from previous 2016 report and some mentions was passed while changing to a correct version (2.3+23-97435a0870befe35)
2. The name uAVS2 was corrected on the title page of Part 1
3. In Part 3, overlapping of x264 description was fixed (in an appendix with codecs)
4. In Part 4, text overlapping in Section 2 (with codecs descriptions) was corrected
5. List of video sequences and their descriptions were completed in Part 4
6. All screenshots from all sequences were converted to JPEG due to make the PDF file size smaller

MSU Video Quality Measurement Tool

MSU Graphics & Media Lab. Video Group.

GRAPHICS & MEDIA LAB
VIDEO GROUP

3 reasons to use VQMT:

- **Fastest implementation of VMAF**
- **Fastest SSIM/MS-SSIM speed on 4K/8K video**
- **Professional analysis with NIQE and artifact metrics**

video-measure@compression.ru

1. Widest Range of Metrics & Formats

1.1 20+ Objective Metrics

PSNR several versions	Spatio-Temporal SSIM
MSAD	MSU Blurring Metric
Delta	MSU Brightness Flicking Metric
MSE	MSU Brightness Independent PSNR
VQM	MSU Drop Frame Metric
SSIM	MSU Noise Estimation Metric
MS-SSIM	MSU Scene Change Detector
3-SSIM	MSU Blocking Metric
VMAF	**NIQE (no-reference comparison)**

1.2 HDR support

1.3 Hundreds Video and 30+ Image Formats

All popular video codecs, including **H264** and **HEVC**.

Special support for: RAW, Y4M, AviSynth, PXM.

All popular image formats: PNG, JPEG, TIFF (**with HDR support**), EXR, BMP, PSD, and others

1.4 2k, 4k, 8k support

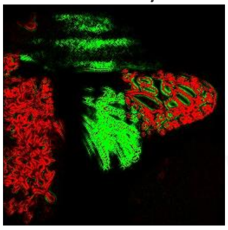
2. Fastest Video Quality Measurement

2.1 Up to 11.7x faster calculation of metrics with GPU (CUDA & OpenGL support)

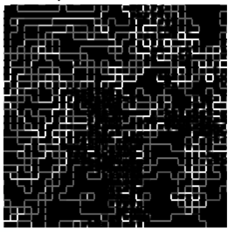
2.2 Multi-core Processors Support

Visualization Examples

Allows easily detect where codec/filter fails



MSU Blurring Metric



MSU Blocking Metric

VQMT average Speedup

3. Easy Integration

3.1 Linux support

DEB & RPM packages

3.2 Batch Processing with JSON and CSV output

3.3 Plugins SDK

4. Professional Analysis

4.1 Comparative Analysis

4.2 Metric Visualization

MSU VQMT Official Page

Tool was downloaded more than 200 000 times!

Free and Professional versions are available

Big thanks to our contributors:

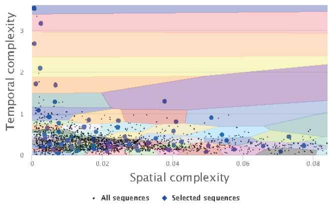
Reduce video file size or encoding speed with optimal codec settings

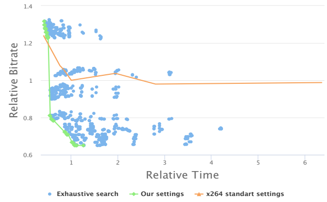
Effective Video Transcoding

For almost 14 years, Lomonosov MSU Graphics&Media Lab's video group has been conducting video codecs comparisons. We know that almost always there is a possibility to find efficient encoding options for every video

We created a representative dataset of **385 videos** chosen from **9000+ FullHD&4K** videos

12 million encoder launches were done on Intel Xeon E3-1125v3

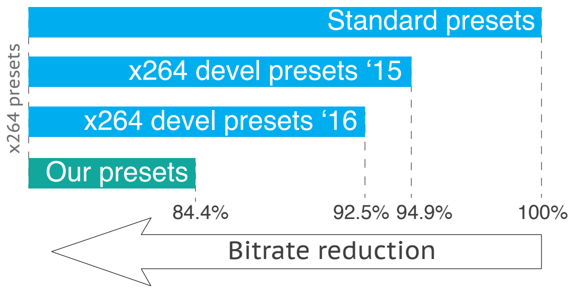




Full-size charts are available on our project page

15% bitrate savings in average

Encoding presets determined by our method beats x264 developers' presets with keeping encoding time and encoded video quality



Percentage of file size reduction in average for a representative dataset of 77 videos

We developed a way to find optimal presets for a large number of video classes

Everything is fair! We don’t declare an “up-to-x%” bitrate reduction — average file size reduction is 15% higher comparing to standard x264 presets

We find presets that **do not reduce encoding speed and objective quality of encoded video**
You give limitations, and we guarantee the same or higher objective quality and encoding speed

You use standard presets and don’t believe that it will work for your videos? Give us a chance — request a demo, for free!

We can find best presets for your videos

1. **Your video** — send us uncompressed video and your preset
2. **Report** — get a report with optimal presets for your video and their gain
3. **Choose and pay** — we offer additional options for better compression and analysis
4. **Get preset** and encode similar videos with it, or **Get video** compressed with chosen preset

Subjective comparisons
Receive subjective quality comparison results for your videos

Codec analysis
Find out strong and weak parts of your codec

Saliency-adaptive encoding
Bitrate savings given by adaptive encoding of salient regions

Gaze maps construction
Raw viewers’ gaze points on your video

Encoding with extremely low bitrates
Get your video of highest quality for low bitrates

4K and 360-degree encoding
Best presets for high-quality formats encoding

contact **evt@compression.ru** to get them!

Our project page compression.ru/video/video_codec_optimization/

In cooperation with Lomonosov MSU Graphics&Media Lab

GRAPHICS & MEDIA LAB VIDEO GROUP