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| *Title:* | **SVT-HEVC encoder performance** | | |
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|  |  |  |  |
| *Source:* | Intel | | |

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# Abstract

SVT-HEVC is an open source HEVC encoder optimized for Intel Xeon processors. The encoder provides three operating modes, namely PSNR/SSIM optimized, VMAF optimized and visually optimized modes. The encoder supports 8-bit and 10-bit YUV 420 formats. The following contribution presents the performance of the PSNR/SSIM optimized SVT-HEVC encoder mode vs. HM16.0, as well as the corresponding density.

# Introduction

The Scalable Video Technology for HEVC (SVT-HEVC) encoder is an HEVC-compliant open source encoder that was first introduced in the 33rd JCT-VC meeting [1]. The encoder achieves excellent density-quality tradeoffs, and is highly optimized for Intel® Xeon™ Scalable Processors and Intel® Xeon™ D processors. The SVT-HEVC encoder supports 3 modes:

* A Visual quality mode optimized for best subjective quality (-tune 0)
* A PSNR/SSIM mode optimized for best PSNR/SSIM objective performance tradeoffs (-tune 1 (Default setting)).
* A VMAF mode optimized for best VMAF objective performance tradeoffs (-tune 2)

For each of the three modes listed above, the encoder supports up to 11 density-quality presets. A preset defines the quality vs. density trade-off point that the encoder is to operate at, with M0 corresponding to the highest quality preset and M9/M10 corresponding to the highest density presets.

As a follow-up on the information presented in [1], this document presents objective PSNR/SSIM performance data for the SVT-HEVC encoder, as well as density data.

# PSNR/SSIM objective quality comparison vs. HM16.0

This section presents the PSNR/SSIM BD-rate performance data of the SVT-HEVC encoder with reference to the HM16.0 encoder, both operating in the random access configuration.

The list of clips considered in the evaluation is included in the Appendix and consists of a subset of the clips in the HM 4:2:0 test list [2] and some additional clips. The encodings were generated using QP 27, 32, 37 and 42 for both encoders. The intra period setting is included in Table 1.

Table 1. Intra period value for random access configurations for both HM16.0 and SVT-HEVC encoders.

|  |  |
| --- | --- |
| Frame rate (frames per second) | Intra period |
| 20 | 24 |
| 24 | 24 |
| 30 | 32 |
| 50 | 48 |
| 60 | 56 |
| 100 | 96 |

The SVT-HEVC vs. HM16.0 PSNR/SSIM BD-rate performance data for different presets and different resolutions is included below in Table 2. Per sequence results are available in the attached Excel spreadsheet.

Table 2. PSNR/SSIM BD-rate performance data for the SVT-HEVC encoder with reference to the HM16.0 encoder.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PSNR** |  |  |  | **SSIM** |  |  |  |
|  | **BD-rate (piecewise cubic)** | | | | **BD-rate (piecewise cubic)** | | | |
| **480p and 240p** | Y | U | V | YUV | Y | U | V | YUV |
| HEVC\_M0 vs HM16 | 20.4% | -12.8% | -10.7% | 12.6% | 15.1% | -15.9% | -13.2% | 10.4% |
| HEVC\_M1 vs HM16 | 21.4% | -10.3% | -8.1% | 14.1% | 15.0% | -14.2% | -11.7% | 10.6% |
| HEVC\_M2 vs HM16 | 24.1% | -7.5% | -4.9% | 16.8% | 16.9% | -11.8% | -8.9% | 12.6% |
| HEVC\_M3 vs HM16 | 31.2% | -6.9% | -3.5% | 22.4% | 21.8% | -10.4% | -7.0% | 17.0% |
| HEVC\_M4 vs HM16 | 36.2% | -2.2% | 1.4% | 27.3% | 26.6% | -5.8% | -2.1% | 21.8% |
| HEVC\_M5 vs HM16 | 43.2% | 5.2% | 9.8% | 34.7% | 31.4% | 1.2% | 6.1% | 27.1% |
| HEVC\_M6 vs HM16 | 53.8% | 11.5% | 17.2% | 44.3% | 37.6% | 6.8% | 13.1% | 33.3% |
| HEVC\_M7 vs HM16 | 61.0% | 17.8% | 24.1% | 51.4% | 42.5% | 12.7% | 19.9% | 38.5% |
| HEVC\_M8 vs HM16 | 71.8% | 28.8% | 36.5% | 62.5% | 51.1% | 24.5% | 34.2% | 47.7% |
| HEVC\_M9 vs HM16 | 89.8% | 37.8% | 46.5% | 78.3% | 62.9% | 33.3% | 44.9% | 59.2% |
|  |  |  |  |  |  |  |  |  |
|  | **PSNR** |  |  |  | **SSIM** |  |  |  |
|  | **BD-rate (piecewise cubic)** | | | | **BD-rate (piecewise cubic)** | | | |
| **720p** | Y | U | V | YUV | Y | U | V | YUV |
| HEVC\_M0 vs HM16 | 19.5% | -13.5% | -6.7% | 12.2% | 17.8% | -15.8% | -10.6% | 12.6% |
| HEVC\_M1 vs HM16 | 20.9% | -11.4% | -3.9% | 13.9% | 18.2% | -14.4% | -8.5% | 13.2% |
| HEVC\_M2 vs HM16 | 21.3% | -11.2% | -3.7% | 14.3% | 18.9% | -14.2% | -8.2% | 13.8% |
| HEVC\_M3 vs HM16 | 37.4% | -6.2% | 1.1% | 27.7% | 35.0% | -9.9% | -4.4% | 26.3% |
| HEVC\_M4 vs HM16 | 40.3% | -4.4% | 3.6% | 30.4% | 37.7% | -8.1% | -2.0% | 29.0% |
| HEVC\_M5 vs HM16 | 45.1% | -0.9% | 7.8% | 35.0% | 40.8% | -4.5% | 2.6% | 32.2% |
| HEVC\_M6 vs HM16 | 51.2% | 1.0% | 10.3% | 39.9% | 44.6% | -2.7% | 5.1% | 35.6% |
| HEVC\_M7 vs HM16 | 54.8% | 3.1% | 12.9% | 43.2% | 47.4% | -0.5% | 7.9% | 38.4% |
| HEVC\_M8 vs HM16 | 61.3% | 14.9% | 25.8% | 51.4% | 52.5% | 13.5% | 24.7% | 45.1% |
| HEVC\_M9 vs HM16 | 66.1% | 16.7% | 27.8% | 55.5% | 56.6% | 15.4% | 27.0% | 48.8% |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | **PSNR** |  |  |  | **SSIM** |  |  |  |
|  | **BD-rate (piecewise cubic)** | | | | **BD-rate (piecewise cubic)** | | | |
| **1080p** | Y | U | V | YUV | Y | U | V | YUV |
| HEVC\_M0 vs HM16 | 18.2% | -20.4% | -19.9% | 9.2% | 15.2% | -23.5% | -23.6% | 9.4% |
| HEVC\_M1 vs HM16 | 19.6% | -18.3% | -17.7% | 10.9% | 15.4% | -22.2% | -22.6% | 9.8% |
| HEVC\_M2 vs HM16 | 22.4% | -16.8% | -16.1% | 13.4% | 17.4% | -20.8% | -21.1% | 11.7% |
| HEVC\_M3 vs HM16 | 26.2% | -15.7% | -14.8% | 16.5% | 19.9% | -19.7% | -19.9% | 14.0% |
| HEVC\_M4 vs HM16 | 31.2% | -11.6% | -10.8% | 21.3% | 25.0% | -16.1% | -16.4% | 18.8% |
| HEVC\_M5 vs HM16 | 36.7% | -6.1% | -5.2% | 27.0% | 29.3% | -11.2% | -11.1% | 23.3% |
| HEVC\_M6 vs HM16 | 44.3% | -2.8% | -1.3% | 33.6% | 34.0% | -8.1% | -7.7% | 27.8% |
| HEVC\_M7 vs HM16 | 48.1% | 0.0% | 1.6% | 37.2% | 36.7% | -5.3% | -5.1% | 30.5% |
| HEVC\_M8 vs HM16 | 57.3% | 11.3% | 14.5% | 47.2% | 44.3% | 6.1% | 7.9% | 38.9% |
| HEVC\_M9 vs HM16 | 65.5% | 15.2% | 18.4% | 54.4% | 49.3% | 10.1% | 12.0% | 43.8% |
| HEVC\_M10 vs HM16 | 80.8% | 22.6% | 26.6% | 67.9% | 61.1% | 18.5% | 20.6% | 55.1% |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | **PSNR** |  |  |  | **SSIM** |  |  |  |
|  | **BD-rate (piecewise cubic)** | | | | **BD-rate (piecewise cubic)** | | | |
| **4k and 2k** | Y | U | V | YUV | Y | U | V | YUV |
| HEVC\_M0 vs HM16 | 18.6% | -17.6% | -18.4% | 9.8% | 18.8% | -21.2% | -22.5% | 12.6% |
| HEVC\_M1 vs HM16 | 19.6% | -16.4% | -17.5% | 10.9% | 18.8% | -20.8% | -22.2% | 12.8% |
| HEVC\_M2 vs HM16 | 22.2% | -14.6% | -16.0% | 13.3% | 20.5% | -18.5% | -20.6% | 14.5% |
| HEVC\_M3 vs HM16 | 27.0% | -10.4% | -12.5% | 18.0% | 24.8% | -14.0% | -16.5% | 18.9% |
| HEVC\_M4 vs HM16 | 38.3% | -1.5% | -4.0% | 28.1% | 35.5% | -5.7% | -8.7% | 29.0% |
| HEVC\_M5 vs HM16 | 42.9% | 1.8% | 0.5% | 32.4% | 38.1% | -2.4% | -4.9% | 31.8% |
| HEVC\_M6 vs HM16 | 49.3% | 5.7% | 4.5% | 38.2% | 42.6% | 2.3% | -0.6% | 36.2% |
| HEVC\_M7 vs HM16 | 57.7% | 18.0% | 17.2% | 47.6% | 50.8% | 16.0% | 12.1% | 45.0% |
| HEVC\_M8 vs HM16 | 64.8% | 23.0% | 22.7% | 54.4% | 56.7% | 22.5% | 18.3% | 50.9% |
| HEVC\_M9 vs HM16 | 71.7% | 25.7% | 25.8% | 60.8% | 60.3% | 25.1% | 20.9% | 54.7% |
| HEVC\_M10 vs HM16 | 85.2% | 35.1% | 35.3% | 73.4% | 72.9% | 40.4% | 32.8% | 67.2% |

# Density performance

The SVT-HEVC encoder achieves real-time encoding of up to two 4Kp60/10-bit streams on the Intel® Xeon® Gold 6140 Processor with the M10 preset running in the PSNR/SSIM objective quality mode.

# Access Information

* The SVT-HEVC open source project is hosted at <https://github.com/intel/SVT-HEVC>
* A user guide is available at <https://github.com/intel/SVT-HEVC/blob/master/Docs/SVT-HEVC_Encoder_User_Guide.pdf>
* The open source license is available at <https://github.com/intel/SVT-HEVC/blob/master/LICENSE.md>

# Appendix

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HM 4:2:0 test sequences used in the evaluation** | | | | | |
| *Class* | *Input* | *Frame rate* | *Encoding format* | *Test sequence filename* | *Encoded frame count* |
| *Size* | *bit-depth* | *Test sequence configuration filename* |
| Class A2 3180x2160 | 10-bit | 60 | YCbCr 4:2:0 | DaylightRoad2\_3840x2160\_60fps\_10bit\_420.yuv | 300 |
| Class B  1920x1080 | 8-bit | 50 | YCbCr 4:2:0 | Cactus\_1920x1080\_50.yuv | 500 |
| 8-bit | 50 | YCbCr 4:2:0 | BasketballDrive\_1920x1080\_50.yuv | 500 |
| 8-bit | 60 | YCbCr 4:2:0 | BQTerrace\_1920x1080\_60.yuv | 600 |
| Class C  832x480 | 8-bit | 50 | YCbCr 4:2:0 | BasketballDrill\_832x480\_50.yuv | 500 |
| 8-bit | 60 | YCbCr 4:2:0 | BQMall\_832x480\_60.yuv | 600 |
| 8-bit | 50 | YCbCr 4:2:0 | PartyScene\_832x480\_50.yuv | 500 |
| 8-bit | 30 | YCbCr 4:2:0 | RaceHorses\_832x480\_30.yuv | 300 |
| Class D  416x240 | 8-bit | 50 | YCbCr 4:2:0 | BasketballPass\_416x240\_50.yuv | 500 |
| 8-bit | 60 | YCbCr 4:2:0 | BQSquare\_416x240\_60.yuv | 600 |
| 8-bit | 50 | YCbCr 4:2:0 | BlowingBubbles\_416x240\_50.yuv | 500 |
| 8-bit | 30 | YCbCr 4:2:0 | RaceHorses\_416x240\_30.yuv | 300 |
| Class E  1280x720 | 8-bit | 60 | YCbCr 4:2:0 | FourPeople\_1280x720\_60.yuv | 600 |
| 8-bit | 60 | YCbCr 4:2:0 | Johnny\_1280x720\_60.yuv | 600 |
| 8-bit | 60 | YCbCr 4:2:0 | KristenAndSara\_1280x720\_60.yuv | 600 |
| Class F  Mixed size | 8-bit | 50 | YCbCr 4:2:0 | BasketballDrillText\_832x480\_50.yuv | 500 |
| 8-bit | 60 | YCbCr 4:2:0 | ArenaOfValor\_1920x1080\_60\_8bit\_420.yuv | 600 |
| 8-bit | 30 | YCbCr 4:2:0 | SlideEditing\_1280x720\_30.yuv | 300 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| **Other clips used in the evaluation** | | | | | |
| *Class* | *Input* | *Frame rate* | *Encoding format* | *Test sequence filename* | *Encoded frame count* |
| *Size* | *bit-depth* | *Test sequence configuration filename* |
| 832x480 | 8-bit | 50 | YCbCr 4:2:0 | BasketballDrill\_832x480\_50 | 500 |
| 1024x768 | 8-bit | 30 | YCbCr 4:2:0 | ChinaSpeed\_1024x768\_30 | 500 |
| 1920x1080 | 8-bit | 24 | YCbCr 4:2:0 | Kimono1\_1920x1080\_24 | 240 |
| 8-bit | 24 | YCbCr 4:2:0 | ParkScene\_1920x1080\_24 | 240 |
| 2560x1600 | 10-bit | 60 | YCbCr 4:2:0 | NebutaFestival\_2560x1600\_60\_10bit\_crop | 300 |
| 8-bit | 30 | YCbCr 4:2:0 | PeopleOnStreet\_2560x1600\_30\_crop | 150 |
| 10-bit | 60 | YCbCr 4:2:0 | SteamLocomotiveTrain\_2560x1600\_60\_10bit\_crop | 300 |
| 8-bit | 30 | YCbCr 4:2:0 | Traffic\_2560x1600\_30\_crop | 300 |
| 3840x2160 | 10-bit | 30 | YCbCr 4:2:0 | TrafficFlow\_3840x2160\_30fps\_10bit\_420\_jvet | 300 |
| 10-bit | 50 | YCbCr 4:2:0 | BuildingHall2\_3840x2160\_50fps\_10bit\_420 | 500 |
| 10-bit | 30 | YCbCr 4:2:0 | Campfire\_3840x2160\_30fps\_bt709\_420\_videoRange | 300 |
| 10-bit | 60 | YCbCr 4:2:0 | CatRobot\_3840x2160\_60fps\_10bit\_420\_jvet | 300 |
| 10-bit | 100 | YCbCr 4:2:0 | Drums\_3840x2160\_100fps\_10bit\_420\_jvet | 300 |
| 4096x2160 | 10-bit | 60 | YCbCr 4:2:0 | RollerCoaster\_4096x2160\_60fps\_10bit\_420\_jvet | 300 |
| 10-bit | 60 | YCbCr 4:2:0 | Tango\_4096x2160\_60fps\_10bit\_420\_jvet | 294 |
| 10-bit | 60 | YCbCr 4:2:0 | ToddlerFountain\_4096x2160\_60fps\_10bit\_420\_jvet | 300 |

# References

[1] F. Kossentini and J. Boyce, “SVT-HEVC open source HEVC encoder,” JCTVC-AG0027-v1. Oct. 2018. Macao, CN.

[2] K. Sharman, K. Suehring, “Common test conditions,” JCTVC-AF1100, July 2018, Ljubljana, SI.