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VVENC: AN OPEN AND OPTIMIZED VVC ENCODER IMPLEMENTATION

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ABSTRACT

The recently finalized Versatile Video Coding (VVC) standard promises to reduce the video bitrate by 50% compared to its predecessor, High Efficiency Video Coding (HEVC). The increased efficiency comes at a cost of increased computational burden. The Fraunhofer Versatile Video Encoder VVenC is the first openly available optimized implementation providing access to VVC's efficiency at only 46% of the runtime of the VVC test model VTM, when not using multi-threading. An alternative operating point allows 30× faster encoding for the price of around 12% bitrate increase, while still providing around 38% bitrate reduction compared to HEVC test model HM. In the fastest configuration, VVenC runs over 140× faster than VTM while still providing over 10% bitrate reduction compared to HM. Even faster encoding is possible with multi-threading. This paper provides an overview of VVenC's main features and some evaluation results.

***Index Terms*—** VVC, Encoder, Software, Quality, QoE.

1. INTRODUCTION

In July 2020, the Joint Video Experts Team (JVET), a collaborative project of the ITU-T Video Coding Experts Group (VCEG) and ISO/IEC Moving Picture Experts Group (MPEG), has finalized a new video coding standard called Versatile Video Coding (VVC) [1]. VVC is the successor of the High Efficiency Video Coding (HEVC) standard [2] and has been released by ITU-T as H.266 and by ISO/IEC as MPEG-I Part 3 (23090-3). The new standard targets a 50% bitrate reduction over HEVC at the same visual quality.

The VVC test model (VTM) [3] serves as a common reference implementation, i.e., a test bed for evaluation and verification of proposed technologies during standardization. It is aimed at correctness, completeness and readability and should not serve as a real-world example of a VVC encoder and decoder.

The Fraunhofer Versatile Video Encoder (VVenC) development was initiated [4] to provide a publicly available, fast and efficient VVC encoder implementation. The VVenC software is based on VTM and written in C++, with optimizations including software redesign to mitigate performance bottlenecks, extensive SIMD optimization, improved encoder search algorithms and multi-threading support to exploit parallelization. Additionally, VVenC supports real-world encoder features such as frame-level rate control and visually optimized encoding in order to provide a flexible, fast and easy to use video encoding solution for the VVC standard.

2. ABOUT VVENC

VVenC is freely available in source-code from GitHub under a copyright 3-clause BSD license at the following address:

https://github.com/fraunhoferhhi/vvenc

It is free for both commercial and non-commercial use. The software was initially released in September 2020, just two months after the VVC standard finalization. Although it has been mostly internally developed by researchers at Fraunhofer HHI, it is open to external contributions and strives to build a broader community.

The current public VVenC version is 0.3.1 and it has been released on March 22nd 2021. If not otherwise indicated, the following results and feature description concern this version.

3. MAIN FEATURES

The purpose of the VVenC software is to encode raw YUV videos into VVC compliant bitstreams in the most efficient way within a limited amount of time. It is based on the VTM reference software and optimized for more practical use cases.

The encoder provides 5 predefined presets that represent different encoding-speed/compression quality offsets: faster, fast, medium, slow, and slower. The slower preset delivers all of VVC's compression efficiency at less than half the time required by the reference encoder, while other presets provide very attractive alternative trade-offs at much lower runtimes.

The encoder can be run multi-threaded with minimal compression efficiency degradation, with very good scaling across up to 10 cores for HD and more than 20 cores for UHD.

Single-pass and two-pass rate control modes have been implemented to allow for easier encoding at fixed rate.

To increase the perceived visual quality, an adaptive quantization mode was implemented, distributing the bitrate between the frames, as well as within the frame, according to a simplified model of the human visual system, thereby optimizing the encoding for the perceptual XPSNR measure [5].

VVenC can be used to encode SDR as well as HDR content in 4:2:0 chroma subsampling format with up to 10 bit bit-depth per component. In the current version, only single slice and tile encoding is supported.

The encoder has a special constrained mode to produce bitstreams that can be used in open-GOP adaptive streaming scenarios with resolution change [6].

4. RESULTS

The runtime and BD-rate [7] scores of different versions of VVenC relative to HEVC test model HM-16.22 are plotted in Fig. 1. Additionally, different trade-off points for two popular alternative freely available encoders are shown: x265 3.4 [9] and aomenc 2.0 [10]. The results represent the average of BD-rate gains for the Class B, A1 and A2 sequences of JVET common test conditions [8]. All encoders were configured to run single-threaded, using 10 bit internal bit-depth, optimized for the PSNR measure, using constant QP mode and ensuring a random-access period of approximately one second.

Fig. 1. shows that VVenC can reach the performance of VTM with less than half of its runtime (slower preset). It can provide over 40% bitrate savings over HM at shorter runtime

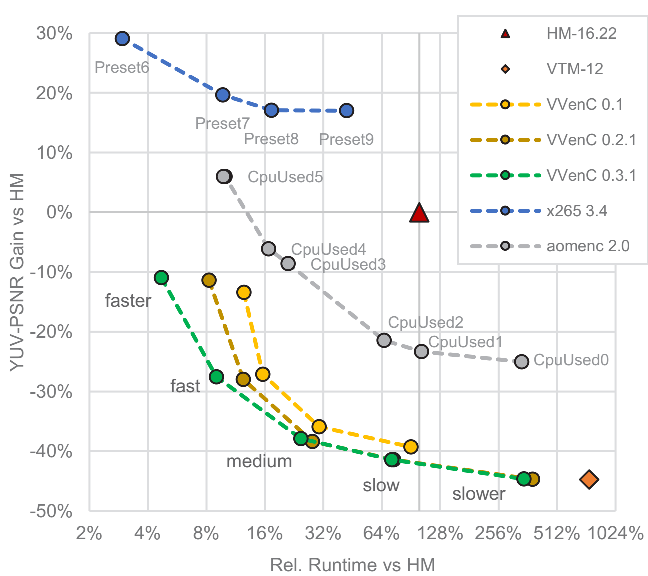

Fig. 1. VVenC single-threaded performance compared to other freely available encoders tested on HD and UHD sequences from JVET common test conditions (CTC) [8].

(slow), or almost 40% at a third of the runtime (medium). Compared to aomenc, VVenC provides either bitrate-savings at similar runtimes or lower runtimes at similar quality. The encoder also provides large bitrate savings over x265 encodings, alas cannot compete with regard to speed with its faster presets.

Bitstreams generated with VVenC 0.1 were used in VVC verification test [11]. In this test, VVenC showed better compression performance than the reference software based on Mean Opinion Scores as measured in professional laboratory settings, while running more than 100 times faster using the medium preset and multi-threading.

5. CONCLUSION

The presented VVenC software allows testing the potential of the VVC standard without the prohibitively large runtime of the VVC test model. It is freely available for non-commercial, as well as commercial use. The software provides easier access to the VVC standard for academy, industry, and video coding enthusiasts.

6. REFERENCES

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