International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

General Article

A Study on High Efficiency Video Coding Technique

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Accepted 02 Sept 2014, Available online 01 Oct 2014, **Vol.4, No.5 (Oct 2014)**

Abstract

HEVC, also known as H.265, stands for High Efficiency Video Coding which is a new video codec that will compress video files to half the size compared to the current encoding format, AVC/MPEG-4. That will be one-quarter the size of files compressed using the MPEG 2 codec that most cable-TV companies still employ. It can also obtain high video quality at the same bit rate using better data compression techniques. This technique will be very useful in mitigating increasing data sizes of next generation video qualities like 4k and 8k resolutions & increasing IP traffic over the internet. This paper analyses this technique, compares it to other existing encoding techniques and proposes a 3D extension to this technique.

Keywords: *H.264, Advanced Video Coding (AVC), video encoding*.

1. Introduction

High Efficiency Video Coding (HEVC) is a video compression standard, a successor to H.264/MPEG-4 AVC (Advanced Video Coding), that was jointly developed by the ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG). (Sullivan, *et al*, 2012).

The objective of this technique is to obtain high levels of coding efficiency, i.e. higher data compression while maintaining a threshold limit of video quality compensation. The coding efficiency relationship between two designs is typically best expressed in terms of percentage savings in bit rate for equal subjective perceptual quality. In addition to enabling service providers to deliver more content at a given quality (e.g., more television channels sent over the same data link or more video stored on the same storage medium), improved coding efficiency can alternatively be used to provide higher quality video (e.g., higher resolution or less distorted video) at a given bit rate, or to provide some other improved balance between bit rate and video quality. An analysis of the IP traffic by Cisco Visual Networking Index (VNI), India has revealed the following facts:

1) An increasing number of devices like mobiles and tablets will increase the demand of connectivity to 18.9 billion by 2016.
2) With increasing number of internet users, ubiquitous Wi-Fi growth and faster broadband speeds Global IP traffic is expected to reach 1.3 zettabytes per year by 2016, India expected to have highest IP growth rate.
3) Almost 80% of this IP traffic will be consumer video.

This video coding technique almost doubles the data compression of a video without compensating the video quality. Hence, a 5GB Blu-Ray Movie encoded using current video encoding technologies will occupy a size of almost 2.5GB (having the same video quality) when encoded using HEVC. Using more efficient encoding-decoding algorithms and exploiting parallel computing, HEVC will provide a standard to the industry for conformities at a global level.

Thus, a need to benchmark the performance of HEVC in comparison to its predecessors like H.264 has arisen to verify the qualitative objectives are satisfied or not. Hence this paper deals with the key features of HEVC and compares its video quality and encoding performance through empirical observations.

With this introductory section, the remainder of the paper is organized as follows:

Section 2 explains the innovatory features used by HEVC in more details followed by Section 3, which compares HEVC to AVC using an experimental setup. Finally, Section 4 ends with a proposal to extend HEVC to 3D video coding by using Multi Video plus Depth (MVD) coding format.

2. Novel features of HEVC

In this section we illustrate the various innovative features HEVC contains and the effect of these features. We compare these effects with the H.264.

2.1 Code Tree Units (CTU)

Also referred to as Largest Coding Unit, CTU is the basic processing unit of HEVC replacing the earlier macroblock units used in AVC. While MacroBlock Units are a fixed 16x16 pixels, CTU's use variable sizes ranging from 64x64, 32x32 to 16x16. These larger block units facilitate in better division of discrete blocks, increasing coding

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efficiency. The CTU consists of a luma (It is brightness and represented by Y) and Chroma for Blue and Red.

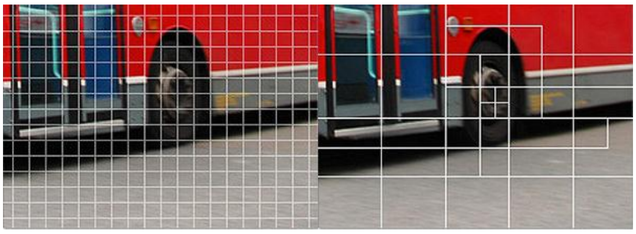

Fig1. Macroblocks in AVC vs. CTU in HEVC

Chroma is half the size of luma as human eye is more sensitive to brightness. The size L×L of a luma CTB can be chosen as L = 16, 32, or 64 samples, with the larger sizes typically enabling better compression.

The splitting of a CTU into luma and chroma CBs is signaled jointly. One luma CB in addition to two chroma CBs, form one Coding unit (CU).

2.2 Prediction units and prediction blocks (PBs)

Interpicture or intrapicture prediction can be made in H.265. This is resolved at the CU level. A PU partitioning structure originates from the CU level. Depending on the basic prediction-type decision, the luma and chroma CBs are also split in size using the luma and chroma prediction blocks. HEVC supports variable PB sizes ranging from 64×64 as well as 4×4 samples.

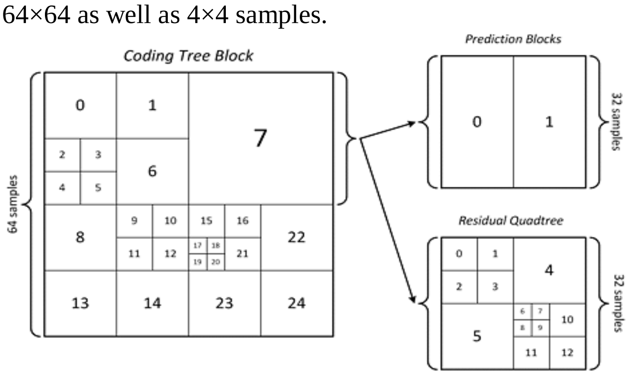

Fig. 2 Coding Tree Unit, Predictive Block, Residual Tree

2.3 TUs and transform blocks

The coding of prediction residual is done using the block transforms created. A TU tree structure has its root at the CU level. The luma CB residual may be identical to the luma transform block (TB) or may be further split into smaller luma TBs. The same applies to the chroma TBs. Integer basis functions similar to those of a discrete cosine transform (DCT) are defined for the square TB sizes 4×4, 8×8, 16×16, and 32×32. For the 4×4 transform of luma intrapicture prediction residuals, an integer transform derived from a form of discrete sine transform (DST) is alternatively specified(Sullivan, *et al*, 2012).

2.4 Motion vector signaling

Advanced motion vector pre- diction (AMVP) is used, including derivation of several most probable candidates based on data from adjacent PBs and the reference picture. A merge mode for MV coding can also be used, allowing the inheritance of MVs from temporally or spatially neighbouring PBs. Improved skipped and direct motion inference make it superior to H.264.

2.5 Motion compensation

Quarter-sample precision is used for the MVs, and 7-tap or 8-tap filters are used for interpolation of fractional-sample positions (compared to six-tap filtering of half-sample positions followed by linear interpolation for quarter-sample positions in H.264/MPEG-4 AVC)(Sullivan, *et al*, 2012). PB's transmitting one motion vectors result in unpredictive coding whereas two motion vectors result in bi-predicitive coding. Weighted prediction for offset and scaling is applied to the prediction signal.

2.6 Intrapicture prediction

The decoded boundary samples of adjacent blocks are used as reference data for spatial prediction in regions where interpicture prediction is not performed. Intrapicture prediction supports 33 directional modes (compared to eight such modes in H.264/MPEG-4 AVC), plus planar (surface fitting) and DC (flat) prediction modes. The selected intrapicture prediction modes are encoded by deriving most probable modes (e.g., prediction directions) based on those of previously decoded neighbouring PBs.

2.7 Quantization control

As in H.264/MPEG-4 AVC, uni- form reconstruction quantization (URQ) is used in HEVC, with quantization scaling matrices supported for the various transform block sizes.

2.8 Entropy coding

Like H.264, the Context adaptive binary arithmetic coding (CABAC) is used for entophy encoding, but numerous improvements to its throughput speed and its compression performance, reducing memory requirements, making it more conducive for parallel processing architectures. *(Pourazad, et al, 2012)*

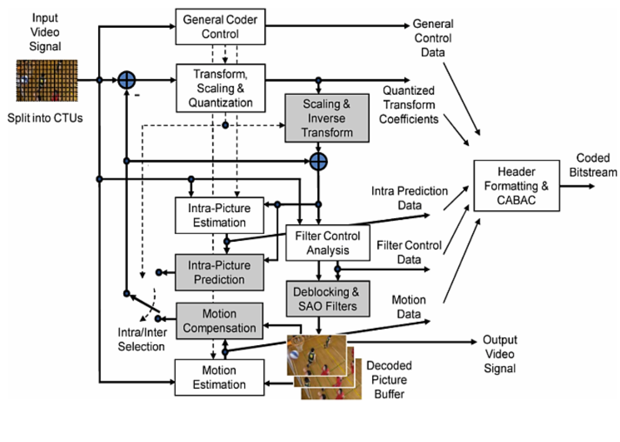

Fig. 3 HEVC Encoding

2.9 In-loop deblocking filtering

Again, like H.264, the same deb locking filter serves within the interpicture prediction loop. However, by simplifying its filtering and decision-making designs, HEVC further exploits the parallel architectures for faster computation.

2.10 Sample adaptive offset (SAO)

The deb locking filter which uses the interpicture loop prediction passes on the signal to a nonlinear amplitude mapping which uses look up tables to imitate the original signal amplitudes. The look up table is constructed using additional attributes (at the encoder side) obtained from histogram analysis *(Tsai, et al,2012)*.

3. The Experimental Setup

The experimental setup makes use of a RAW footage from DSLR. This footage was compressed using H.264 codec and H.265 codec (HEVC).For conversion to these formats we made use of the source code provided by ITU-T Video Coding Experts Group (VCEG). This source code was compiled and used.

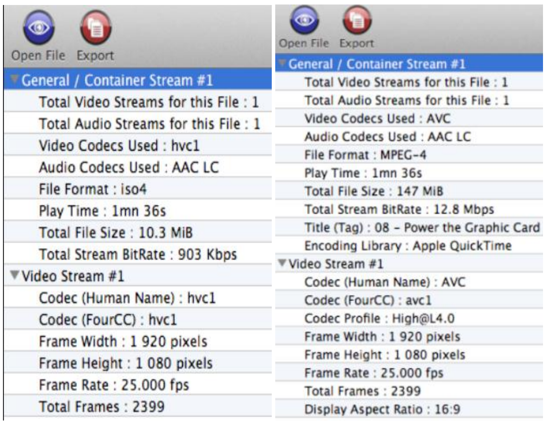

Fig. 7 Before and after HEVC encoding

Compression through HEVC was achieved on Windows and Linux both. Then, Using CodeVisa the two videos were analyzed, real-time, in terms of partition, prediction and Pre- sample Adaptive Offset parameters.

Fig. 5 AVC Video without CTU partitions (147Mb, 12.8Mbps)

Variable CTU’s during runtime were noticed in contrast to AVC which had fixed macroblocks.

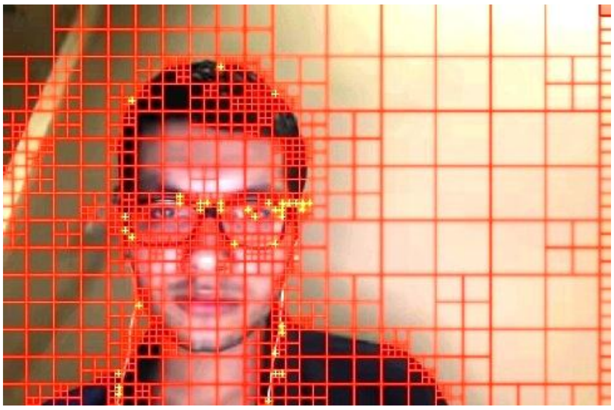

Fig. 6 HEVC video with CTU & residue displayed (10.3Mb, 903Kbps)

H.264 compression gave final file size of 147MB whereas HEVC gave final file size of just 10.3MB. Video Stream Bit Rate was 12.7Mbps in case of H.264 whereas it was just 777Kbps in case of HEVC. This makes the HEVC compressed video ideal for web streaming. Even today, YouTube Half HD video streams at around 700Kbps.

For further analysis, The PSNR Ratio of the two video samplings was compared using MATLAB. Considerable improvement was observed in the two encodings.

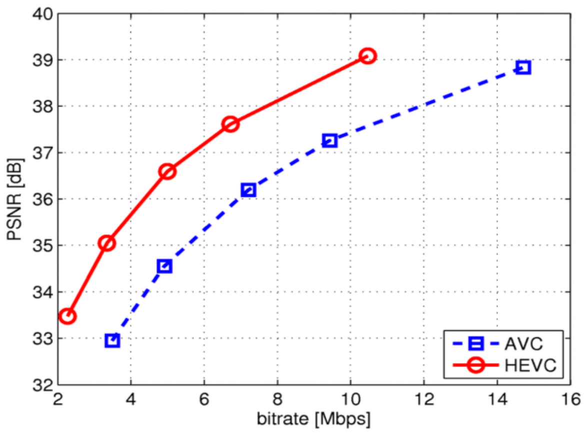

Fig. 7 PSNR vs. Bitrate

Future Scope

Recent 3D video technologies have shown a great deal of improvements. Film makers and now hope to make most of their movies in 3D giving the public a richer entertainment experience. The number of movies being made in 3D are increasing every year. Advancement in technology for 3D screens is engendering Television sets and 3D DVD’s and USB FlashDrives that hold 3D video content. Hence, an increasing trend can be observed and the volume of 3D video is expected to increase exponentially. As movies from the box-office were taken to homes with the help of televisions, similarly 3D watching movies have sparked the idea of 3D TV channels. Watching sports broadcasts in 3D video formats at home may soon become an everyday sight. And as we earlier proved in Section 1, that almost 80% of IP traffic over internet will be video data, the addition of 3D video will add to its already high share of internet traffic.

An interesting concept of multiview video plus depth (MVD) format in which various video views are encoded along with their depth maps can be used for 3D videos. By dividing the block into two regions, each represented with a constant value, such block partitions are well-adapted to the characteristics of depth maps. The results show that this approach reduces the bit rate of the depth component by up to 11% and leads to an increased quality of rendered views *(Merkle, et al, 2012)*. In addition to extant temporal and inter -view prediction techniques, a method of inter-component prediction of non-rectangular depth blocks can be used to extend HEVC encoding to 3D videos.

Conclusions

This paper has researched the encoding and compression efficiency of the newly developing video encoding standards HEVC/H.265. The experimental results of this paper have confirmed that the main objective of the new standard to double the compression efficiency but maintaining the same quality in comparison to the previous standard (i.e. AVC) has been achieved. Also¸ in combination with MVD and DIBR, it can be extended for 3D videos.

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