Comparison between HEVC and AVC for Video Compression

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Abstract:

Video compression is an arising research topic in technology field. This research uses a new High Efficiency Video Coding (HEVC) standard tool technique in compressing video as well as provides the subsequent techniques like joint prediction techniques along with skip, motion compensation, motion estimation, and inter or intra modes. HEVC is the newest video compression standard, which promises a significant improvement over all previous video compression standards. In terms of coding efficiency, the new standard provides about 50% bit-rate reduction for the best previous standards and substantial perceptual quality improvements over to Advance Video Coding (AVC).

Keywords: Video compression, Motion compensation, HEVC

مقارنة بين (HEVC) و(AVC) لضغط الفديو

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المستخلص:

يعد ضغط الفيديو هو موضوع بحث فعال في مجال التكنولوجيا. الغرض من هذا البحث هو استخدام تقنية جديدة (HEVC) في ضغط الفيديو بالاضافة الى توفير تقنيات اخرى مثلا التنبؤ و حذف التنبؤ و تعويض الحركة و تقدير الحركة والتنبؤ. فمن خلال الصورة نفسها و من خلال الصور السابقة في الفيديو. HEVC هي احدث تقنية لضغط الفيديو الذي يكون افضل من جميع التقنيات السابقة. من حيث كفاءة الترميز فانه يقلل الى النصف على الاقل مقارنة مع افضل التقنيات السابقة مع تحسينات في جودة الصور مقارنة مع AVC.

1. Introduction:

Video coding techniques provide efficient solutions to represent video data in a more compact and robust way so that the storage and transmission of video can be realized in less cost in terms of size, bandwidth and power consumption [1]. Data compression is the process of converting data files into smaller files for efficiency of storage and transmission. As one of the essential technologies of the multimedia revolution, data compression is the key in the rapid progress being made in information technology. Simply, it would not be practical to put images, audio, and/or video alone on websites without compression [2]. Recently, the international community for standardization has considered a new generation of video compression technology, known as High Efficient Video Coding. This standard is offering substantially higher compression capability than the H.264/AVC standard. Current comparison results show that HEVC offer superior compression performance compared with H.264/AVC [3].The idea of HEVC is to offer the same level of picture quality as AVC, but with better compression, so there's less data to deal with. Section 2 describes the HEVC coding design. Section 3 shows experiments and results. Section 4 concludes this research.

2. HEVC Coding Design

High Efficiency Video Coding is the most recent standardized video compression technology. It is developed by the Joint Collaborative Team on Video Coding (JCT-VC) of the ITU-T Visual Coding Experts Group (VCEG) and the ISO/IEC Moving Pictures Experts Group (MPEG). The HEVC standard is designed to achieve multiple goals, including coding efficiency, ease of transport system integration and data loss resilience, as well as implement ability using parallel processing architectures [4]. The general architecture of HEVC is shown in Figure (1 and 2).

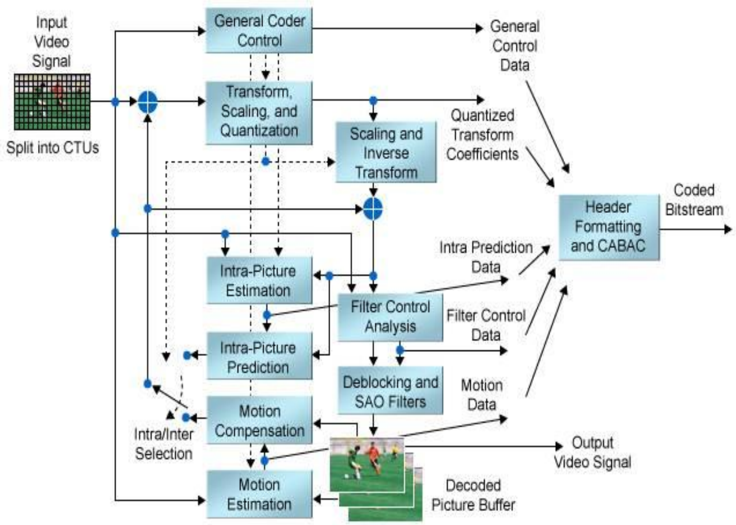


Figure (1): HEVC encoder block diagram

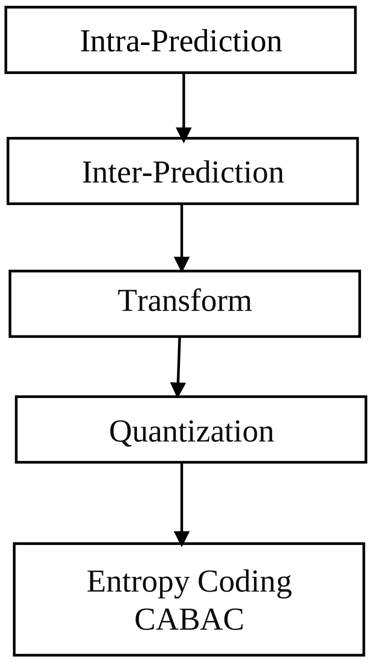


Figure (2): Flowchart of the HEVC encoder

A. Prediction

Data compression is the process of converting data files into smaller files for efficiency of storage and transmission [5]. An accurate prediction means that the residual contains very little data and this in turn leads to good compression performance. HEVC supports a wide range of prediction options: Intra prediction using data within the current frame and Inter prediction using motion compensated prediction from previously coded frames. The I-frames are intra coded, i.e. they can be reconstructed without any reference to other frames. The P-frames are forwardly predicted from the last I-frame or P-frame, i.e. it is impossible to reconstruct them without the data of another frame (I or P). The B-frames are both, forward predicted and backward predicted from the last/next I-frame or P-frame, i.e. there are two other frames necessary to reconstruct them. P-frames and B-frames are referred to as inter coded frames [6].

a. Intra-Prediction:

Intra-picture prediction operates according to the transform block size, and previously decoded boundary samples from spatially neighboring transform blocks are used to form the prediction signal. Directional prediction with 33 different directional orientations is defined for (square) transform block sizes from 4×4 up to 32×32. The possible prediction directions are shown in figure 3. Alternatively, planar prediction can also be used. The Chroma component should be explicitly signed as horizontal, vertical, planar, or DC prediction modes if it is different from Luma prediction modes [7].

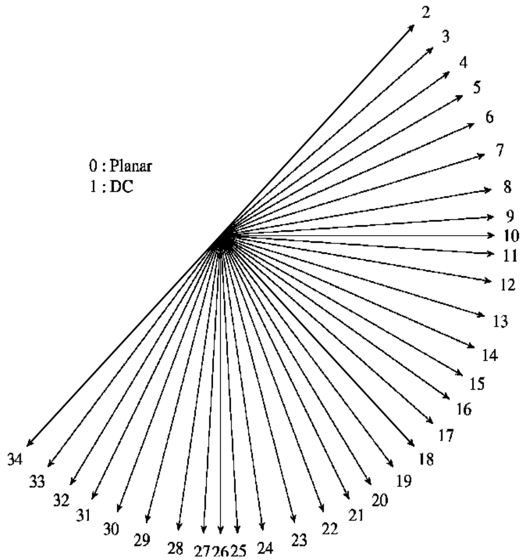


Figure (3): Mode decision for intra picture prediction

b. Inter-Prediction:

Successive video frames may contain the same objects (still or moving). Motion estimation examines the movement of objects in an image sequence to try to obtain vectors representing the estimated motion. Motion compensation uses the knowledge of object motion so obtained to achieve data compression. In interframe coding, motion estimation and compensation have become powerful techniques to eliminate the temporal redundancy due to high correlation between consecutive frames. In real video scenes, motion can be a complex combination of translation and rotation. Such motion is difficult to estimate and may require large amounts of processing. However, translational motion is easily estimated and has been used successfully for motion compensated coding. Figure (4) illustrates a motion compensated Prediction [8].

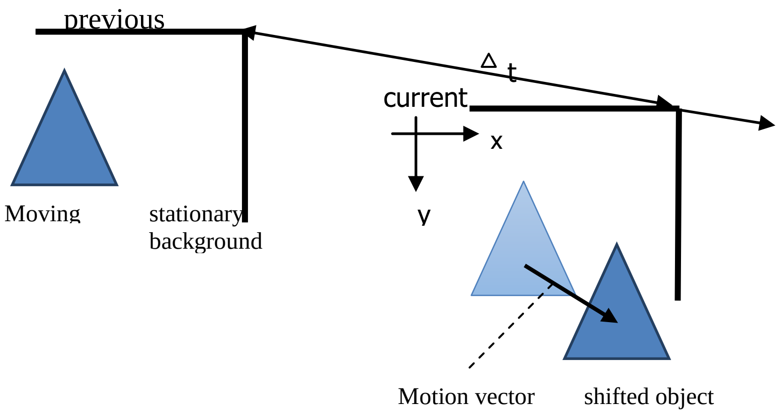


Figure (4): Motion-Compensated Prediction

B. Transform and Quantization

The HEVC standard uses transform coding of the prediction error residual in a similar manner as in prior standards. The residual block is partitioned into multiple square transform blocks. The supported transform block sizes are 4×4, 8×8, 16×16, and 32×32 [4].Pre-scaling operation is not needed when using HEVC since the rows of the transform matrix are close approximations of values of uniformly scaled basis functions of orthonormal DCT [4].

Uniform reconstruction quantization (URQ) is used in the HEVC standard, with quantization scaling matrices supported for the various transform block sizes [4]. The range of the QP values is defined from 0 to 51, and an increase by 6 doubles the quantization step size such that the mapping of QP values to step sizes is approximately logarithmic.

C. Entropy Coding

Entropy coding is applied to code all the syntax elements and quantized transform coefficients after transformation [9]. In HEVC context adaptive binary arithmetic coding (CABAC) is used for entropy coding. CABAC"s arithmetic coding engine and more sophisticated context modeling result in better coding efficiency than CAVLC. CABAC increases coding complexity whilst it improves the coding efficiency. This is more pronounced at higher bit rates [small quantization parameters (QPs)], where transform coefficient data have a dominant role in the encoded bit streams. HEVC uses higher throughput alternative mode for coding transform coefficient data, to improve the worst case throughput.

3. Experiments and Results

The proposed method can describe the motion between consecutive frames with the best prediction accuracy. Extensive experiments have been performed in order to evaluate the performance of proposed extension. Developments have been implemented in reference 2D-HEVC codec version HM-16.6 [10]. All tests have been performed according to JCT-VC Common Test Conditions (CTC), that describe default encoder configuration for evaluation of 2D codec performance used by International Organization for Standardization. Essential parameters of the encoders have been gathered in Table 1.

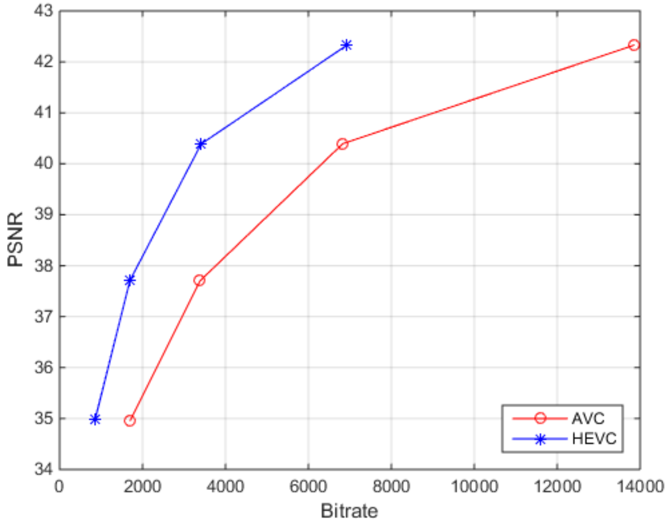
Table 1. Essential configuration parameters of the encoders used in the experiments.

Parameter	Value
Profile	Main
GOP size	4
Intra period	24
FrameSkip	0
SEIDecodedPictureHash	1
MaxCUWidth	256
MaxCUHeight	256
MaxPartitionDepth	6
QuadtreeTULog2MaxSize	6
LoopFilterTcOffset_div2	-2
InternalBitDepth	8
FastSearch	1
SearchRange	64

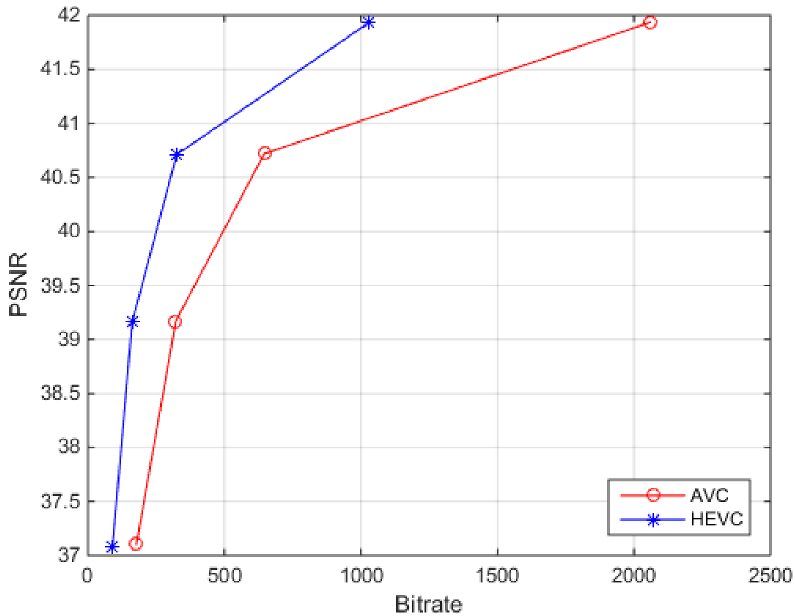
The coding efficiency is measured at four operating points (QP = 22; 27; 32; 37), calculating the average rate reduction in comparison to the AVC following the method described in [11] and the results can be summarized in Table 2. Figure (5) shows bitrate reduction of the Kimono and Jets sequences in low delay configuration. The YPSNR values and the corresponding total bitrates for all test sequences for HEVC and AVC are presented in Table 3.

Table 2: BD-rate calculated by using Bjontegaard rates for PSNR Y introduced by HEVC against AVC for sequences.

Sequences	Random Access Configuration		Low Delay B Configuration	
	Avg.PSNR	BD-Rate %	Avg.PSNR	BD-Rate %
BQMall_832x480	2.8121	-49.7422	2.8664	-49.9507
Kimono_1920x1080	2.1180	-49.6690	2.2202	-49.9930
BlowingBubbles_416x240	2.6963	-49.6926	2.7395	-49.8535
FourPeople_1280x720	2.6937	-49.8470	2.7575	-49.8960
jets_1280x720	1.6038	-49.6110	1.6000	-48.7991
Spincalendar_1280x720	1.8879	-49.4753	1.9907	-49.4182



a. Kimono video



b. Jets video

Figure (5): BD-rate of the kimono and jets videos.

Table 3: Experimental results for all test sequences for HEVC and AVC.

Sequence	QP	Random Access				Low Delay			
		HEVC		AVC		HEVC		AVC	
		Bitrate [kbit/s]	PSNR [dB]	Bitrate [kbit/s]	PSNR [dB]	Bitrate [kbit/s]	PSNR [dB]	Bitrate [kbit/s]	PSNR [dB]
BQMall	22	4248.768	40.1389	8527.824	40.1449	4835.352	40.0581	9632.304	40.0555
	27	2087.688	37.6164	4159.632	37.6220	2269.632	37.2802	4538.448	37.2894
	32	1120.656	34.7988	2236.8	34.7981	1170.36	34.2912	2349.12	34.3079
	37	607.872	31.8244	1212.144	31.8318	618.504	31.2465	1239.6	31.2513
Kimono	22	5977.776	42.0377	11959.6416	42.0426	6922.8096	42.3259	13847.3664	42.3277
	27	2846.496	40.0324	5679.3408	40.0274	3413.7408	40.3882	6829.3056	40.3942
	32	1397.7696	37.5084	2791.2576	37.5124	1696.5888	37.7106	3386.0544	37.7021
	37	714.2784	35.0425	1423.4112	35.0552	852.3264	34.9719	1703.7312	34.9658
BlowingBubbles	22	1668.06	38.8368	3328.28	38.8460	1978.72	38.7513	3957.88	38.7482
	27	770.32	35.6317	1541.44	35.6514	864.74	35.2152	1729.76	35.2161
	32	374.58	32.6058	749.12	32.5790	399.96	32.0627	793.48	32.0429
	37	183.74	29.8399	367.6	29.8825	188.24	29.2632	374.68	29.2643
FourPeople	22	2946.192	43.0172	5857.488	43.0094	3078.168	42.8308	6139.344	42.8304
	27	1424.184	41.1933	2829.648	41.1861	1446.36	40.8473	2871.792	40.8439
	32	828.288	38.8471	1659.84	38.8584	822.744	38.3513	1647.648	38.3567
	37	497.16	36.0458	992.832	36.0606	488.616	35.4456	973.88	35.4489
Jets	22	1002.79	42.0005	1998.32	42.0021	1030.99	41.9354	2060.48	41.9359
	27	322.36	40.9629	641.86	40.9672	325.47	40.7109	645.5	40.7176
	32	163.31	39.5621	325.3	39.5665	162.59	39.1623	322.4	39.1703
	37	92.86	37.5965	185.18	37.6079	90.38	37.0765	177.98	37.1021
Spincalendar	22	5322.63	38.5170	10604.14	38.5167	6207.58	38.7190	12369.4	38.7247
	27	1522.22	36.8216	3033.66	36.8338	1564.12	36.5295	3095.42	36.5328
	32	653.91	35.0241	1299.42	35.0212	670.83	34.5506	1322.54	34.5469
	37	355.98	32.7399	707.74	32.7384	362.25	32.1709	717.86	32.1860

We will notice from table 3 HEVC will use bitrate less than AVC for video and PSNR in HEVC the same or better than AVC. In Kimono sequence with QP=32, Bitrate is in HEVC =1696.59 (Kbit/s) while AVC = 3386.05 (Kbit/s) and PSNR in HEVC= 37.71db while in AVC = 37.70db.

4. Conclusion

In the paper, comparison between AVC and new HEVC standard, that allow to improve average PSNR and decreas bit rate, has been presented. The performed experiments showed that the HEVC led on average over 49% bitrate reduction for video sequences recorded with the HEVC comparing to the AVC codec.

5. References

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