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PERFORMANCE EVALUATION OF H.264/AVC DEBLOCKING FILTER FOR 720P HIGH DEFINITION VIDEO

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High definition Video (HDV) is increasingly becoming common feature in video display devices as it provides superior level of details in comparison to standard video. Latest video compression standard, H.264/AVC can be used for storage and efficient transmission over network. However, blocking artifacts are introduced due to loss of correlation between blocks during compression process. H.264/AVC employs deblocking filter to suppress these blocking artifacts. This paper provides performance evaluation of H.264/AVC deblocking filter for 720p high definition video. Various simulations by using different 720p video sequences are conducted to check the efficiency of H.264/AVC deblocking filter. Simulation results show that H.264/AVC deblocking filter can enhance the perceptual quality of 720p video by suppressing the blocking artifacts.

Keywords : Blocking artifacts, Deblocking filter, 720p high definition video, H.264/AVC

1. Introduction

Increasing demand for superior level quality and higher resolution video calls for need of high definition video in comparison to standard video. Applications like Blue-ray, HD-DVD, HDTV, IPTV, digital cable, dish HD, Web HD downloads etc. are becoming common day by day. The amount of data to be processed and transmitted in case of HDV is significantly high and this requires video compression for efficient archival and transmission. H.264/AVC is the latest standard used for video compression designed for variety of applications from low bit rate internet streaming to HDTV broadcast and digital cinema applications [1-3]. Performance evaluations of H.264/AVC show that it can achieve high compression ratio without compromising the objective and subjective qualities of video [4-5]. However, it suffers from visually disturbing discontinuities known as blocking artifacts, or called blocking effects [6-7]. This makes the decompressed video unacceptable for human eyes. This not only limits the maximum compression performance that can be achieved but also degrades the perceptual quality of image and video to a great extent. The main reason for occurrence of these blocking artifacts is coarse quantization, which is performed to achieve high compression ratio. The fundamental steps in compression are: (1) partitioning of the entire image into blocks, (2) transformation of each block using discrete cosine transform, (3) quantization and (4) entropy coding [8]. During quantization process, transformed coefficients are divided by quantization table and are rounded to integer. In order to achieve high compression ratio, high-order DCT coefficients are more severely quantized. This results in loss of correlation between coefficients of adjacent blocks, which results in visually disturbing discontinuities along the block edges, known as blocking artifacts. H.264/AVC uses in-loop deblocking filters to suppress these blocking artifacts. Considerable research is done about the impact of H.264/AVC deblocking filter for smaller resolutions [9-11]. However, to the best of knowledge of author, very limited research was carried out for evaluation of H.264/AVC deblocking filter for high definition video. Earlier research carried out by author was performance analysis of H.264/AVC deblocking filter for 1080p high definition video for applications like Blue-ray and HD DVD [12]. On the other hand, there are applications like HDTV, wireless high quality HD video, video teleconferencing, Web HD downloads, IPTV and X-box live video which use 720p video resolution. This paper describes in depth

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performance evaluation of H.264/AVC deblocking filter for 720p (1280 × 720 pixels) high definition video.

2. H.264/AVC In-loop Deblocking Filter

There are two primary techniques in incorporating deblocking filters into video codecs. Deblocking filters can be used either as in-loop filters or post filters. In post filter technique, filter is applied after the decoder and operates on buffer outside the coding loop [8]. The in-loop filter works inside the video coding loop. Future reference frames are filtered using deblocking filter prior to use for motion compensation. As a result, conformant decoder is required to carry out deblocking as same as of encoder. Many advantages exist for applying loop filter within coding loop, like improving quality of reconstructed frame and ensuring same filtering is done at encoder and decoder respectively without use of extra frame buffer at decoder [6]. Therefore, the latest H.264/AVC video coding standard incorporates an adaptive loop deblocking filter that reduces the blocking artifacts. The position of deblocking filter in H.264/AVC encoder is shown in Figure 1.

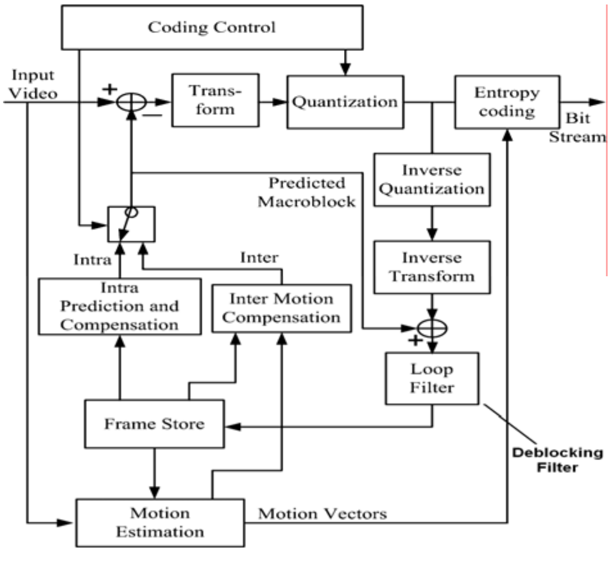


Figure 1. In-loop deblocking filter position in H.264/AVC encoder.

An adaptive deblocking filter is applied to each macroblock after the inverse transform in the encoder and decoder respectively. The overall effect of filtering is improvement of perceptual quality of compressed video. The filtered macroblocks are used for motion compensation of following frames. Luminance and chrominance components of each macroblock are separately filtered. The filter is applied on horizontal and vertical edges of each macroblock except for the edges at the frame boundaries [13]. The filtering order at macroblock level is illustrated in Figure 2.

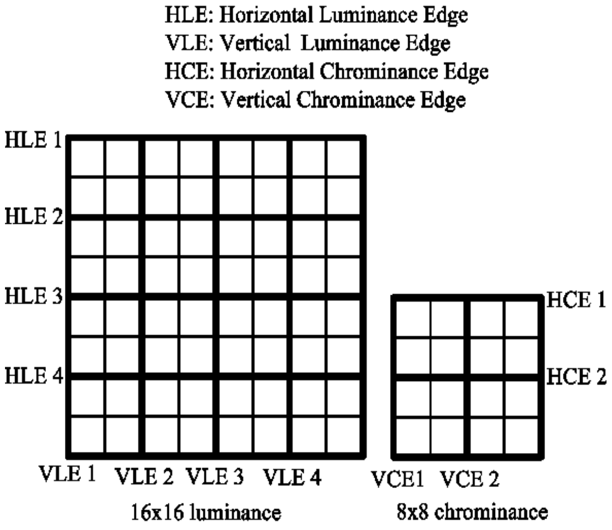


Figure 2. Filtering order at macroblock level .

As shown in Figure 2, vertical edges of the luminance are filtered before the horizontal edges. Subsequently, vertical and horizontal edges of chrominance are filtered for each macroblock respectively. Three samples on each side of edge boundary are affected by filtering process as shown in Figure 3.

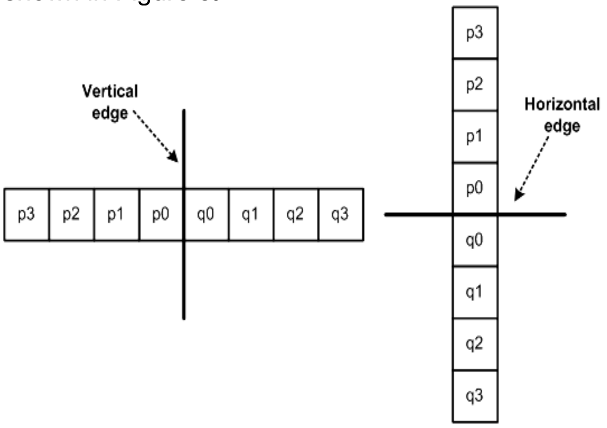


Figure 3. Adjacent samples across block edges.

Two main steps: (1) boundary (filter) strength computation and (2) filter execution are applied in the filtering process. The decision to apply filter on samples of block edges is taken with the help of boundary strength (bS) parameter. The bS is computed for each edge between adjacent 4 x 4 luminance blocks and assigned an integer value from 0 to 4. Same value of boundary strength computed for luminance blocks is used for chrominance blocks. Various parameters are used for computation of boundary strength which includes macroblock type, motion vector, quantization parameter, gradient of samples across edges [13-15]. The filtering operation does not only depend on the non-zero boundary strength. Application of deblocking filter may not be needed even in the case of non-zero boundary strength. For example, filtering is not required in case of real edges in the video as application of filter will do blurring and it may result in difficulty in distinguishing real edges. On the other hand, samples do not have much variation in smooth regions of video and appearance of artifacts is more obvious. Therefore, an additional condition other than non-zero boundary strength is needed for efficient application of deblocking filter. Consequently, block edge samples (p2, p1, p0, q0, q1, q2) are filtered only if they meet the conditions described by Eqs. 1 and 2 [13].

$$bS > 0 \tag{1}$$

$$|p0-q0|<\alpha \ \&\& \ |p1-p0|<\beta \ \&\& \ |q1-q0|\leq\beta \tag{2}$$

where α and β are the thresholds defined in the standard [13]. Two types of filters are used: 5-tap finite impulse response filter (strong filter) and 4-tap finite impulse response filter (normal filter). Filters are applied according to following rule [12, 13]:

if ((abs(p0-q0)< α && abs(p1-p0) < β && abs(q1-q0) ≤ β) && bS ==4) apply strong filter; else if ((abs(p0-q0)< α && abs(p1-p0) < β && abs(q1-q0) ≤ β) && 0<bS<4) apply normal filter;

else

no filter;

The overall process of deblocking filtering in H.264/AVC is shown in flow chart of Figure 4.

3. Simulation Environment & Results

H.264/AVC deblocking is evaluated for suppression of blocking artifacts in 720p high definition video by using joint reference model software JM 10.2 [16]. Different standard 720p high definition video test sequences of a variety of motion content are used to check the accuracy of deblocking filter. Standard sequences used for simulation are PARK RUN, MOBILE & CALENDAR, SHIELDS and STOCKHOLM [17]. Each 720p high definition video sequence is decoded at four different bit rates using 50 frames. The simulation environment used is described in Table 1. The performance of blocking artifacts suppression is measured by measuring peak to signal noise ratio (PSNR) against different bit rates for various 720p high definition video sequences. The objective coding performance (PSNR) without and –with deblocking filter for different 720p sequences for luminance (Y) component is shown in Table 2. The reason for only considering the Y-PSNR is that human visual system is less sensitive to chrominance in comparison to luminance component. The PSNR gains by using deblocking filter in Table 2 and in Figure 5 are not very high due to the fact that blocking artifacts are structural disturbances and are sometimes “buried” in the massively accumulated across the-board pixel-wise error. Therefore, their significance in perceptual visual quality assessment is not reflected proportionally in the conventional PSNR measure [18]. The total number of bits used during coding of various 720p high definition video sequences without and with deblocking filter is shown in Table 3. It is apparent that deblocking filtering is performed at the cost of some extra bits; the reason being mainly the computations required for boundary (filter) strength computations.

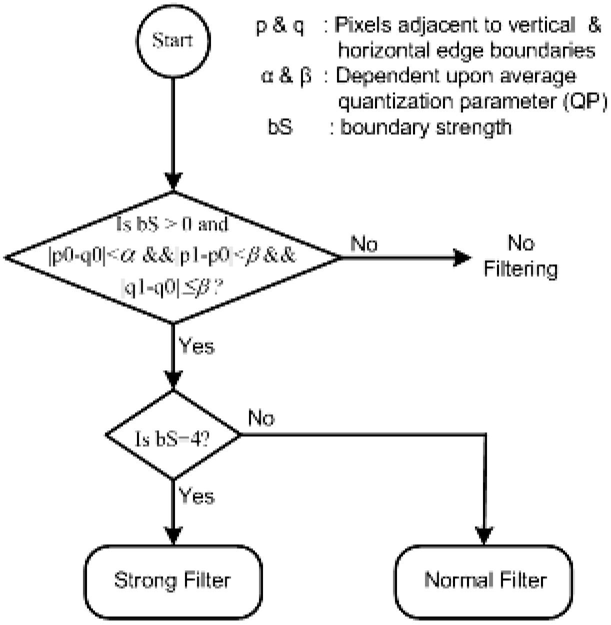


Figure 4. Simplified deblocking filtering process in H.264/AVC.

Table 1. Simulation Environment.

Input video sequence	YUV 4:2:0
Image format	1280x720
Encoded frequency	25 frames/sec
Sequence type	IPPP
Search range	16
No. of reference frames	5
Transform mode	8 x 8
Hadamard transform	used
Entropy coding	CABAC
Rate Distortion optimization	used

Table 2. Objective Comparison of various 720p high definition video sequences without and -with H.264/AVC deblocking filter .

720p HDV Sequence	Bitrate (Mbps)	Average Y-PSNR (dB) for 50 frames		
		No Filter	With Filter	Difference
Park Run	1.98	23.43	23.44	0.01
	3.33	24.15	24.15	0.00
	3.50	24.17	24.21	0.04
	5.92	25.17	25.17	0.00
Shields	0.65	28.32	28.43	0.11
	1.20	29.05	29.05	0.00
	6.96	31.44	31.43	-0.01
	11.2	32.67	32.68	0.01
Mobile & Calendar	0.80	29.31	29.36	0.05
	1.71	29.98	30.02	0.04
	3.17	30.62	30.65	0.03
	11.80	33.01	33.01	0.00
Stockholm	1.08	29.27	29.37	0.10
	1.25	29.37	29.37	0.00
	2. 85	30.10	30.19	0.09
	11.30	32.79	32.82	0.03

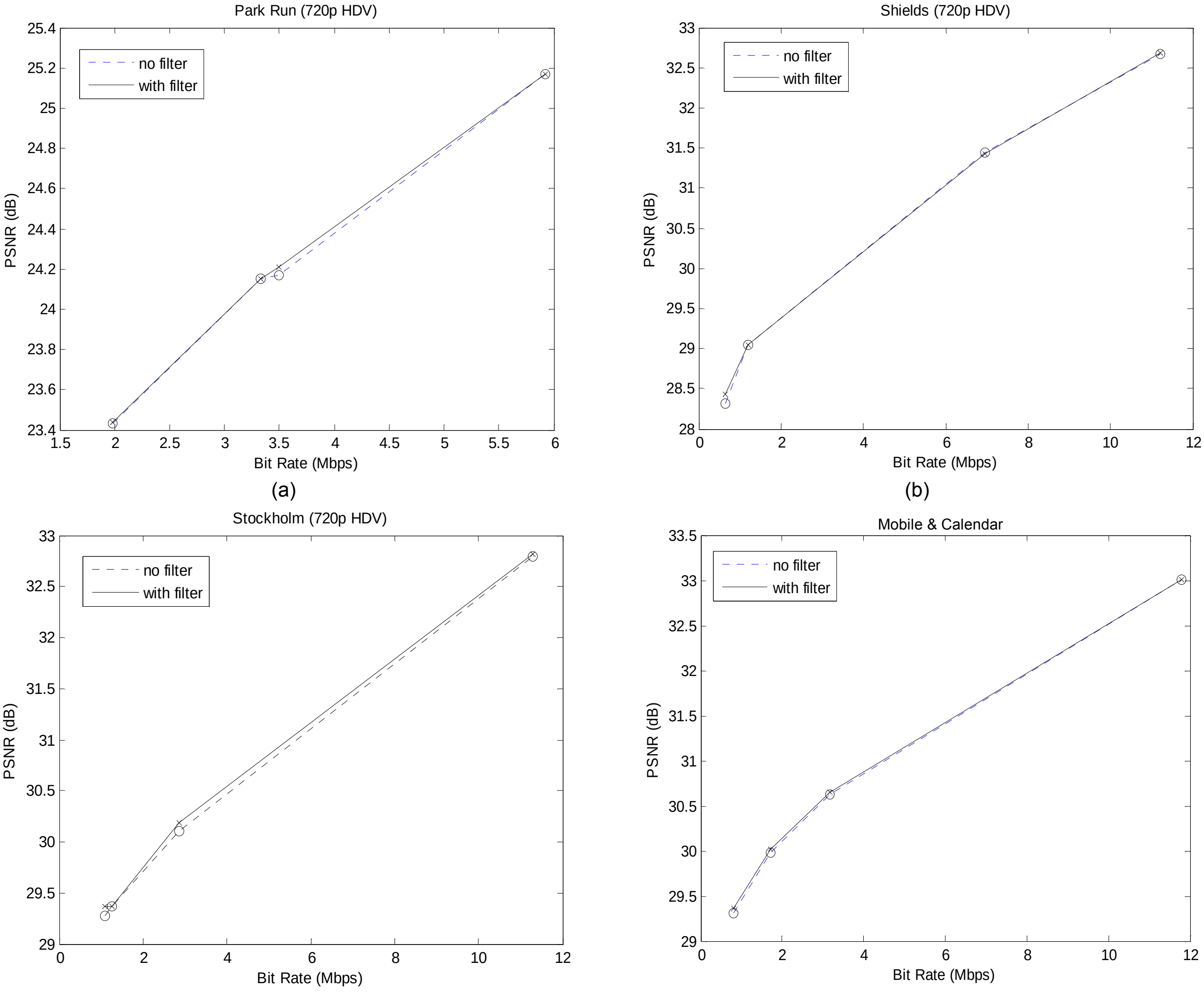
Table 3. Total Bits Comparison of various 720p high definition video sequences without and -with H.264/AVC deblocking filter .

720p HDV Sequence	Quantization Parameter (QP)	Total Bits Used for 50 frames of Video		
		No Filter	With Filter	Difference
Park Run	28	3,955,008	3,959,600	4,592
	24	6,662,704	6,668,008	5,304
	20	6,992,544	6,992,888	344
	16	11,825,496	11,830,536	5,040
Shields	28	1,308,424	1,315,032	6,608
	24	2,369,504	2,380,824	11,320
	20	2,692,728	2,707,656	14,928
	16	5,717,696	5,743,512	25,816
Mobile & Calendar	28	1,623,752	1,624,680	928
	24	2,854,624	2,864,192	9,568
	20	6,337,336	6,359,600	22,264
	16	6,337,336	6,359,600	22,264
Stockholm	28	981,960	987,920	5,960
	24	2,161,984	2,183,032	21,048
	20	2,499,456	2,522,576	23,120
	16	5,692,432	5,716,760	24,328

The subjective performance for 720p high definition video sequence SHIELDS frame 38 decoded at 6.96 Mbps without and –with deblocking filter is shown in Figure 6. It can be seen that H.264/AVC deblocking filter can do substantial suppression of the blocking artifacts. However, blurring also appears during deblocking process, which sometimes displaces the effect of deblocking phenomenon.

4. Conclusion

We have presented the in-depth evaluation of H.264/AVC deblocking filter for suppression of blocking artifacts in 720p high definition video. Various test video sequences of typical content are used for analysis. Experimental results show that use of H.264/AVC deblocking filter substantially suppresses the blocking artifacts without compromising on subjective and objective quality of video. However, occasional appearance of blurring affects the effectiveness of deblocking filter.



(a) (b) (c) (d)

Figure 5. PSNR-Bit Rate comparison for various 720p High Definition Video Sequences.
(a) Park Run (b) Shields (c) Stockholm (d) Mobile & Calendar

(a) (b)

Figure 6. Window of luminance component of High Definition SHIELDS Frame 38 encoded at 6.96 Mbps (a) without deblocking filter (PSNR: 25.64 dB) (b) with deblocking filter (PSNR: 25.68 dB).

References

[1] Z. Chen, D. Zhang and K. N. Ngan, IEEE Transactions on Consumer Electronics **54** (2008) 1852.

[2] S-F. Li: Statistical analysis of H. 264 high definition video sequences for decoder implementation, Proceedings of International Conference on Audio, Language and Image Processing (2008) p. 395.

[3] S. S. Shimu: Performance analysis of H. 264 encoder for high-definition video transmission over ultra-wideband communication link, MS Thesis, University of Saskatchewan, Saskatoon (2010).

[4] J. Ostermann, J. Bormans, P. List, D. Marpe, M. Narroschke, F. Pereira, T. Stockhammer and T. Wedi: Video coding with H.264/AVC: tools, performance, and complexity, IEEE Circuits and Systems Magazine (2004) 7.

[5] G. Raja and M. J. Mirza, Performance comparison of advanced video coding H.264 standard with baseline H.263 and H.263+ standards, Proceedings of 4th IEEE Intl. Symposium on Communications & Information Technologies, Sapporo, Japan (2004) p. 743.

[6] P. List, A. Joch, J. Lainema, G. Bjøntegaard and M. Karczewicz, IEEE Transactions on Circuits and Systems for Video Technology **13** (2003) 614.

[7] G. Raja, M. J. Mirza and T. Song, Journal of IEICE Electronics Express, Japan **5** (2008) 809.

[8] Ian E.G. Richardson: Video Codec Design, John Wiley & Sons, U.K (2003).

[9] Y. Zhong, I. Richardson, A. Miller and Y. Zhao, Perceptual Quality of H.264/AVC Deblocking Filter, IEEE International Conference on Visual Information and Engineering (2005) p. 379.

[10] X. Zheng, B. Yang, Y. Liu and G. Shi, Blockiness Evaluation for Reducing Blocking Artifacts in Compressed Images, IEEE International Conference on Consumer Electronics (2009) 8.1-2.

[11] Y-F Ou, Z.Ma, T. Liu and Y. Wang, IEEE Transactions on Circuits and Systems for Video Technology **21** (2011) 286.

[12] G. Raja, Pakistan Journal of Science **63** (2011) 40.

[13] ITU-T and ISO/IEC, Draft ITU-T Recommendation and Final Draft International Standard of Joint Video Specification (ITU-T Rec. H.264 | ISO/IEC 14496-10 AVC), Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, JVT-G050r1 (2003)

[14] Ian E.G. Richardson, H.264 and MPEG-4 Video Compression-video Coding for Next Generation Multimedia, John Wiley & Sons, UK (2003).

[15] G. Raja and M.J. Mirza, WSEAS Transactions on Signal Processing **2** (2006) 143.

[16] H.264/AVC Joint Model Reference Software Version 10.2, Available on-line http://iphome.hhi.de/suehring/tml/, Accessed Jan. 2011.

[17] 720p high definition video test sequences, available on-line ftp://ftp.ldv.e-technik.tumuenchen.de/pub/test_sequences/720p/, Accessed Jan. 2011.

[18] F. Pan, X. Lin, S. Rahardja, W. Lin, E. Ong, S. Yao, Z. Lu and X. Yang, Signal Processing: Image Communication **19** (2004) 499.