# H.264/AVC DEBLOCKING FILTER FOR 1080P HIGH DEFINITION VIDEO

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**ABSTRACT:** High Definition Video (HDV) is becoming an emerging application due to desire of high display resolution and superior video quality. Video compression is used for efficient transmission of HDV over network. However, loss of correlation between adjacent blocks during quantization process in compression results in visually disturbing artifacts called blocking artifacts. The latest H.264/AVC incorporates deblocking filter for reduction of blocking artifacts. This paper describes performance comparison of H.264/AVC deblocking filter for 1080p high definition video. Various high definition video sequences of typical content have been used for experimentation. The results show that H.264/AVC deblocking filter successfully suppresses the blocking artifacts in HDV without significantly degrading the objective quality of video.

**Key words**: high definition video, blocking artifacts, deblocking filter, H.264/AVC, 1080p

## INTRODUCTION

The need of video communications is increasing day by day with the exponential growth of Internet. As a result, high definition (HD) digital video and video over wireless networks are becoming emerging applications due to higher quality (Alvarez *et al*., 2005). Some of high definition applications are in Blue-ray, HD-DVD, HDTV, IPTV, digital cable, dish HD, Intenet HD downloads etc. High definition standard is developed by ATSC (Advanced Television Systems Committee) and adopted by FCC (Federal Communications Commission) in 1996 (Wu *et al*., 2006). There are two commonly used display resolutions for HD video: (1) 1080p (1920 × 1080 pixels) and (2) 720p (1280 × 720 pixels). In 1080p display resolution, 1080 stands for number of horizontal scan lines and ‘p’ stands for progressive scan (complete frame is scanned sequentially from top to bottom in horizontal direction) whereas in 720p resolution, there are 720 horizontal scan lines of display. The bandwidth required to transmit raw HD video without using video compression is around 4 Gbps (Shimu, 2010). Therefore, video compression is necessary for transmission of HD video over wireless networks. These applications not only require higher compression efficiency for efficient transmission over network but also higher video quality is required. H.264/AVC is the latest international video compression standard designed for variety of applications from low bit rate internet streaming to HDTV broadcast and digital cinema applications. Performance analysis of latest H.264/AVC standard showed its significant coding gains and compression efficiency over existing video compression standards (Weigand *et al*., 2003; Raja and Mirza, 2004) However, during compression process, loss of correlation between adjacent blocks during quantization process results in visually disturbing artifacts called blocking artifacts. Motion compensated prediction is another source of blocking artifacts in video. Interpolated pixel data from different locations in reference frames are used for generating motion compensated blocks. As a result, there is almost never a exact match for this data and this introduces discontinuities on edges of copied blocks. Moreover, visual discontinuities also appear during copying process where existing edge discontinuities in reference frames are carried into interior of blocks to be compensated. The H.264/AVC standard employs deblocking filter for reduction of blocking artifacts while contributing to bit rate saving. Research reported in literature shows that H.264/AVC deblocking filter can successfully suppress blocking artifacts at low bit rates (List *et al*., 2003; Richardson, 2003) This paper describes in-depth performance evaluation of H.264/AVC deblocking filter for 1080p high definition video for IPTV and video over wireless.

**Overview of H.264/AVC Deblocking Filter:** H.264/AVC video compression algorithm employs in-loop deblocking filter after the inverse transform in the encoder and decoder (Puri *et al*, 2004). Vertical and horizontal edges of block in each macroblock (MB) of a frame are filtered for suppression of blocking artifacts. Luminance and chrominance components of video are separately filtered by H.264/AVC deblocking filter. The filtering operation affects three samples on both sides of edges on a block boundary (List *et al*., 2003; Richardson, 2003; Raja and Mirza, 2006). The four samples, p0, p1, p2, p3 and q0, q1, q2, q3 on horizontal and vertical edge in adjacent blocks of a macroblock are shown in Fig-1.

The operation of deblocking filter can be divided into two main steps, i.e., boundary (filter) strength calculation and filter application respectively. 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

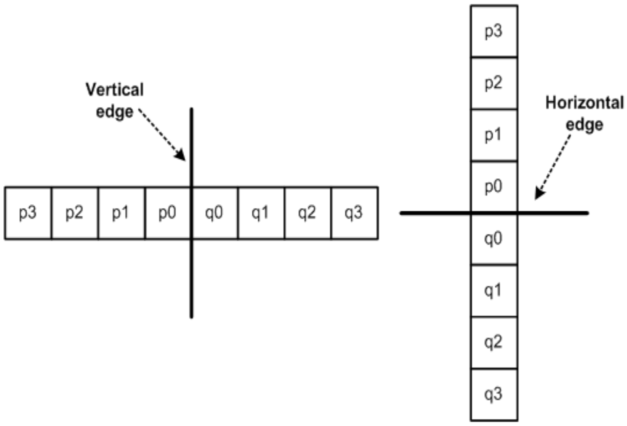


**Fig-1: Adjacent samples across block edges**

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 (Richardson, 2003; Raja and Mirza, 2006). The decision to apply filter on samples of block edges does not only depend on 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 following conditions (ITU-T, 2003).

$bS > 0$ (1)

$|p0\text{-}q0| < \alpha \;\&\&\; |p1\text{-}p0| < \beta \;\&\&\; |q1\text{-}q0| \leq \beta$ (2)

where $\alpha$ and $\beta$ are the thresholds defined in the standard (ITU-T, 2003). Two types of filters are used: strong filter (5-tap filtering) and normal filter (4-tap filtering). Filters are applied according to following:

*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 phenomenon of deblocking filtering in H.264/AVC is shown in Fig-2.

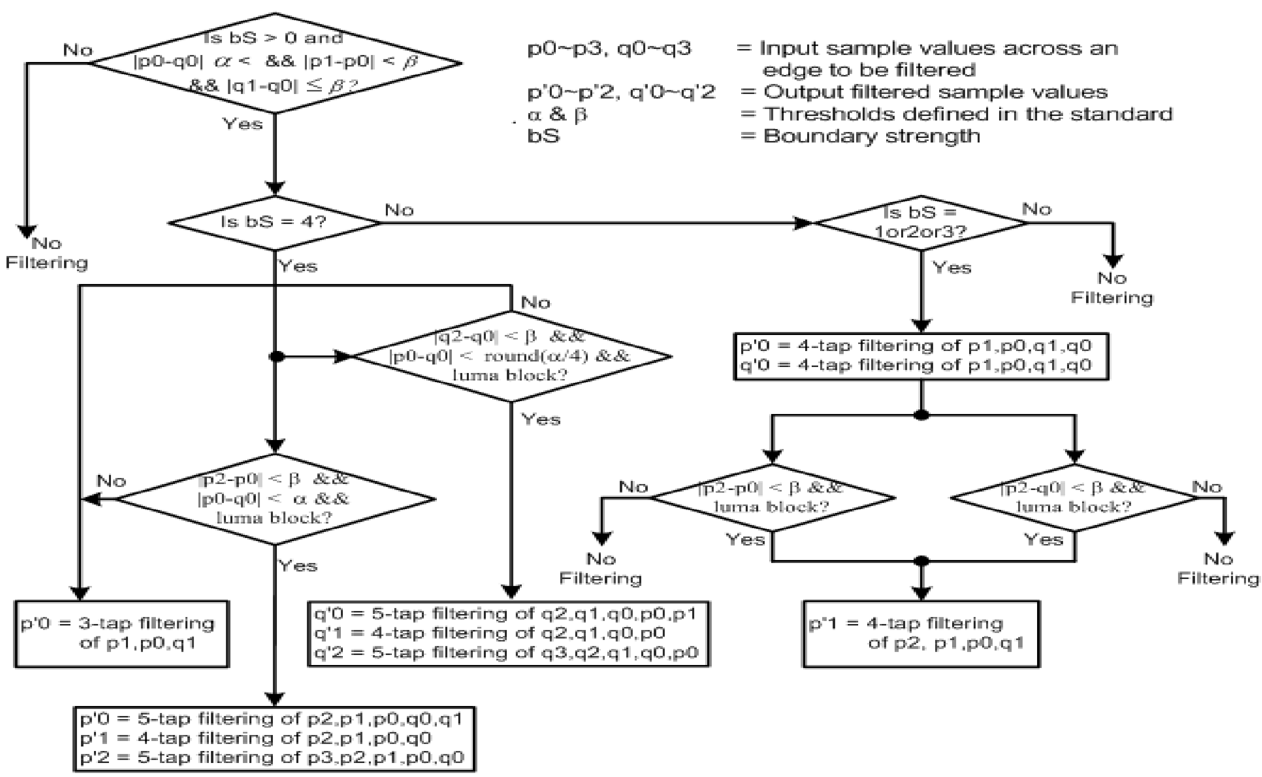


**Fig-2: Deblocking filter process in H.264/AVC**

## RESULTS AND DISCUSSION

Evaluation of H.264/AVC deblocking filter for suppression of blocking artifacts is carried out using joint reference model software version 10.2 (Karsten, 2010). The subjective and objective quality without- and with deblocking filter is measured. Various 1080p high definition video test sequences of different scenarios are used for analysis. The standard sequences used for experimentation are BLUE SKY, DUCKS TAKE OFF, PEDESTRIAN AREA, RIVER BED, RUSH HOUR, STATION, SUNFLOWER, TRACTOR (HDV 1080p, 2010). Each sequence is coded at five different bit rates consists of 50 frames. The other various parameters incorporated in simulation model are:- frame rate: 30, GOP structure: IPPP, B frames not used, search range: 16, no. of reference frames: 5, entropy coding method: CABAC. The coding performance is measured by comparing PSNR (peak signal to noise ratio) with- and without deblocking filter. Table-1 shows the objective comparison of deblocking filter by computing luminance PSNR at different bit rates for various 1080p sequences. Objective results indicate slight improvement in PSNR by use of deblocking filter in comparison without using deblocking filter.

**Table-1. Average luminance PSNR at different bitrates for 1080p sequences with- and without deblocking filter**

| *1080p Sequence* | *Bit-Rate (Mbps)* | *Y PSNR (dB)* | | *1080p Sequence* | *Bit-Rate (Mbps)* | *Y PSNR (dB)* | |
|---|---|---|---|---|---|---|---|
| | | *No Filter* | *With Filter* | | | *No Filter* | *With Filter* |
| **Ducks Take Off** | 5.7 | 22.19 | 22.20 | **Sunflower** | 4.2 | 23.56 | 23.72 |
| | 6.8 | 22.68 | 22.71 | | 4.9 | 24.43 | 24.57 |
| | 8.7 | 23.25 | 23.25 | | 6.1 | 25.27 | 25.35 |
| | 11.9 | 23.91 | 23.93 | | 7.7 | 26.14 | 26.20 |
| | 17.2 | 24.71 | 24.73 | | 10.1 | 27.06 | 27.09 |
| **Pedestrian Area** | 4.3 | 22.93 | 23.01 | **Tractor** | 5.5 | 22.83 | 22.93 |
| | 5.0 | 23.54 | 23.64 | | 6.7 | 23.41 | 23.46 |
| | 6.2 | 24.27 | 24.35 | | 8.6 | 24.02 | 24.07 |
| | 7.9 | 25.08 | 25.16 | | 11.4 | 24.76 | 24.84 |
| | 10.5 | 26.01 | 26.06 | | 15.4 | 25.64 | 25.69 |
| **Rush Hour** | 3.9 | 24.86 | 24.95 | **Station** | 2.4 | 25.95 | 26.06 |
| | 4.4 | 25.53 | 25.58 | | 3.2 | 26.49 | 26.55 |
| | 5.3 | 26.24 | 26.31 | | 4.4 | 27.02 | 27.21 |
| | 6.7 | 27.01 | 27.06 | | 6.4 | 27.72 | 27.81 |
| | 8.8 | 27.88 | 27.88 | | 9.4 | 28.46 | 28.62 |
| **River Bed** | 3.5 | 22.71 | 22.75 | **Blue Sky** | 6.8 | 22.37 | 22.47 |
| | 4.4 | 23.29 | 23.35 | | 7.9 | 23.04 | 23.14 |
| | 5.8 | 23.91 | 23.98 | | 9.8 | 23.77 | 23.82 |
| | 7.9 | 24.69 | 24.72 | | 12.5 | 24.57 | 24.58 |
| | 11.1 | 25.53 | 25.55 | | 16.3 | 25.45 | 25.44 |

**(a)**

Objective comparison of luminance component window of DUCKS TAKEOFF frame 4 encoded at 5.7 Mbps without and with H.264/AVC deblocking filter is shown in Fig-3. It has been observed that H.264/AVC deblocking filter can do substantial suppression of blocking artifacts. However, granular like noise appears and appearance of this noise overrides the effectiveness of deblocking filter in high definition video sequences at lower bit rates.

**Conclusion:** Performance evaluation of H.264/AVC deblocking filter is presented for 1080p high definition video. Different test video sequences are used for analysis. Simulation results show that H.264/AVC deblocking filter can significantly reduce the visually disturbing blocking artifacts. However, appearance granular like noise reduces the efficiency of deblocking filter for 1080p high definition video.



**(b)**

**Fig-3: Window of luminance component of High Definition DUCKS TAKEOFF Frame 4 encoded at 5.7 Mbps (a) without deblocking filter (b) with deblocking filter**

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