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Deblocking Filter for Reduction of Blocking Artifacts in Video

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Abstract - *Many video coding standards such as H.264/AVC (Advanced Video Coding) uses block based coding techniques for compression of raw video. Here, each block is independently transformed and quantized. Block based motion estimation and motion compensation are used in these coding standards. All such block based operations introduces blocking artifacts and degrades quality of reconstructed video. In order to improve the quality, the post-processing deblocking filter algorithm is proposed. This paper deals with activity based classification of smooth, intermediate or complex region and applying the appropriate filtering algorithm that gives improve results for highly compressed video sequences.*

Key Words: **Blocking Artifact, Deblocking Filter, Post Filter, Block Based Coding, Video Coding**

1. INTRODUCTION

Video is a sequence of frames having successive frames are somewhat similar. In H.264/AVC (Advanced Video Coding) standard, the difference between the two frames are integer transformed and quantized. Here in, block based operations such as motion estimation (ME), motion compensation (MC), integer transform and quantization are used to compress video. Here encoder divides each frame in the blocks of 16X16 block called macroblock (MB), which is divided into 16X8, 8X16, 8X8. And these 8X8 is divided into blocks of 8X4, 4X8, 4X4 [1].

Here, each block is independently transformed and quantized. Different block sizes are used for higher compression ratio [2]. This coding produces blocking artifacts at the block boundary. This artifacts gets accumulated and spread due to motion compensation, across the reconstructed frame [3].

Blocking artifacts are classified into three types as: grid noise, staircase noise and corner outliers. Grid noise in smooth area, staircase noise along the image edges and corner outliers at four cross points of 8X8 blocks [5]. Deblocking filter is applied to such blocking artifacts to improve subjective and objective quality of video. There are two types of filter, which are loop filter within the coding loop and post filter is used outside the coding loop of encoder. So post filter is used as it has less computation complexity to remove blocking artifacts [4].

Algorithm proposed in filter [5] gives poor performance in edge or textured areas. The filter proposed in [6] gives poor PSNR (dB) improvement as less pixels are updated to get good PSNR, which is adverse. This paper focus on finding the different filtering mode decision and applying appropriate filter. Section 2. describes proposed deblocking filter algorithm. Section 3. Illustrates results and performance evaluation. At last section 4. gives conclusion.

2. PROPOSED DEBLOCKING FILTER

2.1 Filtering Mode Decision

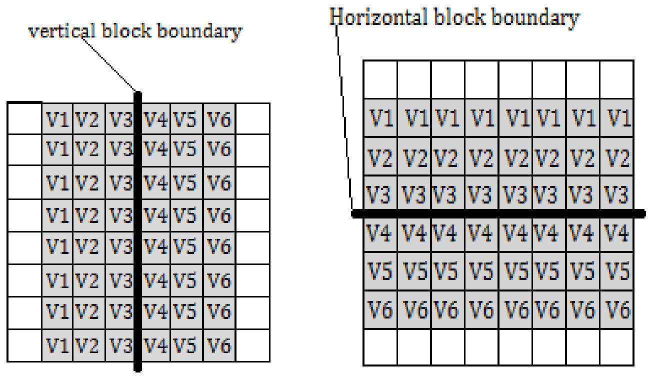
The requirement of the mode decision is for not excessive blurring of the textured and true image edges in the local region and preserving the image quality. Here, the level of blocking effect is measured around the block boundary of adjacent block pixels. As shown in fig. 1(a), one dimensional (1-D) array of pixels at vertical block boundary used to measure the activity of the region using equations as follows

$$A(v) = \sum_{i=1}^{5} \Phi(v_i - v_{i+1}) \qquad (1)$$

Where,
$$\Phi(\Delta) = 0, for\ |\Delta| \le S$$
$$\Phi(\Delta) = 1, for\ otherwise \qquad (2)$$

Depending upon (1) and (2) across block boundary, the filtering mode is decided and appropriate filter is applied. Similarly finding activity for next row, finding appropriate filtering mode decision and applying the filter. Similarly, applying the same procedure across horizontal block boundary.

Here, A(v) is compared with two thresholds, T_1 and T_2 to decide mode of filtering. The value of threshold T_1 is set to the small value to decide essentially smooth region and the value of threshold T_2 is set to the value to decide complex region. If $A(v) < T_1\ and\ abs(offset) < 2 * QP$, then smooth mode filtering; else if $A(v) > T_2\ and\ abs(offset) < QP$, then complex mode filtering and else for $T_1 < A(v) < T_2\ and\ else$, then intermediate mode filtering.



(a) (b)

Fig -1: Eight 1-D array of pixels across (a) vertical block boundary (b) horizontal block boundary

2.2 Filtering Algorithm

A) Smooth Region Deblocking Filtering

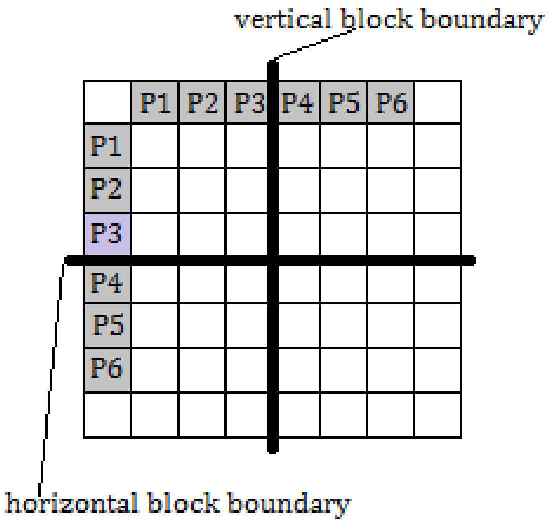
In human visual system (HVS), there are discontinuities between blocks in smooth region which is due to abrupt change appearing at the block boundaries. Here, by applying strong filter across the block boundary as shown in fig. Updating pixels by following equations as

$$offset = P_3 - P_4$$

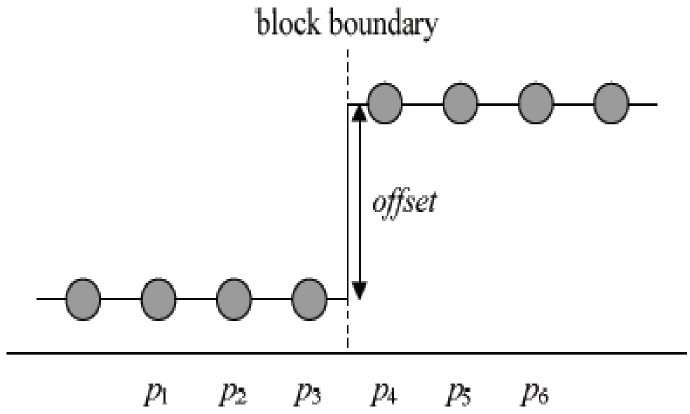
$$P_i' = P_i - sign(offset) * \left(\frac{|offset|}{\alpha_i}\right), for\ i = 1,2,3$$

$$P_i' = P_i + sign(offset) * \left(\frac{|offset|}{\alpha_i}\right), for\ i = 4,5,6$$

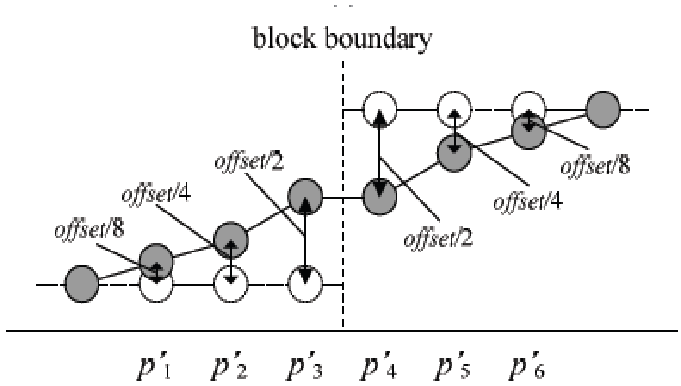
$$where, \alpha_i = \{8,4,2,2,4,8\}$$



(a)



(b)



(c)

Fig -2: (a) pixels for filtering in smooth region (b) offset before applying filter (c) offset after applying filter

B) Complex Region Deblocking Filtering

In textured and true edges regions, the strong filtering can over blur the edges and the quality of the image degrades. So here applying weak filter, updating less pixels across the block boundary preserves the edges. Following equations are used for updating pixels

$$offset = P_3 - P_4$$

$$P_i' = P_i - sign(offset) * \left(\frac{|offset|}{\alpha_i}\right), for\ i = 2,3$$

$$P_i' = P_i + sign(offset) * \left(\frac{|offset|}{\alpha_i}\right), for\ i = 4,5$$

$$where, \alpha_i = \{8,2,2,8\}$$

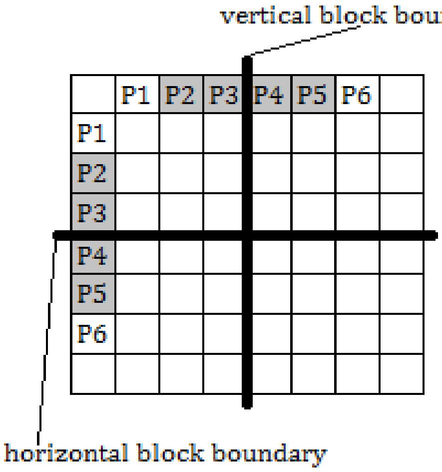


Fig -3: pixels for filtering in complex region

C) Intermediate Region Deblocking Filtering

The decision between two filtering modes may excessively blur or cause insufficient removal of blocking effect. So to improve both the subjective and objective quality of images, intermediate mode filtering is used. A 3 X 3 low pass filter is applied on either side of the block boundary as shown in fig. , preserving the real edges. Filter specifications are as follows

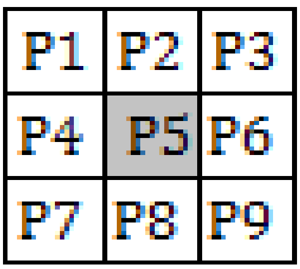
$$S_1 = \sum_{\substack{i=1 \\ i \neq 5}}^{9} \alpha_i P_i$$

$$where, \alpha_i = \begin{cases} 1, & |P_5 - P_i| < TH \\ 0, & otherwise \end{cases}$$

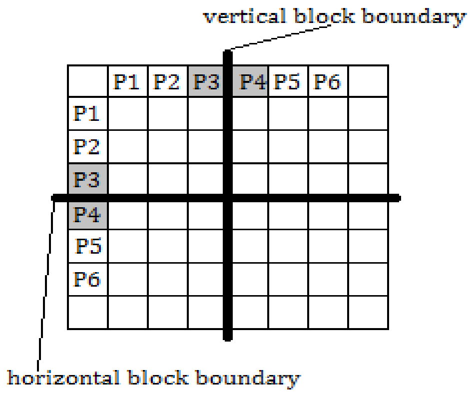
$$S_2 = \sum_{\substack{i=1 \\ i \neq 5}}^{9} \alpha_i$$

$$P_5' = (\beta P_5 + S_1)/(\beta + S_2)$$

Where, TH is set according to Quantization parameter (QP). Here, $TH = QP$ is set if P_5 is within intracoded block and $TH = QP/2$ is set if P_5 is within interceded block and β lies between 8-16 controlling extent of smoothing.



(a)



(b)

Fig -4: (a) a 3 X 3 low pass filter (b) pixels for filtering in intermediate region

D) Results

Here, video sequences of foreman, crew, akiyo, news, pamphlet, city, harbor and soccer [7] with CIF resolution, 300 frames at frame rate of 30fps are used. All the video sequences are coded with H.264/AVC with quantization parameter [12] QP=38. Here for experiment S=2, $T_1 = 2$ and $T_2 = 3$ are taken. For performance evaluation of proposed algorithm uses parameters that are peak signal to noise ratio (PSNR (dB)) and structural similarity index (SSIM) of original and filtered images. The value of SSIM range between -1 to 1, where -1 for both images different and 1 for both images same [9].

Table -1: PSNR of video sequences in Deblocking filter

standard video with CIF resolution	**Without filter**	**Deblocking filter [6]**	**Proposed deblocking filter**	
	Average PSNR(dB)	Average PSNR (dB)	Average PSNR (dB)	Average PSNR improvement (dB) over Ref[6]
foreman	28.9074	28.9257	29.3278	0.4204
crew	29.0288	29.0689	29.5354	0.5066
akiyo	33.5268	33.5731	34.1683	0.6415
news	31.0389	31.0576	31.4619	0.4229
pamphlet	31.1331	31.1394	31.5297	0.3966
city	28.1874	28.1982	28.5429	0.3555
harbour	26.3132	26.3094	26.4446	0.1314
soccer	26.7886	26.8011	27.0527	0.2641

Table -2: SSIM of video sequences in Deblocking filter

standard video with CIF resolution	**Without filter**	**Deblocking filter [6]**	**Proposed deblocking filter**	
	Average SSIM	Average SSIM	Average SSIM	Average SSIM Improvem-ent over Ref[6]
foreman	0.8036	0.8049	0.8270	0.0221
crew	0.7795	0.7814	0.8082	0.0268
akiyo	0.9018	0.9037	0.9262	0.225
news	0.8869	0.8879	0.9071	0.0192
pamphlet	0.8699	0.8708	0.8902	0.0194
city	0.7703	0.7704	0.7835	0.0131
harbour	0.8329	0.8323	0.8351	0.0028
soccer	0.7370	0.7373	0.7545	0.0172

From Table-1 and Table-2 we can observe the improvement in PSNR (dB) and SSIM respectively, over previous proposed filter [6]. Fig -5(a) shows original frame. Fig -5(b) shows reconstructed frame. Fig -5(c) shows filtered frame using ref [6]. And fig -5(d) shows proposed deblocking filter. Fig -5 shows subjective quality improvement of frame over the previous filter. Chart -1. Shows PSNR (dB) and Chart -2. Shows SSIM for all 300 frames of foreman video sequence. Similarly for other video sequences shows improvement.

(a)

(b)

(c)

(d)

Fig -5: foreman frame (a) original (b) reconstructed with PSNR=29.9289(dB) and SSIM=0.8214 (c) filtered using ref [6] with PSNR=29.9510(dB) and SSIM=0.8229 (d)filtered using proposed filter with PSNR=30.4326(dB) and SSIM=0.8493

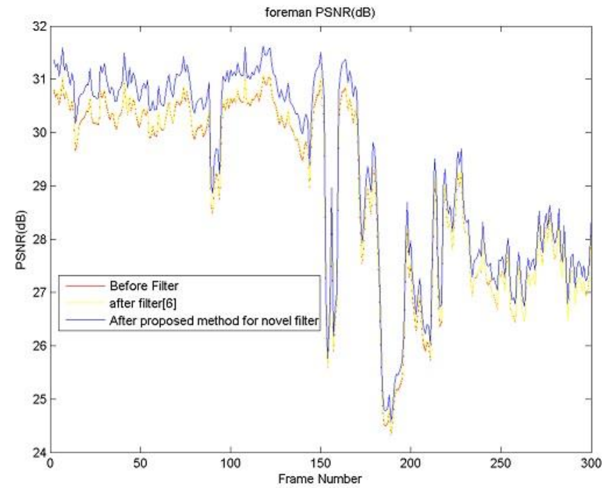


Chart -1: PSNR (dB) for all foreman video sequence

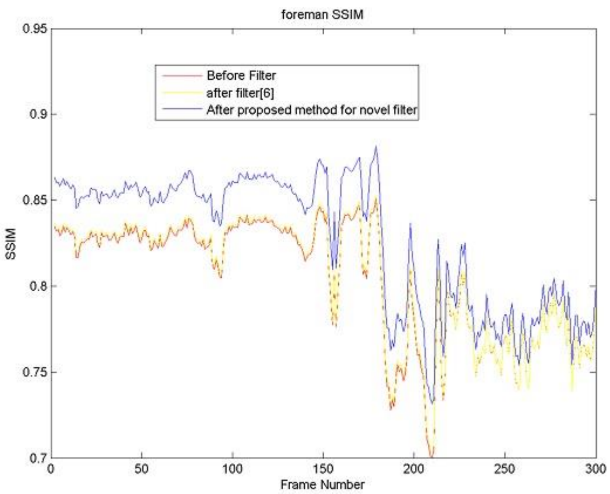


Chart -2: SSIM for all foreman video sequence

3. CONCLUSIONS

From previously proposed post processing deblocking filter less number of pixels are updated to get high value of PSNR but it didn't worked. Applying the deblocking filter proposed in this paper, we see the improved PSNR and SSIM results. So proposed filter efficiently removes blocking artifact over previous state-of-art.

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