Deblocking Filtering Method Based on Separate Modes

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Abstract –The compression of digital images has received wide attention of researchers since it reduces the memory, bandwidth and transmission requirements. One of the major drawbacks of the block-based DCT compression methods is that it may result in visible artifacts at block boundaries due to coarse quantization of the coefficients. This paper proposes a new post-filtering algorithm to remove coding artifacts in block-based DCT compressed medical images. The blocking artifact in the smooth and non-smooth regions are removed by modifying a few DCT coefficients while an edge preserving smoothing filter is applied to the intermediate region. Experimental results illustrating the performance of proposed method on the basis of PSNR and SF indices are presented and evaluated. Compared with other methods, the proposed one achieves better detail preservation and artifact removal performance with lower computational complexity.

Keywords:- Compression, DCT, PSNR, SF.

I. INTRODUCTION

To meet the growing demand for image, video communication, many efficient image compression methods have been developed and standardized, for example, joint photographic expert group (JPEG) [1] and motion picture expert group (MPEG) [2]. The objective of image compression is to reduce the data volume and to achieve a low bit rate in the digital representation of images without perceived loss of image quality. High quality image communication with low bit rate is gaining special importance in the relatively established applications like video conferencing, videophone and interactive TV and new applications like telemedicine, picture archiving and communication systems (PACS), and continue to outstrip the capabilities of existing technologies. The amount of compression is determined by the bandwidth requirements of the application. Applications having a very small bandwidth available need very high compression ratios. The discrete cosine transform (DCT) is amongst the most widely used techniques for compression of still and moving images.

In a typical DCT compression scheme, the input image is divided into small blocks, each block being transformed independently to convert the image pixels into DCT coefficients. The DCT coefficients are then quantized using scalar quantization defined by a quantization matrix. One of the major drawbacks of the block-based DCT compression methods is the introduction of blocking artifacts, which represent the artificial discontinuity between adjacent blocks. Blocking artifacts results because of independent processing of the blocks without taking into account the inter block pixel correlation.

Under very high compression ratios, annoying artifacts known as blocking artifacts are more prominent. Over the past several years, many techniques have been applied to reduce the blocking artifacts in block DCT coded images. Post- processing of the decoded image may be carried out in spatial domain or in frequency domain. Reeve and Lim [3] applied a linear low-pass filter to the block boundaries. Low-pass filtering smoothens out the high-frequency components near the boundaries of DCT blocks. However, low-pass filtering results in blurring around edges of the reconstructed images. A new index to measure the blocking effects namely the mean squared difference of slope (MSDS) has been proposed in the literature [4-6]. It is shown that the expected value of the MSDS increases after quantizing the DCT coefficients. Liu et al. proposed a DCT domain method for blind measurement of blocking artifacts, by modeling the artifacts as 2-D step functions in shifted blocks [7]. Luo and Ward [8] and Singh et al. [9-10] developed techniques, which preserved the edge information. These techniques are based on reducing the blocking artifacts in the smooth regions of the image. The correlation between the intensity values of the boundary pixels of two neighboring blocks in the DCT domain is used to distinguish between smooth and non-smooth regions.

II. PROPOSED FILTERING ALGORITHM

The new methods based on separate modes have been developed for reduction of blocking artifacts in DCT compressed images. The proposed methods detect all possible regions of artifacts and accordingly adapt the filtering strength.

Blocking artifacts are more visible and annoying within the region that is supposed to be smooth in nature. Based on this observation, strong filtering is applied to the flat areas of the block boundary. For non-smooth regions, the blocking artifacts may be masked and less sensitive. Also undesirable blurring of detailed features is prevented when such regions are filtered. Thus, weak filtering is suggested to be applied to preserve the sharpness in areas of high spatial or temporal activity. In addition to two main modes of the deblocking filtering, an intermediate mode is designed to solve the problem of either excessive blurring or inadequate removal of blocking effect.

The proposed reduction method-I_R reduces the blocking artifacts in smooth region (as shown in Figure 1), by modifying the six pixel values three on either side of block boundary as compared to four in case of non-smooth region. The objective and subjective qualities are both improved and the computational complexity of proposed deblocking filter is much lower than the deblocking filter of Singh et al. [9].

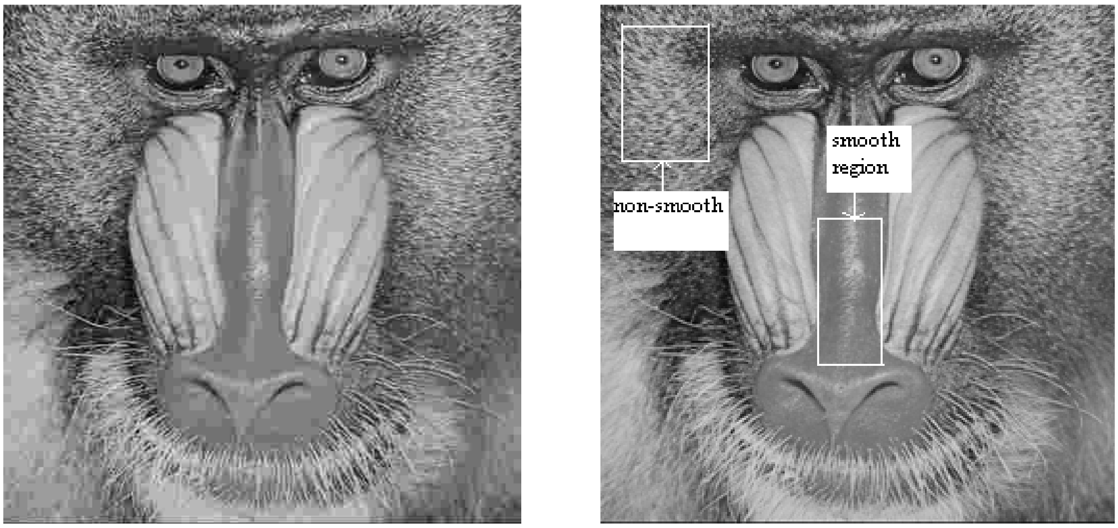


Figure 1. Blocking effects in the image Babbon JPEG-coded at different bit rates. (a) 1 bpp (b) 0.332 bpp.

III. BLOCKING ARTIFACTS REDUCTION

In order to reduce the blocking artifacts between two horizontally adjacent blocks, the variation in pixel values across the block boundary called block boundary activity (BBA) denoted by $A(p)$ is measured as under:

$$A(p) = \sum_{k=1}^{5} \emptyset(p_k - p_{k+1}) = \sum_{k=1}^{5} \emptyset(\Delta p) \qquad (1)$$

where p_k indicates k_{th} pixel value as shown in Fig.1.

$$\emptyset(\Delta p) = \begin{cases} 0, & |\Delta p| \le S \\ 1, & otherwise \end{cases} \qquad (2)$$

where Δp indicates the difference in pixel value. Three pixel values on either side of the block boundary as shown in Fig.2 are taken into account to measure the activity across the block boundary. Thus, hence total six pixel values are used to measure the activity across block boundary. As more pixel values are used to find the activity *A(p)*, thus it leads to more accurate measurement of blocking artifacts. If the activity across the block boundary is low, this indicates a smooth region; whereas the high activity indicates the region with detailed features (non- smooth). Also if the activity lies between two values, i.e. low and high, the region is termed as intermediate region.

A. Smooth region mode

If the two neighboring blocks, have similar frequency properties and the 8×8 pixel area around the block boundary does not have high frequency; the later area is considered to be of smooth nature (shown in Figure 1) as proposed by Singh et al. [9]. The block 'b' can be considered to be of smooth nature if it satisfies $A(p) < T_1$. In order to reduce the blocking artifacts in smooth regions, the offset at the block boundary is measured as given below:

$$\text{Offset}=|M - N| \qquad (3)$$

M, *N a*re the pixel values across the boundary region as shown in Fig.2.

For the region to be of smooth nature:

$$\text{Offset} < 2Q \qquad (4)$$

Here 'Q' is the quality parameter of JPEG and is used to control the bit-rate of the encoded bitstream. If the sum of pixel values M and L is greater than sum of pixel values N and O.

$If\ (M + L) > (N + O).$

The pixel values L, and M are modified as:

l = L-offset/6;
m =M-offset/3;

The pixel values N, O on the other side of block boundary as shown in Fig. 2 are modified as:

n = N+offset/3;
o = O+offset/6;

B. Non-Smooth region mode

If the nature of frequencies of the two neighboring 8×8 blocks differs from each other; the regions are termed as non-smooth regions (shown in Figure 1). The block 'b' can be considered to be of non-smooth nature if it satisfies $A(p) > T_2$. if the sum of pixel values M and L is greater than sum of pixel values N and O.

$If\ (M + L) > (N + O).$

The pixel values M and N on opposite side of the block boundary as shown in Fig. 2 are modified as:

m=M-offset/3;

n = N+offset/3;

C. Intermediate region mode

If the nature of frequencies of the two neighboring 8×8 blocks lies between smooth and non-smooth region, the region is termed as intermediate region. The block 'b' can be considered to be of intermediate nature if it satisfies $T_1 < A(p) < T_2$. Experiments showed that settings S, T_1, T_2 to 2, 1, and 4 respectively would give a good distinction between these modes. Also if the offset is more than $2Q$ in the smooth region or more than 'Q' in the non-smooth region, the intermediate mode filtering is suggested.

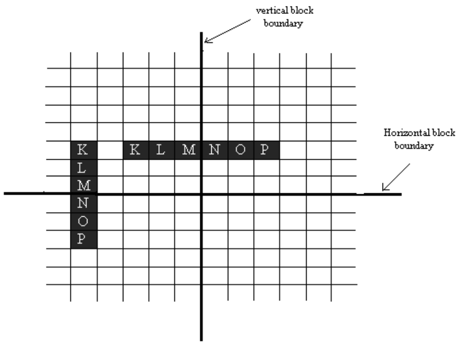


Fig.2 Pixels of the filtering for smooth and non-smooth region

The region is termed as intermediate region, if any one of the following condition is satisfied

$T_1 < A(p) < T_2$ (5)

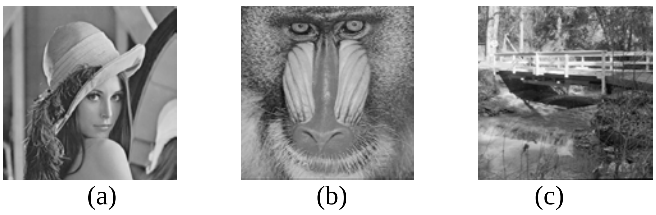
$A(p) < T_1$ & Offset $> 2Q$ (6)

$A(p) > T_2$ & Offset $> Q$ (7)

The filtering in the intermediate region is not as strong as in case of smooth region but is a balance between the strong filtering in smooth region with the weak filtering in a non-smooth region. A 3×3 smoothing low pass filter is used in the intermediate region to filter the pixels M and N on either side of the block boundary as shown in Fig.2. Only the pixels near the block boundary are selected in the filtering window. Applying this low pass filter on either side of block boundary reduces the blocking effect with minimal loss of image content.

IV. RESULTS AND DISCUSSION

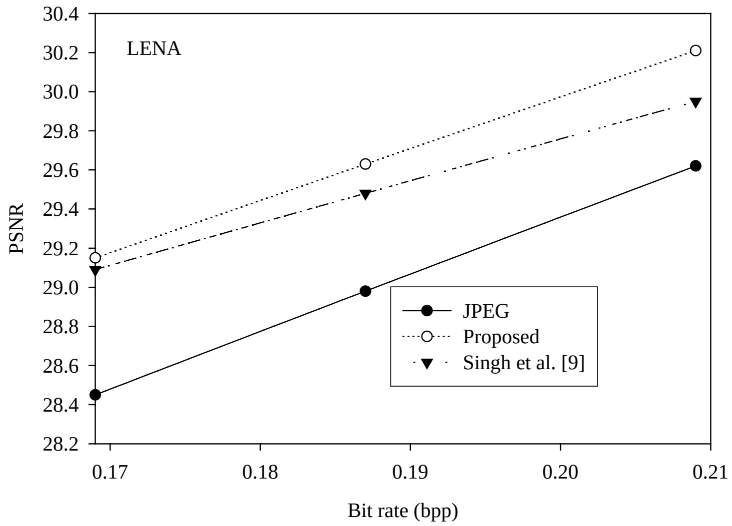
In order to evaluate the performance of the proposed algorithm, it has been applied to a variety of JPEG compressed images and the results are compared with post-processing technique in DCT domain proposed by [8-9]. The experiment is conducted on three test images namely Lena, Babbon and Bridge image as shown in Figs. 3(a-c) encoded by JPEG standard to demonstrate the performance of these techniques for various bit rates.



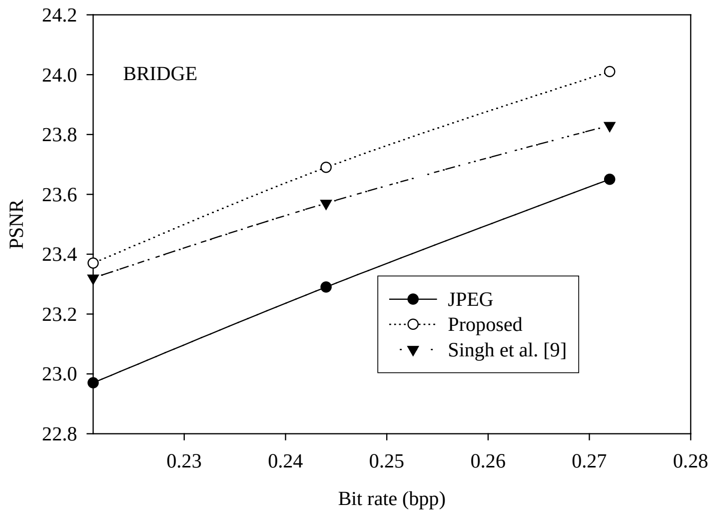
(a) (b) (c)

Figure.3 Test images (a) Lena, (b) Babbon and (c) Bridge image.

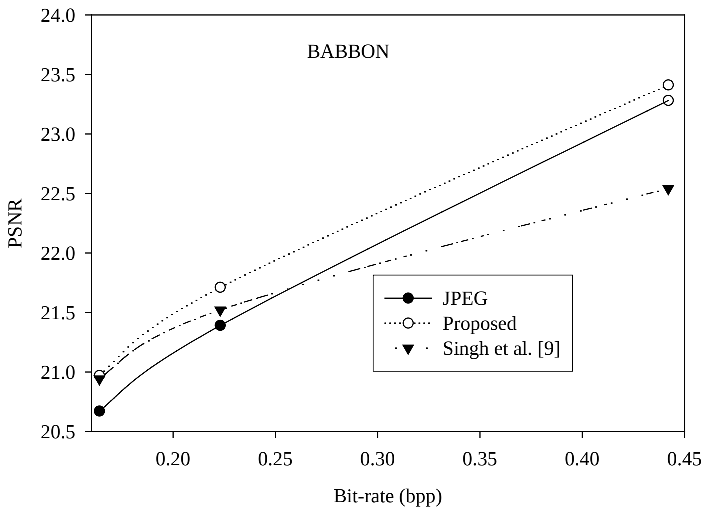
The objective quality of the decompressed image is evaluated using the peak signal to noise ratio (PSNR),) and similarity factor (SF) indices. Figs.4 (a-c) present's experimental results of PSNR obtained by applying the proposed algorithm in comparison with the existing algorithms by Singh et al. [9]. Figs. 4(a-c) presents that the proposed technique gives best PSNR values as compared to all other methods for all images compressed at different bit rates. Results indicate that the proposed method outperforms all other methods proposed by Singh et al. [9] in terms of PSNR. It is well known that PSNR is not always a good measure to reflect the subjective image quality. Wang et al. [12] proposed that SSIM indices measure the structural similarity between two image signals. If two images are identical, MSSIM is equal to 1. However this has been found that the difference in MSSIM values for each method is small and thus difficult to recognize. Thus a SF (Similarity Factor) is proposed to evaluate the similarity of two MSSIM. For a test image with a positive SF, the perception quality is more similar to original image than JPEG signal. In comparison, a testing image with a negative SF is considered more degraded. Figs.5 (a-c) exhibits the SF comparison for different post-processing techniques applied to different JPEG compressed images. The proposed method produces a larger SF value for all the three images as compared to methods by Singh et al. [9]. The proposed method thus reduces the artifact to great extent while preserving the image information, which is important from human observer's point of view.



(a)

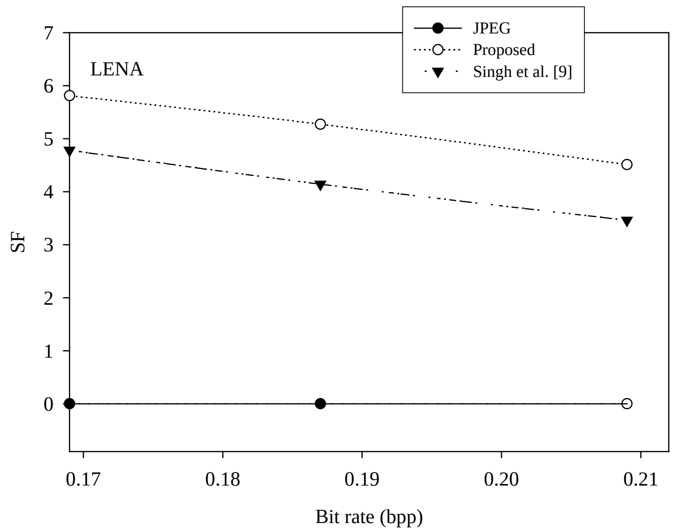


(b)

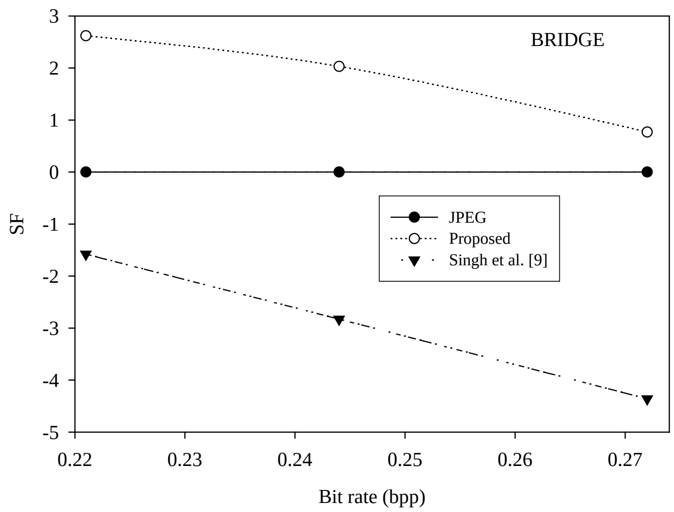


(c)

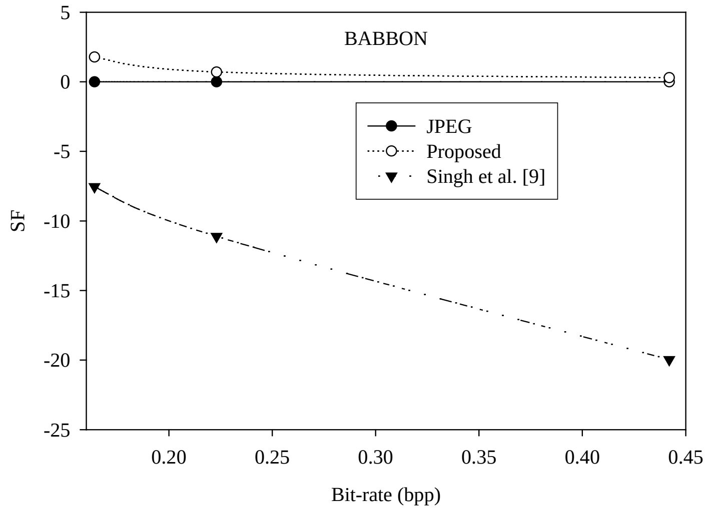
Figure 4. PSNR results of the proposed algorithm in comparison with the existing techniques for images (a) Lena (b) Bridge and (c) Babbon image.



(a)



(b)



(c)

Figure 5. SF results of the proposed algorithm in comparison with the existing techniques for images (a) Lena, (b) Bridge, and (c) Babbon image.

V. CONCLUSION

In this paper, a new post-filtering algorithm to remove coding artifacts is proposed. The proposed method detects all possible regions of artifacts and adapts the filtering strength to the detected artifact level. Thus, the time and the computational load of the deblocking algorithm is reduced compared to other deblocking methods. The boundary regions between blocks are identified as smooth, non-smooth and intermediate regions. To demonstrate the performance of the proposed algorithm, PSNR, index based on HVS perception and SF indices have been used .It is found that there is a significant improvement in the perceptual quality of the JPEG compressed images after removal of blocking artifact by the proposed method.

VI. REFERENCES

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