

## Blocking Artifacts Reduction in Compressed Data

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**Abstract.** Blocking artifacts are significant problem in DCT-based image compression, which introduce the apparent distortion of visual quality. In this paper, an effective blocking artifacts deduction method is proposed. Firstly, the edges identification is done in compressed data, with hysteretic based edge linkage. Secondly, according to DCT coefficients distribution in the half-block-size shifted image block and also in the original target image blocks, an adaptively compound method is carried out to reduce the blocking effects. Since all the computation is performed in DCT domain, the compressibility of the original image is not affected. Furthermore, experiment results verified the effectiveness of our new method.

**Keywords:** Block edge classification, DCT, Blocking artifacts.

### 1. Introduction

Block-based discrete cosine transform (DCT) coding has been widely adopted in image and video compression standards for reducing interpixel redundancy, such as JPEG, MPEG-x and H26x. In the related standards, quantization gives rise to discontinuity of intensities between adjacent blocks and introduces degradation like visually annoying artifacts in reconstructed images. One of the most noticeable degradation of the block transform coding is the “blocking artifact,” which appears as a regular pattern of visible block boundaries. These degradations are highly objectionable and probably will affect the judgment of a final observer. Subjective picture quality can be significantly improved by decreasing the blocking artifacts, or by increasing the bandwidth or bit rate, which is often not possible or is too costly. Many algorithms have been proposed for reducing these artifacts. These algorithms can be classified into two major categories. One is to use different encoding schemes, such as the interleaved block transform, the lapped transform, and the combined transform. The other is to post process the reconstructed images. The latter strategy is of practical interest since it is fully compatible with the image coding standards. Under this category, many original methods have been presented, such as wavelet-based filtering methods, e.g., [1], DCT-domain methods, e.g. [2], [3], and statistical methods based on MRF models, e.g., [4]. Typically, the projections onto convex sets (POCS)-based techniques have produced good effects, but these methods are based on an iterative approach and are too complex for practical use. Some DCT-domain post-processing algorithms have also been investigated recently [2], [5]. However, most of these methods either blur the image too much in an effort to eliminate artifacts or cannot eliminate the artifacts sufficiently. Given this issue, the method of Kong H, S,[6] in spatial domain and one of Popovici, I [2] in DCT domain are all carrying out the effective elimination based on the edge information. However, the threshold for identification of edge block in above edge detectors is difficult to decide and the edge result is much less integrated compared with edge detection of raw data.

In this paper, a novel and systematic scheme is proposed for reducing blocking artifacts in transform domain. With the help of extraction block type (edge, mono, texture) information (Edge Map) based on fuzzy logic reconstruction and hysteretic based edge linkage, deduction of blocking artifacts are carried out

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by an adaptively compound method. The adaptive choice of concrete method is based on the DCT coefficients distributions, which are in the half-block-size shifted image block and also in the original target image blocks. Compared to existing methods [5] and [7], the proposed post-filter is able to extract better edge map. And also compared with some existing classic methods [3], [8] and [9], the proposed method keeps better visual effects no matter under low bit rate encoding or high bit rate encoding scenarios.

The remaining paper is organized as follows: Section 2 introduces the method of locating the edge in compression scheme. Section 3 describes performing deduction of blocking artifacts in DCT domain. Experiment results and conclusion of the paper is given in section 4.

## 2. Locating Edges in DCT Space

The coded image must be deblocked respectively referring to different regions to prevent from blurring of dominant details of different block type. In this section, a novel adaptive edge detection, which is carried out directly with the DCT coefficients, is introduced.

Generally, there are three key edge parameters need to be identified, such as 1) edge orientation, 2) edge strength 3) edge offset. Similar to some existing edge detection methods in compressed domain, the process to determine the offset and orientation starts classifying and reconstructing edge block into one of the edge patterns as shown in Figure 1. The corresponding normalized feature coefficients of the edge block are computed as below.

$$N_1 = \frac{c(0,1)}{c(1,0)}, N_2 = \frac{c(1,1)}{c(1,0)} \quad (1)$$

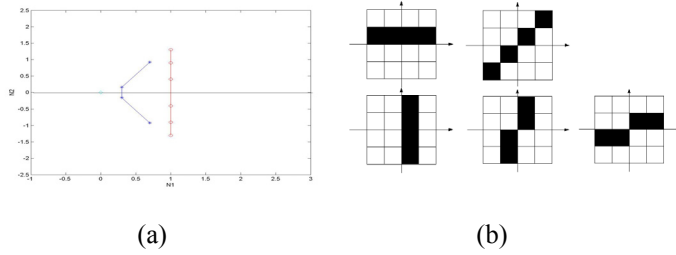


Fig. 1: Edge orientation feature space

Refer to the Figure 1, given different orientation  $\theta$  from  $0^0$  to  $45^0$  and offset  $d$  from  $-3$  to  $3$ , the respective  $N_1$  and  $N_2$  will fall into the different area in the features space composed by  $N_1$  and  $N_2$ , which corresponds to the edge pattern in Figure1 (b). The process to determine the offset and orientation starts to classify an identified edge block into one of the 5 classes of the edge orientation as shown in Figure1 (b) (which is corresponding to  $4 \times 4$  after up sampling).

After making certain the offset and orientation of the edge block, the next step is to identify the real edge block based on its strength. Some adaptive threshold methods, like [5], have been proposed, however, most of them are both empirical and very sensitive to the spurious responses caused by noise. Such spurious responses will usually create a ‘streaking’ problem, which means the breaking up of the edge contour caused by the operator fluctuating above and below threshold.

In order to eliminate such problem, along with deciding the threshold based on SNR (signal noise ration) of the whole image, we also stretch our strong edge map with hysteretic linkage to make sure that the full edge map has been satisfying extracted.

The edge strength of a block is defined as:

$$mag = |c(0,1)| + |c(1,0)| \quad (2)$$

Let  $I$  be an image, whose strength of edge has been quantized to 64 entries, such as  $c_1, c_2, c_i, c_{64}$ . For a block  $p(x, y) \in I$ , we denote  $I(p)$  as its edge strength, and then strength histogram is defined by.

$$I_c = \{p | I(p) = c\}; h_{c_i}(I) = n \cdot \Pr_{p \in I} [p \in I_{c_i}]; H_{c_i}(I) = h_{c_i}(I) / n \quad (3)$$

Where  $n$  is the total number of blocks in an image. Normalized histogram  $H_{c_i}(I)$  gives the probability that

the magnitude of the block is  $c_i$ . Then the threshold can be derived from below.

$$\int_0^{T_h} H_{c_i}(I)dc_i \geq \beta; T_l = T_h \cdot \alpha \quad (4)$$

If any part of a contour is above the high threshold  $T_h$ , those blocks are output immediately (strong edge). For those individual weak responses lying above the low threshold  $T_l$ , the direction and offset, which are derived from the above step, are considered. If these segments are connected to any of the segment with strong responses, they are more likely to be actual edge in the image. The probability of streaking is greatly reduced because a contour mostly fluctuates between high threshold and low threshold. Since it is assumed that in our ideal step edge model the noise has a Gaussian distribution, detector response will be composed of large values occurring very infrequently. Such facts lead to a good separation between signal and noise. Comparing with the method in [5], our method has less isolated edge or noise point in the final results.

### 3. Blocking-artifacts Reduction

Based on the above edge map information, the whole image is classified into three areas (Edge, Texture, and Mono). The deblocking will only be done in the area of Mono.

As we know, blocking effect is introduced by truncating those undesired high frequency DCT components. If the distributions of the pixels' value near the block boundary accords with linear function, the blocking artifacts will be imperceptible to the observer. Let us firstly consider the horizontal situation by choosing 2 adjacent blocks as the deblocking units ( $a_n, b_n$ ). The right four columns of  $a_n$  and left four columns of  $b_n$  form a new image block  $c_n$ , which can be expressed as:

$$c = at_1 + bt_1'; a = at_2 + ct_1'; b = bt_3 + ct_1 \quad (5)$$

With  $t_1 = \begin{bmatrix} 0_{4 \times 4} & 0_{4 \times 4} \\ I_{4 \times 4} & 0_{4 \times 4} \end{bmatrix}$ ,  $t_2 = \begin{bmatrix} I_{4 \times 4} & 0_{4 \times 4} \\ 0_{4 \times 4} & 0_{4 \times 4} \end{bmatrix}$ ,  $t_3 = \begin{bmatrix} 0_{4 \times 4} & 0_{4 \times 4} \\ 0_{4 \times 4} & I_{4 \times 4} \end{bmatrix}$ ,  $t_1'$  is the transpose of  $t_1$ ,  $0_{4 \times 4}$  is zero matrixes,

and  $I_{4 \times 4}$  is the identity matrix. Correspondingly the DCT-domain counterpart is

$$C = AT_1 + BT_1' \quad (6)$$

$C$  is the half-block-size shifted image block, which we need to deal with if any abrupt change happens. Most deblocking solutions are following either zero-masking scheme or curve replacing scheme [9] and [8] to reconstruct the low frequency part of the  $C$  to be a linear one. However, those methods will lose some details or introduce some distortions under higher bit rate encoding cases or detail. Many experienced criteria have been set up to decide whether the above handling should be done or not on current block. Luo [3] introduced a method to cover both high bit rate and low bit rate compression scenarios. Most power of this innovation is coming from the contribution of direct utilization of nearby block  $A$  and  $B$  in the final resulting  $C$ . But unfortunately the performance will be a little poor under very low bit rate if it is judged by perceptual visual inspection.

if original image is highly correlated, which means the block discontinuities are invisible, the nonzero DCT coefficients of the joint block are kept within the range  $N$  times larger than those of inside blocks, the corresponding DCT coefficients distribution of  $C$ ,  $A$  and  $B$  will be the most appropriate criteria to indicate whether the blocking artifact is apparent or not and also the block coefficients is really suffered from blocking artifacts since the heavy compression has been done. Let us defined a threshold like below.

$$\phi = (vA | vB) / vC \quad (7)$$

Where  $vA, vB, vC$  is a linear vector with the length equal to 8, and each composite value is 1 or 0 corresponding to nonzero or not the first line of  $A, B$  and  $C$ .

When  $\phi$  is under the range  $[0 \sim .25]$ , only  $C_D(u, v)$ , the low frequency DCT coefficients of  $C$ , is the best choice for curve replace given the visual effects. Furthermore, the magnitude of  $C_D(0,1)$  is regularized

When  $\phi$  is under the range  $[.25 \sim .5]$ , a handling following below formula will be carried out.

$$C_{res} = \begin{cases} .6 \cdot C_D(u, v) + .2 \cdot \\ [A(u, v) + B(u, v)], u = 0, v = 0, 1 \\ .5 \cdot C_D(u, v) + .2 \cdot \\ [A(u, v) + B(u, v)], u = 0, v = 3, 5, 7 \\ C_D(u, v), \quad otherwise \end{cases} \quad (8)$$

When  $\phi$  is under the range. [.5 ~ .8], Luo [3] method will be utilized to reducing the blocking artifacts.

When  $\phi$  is under the range. [.8 ~ 1.0], we consider it representing that the block coefficients of C are not really suffered and don't need to be handled.

With the above compound method, we adopted the virtue of the Luo [3] and also avoid her shortcoming under low bit rate condition. Furthermore, the threshold has more theoretical support and is more robust than before criteria in [3] and [9] to decide a deblocking handling should be done or not.

#### 4. Experiments and Results

To evaluate the performance of the proposed algorithm, the simulations are performed with a number of  $512 \times 512$  monochrome images. First, edge detection results are testified. Then, the performance of the proposed deblocking method is illustrated under different bpp (bits per pixel) based on the resulting subjective image quality, and also objective measurement in PSNR. Corresponding deblocking results on ideal step, which are corresponding to low bit rate scenario, have also been presented in Figure 2 for a reference regarding the visual result of different deblocking methods.

Since edge map plays an important role. Figure 4 demonstrates the results of different edge detection methods on Lena image (bpp equals to 0.279). It can be seen from the edge maps in Figure 4 that method [5] can't result in edge width with one pixel and will result in overestimating based on  $4 \times 4$  DC Images. And although Method [7] is the latest and finest result in the recent documents regarding DCT domain edge detection, the results we get is quiet competitive with theirs. Figure 3 demonstrates the image enhancement results of different images of Lena under the different bpp values. We can see clearly the blocking artifacts have been greatly reduced no mater under low bit rate compression or high bit rate compression.

The performance of new proposed post-processing method is also examined under different BPP (Bits Per Pixel) condition. Some results measured in PSNR and compared with method [3] and [9] are illustrated in Table I. In Table I, M[3] is corresponding to the method in [3] and M [9] is corresponding to only ACR part of the method in [9]. It can be seen that the proposed method is better than the method in [3] and [9] under many classic conditions with different BPP values.

As a result, the proposed algorithm outperforms some classic methods given the result of edge block identification and also blocking artifact reduction. The efficiency is verified under both the subjective and objective measurement. It is suitable for fast, robust compressed-domain signal enhancement

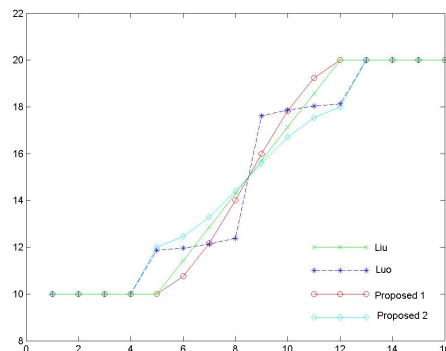


Fig. 2: 1-D plot of the deblocking results on ideal step edge with x- and z- axis taken from Luo [3], Liu [8] and our methods, in which the proposed 1 correspond to  $C_D(u, v)$  , and the proposed 2 is the result handling with equation 8.



Fig. 3: (a) (b) The Lena image with 0.915 bpp before/after deblocking (c) (d) The Lena image with 0.279 bpp before/after deblocking

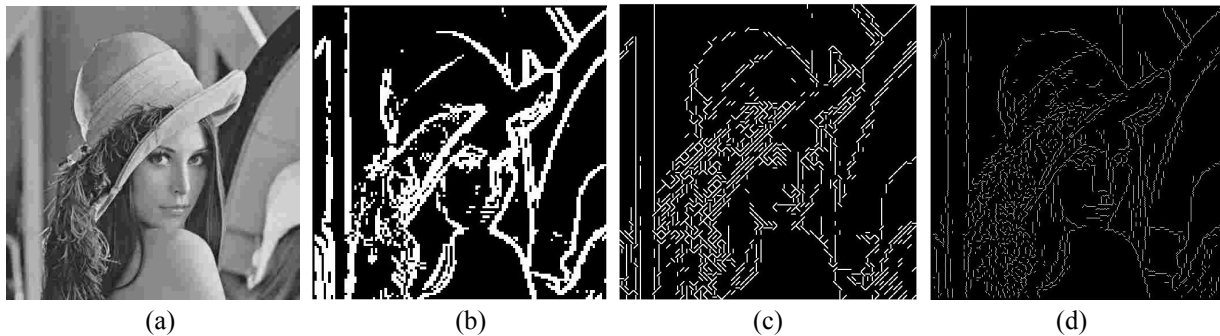


Fig. 4: (a) original image Lena with bpp=0.279 (b) the edge result of [5] (c) the edge detection result of [7] (d) the edge detection result of our method

TABLE I. COMPARISON OF PSNR WITH LENA IMAGE

BPP		0.279	0.391	0.507	0.543	0.671	0.915	1.193
PSNR (dB)	M[3]	30.2736	32.2861	33.182	33.6662	34.1894	33.8118	35.6151
	M[9](ACR)	30.1880	32.7102	34.0070	34.7660	35.3381	35.1020	37.6049
	M[proposed]	<b>30.4842</b>	<b>32.9437</b>	<b>34.1450</b>	<b>34.8774</b>	<b>35.3864</b>	<b>35.1039</b>	<b>37.6086</b>

## 5. References

- [1] S. Mallat, and S. Zhong. Characterization of signals from multiscale edges. *IEEE Trans. Pattern Anal. Machine Intell.* Vol. 14, No. 3, pp. 710-732, July 1992.
- [2] Popovici, I and Withers, W. D. Locating Edges and Removing Ringing Artifacts in JPEG Images by Frequency-Domain Analysis. *IEEE Trans Image Processing.* Vol. 16, No. 5, pp. 1470-1474, May. 2007
- [3] L. Ying and R. K. Ward. Removing the blocking artifacts of block based DCT compressed images. *IEEE Trans. Image Process.* vol. 12, no. 7, pp. 838–842, Jul. 2003.
- [4] T. Meier, K. N. Ngan and G. Crebbin. Reduction of blocking artifacts in image and video coding. *IEEE Trans. Circuits Syst. Video Technol.* Vol. 5, No. 3, pp. 490-500, Apr. 1999.
- [5] C.Wang, W.Zhang and X.Fang. Adaptive reduction of blocking artifacts in DCT domain for highly compressed images. *IEEE Trans. Consumer Electronics.* volume 50, no2, pp. 647 - 654, May. 2004
- [6] Kong, H.S, Vetro, A, and Sun, H.F. Edge Map Guided Adaptive Post-Filter for Blocking and Ringing Artifacts Removal. *TR-2004-003* February 2004
- [7] Chang, H.S and Kang Kyongok. A Compressed Domain Scheme for Classifying Block Edge Patterns. *IEEE Transactions on Image Processing.* Volume 14, No 2, February 2005
- [8] S.Z.Liu and A.C.Bovik. Efficient DCT-Domain blind measurement and reduction of blocking artifacts. *IEEE Trans. Circuits Syst. Video Technol.* vol. 12, no. 12, pp. 1139-1149, Dec. 2002.
- [9] G.Zhai, W.Zhang, X.Yang, W.Lin and Y.Xu. Efficient Deblocking With Coefficient Regularization, Shape-Adaptive Filtering, and Quantization Constraint. *IEEE Trans. Multimedia.* volume 10, no 5, pp. 735 – 745, Aug. 2008