Simple and Fast Subband De-blocking Technique by Discarding the High Band Signals

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Abstract. *In this paper, we propose a simple and fast post-processing de-blocking technique to reduce blocking artifacts. The block-based coded image is first decomposed into several subbands. Only the low frequency subband signals are retained and the high frequency subband signals are discarded. The remaining subband signals are then reconstructed to obtain a less blocky image. The ideas are demonstrated by a cosine filter bank and a modulated sine filter bank. The simulation result shows that the proposed algorithm is effective in the reduction of blocking artifacts.*

1. Introduction

Transform codecs, such as those based on the Discrete Cosine Transform (DCT), are simple codecs widely applied in the industry. However, they usually produce undesirable blocking artifacts at high compression ratios. This is because each block in an image is transformed independently, and the correlation among adjacent blocks is not exploited. Thus, at a high compression ratio, quantization errors lead to blocking artifacts.

In order to tackle this problem, the lapped transform before encoding was proposed to capture the correlation information among the adjacent blocks [8]. However, this pre-processing technique requires a decrease of compression ratio and so it is not adopted in the international standard. Some subband de-blocking techniques [2, 3, 4] have also been proposed, but they are too complex in terms of implementation and computation.

In this paper, we propose a simple and fast post-processing subband de-blocking technique, which discards some high band signals and retains the remaining low band signals. The algorithm is tested by the cosine filter banks and the modulated sine filter banks. The simulation results show that this algorithm can suppress the blocking artifact effectively in both the quantitative measurement and the qualitative evaluation.

2. De-blocking System

Since a block-based transform and a lapped transform can be viewed as a discrete time linear time periodic varying system, it can be realized by a filter bank structure [1]. Due to the fact that block edges always contain high frequency components [5], we propose to retain the low frequency band signals and discard the high band frequency signals.

The more low band signals are retained, the more block boundaries will be captured in the reconstructed image. However, the image details will be destroyed if we only keep a very little subset of the subband signals. We have conducted an intensive simulation and found that the best performance corresponds to retain two subband signals and discard the remaining high band signals.

The block diagram of the subband de-blocking system is shown in figure 1. There are many ways to select the analysis filters, $h_j[n]$, for $j=0,1,\ldots,M$, and the synthesis filters, $f_j[n]$, for $j=0,1,\ldots,M$, where the quantizers are designed as $Q_j(x)=x$, for $j=0,1$, and $Q_j(x)=0$, for $j=2,3,\ldots,M$. The design of the filters should give a perfect reconstruction system when the quantizers are removed. This is because the error introduced due to the filter bank structure is illuminated in the perfect reconstruction system. In this paper, a cosine filter bank [6] and a modulated sine filter bank [7] are selected to demonstrate this idea.

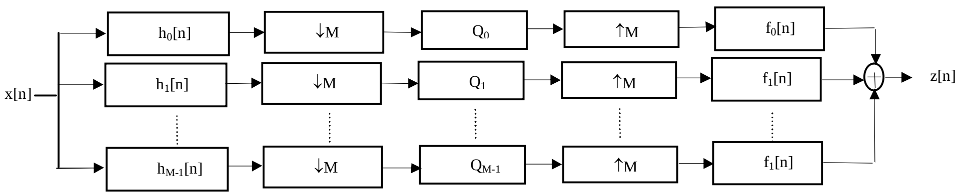

Fig. 1. Block diagram of subband de-blocking technique

2.1 Cosine Filter Bank

The impulse responses of the synthesis filters, $f_j[n]$, for $j=0,1,\ldots,7$, are the transform basis functions of the DCT and the impulse responses of the analysis filters, $h_j[n]$, for $j=0,1,\ldots,7$, are equal to the time-reversed basis functions [6] as follows:

$$h_j[n] = \alpha_j \cdot \cos\left(\frac{\pi \cdot j \cdot (2 \cdot n + 1)}{16}\right), \tag{1}$$

for $j=0,1,\ldots,7$ and for $n=0,1,\ldots,7$, where:

$$\alpha_j = \begin{cases} \dfrac{1}{\sqrt{8}} & ; j = 0, \\ \dfrac{1}{2} & ; \text{otherwise}, \end{cases} \tag{2}$$

$$f_j[n] = \alpha_j \cdot \cos\left(\frac{\pi \cdot j \cdot (15 - 2 \cdot n)}{16}\right),$$

for $j=0,1,\ldots,7$ and for $n=0,1,\ldots,7$.

2.2 Modulated Sine Filter Bank

The modulated sine filter bank is similar to the cosine filter bank except that the impulse responses of the synthesis filters, $f_j[n]$, for $j=0,1,\ldots,7$, are the transform basis functions of the modulated sine transform and the impulse responses of the analysis filters, $h_j[n]$, for $j=0,1,\ldots,7$, are equal to its time-reversed basis functions [7] as follows:

$$h_j[n] = \frac{1}{2} \cdot \sin\left(\frac{\pi}{16} \cdot \left(\frac{15}{2} - n\right)\right) \cdot \cos\left(\frac{\pi}{8} \cdot \left(j + \frac{1}{2}\right) \cdot \left(\frac{23}{2} - n\right)\right), \tag{3}$$

for $j=0,1,\ldots,7$ and for $n=0,1,\ldots,7$,

$$f_j[n] = \frac{1}{2} \cdot \sin\left(\frac{\pi}{16} \cdot \left(n + \frac{1}{2}\right)\right) \cdot \cos\left(\frac{\pi}{8} \cdot \left(j + \frac{1}{2}\right) \cdot \left(n + \frac{9}{2}\right)\right), \tag{4}$$

for $j=0,1,\ldots,7$ and for $n=0,1,\ldots,7$.

3. Simulation Results

The proposed de-blocking technique is applied to the JPEG-coded image "Cancer" of size *512x512* adaptively. The effectiveness of the proposed algorithm can be estimated by both the quantitative measurement and the qualitative evaluation.

For the quantitative measurement, the blocking artifact is mainly due to the grid noise in the monotone areas. Since the intensity of the monotone areas of most natural image change very slowly, but there is a tendency for the intensity in the block-based coded image to change abruptly from one block to another, we propose the following methodology to measure this effect:

If the four neighbor *8x8* image blocks are all DC blocks, that is, all the pixel values in the individual blocks are constant, then we sum up the error square in these four blocks, and finally we compute the mean square error (*MSE*) of all these blocks as follows:

$$MSE = \frac{1}{N} \cdot \sum_{(i,j) \in Q} \left[R(i, j) - O(i, j) \right]^2 , \qquad (5)$$

where **O** is the original image, **R** is the reconstructed image, **Q** is the region where there are four neighbor *8x8* DC blocks and *N* is the total number of pixels in **Q**.

Table 1 shows the comparison of the results of applying existing methods and our proposed de-blocking technique. It can be seen from table 1 that our proposed algorithm gives better quantitative results than that of the existing methods. The qualitative results shown in figure 2 also demonstrates that our proposed algorithm gives a better image quality than that of the existing methods.

	Cancer(0.139bpp)
JPEG coded image	22.6819
DCT zero-masking technique [5]	19.2036
DCT coefficient weighting technique [5]	19.0579
Cosine de-blocking technique	17.9483
Modulated sine de-blocking technique	18.4175

Table 1. Simulation results calculated by MSE of applying existing methods and our proposed algorithms

4. Concluding Remarks

In this paper, we have proposed a simple and fast post-processing subband de-blocking technique, which discards the high band signals and only retains the lowest two low band signals. This algorithm is tested by a cosine filter bank and a modulated sine filter bank. The simulation results show that our proposed method is very effective.

Since it adopts the existing transform codec and do not affect the compression ratio, the proposed algorithm can be applied to the enhancement of very high compression ratio block-based coded images. The given image can be first compressed to a very high compression ratio image through the block-based coder, and then the blocky image is enhanced by the proposed algorithm. Further research work will focus on the finding of the best filter bank that gives the highest coding gain.

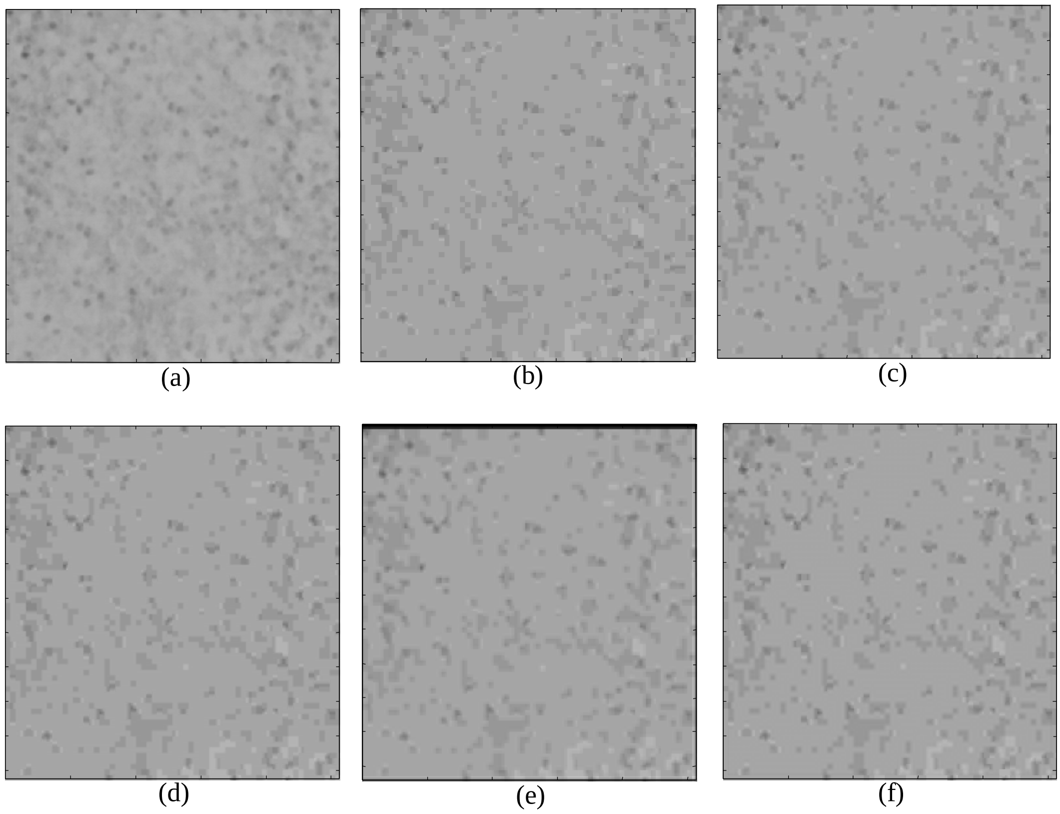

Fig. 2. (a) Original image (b) JPEG-coded image (c) Image processed by zero-masking technique [5] (d) Image processed by DCT coefficient weighting technique (e) Image processed by modulated sine de-blocking technique

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