

Frequency Domain Techniques For Blocking Artifact Reduction-A Review

Jagroop Singh¹

¹Faculty DAV Institute of Engineering and Technology, Kabir Nagar, jalandhar.

roopsidhu@yahoo.com

Abstract: Block-based coding is used extensively both in image and video coding systems. Image coding systems that divide an image into sub-images have problems in very low bit rate applications. In low bit rate applications, this scheme gives rise to “blocking artifacts” that arise due to image segmentation which severely reduce the visual quality of an image or video. Reducing blocking artifacts is essential to render the compressed visual data acceptable to the viewer. Various deblocking methods have been proposed in the literature to reduce blocking artifacts. Many of these methods are based on the post-processing at the encoding side. In the present research paper various deblocking methods applied in the frequency domain are discussed.

Keywords: Block-based, sub-image, deblocking, coding.

1. Introduction

The blocking artifacts manifest itself as artificial boundary discontinuities between sub-images, caused by information loss in each sub-image during coding. As the bit rate is reduced, the blocking artifacts, which are not noticeable at high bit rates, becomes more prominent. Typically the blocking artifacts create two kinds of visual distortions; 1) blurring of sharp edges and changes in texture patterns and 2) formation of false edges at interblock boundaries. The first kind of distortion is due to near elimination or improper truncation of the high frequency discrete cosine transformation (DCT) coefficients. The other kind is due to severe reduction in the low-frequency DCT coefficients.

2. Frequency Domain Techniques

Frequency domain approaches are based on manipulation of pixel values of an image in the transformed domain. Minami and Zakhor (1995) [1] gave a new approach for reducing the blocking effect in frequency domain. A new index to measure the blocking effects namely the mean squared difference of slope (MSDS) has been introduced. It is shown that the expected value of the MSDS increases after quantizing the DCT coefficients. This approach removes the blocking effect by minimizing the MSDS, while imposing linear constraints corresponding to quantization bounds. Lakhani and Zhong (1999) [2] also reduced blocking effects using MSDS. However, they developed a completely different solution of the optimization problem, leading to the computation of the DCT coefficients that minimizes the MSDS globally. Traintafyllidis et al. (2002) [3] proposed another method of minimizing MSDS, which involves

diagonal neighboring pixels in addition to horizontal and vertical neighboring pixels.

Liu et al. (2002) [4] proposed a DCT domain method for blind measurement of blocking artifacts, by modeling the artifacts as 2-D step functions in shifted blocks. A fast DCT domain algorithm extracts all the parameters required to detect the presence of blocking artifacts, by using HVS properties. Then the artifacts are reduced by using an adaptive method. A simple DCT domain method for blocking artifacts reduction by applying a zero masking to the DCT coefficients of some shifted image blocks has been proposed by [5]. However, the loss of edge information caused by the zero-masking scheme is noticeable. Luo and Ward (2003) [6] gave a technique reducing the blocking artifacts in the smooth regions of the image, which preserved the edge information. 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.

Wang et al. (2004) [7] utilized Walsh Transform to form a DC Image for obtaining the edge distribution in the original Image. An adaptive filter and compensatory matrices are used to overcome the drawback of previous algorithm. The weakness of Wang et al. (2004) [7] is to assume that the difference of the pixel values in the block boundary is caused by only the blocking artifacts. Wei et al. (2005) [8] proposed odd tile length low pass first (OTLPF) convention. The proposed OTLPF convention provides a simple method to significantly reduce coding artifacts at tile boundaries in wavelet-based image compression. The proposed method is very simple and involves no changes to the wavelet transform. This method not only reduces tile boundary artifacts, but also reduces the bit rate needed for a given peak signal to noise ratio (PSNR) in the compressed image.

Wasfy et al., (2005) [9] proposed a novel multiple transform domain split vector quantization (VQ) technique for image compression enabling to achieve lower data rates for the same PSNR. This is accomplished at the expense of increased computational complexity at the encoder. Kwan et al. (2006) [10] proposed a complete codec for image compression based on overlapped block transform, post-processing technique in removing the ringing artifacts at extreme compression ratio. The proposed method can control the compression ratio at certain critical regions of the image so that the target recognition performance can be preserved. Singh et al. (2007) [11] gave a new approach for reducing the blocking artifacts in frequency domain. A new index called, block boundary measure (BBM) is applied to both vertical and horizontal block boundaries in addition to PSNR and mean structural similarity index (MSSIM) indices. The proposed method reduces the artifacts to great extent while preserving the image information.

Park et al. (2007) [12] proposed method that can measure the blocking artifacts in both pixel and DCT domain with low computational complexity. The proposed method measures true blocking artifacts using the original image and can be used to improve the performance of existing algorithms by reducing the blocking artifacts. Popovici and Dauglas (2007) [13] presented a method of locating sharp, straight edges in parametric form using frequency-space representation of DCT-coded images. The proposed method shows significant improvement in accuracy over previous comparative methods. Pan et al. (2007) presented [14] a novel non-referenced approach for measuring blocking artifacts in BDCT coding. The proposed algorithm uses the edge directional information of the images and does not need the exact location of the block boundary and is thus invariant to the displacement, rotation and scaling of the images. Zhai et al. (2008) [15] proposed an efficient JPEG image de-blocking algorithm through post filtering in shifted windows (PSW) to smooth the image pixels in a block-by-block approach. Despite the low computational complexity, the proposed method shows superior performance over PSNR gain and visual quality improvements. Zhai et al. (2008) [15] proposed an effective method of evaluating noticeable blockiness without reference image with the help of noticeable blockiness map (NBM). The proposed algorithm successfully preserve the image from over smoothing while the de-blocking ability is not affected.

The deblocking method aims to reduce the blocking artifacts in the compressed image by analyzing their visibility. A perceptual map is obtained using some Human Visual System (HVS) characteristics. This perceptual map is used as input to a recursive filter to reduce the blocking effects. In order to reduce blocking artifacts, two image post processing techniques, Dual Non-local Kuan's (DNLK) filter and Over Complete Dual Non-local Kuan's (OCDNLK) filter, are presented. A more accurate DCT

domain Kuan's filter based on Non-local parameter estimation was proposed from the linear minimum mean-square-error (MMSE) criterion. The goal is to assess MPEG video quality and perform post processing without access to neither the original stream nor the code stream. Lee and Park proposed [5] a new image quality assessment method for block based transform coded image that both detects and measures the strength of blocking artifacts. The proposed method operates only on a single block boundary to detect blocking artifacts. When a boundary is classified as having blocking artifacts, corresponding blocking artifacts strength is also computed. Average values of those blocking artifacts strengths are converted into a single number representing the subjective image quality.

3. Lapped Orthogonal Transforms:

Lapped orthogonal transforms (LOT) provide a way for avoiding the occurrence of blocking artifacts in the first place, rather than reducing them after they have occurred. They are different from regular block transforms. They have basis functions that overlap to adjacent blocks. In other words, to produce transform coefficients for one block, not only samples of that block are used, but also samples from neighboring blocks are used. This means that each block is no more coded independently of other blocks. Hence, blocking artifacts are less prominent. However, other artifacts tend to appear, such as increased ringing effects around edges due to longer basis functions. Detailed discussions on image coding based on LOT can be found in Malvar and Staelin (1988), [16] Malvar and Staelin (1989) [16]. Even though the LOT might seem to be an attractive solution, many standards were developed relying on the block-based DCT and large amounts of investment were made. The amount of improvement the LOT provided could not justify a shift from the DCT to LOT. Overall, the DCT is used immensely in practice, especially in video coding. Therefore, it is important to find ways to reduce blocking artifacts in block-based DCT coded image and video coding applications.

3.1 Wavelet based methods:

Some methods reduce blocking artifacts using the wavelet domain representation of images. These methods start by transforming the compressed image with blocking artifacts to the wavelet domain. Then, the wavelet coefficients related to block boundaries with blocking artifacts are modified. The algorithms to modify these coefficients differ between the various methods based on wavelets and they are the most distinguishing feature between these methods. In the method proposed by Orchard et al. (1993) [17], an over-complete wavelet representation is used. In other words, wavelet representations in all scales have the same number

of coefficients as the image with blocking artifacts. First, an edge map is created using the correlation of wavelet coefficients across scales. Locations above a threshold are identified as edges. Then, wavelet coefficients at non-edge locations are set to zero while coefficients at edge locations are left untouched. Finally, the low-pass component (the scaling coefficients) is averaged at the block-boundary locations with its neighbors. The inverse wavelet transform using the modified coefficients gives the de-blocked image. Xiong et al. (1999) used an over-complete wavelet representation to reduce the quantization effects of block based DCT. Other approaches using wavelet representation are presented by Kim et al. (1998) [18], Hsung et al. (1998), In the method proposed by Hsung et al., (1998) [18] the wavelet transform modulus maxima (WTMM) representation is used for efficient image deblocking.

4. Gaps in the Previous Research

In most of the previous approaches the reduction of blocking artifacts is carried out at the encoding side, but the methods based on this approach do not conform to existing standards. There are many general techniques which use low pass filtering to reduce the blocking artifacts. However, the above filtering approaches are not adaptive to remove different strengths of blocking artifacts and thus frequently result in over blurred recovered images especially at low bit rates. Projection on to convex sets approach is effective in eliminating the blocking artifacts but less practical for the real time applications, since the iterative procedure adopted increases the computational complexity. Most suggested blocking artifacts detection approaches use linear function for the detection of blocking artifacts and thus are not able to detect blocking artifacts accurately.

5. Conclusion:

Literature search indicates that the use of different functions other than step and linear functions for blocking artifacts detection has not been studied in detail. Since the reduction of blocking artifacts is an important problem, especially in low bit-rate image and video coding, new approaches should be explored, even if existing methods work reasonably well. Therefore, a computationally efficient method to detect and reduce these artifacts without smoothing images and without removing perceptual features should be developed.

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