DCT Based JPEG Coded Images and Removal of Blocking Effects

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Abstract- In this research, an adaptive filtering process is employed to reduce the visually annoying artifacts introduced from compression. The type of filtering is decided based on an estimation of the local characteristics of the coded image. For the areas of low image detail a smoothing operator is used; whereas in the high image detail areas (edges - texture) an adaptive Gaussian-type filter is employed. The main advantage of this filter is that the value of the Gaussian kernel is adjusted according to the characteristics of the local image region. Simulation results demonstrate that this method enhances the quality of coded edges and reduces annoying blocking effects, resulting in overall better picture quality.

Keywords – DCT, Blocking Effects, Smoothing Operators

I. INTRODUCTION

Image enhancement is the simplest and most appealing area of digital image processing. The principle objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application. Basically, the idea behind enhancement is to bring out the detail that is obscured, or simply to highlight certain features of interest in an image. A familiar example of enhancement is when we stretch the contrast of an image so that 'it looks better." It is important to keep in mind that enhancement is a very subjective area of image processing. Reduction of blocky artifacts also comes under the area of image enhancement.

Due to the large storage requirements of digital images, as well as the limited bandwidth available to transmit image (such as over the Internet), image compression schemes have been employed. Lossless, as well as lossy compression schemes exist. Lossless compression schemes are used when a precise reconstruction of the compressed image is required such as in medical imaging, where the perfect reconstruction of an image is vital in properly interpreting the image (for example, detecting cancer cells). Other, less critical applications of lossless image compression are for storing diagrams, blueprints, magazine pages for printing, etc.

Lossy image schemes are the most popular because they allow high compression ratios which translate to low storage space and low bandwidth requirements. The high compression ratios can be achieved by voluntarily allowing a certain amount of image information loss. In almost all lossy image formats, the amount of information loss can be controlled by the user.

The most popular lossy image compression scheme used today for still images is the most common compression tool 'BLOCK TRANSFORM CODING' (BTC). These codecs divide the image to nonoverlapping square blocks and apply a transform on each individual block as part of the encoding process. Among the available transforms, the DCT is the most widely adopted as it exhibits very good energy compaction and decorrelation properties. The most popular image transform is the Discrete Cosine Transform (DCT) used by the popular JPEG (Joint Picture Experts Group) image format. As recognized by widespread usage, JPEG is a leading image format used on the Internet and at home for storing high-quality photographic images, as well as the image format of choice for storing images taken by digital cameras.

The Research focuses to deblock the artifacts of JPEG compressed images which are compressed in three sequential steps: DCT computation, quantization, and variable-length code assignment. First the input image is split into 8x8 pixel blocks (hereafter referred to as 'blocks') and Discrete Cosine Transform (DCT) is applied to each block separately.

The result is a series of 64 DCT coefficients representing the scaling factor of each of the 64 image primitives represented by the DCT (see Figure 1). Since each 8x8 block of pixels produces 64 DCT coefficients, if one DCT coefficient from each block is arranged in the same way that the blocks are arranged in the original image, each DCT coefficient produces an image (whose dimensions are $^1/_8$ of the original image width-wise and height-wise) describing each DCT basis function's contribution to the original image. This "image" is termed a 'subband'. Therefore a DCT of an image results in 64 subbands, where each subband is $^1/_{64}$ in size. The first subband is termed the 'DC' subband and is equal to the average brightness of the pixels in the block. The remaining 63 subbands are termed 'AC' subbands and describe various frequencies of edge and texture information.

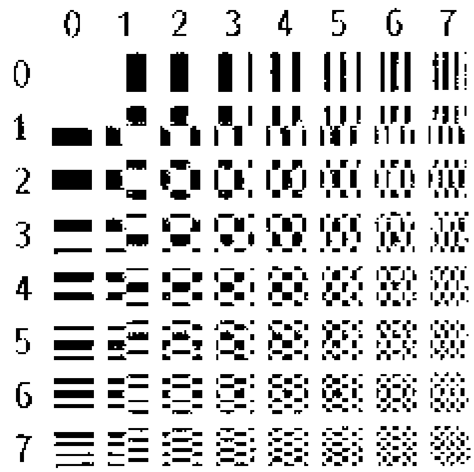


Figure 1. DCT Basic Functions

Here, a new method is proposed for the reduction of blocking effects in JPEG. Initially, better estimates of the reconstructed DCT coefficients are obtained based on their observed probability distribution. Subsequently, a novel post processing scheme is applied consisting of a region classification algorithm and a spatial adaptive filtering for blocks removal. The type of filtering is determined on the basis of an estimate of the local characteristics of the coded image. The aforementioned two stages of the proposed algorithm are acting complementarily for the reduction of blocking artifacts. The efficient performance of the proposed algorithm is due firstly to the proposition that the shape and the position of the filter kernel are adjusted according to the characteristics of the local image region. This approach is shown to produce better results in removing blocking artifacts.

We describe a post-processing method which is designed to remove the picture impairments typically introduced by spatial domain block coding techniques, such as vector quantization (VQ) and block truncation coding (BTC). In these coding methods, the quantization noise is highly correlated with the characteristics of the original signals, so that different areas of the coded image suffer from distinctly different impairments. In particular, uniform areas suffer from the blocking effect, where the boundaries of adjacent blocks become visible resulting in false contours. Moreover, all diagonal edges appear jagged, which is known as the staircase effect. Finally, most of the textured areas are `washed-out'. The post-processing method exploits the properties of smoothed image gradient data to distinguish between high and low detail regions of the decoded image. The filtering process is then decided based on the region classification. For the high detail image areas, which include edges and texture, a fully adaptive Gaussian-type filter is employed. The shape and the position of the Gaussian kernel is adapted according to the characteristics of each local region. For the low detail image regions, which include areas of constant or slowly varying intensity, a simple Gaussian smoothing operator is used. Simulation results confirm that, after applying this post-filtering algorithm to the coded images, the annoying blocking effect is reduced and the jagged edges appear continuous and sharp.

II. Proposed Algorithm

2.1 REDUCTION OF BLOCKING ARTIFACT–

The basic approach for the JPEG compression is fairly simple. The encoding process consists of dividing the image into blocks, typically of size 8x8. A block transform, typically the DCT, is applied to these blocks, and the transform coefficients are individually quantized (scalar quantization). This block DCT scheme takes advantage of the local spatial correlation property of images and also saves processing time. JPEG is very popular in many image coding applications.

However, the individual processing of each block induces visually annoying blocking effects, since the correlation among spatially adjacent blocks is disregarded during coding, particularly when a high quantization parameter is used for achieving high compression ratios. For example, a smooth change of luminance across a border can result in a step in the decoded image if neighboring samples fall into different quantization intervals. Such so called ‘‘blocking’’ artifacts, are often very disturbing. The blocking effect in JPEG images can be classified into three categories [Lee98]: (a) Stair case noise along the image edges, (b) grid noise in the monotone areas, and (c) corner outliers in the corner points of the 8x8 DCT blocks.

Following the description of the main picture quality impairments due to low bit rate JPEG compression scheme and after the biased reconstruction of the DCT coefficients, the design requirements of the proposed efficient post processing method can be outlined as follows. The compressed image is initially segmented into different regions which correspond to areas that suffer from different types of degradation. Hence, a classifier which distinguishes the smooth regions from the detailed ones need to be employed.

Provided that the above step of region classification has been implemented successfully, an adaptive filtering technique takes into consideration the characteristics of the quantization noise in different areas of the coded image. Specifically:

. Staircase noise along the edges must be removed, so that edges appear continuous and sharp. This requires smoothing along, but not across, the edge direction to avoid blurring.

. False contours visible in the areas of slowly varying intensity should be eliminated. This requires smoothing of the intensity changes that occur between adjacent blocks.

. The disturbing blocking effect should also be removed from textured areas, in a manner that preserves any high detail that survived during the coding process.

2.2 POST PROCESSING METHOD USING WSMM

Let $P(x,y)$ denote the image intensity value at point (x,y). The image gradient $\nabla P = (G_x, G_y)^T$ is computed as follows:

$$G_x(x,y) = \frac{P(x+1,y) - P(x-1,y)}{2} \tag{1}$$

$$G_y(x,y) = \frac{P(x,y+1) - P(x,y-1)}{2} \tag{2}$$

The WSMM is then defined as

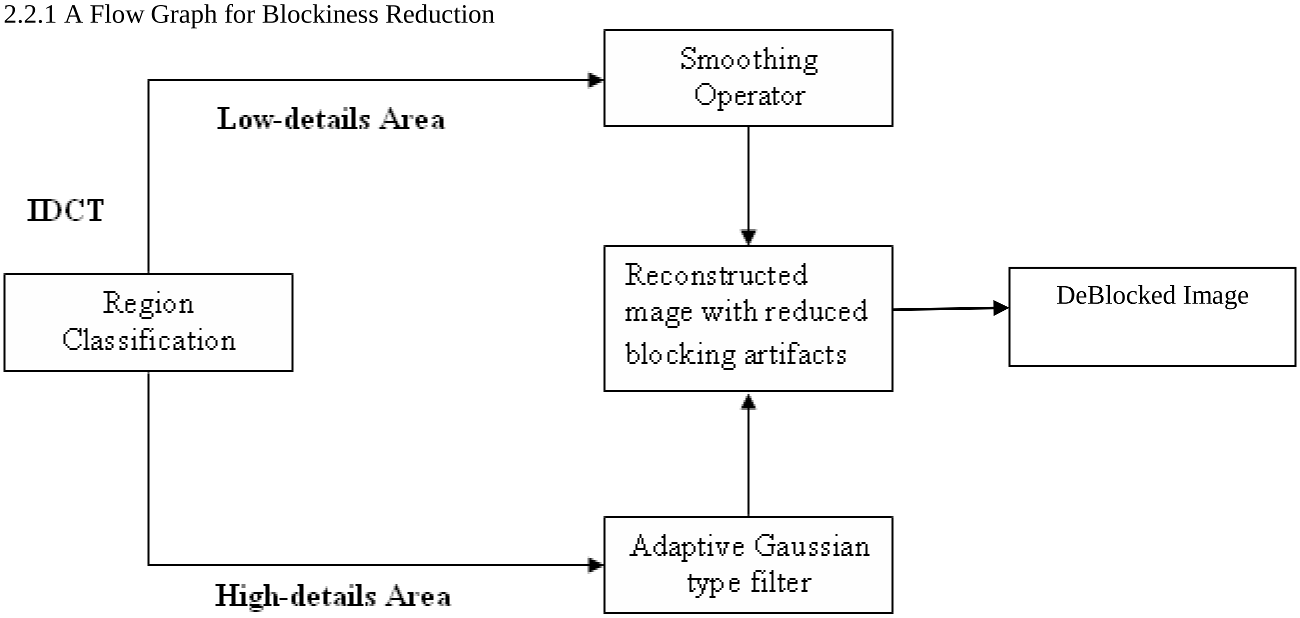
$$W = \begin{bmatrix} \sum_{(x,y)\in(MxM)} W_b(x,y)G_x^2(x,y) & \sum_{(x,y)\in(MxM)} W_b(x,y)G_x(x,y)G_y(x,y) \\ \sum_{(x,y)\in(MxM)} W_b(x,y)G_x(x,y)G_y(x,y) & \sum_{(x,y)\in(MxM)} W_b(x,y)G_y^2(x,y) \end{bmatrix} \tag{3}$$

where MxM is the size of the analysis block, that is, the area from where information is obtained for the calculation of the WSMM components $A = W(0,0)$, $B = W(1,1)$ and $C = W(0,1) = W(1,0)$. We can simply represent as

$$W = \begin{bmatrix} A & C \\ C & B \end{bmatrix} \tag{4}$$

The function $W_b(x,y)$ is a symmetric and normalized window function which is used for local smoothing of image features. This is necessary due to the sensitivity to noise of the first order derivatives of image intensity. A natural choice for $W_b(x,y)$ is a Gaussian function of the form $W_b(x,y) = e^{-(x^2+y^2)/2\sigma^2}$, σ is the standard deviation. The WSMM coefficients are then employed to perform the tasks required for the removal of annoying artifacts from the compressed images, namely, region classification and filtering.

2.2.1 A Flow Graph for Blockiness Reduction



III.EXPERIMENTAL RESULTS

In this section experimental results are presented to evaluate the performance of the proposed algorithm for removal of blocky artifacts. The main aim of these experiments is to demonstrate that it can enhance the picture quality of still images that have been compressed using low bit rate.The new method tried on various digital images corrupted to different quantization factors of 512 x 512 Lena image and Pepper image (Figure 4.1) is used for simulations. The results of the proposed algorithm are compared with the results produced by the more general moving average spatial filter. The subjective results are shown in the following figures when the quantization factors are 2(Quantization value 25), 4(Quantization value 12) and 6(Quantization value 8). The results due to the proposed algorithm are better when compared to that of the filter used for comparison.

3,1 Original Images (Input Data)

(a)Lena Image

(b)Pepper Image

3.2 Gradient Images

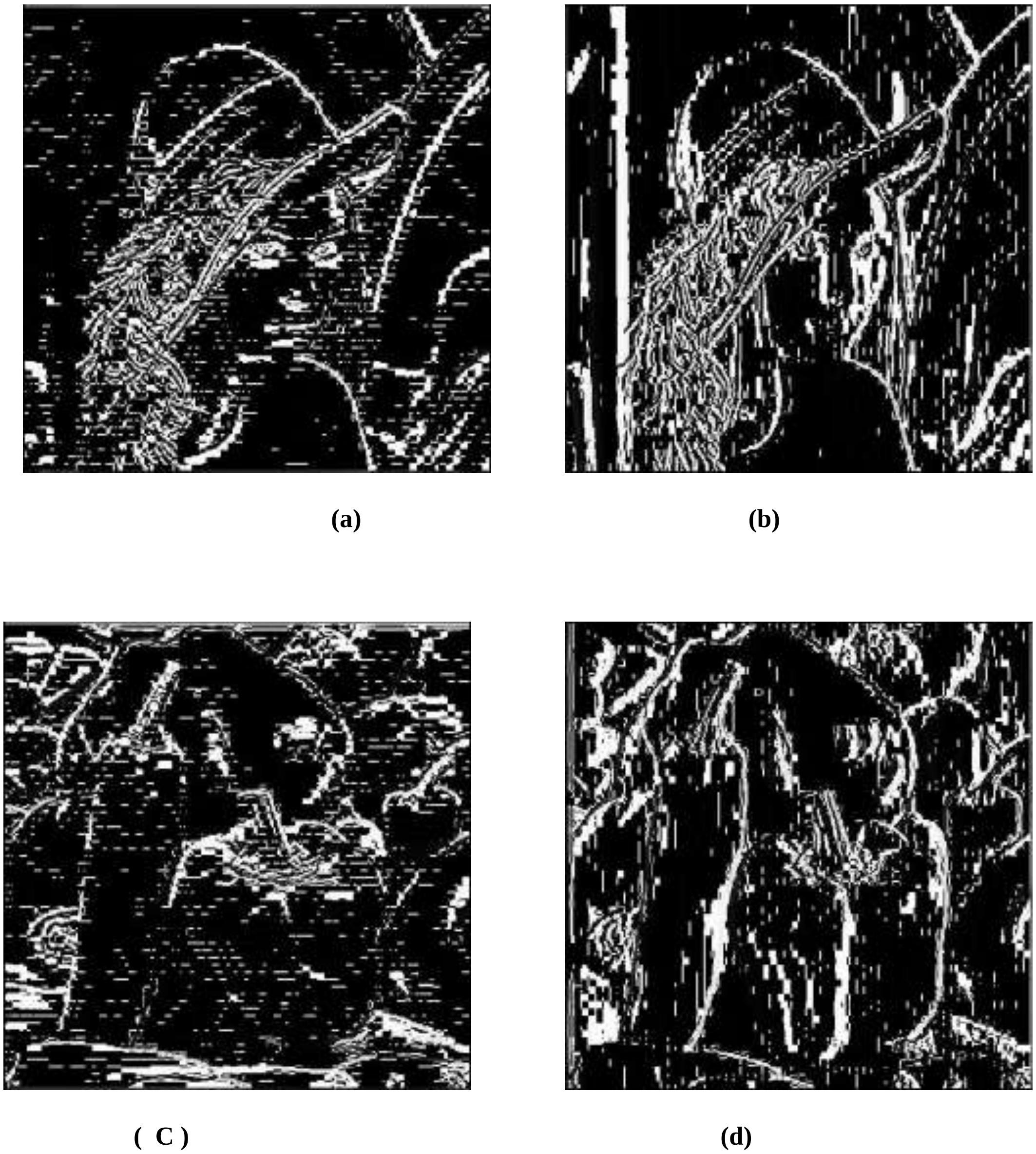


Figure.2 Gradient Of the Images by Quantization Factor 6 (a) Horizontal Gradient of Lena Image (b) Vertical Gradient of Lena Image (c) Horizontal Gradient of Pepper Image (d) Vertical Gradient of Pepper Image

Quantization Factor 6 for Lena Image

(a)

(b)

(c)

(d)

Figure.4.3 Enhancement Results by Quantization Factor 6 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

Quantization Factor 4 for Lena Image

(a)

(b)

(c)

(d)

Figure.4.4 Enhancement Results by Quantization Factor 4 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

Quantization Factor 2 for Lena Image

(a)

(b)

(c)

(d)

Figure.4.5 Enhancement Results by Quantization Factor 2 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

Quantization Factor 6 for Pepper Image

(a)

(b)

(c)

(d)

Figure.4.6 Enhancement Results by Quantization Factor 6 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

Quantization Factor 4 for Pepper Image

(a)

(b)

(c)

(d)

Figure.4.7 Enhancement Results by Quantization Factor 4 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

Quantization Factor 2 for Pepper Image

(a)

(b)

(c)

(d)

Figure.4.8 Enhancement Results by Quantization Factor 2 (a) Blocky Image (b) image obtained by Mean Filter (c) Due to the [Tri03] method (d) Due to the proposed method

IV.CONCLUSION

Decompressed images obtained from compressed JPEG streams, often contain bothersome blocking artifacts which constitute a serious bottleneck for many important visual communication applications. A novel algorithm is proposed in this research aiming to reduce such blocking artifacts. In this approach, better estimates of the reconstructed DCT coefficients are obtained based on their observed probability distribution. Subsequently, a novel post processing procedure consisting of high and low detail region classification and a spatial adaptive filtering is applied for the removal of blocking artifacts. It employed for the high image detail regions, which include edges and texture. By adapting the shape and the position of the Gaussian kernel according to the characteristics of the local region, all jagged edges appear continuous and sharp while at the same time any detail that survived the coding process is preserved. Simulation results illustrated that the proposed post-processing method can significantly improve the picture quality of the compressed images. Small gains in the subjective performance add to the performance of the algorithm. The type of filtering is determined based on an estimation of the local characteristics of the coded image. The performance of the proposed technique clearly demonstrated its ability to detect and alleviate blocking artifacts effectively without increase the bit rates. The main advantage of this filter is that the shape and the position of the Gaussian kernel are adjusted according to the characteristics of the local image region. Simulation results demonstrate that this method enhances the quality of coded edges and reduces annoying blocking effects, resulting in overall better picture quality.

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