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# Transform Domain-Based Perceptual Detection and Reduction of Blocking Artifacts

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**Abstract** —In this paper, provide a simple and effective method for measuring blocking artefacts with an ideal 2-D step function in this study. First, a basic edge detection technique for measuring blocking artefacts is proposed. The ideal 2-D step function is chosen based on the presence of blocking artefacts in the edge image. The blocking artefact reduction algorithm in frequency domain is designed to extract all of the parameters required to detect the presence of blocking artefacts and replace the optimal step function with a ramp function by replacing the coefficient of the first row of horizontal blocks with the coefficient of the shifted block. The proposed strategy was tested on various standard benchmark photos and found to increase the perceptual quality of JPEG compressed images after blocking artefact removal with the proposed method.

Keywords- Blocking Artifact, DCT, Edge Detection, Step Function

## I. INTRODUCTION

Over the last few years, researchers have focused on the topic of removing blocking artifacts from images encoded with the Block Discrete Cosine Transform (BDCT). Because of its compaction property and ease of implementation, the BDCT is a regularly used as transform technique for image compression standards such as JPEG for still images, MPEG for moving images, and H.263 for videophone/teleconference.A common DCT compression system [3] transforms each (88) block into frequency domain, quantizes it using a specified quantization table, entropy encodes it, and then transmits it. There is a decrease in the visual quality of the reconstructed image when the compression ratio of the individual processing of the blocks [31] is large and does not take into consideration the existing correlations among pixels of adjacent blocks. As a result, one of the most visible degradations [28] is the appearance of "blocking artefacts" [2][30] as a direct result of the coefficients' coarse quantization [29] and compression at low bit rate. These artefacts manifest as a consistent pattern of apparent block boundaries. As a result, measuring such artefacts and reducing the visibility of blocking effects in decompressed images is desirable.

Various approaches are routinely used to decrease compression artefacts in both the spatial and frequency domains. They are techniques for pre-processing and post-processing. Technique for pre-processing [16][18-20] modifies the compression encoder and the post-processing algorithm [14].[15][22] was used to improve visual quality by removing artefacts from decompressed images.Post-processing approaches are gaining popularity because they use decoded images as input and are compatible with decoding standards. M.Y. Shen et al. [22] classified post-processing techniques to decrease artefacts into two categories: picture enhancement and image restoration. Image enhancement approaches try to subjectively improve perceived visual quality, whereas image restoration approaches deal with post processing as an image recovery challenge.

Several studies [5-8][12][17] have been published in recent years that model the blocking artefact as a 2-D step function and consider measures to eliminate artefact in the spatial and DCT domains. Bing Zeng recognised in [5] that the visual borders between two adjacent blocks in the coded image are predominantly oriented along the horizontal and vertical directions, thus he modelled the blocking artefact as a 2-D step block [21] and introduced the shifted block between two adjacent blocks. Selection of the AC coefficients are dropped by applying the zero masking approach to the DCT coefficients of select shifted image blocks, resulting in improved results in low bit rate images. It is also found that it lowers blocking artefacts, however the loss of edge information caused by zero masking is visible. Ramamurthi et al. [4] proposed a nonlinear space-variant filtering based on human visual system in different directions to eliminate "staircase noise" and "grid effects" [1]. Byeungwoo Jeon et al. [6] calculate the block discontinuity as the sum of squared pixel differences across the four block boundaries and recover the DCT coefficient lost during network transmission by smoothing the transition pixel over block boundaries as much as possible and optimising with a filtering approach. Tao Chen et al. [27] assessed the activity of a block and estimated it as the sum of its AC coefficient energy, then experimented with an adaptive filter [32] that required less processing. Shizhong Liu et al. [24-25] described the first DCT-domain approach for blind measurement of blocking artefacts using the Human Visual System (HVS) as a parameter. It adapts to the local measured visibility of the blocking artefacts at each block edge in the DCT domain. By applying the shifting method exclusively in the region to be filtered, Jagroop Singh et al [17] devised a filter that removes the blocking artefact while keeping image detail with minimal loss of image content. It improves both the perceived and objective detail of the delivered image.  F. Pan et al. [9] proposed a method for measuring blocking artefacts in pictures and movies. Blocking artefacts are quantified utilising directional information of edges rather than the typical pixel discontinuity along the block boundary [34]. It adapts to the local measured visibility of the blocking artefacts at each block edge in the DCT domain. By applying the shifting method exclusively in the region to be filtered, Jagroop Singh et al [17] devised a filter that removes the blocking artefact while keeping image detail with minimal loss of image content. It improves both the perceived and objective detail of the delivered image.  F. Pan et al. [9] proposed a method for measuring blocking artefacts in pictures and movies. Blocking artefacts are quantified utilising directional information of edges rather than the typical pixel discontinuity along the block boundary [34]. It does not require the exact location of the block boundary and hence is insensitive to image displacement, rotation, and scaling.

Later, to compensate for the loss of edge detail, a DCT-domain blind measurement [24-26][33] is used, in which the 2-D step function is replaced with a linear function.  A new edge detection technique for measuring blocking artefacts with a modified 2-D step function is proposed in this work. We offer a model for reducing blocking artefact in the DCT domain by employing the ramp function, and we also illustrate how to alter the transform coefficient to reduce blocking artefact.

The remainder of the paper is structured as follows: Section II presents a description of the DCT mathematical model. Section III proposes a simplified method for recognising edge from a compressed image for measuring blocking artefact. Section IV describes the suggested blocked artefact reduction algorithm. Section V provides standard performance measurement. Section VI compares the proposed algorithm's results to those of existing post-processing methods. Finally, Section VII contains the final observations.

## II Discrete Cosine Transform

In this study, we focus on reducing blocking artefacts in the transform domain. The intensity of each pixel in the spatial domain is translated into the amplitude of a unique cosine function using the DCT transformation for pictures. The block-based transform, which converts image elements to DCT coefficients, is one type of DCT used in image coding. The transform coefficient for each (N x N) block is represented by the forward DCT transform F(u,v) at co-ordinates u and v. It has excellent energy compaction and coefficient decorrelation.

$$F(u,v)=\frac{2}{N}\cdot C(u)C(v)\left[\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\frac{(2x+1)\cdot u\pi}{2N}\cos\frac{(2y+1)\cdot v\pi}{2N}\right] \quad (1)$$

for u=0,…..,N-1 and v=0,…..,N-1
where N=8

Analysing the transform coefficient reveals that each coefficient reflects some specific properties of the image f(x, y), where x and y are the vertical and horizontal coordinates, respectively. The Inverse DCT transform is used to obtain the pixel from the transform coefficient value, as shown in (2).

$$f(x,y)=\frac{2}{N}\left[\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} C(u)C(v)F(u,v)\cos\frac{(2x+1)\cdot u\pi}{2N}\cos\frac{(2y+1)\cdot v\pi}{2N}\right] \quad (2)$$

for x=0,…..,N-1 and  y = 0,…..,N-1 where N=8

As a result, modelling the artefact in the DCT domain is simple, and adjusting the transform coefficient value leads in artefact reduction, as discussed in Section IV. The coefficient of F(u,v), where u=v=0 denotes the DC coefficient of each block, and the AC terms become smaller in size as they move away from the DC coefficient. This suggests that by applying DCT to the input data, we focused the picture representation in the higher left coefficients of the output matrix, with the lower right coefficients of the DCT matrix carrying less valuable information.

## II. Methodology

### *A. New Edge Detection Technique for Blocking Artifact Measurement*

Step edges, whose intensity quickly shifts from one value to one side of a discontinuity, to a different value on the opposite side, can be modelled. Discontinuity [23][35] arises when two regions have almost constant but varying grey levels. To begin, we investigate one-dimensional edge profiles using the step function u(t), which reflects the region of discontinuity at t caused by independent processing of each block in the compressed domain.

$$u(t) = \begin{cases} 1, & t > 0 \\ 0, & t < 0 \\ \frac{1}{2}, & t = 0 \end{cases}$$

In this transformation, 1, 0, are specified as constant amplitudes at different t values. However, amplitude scaling only affects the quadrature axis values, i.e. the size of the signal, with no effect on the horizontal axis values or signal periodicity. The 1-D step function s(t) is determined by the properties of signal operations as: s(t) =γ.u(t) where γ = 1,,,,,.

The amplitude of the step function at the point of discontinuity is represented byγ in this case. Similarly, as described in (5), the two-dimensional function s(x,y) represents a constant cross-section in both the horizontal and vertical directions. The step function's zero crossing attribute shows the region of rapid intensity change and can thus be used for edge detection.The zero crossing algorithm searches for points in a picture where the sign of the function changes. Such points are frequently found at picture edges; this indicates that there is a reasonably crisp edge between two regions of uniform but varying brightness, and so s(x,y) is defined as.

$$s\ (x,y) = \begin{cases} -\gamma.u(t),\ for x = 0,1,2,3\ ; y = 0,1,2, \dots \dots N - \\ \gamma.u(t),\ for x = 4,5,6,7\ ; y = 0,1,2, \dots \dots N - \end{cases}$$

where u(t) equals to 1/2 at the moment of discontinuity described in (3) and can be taken from (4) and (N x N) indicates block size. To measure the blocking artefact as an edge using a 2-D step function, s(x,y) is modelled as in (5), where positive values indicate only one side of the edge and negative values represent only the other side.

With varying amplitude of 'γ' as ±0.5/ ±0.25/ ±0.125/ ±0.0625 / ±0.03125 of 2-D step function s(x,y) as defined in equation (5) is formulated as the blocking artifact detection method via proposed edge detection technique.The magnitude of the gradient is used to implement the first derivative in a picture, which can be utilised to detect an edge. The gradient is an intensity that indicates the direction of greatest change. To calculate the rate of change of intensity in the horizontal and vertical directions, each (8 x 8) block is convolved with the 2-D step functions sh(x,y) and sv(x,y) specified in (6) and (7) and calculates the rate of change of intensity in the horizontal (gh) and vertical (gv) directions.

sh(x,y)=

$$\begin{cases} -\gamma.u(t),\ for x = 0,1,2,3\ and y = 0,1,2\ .. \\ \gamma.u(t),\ for x = 4,5,6,7\ and y = 0,1,2,\ . \end{cases} \quad (6)$$

Andsv(x,y)=

$$\begin{cases} \gamma.u(t),\ for y = 0,1,2,3\ and x = 0,1,2 \dots \dots ..7 \\ -\gamma.u(t),\ for y = 4,5,6,7\ and x = 0,1,2, \dots \dots ..7 \end{cases} \quad (7)$$

The greater the value ofγ, the greater the significance of the obstructing artifact's visibility. As a result, it is discovered that the visibility of blocking artefacts is exactly related to the amplitude value of. Thus, determining the visibility of blocking artefacts should be possible by measuring them with the relevant step function. The following is the algorithm for measuring blocking artefacts using the edge detection technique.

### *B. Algorithm for the measurement of blocking artifact using edge detection*

Input : Input image with pixel value (0-255), compressed at low bit per pixel (256 x 256)
Output: Edge image (256 x 256)

Begin
Step 1: Read input image I
Step 2: Image I is partitioned into blocks IB of size (16 x 16).
Step 3:Initialize sh(x,y) and sv(x,y) as given in (6) and (7) respectively, for varying amplitude of γ as given in Section III.
Step 4: For each block IB
a) gh and gv are computedby convolving sh and sv with IB respectively.
b) Calculate gradient magnitude (G) as:
Step 5: Output Image with gradient magnitude is formed.
End

The proposed edge detection strategy with variable amplitude γ of s(x,y) utilising the gradient method is practical enough to estimate the ideal 2-D step function, resulting in less blocking artifact. Next the identification of the discontinuity in the neighbouring blocks and measurement with gradient magnitude, a blocking artefact reduction method is developed and explained in the next Section.

## III. Proposed Blocking Artifact Reduction System

In this study, a new strategy for decreasing blocking effects using DCT is proposed. Because blocking effects in the horizontal and vertical directions are similar in concept, we present the suggested algorithm for quantifying horizontal blocking artefacts.

Model each block in a BDCT compressed image distorted by independent identically distributed Gaussian noise as a constant block with zero mean and unknown variance. Consider two adjacent (N × N) blocks a1 and a2, each having an average value of 1 and 2, where 1 2. As a result, we represent these two blocks as follows:

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$c1 = \mu 1 + \varepsilon 1$ and
$a2 = \mu 1 + \varepsilon 2$

Where ε 1 and ε 2 are white noise models. When the matchingorthogonal polynomial blocks a1 and a2 are quantized and compressed at a low bit per pixel, the effect of ε 1 and ε 2 is reduced, and a 2-D step function appears between a1 and a2. Based on this insight, we construct the shifted block b seen in Fig. 1.

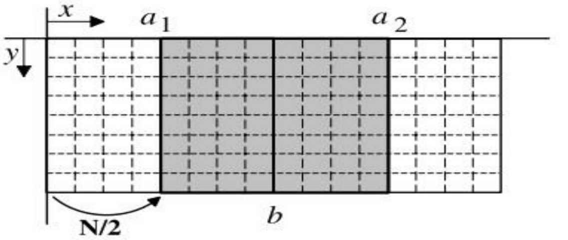


Fig. 1 Graphical explanation of a1, a2 and b

Figure 1 indicates that block b is N/2 pixels to the right of a1. Block b contains the right half of a1 as well as the left half of a2. If there is a blocking artefact between a1 and a2, the pixel values in b will be abruptly changed. We can measure the blocking artefacts by modelling the rapid shift in b. Then shifted block b can be represented as follows:

$a(x,y) = \mu + \gamma.s(x,y)$
for x, y = 0,………7 (8)

where µdenotes the amplitude of the 2-D step function s as defined in (4) and γis the average value of block b. To lessen the influence of blocking artefact in shifted block b, the ramp function is implemented to replace the 2-D step block's' with the ramp function '. As a result, the updated shifted block can be represented as:

(x,y) = a(x,y) + γ. (x,y) – γ.s(x,y)
= a(x,y) + γ.( (x,y) – s(x,y))
for x, y = 0,……..7 (9)

As discontinuity occurs at intersection point of each block and thus defined 1-D step block as (x) = x-( for x = 0,1,…….7, where N represents the block size.

Using the optimal amplitude of γ as obtained in section III, ramp function can beor each (x) of adjacent shifted blocks (see Fig.1). 2-D 8 x 8 linear block can be constituted by (x,y) = (x) where x=0,1,2,……7, y= 0,1,…….7, where magnitude of 2-D step block is constant in the vertical direction and anti-symmetric in the horizontal direction.

The suggested approach can be implemented in the DCT domain without requiring the original image. For the sake of clarity, we only examine blocking artefact measurement in the horizontal direction. In block based transform coding, an image is formed of non-overlapping (NxN) blocks, and hence the fast DCT domain technique [24] is used for each shifted block, as shown below.

where q1*q2 = I and I is identity matrix and 0 is zero matrix of 4x4. Thus the shifted block B is implemented in DCT domain as:

A = A1Q1 + A2Q2
= $\frac{1}{2}[(A1 + A2)(Q1 + Q2) + (A1 - A2)(Q1 -$
(10)

where A,A1,A2,Q1,Q2 are the DCT of a1,a2,q1,q2 respectively.

## IV. Results and Discussion

### A. Performance measure

Peak signal to noise ratio (PSNR) has been accepted and widely used as quality measurement unit in the field of image restoration in order to measure the objective quantitively between the original and restored images. It is defined as:

$PSNR = 1$ (14)

where MSE = $\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}2$ , where MN represents the size of image and I and represent an input image and output image respectively.

### B. Experimental results

The suggested edge-based blocking artefact measurement method has been constructed and tested on hundreds of JPEG compressed images with varied bit per pixel using common benchmark databases.As an example, lena image of size (256 x 256) with pixel values (0-255) is shown in the Fig 2 (a), compressed at 0.215 bpp. The input image is divided into blocks of size (8 x 8). For each block, convolve with 2-D step function as given in (5). The value of γ is assigned to 0.5 or 0.025 or 0.125 or 0.0625 or 0.03125 to compute gradient magnitude and to measure the change of intensity as explained in section III. Through gradient magnitude, edge has been detected and the results are shown in Fig 2(b-f) for the input image Fig. 2(a).

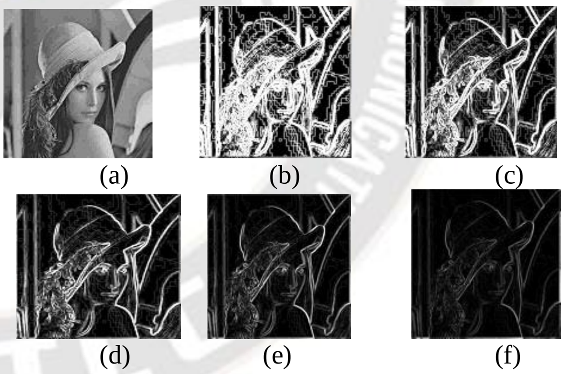

Fig2. a) Original lena image compressed with DCT at 0.215 bpp b) Result of proposed edge detection method when γ = 0.5 c) when γ = 0.025 d) when γ = 0.125 e) when γ = 0.0625 f) when γ =0.03125

Based on experimental results, it is observed that the visibility of blocking artifact is reduced when i.e. γ = ±0.03125 and thus can be considered as optimal constant value with reduced blocking artifact as shown in Fig. 2(e).Experiments were carried out in order to eliminate blocking artefacts in the DCT domain, as stated in section IV.

The identical lena picture is used for experimental analysis. The blocking artefact reduction algorithm in the OPT

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domain is designed to extract all of the parameters required to detect the presence of blocking artefacts and replace step function with ramp function by changing the coefficient of the first row of horizontal blocks with the coefficient of shifted block, as discussed in (12) and (13).

The result of blocking artifact reduction with the proposed scheme on the lena image shown in Fig. 2(a) is presented in Fig. 3.

Fig. 3 Result of proposed blocking artifact reduction technique on the image of size (256 x 256)shown in Fig. 2(a)

Objective measurement is evaluated utilising PSNR for differently coded pictures with equation (14) for performance evaluation of the suggested blocking artefact reduction technique. The PSNR obtained after post-processing using the suggested technique is 30.36 for the image displayed in Fig. 3.Similar, results were also reported in [24] and [26]. The perceptual quality of the five standard images such as lena,bafoon,Barbara,cameraman peppers are examined by comparing the decompressed image, coded at different bit rates, with the proposed scheme. The measured PSNR for the images coded at various bit rates are tabulated in Table 1.

TABLE .1 PSNR VALUES WERE ACQUIRED FOR SAMPLE IMAGES USING THE SUGGESTED TECHNIQUE AND SEVERAL POST-PROCESSING TECHNIQUES.

| **S.No.** | **Image** | **Bit Rate per pixel** | **Decoded image** | **Method in [24]** | **Method in [26]** | **Proposed Method** |
|---|---|---|---|---|---|---|
| 1 | lena | 0.207 | 28.80 | 28.27 | 27.85 | 30.20 |
| 2 | | 0.216 | 30.58 | 29.27 | 29.89 | 30.36 |
| 3 | bafoon | 0.304 | 26.21 | 28.74 | 29.90 | 29.92 |
| 4 | | 0.622 | 30.55 | 32.16 | 31.66 | 32.66 |
| 5 | barbara | 0.26 | 26.44 | 26.66 | 27.01 | 27.97 |
| 6 | | 0.55 | 30.93 | 31.56 | 31.27 | 31.38 |
| 7 | cameraman | 0.26 | 28.76 | 30.32 | 30.10 | 32.53 |
| 8 | | 0.14 | 25.65 | 27.56 | 28.46 | 27.69 |
| 9 | peppers | 0.221 | 29.53 | 29.83 | 29.09 | 30.62 |
| 10 | | 0.300 | 32.06 | 32.79 | 32.88 | 33.96 |

## V.CONCLUSIONS

This study makes an attempt to remove the annoying blocking artefacts from low-bit-rate JPEG compressed photos. We offer a simple and effective approach for measuring blocking artefacts utilising edge detection with an appropriate 2-D step function in the suggested technique. Various approaches are employed in [24, 26] to decrease artefacts with fixed amplitude of step function for smooth, non-smooth, and intermediate regions of a picture. As a result, edge losses are observed following post-processing.To address this limitation, a novel edge-based technique for measuring blocking artefacts is being developed. The ideal 2-D step function is chosen based on the presence of blocking artefacts in the edge image. In the frequency domain, the blocking artefact reduction algorithm is designed to extract all of the parameters required to detect the presence of blocking artefacts and to replace the optimal step function with a ramp function by replacing the coefficient of the first row of horizontal blocks with the coefficient of the shifted block, as discussed in (12) and (13). PSNR is used to illustrate the performance of the suggested algorithm. It is discovered that the proposed strategy improves the perceptual quality of JPEG compressed images after removing blocking artefacts. Because of the method's minimal computing requirements, it can be integrated into real-time image/video applications that process images/video in the DCT domain.

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