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Artifacts Removal and Edge Detection of Digitally Compressed Images

Shanty Chacko, Lijo T Joseph, J Jayakumar

Abstract— Block discrete cosine transform compressed image exhibits visually annoying compression artifacts. In this paper a method for reducing the compression artifacts and to increase the visual quality of image is been presented. The compressed image is filtered using Gaussian filter to reduce the amount of artifacts. In order to reproduce the high frequency coefficients a differential image is been obtained. From the differential image the artifact contents are removed and smoothened edge parts are retained. The edge detected image is added with the filtered image to improve the sharpness of the image. Results show that the image thus restored achieves perceivable image quality.

Index Terms— Block discrete cosine transform (BDCT), compression artifacts, image restoration, JPEG, post-processing

1 INTRODUCTION

Image compression schemes are extremely used now a day's in order to accommodate with the bandwidth of storage medias. To better compress the image, block discrete cosine transform is a method that is widely used. First the image is divided into 8×8 nonoverlapping blocks and each block is transformed independently to convert image into dct coefficients followed by quantization and variable length encoding. Thus binary data streams are generated for data transmission. The BDCT is the recommended transform technique for both still and moving image coding standards, such as JPEG, H.261.H.263 and MPEG. Block discrete cosine transform along with the application of dc quantization give rise to discontinuities between the blocks termed as blocking artifacts. This is due to the fact that the two low frequency dct coefficients in the adjacent blocks similar in value gets quantized to different quantization bins. Removing the high frequency components result in ringing artifacts around the strong edges. Thus the image quality gets decreased and to improve the quality of images image restoration schemes are been used.

There are various approaches to suppress the artifacts in transform domain and spatial domain. Zeng [1] models the blocking artifact as 2-D step functions and reduces it by applying zero masking to the dct coefficients of some shifted image blocks. A signal adaptive filtering scheme is used to reduce blocking artifacts in [2] by means of an adaptive weighting mechanism and quantization. Here local region filtering of each pixel can be performed without the consideration of the predicted coordinates of blockiness and size
of the smoothing window can be varied.

- *Shanty chacko is an assistant professor at the Department of Electronics and Communication Engineering in Karunya University, Coimbatore, India E-mail: shantyc@rediffmail.com*
- *Lijo T Joseph is currently pursuing masters degree program at the Department of Electronics and Communication Engineering in Karunya University, Coimbatore, India E-mail: lijo.joseph8@gmail.com*
- *J Jayakumar is an assistant professor at the Department of Electrical and Electronics Engineering in Karunya University, Coimbatore, India E-mail: jayakumar@karunya.edu*

Certain dct coefficients are modified in [3] by changing the step edge into slope to reduce discontinuities between the pixels in the blocks. [4] proposed a method to reduce compression artifacts by utilizing the wavelet coefficients and by analyzing the statistical characteristics of block discontinuities. Image deblocking algorithms using overcomplete wavelet representation enables multiscale edge analysis and makes suitable for edge based image compression. In [5], blocking artifacts are removed in wavelet domain by exploiting cross-scale correlations among wavelet coefficients and extracting and protecting the edge information. Also the noise components get smoothened out. In [6] the high frequency coefficients are scaled by a factor that depends on the compression ratio and subtracted from the observed image which is then used to design an adaptive filter that depends on the statistical behavior of the preprocessed image.

In [7],[8] filtering is performed in shifted windows by the method of thresholding the neighborhood and applying quantization constraints. [9] presents a method to reduce discontinuities by local ac coefficient regularization of shifted blocks in the discrete cosine transform domain, block-wise shape adaptive filtering in the spatial domain, and quantization constraint in the DCT domain. Iterative postprocessing techniques, based on the theory of POCS are also been proposed. In [10] the deblocking algorithm presents the iterative procedure based on quantization constraint sets and smoothness constraint sets which are the most commonly used convex sets to restore the original image. The images degraded by noise are restored iteratively by using a priori information about the original image, and it deblocks images by iterating the projections onto the quantization constraint set and image smoothness constraint set until convergence. [11] deals with POCS method by adjusting the pixel intensity and by human visual system modeling adjustment. Thus, if we view the blocking artifact as the noises, then we can apply the image restoration techniques to alleviate the artifact.

The rest of the paper is organized as follows. Section II describes in detail the proposed scheme for reducing artifacts by filtering and edge detection methods and establishing the validation criteria of the parameter difference in mean square difference (DMSD). In Section III, the simulation results are discussed. Finally, Section IV presents the concluding remarks.

2 PROPOSED METHOD

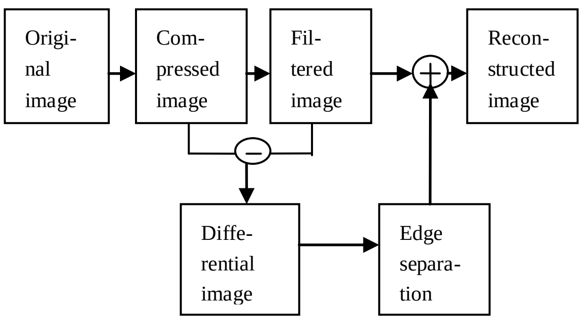


Fig.1 Block diagram of proposed scheme

2.1 Local filtering using Gaussian method

As a result of compression some artifacts are been induced due to signal attenuation and noise. So postprocessing techniques are been employed to reduce the discontinuities between various pixels in the image. The simplest approach among the postprocessing techniques is to filter the image. The blocking artifact is the result of an artificial boundary discontinuity between two adjacent blocks and ringing artifacts can be characterized by high-frequency components. Various filters are been used to smoothen the image including Gaussian filtering, anisotropic filtering, neighborhood filtering, wiener filter or by means of threshold applications [12]. In this paper, local filtering is employed to degrade the image by removing the noise and attenuated coefficients. Although the attenuation intensity varies over different image regions, it has been assumed that the neighboring attenuation appears to be almost similar. The Euclidean distance is used to measure the neighborhood similarity of intensities to obtain the weights of individual pixels, which can be defined as,

$$w(i,j)= \sum_{m,n \in w_n} [(e^{((I(m,n)-I(i,j))2/h}) \times I(i,j)]/z(m,n) \quad (1)$$

where I(m,n) is the value of neighboring pixels, I(i,j) is the intensity level of central pixel and h is the degree of filtering control parameter which is to be set to a suitable value that depends upon the amount of discontinuities in the image. The filtering parameter decays weights as a Euclidean distance function. z(m) is the normalizing constant.

$$z(m,n)= \sum_{m,n \in w_n} (e^{((i(m,n)-i(i,j))2/h}) \quad (2)$$

The image resolution of the filtered image is finite and for different local regions the attenuation intensity will vary. Therefore in this paper a 5×5 window centered at pixel m (w_n) is been employed for local filtering[13] .The filtered value of the central pixel thus becomes the weighted mean of the all pixels in its neighborhood. The filtering technique smoothes out the block boundary and reduces artifacts. But there is an expense of possible loss in high-frequency components, resulting in blurring of the decoded image.

2.2 Edge Detection

By subtracting the local filtered image from the compressed image, a differential image is been obtained. This differential image mainly comprises of the high frequency components. A threshold is applied to detect sharp edges that are present in the differential image. The threshold is selected so as to give more edge information and to get an image which is less susceptible to artifacts. Coefficients are forced to zero for a value less than the threshold to reduce artifacts in the smoothened areas. The isolated non zero coefficients are also forced to zero since it does not possess any edge information. Finally the high frequency image is been added with the filtered image [13] to enhance the sharpness of the image with reduced artifacts.

2.3 Evaluation of DMSD

The objective quality of the restored image is usually evaluated by the peak signal-to-noise ratio (PSNR). The higher the PSNR, the smaller is the difference between the restored image and the original image and the restored image is considered to be better. But higher PSNR value does not always implies that the quality of the image is good. The image with artifacts after compression will have higher PSNR value compared to the filtered image with lesser artifacts. With artifacts, the PSNR value is high since the all the pixel values are not changed from its original values. The above fact is clear in table 3 and 4. Inorder to validate the DMSD, seven images are compressed at different rates using the quantization table given in the appendix. The PSNR and DMSD calculated in each case is tabulated in table 1 and 2. From the quantization table shown in the appendix, it can be observed that as the quantization rate gets increased, the value of PSNR gets reduced due to greater amount of artifacts. From the table, it can be inferred that PSNR alone does not indicate the quality of the image. So a new measuring parameter called difference in mean square difference (DMSD) was also used to measure the quality of the image.

DMSD is given by,

DMSD=(MSD_o-MSD_r)/MSD_o where

$$MSD_o=\sum_{m=1}^{r}\sum_{n=1}^{c-1}[Io(m,n)-Io(m,n+1)]^2 - \sum_{m=1}^{r-1}\sum_{n=1}^{c}[Io(m,n)-Io(m+1,n)]^2 \text{ and} \quad (3)$$

$$MSD_r=\sum_{m=1}^{r}\sum_{n=1}^{c-1}[Ir(m,n)-Ir(m,n+1)]^2-\sum_{m=1}^{r-1}\sum_{n=1}^{c}[Ir(m,n)-Ir(m+1,n)]^2$$

MSD_o denotes the mean square difference of the original image and MSD_r denotes the mean square difference of reconstructed imageFrom the table 1, it can be observed that as the compression rate is increasedDMSD, becomes more negative. The more negative value of DMSD indicates more amount of artifacts present in the image. So DMSD along with PSNR was used to measure image quality.

TABLE 1
EVALUATION OF **PSNR** FOR **V**ARIOUS **I**MAGES **C**OMPRESSED **U**SING **Q**UANTIZATION **T**ABLE

Image	Q1	Q2	Q3	Q4
Lena	33.6407	24.0736	19.6928	15.5063
Flower	32.6035	25.5545	21.3246	17.3218
Moon	28.1283	23.5699	20.8169	18.0414
Peppers	28.3694	23.9335	19.7652	15.9101
Liftingbody	33.3299	27.4806	22.8664	17.4449
Zelda	31.0778	25.3600	20.8447	17.1571
Sailboat	26.4179	21.5348	17.8147	14.2483

TABLE 2
EVALUATION OF **DMSD** FOR **V**ARIOUS **I**MAGES **C**OMPRESSED **U**SING **Q**UANTIZATION **T**ABLE

Image	Q1	Q2	Q3	Q4
Lena	-0.5408	-3.2531	-6.3206	-9.5218
Flower	-1.1588	-3.7477	-7.0178	-8.7492
Moon	-2.4233	-3.4273	-3.7472	-3.7743
Peppers	-1.3515	-1.8610	-3.5005	-4.7476
Liftingbody	-0.4705	-1.9204	-3.4889	-4.9010
Zelda	-1.5121	-3.0738	-5.9165	-7.0998
Sailboat	-1.5620	-2.7958	-4.5934	-5.3886

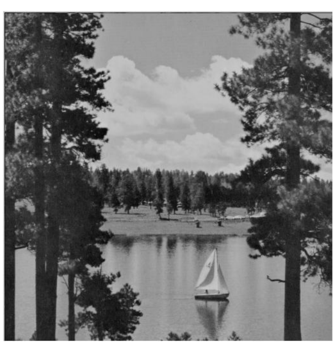
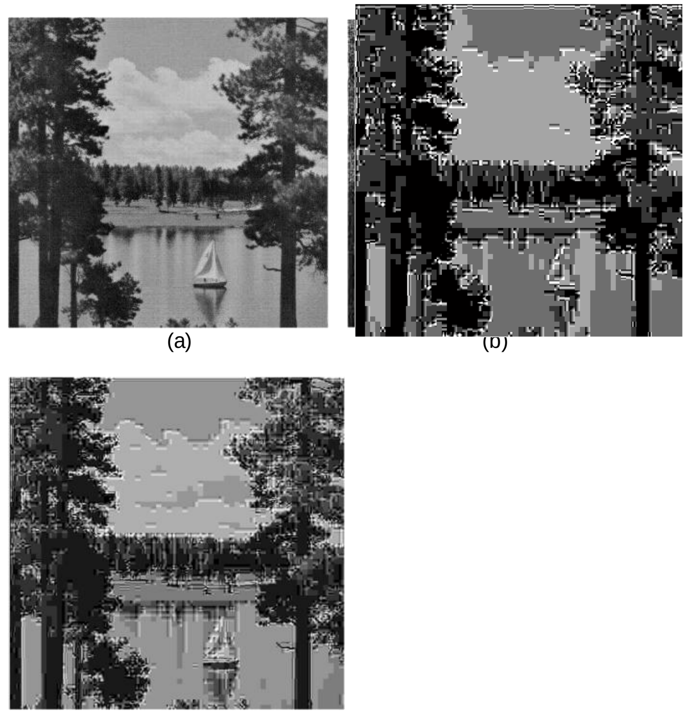


Fig. 2 Original Sailboat image

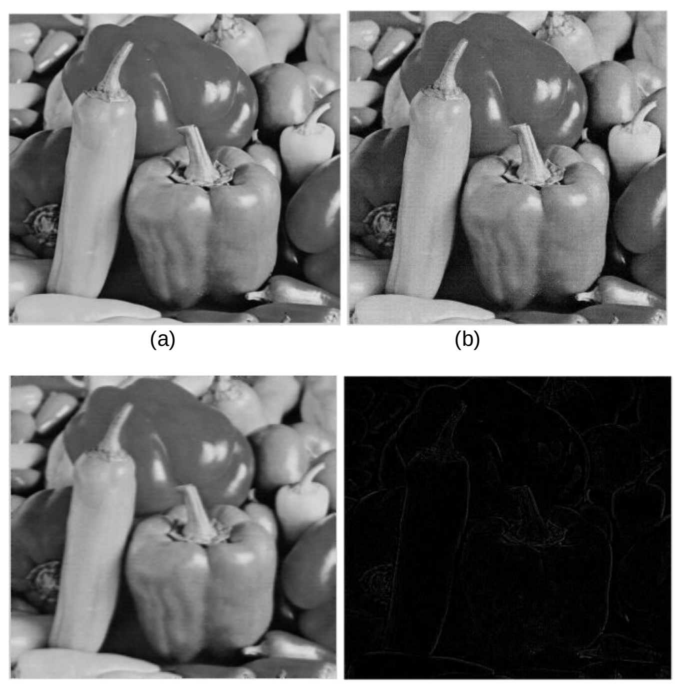


(a) (b)

(c) (d)

Fig. 3 Sailboat image compressed using different quantization tables (a) Q1 (b) Q2 (c) Q3 (d) Q4

3 RESULTS AND DISCUSSION

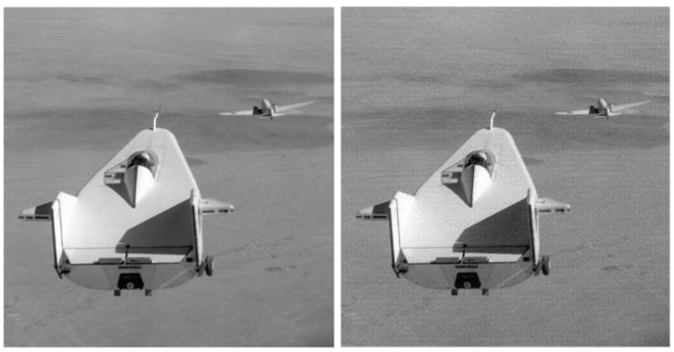


(a) (b)

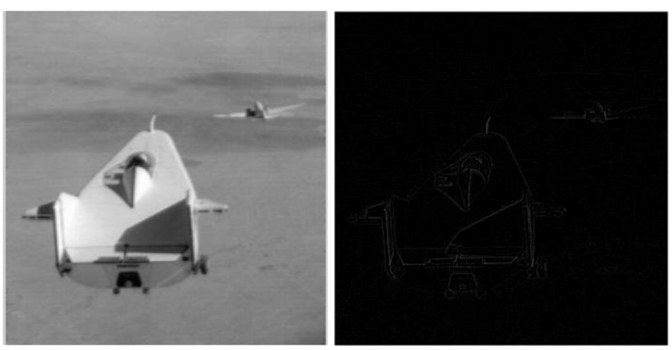
(c) (d)

(e) (f)

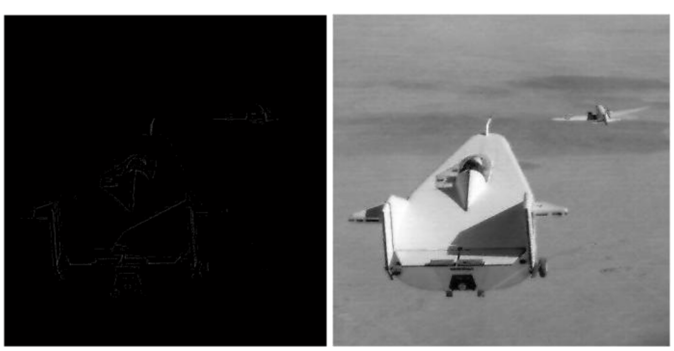
Fig. 4 Results of the proposed scheme (a) original image of Peppers (b) compressed image (c) filtered image (d) differential image (e) edge detected image (f) restored image



(a) (b)



(c) (d)



(e) (f)

Fig. 5 Results of the proposed scheme (a) original image of Liftingbody (b) compressed image (c) filtered image (d) differential image (e) edge detected image (f) restored image

TABLE3

DMSD VALUES OF DIFFERENT IMAGES AT VARIOUS STAGES

	Compressed image	Filtered image	Reconstructed image
Lena	-0.5408	0.6690	-0.0942
Flower	-1.1588	0.7164	-0.0133
Moon	-2.4233	0.8325	-0.0003
Peppers	-1.3515	0.7891	0.0268
Zelda	-1.5121	0.7828	-0.0340
Sailboat	-1.5620	0.8316	-0.0068
Liftingbody	-1.1590	0.7951	-0.0222

TABLE4

PSNR VALUES OF IMAGES AT VARIOUS STAGES

	Compressed Image	Filtered image	Reconstructed image
Lena	33.6407	31.8299	33.6397
Flower	32.6035	33.2409	33.4624
Moon	28.1283	29.9279	30.1678
Peppers	28.3694	29.1036	29.3830
Zelda	31.0788	32.5250	32.5320
Sailboat	26.4179	26.5877	26.8416
Liftingbody	31.7837	31.3311	32.5555

The proposed method of restoration is tested on various images compressed by block discrete cosine transform. Images of size 512×512 have been used for testing. In this method, the degree of filtering is been set to 600. The value of threshold is been set as the 20% of the maximum absolute value of the coefficients in the differential image. The simulation has been done with the help of Matlab 7.9 software.

The PSNR and DMSD are the two parameters used to evaluate the quality of the reconstructed image. Comparing with the compressed image, the processed image shows lesser amount of artifacts. The sharpness of the image is also preserved since the high frequency coefficients are been added to the filtered image. Assessing only by using PSNR does not always give consistent results. From the results it was observed that for a filtered image, the PSNR gets reduced and the value of DMSD becomes more positive. The positive value of DMSD indicates that artifacts are been reduced. But the image gets smoothened. For increasing the quality of the restored image, the high frequency coefficients are been added to the filtered image. Thus the sharpness of the image is increased and only small numbers of DCT coefficients are modified. A visual assessment becomes highly necessary when compression is heavy. By adjusting the DMSD and by obtaining a sufficient PSNR value an image is been restored with better visual quality.

4 CONCLUSION

This paper presented a method for improving the visual quality of block discrete cosine transform based compressed images. The high frequency coefficients obtained by thresholding differential image are added with filtered image to increase the image details. This method was developed to reduce unwanted signal disturbances while preserving the image sharpness and quality. The image quality is also been assessed in terms of PSNR and DMSD. The artifacts are significantly reduced and the overall visual appearance is greatly improved.

APPENDIX

QUANTIZATION TABLES

Q1

6	4	4	6	10	16	20	24
5	5	6	8	10	23	24	22
6	5	6	10	16	23	28	22
6	7	9	12	20	35	32	25
7	9	15	22	27	44	41	31
10	14	22	26	32	42	45	37
20	26	31	35	41	48	48	40
29	37	38	39	45	40	41	40

Q2

20	24	28	32	36	80	98	144
24	24	28	34	52	70	128	184
28	28	32	48	74	114	156	190
32	34	48	58	112	128	174	196
36	52	74	112	136	162	206	224
80	70	114	128	162	208	242	200
98	128	156	174	206	242	240	206
144	184	190	196	224	200	206	208

Q3

50	60	70	70	90	120	255	255
60	60	70	96	130	255	255	255
70	70	80	120	200	255	255	255
70	96	120	145	255	255	255	255
90	130	200	255	255	255	255	255
120	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255

Q4

110	130	150	192	255	255	255	255
130	150	192	255	255	255	255	255
150	192	255	255	255	255	255	255
192	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255

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