양방향 필터를 이용한 부호화 결함 감소

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Coding Artifact Reduction using Bilateral Filtering

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Abstract
Reducing compression artifacts such as ringing and blocking is one of important issues to improve a visual quality of a JPEG compressed image. In this paper, we propose a new post processing technique based on bilateral filtering (BF), which is one of the techniques that are used to reduce compression artifacts. An important issue with the application of the BF is the selection of the filter parameters, which affects the result significantly. In this work, we suggest a new method to select the filter parameter automatically. In addition to artifact reduction using the BF, a contrast enhancement is performed to overcome the contrast loss problem due to compression. The experimental result shows that the proposed approach can alleviate the artifacts efficiently.

Introduction

The efforts on the JPEG image visual quality improvement rely on the reduction of artifacts that manifest due to high compression. The two commonly visible artifact types are blocking and ringing artifact. Blocking artifact appears at the boundary of DCT blocks whereas the ringing artifact observed near strong edges. The main cause of the artifacts is the elimination of high frequency data during quantization.

One of the image processing techniques applied for artifact reduction purpose is BF [6]. As long as suitable spatial and intensity distance parameters are determined for the particular application in consideration, it will reduce artifacts by preserving edges. Its edge discrimination characteristic gives the potential to reduce artifacts appearing near strong edges. However, determining the value of its two parameters is a major challenge in the application of BF. In our level of understanding, there is no effective attempt to determine its values automatically for JPEG artifact reduction application.

Hence, in this work one of its parameters is determined automatically for each block. The automatic parameter selector is included in our new JPEG compressed image artifact reduction framework. Moreover, the framework includes a component that will enhance the contrast loss incurred due to filtering and JPEG compression by applying a new contrast enhancement technique. The experimental result shows that our technique reduces the artifact considerably.

Proposed Framework

Our new framework, which is depicted in Figure 1, uses a highly compressed JPEG image as the input image. The next step is reducing the visible artifact by applying BF. Before the BF is applied, the parameter for each block is determined. Due to BF and JPEG compression, there is the loss of contrast observed on the processed image. To improve the visual quality further, a contrast enhancement technique is applied on the bilateral filtered image. Finally, we will get an output image with better visual quality. In the next sections, the artifact reduction and contrast enhancement techniques are explained in detail.

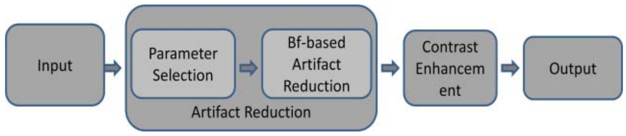

Figure 1: The proposed framework

According to [5], blockiness is represented by the difference of pixel values between border pixels. To associate the definition of blockiness stated above with parameters of BF, let us see the definition given in [6] about the filter parameters. The geometric spread determines how many neighboring pixels will be used to smooth the artifacts. The photometric spread is set to the desired amount of combination of pixel values. If the distance of a current pixel value from the center pixel value is less than the photometric spread, the value of the two pixels will be mixed. In the work of Zhang and Gunturk [2], the geometric and photometric spread effects on the final output of the BF are analyzed experimentally. The analysis points out that the photometric spread has a higher effect than the geometric spread. Hence, in this work, only the photometric spread parameter is determined automatically.

$$\Delta = \max_{j=1}(\max_{i=1}|V_{i1} - V_{i2}|,\ |V_{i2} - U_{i1}|,\ |U_{i1} - U_{i2}|))$$

Δ is the maximum difference of all border pixels, j represents the neighboring blocks and V_{i1}, U_{i1}, U_{i1} and U_{i2} are border pixels.

Our new method starts by computing the maximum difference of all border pixels (Δ) using the equation stated above. It will help the filter to combine all border pixels when it is taken as a photometric spread. Since the parameter determined from Δ is applied to all pixels inside the block, there is a possibility of detail information loss. To alleviate this loss, the parameter value should consider the information inside the block in addition to the border information. If there is high detail information, the maximum difference among consecutive pixels inside the block ω is computed using the equation below.

$$\omega = \max_{i}(|p_i - q_i|)$$

In this equation, ω is the maximum consecutive pixels difference, and p_i and q_i are the consecutive pixels value inside of the block. Finally, if there is detail information, the minimum of Δ and ω are selected as parameter value ∂_r. If there is no detail information, the Δ value is taken as a parameter value∂_r. The mathematical representation of the above statement is shown as this:

	bpp	lena		Pepper		Goldhill		Barbara	
		0.19	0.22	0.19	0.22	0.19	0.23	0.25	0.29
PSNR	[4]m1	28.8	29.9	28.6	29.6	27.3	28.1	24.5	25.3
	[4]m2	28.8	29.9	28.6	29.6	27.3	28.2	24.5	25.2
	JPEG	26.3	27.1	24.7	27.3	25.1	26.6	24.1	24.8
	Our	28.9	30.3	28.9	30.1	27.6	28.8	26.1	26.7
MSDS	[4]m1	372	419	415	434	420	534	2358	3028
	[4]m2	386	426	421	448	435	550	2445	3122
	JPEG	538	442	800	471	599	443	591	510
	Our	181	179	227	193	160	144	310	319

$$\partial_r = \begin{cases} \Delta, & if\ there\ is\ no\ detail\ information \\ min(\Delta, \omega), & otherwise \end{cases}$$

In the process of compression and BF-based artifact reduction, a loss of contrast is observed in the output image. Addressing this problem will boost the visual quality of the output image. Therefore, the following algorithm is proposed:

1. Extracting the detail information from the compressed and processed image, and the original and processed image by computing their difference [3].

$$I_{cp} = I_c - I_p \quad \text{and} \quad I_{op} = I_o - I_p$$

where I_{cp} and I_{op} are the detail information from the compressed and the original image. I_p is image processed by BF, and I_c and I_o are the JPEG compressed and the original image respectively.

2. From the I_{cp} and I_{op}, the minimum (min) and maximum (max) values are computed. In addition, the mean and standard deviation of the I_{op} are also computed. Later these values are used for supervised training of Bayes predictor.

3. The expected output image's minimum (min_x) and maximum (max_x) values are predicted using the Bayes predictor.

4. The I_{cp} values are stretched on the predicted min_x and max_x by using the formula presented in [4].

$$I_f = \frac{max_x - min_x}{max - min} I_{cp} - min + min_x$$

5. To reduce the effect of the noise cascaded from the previous processing steps, some constant value C is subtracted from the value of I_f.

Figure 2 : Comparison of visual quality on Barbara image (0.4 bpp) a) JPEG compressed image (left) b) processed with our method (right)

Experimental Result

The performance of the proposed method is measured numerically using PSNR and MSDS (Mean Square Difference of Slope) and visually. Our result is compared with the techniques presented in Lin et. al. [4] and JPEG standard. Some of the numerical results are presented in table -1 and the visual results are presented in figure -2. According to the numerical and visual result, our method performs better than the related works considered here.

Conclusion

The JPEG compressed image shows some artifacts and to reduce this artifact different post-processing algorithms are proposed so far. BF is one proposed method; it can reduce both ringing and blocking artifacts at the same time. One of the important issues in application of BF is determination of the filter parameters. According to Zhang and Gunturk [2] analysis, the photometric spread parameter has a higher critical effect than the geometric distance parameter on the final result. Hence, an adaptive algorithm to select the intensity distance parameter is proposed in this work. In addition to that, the visual quality of the resulting image is improved by applying our new contrast enhancement algorithm. The experimental result shows that our method performs better than Lin et. al. [1] and JPEG standard.

Reference

[1] W. Lin W. Zhang C. Wang P. Xue and S. Yu, "Fast edge preserved post processing for compressed images," in *IEEE Trans. Circuits and Systems for Video Technology*, September 2006, vol. 16 of *9*, pp. 1142 –1147.

[2] M. Zhang and B. K. Gunturk, "Multi-resolution bilateral filtering for image denoising," in *IEEE Trans. Signal Processing*, Dec. 2008, vol. 17, pp. 2324–2333.

[3] N. Yehya Hassan and N. Aakamatsu, "Contrast enhancement technique of dark blurred image," *IJCSNS International Journal of Computer Science and Network Security*, vol. 6, no. 2A, February 2006.

[4] N.R. Mokhtar N.H. Harun M.Y. Mashor H. Roseline N. Mustafa R. Adollah H. Adilah and N.F. MohdNasir, "Image enhancement techniques using local, global, bright, dark and partial contrast stretching for acute leukemia images," in *Proceedings of the world congress on Engineering*, July 1-3 2009, vol. I.

[5] S. Minami and A. Zakhor, "An optimization approach for removing blocking effects in transform coding," in *IEEE Trans. Circuits Syst. Video Technol*, Apr. 1995, vol. 5, pp. 74–82.

[6] C. Tomasi and R. Manduchi, "Bilateral filtering for gray and color images," in *in Proc. Int. Conf. Comput. Vis.*, 1998, pp. 839–846.