An Efficient Approach to the Reduction of Mosquito Noise for the JPEG/JPEG2000 Decoded Image by Using Epsilon Filter

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Abstract

The JPEG (joint photographic experts group) compression algorithm is possible to decode an image effectively, by considering the visual characteristic of human beings. The mosquito noise generates in the block, when a compression rate of the JPEG is high. On the other hand, the block noise is not generated in the JPEG2000 decoded image because an algorithm of the JPEG2000 based on DWT (discrete wavelet transform). However, the mosquito noise appears to a high compressed image by using the JPEG2000. We lose not only the mosquito noise but also some important image information, when the usual noise reduction filter is applied for a JPEG/JPEG2000 decoded image including the mosquito noise. As a result, the image quality worsens.

In this paper, we propose an efficient algorithm which reduces the mosquito noise of the JPEG/JPEG2000 decoded image by using ε-filter. We confirmed that our proposed method was effective by the computer experiments.

Introduction

JPEG[2] is a compression encoding method widely used in general when we compress the digital image. The reversible encoding method is included in the JPEG algorithm. However, the JPEG base line algorithm of the nonreciprocal encoding method that we can achieve the high compression rate is generally used. The JPEG compression image is lossy compression which combines DCT (discrete cosine transform) and the quantization table with making to the Huffman coding. If we use the nonreciprocal compression method and the image compression is done, a very high compressibility becomes possible but various noises are often generated in the compression image. The generated main noises include the block noise, false contour, and the mosquito noise. And these are eyesore noises in the image compressed by the JPEG/JPEG2000 compression encoding method for human beings. The study of false contour has been researching by *Shohdohji et al*.[5,6]

In this paper, we concentrate on the mosquito noise of these noises, and we propose the new algorithm of reduction of the mosquito noise.

Outline of Our Proposed Algorithm

Mosquito Noise

As for the mosquito noise, the noise which appeared in edge part's surroundings in the motion picture was named from seeming the flight of the mosquito. In this research, we propose especially an efficient algorithm to reduce the mosquito noise of the still picture. This noise is often generated especially in the block including an isolation point and a diagonal line. The block described here is a unit which is DCT (discrete cosine transform) in the process of the JPEG compression restoration.

Our Proposed Algorithm

We have understood a kind of ε-nonlinear digital filter (hereinafter "ε-filter", *see Figure 1*)[1] is effective as a method of removing the mosquito noise with keeping the outline. However, if we remove the noise by using the ε-filter, the effect of the filter becomes visible the entire image. Therefore, this method has the fault that not only removes the mosquito noise but also the pattern included in the original image is smoothed together. Because the quality of the image is ruined, the effect as the filter is reduced by half. Then, first of all we propose the ε-filter by paying attention to the image information (variance of the brightness value) included in an original image (**Phase I**) and the second and we propose the method of the ε-filter in which applies to it (**Phase II**).[3,4,7]

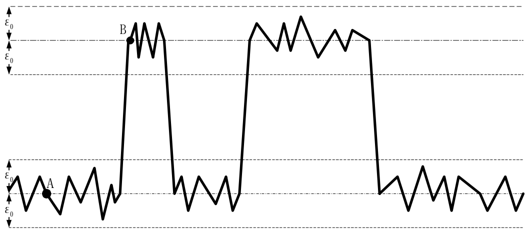

Figure 1. The Fundamental Idea of ε-filter[1)]

Then, our proposed algorithm is possible to restrain degradation of image quality, while reducing noise, by changing weight of filtering every block.

Our proposed algorithm is as follows.

Phase I

(Collection of Image Information Which Use Variation of Brightness Value)

Step 1

To detect a sharp outline which becomes the generation condition of the mosquito noise, we calculate the variance of brightness values to the pixel of N×N to each pixel on the entire image every one pixel centering on a noteworthy pixel (*see Figure 2*). In the JPEG image, the brightness value of the YCbCr color system is used.

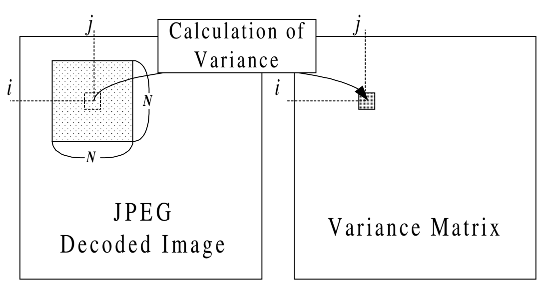

Figure 2. Concept of Calculation of Variance

Step 2

We assume 8×8 pixels to be one block, and divides and processes the entire image, therefore the mosquito noise compares variance of each pixel requested with **Step1** by one pixel in consideration of being generated for sharp outline surroundings at every block, and makes the biggest variance in the block the representative of a variance at every block for the brightness value of the JPEG compression restoration image (*see Figure 3*).

Phase II (Execution of Noise Removal)

The proposed algorithm sets the value in which multiplies a constant coefficient by a decentralized value at every block requested with **Phase I** as the ε value of the ε-filter at every block, and gives the ε-filter at every block (*see Figure 4*).

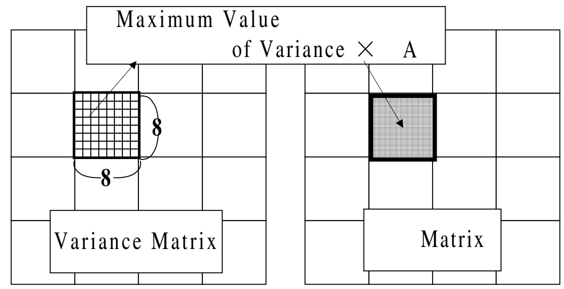

Figure 3. Relation between Variance Matrix and ε Matrix

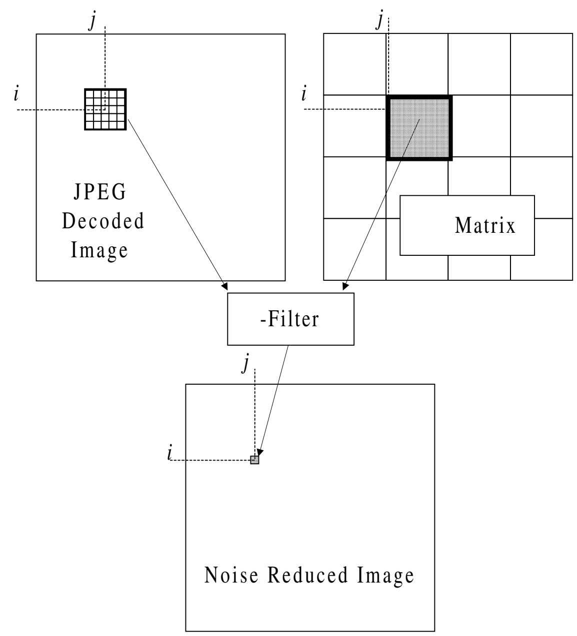

Figure 4. Process of the ε-Filter

Applied ε-filter

In the algorithm, a value of *N* in **Phase I** was set as seven (we calculated variance in the block of 7 x 7), and we used 0.01 as a coefficient "A" of the ε-filter in **Phase II**. The ε-filter preserves a rapid change of the brightness value, and can remove smaller noise than the value of ε that the user of this algorithm set.

Figure 5 shows the ε-filter that we used in this paper. This filter is output filter (filter size: 5×5) as output pixel $y_{n,m}$ (the brightness value of $x_{n,m}$ which is the center of the filter window) as for the mean value of the value within the range of +/- ε. It does not have the function as the filter at $\varepsilon = 0$, but it is the same as the low-pass filter at $\varepsilon = \infty$. This filter is almost the same as the algorithm of NFILTER (*see* http://plaza16.mbn.or.jp/~masaakiy/index. html) that Mr. Masaaki Iwasaki made.

$x_{n-2,m-2}$	$x_{n-2,m-1}$	$x_{n-2,m}$	$x_{n-2,m+1}$	$x_{n-2,m+2}$
$x_{n-1,m-2}$	$x_{n-1,m-1}$	$x_{n-1,m}$	$x_{n-1,m+1}$	$x_{n-1,m+2}$
$x_{n,m-2}$	$x_{n,m-1}$	$x_{n,m}$	$x_{n,m+1}$	$x_{n,m+2}$
$x_{n+1,m-2}$	$x_{n+1,m-1}$	$x_{n+1,m}$	$x_{n+1,m+1}$	$x_{n+1,m+2}$
$x_{n+2,m-2}$	$x_{n+2,m-1}$	$x_{n+2,m}$	$x_{n+2,m+1}$	$x_{n+2,m+2}$

Figure 5. The ε-Filter (in case of 5 x 5)

However, after specifying a separate parameter for each RGB pixel, NFILTER synthesizes and judges the value of RGB in consideration of the connection of the color of the image but we individually process the value of RGB to the color image respectively in the algorithm proposes by this research in consideration of the characteristic of the JPEG decoded image.

Experimental Results

Figure 6 is a JPEG decoded image of the original image. *Figure 7* is an image obtained by applying our proposed algorithm to the original image of *Figure 6*. Moreover, *Figure 9* is an image obtained by applying the ε-filter ($\varepsilon = 20$) to the original image of *Figure 6*. Because we do not understand the difference easily in these images, we show the image that emphasized the outline of each image in *Figures 8 and 10*. In *Figure 9* where we applied the ε-filter, the image quality of the area of trees is deteriorated, and we understand the noise of surroundings of the character is not improved well. *Figure 11* shows a JPEG2000 decoded image, and *Figure 12* is an image to which we restore the image by our proposed algorithm.

Conclusions

As for our proposed algorithm, we understood there is some effect in the removal of the mosquito noise without ruining the quality of the JPEG/JPEG2000 decoded image when the brightness value of the character and the brightness value of the background are greatly different. Moreover, we confirmed that our algorithm is effective in the block where the mosquito noise was generated easily without shading off the part where the change of the brightness value such as forests and woods was low.

On the other hand, when the difference with the brightness value of the character and the background was small as the problem, we did not able to remove the mosquito noise. Similarly, a part of the character was not able to remove the mosquito noise completely from the block of 8×8 for the condition that only a part has overflowed. Perhaps the reason why the detection of the outline did not work effectively is that the outline appears weakly when the noise is generated more strongly than other images. In conclusion, we were able to confirm a considerable effect by appropriately setting the parameter applied to the filter at every the block according to the applied image. The image quality of the JPEG decoded image seems to be improvable further by combining our algorithm and another algorithm for removing the block noise.

The problem left for us is to develop the algorithm which automatically sets the value of the best parameter according to the feature of the JPEG/JPEG2000 compression image.

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References

1. H. Harashima, K. Odajima, Y. Shishikui, and H. Miyakawa, The Transaction of the Institute of Electronics and Communication Engineers of Japan (in Japanese), **J66-A**, 4, pp. 297- 304 (1982).
2. W. B. Pennebaker and J. L. Mitchell, JPEG Still Image Data Compression Standard, Van Nostrand Reinhold, New York (1993).
3. S. Sasaki, T. Shohdohji, Y. Hoshino, Proceedings of the Annual Conference of the Imaging Society of Japan (Japan Hardcopy 2001, in Japanese), pp. 181-184 (2001).
4. S. Sasaki, T. Shohdohji, Proceedings of the 44th Japan Joint Automatic Control Conference, pp. 528 - 531 (2001).
5. T. Shohdohji, N. Iijima, S. Kitakubo, and Y. Hoshino, Journal of the Imaging Society of Japan (in Japanese), **38**, 2, pp. 88-96 (1999).
6. T. Shohdohji and Y. Hoshino, Applied Mathematics and Computation, **120**, 1-3, pp. 301- 311 (2001).
7. T. Shohdohji, Y. Sasaki, and Y. Hoshino, Proceedings of International Congress of Imaging Science 2002, Tokyo (ICIS'02, Tokyo), pp. 678-679 (2002).

Biography

Tsutomu Shohdohji is an Associate Professor of Operations Research at Nippon Institute of Technology, Japan. He received a BE and a ME degrees in Management Engineering from Aoyama Gakuin University, Japan, in 1973 and 1975 respectively. He is a member of the INFORMS (the Institute for Operations Research and the

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Figure 6. JPEG Decoded Image

Figure 7. An Image by Our Proposed Method

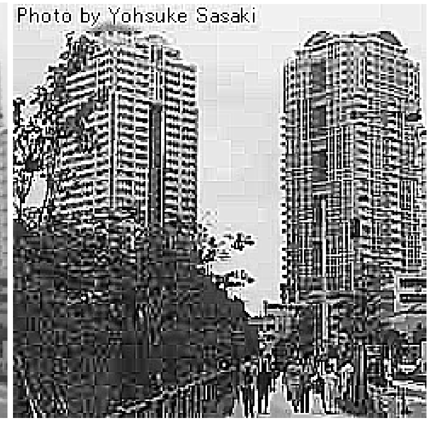
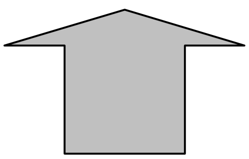


Figure 8. Emphasis of the Outline of Fig. 7



This is an original image.

Figure 9. An Image by ε-Filter (ε = 20)

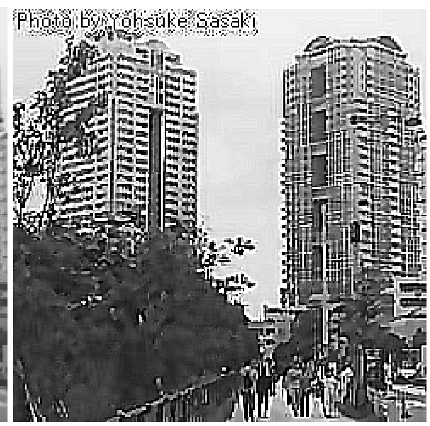


Figure 10. Emphasis of the Outline of Fig. 9

Figure 11. JPEG2000 Decoded Image

Figure 12. An Image by Our Proposed Algorithm