Mosquito Noise Reduction Algorithm for Decoded Image

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Abstract

The mosquito noise and false contour that doesn't exist in the original image sometimes appear in a decoded image. These noises are desirable for us to remove. Thereupon, we propose the new algorithm that mosquito noise is reduced on the basis of the pixel information of a decoded image. First of all, our proposed algorithm calculates the standard deviation by using the luminance of each pixel in the square block. Next, we do the filtering process by using the Epsilon filter algorithm with the standard deviation in each square block.

Through several computer experiments, we understood that we were able to reduce mosquito noise by using our proposed algorithm without damaging the quality of the decoded image.

Introduction

When the digital image is compressed, JPEG (Joint Photographic Experts Group: collegial organization of ISO and ITU-TS)[2,8] compression encoding system is widely used. The reversible encoding system and the nonreciprocal encoding system are prepared in the JPEG compression encoding method. However, the JPEG base line algorithm of the nonreciprocal encoding system that the high compression rate can be achieved is often used. The JPEG compressed image is a compressed image obtained by using DCT (discrete cosine transform) and the quantization table and making to the Huffman coding. The image by the nonreciprocal compression system also has the advantage that high compression can be achieved dramatically, and has the defect that deterioration and various noises of the image quality occur easily.

JPEG2000 was enacted as a standard by which the JPEG compression system was developed further in January of 2001. Because the maintenance of software that can use the format of JPEG2000 and the plug-in is not in order compared with that of the JPEG compression system, this system is widely used at present.

The main noises include the block noise and the mosquito noise when the high compression processing is done by the JPEG system, and both are eyesore noises for human beings. False contour line is generated though the block noise on the characteristic of the algorithm is not generated in JPEG2000 system. We have already reported on the algorithm that reduces block noise and false contour line. Moreover, we have already reported on the algorithm to reduce the mosquito noise that appears when the JPEG/JPEG2000 compression system is used and it compresses it at the high compression rate. Because we succeeded in the great improvement of this algorithm, we report it in this paper.

This algorithm has been improved based on the algorithm made by using the idea of Epsilon-separating nonlinear digital filter (hereinafter, it is called the Epsilon-filter).[1] The feature of this algorithm is as follows.

The parameter of the noise reduction filter (Epsilon value) can be automatically decided by using information (standard deviation of luminance value) at every block of the image to be reduced the mosquito noise.

It doesn't depend on the image for the improvement it has been compressed by which compression algorithm.

Outline of Our Proposed Algorithm

It is known the targeted mosquito noise is appeared when a sharp outline, the isolated point, and the hatched line, etc. are included in the image though we propose the algorithm to reduce the mosquito noise of the still image in this research.

To remove the mosquito noise with the outline kept, the Epsilon-filter algorithm is known to be effective. We have already proposed the changeable Epsilon-filter algorithm (hereinafter, it is called an old algorithm.)[4,5,6,7] that changes the Epsilon value of each area of the image. The Epsilon-filter is a filter that can remove a detailed noise of the Epsilon value or less in which a steep change is set while kept. The original image is not changed at all for the value of Epsilon = 0, and the same working as the low pass filter is done for the value of Epsilon = infinity.

An old algorithm expressed the size of the difference of the luminance value in the block by distributing the luminance value by using luminance value information corresponding to each pixel in the filter window (hereinafter, it is called the block.) that had been provided beforehand. The luminance value of the YCbCr color system is used for the color image. At this time, an old algorithm had the defect that it was necessary to calculate the coefficient to correct a variance. Strictly, the value of the coefficient is different according to the image.

The algorithm that we propose is a suitable algorithm because it need not calculate the correction coefficient for the image that should improve the image quality, and it is excellent in respect of the calculation time compared 7070with an old algorithm.

Our proposed algorithm consists of the following two Phases ("Collection Phase of image information" and "Epsilon-filter application Phase").

- Phase I:

To discover the area where a sharp outline that becomes the generation condition of the mosquito noise exists, standard deviation in the block is calculated from luminance value information by the unit of the block (the size used to experiment is 8×8). When the block is buried by the value of the calculated standard deviation, the matrix (it is called a Epsilon-matrix) of the mosaic pattern for the unit of the block is completed (see *Figure 1*). The value of this standard deviation reaches the Epsilon value of the Epsilon-filter in each block.

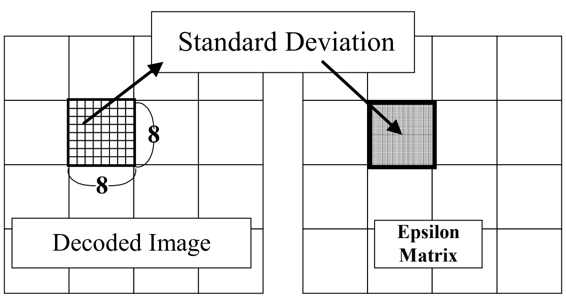

Figure 1. How to make the Epsilon Matrix

- Phase II:

The Epsilon-filter is applied to each pixel of the original image by using the Epsilon-matrix calculated with **Phase I**. The filter is applied, and the mean value of the luminance value in an arbitrary block is output. However, the mean value is calculated by using only the value in which it meets the requirement, or "exist within the range of (luminance value of the representative pixel of the block ± Epsilon value)", for the pixel included in the block of an arbitrary size (see *Figure 2*). In the color image, this operation is executed at each color element.

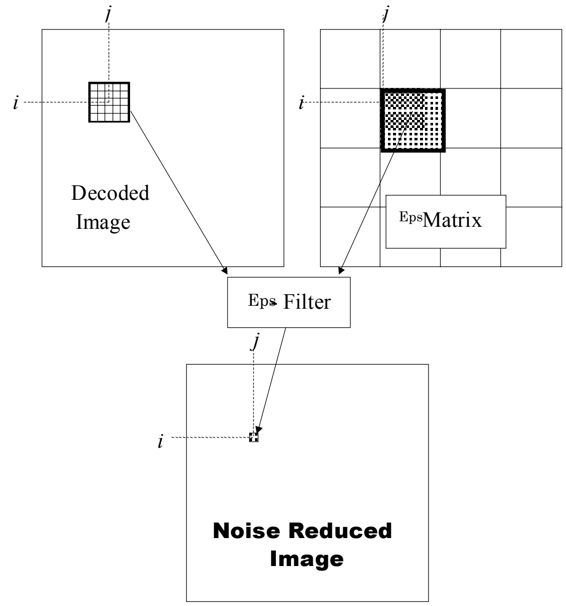

Figure 2. Process of Epsilon Filter

Experimental Results

Experimental results by using our proposed algorithm (hereinafter, it is called a new algorithm) are shown in *Figure 3-Figure 10*. The block size of the Epsilon-filter used to experiment is 5×5. The images used to experiment are parts of Graphic Technology-Prepress Digital Data Exchange-Standard Color Image Data (ISO/JIS-SCID).

Figures 3 and *7* are the original images, *Figures 4* and *8* are the JPEG compression restoration images, *Figures 5* and *9* are images that apply an old algorithm, and *Figures 6* and *10* are images that apply a new algorithm.

We used PSNR (Peak Signal-to-Noise Ratio)[3] based on the mean square error used at present most widely as an evaluation standard of the objective image quality evaluation. However, we know the evaluation by PSNR to be necessarily not corresponding to the result of the subjectivity evaluation.

Actually, the value of PSNR of the image that applies a new algorithm is a little small compared with the value of PSNR when JPEG is applied in *Figures 9* and *10*. The reason is that the noise that exists in the original image disappears when the noise of the compressed image are reduced by using a new algorithm. In the subjectivity evaluation, the image that applied a new algorithm obtained all good evaluations.

The mean value used when standard deviation is calculated in **Phase I** is an arithmetic mean. The average included the geometric mean and the harmonic mean, etc. besides the arithmetic mean, and the case to use the arithmetic mean obtained the good results.

Figure 3. Original Image (a part of SCID N5A) Bit Rate: 24bits/pixel

Figure 4. JPEG Decoded Image (a part of SCID N5A) PSNR: 27.086 [dB], Bit Rate: 1.56bits/pixel

Figure 5. Decoded Image by the Old Algorithm PSNR: 24.851 [dB]

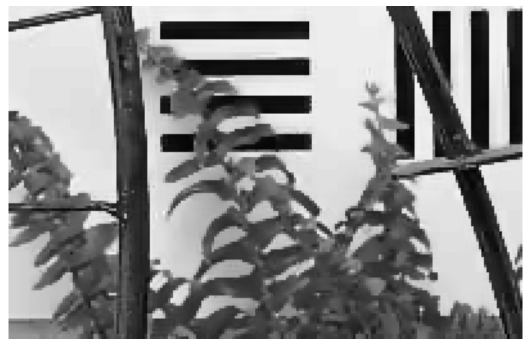

Figure 6. Decoded Image by the New Algorithm PSNR: 25.586 [dB]

Figure 7. Original Image (a part of SCID N6A) Bit Rate: 24bits/pixel

Figure 8. JPEG Decoded Image (a part of SCID N6A) PSNR: 34.699 [dB], Bit Rate: 0.5bits/pixel

Figure 9. Decoded Image by the Old Algorithm PSNR: 34.681 [dB]

Figure 10. Decoded Image by the New Algorithm PSNR: 34.607 [dB]

Conclusions

We proposed a new algorithm that added the improvement to the computational method of the Epsilon matrix of an old algorithm in this paper. In an old algorithm, an arbitrary constant to correct the Epsilon value was necessary. It came to be able to calculate all parameters by using only the object image's information in a new algorithm by having added the improvement to an old algorithm.

As a result, we have understood the followings.

(a) The complication of the computational method can be evaded.
(b) The amount of the total calculation can be decreased.
(c) It is easy to make the program code.

Here, it is meant that the larger the size of the image is the reduction in the computational complexity, the more the calculation cost falls.

On the other hand, it has been understood that a new algorithm can reduce the mosquito noise while keeping feeling of quality compared with an old algorithm from the experimental results. Moreover, we can be expected to apply a new algorithm to the moving picture because it is possible to correspond for the moving picture by the image data processing like the still picture every one frame.

Problems that were left in the future are the following two points.

(1) Application of new algorithm to the moving picture
(2) Automatic changeability setting of size of the block in **Phase II**

Acknowledgment

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Biography

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