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Research Article

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A Comparative Study of Impulse Noise Reduction in Digital Images by Different Filtering Techniques

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Abstract The purpose of this study is to derive the optimal filtering method among the existing filtering methods to remove the impulse noise generated in the digital image. To do this, Median, Gaussian, Bilateral, Guided and Bitonic filtering techniques were applied to standard images with impulse noise. Peak Signal to Noise Ratio (PSNR) and structural similarity (SSIM) are used to quantitatively evaluate the noise reduction performance according to the filtering technique. Experimental results show that the Median filter exhibits improved PSNR values compared to other filtering techniques and better preserves the edge region in the image.

Keywords Impulse noise, Noise reduction, Digital image

Introduction

Research on image acquisition devices such as CCD or CMOS has been actively pursued with increasing use of digital images. Noise inevitably occurs in the process of acquiring from a device. The image is most affected by impulse noise among manynoises. This noise is caused by a malfunction of the camera sensor or an additional noise in the transmission channel in the process of acquiring the image [1]. The characteristic of the impulse noise is that the pixel value of a specific position is destroyed, and the pixel value of an unaffected position is left as it is. By changing the pixel value into very large or small pixel values in the image, the pixel values are completely different from those of the original image. Therefore, this noise is easily visible in the image and degrades the image quality. A number of filters have been proposed to remove impulse noise. The median filter is the most used, and modified filters such as weighted median filter and center weight filter have been proposed. However, these filters are disadvantageous in that blurring phenomenon occurs while noise reduction performance is excellent. In order to overcome these disadvantages, switching median filter is being studied. Among these types of filters, Boundary Discriminative Noise Detection (BDND) filter [2] is known as the best noise reduction method. However, this method has difficulty in real time implementation due to high computational complexity. Many methods have been proposed to solve this problem in that the detection performance is degraded. Therefore, in this study, we compared the performance of the existing filtering techniques in order to overcome the disadvantages of the above-mentioned filters and to derive a filtering technique that can exhibithigh noise reduction performance.

Materials and Methods

In this study, we used a flat image (*Lena*) and a complex image (*Baboon*) among the standard images with a size of 512 x 512 (Figure 1). Impulse noise with a variance value of 0.4 was added to each standard image. All image processing was performed with MATLAB® (R2017a MathWorks®, Natick, MA, USA). In order to evaluate the noise reduction performance, we compared impulse noise reduction performance using different filtering techniques such as Guided [3], Bilateral [4], Gaussian, Bitonic [5], Median filters. To evaluate the performance of existing filtering techniques, noise reduction performance was evaluated using Peak Signal to Noise (PSNR) and structural similarity (SSIM).

(a) (b)

Figure 1: Two test images of the (a) Lena, (b) Baboon

Results & Analysis

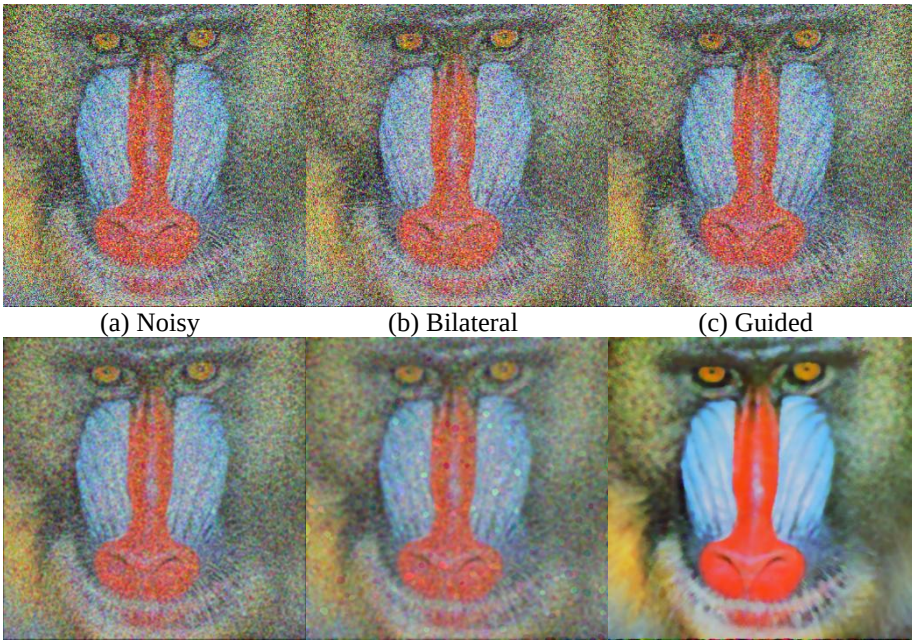
Figures 2 and 3 show the reconstructed images sequentially using the existing filtering techniques for the qualitative comparison of *Lena* and *Baboon* images. In Fig. 2, it can be seen that the image filtered by the Median filter exhibits an excellent impulse noise reduction performance as well as the preservation of the edge information. In the resulting image of Fig. 3, it is confirmed that the resulting image using the Median filter method has superior performance in edge preservation and impulse noise reduction compared to other filtering methods.

Table 1 compared the results of PSNR and SSIM for the existing filtering techniques on *Lena*and *Baboon* images. For the *Lena* image, the Median filter technique shows better PSNR from 18.09 dB (Guided filter) to 9.73 dB (Gaussian filter) than other existing filtering techniques. Also, it can be seen that SSIM has an excellent performance. As can be seen in Table 1, the Median filter method shows better performance in PSNR and SSIM than the other filtering methods in *baboon* image (PSNR=19.44, SSIM=0.59).

(a) Noisy (b) Guided (c) Bilateral

(d) Bitonic (e) Gaussian (f) Median

Figure 2: Simulation results of Impulse noise reduction in Lena image



(a) Noisy (b) Bilateral (c) Guided

(d) Gaussian (e) Bitonic (f) Median

Figure 3: Simulation results of Impulse noise reduction in Baboon image

Conclusion

In this paper, we compared the existing filtering techniques quantitatively and qualitatively in order to derive an optimal filter represented an excellent edge preservation and noise reduction performance for impulse noise in digital images. Experimental results show that the Median filter had better noise reduction performance than the other filtering techniques. In future research, it is necessary to develop a new algorithm suitable for impulse noise based on the results of this paper. Also, it is applied to various images to secure the significance of experimental results.

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Table 1: PNSR and SSIM results for *Lena* and *Baboon* images according to different filtering techniques

Lena		
	PSNR	**SSIM**
Noisy	9.23	0.19
Guided	9.82	0.23
Bilateral	10.94	0.23
Bitonic	16.26	0.57
Gaussian	18.25	0.71
Median	**27.91**	**0.96**
Baboon		
	PSNR	**SSIM**
Noisy	9.23	0.19
Bilateral	9.45	0.23
Guided	9.82	0.23
Gaussian	17.10	0.46
Bitonic	17.33	0.46
Median	**19.44**	**0.59**

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