The Study on Removing Random-valued Impulse Noise

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ABSTRACT

In the transmitting process of image processing system, images always be corrupted by impulse noise, especially random-valued impulse noise. So removing the random-valued impulse noise is very important, but it is also one of the most difficult case in image processing. The most famous method is the standard median filter, but at edge, the filter has a special feature which has a tendency to decrease the preserve. As a result, we proposed a filter that detection random-valued impulse noise firstly, next to use efficient method to remove the noise and preserve the details. And through the simulation, we compared with the algorithms and indicated that proposed method significant improvement over many other existing algorithms.

Keywords

Impulse noise, Random-valued impulse noise, Noise detection, Noise removing

Ⅰ. INTRODUCTION

During the acquisition or transmission, images are often corrupted by random-valued impulse noise. Cleaning random-valued impulse noise is more difficult than cleaning salt and pepper im pulse noise, because salt and pepper impulse n oise is only take either maximum or minimum value, but random-valued impulse noise can be any numbers between maximum and minimum.

Median filter has been widely used in removin g random-valued impulse noise, where the outp ut pixel is set to the median of the neighborho od pixels [1]. However, the simple median filter tends to modify not only noise pixels but also noise-free pixels. This will result the elimination of fine details such as thin lines and corner, bl urring, or distortion in the images. In order to avoid distorting details, many other median file rs were found, such as weighted median filter (WM), center weighted median filter (CWM) an d switching median filter (SW). However, they are not enough to detect impulse noise. Thus, f urther improvement in the impulse detector is required for more accurate image restoration.

In this paper we proposed a novel impulse det ection method, which is simple but efficient. Af ter eliminating, the noise pixels, using adaptive weighted median filter to remove the noise. So the proposed method consists of two stages: fir st, noise detection, second, noise removal. The c ombination of these two stages can remove ran dom-valued impulse noise better than the other methods.

Ⅱ. CONVENTIONAL ALGORITHMS

1. Standard median filter

SM filter is the most important and popular n onlinear filter. Mask size can be defined as (1).

$$W = \{(s,t) | -N \le s \le N, -N \le t \le N\} \qquad (1)$$

Here, (s,t) is the position of the pixels in the mask and the mask size is , and then SM filter chooses the median value in the mask.

$$Y(i,j) = median\{X(i+s, j+t) | (s,t) \in W\} \qquad (2)$$

Where, $X(i,j)$ is denoted as input value, $Y(i,j)$ is the output value and $med\{\bullet\}$ is den oted as median value.

2. Switching median filter

SW filter has been shown to be more effectivel y than uniformly applied filters.

The standard median filter outputs the median value of the pixels in the window is mid. The output of the switching median filter is given b y:

$$Y(i,j)=\begin{cases} mid, & \text{if } |mid-X(i,j)|>T_D \\ X(i,j), & otherwise \end{cases} \quad (3)$$

Where T_D is a fixed parameter. The numerical value of T_D is defined a prior or chosen after many practical tests.

3. Mean filter

MF is a straight forward spatial-domain technique for image restoration. Mean filter is denoted as (4).

$$Y(i,j)=\frac{1}{Z\times Z}\sum_{i,j}^{Z}X(i+s,j+t) \quad (4)$$

$$Z\in W,\ Z=2N+1$$

Here, W is mask size.

Ⅲ. PROPOSED METHOD

The classification of noise pixel is accord to the difference values of pixel's neighborhood region. The image edge gray has continuity in one or several directions in the neighborhood region. But the noise points are discontinuous in most directions. It means if a pixel is impulse noise point, it has the maximum difference value in most direction. In this paper, if the difference (d) between the center pixel and others neighborhood region pixels is larger than threshold, at the same time, the number (N_n) which satisfies this situation is larger than the other threshold, then, the center pixel will be defined as impulse noise. The proposed noise detection method is according to the standard deviation of sub window. The standard deviation will be separated as three levels. T_1 and T_2 are the threshold of standard deviation σ and $T_1>T_2$. T_3 is the number N_n's threshold.

We count the number N_n when the difference d is satisfied these conditions (5), (6) and (7).

1, If $\sigma>T_1,\ d>\dfrac{3(T_1+T_2)}{20(T_1-T_2)}$ (5)

2, If $T_2<\sigma\le T_1,\ d>\dfrac{T_1}{T_1+10}$ (6)

3, If $\sigma<T_2,\ d>\dfrac{1}{T_1-T_2}$ (7)

After defining d's range, we also defined number N_n's threshold . The threshold T_3 is used to distinguish the detail points and noise points. And the appropriate value of T_3 is determined by experiment.

After detecting the noise pixel, it is very important to choose fixed method to remove noise from image. The calculation process of the weighted values is described as follows:

$$V=\sum_{s=-N}^{N}\sum_{t=-N}^{N}\frac{1}{1+[X(i+s,j+t)-mid]^2} \quad (8)$$

Here, mid is the median value of the window W.

$$w(i+s,j+t)=\frac{1}{(1+[X(i+s,j+t)-mid]^2)\times V} \quad (9)$$

$$p(i,j)=\sum_{s=-N}^{N}\sum_{t=-N}^{N}X(i+s,j+t)\times w(i+s,j+t) \quad (10)$$

The output after filtering is:

$$Y(i,j)=\frac{1}{2}[mid+p(i,j)] \quad (11)$$

Ⅳ. EXPERIMENT RESULT ANALYZES

The proposed algorithm is tested using 512×512 standard images such as Lena (Gray). In addition to the visual quality, the performance is quantitatively measured by the peak signal to noise ratio (PSNR).

Fig.1 shows the simulation result of the Lena image. In the Fig.1, (a) is the original image; (b) is the noisy image that corrupted by random-valued impulse noise with the density of p=20%. (c) ~ (f) show the result of restoration by SM (3×3) filter, SW (3×3) filter, MF (3×3) and the proposed method respectively.

Fig.1's simulation result shows that too much noise remains in the images filtered by the SW filter. Although the SM filter and MF filter perform better in noise suppression than the SW filter, they still remains certain amount of noise in the filtered image and they damage some details in the image to a certain extent. But proposed method performs better than any other filters in removing random-valued impulse noise a nd preserve the details.

(a) Test image

(b) Noisy image (20%)

(c) SM (3×3)

(d) SW (3×3)

(e) MF (3×3)

(f) Proposed filter

Fig. 1. Simulation result.

Fig.2 compares the noise removal results by changing the impulse noise density. From Fig.2, the proposed method performs well and the PSNR value are higher than conventional algorithms.

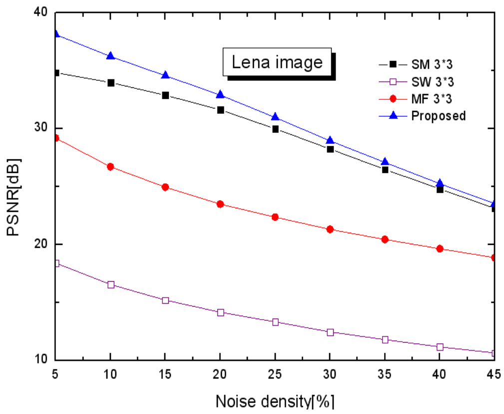

Fig. 2. PSNR for Lena image.

Table 1 listed the results in terms of the PSNR for image quality assessment of Lena image.

Table 1. Performance comparison for restoring Lena[dB].

random valued noise	Method			
	SM 3×3	SW 3×3	MF 3×3	Proposed
10%	33.96	16.55	26.69	36.21
15%	32.86	15.20	24.94	34.55
20%	31.61	14.15	23.47	32.88
25%	29.98	13.32	22.35	30.94
30%	28.23	12.46	21.30	28.93

V. CONVOLUTIONS

In this paper, we proposed a new algorithm is to remove random-valued impulse noise in the images, which first detected impulse noise according to the standard deviation of the filtering mask and the differences between the center pixel and these neighbor region pixels, after detecting the noise, we continue to use adaptive weighted median filter to calculates the output image's pixel. Through the computer simulation on test image, when the noise density is 20%, the PSNR values of SM filter, SW filter and MF are 31.61 dB, 14.15 dB and 23.47 dB, but the proposed method shows the 32.88 dB. It indicates that the proposed method is superior to traditional algorithms and has good capability in random-valued impulse noise suppression, and can reserve image details.

REFERENCES

[1] M. Juneja, P. S. Sandhu, "Design and Development of an Improved Adaptive Median Filtering Method for Impulse Noise Detection", International journal of Computer and Electrical Engineering, vol. 1. pp. 627-630. Dec. 2009.

[2] Hwang H., Haddad R. A., "Adaptive Median Filters New Algorithms and Results", Image Processing, IEEE Trans. Vol. 4, Issue 4, pp. 499 - 502, April 1995.