A Method Based on Statistical Characteristics for Image Denoising

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Abstract. The median filter will cause fuzzy problems on edge details of the image when it is used to remove noise of an image. In this paper we discuss an improved median filtering method. Firstly according to the arithmetic mean we preliminarily detect signal points and suspicious noise points in the image, and further distinguish between signal points and noise points by standard deviation. The determined noise points will be processed by median filter and signal points will be retained the original pixel values. This method is used in numerical experiments. The results show that the clearer image may be obtained by the proposed method for image denoising that can prevent fuzzy image. The denoising image will retain edge details of the image and improve PSNR.

Introduction

During the formation, transmission, reception and processing, impulse noise will appear when the image is often subjected to interference. It is one of the basic tasks how to effectively remove the noise, retain integrity and edge information of the original image and improve PSNR for preprocessing [1-5]. There are many types of image noise, and impulse noise is one of the most common. The median filtering method can keep details of the image while removing the impulse noise, thus it is widely used in the field of image processing. However, the effect for image denoising by median filter is affected by the size of the filter window. A small window can preserve the image details, but it will not effectively remove the noise. On the other hand, the larger window can effectively reduce the noise, but it will destroy details of the image and result in a fuzzy image. Obviously, in an ideal filtering algorithm only noise points are processed, while gray values of signal points are retained. Therefore, before filtering operation for the noise, we need a noise detection process to separate the noise points and signal points.

In order to overcome the shortcomings of the median filter, some scholars have put forward various kinds of improved algorithms, such as adaptive median filtering algorithm [6-9], weighted median filtering algorithm, switch median filtering algorithm [10], extremum and median filtering algorithm [11], image denoising algorithm based on dynamic window [12]. Though the algorithms have made the beneficial exploration in improving the performance of the median filter, they all have their own limitations in practical application. A switching median filter makes good effect when density of noise is low, and its performance since PSNR of the image decreases gradually will close to the standard median filter. As the switch filtering method is a cyclic operation, it not only will take a long running time, but also parameters are needed to estimate in advance. Thus its application is limited. In extremum median algorithm, maximum and minimum values that are regarded as the noise points are filtered out, it will make loss of more image detail and results in a fuzzy image.

An improved median filtering method is presented for removing impulse noise of the image in this paper. Firstly according to the arithmetic mean we preliminarily detect signal points and suspicious noise points in the image, and further distinguish between signal points and noise points by standard deviation. The determined noise points will be processed by median filter and signal points will be retained the original pixel values. The method can not only effectively distinguish signal points and impulse noise points, but also it can improve PSNR. It will effectively retain edge details of the image, and reduce fuzzy image that it is processed by filter.

The Principle of Median Filter Algorithm

Median filter is proposed by Turky in1971. The principle of median filter is that a value of a point in the sequence or digital image is replaced by median values of all points in the neighborhood .One dimensional median filter is defined as follows:

The sequence according to values of the n number $x_1, x_2, \cdots, x_n$ is arranged as follows:

$$x_{i1} \le x_{i2} \le \cdots \le x_{in} \quad (1)$$

thus

$$y = Med\{x_1, x_2, \cdots, x_n\} = \begin{cases} x_{i((n+1)/2)} & n \text{ is odd}, \\ \frac{1}{2}[x_{i(n/2)} + x_{i(n/2+1)}] & n \text{ is even}. \end{cases} \quad (2)$$

Where y is defined as a median value in the sequence. For the two-dimensional median filter, two-dimensional window such as: linear, circular, square, ten-ring shaped and etc. may be adopted. Generally the 3×3 square window is used. It can be gradually increased with a 5×5 square window、 7×7 square window, until the filtering effect is satisfied.

Two-dimensional median filter is defined as follows:

Let $\{x_{i,j}, (i, j) \in I^2\}$ be the gray values of pixels points in a digital image and let A be a filter window whose size is $N = (2K+1)\times(2K+1)$， thus

$$y(i, j) = \underset{A}{Med}\{x_{i,j}\} = Med\{x_{(i+r),(j+s)}, (r, s) \in A(i, j) \in I^2\}. \quad (3)$$

Traditional median filtering method processes all of image pixels by median method. It removes the impulse noise, at the same it also destroys original information of the image, especially more fuzzy edge details of image are made. It is more obvious especially when the filter window is more large. If we can accurately determine the image in which pixels are signal points, which pixels are noise points. We can only handle noise points, and the signal points are remained. Thus we can reduce the blur of the edge details of the image, so that the filtering process does not have effect on signal points for image denosing.

Improved Median Filter

The median filtering method will process all pixels for removing impulse noise. It can process not only impulse noise points but also non-noise points (e.g. edges). As a result it is obvious to make the image blur. In this paper we firstly makes a judgment on the noise points, and then deal them by improved median filtering algorithm, at the same time the non-noise points do not have to deal with. There is a great correlation among gray values of adjacent pixels of the image. That is, if a pixel and its neighboring pixels are determined as impulse noise points. There is a small possibility that all the pixels are true impulse noise points. It is probable that these pixels very close to edge gray values of image edges, or are close to the smooth region. Firstly according to the arithmetic mean we preliminarily detect signal points and suspicious noise points in the image, and further distinguish between signal points and noise points by standard deviation. According to the above principle the image is processed as follows for:

Step1: Let 3×3 filter window move in the image. After the center of filter window is combined with some a pixel, we can calculate the absolute value of the difference between the pixel gray value and the expectation of eight pixel gray values in the neighbor. If the value is more than T1 the pixel is regarded as a suspicious noise point for further detection, on the contrary, the pixel is regarded as a signal point which will is retained the original pixel value.

Step2: We calculate the standard deviation between eight pixels in the neighbor and the detected pixel. If the value is less than T2, the pixel is regarded as a signal point and its gray value is output.

Step3: If the absolute value of calculated standard deviation is more than T2, the point is considered as a noise point, we can output the median value of gray values of eight pixels to replace the original gray value.

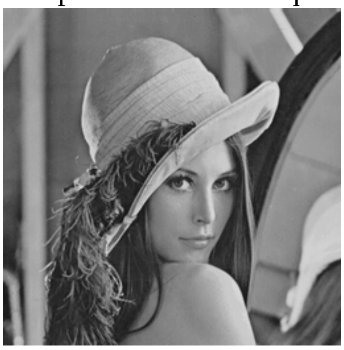
This method avoids processing all pixels by median method, but also avoid that the maximum and minimum values are filtered out as noise by extremum median algorithm, which can effectively protect the image edge details, to avoid the ambiguity of image edges.

The Selection of T_1 and T_2

In a window T_1 is the absolute value of the difference between the gray value of the pixel (i, j) and the expectation E (i.e. mean) of eight pixel gray values in the neighbor, that is $T_1 = \left|E - (i, j)\right|$. T_2 is the standard deviation S of the gray values between the pixel and eight pixels in the neighbor, that is, $T_2 = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$. Let T_1, T_2 be adjusted to make the best effect of image denoising. Finally the values of T_1, T_2 are set on $T_1 = 35, T_2 = 70$.

Experimental Results and Discussion

To implement the algorithm Matlab7.0 software is adopted. A 256×256 Lena map is made as an example. Figure 1 shows denoising results of three different algorithms for impulse noise on Lena. Figure 2 shows denoising results of three different algorithms for impulse noise on Barbara. Figure 3 shows the comparison of PSNR of three different filtering algorithms. Figure 4 shows the comparison of mean square error of three different filtering algorithms.



(a) The original image

(b) Noisy image by 5% impulse noise

(c) The denoising image by 3×3 median filter

(d)The denoising image by extremum filter

(f)The denoising image by the proposed method

Fig.1 Denoising results of three different algorithms for impulse noise on Lena

(a)The original image

(b)Noisy image by 5% impluse noise

(c)The denoising image by 3×3median filter

(d)The denoising image by extremum filter

(f)The denoising image by the proposed method

Fig. 2 Denoising results of three different algorithms for impulse noise on Barbara

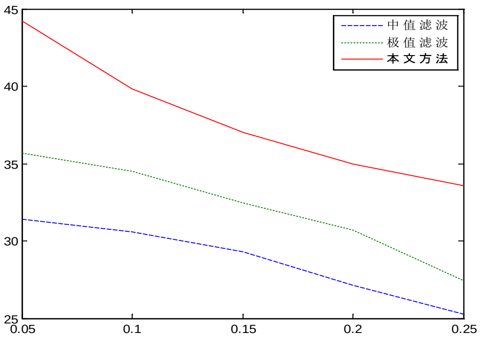


Fig.3 The comparison of PSNR of three different filtering methods

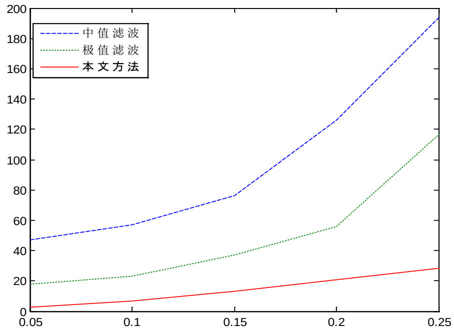


Fig.4 The comparison of mean square error of three different filtering methods

Experimental results show that the algorithm that is used to remove impulse noise of the image is better than traditional median filtering algorithm. It can effectively distinguish noise points and signal points, especially distinguish the edge information of the image and noise points. The algorithm will run quickly and improve PSNR of the image. The clearer image may be obtained and retain the image details. All these can prove the numerical computational algorithm we have constructed is very efficient.

Conclusion

Firstly we preliminarily determine a pixel as a signal point or a suspicious noise point by extreme and mean filter in some area of the image. According to the information in the neighbor of the pixel, we distinguish a signal point and a noise point. The determined noise point will be processed by median filter, at the same time the signal point will be retained the original pixel value.The method can effectively distinguish noise points and signal points, especially distinguish the edge information of the image and noise points. The clearer image may be obtained and retain the image details. The experimental results show that the algorithm that is used to remove impulse noise of the image is better than traditional median filtering algorithm.

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