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A fast and effective impulse noise filter

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ABSTRACT*: In order to eliminate the high density salt and pepper noise effectively in the image, this paper proposes a new algorithm that can eliminate the noise .Other similar algorithms need to adjust the filtering window in the image which is polluted by different concentration of noise constantly. The proposed algorithm use the fixed small scale of filtering window only, at the same time of filter, it can reserve the detail of the image features well. The proposed algorithm extracted the noise points from the contaminated image firstly, according to the relationship between the gray value of signal points and noise points, then determine which is the real noise. The experimental results show us that the proposed algorithm achieved satisfactory result in filter out noise, especially in the treatment of the images that have high levels of noise pollution, and it is better than other algorithm.*

Keywords*: salt and pepper noise, filtering, effective;*

I. Introduction

The effective information of the image and the noise points are always coexist, the normal image processing will be affected, so it is necessary to remove the image noise. Therefore, it is an important research topic in the field of image processing. The most common method of removing salt and pepper noise is median filtering, compared with the Gauss filter and the morphological filtering, median filter has a better filtering effect on noise. However, the method is not strong, which can easily lead to the loss of image details and filter effects. To solve these problems, many scholars have proposed a lot of improved algorithms. For example, the extremum median filtering algorithm [1,2],which determine if there is an extreme value in the window to determine whether there is noise, if there is no noise point, the normal image with the maximum and minimum gray value of the signal point may be mistaken for noise. Adaptive median filter algorithm [4,5], Automatically adjust the size of the filter window by the noise density, but when the noise density is high, the filter window is large, and the time of the filter is increased. The filter effect is increased, and the image details are lost, the image becomes blurred.

To solve the problem, this paper proposes an improved filtering algorithm. After the original image pixel classification, the noise may make a specific analysis to determine the final noise, which improves the noise judgment accuracy, reduce the error rate, improve the algorithm performance.

II. Proposed algorithm

Salt and pepper noise is some high gray value and low gray value of black and white noise point, the value of the salt noise points distribute in the vicinity of 255 and the value of the pepper noise distribute in the vicinity of 0. The salt and pepper noise often appears in the process of image acquisition, decoding and transmission. This paper set the threshold firstly, then determine which is the possible noise points, finally the proposed method determine which is the real noise points on the basis of the possible noise points.

The gray value in the image of a normal which is not polluted by noise is gradual change, it will not change intensely. If this image is polluted by salt and pepper noise, the variations of the gray value between the normal pixel and the polluted pixel is great. According to the characteristics of this, we can judge which pixel is the noise point. Scanning the image, if the gray value of the pixel fall within normal ranges, we determine it is signal point, else we determine it is the possible-noise point.

$$N = \begin{cases} 0 & \sigma \le f(i,j) \le 255-\sigma \\ 1 & other \end{cases}$$

In this expression, N=0 indicates the pixel is signal point, N=1 indicates the pixel is the possible-noise point, σ is the noise threshold.

Steps:

(1)In order to ensure the image details clear, selecting filtering window for 3*3.

(2)Selecting appropriate σ.

(3)Scanning the polluted image, if the gray value of the pixel $f(i,j)$ fall in σ and 255-σ, determining it is signal point and outputting the gray value without handling it.

(4)If the pixel's gray value fall in 0 and σ, we think it is the possible-noise . Finding the signal pixels in this point's 8-neighbor and calculating their average gray value T_1,using T_1 to subtract every signal pixel's value, their values were recorded as A_i separately, then take the absolute value of A_i as B_i,calculating the average of Bi, recording as Si, if $T_1 - f(i,j) > S_1$,Marking this point as a noise point, assigning T_1 to $f(i,j)$.If $T_1 - f(i,j) \le S_1$, marking this point as signal point. $T_1 = \frac{1}{N}\sum_{m=1}^{3}\sum_{n=1}^{3} f(i,j); \quad \sigma < f(i,j) < 255-\sigma$

In this expression, N is the count of the signal pixels of current point's 8-neighbor.

$$S_1 = |T_1 - f(i,j)| \quad \sigma < f(i,j) < 255-\sigma$$

$$O(i,j) = \begin{cases} f(i,j) & \sigma < f(i,j) < 255-\sigma \\ T_1 & f(i,j) \le \sigma \text{ and } T_1 - f(i,j) > S_1 \end{cases}$$

(5)If the pixel's gray value fall in $255 - \sigma$ and 255, we think it is the possible-noise. Finding the signal pixels in this point's 8-neighbor and calculating their average gray value T_2,using T_2 to subtract every signal pixel's value, their values were recorded as C_i separately, then take the absolute value of C_i as D_i,calculating the average of Bi, recording as Si, if $f(i,j) - T_2 > S_2$, Marking this point as a noise point, assigning T_2 to $f(i,j)$.If $f(i,j) - T_2 \le S_2$, marking this point as signal point.

$$T_2 = \frac{1}{N}\sum_{m=1}^{3}\sum_{n=1}^{3} f(i,j); \quad \sigma < f(i,j) < 255-\sigma$$

In this expression,N is the count of the signal pixels of current point's 8-neighbor.

$$S_2 = |T_2 - f(i,j)| \quad \sigma < f(i,j) < 255 - \sigma$$

$$O(i,j) = \begin{cases} T_2 & \sigma < f(i,j) \; and \; f(i,j) - T_2 > S_2 \\ f(i,j) & \sigma < f(i,j) < 255 - \sigma \end{cases}$$

III. The experimental results and the analysis of performance

Selecting the Lena and Baboon images which size is 512×512, the filter window is 3×3. Filtering of the images which are polluted by different concentrations of salt and pepper noise. And compared with the filtering effect of the traditional median filter, morphological filter and extremum median filter. The experimental environment is: dual core CPU, clocked is 3.2GHz, memory is 4G, 32 bit PC, operating system is Win7.

Figure 1 and figure2 are the filtering effect of various algorithms in low density noise image,we can see that various algorithm can filter the noise well when the density of the noise is low.


original image of Lena


polluted by low density noise


median filtering


EMF


article2's algorithm


proposed algorithm

Figure1


original image of Baboon


polluted by low density noise


median filtering


EMF


article2's algorithm

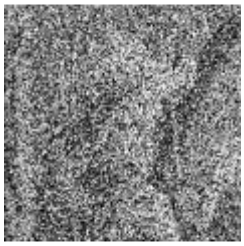

proposed algorithm

Figure2

Figure3 and figure4 are the filtering effect of various algorithms in high density noise image.We can see that, the traditional median filter has become very difficult to deal with the image filtering when the image is polluted by the high density noise, and the filtering effect is very poor. The filtering effect of the extremum median filter and the article[2]'s algorithm is better than the traditional median filter, but it is not able to completely remove the noise. And the algorithm of this paper is better than the other algorithms.


original image of Lena


polluted by high density noise


median filtering

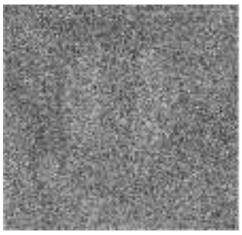

EMF


article2's algorithm


proposed algorithm

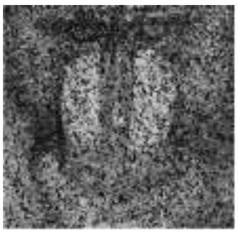
Figure3


original image of Baboon


polluted by high density noise


median filtering


EMF


article2's algorithm


proposed algorithm

Figure4

Objective to compare the performance of various algorithms, and the measure of the objective performance is the peak to noise ratio, which is defined as follows:

$$PSNR = 10 \times \lg \frac{255^2}{\frac{1}{KS}\sum_{m=1}^{K}\sum_{N=1}^{S}[i(m,n)-o(m,n)]^2}$$

The size of the image is $K \times S$, $i(m,n)$ is the input image, $o(m,n)$ is the output image. The greater the value of PSNR, the stronger the filtering ability. From Figure 5 and Figure 6, it can be seen that the PSNR value of proposed algorithm is the largest in the same noise density.

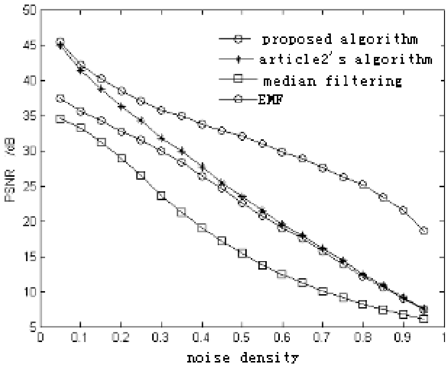


Figure5 PSNR values of various algorithms for Lena images under different noise densities

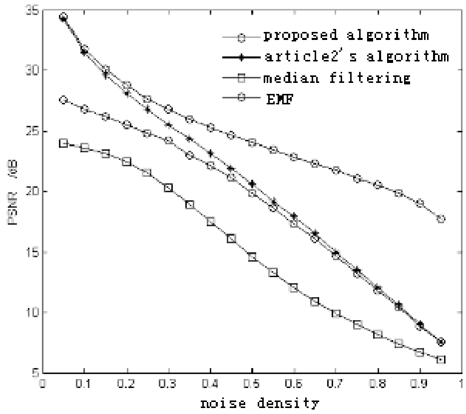


Figure6 PSNR values of various algorithms for Baboon images under different noise densities

IV. Summary

This paper proposes a new method to remove salt and pepper noise, has good filtering performance for images with different noise density after pollution. The algorithm can effectively reduce the operation time of the filter when the image details are ensured.

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