An improved median filter image denoising method

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Abstract

Denoising is an important link in image processing. Median filtering is an effective way to suppress the noise of the image. According to the salt and pepper noise is isolated and the gray value of extreme properties, First, OTSU is used to divide the noise gray range from the signal gray scale. Secondly, the traditional median filter is improved. Further experiments verify the application effect of the improved median filter denoising algorithm. Meanwhile, three denoising algorithms are compared with mean filtering, median filtering and adaptive median filtering, and the feasibility of the improved algorithm is explained from two aspects of subjective evaluation and objective evaluation.

Keywords

Image denoising, Median filter, OTSU.

1. Introduction

Generally speaking, the real images are noisy images, there is a certain degree of noise interference in any unprocessed original image. Before edge detection, image segmentation, feature extraction, pattern recognition and other high-level processing, it is a very important pre-processing step to select appropriate methods to remove noise interference as far as possible. Denoising has become an extremely important step in image processing.

Salt and pepper noise is a kind of common noise in image, and its classical filtering algorithm is median filter series algorithm[1]. For the standard median filtering algorithm, the size of the filter window directly affects the noise reduction ability and the detail retention ability of the algorithm, it is difficult to balance. In order to balance noise reduction and detail retention, scholars at home and abroad have proposed a series of improved algorithms based on standard median filter: (1) Adaptive median filtering[2], adaptively adjusting the size of the filtering window according to a preset condition, and adopting a standard median algorithm for noise pixels satisfying the condition. (2) Fuzzy median filter [3], respectively establishing a membership function for the noise point and the non-noise point according to the gradient of the pixel point, and setting the weight value of the pixels in the filtering window by using the function. (3) Center weighted median filter algorithm[4], setting different weights for each pixel point in the filtering window and adjusting according to the content. (4) Switch median filter[5], Based on noise pixel detection, the algorithm only filters the detected noise pixels.

According to the salt and pepper noise is isolated and the gray value of extreme properties, improved the traditional median filtering algorithm, combined with the Otsu method to the gray distribution of salt and pepper noise of segmentation, denoising method an improved median filtering algorithm to image is given.

2. Improved median filter image denoising method

It is assumed that the gray scale range of the black pepper noise is $[0,T_1]$, the gray scale of the white pepper noise is $[T_2,255]$, and the gray value range of normal signal point is $[T_1,T_2]$.The total number of pixels in the image is N, the number of pixels with a gray value of i is N_i, the corresponding probability is $P_i = \frac{N_i}{N}$, so the average gray level of the whole interval is $E = \sum_{i-0}^{255} i \bullet P_i$. Respectively, the mean value of the gray level in the corresponding gray interval of black pepper salt noise, normal signal point and white pepper salt noise is

$$E_1 = \frac{\sum_{i=0}^{T_1} i \bullet P_i}{P_1} \tag{1}$$

$$E_2 = \frac{\sum_{i=T_1}^{T_2} i \bullet P_i}{P_2} \tag{2}$$

$$E_3 = \frac{\sum_{i=T_2}^{255} i \bullet P_i}{P_3} \tag{3}$$

which $P_1 = \sum_{i=0}^{T_1} P_i, P_2 = \sum_{i=T_1}^{T_2} P_i, P_3 = \sum_{i=T_2}^{255} P_i$.

Defining evaluation function

$$\sigma^2(T_1, T_2) = (E_1 - E)^2 \bullet P_1 + (E_2 - E)^2 \bullet P_2 + (E_3 - E)^2 \bullet P_3 \tag{4}$$

The value of T_1 and T_2 corresponding to the maximum value $\sigma_{\max}$ is the obtained optimal global gray-level interval classification threshold.

We have now completed the determination of the gray range of salt and pepper noise, In other words, the gray value of the current pixel is within the range of the noise gray, and the pixel is likely to be a noise point. We need to further judge the pixel and then deal with it accordingly. The current pixel gray value is within the normal gray range, the pixel is almost impossible to be a noise point, we can regard it as a normal point and retain it.

At the same time, we also consider the influence of filter window size on filtering results. If the image is less polluted by noise, considering the inherent local consistency of the image, using the larger window can make full use of the original information of the image to reduce the influence of noise as much as possible. If the image is seriously polluted by noise, in order to reduce the effect of the noise point on the median value of the action window, a smaller size window should be adopted.

Further, we give the specific steps of improved median filter image denoising method:

Input a gray image with a size of $256*256$;

Getting the signal-to-noise ratio M of the input image, a signal-to-noise ratio threshold T has been given. If $M < T$, we adopt $5*5$ mask window. If $M > T$, we adopt $3*3$ mask window.

The gray interval of noise and normal points is divided by the OTSU method, and the interval of noise gray distribution is $[0, T_1]$ and $[T_2, 255]$.

Mark out the pixels in the window that are not in the two intervals $X_1, X_2, ..., X_k$, $k \neq 0$, and take the median $med(X_1, X_2, ..., X_k)$.

If the gray value of the center pixel of the window is in the range of $[0, T_1]$ or $[T_2, 255]$, and $|X_{ij} - med(X_1, X_2, ..., X_k)| > T_3$, X_{ij} is the gray value of the center pixel of the window , T_3 is a given gray value threshold to determine the abnormal noise point , the gray value of the center pixel is replaced by the median value.

If the gray value of the window pixel is within the interval of the noise gray level, that is k=0, find the median value of all pixels in the window $med(X_{i-1,j-1},...,X_{i+1,j+1})$,

and $\left|X_{ij} - med(X_{i-1,j-1},...,X_{i+1,j+1})\right| > T_3$, the gray value of the center pixel is replaced by the median value.

If neither of the above conditions is satisfied, output the primary value of the gray value of the pixel in the center of the window.

3. Experimental results and analysis

Image quality assessment methods are divided into subjective evaluation method and objective evaluation method [6, 7]. The subjective evaluation method is used to judge the quality of the image by the observer's score. It takes the subjective factors such as the human visual psychology into account. Objective evaluation is obtained by the method of mathematical calculation. The following two evaluation methods are used to evaluate the processing effect of the algorithm.

3.1 Subjective evaluation of denoising effect

In order to compare the advantages and disadvantages of the algorithm, this method is compared with the traditional mean filtering algorithm, median filter method and adaptive median filter algorithm. Given the images of salt and pepper noise with 10%, 20%, 30%, 40%, 45%, 50%, 55%, 60%, 70% degree of pollution. In this paper, we give three result graphs, see Fig. 1, Fig. 2, Fig. 3.

Fig.1 Processing results of 30% salt and pepper noise images with different algorithms.

Fig.2 Processing results of 50% salt and pepper noise images with different algorithms.

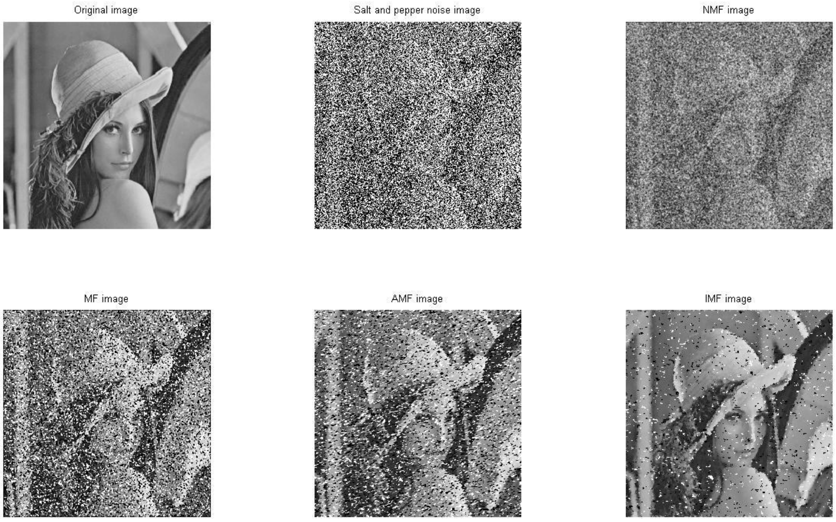

Fig.3 Processing results of 70% salt and pepper noise images with different algorithms.

Where the NMF denotes the mean filter image, the MF denotes the median filter image, the AMF denotes the mean filter image, the IMF denotes the mean filter image. From the image above, we can see that with the increase of salt and pepper noise concentration, the improved algorithm still has good anti-noise performance.

3.2 Objective evaluation of denoising effect

Image fidelity is typically measure with a peak signal - to - noise ratio (PSNR). The greater the peak signal to noise ratio is, the smaller the distortion is. The peak signal to noise ratio is defined as:

$$PSNR = 10 \times \lg \frac{255^2}{MSE} \tag{5}$$

Where mean square error (MSE) is defined as:

$$MSE = \frac{1}{MN} \sum_{0 \le i < M} \sum_{0 \le j < N} [f^{'}(i,j) - f(i,j)]^2 \tag{6}$$

Where $f^{'}(i,j)$ is a noisy image to be evaluated or a processed noisy image, $f(i,j)$ is a standard image without noise, M and N represent the length and width of the image, respectively.

Table 1 shows the quantization data of different methods for the denoising effect of Lena image, from which we can see that the algorithm in this paper is obviously better than other algorithms for noise of various densities.

Table 1 Denoising result of Image lena (PSNR)

Method	Salt & Pepper noise densities (%)								
	10	20	30	40	45	50	55	60	70
NMF	20.7	20.6	18.9	17.4	16.8	15.4	13.8	12.4	10.1
MF	23.9	20.9	20.5	19.0	17.1	16.2	15.7	15.1	14.3
AMF	34.5	29.8	23.9	19.4	18.5	17.3	15.8	14.4	11.4
IMF	43.1	40.0	37.8	35.6	34.4	34.0	32.7	31.7	29.8

4. Conclusion

Compared with the traditional method of median filtering, In this paper, using OTSU method to improve the traditional median filter not only has the advantage of automatically dividing the noise gray interval, but also the gray scale image contaminated by the pepper salt noise can be well processed, particularly when processing the image with severe contamination of the pepper salt noise, the algorithm displays the superiority of the image and has good practical value.

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