Mixed Wavelet and Median Filter for Image Denoising

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Abstract—**Image usually is corrupted by two or more different types noise simultaneously,the paper proposed a new mixture filter method. The proposed method first classsifies the pixels into two classes ,one is the pixels which are corrupted by impulse noise and the other is the pixels corrupted by Gauss noise.Then median filter is used for the pixels corrupted by impulse noise and wavelet threshold method filter is used for the pixels corrupted by Gauss noise. In order to eliminate pseudo-Gibbs phenomenon as a result of wavelet threshold method filter, wavelet transform based on translation invariant is presented in the image denoising. The simulation result verifies that the proposed method is feasible and efficient.**

Keywords-image noise; median filter; wavelet transform; translation invariant

I INTRODUCTION

Image often is corrupted by a variety of noise in the generation, transmission and recording process.Because of its serious impact on the visual image and its interpretation after,so the use of appropriate ways to reduce noise is a very important pre-processing steps.Image noise can be divided into Gaussian noise (white noise) and impulse noise according to the nature of noise. The median filter [1] and wavelet thresholding de-noising method [2] is commonly used in pre-processing.They have different noise characteristics of de-noising, such as median filtering algorithm is good for impulse noise de-noising,Gaussian noise of elimination is not good. In contrast, wavelet thresholding de-noising method has a good de-noising capability of Gaussian noise, impulse noise of elimination is not good.,and will produce pseudo-Gibbs phenomen. In the past few years, it has been working to improve the filtering algorithms, and have achieved tangible results.Such as the literature [3] ,the median filter was directly improved; the literature [4] ,the wavelet thresholding de-noising method was directly improved; the Literature [5] proposed a mean filter and median filter algorithm combining. However, the actual image processing, since image usually is corrupted by two or more different types noise simultaneously, therefore, a separate filter algorithm of de-noising can no achieve the best results. If we can find one way or another distinguish between impulse noise and Gaussian noise pollution pixels, and then elimination noise of different pixels noise pollution by use of different filter methods, in theory, would be a better filtering effect. Based on this, this article presents a different image denoising according to the nature of noise pollution.First, use of local threshold classified as pixels corrupted by Gaussian noise and impulse noise ,then use different filtering algorithm,followed by wavelet transform based on translation invariant algorithm, not only eliminate the impulse noise and Gaussian noise, but also eliminate pseudo-Gibbs phenomenon as a result of wavelet threshold method filter, achieve a better de-noising effect.

II THE SEPARATING NOISE POINTS

In this paper, set to take the threshold T_1,T_2 of the method to eliminate noise.Set $x(i,j)$ pixel value for the image, the pixels in the ordinary sense of the value of output $m(i,j)$.The definition of $l(i,j)=|x(i,j)-m(i,j)|$, that is, $x(i,j)$ and the output value of $m(i,j)$ the absolute difference between. $p1(i,j)$ and $p2(i,j)$ for the domain in the neighborhood and take $x(i,j)$ closest to the two points, so that $a=|p1(i,j-x(i,j)|$, $b=|p2(i,j)-x(i,j)|$, $v(i,j)=(a+b)/2$.Then, de-noising the rules are as follows:

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- If $l(i,j) \geq T_1$ and $v(i,j) \geq T_2$, the use of median filtering al gorithm;
- If $l(i,j) \geq T_1$ and $v(i,j) < T_2$, the use of wavelet thresholding de-noising algorithm;
- If $l(i,j) < T_1$, the use of wavelet thresholding de-noising algorithm.

T_1 threshold used to select the literature [6] to improve the MAD algorithm, this paper select the $T_1 = 2\times\hat{\sigma}_k$. Which, $\hat{\sigma}_k = 1.75\times N_k$, N_k=med ($|n_i|$, $i \in S_k$),S_k as shown in Figure 1. Threshold T_2 is mainly directed against the selected texture image similar in that there is only one line pixels wide, round, triangle, such as' single-pixel 'cases were subtle texture. T_2 values selected based on experience, is generally between 6 and 10 integers, the algorithm in this paper take $T_2 = 10$.

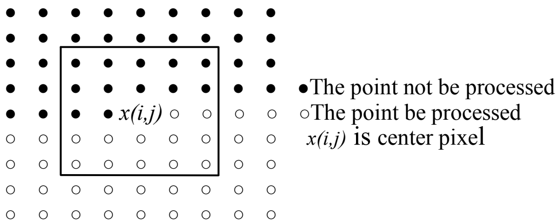

Figure 1 S_k (5 × 5 sliding window around the center pixels $x\ (i, j)$)

III MEDIAN FILTERING ALGORITHM ANALYSIS

Median filter (Median Filter, MF) is based on the statistical theory of a sort can effectively de-noising of non-linear signal processing technology. Median filter is the principle of digital image or digital sequences in the value of that point with the domain points in a neighborhood of the median value substitution. In the form of one-dimensional, the median filter is an odd-numbered points with the value of the sliding window, by sequencing, the window of the sequence of the mid-point value:

$$\{F_{i-k}, \cdots, F_{i-1}, F_i, F_{i+1}, \cdots F_{i+k}\}.$$

Where $k = (n-1)/2$, n for the window length, F_i is the mid-point value window of the median filter output, recorded as

$$G_i = \mathrm{Med}\{F_{i-k}, \cdots, F_i, \cdots F_{i+k}\},$$

Med (•) that take the value of the middle window.

The median filter window length $n = 2k + 1$, if the signal pulse width greater than or equal to k+1, the pulse after filtering will be retained; if the signal pulse width less than or equal to k, after filtering will be the elimination of the pulse. This is the median filter to eliminate impulse noise and to protect the details of the nature of signals.

The one-dimensional median filter theory extended to two-dimensional signal in the extinction, we have had a two-dimensional median filter. Median filter for image processing, first set up a filter window to be moved all over the image of the point, and then use the window of the original value instead of the median value of the center window.

IV TRANSLATION INVARIANT WAVELET THRESHOLDING DE-NOISING ALGORITHM ANALYSIS

A Wavelet De-noising Threshold Principle

Since the wavelet transform is a linear transformation, so noisy image $f(x+y) = s(x,y) + ke(x,y)$ for discrete wavelet transform, the wavelet coefficients $n(k)$ obtained by the two parts, part of the real signal $s(k)$ is the corresponding wavelet coefficients, note $u_{j,k}$,that the other part $n(k)$ is the noise wavelet coefficients corresponding recorded for $v_{j,k}$. Wavelet thresholding denoising method in the minimum mean square error (MSE) sense, to be effective, and has been made in a wide range of applications, the basic idea of this method is:

- with noise signal $f(x+y)$ for the wavelet transform, has been a group of wavelet coefficients $W_{j,k}$;
- $W_{j,k}$ carried out by thresholding, the wavelet coefficients $\hat{W}_{j,k}$ to be estimated, making $\left\|\hat{W}_{j,k} - u_{j,k}\right\|$ as small as possible;
- the use of $\hat{W}_{j,k}$ wavelet reconstruction, the estimated signal $\hat{f}(x+y)$, which is the signal after denoising.

The use of wavelet thresholding for image noise with de-noising is a research hotspot in recent years, various methods of threshold selection is also emerging. In 1992, Donoho and Johnstone proposed a wavelet shrinkage threshold method, given λ equivalent to $\sigma\sqrt{2\log(N)}$ threshold.For images, N for the length of signal, σ is the standard deviation of the noise signal. Bruce and Gao also proposed a soft-threshold and hard threshold methods, soft and hard threshold function shown in Figure 2.

$$\hat{W}_{j,k}=\begin{cases}\operatorname{sgn}(W_{j,k})(|W_{j,k}|-\lambda),|W_{j,k}|\geq\lambda\\0,|W_{j,k}|<\lambda\end{cases}\quad(1)$$

Hard threshold method:

$$\hat{W}_{j,k}=\begin{cases}W_{j,k},|W_{j,k}|\geq\lambda\\0,|W_{j,k}|<\lambda\end{cases}\quad(2)$$

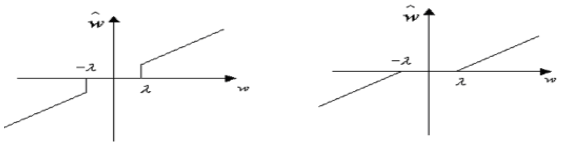

Figure 2 Hardware, soft-threshold comparison of the estimated wavelet coefficients

B.Translation Invariant Wavelet Denoising [7-8]

For a signal x_t *(*$0 \le t \le N$*)*, H_N *= (h:* $0 \le h < N$*)* with S_h that signal x to h of the time-domain shift, h is a positive integer, that is,

$$(s_{hx})_t = x(t+h) \bmod N$$

S_h is reversible, so that $S_{-h}=(S_h)^{-1}T$ that the signal de-noising threshold method to deal with, A check that the "average", the translation invariant wavelet denoising method can be expressed as:

$$\overline{T}(x,(s_h)_{h\in H_N}) = A_{h\in H_N} s_{-h}(T(s_h(x)))$$

This method not only effectively eliminate the phenomenon of pseudo-Gibbs, the map showed a better surface quality, but also more than the threshold value of the root-mean-square error of small to improve the signal to noise ratio.

C. Improved Wavelet Thresholding De-noising method

Combination of translation invariant law, in the threshold method based on wavelet de-noising method in this article that the translation is not based on the variable amplification factor, the steps are as follows:

- Of the original circle with noise signal translation, translation method as described above.
- Post-translational level wavelet decomposition of images of high-frequency coefficients and low-frequency coefficients to the appropriate amplification, as described above magnification.
- In the wavelet domain, the image of the wavelet coefficients thresholding operation: If the wavelet coefficient is greater than λ would be retained; if the wavelet coefficient is less than λ then,wavelet coefficients will be the home to zero.
- Of the image de-noising wavelet series decomposition of the image high-frequency and low frequency coefficients to reduce appropriate.
- Following the above treatment, the reconstruction of the wavelet coefficients can be de-noising image.
- After de-noising of the image circle back to pan, repeat the above steps.

Finally, after more than six steps to deal with images taken after the average, it has been the method of image de-noising. This is the translation of the proposed invariants based on the coefficient of amplification methods. Following the method used and some other method of image denoising simulation.

V.SIMULATION EXPERIMENTS AND RESULTS DISCUSSION

Used of $256\times256\times8bits$ lena image in the simulation, check the window 3×3 , MATLAB7.0 use images taken of the increase in noise filter, wavelet thresholding filter, as well as this paper, wavelet analysis of the new de-noising method of simulation.In order to compare simulation good or bad performance of the experiment can be de-noising images from MSE (dB) and peak signal to noise ratio (dB) to compare the size analysis. After de-noising in general from the smaller mean square error, peak signal to noise ratio the greater the effect of image de-noising, the better. Which is defined as: peak signal to noise ratio:

$$PSNR = 10\log\left(\frac{255^2 A^2}{MSE}\right)\quad(3)$$

Where $x(i,j)$ the noise is not in the position of the original image pixel value , $\hat{x}(i,j)$ for image de-noising in the location of the pixel value, A is the maximum. The size of the image size $M\times N$.

As shown below for a variety of methods to deal with the results of de-noising ($\sigma=0.04$). As can be seen from the Figure 3, using median filter, the image edge rather ambiguous in the use of wavelet thresholding de-noising can eliminate most of the noise, but it will not be continuous in some minor points of the oscillation, that is, pseudo-Gibbs phenomenon. In this paper, the application of the method of dealing with the results of edge clearer and more effective to eliminate the noise, better retention of edge details, such as (f) part of the hair did not result in image de-noising image blurring. Subjective visual image quality is also improved. It also proved the effectiveness of the method and superiority.

(a)Original image (b)Noise image (c)Medianfiltering

(d) Wavelet thresholding (e) Improved wavelet (f) Proposed mixed

Figure 3 Filtered outputs of the noise image of Lena

Table I lists the noise at different rates under different de-noising algorithm for the peak signal to noise ratio. Can be seen from Table I, from the point of view to improve the effectiveness of PSNR, and other circumstances of the proposed filtering algorithm is superior to the effect of wavelet thresholding algorithm and median filtering algorithm, particularly in the smooth Gaussian noise and impulse noise, including mixed significant noise. Overall, in terms of PSNR or visual effects of subjective and objective evaluation of this algorithm compared with the effect of several other algorithms there has been a marked improvement, not only able to eliminate the noise, also can be used to maintain the image edge details, and the algorithm is simple and easy to implement.

TABLE I. PSNR OF DIFFERENT DE-NOISING METHODS

Noise variance	Noise image	Median filtering	Wavelet thresholding	Improved thresholding	proposed thresholding
0.02	22.9937	24.5253	24.5674	26.4249	27.4383
0.03	13.6181	14.9511	14.6985	18.4727	20.3810
0.04	11.3310	12.5107	12.9435	16.2590	18.0719
0.05	7.8216	8.3878	9.5344	12.6303	14.0718

VI. CONCLUSION

This paper presents a new image de-noising method based median filtering and wavelet thresholding de-noising, this is more conducive to the elimination of image noise, image retention of useful information and effective as a result of the elimination of the threshold wavelet de-noising generated by the pseudo-Gibbs phenomena, through the above simulation method, we can see the effect of a better de-noising, image of the mean square error by the lower increase in peak signal to noise ratio is to remove the image contained in Gaussian and a mixture of impulse noise noise a more ideal way. After the DSP algorithm to achieve, will be applied to medical imaging X-ray real-time processing.

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