Image Noise Reduction Processing Research Based on Wavelet Transform Combination with Homomorphic Filtering

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ABSTRACT: The condition monitoring and fault diagnosis of has attracted more and more attention by the infrared technology. The image acquired infrared thermal imaging system is affected by some factors, which needs to be enhanced, so in order to deal with the low contrast and fuzzy human visual defect of the infrared image, The article deal with the image to get to low frequency and high frequency components by the wavelet transform, then the low frequency wavelet coefficients were disposed by homomorphic filtering, and the high frequency wavelet coefficients were enhanced by median filtering. Finally, the reconstructed infrared image with enhancement was obtained by using the inverse wavelet transform. The experimental results show that the meth-od performs well in increasing the image detailed information and improving the gray contrast. The results are consistent with the human visual properties.

KEYWORD: Wavelet transform; Homomorphic filtering; Median filtering; image enhance.

1 INTRODUCTION

Infrared thermal imaging technology has characteristics of the non-contact measurement, temperature measurement range, high sensitivity, intuitive, accurate, rapid and safe (S. bagacathiappan, 2007).But, Due to infrared image in the process of acquisition, restricted by various factors and the influence of factors and the influence of factors with the device itself, causing the infrared image has characteristics of low contrast, fuzzy visual effect, low resolution. Thus the infrared image enhancement technology has been widespread attention by increasing the contrast, to enhance the visual effect to improve the method of infrared image quality. Currently there is a histogram image enhancement method, image sharping, smoothing, wavelet transform, homomorphic filtering, fuzzy algorithm, the Retinex algorithm and so on. Although image enhancement algorithms are diversity, but there are still many deficiencies in resolving the image globally, locally, the contradiction between the noise and the calculation (R H Sherrir, 1987). Wavelet transform combined with other methods have been widely used in image enhancement. Literature (Li Yuguang, 2013) used wavelet transform to decomposes an image into low frequency, high frequency components, and high-frequency, low frequency were treated to achieve the purpose of image enhancement.

In this paper, a simulation experiment is carried out on the gray scale image. in order to better verify the algorithm in this paper, and to add to noise to the original image, then use the wavelet transform to decompose the image into low and high frequency components, and the low frequency component is improved by homomorphic filtering, the high frequency reduce noise processing by median filtering, finally, getting the enhanced image after wavelet reconstruction, which compared with the original image.

2 THE PRINCIPLE OF WAVELET TRANSFORM AND HOMOMORPHIC FILTERING

2.1 *The decomposition and reconstruction of Wavelet transform.*

The wavelet decomposition and reconstruction algorithm is proposed based on multi-resolution analysis theory, the proposed algorithm make wavelet to be a breakthrough and be widely sued at the emerging science of developed rapidly in recent years (Liu Gang. 2010). Infrared images are often used to describe two-dimensional signal $f(x, y)$. It is different with one-dimensional multi-resolution, there is a scaling function and three wavelet functions. For two dimensional signal $f(x, y)$ at the infrared image of 2^j resolution is:

$$A_j f = \left\langle f(x,y), \Phi_{j,n}(x)\Phi_{j,m}(y) \right\rangle;$$
$$D_j^1 f = \left\langle f(x,y), \Phi_{j,n}(x)\Psi_{j,m}(y) \right\rangle;$$
$$D_j^2 f = \left\langle f(x,y), \Psi_{j,n}(x)\Phi_{j,m}(y) \right\rangle;$$
$$D_j^3 f = \left\langle f(x,y), \Psi_{j,n}(x)\Psi_{j,m}(y) \right\rangle_{\circ} \tag{1}$$

Wherein j,n,m are an integer, Φ,Ψ is scaling function and wavelet function respectively. $A_j f, D_j^1 f, D_j^2 f, D_j^3 f$ are decomposed to four sub maps at 2^j resolution. $A_j f$ is an approximation of the original image, Also known as the low frequency part, represented by LL . $D_f^{\lambda} f, \lambda = 1,2,3$ represent such approximation error, the high frequency portion of the image. $D_j^1 f$ corresponds to the low frequency of the horizontal direction and the high frequency of the vertical direction, which is the horizontal edge information, represented by LH . $D_j^2 f$ corresponds to the high frequency of the horizontal direction and the low frequency of the vertical direction, which is the vertical edge information, represented by HL . $D_j^3 f$ corresponds to the high frequency of the horizontal direction and the high frequency of the vertical direction, which is the high frequency component of the diagonal direction, represented by HH . For LL can continue to break down, Figure 1 is a flowchart of a two-dimensional image decomposition.
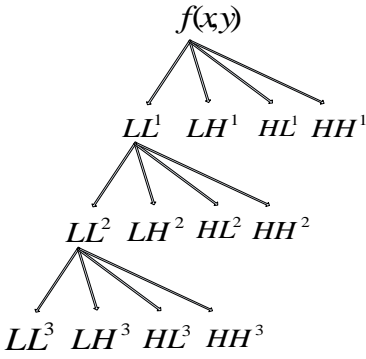

Figure 1. Three decomposition process tree of the two-dimensional

2.2 *The principle of homomorphic filtering*

Homomorphic filtering of image belongs to the frequency domain category of image processing. it is to adjust the gray scale of image. Eliminate the problem of image uneven lighting, the image is processed after homomorphic filtering, the image details is enhanced at its dark areas, without lose the image details at bright areas. It can use usually lighting function $f_i(x,y)$ and reflection function $f_r(x,y)$ to represent the infrared image $f(x,y)$:

$$f(x,y) = f_i(x,y)f_r(x,y)$$
$$0 < f_i(x,y) < \infty; 0 < f_r(x,y) < 1 \tag{2}$$

$f_i(x,y)$ descripts the illumination of image scene, regardless of the scene. $f_r(x,y)$ contains the details of scene, regardless of lighting. Homomorphic filtering flowchart shown in figure 2:
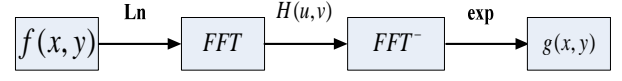

Figure 2. Homomorphic filtering flowchart

3 THE PROCESS OF ALGORITHM REALIZATION

Image is transformed by wavelet, getting a good multi-resolution frequency domain representation. Not only to maintain the spatial characteristic of the original image, and extract well low-frequency components and high frequency components. The low-frequency component represents the area of gray value changes smoothly of the gray image, which is the overall outline the image. Enhancing the low frequency component weight of high frequency information by homomorphic filtering. The high frequency component represents the area of gray value changes rapidly of the gray image, containing noise, edge, details and other information.so reducing noise for it by median filtering. Then the low frequency and high frequency component processed reconstructed to obtain processed image. The algorithm steps are as follows:

(1) The wavelet transform. Gray image decompose to obtain low frequency component and high frequency component by 3 layers of wavelet transform.

(2) High frequency component reduce noise by median filtering. it is a processing method of a nonlinear signal., therefore, the median filter is a nonlinear filter. Median filter not only remove noise of solitary point, but also maintain the edge characteristics of the image. Median filtering don't make a significant blur in the image. The image is decomposition after the wavelet, there are edges, noise and other letter in the high frequency component, so to remove the noise of high frequency by median filtering.

(3) The low frequency component is homomorphic filtering. The key to process the low frequency component of homomorphic filtering is the choice of filter function, which expression is as follows:

$$H(u,v) = (Hh - Hl) \times$$
$$\left[1 - \exp(-c\frac{D^2(u,v)}{D_0^2}\right] + Hl \tag{3}$$

In the formula, Hh, Hl is the high frequency gain and low frequency gain respectively.

$D(u,v) = \left[(u-u_0)^2 + (v-v_0)^2 \right]^{1/2}$ indicates the distance (u,v) and the center of the filter (u_0, v_0), D_0 is the distance from the origin to the frequency. That is cut-off frequency. in this paper, the choice of parameters, so that $Hh = 2$, $Hl = 0.5$ .because the choice of $Hh > 1, Hl < 1$ can reduce the low frequency and enhance the high frequency. Make dynamic range compress and contrast enhance (Sun Huixian. 2013). And select $c = 1.5, D_0 = 3.5$ by experimental verification.

(4) The reconstruction of the wavelet. The low frequency and high frequency component is processed by wavelet transform through the above, and perform inverse wavelet transform, getting the image processed. Flow chart shown in figure 3:
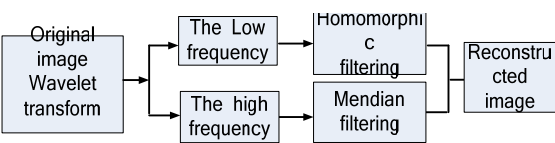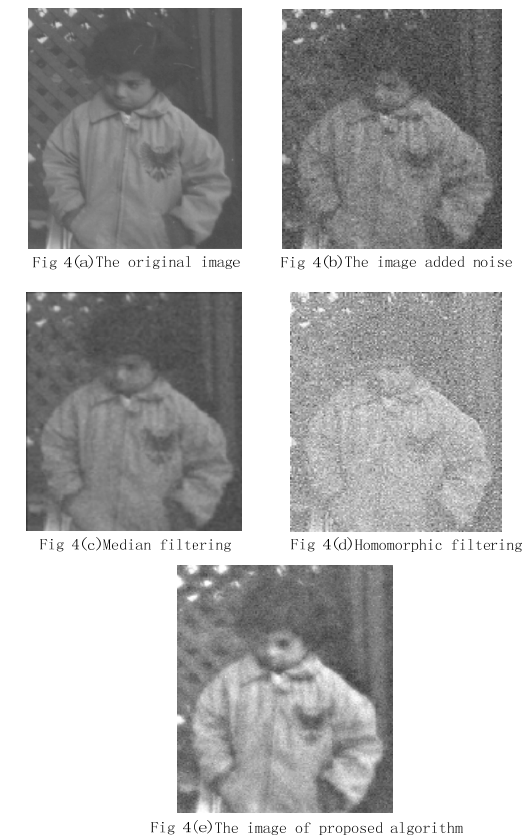

Figure 3 Flow chart of the algorithm

Fig 4(a)The original image

Fig 4(b)The image added noise

Fig 4(c)Median filtering

Fig 4(d)Homomorphic filtering

Fig 4(e)The image of proposed algorithm

Figure 4 the results of experiment

4 THE RESULTS AND ANALYSIS OF EXPERIMENTAL

In order to verify the effectiveness of the proposed method, use the MATLAB to simulate. As shown in figure 4. Figure 4(a) is the original image; figure 4(b) is the image of Gaussian noise added to the mean of 0 and variance of 0.003; figure 4(c) is only done after median filtering; figure 4(d) is the image by homomorphic filtering; figure4(e) is the image by the proposed algorithm. The conclude can be drawn by image contrast: although fig 4(c) have a good de-noise effect, but the image contrast is not obvious; fig 4(d) increase the brightness of image and make some of the details in the dark areas become apparent, but the effect of de-noise is not obvious; fig 4(e) not only increase the contrast of image, but also achieve a better effect of noise reduction.

The above is only qualitative analysis from the image, then in this paper, the simulation calculation is carried out, and the PSNR and the processing time are calculated respectively. The calculation results are shown in table 1, can be seen from the table1, the algorithm of the paper is compared with the traditional median filter and the homomorphic filtering, and the PSNR is improved by about 10 dB, but the time is relatively long.

Table 1. PNSR data and time data comparison in the experiment

Method	PSNR	t/ms
Median filter	21	14
Homomorphic filtering	23	12
Algorithm of the paper	12	17

5 CONCLUSIONS

In the paper, use median filtering to process noise of the image by the wavelet transform and homomorphic filtering, and compared with other methods. Experiment shows that the algorithm not only enhances the contrast of the image, but also highlights the task image area and to achieve good noise reduction, there is a wide range of application. The algorithm is superior to the single use of the method of homomorphic filtering and median filter in noise reduction processing. At the same time, it can meet the requirements of real-time display, and it has a good effect on infrared image enhancement.

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