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Methods and Realization based on Image Enhancement

Wenwen Liu
Department of Electronic Engineering
Tianjin University of Technology and Education
Tianjin, China

Jiming Ren
Department of Electronic Engineering
Tianjin University of Technology and Education
Tianjin, China

Xiaomin Wang
Department of Electronic Engineering
Tianjin University of Technology and Education
Tianjin, China

***Abstract*— The image enhancement is an important branch of the image processing, as well as the technical foundation of image edge extracting and image segmentation and so on. Image enhancement techniques are introduced in this paper, based on Matlab tools to complete the three kinds typical image enhancement algorithm based on image enhancement algorithm of histogram equalization, spatial filtering, image enhancement algorithm and frequency domain image enhancement algorithm, and gives the contrast before and after the processing image.**

Keywords*— Image enhancement; histogram; spatial domain enhancement; frequency domain enhancement

I. INTRODUCTION

Image enhancement processing technology is a very important and has been the basic image processing category in the field of image processing technology. Image enhancement is to highlight the image features which interested in or to inhibit some unwanted features in the image selectively by using some technical means. Image enhancement does not consider the reason for decline in image quality. It's only to highlight the image features which interested in or to inhibit some unwanted features in the image selectively. Its purpose mainly is to improve the image visual quality or highlight some characteristic information. Then, the processed image which is made for some particular application is more effective than the original images [1] [2].

In recent years, image enhancement technology gets fast development, which is inseparable with its wide application [3]. At present, the application of image enhancement processing has been infiltrated the medical diagnosis, aerospace, military reconnaissance, fingerprint identification, nondestructive flaw detection, the processing of satellite images, and other fields. For example, X-ray images, CT images, endoscope image are enhanced, which makes it easier for doctors to determine the lesion area and found the problem from the image detail area [4]. In coal mine industrial TV system uses the image enhancement processing to improve clarity of industrial TV. It overcomes the bad phenomenons (such as image blurring, deviation, and so on.) because of the insufficient light, dust and other reasons. And it reduces the TV system maintenance workload [5]. Developing force image enhancement technology is from new applications of stable emergence. We can expect, image enhancement technology will play a more important role in the future society.

II. METHODS OF IMAGE ENHANCEMENT

According to the different scopes of enhance, the image enhancement method can be divided into space domain and frequency domain to enhance two kinds. Spatial domain enhancement is a direct operation on the gray level of image pixels. The frequency domain enhancement is to use the image transform method to transform the original image space to other space in some form. Then, using the special properties of the space and convenient to deal with the image. Finally, the image is converted back to the original image space, so as to get the processed image. Enhancement methods tend to be targeted to improve the results of the evaluation only by man's subjective feeling [6]. So the image enhancement method can only be used selectively. This paper mainly studies three kinds of typical image enhancement algorithms, such as image enhancement algorithm based on histogram equalization, spatial filtering, image enhancement algorithm and frequency domain image enhancement algorithm.

A. Histogram equalization

Gray-level histogram reflects the relationship between each gray level and its frequency in digital image. It can describe the overview of the image. By modifying the method of histogram to enhance image is a practical and effective processing technology. Histogram modification methods have two kinds, including histogram equalization and histogram specification.

Histogram equalization is a method that the original image through some transformation to get a new image of a grayscale histogram uniform distribution [7] [8]. Histogram equalization algorithm is one of the most commonly used and important algorithms in image enhancement method of spatial domain. It based on probability theory, using the gray scale operation to realize the histogram transformation, so as to achieve the purpose of image enhancement. These methods

based on principles of image fidelity, they are to selectively highlight some information which man or machine analysis is interested in and to inhibit useless information by strengthening treatment. Then it makes valuable by improving the image [9] [10]. In practice, we should use different methods of image enhancement or use the appropriate several enhancement algorithms at the same time when different images are aimed at. Though above experiments, we choose an image algorithm that has good visual effect, simple calculation, and to accord with the requirements of the application.

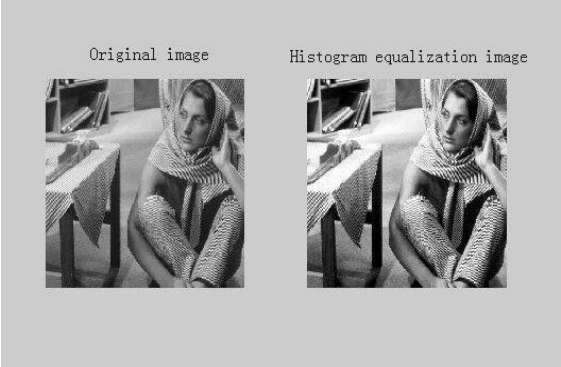

Fig. 1. The original image and the image after histogram equalization

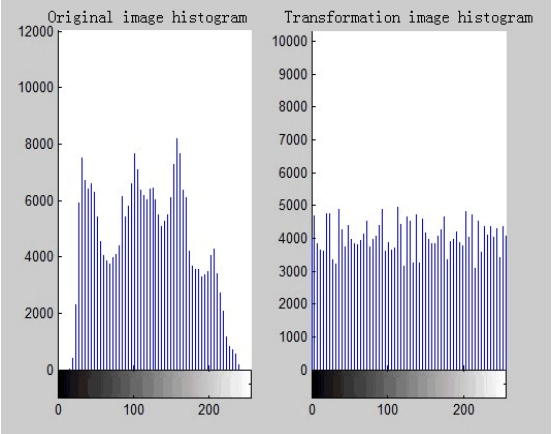

Fig.2. The gray histogram of the original image and the transform image

The gray level distribution can be transformed and changed to improve image quality. One method called histogram equalization processing. Histogram equalization processing is histogram correction method based on cumulative distribution function transformation method. Assume the transformation function is

$$s = T(r) = \int_0^r P_r(w)dw$$

where, ω is integral variables, and $T(r)$ is the cumulative distribution function of r. Here, the cumulative distribution function is a function of r and monotonously increased from 0 to 1. So the transformation function $T(r)$ satisfies single value increasing monotonously within $0< r <1$. Proving that, it can produce the image of uniform probability density of grayscale distribution with the cumulative distribution function of r as the transformation function. The results extend the dynamic range of the pixel values. Usually, the image enhancement technique for uniform histogram is called histogram equalization processing or histogram linearization. Cumulative distribution function with the discrete form is

$$s_k = T(r) = \sum_{j=0}^{k} \frac{n_j}{n}, k = 0,1,2,\cdots,l-1$$

As shown in figure 1, histogram equalizated image more highlight certain information than the original image. Figure 2 show gray histogram of the original image and the image after transformation.

B. Spatial domain enhancement

Spatial domain enhancement includs smooth spatial filter, sharpening spatial filter [11]. Smooth spatial filter including the linear filter (the mean filtering) and statistical sorting filter. Statistical sorting filter is a nonlinear spatial filter. Its response is that pixels of image filter surrounded the image region are sorted. Then value determined by statistical sorting result instead of the center pixel value. The most common example is the median filter.

Linear smoothing (mean filtering) is the gray value of each pixel replaced with its neighborhood value [12]. The neighborhood size is N×N, and N takes an odd number. Through linear smoothing filter, it is equivalent to the image after a two dimensional low pass filter. Although reducing the noise, but also blurs the image edge and details at the same time. This is the common fault of this kind of filter.

Median filtering means that the all the pixel gray level of a point (X×Y) as the center in small window, according to from big to small order, the median value as the gray level values. If there is an even number of pixels in the window, then take an average of two intermediate number as the gray level values. Median filter is a kind of typical low pass filter in the spatial domain. Its purpose is to protect the image edge while removing noise.

Median filter have good denoising ability, and its fuzzy degree is much lower than the small size of the linear smoothing filter. The window of the median filter can take square, circular, cross, etc.

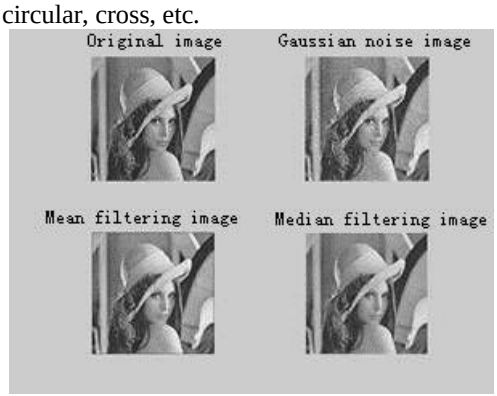

Fig.3. Results with gaussian noise , mean filtering and median filtering

As shown in figure 3, the original image is joined the gaussian noise, then the images obtained by the 3×3 mean filter and with 3×3 median filter. Thought two pictures compared, the effect of median filter is better than mean filter's. In figure 4, the image is the original image, adding impulse noise, by the 3×3 median filtering and by 3×3 median filtering in turn.

Sharpening processing main purpose is to highlight the details in the image or enhanced details of being blurred. The

sort of fuzzy is not due to wrong operation, but is the inherent influence of special image acquisition method. In figure 5, the image is the original image using laplacian operator sharpening and perwitt template sharpening respectively.

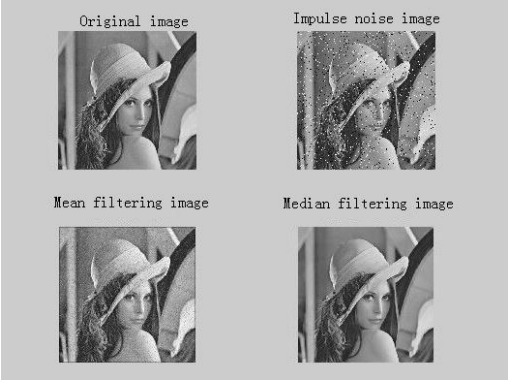

Fig.4. Results with impulse noise , by mean filtering and median filtering

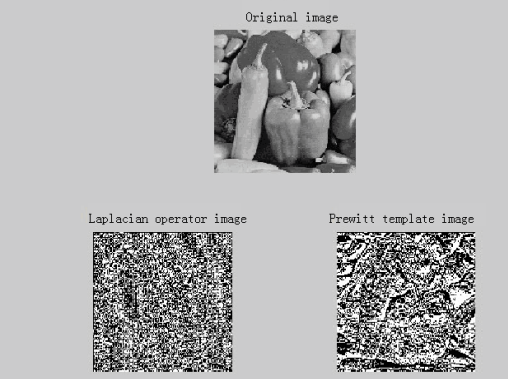

Fig.5. Laplacian operator sharpening and perwitt template sharpening

C. *Frequency domain to enhance*

Frequency method is a transform domain in the image to modify transformated coefficient (such as Fourier transform coefficients, DCT transform coefficients). Then the image is operated and inverse transformated to get processed image [13]. The frequency domain enhancement method is introduced in detail.

Frequency domain enhance is to use the transformation method that the original image of image space in some form transformat to other space. It is simple to deal with image by using the special properties of the space. Finally, it backs to the original image space and to obtain the processed image [14].

III. FREQUENCY DOMAIN ENHANCEMENT TYPES

A. *Low pass filter enhancement*

The noise mainly concentrated in the high frequency part in the process of image transmission. In order to get rid of the noise and to improve image quality, the filter $H(u, v)$ uses low-pass filter to suppress the high frequency components and to pass the low frequency components. Then proceeding inverse Fourier transform for the filtering image can achieve the purpose of smooth image. In the Fourier transform domain, transform coefficient can reflect the characteristics of some of the image, such as spectrum dc component corresponding to the image of the average brightness, noise corresponding to the area of high frequency, and so on. So frequency domain is often used for image enhancement. Tectonic low-pass filter in image enhancement can pass the low frequency component and block high frequency component effectively, namely filtering the noise in this area. By the convolution theorem, low-pass filter mathematical expression is

$$G(u,v) = F(u,v)H(u,v)$$

$F(u, v)$ is original image Fourier transform domain containing noises. $H(u, v)$ is the transfer function. $G(u, v)$ output image Fourier transform after low pass filtering. Assume that the noise and signal components in frequency can be separated, and noise distribute high frequency component. H filter filters the high frequency component and passes the low frequency information.

B. *High-pass filter enhancement*

The details of the image correspond to its frequency of high frequency component, so high-pass filtering can do sharpen the image processing. The high-pass filter and the low-pass filter are on the contrary. It makes the high frequency component passed and the low frequency weakened.

The edge and details of the image mainly locate in the high frequency part. Due to the high frequency component is weak, Image fuzzy comes into being. Sharpening the image processing is to eliminate fuzzy and highlight the edge through high-pass filter. So let the high frequency component pass by high-pass filter and make the low frequency component, then get the edge sharpening the image through the inverse Fourier transform.

C. *Homomorphic filtering enhancement*

In general, the edge of image and noise correspond to the high frequency component of Fourier transform. Low frequency component mainly determine image display in the smooth area overall grayscale. So the image by low-pass filtering smaller some sharp detail than the original image. Also, by high-pass filtering image will reduce some of the changes of grayscale and highlight the details in the image smooth area. In order to enhance image details at the same time try to retain the image of low frequency component, using the homomorphic filtering method can keep image appearance at the same time, enhance image details. Homomorphic filtering process diagram is shown in figure 6.

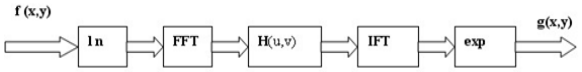

Fig.6. Homomorphic filtering process diagram

D. *Frequency domain enhance instance*

Butterworth low-pass filter can be implemented on a low pass filter in physics. Due to noise, light or others reasons make that the image quality is not high. In order to improve the visual effect or to facilitate people and machine on the analysis understanding of image, its need to enhance the image generally. But the process is not a unified standard. Image enhancement is generally cannot increase the original image information, only for some imaging conditions to stand out the weak signal and make it easier for some information. Buterworth low-pass filter suppress the noise, at the same time, image edge fuzzy degree decrease greatly and no ringing effect. Based on the above characteristics, Buterworth low-pass filter can separate the low frequency component and high frequency component. After equilibrium low frequency

component, two parts are fused to achieve image enhancement.

Butterworth low-pass filter transfer function of an order for n, chopping frequency for D_0 is

$$H(u,v) = \frac{1}{1+\left[\frac{D(u,v)}{D_0}\right]^{2n}}$$

Butterworth low-pass filter section diagram order of 1 is shown in figure 7. The figure shows low-pass butterworth filter is relatively smooth in the transition between high and low frequency. So the ringing effect of the butterworth filter output figure is not obvious. The resulting image is obtained by using a low-pass butterworth filter in figure 8.

In general, cut-off frequency is often to *H* maximize drops a certain percentage ing frequency. In the above type, when *D* (*u*, *v*) = D_0, *H* (*u*, *v*) = 0.5 (to 50%). The value of another cut-off frequency is popular the frequency which H drops to half of the maximum correspond.

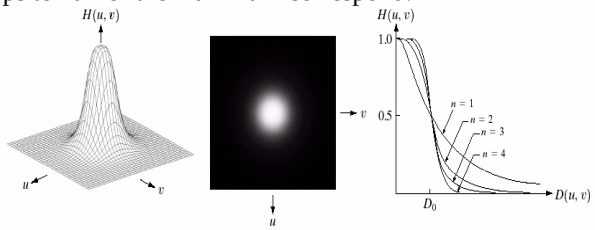

Fig.7. Diagrammatic cross-section of Butterworth low-pass filter transfer function

Fig.8. Image passed low-pass butterworth filter

IV. CONCLUSION

Image enhancement can be divided into spatial domain and frequency domain methodby using methods from the technology. The representative algorithms in spatial domain exist average filtering and median filtering (which is in the middle of the field of local pixels). They can be used to remove or reduce noise. In general, the effect of median filtering is better than the median filter. Frequency domain method sees the image as a two-dimensional signal, and conduct signal enhancement based on the two-dimensional Fourier transform. Using low pass filter method make the interference noise figure weaken.And the order of Using the high-pass filtering method is to enhance the high frequency signal (such as the edge) and the fuzzy image becomes clear.

Image processing involves optics, microelectronics, information science, statistics, mathematics, computer science and other fields, and is a comprehensive strong cross discipline. Among it, the development of any subject will promote the further development of image processing. Along with the rapid development of the computer technology and artificial intelligence and visual psychological research and processor hardware upgrade continuously in recent years, the image processing is to a higher and deeper development. Hence, the long-term development of the image enhancement technology, its applications requirements have been more and more widely.

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