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A NOVEL CONTRAST ENHANCEMENT METHOD BY ARBITRARILY SHAPED WAVELET TRANSFORM THROUGH HISTOGRAM EQUALIZATION

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ABSTRACT

This paper proposes a scheme for arbitrarily shaped wavelet transform based on a generalization of histogram equalization (HE).The proposed method reduces the extreme level changes. This method applies pixel filling to each pixel in non enhanced area of the image by mean levels of surrounding pixels and extract the image using some morphological operations. It decomposes the image with wavelet transform and constructs differential operator using fractional difference equation, then obtains the enhanced image through computing with wavelet coefficients. Apply histogram equalization for the smoothening of an image. And it equalizes the wavelet coefficients. Through the variation of one or two parameters, the resulting process can produce a range of degrees of contrast enhancement.

KEYWORDS

Contrast Enhancement, Histogram Equalization, Wavelet Transform, Fractional differential theory.

I. INTRODUCTION

Contrast enhancement techniques are widely used in image processing. This method is to improve the contrast and visual effects of the image. [1]. This method should make wavelet decomposition of the image and get the coefficients. Then use the appropriate method to adjust the wavelet coefficients in the image and make an inverse wavelet transform to get the enhanced image. This Proposal will deal mainly with the performance study and analysis of image enhancement by arbitrarily shaped wavelet transforms through histogram equalization. In addition with arbitrarily shaped wavelet transform; further applying linear weights for both smooth and edge regions will be tried to improve the performance of images in comparison with the other image enhancement techniques.

Contrast enhancement is one of the useful methods to enhance the features of the images in digital image processing. It is achieved by improving the entire brightness range in the given image. Currently, enhancing the image using this method has a limitation. It stretches the histogram of gray levels. This may occur level changes after applying the image contrasts. That is, the adjacent pixels have a large range of difference, so wavelet coefficients are very large and the level change is large. When the image contrasts are enhanced by this method, an extreme level change may be occurred in the image. This level change grows in the vicinity of the edge .The pixel value contained in the edge changes extremely. Due to this extreme change, the characteristic of the image is lost. That is, the pixel values are scaled-out. Therefore, specialized algorithms have been tried to solve image enhancement problem.

II. CONTRAST ENHANCEMENT BY WAVELET TRANSFORM

Contrast enhancement method by wavelet transform is described below. It may occur level changes after applying the image contrasts. That is, the adjacent pixels have a large range of difference, so wavelet coefficients are very large and the level change is large. The image which is level shifted is resolved eight times by using the wavelet method. Applying this wavelet transform we get high frequency domains and low frequency domains. In this method we apply a linear weight only to high frequency domains, and thereby increasing the image contrasts. Applying inverse transforms eight times to restore the image.

Here, calculating method of weight to enhance the contrast as follows.

$$\alpha(j) = \frac{1}{7}(1 - \alpha_0 j) + (8\alpha_0 - 1) \tag{1}$$

Contrast enhancement method of wavelet transform is as follows.

A mean level of the image is shifted to the center of the gray scale image. From the ratio of the scale-out, the linear weight is calculated. The minimum value of the weight is always 1 and the maximum value of the weight is calculated value and it changes linearly. The image which is level shifted is resolved eight times by using the wavelet method. Now we get the low frequency domains and high frequency domains. Then enhance high frequency domain of the image by applying the linear weight. Applying inverse transform eight times to restore the image.

III. WAVELET BASED HISTOGRAM EQUALIZATION

Histogram techniques provide many methods for modifying the contrast and dynamic range of an image by reassign the intensity of the pixels through a monotonically increasing function. The output image shows a similar histogram to a given target distribution. One of the popular methods used here is local histogram equalization, in which the mapping function for each pixel is generated by accumulating the histogram of the region surrounding the target pixel.

Suppose a grayscale image has discrete intensity values $I_0, I_1, \ldots I_{L-1}$ of in the range [0, 1]. Let n_i denote the number of pixels taking the value I_i. The approximate pixel intensity transformation formula g for HE is given by

$$g(I_i) = \frac{1}{n}\sum_{k=0}^{i} n_k \tag{2}$$

where

$$n = \sum_{k=0}^{L-1} n_k$$

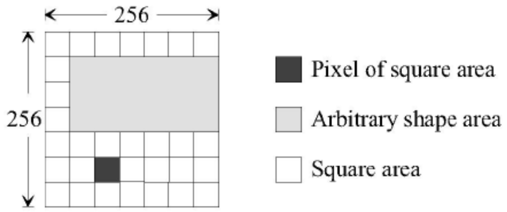
The histogram includes the little information about the pixel characteristics related to contrast gain and informs the probabilistic distribution of intensity levels. It amplifies the contrast for every pixel. From the viewpoint of image enhancement, increasing the occurrence of an intensity level means increasing the contrast gain of that intensity level. Local histogram equalization is used in various fields and it is the most well-known local methods. It uses the histogram of the local region as a contrast gain function.

IV.CONTRAST ENHANCEMENT BY ASWT THROUGH HISTOGRAM EQUALIZATION

A. Arbitrarily shaped wavelet transform (ASWT)

Figure 1 shows the example of arbitrarily shaped wavelet transform. The procedure of the proposal method is described as follows.

FIGURE 1: INSERTION IN SQUARE AREA



Let us suppose that a square area is 256x256 pixels. Arbitrarily shaped area is inserted in the square area of a certain size. The pixel value of the square area in which the area is not inserted is 0. The wavelet transform is done to the given square area. The transformed area is then extracted from the square area.

FIGURE 2: OUTLINE OF THE MODIFIED METHOD

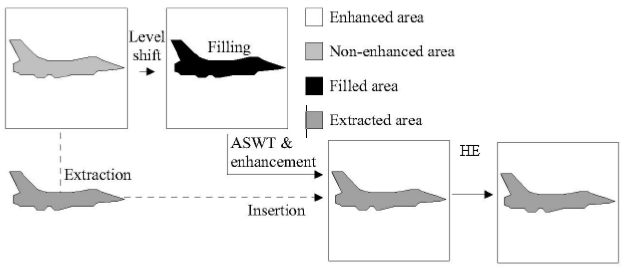
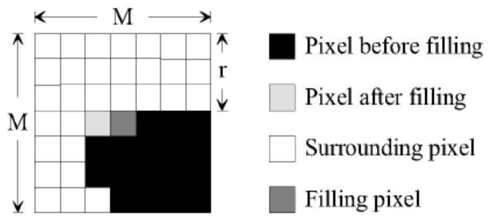


FIGURE 3: REFERENCE BLOCK



B. Procedure of. Contrast enhancement by ASWT

Figure 2 shows the outline of a modified contrast enhancement method by ASWT through histogram equalization. Non-enhanced area is extracted from the source image, and filled in pixel value X. Mean levels V of the enhanced area is shifted to the center of the gray scale. The image is resolved by using the wavelet transform. Set the minimum threshold value. Based on this minimum threshold value adjust the wavelet coefficients of the high frequency domains. The image is composed eight times by using inverse wavelet transform after high frequency domain is enhanced. Then apply the Histogram Equalization to improve the performance of the image. The area that is extracted at the beginning is inserted in non-emphasis area of the image that is composed again.

C. Pixels filling method

Figure 3 shows a reference block when filling in each pixel of non-enhanced area. The method that fills in non-enhanced area is described as follows. All pixels of non-enhanced area are filled at the same value. Pixel filling is set regardless of the surrounding pixel. The pixel in the non-enhanced area is filled by the mean value of level of the filled pixel and the surrounding pixel. The filling order is from the left to the right and from the top to the bottom in non-emphasis area

V.FRACTIONAL DIFFERENTIAL ANALYSIS OF AN IMAGE

A. Differential Operation of Signal

The Fourier transform of s'(t) of any square integrable signal $s(t)\in L2(R)$ is:

$$Ds(t)\overset{FT}{\Leftrightarrow}(\hat{D}s)(w)=(iw)\bullet s(\hat{w})=d(\hat{w})s(\hat{w})$$

(3)

Similarly available, the Fourier transform of its v order fractional differential is:

$$D^{v}s(t)=D^{v}s(t)=\frac{d^{v}s(t)}{dt^{v}}\overset{FT}{\Leftrightarrow}(\hat{D}_{v}s)(w)=$$

$$(iw)^{v}\bullet\hat{s}(w)=d_{v}(\hat{w})s(\hat{w}),v\in R^{+}$$

(4)

And v order differential operator D v = D v is the multiplicative operators of d^ (w) = (iw) v, and its complex exponential form and time domain form are:

$$\hat{d}(w)=(iw)^{v}=\hat{a}_{v}(w)\bullet\exp(i\theta_{v}(w))=\hat{a}(w)\bullet\hat{p}_{v}(w)$$

$$\hat{a}_{v}(w)=|w|^{v},\hat{\theta}(w)=\frac{v\pi}{2}\operatorname{sgn}(w)$$

(5)

$$\hat{d}_v(t) = a_v(t) * p_v(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty}(iw)^v \bullet e^{iwt}dw \qquad (6)$$

$$a_v(t) = \int_{-\infty}^{+\infty} a(w)\bullet e^{iwt}dw = \frac{1}{\pi}\int_{-\infty}^{+\infty} |w|^v \bullet \cos(iwt)dw \qquad (7)$$

$$p_v(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty}\hat{p}_v(w)\bullet e^{iwt}dw =$$

$$\cos\frac{v\pi}{2}\bullet\delta(t) - \sin\frac{v\pi}{2}\bullet\frac{1}{\pi t} \qquad (8)$$

From (5), the fractional differential physical sense can be understood as AM and PM, and the amplitude is fractional exponent with frequency changes, and the phase is the Hilbert transform of frequency [11].
From (6) to (8), the filter function of Fractional differential filter is:

$$\hat{d}_v(w) = (iw)^v = |w|^v \bullet \exp(i\theta_v(w)) \qquad (9)$$

Its amplitude characteristics are dual function, and phase characteristics are odd function. So we can only study the filter characteristics when w>0 [12].
The conclusion is that integer-order differential enhancement in high frequency components of signals is greater than the fractional differential and weakening in very low frequency components of signals is also stronger than the fractional differential. For fractional differential, when 0<*v*<1 and *w*>1, intermediate frequency of signals is also strengthened the same as high frequency, when 0<*w*<1, very low frequency of signals is non-linear attenuation and the attenuation is obviously smaller than the former. So this is the explanation that fractional differential is more conducive to the image enhancement.

B. Fractional Differential Difference Equations
Fractional calculus G-L equation is defined as a continuous function from the study of classical integer-order derivative definition, and the calculus of order and the dimensional are inferring from the integral extended to the fraction. The equation

$${}_a^G D_t^v = \lim_{h\to 0}\frac{1}{h^v}\sum_{m=0}^{\frac{t-1}{h}}(-1)^m\frac{\Gamma(v+1)}{m!\Gamma(v-m+1)}f(t-mh) \qquad (10)$$

And the Gamma function is:

$$\Gamma(n) = \int_0^{\infty} e^{-t}t^{n-1}dt = (n-1)! \qquad (11)$$

Then gets fractional differential difference expression:

$$\frac{d^v f(t)}{dt^v} \approx f(t) + (-v)f(t-1) + \frac{(-v)(-v+1)}{2}f(t-2) + \ldots + \frac{\Gamma(-v+1)}{n!\Gamma(-v+n+1)}f(t-n) \qquad (12)$$

Based on (12), we can write the right side of the equation:

$$a_0 = 1, a_1 = -v, a_2 = \frac{(-v)(-v+1)}{2}$$
$$a_3 = \frac{(-v)(-v+1)(-v+2)}{6}\ldots$$
$$a_n = \frac{\Gamma(-v+1)}{n!\Gamma(-v+n+1)} \qquad (13)$$

C. Construction of Fractional Differential Operator
The adjacent coefficients of low frequency keep the regional relevance. The operators of low frequency as in figure 4.

FIGURE 4: OPERATOR OF LOW FREQUENCY

a_1	a_1	a_1
a_1	8 x a_0	a_1
a_1	a_1	a_1

High frequency sub-band coefficients contain the details of the image and edge components, and high frequency sub-band coefficients distribution has a clearly directional feature. So the vertical sub-band coefficients of the vertical direction generally towards the relevance of the region, and the horizontal sub-band coefficients of the horizontal direction generally towards the relevance of the region, and diagonal sub-band coefficients of the diagonal direction generally towards the region correlation. The operators of high frequency are as in figure 5.

FIGURE 5: OPERATOR OF HIGH FREQUENCY

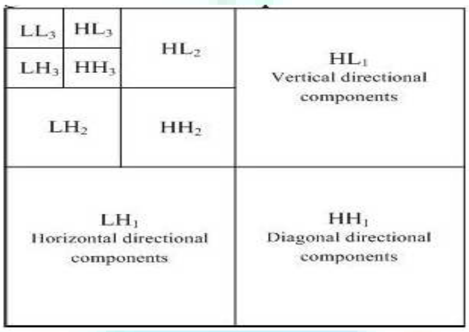
0	a_0	0
0	$2a_1$	0
0	a_0	0

0	0	0
a_0	$2a_1$	a_0
0	0	0

a_0	0	a_0
0	$4a_1$	0
a_0	0	a_0

VI.WAVELET DECOMPOSITION USING FRACTIONAL DIFFERENTIAL OPERATOR

FIGURE 6: WAVELET DECOMPOSITION OF THE IMAGE



The method of wavelet decomposition is described as follows. The low frequency components and high frequency components can be obtained after the decomposition of the wavelet transform of the image. The different frequency components we obtained through the wavelet decomposition are LL_k and HL_k. LL_k is the low frequency components, HL_k is the vertical high frequency components, LH_k is the horizontal frequency components and HH_k is the diagonal frequency components where k is the wavelet decomposition level.

The high frequency sub-band coefficients contain the details of the image and edge components. The lower sub-band or the low frequency components contain more information about the image. So we decompose the lower sub-band again and again up to the k levels. By doing this, we get the low frequency sub-band coefficients and we set a minimum threshold value. Then adjust the higher sub-band frequency coefficients linearly with the minimum threshold value to enhance the image. When doing the fractional differential operation to the signal, the low frequency components will be also improved. The image texture details will become clearer through the fractional differential operation. After the wavelet decomposition, to construct a differential operator using fractional difference equation, then obtain the enhanced image through computing with wavelet coefficients. Making convolution operation between low frequency sub-band component and the low frequency sub-band differential operator to get the low frequency sub-band component. Then making convolution operation between high frequency sub-band component and the high frequency sub-band differential operator to get the high frequency sub-band component. Then making the inverse transforms to get the enhanced image. Therefore, the higher layers of wavelet decomposition, the more texture and detail obtained by image decomposition, and the better image enhancement obtained by making differential operator.

VII.COMPARATIVE ANALYSIS

For comparison, we have applied the ASWT technique on the Jet test image in Fig. 7. It can be found that image sharpening effect is markedly enhanced, and edge information and local details are also strengthened with the differential order increasing. The image enhancement effect of wavelet transform is obvious, but poor image smoothness whereas the proposed method which is wavelet transforms using fractional differential is good and smooth effect. The different levels of wavelet decomposition, fractional differential image enhancement effect is different. The higher level of image decomposition, image enhancement and texture after the local details more clear, the image brightness significantly increased at the same time.

VIII. RESULT AND DISCUSSION

In this paper, we have proposed a new image enhancement method by arbitrarily shaped wavelet transform through histogram equalization to enhance the features of the image. In brief, our algorithm uniquely applies arbitrarily shaped wavelet transform using fractional differential operator to enhance the image, and subsequently, histogram equalization is used to improve the performance of the image and preserve the edges very well. Both phases contain tunable parameters that can be adjusted to obtain sharp and smooth regions, which may yield good contrast of the image. Experimental results show that image enhancement algorithm based on fractional differential of the regional characteristics of the wavelet coefficients is good.

FIGURE 7: ORIGINAL IMAGE

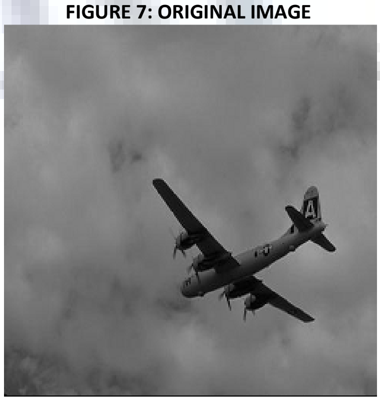


FIGURE 8: AFTER ASWT

FIGURE 9: AFTER EQUALIZATION

IX.CONCLUSION

This paper presents a new proposed algorithm in detail. The performance is found to be better, this new method is easy to implement and has an optimum execution time. Our method provides a more accurate statistical model for analysis, a fast implementation algorithm, and better image enhancement performance. As a result here the noise can be reduced significantly and thus we will obtain an enhanced image.

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