Enhancement of Infrared Image with the Use of Logarithm and Entropy Functions in the Frequency Domain

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Abstract— Homomorphic enhancement could eliminate the Influence of uneven illumination in frequency domain algorithm. It could be made the dynamic range of image to compress and Expanded the gray level image of the interested target and Enhanced image detail; the top-hat and bot-hat can smooth the Outline of the image in spatial domain. According to the background and the target exist on the problem of poor contrast In the infrared image. This paper presents a hybrid algorithm to enhance the image. It is use of the Gauss filter processing to enhance image details in the frequency domain and smooth the contours of the image by the top-hat and bot-hat transforms in spatial domain. Through the hybrid algorithm to enhanced the infrared image. Not only enhanced the infrared image of the details, but the outline of the image has also been smooth. Finally, the enhanced image is better than other algorithm of results.

Index Terms— Homomorphic enhancement, Filtering, Infrared Image Processing, Mathematical Morphology, Dilation, Erosion, Top-hat transforms.

I. INTRODUCTION

Till now, all the domains in which we have analyzed a signal, we analyze it with respect to time. But in frequency domain we don't analyze signal with respect to time, but with respect of frequency[3]. Enhancing an image provides better contrast and a more detailed image as compare to non enhanced image. Image enhancement has very applications. It is used to enhance medical images, images captured in remote sensing, images from satellite etc.

The transformation function has been given below

$$s = T(r)$$

where r is the pixels of the input image and s is the pixels of the output image. T is a transformation function that maps each value of r to each value of s. There are two methods of enhancing contrast. The first one is called Histogram stretching that increase contrast. The second one is called Histogram equalization[7] that enhance contrast and it has been discussed in this paper and results are shown in terms of histogram equalization. Many attempts have been made so far to improve the performance of Histogram Equalization[10]. Most of the existing automatic enhancement techniques make use of global intensity transforms, either for color correction (white balancing) or contrast enhancement. For these global intensity transforms, the mapping of color or intensity is one-to-one and is independent of pixel location or scene context.

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II. METHODOLOGY

a. Logarithm of image

The purpose of the logarithm is to eliminate the influence of non-illumination without loss of image detail**.** In this paper this function applied twice to get the original image without any loss.

$$f1(x,y)=\log f(x,y)$$

b. Gamma correction

Processed image is not clear, so original image is processed by gamma correction.

$$t(x,y)=cf1(x,y)$$

c. FFT of image

In view of the infrared image difference between gray values are very small. The outline of the image information is concentrated in low frequency, and he image detail is mainly concentrated in high frequency. It is easily to separate them from the image by Fast Fourier Transformation.

$$Z(u,v) = F(t(x,y))$$

d. Filter Function

According to the traditional algorithm process, the response function of Gauss filter had improved. New algorithm could enhance image detail and outline. Because the gray value of the infrared image is low, the offset corrections have to change by the function of homomorphic filter. It will make the image more clearly.

$$\boldsymbol{H(u,v) = (r_H - r_L)\left[1 - e^{-c\left(\frac{D}{D_0{}^2}\right)}\right] + (r_H + r_L)/d}$$

Where r_h is regulation parameter to change high frequency. $r_l$is regulation parameter to change low frequency.

$$D(u,v) = u^2 + v^2$$

D_0 is harmonic coefficient

$$D_0 = ((max - \mu)^2 + (min - \mu)^2) / a$$

Where max defines the image of the maximum pixel value, and min image minimum pixel value; µ is average value of all the gray value; a is adjustment parameter for D_0.

$$G(u,v) = Z(u,v)\ H(u,v)$$

e. Inverse Fast Fourier Transform

After multiplying image with the filter function we take the inverse transform to convert image in spatial domain.

$$G(x,y) = F^{-1}(G(u,v))$$

The above steps can be shown as the operational structure of the technique which includes the source file and then the implementation of the technique.

The operational structure of the technique is shown below:

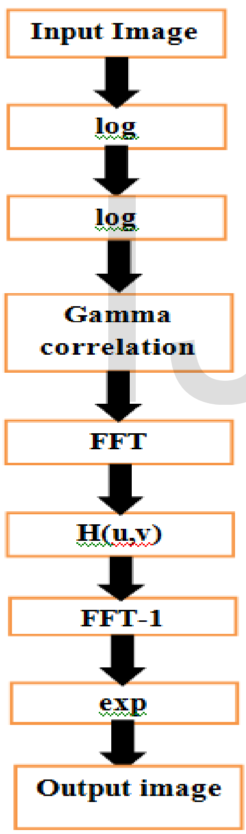


Figure1: Structure of the technique

III. TECHNIQUES USED IN IMAGE ENHANCEMENT

1. Homomorphic filtering

Homomorphic filtering [4] is a generalized technique for signal and image processing, involving a nonlinear mapping to a different domain in which linear filter techniques are applied, followed by mapping back to the original domain. Homomorphic filter is sometimes used for image enhancement. It simultaneously normalizes the brightness across an image and increases contrast. Here homomorphic filtering is used to eliminate multiplicative noise. Illumination and reflectance are not separable, but their approximate locations in the frequency domain may be located. Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain. Illumination variations can be thought of as a multiplicative noise, and can be reduced by filtering in the log domain.

To make the illumination of an image more even, the high-frequency components are increased and low-frequency components are decreased, because the high-frequency components are assumed to represent mostly the reflectance in the scene (the amount of light reflected off the object in the scene), whereas the low-frequency components are assumed to represent mostly the illumination in the scene. That is, high-pass filtering is used to suppress low frequencies and amplify high frequencies, in the log-intensity domain.

2. Mathematical Morphology Enhancement

Preview:

Mathematical Morphology– as a tool for extracting image components, that is useful in the representation and description of region shape.

The language of mathematical morphology is – Set theory.

Unified and powerful approach to numerous image processing problem.

It is a methodology of nonlinear filters, the basic morphological operations which stem from minkowski set operations are dilation and erosion. It was made of the algebra operator of the morphology.

Four basic operations of morphology enhancement are

- dilation
- corrosion
- open operation

- closed operation.

1. Dilation

Dilation is one of the basic operations in mathematical morphology. Originally developed for binary images, it has been expanded first to gray scale images, and then to complete lattices, the dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image.

2. Erosion

Erosion is one of two fundamental operations (the other being dilation) in morphological image processing from which all other morphological operations are based. It was originally defined for binary images, later being extended to gray scale images, and subsequently to complete lattices Erosion is used for shrinking of element A by using element B.

3. Opening operation

In mathematical morphology, opening is the dilation of the erosion of a set A by a structuring element B.

4. Closing operation

In mathematical morphology, the closing of a set (binary image) A by a structuring element B is the erosion of the dilation of that set.

Also, **Top-hat transforms** In mathematical morphology and digital image processing, top-hat transform is an operation that extracts small elements and details from given images. There exist two types of top-hat transform: The white top-hat transform is defined as the difference between the input image and its opening by some structuring element; The black top-hat transform is defined dually as the difference between the closing and the input image. Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others.

$$TOPHAT(f) = f - (f.g) = f - (f\Theta g)\oplus g$$

where f is to enhance infrared image; g is structure elements.

The **Bot-hat transforms** can be implemented as

$$BOTHAT(f) = (f \bullet g) - f = ((f \oplus g)\Theta g) - f$$

Where f is to enhance infrared image; g is structure elements; The Bot-hat transform achieved by close operation in the mathematical morphology. But Bot-hat and Top-hat is the opposite. Its function is used to fill in the empty, connected similar objects. It is easily to smooth the border, but it will not be change their area. Combined the top-hat transform and bot-hat transform is necessary to enhance infrared image.

IV. IMPLEMENTATION

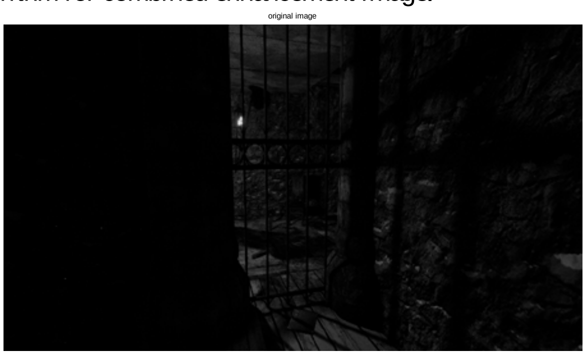
In this paper, in order to enhance the contrast and the smooth outline information, the paper combined the two algorithms. The new algorithm makes image detail more evident and has the outline more clearly. Because of the Top-hat transformations could enhance image aspect and strengthened of the image noise too. To reduce of the noise, this paper perform homomorphic filter for infrared image with the logarithm function, because it not only required getting enhanced image details, but also reducing the noise. And the original image information can be retailed. Then we have used the mathematical morphology transformations to improve the infrared image details and chart also gets the equivalent smooth for the same image.

Table 1: Observations

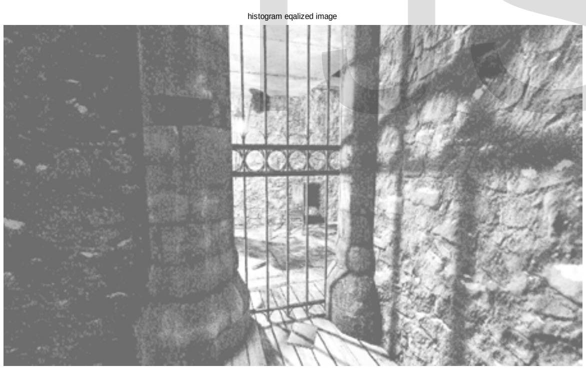
Algorithm	Entropy	PSNR
Original image	5.06	-
Histogram equalization algorithm	4.7624	5.819
Traditional of homomorphic enhancement algorithm	6.663	23.885
Improved Homomorphic enhancement algorithm	4.7776	22.358
Mathematical Morphology Enhancement	6.5584	22.362

V. RESULT

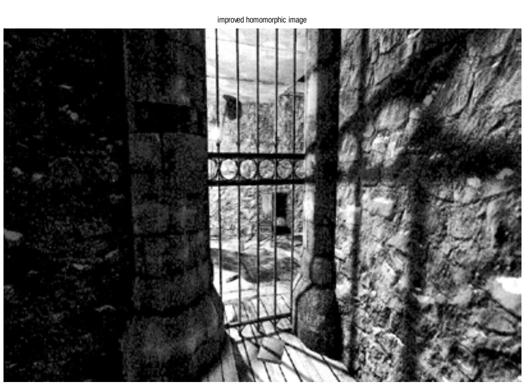
Graph (a) original infrared image, the image of background and target are dark. And the graph (b) is only use of the traditional histogram equalization algorithm. It will make the infrared image brighter and detail blurred. The graph (c) clearly expressed is that improved of the traditional homomorphic enhancement algorithm by some researchers'. Although the effect is relatively clear, the information of image had lost. The graph (d) represents the algorithm for combined enhancement image.



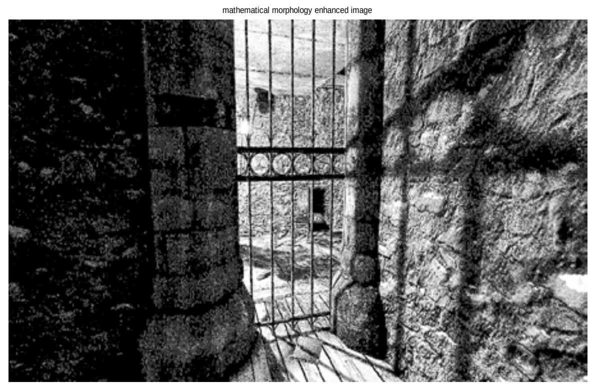
a: Original Image



b: Histogram equalization image



c: Improved homomorphic image



d: Image after mathematical morphology enhancement

VI. CONCLUSION

Improved technique is used in infrared image enhancement processing to get all the features of that particular image. The progress of technique used for the image enhancement has been shown in the results. We have used MATLAB as a simulation tools so that we can get the desired results and this results are more efficient as compared to traditional image enhancement techniques. Observation table is also shown of the results along with suitable diagram. Homomorphic enhancement algorithm as much as possible to retain the original image information and enhanced the details of the image in the frequency domain. Compared with the traditional histogram equalization algorithm, this algorithm is better. The innovation point is based on the γcorrection of the homomorphic filtering enhancements in the frequency domain and the mathematical morphology in spatial to enhance. Numerous different image experiment of outcome proves this algorithm realized good effect for infrared image.

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