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A Comprehensive Study of Image Enhancement Techniques along with Histogram Techniques

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ABSTRACT: THE MAIN GOAL OF IMAGE IMPROVEMENT IS TO PROCESS AN IMAGE IN SUCH A WAY SO THAT RESULT IS BETTER THAN ORIGINAL IMAGE FOR SPECIFIC APPLICATION. APPROPRIATE CHOICE OF SUCH WAYS OF DOING THINGS IS GREATLY INFLUENCED BY THE IMAGING (WAY OF DOING SOMETHING/WAY THAT SOMETHING HAPPENS), JOB AT HAND AND VIEWING CONDITIONS. THIS PAPER WILL PROVIDE AN OVERVIEW OF HIDDEN IDEAS ALONG WITH SETS OF COMPUTER INSTRUCTIONS COMMONLY USED FOR IMAGE IMPROVEMENT. THE PAPER FOCUSES ON SPATIAL DOMAIN TECHNIQUES ALONG WITH REFERENCE OF HISTOGRAM PROCESS TECHNIQUES.

Keywords: Gray Scale Manipulation, Image Enhancement, Digital Image Processing, Histogram Equalization.

1. INTRODUCTION

The main purpose of image enhancement is to improve the explicability or understanding of information in images for viewers or to provide 'better' input for other image processing techniques.[1].It enhance the important features, hidden information and discard the unimportant features. Numerous techniques are available for the process of image enhancement. These are spatial domain techniques And Frequency domain techniques the term *spatial domain* is related to the image plane itself (i.e. the natural image) and includes the direct manipulation of pixels. Spatial domain includes point processing and mask processing. *Frequency domain* processing techniques are based on modification of the Fourier transform of an image. In frequency domain method firstly the Fourier transform is taken and then to get the resultant image the inverse Fourier transform is done. This paper mainly focuses on spatial domain techniques.

2. SPATIAL DOMAIN TECHNIQUES

This technique refers to the computation of pixels forming an image and operates directly on pixels [2]. These techniques are denoted by the expression given below

Where

$$g(x, y) = TC f(x, y)D \quad (1)$$

$f(x, y)$ is the input image, $g(x, y)$ is the output image or the resultant image or the processed image. T denotes an operator on f which is defined over some neighborhood of (x, y) .

The image enhancement techniques include gray-level transformation functions. The values of pixels, before and after processing are denoted by r and s respectively. These values are related by an expression

$$s=T(r) \quad (2)$$

Where T relates to a transformation which maps a pixel value r into a pixel value s .

2.1 Image Negatives

The simplest operation in digital image processing includes the computation of the negative of an image. The gray value of pixels is inverted to get the negative of an image.

For reference, if image of size $R \times C$, where R denotes no. of rows and C denotes no. of columns, is represented by $I(r, c)$. The negative $N(r, c)$ of image $I(r, c)$ can be calculated as $N(r, c) = 255 - I(r, c)$ where $0 \leq r \leq R$ and $0 \leq c \leq C$ (2)

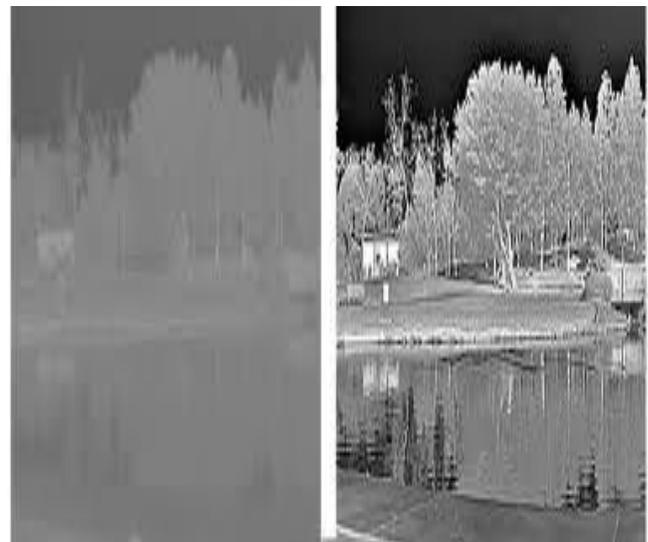


Figure 1: shows the effect of image enhancement.

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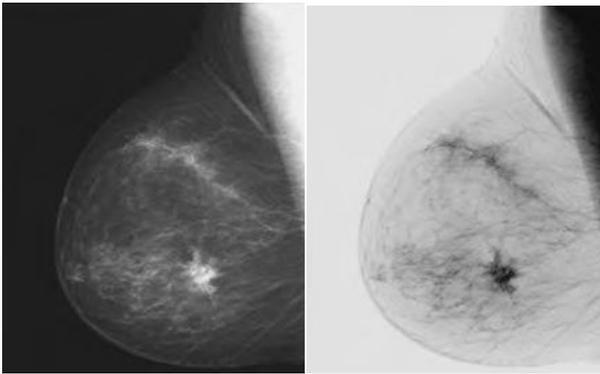


Figure 2: Shows the effect of negative image enhancement

It shows that negative of an image can be calculated by subtracting every pixel of original image from 255. Negative images [3] can be used in various biomedical applications for enhancing white or grey detail which is hidden in dark regions of an image.

2.2 LOGARITHMIC TRANSFORMATIONS

The basic form of the log transformation is

$$s = c * \log (1 + r) \quad (3)$$

It maps [4] a narrow range of low input grey level values into a wider range of output grey level values. The opposite transformation is performed by the inverse log transformation. These functions are used mainly when the input grey level values have large range of values. In the example shown below the Fourier transform of an image is performed through a log transform to extract more detail.

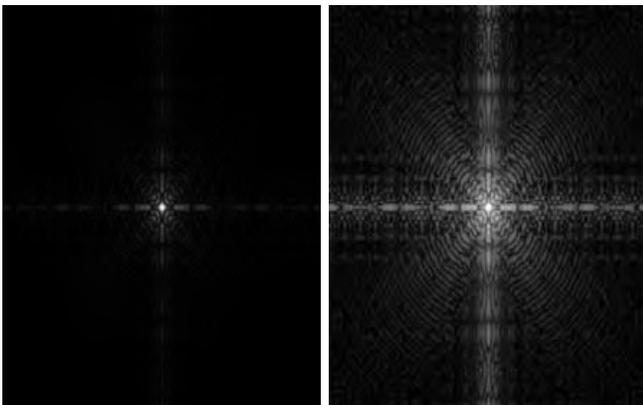


Figure 3: Effect of logarithmic transformation

a. POWER-LAW TRANSFORMATIONS

The basic form of power law transformation is given by the expression

$$s = cr^\gamma \quad (4)$$

The gamma transformation function is also known as *gamma* correction [5]. By varying the values of γ the different levels of enhancements can be obtained. Unlike the log function, a family of possible transformation curves can be obtained simply by varying γ . Gamma correction can be used for

general-purpose contrast manipulation. Figure shows an example of a magnetic resonance image of an upper thoracic human spine having a fracture dislocation. The given image is an expansion of gray levels to 0.3 enhanced a more detail but began to reduce. As shown below the best results in terms of contrast and discernable detail was obtained with $\gamma=0.4$.

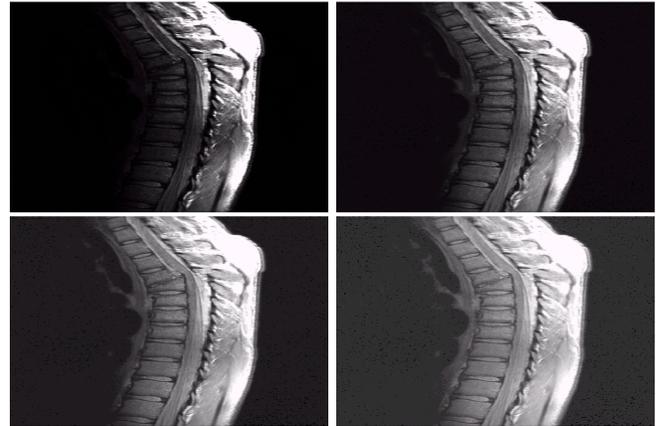


Figure 4; Effect of power law transformation

This fig shows the effects of applying various transformation with $\gamma=0.6, 0.4$ and 0.3 respectively.

3. HISTOGRAM EQUALIZATION

Histogram equalization [6] is a common technique used to enhance the appearance of images. If an image which is predominantly dark, then its histogram would be warp towards the lower end of the grey scale and the image detail is compressed into the dark end of the histogram. If it could stretch out' the grey levels at the dark end to generate a more evenly distributed histogram then the image would become clearer.

For a given image X, the probability density function P(Xk) is defined as

$$P (Xk) = nk / n \quad (5)$$

For $k=0,1,\dots,L-1$, where nk represents the number of times the level Xk appears in the input image X and „n“ defines the total number of samples in the input image[7] [8].

Based on the PDF, the CDF is defined as

$$\sum_{j=0}^{k-1} P(Xj) \quad \text{Where } Xk= X, \text{ for } k=0,1,\dots,L-1. \quad (6)$$

$C (xL-1) = 1$ by definition.

Using the CDF, define a transform function f(x) as

$$f(x) = X0 + (XL-1-X0)C(x) \quad (7)$$

Then the output image $Y=\{ Y(i,j) \}$, can be given as

$$Y=f(X) \quad (4) = \{f(X(i,j)) \mid \forall X(i,j) \in X\} \quad (8)$$

3.1 Brightness Preserving Bi-Histogram Equalization (BBHE)

It divides the image histogram into two parts. The separation intensity is given by the input mean brightness value, which is the average intensity of all pixels that forms the input image

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[7]. After this process, these two histograms are equalized individually. By this, the mean brightness of the resultant image will fall between the input mean and the middle gray level.

3.2 Dualistic Sub-Image Histogram Equalization (DSIHE)

It disintegrates the original image into two sub-images. After that, it equalizes the histograms of the sub-images separately [9]. Instead of disintegrating the image based on its mean gray level, The input image is disintegrate into two sub-images, one being dark and other as bright, showing the equal area property. This method shows that the brightness of the output image out produced by the DSIHE method is the mean of the equal area level of the image I_n and the middle gray level of the image, i.e., $L/2$.

a. Minimum Mean Brightness Error Bi-HE Method (MMBEBHE)

This method follows the same approach of disintegrating an image and applying the HE method to equalize the resulting sub-images separately [10][11]. The main difference is that MMBEBHE searches for a threshold level that disintegrate the image I_n into two sub-images $I_n [0, l_t]$ and $I_n [l_t + 1, L - 1]$, such that the minimum brightness difference between the input image and the output image is obtained, which is known as absolute mean brightness error (AMBE),

$AMBE = |E(X) - E(Y)|$ X and Y defines the input and output image, respectively.

Lower AMBE predicts that the brightness is better preserved. Once the input image is disintegrated by the threshold level l_t , each of the two sub-images $I [0, l_t]$, and $I [l_t + 1, L - 1]$ has its histogram equalized by the HE process, obtaining the output image. MMBEBHE is formally defined by the following procedures: (1) Firstly, calculate AMBE for each of the possible threshold levels. (2) Then, find the threshold level, X_T that obtains minimum AMBE. (3) After that, separate the input histogram into two parts based on the X_T found in Step 2 and equalizes them separately as in BBHE method.

b. Recursive Mean-Separate HE Method (RMSHE)

RMSHE is an advanced version of the BBHE method. The design of BBHE shows that performing mean-separation before the equalization process preserves an image's original brightness [8]. In RMSHE instead of disintegrating the image only once, it performs image disintegration repeatedly to preserve the original brightness up to scale r . As r increases, the brightness of the output image is better preserved.

c. Mean brightness preserving histogram equalization (MBPHE)

This method basically consists of two main groups, which are bisections MBPHE, and multi-sections MBPHE. Bisections MBPHE group is the simplest group of MBPHE [10]. Bisections MBPHE can preserve the mean brightness only to a

certain extent. However, some cases require higher degree of preservation to avoid undesired artifacts. Bisections MBPHE can preserve the original mean brightness only when the input histogram has a quasi-symmetrical distribution around its separating point. But in most of the cases input histograms do not have this property. It leads to the failure of bisections MBPHE in conserving the mean intensity in real life applications.

Multi-sections MBPHE group have better mean brightness preservation property as compared with the bisections MBPHE. In multi-sections MBPHE, the input histogram is divided into R sub-histograms, where R is any positive integer value which is then equalized separately. The cr sub-histograms can be created recursively by using the mean or median intensity value or based on the shape of the input histogram itself. Although in these methods, the detection of the separating point's process generally requires complex algorithms, which requires more computational time. Also, these methods raise the hardware requirement for consumer electronic products. Most of these methods also forces too much constrain on keeping the mean intensity value. As a result, most of these methods are not suitable for enhancement.

d. Dynamic Histogram Equalization

This technique performs the enhancement of an image without making any loss of details in it. DHE divides the input histogram into number of sub-histograms such that no dominating portion is present in the newly created sub-histograms. After that each new sub histogram is allotted with a dynamic gray level. This gray level can be mapped by HE [9] by allocating total available dynamic range of gray levels within the sub-histograms based on their dynamic range values in input image and cumulative distribution (CDF) of histogram values. This prevents small features of image from being dominated and washed out, and ensures a moderate contrast enhancement. Finally a separate transformation function, for each sub-histogram is calculated based on the traditional HE method and gray levels of input image are mapped to the output image accordingly.

e. Brightness Preserving Dynamic Histogram Equalization

This method is an extension to both MPHEBP and DHE [10]. This method divides the histogram based on the local maxima of the smoothed histogram. Before the histogram equalization taking place, the method maps each separation to a new dynamic range which is similar to DHE. The final step of this method involves the normalization of the output intensity as the change in the dynamic range causes changes in the mean brightness. Therefore the mean intensity of the resultant image will be similar to its input. BPDHE produces better enhancement as compared with MPHEBP. Also it is better for preserving the mean brightness as compared with DHE.

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4. CONCLUSION

This paper is based on the study of image enhancement techniques. Also it shows reference of histogram techniques that can be used for the process of image enhancement. In this paper we have studied about power law transformation technique in which the enhancement process is based on the value of gamma parameter. The variation in the value of gamma parameter is done manually but this can be made automatic also. These types of enhancement process can be used for the enhancement of aerial images. Also from the study of Histogram Equalization based methods it can be shown that there are many cases which will require higher brightness preservation. These are not handled well by HE, BBHE and DSIHE. MMBEHE method is an extension of the BBHE method which provides maximal brightness preservation. Although these methods are good for contrast enhancement, but they can cause annoying side effects depending on the variation of gray level distribution. DHE method is free from any type of side effects. BPDHE is used to preserve the mean brightness.

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