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Comparative Study of Spatial Domain Image Enhancement Techniques

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Abstract – Image Enhancement is one of the most important and difficult techniques in image research. The aim of image enhancement is to improve the visual appearance of an image, or to provide a "better transform representation for future automated image processing. Many images like medical images, satellite images, aerial images and even real life photographs suffer from poor contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in medical images detection and analysis is Image Enhancement techniques which improves the quality (clarity) of images for human.

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1. INTRODUCTION

Digital images play a important role in daily life applications. The main objective of image enhancement is to provide details that are hidden in an image, or to increase the contrast in a low contrast image. Image enhancement produces an output image that looks better than the original image by changing the pixel's intensity of the input image. Image enhancement is the process of improving appearance or quality of a given image so that the result is more suitable than the original image for a specific application. It sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis.

The data value of input images will suffer from various kinds of Contaminations. These Contaminations (noise) mostly in the form of external interferences like atmospheric disturbances; imperfect instruments will cause perturbations to the system. These perturbations can produce wrong information in the system operation. The random disturbances in the images are shown as noise and are often caused by malfunctioning pixels in camera sensors, or during transmission through a noisy channel. Image enhancement can effectively reduce the noise and make the image smooth. Many techniques have been developed known as image enhancement techniques to recover the information from an image like Contrast Stretching, Histogram Equalization, Image Negative, Log Transformation, and Thresholding.

II. ENHANCEMENT TECHNIQUES

Enhancement approaches are used to improve the quality of images for specific applications and a lot of effort is put in designing efficient rules towards the development of these approaches. Enhancement approaches are so varied that it's approaches and hence the approaches of interest are described as follows:

IMAGE NEGATIVE

Negative transformations are particularly suitable for Enhancing gray details within the black regions. The negative transformation of an image is obtained by reversing the intensity values; that is, deducting the intensity value of every individual with the maximum value in the original image. in which gray level values of the pixels in an image are inverted to get its negative image. Negative images are useful for enhancing white or gray detail embedded in dark regions of an image.

For example, if the image of size M x N, where M represents number of rows and N represents the number of columns, is represented by input image(M,N).the negative image(M,N) of input image(M,N) can be computed as:

$$\text{Negative image}(i, j) = 255 - \text{input image}(i, j) \ldots\ldots (1)$$

Where $0 \leq i \leq M$ and $0 \leq j \leq N$.

LOG TRANSFORMATION

The log transformation has the important characteristic that it compresses the dynamic range of image with large variations in intensity values. It narrows the range of low input grey level values into wider range of output values. The Log Transformation can be described by the following equation:

$$s=c*\log(1+r)\ldots\ldots(2)$$

Where c is a constant and it is assumed that $r\geq 0$.

THRESHOLDING

In Thresholding one threshold level is set and pixel values below threshold level are set as 0 and pixel values above that threshold level are set as 255. Thresholding is also used to filter the output or input to other operators.

If A (i,j)<T then B (i,j)=0;
Else B(i,j)=255;

Where T is the threshold level and A, B are input and output image matrices.

HISTOGRAM EQUALIZATION

Histogram Equalization is a technique that generates a gray map which changes the histogram of an image and redistributing all pixels values to be as close as possible to a user –specified desired histogram. HE allows for areas of lower local contrast to gain a higher contrast. Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram. Histogram equalization is a method in image processing of contrast adjustment using the image histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram.

Let **f** be a given image represented as a matrix of integer pixel intensities ranging from 0 to L-1. L is the total number of possible intensity values, often 256. Let p denote the normalized histogram of **f.**

$$Pn = \frac{\text{Number of pixels with intensity n}}{\text{Total no of pixels}} \ldots(3)$$

Where $n = 0, 1, 2, \ldots, n-1$

$f_{i,j}$

$$g(i,j) = \text{floor}\{(L-1)\sum_{n=0} Pn\}\ldots\ldots\ldots(4)$$

Where floor(x) rounds to the greatest integer less or equal.

CONTRAST STRETCHING

The technique Contrast stretching is mainly used for improving images by stretching the range of intensity values it contains to utilize the possible values. Firstly we determine the limits over which image intensity values will be stretched. Let these lower and upper limits be a and b, respectively. Next, the histogram of the original image is analyzed to determine the limit values (lower limit=c, upper limit=d) in the output image .The value (r) in the original image is mapped to the value(s) in the output image using the following function:

$$s=(r-c)\ ((b-a)/\ (d-c))\ +a\ldots\ldots\ldots\ldots\ (5)$$

III. IMAGE QUALITY MEASURES

Although many image quality measures have been described in the literature like signal to noise ratio (SNR), peak signal to noise ratio (PSNR), here we use MSE and PSNR to evaluate our subject image.

A. MEAN SQUARE ERROR (MSE)

MSE measures the difference between values of original image and the resultant image. MSE is a function corresponding to the expected values of the squared error. MSE measures the average of the squares of the errors. The error is the difference between the value implied by the estimator and the quantity to be estimated

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(Iij - Kij)^2 \ldots (6)$$

Where matrix I represents input image and matrix K represents output image.

B. PEAK SIGNAL TO NOISE RATIO (PSNR)

PSNR is used to measure the quality of reconstructed image from the original image. PSNR is expressed in terms of logarithmic decibel scale . Higher PSNR generally indicates that the output image is of higher quality. PSNR is defined in terms of MSE as:

$$PSNR = 10\log_{10}\frac{[(\text{peak to peak value of original data})^2]}{MSE} \ldots (7)$$

IV. RESULTS AND DISCUSSIONS

This section presents the simulation results illustrating the performance of the image enhancement approaches discussed above. The experimental image is an Standard Lena image. The size of the image is 256×256. The performance of the enhancement approaches can be seen from the Table.1 below. The image negative and histogram equalization are better as compared to other techniques because they improve the perception of information from the image. The bellow all five figure shows the comparison of original image with all spatial domain enhancement techniques.

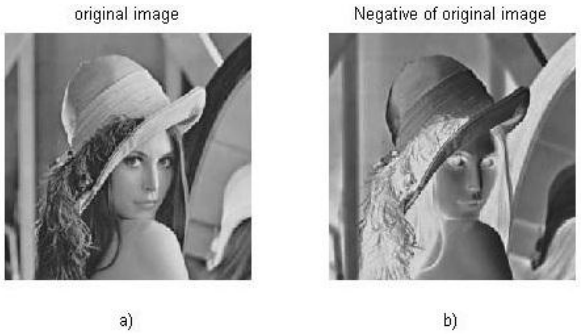

Figure 1. Original Image with Resultant Negative Image.

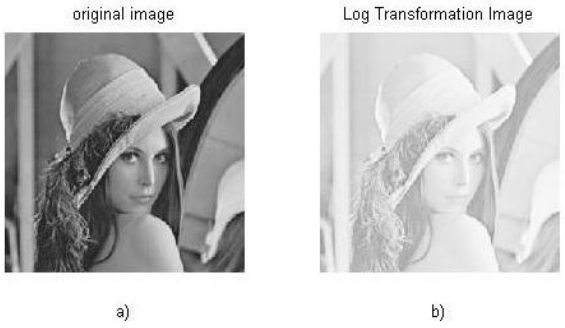

Figure 2. Original Image with Resultant log transformation Image

Figure 3. Original Image with Resultant HE Image

Figure 4. Original Image with Resultant contrast stretching Image

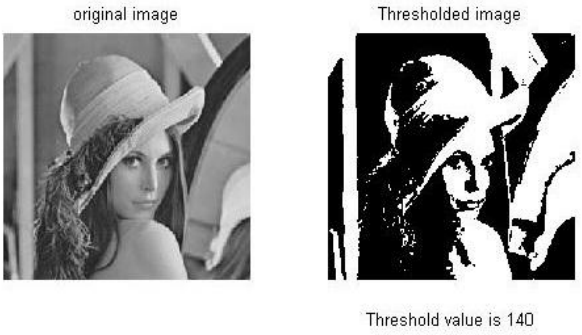

Figure 5. Original Image with Resultant thresholding Image

Image Enhancement Technique	PSNR	MSE
Image Negative	27.44	117.25
Histogram Equalization	27.83	107.22
Contrast Stretching	24.06	254.89
Thresholding	26.35	150.69

Table1: comparison of image quality parameters.

CONCLUSION

This paper presents a few efficient image enhancement approaches. We apply image processing techniques based on spatial domain to get first hand information about the presence of early nodule in order to avoid surgery. We also find that these image enhancement approaches are not ideal for improving the quality of medical images. Therefore, it is concluded that new image enhancement approaches must be put forward that can operate almost in every domain.

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