

# Comparative Study of Different Enhancement Techniques for Medical Images

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## ABSTRACT

Image enhancement is a process of improving the visual quality of an input image which is more suitable for the human observer. The digital images can be enhanced by improving the perceptibility or improving the structural features. The varieties of enhancement techniques are available for digital images. Appropriate choices of such techniques are greatly influenced by the image modality, task at hand and viewing conditions of an application. The objective of an image enhancement is to change or modify the quality of an image for specific application. The enhancement techniques can be categorized by spatial domain and frequency domain method. This paper only discusses about spatial domain enhancement techniques along with their algorithm and also analyzes their performance based on the image quality for medical images.

## Keywords

Image processing, Image enhancement, Transformation, Histogram, Illumination.

## 1. INTRODUCTION

Digital image processing is input image can be converted from one form to another such as digital image; these digital images are play vital in real world application like medical images, satellite images and so on. Before going to processing an image, it is converted into a digital form. Digitization includes sampling of image and quantization of sampled values. After converting the image into bit information, processing is performed. This processing technique may be, Image enhancement, Image reconstruction, Image segmentation [3, 4] and Image compression. During conversion the output images are having possible to the form of degradation, so need to improve the quality of an image. Improvement can be achieved by applying the enhancement techniques. Techniques are to enhance the structural features of an image and also increase the contrast level. The goal of an enhancement techniques are improving the interpretability of information contained in an image and change or modify the attributes for giving better performance of a given task. For choosing of an attributes are depends on techniques and given application or task. Image enhancement is to enlarge the object without degradation and extract the hidden details and also increase intensity of an image and remove noise or brighten an image, making it easier to identify key features.

Here having different enhancement techniques are available to improve the quality of an image. The Spatial domain method

is directly operated on pixels of an image. The pixel values are modified based on the problem domain. The frequency domain method is to compute the Fourier transform of an image then operations are performed on the transformed

image. This transformation is need for modify the vales based on the resultant image. A digital gray image is a simple two dimensional matrix of numbers ranging from 0 to255. These numbers represents different shades of gray. The number '0' represents pure black color and number '255' represents pure white color. This paper deals about some of spatial domain techniques along with its analysis of performance for medical images.

## 2. ENHANCEMENT TECHNIQUES

### 2.1 Spatial domain method

The objective of this method is to improve the perceptibility of information contained in an image and also enhancing the structural features can improve perceived image quality. Spatial domain refers to the aggregate of pixels composing an image and it is denoted by  $P(X, Y)$  [9]. Spatial domain methods are procedures that operate directly on the pixels, the formula is defined by,

$$g(X, Y) = T[f(X, Y)] \quad (1)$$

$g(X, Y)$ = output image,  $f(X, Y)$ = input image.  $T[ ]$  is a transformation operator, it is to define the some neighborhood of  $(x, y)$ .

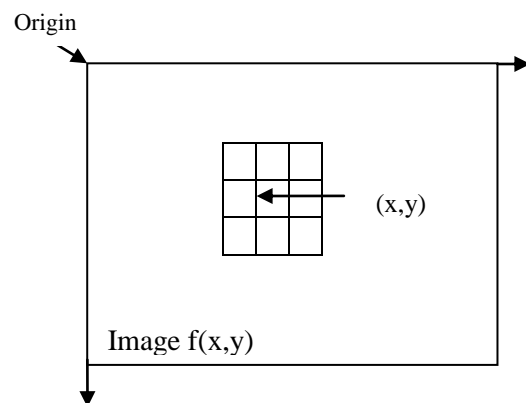


Fig.1: Neighborhood pixels of  $(x, y)$

To defining the neighborhood of a point  $(X, Y)$  can use a square or rectangular subimage at  $(X, Y)$ . The center of the subimage is moved from pixel to pixel and starting at the top left corner. The transform operator  $T$  is applied to each location  $(X, Y)$  to yield the output of that location. Other neighborhood shapes like circles are sometimes used. The following figure shows that representation of pixels in an image. Spatial Enhancement methods are mainly used in different field where the need of image to be analyzed, like satellite image and medical image analysis.

The spatial domain technique can be divided into three types:

### 2.1.1 Gray level transforms

The values of pixels before and after processing is gray level transform and it is denoted by [10],

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

S & r are gray levels;

T is transformation that maps the pixel value r into pixel value s. This transformation is depends on gray level of the pixels and that values are stored in the table. The following are some of the gray level transforms technique.

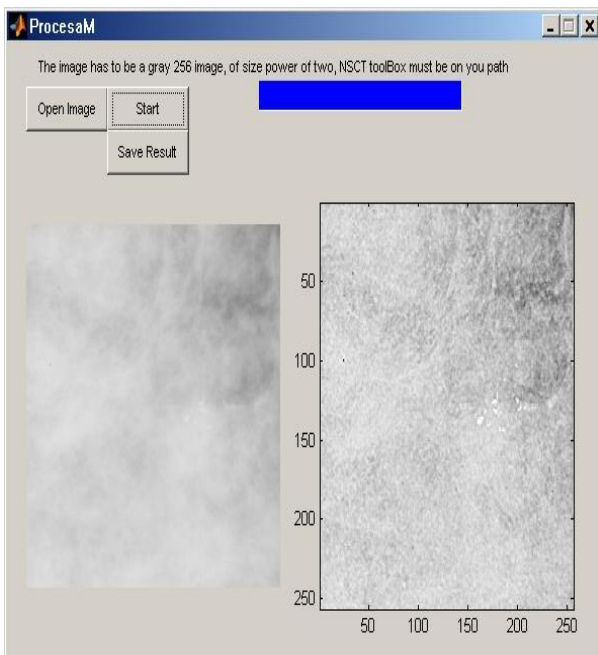
#### 2.1.1.1 Image Negative

Negative of an image with gray levels in the range of 0 to 255 [11]. Every pixel values of an original image are subtracted from 255. The resultant image is the negative of an original image. This technique is mainly suitable for enhancing white or gray details in dark regions of an image. And also used when black areas are highly present in an image.

$$\text{Negative } (R, C) = 255 - I(R, C) \quad (3)$$

I - input image & R, C - Image size (Rows & Columns)

The result of the image negative for mammogram image will be shown below by using Matlab tool.



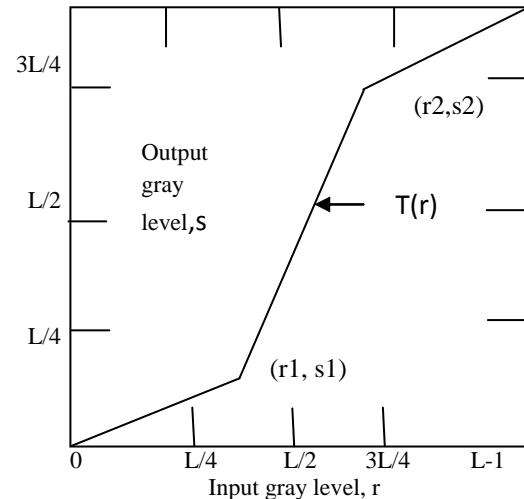
**Fig.2: Input and Output of Image Negative of a Mammogram Image**

#### 2.1.1.2 Contrast Stretching

The key idea of this technique is to improve the quality of an image by increasing the dynamic range of gray levels [2],[6]. Here to enhance the image by increase the contrast of an image. The difference between intensity of two adjacent pixels is represented as contrast.

#### 2.1.1.3 Gray level slicing:

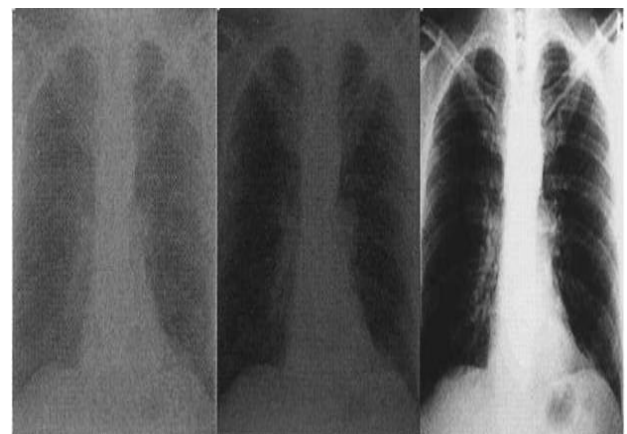
To highlight a specific range of gray levels in an image and enhance the features such as masses of water in satellite image and enhancing the flaws in X-ray image [9]. The method is to display the high value for all gray levels in range of interest and low value for all other gray levels. This technique is



**Fig.3: Transformation of Contrast Stretching**

Low contrast images are result from poor illumination, lack of dynamic range in sensor and wrong setting of a lens [4]. High contrast images are having less difference. The objective of this technique is to group the gray levels. The single value T (r) is increased monotonically; it should preserve the order of gray levels.

Typical transformation denotes locations of points (r1, s1) and (r2, s2) control the shape of transformations functions. If r1 = s1 & r2 = s2, then the transformation is a linear function that produces no changes in gray level. If r1=r2, s1=0 and s2=L-1 then the transformation is thresholding function that can creates a binary image. If there is an intermediate values of (r1, s1) and (r2, s2) then produces different quantity of increasing in gray levels of output image, it should affect the contrast. The result of contrast stretching image is obtained by setting (r1, s1) = (r<sub>min</sub>, 0) and (r2, s2) = (r<sub>max</sub>, L-1), where r<sub>min</sub> and r<sub>max</sub> denote the minimum and maximum gray levels in an image. The result of the contrast stretching is shown below:



**Fig.4: (a) Low-contrast x-ray image, (b) Presence of Noise (c) Output (Enhanced) image using MATLAB for Contrast Stretching algorithm**

highlights the range of gray levels and reduces all others to a contrast level.

The gray slicing technique function can be either highlight a group of intensities and diminish all others or it can emphasize a group of gray levels and leave the rest alone. The following figure shows that the representation of gray level slicing:

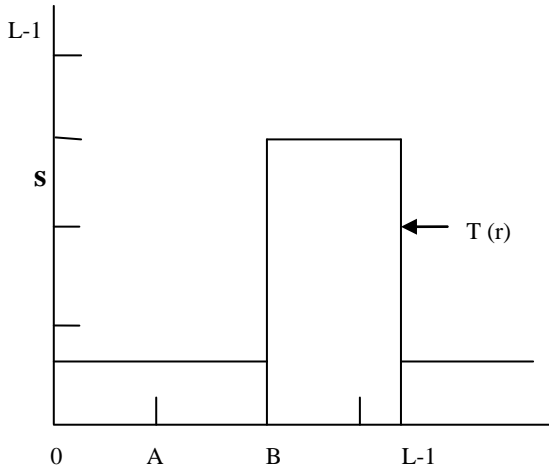


Fig.5: Transformation of gray level slicing

#### 2.1.1.4 Bit plane slicing

This technique is to highlighting the total image appearances by specific bits are desired [10]. Each pixel in an image is represented by 8-bits; the image is composed of eight 1-bit planes range 0 to 7, from bit-plane 0 for the least significant bit and bit-plane 7 for most significant bit. This technique gives a results by decomposition of an image into many bit planes that each contribute to total image. The following figure [6] shows that representation bit plane slicing and figure [7] tells that result of this technique using Matlab for human nee image.

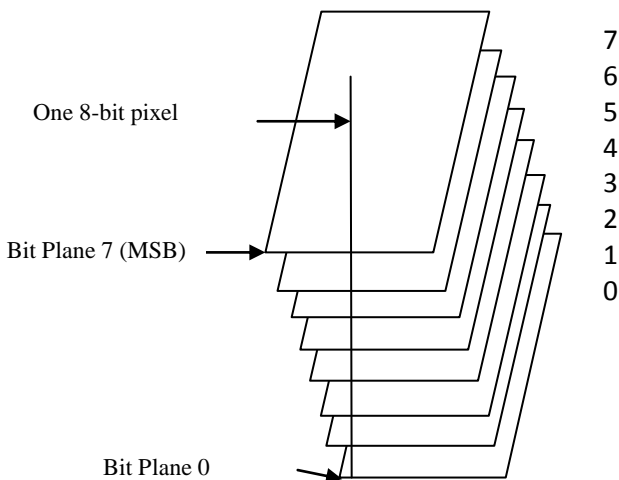


Fig.6: Representation of Bit plane slicing

The image can be classified by number of bit planes.

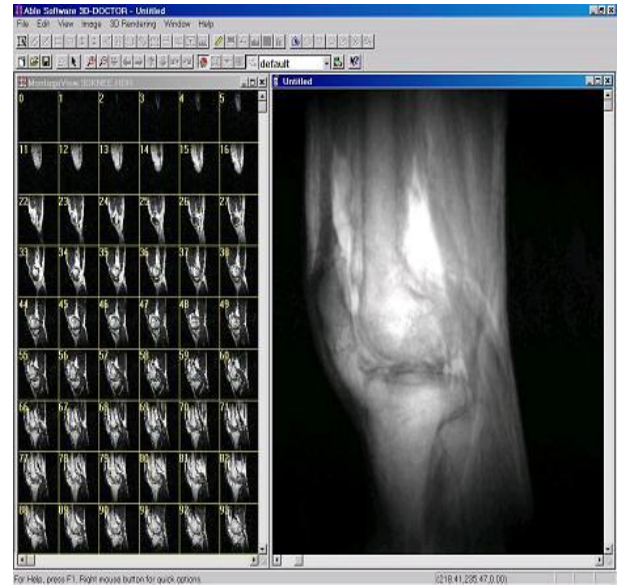


Fig.7: Output of Nee image using Bit- plane slicing

#### 2.1.1.5 Logarithmic transformation

The log transform function is useful when input gray level values have large range of values [10]. The transform should maps a range of low input gray levels into wider range of output values. Fourier transform of an image is composed through a log transformation by using MATLAB tool. Here the range of gray levels should have the limitation between [0.0, 1.0] and it is represented by,

$$s = \log(1 + r) \quad (4)$$

The result of this technique is generated and it is shown below using Matlab tool.

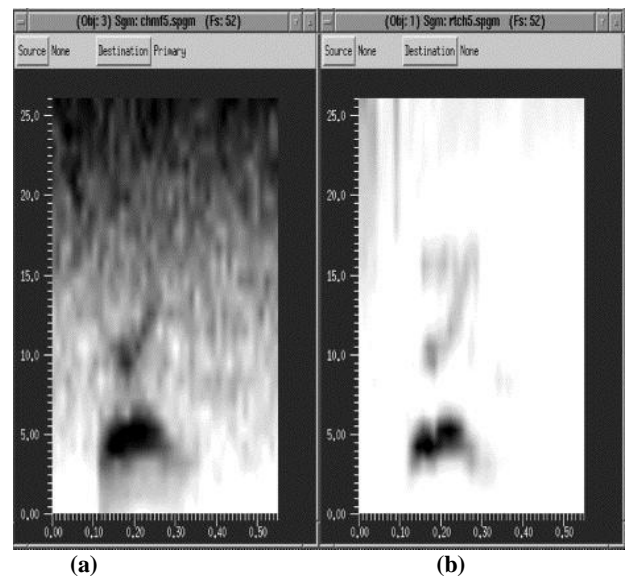


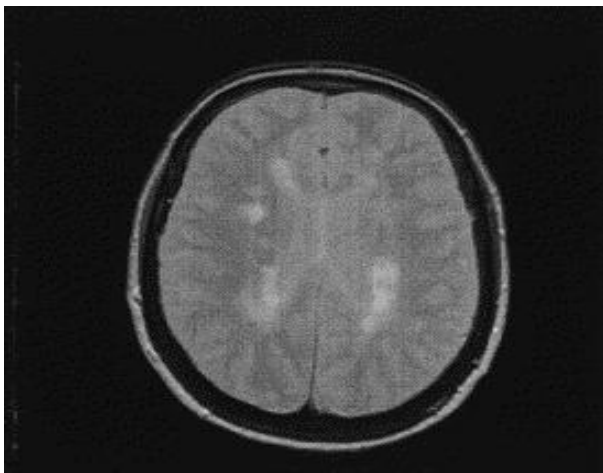
Fig. 8: (a) Noisy image (b) Output of logarithmic transformation

#### 2.1.1.6 Power-law Transformation

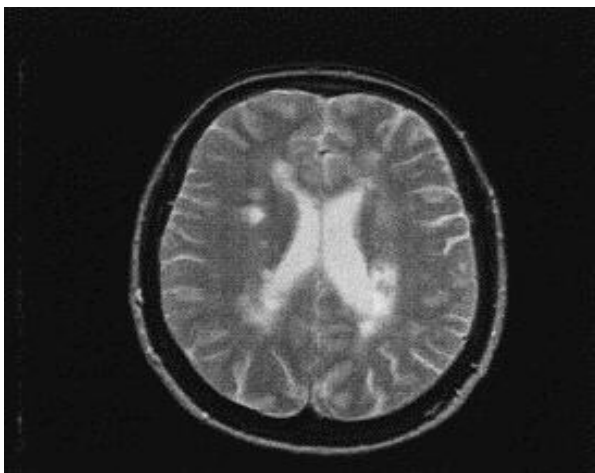
This is to mapping the range of dark input values into range of output values and vice versa. Power law transform in which each input pixel value is raised to a fixed power.

$$I_{out\ put} (i,j) = c (I_{input} (i,j))^{\gamma} \quad (5)$$

$C$  &  $\gamma$  = positive constants and  $C$ - Performs the range of scaling.



(a)



(b)

**Fig.9: (a) Input Image (b) Enhanced image for power law transformation**

The possible transformation curves are obtained by change of gamma values. The value of ‘ $\gamma$ ’ enhances contrast of high value portions of an image at expense of low level regions.

### 2.1.2 Histogram processing

Histograms are the basis for numerous spatial domain processing techniques. Histograms are simple to calculate in software and also to hardware implementations, thus making them a popular tool for real time image processing [6]. The role of histogram processing in enhancement is, horizontal axis of each histogram plot corresponds to gray level values,  $r_k$ . The range of gray level  $[0, L-1]$  is a discrete function,

$$h(r_k) = n_k \quad (6)$$

Where  $r_k$  is  $k^{\text{th}}$  gray level and  $n_k$  is number of pixels in an image having gray level  $r_k$ . To normalize a histogram by dividing each of its values by total number of pixels in the image, it is denoted by  $n$ . the normalized histogram is given by,

$$P(r_k) = n_k / n; k = 0,1...L - 1 \quad (7)$$

$P(r_k)$  is gives a probability of occurrence of gray level  $r_k$ .

#### 2.1.2.1 Histogram Equalization

Consider for continuous functions and let the variable  $r$  represent the gray levels of the image to be enhanced [5][12]. To assume that  $r$  has been normalized to the interval  $[0, 1]$ , with  $r=0$  representing black and  $r=1$  representing white. Later, consider a discrete formulation and allow pixel values to be in the interval  $[0, L-1]$ . For any  $r$  satisfying the aforementioned conditions, to concentrate on transformations of the form that produce a level  $s$  for every pixel value  $r$  in the original image. For reasons that will become obvious shortly, the transformation function  $T(r)$  satisfies the following conditions:

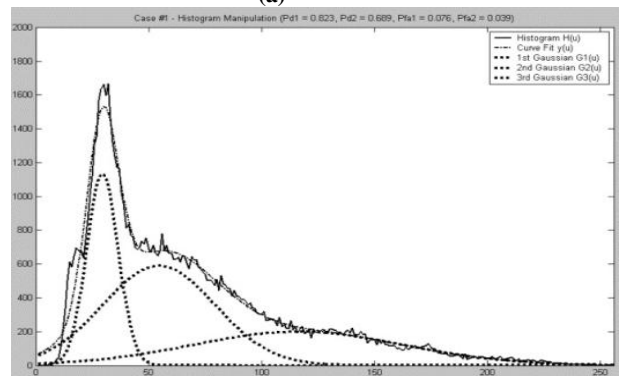
(a)  $T(r)$  is single-valued and monotonically increasing in the interval  $0 \leq r \leq 1$ ; and

(b)  $0 \leq T(r) \leq 1$  for  $0 \leq r \leq 1$ .

The requirement in (a) that  $T(r)$  be single valued is needed to guarantee that the inverse transformation will exist, and the monotonicity condition preserves the increasing order from black to white in the output image. A transformation function that is not monotonically increasing could result in at least a section of the intensity range being inverted, thus producing some inverted gray levels in the output image. Finally, condition (b) guarantees that the output gray levels will be in the same range as the input levels.



(a)



(b)

**Fig.10: (a) 3D Input image (b) Output of histograms of input image using Matlab**

The above figures tell that the input image can be 3D scanned image and generated equivalent histograms.

#### 2.1.2.2 Histogram Specification

Histogram equalization automatically determines a transformation function that seeks to produce an output image that has a uniform histogram [3],[6]. When automatic

enhancement is desired, this is a good approach because the results from this technique are predictable and the method is simple to implement. In particular, it is useful sometimes to be able to specify the shape of the histogram that processed image to have. The method used to generate a processed image that has a specified histogram is called histogram matching or histogram specification [13].

Let us return for a to continuous gray levels  $r$  and  $z$  are considered continuous random variables and let  $p_r(r)$  and  $p_z(z)$  denote their corresponding continuous probability density functions. In this notation,  $r$  and  $z$  denote the gray levels of the input and processed images, respectively. To estimate  $p_r(r)$  from the given input image, while  $p_z(z)$  is the specified probability density function that the output image to have. Let  $s$  be a random variable with the property

$$S = T(r) = \int_0^r p(r)(w) \quad (8)$$

Where  $w$  is a dummy variable of integration.

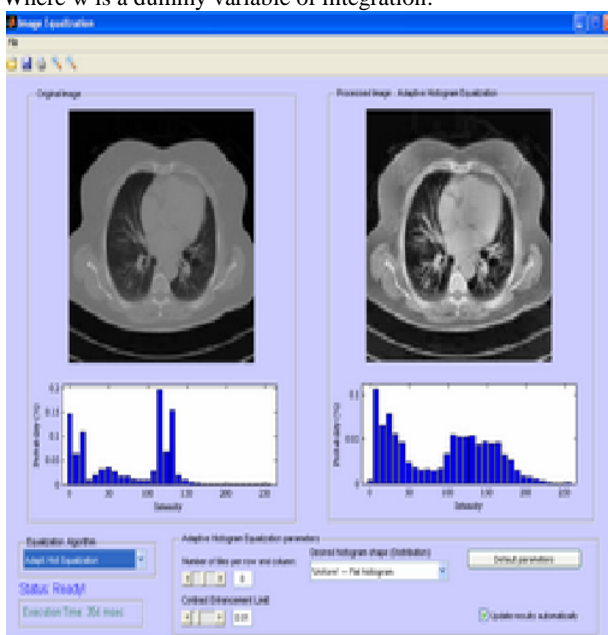


Fig.11: Enhanced image using Histogram specification

### 2.1.3 Arithmetic & Logical Operations

#### 2.1.3.1 Image Subtraction

This technique has numerous applications in image enhancement and segmentation. The fundamentals are based on the subtraction of two images defined as the computation of the difference between every pair of corresponding pixels in the two images. It can be expressed as:

$$g(x, y) = f(x, y) - h(x, y) \quad (9)$$

$h(x, y)$  is mask which can be subtracted from a image  $f(x, y)$ .

#### 2.1.3.2 Image Averaging

The noisy image  $g(x, y)$ , formed by the addition of a certain amount of noise  $\eta(x, y)$  to an original image  $f(x, y)$ :

$$g(x, y) = f(x, y) + \eta(x, y) \quad (10)$$

It is assumed that at every pair  $(x, y)$  the noise is uncorrelated thus uniform over the image and has an average value of zero.

The goal is to reduce the noise-effects by adding a set of noisy images.

### 3. CONCLUSION

This paper have discussed about different enhancement techniques using MATLAB tool with relevant output. The results showed that improved image quality, structural appearance of input image. And also noises were removed from an image. Even though all the techniques gave better result, the combination of contrast stretching and power law transformation yields good performance. Because the contrast stretching is free from ringing, blocking or other false contouring artifacts in structural appearance. The power law transformation gives brightness of the image without any degradation of the input image, and suppresses of noise and preserve the overall brightness of an image. Here implemented only for gray level images. The same theory can be extended for the color images too.

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