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Comparative Study of Mammogram Enhancement Techniques for Early Detection of Breast Cancer

Prof.S.S.Ittannavar[1], Dr.R.H.Havaldar[2]
[1] Assistant Professor, ECE Department, H.I.T, Nidasoshi, India
Email: ishreevijay@gmail.com
[2] Professor, Biomedical Engineering Department, KLESCET, Belagavi, India
Email: ravirajbme@rediffmail.com

Abstract—**This paper presents an analysis and identification of image enhancement techniques suitable for mammogram images. Enhancement techniques are used for mammogram image enhancement to aid an early detection of breast cancer which can identify the micro calcification as benign and malignant. Seven image enhancement techniques are considered here for mammogram images. These techniques are implemented using MATLAB. The results obtained are compared on the basis of Peak Signal to Noise Ratio (PSNR) for a set of mammogram images. Mammogram Enhancement techniques here used are Contrast stretching, Power law transformation, Logarithmic transformation, Contrast limited Adaptive Histogram equalization (CLAHE), Unsharp Masking. These enhancement techniques are also called as Pre-processing techniques. The PSNR values of all pre-processing techniques will be analysing here. A high value of PSNR indicates better suitability of the enhancement technique for further image processing. These identified pre-processing techniques, chosen carefully may give better results for further identification of micro classification and aid in early detection of breast cancer.**

Index Terms—**Image Enhancement, Mammogram, Preprocessing, PSNR**

I. Introduction

Breast cancer has become one of the commonly occurring
Form of cancer in women, particularly in developing countries. It accounts for about 25% to 33% of all type of cancers in women of urban India. Early identification of breast cancer would result in timely diagnosis of the disease thus providing better chances of survival. Image enhancement is a crucial step in most of the image processing applications. Enhancement means improving the visual quality of image for better interpretation and human perception. A number of image enhancement techniques exist but as far as mammogram processing is concerned, the techniques of interest are the ones that do not degrade the quality of image or modify existing information content in the image. One or more attributes of the image are selected and the enhancement processes are categorized in two domains: spatial domain and frequency domain. Techniques belonging to the first category are directly applied to the image pixel values to get desired enhancement. For the second category, Fourier transform is obtained for its frequency domain representation. After doing enhancement operations in frequency domain, Inverse Fourier transform is carried out to get the resultant image in spatial domain.

Image enhancement may include manipulation of image intensity and its contrast, reducing the levels of noise present, background removal in order to avoid any artifacts, filtering, edge sharpening etc. Enhancement may involve operations that are applied only on the selected region i.e. Region-of-Interest (ROI), in the image. Pre-processing of mammogram is essential for increasing the contrast between image background and selected ROI and to sharpen the edges or boundaries of suspected lesions.

In this paper seven image pre-processing techniques are explored for better results suitability in case of mammogram images. The rest of the paper is organized as follows: section II presents review of related literature. Image pre-processing techniques considered are presented in Section III. Results are presented in Section IV. Finally, conclusions and future work are given in Section V.

II. Related Work

The common anomalies indicative of cancer in breast are masses, micro-calcifications (MCs) and architectural distortion. A breast mass could be defined as space occupying lesion seen in at least two different projections or as a localized lump in the breast. A mass is parameterized according to its shape, size, location margins and density etc. Circular or oval shaped mass are generally considered as benign whereas masses with spackles tend to be malignant. Micro-calcifications represent one of the earliest signs of breast cancer. These are small deposits of calcium (and related) salts representing either warnings of malignancy or just benign formations. They are encountered in approximately 25% of mammograms and appear as bright spots or clusters of such spots, due to the high X-ray attenuation factor of calcium.

Numerous approaches for image enhancements using histogram processing are available. It includes histogram equalization, adaptive histogram equalization and local histogram processing. Adaptive histogram equalization is explored in this paper because of improvement in the appearance of images. For a dark image histogram would be oriented towards the lower gray scale values. It means the entire image detail lie in the dark end of the histogram. To obtain uniform distribution of gray levels, stretching of gray levels at the dark end is required. Direct application of this method often

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results in the enhancement of noise present in the image. Contrast-limited adaptive histogram equalization (CLAHE) could be used to solve this over enhancement problem. Histogram Modified Contrast Limited Adaptive Histogram Equalization (HM-It adjusts the level of enhancement giving a strong contrast image and also highlights the local information present in the original image for better interpretation. In an image enhancement algorithm based on edge detection is used to preprocess mammograms. The proposed algorithm was applied on preprocessed mammograms. It helped to get more details from images and lesions were clearly differentiable from background.

Many image processing operations involving enhancement makes use of oriented filters. In this same filter is applied over again by rotating it at different orientations under adaptive control. One can remove noise and enhance oriented structures by angularly adaptive filtering.

III. IMAGE ENHANCEMENT TECHNIQUES

The pre-processing techniques described in this section have been applied on 25 images. ROI are marked on the images by radiologists. These marks don't contribute or affect the outcome of pre-processing techniques considered in this work. It is indicated that the test images are taken from.

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

A. Contrast Stretching

Image may result into low contrast because of poor background lighting, lack of dynamic range in the imaging sensor, improper setting of focus etc. at the time of image acquisition. Contrast stretching is used to increase the dynamic range of gray levels in the image being processed. Contrast stretching is considered here because mammograms generally have low contrast. It aids in identification of suspicious regions in the mammogram

B. Power law Transformation

The power law transformation can also be used for improving the dynamic range. It can be expressed as a set of nth power and nth root curves. The transformation is represented mathematically by (2)

$s = c.r^{\gamma}$ .... (2)

Where, *s*is the output gray level, *r* is the input gray level, *c* is constant and γ is the correction factor. It is also called as gamma correction. Varying the values of γwill give transformations corresponding to different enhancements levels. Figure 1 (c) shows one of the power law transformed image as a sample output.

C. Log Transformation

The general form of the log transformation is

s = c * log (1 + r). .... (3)

Log functions are particularly useful when the input gray level values have an extremely large range of values and due to which some portion of the image is washed out, so dynamic range can be compressed as per our requirement. On the other hand, when the dynamic range is limited, it can be enlarged through anti-log transformation.

D. Contrast limited adaptive Histogram Equalization:

Histogram is the graph between gray levels and the number of pixels corresponding to that gray level. (i.e. frequency). It can be drawn by using MATLAB program or other software programs. The main purpose of drawing histogram is to know about the dynamic range of the image so that we may device some techniques for the proper modification of its contrast. There are many image enhancement techniques which have been proposed and developed. One of the most popular image enhancement methods is Histogram Equalization (HE). HE becomes a popular technique for contrast enhancement because this method is simple and effective. HE technique can be applied in many fields like medical image processing, radar image processing, and sonar image processing. The basic idea of HE method is to re-map the gray levels of an image based on the image's gray levels cumulative density function. (CDF). HE flattens and stretches the dynamic range of the resultant image In HE; we obtain approximately a uniform probability density function (PDF). However, HE is rarely employed in consumer electronic applications such as video surveillance, digital camera, and television, since HE tends to introduce some annoying artifacts and unnatural enhancement, including intensity saturation effect. One of the reasons for this problem is that HE normally changes the brightness of the image significantly, and thus makes the output image to become saturated with very bright or dark intensity values. In order to overcome the aforementioned problems, mean brightness preserving, histogram equalization based techniques have been proposed in the literature. Generally, these methods separate the histogram of the input image into several sub-histograms, and the equalization is carried out independently in each of the sub-histograms.

Adaptive histogram equalization is a computer image processing technique used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. Ordinary histogram equalization simply uses a single histogram for an entire image.

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Sl. No.	Pre-Processing Techniques	PSNR Values in dB		
		Average	Min	Max
1	Contrast Stretching	28.009	26.945	28.876
2	Power Law Transformation	28.307	27.264	29.195
3	Log Transformation	29.142	27.881	29.979
4	CLAHE	33.047	32.315	33.924
5	Unsharp Masking	44.513	43.506	45.363

Consequently, adaptive histogram equalization is considered an image enhancement technique capable of improving an image's local contrast, bringing out more detail in the image. However, it also can produce significant noise. A generalization of adaptive histogram equalization called contrast limited adaptive histogram equalization, also known as CLAHE, was developed to address the problem of noise amplification. CLAHE operates on small regions in the image, called tiles, rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter.

E. Unsharp Masking:
It is a common method of pre-processing employed for Sharpening. It works by subtracting the smoothed image from original. Thus it enhances high frequency components like edges in the image and attenuate low frequency information giving a much sharper image. This may make micro-calcifications more prominent in the processed mammogram image. Un-sharp masking is performed using the equation $g(x,y)=f(x,y)-f'(x,y)$……………………….(4)
Where, $f(x, y)$ is the original image, $f'(x, y)$ is a smooth version of original image. $g(x,y)$ is the enhanced image after unsharp masking.

III. SIMULATION RESULTS

The pre-processing techniques described in Section II have been implemented using MATLAB on a set of Mammogram images for different cases Normal, Benign, Malignant obtained from MIAS Databases. Since only visual inspection of pre-processing is not very prominent, PSNR has been calculated for comparison of all these techniques. Average, minimum and maximum PSNR values obtained for the set of mammogram images are listed in Table I, Table II and Table III. The results clearly help in identifying better suited pre-processing techniques for mammogram images. It is evident from all the tables that power-law transformation, Log transformation, CLAHE and un-sharp masking are having higher values of PSNR as compared to other pre-processing techniques considered in this work. Even the minimum PSNR values for the identified techniques i.e. CLAHE and un-sharp masking are greater than the maximum values of rest of the pre-processing techniques. So, these small number of test images may not affect the result in general.

Table 1. Average, Minimum, Maximum Values of Normal Cases using image Enhancement techniques

Sl. No.	Pre-Processing Techniques	PSNR Values in dB		
		Average	Min	Max
1	Contrast Stretching	28.345	27.053	29.425
2	Power Law Transformation	28.771	26.854	30.512
3	Log Transformation	30.147	28.353	32.007
4	CLAHE	35.180	34.166	36.313
5	Unsharp Masking	44.538	42.575	46.391

Table 2. Average, Minimum, Maximum Values of benign Cases using image Enhancement techniques.

Sl. No.	Pre-Processing Techniques	PSNR Values in dB		
		Average	Min	Max
1	Contrast Stretching	28.582	27.227	30.429
2	Power Law Transformation	28.864	27.848	30.888
3	Log Transformation	30.357	28.858	32.135
4	CLAHE	33.921	31.876	35.690
5	Unsharp Masking	45.328	43.795	47.047

Table 3.Average, Minimum, Maximum Values of Malignant Cases using image Enhancement techniques.

CONCLUSIONS

In this paper, five image pre-processing techniques namely contrast stretching, power law transformation, log transformation; CLAHE un-sharp masking, have been considered to identify its better suitability to mammogram images. These pre-processing techniques have been tested on a set of mammogram images and the result shows that

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CLAHE and un-sharp masking are giving higher PSNR values. So these techniques will be more suitable in pre-processing stage of mammogram images. The identified pre-processing techniques may be followed by segmentation, post processing, texture analysis, feature extraction and classification to yield better results.

FUTURE SCOPE

The future research will be carried out to improve the early identification of masses, calcification, architectural distortion and bilateral asymmetry for detection of breast cancer by using these identified pre-processing techniques.

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