Fuzzy Enhancement for Mammogram Images

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Abstract--- One of the most significant causes of increased women death rate in the world is due to Breast cancer. Mammography is the most effective method for early detection of breast diseases. The main aim of mammography is to detect tiny, non-palpable cancers during its premature stage. Conversely, mammograms are extremely complex to deduce being the fact that the pathological transformations of the breast are slight and their visibility is very poor with low contrast and noise. Mammograms have the significant information such as microcalcifications and masses, which are extremely complicated to detect because mammograms are of low-contrast. Cancer detection using mammography mainly concentrates on features of tiny microcalcifications, together with the number, size and spatial arrangement of microcalcification clusters and morphological features of individual microcalcifications. In the current scenario, Content-Based Image Retrieval (CBIR) techniques have gained considerable attention for medical images analysis. It is necessary to enhance the mammogram images because the mammogram images are very noisy, low-contrast, blur and fuzzy, for accurate identification and early diagnosis of breast cancer**.** In this paper, efficient techniques to enhance the mammogram image using wavelet transforms and fuzzy enhancement are proposed. The results proved that the fuzzy enhancement achieves better results in enhancing the mammogram image using wavelet transform.

Keywords---Breast Cancer, Mammography, Image Enhancement.

I. INTRODUCTION

BREAST cancer is one of the main reason for death among women. Early detection and treatment are regarded as the most suggested approach to reduce breast cancer mortality [`1]. Breast cancer is a type of cancer caused by breast tissue, which occurs mostly in the inner lining of milk ducts or the lobules that supply the ducts with milk [2]. Cancers originates from ducts are known as ductal carcinomas, while those originates from lobules are known as lobular carcinomas. Breast cancer usually occurs in humans and it occurs in other mammals too. Majority of human cases occur in women, male breast cancer can also occur [3].

Mammogram

Mammogram is a medical test that uses x-rays to take pictures of the internal structure of the breast. The testing is also known as "mammography." A mammogram is a radiograph of the breast tissue. It is an effective method of investigating the breast, typically for the diagnosis of breast cancer [4]. Mammography is a radiographic examination of the breast and the most significant investigation to identify early stages of breast cancer.

But the digital mammography is very noisy, low-contrast, blur and fuzzy and hence there is a requirement for enhancing images [5]. This is essential for enhancing the Peak Signal-to-Noise Ratio (PSNR) and reducing the Mean Squared Error (MSE) for accurate identification.

Mammograms are done for two reasons

i. *Screening:* When women participate on a routine basis to have mammograms done to find breast cancer at an premature stage. This type of mammogram looks for the indications that breast cancer may be spreading, even though no symptoms are there.

ii. *Diagnostic:* This is typically done to check for breast cancer after a lump or any other sign/symptom has been found such as pain, nipple discharge, skin thickening, or a change in breast size or shape. It will be used as a second test if a screening mammogram finds something that is not normal.

One of the most important objectives of mammogram image enhancement is to enhance the contrast between regions of interest and the background. Also the medical images fluctuate extensively in terms of acquisition, noise characteristics and quality [6]. Thus, there is a requirement to process an image on the image basis. This motivates the design and construction of effective mammogram image enhancement techniques using wavelet transform and fuzzy enhancement method.

The paper is organized as follows. Section II describes the related work, Section III deals with methodology used for image enhancement and Section IV describes about the experimental results and Section V represents the conclusion of the proposed method.

II. RELATED WORK

Digital mammography is one of the most suitable methods for early detection of breast cancer. However, the visual clues are faint and vary in appearance which makes diagnosis difficult and challenging [7]. There is a significant requirement for developing methods for automatic classification of irregular areas in mammograms for aiding radiologists to improve the efficiency of screening programs and avoid unnecessary biopsies. Micro calcifications occurs in mammogram image as small localized granular points with high brightness. It cannot be detected easily by naked eye because of its miniaturized dimension. Due to its small size, about 10-40% of microcalcification clusters are missed by radiologists [8][9].

III. METHODOLOGY

The proposed method use wavelet transform and fuzzy enhancement for mammogram image.

Mammogram image enhancement using wavelet transforms:

Mammography is a specific kind of imaging that utilizes a low-dose x-ray system to check breasts. A mammography exam is called as mammogram, used to assist in the premature detection and early diagnosis of breast cancer and related diseases in women. An x-ray is noninvasive medical tests that assist physicians in diagnosing the disease. Imaging with x-rays involves exposing a part of the body to a tiny amount of ionizing radiation to generate pictures of the inside of the body. X-rays are the traditional and most commonly used form of medical imaging.

A. Wavelet Transform

The Wavelet transform (WT) is a powerful mathematical tool, with several applications in computer graphics and image processing[10]. The wavelet analysis is done by applying a function called the mother wavelet (usually denoted by $\psi(x)$) to a signal/image, which allows not only to identify its frequency components, but also the spatial location where these components appear. The notion of scale is very important in the wavelet theory such as the coarser the scale of analysis, the fewer details of the signal is caught. On the other hand, finer scales capture more details of the processed signal/image. Model for digital enhancement in the wavelet domain is presented.

It explores wavelet coefficients to ensure the proper preservation of the image structure and correct filling of the enhanced region with block -based texture synthesis. The method takes an image I and a user defined inpainting mask Ω as input, and decomposes both images using a decimated Wavelet Transform. Wavelet Coefficient is then propagated into the enhanced region, and the inverse Wavelet Transform is applied to obtain the final reconstruction image[11].The wavelet transform is a type of multi-scale analysis that decomposes input signal into high frequency and low frequency approximation component at different resolutions.

To enhance the features, the selected coefficients are adjusted by multiplying with an adaptive gain value. The enhanced image is then reconstructed using adjusted wavelet coefficients.

For wavelet coefficient propagation into the enhanced region, there are two important steps that must be executed at each iteration in the algorithm. After the data have been prepared, the proposed model iteratively fills the inpainting region, until it is completely filled. At each iteration, a block with varying size is selected as the filling target, based on its geometric aspects and the energy of the wavelet coefficients in neighboring regions. Once this block is determined, the patch filled is selected by considering the structural aspects and the texture in the neighborhood of the inpainting block. The next inner steps of this model are especially the approach for determining the priority of inpainting blocks and the metric used in the block-based

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wavelet texture synthesis.

Mencattini et al., proposed a novel algorithm for image denoising and enhancement based on dyadic wavelet processing[12]. The denoising stage is based on the limited iterative noise difference evaluation. In addition, in the case of micro calcifications, it is proposed an adaptive change of improvement degree at various wavelet scales, while in the case of mass discovery an original segmentation technique combine with dyadic wavelet information by processing mathematical morphology is evaluated. The new approach consists of using the similar method core for giving out images to distinguish both micro calcifications and masses.

The Wavelet Transform in which, it processes the digital enhancement of mammogram images in the wavelet domain. In the Wavelet Transform in which it consists of many steps like data presentation, searching of the best block to fill, Edge strength, edge orientation and the confidence term. The drawback of Wavelet Transform is the method in which problem of filling the missing data will occur and the PSNR value is very low. So Curvelet transform is used for further enhancement study.

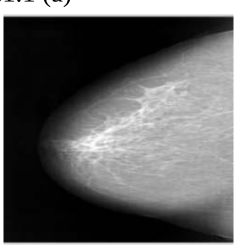
The Experimental results of Wavelet Transform are shown in the Figure 1.1. Two datasets are taken from the UCI Machine Learning Repository [13]. The datasets used in the proposed method are

- Wisconsin Diagnostic Breast Cancer (WDBC)
- Breast Cancer Dataset

Besides, the quality of the images are evaluated using the traditional distortion measurements such as

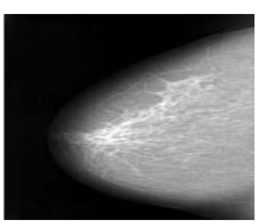
- Mean Squared Error (MSE)
- Peak Signal-to-Noise Ratio (PSNR)

For these images the mean square error and peak signal to noise ratio is calculated to find the better transformation. The input mammographic denoised image is shown in the Figure1.1 (a)



1.1(a)Input Denoised image

The output mammographic Enhanced Image is 1.1.(b)



1.1(b)Enhanced Image Using Wavelet Transform

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Figure1.1: (a) Input Denoised Image (b) Output Enhanced Wavelet Transform images

From the above resultant image it measures that the PSNR value is higher and MSE value is lower in Wavelet Transform. To calculate the mean square error and peak signal to noise ratio, the following formula is used.

Mean Squared Error

MSE of the output image is defined as

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j) - \hat{x}(i,j)|^2}{MN} \quad (1.1)$$

where $x(i,j)$ is the original image, $\hat{x}(i,j)$ is the output image, and MN is the size of the image.

MSE is calculated for all the two approaches shown in the Table 1.1 such as Wavelet Transform and Curvelet Transform.

Table1.1 the Mean Square Error Values for the Wavelet Transform based Image Enhancement Techniques

Image Enhancement Techniques	Database
	WDBC
Wavelet Transform	4.514908

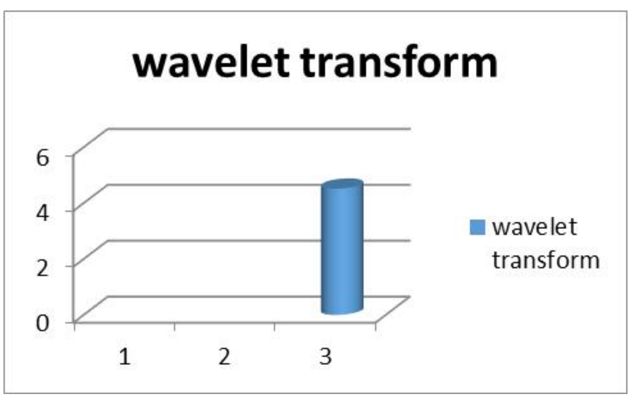


Figure1.2: Mean Square Error Values for Wavelet Transform Based Image Enhancement Techniques

From the Fig. 1.2, it is observed that the wavelet Transform method gives very low MSE values for the dataset wavelet Transform.

Peak Signal to Noise Ratio (PSNR)

PSNR is defined as

$$PSNR = 20 \text{ Log}_{10} \left[\frac{(2^n - 1)}{\sqrt{MSE}}\right] \text{ (dB)} \quad (1.2)$$

where n is the number of 8bits/pixel used in representing the pixel of the image.

PSNR is calculated for the two approaches as shown in the Table 1.2 such as Wavelet Transform based image enhancement techniques.

Table 1.2: PSNR Values for Wavelet Transform Based Image enhancement techniques

Image Enhancement Techniques	Database(db)
	WDBC
Wavelet Transform	42.315603

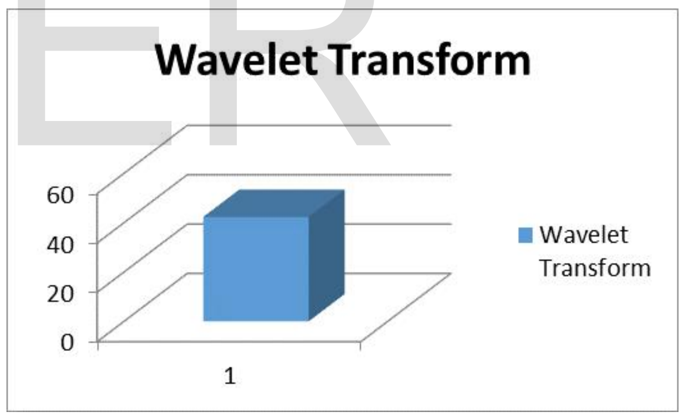


Figure1.3: Comparison of PSNR Values for Wavelet and Curvelet Transform based Image Enhancement Techniques

From the figure 1.2 and 1.3, it is observed that wavelet based enhancement method gives very high PSNR values for the dataset. The higher the value of PSNR, the better is the performance of the denoising filter. Hence, Wavelet enhancement techniques enhance the mammogram image accurately.

Figure 1.3 shows the PSNR values of Wavelet based image enhancement t. From the figure, it is observed that the wavelet Transform based image enhancement is better such as features like the scaling law, in other words, the spatial domain related with scale by parabolic curving and has new pyramid method.

The enhancement using wavelet Transform can obtain good results, especially for images having curve edges. But the directional specificity of the image is also good

Fuzzy Enhancement:

In image denoising, detecting major image details and change the degree of noise smoothing appropriately. Noise is uncorrelated in the spatial domain and the wavelet domain. Fuzzy feature for single channel image denoising is used to enhance image information in wavelet sub-bands and then using a fuzzy membership function to shrink wavelet coefficients, correspondingly. This fuzzy feature space helps to distinguish between important coefficients, whichbelongs to image discontinuity and noisy coefficient.

Large weights should be given to neighboring coefficients with similar magnitude, and a small weight is given to neighboring coefficients with dissimilar magnitude. The larger coefficients are produced by noise which becomes always isolated or unconnected, but their edge coefficients are clustered and persistent. The adjacent points are more similar in magnitude. Hence a fuzzy function $m(l,k)$ of magnitude similarity and a fuzzy function $s(l,k)$ of spatial similarity [14] is defined as follows:

$$m(l,k) = \exp(-((y_1(s,d)\ (i,j) - y_1(s,d)\ (i+l, j+k))/T \quad (1.3)$$

$$s(l,k) = \exp\left(-\left(\frac{l^2 + k^2}{n}\right)\right) \quad (1.4)$$

where $y_{s,d}\ (i,j)$ and $y_{s,d}(i+l, j+k)$ are central coefficient and neighbor coefficients in the wavelet sub-bands respectively. $Thr = c \times \hat{\sigma}_n$, $3 \le c \le 4$, $\hat{\sigma}_n$ is estimated noise variance, and N is the number of coefficients in the local window $k \in [-K \ldots K]$, and $l \in [-L \ldots L]$.

Based on the fuzzy functions, adaptive weight $w(l,k)$ for each neighboring coefficient is determined as follows:

$$w(l,k) = m(l,k) * s(l,k) \quad (1.5)$$

Using the adaptive weights $w(l,k)$, the fuzzy feature for each coefficient in the wavelet sub-bands are obtained as follows:

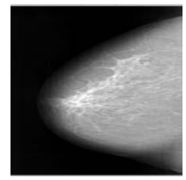
$$f(i,j) = \frac{\sum_{l=-L}^{L}\sum_{k=-K}^{K} w(l,k) * |y_{s,d}(i+l, j+k)}{\sum_{l=-L}^{L}\sum_{k=-K}^{K} w(l,k)} \quad (1.6)$$

Fuzzy feature can distinguish well between edge structure and noise when compared to the local mean.

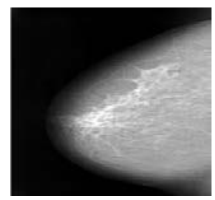
Experimental Results for Fuzzy enhancement with Transform Techniques

For the evaluation of the Fuzzy enhancement of mammogram image.

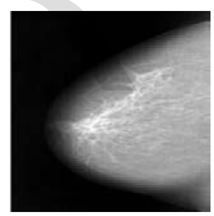
The input denoised image is shown in the Figure 1.10 (a)



(a)Mammogram Image



(a) Enhanced Image Using wavelet Transform



(e) Enhanced Image using Fuzzy Transform

Figure 1.4 Enhancements of wavelet Transform and Fuzzy Enhancement

For these images the mean square error and peak signal to noise ratio is calculated to find which transformation is better. So, MSE is calculated for this approaches. Table 1.3 shows the comparison of the MSE for the mammogram image enhancement technique such as wavelet Transform and Fuzzy Enhancement.

Table1.3: the Mean Square Error Values for the wavelet Proposed Enhancement Techniques and Fuzzy Enhancement

Image Enhancement Techniques	Database
	WDBC
wavelet Transform	3.158480
Fuzzy Enhancement	1.763289

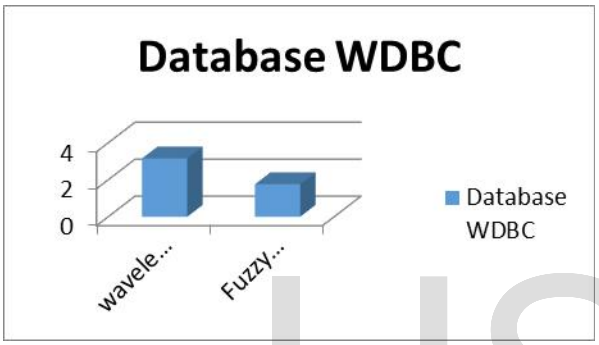


Figure 1.5: Mean Square Error Values for the wavelet Proposed Enhancement Techniques and Fuzzy Enhancement

From the Figure, 1.5 is observed that the Fuzzy enhancement method gives very high MSE values for both the dataset. Hence Fuzzy enhancement is considered as the best enhancement technique for enhancing the mammogram image.

6.3.1 Execution Time

The time taken for the proposed techniques to complete the execution is known as execution time. Execution time for the enhancement techniques .It is revealed that the Fuzzy enhancement method takes very less time to complete the execution for the wavelet transforms. Thus the Fuzzy Enhancement enhances the mammogram image with low MSE values, high PSNR values and executes in very less time. It is clear from the figure that mammogram image enhancement using wavelet transform achieves better results in terms of MSE and PSNR ratio.

IV. Experimental Result

For the evaluation of the proposed mammogram image enhancement technique using wavelet transform, two datasets are taken from the UCI Machine Learning Repository. The datasets used in the proposed method are

- Wisconsin Diagnostic Breast Cancer (WDBC)[13] and
- Breast Cancer Dataset [14]

Besides, the quality of the images are evaluated using the traditional distortion measurements such as

- Mean Squared Error (MSE) and
- Peak Signal-to-Noise Ratio (PSNR)

The quality of reconstructed image achieved by curvelet transform filters is usually specified in terms of mean-square-error (MSE) and Peak Signal to- Noise Ratio (PSNR).

Mean Squared Error

MSE of the output image is defined as

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)-\hat{x}(i,j)|^2}{MN} \quad (1.6)$$

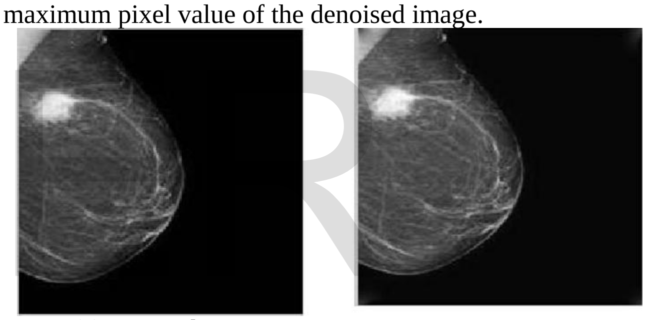
where $x(i,j)$ is the original image, $\hat{x}(i,j)$ is the output image, and MN is the size of the image.

PSNR

PSNR is defined as

$$PSNR = 10\log_{10}\left[\frac{MAX_I^2}{MSE}\right] \quad (1.7)$$

MAX_I is the maximum pixel value of the denoised image.



(a) Original image (b) Enhanced Image using wavvelet Transform

Fig 1.6: Resultant Image of wavelet Transform and fuzzy enhancement

The higher the value of PSNR, the better is the performance of the denoising filter. Thus fuzzy enhancement is used for more efficient enhancement images. It suppresses noises while enhancing weak edges in the textures and boosting the contrast between the lesion area and the background.

TABLE 1.4: OVERALL PERFORMANCE RANKING

Methodology used	Rank
Enhanced image using wavelet transforms	3
Mammogram image enhancement using Fuzzy Enhancement	2
Enhanced image using various wavelet transforms using fuzzy	1

Thus the mammogram image enhancement using fuzzy enhancement with wavelet transform achieves better results since its PSNR value is high with very low MSE value and it is used for efficient image enhancement.

V. CONCLUSION

At present, one of the most important causes of cancer death among middle aged women is breast cancer. Mammography is technique used by radiologists for early detection and diagnosis of cancer in breast images. Digital mammogram has turned out to be the most effective technique for premature breast cancer detection. Digital mammogram captures an electronic image of the breast and accumulates it in a computer. Mammogram images are very noisy, low-contrast, blur and fuzzy and hence the mammogram images are enhanced for accurate identification of breast cancer. Processing these images require high computational abilities. In this paper, the mammogram images are enhanced using wavelet transforms and fuzzy enhancement. It is found from the experiments that Fuzzy image enhancement method is efficient and useful in capturing relevant clinical information since its PSNR value is high with very low MSE value. As a future work , various effective transforms with efficient algorithms are used to detect the mammogram images accurately.

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