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Enhancement of Mammographic Images

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Abstract: **-** Mammography is an effective method for breast cancer detection and breast tumour analysis. In mammography, low dose x-ray is used for imaging, due to which the images are poor in contrast and are contaminated by noise. Hence it is difficult for the radiologist to screen the mammograms for diagnostic signs such as micro calcifications and masses. This ensures the need for image enhancement to aid radiologist. In this paper, we present an algorithm for enhancement of digital mammographic images. The proposed methodology uses mathematical morphology for contrast enhancement and wavelet for denoising. The main contribution of this report is in differentiating the edge pixels from noise. We adopt wavelet-based level dependent thresholding algorithm and modified mathematical morphology algorithm to increase the contrast in mammograms to ease extraction of suspicious regions known as regions of interest (ROIs).The proposed algorithm has been tested on a large number of clinical images, comparing the results with those obtained by several other algorithms. A quantitative measure of Contrast Improvement Index (CII) is used to evaluate the performance of the algorithm. Experimental results show that the proposed algorithm gives significantly superior image quality and better Contrast Improvement Index (Cll). Here, to prove the efficiency of this method, we have compared this with various well-known algorithms like VisuShrink and NormalShrink.Through preliminary tests; the method seems to meaningfully improve the diagnosis in the early breast cancer detection with respect to other approaches.

Keywords: *- Dyadic Wavelet transform, denoising, micro calcification, mass detection, thresholding.*

I. INTRODUCTION

Breast cancer is the leading cause of cancer among women in the United States, and the second leading cause of cancer-related mortality. Worldwide, breast cancer accounts for 22.9 percent of all cancers in women. In 2008, breast cancer caused 458,503 deaths worldwide (13.7 % of cancer deaths in women). Primary prevention seems impossible because the causes of this disease still remain unknown. Early diagnosis and treatment is the key to improving breast cancer prognosis. X-ray mammography is the most common technique used by radiologists in the screening and diagnosis of breast cancer. Low dose x-rays are used for imaging, due to which the images are poor in contrast and are contaminated by noise. Various techniques have been used to enhance the mammographic images. Film screen imaging has certain potential limitations as image artifacts and low sensitivity for detection.

Digital mammography is a specialized form of mammography that uses digital receptors and computers instead of x-ray film to help examine breast tissue for breast cancer. With digital mammography the breast image is captured using a special electronic x-ray detector which converts the image into a digital mammogram for viewing on a computer monitor or storing. Each breast is imaged separately in craniocaudal (CC) view and mediolateral-oblique (MLO) view as shown below.

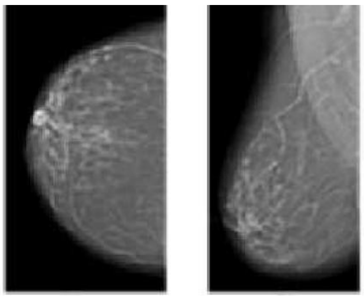

Fig 1: (a) Craniocaudal View (CC) and (b) Mediolateral View (MLO)

Screening mammography enables detection of early signs of breast cancer such as masses, calcifications, architectural distortion and bilateral asymmetry. A mass is defined as a space occupying lesion seen in at least two different projections. A round mass with circumscribed margins is shown in Figure 2 (a). Calcifications are deposits of calcium in breast tissue. Fine pleomorphic clustered calcifications with high probability of malignancy are shown in 2(b).

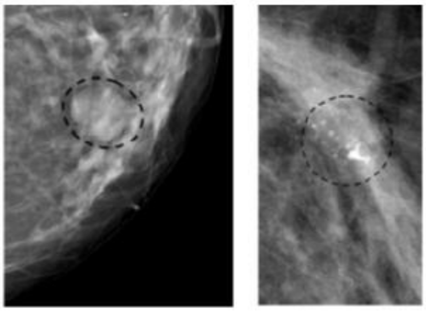

Fig 2: Example of abnormalities (a) round mass with circumscribed margin (b) fine pleomorphic clustered calcifications

Hence to improve the denoising and Contrast enhancement there are various methods employed. Here we are using Wavelet Denoising and Modified Mathematical Morphology for enhancement purpose. The paper is organised in following manner, section II consists of different techniques used for enhancement of mammographic images. Section III shows the whole algorithm and section IV concludes the paper with the comparison results.

II. WAVELET SHRINKAGE AND DENOISING

Any real signal is corrupted by some noise. As the presence of noise could disturb the processing in the wavelet domain and frustrate the enhancement operation, it is first necessary to denoise the data. The conventional filtering techniques cannot be applied in the context of medical imaging because they produce edge blurring and loss of details. Here 2D dyadic Wavelet transform is used. To achieve edge preserving filter, we apply a well known wavelet shrinkage denoising on output coefficients of filters ˆg(.x)andˆg(.y).Two classes of filters are possible: gradient and Laplacian filters. The following shrinking operator is used:

$$C(M) = \begin{cases} |M| - T_n & |M| \geq T_n \\ 0 & Otherwise \end{cases} \qquad (1.1)$$

This operator is a monotonically nondecreasing function to avoid the introduction of artifacts. The key issue is the optimal selection of the threshold Tn. A threshold that is too large produces blurring of small edges, whereas a low one does not remove enough noise. Where Tn should be:

$$T_n = \sigma\sqrt{-2\log(1-p)} \qquad (1.2)$$

Where σ is noise variance and p is the probability of achieving a correct value.

- Micro calcification Detection

Here we describe a general method to accomplish multiscale contrast enhancement. In the wavelet framework, linear and nonlinear enhancement operators have been proposed. To accomplish multiscale contrast enhancement linear as well as non linear operators are proposed. Linear function is given as:

$$E_m(s) = G_m(s) \qquad (1.3)$$

Where s denotes each wavelet coefficient and the gain Gm is, in general, level dependent. A non-linear peicewise mapping Em(s) is of the form

$$E_m(s) = \begin{cases} S - (G_m - 1)T & S < T \\ G_m & |S| \leq T \\ S + (G_m - 1)T & S > T \end{cases} \qquad (1.4)$$

- Mass Detection

Mass Detection because of low contrast appears embedded in and camouflaged by varying densities of tissue structures. Thus, it is very difficult to visually detect them on mammograms but also to distinguish, in the wavelet domain. Hence following steps are carried out for the enhancement, first is the Segmentation, This step eliminates the parts in the image that are not useful for the mammographic interpretation; we extract only the region of the image that corresponds to the breast. It is followed by Morphology where we use operators like erosion and dilation along with the opening and closing followed by top hat operation. and then the Dyadic wavelet is used for denoising. Hence we get an enhanced image.

III. WHOLE ALGORITHM

To summarize the whole algorithm for both micro calcification and mass lesion processing in Fig.3, The solid line denotes the block diagram for the micro calcification enhancement and dashed line for the mass lesion enhancement. The core of the processing, which is represented by the wavelet decomposition, the enhancement, and the wavelet reconstruction, are the same, whereas the main differences are principally due to the level selection and segmentation blocks. Level selection allows wavelet coefficient processing performing a level discrimination so that different weights are applied to different levels. Segmentation is only applied to mass detection to implement a selective enhancement based on the mask provided by the segmentation itself.

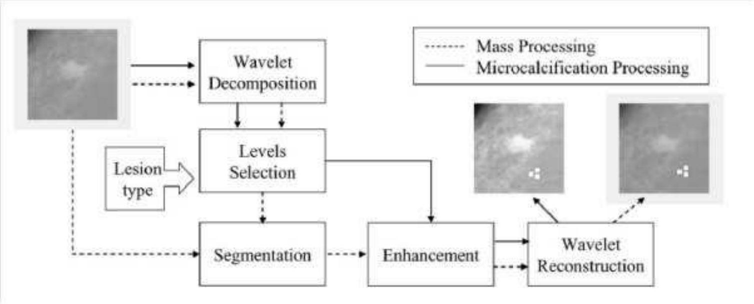

Fig 3: The Whole algorithm

The Fig.4 shows the effect of the enhancement procedure on the whole mammogram. The original mammogram, which indicates the ROI containing the mass lesion and the processed image in which the mass lesion appears enhanced and much more recognizable.

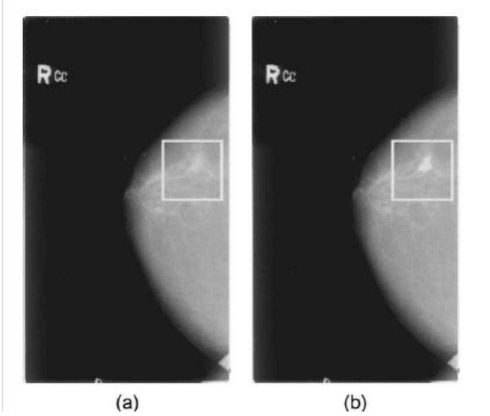

Fig 4: (a) Original Mammogram and (b) Processed Mammograms.

Fig.5 below shows some examples of the algorithm results, identified by the case number in the figure labels. The top figure represents the original image, whereas the bottom figure depicts the comparison between the mass edge identified by the radiologist (white line) and detected by the algorithm (black line). In particular, in the first two cases, the radiologist identified the mass by a circle, and the computerized edge is contained inside this circle. Moreover, one can notice that contour exactly, matches the mass shape.

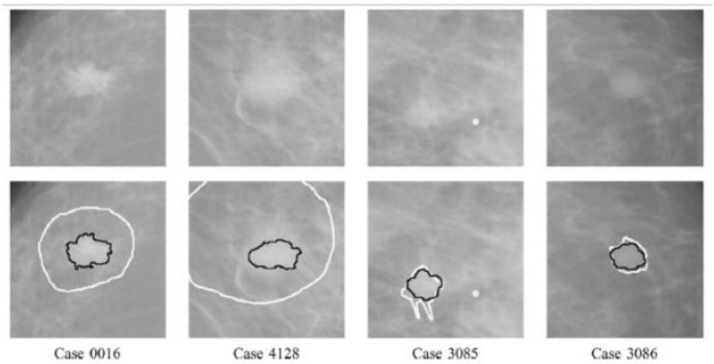

Fig 5: The mass edge identified by the radiologist (white line) and that detected by the algorithm (black line).

A quantitative measure of contrast improvement can be defined by a contrast improvement index. The contrast improvement index is defined as follows:

$CII = C_{Processed} / C_{original.}$

The following table gives the CII Values of enhanced mammograms and compared them with well known algorithms also the figure 6, below shows the comparisons between well known algorithms like Visu shrink, Bayes Shrink, SURE shrink and Wavelet enhancement.

Images from MIAS database	Visu Shrink	Bayes shrink	SURE shrink	Wavelet method
Mbd 148	0.9452	0.9259	0.9830	2.000
Mbd 209	0.9526	0.9370	0.9905	1.8471
Mbd 028	0.9344	0.9251	0.9864	1.8584
Mbd 058	0.9357	0.9177	0.9851	1.9916
Mbd 216	0.9549	0.9494	0.9975	1.7787

Table 1: CII values for Different MIAS database Images.

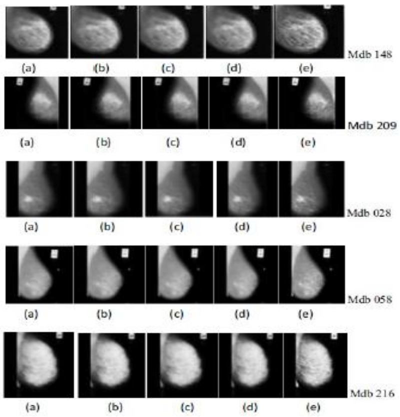

Fig 6 : (a) Original Image (b) Visu Shrink (c) Bayes Shrink (d) SURE shrink (e) Wavelet Enhancement.

IV. CONCLUSION

We have seen that Modified mathematical Morphology and wavelet analysis have been applied to increase the contrast in digital mammograms. Hence we studied an efficient algorithm for detection of breast cancer tumour on digital Mammogram images. The main advantage of the proposed algorithm is the ability of using the same computation core for both micro calcifications and mass detection. Future work can be done in reducing the errors in detection process. This can aid the radiologist in more detailed interpretation of mammograms.

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