Analysis of Breast MRI images using Wavelets for Detection of Cancer

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ABSTRACT
Breast cancer is the second leading cause of cancer death after lung cancer among women. The greatest effect on reducing mortality in breast cancer comes from the detection and treatment of invasive cancer when it is as small as possible. Accurate preoperative diagnosis of breast lesion is essential for optimal treatment planning. In order to avoid unnecessary patient distress, it is important to achieve the definite diagnosis without delay and with as few biopsies as possible. Nowadays, when breast cancer is one of the most frequently diagnosed malignancies among women, cost-effective ways for its diagnosis are necessary. Various methods are being performed on mammographic images to detect it at the early stage. This paper describes the Analysis of the breast MR images with the help of wavelet transform. The first step is to apply histogram modification technique to improve the contrast of the image. Then de-noising and filtering are used to remove unwanted data. Finally DWT is used to separate the frequencies and IDWT and thresholding is used for the final detection of cancer.

Keywords— Breast MRI, Breast cancer detection, Wavelet Transform.

1. INTRODUCTION
One of the most frequently diagnosed malignancies among women is breast cancer. As against an estimated 48,170 women who died of breast cancer in 2007, the number breached the 50,000 mark in 2010. The figure for the year was put at 50,821 [1]. If breast cancer is detected early, more specific and less aggressive therapy options are possible, and mortality from breast cancer falls.

Correct preoperative diagnosis of a breast lesion is essential for optimal treatment planning. To reach as soon as possible the final diagnosis and operation with as few biopsies as possible is humane for the patient. Nowadays, when breast cancer is one of the most frequently diagnosed malignancies among women, cost-effective ways of diagnosis are crucial. Before the early 1990s, the recommended evaluation of a "suspicious" breast abnormality noted on either clinical examination or mammography involved a surgical breast biopsy. Nowadays, less invasive alternatives, fine-needle aspiration cytology (FNAC) and core needle biopsy (CNB), are useful in the evaluation of these breast abnormalities.

Currently the main tool for breast cancer screening is X-Ray mammography. Despite the benefit of real time and wide availability, mammography presents the breast image in a 2-D projective view and has limited sensitivity and specificity. Breast MRI presents a 3-D volume of uncompressed breasts in the prone position [2].

Several methods have been proposed to detect micro-calcifications. Chan et al, 1990 [3] designed a difference-image technique for detecting micro-calcifications on digitized mammograms and to extract these features to distinguish true and false micro-calcifications. Qian et al, 1993 [4], developed a tree structure nonlinear filter and wavelet transform for micro-calcification segmentation. In [5], wavelet transform is used for detecting micro-calcifications in mammograms. Laine et al, 1995 [6-7]. proposed some techniques to enhance contrast of mammographic images from their multi-resolution representation by using non linear operations.

In the proposed technique, Breast MR images are used for the detection of cancer. Breast MR images are decomposed using wavelet transform filter bank. The rest of this paper is organized as follow. Section II illustrates the wavelet decomposition process. Section III describes the structure of the system proposed. Section IV shows results of each stage and finally future work and some conclusions are remarked in section V.

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2. WAVELET DECOMPOSITION
The wavelet transform is defined as

$$WTf(x) = \frac{1}{\sqrt{a}} \int f(x)\psi\left(\frac{x-b}{a}\right) dx \qquad (1)$$

This transform can be seen as a mathematical microscope whose position zooms on location b with a magnification $\frac{1}{a}$ and whose optical characteristics is described by the mother wavelet ψ(x) .It has been shown that the dilations and translations [4][5],

$$\psi_{jk}(x) = 2^{\frac{-j}{2}} \psi\left(2^{-j}x - k\right), (j,k) \in Z^2 \qquad (2)$$

of a mother wavelet ψ(x) can be used as an ortho-normal basis for the multi-resolution decomposition of signals into octave sub-bands (by means of dilation) with an excellent spatial location property (by means of translation). The translation index k is measured in terms of the wavelet's support width. In multi-resolution analysis, one also defines the dilations and translations of the low pass filtering or scaling function as

$$\phi(x) = 2^{\frac{-j}{2}} \emptyset\left(2^{-j}x - k\right), (j,k) \in Z^2 \qquad (3)$$

The wavelet transform of a given signal f(x) may be interpreted as the decomposition of the signal into a set of time frequency functions by the use of translated and dilated basis functions of a mother wavelet, as

$$f(x) = \sum_{j=1}^{j} \sum_k d_{jk}\,\psi_{jk}(x) + \sum_k S_{jk}\,\phi_{jk}(x) \qquad (4)$$

where *j* is maximum level of decomposition.

The multiresolution representation carried out by 2-D discrete wavelet transform fragment the frequency spectrum of an image **I** into a low-pass sub-band image cA^j and a set of band-pass sub-band images with horizontal orientation cDH^j, vertical orientation cDV^j, diagonal orientation cDD^j, $j = 1,\dots,L$, where L denote the number of levels for a representation [10]. Generally speaking, multiresolution representations are implemented by a cascade of analysis/synthesis (A/S) filter banks. The discrete wavelet transform uses two different wavelet mothers: $h(x)$ for multiresolution decomposition (analysis) and $g(x)$ for reconstruction (synthesis) of the original image from its multiresolution representation. An efficient way to implement discrete wavelet transform using filters was developed by Mallat [11]. Figure 1 shows the implementation of a one-level (L = 1) multiresolution representation of the discrete wavelet transform, which partitions orientations into three bands. As seen in Figure 1, the forward 2-D wavelet transform is implemented using a bank of 1-D low pass $(h_1(x))$ and high pass $(h_2(x))$ analysis filters. The reconstruction process, or inverse wavelet transform, is likewise computed via 1-D synthesis filters, $g_1(x)$ and $g_2(x)$.

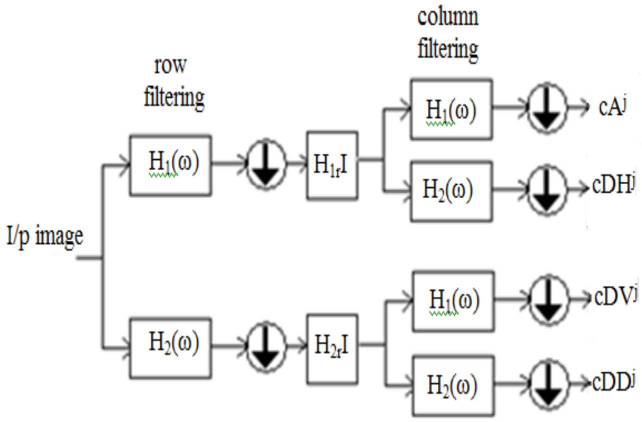


Figure 1: Two dimensional discrete wavelet transform

For a given image *I* of size 2n X 2n , wavelet-based sub-band decomposition can be performed as follows:

The wavelet filters $h_1(x)$ and $h_2(x)$ are applied to the rows of the image I. The filter $h_1(x)$ is a low-pass filter with frequency response $H_1(\omega)$ and $h_2(x)$ is a high pass filter with frequency response $H_2(\omega)$. By filtering the image I with $H_1(\omega)$, low-frequency is obtained information (background). By filtering the image with $H_2(\omega)$, the high-frequency information is obtained (edges). After down sampling by a factor of two, two sub-bands are obtained: $H_{1r}I$ and $H_{2r}I$ (the subscript r suggests that the filters are applied to rows of the image I). The filters $H_1(\omega)$ and $H_2(\omega)$ are then applied to the columns of the subbands $H_{1r}I$ and $H_{2r}I$, followed by down sampling by a factor of two, and the following four subbands are obtained: cA^j, cDH^j, cDV^j and cDD^j. The sub-band cA^j contains the smooth information of the image, and the subbands cDH^j, cDV^j and cDD^j contain the detail information of the image. Then the cA^j sub-band of the frequency domain is segmented into four sub-bands at the second level decomposition, and so on.

3. ALGORITHM DESCRIPTION

Breast MR images considered in this work for Cancer detection were chosen from the Advanced Center for Treatment Research and Education in Cancer (ACTREC) Database, The algorithm of the Breast cancer detection system has been implemented by using MatLAB 7.10.

The proposed algorithm block diagram is shown below in figure 2,

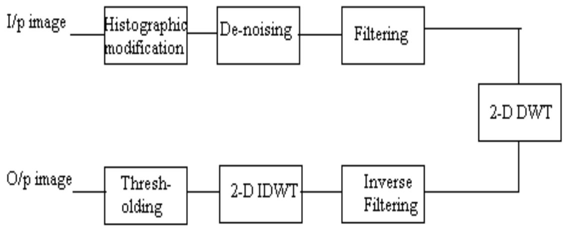


Figure 2: detection algorithm block diagram

The original image is processed by using the histogram modification technique for bounding the pixel values in a range[0 255], After modification de-noising using median filter and then unsharp masking is done in order to emphasize in the strong edge of the image, with a 3-by-3 unsharp contrast enhancement filter with negative of the Laplacian filter with parameter alpha. alpha controls the shape of the Laplacian filter and must be in the range 0.0 to 1.0. The default value for alpha is 0.2.

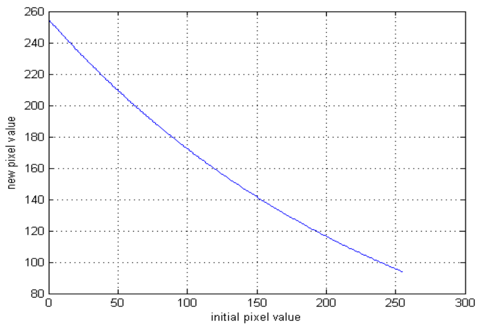


Figure 3 histographic modification function

For the wavelet decomposition of the image the bi-orthogonal wavelet is chosen due to their compact support, symmetry and its efficient energy compactness preserving the essential information of the image [7]. The wavelet decomposition is done with the help of bior3.7 wavelet.

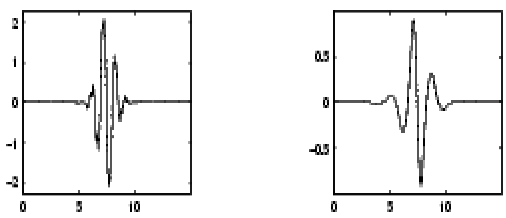


Figure 4: Birthogonal wavelet for decomposition and reconstruction

All approximation sub-bands are suppressed in order to eliminate low frequency components of the image and to carry out the detection process.

Finally, the Breast MR image is reconstructed (IDWT is applied), which is expected to contain only high frequency components including the cancer lesions. To obtain a binary image that shows the detected lesion, the universal threshold method is used. As Breast MR image contains the inner portion of heart and it must be excluded from the resulting image, the thresholding is also applied to upper portion of image to remove results from upper portion

4. RESULTS

Figure 5 shows an original Breast MR image and figure 6 and 7 show findings obtained for each stage of the algorithm.

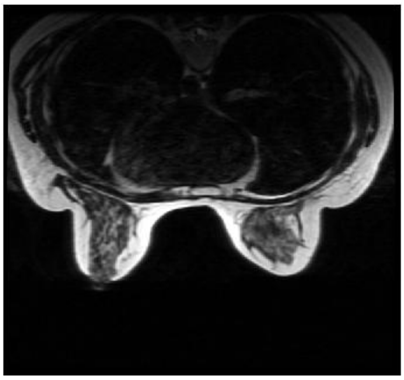
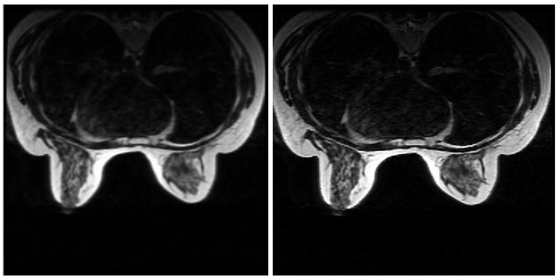


Figure 5: original Breast MR image



(a) (b)

Figure 6(a) denoised image and figure 5(b) filtered image

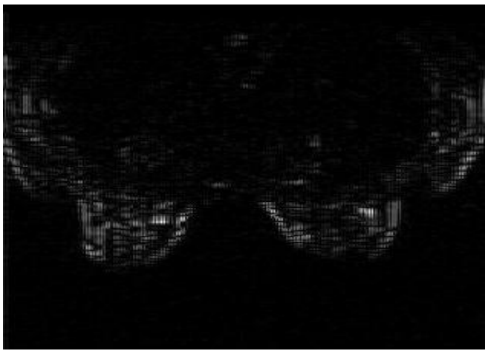


Figure 7: reconstructed image using bior3.7 wavelet

The results which are obtained from the above method are verified from the radiologist in ACTREC. The algorithm was applied on 10 images and found to be 90% correct detection and 10% false positive results are coming.

5. CONCLUSION

An attempt has been made to detect breast cancer in Breast MR images through wavelet transform. This paper concentrates on the use of bi-orthogonal wavelet for the detection. Different techniques are implemented for detection of breast cancer but the above method is found to be more efficient.

Application of different types of wavelets may give different results as compared to bi-orthogonal wavelet. So future work consist of implementation and comparison of different wavelets with different decomposition levels and coming out to a conclusion as which wavelet will be more suitable for this application. Also the interest will be to minimize the errors in the detection process and commenting on the size of lesion that can be detected easily through the algorithm. Detection of breast cancer at an earliest stage is the ultimate aim which can be achieved after going through these preliminary steps.

6. ACKNOWLEDGEMENT

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