Comparison of Wavelet Based Decomposition Techniques for the Analysis of Masses and Calcification in Mammogram Detection

D. Narain Ponraj, Sweety Kunjachan, P. Poongodi, and M. Evangelin Jenifer

***Abstract*—Mammographic mass detection is an important task for the early diagnosis of breast cancer. In this paper we proposed a method for the detection of masses and calcifications based on wavelet transforms using digital mammography. In digital mammography the breast image is captured using a special electronic X-ray detector which converts the image into digital mammograms. The results show that the proposed detection scheme achieves greater detection performance compared to conventional methods.**

***Index Terms*—Breast cancer, mass detection, digital mammography,** m**icrocalcification.**

I. Introduction

Breast cancer is one of the most frequent leading causes of cancer deaths in women [1],[2]. Therefore the early detection of breast cancer is a main factor to decrease the death rate caused by the disease. Mammography gives the evidence of abnormality in breast and the most effective tool for early detection of breast cancer [3],[4].

Different schemes have been developed for the detection of masses and calcifications in mammograms. Early diagnoses were based on filtering and enhancing techniques [5]. But more sophisticated methods are introduced nowadays. The texture analysis approach is done by analysing the tissues surrounding the micro calcification clusters for the prediction of presence of malignancies [6]. Another technique is the application of wavelet transforms. It can be done in two ways.

In the first process, the decomposition of mammograms into frequency sub bands and reconstruction from high frequency sub bands was done. In the second process, energy of image is calculated and pixel intensities are mapped by suppressing high frequency bands [7]-[9]. Another method of detecting masses is to divide the segmented suspicious mass regions into different learning tasks based on neural network approach [10]. Computer based detection is also possible which improves accuracy of detection [11]. In this paper, we proposed a detection scheme which uses modified wavelet transform which makes the point wise regularity analysis possible. It provides better resolution and is capable of producing good reconstruction.

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II. Decomposition and Reconstruction of Images

A. Decomposition

The resolution of the signal is determined by the filtering operations and the scale is determined by sub sampling operations. DWT is computed using MALLAT–TREE decomposition in which successive low pass and high pass filtering of the discrete time-domain signal has been done. It connects the continuous-time multi resolution to discrete-time filters. In the figure 1, X[n] is the input signal. The low pass filter is denoted by L and high pass filter is denoted by H. In each level, high pass filter produces detail information d[n] and the low pass filter produces coarse approximations y[n].

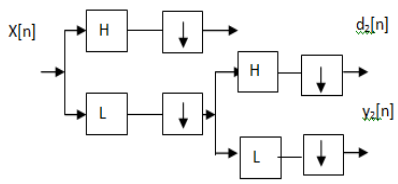


Fig. 1. Block diagram of image decomposition

At each decomposition level, the half band filters produce signals with half frequency band which doubles frequency resolution. In reference to Nyquist's rule, if the original signal has a highest frequency of ω , which requires a sampling frequency of 2ω radians, it now has a highest frequency of ω/2 radians which can now be sampled at a rate of ω radians discarding the half samples with no loss of information. As the entire signal is represented as half frequencies; the decimation by 2 halves the time resolution which also doubles the scale. Therefore the time resolution becomes arbitrarily good at low frequencies. The process is continued till the desired level is reached. DWT can be obtained by concatenating all the coefficients d[n] and y[n] starting from last level of decomposition.

B. Reconstruction

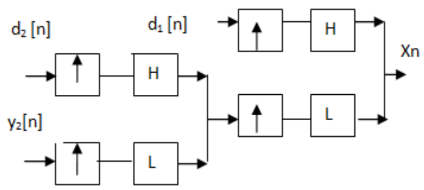


Fig. 2. Block diagram of image reconstruction.

III. Detection Algorithm

Different algorithms are used for the detection of masses and calcifications. They are given below.

A. Mass Detection Algorithm

A mass is defined as a space occupying lesion seen in at least two different projections. Malignant masses appear with rough, speculated, or microlobulated contours and benign masses have smooth, round, oval or macrolobulated contours.

Breast mass detection algorithm consists of the following steps: segmentation, feature extraction, feature selection and classification. In segmentation step, the regions of interests (ROIs) that contain abnormalities are segmented from the normal breast tissue. In second stage, each ROI is characterized with a set of features. In feature selection, the best sets of features are selected and in the classification step suspicious ROIs are classified as benign masses or malignant masses.

Pre-processing is the foundation of mass detection system. So to preserve the local contrast and morphological features and to suppress the negative impaction of blood vessels and structural noises, an effective method to improve the detection process is proposed in this paper based on wavelet transforms.

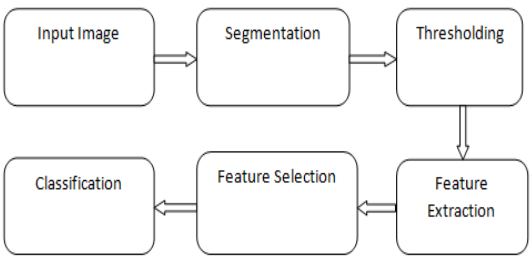


Fig. 3. Proposed mass detection scheme

Assuming that an image I is a linear combination of N components, i.e, I= $\Sigma\ ^{N}_{k=1} I_{k}$ .To get a sparest solution over dictionaries μ_k, i.e, $\{\beta_1^{opt}, \ldots\ldots. \beta_N^{opt}\} = \arg\min \Sigma_{k=1}^{N} \|\beta_k\|_1 + \lambda \| I - \Sigma_{k=1}^{N} \mu_k \beta_k \|_2^2$ where β_k represents the k^{th} sparse solution. Mammogram can be segmented into piecewise –smooth component and texture component. To represent these components, two dictionaries are needed. Undecimated version of bi-orthogonal wavelet transforms (UWT) can effectively represent the piecewise-smooth component and also the shift invariance property of UWT could make the mass location process more accurate. So UWT is applied in our work. Local discrete cosine transform (LDCT) possesses good performance in extracting the local texture. Assume T_{LDC} and T_{UWT} denote the UWT and LDCT respectively. Under this setting the solutions are given by $\{\ \beta_{LDC}^{opt}, \beta_{UWT}^{opt}\}$ and the two components I_{LDC} and I_{UWT} is rewritten as $\{I_{LDC}^{opt}, I_{UWT}^{opt}\}$ $=\arg\min_{(ILDC,LUWT)} \| T_{LDC} I_{LDC} \|_1 + \|T_{UWT} I_{UWT}\|_1 + \lambda \| I - I_{LDC} - I_{UWT} \|^2_2$.

The detailed procedure for mass detection scheme can be summarized as follow:

Step 1: Breast regions are segmented and mammograms are decomposed into components.

Step 2: Thresholding is done starting from the highest gray level to lowest gray level.

Step 3: Morphological features are extracted and features are selected. Regions satisfying the conditions are referred to as suspicious regions

Step 4: The ROIs are classified into malignant and benign cases.

B. Microcalcification Detection Algorithm

Calcifications are calcium deposits inside the breast. They are of two types: microcalcifications and macrocalcifications. Detection of micro calcification is very important for the early diagnosis of breast cancer. Micro calcifications are the extra cell activities in the breast tissue. If the micro calcifications are grouped in clusters, it can be a sign of malignant tumour and the scattered micro calcifications are usually the benign breast tissue. Calcifications are seen as bright dots of different sizes in mammograms.

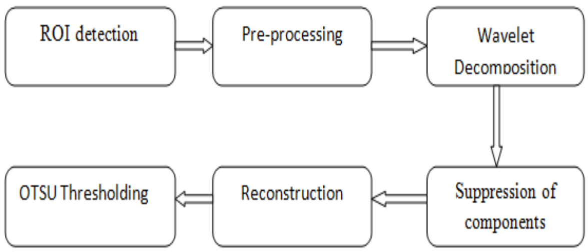


Fig. 4. Proposed calcification detection scheme

High quality digitized images with good resolution is retrieved due to the development of information technology. Digital mammography delivers sharper images with high resolution and richer with details that is needed for diagnosis. CADe software makes the diagnosis process easier. The purpose of CADe is to detect the presence of micro calcifications, especially clustered ones, because they can be the early signs of cancer. It will give good results by producing less false negative (FN) results. After the image enhancement, region of interest (ROI) should be detected. Feature extraction and selection are the next two steps. Finally the decision algorithm based on selection features provides detection results.

IV. Experimental Results and Discussion

The scheme for the detection of abnormalities has been tested by using images from MIAS (Mammographic Image Analysis Society). Images in database are having resolution of 50 μm with 256 gray levels. Mammograms were down-sampled before the application of scheme which will speed up the processing. The input image is first pre-processed and a 3 level decomposition have been done to obtain the reconstructed image. Then thresholding is applied to reconstructed image to get the output image. The detection results are shown below.

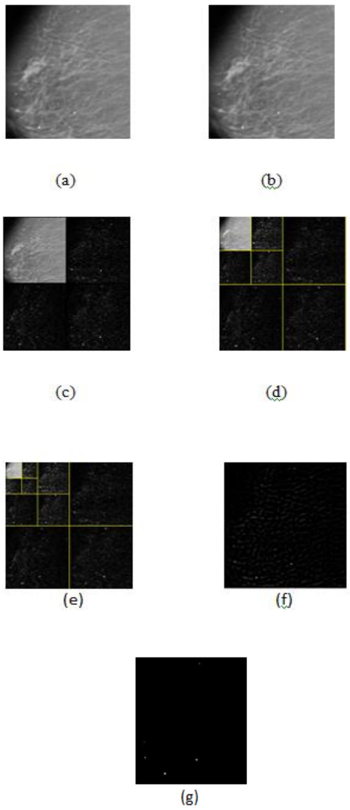
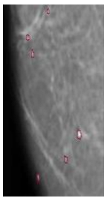
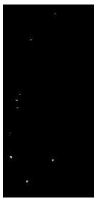
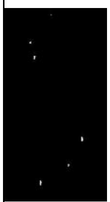
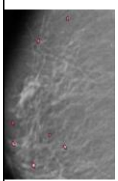
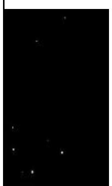
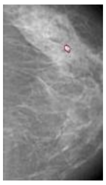
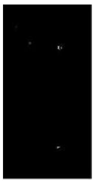
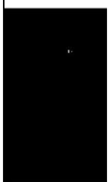
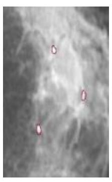
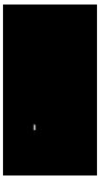


Fig. 5. Detection Results: (a) Original image, (b) Pre-processed image, (c) Level 1 decomposition, (d) Level 2 decomposition, (e) Level 3 decomposition, (f) Reconstructed image, (i) Output image.

TABLE I: COMPARISION OF RESULTS

	Input Image	DWT	Proposed Method
1			
2			
3			
4			

V. CONCLUSION

A novel scheme for detection of masses and calcifications based on digital mammography has been proposed. For the detection of masses the schemes first pre-process the mammogram and then by thresholding, features are extracted and selected. Then they are classified as benign or malignant masses. For micro calcification detection, the ROIs are selected and decomposed by wavelet decomposition. Then the results are obtained by further processing. The experimental results show that the proposed methodology gives a higher degree of accuracy in comparison to conventional discrete wavelet transform. The scheme could achieve satisfactory detection sensitivity with acceptable false positives. New features such as Gaussian distribution characteristics of mass regions and local texture should be introduced further to reduce the false positives.

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