FPGA Implementation for Automated Detection of Breast Cancer using Wavelet Transform

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Abstract- The mortality rate due to breast cancer is increasing, for five minute a women dies worldwide. Mammogram is one which reduces the death rate by early diagnosis and regular screening. This paper hypothesize a consolidate approach of FPGA implementation for automatic detection of breast cancer and classification of the tumor by adopting 2D discrete wavelet transform and artificial neural network (ANN). Initially mammogram is segmented from the background which improves the quality of the image by reducing noise followed by wavelet transform implemented both on software and FPGA hardware. The tools used are MATLAB 2010b and wavelet transform is implemented in Verilog and simulated in Xilinx 13.1 ISE. The paper posits a system which serves as a second opinion to the radiologists and helps in classifying the abnormalities. The images are tested and classified by using Mammography Image Analysis Society (MIAS) database.

Keywords- Breast cancer, mammography, Computer Aided Diagnosis (CAD), FCM Clustering, Wavelets, feature extraction, Artificial Neural Network (ANN).

I. INTRODUCTION

The most common type of cancer in ladies is Breast cancer and lamentably the second driving reason for mortality in ladies because of malignancy [1]. In India one women dies due to breast cancer for every 2 women newly diagnosed [2]. At the point when contrasted and China US and, India has the most extreme number of mortality rate in ladies due to breast cancer, and that number is colossal.

Breast tumor is a most prevalent amongst the most well-known malignancies that effect ladies. As indicated by the World Health Organization, breast cancer is most predominant cancer being diagnosed among moderately aged ladies. In spite of the high incidence rates in US, it has been found that around 89% of ladies determined to have bosom growth are still alive 5 years after their diagnosis. This is principally because of early stage detection of cancer and treatment for malignancy [3].

Although curable, particularly when identified at early stages, breast cancer is a noteworthy reason for death in most women worldwide. An essential element in breast tumor growth is that it has a tendency to happen prior in life than different sorts of malignancy and other significant illnesses. Despite the fact that the reason for breast cancer has not yet been completely known, early detection and expulsion of the primary tumor are crucial and successful strategies to decrease mortality, just a couple of the cells that left from the primary tumor would have succeeded in framing secondary tumors. When clinically localized by regular screening breast cancer can be detected at early stage which dramatically increases the survival rate. The essential part of imaging strategy is hence the recognition of primary sores in the breast [4]. Currently, the best technique for the location of early breast disease is X-beam mammography. However radiologists need to encounter a special training and experience to read the mammograms, as it is difficult task. Hence, there is a solid requirement of frameworks for the advancement computer-aided diagnosis systems (CAD).

Recent advances in science and technology have helped in the recognizable proof of breast malignancy at early stages, one of the methods being mammography. Mammography method saves lives...
by detecting breast tumor cells to cure while they are at starting phase of breast disease. According to recent statistics by this method of mammography for early diagnosis the mortality rate due to breast cancer can be reduced to one-third. Some of the current practice in distinguishing the tumors in breast tissues has a 10% of false negative and 20% false positive cases being accounted [4]. This method can be solved by adopting effective algorithm for reducing the false negative and false negative and by detecting breast tumor more precisely [5]. In the long run, it saves more ladies from breast cancer.

A common benign mass has a round, smooth and very much clear boundary; while, a malignant tumor for the most part has a rough, hypothesized, and obscured boundary [6]. By spotting areas with high impressions of danger Computer Aided Detection (CAD) frameworks in screening mammography which serve as an affirming factor for radiologists [7]. A definitive objective of CAD is to spot such malignant areas with a high exactness and dependability and most studies embrace that CAD innovation for early breast malignancy discovery which has a productive impact.

The basic concept of artificial neural networks (ANN) was inspired from biological neural networks just like how the human brain works. For decision support ANN is one of the best tools which reduces the artifacts and reduces the workload and serves a second opinion for the radiologists for detection of breast cancer. ANN model is reliable, fast and risk free with less false negative cases.

II. LITERATURE SURVEY

Cheng et al. [8] discussed the automated detection method for breast cancer. In this, the most of the death reason for women’s is breast cancer. The death factor can be decreased by detecting and diagnosing the early stage of the cancer. Recently, an ultra sound imaging was used to identify the irregularities in breast. The authors have also discussed advantages and disadvantages of each stage of CAD systems.

Jalalian et al. [9] have presented a survey over the ultrasound and CAD based breast cancer diagnosis method using mammography. The standard for the breast imaging, cancer detection is mammography. The mammography method has its limitations against low sensitivity and the ultrasound and MRI are used to achieve more information for breast cancer detection.

Zheng et al. [10] have presented a digital mammogram method for breast cancer detection of Gabor cancer detection (GCD) algorithm. The algorithm is consists of three main steps like preprocessing, segmentation and classification. This algorithm promises the better breast cancer detection.

Pereira [11] have presented an breast cancer segmentation and detection in mammograms. For de-noising and image enhancement the wiener filtering and wavelet transform based pre-processing performed. The post processing is performed after the segmentation of suspicious area in the image. From the combined method the author has achieved accuracy results.

Kalager et al. [12] have discussed the screening effect of mammography in breast cancer. The author has compared the death rates of different age groups. The comparative analysis suggests that the most of the death rates due to breast cancer.

Ali Raad et al. [13] discussed the neural network classification for breast cancer. The comparison between multi-layer perceptron (MLP) and Radial basis function (RBF) network is carried on and proves RBF network classifies the breast cancer with high accuracy rate.

Bhateja and Devi [14] have presented improved non-linear transformation faction to enhance the suspicious mammographic breast tissues.

Gorgel et al. [15] have presented a hybrid scheme of spherical wavelet transform and local seed region growing for breast cancer tissue detection. The method supports the classification of malignant tissues. The method is adopted over the data taken from the Istanbul hospital and it achieves the successful mass identification rate of 94%.
III. METHODOLOGY

The proposed approach is as shown in Fig.1. The major steps involved in the proposed approach are mammogram image preprocessing which involves orientation correction, removal of label, suppression of pectoral muscle followed by segmentation by means of fuzzy C-means clustering. For the segmented image wavelet decomposition is applied from which only the average co-efficient are extracted. Next step is feature extraction based on mean, kurtosis, variance, skewness, standard deviation and entropy features extracted from the average co-efficient and finally by means of Artificial Neural Network(ANN) classifier the mammogram is classified into normal or malignant.

Fig.1. Block Diagram of proposed methodology

A. Pre-Processing

With a specific goal to enhance the quality and reduce the noise from the input digital mammogram image, some of the steps involved in the pre-processing stage are orientation correction and removal of black background. This step is carried on in order to avoid the unnecessary search for anomalies from the image background. Following are steps involved in pre-processing stage:

a) Breast Orientation Correction:

In order to process the image further the input mammogram image is currently isolated into two sides (left and right) and the total of each side is computed. This helps in arranging the mammogram as left or right breast based on the greatest aggregate between the two sides. For further processing the mammogram image is always viewed to the left side in this proposed method.

b) Black background Removal:

Once the orientation is corrected the unnecessary black background is removed by finding the sum of intensities for all rows and columns are computed. The threshold value is set for these computed sums by trial and error method. The complete row (m) and column (n) is eliminated if the computed sum falls below the threshold value and thereby removing black background from the mammogram image as shown in formula (1) for each column and formula (2) for each row:

\[
\sum_{i=1}^{n} I(i,j) \leq \theta_1
\]  

\[
\sum_{i=1}^{m} I(i,j) \leq \theta_2
\]
where $\theta_1$ and $\theta_2$ represent the threshold values for column and row pixels; $I(i,j)$ is the intensity of the pixels and $m, n$ are the dimensions of the window.

B. Segmentation:

Segmentation is the process of dividing the digital image into different fragments. The main objective is to streamline and/or change the representation of the image into something that is more significant and less demanding to investigate. Pixels in the homogeneous region share similar attributes in characteristics like color, intensity or texture.

Fuzzy C-means clustering is a method which permits one bit of information to have a place with two or more clusters. Clustering is the process in which the groups of data points are partitioned into clusters of small number. In conventional, there are $n$ data points where $x_i$, $i=1,2,\ldots,n$ which has to be partitioned into $k$-clusters. The objective is to relegate a cluster to every data point and to minimize the objective function.

The algorithm aims by allotting membership to each data point on the basis of distance between the cluster and the data point corresponding to each cluster center. As the more the number of the data is closer to the cluster center then membership of that particular cluster center increases.

By an iterative optimization of the objective function the membership $u_{ij}$ and the cluster centers $c_j$ gets updated this process is called Fuzzy partitioning. The FCM algorithm endeavors to divide a finite collection of elements into a set of $c$ fuzzy clusters regarding some given measure. The algorithm is made out of the few steps:

i. The cluster center has to be selected randomly.
ii. The matrix $U$ is initialized as $U=[u_{ij}]$ with the initial value being $U^0$.

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \frac{\|x_i-c_k\|^2}{\|x_i-c_k\|^2}}$$

iii. The membership function $u_{ij}$ is calculated.
iv. The centers vectors are calculated at the k-step $C^{(k)}$=$[c_j]$ with $U^{(k)}$.

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^m x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

v. $U^{(k)}$, $U^{(k+1)}$ should be updated.
vi. If $\|U^{(k+1)} - U^{(k)}\| < \varepsilon$ or if the minimum $J$ is attained , then clustering has to be stopped; otherwise return to step ii.

vii. At the end clusters are displayed that belong to those cluster centers.

From these steps of fuzzy c means clustering mammogram segmentation is achieved. As segmentation is removal of unwanted regions and to retain the region of interest. Two major steps are label removal from the digital mammogram and suppression of pectoral muscle. Thus the image is segmented by removing the fragments that are not significant for further detection and classification.

C. Wavelet Decomposition:

The fundamental thought of wavelet transform is that the change ought to permit just changes in time augmentation, yet not shape. This is affected by choosing appropriate basic functions.

A wavelet is a waveform of viably constrained length hat has a normal estimation of zero. A discrete wavelet transform (DWT) are those where in the wavelets are sampled discretely for any of the wavelet transform. The image decomposition utilizing wavelets results as a part of an arrangement of coefficients which act as features for classifiers for classification. Some of the coefficients results are LL,
LH, HL, HH which are associated with the pixels in the image. These coefficients are then being decomposed more easily because the data of these decomposed images are statistically gathered in just few coefficients. In the DWT, every level is measured by passing just the previous wavelets that are approximated for coefficients i.e. average coefficients through discrete high and low filters. However there are only detailed coefficients with 1-D case and in 2-D case detailed coefficient and approximation coefficients are present.

Harr is the wavelet type used in this paper through which coefficients are determined. For a list of input constituted by $2^n$ numbers, this proposed Haar wavelet transform stores the difference and passes the sum for the pair input values. This transform is found effective as they allow inspect each signals local aspects and involves simple computation.

**D. Average Co-efficient:**

From previous step there are three detailed coefficients- LH, HL and HH and average coefficient LL at the decomposition 1- scale. Since LH, HL and HH subbands are those which store errors and are ambiguous with no useful information. Hence the remaining coefficient is average coefficient from which features are being extracted. Before extraction of features from average coefficient (LL), the coefficient has to be normalized. Normalization is accomplished by dividing each and every vector by its most extreme value. Such that the coefficient results will be equal to 1 or less than 1 which simplifies the coefficient values that are extracted for feature extraction.

**E. Feature Extraction:**

After wavelet decomposition, the average coefficients are normalized. From these normalized coefficients six features are extracted they are mean, standard deviation, kurtosis, skewness, entropy and moment. The mean is the average intensity value of the pixels. In probability theory and statistics, fluctuation measures how far an arrangement of numbers is spread out. Variances are identical of zero shows that all the values are identical. One of the property of variance is it is always non-negative : if there is high variance it indicates the mean is spread out with respect to the data set, while if there is small variance it indicates the mean is close to the data set. Standard deviation is calculated as the square root of the variance. It is comparable with the mean deviations.

The term kurtosis is utilized as a part of probability hypothesis and statistics. Kurtosis is a statistical feature which measures the data whether it is flat or peaked that is relative to normal distribution. That is, if high kurtosis is seen for the data sets then they have a tendency to have a clear peak near the mean and these peak values reduce rapidly with heavy tails. If low kurtosis is found then they have a tendency to have a flat top close to the mean rather than a sharp crest. For data with one variate $Y_1, Y_2, ..., Y_N$, the formula for kurtosis is given by equation 3,

$$\text{Kurtosis} = \frac{\sum_{i=1}^{N} (y_i - \bar{y})^4}{(N-1) s^4}$$

(5)

Skewness is an estimate of symmetry, or all the more decisively, the absence of symmetry. If the distribution looks same on both left and right side from the center point. The formula for skewness is given by equation 4,

$$\text{Skewness} = \frac{\sum_{i=1}^{N} (y_i - \bar{y})^3}{(N-1) s^3}$$

(6)

Entropy is defined as the measure of abnormalities in a mammogram image. The entropy value is said to be high in microcalcification, if the entropy value is low then it is said to masses. The formula for entropy is given by (5),

$$H = \sum_{i=0}^{N} p(i,j) \log P(i,j)$$

(7)

Where, $N$ is the number of data points, $P(i,j)$ is the cell associated with row and the column of the image.
Moment is some weighted average associated with the intensities of the image pixels, which is calculated for interpretation for classifiers.

F. Artificial Neural Network:

The basic concept of artificial neural networks was inspired from biological neural networks just like how the human brain works. ANN constitutes set of inputs that have desired output that are compiled with processing component which are highly connected called neurons. The characteristics of the components that are interconnected are associated with weights. These highly connected neurons are trained by creating the database with set of features and allow the network to solve the untrained cases. The type of neural network adopted in this paper is Radial basis Function (RBF) neural network. The architecture of RBF is composed of multiple layers: input layer, hidden layer and output layer. The number of neurons i.e. input by the number of features and output by classifier classes. Hidden layer is determined by the number of input layer and in this paper 2n (n is number of input neurons) hidden layers are used. There is prototype vector in each of the hidden neuron as a parameter. The hidden neuron output is weighted and then passed onto the output layer which has two classes (normal or malignant).

For a given set of images first the neural network has to be trained for both normal and abnormal image and these trained set of images stores the weights of the features for both normal and abnormal image data set separately. Once training is done, testing of untrained images is carried on. From the stored weights each feature of the untrained image is weighted. If the output layer (y) is one then the image that is untrained is normal else it is malignant.

IV. RESULTS AND DISCUSSION

The mammogram images were acquired online from Mammographic Image Analysis Society (MIAS) on which the experiments are carried out for automated detection of breast cancer. The MIAS database has 322 images; out of which 30 images (15 normal and 15 malignant mammograms) were trained using ANN classifier with six classes as a set of feature vectors and are stored as trained weights. Likewise 80 images (40 normal and 40 malignant mammograms) were tested using the proposed method for automated detection and classification as illustrated in TABLE I.

Initially the input mammogram images are preprocessed using orientation correction and removal of black background as in Fig.2. Next step is segmentation using fuzzy c-means clustering approach which involves removal of label and pectoral muscle suppression as in Fig.3. The ROI is resized to 256*256 for FPGA implementation and the image is converted to text file Fig.4. The simulation result of wavelet decomposition is shown in Fig.5. The output of FPGA i.e. text file is given to MATLAB to read the wavelet transformed image Fig. 6. From the wavelet decomposed image only average co-efficient is analyzed. Next the features were extracted for acquiring optimized feature set. The ANN algorithm which is adopted classifies the set of input features into normal or malignant (abnormal).

![Fig.2](image1.png)

**Fig.2.** (a) Normal mammogram image; (b) Orientation Correction; (c) Removal of Black Background
Fig. 3. (a) Removal of label and pectoral muscle suppression using FCM segmentation; (b) Segmented 1024*1024 sized image

Fig. 4. (a) Resized segmented image to 256*256; (b) Input text file to Xilinx

Fig. 5. Simulation Result of Wavelet Decomposition for 256*256 sized segmented image

\[ \text{TABLE I Training and Testing Dataset} \]

<table>
<thead>
<tr>
<th>Type</th>
<th>Training</th>
<th>Testing</th>
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<tbody>
<tr>
<td>Normal</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Malignant</td>
<td>15</td>
<td>40</td>
</tr>
</tbody>
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Fig. 6. Wavelet decomposition of normal mammogram image

The proposed system performance is being calculated by measuring performance metrics as in Table II

\[ \text{TABLE II Performance} \]

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>Performance Parameters</th>
<th>Performance %</th>
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<tbody>
<tr>
<td>1.</td>
<td>Accuracy</td>
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</tr>
<tr>
<td>2.</td>
<td>Sensitivity</td>
<td>97.5</td>
</tr>
</tbody>
</table>
3. Specificity 95
4. False positive rate 5
5. False negative rate 2.5
6. False discovery rate 4.87

V. CONCLUSION AND FUTURE WORK

An improved automated detection technique using FPGA implemented using wavelet transformed algorithm with ANN classifier for detecting and classifying mammogram as normal or abnormal (malignant tumor) has been proposed and the performance is evaluated. It is concluded from the analysis that the multiple features, Fuzzy C-means segmentation approach, Wavelet Transform and the ANN classifier, on the whole increases the classification of mammogram image into normal and malignant classes. The proposed approach is most efficient for detection with high specificity, sensitivity and accuracy. In future work wavelet decomposition can be carried on for 2-5 scales of decomposition.

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