Benign Calcification Detection in Mammogram Images

Pournami S. Chandran 1, Byju N B 2, Rajesh Kumar R 3, Dr. Sumod Mathew Koshy 4, Dr. K. Ramachandran 5

1, 2, 3 Centre for Development of Advanced Computing
4, 5 Regional Cancer Centre
Thiruvananthapuram, India
pournamisc@yahoo.co.in

Abstract- This paper describes an algorithm for detecting calcifications which are benign in nature. Computer Aided Detection (CAD) for breast cancer is useful for screening and for second look, because it assists the radiologist to evaluate a large number of patient cases and also to improve accuracy of cancer detection. Calcification is one of the important abnormalities which indicate cancer in breast. But they can be seen along with many benign changes too. Hence it is essential to differentiate between benign or malignant calcifications and accurately list the finding in the final mammography report for avoiding unrequired biopsy of patients. The proposed method uses a three level wavelet enhancement technique. Reconstruction of the image by scaling the detailed coefficients emphasizes the calcifications in the image. Background tissue suppression of the reconstructed image is performed with the help of morphological filtering. The microcalcifications and skin thickening regions which get delineated along with calcifications are filtered out by area thresholding and edge detectors respectively. Experimental results show that multilevel wavelet reconstruction method can be effectively used for benign calcification detection by suitable selection of wavelet type and detailed coefficient scaling factor. The algorithm gives better results with an image level true positive rate of 96.15%. This approach results in reduced number of false positives with a false positive rate of 3.85%. For evaluation of the proposed method a database of digital images in DICOM format is employed.

Keywords – Digital Mammograms, Benign Calcification, DICOM, CAD, Wavelet Transform, DWT, Tophat Transform

I. INTRODUCTION

Mammography is a low-dose x-ray procedure that allows visualization of the internal structure of the breast for detecting breast pathology. Hence x-ray mammography is used as the imaging technique for early detection of breast cancer. Mammogram images are widely used as a supportive measure for screening purpose to detect cancer much earlier before it spreads. This increases the chances of recovery and reduces mortality rate due to breast cancer [1]. After a close examination of the mammogram, the radiologist suggests any of these, a routine interval mammography, short-term follow-up or a biopsy. It depends upon the suspicious findings in the mammogram image under consideration. Among the possible abnormalities, important lesions are mass and calcifications. Calcifications appearing in a mammogram may or may not be an indicative of cancer. It is very necessary to decide whether the calcifications present in a mammogram are benign (non-cancerous) or malignant. If it can be evaluated as absolutely benign then it helps avoiding unwanted biopsy of a patient.

A. Relevance of the work

It is suggestive that every woman above an age of 40 should do screening test of mammogram for breast cancer. There are 7 assessment categories described in American College of Radiology (ACR) BI-RADS [2] and mostly they have a correlation with the likelihood of malignancy. It is shown in Table 1. Depending upon the category in which the patient’s BI-RADS final assessment falls, Radiologist recommends the necessary action plan for them. In the table, for categories 1 and 2 only routine follow up is needed. Category 1 is used if there is no particular finding to report. Category 2 is the one which is under our consideration and is used to describe a benign finding which is concluded that there is no mammographic finding of malignancy associated with it. This work of benign calcification detection is part of a work to identify those patients whom fall in category 2 and ensure that only routine follow up is needed, thus avoiding panic situations. This work is in fact a part of a project for developing a computer aided
Benign Calcification Detection in Mammogram Images

diagnosis for mammograms. While developing a CAD for mammograms, apart from lesion detections, the final assessment category of BI-RADS need to be reported. For that any mammogram findings should be mentioned, whether it is of benign or malignant change. This should aid in suggesting a patient case to be a follow up or a biopsy. There are mainly two modules; calcification detection and mass detection modules. Calcification module is again subdivided into benign calcification detection and microcalcification cluster detection modules. For this purpose calcifications which are categorized as benign in BI-RADS, have to be identified from other malignant microcalcifications. The result of this benign calcification module and mass detection module is finally combined for getting the final category. If any of these modules contains a benign finding and no other malignant lesions are detected, then the assessment level falls into category 2. This paper presents a simple method for benign calcification segmentation without using classifiers for classifying calcifications based on malignancy and benignity. The calcifications are needed to be segmented and marked for the assessment of the mammogram images.

Table -1 Assessment categories

<table>
<thead>
<tr>
<th>Assessment levels</th>
<th>BI-RADS Category</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete Assessment</td>
<td>0-Incomplete</td>
<td>Additional evaluation needed</td>
</tr>
<tr>
<td>Final Assessment</td>
<td>1-Negative</td>
<td>No lesion found (routine follow up)</td>
</tr>
<tr>
<td></td>
<td>2-Benign finding</td>
<td>No malignant features (routine follow up)</td>
</tr>
<tr>
<td></td>
<td>3-Probably benign</td>
<td>Short interval follow-up</td>
</tr>
<tr>
<td></td>
<td>4-Suspicious abnormality</td>
<td>Biopsy should be considered</td>
</tr>
<tr>
<td></td>
<td>5-Highly suggestive of malignancy</td>
<td>Take appropriate action, biopsy</td>
</tr>
<tr>
<td></td>
<td>6-Known biopsy proven malignancy</td>
<td>Appropriate action should be taken.</td>
</tr>
</tbody>
</table>

they are not much interested in benign calcifications. They are CAD for malignant lesions alone and a reporting system in compliance with the BI-RADS reporting is not present in most of the literature. This work focuses on this. In this point of view the calcifications are to be detected and also they need to be identified as the calcifications which are not malignant. A work on accurate segmentation of microcalcification using parametric active contour is presented in [3]. The detection of microcalcification cluster using neural networks and support vector machines is illustrated in [4]. After enhancement some features are extracted from the region containing clusters and used for classification of clustered microcalcifications. In [5] also a cluster detection method using graphical method is explained by the author. It uses a Waxman model for detecting a cluster from microcalcifications seen in a mammogram. The paper [6] uses grouping of nearby pixels for cluster detection. Different enhancement techniques are available for microcalcification present in a mammogram. Contrast enhancement of microcalcifications using wavelet is present in [7].

C. Benign patterns of calcifications

Calcifications are deposits of calcium in breast tissue. They can be broadly classified as microcalcification and macrocalcification. A microcalcification is a tiny granule-like calcium deposit that has accumulated in the breast tissue, appearing as a small bright spot on a mammogram. When many microcalcifications are seen in one area, they are referred to as a cluster and may indicate cancer. But macrocalcifications are coarse calcium deposits that are often associated with benign changes in the breasts. They do not usually require a biopsy, because macrocalcification deposits are associated with benign conditions. The form of calcifications (Morphology) is the most important factor in the differentiation between benign and malignant. If calcifications cannot be readily identified as typically benign or as malignant, they are termed of ‘intermediate concern or suspicious’. Benign calcifications [8] (those categorized as BI-RADS category 2) include the following types: skin, vascular calcifications, coarse, large rod like, milk of calcium, lucent centered, dystrophic, egg shell or rim and suture. Skin Calcifications are usually lucent centered deposits confined near skin. Vascular Calcifications shows a linear configuration and are associated with blood vessels. Coarse or Popcorn like are large calcifications. The foci of Large Rod like or Plasma cell mastitis calcifications are thick and follow ducts forming continuous rods. Lucent centered calcifications are rounded calcifications with a lucent center. Milk of Calcium are tiny tea cup shaped calcifications present in small cysts. Dystrophic calcifications are coarse irregular lava-shaped calcifications. Eggshell or Rim Calcifications are thin,
round rim-like calcifications that often seen in the walls of cysts. Suture calcifications represent calcium deposit on suture material.

![Mammographic image with microcalcifications](image1)

![Mammographic image with benign calcifications](image2)

Figure 1. (a) Mammographic image with microcalcifications (b) Mammographic image with benign calcifications

(a)                                (b)                                (c)                                 (d)                                (e)                         (f)                      (g)                           (h)                            (i)

Figure 2. (a) Skin Calcifications (b) Vascular (c) Coarse calcification (d) Large rod-like (e) Lucent centered (f) Milk of calcium (g) Eggshell (h) Dystrophic (i) Suture

![Calcifications Morphology](image3)

Figure 3. Different types of calcifications

II. MATERIALS AND METHODS

A. Materials

The digital mammographic images used for this study are from the Hologic Selenia Dimensions full field digital mammography (FFDM) system installed in Regional Cancer Centre (RCC), Thiruvananthapuram. Digital
mammography units have been replacing the conventional mammography units because of the high quality images it delivers. It proves to be more accurate for younger women and women having dense breast tissue. Calcifications have a higher X-ray attenuation than the normal breast tissue and appear as a bright structure in the mammograms. The images have ground truth marked by the radiologist. They marked the calcifications present in the mammogram. The images have $65\mu m$ pixel size and bit depth of 12 bit. The images are in the DICOM format [9], DICOM is a standard for storage and exchange of medical images independent of the imaging equipment manufacturer. DICOM (Digital Imaging and Communication in Medicine) image file formats supports image data and other information useful to describe the image.

**B. Proposed methodology**

The calcifications present in the mammograms need to be enhanced from its surrounding tissue. The underlying breast structure and microcalcifications are the counterparts for the benign calcification while detection. The mammogram images in DICOM format are taken for processing, from the digital mammography machine. Contrast enhancement for calcifications is done using the wavelet reconstruction of the image. The detailed coefficients from the wavelet decomposition are multiplied with a weighting factor. Wavelet reconstruction of the images with the corresponding detailed coefficients and the approximation coefficients provides the enhanced image. It follows with the morphological filter for better background suppressed output. Then candidate calcifications are segmented from the final enhanced image. Finally microcalcifications and tissue regions which are segmented along with benign calcifications are eliminated. The skin thickening which may be present near the boundary region also have to be eliminated.

![Figure 4. Mammographic image with microcalcifications](image_url)
C. Image enhancement using wavelet transform

The benign calcifications have to be identified from the underlying breast structure and malignant microcalcifications. The calcifications present in the mammograms need to be enhanced from its surrounding tissue. It is necessary for extracting useful high frequency information relevant to benign calcifications from low frequency background and very high frequency microcalcification. This contrast enhancement method using wavelet decomposes the input DICOM image into its subbands using a separable two dimensional wavelet transform. Any 2D separable transform function can be expressed as the product of two 1D transforms. For an image 2D wavelet transform [10] can be implemented as two 1D wavelet transforms in series, one for row matrix and the other for column matrix of the image. In one dimensional wavelet transform the input signal is filtered using two filters; the low pass filtered signal gives the approximation coefficients and high pass filter gives the detailed coefficients. Consider the filter bank of figure 5; the input image is applied to a system of a pair of filter banks. The analysis filter decomposes the input image into subbands. At first the wavelet filters are applied to the rows of the image. It consists of a low pass filter with z transform \( H(z) \) and high pass filter of z transform \( G(z) \). The filtered outputs are down sampled by two and again the filters are applied to the columns of the corresponding subbands. Further down sampling by a factor of 2 gives the final decomposition of the input image into sub images with low-low component (LL) giving approximation coefficients, low-high component (LH) giving vertical coefficients, high-low component (HL) giving horizontal and high-high component (HH) giving diagonal coefficients. The synthesis filter recombines these subbands.

In the overall system the two dimensional wavelet transform is considered as a combination of two one dimensional wavelet transforms which first computes the wavelet transform along rows and then along columns of the image. The perfect reconstruct filter decomposes the input image into its subbands and reconstruction is performed by recombining these subbands. Three stages of decomposition are necessary because the necessary high frequency details should be extracted. There are four basic functions for 2D signal like image. One 2D scaling function and three 2D wavelet functions are given in the equation below.

\[
\begin{align*}
\Phi(u,v) &= \Phi(u)\Phi(v) \\
\varphi_1(u,v) &= \varphi(u)\Phi(v) \\
\varphi_2(u,v) &= \varphi(u)\varphi(v) \\
\varphi_3(u,v) &= \varphi(u)\varphi(v)
\end{align*}
\]

Where \( \Phi(u) \) is the 1D scaling function, \( \varphi(u) \) is the 1D wavelet function, \( \Phi(u,v) \) is the 2D scaling function and \( \varphi_1(u,v), \varphi_2(u,v) \) and \( \varphi_3(u,v) \) are the 2D wavelet functions. The transform coefficients are found out by projecting the input onto the basis functions. This gives the four transform coefficients; in which \( A(j,x,y) \) Coefficients give the coarse approximation of the input image \( I(u,v) \). \( D^{(1)}(j,x,y) \), \( D^{(2)}(j,x,y) \) and \( D^{(3)}(j,x,y) \) coefficients contains vertical, horizontal and diagonal details respectively. Mathematically it can be written as

\[
\begin{align*}
A(j,x,y) &= LL = \iint I(u,v) 2^j \Phi(2^j u-x)\Phi(2^j v-y) dx dy \\
D^{(1)}(j,x,y) &= LH = \iint I(u,v) 2^j \varphi(2^j u-x)\Phi(2^j v-y) dx dy \\
D^{(2)}(j,x,y) &= HL = \iint I(u,v) 2^j \Phi(2^j u-x)\varphi(2^j v-y) dx dy
\end{align*}
\]
Benign Calcification Detection in Mammogram Images

\[
D^{(3)}(j,x,y) = HH = \iint I(u,v)2^j \Phi(2^j u - x) \varphi(2^j v - y) \, dx \, dy
\]  

A single level wavelet decomposition is not adequate for getting the essential high frequency details in an image, so a three level wavelet transform is employed here. The LL subband is further decomposed into another four subbands and the LLLL subband is decomposed once again.

The wavelet reconstructed image is obtained by taking the inverse wavelet transform. There is some information hidden in the high frequency details of the sub image in each scale. The detailed coefficients are scaled using suitable multiplication factor to obtain the hidden high frequency details in the image. Thus the LL coefficients are kept as such and the set of detailed coefficients HL, LH and HH are multiplied with a weighting factor. The same will be applied to all the other levels of decomposition by keeping LLLL and LLLLLL bands remains the same. Finally wavelet reconstruction is done using the LL, HL, LH, and HH.

\[
\begin{align*}
H_L &= s_{1a} * H_L, \\
L_H &= s_{1b} * L_H, \\
H_H &= s_{1c} * H_H
\end{align*}
\]  

\[
\begin{align*}
H_{LL} &= s_{2a} * H_{LL}, \\
L_{HLL} &= s_{2b} * L_{HLL}, \\
H_{HLL} &= s_{2c} * H_{HLL}
\end{align*}
\]  

\[
\begin{align*}
H_{LLL} &= s_{3a} * H_{LLL}, \\
L_{HLLL} &= s_{3b} * L_{HLLL}, \\
H_{HLLL} &= s_{3c} * H_{HLLL}
\end{align*}
\]  

Where \( s_{1a}, s_{1b} \) and \( s_{1c} \) are the scaling factors for detailed coefficients in 1st level wavelet decomposition. \( s_{2a}, s_{2b} \) and \( s_{2c} \) are the scaling factors for detailed coefficients in 2nd level and \( s_{3a}, s_{3b} \) and \( s_{3c} \) are the scaling factors for the last level.

D. Morphological filtering using tophat transform

The calcifications are usually present in the nonhomogeneous background consisting of different types of tissue structures. Morphological enhancement is used for emphasizing calcifications in the mammograms irrespective of the type of the underlying tissue. A grayscale tophat filter [6] is used as the tool for morphological filtering. The top-hat transform of a gray scale image is defined as the difference between the original image and its opening. Let \( f(x,y) \) be an image and \( g \) be a structuring element. Then tophat transform of an image is

\[
\text{Tophat}(f) = f - (f \circ g)
\]  

Where \( f \circ g \) is the morphological filter operation ‘opening’. The opening operation consists of erosion followed by dilation on a kernel that defines the size of the region over which pixel values are taken.

E. Calcification segmentation

For candidate calcification detection, segmentation is done using global thresholding with a threshold value which represents perfectly the intensity values characterizing benign calcifications.

\[
BI(x,y) = \begin{cases} 
0 & \text{if } I(x,y) < T \\
1 & \text{if } I(x,y) \geq T
\end{cases}
\]  

\[ (13) \]
Where BI is the binary image, \( I(x,y) \) is the value of the intensity of the pixel at the point \((x,y)\) of the image \( I \) and \( T \) is the selected threshold.

**F. Microcalcification detection and removal**

The individual calcifications segmented sometimes may contain microcalcification which are small in size and have similar textural features as that of the benign calcifications. The connected components in the binary image are found out with a connectivity of 8. The area of each of these connected components are estimated which is roughly the sum of the pixels in it. There is a size cut off for the segmented objects and the candidate calcifications which are only above a specific area are only retained. All others including segmented microcalcification and other tissue region segmented are removed.

**G. Skin thickening removal**

In some cases the normal skin thickness of breast increases to a few millimeters. This appears as a white region along the boundary. This skin thickening is removed by eliminating the boundary pixels with suitable thickness. At first, the breast region is segmented from the background. Using Sobel edge detectors the edge pixels are extracted. The Sobel operator detects the edges by looking for the maximum and minimum in the first derivative of the image. This is the gradient method of edge detection in which a 2-D spatial gradient measurement on an image is performed. The boundary pixel extracted binary image thus obtained is dilated with a structuring element of definite size. A strip of region along boundary is obtained and this region is subtracted from the input image for rejecting skin thickened portion of mammogram.

**III. EXPERIMENT AND RESULT**

Test set for evaluation is generated form the total image data set provided from RCC (T) and it consists of 122 images with 44 normal images and 78 images having benign calcifications. The algorithm development is carried out by using MATLAB 7.11.0 platform. The experiments are performed on windows 7 OS with core Quad 2.66 GHz processors having 16GB RAM. The radiologist from RCC (T) analyzed and marked the ground truth for the experiments. The ground truth generation for test set and training set images are done by using software named lesion marker developed by CDAC (T). The images are in DICOM format of more than 20MB size.

The calcification containing images are enhanced using wavelet reconstruction. The detailed coefficients are scaled with a weighting factor which is suitable for highlighting benign calcification. The scaling factor is selected in trial and error manner which gives the maximum true positive rate in the generated test set. It is finalized as 1.7 for \( S_{1a} \), \( S_{1b} \), \( S_{1c} \), \( S_{2a} \), \( S_{2b} \), \( S_{2c} \), \( S_{3a} \), \( S_{3b} \) and \( S_{3c} \). The wavelet enhancement for calcifications in available literature focus in microcalcification since most of the work in literature is concentrating in lesion detection alone. The wavelet transform acts as a useful tool in this scenario, because it can be properly make it suitable for different objects with varying intensities and textural features by selecting the apt wavelet functions which matches with the object and selecting suitable multiplying factor for that object. The wavelet function used here for contrast enhancement is Daubechies wavelet of order 8. The background removal is done using tophat filter. The structuring element employed for benign calcification detection algorithm is much larger than that used for microcalcification detection. A disk structuring element of radius 60 is used here. The segmentation is done by thresholding with the correct value which is specific for the benign calcifications alone. The threshold value is set such that it is high enough to eliminate noise, microcalcifications and background tissue regions. By analyzing tophat images it is clear that the pixels belong to calcifications possess very high values and mostly it is above 0.85. Thus the reasonable value for the threshold that came out after thorough testing on numerous test images is 0.85. The holes inside the segmented objects are filled using the function ‘imfill’ of MATLAB. For microcalcification rejection the size threshold is selected as 20 pixels. Because microcalcifications are tiny granule like calcium deposit with very small spatial support.
Benign Calcification Detection in Mammogram Images

Figure 7. (a) Input image (b) wavelet reconstructed image (c) tophat filtered image (d) segmented image (e) microcalcification and skin thickening removed image (f) final benign calcification detected output

The results in Figure 7. indicated that the proposed approach detects the benign calcifications after enhancement and noise removal. The input mammogram image for processing is shown in figure 7(a). Figure 7(b) corresponds to the enhanced image wavelet transform. Background rejection is done by tophat transform and 7(c) illustrates the tophat transform of the enhanced image. The calcification segmented binary image is in 7(d). Microcalcifications in the mammogram are filtered out using an area thresholding and after that skin thickening removal is done using edge detectors. Its combined output can be seen in 7(e), which shows only the delineated benign calcifications. 7(f) provides the final image with outlined benign calcifications in the input image. Figure 8. shows the intensity profile of the corresponding input image and other intermediate output images. The intensity profile of an image is the set of intensity values taken from regularly spaced points along a line segment or multiline path in an image. It shows the changes in the intensity level of the image after each process. It is clearly depicted from the picture that in tophat transformed images the intensity of benign calcification is above 0.85.
Table 2 shows the classification performance in terms of image level true positives, true negatives, false positives and false negatives. Where True positive (TP): mammograms correctly detected as having benign calcification; False positive (FP): mammograms with benign calcification detected incorrectly as normal images; True negative (TN): normal mammograms correctly detected as normal; False negative (FN): mammograms with benign calcifications incorrectly detected as normal.

Table 2 Image Level Classification Performance

<table>
<thead>
<tr>
<th>Classification Performance</th>
<th>Number of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positives</td>
<td>75/78</td>
<td>96.15</td>
</tr>
<tr>
<td>True negatives</td>
<td>40/44</td>
<td>90.91</td>
</tr>
<tr>
<td>False positives</td>
<td>3/78</td>
<td>3.85</td>
</tr>
<tr>
<td>False negatives</td>
<td>4/44</td>
<td>9.09</td>
</tr>
</tbody>
</table>

The total number of true positive and false positive calcifications are counted within the selected input mammogram images and tabulated as in Table 3. There are 167 true positives detected from the 78 input images with calcifications. In those images 9 false marks are also detected. Out of the 44 normal images the algorithm gives 8 false marks. In short the approach results in a total of 17 false positives.

Table 3 True positive and false positive calcifications present in the test set

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of calcifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive (TP)</td>
<td>167</td>
</tr>
<tr>
<td>False positive (FP)</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 4 Lesion level detection rate

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive rate</td>
<td>0.9076</td>
</tr>
<tr>
<td>False positive rate</td>
<td>0.0924</td>
</tr>
</tbody>
</table>

Table 4 gives lesion level true positive rate and false positive rate. True positive rate and false positive rate can be calculated using the following equations.

\[
\text{True Positive rate} = \frac{TP}{TP + FP} \quad (15)
\]

\[
\text{False Positive rate} = \frac{FP}{TP + FP} \quad (16)
\]

Table shows that better classification results are obtained with a true positive rate of 0.9076 and a false positive rate of 0.0924. Thus benign calcifications are detected accurately for reporting. The work on mass identification is being undergoing in C-DAC (T) and after completion, its result and result of this paper are taken together for benign lesion finding in a mammogram image. Combining the results of all the four images in a patient case will give the final assessment category of the patient. The work on detection of microcalcification clusters which are typically malignant is already being completed and final results can be found out in [5].
Benign Calcification Detection in Mammogram Images

IV. CONCLUSION

A novel technique for benign calcification detection is proposed in this paper. This employs to detect benign calcifications and mention in the final mammography report. This approach is in fact a first step towards finding benign calcifications and enhancement of available reporting module by reporting benign calcifications also in addition to microcalcifications and mass. The different types of benign calcification patterns are able to be segmented and identified using this method. It is proved with significant results that wavelet decomposition can be applied to benign calcium detection also. With the help of suitable selection of the scaling factors better enhancement of benign calcifications is provided by Daubechies wavelet of order 8, which eliminates the need for a classifier. Morphological filtering can also be applied but with a much larger size for structuring element. Thresholding of very high intensity benign calcifications is not an issue here. But dealing with hazy calcifications needs to be very careful in the segmentation issues. So an optimal threshold is selected here. Then filtering of the segmented objects from the binary image using an object removal method by area thresholding clearly removes the microcalcifications segmented. It is able to remove skin thickening regions properly, with the help of edge detectors, which if not eliminated will affect the accuracy of the results. The result of this work demonstrates that it can be suitably employed for detecting benign calcifications with little computational complexity but better performance. In future this work on benign calcification detection can be extended to detection of different types of benign calcifications on the basis of morphology. The different pattern of benign calcifications can be found out by a shape analysis.

V. ACKNOWLEDGEMENT

The Department of Imageology, Regional Cancer Center, Thiruvananthapuram (RCC-T) provided us with the required set of digital mammogram images. The radiologists from RCC-T were consulted for gaining domain knowledge and for the verification and establishment of ground truth for the experiment. This work is carried out as part of the R&D project ‘Development of Computer Aided Detection System for Mammograms’ funded by Department of Electronics and Information Technology, Ministry of Communications and Information Technology, Govt. of India.

REFERENCE