CLASSIFICATION OF MICROCALCIFICATIONS IN DIGITAL MAMMOGRAMS USING NONSUBSAMPLED CONTOURLET TRANSFORM

Komal Chaudhari¹, Prof. Priti Subramanium²

¹²Computer Science & Engineering Dept., Shri Sant Gadge Baba College of Engineering & Technology, North Maharashtra University, Bhusawal, India,

ABSTRACT

With the advances in medical science there have been a various of techniques that have been emerged in order detect the disease like cancer. Breast cancer is one of the most common disease that occurs in majority of women. In the few decades a lot of research has been occurred on breast cancer for it’s detection. Breast cancer occurs due to the collection of mass or calcium deposit such as microcalcifications in the breast. This paper represents the various analysis steps used to classify the microcalcifications in mammogram images. This steps includes preprocessing, segmentation, characterization and classification. The proposed system represented within this paper consists of three main steps. The first step of the proposed system is used to transform the parameters by decomposing the into multiple subbands using nonsubsampled contourlet transform. After decomposing the image the edges of the image are detected using the prewitt operator. The second step of the proposed system is modification in which the subbands of the decomposed image are modified. The last step of the proposed system is reconstruction in which the modified subbands are used to reconstruct the enhanced image. The input database that has been used for classification of microcalcifications is MAIS database. The results shows an improved image which is effective for the classification of microcalcifications in mammograms.

Keywords: Breast Cancer, Microcalcifications, Modification, Nonsubsampled Contourlet Transform, Reconstruction.
I. INTRODUCTION

Nowadays, due to increased growth of the disease cancer, many advances have been occurred in the medical field for detecting the disease. Breast cancer is one of the most leading cancer in women than men. The percentage of occurrence of breast cancer is more in women and very less percentage of occurrence of the disease occurs in men. Therefore, a lot of women’s death is caused due to breast cancer raising the rate of death in women’s. Mammography is the most initial test that have been used for the detection of the distortions in mammogram image. It is very essential to detect the breast cancer in the early stage to apply better treatment for curing it in order to increase the chances of survival as well. The various steps used for mammogram analysis consists of preprocessing, segmentation, characterization, and classification.

1. Preprocessing

In the preprocessing step contrast of the mammogram image is enhanced. But this enhancement of the contrast of the image completely depends on the resolution of the image to be enhanced. The mammogram images have less resolution as it is noisy in nature and less clarity of the image. The contrast of the mammogram image can be improved globally using the conventional techniques whereas many region based and feature based techniques can be used for preprocessing of the mammogram image by improving the contrast of the region by growing from pixel to pixel of the image and characterizing the features of the image respectively.

2. Segmentation

Segmentation is the step in which the region of interest (ROI) is recognized. This region of interest are nothing but the areas affected by the breast cancer. Therefore segmentation is the process which is used to detect the various abnormal areas present in the mammogram images. There are various techniques that are used for segmentation such as region based which is a approach that is used for the detection of the affected region, edge based approach is used for detecting the edges of the affected areas and cluster based approach which is used for the detection of cluster that represent the presence of the tumour.

3. Characterization

Characterization is the step in which the characters are extracted from the segmented region of interest that is the abnormal areas detected. The extracted features or characters are used for further classification process. Hence characterization is the step in which all the abnormal characters that have been segmented in the early step are extracted in this step for further process of classification.

4. Classification

Classification is the process in which various characters that have been extracted are classified into the various abnormalities such as malignant or benign. Many different types of classifiers can be used in this step for classification of the abnormal areas. These classifiers are used for classifying the abnormalities into benign or malignant. Hence in this way it is the final step used for analysis of mammogram images which the microcalcifications present in the mammogram images.

II. RELATED WORK

The wide variety of different types of approaches that are used for classifying the suspicious areas in the mammogram images includes histogram analysis, wavelet transform, empirical mode decomposition (EMD), curvelet transform and contourlet transform. These are useful for
mammogram analysis as they undergo the process of preprocessing, segmentation, characterization and classification of the mammogram image. Each of the technique have it’s own unique properties and way of classifying the abnormalities in mammogram images. Each and every technique has some limitations in it due to which some problems occurs during the enhancement of the image.

1. **Histogram Analysis**

   Histogram analysis consists of the histogram techniques such as histogram equalization (HE), histogram specification (HS), etc. This histogram techniques are used for enhancing the contrast of the mammogram image. The image can be enhanced by two ways that are local and global. Histogram analysis is the method in which the image is enhanced excessively due to absence of the control over the level of enhancement [1]. Hence it is one of the technique used for providing information with the mammogram image by improving the clarity of the image.

2. **Wavelet Transform**

   Wavelet transform is a technique used for classifying the abnormalities in mammogram images. It is technique in which the image is decomposed into multiple scales [2][3]. Therefore it provides multiscaleability. Hence wavelet transform is used to decompose the image into multiple subbands [4]. Wavelet transform consists of the major drawback that it does not provide the property of multidirectionality. Therefore it is a technique which the image cannot be decomposed into multiple directions. Due to this reason the contrast of the image can be enhanced but the noise within the image still exits. Hence it is not capable of enhancing the contrast of the image as well as remove the noise within the image at the same time.

3. **Empirical Mode Decomposition**

   Empirical mode decomposition (EMD) is a method which similar to wavelet transform in many aspects. Empirical mode decomposition (EMD) [5] is also used to decompose the image into multiple subbands but the main difference between both the methods is that this method can generate the basic image from the original one. Therefore this technique is also useful to process the data that is non linear in nature [6]. But still there are many problems that remains unsolved due to this method such noise within the image, loss of image information, etc.

4. **Contourlet Transform**

   Contourlet transform is a technique that was developed from the inspiration of the technique curvelet transform. This technique provides both the properties multiscaleability as well as multidirectionality. Therefore it can overcome all the drawbacks of wavelet transform [7]. Contourlet transform is used to decompose the image into multiple scales as well as multiple directions due to which it becomes quiet easy and fast to detect the abnormalities within the image. Contourlet transform consists of two parts including laplacian pyramid and directional filter bank. The laplacian pyramid converts the image into multiple scales such as low band pass and high band pass. Further the high band pass is used to convert the image into multiple directions using directional filter bank [8]. It is one of the most efficient and flexible transform than wavelet transform, it is used to provide smooth contours to the image after decomposition. The main drawback of this technique is that it provides very less redundancy.

   In order to overcome the redundancy problem of contourlet transform a modified technique which is known as nonsubsampled contourlet transform (NSCT) can be proposed. Nonsubsampled contourlet transform is shift-invariant in nature hence it decomposes the image into multiple directions and multiple scale.
III. PROPOSED SYSTEM

The mammogram images provide very less visibility as they have very low contrast. This mammogram images are very noisy by nature. Therefore due to these qualities of the mammogram image it becomes quiet difficult to detect the disorders within them. Hence it becomes very necessary to improve the contrast of the mammogram image and remove the noise from the mammogram image simultaneously. The proposed system aims at contrast enhancement and denoising of the mammogram image. The proposed system proposes the nonsubsampled contourlet transform technique which can be used for improving the contrast of the mammogram images and removing the noise from the mammogram images simultaneously. Due to this the image gives effective results in classifying the microcalcifications.

1. System Architecture

The proposed system consists of three main stages in it which are decomposition, modification and reconstruction. Fig 1 illustrates the system architecture of the proposed methodology.

The algorithm of the proposed system is as follows:

1. The input mammogram image is taken from the MIAS database and then this image is preprocessed. In preprocessing the image data is improved that is the pixels of the mammogram image is doubled.
2. The first step is known as decomposition in which the transform parameters are defined and initialized. This transform parameters consists of the decomposition level, pyramidal filter and directional filter.
3. The transform parameters are defined by setting the decomposition levels where this levels are nothing but a vector of no of directional filter bank decomposition levels at each pyramidal level. Transform parameters also consists of filter selection of pyramidal and directional. This filters are selected as default filters such as:
   pfilter=Maxfilter.
   dfilter=dmaxfilter.
4. Transform NSCT decomposition is used to decompose the image into multiple scales and directions. After decomposition of the image into multiple subbands the coefficients are obtained by performing thresholding on the decomposed image. The threshold obtained for each direction at each level is as follows:
\[ T_{\{Nivel\}}\{i\} = (3 \times Var) \]
Where, \( T \) stands for threshold,
\( Nivel \) stands for the level,
\( i \) stands for direction of the nivel,
\( Var \) stands for standard deviation of matrix elements.
This matrix elements are the coefficients of each direction of each level.

5. In edge detection all the edges of the coefficients are detected using the prewitt operator for the specified thresholding value.

6. The second step is modification in which the coefficients that are obtained in the first step are modified. In order to modify the coefficients of the mammogram image global gain is obtained first and then depending upon this global gain the coefficients are modified. The global gain can be obtain by:
\[ g = \left( \frac{1}{Var} \right) \times 4 \]
Where, \( Var \) stands for standard deviation of matrix elements.
This matrix elements are the coefficients of each direction of each level. Therefore depending upon the global gain and the edges detected modified coefficients are obtained for the image.

7. The third step is reconstruction in which the modified coefficients are taken as a input to give enhanced mammogram image as a output image. Therefore this enhanced image is very effective for classifying the microcalcifications in the mammogram.

2. Nonsubsampled Contourlet Transform (NSCT)

Contourlet transform is a technique that is used for image decomposition into multiple scales and directions. It is divided into two main steps which are the laplacian pyramid (LP) and directional filter bank (DFB). The laplacian pyramidal filter decomposes the original image into lowpass and highpass image [8]. There are downsamplers as well as upsamplers present in the laplacian pyramid and directional filter bank due to which this technique is not shift invariance in nature. Therefore in order to achieve fully shift invariance, multiple scale decomposition and multiple directional decomposition the improved version of contourlet transform is introduced which is known as nonsubsampled contourlet transform. Nonsubsampled contourlet transform is a technique which consists of two main parts in it. The first part is the nonsubsampled pyramidal filter bank (NSPFB) and the second part is the nonsubsampled directional filter bank (NSDFB). Fig 2 illustrates the block diagram of nonsubsampled contourlet transform.

![Fig. 2 Block diagram of nonsubsampled contourlet transform](image-url)
In nonsubsampled contourlet transform the nonsubsampled pyramidal filter bank is used to decompose the image into a lowpass image as well as a highpass image without any downsampling or upsampling. The highpass image is decomposed into multiple directions using nonsubsampled directional filter bank. The entire process is continuously repeated on the lowpass image. The difference between nonsubsampled pyramidal filter bank of nonsubsampled contourlet transform and laplacian pyramid of contourlet transform is that nonsubsampled pyramidal filter bank is two channel filter bank. Fig 3 illustrates the block diagram of nonsubsampled pyramidal filter bank.

![Block diagram of nonsubsampled pyramidal filter bank](image)

The nonsubsampled pyramidal filter bank consists of two main filters decomposition filter and reconstruction filter. This decomposition filters is used to decompose the input image into multiple subbands for its processing and the reconstruction filters are used to reconstruct the output image after processing the input image giving output image as the enhanced image. The reconstructed image is perfect in nature if it satisfy the following identity:

\[ L_0(I)H_0(I) + L_1(I)H_1(I) = 1. \]

Where, \( L_0(I) \) is the lowpass decomposition filter, \( H_0(I) \) is the highpass decomposition filter, \( L_1(I) \) is the lowpass reconstruction filter, \( H_1(I) \) is the highpass reconstruction filter.

Therefore in this the original image is enhanced more than nonsubsampling it using nonsubsampled contourlet transform.

3. **Edge Detection**

The edges of the image are obtained once it is decomposed into multiple subbands. This detected edges are used for modification of the co-efficients of the mammogram image. The operator that is used for edge detection is the prewitt operator in the proposed system. This operator is used to calculate the gradient value of the intensity of the image by giving the direction of the largest possible increase that occurs from the light to dark pixels and it also gives the rate at which the change occurs in that direction. This operator is used to detect all the edges of the co-efficients of the decomposed image in order to create the modified co-efficients for reconstructing the image to give enhanced results. This operator is used to detect the edges from darker to lighter values.

IV. **RESULTS**

Simulations are done using the MATLAB version 7.11.0. The input images of mammograms are taken from the MIAS database and the proposed algorithm in implemented on this mammogram images. The proposed algorithm can be applied on many different types of
mammogram images. The input images of mammograms that are taken for simulations are of 256x256 pixels. Fig 4 illustrates the first input mammogram image that has been selected for implementation and the output mammogram image whose contrast is enhanced than the original image after implementation of the proposed algorithm on it.

The mammogram image present at the left side is the original image as well as the image present at the right side is the output image. The results shows that the contrast of the mammogram image is enhanced and the image is improved than the original image. Fig 5 illustrates the total time required for all the processes of the proposed system to implement in order to obtain the output image for the first mammogram image. Fig 6 illustrates second mammogram image taken as an input image from MIAS database and fig 7 illustrates the total time taken by this image for execution of the second mammogram image. Fig 8 illustrates third mammogram image taken as an input image from MIAS database and fig 9 illustrates the total time taken by this image for execution of the third mammogram image. Fig 10 illustrates fourth mammogram image taken as an input image from MIAS database and fig 11 illustrates the total time taken by this image for execution of fourth mammogram image.

![Fig. 4 Input and output of first mammogram image](image1)

![Fig. 5 Total execution time required for first mammogram image](image2)
Fig. 6 Input and output of second mammogram image

Fig. 7 Total execution time required for second mammogram image

Fig. 8 Input and output of third mammogram image
In this paper four different examples of mammogram images are taken as input for processing and it is observed that each mammogram image requires different time for its execution. Therefore the total time required for execution is different for each image. This time depends on size.
of the image, if the size of the image is higher the total time required for execution is also greater. Table 1 illustrates the total execution time required for each mammogram image taken as an input for processing. The total time that is required for decomposition of the original image in multiple subbands is given as the decomposition time. The total time taken for the modification of the subbands is modification time. The total time taken for the reconstruction of the output image from the modified subbands is reconstruction time.

<table>
<thead>
<tr>
<th>Mammogram images</th>
<th>Decomposition time (Seconds)</th>
<th>Modification time (Seconds)</th>
<th>Reconstruction time (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Image</td>
<td>109.84 sec</td>
<td>96.267 sec</td>
<td>111.706 sec</td>
</tr>
<tr>
<td>Second Image</td>
<td>31.809 sec</td>
<td>27.581 sec</td>
<td>30.108 sec</td>
</tr>
<tr>
<td>Third Image</td>
<td>29.165 sec</td>
<td>27.987 sec</td>
<td>29.425 sec</td>
</tr>
<tr>
<td>Fourth Image</td>
<td>237.158 sec</td>
<td>211.571 sec</td>
<td>226.246 sec</td>
</tr>
</tbody>
</table>

This table shows that each mammogram image has taken different time for its execution. According to the results the time required by third mammogram image is lesser than all the other mammogram image and the time required by the fourth image is greater than all the other mammogram image.

V CONCLUSION

This paper mainly represents a proposed algorithm using nonsubsampled contourlet transform technique for automatic contrast enhancement of the mammogram for effective detection of microcalcifications in digital mammograms. The results obtained in this paper shows that the output mammogram image obtained is improved and can be easily used for classification of microcalcifications. In future this method can be used in various applications such as digital mammography, computer aided detection and breast tomosynthesis.

REFERENCES


