ISSN 2348-1196 (print)
International Journal of Computer Science and Information Technology Research ISSN 2348-120X (online)
Vol. 3, Issue 2, pp: (905-910), Month: April - June 2015, Available at: www.researchpublish.com

Detection of Micro Calcifications in Ultrasound Images

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Abstract: **Breast cancer is the second major cause of death among women. Early detection is a key factor to reduce the cause of deaths. Ultrasound imaging is one of the most common procedures for diagnosing breast cancer due to its portability, simplicity and cost effectiveness. Microcalcifications (calcium deposits) are the earliest signs of breast carcinomas and their detection is one of the key issues for breast cancer control. Computer Aided Diagnosis (CAD) schemes was an active field of research in the past few years, and these CAD systems serve as a second decision tool for radiologists to discover Microcalcifications in the ultrasound image. This paper aims to detect the Microcalcifications in Ultrasound images. Steps of the research consist of Image Pre-processing using Median Filter and contrast enhancement, determining the ROI using Watershed segmentation, measuring the intensity, area and energy of the cancer image and classification is done using Artificial Neural Network method. The algorithm is implemented using MATLAB environment.**

Keywords: **Median filter, Ultrasound, Watershed Segmentation, Artificial Neural Network.**

I. INTRODUCTION

Cancer is a class of disease characterized by abnormal cells that grow and invade healthy cells in the body. Breast cancer is one of the most common types of cancer in women worldwide and 10% of women are confronted with the breast cancer in their lives. It can be described as the uncontrolled growth of abnormal cells in the breast that can then spread (metastasis) to other areas of the body. Breast cancer spreads in three important ways: by creating more damaged cells and microcalcification growth, lymph and blood vessels can carry the cancer to others areas of the body and lastly body's hormones and chemicals can accelerate the growth of some microcalcifications. Breast cancer accounts for more than 1.6% of deaths worldwide and the fatality rates are highest in low-resource countries. In India, the average age of the high risk group is 43-46 years unlike in the west where women aged 53-57 years are more prone to breast cancer. People over the age of 50 accounts for 76% of breast cancer cases and while only 5% of breast cancer diagnosis are in people under the age of 40 and 18% in their 40's. Less than 1% of all breast cancer cases develop in men, and only one in a thousand men will ever be diagnosed with breast cancer.

Microcalcifications are tiny deposits of calcium oxalate or calcium hydroxyapatite within the breast tissue that constitute the main diagnostic feature in breast cancers. The usefulness of breast ultrasound could be extended by improving the detection of microcalcifications by being able to detect and enhance microcalcifications while simultaneously eliminating hyper echoic spots (e.g. speckle noise and fibrocystic changes) that can be mistaken for microcalcifications (i.e. false microcalcifications).The dense tissues, and especially in younger women, cause suspicious region to be almost invisible and may be easily misinterpreted as calcifications and yield a high False Positive (FP) rate that is a major problem with most of the existing methods. Thus, an early detection of the breast cancer disease can avoid disfiguring surgeries and greatly contributing to the patient's long-time survival.

Ultrasound is the effective imaging technique used by radiologists for the screening of breast cancer. There is still challenging problem to find robust, efficient and accurate breast segmentation. In order to increase the accuracy in the interpretation of microcalcification on ultrasound images, Computer aided diagnosis (CAD) is used to distinguish between the benign and malignant microcalcifications in early detection. CAD tool has direct impact on the analysis of breast cancer and its treatment. The CAD system takes three stages like detection of region of interest in ultrasound image, segmenting the ROI and classification. CAD system is used to identify the region which is malignant. CAD tool's goal is to indicate the abnormal locations with great accuracy and reliability. Thus it provides positive impact on the early detection of cancer. Sometimes identification will lead to false positive and false negative. False-positive results occur when radiologists decide microcalcificaions are abnormal but no cancer is actually present. False-negative results occur when the microcalcifications appear normal even though breast cancer is present.

This paper is organized as follows. Section II provides a survey on various methods used for the detection of microcalcifications. Section III describes the proposed method. In Section IV, experimental results of described techniques are shown. In the next section, the conclusion and future work are given.

II. LITERATURE SURVEY

Several works have been formulated for detecting the breast microcalcifications and classified them as benign and malignant.

W. K. Moon[1] used the 3-D ultrasound to determine microcalcifications. In each slice, the proposed method adopts the top-hat filter to find bright spots, and employs four 2-D criteria to select the spots as candidate microcalcifications. Finally, spots appearing in sequent slices at the same position are considered as a microcalcification.Wen-Hung Kuo [2] investigated the use of a strain-compounding technique with speckle factor (SF) imaging to analyze the degree of scattered redistributions in breast tissues under strain conditions for identifying microcalcifications and false microcalcifications.The different strain conditions were created by applying manual compression to deform the breast lesion. For each region in which microcalcifications were suspected, estimates of the SNR of the strain-compounding B-scan images and estimates of the mean SF (SFavg) in the strain-compounding SF images were calculated. These findings indicate that the strain-compounding SF imaging method is more effective at discriminating between microcalcifications and false microcalcifications.John Zakos [3] analysed the Computer-aided diagnosis system based on fuzzy-neural and feature extraction techniques which presented a CAD system for detection and classification of micro calcification.Investigation and analysis on different features are done using neural-network settings and a FL detection algorithm. Modification on some traditional features are done and found that a combination of three modified features, such as entropy, standard deviation and no. of pixels were efficient.Anupa Maria Sabu[4] proposed that texture analysis is a method to classify benign and malignant masses and to identify the microcalcification. Jaspreet Singh Cheema[5] has captured ultrasound images, which are suspected by radiologists. The technique uses median filter to reduce the speckle noise, unsharp masking for contrast enhancement, binary thresholding ,edge detection for mass segmentation and identify micro calcification for detection.Sheng-Wen Huang[6] proposed beamforming techniques for imaging microcalcifications. The strategy is to involve channel-data-based parameters that favour point/sub-resolution targets, which microcalcifications resemble acoustically. Accordingly, algorithms are devised based on coherence factor and dominance of the first Eigen value of covariance matrices. To further improve sensitivity and specificity, the proposed techniques can be combined with image processing and/or RF data processing techniques.Te-I Chiu[7] experimented on optoacoustic imaging of microcalcification for early breast cancer detection. In this study, the feasibility of visualization of microcalcification using optoacoustic (photoacoustic) imaging (PAI) technique is investigated. The non-ionizing radiation and speckle-free characteristic makes the PAI a potential diagnostic tool for early breast cancer detection.

III. PROPOSED METHOD

Breast cancer detection can be carried out using various techniques. For the successful treatment, breast cancer has to be detected in the early stage. In the proposed system, Ultrasound image will be input to the system in the image acquisition stage, which will be pre-processed to remove noise. Next, Segmentation is performed to extract the feature of the segmented microcalcification from the breast region. Finally, the proposed system classifies the microcalcifications as benign or malignant.

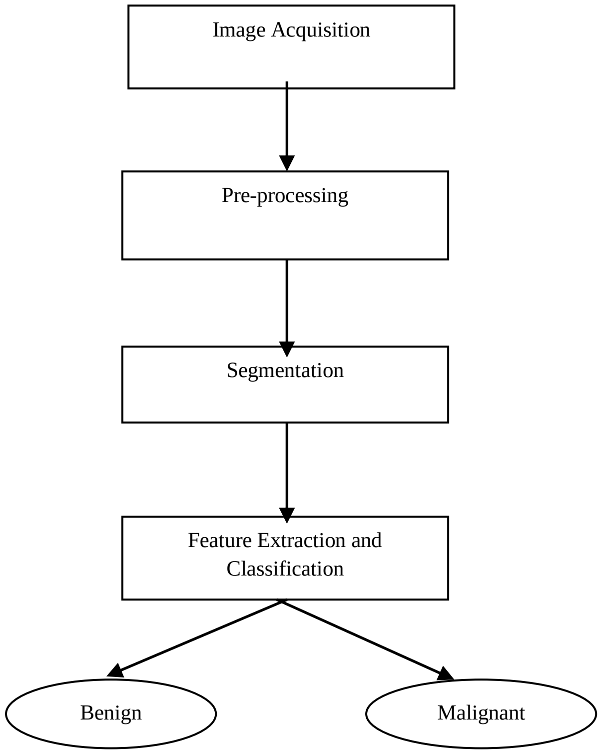


Fig 1: Flow Chart of Proposed Method

A. Image Acquisition:

The first step is the image acquisition, where the data in the form of digital ultrasound images are acquired. The acquired ultrasound images are classified into two major cases like malignant and benign. The images are digitized at 200 micron pixel and padded in order to obtain all images with a size of 1024 × 1024 pixels. Images are in the format of PGM (Portable Gray Map) which is a lossless type image format and the details of the image will not be lost at the time of data compression.

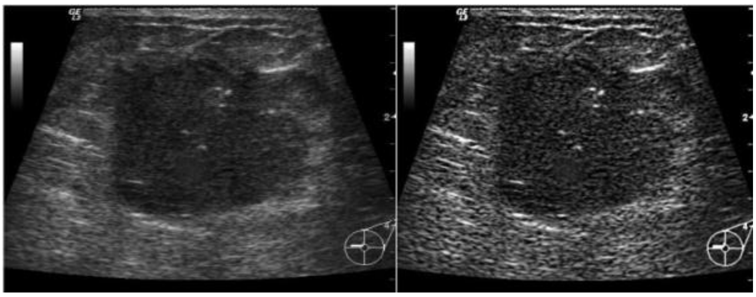
B. Image Pre-processing:

Second step is to Pre-process the input image, in order to improve the quality by removing the noise. The ultrasound image is pre-processed using Median filter. Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing salt and pepper noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbours is called the window, which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

The breast ultrasound image presented in Fig. 2(a) has a highly non-uniform background and very little contrast. So the image enhancement is required before segmentation. The enhancement technique is a well-known technique of adaptive contrast enhancement. The normal and adaptive histogram equalization may over-enhance the noise and sharp regions in the images due to the integration operation. It yields large values in the enhanced image for high peaks in the histogram of the nearly uniform regions in the original image. To solve this problem, the morph uses a clip level to limit the local histogram in order to limit the amount of contrast enhancement for each pixel. This clip level is a maximum value of the local histogram specified by users. An interactive binary search process is used to redistribute the pixels which are beyond the clip level. The CLAHE algorithm has following steps:

- Divide the original image into contextual regions
- Obtain a local histogram for each pixel
- Clip this histogram based on the clip level

- Redistribute the histogram using binary search
- Obtain the enhanced pixel value by histogram integration. The result of this technique is shown in Fig. 2(b).



(a) **(b)**

Fig.2 (a) Original image **(b) Enhanced image**

C. Image Segmentation:

Segmentation partitions an image into distinct regions containing pixels with similar attributes. Main goal in image segmentation is to extract the region of interest from the processed image. Watershed Segmentation technique is used to extract the microcalcification part from the breast region. Watershed segmentation classifies pixels into regions using gradient descent on image features and analysis of weak points along region boundaries. The image feature space is treated, using a suitable mapping, as a topological surface where higher values indicate the presence of boundaries in the original image data. It uses analogy with water that gradually fills the low lying landscape basins. The size of the basins grows with increasing amounts of water until they spill into one another. Small basins (regions) gradually merge together into larger basins. Regions are formed by using local geometric structure to associate the image domain features with local extremes measurement. These methods are well suited for different measurements fusion and they are less sensitive to user defined thresholds.

The steps of watershed algorithm are shown below:

- Pre-process the input image using appropriate filtering and image enhancement techniques.
- Convert the grey scale into binary image.
- Perform morphological operation of opening and closing to get better accuracy in segmenting the image.
- Compute the internal and external marker in order to identify all those regional minima’s which have higher values than a specified threshold.
- Segment the region having higher thresholding value.

D. Feature Extraction and Classification:

Feature Extraction is a special form of dimensionality reduction. Feature refers to a piece of information that has relevance in solving the computational tasks related to a certain application. Feature extraction can be defined as a quantitative measurement or analysis of the medical images. To deal with the abnormalities of the ultrasound images, many types of features can be extracted. The different types of features calculated from the extracted ROI broadly come under the category statistical, geometrical or structural. The statistical features are the simplest ones and they include mean, standard deviation, variance etc.

Texture analysis of microcalcification helps to identify texture feature information about the spatial distribution of tonal variations and describes the pattern of variation in gray level values in a neighbourhood. Gray Level Co-occurrence Matrix (GLCM) is used to extract texture information from images. The GLCM characterizes the spatial distribution of gray levels in an image. The features that are used for classification are:

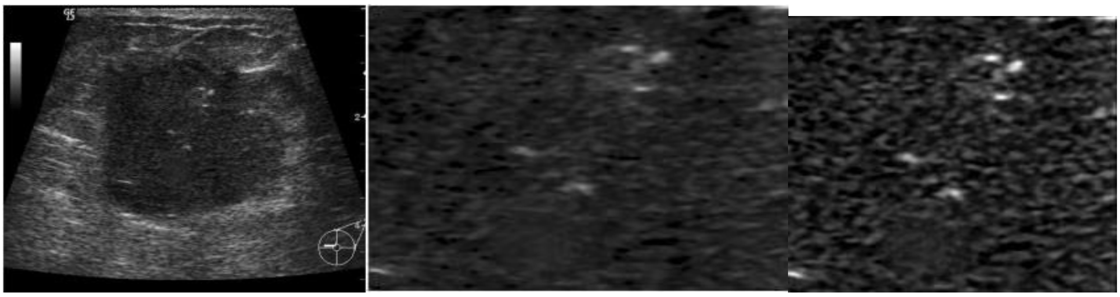
- ***Energy*****:** Energy returns the sum of squared elements in the Grey Level Co-Occurrence Matrix (GLCM). Energy is also known as uniformity. The range of energy is [0 1]. Energy is 1 for a constant image. Energy is also known as uniformity of ASM (angular second moment) which is the sum of squared elements from the GLCM.

- ***Area*****:** The area is a measure of the size of the foreground of the image. Area is a quantity that expresses the extent of a two-dimensional surface or shape in the plane. Area can be understood as the amount of material with a given thickness that would be necessary to fashion a model of the shape .It is the two-dimensional analog of the length of a curve (a one-dimensional concept) or the volume of a solid (a three-dimensional concept).The area of a shape can be measured by comparing the shape to squares of a fixed size.

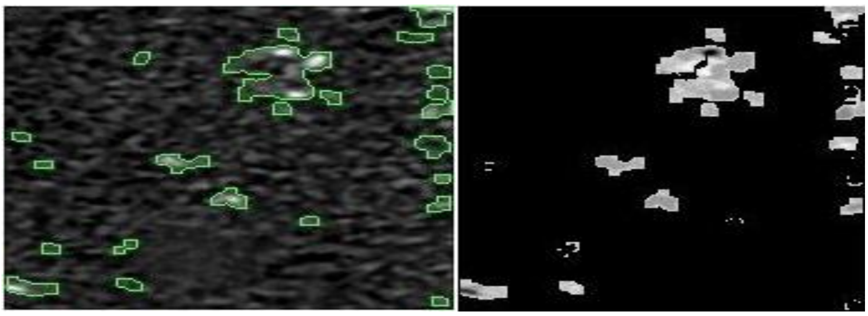
Once the features are extracted, they are input to a classifier to classify the detected suspicious regions into benign or malignant microcalcifications. Classifier such as Artificial Neural Network (ANN) is used. ANN is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working to solve specific problems. The advantage of ANNs is their capability of self-learning and often suitable to solve the problems that are too complex to use the conventional techniques or hard to find algorithmic solutions.

IV. RESULT

In ultrasound images, microcalcifications are assumed to be distinctive regions that are relatively brighter than their surrounding tissues. Hence the morphological operation removes the small spots and thereby produces better segmented result. The filters and segmentation algorithm applied are efficient in detecting microcalcifications.Features like energy and area is calculated from the segmented image and is used to efficiently classify the image as benign or malignant by comparing with the threshold value. Breast Ultrasound images were collected and the proposed technique was applied to 7 breast microcalcification images (5 malignant and 2 benign) which were used as training samples.The proposed technique yields better result by classifying 4 images as malignant and 3 as benign. The results of the proposed system are shown in the Fig 3.



(a) **(b)** **(c)**



(d) **(e)**

Fig 3: (a) Original image (b) Pre-processed image (c) Morphological operations

(d) Computing external and internal markers (e) Segmented region

V. CONCLUSION

Breast cancer is one of the major causes of death among women. Microcalcifications indicate the early signs of breast cancer and if ignored, leads to death. So, detection of breast cancer is a crucial task. Image processing algorithms allow development of systems for the detection of breast cancer. This paper presents an efficient method for detection and classification of micro calcifications based on texture features. Texture features are extracted using GLCM method. ANN classifier is used for the classification of micro calcification and classifies them as benign or malignant based on the extracted features. This flow is proved robust for the detection of micro calcifications

Several research avenues are envisioned for a future research. Future work can be to develop a system that uses multi-model technique in multi-programming environment and substituting different methods in order to increase accuracy rate. Improving existing methods such as enhancing low contrast microcalcifications and better scale selection to ease segmentation process can be done in future. The method can also be extended to detect advanced stages of cancer and modifications to improve the performance.

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