A COMPUTER AIDED SYSTEM TO DETECT BREAST MASSES USING DIGITAL MAMMOGRAMS

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ABSTRACT

For centuries, cancer has been a threat to human lives. It has become one of the leading causes of death since many decades. The early detection of cancer can contribute much to reduce the morbidity rate of the disease. The goal of mammography is the early detection of breast cancer, usually through the detection of featured masses and/or micro calcification. In this paper, we proposed a methodology to detect tumors on digital mammograms. To proceed with the work, we focus on image pre processing. It is done using a scheme (a) mammogram enhancement and (b) mammogram segmentation. The first stage involves enhancement which can be outlined as enhancing the quality of the image to a much apprehensible and a better level. The second stage pertains to improving the global contrast of an image using image’s histogram. The final stage includes the segmentation to change the image representation into a form which is more substantive and easier to analyze. The experimentation of these methods is performed on mammograms of MIAS database.

Key words: Mammography, Micro calcification, Enhancement, Segmentation.

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1. INTRODUCTION

During the research by National Alliance of Breast Cancer Organization (NABCO, 2002), breast cancer is rated as the second most common form of cancer in women, falling behind skin cancers [9]. The National Cancer Institute (NCI) estimates that around 194,000 cases of breast cancer were handled in the United States in 2009 [10]. More than 40,000 people died of
the malignant disease. Although breast cancer occurs in both genders, but prevalence is more in women. Breast cancer in male is rare [10]. The comprehensive studies pertaining to the mammography screening estimates that mammography reduces the breast cancer mortality rate by 15-16 % [9]. The masses and micro calcifications in the breasts contribute to the early signs in the detection of breast cancer [3]. A possible abnormality in a mammogram may be called as a mass or a lump. It can be classified into benign or malignant. A mass with a well defined boundary is often benign. However, a mass with contours having irregular borders can be categorized into a cancerous tumor.

To reduce the incorrect interpretations about the mammograms due to manual experimentations, CAD (Computer aided Diagnosis) has emerged as an interesting field for the radiologists. The tremendous amounts of mammograms produced are investigated against the CAD schemes for the reliable and prompt results aiding in the cancer detection. The studies reveal that tele-mammography also uses CAD systems for mass breast screening programs [4].

Figure 1 (a) Mammogram having mass (b) Mammogram with micro calcification

An extensive review of literature shows that much of the CAD systems are used in digital mammography for the detection of masses. Most of them follow a hierarchy consisting of mainly: 1) Detection of nipples 2) Alignment of mammograms 3) Normalization of mammograms 4) Subtraction of mammograms 5) Reduction of false positives [4].

This paper is coordinated as follows. Section II gives an overview of mammogram segmentation. Section III describes a mammogram segmentation technique presented in this paper including image pre processing techniques employed on mammograms .Section IV shows experimental results of the described techniques. Lastly, Section V contains the conclusion and future works.

2. MAMMOGRAM SEGMENTATION
Mammogram Segmentation usually incorporates classifying mammograms into distinct regions like breast border, nipples and pectoral muscle. The primary feature on mammogram is the breast boundary or breast contour. It can be derived by partitioning the mammograms into breast and non-breast regions. Pectoral Muscle is the optimistic area in MLO situated on either upper right or upper left. It is bright on matching with tumorous tissues. The processing over pectoral helps in accurate finding of breast cancer. [12][13]
A number of problems arise with the precise segmentation of the breast. Firstly, each pixel in a mammogram constitutes of two or more tissues. Superimposition of varying tissues makes it difficult to distinguish between different regions in the breast. Moreover, there is a portion of decreasing contrast near the breast boundary where the breast tapers off. The tapering effect results in lack of visibility along the peripheral regions of the mammogram, making it quite difficult and tedious to visualize the breast contour. The digitization process may accentuate the noise intensity, thus decreasing the visibility. Various approaches have been proposed in literature for the segmentation of breast regions in mammograms. Some of them were the use of active contours, gradients, or threshold.

3. METHODOLOGY
The nodules or masses in mammograms can be detected by the proposed method which broadly incorporates two stages. The first stage includes the image enhancement for improving the overall quality and tone of a mammogram. It is done using various enhancement techniques involving spatial domain methods. The second stage includes the image segmentation using threshold method. It turns a gray-scale image into a binary image based on threshold value.

3.1. Mammogram Enhancement
The process of improving the character of a digitally stored image is known as image enhancement. The mammograms can be enhanced in 3 steps (a) Noise removal (b) Mediolateral oblique view (MLO) (c) Background removal (d) Mammogram dilation (e) Histogram equalization.

3.1.1. Noise Removal
Digitization noises like random lines which are found in majority of mammograms can be removed using a two-dimensional (2D) median filter approach. A median filter is used to remove impulse noise spikes from a mammogram and thus smoothing the image. Each of the output pixels contains the median value in the neighborhood around the corresponding pixels in the input images. The resulting image is then free of pixel brightness that is at the extremes in each input group of pixels. The median filter generates the noise reducing effect and it depends on two factors: the number of pixels involved in the computation and the spatial extent of the mask.

3.1.2. MLO Type View
It is necessary to detect type of MLO view of a mammogram; whether it’s Left sided (LMLO) or Right sided (RMLO). An algorithm is applied to determine the mammogram view.

3.1.3. Background Separation
Certain radio opaque objects like labels and wedges in the mammogram images may affect the reliability of the segmentation algorithm. In order to separate such background from the image of interest, threshold techniques and morphological operations are used.

Fig.3 shows a mammogram image with a radio opaque artifact present. After the background separation, the mammogram image is as shown in Fig. 3.
The algorithm to find artifacts to separate breast visibilities is as follows:

- The grayscale mammogram is converted into binary using threshold technique.
- The binary objects except for the largest object, which is the breast profile, is cleared. (Fig. 3)
- The next step is to apply morphological operations to eliminate isolated pixels.
- After all the pixels are checked, their value is set to 255 if the number of pixels in the neighborhood is greater than the threshold else pixel value is set to 0.
- The mammograms are applied to two different thresholds and the resulting binary image without labels etc. can be obtained by subtracting the previously obtained images.

3.1.4. Mammogram Dilation

The mammogram is undergone a morphological processing technique of dilation which generally increases the pixel values of an image and augments the brightness of the image. The result of dilation can be visualized in Fig. 5. It shows the original image and the image after dilation of mammogram.

3.1.5. Histogram Equalization

It is a contrast adjustment technique which uses image’s histogram. It increases the overall contrast of a mammogram by homogenously distributing the intensities on the histogram. This, in turn, results a lower contrast image to convert to a higher contrast image. Fig 5 shows the result of a mammogram image before and after histogram equalization.
3.2. Mammogram Segmentation

After the former steps, the ROI of the breast is obtained. Now, the edge map that concerns only to the breast ROI is considered. The edge map encloses various anatomical regions corresponding to the breast. The aim is to distinguish such regions on the mammogram image. The segmentation of mammogram is done to achieve the objective using threshold approach. During the process of threshold, the foreground is discriminated from background. By selecting a suitable threshold, the gray scale image can be converted to a binary image. The binary image should comprise of all the necessary information about the positions, structure and shape of objects of interest. The binary image should be obtained as it simplifies the process of classification. It can be obtained by selecting an adequate threshold value and then applying the concept of “threshold above” and “threshold below”. It is used by categorizing the gray level pixels into object pixels if their value is greater than the selected threshold value and as background pixels if their value is less than the selected threshold value. The key parameter of choosing a particular threshold value is done manually. Fig 6 shows a threshold image of mammogram.

The iterative algorithm to be used in threshold process includes the following steps:

- A specific threshold (T) is chosen, initially, manually.
- The mammogram is segmented into object and background pixels, forming two sets:
  1. \( G_1 = \{ f(x,y) : f(x,y) \geq T \} \) (object pixels)
  2. \( G_2 = \{ f(x,y) : f(x,y) < T \} \) (background pixels) (note, \( f(x,y) \) is the value of the pixel located in the \( x \)th column, \( y \)th row)
- The mean of each set is calculated:
  1. \( m_1 \) = average value of \( G_1 \)
2. \( m2 = \text{average value of G2} \)
   - A new threshold value is created that is the mean of \( m1 \) and \( m2 \).
     \( T' = (m1+m2)/2; \)
   - These steps are reiterated, now using the new threshold value computed in prior steps. These algorithm steps are repeated until the convergence is reached.

4. EXPERIMENTAL RESULTS
To demonstrate the validity of the algorithms implemented, it has been tested on various mammograms with differing breast tissue densities. Overall, for most of the mammograms assessed, the quality measure for breast mass detection was quite high. It indicates the robustness of the algorithm with respect to varying densities. In Fig.7 is shown the experimental results for the segmentation of breast profile and mass detection in mammograms.

![Figure 6](image_url)

**Figure 6** (a) Original Image (b) Image enhancement (c) Mass (d) Mass

5. CONCLUSION AND FUTURE WORKS
A number of factors exist due to which it is difficult to postulate the precise and accurate effect on digital mammograms using a particular segmentation process. The foremost of these concerns the acquisition parameters, such as vulnerability time and energy level. These immensely influence the image quality of mammograms. Secondly, separation of the breast region from the background portion is hindered by the tapering trait of the breast.

As the results show, the mammography segmentation used in this paper is quite efficient. For the future work, it is planned to improve the algorithms to obtain a smoother breast region contour. Also, the detection of abnormalities like masses more efficiently, feature extraction from the tumor area and the classification using SVM classifier is planned.

REFERENCES


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