

Automatic Suppression of Pectoral Muscle in Digital Mammogram using Triangular Mask

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Abstract: Worldwide, breast cancer becomes major women's health problem. It is the most common cancer leading to death after lung cancer. Mammography is a technique used by radiologist for diagnosis of breast cancer. Computer aided detection/diagnosis (CAD) may help to improve the sensitivity of the radiologist for analysis and detection of breast cancer. Medio-Lateral oblique (MLO) view of digital mammogram shows existence of pectoral muscle. Because of the microcalcification clusters, masses and pectoral muscle have almost same range of intensity; it becomes necessary step for suppression of the pectoral muscle to achieve appropriate segmentation of definite region of interest (ROI). This paper presents an algorithm for automatic suppression of the pectoral muscle and removal of the artifacts presents in digital mammogram. The proposed algorithm uses mathematical morphology for removal of artifacts, wavelet transform for mammogram enhancement and application of triangular mask to the upper left corner of mammogram for pectoral muscle detection & suppression. The algorithm is applied to 322 MLO view digital mammograms of mini-MIAS database and gets the accuracy rate of around 98%.

Keywords - Breast cancer, Mammography, Medio-Lateral oblique view, Pectoral muscle, Wavelet transform

1. INTRODUCTION

Universally, breast cancer is the prime type of malignancy in women [1]. It is most widespread in developed countries and is more than 100 times more frequent in women than in men. Every year, breast cancer kills more than 500,000 women around the world [2]. According to latest information the proportion between the occurrence and death in US is 4.5:1 (1 death from 4.5 new cases detected) and in India it is 2:1 which is alarming [3]. There is an exceptional rise in breast cancer cases in India. The health care trouble related to breast cancer in India has been gradually increasing. In India approximately 100,000 new breast cancer patients are diagnosed yearly [6][7]. The incidence rate of breast cancer is expected to double in India by 2020.

Mammography screening is proved to be an effective method for Breast cancer. Early detection in order to improve breast cancer outcome and survival remains the cornerstone of breast cancer control. Interpretation of mammograms is an extremely challenging job for radiologists. In lots of cases, cancer is not simply detected by the eyes because of the poor imaging conditions. The differentiation among malignant and benign tumors sometimes is difficult because the characteristics of areas of abnormality are significant and complex [4]. Well-trained experts may have sensitivity of 65–75%. Since 65–90% of the biopsies of suspected cancers turned out to be benign, it is very

important to develop CADs that can distinguish benign and malignant lesions.

The combination of CAD scheme and experts' knowledge would greatly improve the detection accuracy. The detection sensitivity without CAD is 80% and with CAD up to 90% [5]. It would be precious to design a CAD algorithm using extracted features from the breast profile region; region of interest (ROI). This would decrease the number of unnecessary biopsies in patients with benign disease and thus avoid patients' physical and mental suffering, with a bonus of reducing healthcare costs [8]. Figure 1 shows a typical block diagram of CAD system. Pre-processing step of the CAD system includes: noise removal, image enhancement, extraction of breast region (high intensity label suppression), and pectoral muscle extraction (if the image in MLO view)

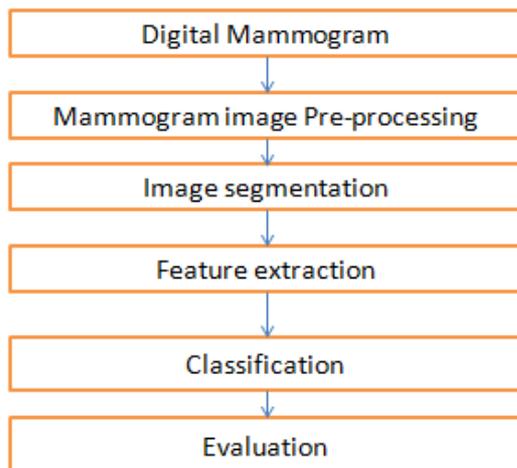


figure 1: Block diagram of CAD system

In this paper I propose an automated method for Pectoral muscle suppression by mathematical morphology, wavelet transform and application of triangular mask on the top corner of mammogram.

1.1 Pectoral muscle and requirement for its suppression

In medio-lateral oblique (MLO) digital mammogram images, the pectoral muscle is one of the high intensity landmarks in the breast as shown in figure 2.

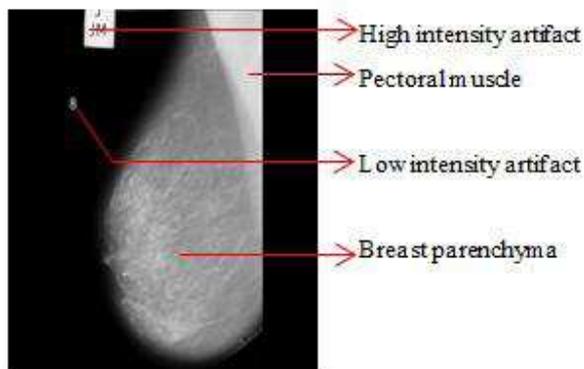


figure 2: Digital Mammogram[11] .

Pectoral muscle region is the triangular chest muscle area present in the upper right or left corner. It shares a similar opacity as with that of neoplasms [3]. Because of the microcalcification clusters, masses and pectoral muscle have almost same range of intensity, it can bias and affect the result of any mammogram processing method [11]. Due to that, it is often necessary to automatically identify and remove the pectoral muscle to get appropriate definite region of interest(ROI).

2. LITERATURE REVIEW

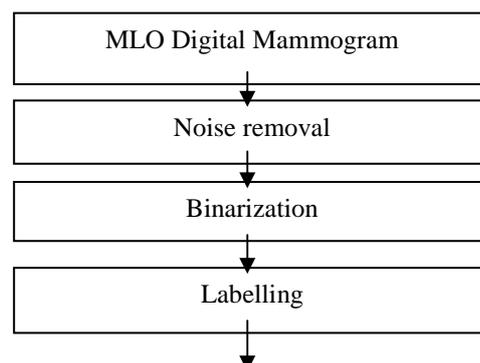
Various methods have been proposed for the extraction of pectoral muscle in MLO view of mammogram. Work proposed in [9] uses Hough transformation for pectoral muscle identification. They also stated that the Hough transformation gives missed detection of pectoral muscle in some case where pectoral muscle boundary is curved because Hough transform identifies the pectoral muscle as a straight line. For the solution of this problem they apply active contour method as an optimization step. In [10] Region growing intensity threshold estimation and boundary refinement was proposed for pectoral muscle removal. Seeded region growing algorithm was proposed in [8] for pectoral muscle suppression and identification. Work proposed in [11] uses straight line with processing of upper left part of mammogram for suppression of pectoral muscle. Work done in [3] uses the Otsu thresholding and slope detection for pectoral muscle suppression.

3. MAMMOGRAM DATABASE

The database for the study is taken from mammographic image analysis society (MIAS). The database comprises a set of 322 digitized mammograms corresponding to left and right breast of 161 women. Each pixel is described as an 8-bit word. Every image is of size 1024 x 1024 in Portable Grey map (PGM) format. Where the images are in greyscale format with a pixel intensity of range[0, 255]. Mammograms with three different type of background tissues, Fatty, Fatty-glandular and Dense-glandular are provided. The database also comprises of mammograms with six different types of abnormalities like calcifications, circumscribed masses, spiculated masses, other ill-defined masses, architectural distortion, and asymmetry of both benign and malignant types along with normal [12].

4. PROPOSED METHODOLOGY

Figure 3 shows the proposed methodology for pectoral muscle suppression and steps involved are described below.



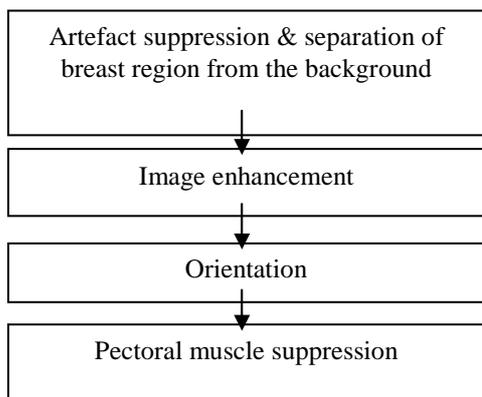


Figure 3: proposed methodology for pectoral muscle suppression

4.1. Noise removal

2D median filter is used to remove the digitization noise of digital mammogram which is performed by MATLAB function `medfilt2`.

4.2. Binarization

Global thresholding with threshold value 0.0706 is used to convert gray scale image into binary image.

4.3. Labeling

In this step, labeling is performed for the all connected components present in binary image by MATLAB function `bwlabel`.

4.4. Artifact suppression & separation of breast region from the background

After labeling, area of the all connected components (all regions) of the binary image is calculated using MATLAB function `regionprops`. Largest region (breast region) is selected using MATLAB function `bwareaopen`, which removes the all connected components (regions) in binary image except the biggest region (breast profile). So artifact is suppressed and breast region is separated from the background. To get the gray scale image, binary image is multiply with original image by MATLAB function `immultiply` (shown in fig. 4)

4.5. Image enhancement

In this step, Feature based enhancement method means wavelet transformation is used to enhance the

mammogram because it can enhance both masses and microcalcification.

The wavelet-based enhancement procedure involves three steps:

- (1) the DWT (discrete wavelet transform) is applied to mammogram.
- (2) The coefficients are processed at second level to enhance the mass characteristics.
- (3) The enhanced mammogram is obtained using the inverse wavelet transformation (shown in fig. 5)

4.6. Orientation

To find the mammogram orientation is left or right. Following steps are involved:

- (1) Divide the image into equal parts.
- (2) Find out the sum of each part.
- (3) If $\text{sum}_{\text{Leftpart}} > \text{sum}_{\text{rightpart}}$, then breast orientation is left else breast orientation is right.
- (4) Left oriented breast in MLO mammogram is flipped using MATLAB function `fliplr` before suppressing the pectoral muscle.

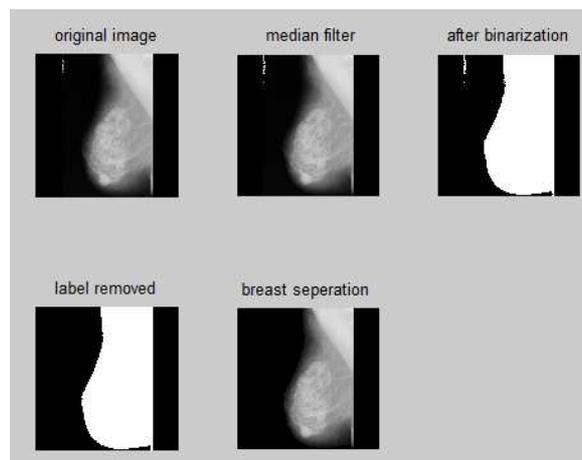


Figure 4: Results of mdb021 for artifact suppression and breast separation

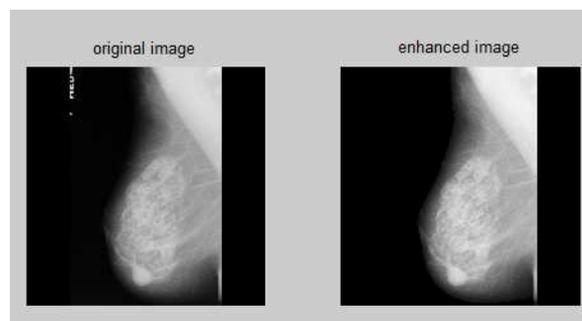


Figure 5: Result of mammogram enhancement

4.7. Pectoral muscle suppression

Following steps are involved for suppression of pectoral muscle:

- (1) The given MLO mammogram image is partitioned into four quadrants of 512 x 512 each.
- (2) The top left quadrant is processed further to detect the pectoral muscle.
- (3) Create a triangular mask using MATLAB function `roipoly` with three co-ordinate (200,512),(512,128) and (512,512).
- (4) Apply triangle mask to the upper left quadrant to find region contain only pectoral muscle.
- (5) This region is now thresholded with the value of $Th = (Imax + Imin) * 0.05$ to obtain the binary image(as shown in fig.6)
- (6) Create Black Square of 1024x1024 pixel.
- (7) Substitute upper left quadrant of Black Square with thresholded pectoral muscle.
- (8) Subtract the original image with square image and get the mammogram without pectoral muscle (shown in fig. 7).

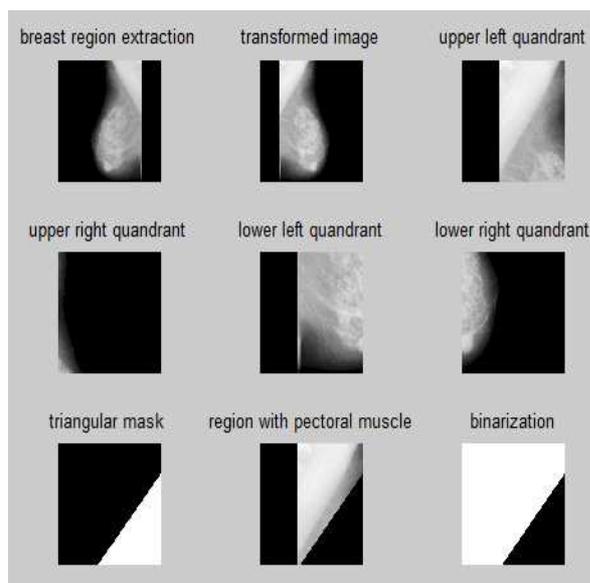


Figure 6: Result of transformed image, four quadrants of image, triangular mask and binarization.

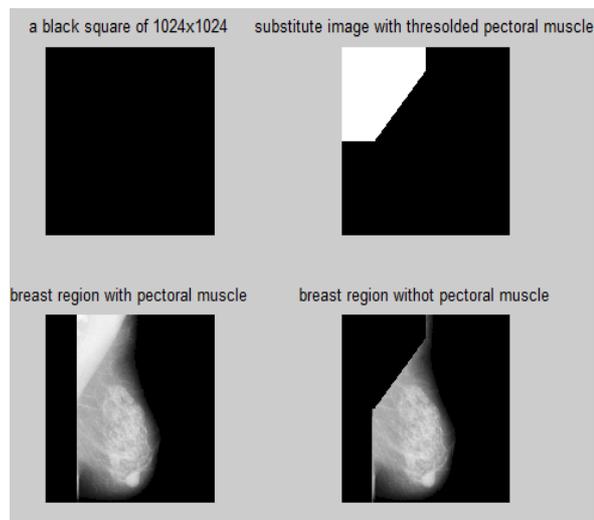


Figure 7: Result of Black Square, substitution, breast region with pectoral muscle and without pectoral muscle.

5. EXPERIMENTAL RESULT & CONCLUSION

A new method to segment the breast with pectoral muscle suppression has been presented. Proposed algorithm is tested over 322 images for breast region extraction and image enhancement gave excellent result with a accuracy of 100% on the other hand for pectoral muscle removal gave good result with a accuracy of 98%. The proposed algorithm can be efficiently used as preprocessing step for development of CAD system.

Future work will involved to design an algorithm for segmentation, feature extraction and classification using an algorithm developed in this paper.

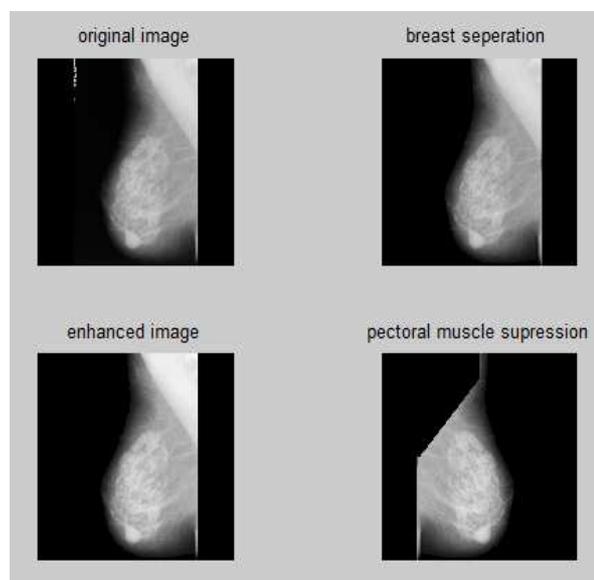


Figure 8: Result of major steps like breast separation, enhanced image and pectoral muscle suppression.

6. ACKNOWLEDGEMENT

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