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A Novel Approach for Breast Cancer Detection and Segmentation in a Mammogram

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Abstract

Mammography is a well-known method used for the detection of breast cancer. Many researchers worked in the area of breast cancer detection and proposed segmentation methods. However, no solution given by researchers is best promising and has limitations and it is still a challenging problem to solve. We introduce a simple and easy approach for detection of cancerous tissues in mammogram. Detection phase is followed by segmentation of the tumor region in a mammogram image. Our approach uses simple image processing techniques such as averaging and thresholding. We introduce a Max-Mean and Least-Variance technique for tumor detection. Experimental results demonstrate the effectiveness of our approach.

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Keywords: Breast cancer detection; Image Segmentation; Mammograms; Smoothing; Window mapping.

1. Motivation

Breast cancer is the main leading cause of death for the woman in world. It is observed that early detection of malignancy can help in the diagnosis of the disease for woman and it can help strongly to enhance the expectancy of survival. For the detection of breast cancer, various techniques are used in which mammography is the most promising technique and used by radiologist frequently. Mammogram images are usually of low contrast and noisy. In breast mammography, bright regions represent cancer. In some mammogram images, malignant tissues and normal dense tissues both may be present. To contrast between malignant and normal dense tissues is not possible only through applying thresholding. Understanding the information of mass regions of cancerous lesions in a mammogram is necessary and helps to identify the tumor and its segmentation. Therefore, detection of cancerous lesions in mammogram images becomes an active research area. Many techniques including computer-aided detection systems and intensity-based methods were introduced for breast cancer segmentation in mammogram images. However, no solution is best promising or able to satisfy detection criteria of only including cancerous regions successfully.

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2. Contribution of Our Work

Initial detection of the cancerous region in mammogram helps in early diagnosis of a diseased person which can reduce death possibilities. Methods developed for detection of the malignant region in mammograms may not be able to provide results successfully. To overcome this limitation, it is necessary to develop an approach which can segment malignant regions properly. This inspired us to work on the problem of breast cancer detection in mammogram images which are able to segment cancerous region along with detection. Consumption of time in execution is also important to provide good results in real time. Having this factor in mind, we develop an important and significant method which first detects the cancerous region and then segment the area covered by malignant tissues. In this paper, we are focusing onto detecting the malignant tissues which represent higher intensity values compared to background information and other regions of the breast. However, in case of some normal dense tissues having similar intensities to tumor region, it is necessary to detect tumor region excluding those regions successfully. We propose a method including detection followed by segmentation of mammogram images based on simple image processing techniques which provide good results in real time. Our method consists of two main steps (1) detection and (2) segmentation. In the detection phase, an averaging filter and thresholding operation is applied on original input image which outputs malignant region area. To find the malignant tissues, we create a rectangular window around the outputted region area and apply Max-Mean and Least-Variance technique. In segmentation phase, a tumor patch is found using morphological closing operation and image gradient technique to find the region boundary. We highlight the resultant region boundary and detected malignant tissues on the original input image.

3. Organization of the Paper

Organization of the paper is as follows: In section 4, we discuss some state-of-the-art methods. In section 5, we explained our method and give a detailed diagram of a whole method. In section 6, we perform our method on two mammogram images and show the comparison with one existing method. Performance analysis of our method is explained in section 7. Finally in section 8, we conclude our work.

4. Related Work

Abo *et al.* proposed an algorithm to detect suspicious region on digital mammograms¹. Proposed algorithm is based on the Fisher information measure. Bethapudi *et al.* proposed a detection and identification method of mass structure in digital mammogram images³ which detect malignant tissues in following steps: (1) Thresholding to remove the background information, (2) Apply median filter for random noise removal, (3) Extract the binary image contours. Thereafter, morphological open and close operations to fill the gaps in holes inside the image region. Authors proposed methodology to identify the shape of mass. Basheer *et al.* proposed a breast mass segmentation method based on adaptive median filtering and texture analysis². Authors used adaptive median filtering for contouring the image. Thereafter, best contour is chosen based on the texture properties of the resulting Region-of-Interest (ROI). Dalmiya *et al.* introduced a segmentation method for mammograms using wavelet and k-means clustering⁵. Authors defined their method in following steps: (1) Discrete wavelet transform is used to extract high level details from MRI images, (2) the outputted image is then added to original input image to get sharpened image, (3) k-means clustering is performed on sharpened image to locate the tumor region. final tumor region is extracted by performing thresholding on clustered image.

Sampaio *et al.* presented a computational methodology for detection of masses in mammogram images¹⁰ which can be described in following steps: (1) removing noise and objects outside the boundary and highlighting the internal structures of the breast, (2) regions containing mass are segmented using cellular neural network, (3) Thereafter the shape of these regions are analyzed through shape descriptors, (4) classification of candidate region is classified as masses or non-masses through Support Vector Machine.

Kekre *et al.* proposed a segmentation method for tumor detection in mammography images based on vector quantization technique using Linde Buzo and Gray (LBG)⁷. Cascio *et al.* proposed a mammogram segmentation method using Contour Searching and Mass Lesions Classification With Neural Network⁴. Authors achieved to segment

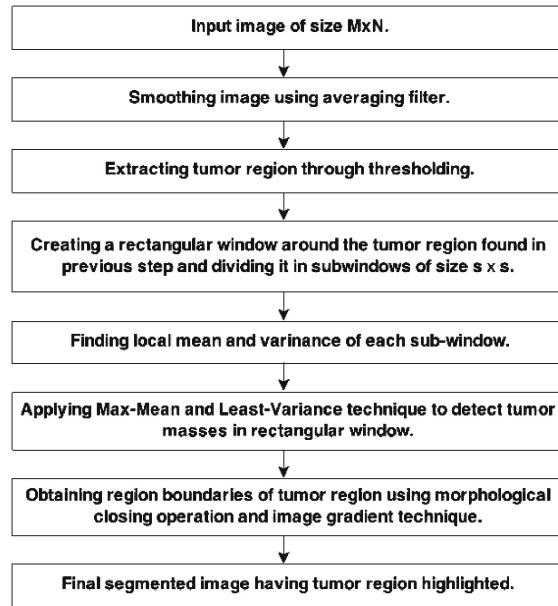


Fig. 1. Outline of our method.

the whole image's area without loss of meaningful information by means of a hunter algorithm. In classification step, some features give geometrical information and remaining shape parameters. Computed features for each ROI are used as inputs to a supervised neural network. Decision of selected ROI is pathological or not depends upon the probability provided by output neuron. Sheshadri *et al.* introduced the use of functions for computing texture based on statistical measures¹¹. Authors employed MPM (Maximizer of the posterior margins) to perform segmentations and evaluate the region properties of mammogram image. Raba *et al.*⁹, proposed a breast segmentation method with pectoral muscle suppression on mammogram images. Authors of this method emphasized to split the mammogram into interesting regions to achieve optimal search for abnormalities. Guliato *et al.* proposed a segmentation method of breast tumor using fuzzy sets⁶. Authors proposed two segmentation methods using fuzzy sets which determines the boundary of a tumor by region growing.

5. Proposed Work

In this paper, we introduce a simple and efficient approach to detect the cancer region in mammogram images. Our approach also segment the cancer region on input mammogram image. The outline of our method is described in Fig. 1. We describe our method in following step:

- We take a $M \times N$ mammogram image I as input and perform averaging filter of size $s \times s$ to smooth pixels which are having intensity values similar to pixels belonging to cancer region in I , shown in Fig. 3(b).

$$I_F = I(i, j) * g(x, y)$$

- A thresholding parameter d is used to separate pixels of cancer region from normal region. we get a white patch after thresholding covering cancer region, shown in Fig. 3(c). However it still left some pixels belonging to cancer region.

- **Max-Mean and Least-Variance technique**

To cover whole region, we create a rectangular window along the white patch and apply this window to I . Thereafter, we divide this large window into sub-windows of size $w \times w$ and find local mean and variance in



Rectangular window around the patch obtained after performing thresholding.

Fig. 2. Rectangular window around the patch.

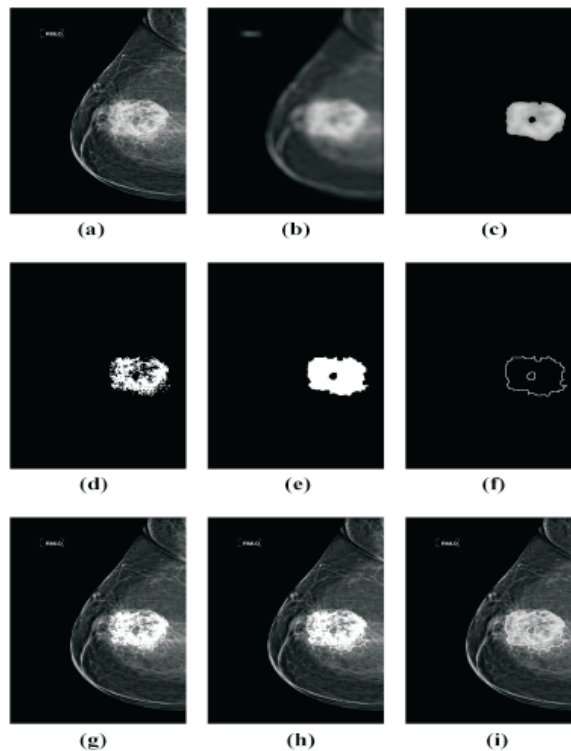


Fig. 3. Segmentation and detection result on mammogram image by our method, (a) Original image; (b) Smoothed image; (c) Patch image after thresholding; (d) Cancer region found in input image in window; (e) Region patch found after morphological closing; (f) Region boundary using gradient; (g) Cancer area detected; (h) Cancer area with region segmentation; (i) Our segmentation result of cancer in input mammogram image.

each sub-window. Assuming that pixels belonging to cancer region contains the higher pixel value compared to normal region, first we find sub-windows which are X highest means. The value of X is set for image used in this paper, it is set to 2800. Thereafter, we find Y sub-windows which are having least variance from the sub-windows obtained above. The value is set to 1800.

- Highlighting all the pixels of sub-windows found in previous step helps to identify cancer region, shown in Fig. 2(d).
- To segment the cancer region in input image, we get region boundary using morphological closing and image gradient technique, shown in Fig. 3(e), (f).
- Thereafter we segment the cancer region in given input image I , shown in Fig. 3(h), (i). Detected cancer is also shown in Fig. 3(h).

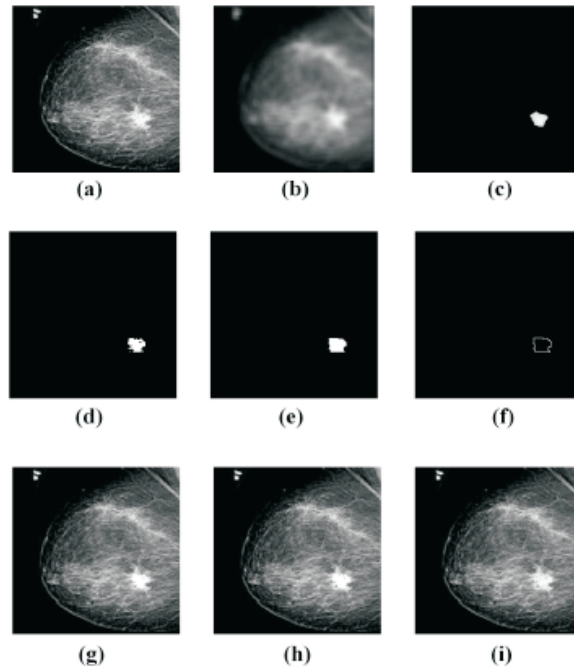


Fig. 4. Segmentation and detection result on mammogram image by our method. (a) Original image; (b) Smoothed image; (c) Patch image after thresholding; (d) Cancer region found in input image in window; (e) Region patch found after morphological closing; (f) Region boundary using image gradient; (g) Cancer area detected; (h) Cancer area with region segmentation; (i) Our segmentation result of cancer in input mammogram image.

6. Experimental Results and Discussion

Initially, we take a 2-d mammogram image of size $M \times N$ as input and applied averaging filter on it, shown in Fig. 3(b). We use averaging mask of size 25×25 pixels. Thereafter, thresholding operation is performed in which cutoff intensity is taken 125 for first image and 195 for second image. A rectangular window is formed around the patch region. This window is subdivided into local windows of size 3×3 . In Fig. 3(a), it can be seen that some portion is having brighter pixels in comparison to other pixels. Considering that cancer lesions will be dense and higher pixel intensity value than other breast tissues. However, it can be seen that cancer region is also not uniform. We applied Max-Mean and Least Variance technique on patch window to detect cancer area of input image, shown in Fig. 3(d). In Fig. 3(e) and (f), region patch and region boundary is shown obtained through morphological closing and image gradient. Figure 3(h) and (i) show final segmented and detected area for cancerous cancer of given input image. Through visual analysis, it is clear that our method is able to detect and segment cancer area in a given mammogram image. Mammogram image used in this paper is taken from⁸. We showed results of our method on second mammogram image similar to first image. A comparison is shown between our method and Dalmiya's method⁵. Through visual analysis, it is clear that our method is able to segment tumor region better than Dalmiya's method. Where Dalmiya's method includes some non tumor region in the final segmented image, our method only detects tumor region locate tumor region on original input image successfully.

7. Performance Analysis

We Implemented our method under MATLAB version 2013 and tested on several mammogram images on a desktop with IntelCore2Quad Q9550 2.83 GHz CPU with 4GB RAM. In this paper, we showed results on two mammogram images in which approximate time 4.20 sec is taken to perform experiment on each image. Which shows that our

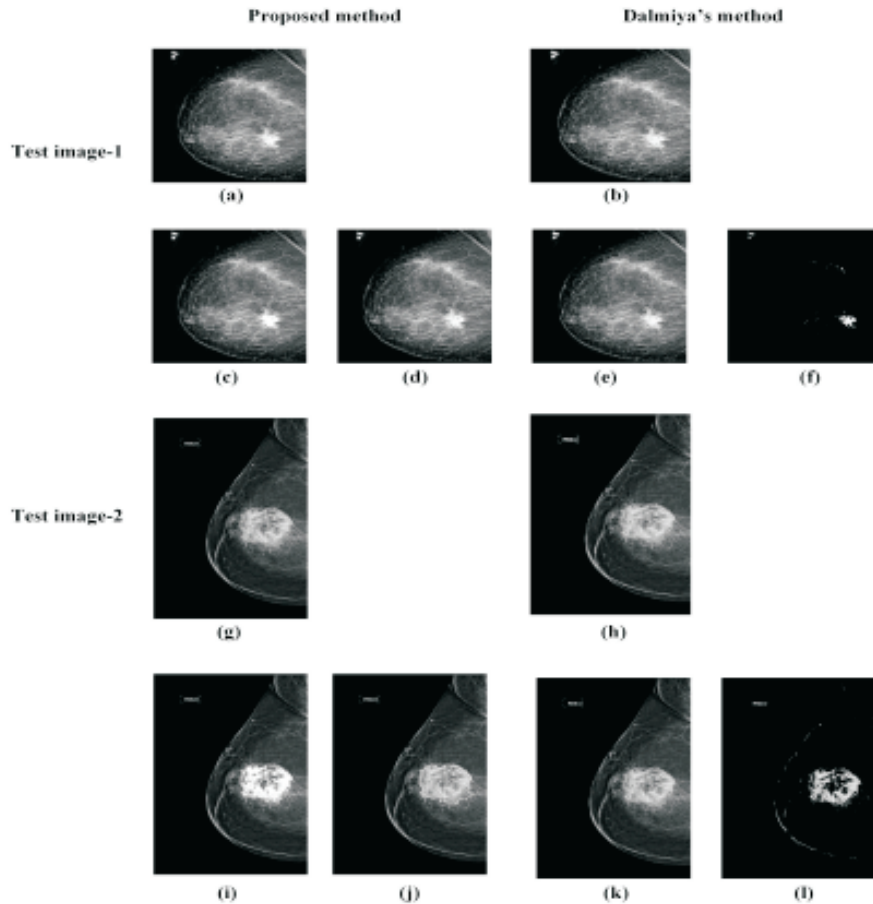


Fig. 5. Comparison in results of Proposed method and Dalmiya's method on two test images, (a), (b), (g), (h) Are original input images to respective methods. Resulted segmented images: Proposed method-(c) and (d) for test image-1; (i) and (j) for test image-2. Dalmiya's method-(e) and (f) for test image-1; (k) and (l) for test image-2.

method is able to give results in real time. Other methods which are based on clustering algorithm take too much time to converge which increase the overall execution time of clustering based methods.

8. Conclusion

We performed our method on two input mammogram images in Fig. 3 and 4. Through visual analysis, it is clear that our method is successful in segmenting the cancer region of mammogram. Along with segmentation, pixels of cancer region are also identified. Our method is simple and fast because of using basic image processing techniques. Our method can also be helpful in other medical imaging applications, pattern matching, feature extraction. The main drawback of our method is the manual selection of threshold parameter and size of averaging filter. In future, we will work to reduce the dependability on parameter to make our method adaptive to different images.

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