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Region Based Approach for Pectoral Muscle Isolation

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Abstract: ***The pectoral muscle, a non-breast region in mammograms, acts like an additional complexity in automated analysis using Computer Aided Diagnosis (CAD) systems. The pectoral muscle represents a predominant density region in most medio-lateral oblique (MLO) views of mammograms and can affect the results of image processing of detection of breast abnormalities. Intensity-based methods can present poor results when applied to differentiate dense structures such as suspicious masses or fibro-glandular discs because the pectoral muscle has a similar opacity as tumours. Another important reason for detecting the pectoral muscle in mammograms is that CAD system can detect the possible presence of abnormal axillary lymph nodes which is a major sign of breast carcinoma. Two distinct approaches in pectoral muscle isolation are used. These are Region Based and another is edge based. In Regionbasedapproachconsecutive steps are used to isolate and suppress the pectoral muscle. The initial step involves defining a rectangle to isolate the pectoral muscle from the region of interest (ROI) and the next is to suppress the pectoral muscle using proposed modified seeded region growing (SRG) algorithm. The quantitative and qualitative measures on breast images are calculated for showing better performance than existing methods. This paper actually proposed Regionbasedapproach for pectoral muscle isolation.***

Keywords: CAD, Tumor, Pectoral Muscle, Region Based Approach

1. Introduction

The breast is prone to various benign and malignant conditions. The most common benign conditions are puerperal mastitis, fibrocystic breast changes and mastalgia. The latter part is very serious in nature that is Breast Cancer. Breast cancer, a malignant our developed from breast cells is considered to be one of the major causes for the increase in mortality among women, especially in developed and developing countries. More specifically, breast cancer is the second most common type of cancer and the fifth most common cause of cancer-related death. So, it continues to be a significant public health problem in the world.

Some cancerous breast tumours are invasive or infiltrating. The seriousness of invasive breast cancer is strongly influenced by the stage of the disease, that is, the extent or spread of the cancer when it is first diagnosed [1].

High blood levels of estrogen have been related with breast cancer. Besides gender, age is the next most strongly connected risk factor of breast cancer. It has been widely accepted that the elderly women are more susceptible to breast cancer than young.

According to Cancer Facts and Figures 2012 in US, an estimated 226,870 new cases of invasive breast cancer are expected to occur among women in the US during 2012; about 2,190 new cases are expected in men. Most significant observation is that 1 out of 8 women are experiencing breast cancer in their life time in US [2]. The fact and figurers of breast cancer is almost similar in other developed counties for instance about 2100 new cases of breast cancer and 800 deaths are registered each year in Norway [2-3] and also percentage of deaths in nowadays are increasing in other parts of the world.

In early stage of breast cancer there are no visualorany significant symptoms, however, if diagnosed it is the right time for curative treatment because the size of the tumour is small. Even some time large tumours in breast may be painless. Typically, breast pain results from benign conditions and is not an early symptom of breast cancer [4-5].

Growing age increases the risk factoral most in exponential order in females. Definite cause of breast cancer is still not identified, so, prevention becomes impossible. Early stage detection is more effective for affecting treatment and increases the probability to be cured rapidly. Several studies have shown that early detection saves live and increases treatment opportunities. It is also evident that early detection and improvements in treatment can decrease the rate of mortality among women considerably.

Breast cancer stages range from 0 to IV. Early and efficient diagnosis is the most effective way for treatment and to reduce mortality. The breast cancer diagnosis process is basically two folds. The screening process is simply used to find abnormalities in the breast. The conclusion reached through process of analyzing his to pathological slide with present technologies and procedures like biopsy to determine whether a tumour is malignant or benign. Breast cancer screening is a professional medical examination performed to check women's breasts for abnormalities such as calcification, tumours and cysts, and identify where they exist.

Digital mammography is a recent technique for recording x-ray images in digital code instead of on x-ray film, as with conventional mammography. Digital mammography has some advantages over conventional mammography. Digital Mammography has been proved to be the most effective and reliable screening method for early breast cancer detection.

Imaging techniques play an important role in helping to perform breast biopsies, especially of abnormal areas that can be identified and located by a mammogram. There are several types of biopsies present, like vacuum-assisted biopsy (Mammotome) or core needle biopsy, but traditional open surgical biopsy is the gold standard to which other methods of breast biopsies are compared. Pathology laboratories use two methods to study cancer tissue sample.

The pectoral muscle, a non-breast region in mammograms, acts like an additional complexity in automated analysis using Computer Aided Diagnosis (CAD) systems. The pectoral muscle represents a predominant density region in most medio-lateral oblique (MLO) views [6] of mammograms and can affect the results of image processing methods. Intensity-based methods can present poor results when applied to differentiate dense structures such as suspicious masses or fibro-glandular discs because the pectoral muscle has a similar opacity as tumours. Another important reason for detecting the pectoral muscle in mammograms is that CAD system can detect the possible presence of abnormal axillary lymph nodes which is a major sign of breast carcinoma.

This paper proposed a Region based approach and it consists of consecutive steps to isolate and supress the pectoral muscle. The initial step involves defining a rectangle to isolate the pectoral muscle from the region of interest(ROI) and the next is to suppress the pectoral muscle using proposed modified SRG algorithm.

2. Literature Review

The basic task of image segmentation is to divide the image into a number of segments containing of images. Image segmentation is the process of assigning labels to each pixel of an image based on some similarity criteria to form region(s). A hierarchical stepwise optimisation algorithm for region merging is proposed based on stepwise optimization. It produces a hierarchical decomposition of the image by partition. The sequences of partitions reflect the hierarchical structure of the image[7-9]. An algorithm is also proposed to combine the region growing and edge detection methods for segmenting the images. In the method the adding of segments to a region may cause some pixels belong to a different region may be m is classified. Such erroneous regions may participate in the growing process. A nearest neighbor rule is then used to locally reclassify them [10-12]. A new region growing approach for image segmentation using gradient information to specify the boundary of a region. The main advantage of the algorithm is that no prior knowledge is needed about the regions[13-16]. The most effective and robust method for image segmentation is Seeded region growing algorithm (SRG). Improved Seeded Region Growing Algorithm (ISRG) algorithm retains the advantages of SRG such as fast execution, robust segmentationandnoparameterstotune [17]. ISRG algorithm ensures the pixels with the same priority are processed in the same manner simultaneously [18]. A stepwise optimisation algorithm for region merging is based on stepwise optimisation and produces a hierarchical decomposition of the image. In the algorithm two segments are merged at each iteration for producing sequence of partitions in the hierarchical structure of the image[19]. Some researchers proposed a new region growing approach for image segmentation based on gradient information to specify the boundary of a region [20-21 Various other methods are also presented in literature for removal of pectoral muscle in [22-27]. In mammography, the pectoral muscle region is utilized as an index to compare the symmetry between LMLO and RMLO views [28-30].

3. Proposed Method

The proposed Modified Seeded Region Growing Algorithm (MSRGA) is a region based approach. The pectoral muscle suppression process consists of two distinct separate processes, initially define rectangle to isolate pectoral muscle from region of interest (ROI) and followed by suppression of pectoralmuscle. It is shown in figure 1.

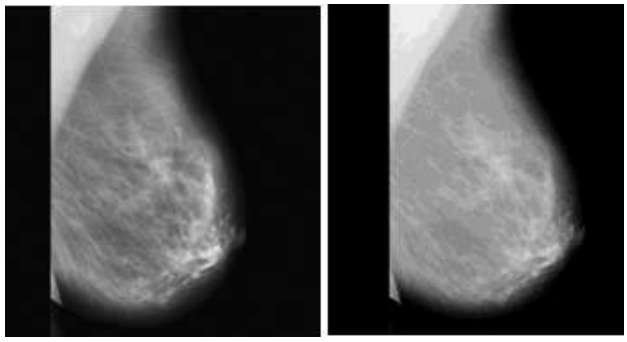

Figure 1: The Original Mammogram and Mammogram after Homogeneity Enhancement

The two common projections of mammogram are medio-lateral oblique (MLO) and cranio- caudal (CC) view. In medio-lateral oblique projection the whole breast is visible, often including lymph nodes. The main disadvantage is that part of the pectoral muscle is shown in upper left for left oriented breast image whereas upper right corner for right oriented breast mammogram respectively. In contrast the cranio- caudal view is taken from above, resulting in an image that sometimes does not showthe area close to the chest wall. In this research work, MLO view is consider for its complete visibility though it introduces a new challenge to detect and isolate pectoral muscle.

Accurate segmentation is essential in obtaining a correct computer aided diagnosis. Intensity based method with pectoral muscle present may producer roneous result when applied to dense structure i.e. abnormal masses, fibro-glandular disc, because that has the nearly same opacity. So, it is important to detect the pectoral muscle and isolate it from the region of interest (ROI), for further analysis. The pectoral muscle has a slightly higher intensity compared to the rest of the breast tissue and appears in upper left corner of MLO view of mammogram (the orientation of right breast mammograms are flipped horizontally to left).

The most important landmark in mammogram image is the vertical straight line that separates background of the mammogram and the left side of breast region. This line is considered as horizontal reference and demarcated the line

as $\overrightarrow{AB}$ from top to bottom of the mammogram. The next step is to search for the last pixel of breast region at the top marginofmammogram This point is referred as C. Now point Chas been connected to the bottom left corner point of the mammogram namely D as $\overrightarrow{CD}$ The line$\overrightarrow{CD}$ intersects horizontal reference $\overrightarrow{AB}$ at the point E. A parallel line is plotted with respect to the top boundary and passing through E. Another line parallel is plotted to horizontal reference passing through C. These two parallel lines intersect at point F. So, a rectangle is formed ACFE. The inverted right angle triangle ACE is considered to isolate the pectoral muscle and the other half of the rectangle CEF, the intensity values are changed to black. The experimental results show that except for very few mammograms of MIAS database and other available database, pectoral muscle lies within the defined triangle.

Demarked rectangle is then cropped out from the original mammogram for further processing. The steps are depicted in Figures 2 and 3.

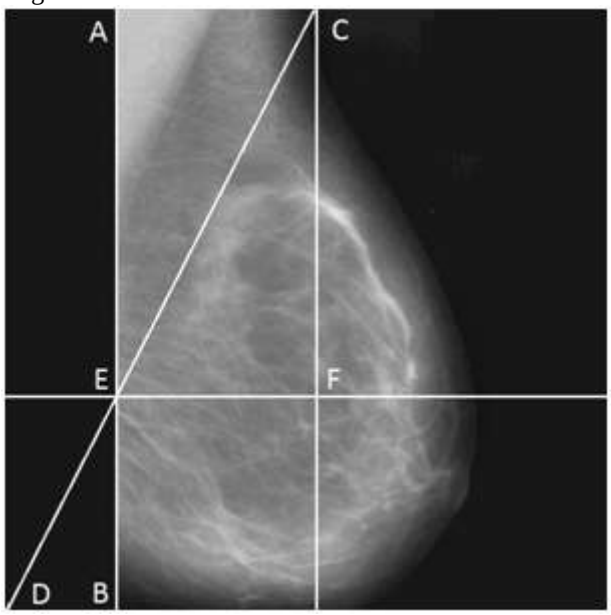

Figure 2: Mammogram showing Lines Passing through Points A, C, F and E

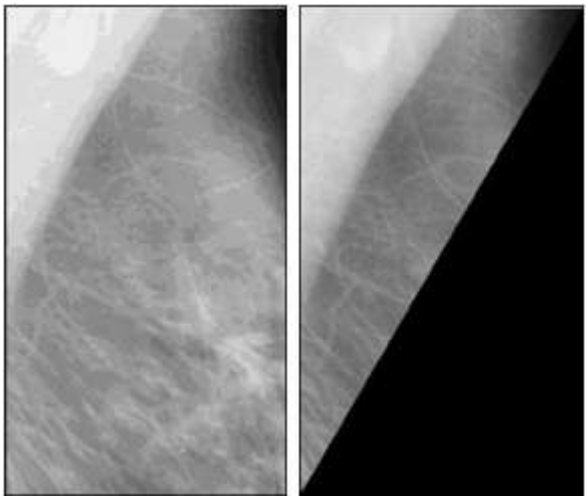

Figure 3: Cropped rectangle ACEF and Inverted right angled triangle (ACE) and rest (CEF) masked

Seeded region growing (SRG) algorithm is applied on the extracted rectangle, to suppress the pectoral muscle.In this proposed method, the basic rules of SRG algorithm is used with the introduction of some new ideas to make it more efficient, problem specific and less time consuming. Instead of the seed being selected automatically by the system, a path has been provided to find the next seed. The left top to right bottom diagonal has been considered to select the seeds, specifically up to the intersection point of line from right top to left bottom diagonal in the cropped image. The double arrow dotted line in Figure 4 is indicating the line of consideration.

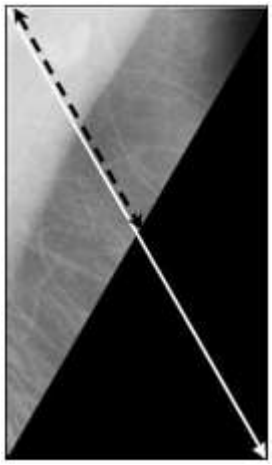

Figure 4: The double arrow dotted line of consideration to collect the seeds

The Cartesian slope-intercept equation for the line may be chosen for traversing the line of consideration with end points (x1, y1) and (x2, y2) in cropped rectangle image.

$$=mx+b \quad (1)$$

The m is representing the slope of the line and b as the y intercept. If the two end points (x1,y1) and (x2,y2) have been specified in the cropped rectangle image, value of the slope can be determined and y intercept as following:

$$m = (y_2 - y_1)/(x_2 - x_1) \quad (2)$$

$$=y_1 - mx_1 \quad (3)$$

For any given x interval Δx along a line, corresponding y interval Δy can be calculated from the following equation:

$$\Delta = m.\Delta x \quad (4)$$

Similarly, the x interval Δx can be obtained corresponding to a specified Δy as

$$\Delta x = \Delta y/m \quad (5)$$

All pixels along the line of consideration is read one after another from left top to right bottom and calculation of the minimum, maximum and average intensity value of the pixel is done.

Now a selection criterion of pixel for region growing has been introduced. The selection method is obtained by subtracting average intensity from that pixel intensity and then dividing it by the difference between maximum intensity and average intensity. If the pixel intensity is greater than 0 and less than equals to 1, pixel will be merged to the region growing and the intensity value will be

0 else it will be remained unchanged.

The proposed algorithms have reduced the running time drastically. In general the time complexity of image processing algorithms are n^2 or higher because atleast once the entire image has to be scanned. But here the algorithm defines a rectangle to Isolate Pectoral Muscle from ROI. The later processes just do the processing within that rectangle only. By observation it has been found that the defined rectangle is only occupying the 1/6 part of the entire mammogram. Further to reduce the complexity, the Suppression of Pectoral Muscle part is only using the upper triangular part of the rectangle i.e. called here the inverted triangle. So, the complexity is reduced further. Hence, it may be concluded that the effective running time is $O(n^2/12)$ approximately depending on the sample shape and size.

The results obtained by the proposed region based method is shown in Tables 1 and 2.

Table 1: Quantitative and Qualitative measures on 322 images overDataset obtained from Hospital

Mean Result	Fatty	Glandular	Dense
Intersection (TP)	34175	37441	33273
Over segmentation (FP)	1034	947	194
Under segmentation (FN)	1297	861	311
Completeness (CM)	0.963	0.978	0.991
Correctness (CR)	0.971	0.975	0.994
Quality	0.958		

Table 2: A qualitative measure of the algorithm

Result	Acceptable (quality > 0.95)	Unacceptable (quality <0.95)
Total no (322)	308	14
Percentage	95.7%	04.3%

4. Conclusions

The proposed region based and edge based method for pectoral muscle detection and suppression have been discussed. The results obtained over database have shown excellent output. The algorithms are used to accurately identify pectoral muscle and suppress the pectoral muscle successfully without losing any information from the rest of the mammogram.

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