Image Processing for Early Diagnosis of Breast Cancer Using Infrared Images

Pragati Kapoor, Dr. S.V.A.V. Prasad
Dept. of Electronics & Communication Engineering
Lingaya's University
Faridabad, Haryana, India
e-mail: pragati_ahuja@yahoo.com

Abstract—**Early diagnosis of Breast Cancer is the key to improve survival rate. Infrared thermal imaging or thermography is a promising screening tool as it is able to warn women of breast cancer ten years in advance. However, interpretation of a thermogram can be inconsistent. In order to improve the accuracy of preliminary breast cancer screening using thermogram, image segmentation is proposed as an automatic approach for analysis of infrared thermal images. Edge detection and Hough transform are outlined for asymmetry analysis of heat patterns in contralateral breasts**

Keywords- Breast Cancer; infrared thermal imaging; thermogram; image segmentation; edge detection; Hough transform; asymmetry analysis

I. INTRODUCTION

Breast cancer has been known for decades to be the most common type of cancer among women. The incidence of breast cancer in India is on the rise and is rapidly becoming the number one cancer in females. India accounts for nearly six percent of deaths due to breast cancer in the world. One out of every 22 women in India is diagnosed with breast cancer [1]. Recent studies have determined that the key to breast cancer survival rests upon its earliest detection possible.

However, mammography the most widely employed detection method is not as effective for women with fibrocystic or dense or surgically implanted breasts. Furthermore, there is concern regarding the risk of ionizing radiation and patients complain of discomfort due to high compression of breasts. In a search for other imaging techniques, thermography has emerged as a potential method to complement mammography and improve overall detection efficiency [2]. Thermography possesses many advantages, such as noninvasive, non-contact, risk free, non-radiation, less expensive and particularly valuable for early tumor detection [3]. Ng E.Y.K. et al also mentioned that the result of thermography can be correct 8-10 years before mammography can detect a mass [4].

Clinical interpretation of breast thermograms can be done by making comparisons between the images of contralateral breasts. The higher chemical and blood vessel activity of the cancerous tissue will cause an increase in regional surface temperature of the breast [5]. When the images are relatively symmetrical, small asymmetries in the heat patterns of contralateral breasts indicate a suspicious region. These asymmetric heat patterns are found visually using new generation of IR cameras. In order to provide a more objective result, based on the assessment of thermograms, an approach using image segmentation and Hough Transform for the analysis of asymmetry is proposed in this paper.

II. IMAGE ACQUISITION

Fig 1, Fig 2 and Fig 3 show the thermograms of a volunteer with a normal mammogram but a concerned thickening of the left breast. The images are taken using IRI4040 long range thermal imager having a spectral response of 8μm to 14 μm. Fig. 1 shows a significant increase in temperature of the entire left breast along with noticeable vascularity (angiogenesis)

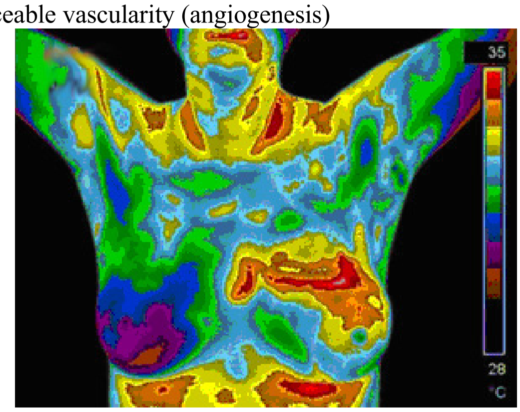

Figure 1. Front Position

In Figure 2, the right breast is seen to be normal and cool without evidence of suspicious blood vessel activity. Figure 3 shows in full detail the significant amount of thermovascular activity in the left breast. The thermograms of Fig. 1and Fig. 3 are risk indicators and it is recommended for the patient to have routine follow ups.

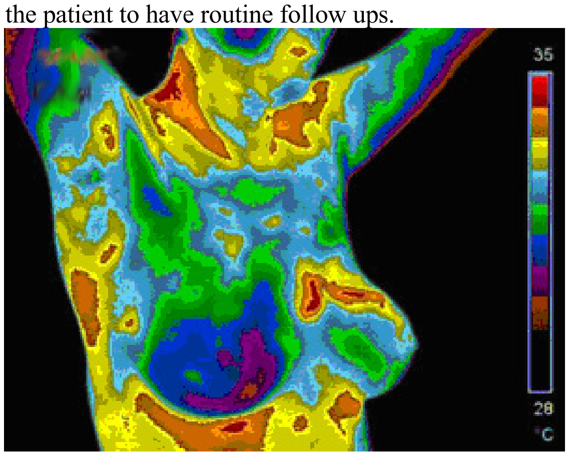

Figure 2. Right semi side position

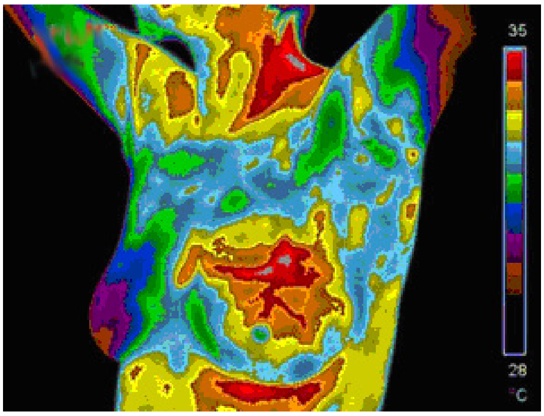

Figure 3. Left semi side position

Skin surface temperature is greatly affected by numerous conditions. In order to reduce the errors due to thermal artifacts, the above images are taken using a recommended set of instructions to ensure the usefulness and consistency of thermal images[6]. The patient was asked to avoid alcohol, caffeine and stop smoking two hours before the test and avoid use of lotion, cream on the body area to be imaged. The chest area was cooled slightly with a fan for approximately 7-10 minutes just prior to image taking. The room temperature was approximately 22 degrees Celsius and darkened during the test to minimize infrared source interferences.

III. Approach

Early methods for interpretation of breast thermogram were solely based on subjective criteria. The images were read for variations in vascular patterning with no regard to temperature variations between the breasts [7]. In this paper, image segmentation and asymmetry analysis are proposed as an efficient method for breast analysis using infrared images. The approach outlined includes the following steps:

1) Edge Detection to extract the boundaries of the breasts.

2) Hough transform to extract the lower breast boundaries.

3) Classify each segmented pixel into a certain number of clusters.

4) Diagnose the breast diseases based on asymmetric analyzing of the pixels in every cluster.

Fig. 4 is a system guideline of the steps involved in the proposed approach.

B. Edge Detection

Edge detection is a well developed field on its own within image processing. It is by far the most common approach for detecting meaningful discontinuities.

The built in Canny edge detector in the Matlab Image Processing toolbox can be used to extract the boundaries of the breasts because it is one of the most precise edge detection operators and has been widely used [8]. The Canny method uses two thresholds to detect strong and weak edges. It includes the weak edges in the output only if they are

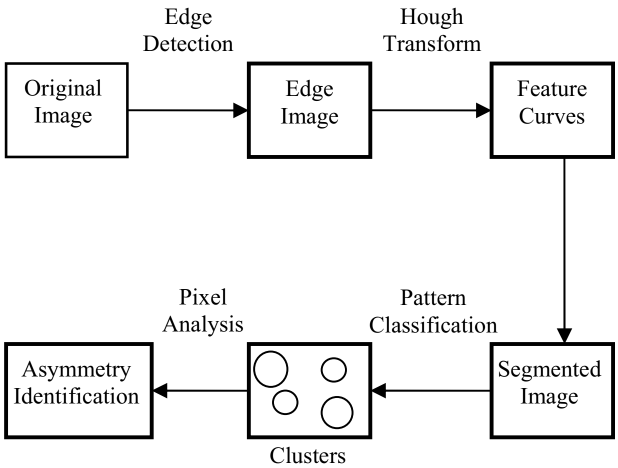

Figure 4. Block Diagram for asymmetry analysis of thermogram using segmentation

connected to strong edges. As a result , it is robust to noise and implements Gaussian function to smooth the image and to obtain the magnitude and orientation of the gradient for each pixel.

C. Hough Transform for detection of breast boundaries

To find the lower boundaries of the breast is difficult because they are mostly like parabolic curves. Therefore Hough transform can be applied to extract the boundaries of the breasts. Hough transform that was proposed by Paul Hough is a method to implement a kind of mapping relation from image space to the parameter space. The main idea can be explained as the duality between point and line. The points that in the same line in image space correspond to the intersecting lines in the parameter space. On the other hand, all the lines that intersect at a same point in the parameter space correspond to the points in the same line in image space. Hough transform is usually used to find the line or curve in binary map and transform the binary map into the Hough parameter calculation space [9].

An approach based on the Hough transform is as follows:

- Complete the gradient of an image and threshold it to obtain a binary image.
- Specify subdivisions in the $\rho\theta$-plane
- Examine the counts of the accumulator cells for high pixel concentrations.
- Examine the relationship (principally for continuity) between pixels in a chosen cell.

D. Feature extraction for symmetry analysis of contralateral breasts

The features of the heat patterns will include the statistical parameters such as skewness, temperature variation and kurtosis. More larger the tumor size is, the steeper the temperature variation is [10]. The cumulative histogram which describes the temperature variation with area will reflect the asymmetry. The histogram will describe the frequency of existence of pixels of the same intensity in the whole image or the region of interest (ROI). The asymmetry can be measured by the maximum ratio between temperature difference and area. The further the ratio from 1, the greater asymmetry the is.

Skewness and kurtosis can be measured using the Statistics toolbox in Matlab. Skewness is the measure of asymmetry of data around the sample mean. The Skewness (y) of a distribution x is given by (1).

$$y = \frac{E(x-\mu)^3}{\sigma^3} \tag{1}$$

μ is the mean of x, σ is the standard deviation of x and E(t) is the expected value of quantity x.

Kurtosis is a measure of how outlier prone a distribution is. The kurtosis(k) of a distribution x is given by (2).

$$k = \frac{E(x-\mu)^4}{\sigma^4} \tag{2}$$

The kurtosis of the normal distribution is 3. Distribution that are more outlier prone than the normal distribution have kurtosis greater than 3, distribution that are less outlier prone have kurtosis less than 3.

IV. CONCLUSION

This paper proposes an approach to diagnose breast cancer based on infrared images. Firstly, the breast picture can be segmented accurately and automatically with the application of the methods of edge detection and Hough transform. Then based on pattern classification and pixel distribution, asymmetries are identified for the breasts. The pathological changes of the breasts will be diagnosed based on this. The approach will be effectual and feasible and would be of great practical value in diagnosing the asymmetric abnormalities for breast using infrared images and will help as a useful second opinion.

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