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Bilateral Breast Geometry Analysis –A Preliminary Tool for Detection of Breast Abnormality

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***Abstract*—**With the increase in the mortality rate due to Breast cancer among young women folks, different techniques are developed for the early detection of breast abnormality. Thermal Infrared Imaging is one such modality that made use of thermal camera for the detection of the dreadful disease. This research work presents the use of bilateral breast geometrical analysis on the breast thermal signatures collected from Kidwai Institute of Oncology, Bangalore. The analysis has been performed on 70 bilateral breast thermal signatures. Breast thermal signatures have been captured at distances 1m, 1.5m and less than 1.5m. An algorithm has been implemented based on Digital Image Processing techniques. ROI processing has been performed on suitable palette. After detecting contour of breast area, edge linking has been implemented using Parabolic Hough Transform. Obtained results are correlated with ground truth mammography reports. It has been observed that out of 70 bilateral images, 21 have shown asymmetry which matches with ground truth. The analysis gives 77% sensitivity and 60.4% specificity. The distance between subject and camera also shows the effect on sensitivity. It is observed that the images taken at 1.5m distance are more apt for analysis purpose.

***Keywords*—** Breast asymmetry, thermal imaging, data acquisition, Canny edge detector, Hough Transform, BIRADS, Matlab, SmartView, ROI (Region of interest)

I. INTRODUCTION

Mortality rate of young women folks due to breast cancer has increases tremendously. Different techniques have been developed for the detection of breast abnormality. Currently the imaging modality which is used for the detection of Breast Cancer is Mammography. Mammography procedure is painful and for early detection of cancer, biopsy is to be performed. For mass screening of the patient, mammography is not suitable, hence research work is on-going to determine efficacy of thermography for mass screening as an adjunctive tool for the detection of breast cancer. This research work presents bilateral breast geometry analysis which is a preliminary step to detect breast abnormality. In normal condition, breast is symmetrical in nature. When there is certain abnormality this symmetry gets disturbed.
Fluke thermal camera TiX560 having 0.05˚C sensitivity have been used for data acquisition.

The paper is organized as follows, Section I contains the introduction of why thermal imaging technique has been considered in the recent trend, Section II contain the related work prior to the research work being studied, Section III explains the methodology of the research work with suitable flow charts and figures. It also contains the stepwise explanation of the algorithm used, Section IV contains the results obtained for the particular research work with suitable tables and figures, Section V contains observations and discussion and Section VI concludes with Conclusion along with future scope.

II. RELATED WORK

Many authors have already been published papers on the breast asymmetry analysis. In their papers, there involved a use of Digital Image Processing algorithms like canny edge detection and Hough Transform for the segmentation. Machine learning classifiers like k-means clustering have also been practiced.

Pragati Kapoor *et al*[13] in their paper introduced a robotized technique for distinguishing the ROI in thermal pictures and fragmented utilizing canny edge locator and gradient operator. Further, asymmetry investigation is then performed utilizing HOS parameters, center calculation and histogram generation. The GUI's made make the framework constant and working framework free.

Dave Tahmoush *et al*[18] in their paper showed that for the asymmetrical analysis, image similarity method can be employed and further determined by using a contextual and spatial method. Supervised learning of model parameters are also employed for the detection of asymmetry. They have used mammography images to detect the asymmetry.

Hairong Qi *et al* [11] in their paper, a programmed division is done using Hough transform and an unsupervised pattern classification is performed for section correlation. By utilizing Hough transform feature bends are precisely separated, and k-means algorithm gives helpful data in the examination of variations from the norm.

CHEN Bao-ping et al [16] proposed a programmed way to deal with division and awry investigation for breast malignant growth from infrared images. Their investigations demonstrates that the methodology is efficacious and plausible and it has been of extraordinary functional incentive in diagnosing the deviated variations from the the norm for breast utilizing infrared images. It uses Hough transform and canny edge detection. Unsupervised learning algorithm, k-means clustering had also been used for classification purposes.

III. METHODOLOGY

Fig.1 gives the pictorial representation of the proposed methodology. Data acquisition has been done at Kidwai Memorial Institute of Oncology, Bangalore after getting ethical clearance. To capture the data, protocol has been established. Initially breast thermal signatures were captured at 3 distances. It is found that distance 1.5m is the most suitable as subjective quality of the images was very good. In order to verify the effect of change in distance, images have been captured at 3 distances. In total, 193 samples have been collected. Out of that 70 samples were of bilateral breast and considered for study. Remaining were of unilateral wherein one breast was already removed. Thermography images were acquired with the help of Fluke thermal cameral TiX560 model with sensitivity 0.05˚C. The details of protocol established are as follows.

- During the camp, for every patient the purpose of the data collection drive was informed. Initially subject details were entered in the Performa form, then Consent form (in Kannada and English) was given to each subject before capturing the data.
- Thermal images were captured after mammography data has been taken. After mammography examination, subject was told to rest for 10 minutes as during mammography procedure, there involved compression of the breast.
- Room was set up with camera and proper ambience. Images were captured maintaining 3 distances.
- Subjects were also asked if they have applied any body lotion, body cream or perfume. If so, they were instructed to wipe it out before data acquisition so that it won't affect emissivity.
- Data has been collected in 6 positions. The detail about this is in Fig 2.

And for viewing the thermal images, a software known as Smart-View came along with the used Fluke Thermal Camera. The software is thus used for the selection of colour palette. Six colour palettes are included, out of which Gray scale palette has been chosen as it makes the implementation easier. Suitable methods were then applied for the pre-processing, extraction of probable region of interest and breast asymmetry analysis purposes using Matlab Image processing toolbox.

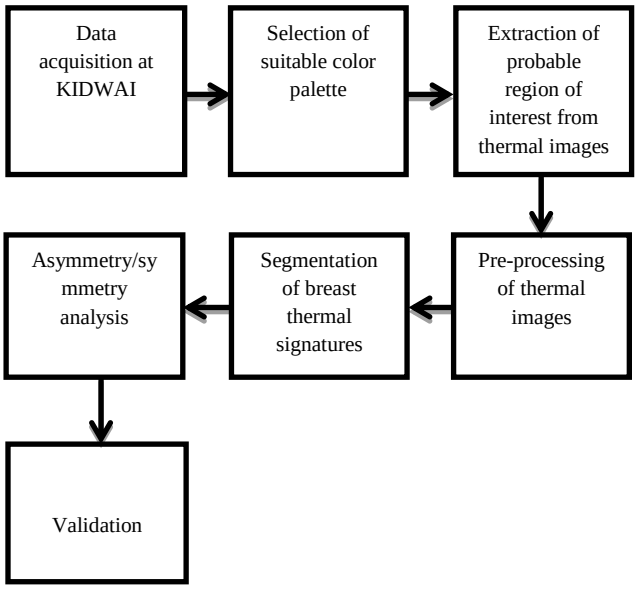


Fig 1: Proposed methodology for the asymmetrical analysis.

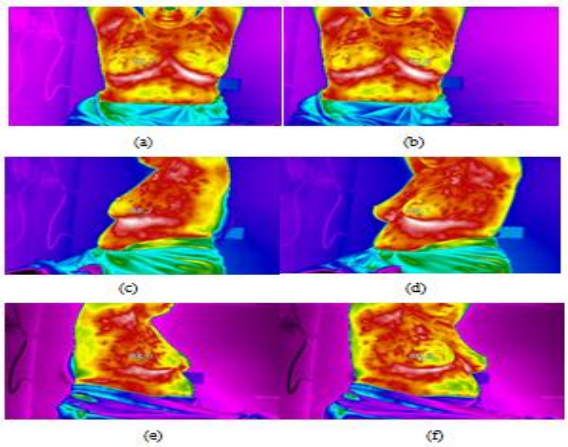


Fig 2: (a) Position with the right breast focused (b) Position with left breast focused (c) Position with 90˚ facing left (d) Position with 30˚ tilt toward left (e) Position with 90˚ facing right (f) Position with 30˚ tilt toward right

Fig3 shows the algorithm for the breast asymmetry analysis.

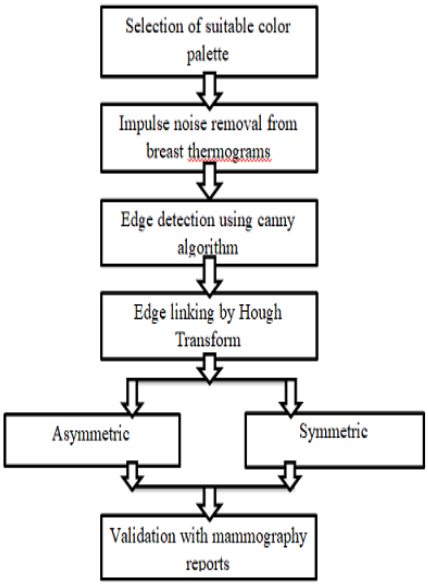


Fig3: Breast asymmetry analysis.

Steps followed for the breast asymmetry analysis are as follows:

Step–I. Selection of suitable color palette:
Gray- scale palette has been selected using the Smart-View software. Gray scale has been chosen other than any other palettes because it made the implementation a lot easier. Fig 4 depicts it.

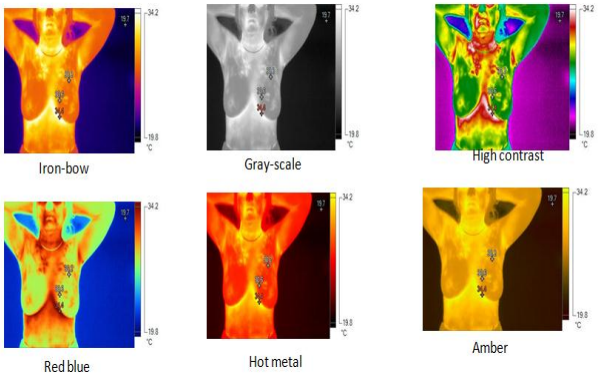


Fig 4: Pictorial representation of color palettes seen in smart-view software.

Step–II Impulse noise removal from the thermograms:
The image obtained from the thermal camera contains noise as well as unwanted portion of the breast area. Therefore selection of ROI and then noise removal using median filter of mask size 3 has been performed. While selecting ROI, region from left armpits to right armpits till the lower breast area have been selected. It is depicted below in Fig 5.

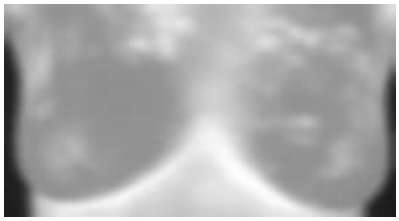


Fig 5: Output obtained in ROI after applying median filter

Step–III. Edge detection using canny edge algorithm:
After preprocessing canny edge detection kernel is used to detect the contour of the breast. The result obtained is shown in Fig 6.

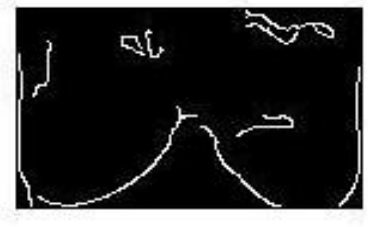
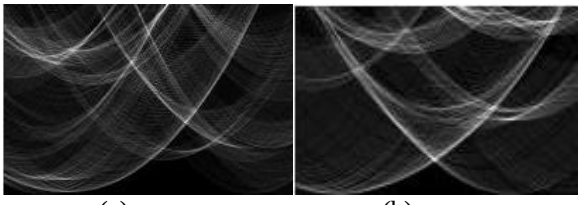


Fig 6: Output obtained when canny algorithm is utilized.

Step-IV. Edge linking using Hough Transform:
To get exact contour of the breast, parabolic Hough transform is implemented. Breast image resembles parabolic curves; hence parabolic Hough Transform is used to obtain breast contour.
The parabolic Hough Transform uses (x, y) points in the original image space to generate ($\check{x}$, $\check{y}$, $\check{\phi}$, p) points in the Hough Transform in order to isolate parabolas.
The algorithm uses the following representation of parabola

$$[(y-\check{y})\cos\check{\phi} - (x-\check{x})\sin\check{\phi}]^2 = 4p[(y-\check{y})\sin\check{\phi} + (x-\check{x})\cos\check{\phi}] \quad (1)$$

Where $\check{x}$ and $\check{y}$ are the coordinates of the parabola vertex, $\check{\phi}$, the angle between the axes and the coordinates of the vertex and p is the distance between vertex and the focus. Fig 7 shows the result obtained after applying parabolic Hough Transform.

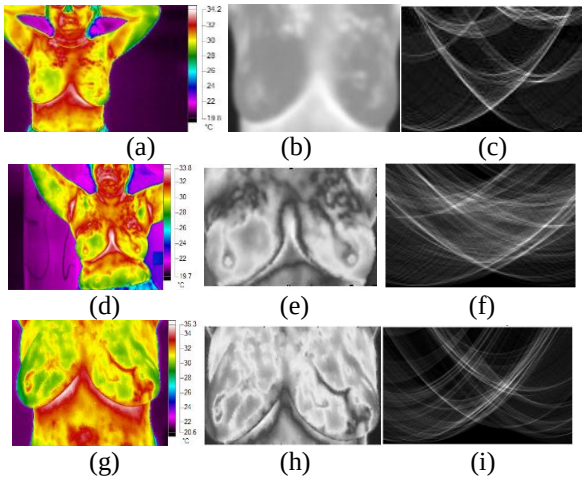


(a) (b)

Fig 7: Hough Transform Output (a) abnormal image (b) normal image

IV. RESULTS

Fig8 shows the result obtained for normal and abnormal breast thermal signatures. Symmetry image intersects just at the mid point of the breast image whereas asymmetry does not.



(a) (b) (c)

(d) (e) (f)

(g) (h) (i)

Fig:8 Step wise obtained result with respect to the breast asymmetry algorithm. (a) raw image from TiX560 model thermal camera, normal image (1.48m distance) (b) gray scale preprocessed image, (c) symmetry image obtained through Hough transform, (d) abnormal image (1.5m distance) (e) gray scale processed image, (f) asymmetry image obtained through Hough Transform, (g) abnormal image (1m distance), (h) gray scale preprocessed image and (i) asymmetry imaged obtained through Hough Transform.

Looking at the Hough Transform, it is seen that images where symmetry is observed, Ground truth for the same represent normal state of the breast whereas when thermal breast signature shows asymmetry, corresponding ground truth shows BI-RADS score 3, 4 and 5. BI-RADS score 3, 4 and 5 represent benign, suspicious and malignant stage of the breast cancer respectively.

Table 1 shows analysis of symmetry/ asymmetry for the breast thermal signatures acquired.

TABLE1: ASYMMETRIC ANALYSIS THROUGH HOUGH TRANSFORM

SL No.	BI-RADS Score	Results of the Algorithm
1.	R-2 L-4	Asymmetry
2.	1	Symmetry
3.	2	Symmetry
4.	L-2 R-4	Symmetry
5.	1	Symmetry
6.	3	Asymmetry
7.	2	Symmetry
8.	R-3 L-1	Asymmetry
9.	2	Asymmetry
10.	2	Symmetry
11.	1	Asymmetry
12.	2	Symmetry
13.	1	Asymmetry
14.	3	Asymmetry
15.	1	Symmetry
16.	1	Asymmetry
17.	2	Symmetry
18.	2	Symmetry
19.	2	Asymmetry
20.	1	Symmetry
21.	1	Asymmetry
22.	2	Symmetry
23.	2	Symmetry
24.	1	Asymmetry
25.	1	Symmetry
26.	1	Symmetry
27.	1	Symmetry
28.	2	Symmetry
29.	L-4 R-1	Asymmetry
30.	L-1 R-2	Symmetry
31.	L-1 R-5	Asymmetry
32.	4	Symmetry
33.	L-5 R-2	Asymmetry
34.	1	Asymmetry
35.	1	Symmetry
36.	L-1 R-2	Asymmetry
37.	L-4 R-3	Asymmetry
38.	L-5 R-1	Symmetry
39.	L-2 R-4	Asymmetry
40.	L-1 R-5	Asymmetry
41.	L-2 R-1	Symmetry
42.	1	Asymmetry
43.	L-1 R-3	Symmetry
44.	L-1 R-3	Asymmetry
45.	3	Asymmetry
46.	L-4 R-1	Asymmetry
47.	L-3 R-2	Asymmetry
48.	L-3 R-4	Asymmetry
49.	L-5 R-3	Asymmetry
50.	L-2 R-1	Symmetry
51.	1	Asymmetry
52.	1	Asymmetry
53.	L-2 R-1	Asymmetry
54.	L-2 R-1	Symmetry
55.	L-2 R-1	Symmetry
56.	L-2 R-1	Symmetry
57.	L-3 R-4	Asymmetry
58.	L-1 R-4	Asymmetry
59.	L-4 R-1	Symmetry
60.	1	Symmetry
61.	L-4 R-1	Symmetry
62.	1	Asymmetry
63.	1	Asymmetry
64.	2	Symmetry
65.	L-4 R-2	Asymmetry
66.	L-2 R-4	Asymmetry
67.	2	Asymmetry
68.	1	Symmetry
69.	5	Asymmetry
70.	2	Asymmetry

VALIDATION

With respect to Table1, correlation has been established in order to calculate sensitivity using True positive, True negative, False positive and False negative.

CONFUSION MATRIX:
It is a performance measure of how good the algorithm predicts the results. Table 5.2 represents obtained confusion matrix of this analysis.
Row matrices are meant to be written for predictive values obtained from the algorithm and the column matrices are for the actual values obtained from the mammography report.

Table 5.2: CONFUSION MATRIX BASED ON VALIDATION RESULTS

		Predicted values: Positive	Predicted values: Negative
Actual values	Positive	TP=21	FN=6
	Negative	FP=17	TN=26

Following performance measures are calculated.
Sensitivity/Recall/True positive rate = (TP/TP+FN) =21/ (21+6) =0.77.

Specificity/Selectivity/True negative rate = (TN/TN+FP) = 26/ (26+17) =0.604.

Precision/Positive predictive =(TP/TP+FP) = 21/ (21+17) =0.55.

Accuracy = (TP+TN/TP+TN+FP+FN) = (21+26) / 70 =0.67
F1 score = (2 x sensitivity x precision) / (sensitivity + precision) =2 x 0.55 x 0.77 / 0.55 + 0.77 =0.64.

V. OBSERVATIONS AND DISCUSSION

This research work analyzes the images into asymmetry / symmetry. Those having asymmetry has been considered as of having probability of breast abnormality.
Sensitivity and Specificity of the algorithm are 77% and 60.8% respectively.

Results obtained are encouraging. Further improvements can be seen with more number of thermal signatures.

- Breast size varies from person to person but the parameters like distance between the camera and the subject matters a lot on image quality and hence the results.
- While selecting region of interest, area from left armpits to right armpits till the breast portion has to be carefully extracted out in segmentation stage otherwise it can lead to wrong values.

VI. CONCLUSION AND FUTURE SCOPE

This research work presents the use of Digital Image Processing algorithms in order to detect breast symmetry. After initial pre-processing and segmentation of the breast, Hough Transform has been implemented to detect symmetry of the breasts. 70 bilateral breast thermal signatures are used in this research work. This analysis gives encouraging results with a sensitivity of 77% and accuracy of 67%.

It is important to maintain constant distance between subject and the camera during image acquisition, as if images are captured at short or with large distance it affects quality of the image.

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