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Breast Abnormality Detection Through Statistical Feature Analysis Using Infrared Thermograms

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***Abstract*—The utilization of medical infrared thermography in breast abnormality detection is mostly due to its radiation-free, non-invasive and painless nature. Infrared breast thermography is an alternative breast imaging modality that can detect those tumors or early changes which are undetectable by the gold standard method X-ray mammography. However, breast cancer is a highly treatable disease, with 97% chances of survival if getting detected earlier. Thus, early detection of breast cancer using infrared breast thermography may improve the survival rate of breast cancer patients. The temperature pattern in both breasts of a healthy breast thermogram is closely symmetrical. Hence, a small asymmetry in the temperature pattern of the left and right breast may signify a breast abnormality. There are a series of texture features that play a vital role in asymmetry analysis of breast thermograms. This paper mainly emphasizes on investigating those statistical features, which can adequately differentiate the healthy breast thermograms from pathological breast thermograms. A survey work on texture features used by various authors for asymmetry detection is provided in this work. Our analysis is performed on 30 healthy and 30 abnormal breast thermograms of existing DMR (Database for Mastology Research) Database. The analysis and experimental results show that among the first order statistical features, the mean difference, skewness, entropy and standard deviation are the most efficient features that contribute most towards the asymmetry detection.**

Keywords—Breast Cancer; Infrared Breast Thermography; Texture Feature; Asymmetry Analysis;

I. INTRODUCTION

Breast cancer is the most common deadliest cancer in India accounting 25% to 32% of all cancers in female [1]. Although, no effective cure is there to prevent breast cancer, early detection of breast cancer has 97% of survival rate [2]. Thus, early detection of the breast tumor is the only way to reduce the high mortality rate due to breast cancer. However, the breast cancer is a heterogeneous disease which makes the early detection of the disease as a major clinical challenge. Among various breast imaging modalities, the X-ray mammography is considered as the typical gold standard for early breast cancer detection [3], [5]. Along with its advantages in breast cancer detection, it possesses several limitations [3], [4]. Mammography is an invasive imaging modality and the electromagnetic radiation associated with the mammography triggers the factors that are responsible for cancerous growth. Moreover, the sensitivity of the mammography decreases in case of dense breasts [4]. Also, women under age 40 are not recommended to have routine mammography due to its radiation exposure [6]. Therefore, particularly for younger women under 40, the infrared breast thermography acts as a safe early risk marker of breast pathology. Infrared thermography has the capability of mapping the temperature distribution of the human skin [7]. Also, the application of thermography in case of malignant breast cancer holds a great promise in detecting cancer at an early stage. Infrared imaging of the breast has achieved an average sensitivity and specificity of 90% [2], [8]. Thermal imaging has distinguished itself as the earliest breast cancer detection technology as it has the potentiality of detecting breast cancer 10 years earlier than traditional gold standard - X-ray mammography [9], [10]. This radiation-free, cost-effective, non-invasive nature of breast thermography makes it useful for women of all ages along with the pregnant women.

One most common method for breast abnormality detection from breast thermograms is to analyze the contralateral symmetry between the left and right breast of a breast thermogram [11], [13]. It is because, the temperature distribution in a healthy breast thermogram is almost similar and symmetrical in both breasts. Alteration of the temperature distribution is often the first sign of tissue lesions. Hence, the presence of a small asymmetry in any breast may indicate the breast pathology. But, due to the shortcoming of the human visual system, these minute asymmetries are difficult to detect. Therefore, designing of a system that can assist the physician in medical decision-making is very crucial. Like the other breast imaging modality, infrared breast thermography is not an anatomical imaging modality; it only represents the temperature distribution of breasts. Therefore, texture features play a crucial role in the quantitative analysis of breast thermograms. The main objective of this work is to evaluate the potentiality of breast thermography in early breast cancer detection. Our main contribution is to identify the statistical features that can more strongly signify the contralateral breast asymmetry and thus detect the breast abnormality. For this exploration, a series of statistical features are extracted from each breast thermogram to identify the thermal asymmetry between two breasts. The experimental result shows that among various features, the mean difference, skewness, entropy and standard deviation contribute most towards the

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asymmetry detection. Thus, instead of using all first order texture features for breast abnormality detection, only these four features can be used to detect the breast abnormality.

In this paper, a special attention is given to find out the most efficient first order statistical features that can highly signify the contralateral breast asymmetry in an infrared breast thermogram. This paper is organized as follows. A short review work on the extraction of different statistical features is given in Section 2. A brief description of the infrared breast thermography dataset used in our research work is provided in Section 3. Section 4 illustrates the procedure of asymmetry analysis of the infrared breast thermograms. This Section describes each step of asymmetry analysis including preprocessing, segmentation and feature extraction of breast thermograms. In the last part of this section, a feature value based graph is plotted to highlight the efficient features. In Section 5, a comparative study of the feature values is made with the typical values obtained in other research works. Finally, Section 6 concludes this paper.

II. Review Work

Like the other breast imaging modalities, infrared breast thermography is not an anatomical imaging technique, it is just distribution of temperature which can only be analyzed. Due to this amorphous nature of infrared breast thermography, texture features are considered to be one of the most widely used tool in the analysis of breast thermograms. As suggested by H. Qi et al. [13], a useful approach to automatically detect breast cancer from breast thermograms is the asymmetry analysis of the left and right breast. Texture features play a vital role in the quantitative assessment of breast thermograms for detection of minute differences between the two breasts. There are several statistical parameters that can more or less contribute towards the asymmetry analysis of breast thermograms. Several authors are there whose experimental results show the effectiveness of different statistical parameters in early breast cancer detection. M. Milosevic et al. [14] had proposed a feature extraction approach for detecting and diagnosing abnormal patterns in breast thermograms. They had extracted total 20 Gray Level Co-occurrence Matrix features including 13 Haralick features and features proposed by Soh [15] and Clausi [16] from each breast thermograms. By analyzing these textural features, they had evaluated the effectiveness of the textural information in differentiating the abnormal thermal patterns from the normal thermal patterns. In [17], B. Krawczyk et al. had proposed a medical decision support system based on the bilateral asymmetry analysis of the breast thermograms. In their method, they had extracted four basic statistical features, four moment features, eight histogram features, eight cross co-occurrence features, mutual information and two Fourier spectrum features. S.V. Francis et al. [3] had proposed a curvelet transform based feature extraction method for automatic detection of abnormality in breast thermograms. They had extracted statistical and texture features from each thermogram in curvelet domain. First order statistical features such as mean, median, mode, variance and standard deviation were obtained from the breast thermograms. The Haralick features [18] were also extracted from the GLCM (gray-level co-occurrence matrix) in the curvelet domain. In [19], H. G. Zadeh et al. had proposed a method for early detection and diagnosis of breast cancer. From each left and right region of a breast thermogram, they had plotted the histograms. Along with the histograms of each breast, they also extracted mean, variance, skewness and kurtosis from each breast for better asymmetry analysis between the left and right breast. H. Qi et al. [13] had provided an automatic approach for asymmetric analysis in breast thermograms. Through their work, they evaluated the most efficient features to differentiate the normal breast thermograms from the abnormal. To measure the asymmetry between left and right breast of a thermogram, they used mean, variance, skewness, kurtosis, and entropy. From their experimentation result, they had found that higher order statistics like variance, skewness and kurtosis were the most effective features to measure the presence of asymmetry in a breast thermogram. J. Koay et al. [20] had divided a breast area into four quadrants. A series of 10 statistical parameters including mean, standard deviation, median, maximum, minimum, skewness, kurtosis, entropy, area and heat content of each breast and each quadrant were computed. Using SPSS statistics software, they had made a correlation analysis of the statistical parameters. Out of these ten features extracted from each breast thermogram, five features including: mean, standard deviation, skewness, kurtosis and heat content were found to be highly effective for breast abnormality detection. G. Schaefer et al. [21] had extracted a series of statistical features from each breast thermogram to describe the presence of any bilateral difference between the left and the right breast. For characterizing each breast, they used four basic statistical features, four moment features, eight histogram features, eight cross co-occurrence features, mutual information and two Fourier descriptors. Extraction of these features was followed by the application of Laplacian filter. Another set of statistical features including, eight cross co-occurrence features together with mutual information and two Fourier descriptors were also extracted from the Laplacian filtered breast thermograms. In [22], U. R. Acharya et al. evaluated the feasibility of infrared breast thermography in breast cancer detection. They extracted four moment features from co-occurrence matrix and features like run-length percentage, and gray level non-uniformity were also extracted from the run-length matrix. T.B. Borchartt et al. [23] had performed thermal image analysis to detect the temperature difference between the contralateral breasts and thus to identify the breast cancer indicatives. In their approach, after segmentation of breast thermograms, a list of features including range temperature, standard deviation, mean temperature, and the quantization of the higher tone in eight level posterization were obtained from each breast segment. First, all of these features were extracted from the entire image and then the region of interest was segmented into four quadrants. From each quadrant, above features were obtained. Based on their experimental result, they had concluded that the procedure of feature extraction from the four quadrants was more appropriate since each quadrant contains some relevant information. The summary of all the statistical features used by different authors in their research work is listed in TABLE I.

TABLE I. SUMMARY OF DIFFERENT TEXTURE FEATURES USED IN VARIOUS RESEARCH WORKS

Authors	Texture Features	Number of Patients / Breast Thermograms used
S.V. Francis et al. [3]	Mean, Median, Mode, Variance, Standard deviation, Energy, Contrast, Correlation, Variance, Inverse difference moment, Sum variance, Sum entropy, Entropy, Difference variance, Difference entropy, Information measure of correlation1, Information measure of correlation2.	22 Patients (11 Cancerous & 11 Normal)
H. Qi et al. [13]	Mean, Variance, Skewness, Kurtosis and Entropy.	24 Patients (18 Cancerous & 6 Normal)
M. Milosevic et al. [14]	Angular second moment, Contrast, Correlation, Variance, Inverse difference moment, Sum average, Sum variance, Sum entropy, Entropy, Difference variance, Difference entropy, Information Measure of Correlation 1, Information Measure of Correlation 2, Autocorrelation, Dissimilarity, Cluster Shade, Cluster Prominence, Maximum Probability, Inverse Difference Normalized, Inverse Difference Moment Normalized.	40 Breast Thermograms, (26 Normal &14 Abnormal)
B. Krawczyk et al. [17]	Mean, Standard deviation, Median, 90-percentile, Centre of gravity, Distance between moment centre, Geometrical centre, Cross-correlation between histograms, Maximum, Number of non-empty bins, Number of zero-crossings, Energy, Difference of positive and negative parts of difference histogram, Homogeneity, Energy, Contrast, Symmetry, First 4 moments, Mutual information between the two temperature distributions, The difference maximum and distance of this maximum from the centre.	146 Breast Thermograms (29 Malignant &117 Benign)
H.G. Zadeh et al. [19]	Mean, Variance, Skewness and Kurtosis.	150 Patients
J. Koay et al. [20]	Mean, Standard deviation, Median, Maximum, Minimum, Skewness, Kurtosis, Entropy, Area and Heat content.	19 Patients
G. Schaefer et al. [21]	38 features (basic statistical features, moments, histogram features, cross co-occurrence matrix features, mutual information and Fourier descriptors).	150 Patients
U. R. Acharya et al. [22]	First 4 moments, entropy, contrast and correlation, gray level non-uniformity and run percentage.	50 Breast Thermograms (25 Cancerous & 25 Normal)
T.B. Borchatt et al. [23]	Range temperature, Standard deviation, Mean temperature, and The quantization of the higher tone in eight level posterization.	28 Breast Thermograms

III. DATASET OF INFRARED BREAST THERMOGRAMS

Our research work is performed on the breast thermograms of the existing DMR (Database for Mastology Research) Database [24]. DMR-Database for Mastology Research is an online available database that consists of breast thermograms for early detection of breast cancer. For the acquisition of thermograms, they have used FLIR SC-620 Thermal Camera with a spatial resolution of 640 x 480 pixels. Currently, the DMR database contains breast thermograms of total 279 patients, out of which more than 40 patients' thermograms are found to be abnormal. From the set of abnormal breast thermograms, 30 thermograms with bilateral breasts are randomly selected in our research work for doing asymmetry analysis. Similarly, 30 healthy breast thermograms are also randomly selected from the DMR Database for bilateral asymmetry analysis. In the dataset of the healthy breast thermograms, it has been noticed that there is a symmetry in the thermal patterns of both the left and right breasts. Also, the healthy breast thermogram does not contain any hot spot. *Fig. 1(a)* shows some breast thermograms of healthy persons. On the other hand, there is a noticeable asymmetry and presence of hotspots in the thermograms of the sick patients. *Fig. 1(b)* shows some breast thermograms of sick patients.

IV. ASYMMETRY ANALYSIS OF BREAST THERMOGRAMS

In a normal breast thermogram, the temperature pattern of both the left and right breasts is closely symmetrical. As mentioned earlier, development of a breast tumor may result in a temperature variation between two breasts. However, it is very rare to have tumors simultaneously in both the left and right breast. Thus, a small asymmetry in the thermal pattern of both breasts may signify breast pathology. For identifying a minute difference in the temperature pattern of both breasts, asymmetry analysis of both breasts is performed using several statistical features. Texture features are most efficient features that represent the image characteristics, and these image characteristics are very useful in breast thermogram analysis [12]. In our work, the asymmetry analysis of breast thermograms consists of several steps including pre-processing of breast thermograms, then segmentation of breast thermograms which is followed by the feature extraction and feature analysis. Each of these steps is described below-

A. *Pre-processing of Breast Thermograms*

The infrared breast thermograms are usually captured in a larger area, which makes it necessary to remove the unnecessary part from the breast thermogram before going to process it. Hence, at first the background and the unnecessary region of the breast thermogram are manually removed. Then for further processing of these thermograms, they are converted into grayscale images. Grayscale conversion of the thermograms is followed by the segmentation of the region of interest.

B. *Segmentation of Breast Thermograms*

In the analysis of breast thermograms, the segmentation of the region of interest (ROI) plays a vital role. However, the extraction of the ROI from the thermal infrared image is a very challenging task, and it requires tremendous effort due to

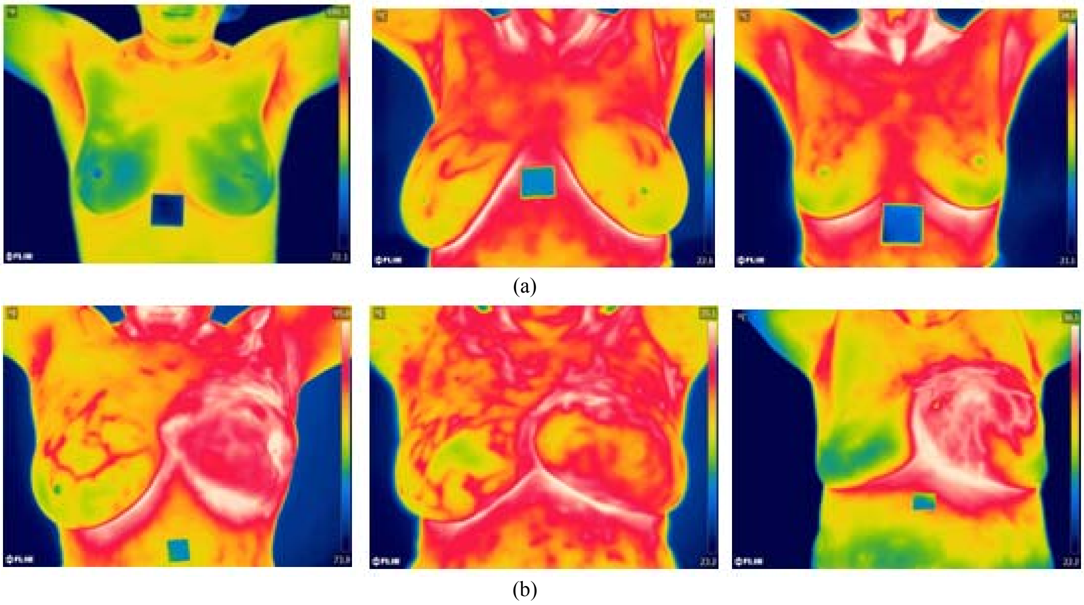


Fig. 1. Shows some samples of (a) Healthy Breast Thermograms; and (b) Abnormal Breast Thermograms

the amorphous nature and the lack of clear limits in these images [25]. The extraction of texture features strongly depends on the correct segmentation of the Region of Interest. Hence, in our approach a manual segmentation technique has been used to avoid the factors that can make an erroneous analysis of breast thermograms. Here, for the segmentation of the ROI, the canny edge detector is used with a threshold value to get the prominent lower parabolic boundary of each breast in a breast thermogram. With the help of this edge image, an individual mask is designed for each breast thermogram. The breast masks designed for one healthy breast thermogram and an abnormal breast thermogram are shown in *Fig. 2. A*nd the corresponding ROI of each breast thermogram segmented after the application of breast mask is also shown in *Fig. 2.*

C. Breast Thermogram Feature Extraction

The feature specifies some quantifiable property and significant characteristics of an image. Thus, features of an image can assist the discrimination of various regions in an image. The features can be either low-level features or high level features. The low-level features are directly extracted from the image intensity values [26]. Pixel intensity values in a breast thermogram represent the thermal radiation resulting from the heat emission from the human body. Extraction and selection of appropriate features is a crucial task in asymmetry analysis of breast thermograms. In this section, the paper intends to identify those statistical features that provide enough distinguishable information of a breast thermogram, based on which a conclusion on the breast health of a patient can be drawn. A brief description of each feature used in asymmetry analysis is provided below.

1) First-order histogram based features: The first order statistical features are the simplest of all statistical features. They are calculated directly from the original image intensity values i.e. they can be computed from the histogram of an image. Hence, these features are known as First order

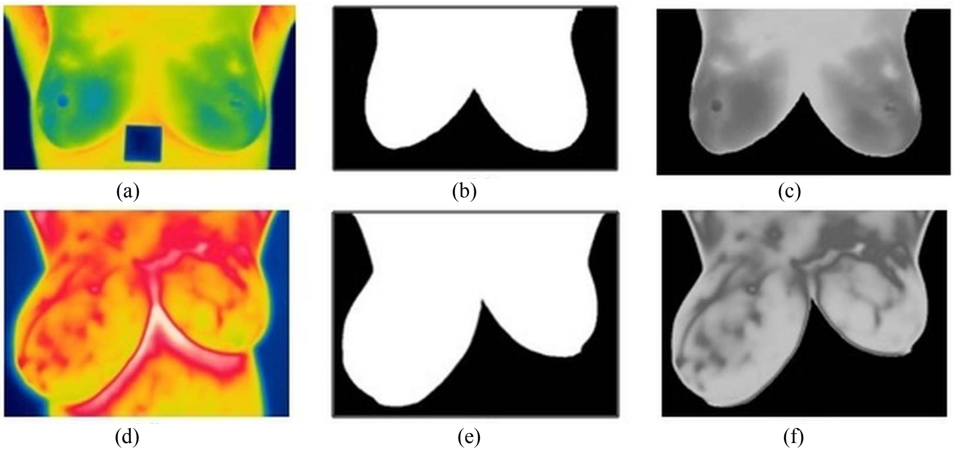


Fig. 2. Shows (a) A healthy breast thermogram; (b) Its corresponding breast mask; (c) Segmentation of breast region from background; (d) An abnormal breast thermogram; (e) Its corresponding breast mask and (f) Segmentation of breast region from breast thermogram.

histogram based features. A histogram of an image contains all the statistical information about an image. They do not consider the relationship of the neighboring pixels. The first order statistical feature includes mean, standard deviation, entropy, variance, skewness, kurtosis of an image. Each of these first order features mentioned above is defined by the following equations -

If P(i) is the probability of occurrence of each gray level i in an image F(x,y), where G is the total number of gray levels, then-

a) Mean: $$\mu = \sum_{i=0}^{G-1} i.P(i) . \tag{1}$$

b) Variance : $$\sigma^2 = \sum_{i=0}^{G-1} (i-\mu)^2 .P(i) \tag{2}$$

c) Standard Deviation: $$\sigma = \sqrt{\sum_{i=0}^{G-1} (i-\mu)^2 .P(i)} \tag{3}$$

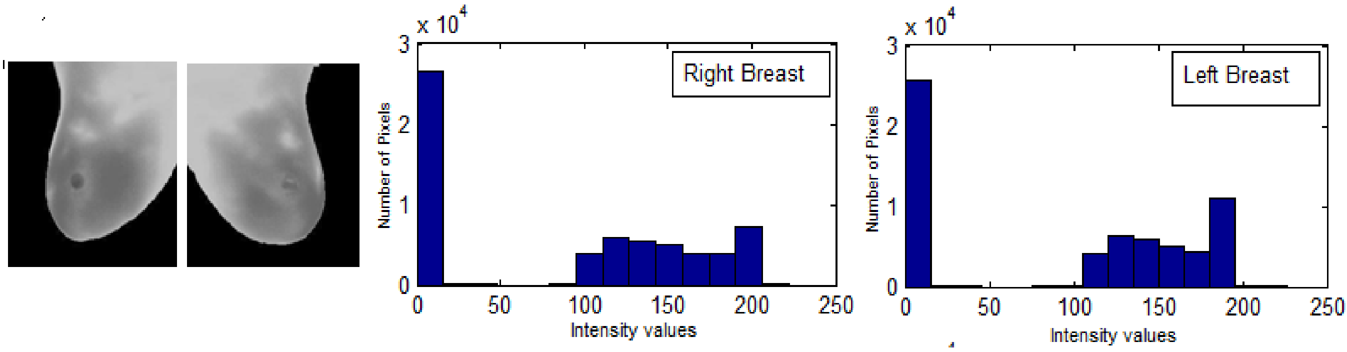
d) Skewness: $$\gamma_1 = \sigma^{-3}[\sum_{i=0}^{G-1} (i-\mu)^3 .P(i)] \tag{4}$$

e) Kurtosis: $$\gamma_2 = \sigma^{-4}[\sum_{i=0}^{G-1} (i-\mu)^4 .P(i)] \tag{5}$$

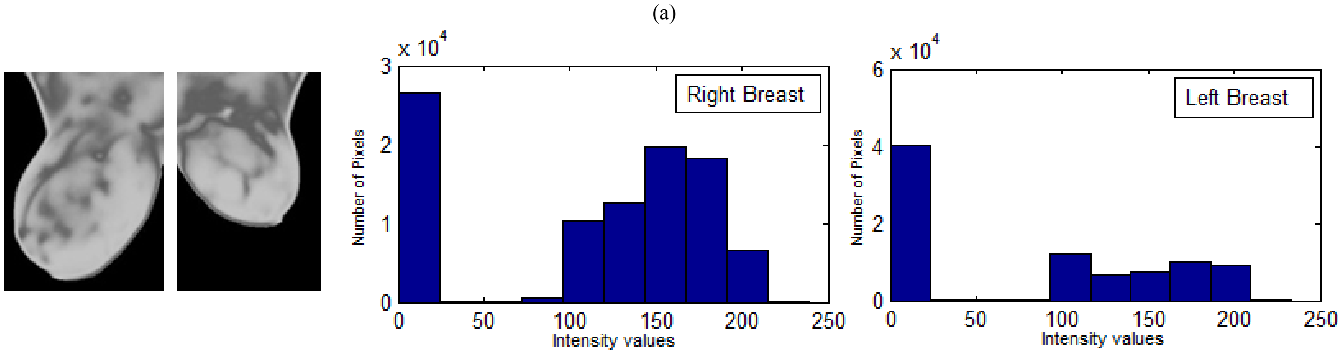
f) Entropy: $$H = -\sum_{i=0}^{G-1} P(i).\log_2[P(i)] \tag{6}$$

2) Other Statistical Features: Computation of first order statistical features is followed by the calculation of some other features including: maximum intensity value difference, mean difference of left and right breast, median, intensity range from each breast.

In our research work, the histogram of both left and right breast of each breast thermogram has been plotted for analyzing the intensity distribution in both breasts. The X-axis of the histograms indicates the temperature or the intensity values and the Y-axis represents the number of pixels having that intensity values. The histogram of intensity values is the summary of the statistical information of an image. In a breast thermography, each intensity value represents a different temperature. Thus, a healthy breast thermogram with contralateral symmetry in both breasts will produce histograms for each breast which are also symmetrical. A sample of histograms generated from the left and right breast of a healthy breast thermogram is shown in *Fig. 3(a),* which illustrates the thermal symmetry in both breasts. On the other hand, histograms of the left and right breast of an abnormal breast thermogram illustrate an asymmetry in the thermal patterns of both breasts. *Fig. 3(b)* displays the histograms of an abnormal breast thermogram. Thus, histogram is an important feature for asymmetry analysis in the breast thermograms. But, plotting of histogram is not sufficient for asymmetry analysis and hence, histogram plotting is followed by the computation of values for each statistical feature defined above. The typical feature values for a healthy and an abnormal breast thermogram shown in *Fig. 2* are tabulated in Table II.



(a)



(b)

Fig. 3. Histograms of the left and right breast part of a (a) Healthy Breast Thermogram and (b) Abnormal Breast Thermogram

TABLE II. MEASURE OF ASYMMETRY IN LEFT AND RIGHT BREAST BASED ON STATISTICAL FEATURE VALUES

Statistical Features	**Healthy / Asymptomatic Patient**		**Abnormal / Symptomatic Patient**	
	Left	***Right***	***Left***	***Right***
Mean	92.67	88.87	78.53	110.77
Variance	0.0983	0.0952	0.0936	0.0823
Standard Deviation	0.3136	0.3086	0.3060	0.2869
Skewness	-0.1531	-0.0257	0.1756	-0.6349
Kurtosis	1.2656	1.2890	1.3214	1.7720
Entropy	4.8304	4.7781	4.6771	5.7700
Range	225	221	116	110
Median	125	112	96	139
Max_difference	4		6	
Mean Difference	3.8		32.24	

By computing the feature values for each healthy and abnormal breast thermogram of our dataset, it is found that there is a significant difference between the mean values of the left and right breast of the abnormal breast thermograms which produce a high absolute mean difference in comparison to the healthy breast thermograms. It means that a higher value of the absolute mean difference between the left segment and the right segment of a breast thermogram may signify the asymmetry and abnormality in the thermogram. Again, for the healthy breast thermograms, it has been noticed that the values of skewness, kurtosis, standard deviation, variance, entropy are quite similar in both left and right breasts (as shown in Table II). But, for the abnormal breast thermograms there is a considerable difference in the skewness, entropy and standard deviation values of left and right breasts. The typical values of these statistical features are graphically plotted for a healthy breast thermogram (in *Fig. 2(a)*) and for an abnormal breast thermogram (in *Fig. 2(b)*) and shown in *Fig. 4* and *Fig. 5* respectively. The graph evaluates the effectiveness of the statistical features in asymmetry analysis. The data points along X-axis of the graph indicate skewness (SK), variance (Var), standard deviation (SD), kurtosis (K) and entropy (En) respectively. The graphs suggest that skewness, kurtosis, and entropy can highly assist in asymmetry detection. Thus, contralateral asymmetry can be highly quantified using these 4 basic statistical features among the first order statistical features.

V. COMPARATIVE STUDY

In this section, a brief comparative study of the statistical features and their typical values obtained by various researchers in their research work for asymmetry detection has been done. The values of skewness, kurtosis, mean, standard deviation, variance and entropy for a healthy breast and for a cancerous breast thermogram, obtained in different research works are tabulated in the Table III and Table IV, respectively.

In 1995, H.Q. et al. [13] had investigated different statistical features that contribute the most towards the detection of asymmetry. They had computed moments like mean, variance, skewness, kurtosis, entropy, correlation and joint entropy for both the left and right segments of each breast thermogram. Based on their experimental result, they concluded that high order statistics like kurtosis, skewness and variance were more effective features to quantify the contralateral breast asymmetry. In the research work carried out by E.Y.K.Ng et al. [27], statistical features like mean, standard deviation, median, mode, and skewness were obtained from the histogram of each breast thermogram. P. Kapoor et al. [28] had extracted biostatistical features like skewness, kurtosis, entropy, joint entropy and gray-level co-occurrence matrix features like energy, homogeneity, correlation for analysis and diagnosis of breast thermograms. In [29], P. Kapoor et al. extracted seven features including 4 higher order statistical features, histogram parameter, center of gravity and geometrical center for asymmetry analysis of breast thermograms. They concluded that the abnormality of the breast thermogram was clearly indicated by these features. From the experimental values in Table III and Table IV, it has been seen that there is a variation in the skewness and kurtosis values of an abnormal breast thermogram. However, in our research work, it has been found that among different statistical features, skewness, kurtosis, and entropy contributes

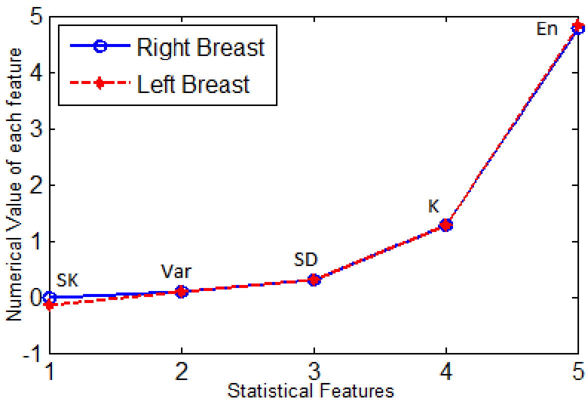


Fig. 4. Graphical representation of the statistical feature values for left and right breast of the Healthy breast thermogram

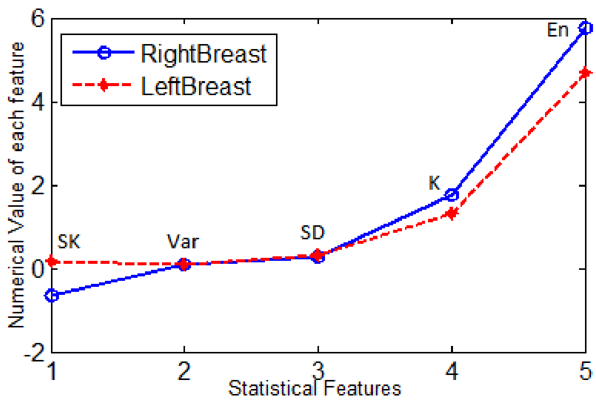


Fig. 5. Graphical representation of the statistical feature values for left and right breast of the abnormal breast thermogram.

TABLE III. STATISTICAL FEATURE VALUES FOR A HEALTHY / ASYMPTOMATIC BREAST THERMOGRAM

Authors	**Statistical Features**											
	Skewness		**Kurtosis**		**Mean**		**Entropy**		**Variance**		**Standard Deviation**	
	Left	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***
H.Q. et al. [13]	4.8×10^{-6}	4.5×10^{-6}	2.2×10^{-8}	2.4×10^{-8}	.0012	.0010	1.70684	1.4428	3.2×10^{-6}	2.8×10^{-6}	__	__
E.Y.K.Ng et al. [27]	0.237	0.118	__	__	31.80	31.93	__	__	__	__	0.576	0.710
P. Kapoor et al. [28]	1.9879	2.2260	8.9915	10.4204	__	__	33.9573	35.4228	__	__	__	__
P. Kapoor et al. [29]	1. 6520	1. 7955	8. 0113	8. 7051	__	__	27. 5288	28. 2562	__	__	__	__
Our Result	-0.1531	-0.0257	1.2656	1.2890	92.67	88.87	4.8304	4.7781	0.0983	0.0952	0.3136	.3086

TABLE IV. STATISTICAL FEATURE VALUES FOR A CANCEROUS / SYMPTOMATIC BREAST THERMOGRAM

Authors	**Statistical Features**											
	Skewness		**Kurtosis**		**Mean**		**Entropy**		**Variance**		**Standard Deviation**	
	Left	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***
H.Q. et al. [13]	2.3×10^{-6}	1.2×10^{-6}	1.04×10^{-8}	0.35×10^{-8}	0.0010	0.0008	1.52956	1.3033	3.38×10^{-6}	1.15×10^{-6}	__	__
E.Y.K.Ng et al. [27]	0.379	1.186	__	__	30.80	31.21	__	__	__	__	0.640	0.641
P. Kapoor et al. [28]	0.4725	0.1290	3.6957	2.8146	__	__	13.2232	13.1474	__	__	__	__
P. Kapoor et al. [29]	1. 1910	0. 3409	9. 7398	2. 1670	__	__	15. 9552	21. 1875	__	__	__	__
Our Result	0.1756	-0.6349	1.3214	1.7720	78.53	110.77	4.6771	5.7700	0.0936	0.0823	.3060	0.2869

more towards the asymmetry detection.

VI. CONCLUSION

The primary objective of screening a disease is to reduce the rate of mortality from that disease by early detection. But, early detection is possible only when the screening test can be performed on the asymptomatic population. In such situation, the Infrared Breast Thermography is very adequate. Due to its radiation-free and non-invasive nature, it can be used as a routine screening tool for the asymptomatic and normal patients of 20-70 years age group. Among those asymptomatic patients, a noticeable number of patients (10% of patients in case of Tripura State) may found to be suffered from any of the breast diseases or having a breast lump. Considering this breast thermography result, these patients may go for some alternative screening and diagnosis methods like mammography, ultrasound, biopsy, etc. for further confirmation. Hence, utilization of thermography along with the other breast screening modalities will help in early detection of the breast abnormalities as well as breast cancer. An abnormal breast thermogram with a hyperthermic area may signify a greater abnormality in the breast that can be quantitatively analyzed by using several statistical parameters.

The present work investigated the efficiency of the first order statistical parameters in breast asymmetry detection from infrared breast thermograms. It has been found that, the feature values of left and right breast of a normal breast thermogram are quite similar while, in case of an abnormal breast thermogram, there is a significant difference in the feature values of both breasts. Statistical features like mean difference, kurtosis, skewness, and entropy show a noticeable difference between the left and right breast of an abnormal breast thermogram compared to other features.

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