Breast Cancer Detection using Thermogram-A Review of Latest Techniques

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***Abstract*—Breast cancer is the most frequently diagnosed cancer of women in India. Generally breast cancer increases with age, age and gender are largest risk factors associated with it. Also age and gender are not modifiable. Despite advancements in treatment to reduced breast cancer mortality over the past two decades, next to lung cancer, this disease still remains the second leading cause of cancer induced death in women. In the last ten years, the infrared thermography has shown to be a promising technique to early diagnosis of breast pathologies. Many research papers on the use of infrared imaging for breast screening is available in the current medical literature. In this paper a review on different researches for the detection of breast cancer using thermogram are represented.**

Keywords*— *Breast Cancer, infrared thermal imaging, feature extracted, classification criteria

I. INTRODUCTION

Breast cancer is second leading cause of the death of women above 30 years age after the lung cancer and it is 30% of the all cases of the cancer [1]. India also facing a potential breast cancer epidemic from the next decade and oncology experts say that it is due to adoption of Western lifestyles by marrying and bearing children later in life by women, In India One out of every 22 women in India is diagnosed with breast cancer [2]. Oncology experts also say that as having fewer children and weaning them earlier, altering hormone flow puts women at higher risk of contracting breast cancer. A study in 2012 says that 144,937 women were newly detected with breast cancer while 70,218 women died [3], it shows from every two newly diagnosed women with breast cancer one lady is dying. Thermography is also being used for the earlier detection of breast cancer and according to the American Academy of Thermography: "Thermography is the medical science that derives diagnostic indications from highly detailed and sensitive infrared images of the human body" [4]. The start of the Breast thermography was in 1956 and it was the first documented application of infrared (IR) imaging or thermography in medicine, when IR images of the breasts of patients of breast cancer were examined for asymmetric hot spots and vascularity. According to the documentation of first infrared (IR) imaging in medicine in 1956 [5] that the malignant tumors have one the important biological characteristics that malignant tumors is the increased rate of growth as compared to that of the surrounding or host tissue. But the results of Breast Cancer Detection and Demonstration Project (BCDDP) done between 1973 and 1981 by American Cancer Society and National Cancer Institute of United States were not promising due to lack of trained professionals [6]. Chaotic poorly regulated growth in human body is characterized as cancer. It is demonstrated by Etehadtavakol et al. [7] that highly sensitive infrared (IR) cameras which produce high-resolution which generate thermal images and these images are being used to develop an algorithm for detecting benignity and malignancy of breast diseases and it is shown that the fractal dimension results significantly differ between malignant and benign patterns. Early detection of breast cancer using thermography is based on asymmetrical temperature distributions as well as hot or cold spots analysis of breast. Thermogram picks up changes in blood perfusion. Human skin has its own radiance and it is function of the surface temperature, which is influenced by the level of blood perfusion in the skin. Thermal dependencies between two breasts are similar the thermal image of right breast to the thermal image of left breast, this is showed in the study of Etehadtavakol et al. [8] to better understand two images normal and abnormal shown in the Fig.1 and Fig.2 below.

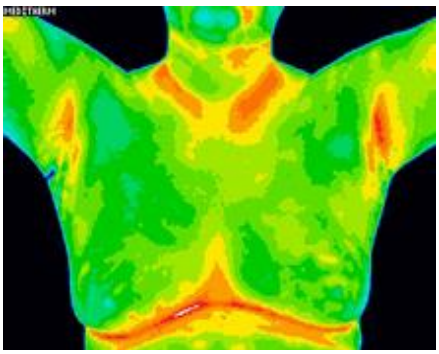

Fig.1: Normal thermograph

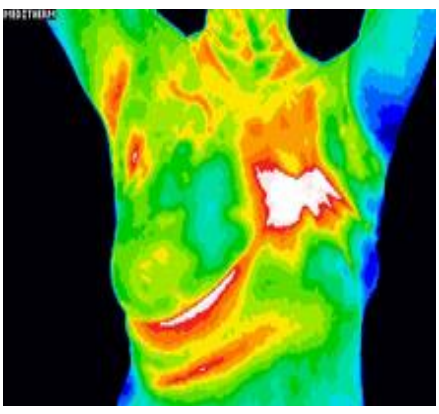

Fig.2: Abnormal thermograph

II. THERMOGRAPHY IN BREAST CANCER

It is good question to ask that when we have standard method of mammography whose accuracy is greater than thermogram than why thermography is required answer is to reduce mortality it is required to have early detection of the breast cancer and thermography used for early detection of the breast cancer. Infrared thermal imaging or thermography is a promising screening tool as it is able to warn women of breast cancer ten years in advance [26]. Whereas for mammography it can detect tumors only when they exceed a certain size [18].

III. GENERAL METHODOLOGY FOR EARLY DETECTION OF BREAST CANCER

General methodology for early detection of breast cancer is shown in block diagram and Fig.1 shows an abnormal thermogram. Whole method is divided in to five part Pre-Processing, ROI Selection, Segmentation of Left and Right breast, Feature Extraction and last part classification.

A. Pre-Processing

Pre-processing is one of the basic processes of breast cancer detection in which resizing of the image background removal and removal of undesired body part is done, which is followed by normalization and binarization of the Image shown in Fig.3 and Fig.4 [9].

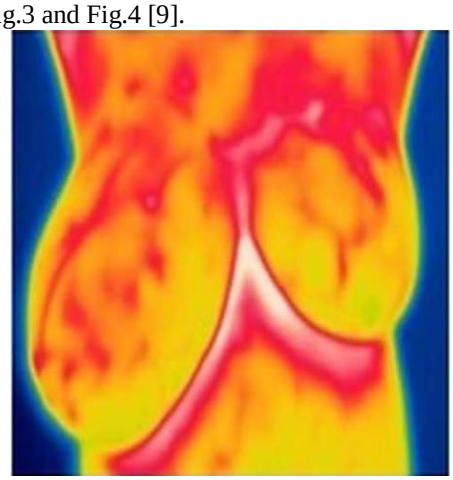

Fig.3: An abnormal breast thermogram

Fig.4: Binarization of image

B. ROI Selection

After pre-processing to select only the breast part of the image for better accuracy some algorithm for example Hough transform used or this can be done manually. Segmentation of breast region from breast thermogram after ROI selection is shown in Fig.5 [9].

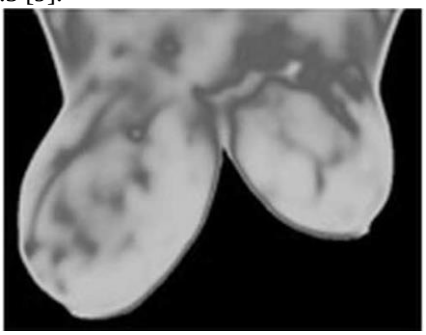

Fig.5: Segmentation of breast region from breast thermogram

C. Segmentation of Left and Right breast

After ROI selection from pre-processing, centroid is determined on the processed image which separate two parabolic curves from a straight line and there separated parts of images have right breast at right side of the straight line and left breast at the left side of the straight line in the image as shown in Fig.6 [9]

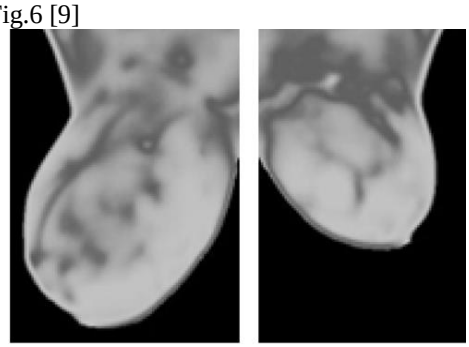

Fig.6: Segmentation of Left and Right breast

D. Feature extraction

Now after separating right and left breast the process named feature extraction of each images is done, in which different feature of the image is determined some of those features are formulated below [10].

Mean: $\bar{x} = \frac{\sum fx}{n}$ (1)

Variance: $\sigma^2 = \frac{\sum f(x-\bar{x})^2}{n}$ (2)

Skewness: $S = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(\frac{P(i,j)-\mu}{\sigma}\right)^3$ (3)

Kurtosis: $S = \left\{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(\frac{P(i,j)-\mu}{\sigma}\right)^4 - 3\right\}$ (4)

E. Classification

Classification is a key step in pattern recognition techniques for the classification and evaluation of the measured features. In medical diagnosis, there are typically far fewer malignant cases than there are benign ones, and consequently, conventional classification approaches often suffer from low sensitivity due to the skewed class distribution. Several approaches have been proposed to deal

with imbalanced data sets some of the name of classifiers are ANN, SVM, KNN, ensemble and FUZZY etc.

IV. REVIEW OF TECHNIQUES OF THERMOGRAHY FOR BREAST CANCER DTETECTION

In 1997 Lipari and Head [11] used mean, median, standard deviation, maximum and minimum value of temperature for each mama and each quadrant feature in this paper only a comparative study is shown no evaluation criteria is used. Kuruganti and Qi [12] observed that Hough transform can be effectively used for breast segmentation and the derived features Means, variance, skewness, and kurtosis, the peak pixel intensity of the correlated image, entropy and joint entropy and for evaluation criteria they use correlation measure for asymmetric analysis of breast cancer. Artificial neural network (ANN) with back propagation used as an evaluation criteria by the Koay et al. [13] in 2004 for study they analyzed thermal images of 19 patients with known clinical outcome taken from a database of 86 patients at Moncton Hospital's breast cancer screening clinic. Monique Frize and her team recorded the thermal images in 1984 by Thermovision 680 Medical from Agatronics connected to an OSCAR 780 it is first generation thermographic camera. They extract Mean, standard deviation, median, maximum, minimum, skewness, kurtosis, entropy, area and heat content as feature for the analysis. In 2007, Ng and Kee [14] investigates the analysis of thermograms with the use of biostatistical methods and Artificial Neural Networks (ANN), in the technique proposed by Ng and Kee, they used comprising of Linear Regression (LR), Radial Basis Function Network (RBFN) and Receiver Operating Characteristics (ROC) as multipronged approach. For evaluation ANN, RBFN is applied, the purpose of using is RBFN include fast training, superior classification and decision making abilities as compared to other networks such as back-propagation and the best obtained results are accuracy rate of 80.95%, with 81.2% sensitivity and 88.2% specificity. The research paper by Arora et al. [15] in 2008 used three way for evaluation an overall risk score in the screening mode, a clinical score based on patient information, and a third assessment by artificial neural network in which they found Digital infrared thermal imaging identified 58 of 60 malignancies, they had used of 94 biopsies in which 60 were malignant and 34 were benign and in result the 97% sensitivity, 44% specificity, and 82% negative predictive value depending on the mode used. A new criterion of breast cancer detection proposed by Tang et al. [16] in 2008 and the method of its realization were: (1) surface temperature distribution of a healthy breast usually exhibits a gentle variation which is background. (2) Localized surface temperature of a carcinomatous breast will increase on the basis of the above background which is LTI. (3) The carcinomatous possibility is proportional to the LTI maximum (amplitude) of the suspicious focus region. (4) The LTI amplitude can be measured through morphological signal processing. In this paper 117 breast disease patients were used in which 70 were benign cases and 47 were malignant cases. Results were obtained in the form of sensitivity, NPV (negative predictive value) and FPR (false-positive rate) and the obtained values are 93.6%, 91.2% and 55.7%. Multi-channel system with for advanced image processing for thermal, visual and radiological images presented by Wiecek et al. [17] in 1999 this methods mainly based on statistical data processing and 3D reconstruction are implemented. In this novel Mean, standard deviation, variance, skewness, kurtosis, energy, variance, difference variance, correlation, inverse difference and entropy are used as feature and for classification criteria ANN is used. A series of statistical features extracted from the thermograms quantifying the bilateral differences between left and right breast areas by Schaefer et al. [18, 19] in 2009, coupled with a fuzzy rule-based classification system for diagnosis. In this research work they extract Basic statistical features, moments, histogram features, cross co-occurrence matrix, mutual information, and Fourier analysis of thermograms of a large dataset of nearly 150 cases confirm and provides a classification accuracy of about 80%.

In 2009 Silveira Filho et al. [20] presented an experimental scheme for identification of breast diseases based on thermal images. This experimental investigation consider the image Lacunarity measures by the gliding box algorithm and used a set of infrared images from a database that is being developed. To study the possibility of using Fractal Geometry Lacunarity to measures some abnormality in thermo-mammographies was the goal of this work. Lacunarity is higher with images with large gaps or holes present and lower with an image with high homogeneous structure presents. Work on Lacunarity measures is continued by Serrano et al. [21] and Conci et al. [22, 23] in 2010 with Hurst coefficient. Hurst Coefficient is related to the density of the image or object, mean, how much the image or object occupies the space that contains it and it will be used in two ways: the first is using the images of the right breast and left breast and second it used the average and standard deviation of Hurst coefficient for each window w to form the first four characteristics. For this, 133 features are extracted, Using Hurst Coefficient were extracted 36 features. Others 97 features were obtained by Lacunarity.

A research work on Graphics with features chosen by principal component analysis (PCA) technique published in 2011 by Nurhayati et al. [24, 25], in this research work mean, variance, skewness, kurtosis, and entropy are measured feature.

An automatic segmentation technique composed by two main steps proposed by Kapoor and Prasad [26] in this paper a canny edge detector to extract the lateral boundaries of breast and Hough transform to extract lower breast boundaries. Statistical parameters such as skewness and kurtosis are used as features.

In 2011 Borchartt et al. [27] found average results of accuracy 85.71%, sensitivity 95.83% and specificity 25.00% for the extracted feature classification a supervised learning method based on support vector machine (SVM) was used. Extracted features were Range of temperature, mean, standard deviation and the last bin of a quantization of ten bins. In 2011 two more research papers are published one is by Zadeh et al. [28] in which for classification k-means and c-means is used where as in other paper SVM implementation present on WEKA software is used by Resmini [31]. In [31] obtained accuracy 82.14%, sensibility 91.7% and specificity 25%.

In 2012 and 2013 Krawczyk et al. [32, 33, 34] publish three paper of using feature 4 basic statistical features, 4 moment features, 8 histogram features, 8 cross co-occurrence features, mutual information and 2 Fourier descriptors for classification cost-sensitive fuzzy optimised by a genetic algorithm [36], neural network classifier using an ant colony optimization classifier in [35], Ensemble classification and PUSBE are used. Result in the form accuracy Sensitivity and specificity for [32] were 79.52%, 79.86% and 79.49%, for [33] were 91.09%, 80.64% and 94.82% and for [34] 88.76%, 81.37% and 90.59%.

Two more type of classifications, four way: screening, clinical and two ANN and Hybrid fuzzy-neural system with good classification capabilities at reduced training times are used by Wishart et al. [29] and FALCON- AART [30] in 2010 and 2007.

V. CONCLUSION

This paper explores different research works and summarized about feature extraction, classification criteria's and the results are obtained from different papers in the form of accuracy, sensitivity, specificity and precision. This paper also describes the basic methodology of the early breast cancer detection. Mortality can be reduced by the screening for any disease for breast cancer by performing a test on an asymptomatic population to detect disease at an earlier stage. IR images are very adequate to detect breast cancer in early stage. However, they are much more effectively used in combination with some other systems helping on the diagnosis and allowing it to be performed also by trained nurses or infrared thermography practitioners Criteria for assessing the validity of screening programs includes-the screening test must be reliable, valid and repeatable, must be acceptable, safe and easy to be performed, have a high positive predictive value and be sensitive and specific. The screening program's cost should be evaluated with the benefits of early detection and there should be an available effective treatment for managing the abnormality identified by the screening test. These criteria highlight necessary outcomes for studies of the effectiveness of infrared thermography in the domain of breast cancer screening and have suggested that thermograms should not be used alone as a method of screening but mammography should be used and evaluated as a complementary screening.

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