Detection and Classification of Breast Cancer using Thermograms

[1]Preksha A Das, [2]Supritha S, [3]S Y Pattar

[1]Student, [2]Student, [3]Professor
Department of Medical Electronics,
BMS College of Engineering, Bangalore,India

Abstract—**Breast cancer is the second most common cancer in the world. Early diagnosis and treatment increase the patient's chances of healing. The temperature of cancerous tissues is generally higher than that of healthy neighboring tissues, making thermography an option to be considered in screening strategies for this type of cancer. In this, we propose a computational method for breast - thermography image analysis for screening patients with abnormalities in the breast.Automated diagnostic tools always provide the doctors with the very valuable second opinion during disease diagnosis. This paper discusses an automated approach for breast cancer detection using Thermal Infrared (TIR) images. Images are extracted from the temperature matrix, dataset available at DMR visual labs and Kaggle website the texture features based on different grey levels are extracted. 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.**

***Index Terms*—Breast thermal images, Statistical features. Screening strategies, Diagnosis**

I. INTRODUCTION

There are various diagnostic imaging techniques available in the field of breast cancer detection. In place of traditional invasive X-ray imaging, we use TIR imaging, a non-invasive imaging technique, as a diagnostic tool. Because of their high metabolic rates, cancerous cells have a higher temperature than normal cells around them. As a result, cancer cells can be visualized as hotspots in the body. This paper proposes an efficient method of automatic image segmentation and asymmetry analysis for breast images captured with an infrared camera. Breast thermography is a new medical imaging device that monitors physiological changes in the breast. It can detect breast cancer growth in its early stages before structural changes occur in the breast. It is a useful imaging procedure for risk assessment and early detection. It is appropriate for women of all ages, all breast densities, breast implants, and breast monitoring following medical procedures. The presence of an asymmetric heat pattern in the right and left breast distinguishes the abnormal thermogram image from the normal thermo gram image. Infrared thermography uses a camera with infrared sensitivities to create a picture of the temperature distribution in the human body. The most important factor in clinical interpretation of breast thermograms is asymmetry analysis. A symmetrical tumor in both breasts is impossible to have, and asymmetrical heat patterns appear. Small asymmetries in asymmetry analysis may indicate a suspicious region when the images are comparatively symmetrical. Breast cancer is the most commonly perceived disease in females all over the world. Because of lifestyle changes and the rapid development of industries, urbanization has resulted in a gradual increase in the occurrence of breast cancer. Breast cancer is a type of cancer that starts in the breast. Cancer starts when cells begin to grow out of control. Clinical imaging strategies such as mammography, ultrasound, and magnetic resonance imaging (MRI) are used to detect early signs of breast cancer. Mammography is a commonly used method for detecting breast abnormalities. Breast cancer can occur in women and rarely in men. Its treatment depends on the stage of cancer. It may consist of chemotherapy, radiation, hormone therapy and surgery. It occurs when some breast cells begin to grow abnormally. These cells divide more rapidly than health cells do and continue to accumulate, forming a lump or mass. Cells may spread through breast to lymph nodes or to other parts of your body.Breast cancer most often begins with cells in the milk-producing ducts (invasive ductal carcinoma). Breast cancer may also begin in the glandular tissue called lobules (invasive lobular carcinoma) or in other cells or tissue within the breast. Researchers have identified hormonal, lifestyle and environmental factors that may increase risk of breast cancer. But it's not clear why some people who have no risk factors develop cancer, yet other people with risk factors never do. It's likely that breast cancer is caused by a complex interaction of genetic makeup and environment.
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II. LITERATURE REVIEW

Although infrared thermography with 90% of sensitivity has proved itself as a potential tool for early detection of any breast abnormality, its accuracy relies on several factors Ignoring these factors may degrade the efficiency and sensitivity of the breast thermography. Hence, a standard protocol suite is desired to be followed during the acquisition of breast thermograms so that the thermogram can provide accurate temperature values. However, there is no standard protocol for acquisition and interpretation of abnormal thermal images and to fix the size and location of an embedded tumor.

Signal and image processing techniques have been successfully applied on medical data as a tool for screening and improving diagnosis. However, it is not easy to find papers containing a critical analysis of works on thermal images of breasts. Keyser lingk et al. Consider the utilization of infrared (IR) imaging to assist on the designation of clinical exams from the most recent Nineteen Sixties.Contemplate the utilization of infrared (IR) imaging to assist on the designation of clinical exams from the most recent

Nineteen Sixties. Throughout the Seventies they showed that the mixture between diagnostic technique and diagnostic procedure inflated the sensitivity of cancer detection in roughly 10 percent. In the last 20 years, the breast diagnostic technique has achieved a mean sensitivity and specificity around ninetieth for breast growth detection.An abnormal thermogram could indicate vital biological risk for the existence or for the event of breast tumors. Studies showed that a thermogram screening strategies may establish metastatic tumors or cancerous wellness sooner than others exams. Some authors state that the diagnostic procedure might have the potential to sight carcinoma up to ten years ahead of the historically golden method the mammography. Moreover, each time the breast is exposed to X-ray, the cancer risk increase by two percent, and therefore the biological time breast is extremely sensitive to radiation.In, E.Y.K. Ng discussed the performance and environmental requirements in characterizing thermography to be used for breast tumor screening. Based on the information from the existing breast thermography acquisition protocols, a new protocol suite for the acquisition of breast thermogram has been designed. The projected protocol suite consists of aspects like patient preparation, the status of the examination space, patient’s intake kind, patient adaptation, patient positioning, thermal imager system and capturing views.Each of those parts has their individual influence on Infrared diagnostic procedure. By maintaining of these protocols, AN infrared breast thermogram acquisition setup has been established at the Regional Cancer Centre (RCC) of Agartala Government Medical faculty (AGMC), Govt. of Tripura, India. This section in an elaborate way describes the set of protocols used for patient preparation, patient adjustment, breast thermogram acquisition, etc. during this research work. Wiecek et al. counsel as options applied mathematics parameters of the first order (i.e., obtained while not considering the neighborhood), characteristics supported histogram, and also the second order options (i.e., considering the placement of pixels) from the matrix of co-occurrences. The used first-order parameters are: mean temperature, standard deviation, variance, skewness and kurtosis measure. The second-order measures are: energy, variance, difference variance, correlation, inverse difference and entropy.Kapoor and Prasad use applied math parameters like skewness and kurtosis as options. They state that the larger the tumor is, the larger it's the temperature variation. They use the additive bar graph for representing the temperature variation. Additionally, neither they created any comments regarding their results on classification nor even compare their Work with others. Analysis of breast thermography may be a labor- intensive task that typically needs careful scrutiny of tiny temperature variations and abnormal tube patterns. During this paper we tend to bestow a machine approach to detection of tumor in breast thermograms supported medical infrared imaging. An automatic methodology for characteristic the ROI in thermal pictures is devised mistreatment cagy edge detector and gradient operator.After Associate in nursing initial stage that concerned removing waistlines and shoulders, left, right and lower breast boundaries are known. Asymmetry analysis is then performed victimization HOS parameters, center calculation and histogram generation. Importance of the work is high because the level of imbalance will predict the degree of future risk and remedial method earlier. This kind of approach can facilitate the nosology as a helpful second opinion.IR thermography has the good thing about timeliness, no pain, no risk, no contact, non-invasive and may beused for mass screening of patients for medical diagnosis of ladies breast diseases as a robust adjunct tool to mammography. The GUI‟s created create the system real time and operating system independent.

III. METHODOLOGY

A. *Subject*:

Adapting a patient before breast thermography is necessary since external factors can vary the human body's temperature. As a result, before to breast imaging, the patient's body must be allowed to adjust to the room temperature of the examination room. Then the patient is asked to sit down on a chair for 15-20 minutes, and this will allow the patient's body to equilibrate with the ambient temperature of the examination room. During the period of equilibrium, the patient is instructed to keep his/her hands over head and also to Avoid crossing of arms. Moreover, during the time of patient acclimation, the examination room is kept dark.

B. *Thermal image of breast:*

The entire procedure of breast thermography mainly depends on the infrared camera specifications such as the dynamic range, image resolution and thermal sensitivity of the infrared camera. The dynamic range of the infrared camera should be sufficient enough so that it can preserve the fine details in breast thermograms . Like dynamic range, a thermal camera with good thermal sensitivity can detect a minute temperature variation by discriminating the thermal radiation more precisely For mounting the thermal camera, a vertical height adjustable tripod stand with a heavy base is used. The FLIR Thermography cameras were licensed by FDA in the year 2004 to use as an adjunctive tool to other clinical agnostic measures for the diagnosis and screening of the changes in skin surface temperature.

C. *Pre-processing & segmentation of breast thermograms:*

The primary objective of segmenting a breast thermogram is to discard all those portions that are not belonging to the breast region. Thermal images are poor in contrast for which it lacks clear edges, and it is amorphous in nature. Hence, segmentation of breast thermogram is a task. However, the precision of interpretation of a breast Thermogram entirely relies on the accurate segmentation of breast thermogram. Segmentation of breast thermogram can either be manual or automatic. Here in this work, extraction of breast region is performed manually from an edge image. The pre-processing and segmentation procedure of a breast thermogram is shown. The segmentation of breast thermogram results in the extraction of left and right breast of a thermogram. Moreover, the dimensions of all the segmented images are kept fixed of size 200 x 200 for ease of computation. The preprocessing & segmentation procedure comprises of conversion of the breast thermos grams from RGB to grayscale images; Removal of the unnecessary portions of the grayscale thermograms manually; Use of the canny edge detector: The canny edge detector with a threshold value is used to detect only the significant edges of breasts while neglecting the weak edges; Segmentation of breast region from each breast thermogram; Finally, separation of left and right breast segments of each breast thermogram.

D. Feature Extraction:

Feature extraction is the process of defining a set of features where each feature represents the most significant information of an image. Thus, by doing feature extraction, an image to be analyzed is represented by a reduced set of features known as texture features. Texture feature describes the textural properties of an image, such as orientation, roughness, smoothness, contrast, regularity and spatial structure, etc. Here in our approach, extraction of statistical features is performed, which provides information about the texture or spatial distribution of the gray values in a thermogram. The statistical features compute the properties of individual pixel value and the texture features is based on the probability of finding a gray-level pair at a Random distances and orientations over the whole image, which is also known as Gray-level Co-occurrence Matrix. It is measure of how often various combinations of grey levels co- occur in an image. We have computed GLCM matrices in four directions, horizontal, left diagonal, vertical and right diagonal at a distance of 1 pixel. Mean, variance, entropy, contrast, correlation, energy and homogeneity features are computed from the four GLCMs. Since the cancer development in the breast is chaotic, average value of features obtained from GLCM at four directions is calculated. Absolute difference of each feature from ROI of right and left breast is computed to measure the asymmetry between right and left breast and then normalized.

E. Statistical feature analysis:

After extracting these twelve feature values from both left and right breast segment of each normal and abnormal breast thermogram, an analysis of the feature values are done to find out any abnormal characteristics. A sample of feature values obtained from the left and right breast of a normal and an abnormal breast thermogram are given. Then the feature values extracted from all normal breast thermograms, feature have been created for both left & right breast like left skewness, -right skewness, -left kurtosis, -right kurtosis etc.. In a breast thermogram, each intensity value represents a temperature and hence, a small difference in the feature values of the left and right breast indicates an abnormality. The absolute maximum values of each left and right breast of each feature in the normal group are almost similar. But, in the abnormal group, the maximum feature values of the left and right breast of each feature are quite different from each other. The amount of difference is different for each feature. The features that show a greater extent of difference between the maximum values of left and right breast feature are considered as most discriminative features.

The first order Statistical Features:

The first order statistical features are also known as the Gray Level Histogram Based Texture Features as they can directly be computed from the image histogram or pixel occurrence probability. They do not consider the relationship between the neighboring pixels for which it cannot provide the texture information of an image.

The Second Order Statistical Features:

The second order statistical features deal with the relative positions of the gray levels within an image. The Gray Level Co- occurrence Matrix (GLCM) is a well-known method for extracting second order statistical texture features. The GLCM is a presentation of how often different combinations of pixel gray levels could occur in an image.

For the first order statistical features, it is clear from the table, that there's a large distinction between the mean intensity values of the left and right Breast for a number of images. The difference between the mean of the left and right breasts is greater than ten. Whereas it is lesser than 10 for a few images. For certain images, the variance is greater than 0.05, whereas for others, it is less than 0.05.The left and right breasts have vastly different skewness and kurtosis values. These numbers, on the other hand, demonstrate a lesser difference. For entropy, the differences are more than 0.1 for both left and right breasts. For the second order statistical features, for energy values in the left and right breast, the difference is in the range of 1-5. Other images, on the other hand, have a value of less than one. For certain images, the value of homogeneity differs by more than one, whereas for others it differs by less than one. Correlation, on one hand, reveals a difference more than 1, on the other hand, a difference less than or equal to 1 for the images is considered. For both sides of the breasts, the second angular moment shows a difference of more than one for some images and less than one for others. For one group of images, the contrast value is higher, whereas for the remaining images, it is lower. Through dissimilarity value for a couple of images, a big difference of greater than 1 is noticed, while the difference is smaller for others. The information evaluated from the table is provided above, and we can detect a significant variation in value for all statistical features. As a result of the data, we can conclude that the figures given are abnormal. On the other side, there is a minor disparity in the readings, which can be classified as normal .For the those subjects who are having abnormalities that detected while in analysis of image processing time, can approach a physician advice for more diagnosing and therefore for the other treatments.

IV. RESULTS

Thermography is highly suited for breast cancer screening owing to its ability to detect cancer much earlier than any other modality, patient safety and privacy. The complexity and subjectivity in interpretation of thermal imaging has been a major deterrent in wide acceptance of the usage of thermography. With software support, thermal analysis and interpretation can be more efficient, effective and non- subjective. For future work, this approach can be applied to other machine learning algorithms or other data analysis processes. The possibility of doing operations on encrypted data is very relevant to the massive use of cloud systems today, to maintain the security of the data while analyzing it at the same time. Another extension of this work is to choose and select the most informative unlabeled images which can improve the performance of the used classifier. Future research needs to work toward improved classification of breast thermograms. This will require providing representative datasets, preparing good ROIs, assigning good kernels, implementing lightweight

CNN models. A risk-free screening method using thermography could then be proposed for self-breast screening method at an early stage without requiring physical involvement.

V. Conclusion

The thermography is non-invasive, radiation-free and complementary to anatomical investigations based on X-rays, ultrasound and three-dimensional scanning techniques such as CT and MRI.This proposes an approach to diagnose breast cancer based on thermal imaging. Due to the increasing incidence and mortality rate of breast cancer, the early detection of breast cancer is a challenge for today's medical system and biomedical engineering. In this scenario, breast thermography with 90% sensitivity has proved itself as an efficient tool for early breast cancer detection. Moreover, designing of a computerized system for analysis of the breast thermograms plays a crucial role in early breast cancer detection. Statistical feature based analysis of the breast thermograms allows us to differentiate the normal thermograms from the abnormal thermograms even when the degree of dissimilarity present between the left and right breast of each thermogram is subtle. Thus, it helps to find out the presence of any breast abnormality that may be developed to breast cancer in future.

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