

Breast Cancer Detection through Thermography: A Review¹Sonalee P. Suryawanshi, ²Bhaveshkumar C. Dharmani*¹Ph.D. Student, Lovely professional University, Phagwara, Punjab, India²Associate Professor, Lovely professional University, Phagwara, Punjab, India

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ABSTRACT

Breast cancer is one of the leading causes of death among women worldwide. Survival rate can be improved by early detection of breast cancer and this can be achieved by periodic clinical checkups and self-tests. Mammography, an established technique for diagnosing breast, is an invasive technique but may cause rupture of tumor with possibility of the spread of cancer in area surrounded by lump. Also, it is not reliable for cancer detection in dense breast tissue. Hence, there arises a need of breast cancer detection technique which is more robust, efficient, fast, accurate, non-invasive and can be used for periodical check-ups. Thermography is a non-invasive and non-contact technique of breast cancer detection. Initially rejected for poor sensitivity and accuracy, the technique recently has shown comparable and promising results. Specifically, it shows better performance for younger age women, as well, for dense breast tissues. Being non-invasive, painless and cheap compare to other diagnostic techniques, if accuracy is improved can be used for early detection. Recently deep learning approaches and alternative entropy definitions have shown very good results for other classification tasks. So, the papers aim to incorporate these modern approaches to increase the rate of early breast cancer so that more number of effective treatment can be used which further can reduce the risks of death from breast cancer.

Keywords: Computer Aided design (CAD), Digital infrared thermal imaging (DITI), Deep Neural network (DNN), Convolutional neural network (CNN) etc.

1. INTRODUCTION

Breast cancer is the second most commonly diagnosed cancer in women which results in 2.1 million new cases each year. In 2019 there will be 30% of new cases of breast cancer while in 2018 there is estimated that 627,000 women died from breast cancer and over 2 million new cases have been diagnosed. Globally the rate of breast cancer in developed region is higher and every year is increasing in every region. The problem of breast cancer is that in the majority of cases it is diagnosed in late stages. India has a low survival rate for breast cancer. India has reported 1,62,468 new cases and 87,090 deaths for breast cancer in the year 2018. According to the study published in Asia-Pacific Journal of Clinical Oncology, the number of cases with breast cancer diagnosed in 2017 per 100,000 women were 41 in Delhi, 37.9 in Chennai, 34.4 in Bangalore and 33.7 in Thiruvananthapuram. According to the study, by 2020 breast cancer diagnosis patients will be double.

CURRENT DIAGNOSTIC METHODS: Mammography is breast cancer screening tool which is acceptable currently. Mammography is type of x-ray picture of breast that is nothing but low x-ray dose that is used to detect breast cancer. However, mammography screening tool is not accurate. The mammography screening which show abnormal result may have a false negative or false positive rate about 1 in 10 women [7]. Mammography is not accurate to the woman having dense breast tissue and near about 50% women undergoes screening have dense breast. There is also a risk of causing radiation induced breast cancer as younger women are more susceptible to effect of radiation compared to olden women [7]. Clinical breast exam and self-breast exam is also used to detect breast cancer which are manual exams carried out by clinician or patient by self. Clinical breast exam performed by experienced clinician may use in detection of cancer that may not be detected by mammography [1,7]. A digital tomosynthesis is a 3D mammography which is a three-dimensional image. Tomosynthesis is typically performed in along with mammography due to this the patient's radiation exposure increases by twice. When tomosynthesis is used with the combination of mammography it increases the detection rate and reduces the false positive rate of mammography compared to mammography screening alone [1,26]. Sonography or ultrasound is another technique which is used for further investigation to find suspicious area of breast in the mammograms which distinguishes between cyst and solid masses[1,3,7] which is used in combination of mammography it improves the sensitivity of mammography. Breast MRI to help find the size of the tumor or to find out the presence of other

tumors in the breast, to check the spread of the tumor after detection of cancer, to check the chemotherapy working or not and also as a part of follow up after removing the breast lump. MRI is not suggested as a single screening test for breast cancer detection an image of the breast because it has high false positive rate[1,3].

Need of Early Detection:To improve the survival rate early detection is necessary. The problem of breast cancer in most of the patients diagnosed at advance stage hence makes difficult for treatment. In that case there is a need of early diagnosis which is possible by making the people aware of early signs and symptoms also there is a need of accurate diagnosis and easy availability of treatment. The aim of the paper to focus on reducing the breast cancer death by creating the awareness among the people so that it will help them to detect the symptoms at early stage.

2. Steps in the Digital Infrared Thermal Imaging (DITI) system:

Following figure shows steps to follow for detection of breast cancer through thermographic images. The input thermal image first preprocessed to removes extra region to get region of interest and then converted into number of segments. Based on extracted features classification is done to detect image as normal and cancerous.

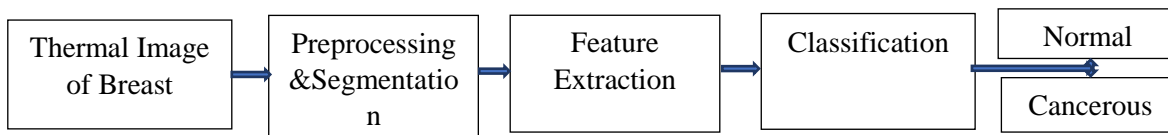


Figure: Block diagram of generalized steps in DITI

3. REVIEW OF RESEARCH & RESEARCH GAP IDENTIFICATION

This part of the work covers the literature review of reliable research work done for the detection of the breast cancer. The brief overview of some research papers in concerned field with different methodologies has been explored in this section.

S. No	Title	Year of Publication	Author	Publication	Reference No.	Segmentation, Feature extraction, Classification techniques

1	“Thermography based breast cancer detection Using Texture features and Support Vector machine.”	2012	U. Rajendra Acharya	Springer	12	Used texture feature and support vector machine
2	“Anisotropic diffusion filter-based edge enhancement for segmentation of breast thermogram using level sets.”	2014	Suganthi S.	Biomed. Signal Processing	16	Wavelet based thermogram analysis
3	“A new database for breast research with infrared image.”	2014	LF Silva	ELSEVIER	43	K-nearest neighbors (KNN) algorithm to classify and uses AffineScale-Invariant Feature Transform
4	“Breast abnormality detection through statistical feature analysis using infrared thermograms.”	2014	Usha rani Gogai	IEEE	18	Statistical feature analysis
5	“Breast thermogram analysis using classifier ensembles and image symmetry features”	2014	Krawczyk, B.,	IEEE	31	Multiple classifier system
6	“Thermography based breast cancer detection using texture features and minimum variance quantization.”	2014	Milosevic, M.,	. EXCLI J	30	Detection using texture features and minimum variance quantization
7	“Color morphology and segmentation of the breast thermography image.”	2014	Lanisa, N., Cheok,	IEEE	33	Edge detection and color morphology
8	“Detection of breast abnormality from thermograms using Curvelet Transform Based feature extraction.”	2014	Sheeja V Francis	Springer	17	Curvelet transform based feature extraction
9	“Breast cancer risk detection using digital infrared thermal images”	2015	Mohamed N. A.E. R	Biomed. Signal Processing	27	Neural network (NN) classifier
10	“Extended hidden markov model for optimized segmentation of breast thermography images”	2015	EMahmoudzadeh.	ELSEVIER	48	Extended hidden Markov models for breast segmentation
11	“Segmentation of infrared images: a new technology for early detection of breast diseases”	2015	de Oliveira,	IEEE	32	Automatic segmentation
12	“Thermal signal analysis for breast cancer risk verification”	2015	Lincoln F Silva	IOS	49	K-means and clustering from silhouette Davies-Bouldin and Calinski-Harabasz indexes
13	“Hybrid analysis for indicating patients with breast cancer using temperature time series”	2016	Lincoln F Silva	ELSEVIER	44	BayesNet, KNN & Radom Forest (RF) models for pixel intensity and time series analysis

14	Role of normalization of breast thermogram images and automatic classification of breast cancer.	2016	Dayakshini Sathish	Springer	50	SVM & Genetic Algorithm (GA) for classification of normalized breast thermograms using local energy features
15	“Asymmetry analysis of breast thermograms using automated segmentation and texture feature”	2016	Dayakshini Sathish	Springer	20	Canny edge detection and SVM classifier
16	“Thermal infrared image analysis for breast cancer detection”	2017	Sedong, M	KSII Trans. Internet Inf. Syst	36	Thermal infrared image analysis
17	“Thermal imaging-based breast cancer analysis using BEMD and uniform RLBP”	2017	Vijaya Madhavi,	IEEE	10	Level set segmentation Manual, LSSVM [BEMD UNIFORM RLBP]
18	“Computer aided diagnosis for breast diseases based on infrared images”	2018	Araújo, A. D. S.,	IEEE	11	Manual Segmentation, SVM Classifier
19	“Breast cancer detection using infrared thermal imaging and a deep learning model”	2018	Mambou, S. J.,	Sensors	37	SVM classifier deep learning
20	“Designing of ground-truth-annotated dbt-tuju breast thermogram database toward early abnormality prediction”	2018	Mrinal Kanti	IEEE	51	Bilateral asymmetry and statistical analysis for annotation of thermograms
21	“Breast cancer diagnosis based on mammary thermography and extreme learning machines”	2018	Maíra Araújo de	SCIELO	52	Multi-Layer Perceptron (MLP), DT & RF using Zernike and Haralick moments as features
22	“A new approach for breast abnormality detection based on thermography”	2018	Chebbah Nabil	MTJ	53	SVM, KNN & ANN for texture features and statistical analysis
23	“Breast cancer detection using infrared thermal imaging and a deep learning model”	2018	Sebastien Mambou	MDPI	3	SVM, Artificial Neural Networks (ANN) Deep ANN, Recurrent ANN
24	“Breast cancer detection in thermal infrared images using representation learning and texture analysis methods”	2018	Mohamed Abdel-	MDPI	45	CNN models for static & dynamical analysis
25	“Detection of breast cancer using infrared thermography and deep neural networks”	2019	Francisco Javier	Springer	47	State-of-the-art benchmark of several CNN architectures
26	“Convolutional neural networks for static and dynamic breast infrared imaging classification”	2019	Mohamed Abdel.	IEEE		Learning-to-rank (LTR) and texture analysis methods like histogram of oriented gradients

Table 1 shows that initially there was not available any standard datasets and so researchers were using their own specially prepared dataset. Later on, the standard databases have been identified [43]. In general, canny edge detection [16,18,20], sobel edge detection [17], level set segmentation [10,11] techniques have been used for segmentation. The classifier used were for classification support vector Machine (SVM) [11,12,17,20,53], Convolution Neural Network [45,47], artificial neural network (ANN) [3,53].

This section mentioned above analyses a new different directions and trends to improve the current state-of-the-art methods. This also enlists the limitations, database information and technique that is used for segmentation and classification. The accuracy, sensitivity and specificity can be improved using a greater number of database and extracting more better features [12]. To improve efficiency of segmentation method, it is necessary to obtain the quantitative measure of the breast image which is used to find out the abnormality present in the breast tissue. Statistical features and texture feature have been used for feature extraction. Using more of features than used and large number set of databases should be used to enhance result.

4. RESEARCH GAP

The literature review as enlisted above have different methodology in detection and classification of breast cancer using thermography. There is observed some scope to improve the result in terms of accuracy, sensitivity and specificity and based on that research gap have been identified. The usability of the method can be improved by increasing accuracy and reducing true negative and false positive rate. Till now Deep learning with CNN has been used which has a problem of overfitting. So, there is a large scope of applying other DNN approaches, specifically those requiring low resources and that are robust. Also, there is need of testing other DL approaches like, transfer learning, variational auto encoders and others.

5. Conclusion:

In this paper, a review of techniques and state of the art methods used for the detection and classification of breast cancer using thermal imaging was introduced. The aim of thermography is to improve survival rate by detecting it at early stage. In future work more reliability and accuracy

can be improved with thermography by using robust statistical divergence features for classification and using deep learning.

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