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Review Article

The Effect of Thermography on Breast Cancer Detection

PR Pavithra, KS Ravichandran, KR Sekar, R Manikandan
School of Computing, SASTRA University, Thanjavur, Tamil Nadu, INDIA.

ABSTRACT

Image processing technique in general, involves the application of signal processing on the input image for isolating the individual color plane of an image. Cancer has generally an abnormal cell that grows and invade healthy cells in the body. Breast cancer occurs when malignant tumors develop in the breast. Early detection of the breast cancer can effective in increasing the rate of survival. There are several Medical image techniques which has been used for detecting breast cancer. The survey explored the needs for the thermography over other screening tools. Thermography detects and records temperature changes on the surface of the skin which is known as Digital Infrared Thermal Imaging (DITI). Thermography is known for its features like non-invasive, painless, cost effective and high chances of recovery, which has got ability to detect the breast cancer at near beginning. There is no such tool which provides accurate predictability unless biopsy. But the combination of tools with thermography may boost the sensitivity and specificity when compared with other mechanisms.

Key words: Breast cancer detection, Medical Image techniques, Thermography, Digital infrared thermal imaging.

Correspondence:
K.R.Sekar
School of Computing, SASTRA University, Thanjavur, Tamil Nadu, INDIA.
E-mail id: sekar_kr@cse.sastra.edu
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INTRODUCTION

There are so many Digital image processing tools for breast cancer detection like Mammogram, ultrasound, MRI etc. A mammogram (low energy x-ray of breast) is done to detect breast cancer in early stage when one cannot feel the presence of the lump in the breast. Its signatures include masses and micro calcifications appearing on mammograms which are used to diagnose breast cancer in advance. Mammogram is widely used screening tool and not a perfect one since it requires repeated exposure to radiation. The women with dense tissue have high rate of false-positive results in terms with breast cancer. Ultrasound detects tumor by passing sound waves on surface of the tissue. Its accuracy depends on quality of the tool and physician knowledge in using multidisciplinary approach. MRI (Magnetic Resonance Imaging) uses strong magnetic fields combined with pulsing radio waves to get cross section, high resolution image of the breast. Ultrasound, MRI is recommended for the positive mammogram.

The need for the consideration of thermography increases as it deals with better features like Digital Infrared Thermal Imaging (DITI) that records the thermal pattern of the body without involving radiations using functional image rather than structural image unlike other screening tools. Effectiveness of the dense tissues and the thermography is not affected even due to hormonal changes. Thermography has 83% of sensitivity alone and 95% of sensitivity while combined with mammogram. This also has high false-positive rate and false-negative rate but can be reduced further by using enhanced methods. Breast thermography works by finding an increase in surface temperature on breasts. The approach leads to analyze the breast using various techniques like color analysis, asymmetric analysis, artificial neural networks, feature extraction, data mining techniques, segmentation approaches, sequential feature selection technique etc., Breast cancer detection using thermography begin with the screening of breast and analyzing thermal changes in obtaining thermogram. The image is observed, and further processing begins with the ordered sequence like pre-processing, segmentation, feature extraction, classification and post processing Figure 1. Asymmetric analysis is one of the effective methods to differentiate abnormal image from normal thermogram. Since thermogram detects and record temperature changes on the surface of the skin, abnormal breast is identified by using various methods and techniques.

Segmentation is the process of partitioning the digital image into various segments which make the analysis trouble-free. It is used to locate objects and boundaries (lines, curves etc.) in images. Practical applications of image segmentation include content-based image retrieval (CBIR), medical imaging, object detection etc. There are so many image segmentation methods like thresholding, clustering, compression-based methods, histogram-based methods, edge detection, graph partitioning methods etc. Graph partitioning method is an effective tool for image segmentation. Markov Random Field (MRF) is one of the popular applications which come under graph partitioning method. This provides a global optimal value even when defined locally and has a major impact on image analysis, de-noising and segmentation. The broad classification of the image segmentation using MRF is supervised and unsupervised segmentation.

Texture is one which has a repeated pattern with regular interval. Since it deals with the characteristics and appearance of objects like the size, shape, density and arrangement it has major role in areas like remote sensing, medical imaging and content based image retrieval. Temperature variations in thermogram images can be represented by its texture. It has an impact in major application domains like texture classification, segmentation, synthesis and shape from texture. Texture features can be extracted using several methods such as statistical, structural, model-based and transform information. Medical applications involve the automatic extraction of features from the image which is then used for a variety of classification tasks such as distinguishing normal tissue from abnormal tissue which can be done using texture features. Using multiple features of the image and the selection of a suitable classification method are especially significant for improving the classification accuracy.

The segmented images are then fed into the classifiers for further analysis. Many advanced classification approaches, such as artificial neural networks, fuzzy-sets and expert systems have been extensively applied for image classification. Image classification approaches is generally partitioned into supervised and unsupervised, or parametric and non-parametric. Classification algorithms are used in image analysis to automatically decide whether patient should be more thoroughly examined. The common machine learning algorithms used for classification includes Naïve Bayes Classifier Algorithm, K Means Clustering Algorithm, Support Vector Machine Algorithm, A priori Algorithm, Linear Regression, Logistic Regression, Artificial Neural Networks, Random Forests, Decision Trees and Nearest Neighbors. Not all classifiers are suitable for all image processing techniques. Classifiers and related machine learning algorithms are preferred according to the need and the result. Each model has its own advantages and disadvantages consequently.

LITERATURE SURVEY

Survey on breast cancer detection techniques

Deborah A. Kennedy *et al.*[1] states that there is no single tool that provides excellent predictability over breast cancer detection. A combination that incorporates thermography may boost both sensitivity and specificity when the comparison is done with other screening techniques like mammography, ultrasound etc. This paper has come up with a result as 83% of sensitivity where thermography is used alone and 95% sensitivity when combines with mammography. Thermography also deals with some curable limitations like false positive, inability to detect abnormalities like micro-calcifications which results in false negative, but mammography does. This also compares thermography with ultrasound which resulted as ultrasound accuracy depends on the quality of tool, expertise of physician and use of multidisciplinary approach. When it comes to mammogram, its sensitivity lies between 75% and 90% but with positive predictive value only up to 25% which varies widely.

Prof. Priya Hankare *et al.*[2] presented a framework using color analysis and are evaluated. As stated, infrared breast thermography detects tumors based on thermal changes in the body. Breast thermography works by finding an increase in surface temperature on breasts. Here analysis of thermogram images is done based on color analysis on segmented regions using three clusters. This paper presents an efficient image segmentation approach using k-means clustering technique based on images with color features. The proposed approach provides automated approach for abnormality detection of breast thermogram using color analysis. They also stated limitations of k-means like difficulty in predicting k values, unable to get the same result every time, not much efficient with global clusters, cluster with different size and different density is not suitable. To overcome the limitations of k-means author suggests using Fuzzy C Means and level setting methods for breast segmentation which is more accurate.

Dayakshini Sathish *et al.* and Satish G. Kandlikar *et al.*[3,4] reviewed about various medical image models and presented a survey on respective CAD approaches. This paper deals with the study on imaging procedures, analysis of images, benefits and limitations of mammography, ultrasound, thermography etc. This also includes various steps to develop CAD tool for respective imaging technique. CAD for mammography is suggested as back propagation and generic algorithm in ANN (Artificial Neural Network), Breast US has proposed a CAD which uses facile texture features (block difference of inverse probabilities, block variation of local correlation coefficients and auto-covariance matrix) to identify the tumors. Thermography CAD depends on asymmetry analysis. Limitations of imaging techniques is also given as mammography has both false-negative and false-positive results, breast US doesn't reveal calcifications, need expertise to recognize abnormalities found and need additional procedures to obtain accuracy. Breast MRI requires more time has high false-positive and produce allergic side effects. The result is stated as thermography with respective CAD gives high accuracy.[3,4] Reviewed the process of thermal imaging over past three decades and identifies aspects that need further refinement to make it as a reliable tool. This paper also suggests the future work using advanced simulation methods, inverse modeling, imaging protocols and ANN. Techniques used here includes numeric simulations of cancerous tumors, transient numerical simulation, inverse modeling and AI (Artificial Intelligence) which uses ANN. The paper results in the improvement in sensitivity of IR cameras from 0.5 to 0.02 degree Celsius. Protocol proposed for IR breast thermography to improve quality of thermogram and to remove undesired effects. Usage of SVM (Support Vector Machine) classifier in AI has 85.71 % sensitivity, accuracy as 90.91% and specificity as 90.48%. Drawbacks deals with the low sensitivity of IR detectors, lack of standardized acquisition procedures which leads to limitation of high accuracy in diagnosis.

Sachin *et al.*[5] surveyed on neural network and its implementation on breast cancer detection. Here ANN is used to detect trends and extracting complex patterns. Reduction of medical inaccuracy is done, and it also compares various ANN algorithms in classifying breast cancer detection. Several methods like ARNN (Adaptive Resonance Neural Network) which uses vigilance parameter as stopping criteria, concept of image registration, SVM and Fuzzy C-means for classifications of brain tumor, parallel computation approach for speeding up the classification process in diagnosis of breast cancer, CAD system to assist radiologists in finding abnormalities using PSOWNN (Particle Swarm Optimized Wavelet Neural Network) and used extreme learning machine. The results and limitations are tabulated and concluded that ANN is one of the best tools as it has high level of accuracy and efficiency.

T.B. Borchartt *et al.*[6] presented a survey which explores the individual use of technologies from the view of image processing. The study involves main steps of pattern recognition system, signal and image processing techniques has been successfully applied on medical data as a tool for screening and improving diagnosis. An acquisition protocols are studied and tabulated. The methods used in the paper involve thermal image acquisition and storage, preprocessing segmentation and ROI (Region of Interest) extraction and feature extraction. The classification includes SVM (Support Vector Machine), RBF (Radial Basis Function) and MLP (Multi Layer Perceptron's). Clusters include K-means, SOM (Self Organizing Maps) and neural network. This results in finding sensitivity of thermography as 83% and when combined with mammography the resulted sensitivity is 95%. But the limitation is that IR cannot substitute any other technique but can be used as a complimentary measure.

Asnida Abdul Wahab *et al.*[7] uses ANN for tumor localization which utilizes multiple features extracted from a series of numerical simulations. This paper builds a ANN system of 6-8-1(6 inputs, 8 neurons in the hidden layers and 1 output) network with a learning rate of 0.2, an iteration rate of 20,000 and momentum constant value as 0.3. The methodology followed here includes various steps like developing an ANN, data managing and sampling, network configuration, training and optimization and finally testing and validation. This resulted in performance accuracy of 96.33% to testing data and 92.89% to validation data.

Bryan F. Jones [8] presented a study about the use of infrared thermography, infrared images, thermal imaging and infrared cameras. No specific methods are used unless basic thermal imaging concepts. The results obtained here leads to the development in camera technology and in new software development. It also results in non-invasive and powerful indicator of psychological dysfunctions.

Hong-qin Yang *et al.*[9] has interpreted the problem of thermogram by establishing the reference standard of thermal symmetry for normal female breast with a new infrared thermal imaging concept. The criteria for thermal symmetry of breast are found as 0.5 degree Celsius. The methods followed include thermal imaging system, Thermal Texture Mapping (TTM) and statistical analysis. It results in the determination of thermal symmetry criterion for the breast is 0.5 degree Celsius which is used as a cutoff and projected thermography as a risk indicator.

Moh'd Rasoul Al-hadidi *et al.*[10] has proposed a new method to detect breast cancer with high accuracy. This method includes preprocessing of mammographic images and fed it as an input to the supervised learning models like BPNN (Back Propagation Neural Network) and LR (Logistic Regression). They also compared the results and accuracy from both models. The author used Artificial Neural Networks (ANN) a machine learning technique which includes BPNN and LR. LR is a statistical classification model. The study compares various algorithms which uses Ultra Wide Band (UWB) antenna that involves Gaussian pulse generator in UWB app, GAM (Generalized Addictive Model), BPNN and FDTD (Finite Difference Time Domain). Among this BPNN gives the best result by producing good regression value that exceeded 93% with 240 features.

G.T. Shrivakshan *et al.*[11] compare two main edge detection techniques gradient-based (Roberts, Sobel and Prewitt edge detection operators) and Laplacian based edge detector and canny edge detector. These filters are applied in a case study (shark fish type) and filters are used on case study to identify the image by locating sharp edges, which are discontinuous. The methods include gradient, Laplacian edge detection and Gaussian. Canny has better performance when compared with others. Even under noise canny, LoG, Sobel, Prewitt, Roberts's are reveal better performance correspondingly. This paper also exhibits the limitations like gradient based algorithm have drawback as it is sensitive to noise, performance of canny algorithm relies on SD (Standard Deviation) for Gaussian filter and its threshold values, the size of the Gaussian filter is controlled by greater values and large size. But large size results in producing more noise.

B.M.Gayathri *et al.*[12] compared RVM (Relevance Vector Machine) with various machine learning techniques and shows RVM is better than other techniques with high accuracy. The paper Uses RVM classifier to segment normal and abnormal data and the features in datasets are reduced using Linear Discriminant algorithm (LDA). This results in reduced computational costs. The method suggested can be generally used for classifying breast cancer only for benchmarked datasets.

Survey on various segmentation methods

X. Tang *et al.*[13] presented a paper which deals with the LTI (Localized Temperature Increase). The author proposed a new criterion of breast cancer detection and method of its realization. LTI is used in breast infrared thermograms and its amplitude is measured. This study results in high sensitivity of 93.6% and high NPV of 91.2%. Patient with higher LTI amplitudes will be considered as having higher possibilities. Optimal LTI amplitude threshold is calculated as 1 degree Celsius for breast cancer detection. The limitation is that it doesn't have good specificity due to FPR (False Positive Rate) 55.7%.

Dayakshini Sathish1 et.al.[14] proposed a system which Uses polynomial curve fitting to find bifurcation line, texture feature extraction (histogram and GLCM matrix) for segmentation and classified using SVM RBF classifier. This results in the accuracy of 90% when SVM RBF classifiers and SVM polynomial classifiers are used. Proposed algorithm has reduced computational complexity when compared hough transform. The database is limited only to 40 training and 40 testing images. And hence Accuracy of classification slowly reduces, when the segmentation error increases.

Hossein Ghayoumi Zadeh *et al.*[15] presented a fully automated approach to detect the thermal edge and core of contours area in the thermograms. The proposed model is based on fuzzy active contour which is designed by fuzzy logic. It Segments cancerous areas from its borders. The evaluation process is done by using hands off and mean distance between manual and automated methods used. This includes step by step methodologies like detection of abnormal thermal core, detection of abnormal thermal edge and the process of fuzzified contour. The result has been proved from the obtained sensitivity of 85% and accuracy of 91.98% but only for limited dataset.

Hairong Qi *et al.*[16] use asymmetry analysis to detect abnormalities. They have proposed a method which includes automatic segmentation and pattern classification. Here left and right breast are segmented to extract feature curves using Hough transform. Methods include steps like edge detection (by canny edge detection), feature curve extraction (by Hough transform), segmentation and unsupervised learning which includes pixel distribution (within clusters). The experiments are done only on specific set of images.

Dayakshini *et al.*[17] proposed a method which uses asymmetry analysis to segment an image using projection profile approach. HPP (Horizontal Projection Profile method which is used to locate upper and lower borders of the breast), VPP (Vertical Projection profile method which is used to detect parabolic shape) is used. The generalized version of this method is done by standardizing height, background and removal of noise in the image. It uses sobel operator (which performs 2-D spatial gradient measurement of thermogram) for edge detection, then followed by Inframammary Fold Detection of the Breast, axilla detection (upper border detection) and left and right border detection. Satisfactory results are obtained but with certain limitations with generalization.

Elham Mahmoudzadeh *et al.*[18] proposed a novel method for boundary detection. Here breast boundary is grouped into three regions depending on region property. It uses different algorithms for different regions and experiment is done on three set of databases. The methods used in directional SUSAN edge detector include Hough transform and cubic parabolic interpolation. Results are simulated via MATLAB 2010 and built in canny edge detector tool is used. The proposed algorithm properly separates two breasts from background and from each other. It is limited in a way that this method can be used only as a first stage in automatic/semi automatic analysis. Runtime of the algorithm need to be improved in case of online application.

N. Golestani *et al.*[19] use level set method for image segmentation. Image segmentation plays important role to segment and extract hot regions from breast infrared images. Three image segmentation methods (say K-means, Fuzzy C-means and Level set) are discussed and compared. While tested on different cases level set method is accurate. Improved level s*et al*gorithm used here resulted in high accuracy, efficiency and robustness.

E. Mahmoudzadeh *et al.*[20] apply extended hidden markov model for optimized segmentation of breast thermography images. They proposed a novel extended HMM for effective image interpretation and easier analysis of TR thermal pattern. Advantage of EHMM is that, it can handle random sampling of breast IR images with re-estimation of model patterns. The proposed algorithm is illustrated by applying it on ITU-OPTIC database and is simulated by using MATLAB 2010. The execution time is effectively reduced when compared with Fuzzy C-Means, SOM and standard HMM algorithms. H. D. Li, M. Kallergi *et al.*[21] carry out detection by segmentation (ROI and MRF) and classification (Fuzzy- binary decision tree). The method includes MRF (Multi resolution segmentation) which uses adaptive thresholding and FBDT (Fuzzy Binary Decision Tree). The proposed system results in 90% of sensitivity. But it is limited only for small tumors.

Survey on various feature extraction techniques

Feature extraction is the main process in image processing technique. It is used to reduce the size which is literally known as dimensionality reduction by feature selection (The process of transferring the information to reduce set of features is called the feature selection). Feature extraction techniques are used to reduce complexity in classifying and recognizing images which will effectively reduce time complexity. It can also be classified into low-level feature extraction and high-level feature extraction.

Low-level feature extraction is based on finding the points, edges, lines. While high-level feature extraction will use low-level techniques initially and move further to provide detailed information. Three main types of feature extractions are color feature, shape feature and texture feature. The main challenge deals with the efficiency and effectiveness of feature selection and extraction.

Rajkumar Goel *et al.*[22] presented a review about various feature extraction techniques used for image analysis. Feature extraction methods are classified as the low-level feature and high-level feature extraction. The techniques for feature extractions are classified into color, shape and texture features. Various image analysis techniques are compared, and region based shape feature are more robust as these methods extract all the shape information. The study also examined that supervised classification methods SOM Hopfield ANNs surpass unsupervised algorithms.

Pranali Yadav *et al.*[23] proposed a system with advanced pre-processing stage and combined feature matrix. The results can be improved through combination of statistical and texture features. Methodologies include image acquisition, original image, pre-processing, feature extraction and KNN and SVM classifiers. This paper compared various techniques and defined some problems associated with them. Advanced pre-processing along with combined feature system can be used to improve efficiency of detection.

Taha Mahdy Mohamed [24] proposed an algorithm for decreasing number of features required to detect the tumor. Here two classifiers are chosen to test the classification accuracy (Linear and quadratic). The outlier used in the dataset has no effect on classification accuracy. The methods include data pre-processing, dimension reduction, feature selection and classification. Some features are selected using SFS (Sequential Feature Selection) algorithm. Two techniques are used in feature selection (Filter techniques and Warp techniques). There is a decrease in accuracy while SFS is used but the proposed system concentrates in reducing features not in increasing accuracy. Greater than 96% of accuracy is achieved only by using for features which is classified using QCF.

Marcus C. Araújo *et al.*[25] proposed a three-stage feature extraction approach and evaluate the practicality of using interval data in the Symbolic Data Analysis (SDA) framework. It is used to model the breast abnormality. This three-stage approach starts by obtaining variables from minimum and maximum temperature values, secondly continuous features are obtained by considering of the operators based on dissimilarities for intervals. Then finally, the input is fed into the classification algorithm after transforming the input (continuous features) by fisher's criterion. By using the proposed feature extraction approach, the results can be divided into malignant, benign and cyst in breast thermograms. The author has finally recommended thermography as an approving preliminary breast screening tool.

Sheeja V. Francis *et al.*[26] proposes a curvelet transform based feature extraction method for automatic detection of abnormality in breast thermograms. Features like statistical and textures are extracted from the thermograms and fed into SVM for automatic classification. The accuracy has been calculated as 90.91% and the usage of texture feature when extracted from multi resolution curvelet domain provides better latent when compared. The steps include Preprocessing and segmentation, Feature extraction in curvelet domain (uses curvelet transform) and classification. The result shows that curvelet based texture features are used to improve the efficiency of automatic detection of abnormality in breast thermograms.

Sourav Pramanik *et al.*[27] developed a new local texture feature extraction technique, called block variance (BV), for texture analysis in the thermal breast image. The classification performance is evaluated using a feed-forward neural network (FANN) with gradient decent training rule. The proposed feature is compared with the specific method and shows its efficiency. The method involves pre-processing, color conversion, Block Variance (BV) as texture Measure, classification of Blocks, feature extraction and feature Normalization. The proposed system is experimented using asymmetry analysis and results have shown that the projected technique provides noticeably good classification accuracy, sensitivity, and area under the ROC curve when compared. It also provides 100% true positive recognition at less than 0.1 false positive rates.

Survey on various classification methods:

Rafal Okuniewski *et al.*[28] carried out research on different classification algorithms which are used in thermographic images obtained from braster device. It is based on the approach of classifying contours visible on thermographic images of breast. Images are first classified using contours and then sec step of classification is carried out calculating its attributes.

These attributes are fed into four classifiers to get the final decision. The main algorithm considered is the discretization algorithm which is used by the Naive Bayes Classifier, the Decision Tree Classifier and the Random Forrest Classifier. The Naive Bayes Classifier has very high specificity, Support Vector Machine classifier has highest sensitivity and the Random Forest Classifier achieves good results both in terms of sensitivity and specificity. The segmentation algorithm used should be developed further and results may also be degraded with too large number of attributes.

Cruz-RamírezNicandro *et al.*[29] evaluated the diagnostic power of thermography in breast cancer using Bayesian network classifiers (a graphical model that represents relationships of a probabilistic nature among variables of interest). This paper tried to propose a score value which can be used as a threshold value to distinguish patients. Bayesian networks model does not only carry out a classification task, but it is also able to show interactions between the attributes and the class as well as interactions among the attributes themselves. The method results in high sensitivity but poor specificity.

Chiranji Lal Chowdhary *et al.*[30] provide a digital execution of a model based on an intuitionistic fuzzy histogram hyperbolization and probabilistic fuzzy c-mean clustering algorithm for early breast cancer detection. Developed rules were applied in classifier to detect about the presence of cancerous tumor in mammogram images. The classification accuracy is achieved up to 94% during training stage.

Vrushali Gaike *et al.*[31] attempted up to using 7th order in GLCM (Gray Level Co-occurrence Matrix) and observed the results by analyzing the effects of higher order features in recognition of malignancy in breast mammogram. The GLCM technique is used to compute sec-order statistical textural features. This includes preprocessing, GLCM feature extraction and classification. Four different classifiers (SVM, MLP, KNN and Adaboost) are used. The classification result with Adabosst gives better result when compared. The study indicates that inclusion of higher order GLCM features do contribute in improving the classification percentage.

AmirEhsan Lashkari *et al.*[32] presented a fully automated technique to help physicians in early detection of breast cancer. It starts with finding Region of Interest (ROI) to improve the quality of image. Then feature extraction is done by some known features like statistical, morphological, frequency domain, histogram and grey-level co-occurrence matrix which is extracted from segmented right and left breasts. The accuracy of the proposed method is increased by selecting features selectors such as minimum redundancy and maximum relevance, SFS, SBS, sequential floating forward selection, sequential floating backward selection and genetic algorithm. For classification purpose supervised learning algorithms such as AdaBoost, support vector machine, nearest neighbor, Naïve Bayes and probability neural network are applied and compared with each other. The proposed method is examined with all combinations and

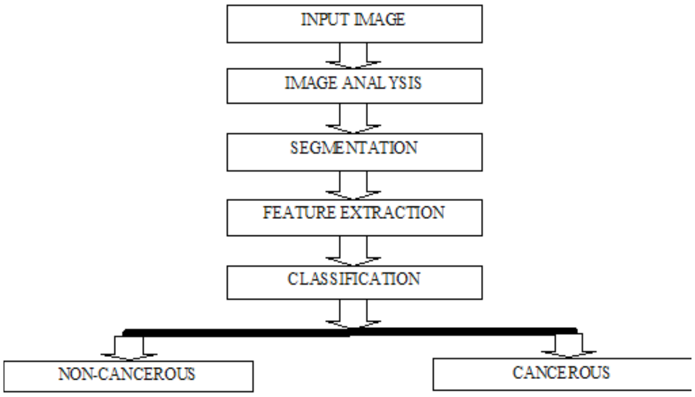

Figure 1: General flow chart for analysis of images.

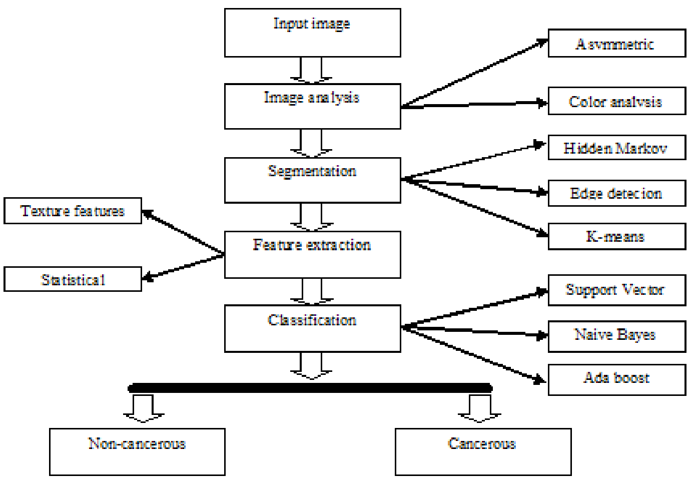

Figure 2: Flow chart for image analysis in thermogram with efficient techniques.

resulted with better efficiency. Figure 2 represents a image and their analysis to the core .The image has segmented into different pieces for feature selection. The classification has been made by different techniques and methodologies. The same has exhibited in the diagram.

G. Lalli *et al.*[33] have developed a computerized scheme for predicting early-stage micro-calcification clusters in thermogram. It uses Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance the color and gray channels of the thermographic images. Genetic algorithm is used to select the optimal set of features which need to be fed into the Adaptive Neuro-Fuzzy Inference System (ANFIS) for classification of images into normal, suspect and abnormal categories. The convergence time of the proposed system is used for evaluation purpose and experimental results give the satisfied output. The proposed approach has combined the adaptive capabilities of neural network and the qualitative approach of fuzzy logic capably. Thus, the proposed system is evaluated for limited set of images and can give acceptable results when the rate of misclassifications is considered.

Ryuei Nishiia *et al.*[34] considered MRF for image classification where it adopts Jeffreys divergence between category-specific probability densities. It is an extension of Switzer's soothing method, which is applied in remote sensing and geospatial communities. Gaussian MRFs and error estimates includes relationship between the divergence model and Switzer's model and Error rates due to divergence model and Switzer's model. The proposed model exhibits a better performance than that of the Potts model. Ahmed B. Ashraf *et al.*[35] presented a framework for multichannel Markov random fields (MRFs). This paper shows that conditional independence allows loopy belief propagation to solve a multichannel MRF as a single channel MRF. Presented an honorable way for choosing conditionally independent features as different channels in the MRF observation model using conditional mutual information. This study has proved that the superior segmentation leads to improved feature extraction and tumor characterization. The multichannel MRF involves Inference in Multichannel MRFs and multichannel MRF based on DCE-MRI kinetics includes candidate feature channels, MRF representation-Super pixels, feature choice for multichannel MRF and training-learning node Potentials. The segmented results are compared with other segmentation algorithms like normalized cuts, fuzzy C-means etc. SVM classifier is used for final result and it gives comparatively better performance.

M. Etehad Tavakol *et al.*[36] compared contra lateral breast images which involves asymmetric thermal distribution. The proposed idea discussed about mutual information and nonparametric windows to estimate the joint histogram for a pair of images. Nonparametric windows give in accurate histogram. It incorporates an interpolation model which enhances the resolution to a highly oversampled image. The results are obtained only from set of 60 thermal images.

Gerald Schaefer *et al.*[37] performed a breast cancer analysis based on thermography, using a series of statistical features extracted from the thermograms. The bilateral differences between left and right breast areas are used as a quantifying parameter and a fuzzy rule-based classification system is used for analysis. A classification accuracy achieved is about 80%. Breast thermogram feature analysis involves basic statistical features, moments, histogram features, cross co-occurrence matrix, mutual information and Fourier analysis. Fuzzy rule-based classification makes use of fuzzy rule generation, fuzzy reasoning and rule reduction techniques. Statistical features obtained from asymmetry analysis are fed into fuzzy if-then rule-based classification system to provide the final output.

Hossein Pourghassem *et al.*[38] proposed a hierarchical medical image classification method using both shape and texture features. They also proposed a tessellation-based spectral feature and directional histogram. It also uses merging scheme and Multilayer Perceptron (MLP) classifiers and homogeneous classes. The algorithm is evaluated using 9100 medical X-ray images of 40 classes. It provides accuracy of 90.83% (25 merged classes in first level) and it can also be increased to 97.9% if best cases were considered. Medical X-ray image classification involves feature extraction, feature selection, multi-layer perceptron classifier and the merging based hierarchical classification. The classification performance is improved by the proposed concept.

Xiao Bai *et al.*[39] recommend a SoftMax regression-based feature fusion method by learning different weights for different features. The assessment of object-to-class similarity measures and the conditional probabilities that each object belongs to different classes is enabled by the fusion method. The class-to-class similarities between unlike classes are calculated using approximate method. Support vector machine classifier is built by integrating obtained results from fusion and similarity methods into a marginalized kernel. The constructed model is evaluated on Quick Bird imagery. Feature fusion with marginalized kernels involves various steps like object representation, feature fusion using SoftMax regression, class-to-class similarity and new marginalized kernel. The proposed method is evaluated, and the obtained result has outperformed the baseline SVM and LRFF methods.

Gerald Schaefer *et al.*[41] confer three different strategies for constructing classifiers i.e. an ensemble constructed of cost-sensitive decision tree classifiers, an ensemble whose base classifiers are trained on balanced subspaces, and an ensemble that is based on the combination of one-class classifiers. The performance is carried out initially by image analysis (to identify features describing bilateral differences in regions of interest in the thermogram). Then these are fed as input for a pattern classification stage (where several strategies are addressed to the existing class imbalance in the context of ensemble classifiers). The study provides three strategies to overcome inherent class imbalance.

Gerald Schaefer [41] has projected an approach to analyze the breast thermograms. Initially it extracts a series of image features which shows asymmetry between left and right breast. Then obtained results are fed into the classification system which is designed using an ant colony optimization based pattern recognition algorithm which provides a short rule base with superior classification performance. Ant colony based classification engage Ant colony optimization (ACO), ACO based classification (using Ant-Miner algorithm), cAnt-Miner algorithm (Discrete intervals are created on-the-fly which reduce pre-processing). The proposed combinational method provides good diagnostic performance based on a compact rule base.

CONCLUSION

The study reveals the effectiveness of thermography over other diagnosing techniques and also surveyed about various segmentation and classification methods used for the detection of breast cancer. Thermography provides functional information on thermal and vascular conditions of the tissue rather than structural characteristics like any other breast cancer detection techniques. There is no one screening tool currently available that provides 100% predictability unless biopsy. The limitations of thermography like false-positive and false-negative can be reduced further by using appropriate combination of the feature extraction technique, type of the segmentation and classification algorithm.

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