# PERFORMANCE EVALUATION OF LEARNING ALGORITHMS ON BPN BASED AUTOMATIC ABNORMALITY CLASSIFIER FROM BREAST THERMOGRAPHS

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## ABSTRACT

High mortality arte due to breast cancer can be reduced if it is diagnosed at the early stage. Clinical Infrared Thermography is a non-contact, non-invasive, non-hazardous technique which is widely accepted as reliable tool for early detection of breast cancer. It maps the heat emitted from the region into thermal patterns called thermographs. Thermographs of a normal person show uniform and symmetrical pattern. On the other hand thermographs of affected persons result in non-uniform and asymmetrical thermal patterns. Interpretation of these thermographs helps in identifying the abnormality and classifying the same. In this paper the impact of learning method on the performance of automatic classifier system based on BPN is studied in terms of Mean Square Error. Levenberg-Marquardt method provides better accuracy with the least Mean Square Error.

**Keywords:** Levenberg-Marquardt, Scaled Conjugate Gradient, BPN, normal, fibroadenoma, cancer

## I. INTRODUCTION

Breast cancer is the most commonly occurring disease in women and the mortality rate due to breast cancer is high [1-3]. Breast cancer becomes fatal when detected in the last stages of development as it can not be treated. On the other hand, early detection of breast cancer can reduce the mortality rate. Clinical Infrared thermography is now accepted as the reliable technique for early detection of breast cancer. Infrared thermography is a non-contact, non-invasive and non-hazardous technique that maps the temperature distribution into thermographs. For normal cases, temperature is uniform throughout the region and is symmetrical for left and right halves. On the other hand, an abnormality results in abrupt temperature variation and hence introduces asymmetry [1-5].

The underlying principle for thermal asymmetry is that cancer cells require large amount of nutrients for its growth hence resulting in higher metabolic activity around that region. As a result temperature increases in that area when compared to the other regions [4]. Severity of the disease can be determined by measuring the temperature variations in the abnormality region. Due to recent advances in Infrared technology, specifically designed focal array planes are available for obtaining high quality thermographs.

These thermographs are sent to human interpreters for abnormality characterization and classification. But human interpretation of thermograph is subjective in nature as it is dependent on the expertise of the individual and may at times result in misinterpretations as cancer and fibroadenoma may appear nearly similar to human. Hence automated analysis is aimed at and extensive research is carried out in computer aided classification of thermographs. It involves three phases namely suitable feature extraction techniques for abnormality region isolation, proper choice of statistical parameters for abnormality detection, and development of soft computing tool for decision making and classification of cancer (normal, benign or malignant). However an image segmentation technique that could isolate only the abnormality region by completely removing the undesirable artifacts (similar characteristics) has not yet been developed. Though considerable research is done in describing the abnormality with feature vectors, suitable descriptors are yet to be defined. Also the effectiveness of the neural based classifier lies in appropriate training and feature vector selection. In this paper BPN based classifier has been developed for classifying the abnormality. The performance of the network is analyzed for different learning methods namely Adaptive Learning rate, Scaled Conjugate Gradient, Variable Learning rate and Levenberg-Marquardt learning methods is student and the optimum learning method is decided.

Section II discusses the related work. Section III describes the image dataset used in this work. Section IV describes the proposed BPN architecture and the impact of learning methods for classification of abnormality. Results and Discussion is dealt in Section V and Section VI concludes the work.

## II. RELATED WORK

In recent years automated analysis tools for breast thermograph interpretation and description are developed. Negin et al (1977) proposed a computerized breast thermographic interpreter that takes decisions through linear discriminant classifiers based on extracted features [6]. Head et al (1997) used second generation Amber Indium Antimonide focal plane staring array system to acquire breast thermographs. Sensitivity and resolution of these thermographs are high and hence asymmetric analysis can be performed more easily on these thermographs [7]. They also found that the upper outer quadrant of the breasts is the most probable area for tumor growth. Qi et al (2000) found that the difference in histogram curvature of the left and right breasts is used as a measure for abnormality identification [8]. Yang et al (2007) analyzed the breast thermographs based on temperature distributions between the left and right breasts. In normal cases, the histograms of the left and right breasts are symmetrical in contrast to asymmetrical histograms in abnormal breasts [9]. Tang et al (2008) proposed an automated analysis technique for breast cancer detection based on measuring Localized Temperature Increases (LTI). LTI is calculated as the difference between the pixel temperature and the corresponding background temperature. They found that there is a significant difference between benign and malignant cases in terms of LTI amplitude [10]. Nurhayati et al (2010) proposed an automated algorithm based on first order moments for abnormality detection in breast thermographs. Initially thermographs were deblurred using Weiner filter, contrast enhancement is done by histogram equalization, abnormality is detected by segmentation and is described using the first order moments namely mean, variance, skewness and kurtosis. Based on these parameters, abnormality detection is achieved [11]. Scales et al (2010), Kapoor et al (2010), Wang et al (2010) proposed automated analysis for breast cancer detection which involved Hough Transform, boundary detection and asymmetry analysis based on skewness, kurtosis and histogram [12-14]. Nurhayati et al (2011) developed an automated breast cancer classification tool by combining five statistical parameters namely mean, variance, entropy, Skewness, kurtosis, eigen values, eigen vectors and covariant matrix (Principal Component Analysis) [15]. Zadeh et al (2011) found that for their set of thermographs from a specific IR camera, tumor cells correspond to pixels in Pseudocolor thermographs with Red intensity, $R_T$>100, Green and blue intensities $G_T$&$B_T$<20 [16]. Drosu et al (2006) proposed an ANN based approach for determining the shape of the abnormality from breast thermographs based on the principle that malignant tumor leads to a change of the volume distribution of the losses inside the breast tissue. They also inferred that the shape of the abnormality can be correlated to the temperature distributions on the breast surface. A square functional of the difference for tumor was obtained by minimizing the function through gradient procedure. They also used ANN for minimizing the gradient function. Ng and Kee (2008) proposed an ANN based integrated approach for classification of abnormality from breast thermographs. In this method, linear regression, Radial Basis Function Network (RFBN) and Receiver Operating characteristic (ROC) curves were used to analyze thermographs. Linear Regression is used to decide the most significant features that can be used as inputs to the neural networks. After training RFBN gives an output as 1, if the abnormality is present and 0 if the abnormality is absent. ROC was used to evaluate the accuracy, sensitivity and specificity of the outcome of RFBN. Though the proposed method provided better results, it could not specify the actual location and size of the tumor. Wishart et al (2010) proposed an Artificial Intelligence based system for the interpretation of breast thermographs. They used a total of seven parameters for describing the abnormality. Of which four parameters described the temperature distribution between the left and right breasts, three parameters were used for determining the excess heat in individual breasts. They used Artificial Neural Networks to obtain the severity of the disease.From the literature, it is found that better results can be obtained if the abnormality is isolated properly and is described with suitable parameters.

## III. IMAGE DATASET

An image dataset has been initially created with nine breast thermographs (2 for normal cases, 3 depicting cancer and 4 depicting fibroadenoma). The size of these thermographs is 165x220. From rigorous subjective analysis of these thermographs it is understood that thermographs of normal cases is symmetrical and uniform in nature. On the other hand, if there is an abnormality either as fibroadenoma or breast cancer, the temperature distribution between the left and right breasts and also there is an abrupt variation in the affected regions. Also from the analysis it is found three degree rise in temperature from the surroundings corresponding to the abnormality. Intensities of tumor/ fibroadenoma are Fr (x,y) = 255 and Fb (x,y) >= 33 and Fg (x,y) >= 33. The color coding used for pseudocoloring is shown in Fig. 1. Abnormality is coded with red and white intensities. Fig. 2 describes the cancer and fibroadenoma thermographs. The desirable regions are shown by arrow marks. Fig. 3 represents the normal person. It does not show any significant variation in temperature and the left and right halves are symmetrical.

Fig. 1. color coding

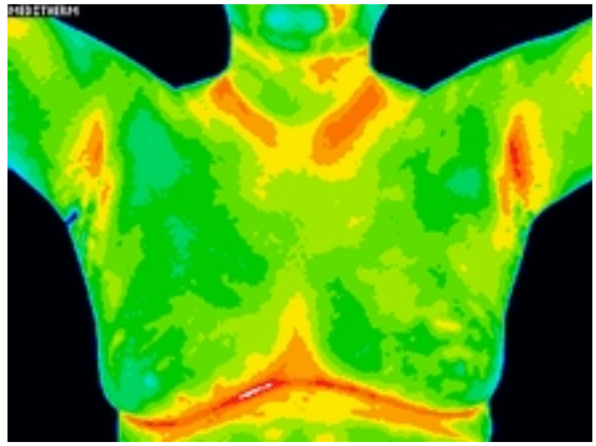

Fig. 3. Thermograph of a normal person

## IV. SLOPE BASED SEGMENTATION AND ABNORMALITY DESCRIPTORS

The proposed method involves developing a suitable segmentation algorithm for detecting the abnormality and identifying the effective set of statistical and regional descriptors for describing the abnormality. In the proposed work, slope based segmentation technique has been used for extracting the abnormality region. After a rigorous literature survey, a set of statistical and regional descriptors have been identified. In addition to the conventional descriptors, central moments and histogram based parameters were also used for effectively describing the abnormality. In the

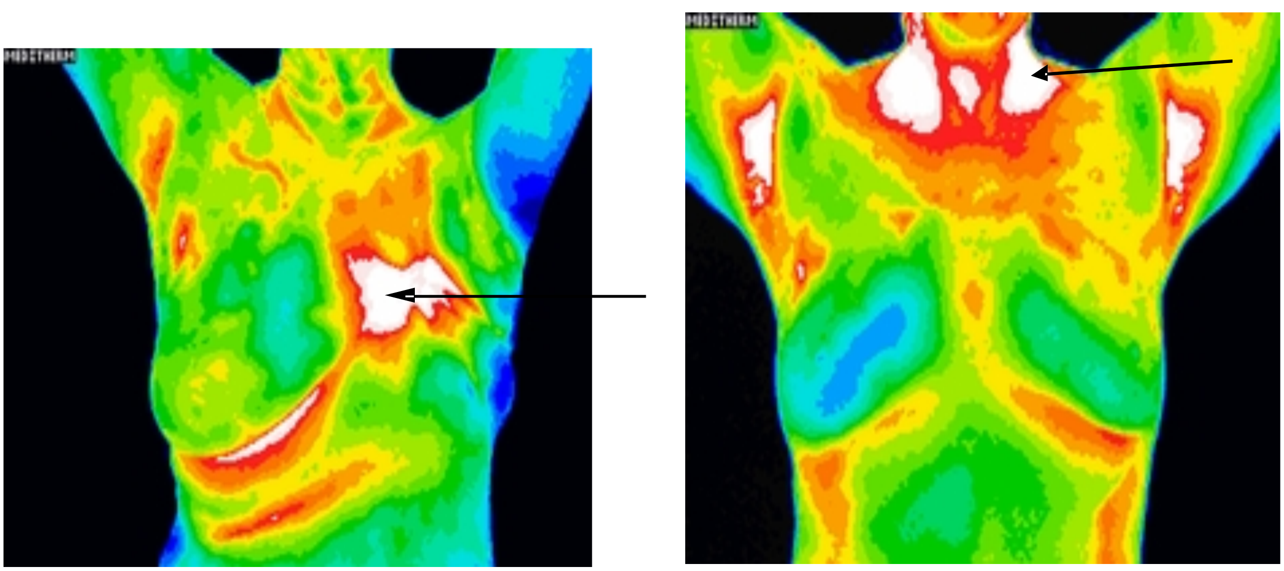

Fig. 2. Cancer and fibroadenoma thermographs

proposed technique, the edge points are determined using slope gradient based segmentation.

Back Propagation Network is the widely used network for classification due to its generalization capability. Five layered feed forward network architecture is chosen with three hidden layers and one output layer. Of the various choices, it is found that for this particular application, the number of hidden layer neurons is 20, 10 and 5. 'Tansigmoidal' is the training function chosen for all the layers excepting the output layer. 'Purelinear' is the function chosen for output layer as real time outputs are needed. Supervised learning based on Gradient Descent is chosen for training the neural network. The learning and the momentum parameters are fixed as 0.6 and 0.9. The network is then trained with four different learning methods namely Adaptive Learning rate, Scaled Conjugate Gradient, Variable Learning rate and Levenberg-Marquardt.

Exemplars are created with 17 input parameters and one output parameter. The input parameters are carefully chosen to describe the abrupt rise in temperature and hence the intensity variation (if any) in the affected region, asymmetry due to abnormality, shape of the abnormality region and size of the abnormality region. The metrics used for the above are entropy of histograms of the left and right halves (indicates the rise in temperature), absolute difference in entropy, mean, variance between the left and the right halves, skewness and kurtosis (asymmetry metrics), second order central moments (shape metrics) and area, major axis length and minor axis length (size metric) Normal (absence of abnormality) is coded as 1, Fibroadenoma as 2 and cancer as 3. These codes are used as output parameters for training the neural network. These values are normalized to facilitate better training.

## V. RESULTS AND DISCUSSION

The gray scale and the corresponding output thermographs from slope based segmentation are shown for normal, cancer and fibroadenoma thermographs in Fig. 4-6. The proposed segmentation technique has effectively removed the undesirable artifacts and has retained only the abnormality region in its original form.

Fig. 4. Gray scale and segmented images (normal)

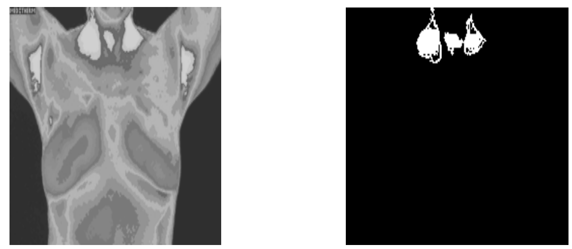

Fig. 5. Gray scale and segmented images (Fibroadenoma)

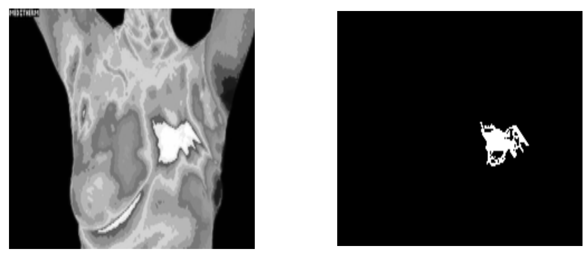

Fig. 6. Gray scale and segmented images (cancer)

The relationship between the desired and the actual outputs for Adaptive Learning rate, Scaled Conjugate Gradient, Variable Learning rate and Levenberg-Marquardt learning methods are shown in Fig. 7-10.

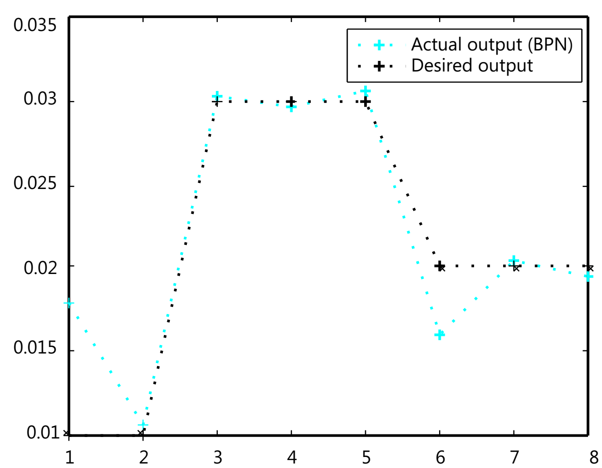


Fig. 7. Relationship between desired output and actual output (BPN) (Adaptive Learning rate)

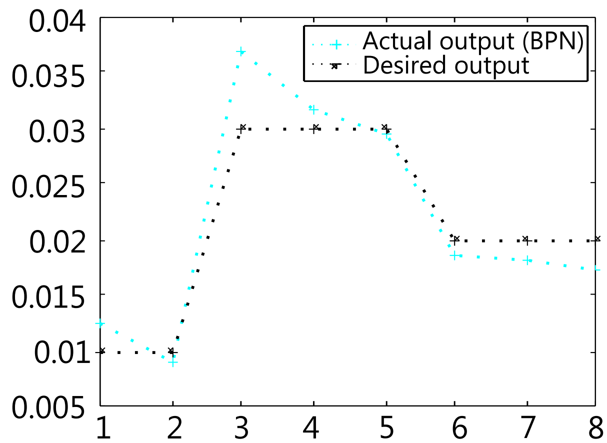


Fig. 8. Relationship between desired output and actual output (BPN) (Scaled Conjugate Gradient Learning)

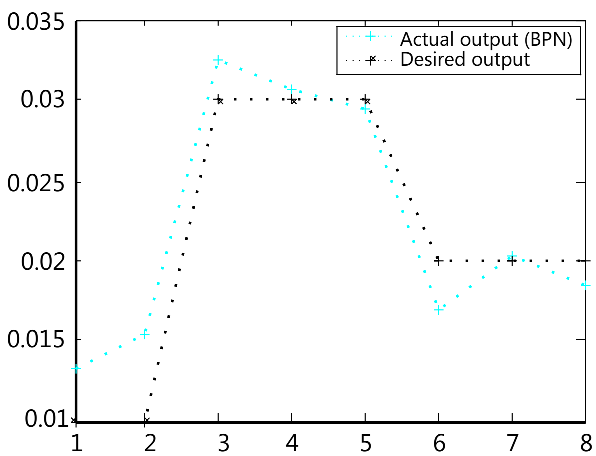


Fig. 9. Relationship between desired output and actual output (BPN) (variable Learning rate)

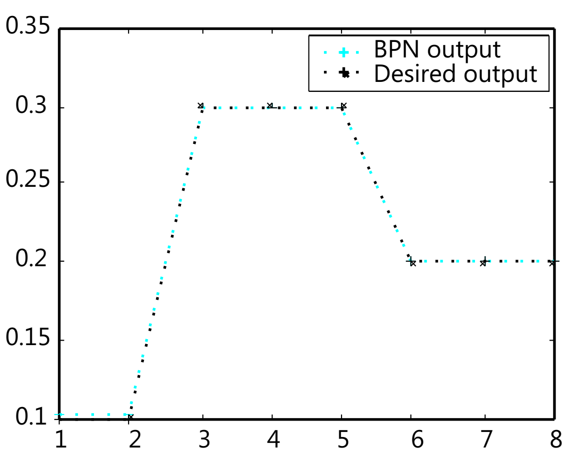


Fig. 10. Relationship between desired output and actual output (BPN) (Levenberg-Marquardt)

From the figures, it is found Levenberg-Marquardt method provides better correlation between the desired and the actual outputs. The desired output and the actual output (from BPN) for Adaptive Learning rate, Scaled Conjugate Gradient, Variable Learning rate and Levenberg-Marquardt learning methods are shown in Table 1. Mean Square Error is calculated for all the above learning methods and is tabulated in Table 2.

**Table 1: Impact of Learning Algorithm on the performance of BPN based Classifier**

| Desired output | Actual output from BPN | | | |
|---|---|---|---|---|
| | Levenberg-Marquardt | Adaptive learning rate | Variable learning rate | Scaled Conjugate Gradient |
| 0.01 | 0.01000 | 0.0179 | 0.0132 | 0.0125 |
| 0.01 | 0.01001 | 0.0104 | 0.0154 | 0.0089 |
| 0.03 | 0.03002 | 0.0303 | 0.0324 | 0.0370 |
| 0.03 | 0.02999 | 0.0296 | 0.0306 | 0.0317 |
| 0.03 | 0.03000 | 0.0307 | 0.0295 | 0.0293 |
| 0.02 | 0.02000 | 0.0160 | 0.0169 | 0.0186 |
| 0.02 | 0.01996 | 0.0205 | 0.0202 | 0.0183 |
| 0.02 | 0.01997 | 0.0195 | 0.0183 | 0.0175 |

**Table 2: Impact of Learning Algorithm on the performance of BPN based Classifier (MSE)**

| Parameter/ training method | Levenberg-Marquardt | Adaptive learning rate | Variable learning rate | Scaled Conjugate Gradient |
|---|---|---|---|---|
| Mean Square Error | 3.5552e-008 | 9.8877e-006 | 7.2718e-006 | 8.8551e-006 |

From Table 1, it is found that Levenberg-Marquardt provides accurate results than the other methods. Also the Mean Square Error is less for Levenberg-Marquardt learning method. Hence Levenberg-Marquardt is the best suited learning method for better classification network.

## VI. CONCLUSION

In this paper, an automated breast cancer classifier with higher accuracy (less Mean Square Error) has been developed using Back propagation Network. The performance of the network is compared for four different learning algorithms. Levenberg-Marquardt learning algorithm provides better result when compared to other learning methods. The performance of the classifier can be improved by choosing various other networks such as ART, Simulated Annealing etc.

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