Recognition of Breast Cancer Using Hybrid Method

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Abstract

In this paper, a computer aided diagnosis [CAD] system has been developed for tumor detection in digital mammography. The system consists of four parts: first enhance the image, second Feature extraction using six decomposition levels of two dimensional Discrete wavelet transform (2DWT),the features are extracted from regions of interest(ROI), third Reducing the features extracted using two algorithm energy root mean square and mean algorithm of each set of coefficients in each decomposition level, fourth classification of tumor using three layers artificial neural network (ANN) with (19) features is proposed for classifying the marked regions into benign and malignant.

Experiments are done on 63 benign tumors and 52 malignant one. The recognition rate of the malignant tumor is (96%) while that of the benign ones is (100%). The result shows that the proposed method can classify the breast tumors effectively when using root mean square algorithm.

Keywords: Recognition, Breast Cancer, Artificial Neural Network, root mean square.

تمييز سرطان الثدي باستخدام الطريقة الهجينية

لؤي سالم يحيى
المعهد التقني في الموصل

الخلاصـــــــة

في هذا البحث ، تم تطوير نظام للكشف عن الأورام الموجودة في الصـور الرقميـة للثدي بمسـاعدة الحاسبة .النظام مكون من أربعة مراحل : الأولى تحسين الصورة , الثانية استخلاص الخصائص باستعمال ستة مستويات للتحليل وباستخدام التحويل المويجي المقطع ثنائي الأبعاد لاستخلاص الخصائص من منطقة الورم ، الثالثـة تقليل حجم الخصائـص المستخلصة باسـتخدام طريقتين المعدل وحزم الطاقـة (جذر متوسط التربيع) لكل مجموعة من العوامل ولكل مسـتوى من مستويات التحليل ، الرابعـة تصنيف الـورم (خبيث أو حميد) باستخدام الشبكة العصبية الاصطناعية مكون من ثلاثة طبقات لتصنيف متجه الخواص المحتوي على (19) معامل المستخلص من منطقة الورم .

أجريت التجارب على (63) نموذج لأورام حميدة و(52) نموذج لأورام خبيثة . نسبة التمييز للأورام الخبيثة (96%) بينما للحميدة (100%) .أظهرت النتائج للطريقة المعروضة كفاءة في تمييز أورام الثدي عند استعمال خوارزمية جذر متوسط التربيع .

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1- Introduction:-

Breast Cancer is a malignant tumor that has developed from cells of the breast , Breast cancer is one of the leading causes of deaths among women in many countries , only exceeded by lung cancer in Asian countries and recently in united states [1].

The International World Health Organization estimated that more than (1,050,000) women worldwide die of breast cancer in each year. In India, breast cancer accounts for (23%) of all the female cancer death[2], In Norway about 2100 new cases of breast and (800) deaths are registered each year [3].

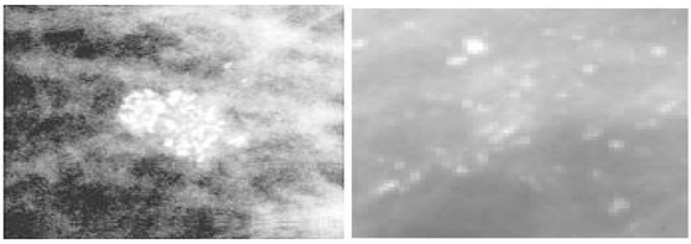
The most effective way to reduce breast cancer deaths is to detect it earlier. Mammography, ultrasound and thermal texture mapping systems are the main image techniques for its detection [4].

The screening program based on X- ray examination of breast ,mammography, is currently the best method for early detection. An increasing number of countries have started mass screening programs that have resulted in a large increase in the number of mammograms requiring interpretation. In the interpretation process radiologists carefully search each image for any visual sign of abnormality. However, abnormalities are often embedded in and camouflaged by varying densities of breast tissue structures. Indeed, estimates indicate that between (10% and 30%) of breast cancers are missed by radiologists during screening [5,6]. Moreover, the high percentage of negative cases, which is rated 70% to 90% of breast biopsies performed in women [7].

In order to reduce the cost and improve the accuracy of interpretation a variety of computer aided diagnosis (CAD) systems have been applied. In mammography there are two types of tumors:

1. Micro calcification, and
2. Masses or opacities.

Micro calcification clusters are groups of small and brilliant objects of different shapes and intensities in a very noise background. A micro calcification is a rather small objects (0.1 to 1)mm in diameter but very brilliant objects. Some of them, either grouped in clusters or isolated, may indicate the presence of a tumor. In our data base the average diameter of micro calcification clusters, as indicated by radiologists, is 2.3 cm [8]. In Fig.(1) micro calcification clusters are shown.



Fig(1): Some examples of micro calcifications selected from the data base

The mammographic masses are rather 'large objects' usually characterized by peculiar shapes. Masses can be characterized through density, shape, or type of margin. The typical sign of an invasive breast is an irregular or speculated density. Circumscribed lesions with well defined margins, on the other hand, are usually benign and may represent fibro adenomas, cysts or lymph node in Fig.(2) some mass lesions are shown [8].

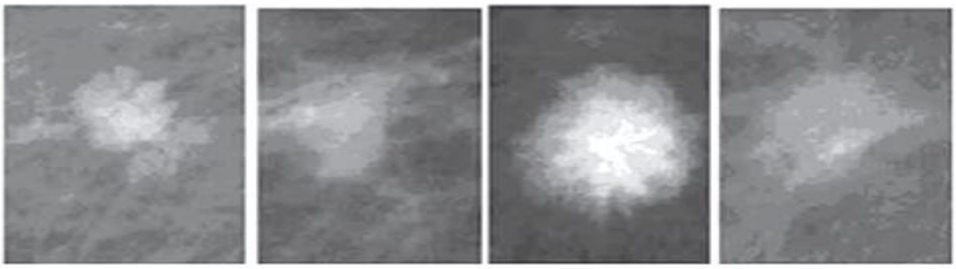


Fig (2): Some examples of mass lesions selected from the data base

Different methods have been used to classify the types of tumors such as benign or malignant, also, many segmentation and feature extraction algorithms have been developed during the past decades for breast cancer detection. J.Salavado et –al [9] used the wavelet transform (WT) for noise removal and improving the image contrast, the authors applied the (WT) using Daubechies 6 coefficients with (10) decomposition levels to separate the high frequencies from the low frequencies of the tissue in the mammograms.

Essam et-al [10] proposed a supervised classifier for digital mammography's using (WT) decomposition, they used Daubechies 4, 8, and10 as the wavelet using four different decomposition levels. They obtained the beast results with Daubechies 8, with 91% for cases of benign detection and 100% for cases of malignant detection .

Y.Ireaneus Anna Rejani and S.Thamaraiselvi[11] used three level wavelet for smoothing and fractal analysis to obtain the suspicious area and back propagation for classification. T.Balakumaran et-al [12] proposed micro calcification detection method involving image DE noising using wavelet-based multiscale product thresholding, image enhancement by adaptive operator integrated in the wavelet domain, and micro calcification detection using Neural Network.

F.Paulin and Asanthakumaran[13] used various machine learning techniques for back propagation algorithm. The highest accuracy of 99.28% was achieved when using lerenberg marquardt .

Dr.V.Saravanan et-al[14] he studied various data mining models including Fuzzy C means, decision tree, and Neural Network were used to compare with genetic algorithm model by evaluating prediction accuracy.

Dr Mohammed J.Islam et-al [15] used the statistical features extracted from region of interest [ROI] and neural network to classify mass tumor between benign-malignant.

In this paper, use six decomposition levels of (2DWT) for specific locations are used to extract the region of interest (ROI), reduce the coefficients of wavelet by taking the energy and mean value of each set in each level, therefore each level is represented by three features and the last level is represented by four features Two features vectors are extracted from region of interest of mammograms, the first one represent the mean value and the second represent the energy value. These vectors are used to train multilayer back propagation neural network for mammograms diagnosis.

2-Proposed Algorithm

The principle stages of computer aided breast cancer detection that is used in this paper is shown in Fig.(3).

The accuracy of the proposed system is measured using two parameters:
Specificity and sensitivity, which can measure accuracy using the equation given below[8]:

$$\text{Specificity (SP)} = T_N / (T_N + F_P) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$\text{Sensitivity (SN)} = T_P / (T_P + F_N) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where, T_P is the rate of true positive, T_N is the rate of true negative, F_P is the rate of false positive, and F_N is the rate of false negative [16].

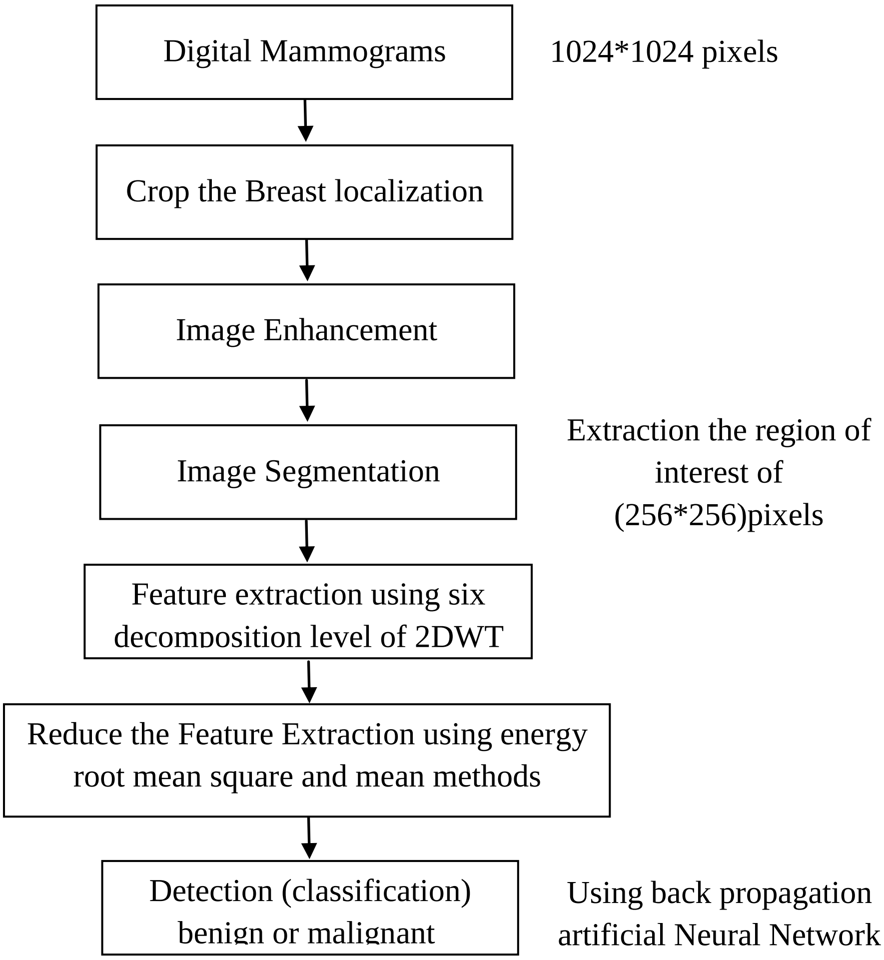


Fig.(3): Block diagram of the system

Achieving high specificity means that few cases will be unnecessary recommended for biopsy. While a high sensitivity means that few cancer tumors will be missed. The most important parameter is sensitivity since errors in recognizing cancerous lesions are life-threatening. Errors in recognizing (TNs) are not life-threatening but they do cause stress, anxiety, waste of resources, and may be waste of money [10].

3- Data base

The data base that is used in the experiments is taken from the Mammographic Image Analysis Society (MIAS) [17].The abnormal cases are (115), consisting of (63) benign and (52) malignant. This data base contains the diagnostic opinion for each of the mammograms include in it. In addition, the abnormal cases are further divided in six categories: micro calcification, circumscribed masses, speculated masses, ill-defined masses, architectural distortion and asymmetry.

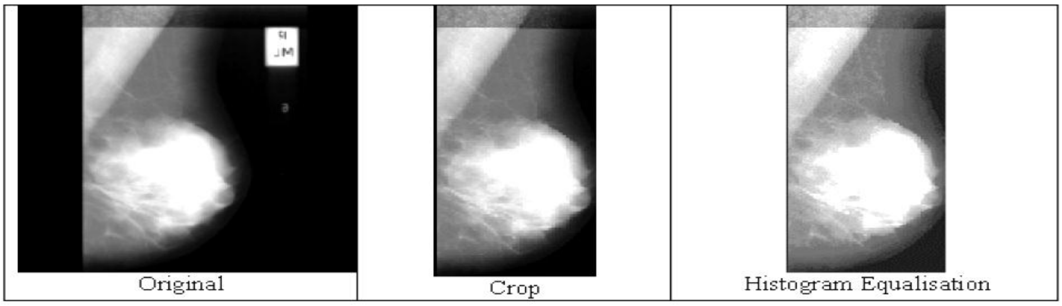
All the images also include the locations of any abnormalities that may be present. The existing data in the collection consists of the location of the abnormality (like the centre of a circle surrounding the tumor), its radius, breast position (left or right), type of breast tissues (fatty, fatty-glandular, and dense) and tumor type if exists(benign or malign).

4-Pre-processing:-

Mammograms are images difficult to interpret, and preprocessing of the images is necessary to improve the quality of the images and make the feature extraction more reliable. In the digitization process, noise could be introduced that needs to be reduced by applying some image processing techniques.

Two techniques are applied here: Cropping operation and image enhancement. The first one is employed in order to cut the black parts of the image as well as the existing artifacts such as written label etc. The second one is used to prepare the cropped area to be suitable for image transforming and feature extraction.

Cropping remove the unwanted parts of the image usually peripheral to the area of interest. An example of cropping that eliminates the artifacts and the black background is given in figure(4). The cropping to eliminate noise is done first before the image enhancement to avoid enhancing noise and hindering the cleaning phase. The cropping operation is done automatically by sweeping through the image and cutting horizontally and vertically the image parts that had mean less than certain threshold.



(a) (b) (c)

Fig(4) : Image processing (a):Original (b):Cropping (c):Histogram Equalization.

The enhancement stage is accomplished by contrast stretching and histogram equalization in succession. The contrast stretching is the simplest method to increase the contrast of the image and to adjust the histogram so that there is a greater separation between foreground and background gray level distribution. Applying contrast enhancement filters improve the readability of low contrast area in the image. Also they destroy areas of the image where intensity of the pixels is outside the range of intensities being enhanced [18].

Histogram Equalization is useful to produce output images that are easily analyzed by the human eye. It modifies the image such that its histogram has a desired shape. This is useful in stretching the low contrast levels with narrow histograms.

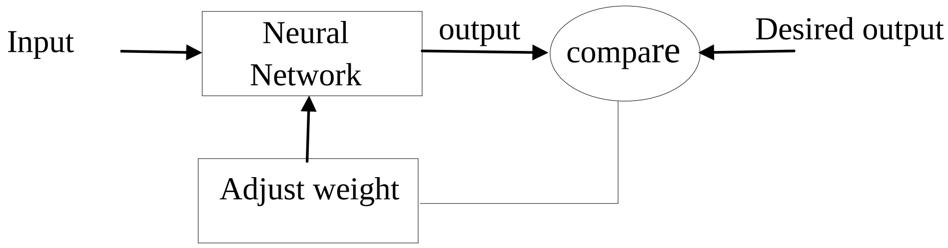
The uniform distribution of the histogram, is considered as probability distribution, it achieves the maximum entropy which contains the most information. Therefore, redistribute the gray levels to obtain a uniform histogram as possible, and then the image information are maximized [18].

5-Wavelet based feature extraction:-

The theoretical of two dimensional DWT is found in [9, 11, 19]. 2-D DWT is used to extract features vector by applying six levels decomposition on the region of interest that contains the abnormal tumor. The(ROIs) are of size (256*256) pixels, and then the feature vector is reduced using the energy and mean of coefficients in each sub band in each level, therefore each (ROI) is represented by two feature vectors each one contains (19) coefficients.

6- Artificial neural network (ANN):-

ANN is a powerful tool to model complex data(including medical) with high classification accuracies. It resembles human brain in acquiring knowledge through learning and storing knowledge with in interneuron connection strengths. Ann's synaptic weights are adjusted or trained so that a particular input leads to a specific desired or target output, Fig(5) shows the block diagram for a supervised learning ANN, where the network is adjusted on the basis of comparing neural network output with the desired output until the network output matches the desired output. Once the network is trained it can be used to test new input data using the weights provided from the training section[15].



Fig(5): Block diagram of a supervised training ANN.

In this work, ANN utilizes a three-layer feed forward network with back propagation algorithm. The first layer has (19) neurons, the number of neurons in the input layer corresponds to the number of characters to be presented to the network. The number of neurons in the output layer corresponds to the number of classes for which is being trained, a single neuron in the output layer, when output "1" is malign and when output "0" is benign. The hidden layer consists of (10) neurons.

The back propagation algorithm is used. The interface made is designed for parameters as learning rate, moment, minimum error and variation in the architecture of intermediate layers, to be changed in the attempt of improving the performance of training. The tests are performed with training that gives minimum error. The function newff is used to create feed forward back propagation network. The architecture generally used in these application consists of tan-sigmoid function. The learning rate (0.1) is used, and the mean square error (MSE) value of (0.0001), and levenberg marquarght algorithm is used for training.

7-Experiments and result:-

The proposed method is implemented using MATLAB version 7.8 and tested on various mammogram images taken from (MIAS) mammogram data base . A set of (115) images that contain (63) benign and (52) malignant, region of interest (ROIs) of size (256*256) pixels are extracted from (MIAS) images which is originally of (1024*1024)pixels after making cropping, histogram equalization and contrast stretching. These (ROIs) are chosen to contain the abnormalities centered in each cropped image.

The diagnosis system consists of two basic steps, step one is done by applying (DWT) on (ROIs) for six levels of decomposition using Daubechies wavelet of order (4), this produces a approximation sub band and six sub bands of horizontal, vertical, and diagonal detailed coefficients. Then reducing the size of the input vector provided to the neural network, the mean value and energy value (Root mean square) is calculated for each set in each level of wavelet decomposition.

The mean value and energy value are calculated using equation (3)[15] and equation (4)[15] respectively

$$\mu = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j) \qquad \dots\dots\dots\dots\dots\dots. (3)$$

$$E = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[P(i,j)]^2} \qquad \dots\dots\dots\dots\dots\dots. (4)$$

Where P(i,j) is the coefficient value, at point (i,j) of a coefficients sub band of the size (M*N) in each decomposition level. Therefore two features vectors are obtained the first one represents the mean value in the following form.

$$F_\mu=[\mu A_k \quad \mu V_k \quad \mu H_k \quad \mu D_k \quad \mu V_{k-1} \quad \mu H_{k-1} \quad \mu D_{k-1} \quad \mu V_1 \quad \mu H_1 \quad \mu D_1]$$

k:- the last decomposition level of (DWT)

Where Fμ: Feature vector representing the mean values.

μA_k : the mean of low frequency coefficients(A) for last 2DWT level.

$\mu V_{k\dots1}$: the mean of vertical high frequency coefficients(V), for all levels.

$\mu H_{k\dots1}$: the mean of horizontal high frequency coefficients(H), for all levels.

$\mu D_{k\dots1}$: the mean of diagonal high frequency coefficients(D), for all levels.

The second features vector represents energy features for each DWT sub band in the following form:

$$F_E = [EA_k \quad EV_k \quad EH_k \quad ED_k \quad EV_{k-1} \quad EH_{k-1} \quad ED_{k-1} \quad EV_1 \quad EH_1 \quad ED_1\,]$$

Where F_E : Feature vector of energy value.

EA_k: the energy of low frequency coefficients of (A) sub band in last DWT level.

$EV_{k\dots1}$: the energy of vertical high frequency coefficients of(V)sub band in all levels.

$EH_{k\dots1}$: the energy of horizontal high frequency coefficients(H) sub band in all levels.

$ED_{k\dots1}$: the energy of diagonal high frequency coefficients (D) sub band in all levels.

Now we have two features vectors each with 19 elements, These are used for training the artificial neural network with properties given in section (6).

In practical evaluation of the diagnosis system, a set of (115) mammograms each with one region of interest that contains (malignant and benign)is utilized. Training of ANN uses 65 samples. While testing the ANN utilizes 50 samples, 25 for benign class, and 25 for malignant class.

The results for the reduced features vectors using mean and energy are shown in the tables (1) and (2). The results of sensitivity(SN) and specifity (SP) are obtained using equations (1) and (2).

Table(1): The sensitivity and specificity using mean value of wavelet coefficients.

T_P	T_N	F_P	F_N	S_N%	S_P%	Correct classification	
						Benign%	Malignant%
23	24	2	1	95.8	92.3	96	92

Table(2): The sensitivity and specificity using energy value of wavelet coefficients.

T_P	T_N	F_P	F_N	S_N%	S_P%	Correct classification	
						Benign%	Malignant%
24	25	1	0	100	96	100	96

For the test set using the energy of wavelet coefficients, it gives the best classification accuracy (100%) sensitivity , and (96%) specificity, while when using mean value of wavelet coefficients it gives (95.8%)sensitivity and (92.3%) specificity.

8-Conclusions:-

In this paper , a technique for detection of tumors (benign and malignant) in digital mammograms is developed . It reduce the false positive rate by reducing the unnecessary biopsy and health care cost as well.

The proposed method is effective in breast cancer detection environment and it gives (100%) sensitivity and (96%) specificity when using the energy algorithm for features vector reduction and (95.8%) sensitivity and (92.3%) specificity when using the mean algorithm for features vector reduction. This system is hoped to assist the radiologists in a better way for their diagnosis of early breast cancer detection.

The results has been compared with other results present by the previous study published by [10, 20, 21, 22], the recognition rate of the benign tumor is (100%, 89%, 90%, 97.5%) respectively while that of the malignant ones is [91.7%,92%,80%,91.84%] respectively. The proposed diagnosis system achieves good results in classifying the mammograms. The presented results appear as appositive achievement compared with previous results

References:-

[1] Ries,L., Eimer, M.,et-al "SEER Cancer Statistics Review 1975-2002" National Cancer Institute, BethesdyMD,2004.

[2] Barr E,"The Handbook of Artificial Intelligence", William Kaufmann, Los Altos, Vol. 1-3 ,1982.

[3] Noram, J., "Breath Cancer Screening by Mammography in Norway, Isit cost – effective?",Annals of oncology ,Vol.10,no.2,1999,pp.197-203.

[4] Yaan,Y.,et-al "Analysis of Breast Diseases Examination With Thermal Texture Mapping Mammography and Ultrasound". Proceeding of the 26th annual international conference of the IEEE EMBS, San Francisco ,CA, USA,2004,Pages 1166-1169.

[5] Baines ,C., et-al "The Rote of The Reference Radiologist: Estimates of Interobserver Agreement and Potential Delay in Cancer Detection in The National Screening Study ,"Investiga Radiol.,Vol.25, 1990,PP. 971-976.

[6] Wallis,M., Walsh, M. and Lee, J. "Areview of False Negative Mammography in Symptomatic Population , "Clin. Radiology , Vol. 44, 1991,PP. 13-15.

[7] Meyer,J.,et-al "Biopsy of Occult Breast Lesions: Analysis of 1261 Abnormalities, "J.Amer.Med.Assoc., Vol. 263,1990,PP.2341-2343.

[8] Giovann,L. "Compute Aided Detection on Mammography" Transaction on Engineering ,Computing and technology ,Vol. 15,ISNN 1305-5315, October 2006.
[9] Salvado, J., et-al "Detection of Calcification in Digital Mammograms Using Wavelet Analysis and Contrast Enhancement" Intelligent signal processing . IEEE International workshop on 2005,PP. 200-205.
[10] Rashed ,E., et-al "Multiresolution Mammogram Analysis in Multilevel Decomposition" Pattern Recognition Letters, Science Direct, El Sevier,Vol.28,2007,PP. 286-292.
[11] Rejani, Y., Thamarai ,S."Digital Mammogram Segmentation And Tumor Detection Using Artificial Neural Network" International Jornal of soft computing,Vol. 3,No.2: 2008,PP.112-119.
[12] Balakumaran,T.,et-al."Micro Calcification Detection Using Multiresolution Analysis and Neural Network" International Journal of Recent Trends in Engineering ,Vol.2, No.2,November 2009.
[13] Paulin,F., Santhakumaran, A. "Classification of Breast Cancer by Comparing Back – Propagation Training Algorithms"International Journal on Computer Science And Engineering(IJCSE) ,Vol.3,No.1,2011.
[14] Saravanan,V., et-al "ANovel Approach for Cancer Detection in MRI Mammogram Using Decision Tree Induction and BPN" International Journal of Image Processing, Vol.(4) Issue(6),2011.
[15] Islam,M., "An Efficient Automatic Mass Classification Method in Digitized Mammograms Using Artificial Neural Network" International Journal of Artificial Intelligence &Applications(IJAIA),Vol.1,No.3,July 2010.
[16] Cheng ,H., et-al "Computer –Aided Detection and Classification of Micro Calcifications in Mammograms Survey", Pat.Rec.,Vol.36,2967-2991,2003
[17] http://www.Wiau.man-ac.uk/services/MIAS/ MIAS web .html
[18] Gonzaleza, R., Woods, R. "Digital Image Processing "Prentice Hall ,3rd Edition,2008.
[19] Ferreira ,C., Borges,D. "Analysis of Mammogram Classification Using Wavelet Transform Decomposition "Pat.Rec.Let.,Vol.24,2003,pp.973-982.
[20] Yu,S.,et-al"Detection of micro calcification in digital mammograms using wavelet filter and Markov field model "Computerized Medical Imaging and Graphics,Elsevier,Vol.30,2006,pp.163-173.
[21] Juare Z,C.,et-al "Detection of micro calcification in digital mammograms images using wavelet transform " Proceeding, Electronics,Robotics and Automotive Mechanics Conference,IEEE Computer society, 2006.
[22] Song,L.,et-al" Micro calcification detection using combination of wavelet transform and morphology" signal processing 8th International conference on (ICSP), IEEE,Vol.4.,2006.

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