Neural Network Based Automatic Detection of Lesion Diagnosis in Mammogram Using Image Fusion

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Abstract— **Breast cancer is the second-most common and leading cause of cancer death among women. A Computer Aided Diagnosis (CAD) system for the classification of micro-calcification (tumor) lesions in mammogram images is presented in this work. The process uses tumor characteristics in mammogram images, such as shapes (circle or elliptical), sizes (2mm to 5mm), locations (distance from center) and intensities (pixel values) for the isolation of the tumor which depends on manual tracing by experts. This project proposes automatic mammogram tumor detection and isolation of tumor cells from mammogram images using image fusion and neural networks. The performance of the proposed algorithm is also compared to the existing methods. The system classifies the mammogram images as normal or abnormal, and abnormal severity as benign or malignant. The experiments results demonstrate that this approach can provide better classification rate. The evaluation of the system is carried on Mammography Image Analysis society (MIAS) database.**

Keywords— **CAD, Neural Network classifier, Mammography, SVM classifier.**

I. INTRODUCTION

Cancer has been one of the biggest threats to human life; it is expected to become the leading cause of death over the next few decades. Based on statistics from the World Health Organization (WHO), cancer accounted for thirteen percentage of all deaths in the world in 2004; deaths caused by cancer are expected to increase in the future, with an estimated twelve million people dying from cancer in 2030 .Of all the known cancers, breast cancer is a major concern among women. BREAST cancer is the most frequently diagnosed cancer and the leading cause of cancer death in females worldwide. To reduce the mortality of breast cancer screening programs have been introduced. Because early detection reduces the risk of metastatic disease these programs are a key to successful treatment. Currently, mammography is the most effective method for detection of breast cancer and early detection has proven to be an efficient tool to reduce the number of deaths.

It is the most demanding of all clinical imaging applications as it requires high contrast, high signal to noise ratio and resolution with minimal x-radiation.

According to studies, ten to thirty percentages of women having breast cancer and undergoing mammography has negative mammograms, i.e. are misdiagnosed. Furthermore, only twenty to forty percentages of the women who undergo biopsy has cancer. Biopsies are expensive, invasive and traumatic to the patient. The high rate of false positives motivate research aimed to enhance the mammogram images, to provide computer aided diagnostics tools that can alert the radiologist to potentially malignant regions in the mammograms and to develop tools for automated classification of mammograms into benign and malignant classes. Radiologists basically look for two types of patterns in mammography. They are micro-calcification and masses. The diagnosis result of tissue is classified into three categories: normal which represents mammogram without any cancerous cell, benign which represents mammogram showing a tumor, but not formed by cancerous cells and malign which represents mammogram showing a tumor with cancerous cells. This paper proposes automatic mammogram tumor detection and isolation of tumor cells from mammogram images using image fusion and neural networks.

II. BREAST CANCER AND MAMMOGRAPHY

A. Cell Division

The body is made up of tiny cells - for example, skin cells, muscle cells, heart cells, nerve cells, and bone cells. When a baby grows, the number of cells increases very quickly. A cell becomes a bit larger, and then divides into 2 "daughter" cells (Figure 2.1). After a period of time, each of these cells divides, and so on.
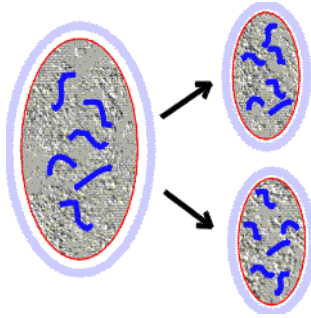
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Fig 1: cell division

1. Normal Cell Division

A cell grows a bit larger then divides in to 2 cells. Once a child grows to adulthood, the size of the body no longer increases. However, our bodies go through a lot of wear and tear, both inside and outside. Worn-out cells constantly need to be replaced, so cell division still takes place, but more slowly. An obvious "outside" change is the tiny bits of dead skin flaking off as the skin constantly renews itself. Although our bodies' cells continue to divide to replace worn-out cells, this happens in a very ordered, systematic way. The reason is that each cell carries genetic instructions that regulate how fast the cell should grow and divide and when the cell should die. A balance between cells growing and dying keeps our bodies functioning normally.

2. Abnormal Cell Division

Cell growths can be classified as either benign or malignant.

Benign growth: Sometimes a cell starts to grow without regard for the normal balance between cell growth and death, and a small, harmless (or benign), lump of cells will form. A benign growth can occur in any part of the body, including the prostate, skin, or intestine.

Malignant growth: In other cases, a cell may grow and divide with complete disregard for the needs and limitations of the body. Cells that have this aggressive behaviour are called malignant. They have the potential to grow into large masses or spread to other areas of the body. More commonly, a mass of such cells is called a cancer. When clumps of these cells spread to other parts of the body, they are metastases.

A cancer that continues to grow can eventually overwhelm and destroy the part of the body or particular organ where it is located.

B. Breast Cancer

Breast cancer is a disease in which certain cells in the breast become abnormal and multiply without control or order to form a tumor (malignant tumor). Although breast cancer predominantly occurs in women it can also affect men. Breast cancer may be invasive or noninvasive. Invasive means it has spread from the milk duct or lobule to other tissues in the breast. Noninvasive means it has not yet invaded other breast tissue.
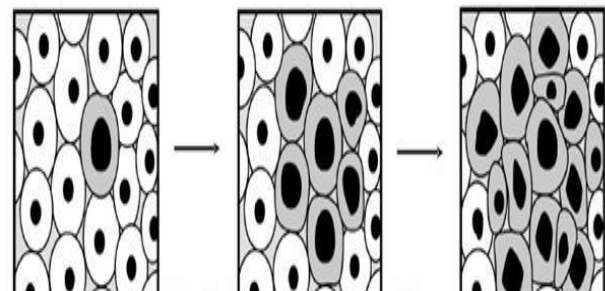

Fig 2: Malignant Growth of Breast cells

1. Stages of Breast Cancer

Stage I: This stage is where the tumor is less than 1 cm across, and has not spread into the surrounding areas.

Stage II: Stage II is when the cancer is anywhere from 1-2 cm across, and has spread into the surrounding areas including the lymph nodes (which must also be removed to prevent the further spread of the cancer)

Stage III: This is the stage for cancer in the advanced stages. It's more than 2 cm across and has spread to the lymph nodes. A type of cancer most associated with this is called inflammatory breast cancer, because the breast is inflamed because the cancer is blocking the lymph nodes.

Stage IV: In this stage, the cancer has spread past the breast and the lymph nodes and needs immediate treatment of chemotherapy and hormonal therapy to keep it under control. Then there is remission. If you are in remission you have an extremely high risk of reoccurrence with in the first 5 years after the last know cancer is killed.

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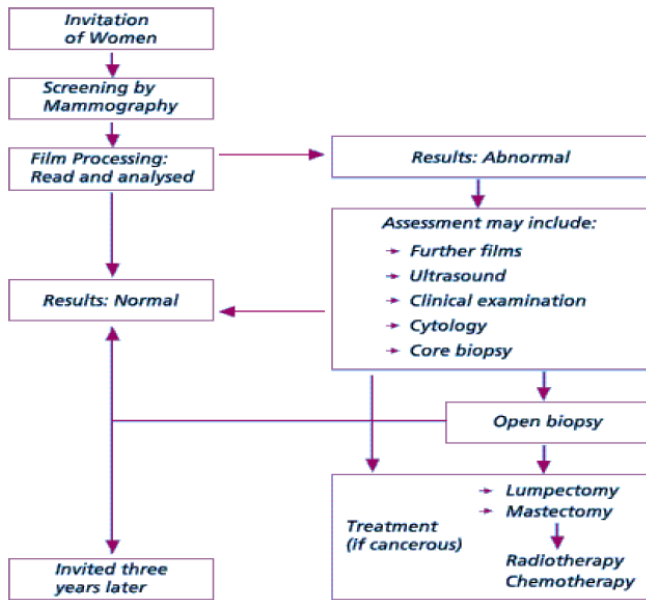
C. Screening

Fig 3: Screening

D. Mammography

Mammography is a specific type of imaging that uses a low-dose x-ray system to examine breasts. A mammography exam, called a mammogram, is used to aid in the early detection and diagnosis of breast diseases in women. Mammograms are used as a screening tool to detect early breast cancer in women experiencing no symptoms and to detect and diagnose breast disease in women experiencing symptoms such as a lump, pain or nipple discharge.

1. Different Types of Mammograms

Screening mammograms are done for women who have no symptoms of breast cancer. It usually involves two x-rays of each breast. Screening mammograms can detect lumps or tumors that cannot be felt. They can also find micro calcifications (my-kro-kal-si-fi- KAY-shuns) or tiny deposits of calcium in the breast, which sometimes mean that breast cancer is present.

Diagnostic mammograms are used to check for breast cancer after a lump or other symptom or sign of breast cancer has been found. Signs of breast cancer may include pain, thickened skin on the breast, nipple discharge, or a change in breast size or shape.

This type of mammogram also can be used to find out more about breast changes found on a screening mammogram, or to view breast tissue that is hard to see on a screening mammogram. A diagnostic mammogram takes longer than a screening mammogram because it involves more x-rays in order to obtain views of the breast from several angles. The technician can magnify a problem area to make a more detailed picture, which helps the doctor make a correct diagnosis. A digital mammogram also uses x-rays to produce an image of the breast, but instead of storing the image directly on film, the image is stored directly on a computer. This allows the recorded image to be magnified for the doctor to take a closer look. Current research has not shown that digital images are better at showing cancer than x-ray film images in general. But, women with dense breasts who are pre- or premenopausal, or who are younger than age 50, may benefit from having a digital rather than a film mammogram.

2. Mammography Equipment

Fig 4: Mammography Equipment

A mammography unit is a rectangular box that houses the tube in which x-rays are produced. The unit is used exclusively for x-ray exams of the breast, with special accessories that allow only the breast to be exposed to the x-rays. Attached to the unit is a device that holds and compresses the breast and positions it so images can be obtained at different angles.

During mammography, a specially qualified radiologic technologist will position your breast in the mammography unit. Your breast will be placed on a special platform and compressed with a paddle (often made of clear Plexiglas or other plastic). The technologist will gradually compress your breast.

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E. Existing Flow

The first step is getting the Mammogram image. Second step is preprocessing. It is done in two stages. One is Otsu's Thresholding and another one is Morphological Opening Filter. Third step is applying Gabor filters on smoothed image in order to obtain magnitude and phase response with the highest response at each pixel. Fourth step is extract features such as Laws' Texture Energy Measures and Haralick's Texture Measures. Finally apply SVM Classifier for classification
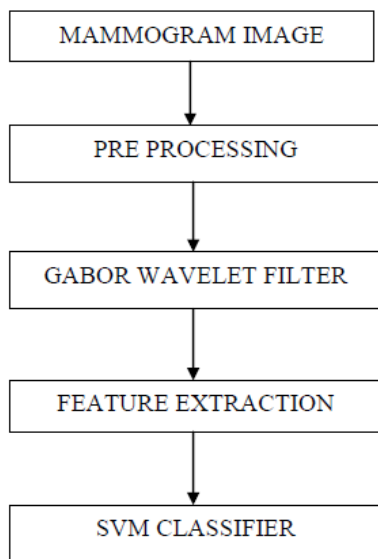

Fig 5: Existing Flow

III. PROPOSED FLOW

The first step is getting the Mammogram image 1 and rotates image 1 by an angle of ten degrees in a counterclockwise direction around its center point. After rotation we get mammogram image 2.Second step is Image fusion. In this step Discrete Wavelet transform is used for image fusion. Third step is preprocessing. It is done in two stages. One is Otsu's Thresholding and another one is Morphological Opening Filter. Fourth step is applying Gabor filters on smoothed image in order to obtain magnitude and phase response with the highest response at each pixel. Fifth step is extract features such as Laws' Texture Energy Measures and Haralick's Texture Measures. Finally apply Neural Network Classifier for classification
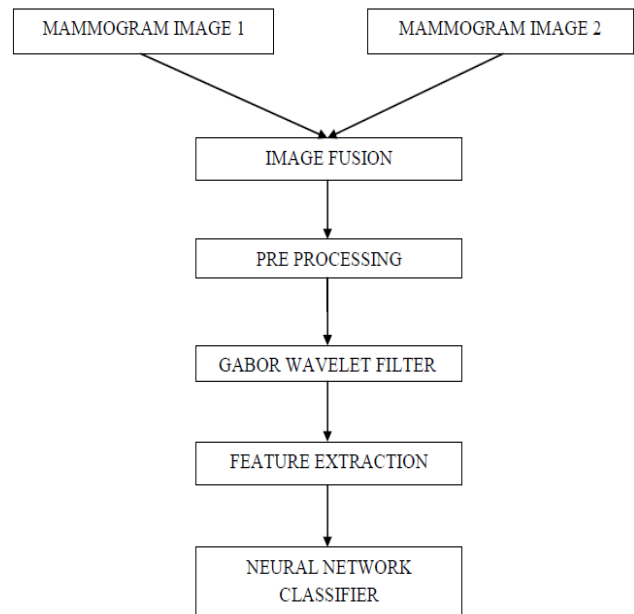

Fig 6: Proposed Flow
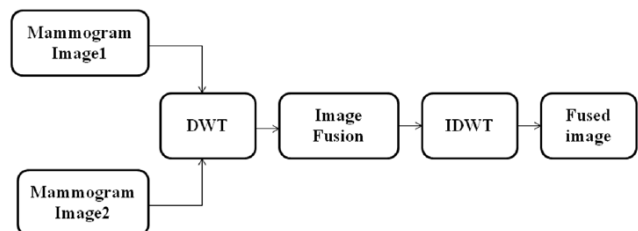
A. Image Fusion Method

Fig 7: Image Fusion Method

DWT is very useful for image processing because the image data are discrete and the spatial-spectral resolution is dependent on the frequency. The DWT has the property that the spatial resolution is small in low-frequency bands but large in high-frequency bands. The left-top sub-image (the band with lowest frequencies) has the smallest spatial resolution and represents the approximation information of the original image. Thus, the DWT is suitable for image compression. On the contrast, the other sub-images (the bands with high frequencies) show the detailed information of the original image. Therefore, these sub-images can be used for edge detection or corner detection.

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B. Pre Processing

Pre-processing done in two stages

1. Otsu's Thresholding
2. Morphological Opening Filter

1. Otsu's Thresholding

Otsu's method is used to automatically perform histogram shape-based image thresholding or the reduction of a gray level image to a binary image. The algorithm assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram (e.g. foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. Approximate segmentation of the breast portion in the mammographic image is performed by using Otsu's thresholding method. LEVEL = GRAYTHRESH (I) computes a global threshold (LEVEL) that can be used to convert an intensity image to a binary image with IM2BW. LEVEL is a normalized intensity value that lies in the range [0, 1].

2. Morphological Opening Filter

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image.

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion.

C. Gabor Filter

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection.

Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. Gabor filter is a directional filter used to separate the pixels in mammogram image with respect to different orientation of the vessels or nerves or other tissues converging towards the nipple of the mammogram image. A set of Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image.

1. Need For Gabor Filtering Or Transform

All the Images (time versus Amplitude) acquired by camera unit is in Spatial Domain Mode. The Fourier Transform is used to convert the spatial domain mode in to frequency domain mode (Single Resolution Mode– frequency versus Amplitude).For the mammogram image; we need the image in Multi Resolution mode (frequency versus time versus Amplitude). For this multiresolution mode and we need Wavelet Transform instead of FT.

D. Feature Extraction

Feature extraction is an essential pre-processing step to pattern recognition and machine learning problems. It is often decomposed into feature construction and feature selection. Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems stems from the number of variables involved. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over fits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

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The features are extracted for ROI (Region of interest) of 128*128 pixels on the node point in the mammogram image. Extracted features use the following two measures

- Laws' Texture Energy Measures.
- Haralick's Texture Measures.

E. Neural Network Classifier

A neural network consists of units (neurons), arranged in layers, which convert an input vector into some output. Each unit takes an input, applies a (often nonlinear) function to it and then passes the output on to the next layer. Neural classification consists of two processes: Training and Testing. Neural network is the best tool in pattern classification application. The classifier is trained and tested on mammogram image. The classification accuracy depends on training.

Neural network contains three layers: input layer, hidden layer and output layer. The input layer introduces input values into the network. The hidden layer(s) perform classification of features. The output layer, functionally just like the hidden layers. Outputs are passed on to the world outside the neural network. Extracted features are given as input. So the number of input nodes is equal to the number of extracted features. The second layer is hidden layer. It consists of fifteen nodes. One node is needed for output layer. The back propagation algorithm uses supervised learning, which means that we provide the algorithm with examples of the inputs and outputs we want the network to compute, and then the error (difference between actual and expected results) is calculated. The idea of the back propagation algorithm is to reduce this error, until the Neural Network learns the training data. The training begins with random weights, and the goal is to adjust them so that the error will be minimal. GLCM features fed to neural input layer. The output layer produce either 1(normal) or 0 (cancer).

The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "input" units is connected to a layer of "hidden" units, which is connected to a layer of "output" units.
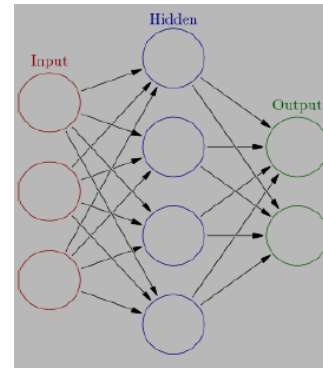

Fig 8: Network Layers

- The activity of the input units represents the raw information that is fed into the network.
- The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units.
- The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

1. Back propagation

Back propagation, an abbreviation for "backward propagation of errors", is a common method of training artificial neural networks. From a desired output, the network learns from many inputs, similar to the way a child learns to identify a dog from examples of dogs. The back propagation learning algorithm can be divided into two phases: propagation and weight update.

Phase 1: Propagation

Each propagation involves the following steps:

1. Forward propagation of a training pattern's input through the neural network in order to generate the propagation's output activations.

2. Backward propagation of the propagation's output activations through the neural network using the training pattern target in order to generate the deltas of all output and hidden neurons.

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Phase 2: Weight update

For each weight-synapse follow the following steps:

1. Multiply its output delta and input activation to get the gradient of the weight.

2. Bring the weight in the opposite direction of the gradient by subtracting a ratio of it from the weight.

This ratio influences the speed and quality of learning; it is called the learning rate. The sign of the gradient of a weight indicates where the error is increasing; this is why the weight must be updated in the opposite direction. Repeat phase 1 and 2 until the performance of the network is satisfactory.

F. MAT LAB

MATLAB is a high performance language for technical computing. It integrates computation, visualization and programming in an easy to use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include

a.   Math and computation
b.   Algorithm development
c.   Modeling, simulation and prototyping
d.   Data analysis, exploration and visualization
e.   Scientific and engineering graphics
f.   Application development including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in scalar non-interactive language such as C or FORTRAN. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering and science. In industry, MATLAB is the tool of choice for high productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology.

IV.   SIMULATION RESULTS AND PERFORMANCE ANALYSIS

A.   Simulation Results

1.   Normal Mammogram Image

Fig 9: Normal Mammogram Images

These Normal Mammogram Image is the input image for this project
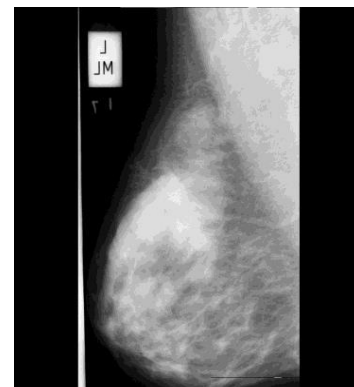
2. Architectural Distorted Mammogram Image

Fig 10: Architectural Distorted Mammogram Image

This image is observed from the results of the image fusion method.

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3. Ground Truth Images

These images are observed from the results of the image fusion method. The results of the image fusion method was taken to pre processing and the changes occurred in the image is separately showed here
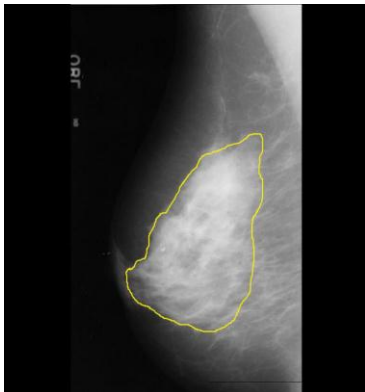
Fig 11: Ground Truth Images

4. Gabor Orientation Field

Fig 12: Gabor Orientation Field

These are the images observed after the occurrence of gobar wavelet filter. After this step the image will be in noise free form and these images are used for neural network classifier in the future enhancement work

B. Performance Analysis

Sensitivity and specificity are statistical measures of the performance of a binary classification test, also known in statistics as classification function.

Sensitivity (also called the true positive rate, or the recall rate in some fields) measures the proportion of actual positives which are correctly identified as such (e.g. the percentage of sick people who are correctly identified as having the condition). Specificity measures the proportion of negatives which are correctly identified as such (e.g. the percentage of healthy people who are correctly identified as not having the condition, sometimes called the true negative rate).

Imagine a study evaluating a new test that screens people for a disease. Each person taking the test either has or does not have the disease. The test outcome can be positive (predicting that the person has the disease) or negative (predicting that the person does not have the disease). The test results for each subject may or may not match the subject's actual status. In that setting:

- True positive: Sick people correctly diagnosed as sick
- False positive: Healthy people incorrectly identified as sick
- True negative: Healthy people correctly identified as healthy
- False negative: Sick people incorrectly identified as healthy.

In general, Positive = identified and negative = rejected. Therefore:

- True positive = correctly identified
- False positive = incorrectly identified
- True negative = correctly rejected
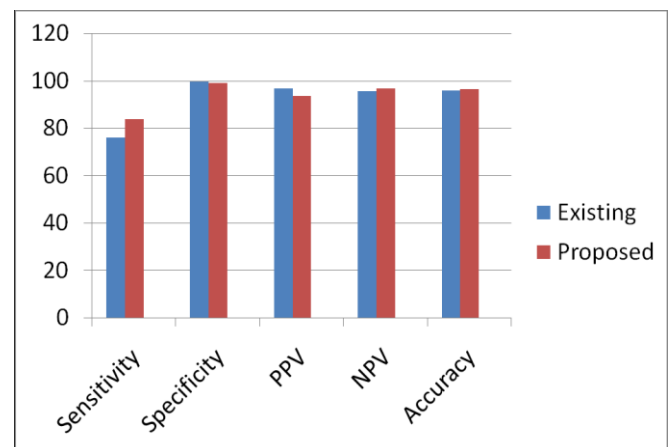- False negative = incorrectly rejected

Fig 13: Performance Analysis Chart

V. CONCLUSION

Mammography is one of the best methods in breast cancer detection, but in some cases radiologists face difficulty in directing the tumors. This project presents automatic Mammogram tumor detection and isolation of tumor cells from mammogram images using Neural Network. It includes several stages such as Image fusion, pre-processing, Gabor filter, feature extraction and classification. Discrete Wavelet Transform is used for image fusion. The pre-processing step is achieved by otsu's thresholding and morphological opening filter. Approximate segmentation of the breast portion in the mammographic image is performed by using Otsu's thresholding Method. Gabor filter is a directional filter used to separate the pixels in mammogram image with respect to different orientation of the vessels or nerves or other tissues converging towards the nipple of the mammogram image. In the next stage Features such as Laws Texture Energy Measures and Haralick's Texture Measures are extracted. The features are extracted for ROI (Region of interest) of 128*128 pixels on the node point in the mammogram image. The Neural Network classifier is applied for the classification. The evaluation of the system will be carried out on MIAS dataset.

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