BREASTMASS CLASSIFICATION ON SONOGRAPHIC IMAGES

By

P.SAJEEVANAND Reg no: 0710107082

E.SATHESH Reg no: 0710107092

B.VIGNESH Reg no: 0710107111

B.YUKENDAR Reg no: 0710107119

of

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE- 641049

(An Autonomous Institution affiliated to Anna University, Coimbatore)

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BONAFIDE CERTIFICATE

Certified that this project report title "**BREASTMASS CLASSIFICATION ON SONOGRAPHIC IMAGES**" is the bonafide work of **Mr. P.SAJEEV ANAND -0710107082, Mr. E.SATHESH – 0710107092, Mr. B.VIGNESH -0710107111, Mr.B.YUKENDAR -0710107119** who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported here in does not form part of any other project report of dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

18/04/2011

Project Guide

Mrs. S.Sasikala

Head of the Department

Dr. Rajeswari Mariappan

The candidates with **University Register Nos. 0710107082, 0710107092, 0710107111, 0710107119** were examined by us in project viva- voce examination held on 19-4-2011

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INTERNAL EXAMINER

EXTERNAL EXAMINER

ABSTRACT

Breast cancer affects one of every ten women in Europe and one of every eight women in the US. This cancer can be most effectively treated when detected in its early stages, and its death rate can be reduced

To evaluate the efficiency of novel shape features for classification of benign and malignant sonographic breast masses, mass regions are extracted from the region of interest (ROI) sub-image by applying a segmentation algorithm based on the level set method. Anisotropic diffusion filter acts as a diffusive process suppressing speckle & noise in homogeneous regions which improves image quality and important boundary information.

The level set method is a numerical technique used for segmentation in medical imaging. It can perform numerical computations involving curves and surfaces on a fixed Cartesian grid without having to parameterize these objects. Five features are extracted for further classification. This 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. A multilayered perceptron neural network (MLP) classifier with two hidden layers is used to classify breast mass in this study. Five shape features extracted from the segmented mass area are applied as an input vector to the MLP to the discriminate malignant masses from benign masses.

This can improve the positive rate of biopsies and provide a second opinion for physicians, and be used as a useful tool for mass classification.

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INTRODUCTION

1.1 BREAST CANCER

Breast cancer is an uncontrolled growth of breast cells. Cancer occurs as a result of mutations, or abnormal changes, in the genes responsible for regulating the growth of cells and keeping them healthy. A tumour can be **benign** (not dangerous to health) or **malignant** (has the potential to be dangerous). Benign tumours are not considered cancerous: their cells are close to normal in appearance, they grow slowly, and they do not invade nearby tissues or spread to other parts of the body. Malignant tumours are cancerous. Left unchecked, malignant cells eventually can spread beyond the original tumour to other parts of the body.

The term "breast cancer" refers to a malignant tumour that has developed from cells in the breast. Usually breast cancer either begins in the cells of the lobules, which are the milk-producing glands, or the ducts, the passages that drain milk from the lobules to the nipple. Less commonly, breast cancer can begin in the stromal tissues, which include the fatty and fibrous connective tissues of the breast.

Breast cancer is always caused by a genetic abnormality (a "mistake" in the genetic material). However, only 5-10% of cancers are due to an abnormality inherited from your mother or father. About 90% of breast cancers are due to genetic abnormalities that happen as a result of the aging process and the "wear and tear" of life in general.

1.2 STAGES OF BREAST CANCER

Cancer stage is based on the size of the tumour, whether the cancer is invasive or non-invasive, whether lymph nodes are involved, and whether the cancer has spread beyond the breast [15].

The purpose of the staging system is to help organize the different factors and some of the personality features of the cancer into categories, in order to:

- best understand your prognosis (the most likely outcome of the disease)
- guide treatment decisions (together with other parts of your pathology report), since clinical studies of breast cancer treatments that you and your doctor will consider are partly organized by the staging system
- provide a common way to describe the extent of breast cancer for doctors and nurses all over the world, so that results of your treatment can be compared and understood

Stage 0

Stage 0 is used to describe non-invasive breast cancers, such as DCIS and LCIS. In stage 0, there is no evidence of cancer cells or non-cancerous abnormal cells breaking out of the part of the breast in which they started, or of getting through to or invading neighbouring normal tissue.

Stage I

Stage I describes invasive breast cancer (cancer cells are breaking through to or invading neighbouring normal tissue) in which:

- the tumour measures up to 2 centimetres, and
- no lymph nodes are involved

Stage II

Stage II is divided into subcategories known as IIA and IIB.

Stage IIA describes invasive breast cancer in which:

- no tumour can be found in the breast, but cancer cells are found in the axillary lymph nodes (the lymph nodes under the arm), or
- the tumour measures 2 centimetres or less and has spread to the axillary lymph nodes, or
- the tumour is larger than 2 centimetres but not larger than 5 centimetres and has not spread to the axillary lymph nodes

Stage IIB describes invasive breast cancer in which:

- the tumour is larger than 2 but no larger than 5 centimetres and has spread to the axillary lymph nodes, or
- the tumour is larger than 5 centimetres but has not spread to the axillary lymph nodes

Stage III

Stage III is divided into subcategories known as IIIA, IIIB, and IIIC.

Stage IIIA describes invasive breast cancer in which either:

- no tumour is found in the breast. Cancer is found in axillary lymph nodes that are clumped together or sticking to other structures or cancer may have spread to lymph nodes near the breastbone.
- the tumour is 5 centimetres or smaller and has spread to axillary lymph nodes that are clumped together or sticking to other structures.

- the tumour is larger than 5 centimetres and has spread to axillary lymph nodes that are clumped together or sticking to other structures

Stage IIIB describes invasive breast cancer in which:

- the tumour may be any size and has spread to the chest wall and/or skin of the breast
- may have spread to axillary lymph nodes that are clumped together or sticking to other structures, or cancer may have spread to lymph nodes near the breastbone
- Inflammatory breast cancer is considered at least stage IIIB.

Stage IIIC describes invasive breast cancer in which:

- there may be no sign of cancer in the breast or, if there is a tumour, it may be any size and may have spread to the chest wall and/or the skin of the breast
- the cancer has spread to lymph nodes above or below the collarbone
- the cancer may have spread to axillary lymph nodes or to lymph nodes near the breastbone

Stage IV

Stage IV describes invasive breast cancer in which:

- the cancer has spread to other organs of the body -- usually the lungs, liver, bone, or brain
- "Metastatic at presentation" means that the breast cancer has spread beyond the breast and nearby lymph nodes, Metastatic cancer is considered as stage IV.

Chapter II

CHAPTER 2
DIAGONISATION

2.1 METHODS

The various methods to diagnosing breast cancer are as follows:

- Self examination
- Mammography (low-dose amplitude-X-rays)
- Biopsy(accurate method yet costly)
- Sonography(ultrasound-based diagnostic imaging technique)

2.1.1 SELF EXAMINATION

Self examination is an important method which is necessary for finding the breast cancer. All women should aware of this individually. It involves 5 important steps:

Step 1: Begin by looking at breasts in the mirror with shoulders straight and arms on hips.

One should look for:

- Breasts that are their usual size, shape, and color
- Breasts that are evenly shaped without visible distortion or swelling.

Step 2: Now, raise the arms and look for the same changes.

Step 3: While seeing at the mirror, look for any signs of fluid coming out. (It could be a watery, milky, or yellow fluid or blood).

Step 4: Next, feel the breasts while lying down, using your right hand to feel the left breast and then the left hand to feel the right. Use a firm, smooth touch with the first few finger pads of your hand, keeping the fingers flat and together. Use a circular motion, about the size of a quarter.

Step5: Repeat the step in standing or sitting position.

Doctor's attention is needed, if any of the following changes was found:

- Dimpling, puckering, or bulging of the skin
- A nipple that has changed position or an inverted nipple (pushed inward instead of sticking out)
- Redness, soreness, rash, or swelling

2.1.2 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. An x-ray (radiograph) is a non invasive medical test that helps physicians diagnose and treat medical conditions. Imaging with x-rays involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X-rays are the oldest and most frequently used form of medical imaging.

There are two recent advances in mammography. They are

1. Digital mammography
2. Computer-aided detection.

2.1.2.1 DIGITAL MAMMOGRAPHY

Digital mammography, also called full-field digital mammography (FFDM), is a mammography system in which the x-ray film is replaced by solid-state detectors that convert x-rays into electrical signals. These detectors are similar to those found in digital cameras. The electrical signals are used to produce images of the breast that can be seen on a computer screen or printed on special film similar to conventional mammograms. From the patient's point of view, having a digital mammogram is essentially the same as having a conventional film screen mammogram.

2.1.2.2 COMPUTER-AIDED DETECTION (CAD)

Computer-aided detection (CAD) systems use a digitized mammographic image that can be obtained from either a conventional film mammogram or a digitally acquired mammogram. The computer software then searches for abnormal areas of density, mass, or calcification that may indicate the presence of cancer. The CAD system highlights these areas on the images, alerting the radiologist to the need for further analysis.

2.1.3 BIOPSY

A biopsy is a medical test involving the removal of cells or tissues for examination. It is the medical removal of tissue from a living subject to determine the presence or extent of a disease. The tissue is generally examined under a microscope by a pathologist, and can also be analyzed chemically.

There are two types of biopsy. They are

1. Excisional biopsy,
2. Incisional biopsy or core biopsy

When an entire lump or suspicious area is removed, the procedure is called an **excisional** biopsy. When only a sample of tissue is removed with preservation of the histological architecture of the tissue's cells, the procedure is called an **incisional** biopsy or core biopsy. When a sample of tissue or fluid is removed with a needle in such a way that cells are removed without preserving the histological architecture of the tissue cells, the procedure is called a needle aspiration biopsy.

Biopsy is the most accurate method, but it is an invasive and costly procedure for patients and society.

2.1.3.1 PURPOSE

A biopsy is recommended when a significant abnormality is found which cannot be identified conclusively by imaging studies. The abnormality in question might be a finding on breast self-examination, on routine physical or gynaecological examination, or on a mammogram [2]. Signs of concern in addition to palpable lumps include:

- Severe breast pain
- Changes in the size of a breast or the nipple
- Changes in the shape of the breast or nipple
- Pitting, dimpling or redness of the breast skin.
- Nipple redness, irritation or inversion of the nipple which is new
- Changes in the pattern of veins visible on the surface of the breast
- Some types of nipple discharge

If imaging studies are not decisive, the differentiation of cancer from a benign breast condition must be determined using a biopsy.

2.1.4 SONOGRAPHY

Ultrasound imaging is also called ultrasound scanning or sonography, involves exposing part of the body to high-frequency sound waves to produce pictures of the inside of the body. Ultrasound exams do not use ionizing radiation (as used in x-rays) [15]. Because ultrasound images are captured in real-time, they can show the structure and movement of the body's internal organs, as well as blood flowing through blood vessels.

Ultrasound imaging is a non-invasive medical test that helps physicians diagnose and treat medical conditions. Ultrasound imaging of the breast produces a picture of the internal structures of the breast.

2.1.4.1 PURPOSE

The primary use of breast ultrasound today is to help diagnose breast abnormalities detected by a physician during a physical exam (such as a lump or bloody or spontaneous clear nipple discharge) and to characterize potential abnormalities seen on mammography. Ultrasound imaging can help to determine if an abnormality is solid (which may be a non-cancerous lump of tissue or a cancerous tumour) or fluid-filled (such as a benign cyst) or both cystic and solid. Ultrasound can also help show additional features of the abnormal area. Doppler ultrasound is used to assess blood supply in breast lesions.

2.1.4.2 WHY ULTRASONOGRAPHY?

Ultrasound can be offered as a screening tool for women who:

- Are at high risk for breast cancer and unable to tolerate an MRI examination.

- Are at intermediate risk for breast cancer based on family history, personal history of breast cancer, or prior biopsy showing an abnormal result.
- Have dense breasts.
- Have silicone breast implants and very little tissue can be included on the mammogram.
- Are pregnant or should not to be exposed to x-rays (which is necessary for a mammogram).

2.1.4.3 ADVANTAGES OF ULTRASONOGRAPHY

- Most ultrasound scanning is non invasive (no needles or injections) and is usually painless.
- Ultrasound is widely available, easy-to-use and less expensive than other imaging methods.
- Ultrasound imaging does not use any ionizing radiation.
- Ultrasound scanning gives a clear picture of soft tissues that do not show up well on x-ray images.
- Ultrasound provides real-time imaging, making it a good tool for guiding minimally invasive procedures such as needle biopsies and needle aspiration.
- Ultrasound may help detect and classify a breast lesion that cannot be interpreted adequately through mammography alone.
- Using ultrasound, physicians are able to determine that many areas of clinical concern are due to normal tissue (such as fatlobules) or benign cysts. For most women 30 years of age and older, a mammogram will be used together with ultrasound. For women under age 30, ultrasound alone is often sufficient to determine whether an area of concern needs a biopsy or not.

Chapter III

CHAPTER 3
LITERATURE SURVEY

The most widely used method for detecting the presence of tumour cells in breast is mammography. Since mammogram includes x-rays, many people find it uncomfortable. For this reason, ultrasonography is a much better way to analyse the patients.

In this project speckle reducing anisotropic diffusion [5, 7] is used for removing multiplicative noise in imagery. Unlike other existing diffusion techniques that process log-compressed data, our technique processes the data directly in order to preserve useful information in the image.

The Level set method [8] provides flexibility to be tailored as an opportunity to approach the highly non-convex shapes. The image driving mechanism is used to generate the tailoring on the gray-level shapes and this mechanism is reinforced with a selective preservation method for the edges. The level set method is more efficient and speeds up the curve evolution.

Sonographic method includes two kinds of feature extraction. 1. Textural features 2. Morphological features.

Textural features are based on the relationship between pixels and their neighbours [11]. Shape features are also called as morphological or geometric features. They are based on the shapes of suspicious areas and boundaries.

Morphological features are used in the project because; textural features can be affected by changes in sonographic machine settings and the use of different kinds of machines. Morphological features do not depend on the transfer function of sonographic machines and machine settings.

Chapter IV

CHAPTER-4

MASS CLASSIFICATION

The various stages used for classifying the breast mass using the ultrasound technique are as follows

1. Image filtering
2. Segmentation
3. Feature extraction
4. Classification

4.1 IMAGE FILTERING

Digital images can be processed in a variety of ways. The most common one is called filtering and creates a new image as a result of processing the pixels of an existing image.

Each pixel in the output image is computed as a function of one or several pixels in the original image, usually located near the location of the ouput pixel.

Image filtering is the process which allows you to apply various effects on photos. Sonographic images contain speckle and noise that can affect segmentation results. Hence, many methods have been developed to remove this noise in images, while preserving edges and local image details, in order to provide efficient results in the segmentation phase. Anisotropic diffusion filter is used to remove the speckle and noises.

4.1.1 INTRODUCTION

In Image processing and computer vision, anisotropic diffusion, also called Perona–Malik diffusion, is a technique aiming at reducing image noise without removing significant parts of the image content, typically edges, lines or other details that are important for the interpretation of the image. Anisotropic diffusion resembles the process that creates a scale-space, where an image generates a parameterized family of successively more and more blurred images based on a diffusion process [5]. Each of the resulting images in this family is given as a convolution between the image and a 2D isotropic Gaussian filter, where the width of the filter increases with the parameter. This diffusion process is a linear and space-invariant transformation of the original image.

Anisotropic diffusion is a generalization of this diffusion process: it produces a family of parameterized images, but each resulting image is a combination between the original image and a filter that depends on the local content of the original image. As a consequence, anisotropic diffusion is a non-linear and space-variant transformation of the original image.

Some essential necessities in speckle filtering must be considered. Important information about edges and fine structures should not be lost in filtering methods, the noise must be removed effectively in homogeneous regions, and discontinuities should be sharpened in order to enhance morphological characteristics. An anisotropic diffusion filter introduced by Yu and Acton acts as a diffusive process suppressing speckle and noise in homogeneous regions and preserving edges by stopping diffusion in boundaries by adjusting a local diffusion coefficient.

4.1.2 SRAD

SRAD is nothing but Speckle Reduction Anisotropic Diffusion filter. Speckle, a form of multiplicative, locally correlated noise, plagues imaging applications such as medical ultrasound image interpretation. SRAD is the edge-sensitive diffusion for speckled images, in the same way that conventional anisotropic diffusion is the edge-sensitive diffusion for images corrupted with additive noise [5]. SRAD exploits the instantaneous coefficient of variation, which is shown to be a function of the local gradient magnitude and Laplacian operators. In the presence of speckle noise, speckle reducing anisotropic diffusion excels over the traditional speckle removal filters and over the conventional anisotropic diffusion method in terms of mean preservation, variance reduction, and edge localization.

In cases where speckle removal is desired (e.g., region-based detection, segmentation, and classification) the speckle reducing filters have originated mainly in the synthetic aperture radar (SAR) community. The most widely cited and applied filters in this category include the, Frost, Kuan, and Gamma MAP filters.

SRAD not only preserves edges but also enhances edges by inhibiting diffusion across edges and allowing diffusion on either side of the edge. SRAD is adaptive and does not utilize hard thresholds to alter performance in homogeneous regions or in regions near edges and small features.

4.1.3 SPECKLE

The most common form of noise is data dropout noise generally referred to as speckle noise [6, 7]. This noise is caused by errors in data transmission. The corrupted pixels are either set to the maximum value, which is something like a snow in image or have single bits flipped over. This kind of noise affects the ultrasound images. Speckle noise has the characteristic of multiplicative noise.

4.1.4 ANISOTROPIC DIFFUSION

Perona and Malik proposed the following nonlinear PDE for smoothing image on a continuous domain:

$$\begin{cases} \frac{\partial y}{\partial x} = div[c \mid \nabla I \mid \cdot \nabla I] \\ I(T=0) = I_0 \end{cases} \quad 4.1$$

Where ∇ is the gradient operator, div the divergence operator, $||$ denotes the magnitude, the diffusion coefficient, and the initial image. They suggested diffusion coefficient,

$$C(x) = \frac{1}{1+\left(\frac{x}{k}\right)\text{^}2} \quad 4.2$$

Where k is an edge magnitude parameter.

In the anisotropic diffusion method, the gradient magnitude is used to detect an image edge or boundary as a step discontinuity in intensity.

If $|\nabla| >> k$, then c ($|\nabla|$) $\rightarrow 0$, and we have an all-pass filter;

If $|\nabla| << k$, then c ($|\nabla|$) $\rightarrow 1$, we achieve isotropic diffusion (Gaussian filtering).

4.1.4.1 ADVANTAGES

The advantages of anisotropic diffusion are as follows:

- intra-region smoothing
- edge preservation
- performs well for images corrupted by additive noise
- Non-linear and space-variant transformation of the original image
- Acts as a diffusive process for suppressing speckle and noise in homogeneous regions

Chapter V

CHAPTER-5
SEGMENTATION

5.1 INTRODUCTION:

Segmentation refers to the process of partitioning a digital image into multiple segments. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristics or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. When applied to a stack of images, typical in Medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like marching cubes.

5.2 THRESHOLDING

The simplest method of image segmentation is called the thresholding method. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image.

The key of this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry

including the maximum entropy method, Otsu's method (maximum variance). K-means clustering can also be used.

5.3 SEGMENTATION METHODS:

The various types of segmentation methods available are as follows:

- Clustering methods
- Compression based method
- Histogram based method
- Edge detection
- Region growing method
- Partial differential Equation based

5.3.1 PARTIAL DIFFERENTIAL EQUATION BASED

Using a partial differential equation (PDE)-based method and solving the PDE equation by a numerical scheme, one can segment the image. Level set is the only method under partial differential equation based method.

5.3.1.1 LEVEL SET METHOD

Curve propagation is a popular technique in image analysis for object extraction, object tracking, stereo reconstruction, etc. The central idea behind such an approach is to evolve a curve towards the lowest potential of a cost function, where its definition reflects the task to be addressed and imposes certain smoothness constraints. Lagrangian techniques are based on parameterizing the contour according to some sampling strategy and then evolve each element according to image and internal terms. While such a technique can be very efficient, it suffers from various limitations like deciding on the sampling strategy, estimating the internal geometric properties of the curve, changing its topology, addressing problems in higher

dimensions, etc. In each case, a partial differential equation (PDE) called the level set equation is solved by finite differences.

5.3.1.2 WHY LEVEL SET?

- First, a significantly larger time step can be used for numerically solving the evolution partial differential equation, and therefore speeds up the curve evolution.
- Second, the level set function can be initialized with general functions that are more efficient to construct and easier to use in practice than the widely used signed distance function.
- Third, the level set evolution in our formulation can be easily implemented by simple finite difference scheme and is computationally more efficient.

5.4 VECTOR FIELD CONVOLUTIONS

Snakes, or active contours, have been widely used in image processing applications. VFC is calculated by convolving the edge map generated from the image with the user-defined vector field kernel. VFC snakes are constructed by way of a force balance condition.

The calculation of the external force can be broken down to two independent steps: the formation of edge map from the image, and the computation of the external force from the edge map. Although the quality of the edge map is a critical factor in snake performance, this project focuses on how to obtain a desirable external force field given an edge map, which is likely to be corrupted by noise.

5.4.1 VECTOR FIELD CONVOLUTION SNAKES

Vector field convolution snakes are active contours using the VFC field as the external force [8].By replacing the standard external force $k(x,y)=[u_k(x,y),v_k(x,y)]$ in which all the vectors point to the kernel origin $k(x,y)=m(x,y)n(x,y)$

where m(x,y) is the magnitude of the vector at (x,y) and n(x,y) is the unit vector pointing to the kernel origin (0,0)

$$n(x,y)=[-x/r,-y/r]$$

except that n(0,0)=[0,0] at the origin,

where $r=\sqrt{(x^2+y^2)}$ is the distance from the origin. If the origin is considered as the FOI, this vector field kernel has the desirable property that a free particle placed in the field is able to move to the FOI, such as edges.

The vfc external force is given by calculating the convolution of the vector field kernel k(x,y) and the edge map f(x,y) generated from the image I(x,y)

$$f_{vfc}(x,y) = f(x,y)*k(x,y)$$

$$= [f(x, y)*u_k(x,y),f(x,y)*v_k(x,y)] \qquad 5.1$$

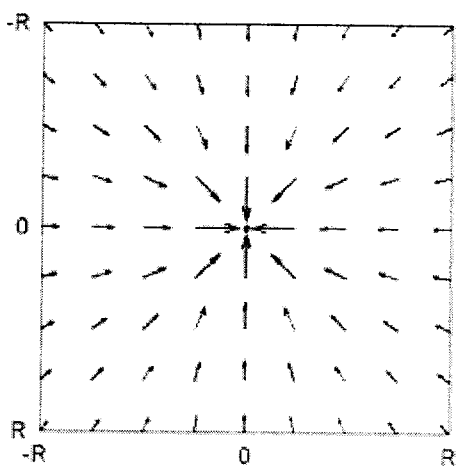

FIGURE 5.1 VECTOR FIELD KERNEL

The VFC field highly depends on the magnitude of the vector field kernel m(x,y). By considering the fact that the influence from the FOI should decrease as the particles are further away, the magnitude should be a decreasing positive function of distance from the origin

The VFC external force $F_{vfc} = f(x,y)*k(x,y)$

$= [f(x,y)*uk(x,y), f(x,y)*vk(x,y)]$ 5.2

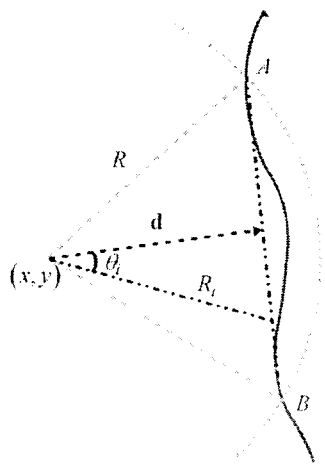

FIGURE 5.2 FEATURES OF INTEREST

Using a line AB to approximate the effective features of interest (FOI) AB of (x; y).

K = {k(x,y);x,y = - R ,…. , -1,0,1,…., R}

Here R denotes the preferred kernel radius.

5.4.2 ADVANTAGES OF VFC

The advantages of VFC technique are as follows

- large capture range
- ability to capture concavities
- superior robustness to noise
- flexibility of tailoring the force field
- reduced computational cost

Chapter VI

CHAPTER 6
FEATURE EXTRACTION

6.1 INTRODUCTION:

When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (much data, but not much information) 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.

In image processing, feature extraction is a special form of dimensionality reduction. The task of the feature extraction and selection methods is to obtain the most relevant information from the original data and represent that information in a lower dimensionality space.

The feature space is very large and complex, because of the wide variety of normal tissues and the diversity of abnormalities. Yet, only some of these features are significant [9]. Using too many features increases the classifier complexity and reduces system performance. Further, some redundant features should be removed to improve the performance of the classifier. The most important issue in extracting features is that the selected features represent properly the characteristics of masses in the breast sonographic images.

6.2 VARIOUS TYPES OF FEATURE EXTRACTION:

The various types of feature extraction are as follows

Low-level

- Edge detection
- Corner detection
- Blob detection
- Ridge detection
- Scale-invariant feature transform

Curvature

- Edge direction, changing intensity, autocorrelation.

Image motion

- Motion detection. Area based differential approach. Optical flow.

Shape Based

- Thresholding
- Blob extraction
- Template matching
- Hough transform
  - Lines
  - Circles/Ellipse
  - Arbitrary shapes (Generalized Hough Transform)

Flexible methods

- Deformable, parameterized shapes
- Active contours (snakes)

6.3 FEATURES USED:

The methods that were used by us for feature extraction are as follows

Five features are extracted from the variation function as:

1. SD variation: standard deviation value of variation function.
2. Variance variation: variance value of variation function.
3. Skewness variation: skewness value of variation function.
4. Kurtosis variation: kurtosis value of variation function.
5. Entropy variation: entropy value of variation function.

6.4 VARIATION FUNCTION:

The projection of the distance between the farthest pixels of a mass region at all angles.

6.4.1 MEAN VARIATION

In statistics, mean has two related meanings:

- The arithmetic mean (and is distinguished from the geometric mean or harmonic mean).
- The expected value of a random variable, which is also called the population mean.

The mean of a set of numbers $x_1, x_2 \ldots x_n$ is typically denoted by $\bar{x}$, pronounced "x bar". This mean is a type of arithmetic mean.

The arithmetic mean is the "standard" average, often simply called the "mean".

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i \qquad 6.1$$

The mean may often be confused with the median, mode or range. The mean is the arithmetic average of a set of values, or distribution; however, for skewed distributions, the mean is not necessarily the same as the middle value (median), or the most likely (mode).

Nevertheless, many skewed distributions are best described by their mean such as the exponential and Poisson distributions.

Syntax

M = mean (A)

M = mean (A,dim)

6.4.2 VARIANCE VARIATION:

Variance is a measure of the amount of variation of the values of that variable, taking account of all possible values.

If a random variable X has the expected value (mean) $\mu = \mathrm{E}[X]$,

then the variance of X is given by:

$\mathrm{Var}(X) = \mathrm{E}[(X - \mu)^2]$. Where X is the random variable.

Syntax

V = var(X)

V = var(X,1)

V = var(X,w)

V = var(X,w,dim)

6.4.2.1 DISCRETE CASE

If the random variable X is discrete with probability mass function $x_1 \mapsto p_1 \ldots x_n \mapsto p_n$, then

$$\mathrm{Var}(X) = \sum_{i=1}^{n} p_i \cdot (x_i - \mu)^2 \qquad 6.2$$

where

$$\mu = \sum_{i=1}^{n} p_i \cdot x_i \qquad 6.3$$

(When such a discrete weighted variance is specified by weights whose sum is not 1, then one divides by the sum of the weights.) That is, it is the expected value of the square of the deviation of X from its own mean. In plain language, it can be expressed as "The mean of the squares of the deviations of the data points from the average". It is thus the mean squared deviation.

6.4.2.2 PROPERTIES OF VARIANCE:

- Variance is non-negative because the squares are positive or zero. The variance of a constant random variable is zero, and the variance of a variable in a data set is 0 if and only if all entries have the same value.
- Variance is invariant with respect to changes in a location parameter. That is, if a constant is added to all values of the variable, the variance is unchanged. If all values are scaled by a constant, the variance is scaled by the square of that constant. These two properties can be expressed in the following formula:

$$\mathrm{Var}(aX + b) = \mathrm{Var}(aX) = a^2\mathrm{Var}(X). \qquad 6.4$$

- The variance of a finite sum of uncorrelated random variables is equal to the sum of their variances. This stems from the identity

$$\mathrm{Var}(X + Y) = \mathrm{Var}(X) + \mathrm{Var}(Y) + 2\,\mathrm{Cov}(X, Y), \qquad 6.5$$

$$\mathrm{Var}(aX + bY) = a^2\mathrm{Var}(X) + b^2\mathrm{Var}(Y) + 2ab\,\mathrm{Cov}(X, Y), \qquad 6.6$$

and from the fact that for uncorrelated variables the covariance is zero.

6.4.3 SKEWNESS VARIATION:

Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable. The skewness value can be positive or negative, or even undefined. . Qualitatively, a negative skew indicates that the tail on the left side of the probability density function is longer than the right side and the bulk of the values (including the median) lie to the right of the mean. A positive skew indicates that the tail on the right side is longer than the left side and the bulk of the values lie to the left of the mean. A zero value indicates that the values are relatively evenly distributed on both sides of the mean, typically but not necessarily implying a symmetric distribution.

6.4.3.1 TYPES OF SKEWNESS:

1. Negative skew: The left tail is longer and the mass of the distribution is concentrated on the right of the figure. It has relatively few low values. The distribution is said to be left-skewed or "skewed to the left".
2. Positive skew: The right tail is longer and the mass of the distribution is concentrated on the left of the figure. It has relatively few high values. The distribution is said to be right-skewed or "skewed to the right"

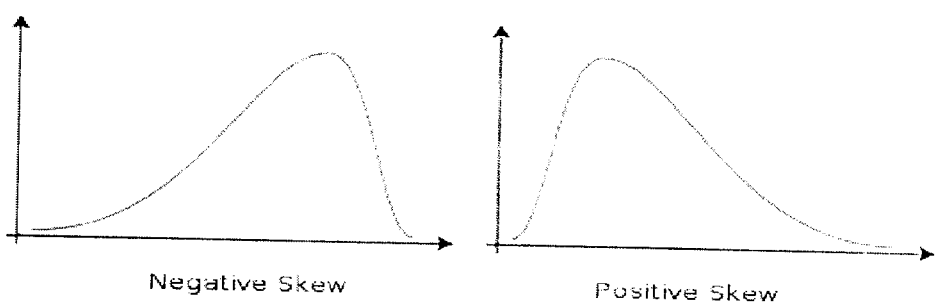

FIGURE 6.1: NEGATIVE AND POSITIVE SKEWNESS

The skewness of a random variable X is the third standardized moment, denoted γ_1 and defined as

$$\gamma_1 = \mathrm{E}\left[\left(\frac{X-\mu}{\sigma}\right)^3\right] = \frac{\mu_3}{\sigma^3} = \frac{\mathrm{E}\left[(X-\mu)^3\right]}{\left(\mathrm{E}\left[(X-\mu)^2\right]\right)^{3/2}} = \frac{\kappa_3}{\kappa_2^{3/2}} \qquad 6.7$$

where

μ_3 is the third moment about the mean μ,

σ is the standard deviation,

E is the expectation operator

k cumulant

The last equality expresses skewness in terms of the ratio of the third cumulant κ_3 and the 1.5th power of the second cumulant κ_2. This is analogous to the definition of kurtosis as the fourth cumulant normalized by the square of the second cumulant.

The skewness is also sometimes denoted Skew[X].

Syntax

y = skewness(X)

y = skewness(X,flag)

6.4.4 KURTOSIS VARIATION

Kurtosis is a measure of the "peakedness" of the probability distribution of a real-valued random variable. Kurtosis is a measure of the pointness of a distribution. The standard normal curve has a kurtosis of zero. Kurtosis is more commonly defined as the fourth cumulant divided by the square of the second cumulant, which is equal to the fourth moment around the mean divided by the square of the variance of the probabiility distribution minus 3,which is also known as excess kurtosis.

$\gamma_2=k_4/k_2^2=\mu_4/\sigma_4=-3$

$$Kurtosis = \left[\frac{(n-1)(n+1)}{(n-2)(n-3)}\right]\times\frac{m_4}{(m_2)^2} - 3\left[\frac{(n-1)^2}{(n-2)(n-3)}\right] \qquad 6.8$$

Syntax

k = kurtosis(X)

k = kurtosis(X,flag)

k = kurtosis(X,flag,dim)

6.4.5 ENTROPY VARIATION

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy converts any class other than logical to uint8 for the histogram count calculation so that the pixel values are discrete and directly correspond to a bin value.

Entropy is defined as

$$-sum\ (p.*log2(p)) \qquad 6.9$$

Where p contains the histogram count

Syntax

E = entropy (I)

6.5 ADVANTAGES OF MORPHOLOGICAL FEATURES

The advantages of morphological features over textural features are as follows:

- Textural features can be affected by changes in sonographic machine settings and the use of different kinds of machines.
- To overcome these drawbacks, morphological features are extracted.
- They do not depend on the transfer function of sonographic machines and machine settings.

Chapter VII

CHAPTER 7
MLP NEURAL NETWORKS

7.1 INTRODUCTION

A multilayer perceptron (MLP) is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate output. An MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network. MLP is a modification of the standard linear perceptron, which can distinguish data that is not linearly separable.

MLPs consist of several layers of nodes, interconnected through weighted acyclic arcs from each preceding layer to the following, without lateral or feedback connections [13]. Each node calculates a transformed weighted linear combination of its inputs of the form, with the vector of output activations from the preceding layer, the transposed column vector of weights, and a bounded non-decreasing non-linear function, such as the linear threshold or the sigmoid, with one of the weights acting as a trainable bias connected to a constant input.

7.2 MLP MODEL

A multilayer perceptron is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate output. It is a modification of the standard linear perceptron in that it uses three or more layers of neurons (nodes) with nonlinear activation functions and is more powerful than the perceptron in that it can distinguish data that is not linearly

separable, or separable by a hyper plane. MLP networks are general-purpose, flexible, nonlinear models consisting of a number of units organized into multiple layers.

The complexity of the MLP network can be changed by varying the number of layers and the number of units in each layer. Given enough hidden units and enough data, it has been shown that MLPs can approximate virtually any function to any desired accuracy [10]. Perceptron is a steepest descent type algorithm that normally has slow convergence rate and the search for the global minimum often becomes trapped at poor local minima. The current study investigates the performance of three algorithms to train MLP networks. It was found that the back propagation algorithm are much better than others algorithms

The neuron is the basic computing unit of a neural network. A model of a neural network is shown in Figure 6.1. It consists of four basic elements: (a) a set of weights: each input signal xi is multiplied by weight wi, and p is the number of input signals; (b) the adder, an operation used for summing the weighted signals; (c) an activation function, for limiting the amplitude of the output signal, chosen to satisfy some specification of the problem that the neural network is attempting to solve; and (d) the threshold, a parameter that lowers the input signal of the activation function.

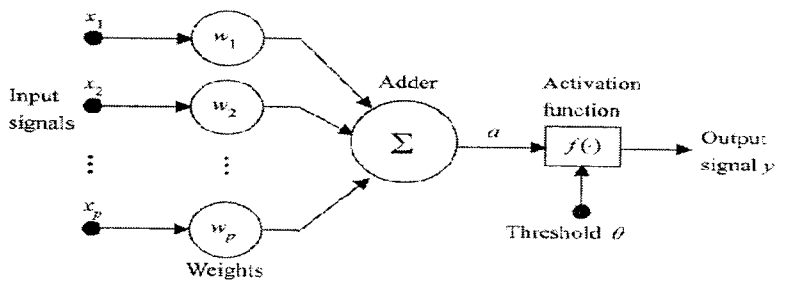

FIGURE 7.1 MODEL OF A NEURAL NETWORK.

We can formulate the neural network in the following mathematical terms

$$a = \sum_{i=1}^{p} w_i x_i \qquad 7.1$$

$$y = f(a - \theta), \qquad 7.2$$

Where x1, x2,xp = input signals, w1,w2,.. wp =weights , a = the output of the adder, theta= the threshold, $f(.)$ = the activation function, and y = the output signal of the neural network.

MLP neural networks are an important class of neural networks. In general, there is at least one hidden layer in an MLP neural network, and the function of its neurons is to arbitrate between the neural network's input and output. The architecture of an MLP neural network is shown in Figure

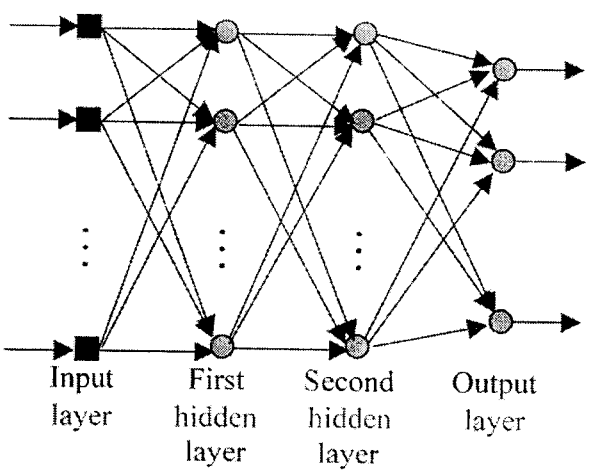

FIGURE 7.2 MLP ARCHITECTURE

7.3 BACK PROPAGATION ALGORITHM

The back propagation algorithm, the most popular learning algorithm, is usually used in an MLP neural network. It can typically be divided into two phases: forward and backward. In the forward phase, input signals are

propagated forward through the network, and output signals are produced in the output layer. Meanwhile, error signals are generated by comparing the produced output with the desired response. In the backward phase, error signals are propagated backward through the network, and some parameters, such as weights, can be adjusted in reference to the error signals. The back propagation algorithm includes four steps:

Initialization: Set initial weights and learning rate η for all layers of the MLP neural network. A terminating error threshold value τ is also selected to stop the learning process.

Forward computation: Calculate the output values of the MLP neural network layer by layer. We define the internal output signal $h_j^{(l)}(n)$ for neuron *j* in layer *l* at iteration *n* as follows:

$$h_j^{(l)}(n) = \sum_{i=0}^{k} w_{ji}^{(l)}(n) p_i^{(l-1)}(n), \qquad 7.3$$

Where $p_i^{(l-1)}(n)$ is the output signal of neuron i in layer $w_{ji}^{(l)}(n)$ is the weight between neuron j in layer l and neuron *I* in layer *l-1*, and k is the dimenstion of input vectors. The output signal of neuron j is define as

$$p_j^{(l)}(n) = \begin{cases} x_j(n) & \text{if neuron } j \text{ is in the input layer,} \\ o_j(n) & \text{if neuron } j \text{ is in the output layer,} \\ f(h_j^{(l)}(n)) & \text{otherwise,} \end{cases} \qquad 7.4$$

Where $x_j(n)$ = the *jth* element of the input vector x(n). Then we can achieve the error signal ej (n), which is defined as,

$$e_j(n) = z_j(n) - o_j(n), \qquad 7.5$$

Where $z_j(n)$= the *jth* element of the desired output vector z(n) and $o_j(n)$ = the *jth* element of the produced output o(n).

Backward computation: Calculate the local gradients of the MLP neural network layer by layer. The local gradients can point to the required change in respective weight. They are defined as follows:

$$\delta_j^{(l)}(n) = \begin{cases} e_j(n)o_j(n)[1 - o_j(n)] \\ \quad \text{for neuron } j \text{ in output layer} \\ h_j(n)[1 - h_j(n)] \sum_{i=1}^{m} \delta_i^{(l)}(n) w_{ij}^{(l+1)}(n) \\ \quad \text{for neuron } j \text{ in hidden layer.} \end{cases} \quad 7.6$$

Where *m* is the total number of neurons in layer *l*. Then the connection weights between layer *l* and layer *l* - 1 are modified according to

$$\Delta w_{ij}^{(l)} = \eta \delta_j^{(l)}(n) h_i^{(l-1)}(n). \quad 7.7$$

Iteration of learning procedure: An average distortion function is defined as follows:

$$D = |\mathrm{SE}_{\mathrm{avg}}[\mathbf{w}(n)] - \mathrm{SE}_{\mathrm{avg}}[\mathbf{w}(n-1)]|. \quad 7.8$$

Where is average squared errors for the training samples with the weight vector *w (n)* in iteration *n*.

The learning procedure will iteratively execute until the stopping criterion (i.e, $D < \mathbf{T}$) is satisfied.

7.4 CLASSIFICATION

Once the features related to masses are extracted and selected, the features are input into an automatic classifier, to classify the detected suspicious area as normal tissues, benign or malignant tissues [11]. Classifiers used are

- Linear discriminant analysis (LDA)
- Artificial neural network (ANN).

7.4.1 MAJOR CLASSIFIERS FOR MASS CLASSIFICATION

TABLE 7.1 MAJOR CLASSIFIERS FOR MASS CLASSIFICATION

CLASSIFIER	DESCRIPTION	FEATURES USED
LDA	Constructs linear decision boundaries by optimizing error to classify cases into one of several mutually exclusive classes	Textural features, shape features, morphological and speculation features.
ANN	Construct nonlinear mapping function as a decision boundary. Two ANN's are used: three layer back propagation neural network and the radial basis function (RBF) network	Textural features, shape features, wavelet based features, peak related and contour related features

Chapter VIII

CHAPTER 8

TOOLS USED

8.1 MATLAB

8.1.1 INTRODUCTION

MATLAB® is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Using the MATLAB product, one can solve technical computing problems faster than with traditional programming languages, such as C, C++, and Fortran.

MATLAB can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. Add-on toolboxes (collections of special-purpose MATLAB functions, available separately) extend the MATLAB environment to solve particular classes of problems in these application areas.

MATLAB provides a number of features for documenting and sharing the work. MATLAB code can be integrated with other languages and applications, and distribute your MATLAB algorithms and applications.

8.1.2 KEY FEATURES

- High-level language for technical computing
- Development environment for managing code, files, and data
- Interactive tools for iterative exploration, design, and problem solving
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, and numerical integration

- 2-D and 3-D graphics functions for visualizing data
- Tools for building custom graphical user interfaces
- Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, Fortran, Java, COM, and Microsoft Excel

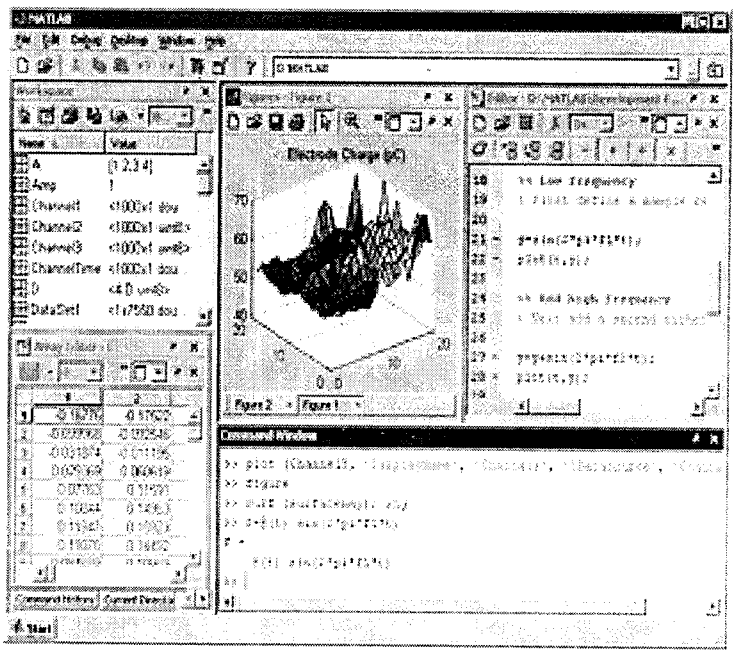

FIGURE 8.1 MATLAB

8.1.3 IMAGE PROCESSING TOOLBOX

Perform image processing, analysis, and algorithm development

Image Processing Toolbox™ provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. Image enhancement, image deblurring, feature detection, noise reduction, image segmentation, spatial transformations, and image registration can be performed using image processing toolbox. Many functions in the toolbox are multithreaded to take advantage of multicore and multiprocessor computers.

Image Processing Toolbox supports a diverse set of image types, including high dynamic range, gigapixel resolution, ICC-compliant color, and tomographic images. Graphical tools let us explore an image, examine a region of pixels, adjust the contrast, create contours or histograms, and manipulate regions of interest (ROIs). With the toolbox algorithms degraded images, detect and measure features, analyze shapes and textures, and adjust the color balance of images can be restored.

Image Processing Toolbox extends MATLAB graphics to provide image display capabilities that are highly customizable. One can create displays with multiple images in a single window, annotate displays with text and graphics, and create specialized displays such as histograms, profiles, and contour plots.

In addition to display functions, the toolbox provides a suite of interactive tools for exploring images and building GUIs. Image information, zoom and pan around the image, and closely examine a region of pixels can be viewed. ROIs including points, lines, rectangles, polygons, ellipses, and freehand shapes can be interactively placed and manipulated. Images can be cropped and the contrast can also be adjusted. The suite of tools is available within Image Tool or from individual functions that can be used to create customized GUI.

8.1.4 KEY FEATURES

- Image enhancement, filtering, and deblurring
- Image analysis, including segmentation, morphology, feature extraction, and measurement
- Spatial transformations and image registration

- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- Workflows for processing, displaying, and navigating arbitrarily large images
- Modular interactive tools, including ROI selections, histograms, and distance measurements
- ICC color management
- Multidimensional image processing
- Dicom import and export.

Chapter IX

CHAPTER 9

RESULTS

IMAGE FILTERING

The anisotropic filtered outputs of the malignant and benign case are shown below:

MALIGNANT CASE

FIGURE 9.1 INPUT IMAGE

FIGURE 9.2 ANISOTROPIC FILTERED IMAGE

BENIGN CASE

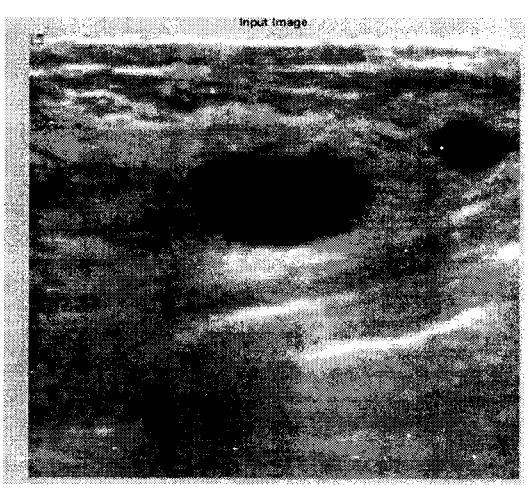

FIGURE 9.3 INPUT IMAGE

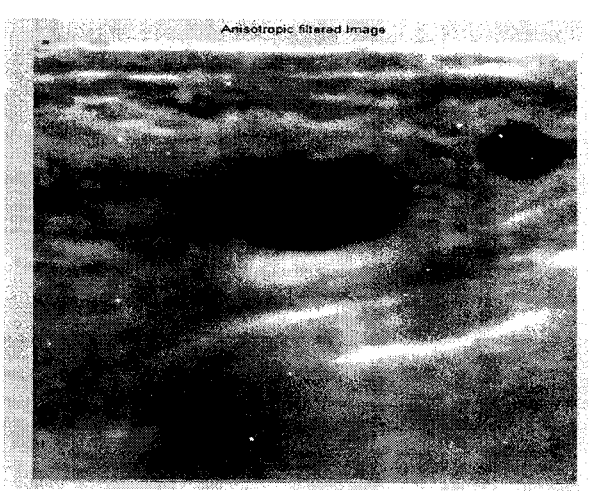

FIGURE 9.4 ANISOTROPIC FILTERED IMAGE

SEGMENTATION

The segmented output of the input image is shown below:

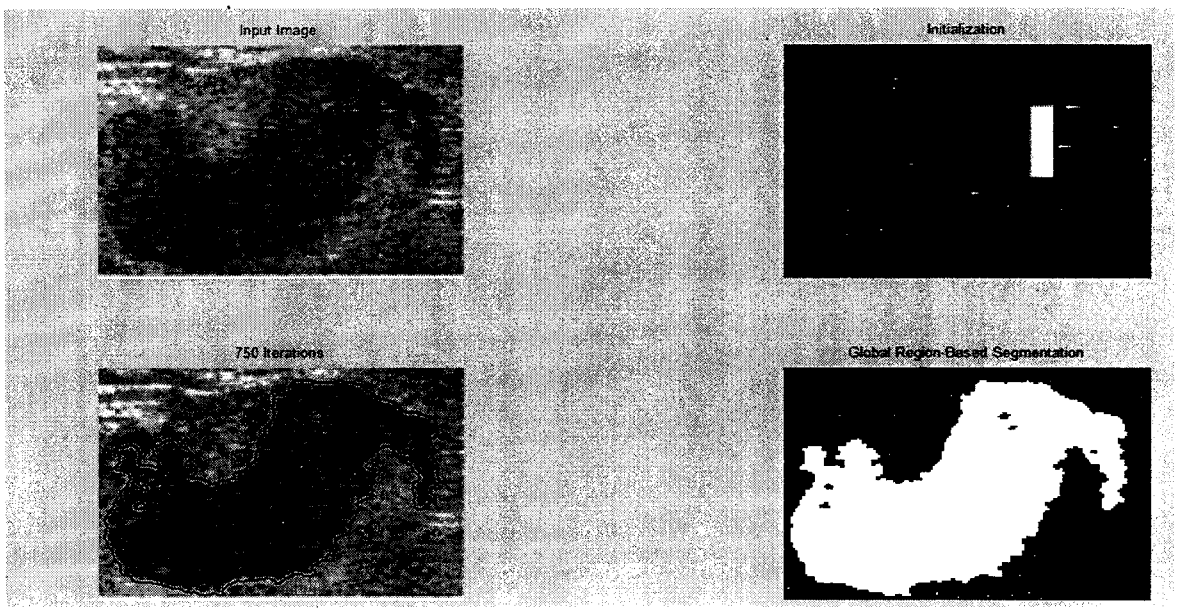

FIGURE 9.5 SEGMENTED IMAGE-MALIGNANT

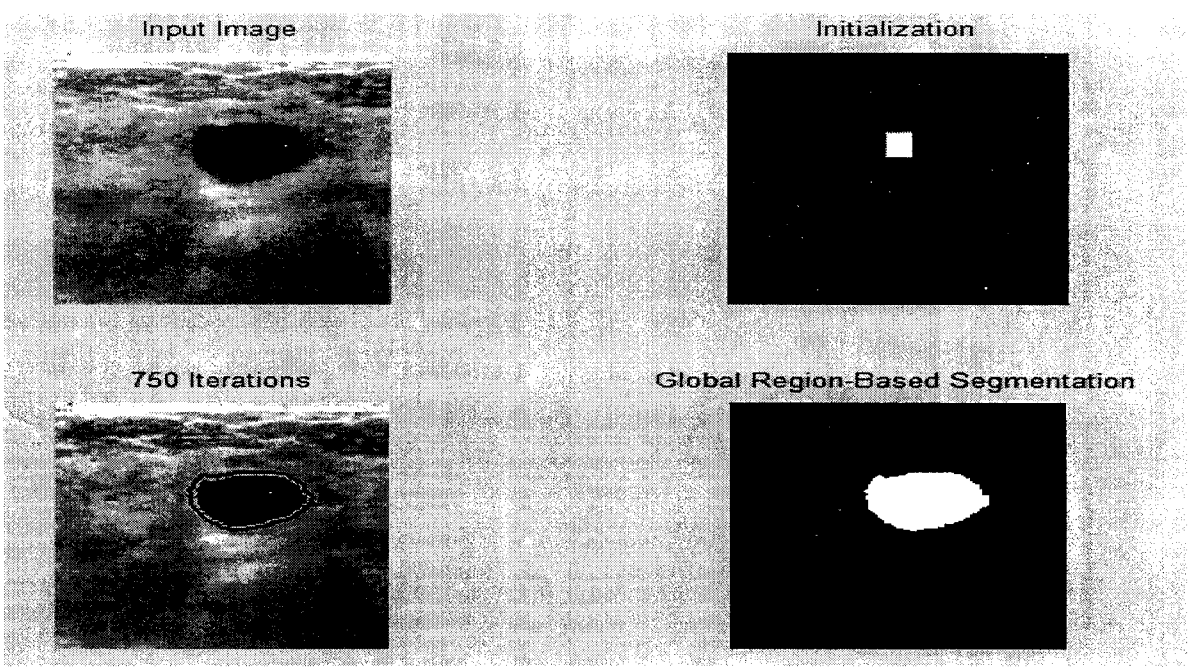

FIGURE 9.6 SEGMENTED IMAGE-BENIGN

FEATURE EXTRACTION

The images for feature extraction at different angles are shown below:

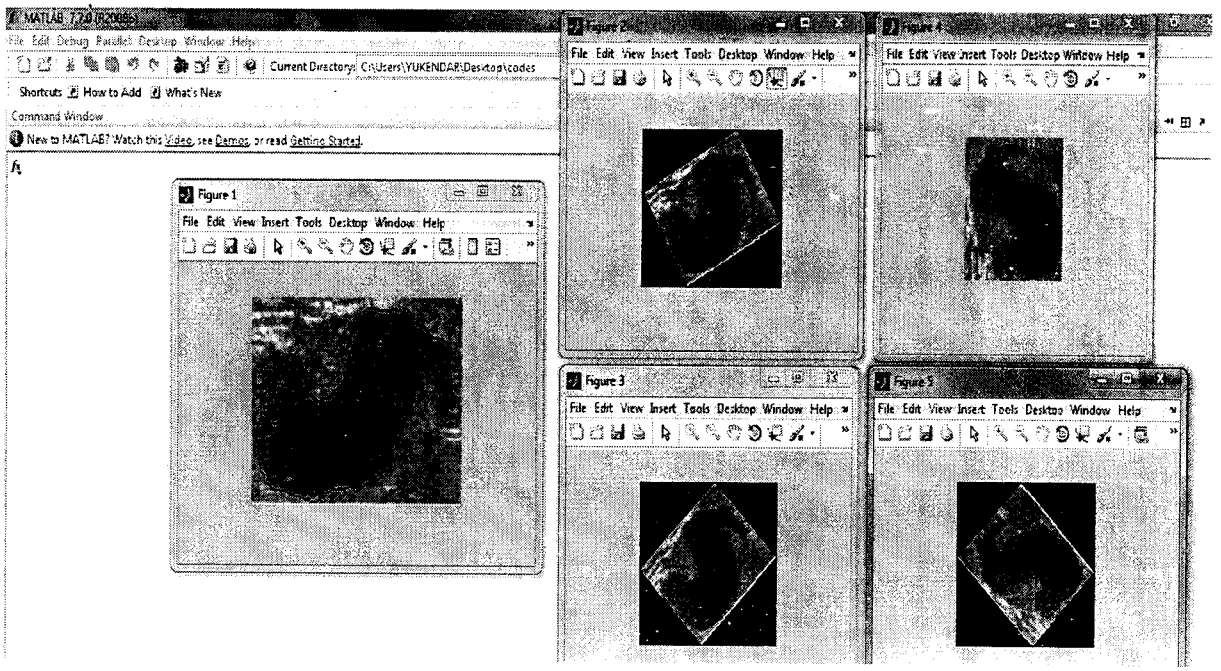

FIGURE 9.7 ROTATED MASS AT DIFFERENT ANGLES. A) 30, B) 45, C) 90, D) 135.

TABLE 9.1 BENIGN CASES

Image samples ► / Functions ▼	1	2	3	4	5
ENTROPY	7.5737	7.677	4.2875	4.6153	6.5092
SKEWNESS	-1.4698	-1.4601	-1.4511	-1.4426	-1.4347
VARIANCE	340.45	337.7	335.19	332.55	330.03
SD	18.45	18.38	18.31	18.24	18.17
KURTOSIS	4.378	4.344	4.314	4.288	4.265

TABLE 9.2 MALIGNANT CASES:

IMAGE ► SAMPLES / FUNCTIONS ▼	1	2	3	4	5
ENTROPY	6.4540	5.2940	5.9847	6.3432	6.3475
SKEWNESS	-1.5434	-1.5336	-1.5243	-1.5157	-1.5443
VARIANCE	327.73	325.21	322.75	320.33	317.96
SD	18.10	18.03	17.97	17.90	17.83
KURTOSIS	4.672	4.636	4.603	4.574	4.548

MLP NEURAL NETWORKS

The images for MLP neural networks are shown below:

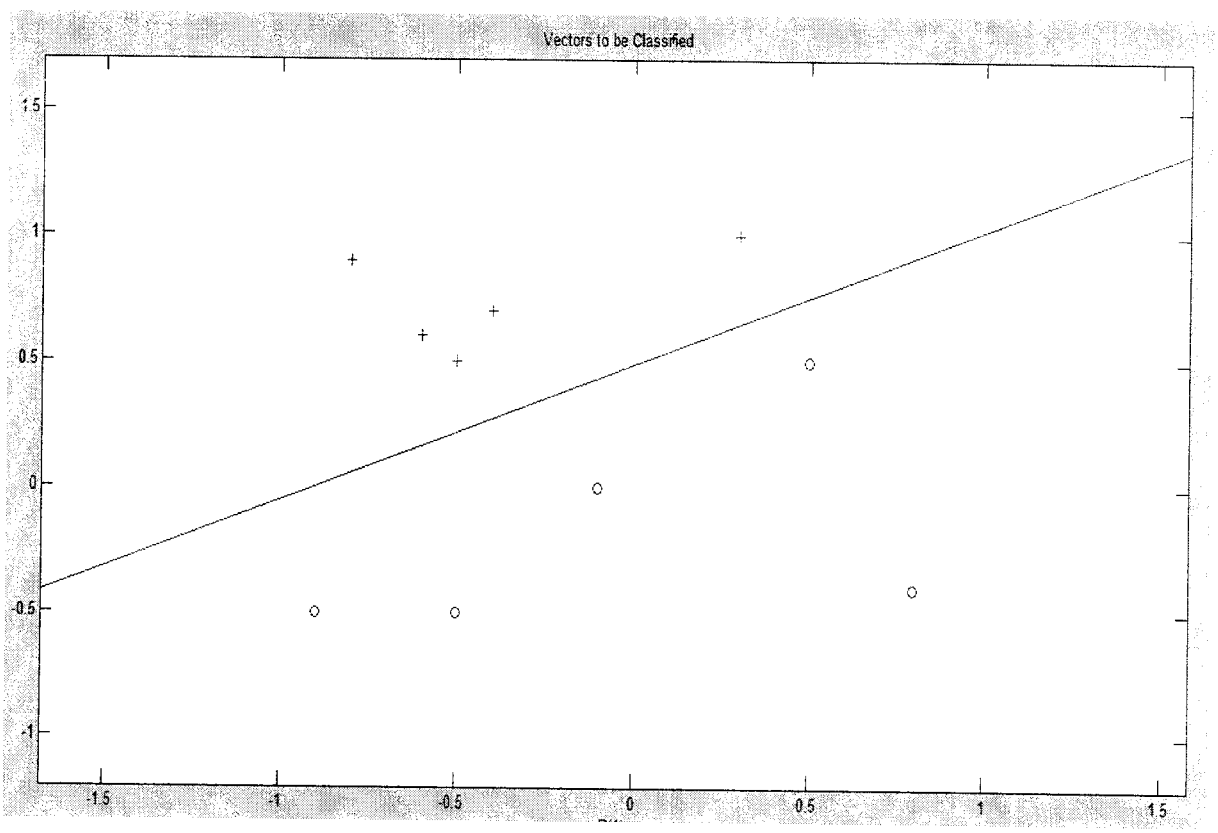

FIGURE 9.8 PLOTTING OF BENIGN (O) AND MALIGNANT (+) IMAGES

INPUT AND OUTPUT PARAMETERS:

The MLP neural network is trained with the values from features extraction with an input layer, 2 hidden layers and an output layer.

The input parameters in the MLP are as follows:

- Learning rate parameter = 0.100000
- Epochs i.e. iteration=1000
- Goal= 0.000001
- Momentum factor used is 0.900000

The output for the training of the MLP was obtained as follows:

- Final Train Error = 1.3677e-006

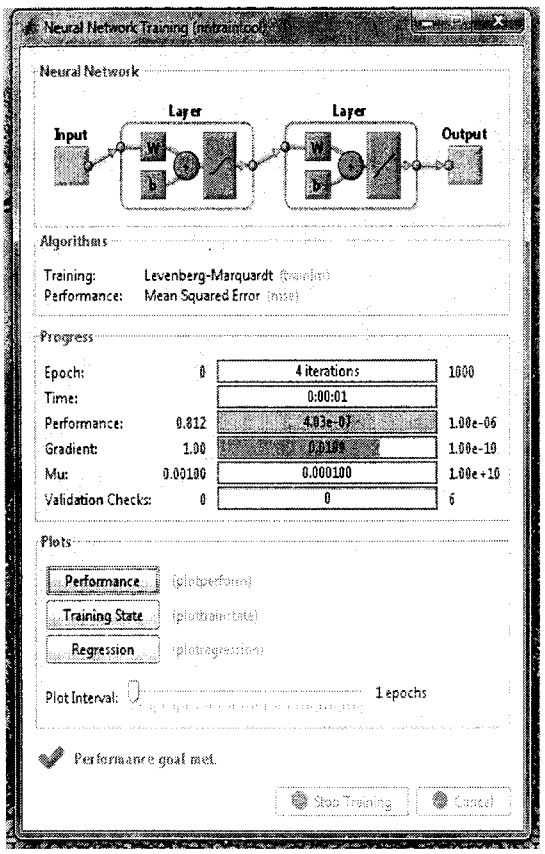

FIGURE 9.9 NETWORK TRAINING TOOL

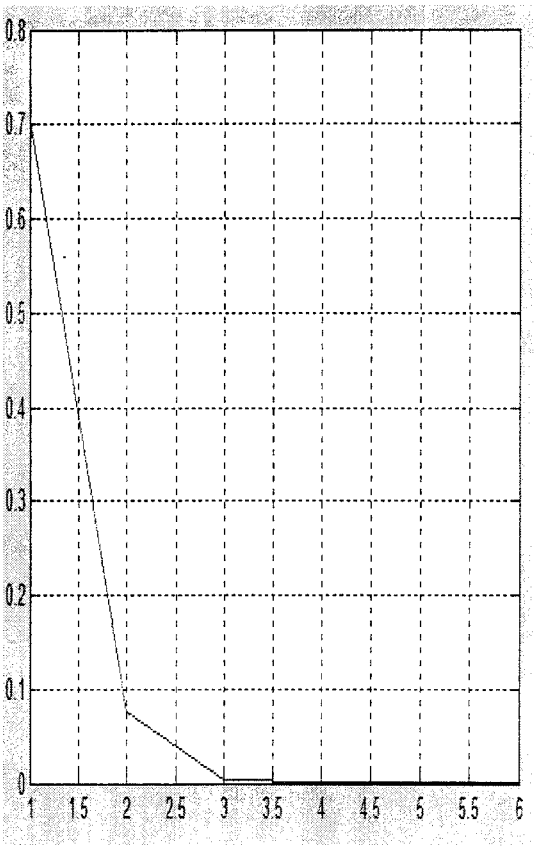

FIGURE 9.10 TRAIN ERROR

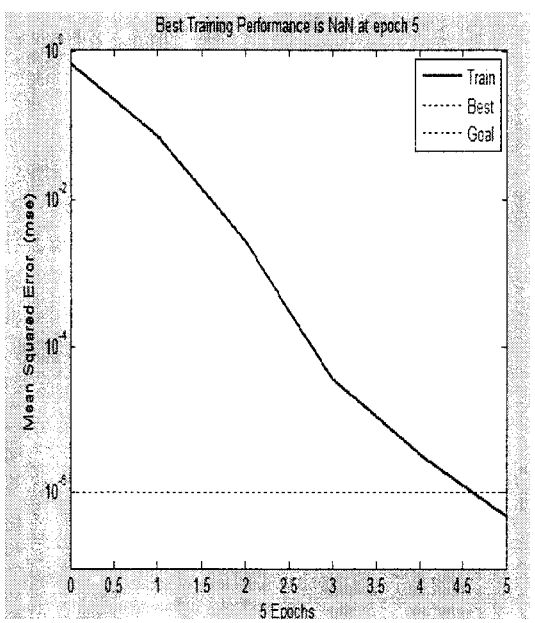

FIGURE 9.11 PERFORMANCE

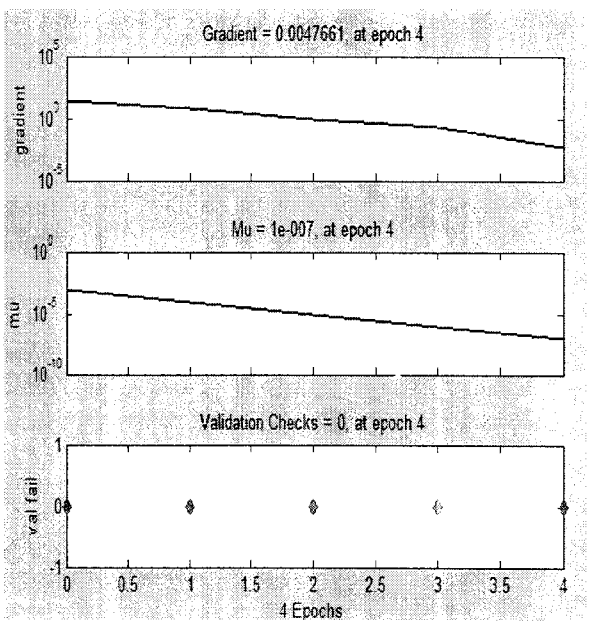

FIGURE 9.12 TRAINING STATE

Chapter X

CHAPTER 10

CONCLUSION

The experimental results showed that the anisotropic diffusion filtering is the good technique for the removal of speckles in ultrasonic images. In the case of segmentation of the medical images various methods are available which includes Edge detection, texture based segmentation, clustering methods and PDE based segmentation. Among these, for sonographic images, PDE based level set method is the felicitous method. For feature extraction of the sonographic images textural features and morphological features are needed.

Textural features are machine dependent. To overcome this drawback, morphological features are extracted instead of textural features because they do not depend on the transfer function of sonographic machines and machine settings. SVM is mostly used mass classifier, but for this proposed system a simple MLP classifier is sufficient. The computational time is also less when compared to SVM, since MLP classifier is less complex when compared to State vector machine classifier. Thus MLP was trained using the features of the images.

Thus the diagnostic system with the features proposed can improve the positive rate of biopsies, provide a second opinion for physicians, and be used as a useful tool for mass classification.

FUTURE EXTENSION

In the future work, testing of the images using the trained MLP and the ROC analysis will be done. The breast mass classification can be done for the following also:

- Volume analysis can be done to find the growth of the tumour and
- Using 3D ultrasonic images the size of the tumour can be found out.

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COIMBATORE - 641049, TAMIL NADU, INDIA.

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This is to certify that Mr./~~Ms.~~ P. SAJEEV ANAND, B.E/ECE

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE has ~~attended~~ / presented a paper titled BREAST MASS CLASSIFICATION ON SONOGRAPHIC IMAGES in the 3rd National Conference on **COMMUNICATION, INFORMATION AND TELEMATICS (CITEL 2011)** on 3rd & 4th March 2011, organized by the Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore.

Dr. Rajeswari Mariappan
HOD - ECE

Dr. S. Ramachandran
Principal

Dr. J. Shanmugam
Director

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COIMBATORE - 641049, TAMIL NADU, INDIA.

CERTIFICATE

CITEL 2011

This is to certify that Mr./~~Ms.~~ E. SATHESH, B.E/ECE

KUMARAGURU COLLEGE OF TECHNOLOGY, CBE has ~~attended~~ / presented a paper titled BREAST MASS CLASSIFICATION ON SONOGRAPHIC IMAGES in the 3rd National Conference on **COMMUNICATION, INFORMATION AND TELEMATICS (CITEL 2011)** on 3rd & 4th March 2011, organized by the Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore.

Dr. Rajeswari Mariappan
HOD - ECE

Dr. S. Ramachandran
Principal

Dr. J. Shanmugam
Director

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Dr. Rajeswari Mariappan
HOD - ECE

Dr. S. Ramachandran
Principal

Dr. J. Shanmuga
Director

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COIMBATORE - 641049, TAMIL NADU, INDIA.

CERTIFICATE

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This is to certify that Mr./~~Ms~~. YUKENDAR B , BE/ECE

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE has ~~attended~~ / presented a paper titled BREAST MASS CLASSIFICATION ON SONOGRAPHIC IMAGES in the 3rd National Conference on **COMMUNICATION, INFORMATION AND TELEMATICS (CITEL 2011)** on 3rd & 4th March 2011, organized by the Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore.

3/11

Dr. Rajeswari Mariappan
HOD - ECE

Dr. S. Ramachandran
Principal

Dr. J. Shanmugam
Director