SEGMENTATION AND ANALYSIS OF DIAPHRAGM FROM ULTRASOUND IMAGES

A PROJECT REPORT

Submitted in the partial fulfillment of the requirement for the award of the Degree of

BACHELOR OF TECHNOLOGY

in

Electronics and Communication Engineering

Under the supervision of

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HIMACHAL PRADESH, INDIA

MAY- 2019

STUDENT DECLARATION

We hereby declare that the work presented in the Project report entitled **"SEGMENTATION AND ANALYSIS OF DIAPHRAGM FROM ULTRASOUND IMAGES"** submitted in the fulfillment of the requirements for the degree of Bachelor of Technology in Electronics and Communication Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Dr.Meenakshi Sood.** This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of this project report.

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CERTIFICATE

This is to certify that the work reported in the B.tech project report entitled **"Segmentation and Analysis of Diaphragm from Ultrasound Images"** which is being submitted by **Nikhil Verma and Swarit Sood** in fulfillment for the award of Bachelor of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by him/her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

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ABSTRACT

Main aim of image processing is to extract important data from images. Using this extracted information we can describe, interpret and understand the scene provided by the machine. The main aim of image processing is to modify images in desired manner using several techniques.

It is generally found that size of medical images is so large due to high resolution so it is difficult to analyze them. Also, radiologists find it difficult to segment the desired part out of ultrasound images. This process is highly cumbersome and time consuming. In order to simplify the task we can design several algorithms to simplify the tasks.

In this project, we are dealing with segmentation of diaphragm from ultrasound image which is a muscle that separates the chest (thoracic) cavity from the abdomen. The diaphragm is the main muscle of respiration. Image processing involves lot of steps i.e. image acquisition, image pre-processing and then segmentation take place. We have used one global thresholding technique i.e. Otsu method and one local thresholding technique i.e Niblack method. Finally we used combination of both techniques to yield desired result. We observed the segmented images after implementing these techniques. In order to check the performance we calculated and analyzed the SNR values and proposed the best method for the segmentation.

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LIST OF ACRONYMS AND ABBREVIATIONS

ROI	Region of Interest
SNR	Signal to Noise Ratio
MRI	Magnetic Resonance Imaging
CT	Computed Tomography
MSE	Mean Square Error
SAR	Synthetic Aperture Radar
PDF	Probability Distributed Function
US	Ultrasound
LOG	Laplacian Of Gaussian

CHAPTER -1

INTRODUCTION

Medical image is the best way by which doctors can analyze what is the disease present inside body and doctors can plan treatment of patient without the need of surgery. It is most powerful resource available to effectively diagnose diseases. Radiologist usually find it difficult to manually segment the ROI from medical images.

1.1 Various image modalities

1. X-ray
2. MRI
3. CT
4. Ultrasound

1.1.1 X-ray imaging

It is most widely used imaging type.It is form of electromagnetic radiation and we are not able to see it with naked eyes but it can pass through the skin so as to create a picture of what is going on inside. They are low cost, quick and relatively easy. It can be used to examine fractured bones. However, there are risks associated with its use.

1.1.2 MRI

It is used to generate images of those body parts that cannot be seen well using x-rays. It uses strong magnetic and radio waves. Typically use to examine internal body structures to diagnose strokes, tumor and spinal cord injuries.It doesn’t use ionizing radiation. But, there are some problems associated with the use of MRI scanning as they use highly ionized radiations.

1.1.3 CT Scan

It uses X-rays to produce cross-sectional images of the body.It provides greater clarity than X-rays providing detailed images of blood vessels, bones and soft tissues within the body. Patients are exposed to ionized radiations which are harmful for their health. There are risks involved with CT scan so it is generally not recommended as first stage diagnosis.

1.1.4 Ultrasound

It is safest form of medical imaging. It does not have any negative effects on body. It uses sound waves other than harmful ionized radiations.Because the risk is minimum it is first choice for pregnancy and other applications such as emergency diagnosis, cardiac and spine.It is generally painless and do not require needles, shots and cuts.It is widely accessible.

1.2 MOTIVATION

The main motivation behind image segmentation lies in the field of medical science. It is generally seen that radiologists take lot of time to segment the region of interest from image.Hence; this process is very cumbersome and time consuming. Radiologists have to manually segment the desired part and this may lead to ambiguity .Doctor may face difficulty in analyzing the segmented part of image. For the sake of greater clarity let us consider a situation if we see a particular image, then we may not be interested in all the details of that image .He require only a particular part of that image. So what is the use of whole image? So, here comes the motivation to process called segmentation. Segmentation not only saves lot of time but also decreases the probability of error. For segmentation we use several algorithms.Furthermore,segmentation can be applied on various modalities like X-Ray,CT,MRI,Endoscopy,ultrasound etc.Segmentation is only one of the step image analysis process.

Image Processing

Image processing is a technique to convert an image in to digital form and perform several operations in to it so as to get enhanced image or to extract some useful information from it. In general, input may be image and output may be image charactestics associated with them.

It is one of exponentially growing technology today and the best part is that it has applications in not only in science or engineering but also in business.

Three steps of image processing

1. Acquiring a image via digital camera or optical scanner.
2. Once , image is obtained we need to analyze the image and perform several operations such as data compression , image enhancement .Image compression is important in case of medical images because they have large size .Hence, it is difficult to real time transmit the images.
3. Hence we obtained image or characteristics associated with the image.

Need of image processing

Improvement of pictorial information for human perception: In order to observe the objects that are not visible to human eye we can perform operation like taking negative of image, performing contrast stretching or histogram equalization we can make it visible.

Image retrieval: we need to seek image that is in interest of us .It is done with the help of segmentation.

Image Recognition: It is required to differentiate objects in image .It is highly used in finger print recognition.

Applications of image processing:

Face Recognition, Feature Detection, Remote Sensing, Finger Print Recognition, Medical Image Processing.

Types of image processing

Analog image processing: Visual techniques of image processing that can be used for hard copies like print outs and photographs**.**

Digital image processing: It helps in manipulation of digital images by using computers.

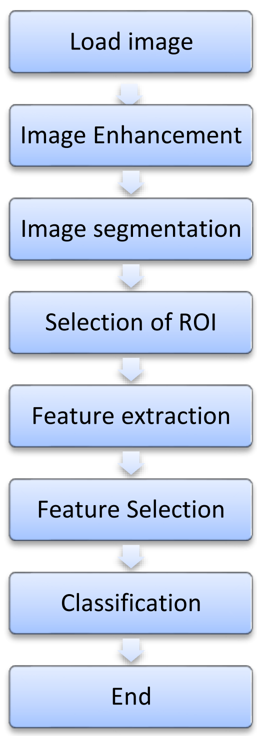


Fig1.1: Different phases in digital image processing

Objectives:

- Collection of dataset.
- Pre-processing of images that involve removing of noise using several filters.
- Segmenting the ROI using Otsu's and Niblack method and implementing the algorithm on MATLAB.
- Comparison of results obtained by these methods on the basis of SNR and MSE.

Software used: MATLAB

Noise:

There are factors, however, that tend to produce variation in the brightness of a displayed image.This variation is usually random and has no particular pattern.It reduces image quality.There are various noise present in image like Gaussian noise,speckle noise, poisson noise etc .The details of these noise can be found in upcoming chapters.For denoising an image we can use filter like sobel,average,prewitt,Gaussian etc.

Image acquisition

This is first step of image processing model. Image must be captured by camera and converted into manageable entity so that we can analyze it.

Image pre-processing

It is second step after image acquisition.After images are acquired they may contain error related to geometry and brightness value of pixels.It allows much wider range of algorithms that can be applied to input data and can avoid problems such as noise.

Segmentation

It is the process by which we extract the region of interest from any image and therefore dividing a digital image in to multiple segments. Main aim of segmentation is to simplify or change the representation of image in to more meaningful one so that it becomes easier to analyze and we can extract meaningful information from it. It is widely used for locating objects and its boundaries.

Approaches to segmentation:

- **Discontinuity based**
- **Similarity based**

Discontinuity based

It is technique used to detect edges in transition regions.If image is noisy, non-uniform then images cannot be detected properly. There may be breaks in boundary. So edges are to be linked.It can be done with the help of local processing and global processing.

Similarity based approach

This approach is slightly different from discontinuity based approach as in this approach we group those pixels in an image which are similar in some sense.

Under similarity based approach, we have three techniques

- Thresholding technique
- Region splitting and merging
- Region growing technique

Thresholding technique

It is one of the widely and basic approaches of segmentation. Image is a nothing but a matrix of pixels where each pixel is represented by a two dimensional function f(x,y).There are bits that are associated with a particular pixel which is responsible for overall size of image. Let us assume that any image contains a dark object and a light background and we want dark object out of it. We can perform thresholding techniques like Otsu's and Niblack are used for this purpose.

Region growing technique

In this approach, we start from particular point and check intensity values of adjacent regions. It is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method.

Region splitting and merging

In this approach, we split image in to number of smaller components and try to merge smaller to get larger segment. Its main idea is to have similar properties to form a region.

Applications of Segmentation

Recognition tasks: It is one of the growing field now a day and of course, a topic of research. It includes tasks like facial recognition, face detection and locating objects in satellite images.

Traffic control Systems: It includes video surveillance that may be required for object positioning, verification etc.

Medical imaging: It has greatest contribution in medical field. It can be used to segment ROI from MRI and US images. It can be used for surgery planning, virtual surgery simulation, measure tissue volumes etc.

Object detection: It can be used for detecting a pedestrian walking on a street and then extracting important feature like face, legs etc and then analyse them independently. It can be used by police and forensic sciences.

1.3 DIAPHRAGM

It is primary muscle which is use for respiration. Diaphragm is dome-shaped muscle which is located below the lungs and heart. It contracts as we breathe in and out.

1.3.1 Diaphragm anatomy and function

Diaphragm is thin skeletal muscle that lies at the base of chest and separates abdomen from chest. It contracts when we inhale. When we inhale, it contracts due to which thoracic cavity expands which results in the flow of air into the lungs. In ultrasound diaphragm appear as thick curvy line. It has some non-respiratory functions as well.

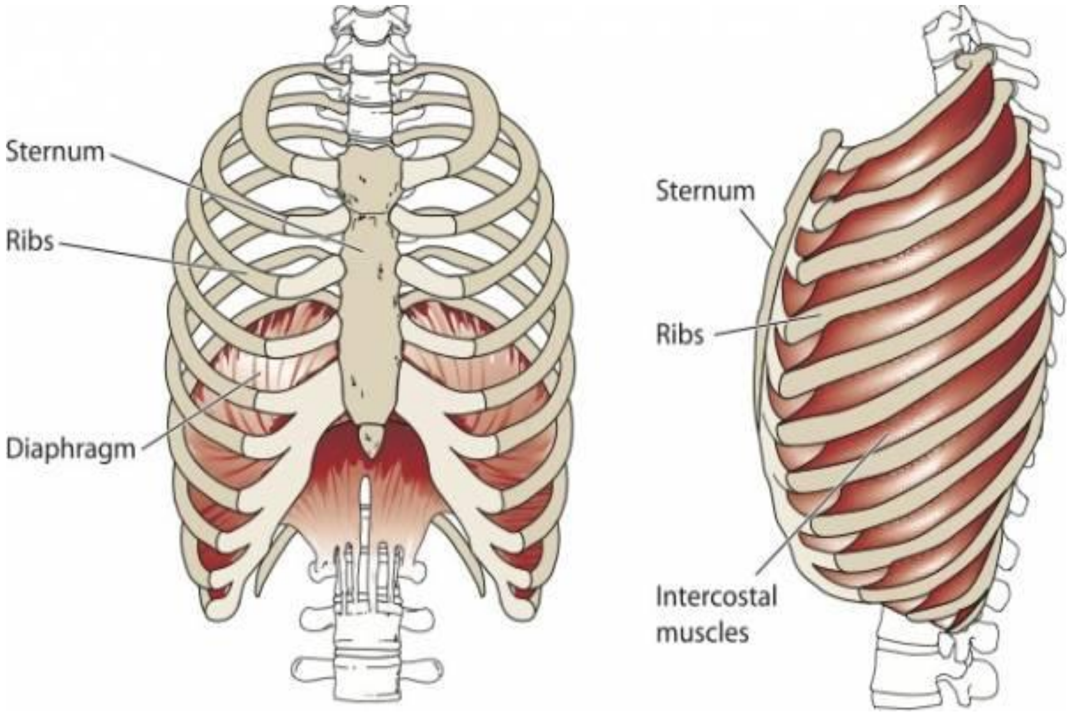


Fig 1.2: Location of Diaphragm in human body

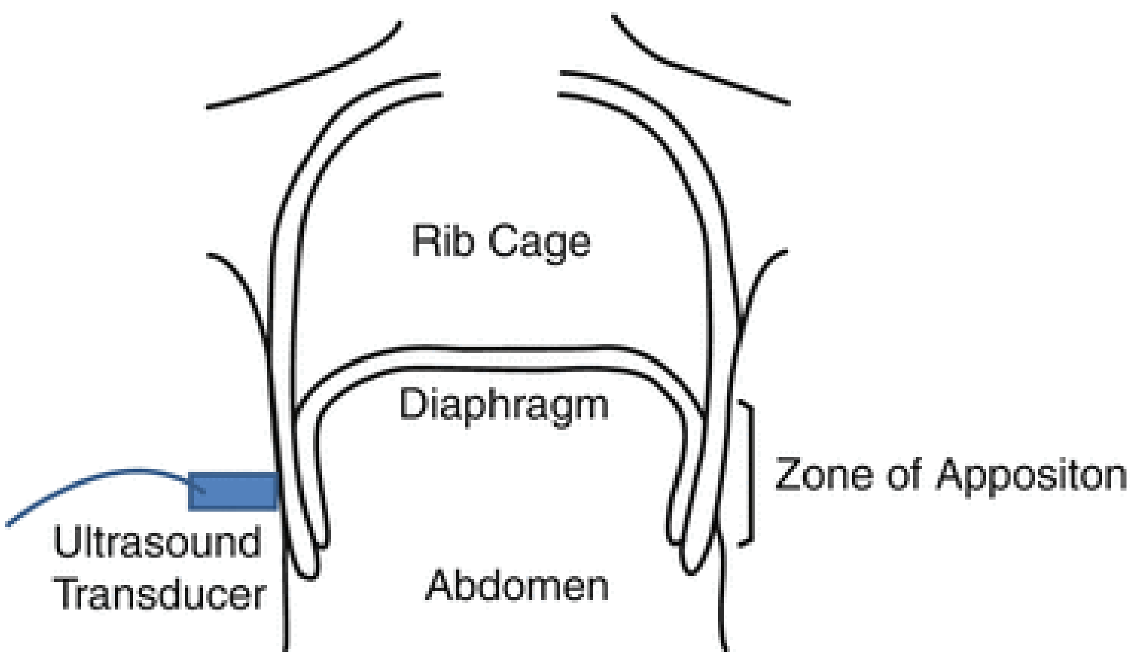


Fig 1.3: Location of Diaphragm with ultrasound transducer

From figure1.1 we can see the location of diaphragm in the human body and from figure1.3 we can see the location of diaphragm with ultrasound transducer which is used for taking the ultrasound images.The below figure is the representation of Diaphragm along with other neighbouring organs as is seen in an US image.

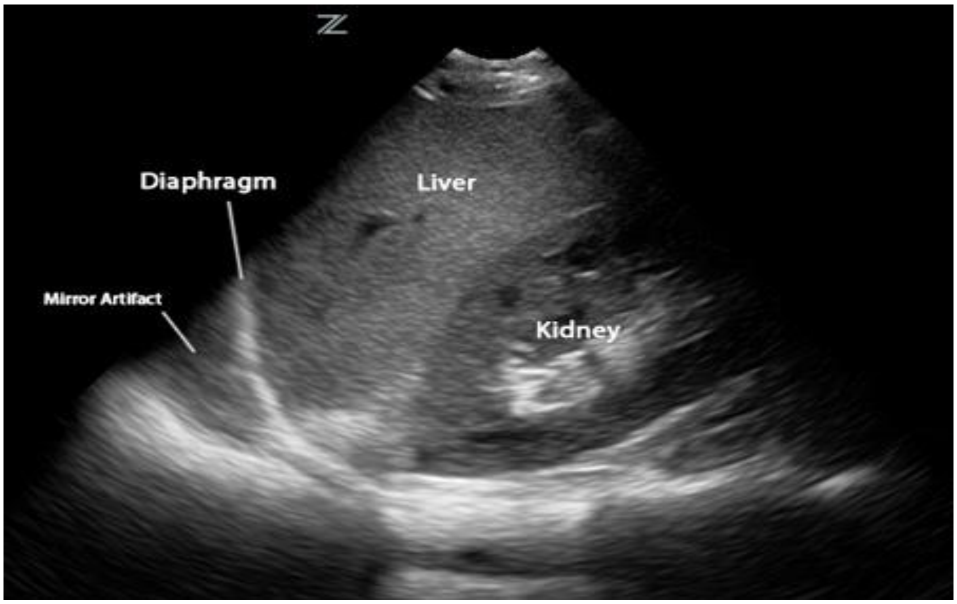


Fig 1.4: Diaphragm along with other neighbouring organs in Ultrasound image

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

Firstly, the overall goal of this chapter is to establish the significance of the past studies conducted across the world. The bulk of the chapter was on critically evaluating the different methodologies used in this field so as to identify the appropriate approach for investigating the research.

2.2 SUMMARY OF LITERATURE REVIEW

H. Kasban , M. A. M. El-Bendary and D. H. Salama ,provided details about various medical imaging techniques that provides ways of looking inside the body. They are used to help in the treatment of different medical conditions. They gave us review of various techniques, concepts and advantages. They provided deeper insight of X-ray radiography, computed Tomography, Magnetic Resonance Imaging etc.They explained advantages and disadvantages of various imaging modalities.

M.E. Haaksma, L. Atmowihardjo, L. Heunks, A. Spoelstra-de Man, P.R. Tuinmanprovided detailed anatomy of diaphragm and methods used for visualizing diaphragm using ultrasound images. It gives deeper insight that how ultrasound is used for analyzing diaphragm.They also explained about limitations of diaphragm.

BhawnaDhruv,NeetuMittal,MeghaModi,provided details about various type of noise present in image like Gaussian,speckle,poissonetc . They explained various filtering techniques used for noise removal.They explained details about various filters like median filter,average filter and wiener filters for denoising.

BasavaprasadB,Ravi M, explains significance of picture handling and its applications to the field of computer vision in image processing. A picture is characterized as an exhibit, or a framework, of square pixels organized in lines and segments. Image processing is a method of changing over a picture into advanced structure and do some manipulations on it, so as to get an improved picture and extract out suitable data from it. They gave details of image compression and its importance in medical images.

Ravindra S. Hegadi,explains details how a image is represented in digital device and explains about fundamentals of image processing, image analysis. They gave deeper insight about various application of image processing. There are number of picture handling in wide range of human exercises from remotely detected scene translation to biomedical picture translation.

S. Muthuselvi and P. Prabhu, explains the DIP technique using image compression, edge detection and segmentation provides better compression ratio and accuracy of an image. They explains about digital image processing, compression, edge detection and segmentation.

Vikas Kumar Mishra, Shobhit Kumar and NeerajShukla ,explains image acquisition ideas. Quantum Detector is the most significant instrument of picture detecting and procurement and it depends upon the vitality of retained photon being utilized to advance electrons from their stable state to a higher state .

Dr. J. Thirumaran, S. Shylaja,explains the basics of medical image processing, background it as a plastic mix of science and art. They explains that how to perform data acquisition and various challenges involved in medical image processing.

Amira A. Mahmoud, S. EL Rabaie, T. E. Taha, O. Zahran, F. E. Abd El-Samieexplains how image denoising includes preparation of the image information to create an outwardlyimage suitable for analysis. The denoising calculations might be grouped into two classifications, spatial separating calculations and change space based calculations.They explains various linear filters like Gaussian filters,Gabor filters and non linear filters like median filter and homophobic filters.They also explains performance parameters like PSNR,MSE determines the quality of image.

PriyankaKamboJ and Versha Rani, explains the importance of removing the noise from image using various straight forward and indirect separating approaches. Various methodologies are used for decreasing noise content and image enhancement, each of which has their very own confinement and points of interest.

Song Yuheng, Yan Haoexplains,the technology behind image segmentation which is widely used in medical image processing, facial recognition and extracting useful information from satellite images. Currently, image segmentation techniques include region-based segmentation, edge detection segmentation, segmentation based on clustering, segmentation based on weakly-supervised learning in CNN algorithms of image segmentation and compares the advantages and disadvantages of different algorithms.

AnjuBala*, Dr.Aman Kumar Sharma, explains various image segmentation algorithms. Region segmentation is classified into three categories like region growing, split and merge and watershed segmentation.

DilpreetKaur, YadwinderKaur, explains image segmentation is the technique of dividing an image into parts called segments which can be useful for image compression and object identification. Several image segmentation are there which parts the image on the basis of color, texture, pixel intensity etc.

JamilehYousefi, explains binarization is important in digital image processing and threshold plays a vital role in it and it tell that how threshold value can be calculated by Otsu's method and Gaussian Otsu's method.

SenithilkumaranN and Vaithegi, explains Thresholding is of two types i.e global and local Thresholding. Locally adaptive thresholding technique removes background by using standard deviation and local, mean . The quality of segmented image can be checked by Signal to Noise ratio.

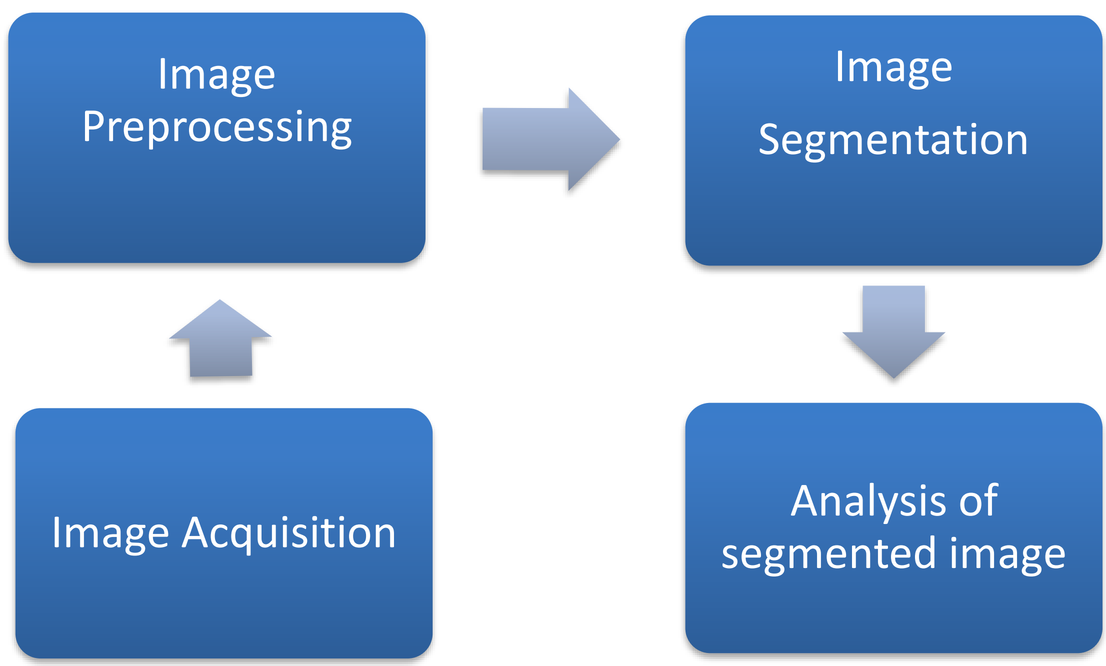
CHAPTER 3

METHODOLOGY

3.1 GENERAL

Image processing is a process of converting an image into digital form as understood by machines and thus perform several operations and manipulations on it like enhancing image or extracting some useful information from it i.e. Segmentation. Usually image processing system includes treating images as 2-D signals while applying already set signal processing methods to them. It is one of the rapidly growing technologies in today's world. It has applications not only in science but in various aspects of business.

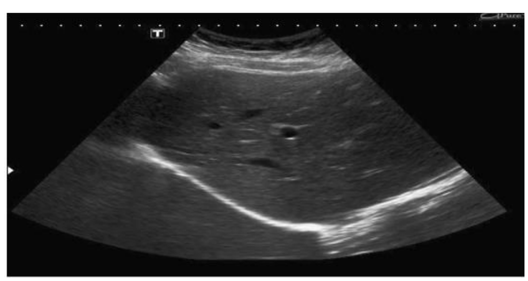
3.2 WORK PLAN

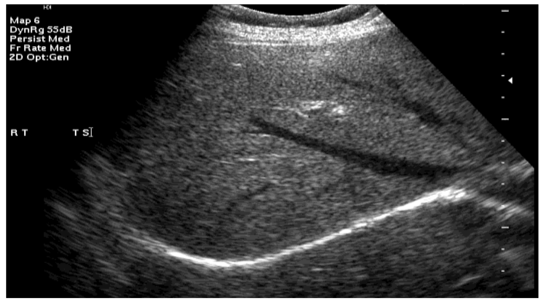


3.2.1 IMAGE ACQUISITION

This is first step of image processing model.Image must be captured by camera and converted into manageable entity so that we can analyze it.Main aim of image acquisition is to transform real world data into numerical data which can be later manipulated on a computer.

Table 3.1 Original Ultrasound Images

S.No	Ultrasound Images
1.	
2.	
3.	

4.	
5.	

3.2.2 IMAGE PREPROCESSING

It is second step after image acquisition. After images are acquired they may contain error related to geometry and brightness value of pixels. It allows much wider range of algorithms that can be applied to input data and can avoid problems such as noise. Image pre-processing helps us to decrease noise content by using several filters. Image enhancement involves collection of techniques used to improve visual appearance of image.

3.2.3 IMAGE SEGMENTATION

It is a procedure of extracting the ROI or the desired region through an automatic or semi-automatic process.Applications of image segmentation are surgical planning, simulation of surgeries, tumour detection and segmentation, mass detection in mammograms, analysis of cardiac images. Segmentation can be used for separating different tissues from each other which can further help us in extracting and classifying features. There are two types of segmentation techniques i.e discontinuity based and similarity based and on the basis of similarity there are two approaches known as thresholding and region growing.

3.2.4 ANALYSIS OF SEGMENTED IMAGE

It is the process which is followed by segmentation of image.In this process, image was segmented using Otsu's and Niblack algorithm.In order to obtain desired results both of these methods were implemented together. Performance attributes like SNR, MSE were found in order to check the quality of images. Better the SNR better is the quality of segmented image.

CHAPTER 4

NOISE

4.1 NOISE

Image is basically a combination of pixels or in mathematical sense image is equivalent to matrix where each pixel represent grey level of image at that point. There are factors, which leads in the contamination of pixels of image which results in produce variation in the brightness of a displayed image.This variation is generally random and it has no regular pattern.It leads in reduction of image quality. In some cases, noise is too high that it hides the most useful information which leads to problem.Noise in image is due to random variation in pixel intensity of image. More precisely, it is electronic noise that occurs in our images. Generally it is produced by sensor, circuit of digital Camera or scanner. It is never desired in images, it destroys the useful information that should be obtained by normal image. We can take example of noise in communication like in amplitude modulation we use analog signals which due to noise present in channel are highly affected. There is variation in voltages obtained in signal affected by noise. Even in digital modulation schemes like amplitude shift keying, phase shift keying they are also affected by noise. In the same way since image consists of array of pixels which show different intensity values .If it is 8 bit per pixel then it can have 256 colours. Due to sensorial disturbances these values may get affected and destroying the overall image. A noisy image can be modelled as follows:

$$C(x,y)=A(x,y)+B(x,y)$$

Here A(x,y) is pixel value of original image ,B(x,y) is the noise added in the image and C(x,y) is the noisy image.

4.1.1 GAUSSIAN NOISE

Itis named after Carl Friedrich Gauss. In communication networks, Gaussian noise affects the communication channels. The source of Gaussian noise can be anything like it can come from natural sources such as temperature. As temperature increases the vibrations in atom in conductors also increases leading to disturbance known as noise.

Main source of Gaussian noise in digital images is due to image acquisition because in image acquisition we have to generate image using some hardware typically a camera .So sensor is involved in capturing image. Due to hardware dependency noise is introduced in images. It shows bell shaped curve in histogram.

Gaussian noise is a statistical noise which has a probability density function (PDF) equal to that of the normal distribution.Gaussian, independent at each pixel and independent of the signal intensity.The PDF of Gaussian noise is given by:

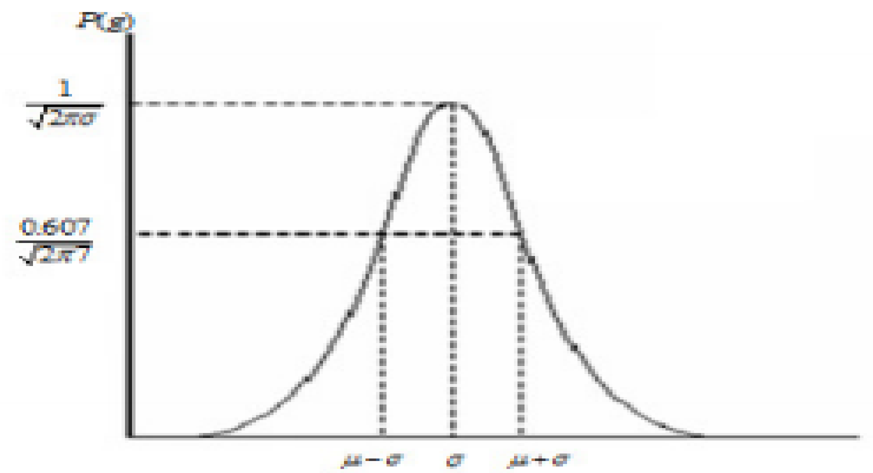


Fig.4.1 Probability distribution function of Gaussian Noise

P(g) is given as:

$$P(g) = \sqrt{\frac{1}{2\pi\sigma^2}} e^{-\frac{(g-\mu)^2}{2\sigma^2}}$$

where ‘g’ represents the grey level, ‘μ’the mean value and sigma represents the standard deviation.

Let us see the effect of Gaussian noise on ultrasound image:

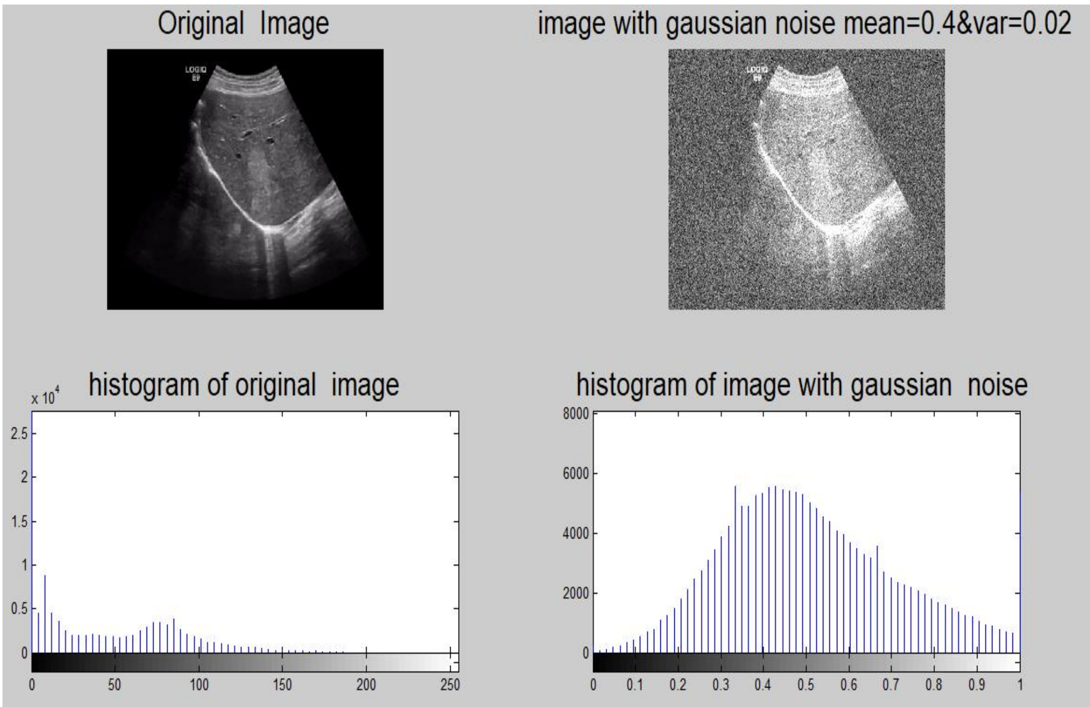


Fig 4.2 Effect of Gaussian noise on ultrasound image with histogram

As shown in the figure 4.2 on applying Gaussian noise on the ultrasound image with mean 0.4 and variance 0.02 we got the above shown histogram.

4.1.2 POISSION NOISE

The concept of shot noise was first given by Walter Schottky in 1918.In case of different medical modalities, like X-ray number of photons are emitted with respect to time. These sources have different photons emitted per unit time which leads to variation in intensity levels causing noise. For example, consider a laser light being focused on wall every time we different number of packets of lights will come together and a laser point will be observed on wall and if we keep on repeating the process we will observe dimmer light sometimes sharp light .These fluctuations in number of photons emitted per unit time will cause a noise which is called speckle noise. This noise follows discrete distribution and it's probability mass function is given by:

$$P(f_{(pi)}) = k) = \frac{\lambda^{k}{}_{i}e^{-\lambda}}{k\,!}$$

Lambda denotes both mean and variance. It is expected number of events in interval.Poisson noise, also known as photon noise, is a basic form of uncertainty associated with the measurement of light.It is a type of electronic noise that occurs when the finite number of particles that carry energy such as electrons in electronic circuit.

Let us see the effect of Poisson noise on ultrasound images:

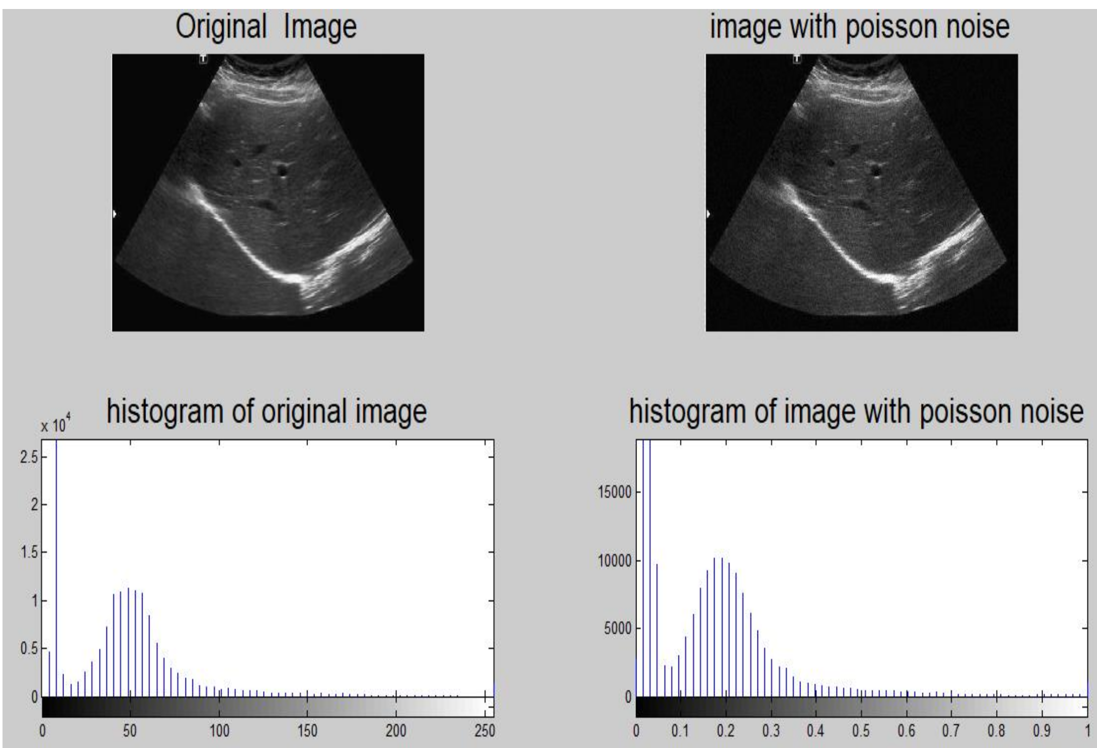


Fig 4.3 Effect of Poisson noise on ultrasound image with histogram

4.1.3 Speckle noise

Ultrasound images are very prominent to the presence of speckle noise. It is random and deterministic in image. They have very negative effect in ultrasound images. In medical science, speckle noise is called textures.The general model of Speckle noise is given by:

$$g(n,m) = f(n,m) * u(n,m) + \xi(n,m) \qquad \text{................ (1)}$$

Here, g(n,m) is the observed image, u(n,m) is the multiplicative component and (n,m)ξ represents the component of speckle noise in image and m,n denote indices of images. On subtracting noisy component from image we can modify equation (1)

$$g(n,m) = f(n,m) * u(n,m) + \xi(n,m) - \xi(n,m)$$
$$g(n,m) = f(n,m) * u(n,m) \qquad \text{.................(2)}$$

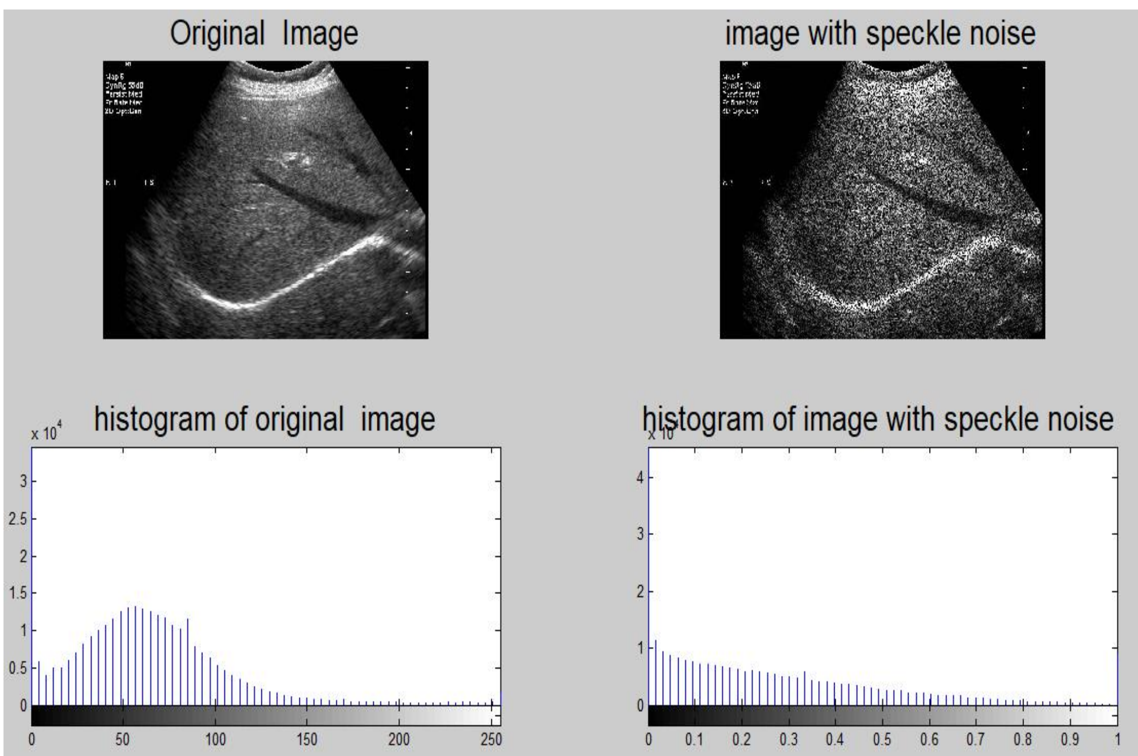


Fig 4.4 Effect of Speckle noise on ultrasound image with histogram

4.2 DENOISING

It is the process of removing noise from images. We use filters to attain denoising.

Filters: Filtering is image processing technique which is used for noise reduction, Interpolation, zooming or shrinking. Filtering image data is a standard process used in almost all image processing systems. Filters are used to remove noise from digital image keeping the necessary details as part of image. The choice of filter depends on application to application. If g(x,y) is noisy image or corrupted image .We apply filters so as to reduce the content of noise and thus producing a image free of noise denoted by f(x,y).

There are various techniques of filtering the image. It is divided in to two categories as shown in Fig()

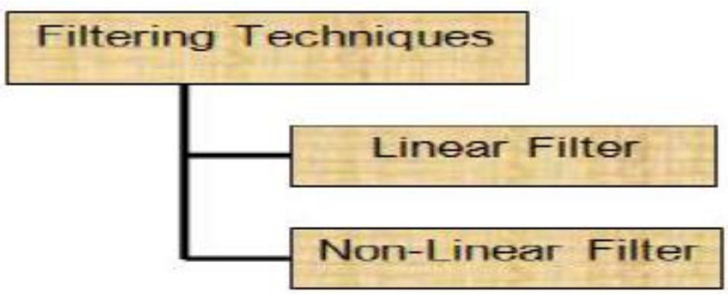


Fig4.5 Techniques of filtering

Linear filter: These filters are basically used to remove only certaintypeof noises such as Gaussian or Average filters. These filters produce blurring effect. These filters tend to blur the sharp edges, removing lines and removing fine details of image. These filters should not be used when removal of details is not desirable.

Non Linear filter: There were some disadvantages with linear filters so non linear filters are used. The filters such as weighted median, relaxed median are used in order to remove the shortcomings offered by linear filters. These filters are very less used in image processing.

Various linear and non-linear filters are as following:-

4.2.1 AVERAGE FILTER

It is also called smoothing filter or low pass filter. It reduces high frequency component.It reduces the intensity variation between neighbouring pixels.Itproduces smoothening effect in images. It is a kind of linear filtering techniques. Average filter is also called low pass filter or Box filter. It reduces the high frequency component in image. The mask used for average filter is as following:

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Here it is 3*3 mask .This mask is placed on image pixels and average has to be taken of neighboring elements. It is a kind of spatial filtering technique. It may be possible that on applying 3*3 window on pixels the results may not be clear or desired so, we can always increase window size in order to create more and more blurring.

In weighted average filter, the Centre value is given more weight and each element is divided by sum of elements. We can see sum of all the elements is 16 so each and every element is divided by 16.

$\frac{1}{16} \times$

1	2	1
2	4	2
1	2	1

4.2.2 GAUSSIAN FILTER

It is controlled by parameters such as mean and standard deviation. Degree of smoothing is controlled by standard deviation. Gaussian filters are used in image processing as infrequency representation of Gaussian function is as its time domain representation. Gaussian filtering is also used to blur images and remove noise. It is product of two one dimensional Gaussian functions which will provide us two dimensional Gaussian functions and we require two dimensional Gaussian function for applying in images which is shown in figure 4.7. Since Gaussian function is non-zero everywhere its domain is all real numbers. So theoretically, we require infinite kernel so as to convolve it with image. Gaussian filter is low pass filter. The weight of middle element is highest and that keep on decreasing on increasing the distance. Here greater value of standard deviation will cause greater blurring. We can use kernel as shown in fig 4.6and convolve it with original image so as to get filters image.

$\frac{1}{273}$

1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

Fig 4.6 Kernel for Gaussian filter

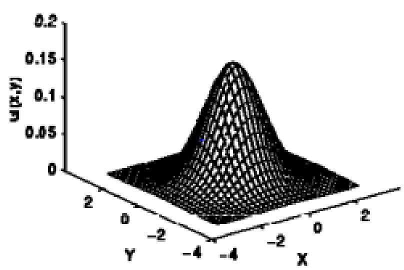


Fig 4.7 2-D Gaussian function

4.2.3 PREWITT FILTER

It is used in image processing, particularly in edge detection algorithms.It is a computing approximation of the gradient of the image intensity discrete differentiation operator function.It uses two 3*3 windows. One window is used for changes in the horizontal direction, and one for changes in the vertical direction. These two windows are then convolved with original image. Here horizontal and vertical derivatives are used for convolving it with original image as shown below:

$$G_x = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{pmatrix} * A \quad G_y = \begin{pmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix} * A$$

4.2.4 SOBEL FILTER

It is also first derivative operator. It gives averaging effect. Effect due to noise is reduced but not taken care by prewitt operator.Like sobel operator it is also used to detect edges in horizontal and vertical directions.It is particularly used in edge detection algorithms.It will convolve the mask on to image which would prominent vertical edges.

-1	0	+1
-2	0	+2
-1	0	+1

4.2.5 LOGARITHMIC FILTER

The logarithmic operator calculates the second derivative of an image.The problem with this is that it gives double edges.It can be used to detect secondary information like whether point lies on darker or lighter side.

4.2.6 LAPLACIAN FILTER

Laplacian Operator is also a derivative operator which is used to find edges in an image. The major difference between Laplacian and operators like Prewitt, Sobel is that these all are first order derivative masks but Laplacian is a second order derivative mask. The strategy used here is that highlight gray level discontinuities.

4.3 PERFORMANCE ATTRIBUTES

4.3.1 Signal to Noise Ratio(SNR)

Signal to noise ratio is popularly used in communication systems so as to calculate the quality of signal. Typically, SNR is used to determine the quality of image. Greater the SNR value, hence greater is the quality of image.It is given by formula:

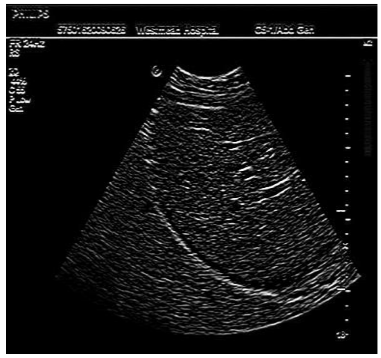
SNR=10log(Signal power/noise power).

It is used to express result in decibel. Lesser the noise, higher will be SNR.

4.3.2Mean square error(MSE)

It is the measure of image quality.Mean Square Error (MSE) is used for comparing the squared error between the original image and the reconstructed.Mean square error is one of best performance attribute used to measure the quality of image.It calculates the square of error which is difference between real value and actual value.The mathematical equation used in calculation of MSE is

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{ij} - B_{ij}\right)^2$$



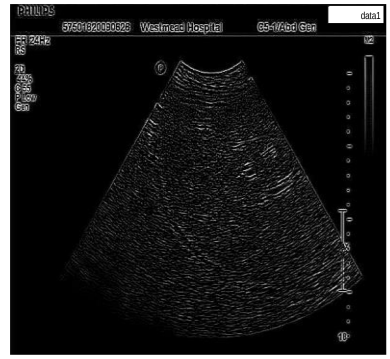


Fig: 4.8.1 Original 1 **Fig: 4.8.2 with prewitt** **Fig: 4.8.2 with logarithmic**

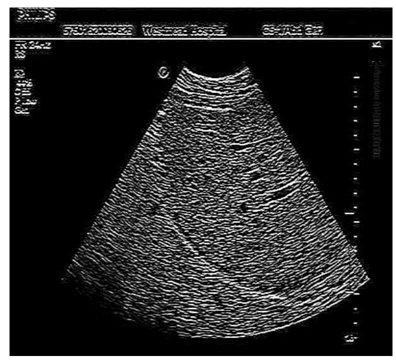


Fig: 4.8.1 with Average **Fig: 4.8.1 with Gaussian** **Fig: 4.8.1 with sobel**

Table 4.1 Properties Comparison of ultrasound image 1

Property	Original	Sobel	Gaussian	Average	Prewitt	Logarithmic
SNR	14.0215	13.9624	14.8552	11.64	19.1299	20.99
MSE	50.7537	51.1	36.286	9.799	9.33	413.9

Fig: 4.9.1 Original 2

Fig: 4.9.2 with average

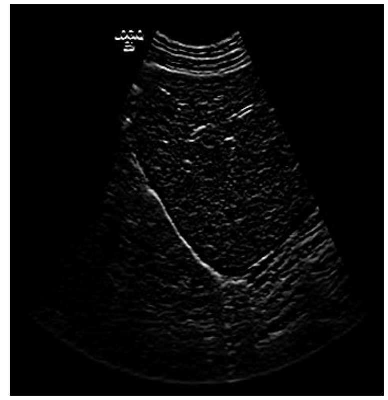


Fig: 4.9.3 with prewitt

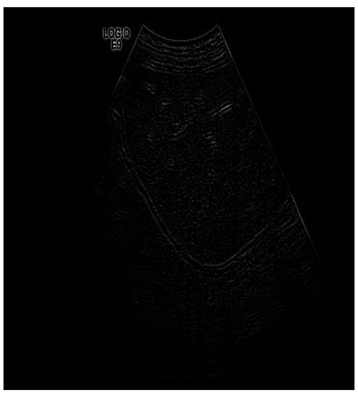


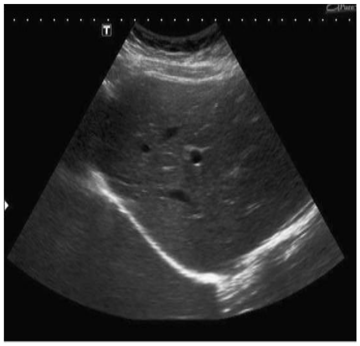
Fig: 4.9.4 with laplacian

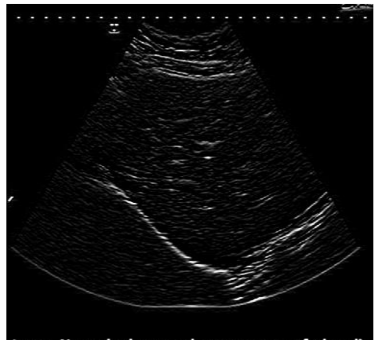
Fig: 4.9.5 with Gaussian

Fig: 4.9.6 with sobel

Table 4.2 Properties Comparison of ultrasound image 2

Property	Original	Sobel	Gaussian	Average	Prewitt	Laplacian
SNR	12.04	16.5	17.36	18.71	22.1	22.5
MSE	63.71	38.14	27.18	7.64	6.6	16.62





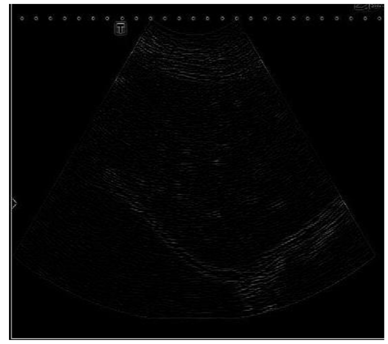


Fig: 4.6.1 original3 **Fig: 4.6.2 with prewitt** **Fig: 4.6.3 with laplacian**

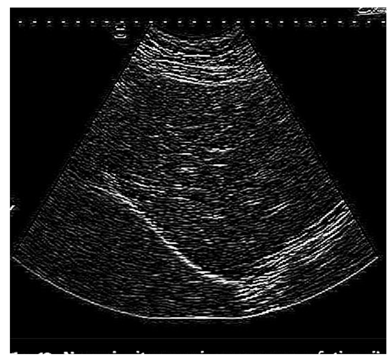


Fig: 4.6.4 with logarithmic **Fig: 4.6.5 with Gaussian** **Fig: 4.6.6 with sobel**

Table 4.3 Properties Comparison of ultrasound image 3

Property	Original	Sobel	Gaussian	Prewitt	Laplacian	Logarithmic
SNR	13.95	26.26	26.12	26.43	27.16	27.6
MSE	51.12	49.61	35.38	10.73	27.26	113.93

Fig: 4.7.1 Original 4

Fig: 4.7.2 with average

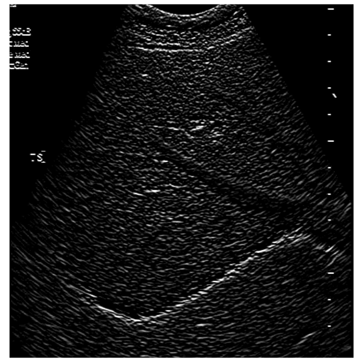


Fig: 4.7.3 with prewitt

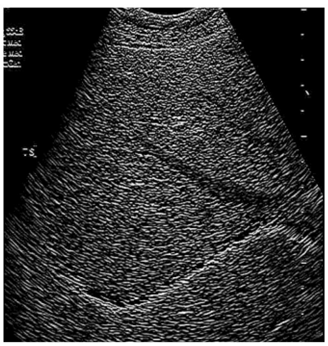


Fig: 4.7.4 with sobel

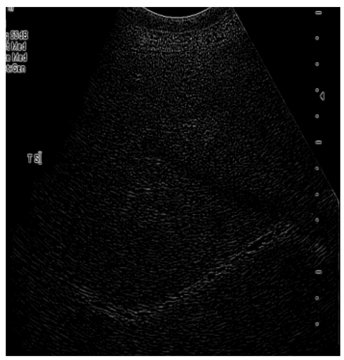


Fig: 4.7.5 with logarithmic

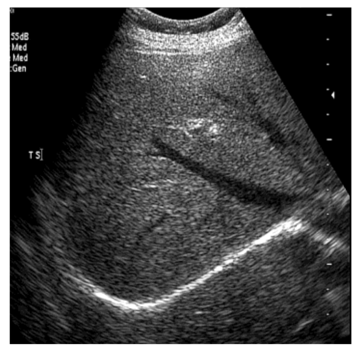


Fig: 4.7.2 with Gaussian

Table 4.4 Properties Comparison of ultrasound image 4

Property	Original	Sobel	Gaussian	Average	Prewitt	Logarithmic
SNR	14.1188	25.3598	25.4827	25.17	28.1	28.81
MSE	50.18	55.03	38.11	9.195	9.13	30.75

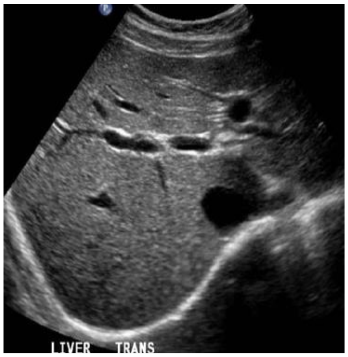


Fig: 4.8.1Original 5

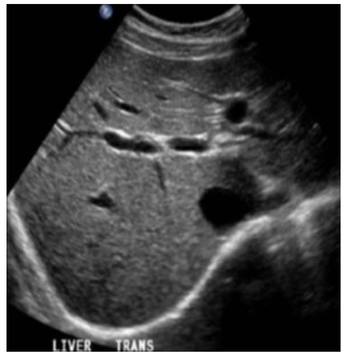


Fig: 4.8.2 with average

Fig: 4.8.3 with prewitt

Fig: 4.8.4 with logarithmic

Fig: 4.8.5with Gaussian

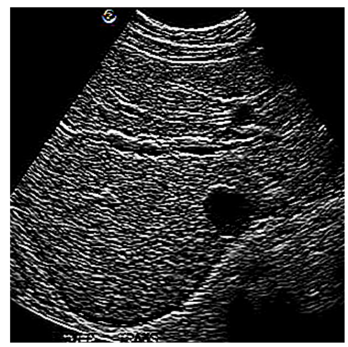


Fig: 4.8.3 with sobel

Table 4.5 Properties Comparison of ultrasound image 5

Property	Original	Sobel	Gaussian	Average	Prewitt	Logarithmic
SNR	12.04	16.5	17.36	18.71	22.1	23.43
MSE	63.71	38.14	27.18	7.64	6.6	69.12

4.4 CONCLUSION

We have used various linear and nonlinear filters in ultrasound images so as to decrease the noise content from image. Here, we have compared the SNR and MSE values after applying several filters to our image. On applying average filter to our original image we found that it gave blurring effect thus improving the SNR value. But it reduces the sharpness of image. In our case the quality of images obtained by average filter is not that bad but the results may not look good when sharpness of image along with other details is highly desired. We have used 5*5 mask for applying average filter but mask can be changed according to our convenience .On applying Gaussian filters we found that it also gave blurring effect because it is another kind of linear filtering technique. On applying Prewitt, Sobel and Logarithmic filter we found that we obtained the edges out of image because they are used in edge detection algorithms. The SNR value in logarithmic filter was found high but visibility was very poor. It is important to note here that it is not necessary that if we are getting higher SNR value then quality of image will also be good.

CHAPTER 5

SEGMENTATION AND RESULT

5.1 GENERAL

It is the process of extracting the region of interest out of image and dividing an image in to several segments. Main aim of segmentation is to modify or manipulate the visual representation of image in to more useful one so that it becomes easier to analyze and we can extract meaningful information from it. It is mostly used for locating objects and image boundaries in images. We assign a label to every pixel in image so that pixel with same label shares common properties.

5.2 Approaches to segmentation:

- **Discontinuity based**
- **Similarity based**

Discontinuity based

It is technique used to detect edges in transition regions.If image is noisy, non-uniform then images cannot be detected properly. There may be breaks in boundary.So edges are to be linked.It can be done with the help of local processing and global processing. Global processing is used for linking edges. Techniques like Hoff Transform are used for detecting straight lines.Basically, in discontinuity based approach we have to detect edges, points and edges. For this purpose we use mask. So mask processing is used. For this purpose different type of masks are used. Different types of masks are used for point detection, line detection.For point detection we use following mask:

−1	−1	−1
−1	8	−1
−1	−1	−1

For line detection we use following masks:

−1	−1	−1
2	2	2
−1	−1	−1

Horizontal (R_1)

−1	−1	2
−1	2	−1
2	−1	−1

45° (R_2)

2	−1	−1
−1	2	−1
−1	−1	2

−45° (R_3)

−1	2	−1
−1	2	−1
−1	2	−1

Vertical (R_4)

Now, edge detection is one of the most commonly used approaches. So, edge is nothing but a boundary between two regions having distinct intensity levels or having distinct gray level. For detection of edges, we use derivative operators.

Sobel edge detector

It is first derivative operator. Following masks are used for detection of vertical and horizontal lines.

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Prewitt edge detector

It is also first derivative operator. Following masks are used for detection of horizontal edges and vertical edges.

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

LOG operator

It is second derivative operator. It is normally not used. It give problem of double edges. it can be used to detect secondary information. It can be used to tell whether point lie on darker side or lighter side.

Following is the mask used for LOG operator:

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Similarity based approach

This approach is slightly different. In this approach we group those pixels of an image that are similar to each other. Under similarity based approach Thresholding operation issimplest in its own kind. It is used in finalization of image. So, this is the approach that can be used for image segmentation purpose.

There are three approaches under similarity based approach

- Region splitting and merging
- Region growing technique
- Thresholding technique

Region splitting and merging

In this approach we split image in to number of smaller components and try to merge smaller to get larger segment. Its main idea is to have similar properties to form a region.Generally, this method require seed pixel and then merging similar pixels around seed pixel in to region where seed pixel is located.

Region growing technique

In this approach, we start from particular point and check intensity values of adjacent regions. It is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method because it generally involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial "seed points" and determines whether the pixel neighbors should be added to the region or not.

It can correctly separate the regions that have same properties that are defined by us. We only need a small numbers of seed point to represent the property we want, then grow the region. The main advantage is that it performs well with respect to noise. The main disadvantage is that computation is time consuming.

Thresholding technique

It is one of the widely and basic approaches of segmentation. Image is a nothing but a matrix of pixels where each pixel is represented by a two dimensional function f(x,y).There are bits that are associated with a particular pixel which is responsible for overall size of image. Let us assume that any image contains a dark object and a light background and we want dark object out of it.We can perform thresholding techniques like Otsu's and Niblack are used for this purpose.

Thresholding is represented as:

$$g(x,y) = \begin{cases} 0 & \text{if } f(x,y) > T \\ 1 & \text{if } f(x,y) \leq T \end{cases}$$

There are two kinds of thresholds that are obtained by two-model or multimodel histograms.Following is histogram representation by which threshold can be calculated:

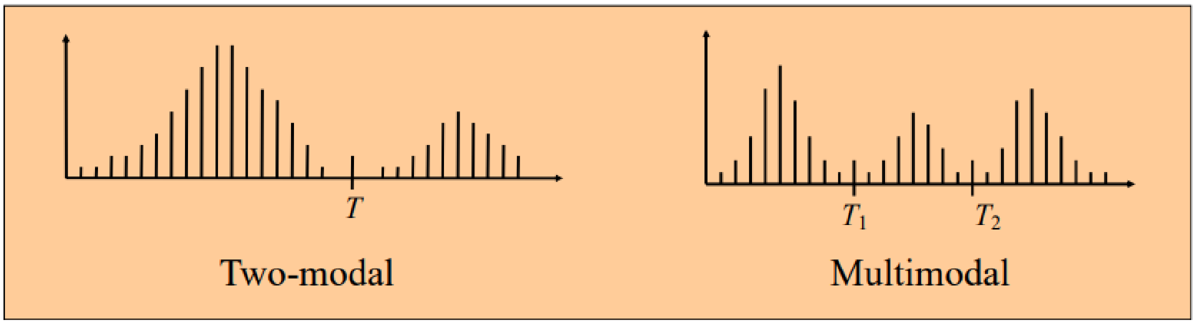


Fig5.1: Two-modal and Multimodal histogram representation

There can be a single threshold present in image which is called two modal or there may be more than two threshold present in image which is called multimodal histogram and it varies from image to image. We need to choose threshold in valley region which is the separation between two objects. Then intensity value has to be compared to threshold. Threshold T is called global threshold.

Some techniques of thresholding

Otsu's method

Segmentation is usually the first step to pre-process an image and extract objects of interest for further analysis like feature extraction, classification and quantification. Otsu's method, which is a global Thresholding method is widely used in image binarization. Otsu's method is generally used to instinctively perform clustering-based image thresholding or to reduce a gray level image to a binary image. Otsu's method searches that threshold which minimizes the variances of the segmented image and helps usin achieving good results The algorithm has assumptions that the image contains two threshold classes of pixels or bi-modal histogram of the original image has two different peaks, where one part belongs to the background, and the other belongs to the foreground.

Output on applying Otsu's algorithm on all ultrasound images we got the below shown result:

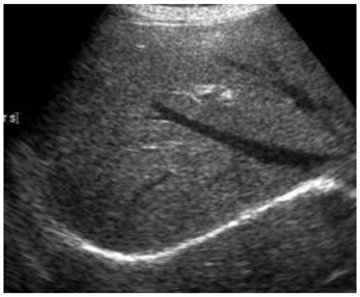


Fig 5.2.1: original image1

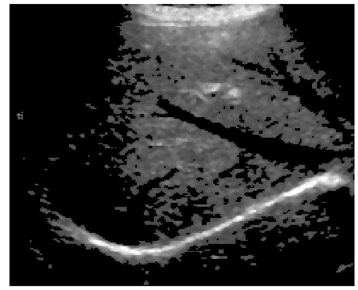


Fig 5.2.2 otsu threshold image 1

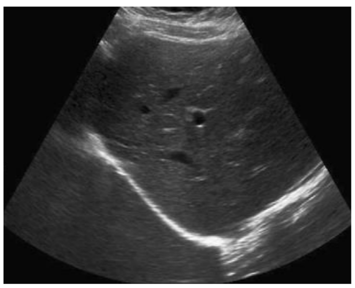


Fig 5.2.3: original image 2

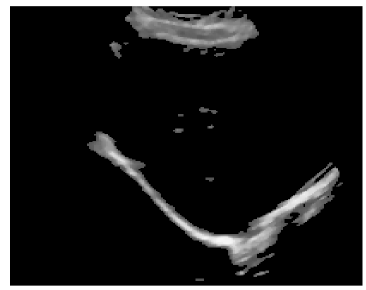


Fig 5.2.4: otsu threshold image 2

Fig 5.2.5: original image3

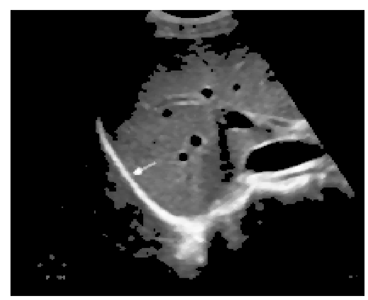


Fig 5.2.6: otsu threshold image 3

Fig 5.2.7: original image 4

Fig 5.2.8: otsu threshold image 4

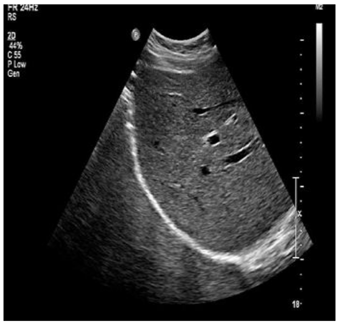


Fig 5.2.9: original image5

Fig 5.2.10: otsu threshold image 5

Niblackmethod:

Niblack’s algorithm is a local adaptive thresholding method.Thismethod isquite simple and effective.Niblack’s algorithm determines a threshold value to each pixel-wise by sliding a rectangular window over the gray level image therefore we have to convert an image to gray level image before implementing this technique. The size of the rectangle window may differ from user to user.It is based on the calculation of mean and standard deviation of local pixel. The formula for calculation of threshold is given as:

$$T(x, y) = g(x, y) + k * a(x, y)$$

Where, g(x, y) and a(x, y) are the mean of a local area and standard deviation values and standard deviation. The value of k can be varied accordingly as per requirements.The size of the neighborhood should be small enough to preserve local details, but large enough to suppress noise. The value of k is used to adjust how much of the total boundary is taken as part of given object.

Output on applying Otsu’s algorithm on all ultrasound images we got the below shown result:

Fig 5.3.1: original image1

Fig 5.3.2: Niblack threshold image 1

Fig 5.3.3: original image2

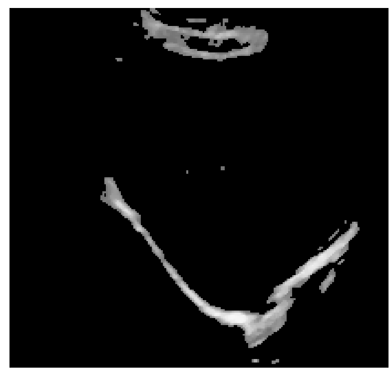


Fig 5.3.4: Niblack threshold image 2

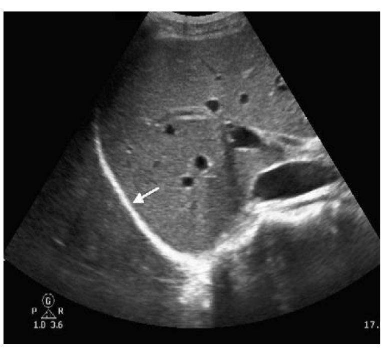


Fig 5.3.5: original image3

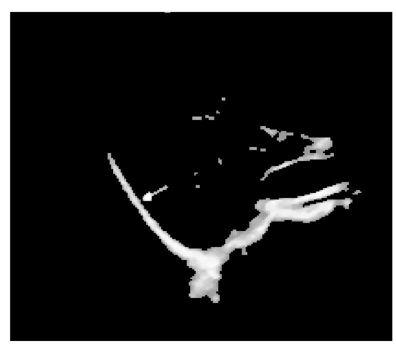


Fig 5.3.6: Niblack threshold image 3

Fig 5.3.7: original image 4

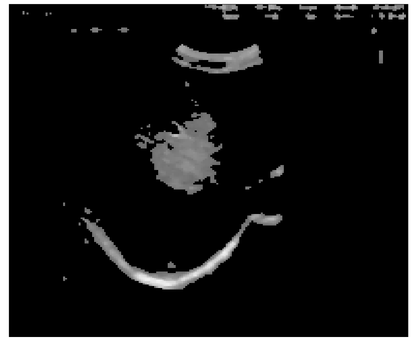


Fig 5.3.8: Niblack threshold image 4

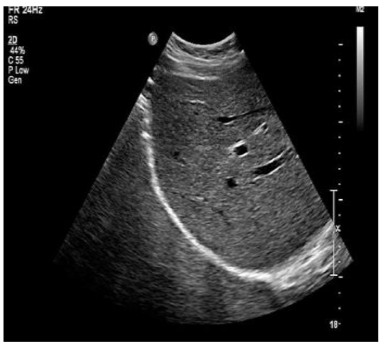


Fig 5.3.9: original image 5

Fig 5.3.10: Niblack threshold image 5

Niblack followed by otsu:

It was seen in Niblack method and Otsu's method , the segmented portion of diaphragm was visible but there were undesirable parts visible other than diaphragm. But then we used Niblack followed by Otsu method in order to obtain better results and then we got the following result.

Output on applying Niblack algorithm followed by Otsu's algorithm on all ultrasound images we got the below shown result:

Fig 5.3.1: original image1

Fig 5.3.2: Niblack followed by otsu threshold image

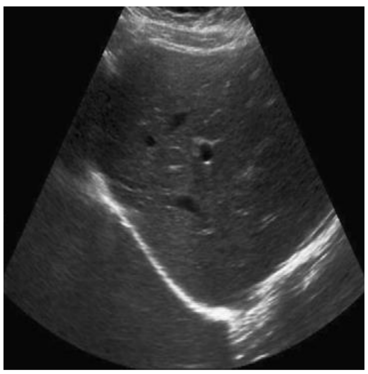


Fig 5.4.3: original image2

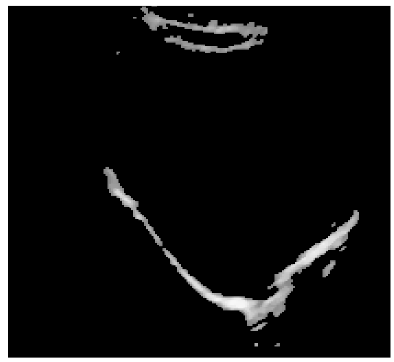


Fig 5.4.4: Niblack followed by otsu threshold image 2

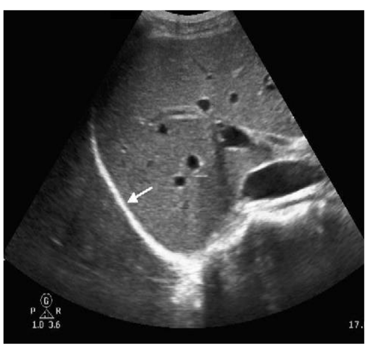


Fig 5.4.5: original image3

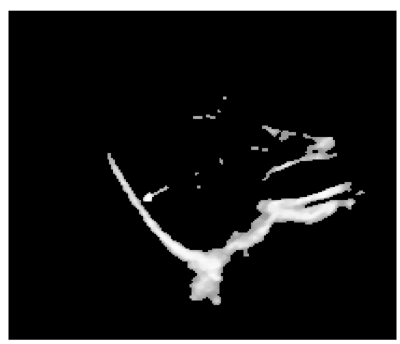


Fig 5.4.6: Niblack followed by otsu threshold image 3

Fig 5.4.7: original image4

Fig 5.4.8: Niblack followed by otsu threshold image 4

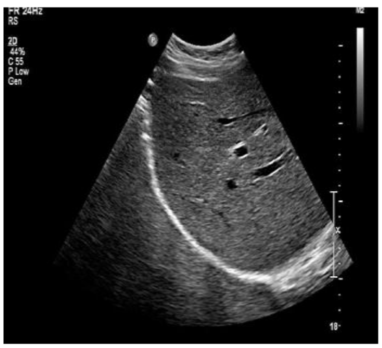


Fig 5.4.9: original image5

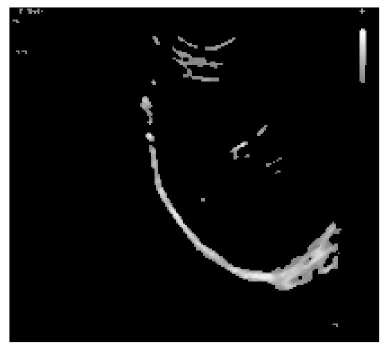


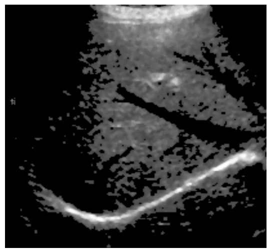
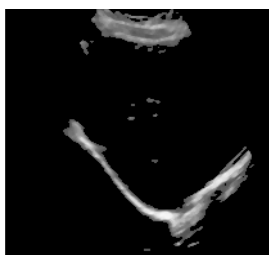
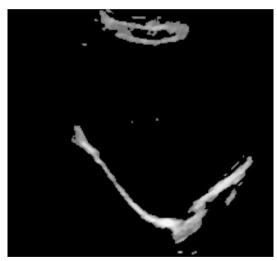
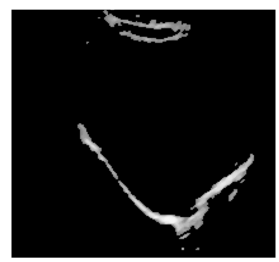
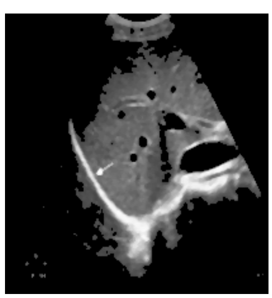
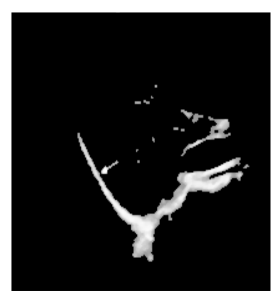
Fig 5.4.10: Niblack followed by otsu threshold image 5

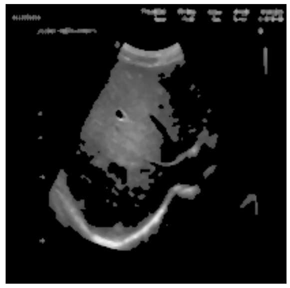
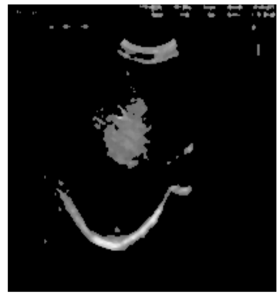
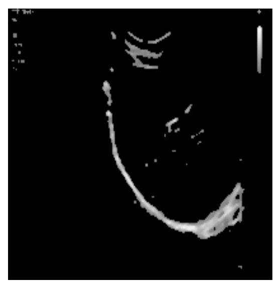
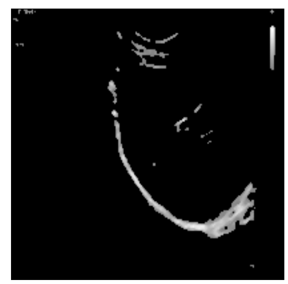
5.3 RESULT

After doing segmentation of diaphragm from ultrasound images by using Otsu's, Niblack and Niblack followed by Otsu's technique we got the results as shown in table 5.1.

We had also calculated the SNR and MSE values for each ultrasound image after segmentation as is shown in the table 5.2 and for comparing the applied techniques we have plotted the SNR graph as shown in the figure 5.5 and it is clear from the graph that Niblack followed by Otsu's method give the highest value of SNR in all the cases thereafter Niblack method and the least value of SNR is given by Otsu's method.

Table 5.1: Result after Segmentation

Original Image	**Otsu**	**Niblack**	**Niblack followed by Otsu**
 Image 1	 A	 B	 C
 Image 2	 A	 B	 C
 Image 3	 A	 B	 C

Original Image	Otsu	Niblack	Niblack followed by Otsu
 Image 4	 A	 B	 C
 Image 5	 A	 B	 C

Signal to Noise Ratio(SNR)

Signal to noise ratio is popularly used in communication systems so as to calculate the quality of signal.Typically, SNR is used to determine the quality of image. Greater the SNR value, hence greater is the quality of image. It is used to express result in decibel.It is given by formula

SNR=log(Signal power/noise power).

Mean square error(MSE)

It is the measure of image quality.Mean Square Error (MSE) is used for comparing the squared

Error between the original image and the reconstructed image.

Table 5.2 SNR and MSE values after segmentation

Image	Otsu	Niblack	Niblack then otsu
1	SNR: 8.6728 db MSE:25.7904	SNR: 12.2168 db MSE: 34.7893	SNR: 15.7525 db MSE: 41.5828
2	SNR:10.6154 db MSE: 24.1571	SNR: 12.4987 db MSE: 26.8005	SNR: 16.8915 db MSE: 35.3282
3	SNR:10.3417 db MSE: 20.9781	SNR: 11.1393 db MSE: 41.0484	SNR: 14.9186 db MSE: 45.5937
4	SNR:11.3958 db MSE: 20.4657	SNR: 13.6827 db MSE: 22.3507	SNR: 18.8052 db MSE: 27.6538
5	SNR:10.1361db MSE: 9.1858	SNR:13.9928db MSE: 37.0462	SNR: 17.6838 db MSE: 33.0318

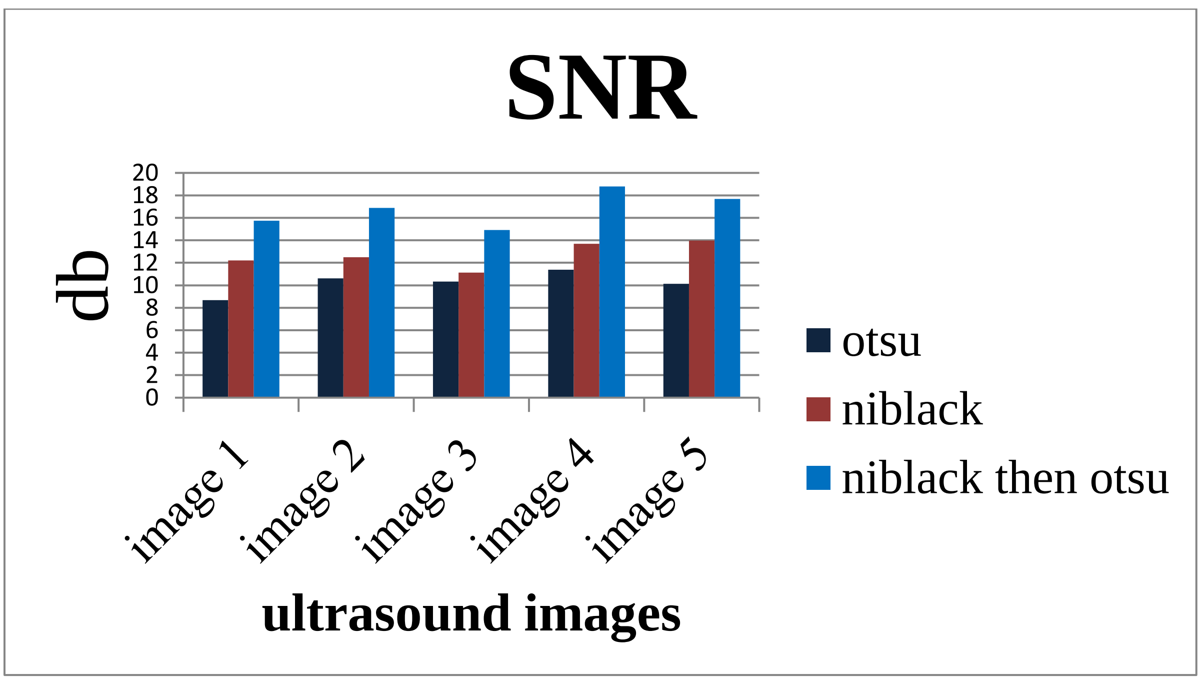


Fig 5.5: Graph comparing the SNR values

5.4 CONCLUSION

We segmented Region Of Interest using Otsu thresholding and we found that the segmented images were not clear or they did not give accurate results because in segmented ultrasound images, other body parts were also visible. Hence, image was not properly segmented. Since the results were not precise. So, we used Niblack thresholding technique for the segmentation and then we calculated the SNR for this technique and we found that SNR for Niblack was found better than Otsu.

For further improvement in segmented result we performed Niblack followed by Otsu and we obtained much better result with much better SNR values. So from this we concluded that in comparison with global and local thresholding,hybrid technique have better performance against noise and error. As evident from Fig 5.5, Niblack has better SNR value than Otsu .But for further improvement, we used Niblack followed by Otsu method which produced much better results and we were getting the best segmented image from hybrid technique as seen in table 5.1 , so we can say that hybrid or Niblack followed by Otsu's technique for segmenting of diaphragm is the best segmentation technique.

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