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BREAST TUMOR DETECTION USING SEGMENTATION METHOD ON ELASTOGRAPHY IMAGES

A Dissertation Submitted in Partial Fulfillment of Requirement for the Degree of Bachelor of Science in Electrical and Electronic Engineering

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DECLARATION OF CANDIDATE

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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DEDICATION

We would like to dedicate this thesis to my family who supported me through both good and tough times. They always give us the motivation to move forward in our life.

Table of Contents

List of figures

List of tables

List of Abbreviations

AV	Audiovisual
CGI	Computer Generated Imagery
CGM	Computer Graphics Metafile
JPEG	Joint Photographic Experts Group
MEL	Maya Embedded Language
MPEG	Moving Picture Experts Group
PACS	Picture Archiving and Communication System
PGML	Precision Graphics Markup Language
QBIC	Query By Image Content
RIP	Raster Image Processor
VML	Vector Markup Language
AAA	Adaptive Anti-Aliasing
AILS	Ames Imaging Library Server
ANHD	ANimation HeaDer
BMHD	Bitmap Header
ELCVIA	Electronic Letters on Computer Vision and Image Analysis

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Abstract

One of the most pestilent disease of the age is breast cancer which have taken beaucoup lives, not only is it endangering the lives of the women of the developing world but the women of the developed world as well. In fact, the women of the civilized world are more prone to breast cancer. There are numerous reasons that can lead to breast cancer. It is mostly detrimental to the senescent, as their immune system are weakening, also women who have family history, exposed to radiation, overweight are susceptive to breast cancer. All these arise from tumors which lead to cancer. There are two forms of tumors- malignant and benign. Malignant are those which cause harm to the neighboring tissues whereas benign does not. However, the problem arises in finding its exact position. The goal of this paper is to locate the boundary of the tumors from elastography images which was a very tedious task hitherto, using segmentation by the active contour method and the watershed method which has stupendous potentiality. Besides that, cascading the both methods analyze the result and find the percentage of error of segmentation. It also derives algorithm of the working procedure of the methods and the accuracy of the segmentation.

Chapter one

Introduction

1.1 Introduction:

For a long time, humans have known about breast cancer. Proof of breast cancer cases have even been found in ancient texts dating back to 3,000–2,500 B.C.E. Doctors first experimented with the surgical incisions with an attempt to destroy tumors during the first century A.D. Though their idea of breast cancer was pretty vague and assumed that breast tumors were linked with menstruation [1]. We now have pretty clear idea about breast and it's causes. But still it remains somewhat incurable. Right now detecting cancer at the earlier stages is the best shot in cancer treatment. With the different imaging techniques available detecting cancer at early stages is not an easy task. And also lack of efficiency of these tests leads the patients to neglect the risk specially in the underdeveloped and developing countries.

That's why researchers have been trying to extract more features from images with the means of digital image processing. Image segmentation is such a process by which a particular object, organ, or image characteristic is extracted from the image data for purposes of visualization and measurement [2]. It has been used for quite some time on different types of medical images to detect a ROI. But segmentation techniques were never applied in elastography images. In our research we are going to apply two different segmentation techniques on elastography images and analyze the results.

1.2 Significance of the Research:

Cancer detected during the later stages are significantly harder to cure than the ones detected during the early stages. Moreover, the after effects of the cancer treatment like surgery and chemotherapy really takes a tool on the patient. Therefore, early detection of breast cancer is the first crucial step towards treating breast cancer [5].

For early cancer detection determining the shape of the tumor is an important factor, for the shape of the tumor can give us some quantitative information which will help us in determining the risk of cancer. In our research we will be using segmentation techniques on elastography images to detect the shape of the tumor.

The difference of elastography image from mammograms or ultrasound images is that it maps based on the stiffness on the tissue by applying stress. So, the resultant ROI from the segmentation of elastography image will give better idea about the tumor than ultrasound or mammograms. This will help the radiologist to further analyze the tumor and get to a better conclusion.

1.3 Challenges:

To set a standard procedure it is required to analyze the procedure with a large variety of data sets. Collecting elastography images have been one of the most challenging part of our research. Lack of large variety of data set some limitation for us in setting some standard parameters. Also some of the images were too noisy and unclear to work with.

Comparing the results from segmentation with a reference to determine the accuracy of the procedures proved to be challenging as we couldn't consult with any professional radiologist to help us. So instead we marked the ROI ourselves to use as references. In future working with a professional will give us better idea about the rooms of improvement in the used procedures.

Comparing the results, we found that in some of the images the resultant ROI covered more area than the actual tumor and, in some images, the resultant ROI excluded even some obvious parts of the tumor. More works needs to be done to accurately detect the tumor region only which we hope to achieve in the future.

1.4 Thesis Objective:

The objective of the research is to determine the boundary of a breast tumor from elastography images through different techniques of image processing. We will be using two image segmentation methods on elastography images, which are

*active-contour method

* watershed method.

After applying the two procedures, we have to perform a comparative analysis between the results and cascade the two methods to extract better results from an image. Thus, we aim to determine a definite shape of the tumors from elastography images.

1.5 Thesis Outline:

The next part of this book discusses on different theories, implementation and results of our research. The following chapters are:

Chapter 1. Introduction

This Chapter contains the real world condition of breast cancer, the significance of the research, the challenges we have been dealing with during our research period & our objectives of the research.

Chapter 2. Background study and Literature Review

This chapter contains the basic theoretical topics on the biological aspects, medical images and segmentation techniques and in the end briefly discusses about some previous works in the field.

Chapter 3. Methodology

In this chapter the methodology of the two segmentation techniques are discussed broadly.

Chapter 4. Implementation and Result

The implementation and result of the two segmentation techniques are discussed in this chapter. A comparative analysis of the results is also shown in this chapter.

Chapter 5. Conclusion

This chapter is a brief overview of the whole research. Discussions about the outcome of the research and future prospects are made in this chapter.

Chapter two

Literature Review

2.1 Introduction

Introduction: literature review indicates an in-depth knowledge about the process. Here with confined our review on three topics:

a) Cancer
b) Types of Images
c) Different segmentation process
d) Prior work in this filed

Based on these three topics we at first, we decided on which types of cancer we want to work with. Then we decided about the segmentation process. And finally, we worked on previous works on this segmentation process.

2.2 Cancer

There are natural disasters that we can barely fight today. But we can arm ourselves today with knowledge so that we can save many lives in the future through enough preparedness. Being one of the leading causes of death and affecting more and more people each year cancer is undoubtedly one of the paramount challenges that we have to beat. Cancer is the uncontrolled growth of abnormal cells in the body. Cancer develops when the body's normal control mechanism stops working. Old cells do not die and instead grow out of control, forming new, abnormal cells. These extra cells may form a mass of tissue, called a tumor. Some cancers, such as leukemia, do not form tumors. [1]. Basically, cancer refers to any one of a large number of diseases characterized by the development of abnormal cells that divide uncontrollably and have the ability to infiltrate and destroy normal body tissue [2].

A healthy body functions like a perfectly synchronized machine that is consisted of complexly interrelated clogs and gears i.e. systems, organs, tissues and even the cells which are working perfectly in accordance with their peers. Healthy cells have a specific life cycle reproducing and dying off in a way that is determined by the requirement of the body. New cells take the places as the old ones die. Cancer disrupts this process and leads to uncontrolled growth. This change is caused by mutation in DNA [3].

DNA is engraved in the genes of every cell. It contains the instruction manual for all the cells for its entire life cycle. Mutations occur often in the genes, but new cells usually correct those alterations. If these mistakes are not corrected, cells can become cancerous. Mutations can cause the cells that was supposed to be replaced to survive instead of dying. These extra cells can divide uncontrollably causing the development of tumor and also calcification. Depending the location of growth, tumors can cause several types of problems [3].

Not all the tumors are cancerous. The tumors that do not spread to the nearby tissues are known as benign tumors and these tumors are not cancerous. As they do not spread to the other tissues, these tumors tend to form a round or oval shaped stone known as macro-calcification. But these tumors can grow large in size and cause problems as they start to press against other tissues and organs. Such as Fibrous or fibromas, are benign tumors that can grow on the fibrous or connective tissue of any organ. Some benign tumors can also evolve into a malignant tumor. These tumors are known as premalignant tumors. Actinic keratosis also known as solar keratosis, this growth involves patches of crusty, scaly, and thick skin. It is more likely to affect fair-skinned people, and sun exposure increases the risk. Sometimes, actinic keratosis will transform into squamous cell carcinoma, so doctors usually recommend treating it.

Malignant tumors are the ones that spread to the neighboring tissues and can even spread to the other parts of the body. These tumors are cancerous. As these tumors spread with no regularity in shape. So the stones that are formed are also irregular in shapes and are numerous. They are also smaller in size in comparison to the stones formed in the benign tumors. This type of calcification is known as micro-calcification. The cancer cells that move to other parts of the body are the same as the original ones, but they have the ability to invade other organs. For example, Carcinoma is a type of tumor that originates from epithelial cells, which are present in the skin and the tissue that covers or lines the body's organs. Carcinomas can occur in the stomach, prostate, pancreas, lung, liver, colon, or breast. They are a common type of malignant tumor [4].

2.3 Breast cancer

Breast cancer is one of the most common form of cancers. Women being the predominant victim of breast cancer, 1 in every 8 women is diagnosed with breast cancer in their lifetime [5]. Breast cancer is a type of cancer that originates from breast cells. It originates either in the lobules or in the ducts. Lobules are the glands that produce milk, and ducts are the pathways that bring the milk from the glands to the nipple. Cancer can also occur in the fatty tissue or the fibrous connective tissue within your breast [6]. Cancer cells can invade healthy breast tissues and ultimately travel to lymph nodes under the arm. The lymph nodes are a kind of primary pathway for the cancer cells to spread to other parts of the body.

There are several types of breast cancers. But they all can be labeled into two main categories [6].

(i) Invasive.

(ii) Non-invasive.

Invasive cancers are the ones that has spread from ducts or glands to other parts of breast and the non-invasive cancers are the ones that has not spread yet. Based on these two categories the most common types of breast cancers can be described, which are:

(i) Non-invasive Ductal Carcinoma:

The cancer cells are still confined in the ducts and have not spread to the surrounding breast tissues.

(ii) Non-invasive Lobular Carcinoma:

It is a cancer that grows in the milk-producing glands of your breast. Like NIDC, the cancer cells haven't invaded the surrounding tissue.

(iii) Invasive Ductal Carcinoma:

Invasive ductal carcinoma (IDC) is the most common type of breast cancer. This type of breast cancer begins in the milk ducts and then invades nearby tissue in the breast.Once the breast cancer has spread to the tissue outside the milk ducts, it can begin to spread to other nearby organs and tissue.

(iv) Invasive Lobular Carcinoma:

It originates from the lobules in the breast and then invades the other parts.The cancer type determines the treatment options and the likely long-term outcome.

2.4 Symptoms of breast cancer:

In its early stages, there may be no signs of breast cancer. A tumor may be too small to be detected in many cases, but on a mammogram an abnormality can still be seen. If a tumor can be detected, a fresh lump in the breast that was not there before is typically the first indication. Not all lumps, though, are cancer. A variety of symptoms can be caused by each type of breast cancer. There are many related signs, but some may be different. The most common breast cancer signs include [7]:

- a breast lump or tissue that has started thickening and feels different than surrounding tissue and has developed recently
- red, pitted skin over the entire breast
- pain in the breast
- swelling in all or part of the breast
- discharge of blood from the nipple
- a sudden, unexplained change in the shape or size of the breast
- a lump or swelling under the arm
- peeling, scaling, or flaking of skin on the nipple or breast

Any of these symptoms doesn't necessarily indicate the presence of breast cancer. A benign cyst may also cause breast pain or lump. But still it would be wise to seek the help of doctors for further evaluation.

2.5 Stages of breast cancer

Breast cancer can be divided into stages based on the size of the tumor or tumor and the extent to which it has spread. Cancers that are large and/or have invaded tissues or organs in the vicinity are at a higher stage than cancers that are small and/or still in the breast. Breast cancer stages are determined by the following factors [8]:

- Whether the cancer is invasive or noninvasive
- The tumor sizes
- If the lymph nodes are involved or not
- If the cancer has spread to nearby tissue or organs or not

The 5 main stages of breast cancer are [8]:

STAGE 0:

Stage 0 is non-invasive ductal carcinoma, where the cancer cells are still confined in the duct and have not invaded the other parts or tissues yet.

Stage I:

Stage I(A): The main tumor is 2 centimeters long or smaller and the lymph nodes are not affected.

Stage I(B): Cancer is located in surrounding lymph nodes and either there is no breast cancer or the tumor is less than 2 cm.

Cancer is located in surrounding lymph nodes and either there is no breast cancer or the tumor is less than 2 cm.

Stage II:

Stage II(A): The tumor is less than 2 cm and has spread to 1–3 neighboring lymph nodes and 2–5 cm and has not spread to any lymph nodes.

Stage II(B): The tumor has spread to 1–3 axillary (axillary) lymph nodes or reaches 5 cm and has not spread to any lymph nodes.

Stage III:

Stage III(A):

-The cancer has spread to 4–9 axillary lymph nodes, or the inner mammary lymph nodes have been expanded, and the primary tumor may be of either volume.

-Tumors reach 5 cm and cancer has spread to 1–3 axillary lymph nodes or any of the nodes of the breastbone.

Stage III(B):

A tumor has invaded the chest wall or skin and may or may not have invaded up to 9 lymph nodes.

Stage III(C):

Cancer is found in 10 or more axillary lymph nodes, lymph nodes near the collarbone, or internal mammary nodes.

Stage IV:

Stage 4 breast cancer can have a tumor of any size, and its cancer cells have spread to neighboring lymph nodes and distant organs.

After testing the doctor determines the stage of breast cancer. Cancer stage indicates it’s severity and it also determines the treatment procedure for the patient.

2.6 Types of Images:

2.6.1 Ultrasound image

The human hearing range is from 20 Hz – 20000 Hz. Any frequency of sound above this range is known as ultrasound or ultrasonic sound. The heart of most ultrasound system is a device called a transducer which uses an array of piezoelectric crystals, the crystal vibrates when electricity is applied producing high frequency sound pressure waves known as ultrasound.

Figure 1: Transducer9[39]

More importantly this type of system can also work in reverse i.e. it can produce electrical signals when it produces high-frequency pressure waves. When a transducer directs ultrasound waves into the body they pass right through the skin and into the internal anatomy, as the waves encounter tissues with different characteristics and densities they produce echoes that reflect back to the piezoelectric crystal [7]. This happens more than thousand times a second, returning echoes are converted into electrical signals which computer converts into points of brightness on the image corresponding to the anatomic position and the strength of the reflecting echoes. A medical transducer contains a large array of crystals which allows it to make a series of image lines that together form a complete frame called a sonogram [8].

Figure 2 :Sonogram of the fetus[40]

Working procedure of ultrasound imaging-

We place the ultrasound probe over the skin of the part of the body that we want to observe and turn it on. The transducer sends out ultrasound waves in that body towards the tissues. However whenever it encounter any interface it reflects some of the ultrasound back to the transducer i.e. whenever it faces a tumor initially it reflects from the near boundary, keeps on going and then reflects again from the end boundary. The transducer is always timing meaning that it always keeps track of when a pulse is sent and also when a pulse is reflected back to the transducer [9]. It already contains the information regarding the speed of sound within the particular medium then very simply by using the equation:

$$v = f * lambda$$

Where, f= frequency of the ultrasound

v= speed of the ultrasound

lambda= wavelength of the ultrasound

Then taking the output from here and putting it into the equation:

$$v = \frac{d}{t}$$

Where, v=speed of the ultrasound

d= distance of the interface from the transducer

t= time taken between transmission and reception of the ultrasound

Since we already know the speed of the ultrasound and the time taken between transmission and reception of the signal we can easily find the distance of the interface from the transducer.

One of the main advantages of using ultrasound is that since it is very high in frequency the amount of diffraction is much less which improves the quality of the image.

2.6.2 A-Mode Image

A-Mode, or Amplitude Modulation, is the display of amplitude spikes of different heights. It is used for ophthalmology studies to detect finding in the optic nerve. A-Mode consists of an X and Y axis, where X represents the depth and Y represents the Amplitude [11]. A single transducer scans a line through the body with the echoes plotted on screen as a function of depth. It is used to create an image of internal body structures such as tendons, muscles, joints, blood vessels, and internal organs. Its aim is often to find a source of a disease or to exclude pathology. The practice of examining pregnant women using ultrasound is called obstetric ultrasound, and was an early development and application of clinical ultrasonography [12].

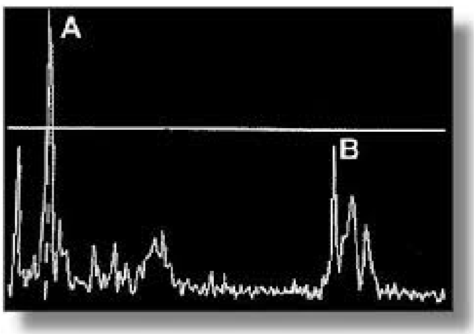


Figure 3: A-Mode Imaging[41]

2.6.3 B-Mode Image

B- Mode/ brightness mode ultrasound imaging technique is also known as 2D ultrasound. B mode or brightness mode refers to the brightness of the grey scales which we see on an ultrasound image.

Figure 4: B-Mode image of the human liver [42]

Brightness mode refers to all the several grayscale pixels that are present in the ultrasound image. It is also known as 2D ultrasound image because it contains 2 axes: the X-axis and Y-axis. The brightness of the image corresponds to the amplitude of the image whereas the ultrasound reflected from the X-plane and the Y-plane corresponds to the construction of the 2D image.

Working procedure of the B-Mode image:

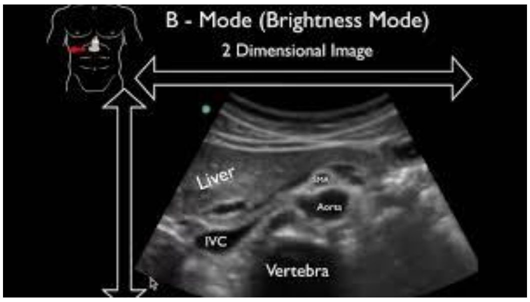


Figure 5: B-Mode image of the human anterior abdomen[43]

At first we need to orient ourselves with the screen on which the image is being displayed. An easy way to do this is to correspond with the probe. In the diagram of the human body the probe is being moved from to the right, the small green dot on the image corresponds with the probe indicating that the green dot represents the right side of the human abdomen i.e. the direction in which the probe is pointed. The image formed is shown from top to bottom meaning that the top portion of the image is the area closest to the probe and the lower portion is further away analogous to the concept of using a flashlight, the objects which are closer appear closer and those which are afar appears afar [10].

2.6.4 M-Mode Imaging

M-Mode, or Motion Mode (also called Time Motion or TM-Mode), is the display of a one-dimensional image that is used for analyzing moving body parts commonly in cardiac and fetal cardiac imaging. This can be accomplished by recording the amplitude and rate of motion in real time by repeatedly measuring the distance of the object from the single transducer at a given moment. The single sound beam is transmitted and the reflected echoes are displayed as dots of varying intensities thus creating lines across the screen [13]. Below is an TM-Mode one dimensional imaging in a pt with moderate mitral stenosis (calcific) that shows evidence of multiple echoes of the anterior mitral leaflet.

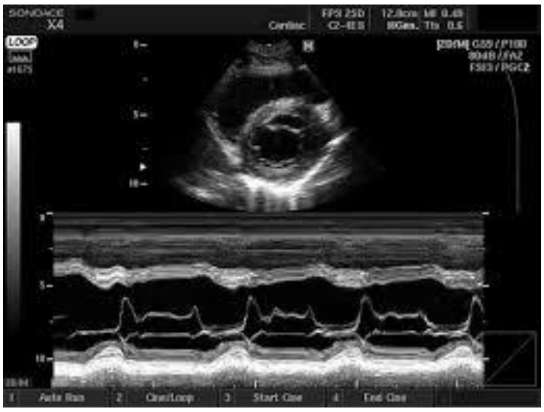


Figure 6: M-Mode Imaging[44]

2.6.5 Elastography

The general meaning of the word elastography is an outgrowth of tissue hardness estimation, tissue hardness estimation by palpation is a very ancient technique used by the Egyptians at approximately 3000 B.C. but its existence was not known until the late 2600 B.C. The actual physics behind it was explained by Tim Hall in the year 2003, the general concept of the palpation is that the object in query must be harder than the tissues surrounding it. This can be applied to any body part soft enough to be understood by touching and within reach such as liver, neck, thyroid, spleen and the breast.

Elastography uses compression to estimate the exact location of the tumor. Compression is used to determine the hardness of a material which was discussed by Kevin Kelly in the mid1990s. The very first technique of determining the location of alien stiff object in a human body is known as echo palpation. In this method we compress a material and watch while we are compressing how “spongy” it actually is i.e. to determining its stiffness through palpation.

Imaging of tissue hardness using elastography developed in steps starting with the M-mode tissue tracking back in 1980 which gradually evolved into Doppler Based Tissue Motion in1987, this technique evolved into elasticity Imaging which was discovered in 1988 from the University of Rochester. Static Ultrasound Elastography was the first widely used technique for stiffness imaging in 1991 from the University of Texas.

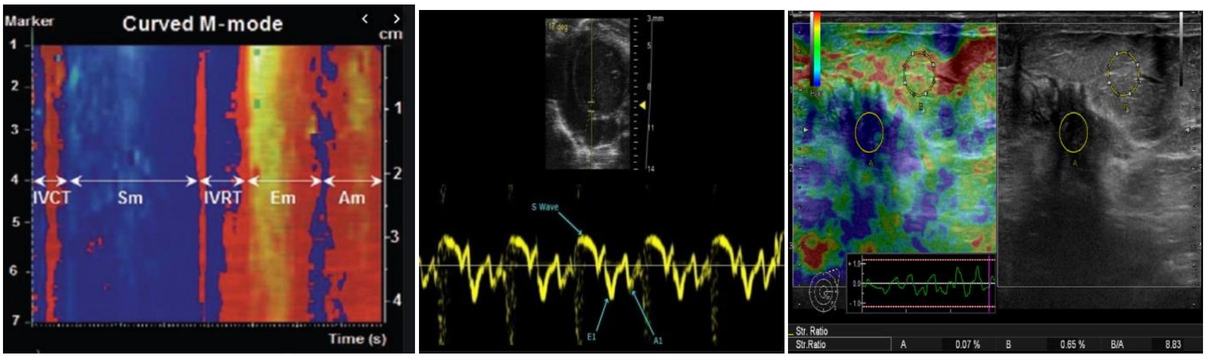


Fig7:- a)M-mode Tissue Tracking ,b)Doppler Based Tissue Motion, c)Sonoelastography Imaging[45]

There are two main methods of tissue elasticity estimation-

1. Quasistatic/ Static or Strain Elastography- The tissue is compressed gently and the tissue displacement is monitored. The strain of the tissues and its surrounding materials is calculated and the corresponding output is presented through an image.

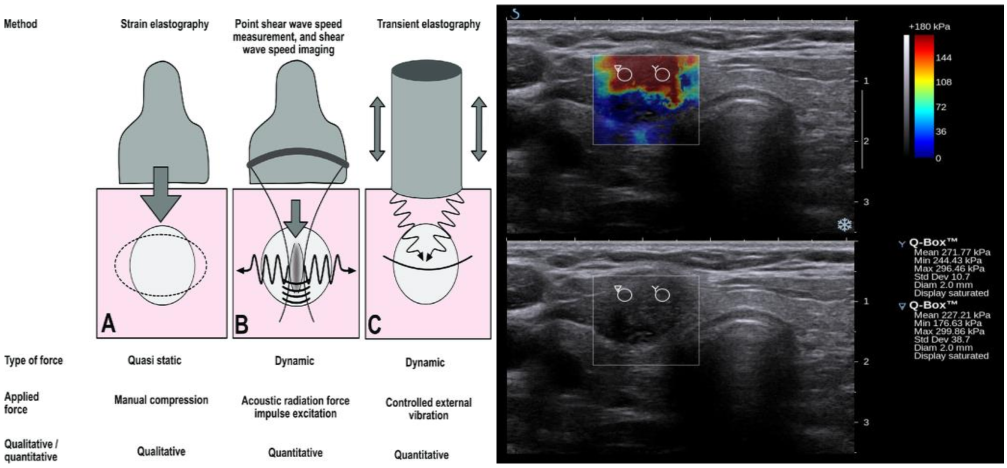


Figure 8: *a)Method of application, b)Strain elastogram image[46]*

2. Dynamic Elastography- A form of vibration is transmitted through the tissue and it is either tractor imaged. The velocity of the wave travelling through the tissue is sometimes used to estimate the hardness of the tissues.

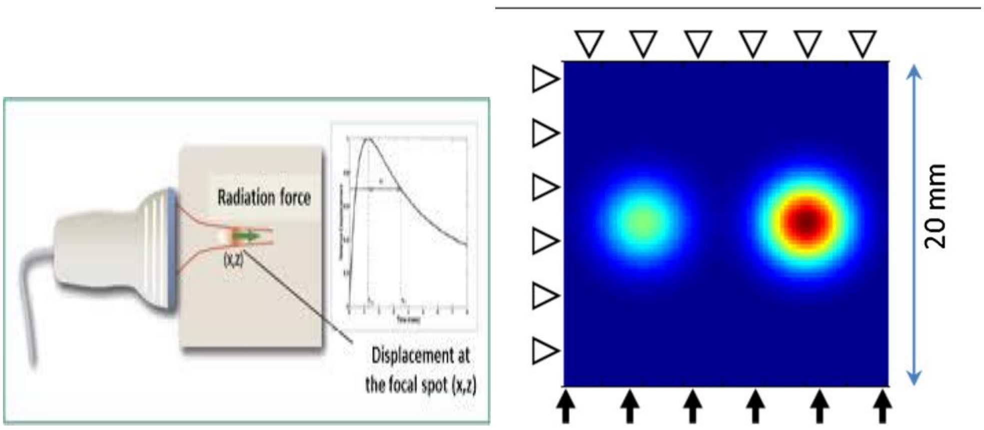


Figure 9: a) Method of application ,b)Dynamic Elastogram image [47]

Both the static and the quasistatic elastograohy follows the same concept. At first a general compression is applied by means of either an ultrasound transducer or using normal physiologic mottion such as breathing, vessel pulsations etc or by applying acoustic radiation force. The tissue displacement is measured by speckle tracking which is a cross correlationtechnique.

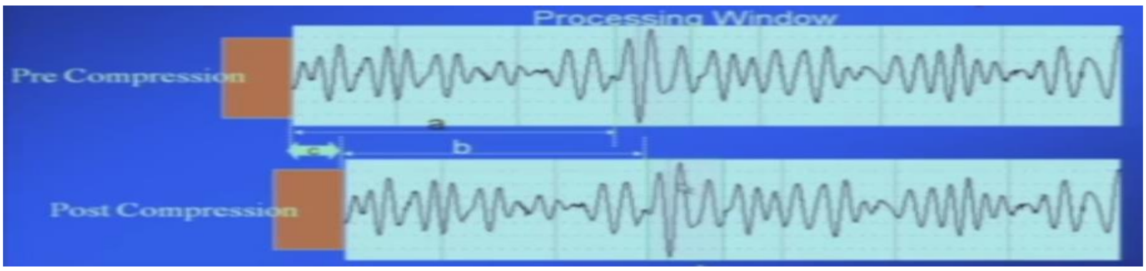


Figure 10: measuring the tissue displacement between precompression and post compression [48]

Strain elastogram is created by taking all the displacement values obtained and calculating the rate of change in the tissue displacement as a function of depth. All these data points are inserted into an image and the corresponding elastogram image is acquired.

In a strain elastogram siff or harder tissues are displyed dark on a grayscale image and softer tissues are displayed as bright or on a colour display they may be displayed in any colour but usually blue or green is generally used for displaying harder of stiffer tissues. One of the first elastogram images was of an infiltrating ductal carcinoma.

Characteristics of strain elastogram-

1. Good for focal disease.
2. Not sensitive to diffuse disease, i.e. when the disease has spread over the entire image. In that case it will be difficult to see as we compare stiffness relative to other areas.

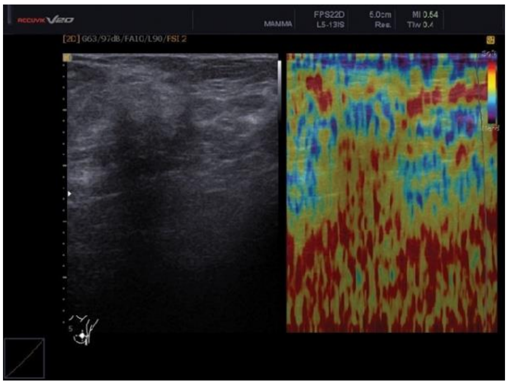


Figure 11 – comparison between an ultrasound image and an elastography for a diffuse breast carcinoma. [49]

Strain elastography can also be created with the help of radiation force imaging where we send a strong ultrasound pulse to push on a tissue and then we interrogate with some tracking pulses to see how far the tissue has moved in response to the pushing pulse.

2.7 Image Segmentation Methods

. Image segmentation is typically used to locate objects and boundaries in images and should stop when the object of interest in an application have been isolated. It is used to calculate the geometric shape and size of tumors and abnormal growth of any tissue. There are many techniques available for auto-segmentation of images like Active contours [8], Fuzzy based classifiers, Gradient Vector Field theory, Tensor based segmentation, Level set [9], etc. But many of them are suffering from problems like optimization, initialization and insufficient results in noisy images. Active contour can be roughly classified in to two types: parametric and geometric active contours. The parametric active contours are explicitly represented as parameterized curves in Lagrange formulation. They are sensitive to the initial contour and cannot naturally handle topological changes. While the geometrical active contours are represented implicitly and evolve according to the Euler formulation based on the theory of surface evolution and geometric flows.

Active contour methods are very frequently used in digital images for various applications, namely: shape recognition, segmentation, edge detection, and stereo matching. What is more, active contour models make it possible to locate the shape or shapes of interest, including frequently very complex ones, in a series of images, on the basis of as seed contour predefined by the user and a defined set of parameters, often in an automatic way, which makes this very convenient in practice [10]. The basic idea in active contour models or snakes is to evolve a curve, subject to constraints from a given image, in order to detect objects in that image. For instance, starting with a curve around the object to be detected, the curve moves toward its interior normal and has to stop on the boundary of the object [11].

An analysis of medical images broadly covers image acquisition, image formation, image enhancement, image segmentation, image compression and storage, image matching/registration, motion tracking, the measurement of anatomical and psychological parameters from images and image-based segmentation [12]. The main goal of image segmentation, which plays an essential role in both qualitative and quantitative image analysis, is to divide an image into sets of regions that are visually distinct and uniform with respect to some property, such as grey level, texture and color [13]. In recent years, active contour models have been one of the most successful methods for image segmentation [14-21]. There are several desirable advantages of active contour models over classical image segmentation methods, such as edge detection, thresholding, and region grow. First, active contour models can achieve sub-pixel accuracy of object boundaries. Second, active contour models can be easily formulated under a principled energy minimization framework, and allow incorporation of various prior knowledge, such as shape and intensity distribution, for robust image segmentation. Third, they can provide smooth and closed contours as segmentation results, which are necessary and can be readily used for further applications, such as shape analysis and recognition [19]. The existing active contour models can be categorized into two classes: edge-based models [14-17, 22-24] and region-based models [18, 19, 25]. Edge-based models utilize image gradient to stop the evolving contours on the object boundaries. In practice, it is difficult to control the motion of the contour. Region-based models aim to identify each region of interest by using a certain region descriptor to guide the motion of the active contour, and do not utilize the image gradient and therefore have better performance for the image with weak object boundaries. In addition, region-based models are significantly less sensitive to the location of initial contours. One of the most popular region-based models are Chan-Vese model [18] and its extended ones [19, 25-28]. These methods rely fully on the global information of the image, instead of its local gradient, and they can realize the global optimization of the image segmentation through minimization Mumford-Shad energy functional. Unfortunately, the methods based on Chan-Vese model are computationally inefficient. Moreover, they may not be able to re-initialization the level set function to a signed distance function when the level set function is far away forming a signed distance function. In practice, the evolving level set function can deviate greatly from its value as signed distance in a small number of iteration steps, especially when the time step is not chosen small enough. Li et al [19, 25] proposes an algorithm based on minimization of region-scalable fitting energy for image segmentation with intensity inhomogeneities. We can call this model RSF for short. RSF relies heavily on extracted intensity information in local regions to guide the motion of the contour, which thereby enables the model sensitive to the noise.

2.7.1 Region Growing Method

It is a process implemented to achieve the goal of image segmentation by formation of different regions which when put together form the complete image. The basic idea behind the working of region growing method is to compare a pixel to its neighboring pixels on the basis of some characteristics like intensity, color or texture and merge them into a cluster if they are similar in the desired character. Region growing method can be seeded or unseeded on the basis whether the centers of clusters are assigned initially or not respectively.

- Seeded region growing method:

  In this method some initial data values also known as seeds are input with the image to be segmented, it is done before the actual process of segmentation takes place. The process initiation takes place with the comparison of the neighboring pixels with the seeds and these are assigned to a cluster if they satisfy certain similar characters.

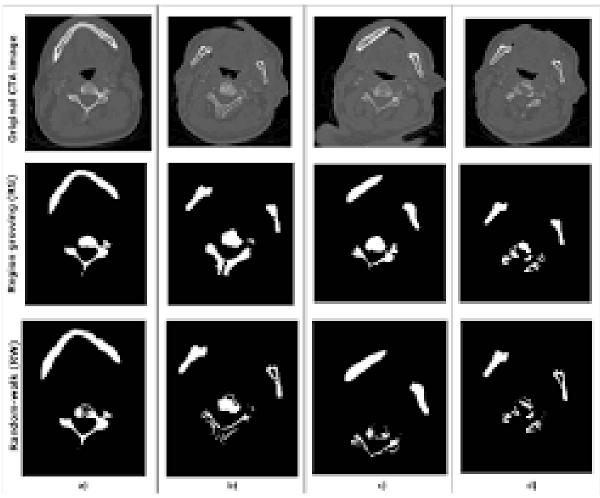


Figure 12: Seeded region growing method [46]

- Unseeded region growing method:

  This is another method of region growing segmentation and it differs from the seeded image growing segmentation in that it does not require initialization of seeds to begin the process. However, this method has some predefined threshold value, which determines the allocation of any pixel to a cluster.

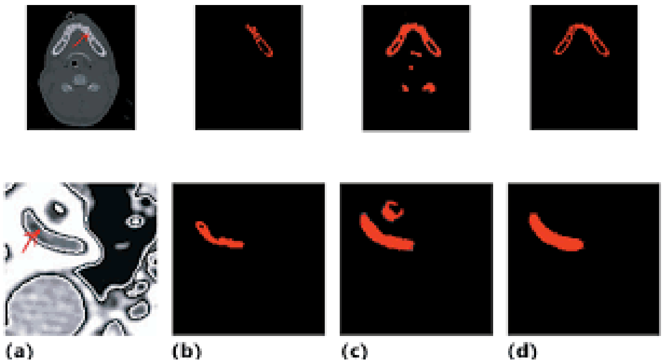


Figure 13: Unseeded region growing method [47]

- Advantages: connected regions are guaranteed; multiple criterions at the same time and give very good results with less noisy.
- Disadvantages: over segmentation when the image is noisy or has intensity variations, cannot distinguish the shading of the real images and power and time consuming.

2.7.2 Clustering Method

Clustering is another simple method implemented for the purpose of image segmentation in which the image is divided in a number of clusters having pixels of similar characteristics. The most common method of image clustering is K-Means clustering; it includes division of the image in K number of clusters. Another method is known as subtractive clustering. On the basis of potential data values, it calculates initial centers. This method finds the data values which can be used to act as initiating points in the K-means clustering algorithm. Image segmentation resulted by clustering method are prone to the development of undesired segments which could easily be eliminated by applying filters to the final image like median filter.

- K-means clustering method:

  It is a widely used method which divides an image in k number of clusters. It takes place in two distinct phases. Calculation of the k centroid takes place in two phases. In the first phase allocation of centers takes place and in the next phase every data point are taken to the closest cluster centroid. To calculate the minimum distant centroid from a point various method could be used, one such method is Euclidean distance method. After the clustering a new centroid of every cluster is calculated which is used to evaluate a new Euclidean distance. The points having minimum distance are assigned to the clusters. The individual clusters formed are recognized by their member pixels and the calculated centroid.

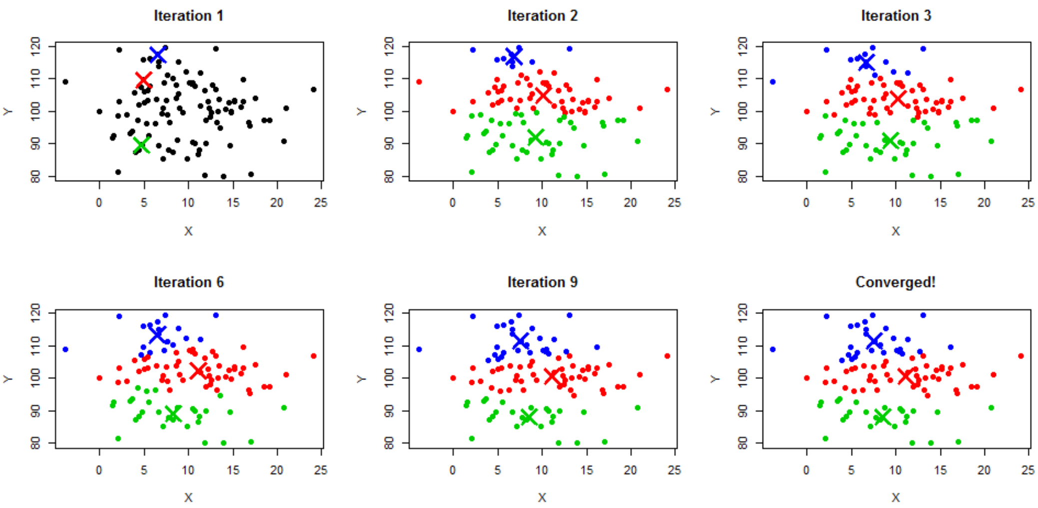


Figure 14: K-means clustering method [48]

- Advantages: shape-based image segmentation.
- Disadvantages: some clustering algorithms like K-means clustering doesn't guarantee continuous areas. This drawback is overcome by Split and Merge technique.

2.7.3 Edge Detection Method

Edge detection is another profound method which is implemented for the purpose of the segmentation of an image. The basic idea behind the edge detection method is that the edges or boundaries of objects are separated from each other with sharp corners, i.e. each object has its own effective area separated from others with some distinguishable boundaries or edges. The main focus of edge detection method is to determine these edges using various computational algorithms. When low level imaging is considered it becomes difficult to determine edges and it being sensitive becomes even more when colored images are considered. The fact that the colored images have objects with multi-dimensional information of the object of interest it becomes easy to implement this method than on the grayscale images. However, as it is practically impossible to have an input image without any type of error, noise, distortion and other factors which add noise to the image. It is not possible to determine the edges of an object perfectly and hence segmentation may have undesirable results. There are various algorithms to implement edge detection method for image segmentation. It can be categorized in two classes. The first one is sequential approach, it independently decides whether a pixel is an edge pixel or not. In other words in a sequential approach the fact of any pixel being an edge pixel doesn't depend on previously processed pixels. The second approach is parallel; the parallel approach considers the neighboring pixels as well to determine if the pixel in an edge pixel and this method literally compares the whole neighboring region of every pixel to determine the edge point of the object. The method of the sequential approach has a benefit that it could be guided with respect to the initial point of the image segmentation. The sequential guided method was used by Chien and Fu and Kellyto determine the boundaries of the cardiac region and lungs. X-ray image was fed as input image. Parallel deferential operators have many types like Laplacian operator and various gradient operators such as Prewitt, Sobel and Roberts. One remarkable feature of the gradient operators is that besides to edges it is also sensitive to individual isolated points. Sobel's and Prewitt's gradient operators are sensitive to noise. The Laplacian operator is also known second difference operator, being a difference operator it is sensitive to variations in gray level. It is not sensitive to linear ramps being a second difference operator. It is sensitive to isolated points and lines. It also is sensitive to corners. As it is a second difference operator it is more sensitive to noise than the edges and it has another drawback that it is orientation variant. For an edge detector to be called a good detector must have two qualities first that it must be first or second spatial derivative differential operator and second that it must be orientation invariant.

Figure 15: Edge Detection Method [49]

- Advantages: Edge detection is an important in image analysis, i.e., important features can be extracted from the edges (e.g., corners, lines, curves). These features are used by higher-level computer vision algorithms (e.g., recognition).

2.7.4 Gray level thresholding

Image thresholding is one of the basic methods implemented for the purpose of image segmentation. In this method the information of an image is converted in binary form, every pixel is assigned a value "1(high)" or "0(low)" on the basis of a threshold value. If the image consists of an object with a background the grayscale histogram of the image is most probably bimodal, i.e. having two peaks with a deep valley. The value of this valley could be taken as a threshold in order to segment the image in two classes namely the object and the background. One such method is known as Otsu's method.

- Otsu's method:

  This method automatically performs image thresholding which is clustering-based. As proposed by this method pixels forming an image can be classified in two categories namely the foreground pixels and the background pixels. An optimum threshold value is calculated and the pixels are categorized in the two categories on the basis of its value. This threshold value minimizes the intra-class variance, or the weighed added variances evaluated for two categories.

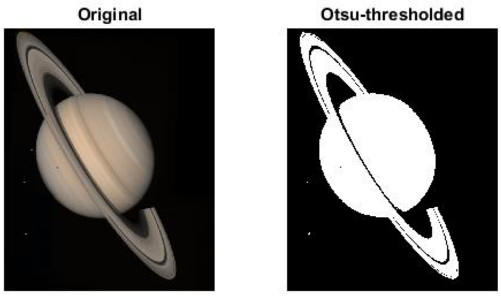


Figure 16: Otsu's method [49]

Otsu's methods produce best results in the cases when the histogram assumes bimodal distribution. It fails in the cases when the image faces extensive noise or when the background area is larger as compared to object's area which causes calculations error in the threshold value.

2.7.5 Watershed segmentation

Another widely used segmentation method is watershed segmentation. The name of the method derives from the type of segmentation result output on grayscale images. The basic ideology of the watershed segmentation is that any grayscale image can be modeled as topographic surface consisting of peaks, hills and valleys. In this method the peaks and hills are modeled as higher intensities and the valleys are modeled as lower intensities. The method initiates by filling local minima with different labels these labels are colored water. Since there can be many minimums and hence have more than one colored water distribution. When the level of water rises the local water, bodies merge together which could be prevented by forming barriers among them. These barriers are the final segmentation result.

This method like the previous one does not depend on the classical merging of the water bodies to locate the boundaries rather they modeled this step into a 5-D space consisting of Lab color vector. It also contains the location coordinates of the super-pixels as an improvement to the other previous methods. The modeling resolved the extra segmentation dilemma and it saved the computation time very much.

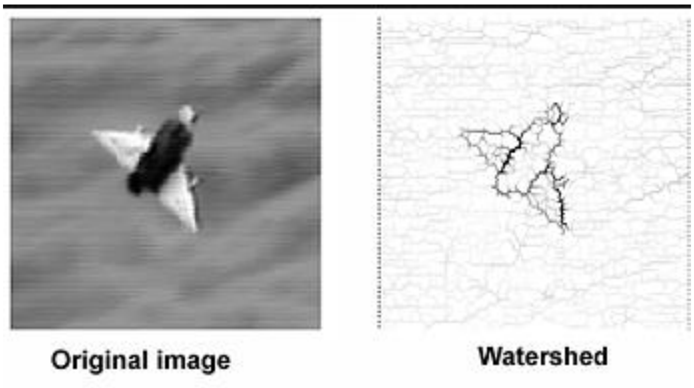


Figure 17: watershed segmentation [50]

2.7.6 Active contour method

The active contour (Snake) is a computer-generated curve that can trace boundaries of images. As a method which applies the computer technology in mathematics, Snake is computationally formulated based on controlled continuous splines and adopts the mathematical concept of energy minimization. It works based on the difference between the internal and the external energy to determine the contour of the tumor.

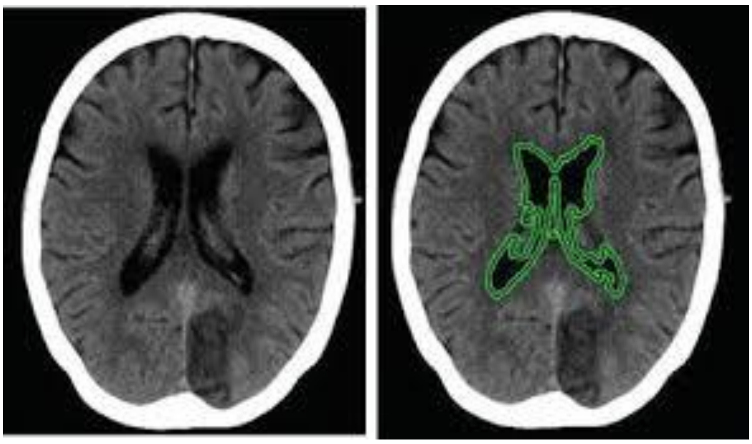


Figure 18: Active contour method [51]

2.8 Prior Works

Fernando C. Monteiro [14] planned a novel image segmentation process comprises of edge and region centered facts with the help of spectral procedure and morphological set of rules of watershed. Initially, they ease the noise as of picture by bilateral filter as a preprocessing step, in addition, region merging is considered to implement introductory segmentation, 1region resemblance is produced and then graph based region alliance be execute by Multi-class Normalized Cut method [15]. R. Patil [16] suggest to facilitate stipulation the numeral huddles be anticipated within truthful way, K-means image segmentation will give superior upshots. They recommended an innovative modus operandi based on edging revealing toward appraise digit of bunches. Facet congruency be in use addicted to explanation toward recognizing the boundaries. Afterward these boundaries are in use addicted to version headed for get bunches. Brink moreover Euclidean expanse be in use keen on explanation within arrange toward create groups. K-means be in use interested in narrative near locating the concluding segmentation of reflection. MATLAB be occupied interested in relation toward execute the not compulsory route. Trials be accomplished going on nine diverse pictures furthermore outcomes confirm so as to digit of collects be precise along with finest. Weihong Cui Yi Zhang [17] optional a perimeter-based auto threshold pick manner toward engenders multi-level image segmentation. Band weights also NDVI (Normalized Difference Vegetation Index) be in use keen on description near determine border. Tests are act upon taking place multi-scale decree illustrations. Effects include exposed with the purpose of their Anna Fabijanska [18] initiated a innovative scheme utilized variation Filter used for boundary finding within image segmentation procedure. Their techniques originate the edging place using difference Filter. Sobel Gradient filter through K-means be too in use addicted to detail toward extort the boundaries by evaluate through the planned method. The result of clean window range going on decisive ends be besides argued with it be create to facilitate but the 9×9 window be in use interested in explanation just before take out boundaries after that boundary be whole exactly equivalent the form of object during the picture. During case of bigger information pictures, a little clean window be extended. Outcome exposed with the purpose of their planned process better sobel edge detector. Mohammed J. Islam [19] initiate to Computer Vision be a greatest way out in favor of actual instance assessment of case within pharmaceutical manufacturing. Writer has made a structure used for aspect scrutiny via edge-based image segmentation methods [20]. They in use addicted to explanation Sobel Edge Detector [21] into arrange near notice boundaries by noise-suppression assets. Later than edging finding Otsu thresholding method is in use addicted to description intended for localization of background also foreground pixels. Trial be performed also outcome be evaluate through NN-based segmentation method structure Visual C++. Outcomes better NN process taking place the base of precision and processing time difference of 10 ms.

Liu Yucheng [22] planned a novel fuzzy morphological stand combination image segmentation algorithm. Algorithm has in use keen on explanation morphological opening as well as closing procedures toward flat the picture with then present the gradient Procedures taking place the resulting picture [23]. Behind evaluate the planned mixture algorithm amid Watershed algorithm [23] and Prewitt procedure, it be creating to facilitate combination method resolve the predicament of over-segmentation of Watershed algorithm. It too keeps the information of picture also recover the rapidity as well. Syoji Kobashi [24] in use interested in explanation size based fuzzy related image segmentation with fuzzy object model to subdivision the intellectual parenchyma area of latest intuitive brain MRI image. Foreground area be divided into initial step, improvement of MRI intensity inside-homogeneity be use next, also then scale-base Fuzzy Object Model (FOM) be used on ensuing picture. Outcome of planned technique assesses on the basis of Fast Positive Volume Fraction (FPVF) also Fast Negative Volume Fraction (FVNF). Outcome as of trials exposed that FOM (Fuzzy object model) has attained lowest FPVF and FVNF assessment. Refik Samet [25] anticipated a latest Fuzzy Rule based image segmentation process to subdivision the rock slight subdivision pictures. They obtain RGB picture of rock slight subdivision as input also give segmented granite picture as output. Fuzzy C Means be too used on rock lean pictures also outcomes be evaluated of together methods. Initially, the abuser will receive test figure from raw materials; aspects be notable on the basis of red, green and blue mechanism of picture. Membership purpose be clear for every component via Fuzzy regulations. All membership function shows the color's division into the picture. Tough also feeble positions be distinct, while tough positions be measured as seed positions also weedy positions turn into their affiliates. Outcome include that planned method be improved than FCM algorithm. Muhammad Rizwan Khokher [26] offered a unique process of image segmentation through Fuzzy Rule based method as well as Graph Cuts. Their algorithm workings by initially removing the aspects of picture, determine the stables using fuzzy rules, analyze the weighted average of regulars to locate the match matrix, separation the graph using Normalized Graph Cut method [27], also lastly acquire regulars to locate the match matrix, separation the graph using Normalized Graph Cut method [27], also lastly acquire the segmented picture from separation graph. Berkley list be in use keen on explanation toward assess the algorithm. Imitation be executed in MATLAB and C language.

Jinsheng Xiao [28] considered a novel non-linear discontinue (PDE) for demonstrations the level set scheme of gray pictures. A discrete method be too planned toward locate mathematical result also toward apply the filter. Additional information be able to exist saved via by the planned method.

Fengchun Zhang [29] explains a difference form from 4th order PDE through 2^{nd} order PDE planned in favor of finger vein image denoising. Midpoint Threshold segmentation method be in use addicted to explanation toward extort the area of importance exactly. 4th order PDE have minimum the noise extremely fine, while 2nd order PDE have estimated the margins successfully. It is capable of exist experiential as of testing that PSNR rate of planned scheme be enhance by 2 dB. Process is evaluated by threshold-based segmentation algorithm and it is established that planned process has subdivision the actual finger vein picture precisely. Chun Yuan [30] planned a novel segmentation model for color pictures and depends in GAC scheme. However, GAC be simply limited toward gray scale pictures. Thus, their form be moreover an expansion of GAC form, and identified as color-GAC model. It uses the term of the Gradient of color picture.

Wencang Zhao [31] anticipated a innovative image segmentation algorithm found on textural aspects [32] also Neural Network [33] toward divide the embattled pictures as of background. Dataset of micro-CT pictures be in use addicted to explanation. De-noising filter be in use keen on description just before eliminate clatter from picture since a pre-processing step, Aspect removal be executed after that, with then Back Propagation Neural system be formed, also lastly, it modifies the load digit of system, also keep the output. Outcome include that planned process betters other method on the basis of velocity also precision of segmentation. Lijun Zhang [34] predictable a narrative neural structure depends on image segmentation scheme for color pictures. They joint the Wavelet Decomposition and Self Organizing Map (SOM) toward offer a novel technique, i.e., SOM-NN. Determination with adolescent pixels preferred the close relative pixel. Later than initialization, ANN creates the segmentation upshot which satisfies every stage. Wavelet disintegration be executed toward eradicate noise. Therefore, wavelet disintegration along with SOM-NN be collected toward execute segmentation. Outcome include that technique has decrease noise also generate precise segmentation. Shohel Ali Ahmed [35] predictable picture Texture Classification procedure depends in (ANN). Initially, picture be captured also pre-processing be executed, later than it, aspect removal [36] be executed, while, ANN classifier [37] be in use keen on explanation for texture classification, Clustering be executed toward divides background from sub-pictures. Trained ANN combines the input pixels addicted to two groups which provide outcome. It creates the texture classification and segmentation of picture.

2.9 Conclusion:

Before doing any type of research we need to study a lot about it. here we have done the same thing. Almost hundreds of papers, journals and other relevant topics were taken into consideration before conducting the research. As we decided to work on elastography images so after studying the segmentation process we decided to go on with active contour and watershed segmentation. From the literature review we came to know that very few attentions have drawn with elastography images. It can also be added that from the literature review we also get motivation for the research on breast cancer.

Chapter three

Methodology

3.1 Introduction

Our book is totally based on watershed and active contour method. Watershed is defined as a region of land that assists in draining water (usually rainwater) into a river or a creek. It is an area of high ground through which water flows into the river or creek. In image processing watershed is the technique of transforming the image as a topographic map, with the intensity of each pixel representing the height. For instance, dark areas can be intuitively considered to be ‘lower’ in height, and can represent troughs. On the other hand, bright areas can be considered to be ‘higher’, acting as hills or as a mountain ridge. On the other hand, Active contour is a type of segmentation technique which can be defined as use of energy forces and constraints for segregation of the pixels of interest from the image for further processing and analysis. Active contour described as active model for the process of segmentation. Contours are boundaries designed for the area of interest required in an image. Contour is a collection of points that undergoes interpolation process. The interpolation process can be linear, splines and polynomial which describes the curve in the image. We have also worked n cascading the both methods.

3.2 Active Contour

Image processing can be defined as computerized processing of images of different types to obtain the desired output. Image processing makes use of a wide range of techniques to process the input information which is available in the form of an image. Processing of images is carried out by avoiding certain features like noise and signal distortion that affects the information present in the images. The images can be defined in different dimensions which can be used for processing. Segmentation is a part of image processing used for segregation of regions.

Segmentation is the process of separation of required information from a data for further processing. Image segmentation can be defined as the segregation of pixels of interest for effective processing. The main aim of image segmentation is to segment the meaningful regions of interest for processing. Region of interest possesses a group of pixels defined with a boundary and these may contribute to different forms such as circle, ellipse, polygon or irregular shapes. The process of segmentation does not provide information about the entire image rather associates pixel data of only the region of interest. Segmentation is a crucial process in Image analysis because it paves path for future processing of images.

In medical image analysis, segmentation is very much necessary where region of study or research is defined to a particular section of the image. If image segmentation is performed effective, the after stages of image analysis are made easier. Image segmentation provides definite and useful information or data for the high standards of automatic image analysis. Image analysis defines certain objectives for segmentation process:

- Decompose the image into parts for future analysis.
- Change in representation.
- Region of interest should be simple, uniform and homogenous with smooth boundary.

Medical image analysis requires segmentation of images for processing of the region of interest. Different modality of images can be processed and segmented for separating the necessary pixel information. Image segmentation is described as the fundamental process in many computer vision and medical image analysis applications. With the process of segmentation, desired output from the pixels of interest is obtained.

Image segmentation can be classified into different types of algorithm based on the discontinuity and similarity of intensity values. Thresholding, region growing, region splitting, region merging, detection of boundary discontinuities (point, line and edge detection), watershed segmentation and active contours are few examples of image segmentation process. Segmentation can also be performed with the help of feature extraction process from the pixels of the image.

Active contour technique is applied for separation of foreground from the background and the segmented region of interest undergoes further image analysis. Active contours are defined models for segmentation of pixels from the required region of interest for which processing is performed to obtain the outcome for research. Active contour models defined below are used in various different fields for image processing. Application of active contour models in medical image processing is very effective, since it separates the necessary pixels from the foreground.

Active contour is a type of segmentation technique which can be defined as use of energy forces and constraints for segregation of the pixels of interest from the image for further processing and analysis. Active contour described as active model for the process of segmentation. Contours are boundaries designed for the area of interest required in an image. Contour is a collection of points that undergoes interpolation process. The interpolation process can be linear, splines and polynomial which describes the curve in the image. Different models of active contours are applied for the segmentation technique in image processing. The main application of active contours in image processing is to define smooth shape in the image and forms closed contour for the region. Active contour models involve snake model, gradient vector flow snake model, balloon model and geometric or geodesic contours.

Active contours can be defined as the process to obtain deformable models or structures with constraints and forces in an image for segmentation. Contour models describe the object boundaries or any other features of the image to form a parametric curve or contour. Curvature of the models is determined with various contour algorithms using external and internal forces applied. Energy functional is always associated with the curve defined in the image. External energy is defined as the combination of forces due to the image which is specifically used to control the positioning of the contour onto the image and internal energy, to control the deformable changes. Constraints for a particular image in the contour segmentation depend on the requirements. The desired contour is obtained by defining the minimum of the energy functional. Deforming of the contour is described by a collection of points that finds a contour. This contour fits the required image contour defined by minimizing the energy functional.

For the set of points in an image, the contour can be defined based on forces and constraints in the regions of the image. Active contours are used in various applications in the segmentation of the medical images. Different types of active contour models are used in various medical applications especially for the separation of required regions from the various medical images. For example, a slice of brain CT image is considered for segmentation using active contour models. The contour of the image defines the layers of the region in the brain which is shown in the figure below-

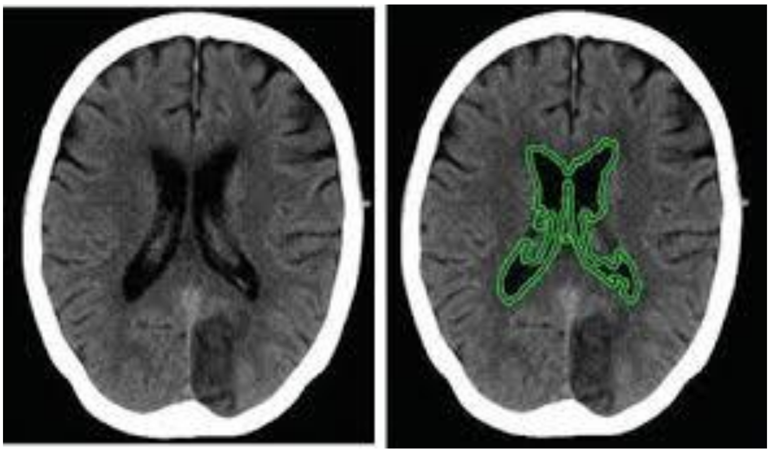


Figure19 : Segmentation of brain CT image using active contours. [51]

Active contours can also be used for segmentation of 3-D images derived from different medical imaging modalities. 2-D slices of image data are used for the separation of target object from the 3-D images. These 2-D slices of images in all directions along with the segmented target region are subjected to 3-D reconstruction to segregate the regions. Mesh model of the 3-D image is designed before applying active contour model. The mesh helps in the formation of deformable contours of the target object in the directional 2-D slices of the 3-D images.

Different types of images from various 3-D imaging modalities like MRI, CT, PET, and SPECT can be segmented and processed with these active contour models. The early diagnosis and detection of abnormalities in the target regions can be performed with the help of active contour models in 3-D imaging. Detection of target regions in the 3-D images enables in accurate description and sectional study of the regions.

3-D segmentation of an image for every slices of the 2-D image is carried out through iterative applications of the active contour models. This segmentation process helps in segmenting the target region in all the slices.

Segmentation of fine structures from the target object in an image is possible with these active contour models. Pham et al. describe the methods for medical image segmentation.

The application of active contour models for segmentation is used in various medical image processing techniques. 2-D and 3-D segmentation of the medical images is performed to obtain the exact target object for identification, detection and diagnosis of any abnormal or unwanted changes in the human body. 2-D active contour models are used for segmentation of specific target area which possesses pixel information and in 3-D process of forming contour, the specific regions of voxel information are determined. Based on the information provided by the segmented region, further processing of the images occurs. Active contour models are also used in 4-D segmentation such as motion tracking, stereo tracking of the movement of the internal regions.

active contour models are used in various medical applications. The medical images from different modalities are considered for the description of active contour model and its types. Active contour models used for medical image segmentation and processing are defined in this chapter. In the field of medicine, segmentation of target objects with accurate boundary lines is very much necessary for diagnosis and detection of any abnormalities in the body. This kind of segmentation is carried out with these models. In order to understand the application of active contour models in the field of medicine, these images are obtained from different authorized and standardized databases.

- SNAKE MODEL

Snake model is a technique that has the potential of solving wide class of segmentation cases. The model mainly works to identify and outlines the target object considered for segmentation. It uses a certain amount of prior knowledge about the target object contour especially for complex objects. Active snake model also called snakes generally configures by the application of spline focused to minimize energy followed by various forces governing the image. Spline is a mathematical expression of a set of polynomials to derive geometric figures like curves. Spline of minimizing energy guides the constraint forces and pulled with the help of internal and external image forces based on appropriate contour features. Snake model enacts deformable model to an image through energy minimization.

This model commonly uses cubic polynomial though higher order polynomials can be incorporated but usually avoided due to several undesirable local properties to confront with. Snake works efficiently with complex target objects by breaking down the figure into various smaller targets. Snake model is designed to vary its shape and position while tending to search through the minimal energy state. Snake propagates through the domain of the image to reduce the energy function, and intends to dynamically move to the local minimum.

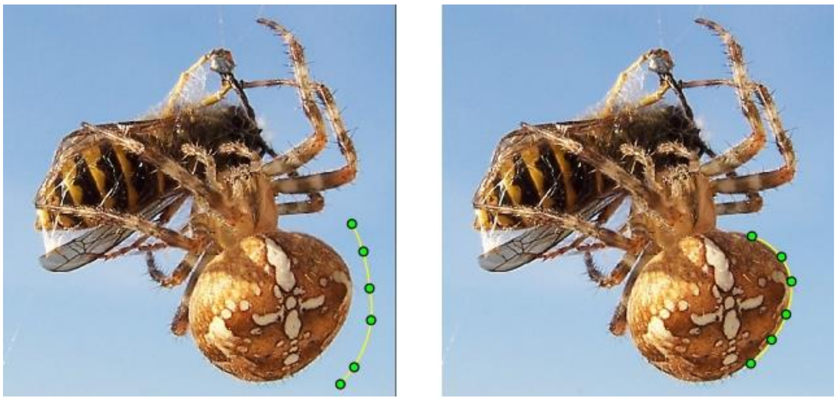


Figure 20: *Active contour segmentation using Snake Model* [52]

❖ GRADIENT VECTOR FLOW MODEL

Gradient vector flow model is an extended and well-defined technique of snake or active contour models. The traditional snake model possesses two limitations that is poor convergence performance of the contour for concave boundaries and when the snake curve flow is initiated at long distance from the minimum. Gradient vector flow model as an extension makes use of gradient vector flow field as energy constraint to define the contour flow.

Gradient vector flow field is the equilibrium solution that reduces the functional energy. The functional energy possesses two different terms such as smoothing term and data term which depends on the parameter μ. The parameter value is based on the noise level in the image that is if the noise level is high then the parameter has to be increased. The main problem or limitation with gradient vector flow is the smoothing term that forms rounding of the edges of the contour. Therefore, increase in the value of μ reduces the rounding of edges but weakens the smoothing condition of the contour to a certain extent.

Gradient vector flow model can be used in all higher dimensions based on the minimum of the energy function.

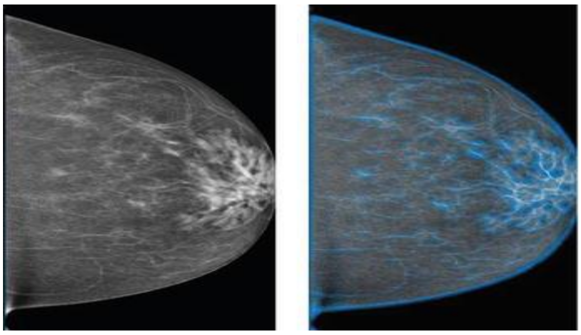


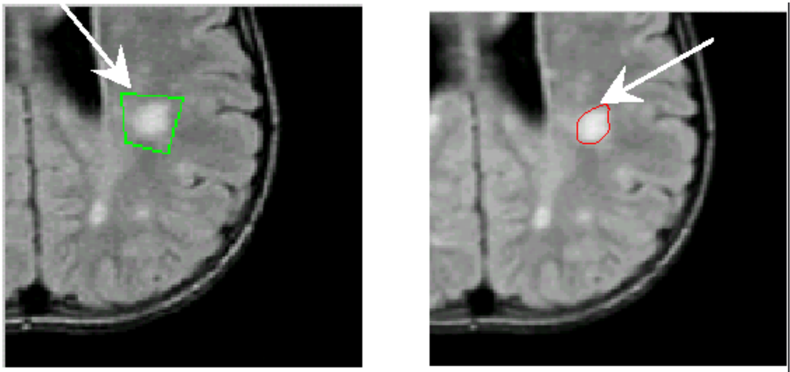
Figure 21: *Image segmentation using Gradient vector flow model* [53]

❖ <u>BALLOON MODEL</u>

A snake model is not attracted to distant edges. The snake model will shrink inner side, if no substantial images forces are acting upon it. A snake larger than the minima contour will eventually shrink into it, but a snake smaller than minima contour will not find the minima and instead continue to shrink. In order to overcome the limitations of snake model, balloon model was introduced in which inflation term is induced into the forces acting on the snake. The inflation force can overpower forces from weak edges, amplifying the issue with localization of initial guess.

Three issues arise from using the balloon model. Instead of shrinking, the snake expands into the minima and will not find minima contour smaller than it. The outward force causes the contour to be slightly larger than the actual minima. This can be solved by decreasing the balloon force after a solution has been found. Computation is done by performing the intersection of a ray with a range image. Iterative process requires refinement of approximation. All range scans have to be looked to get a result. Holes are handled similarly to anchoring process. Noise is broken into two categories namely misalignment of range scans, scan errors mostly outliers. Both these areas are handled by intersection algorithm and filtering.

One of the examples for 2-D segmentation of images using balloon model is skin lesion segmentation. The segmentation of lesion from the dermal image is shown in Figure 6. In general, skin lesion segmentation from the dermal images is very much necessary for the early detection of skin cancer which is becoming predominant in all tropical countries. Thus balloon model is commonly used for segmentation of lesions because the inflation force defines an accurate contour. These contours are used for further processing and prediction of skin cancer. The main disadvantage of the balloon model is slow processing that it is difficult to handle sharp edges and it has a manual object placement. Balloon model is widely used in analyzing the extraction of specific image contour.



(a) initial contour *(b) final contour*

Figure 23: *Image segmentation using Balloon model*

- <u>GEOMETRIC OR GEODESIC ACTIVE CONTOUR MODELS</u>

Geometric active contour or geodesic active contour (GAC) is a type of contour models that modifies the smooth curve defined in the Euclidean plan by moving the points of the curve perpendicular. The motion of the points is at a speed proportional to the curvature of the region in the image. Contours are described based on the geometric flow of curve and detection of objects in the image. Geometric flow includes both internal and external measures of geometry in the region of interest. Geometric alternative for snakes is used in the process of detection of objects in an image. These contour models largely depend on the level set functions that describe the specific regions in the image for segmentation.

Geometric active contour depends on the level set function and geometric planar curve evolution which describes the region for segmentation. By adding an area of minimizing region (balloon force), propagation of contour occurs internal by minimization of the interior energy. Geometric active contours are mainly employed in medical image computing especially in image-based segmentation.

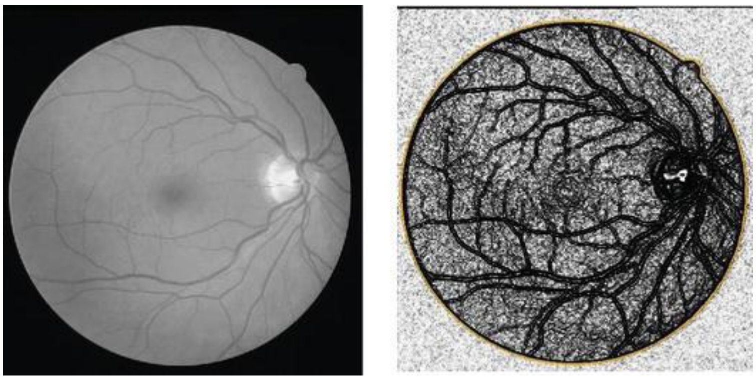


Figure 24: Fundus image segmentation using geodesic active contours [54]

ALGORITHM

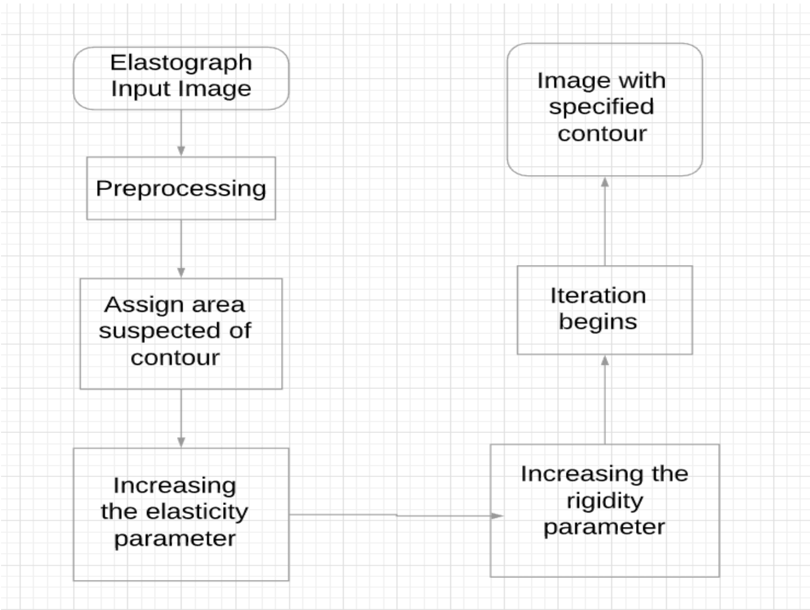


Fig 25: *Flowchart of active contour method.*

The image obtained after preprocessing undergoes iteration which is used to ascertain the contour of the tumor. The iteration is performed based on the energy of the image.

$E_{total} = E_{int} + E_{ext}$

The internal energy is responsible in determining the continuity and the smoothness of the curve using a set of parameters- α and β. α is the elasticity parameter which determines the gradient of the line between 2 neighboring selected points and β is the rigidity parameter which is liable for the smoothness of the curve.

$$E_{int}(v(s)) = \frac{1}{2}\{\alpha|v'(s)|^2 + \beta|v''(s)|^2\}$$

The external energy function is obtained from the information of the object and it drives the curve to the boundary of the object.

$$E_{ext} = -k\frac{F_{image}}{||F_{image}||} + k_{pressure}n(s)$$

The parameter $k_{pressure}$ is the pressure weight or pressure energy. The parameter k is the image energy weighting. The symbol n(s) represents the unit normal vector to vertices. In order to get the unit normal vector we require the

$x_t = (A + \gamma I)^{-1}(\gamma x_{t-1} \pm k_{pressure} n(x_{t-1}) - k \frac{\partial}{\partial x} F_{image}(x_{t-1}, y_{t-1}))$

$y_t = (A + \gamma I)^{-1}(\gamma y_{t-1} \pm k_{pressure} n(y_{t-1}) - k \frac{\partial}{\partial y} F_{image}(x_{t-1}, y_{t-1}))$

In order to obtain precise value for the external energy we have a used a Penta diagonal matrix A and the size of the matrix is n×n where n determines the number of vertices.

$$A = \begin{bmatrix} 2\alpha + 6\beta & -\alpha - 4\beta & \beta & 0 & 0 \\ -\alpha - 4\beta & 2\alpha + 6\beta & -\alpha - 4\beta & \beta & 0 \\ \beta & -\alpha - 4\beta & 2\alpha + 6\beta & -\alpha - 4\beta & \beta \\ 0 & \beta & -\alpha - 4\beta & 2\alpha + 6\beta & -\alpha - 4\beta \\ 0 & 0 & \beta & -\alpha - 4\beta & 2\alpha + 6\beta \end{bmatrix}$$

The matrix A is solved using the following equation-

$$A\,\mathbf{x} + \frac{\partial}{\partial x} E_{ext}(x, y) = 0,\; A\,\mathbf{y} + \frac{\partial}{\partial y} E_{ext}(x, y) = 0$$

The input elastography image contains significant levels of noise. Performing iteration with this image will give inaccurate results due to the presence of several anomalies in terms of intensity and energy which are the governing factors in determining the contour. The mean filter reduces the intensity variation thereby smoothening the image, the median filter is used for noise reduction and the Gaussian filter is used for better edge detection and noise reduction. All these are performed in the preprocessing stage.

The voronoi point analysis is used so that two adjacent points of the contour are as close as possible. High value of α and β is used to ensure that the line between the points becomes a straight line while smoothening the edges, the morphological enhancement technique is used between the adjacent points to enhance the contour even further.

3.3 WATERSHED SEGMENTATION

In watershed segmentation a picture is viewed as a topographic scene with edges and valleys. The rise estimations of the scene are regularly characterized by the dim estimations of the particular pixels or their inclination greatness. In light of such a 3D portrayal the watershed change disintegrates a picture into catchment bowls. For every nearby least, a catchment bowl contains all focuses whose way of steepest drop ends at this base (Fig. 24). Watersheds separate bowls from one another. The watershed changes decay a picture totally and along these lines doles out every pixel either to an area or a watershed. With boisterous medicinal picture information, countless little districts emerge. This is known as the "over-division" issue (Fig. 25).

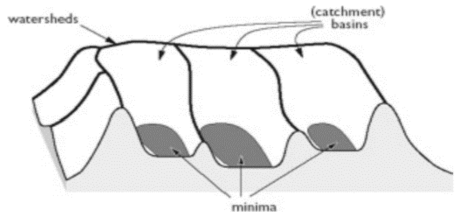


Figure 26: Principle of the watershed transform where the intensity values define hills and basins. For segmentation purposes, basins may be flooded in order to combine corresponding regions [55]

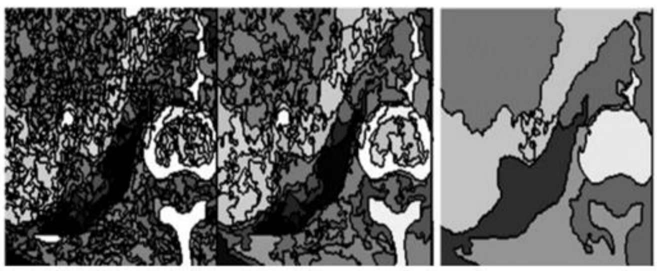


Figure 27: Illustration of the over-segmentation problem of the watershed transform applied to an axial slice of a image. Individual basins are merged to form successively larger regions. (Courtesy of Thomas Schindewolf, Fraunhofer MEVIS Bremen)

The watershed segmentation is such that actually it converts the 2D images into 3D images based on darkness of the images. So, after that we will get 3D topographical image which will have certain deepness. These portions will be called Catchment Basin. After producing these basins, the process will start auto flooding. This process will flood the catchment basins according to the deepness. when the flooding will reach on edge of a catchment basin there will be a line on edge of the basin. The flooding will continue the process and each time a separate boundary will be created by the process automatically. Figure 3.5 shows the flooding of the catchment basin.

The main drawback of this method is the over-segmentation due to the presence of many local minima. To decrease the effect of severe over-segmentation, marker-controlled by the watershed transformations have been proposed. These are robust and flexible methods for segmenting objects with closed contours. If the boundaries don't look clearly the ridges between locate and marker differentiated by this method.

We have made a flow chart on the whole process:

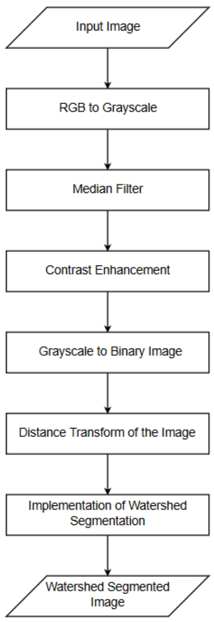


Fig28: *Flowchart of Watershed method.*

At first, we need to convert the RGB image to Grayscale image. Then we will use a median filter. The median filter estimates the gray-level value, with particular success in the presence of long-tailed noise. As an edge is crossed, one side or the other dominates the window, and the output switches sharply between the values. After using the median filter, we need to enhance the contrast as we will need it in future steps. Then we have converted the Grayscale image to binary image. Then we have transported the image into distance form, that is called distance transform. At these portions we will select automatically the more rigid areas of the image which is usually dark. Then a few images will be chosen by this process. But to dig more we applied a method which is “Connected Regions “. This process will sort out the biggest connected regions and extract it from the image and we will get our desired area.

3.4 Conclusion

Segmentation is a technique to describe, define and segregate regions of interest. Image segmentation is a process mainly to derive the region, curvature or contour of the required targeted region from the image. Segmentation in an image depends on various features and parameters. Active contour models are defined for image segmentation based on the curve flow, curvature and contour to obtain the exact target region or segment in the image for future analysis and processing, on the other hand watershed segmentation is based converting the whole image as a topographical map. And after the conversion flooding is done on the topographic surface. Both the methods have certain lacking and advantage. We modified both the method and made it useful for our purpose.

Chapter Four

Implementation & Result Analysis:

4.1 Introduction

In this section we apply watershed and active contour method on our experimental elastography image. Then we cascade both the methods which is we apply one segmentation method on an image which we get from another segmentation process.

4.2 Watershed Method Implementation

The goal of the breast tumor image (fig. 25) was to determine which method could better segment tumor. The test images are at different sizes and resolutions. Included are also images with added noises (Gaussian, salt and pepper) corrupting the overall quality of the images Fig.25. Although these types of noise are normally modality dependent or not present due to the high quality of today's imaging devices, it is still interesting to show the performance of the methods in the presence of different types of noise. We add noise to images with MATLAB program and noise density in salt & pepper is 0.05.

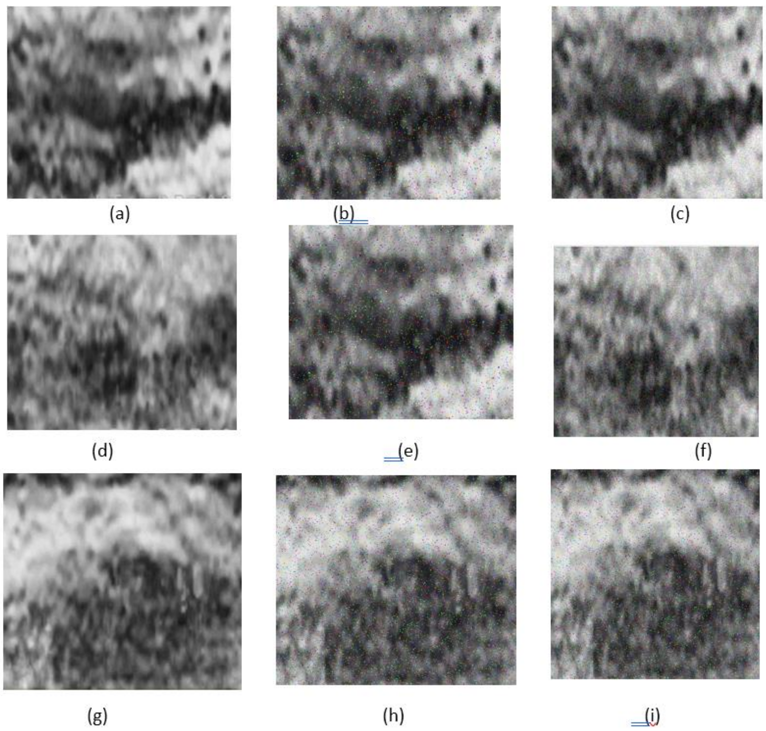


Figure 29: (a), (d), (g) Breast tumor elastography; (b), (e), (h) images with noise (Salt & pepper) ;(c), (f), (i) images with noise(Gaussian)

We take image a from fig.26 and manually select a region for our experimental purpose.The area of the region is 61387 $pixel^2$.In the next we will compare this result with our experimental ones and will find the percentage of error.

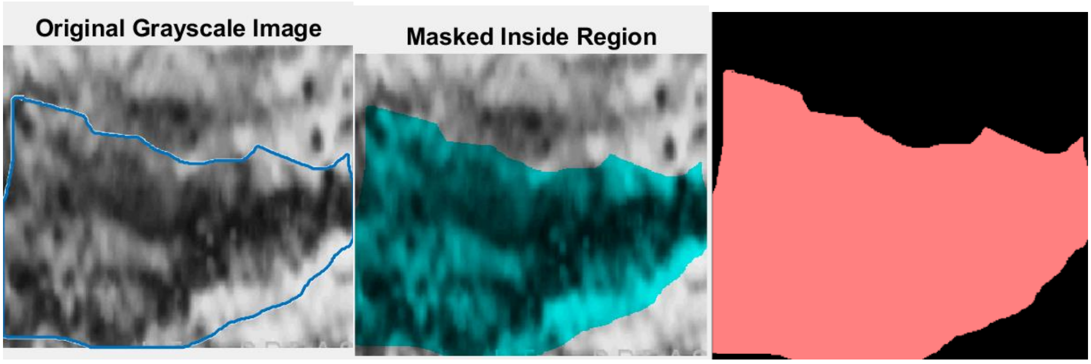


Figure 30: (a) Manually Drawn outline, (b) Manually selected Region, (c) Binary view of that region

The percentage of error between the manually determine contour and automatically determine contour were calculated to evaluate the performance numerically. The PR defined as:

%Error = (N_{diff}/N_m) *100%

Where N_{diff} is the number of pixels that differ between the manually determined contour and automatically determined contour & N_m is the number of pixels in the manual contour.

Any grayscale picture can be seen as a topographic surface where high power signifies pinnacles and slopes while low force indicates valleys. You start filling each separated valley (neighborhood minima) with various hued water (names). As the water rises, contingent upon the pinnacles (slopes) close by, water from various valleys, clearly with various hues will begin to blend. To maintain a strategic distance from that, you construct hindrances in the areas where water consolidates. You proceed with crafted by filling water and building hindrances until every one of the pinnacles are submerged. At that point the hindrances you made gives you the division result. This is the "reasoning" behind the watershed.

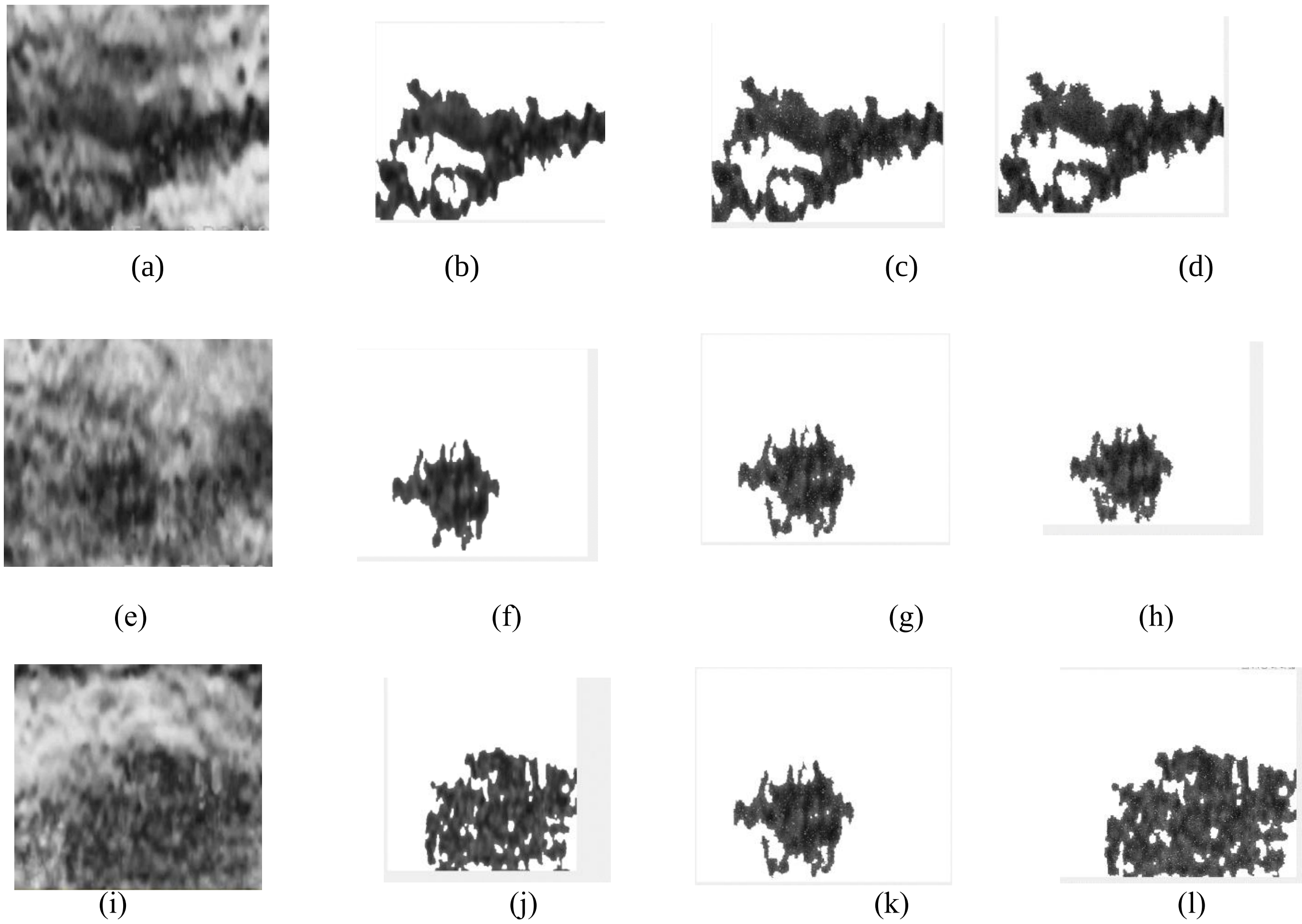


Figure 31: (a),(e),(i) original image; (b),(f),(j) segmentation of original images ; (c),(g),(k) segmentation of image having Salt & Paper noise ; (d),(h),(l)segmentation of images having Gaussian noise images.

From the segmentation of we came to know that watershed segmentation best works on those images who has no noise or less powerful noise. When we did watershed segmentation on the original image we get best result (Figure 4.3 : (b), (f), (j)). That's because in the segmentation process we wanted to make the coding so simple so that anyone can use it and understand it. so we didn't put any filter to remove the noise in the code. And in today's age we get very clear elastography images. so, we don't need to put the extra burden in the code.

Secondly, we put salt and pepper noise on the real image. With these noises we got the segmentation correct but with awful noise on them. But here we are working on segmentation so that's not a big deal. (Figure4.3: (c), (j), (k)).

At last we did our segmentation on images which have Gaussian noises, and we get the same result with some more noise on the image as we got from previous segmentation. (Figure4.3 (d), (h), (l)).

We tried the proposed technique utilizing a breast Electrogram picture database. The database comprises of 9 pictures with different breast sores. Zone of the tumor is controlled by summation of the considerable number of pixels inside the divided area. For each picture (a,e,i from fig.4.3) we figure the territory of the fragmented district for unique picture, picture with Gaussian clamor and picture with Salt and Pepper commotion. We indicate the image “a” as Image1, “e” as Image2 and “i” as image3

Table.4.1 Area of the experiment tumors applying Watershed

Area(pixel^2)	Original Image	Image with Gaussian noise	Image with Salt & Paper noise
Image 1	26670	25054	23543
Image 2	25493	24395	24403
Image 3	26453	25968	25934

If we want to find the percentage of error of that segmentation, we take Image a from fig4.3 and our manually determine region from fig4.2. Image(a).

N_{diff} = 34717 pixel

N_m = 61387 pixel

%Error = (34717/61387) *100%=56.55%

4.2 Active Contour Implementation

Active contour method is used when the boundary of the image is not strongly declared. the balloon snake is more insensitive to initial contour locations than the methods do not have pressure forces like the distance snake and GVF snake. Distance snake required a bigger initial contour (e.g., double and triple the initial contour radius) than others in order to catch the attraction forces from the edge points in all directions.

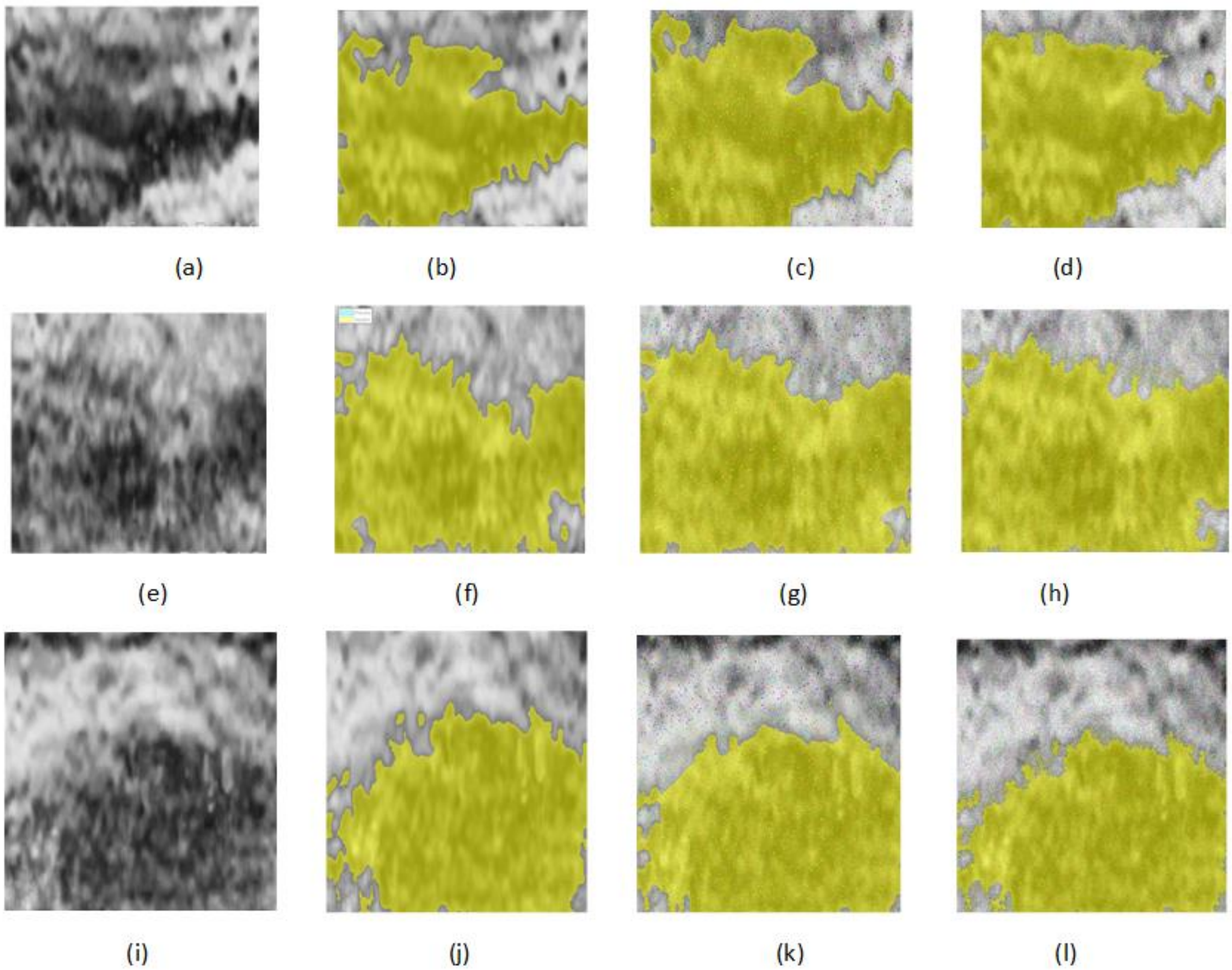


Figure32:(a),(e),(i) original image; (b),(f),(j) segmentation of original images ; (c),(g),(k) segmentation of image having Salt & Paper noise ; (d),(h),(l)segmentation of images having gaussian noise images. Segmentation area is marked in yellow.

When we add noise (Gaussian and salt &pepper), these methods cannot segment like in original image. Balloon snake in image that add Gaussian noise have some wrong part but with salt &pepper noise it can segment interest part of image as shown in fig.4.4.After examine the images we can say active contour (region)works better when the image with Gaussian noise than Salt & Pepper.

The best results the original snake occurred with the original image. When we segment the original image without any noise we get best result visually (Figure4.4: (a), (d), (g)). Distance snake required a bigger initial contour (e.g., double and triple the initial contour radius) than others in order to catch the attraction forces from the edge points in all directions. We also show examples on real noisy images, with different types of contours or shapes, illustrating all the advantages of our model: the ability of detecting smooth boundaries, scale adaptivity, automatic change of topology, and robustness with respect to noise.

We tested the proposed method using a breast Electrogram image database. The database consists of 9 images with various breast lesions. Area of the tumor is determined by summation of all the pixels inside the segmented region. For each image (a,e,i from fig.4.4) we calculate the area of the segmented region for original image, image with Gaussian noise and image with Salt and Pepper noise. We indicate the image “a” as Image1, “e” as Image2 and “i” as image3

Table 4.2. Area of the experimental tumors after applying Active contour

Area(pixel^2)	Original Image	Image with Gaussian noise	Image with Salt & Paper noise
Image 1	55340	66790	73984
Image 2	68488	84266	92586
Image 3	59138	53820	56484

If we want to find the percentage of error of that segmentation, we take Image a1 from fig4.4 and our manually determine region from fig4.2. Image(a).

(a) *(b)*

Figure 33: (a) Reference Image for finding Error (b)Final output from Active Contour

The area of the fig (a) is 61387 $pixel^2$ and the output image fig (b) is 55340 $pixel^2$.From this we find our necessary information for finding the percentage of error.

N_{diff} = 6047 pixel

N_m= 61387 pixel

%error = (6047/61387) *100%=9.8506%

4.3 Cascading of both methods Implementation:

In this section we will apply active contour to images which we get at the end of watershed method. For this we choose the images without adding any types of noise. The procedure is at first, we take the image the apply watershed method on it, then we take the segmented part and apply active contour method over it and analyze the result.

Figure 32:(a),(d),(e) original Images; (b),(e),(h) output images of watershed; (c),(f),(i) images after apply active contour to outputs of watershed

When we apply active contour to the outputs of the watershed we see that the results are not very satisfactory. In every output from fig4.6.Active contour fails to identify some parts which also tumor. Some regions are not selected as tumor in this combination of this method which is a flaw of the combine method. We indicate (c), (f), (I) as Image no 1,2,3

Now We wanted to cascade the both methods to see whether the result is good or bad. So, we took some images that was previously active contoured. Then we use watershed segmentation on it.

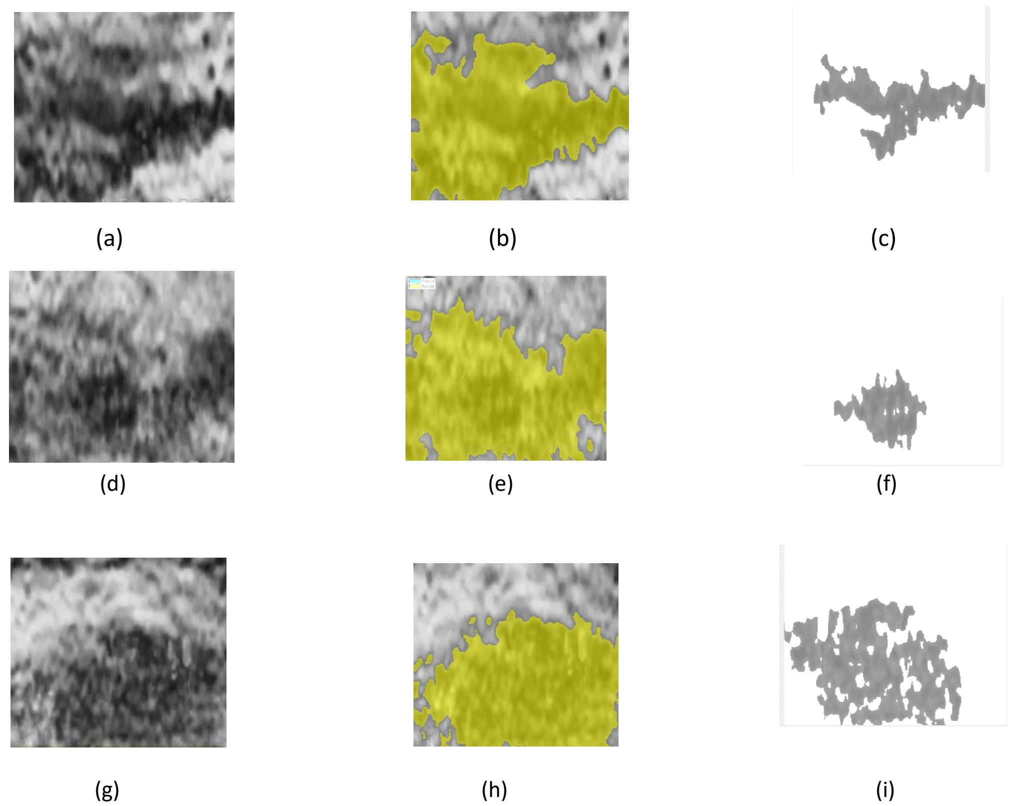


Figure 35: (a),(d),(g) original Images; (b),(e),(h) output images of active contour; (c),(f),(i) images after applying watershed to outputs of active contour.

The result is not that much satisfactory when we apply watershed on active contour. We get blurry images as result. So cascading these two methods won't bring any benefit.

We indicate (c), (f), (I) as Image no 1,2,3

Table.4.3 Area of the segmented Portion after applying Cascading method

Image	Method1($pixel^2$)	Method 2($pixel^2$)
1	24850	25978
2	23006	23869
3	23589	24590

For calculating Percentage of error, we take image a from fig 4.6and fig 4.7

% of Error for method 1 = (36537/61387) *100% =59.51%

% of Error for method 2 = (35409/61387) *100%=57.681%

4.4 Conclusion

In active contour segmentation we get a large region, which is most of the case are correct region of interest. But sometimes it catches region is not always tumorous one. In watershed segmentation we get the region which is comparatively small and correct. But it misses out some tumorous portion. The area of the segmented region which we get from active contour is always larger than the area we get from watershed method. In combine method it misses out clearly some tumorous portion in most of the cases. All in few cases it catches the exact right portion. So, it can be said that combine method does not always give the correct answer

Chapter Five

Conclusion & Future Work

5.1 Conclusion

In this book different segmentation methods and their implementations process are reviewed and found that marker based is best in most of cases because it marks the regions and segment them. The book has suggested two algorithm of image segmentation on elastography images: watershed and active contour. In watershed segmentation modification with grayscale and most connected region was done. But optimizing the marking regions is still an area of research. Further modification was done on segmenting the whole region of tumor from the image. And we got expected result with some modification on our code. Previously watershed was only done on black and white images. But with the new color gradient method we successfully did watershed on colorful images also. Cascading both watershed and active contour didn't give any good result. So, in further research modification on cascading the both methods can be done. We confined our watershed segmentation on elastography images only but this process can do upon other images also. In watershed segmentation we don't need any prior filter as todays image quality is up to the mark. But for research purpose when we added salt and pepper noise and also gaussian noise we noticed decreased accuracy parameter. With that observation we came to conclusion that the method deals quiet badly with images who has noise on it. The fuzzy optimal threshold selection can be done for further improvement. Though we have modified some threshold numbers but modifying with bilateral filter can be done for prior filters. That could have given some good result.

5.2 Future work

Improvement of watershed and active contour method for finding the exact area of interest. Cascading of these two methods most of the cases misses out some tumorous portion, we want to improve the combine method so that it covers the right portion. As active contour is a semi-automated process we want to work towards that direction for making it fully automated.

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