

# SURVEY OF IMAGE SEGMENTATION ALGORITHMS ON ULTRASOUND MEDICAL IMAGES

S. Sridevi

Department of Information Technology,  
Bharathiar University,  
Coimbatore-641046, India  
devisris.mphil@gmail.com

Dr. M. Sundaresan

Department of Information Technology,  
Bharathiar University  
Coimbatore-641046, India  
bu.sundaresan@gmail.com

**Abstract** - Visual information plays an important role in almost all areas our life. Nowadays, much of this information is represented and processed digitally. Image processing is ubiquitous, with the applications ranging from Television (TV) to Computed Tomography, from Photography to Printing, from Robotics to remote sensing and medical applications. Ultrasound is one of the techniques for medical application. It is used for clinical usage. The most important technologies include transducers, beam forming, contrast agents, pulse compression techniques for measuring blood flow and three-dimensional imaging. Ultrasound imaging provides valuable imaging modality to provide the following functionalities as ease of use, low cost, safe, non invasive and fast examination. Ultrasound imaging system provides effective way for examining the various tissues of human body including thyroid, breast, abdominal organs, heart, muscles, tendons, arteries and veins. This paper aims to present on current segmentation algorithms used for medical images. Each and every type of algorithm is discussed as well as their main application fields identified. Experiments that apply the algorithms to segment ultrasound images are presented to further evaluate their behaviour.

**Keywords:** Ultrasound image processing; Segmentation; Ultra-Sonography; Similarity; B-mode images; Thresholding; Radio-frequency.

## I. INTRODUCTION

Image processing [1] is the use of computer algorithms to images, perform some operations on in order to extract some useful information. It allows wide range of algorithms applied to the input data and can avoid problems such as build-up of noise and signal distortion during processing.

Broad areas of digital image processing applications include Medical applications, Digital cinema, Remote Sensing, Robot vision, Hybrid techniques, Image transmission and coding etc. Medical applications has wide variety of modalities which is Ultrasound, Positron Emission Tomography, Computed Tomography, Digital X-ray, Vein Viewer, Magnetic Resonance Imaging, Hyper spectral imaging.

In this paper Segmentation is performed on Ultrasound [2] images. Analysis of Images usually refers to processing of

images by computer with the goal of finding what objects are presented in the image. Image segmentation [2] is one of the most critical tasks in image analysis. In an ultrasound system there are three basic types of data available for analysis: Radio Frequency (RF) signals, B-mode images [5], and envelope-detected signals.

An ultrasound transducer receives multiple analogue radio-frequency (RF) signals which are converted into digital RF signals and beam formed into a single RF signal shown in Fig 1. The RF signal is filtered and envelope detection is performed to give an envelope detected signal.

Finally, proprietary post-processing and the envelope-detected signal undergoes log compression is applied to give a greyscale representation. The resulting signals are interpolated and rasterized to give a B-mode images or display images.

## II. ULTRA-SOUND IMAGING

Ultrasound imaging [4] is also called Sonography. Ultrasound imaging system used high frequency sound waves for producing pictures of the inside body. Because ultrasound images are captured in real-time that they can show the structure and movement of the internal body organs, as well as blood flowing through blood vessels [5].

Ultrasound imaging [6] is a non-invasive medical test that helps doctors to see the internal body organs. Advancements in ultrasound technology include Two-Dimensional (2-D) ultrasound that formats the sound wave data into 2-D images, Three-dimensional (3-D) ultrasound image that formats the sound wave data into 3-D images and Four-dimensional (4-D) ultrasound which is 3-D ultrasound in motion.

Doppler ultrasound is the part of an ultrasound examination. Ultrasound imaging is also named as a popular research tool for capturing raw data set, which can be made available through an ultrasound research interface. It is used for the purpose of tissue characterization [8] and implementation of new image processing techniques and methodologies. These concepts of ultrasound imaging are totally differing from other medical imaging modalities in the fact that it is operated by the transmission and receipt of sound waves. Different modes of ultrasound are used in medical

imaging. These are: A mode, B mode, C mode, M mode, Doppler mode, color Doppler, Continuous Doppler, Pulse Wave (PW) Doppler, Duplex Doppler, pulse inversion mode.

### III. PROPERTIES OF ULTRASOUND IMAGING

Ultrasound imaging Modalities provides the following properties:

- Most Ultrasound image scanning is invasive and is usually painless.
- Ultrasound is most widely available, ease of use and inexpensive when compared with other imaging modalities.
- Ultrasound system scanning gives a clarity and clear picture of soft tissues.
- Ultrasound has no side effects.
- Ultrasound imaging modalities are used to clearly monitoring the patients.
- It should be performed only when clinically needed.

### IV. ADVANTAGES OF ULTRASOUND IMAGE PROCESSING

Ultrasound image processing [6] is very safe to use and does not appear to cause any adverse effects. It is inexpensive and quick to perform the processing on images. Ultrasound scanners should be taken to critically ill patients to avoiding the danger caused while moving the patient to the intensive care. Doppler capabilities on modern scanners that allow the blood flow in arteries and veins to be assessed.

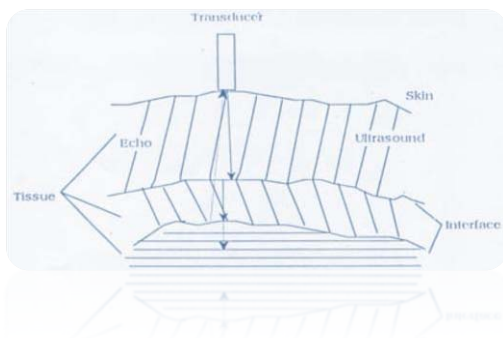


Figure 1. Ultrasound imaging System

### V. ULTRASOUND IMAGING METHODOLOGIES

Ultrasound contains two types of imaging methodologies:

- Intravascular ultrasound image
- Doppler Ultrasound image

Intravascular ultrasound (IVUS) [7] [8] is based on catheter medical imaging technique particularly useful for studying atherosclerotic disease. IVUS [9] produces cross-sectional images of blood vessels that provide quantitative and qualitative assessment of the vascular wall and information about the nature of atherosclerotic disease lesions as well as plaque format that named as a shape and size. Accurate results

were obtained on simulated data with average point to point distances between detected vessel wall borders.

Doppler ultrasound is a special ultrasound technique. It is one of the parts of intravascular ultrasound image. It evaluates the blood flow through a blood vessel. It includes the body's major arteries and veins in the arms, abdomen, legs and neck.

Doppler ultrasound divided into three parts:

- Color Doppler used in computer to convert Doppler measurements into an array of colors to visualize the speed and direction of blood flow through a blood vessel.
- Power Doppler is a newer technique that is more sensitive than color Doppler and capable of providing greater detail of blood flow when blood flow is little or minimal.
- Spectral Doppler used to display blood flow measurements graphically, in terms of the distance travelled per unit of time.

### VI. ULTRASOUND IMAGE SEGMENTATION ALGORITHMS

Segmentation is a process by which digital image can be portioned into multiple segments. Image segmentation is shown in Figure 4, 5, 6, 7 and 8. It is mainly used to locate the objects and boundaries (edges, lines, curves etc).

Segmentation algorithms are based on the basic properties of color, gray values or texture: discontinuity and similarity.

- First: it is used to partition an image based on changes in intensity, such as edges, lines, curves in an image.
- Second: it is based on partitioning an image into regions that are similar according to predefined criteria. Thresholding for Histogram approach falls under this category.

Some of practical applications of image segmentation are namely Medical imaging, Face recognition, Fingerprint recognition, Traffic control systems, Iris Recognition, Brake light detection, Machine vision, Locating objects in satellite images, Agriculture imaging. Several general purposes techniques and algorithms have been developed for image segmentation.

These techniques are to be combined with domain knowledge in order to effectively solve an image segmentation problem for a problem domain.

#### A. Thresholding

The simplest and popular method of image segmentation is also called Thresholding method. This method is used to convert a grey-scale image into a binary image. In this technique, predefined values (thresholds) are selected, and an image is divided into groups of pixels having values within

the ranges defined by the thresholds and groups of pixels with values beyond such range.

There are several threshold algorithms.

- Global
- Local
- Dynamic
- Adaptive

Global Thresholding is one of the most intuitive approaches. When only one threshold value is selected for the entire image, based on the image histogram, the Thresholding is called global. If the threshold depends on local image properties, for example, the local average gray value, the Thresholding is called local. If the thresholds are selected independently for each pixel or groups of pixels, then the Thresholding is called dynamic or adaptive [3].

The key of this method is to select the values at multiple-levels. Local Thresholding operations are as follows:

- i. Splitting the input image into sub images and calculating threshold for each sub image.
- ii. Examine the image intensities in the neighborhood of each pixel.

Thresholding operations are best suited for (350 x 184 pixels, file size: 5 KB, MIME type: image / png). Local Thresholding is computationally more expensive than global Thresholding. It is very useful for segmenting structures from a varying background, and for extraction of regions that are very small and sparse.

### B. Clustering Methods

Clustering is the process of grouping similar image structures into a single cluster, while structures with dissimilar features are grouped into different clusters based on some similarity in criteria. The similarity is quantified in terms of an appropriate distance measure. Clustering is the process of grouping similar image Structures into a single clusters.

Clustering Technique can be divided into

- a. Supervised Technique
- b. Unsupervised Technique

#### a. Supervised Technique

Supervised clustering Technique need to be used for pre defined images. Predefined will be called as prototype used for images. This type of prototype image is overlapped to the image to be segmented. Supervised Clustering Techniques are:

- KNN (K Nearest Neighborhood).
- ML (Maximum Likelihood).
- Supervised Artificial Neural Network.
- Support Vector Machines.
- Active Shape Models.
- Active Approach Models.

#### b. unsupervised technique

This technique is also called Clustering Algorithm. With these techniques the structure features are extracted from the classified points. Unsupervised Clustering Techniques include the following:

- Fuzzy C Mean (FCM).
- ISODATA.
- Unsupervised Neural Network.

The interactive technique of image segmentation is the k-means algorithm is one of the examples for segmentation. It is used to partition an image into k-clusters.

- Pick  $k$  clusters centers or randomly.
- Allocate each pixel in the image to the cluster that minimizes the distances between the pixel and cluster center.
- Recomputed the central pixel by averaging all of the pixels in the cluster.
- Repeat the steps 2 and 3 until attained when no pixels change clusters.

### C. Discontinuity

Edge detection is a well – known field on its own within image processing. Region boundaries, edges, and shapes are closely related, since the sharp adjustment in intensity at the region boundaries. These approaches are used as the base of another segmentation technique.

An edge can briefly be described as a collection of connected pixels. Edge based techniques are computationally fast and do not require a priori information about the image contents. Main problem of these techniques is that often edges do not enclose the structures completely. To avoid this problem, a post-processing step of linking or grouping the detected edges that correspond to the structures boundaries is needed. However, in general, edge linking is computationally expensive and not very reliable.

### D. Deformal Models

Deformal models are one of the segmentation techniques that are able to represent the complex shape and broad shape variability of anatomical structures. Deformable models overcome many of the limitations of traditional low-level image techniques, by providing compact and analytical representations of structures, by incorporating anatomical knowledge and by providing interactive capabilities. Deformable models can be parametric or geometric model can be defined, according to the way used to track the moving contours.

Parametric deformable models, or active contours, try to adjust a deformable model to an image by using an energy minimizing formulation. The snakes are the most well-known method in this category. This model describe the optimization of the energy functional Segmentation. Two type of Energy functions are there.

- Internal Energy  $\sum_{int}$
- External Energy  $\sum_{ext}$

Geometric deformable models are based on the level set method, which was proposed to handle topological changes during the curve evolution. The main aim of the level set method. It is to implicitly embed the moving contour into a higher-dimensional level set function and view the contour as its zero level set. Then it should be instead of tracking the discrete contour points, one can track the zero level set of the level set function.

The proficiency of adaptation to changes in the topology can be useful in many applications. This model was proposed to handle topological changes during the curve Evolution.

*E. Compression Based Approaches*

An image can be segmented based on compression based approaches. This approach involves the process named as Pre processing, contour relaxation and region growing.

*F. Histogram-Based Image Segmentation*

It is one of the simplest techniques for segmentation. It used to grouping pixels into regions. Histogram has two entities for image segmentation: The background and the object of the segmentation. Another one is grey level, which occupies the most of the image portions.

*G. Region Growing*

Region Growing is one of the approach to image segmentation is to start from some pixels (seeds) representing distinct image regions and to grow them, until they cover the entire image.

For region growing this system need a rule describing a growth mechanism and a rule checking the homogeneity of the regions after each growth step

- The growth mechanism – at each stage  $k$  and for each region  $R_i(k)$ ,  $i = 1, \dots, N$ , we check if there are unclassified pixels in the 8-neighbourhood of each pixel of the region border.
- Before assigning such a pixel  $x$  to a region  $R_i(k)$ , this system check if the region homogeneity:

$$P(R_i(k) \cup \{x\}) = \text{TRUE}, \text{ is valid}$$

- A class  $R_i$  having  $n$  pixels: The  $sd$  standard deviation and arithmetic mean value  $m$  of

$$M = (1/n)(r,c) \in R(i) \sum I(r,c)$$

$$s.d = \text{Square root}((1/n)(r,c) \in R(i) \sum [I(r,c) - M]^2)$$

Can be used to decide if the merging of the two regions Region1, Region2 is allowed, if

$$|M1 - M2| < (k)s.d(i), i = 1, 2, \text{ two regions are merged.}$$

*H. Level Set Method*

Level set method is used to reduce the two type of problems which one object need to split and another one object need to merge. That time level set method used to provide the solution.

The opposite approach to region growing is region shrinking (splitting) shown in Fig 2. It is a top-down approach and it starts with the assumption that the entire image is homogeneous. the image is split into four sub images, If this is not true. This splitting procedure is repeated recursively until we split the image into homogeneous regions.

- If the original image is square  $N$  by  $N$ , having dimensions that are powers of  $2^{(N=2^n)}$
- All regions are produced by the splitting algorithm are squares having dimensions  $M$  by  $M$ , where  $M$  is a power of 2 as well.
- Since the procedure is recursive, when it produces an image representation that can be described by a tree whose nodes have four sons each.
- Such a tree is called a Quad tree.

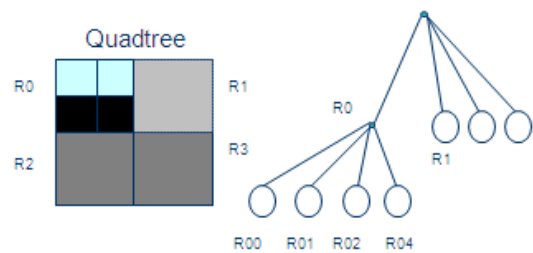


Figure 2. Splitting into regions

The split and merge algorithm produces more compressed regions, than the pure splitting algorithm.

*I. Partial Differential Equation Approaches*

The PDE based methods are the most uses of effective methods for image segmentation. The main advantage is that the PDE is well established in the fields such as physics and mechanics. The snake the gradient vector flow and the level set method are typical of the methods. Nowadays, a level set model without re-initialization Sobolev gradient method and p-Laplace model is proposed.

*J. Parametric Model*

Parametric model generate the intensity value for an image. Intensity level used to segment the image for applying clustering technique to group the image information and segment the set of portions.

*K. Fast Marching Method*

Fast marching algorithm is used to provide the capable of manipulating the contours and the corresponding boundaries of expanding regions.

It is effectively made independent of the number of distinct regions present in the initialization. The new algorithm targets applications requiring static segmentation as well as labelling and clustering problems.

L. Graph Portioning

These methods can be effectively used for image segmentation. These methods are used for the image is modelled as a weighted, undirected. A pixel or a group of pixels are associated with node of images and edge weights define the (dis)similarity between the neighborhood pixels of an image. Each partition of the nodes (pixels) output from these algorithms are considered an object segment in the image shown in Fig 3. Some of the algorithms are normalized cuts, random walker, minimum cut, is parametric partitioning and minimum spanning tree-based segmentation.

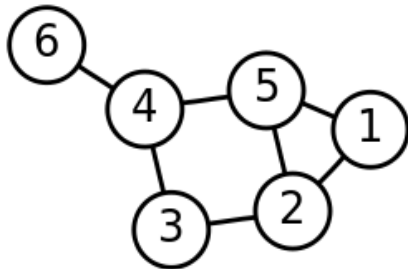


Figure 3. A labeled graph of 6 vertices and 7 edges

M. Watershed Segmentation

Watershed segmentation has different type of approaches.

- Local minima of the gradient may be chosen as a markers, this case produced the over segmentation.
- It involves the region merging used to specify the marker position which have been defined by users or automatically or morphological operations.

N. Multi Scale Segmentation

Multi scale segmentation is used to compute the scale space for connected for each region. Different type of segmented portions will be merged in one segment and is called the Multi scale Segmentation.

O. Trainable Segmentation

Most segmentation methods are based only on color information pixels in the image. Which is normally human would consider a computation time and require the knowledge database. This is not available in electronic form. But this type of segmentation provides the artificial neural network [7], pulse coupled neural network and decision making mechanism.

VII. SIMPLE SEGMENTATION RULE

$$\text{Image ub regions Region}(i), i=1, \dots, N \text{ such that} \\ X = i=1, \dots, N \cup R(i) \tag{1}$$

$$R(i) \cap R(j) = 0 \text{ for } i \neq j \tag{2}$$

$$P(R(i)) = \text{TRUE for } i = 1, 2, \dots, N \tag{3}$$

$$P(R(i) \cup R(j)) = \text{FALSE for } i \neq j \tag{4}$$

The segmentation property is a logical predicate of the form  $P(R, x, t)$ .  $x$  is a feature vector associated with sub region  $R$  and  $t$  is a set of parameters (usually thresholds). The Segmentation rule has the form:

$$P(R) : I(r, c) < T \text{ for all } (r, c) \text{ in } R \tag{5}$$

In the case of color images the feature vector  $x$  can be three RGB image components  $(R(r, c), G(r, c), B(r, c))$ .

The segmentation rule may have the form:

$$P(R) : (R(r, c) < T(R)) \ \&\& \ (G(r, c) < T(G)) \ \&\& \ (B(r, c) < T(B)) \tag{6}$$

VIII. SIMPLE SEGMENTATION RULE



Fig 4: Original Image



Fig 5: Region1



Fig 6: Region 2



Fig 7: Region 3



Fig 8: Region 4

## IX. CONCLUSION

Here the formation of Ultrasound Images and their advantages in medical field are discussed. In this field of analysis there are variety increasing applications for ultrasound images in diagnosis as well as therapeutic purposes it will need to enhance the feature which we require for further processing. Image segmentation has become a very important task in today's scenario. Nowadays world computer vision has become an interdisciplinary field and its applications can be found in any area be it medical, remote sensing, electronics and so on. Thus, to find an appropriate segmentation algorithm based on your application and the type of input image is very important. In this paper the author has explained and suggested a few application specific segmentation algorithms.

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