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Study and Theoretical Analysis of Various Segmentation Techniques for Ultrasound Images

Sheela.Sa, Sumathi.Mb

aResearch Scholar, ECE, Sathyabama University, Chennai and 600 119, India
bProfessor, ECE, SathyabamaUniversity, Chennai and 600 119, India

Abstract

Image segmentation is an important and also necessary technique as it facilitates the delineation of anatomical structures and other region of interest in various imaging modalities such as Ultrasound, Computer Tomography… of medical field. Among the several imaging modalities, an Ultrasound technique plays a vital role in medical field because it is non-invasive and mainly radiation used in this modality is not harmful. On the other hand, the image obtained using this modality is distorted due to the several reasons like inherent noise of the equipment, lack of operator knowledge…etc. This makes the complexity in identifying the region of interest. Several segmentation techniques are used to segment the region of interest from the noisy image. This paper explores various segmentation techniques like edge based, threshold based, region based and texture based segmentation.

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1. Introduction

The medical field is the discipline that deals with finding solution for every conceivable type of diseases. In this, Image is an important source as it gives various details to the physician to identify various diseases. But due the noises present in an image, makes this process complex. In order to avoid such complexity, segmentation techniques are used [2]. Segmentation is the process of subdividing an image into different regions that are may be homogeneous or heterogeneous based on some criteria. The main objective of image segmentation in medical field is, to simplify theimage representation into something which is more meaningful and easier to analyze the region of interest. Segmentation technique is classified into two categories. There are, segmentation based on similarity in which the image is partitioned on the basis of similarities in the gray levels of a pixel in an image [3]. Threshold based and region based segmentation techniques are comes under this category. Next, segmentation based on discontinuity; in this the image is partitioned on the basis of abrupt

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change in the intensity of an image. Edge based segmentation techniques are comes under this category [5] [7] [9].

2. Segmentation Techniques

The application of the image segmentation in a medical field is a major research area. Even though several segmentation techniques available, finding an appropriate also generalized segmentation technique for any kind of image is a critical one. Therefore, different segmentation techniques are used in different images like CT, Ultrasound and MRI based on the image characteristics. The image segmentation techniques are categorized based on two basic properties of intensity values [2] [5] [6] [7].

1.1. Based on Discontinuity

There are three types of gray level discontinuities available in an image. They are points, lines and edges. Among these, Edge based segmentation is widely used. Mask processing is performed to identify the discontinuities [7] [1].

1.1.1. Edge Detection

In an image, where there is an abrupt change in the intensity levels among neighborhood pixels in certain direction are referred as an edge or boundary. The edge based segmentation segments the region of interest by detecting the edges between the different regions in an image. In an ultrasound image, due to the speckle noise, the edge cannot be segmented properly. To overcome this drawback, edge detection involves image smoothing operation in which using suitable filter a noise is removed. This makes the image more suitable for segmentation [1] [8].

The edge can be detected using gradient. Whenever there is a abrupt change in a intensity of the image near its edge, derivative for that image f(x,y) is used, which is called gradient. In this, a gradient operator convolved with theimage [1] [10].The gradient (∇f) of an image f(x,y) is defined as,

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} \tag{1}$$

The magnitude and the direction of the gradient vector are used for edge detection. It is expressed as,

$$mag(\nabla f) = \sqrt{G_x^2 + G_y^2} \quad , \quad \propto (x, y) = \tan^{-1}\left(\frac{G_Y}{G_x}\right) \tag{2}$$

There are three types of gradient operators can be used to calculate the first order derivative for an 3 x 3 image area, which is shown in Fig.1 at point 'z_5'. Where, z = Gray level values.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Fig.1. 3 x 3 Image Area