Chapter XIII
Image Segmentation

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ABSTRACT

This chapter introduces image segment techniques. These techniques, including pixel- based approaches, region-based approaches, classification techniques, deformable model algorithms, artificial neural network approaches and texture-based algorithms are detailed. Color image segmentations and 3D image segment methods are briefly introduced. With developments of computer and medical imaging techniques, there is an increase in demand of new segment algorithms for developing or upgrading medical image systems. Therefore, the author hopes that this chapter not only details the current segment techniques, but also assists researchers in quickly selecting their research directions under their applications, imaging modality, image features and other factors.

INTRODUCTION

Image segmentation is the process that divides an image into regions corresponded to similarly characteristic objects in the scene. Image segmentation is a kind of image representation. Image segmentation is one of the most important methods in image analysis or understanding since interested objects or features are extracted at segmentation.

Image segmentation algorithms can most widely be divided into two classes as pixel- based segment algorithms and region-based segmentation algorithms. Region-based segmentation algorithms assign pixels to a certain region by taking local image properties into account. It is to analyze the neighborhood of a pixel for the occurrence of properties that cluster for a region. Searching regions of similar image properties uses two methods. These are pixel classification and boundary determination. Pixel classification is generally called a region growing process, which method is to select a seed pixel in an of-interest region and then to expand it in all directions until the properties of the image change. The boundary of the image is found implicitly by this method.

The boundary determination is explicitly aimed at locating the boundary of an image initially. Then, the located boundary implicitly determines its region. The two kinds of image segmentation algorithms have their own advantages in different applications. Sometimes, a combined algorithm is most adequate.

In practice, performances of segment algorithms vary depending on the private application, imaging modality, and other factors. General imaging artifacts, such as noise, partial volume effects, and motion, also have significant consequences on the performances of segment algorithms. Furthermore, applications of each imaging modality have its own advantages. There is not any segment method that produces acceptable results for every medical image. Segment algorithms were developed for applying to different kinds of images. However, methods developed for particular applications often achieve better performances, especially when taking into account prior knowledge. It is therefore difficult to select an appropriate segment approach to a kind of image and an application. Analysis of the image features in advance and trials with different algorithms are needed during the select process.

This chapter provides an overview of various segment techniques. Traditional robust methods such as pixel-based approaches, region-based techniques and texture-based segmentations are detailed. Segment algorithms for manipulating medical images, which include classification approaches, artificial neural network techniques, deformable model algorithms and atlas-guided medical image segmentations, are briefly described. These methods only concern to the very commonly radiological modalities, such as magnetic resonance imaging (MRI), x-ray-computed tomography (CT), ultrasound imaging, and x-ray projection radiography. Of course, these algorithms may also be applied to other imaging modalities.

PIXEL-BASED SEGMENTATION

Image segmentation only-based pixel values have different mature approaches. The common and robust algorithms are from selecting the best intensity threshold by an analysis of the grey level histogram. The size of the segmented objects varies with the threshold value. The approaches can give very good results when the background is uniformly illuminated and the objects to be segmented have distinct ranges of intensity. The key of these segmentation algorithms is how to automatically obtain a threshold value from the grey level histogram in an image.

Adapted Threshold Algorithm

Automatic image segmentation algorithm based on an adapted threshold defines the threshold of the pixel values in the image, which hopefully divides the image into two regions, background and foreground. The success of histogram threshold depends entirely on the separability of the grey level bands in the histogram and of the spatial occurrence of the grey levels. Otsu (1979) used a clustered analysis to calculate automatically the threshold from the histogram of the image, and then used this threshold to binary the image. Suppose that the original image is f (x, y), its binary image is g (x, y) and threshold value is T. The automatic image segmentation algorithm based on a histogram threshold consists of the following six steps:

1. Calculates the grey value histogram of f (x, y). It is defined as h (i).
2. Computes the grey level average μ_T.

$$\mu_T = \sum_{i=0}^{255} ih(i) \qquad (1)$$

3. Calculates the zero order moment ω (k) and first order moment μ (k). Here, k is a series of integers from 0 to 255.