

A Review on Segmentation Techniques in Medical Images

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Abstract - Image segmentation is an essential but critical component in low level vision image analysis, pattern recognition, and in robotic systems. It is one of the most difficult and challenging tasks in image processing which determines the quality of the final result of the image analysis. Image segmentation is the process of dividing an image into different regions such that each region is homogeneous. A precise segmentation of medical image is an important stage in contouring throughout radiotherapy preparation. Medical images are mostly used as radiographic techniques in diagnosis, clinical studies and treatment planning. This review paper defines the limitation and strength of each methods currently existing for the segmentation of Medical images.

Keywords— Medical image; Image Segmentation; Feature Extraction; Classification; MRI;

I. INTRODUCTION

The application of image processing techniques has rapidly increased in recent years. Nowadays, capturing and storing of medical images are done digitally. However, the interpretation of details of medical images is still time-consuming. This matter is especially observed in regions with abnormal color and shape which should be identified by radiologists for future studies. Image segmentation is a key task in many image processes and computer vision applications. The purpose of image segmentation is to partition image to different regions based on given criteria for future process. Medical image segmentation is a key task in many medical applications such as surgical planning, post-surgical assessment, abnormality detection, and so on. There are lots of methods for automatic and semi-automatic image segmentation, though, most of them fail because of unknown noise, poor image contrast, in homogeneity and weak boundaries that are usual in medical images [1]. Medical images mostly contain complicated structures and their precise segmentation is necessary for clinical diagnosis.

One of such is brain image segmentation which is quite complicated and challenging but its accurate segmentation is very important for detecting tumors, edema, and necrotic tissues. Accurate detection of these tissues is very important in diagnostic systems. Also, magnetic resonance imaging (MRI) is an important imaging technique for detecting abnormal changes in different parts of the brain in early stage. MRI imaging is a popular way to obtain an image of brain with high contrast. MRI acquisition parameters can be adjusted to give different grey levels for different tissues and various types of neuropathology. MRI images have good contrast in comparison to computerized tomography (CT) [2].

Therefore, most of research in medical image segmentation uses MRI images. The identification of brain structures in magnetic resonance imaging (MRI) is very important in neuroscience and has many applications such as: mapping of functional activation onto brain anatomy, the study of brain development, bone cancer detection, etc [3]. A tumor is an abnormal growth of tissues. As the tumor grows, the abnormal tissue displaces healthy issue. Bone tumors develop when cells within a bone divide uncontrollably, for mingalumpormass of abnormal tissue. There is a large class of bone tumor types which have different characteristics. There are two types of bone tumors, Noncancerous (Benign) and Cancerous (Malignant). MRI image segmentation is also useful in clinical diagnosis of neurodegenerative and psychiatric disorders, treatment evaluation, and surgical planning. There are lots of methods for automatic and semi-automatic image segmentation, though, most of them fail because of unknown noise, poor image contrast, and weak boundaries that are usual in medical images.

II. MR IMAGING (MRI)

MR imaging (MRI), invented in 1970, is a popular method in medical imaging. MRI scanning is relatively safe and unlike other medical imaging modalities, can be used as often as necessary. Moreover, it can be adapted to image

brain. Clinical MRI is based on the hydrogen nucleus due to their abundance in the human body and their magnetic resonance sensitivity.

For image formation, a large static magnetic field is used to perturb magnetic moments of proton that exist in the hydrogen nucleus from their equilibrium and observing how perturbed moments relaxes back to their equilibrium. Naturally, the protons are oriented randomly. But in existence of a static magnetic field, they line up with the field and the net magnetization of protons tends toward the direction of the field. In existence of enough energy, it is possible to make the net magnetization zero. In the relaxation process an induced electronic signal is recorded.

The strength and duration of the signal depend on three quantities:

1. ρ (proton density)
2. Spin-lattice relaxation time: the time which describes how fast the net magnetization takes to relax back to its equilibrium (T1).
3. Spin-spin relaxation time: with this time, magnetization components decrease to zero (T2).

In scanning of a person's body, by using different parameters setting, it is possible to obtain three different images of the same body: T1-weighted, T2-weighted, and ρ -weighted.

Magnetic resonance imaging (MRI) is a sophisticated medical imaging technique that uses magnetic fields and radiofrequency to visualize the body's internal structures. Magnetic field gradients cause signals from different parts of the body to have different frequencies. Signals collected with multiple gradients are processed by computer to produce an image. MR imaging of the body is performed to get the structural details of brain, liver, chest, abdomen and pelvis which helps in diagnosis or treatment.

III. MRI SEGMENTATION TECHNIQUES

In medical fields nowadays, medical imaging is a crucial component in a many applications. Such applications take place throughout the clinical track of events; not only within diagnostic settings, but prominently in the area of preparation, carrying out and evaluation before surgical operations. Generally, image segmentation is the procedure of separating an image into several parts. Instead of considering the whole data presented in an image all at once, it is better to focus on a certain region-based semantic object in image segmentation. Image segmentation has been widely implemented in medical imaging to separate homogeneous area.

Studied reflects that region of interest (ROI) segmentation

(shown in Figure 1) plays a crucial role in multilevel authentication [1]. Thus the goal of image segmentation is to find the regions that represent meaningful parts of objects for easier analysis purpose. This survey aims to gather and analyze methods used in image segmentation. So, in general this paper will summarize suitable image segmentation methods to be used for each types of medical images scan. Segmentations are divided mainly in four different techniques, which are thresholding-based, region-based, edge-based, and clustering-based. Additionally there are also other methods for image segmentations, as shown in Figure 2.

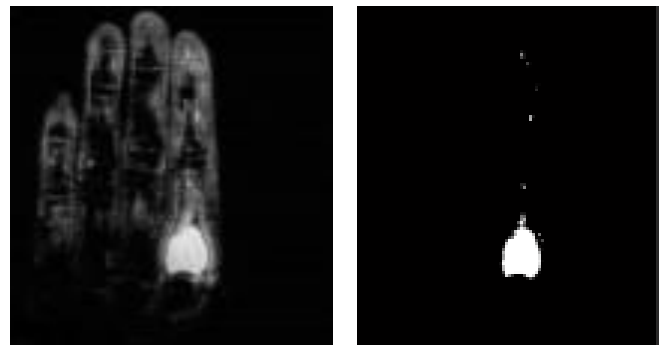


Figure 1: MRI segmentation

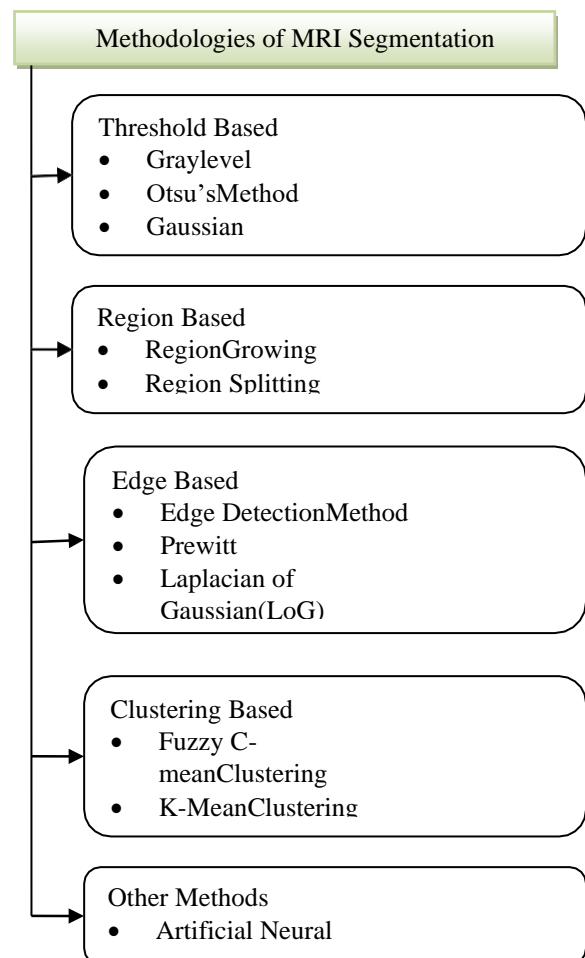


Figure 2: Methodologies of MRI segmentation

A. Thresholding-Based

Gray- Level Thresholding

The work of [2] offered a decent example of a procedure that integrates gray level thresholding which is a technique under the thresholding based image segmentation. In their paper, an input image can either be a gray scale or colored image. The image is then divided into sectors of fixed size and fixed location. An intensity histogram is calculated for each sector (and on colour images, for each colour channel), and used to produce a local segmentation. For every sector, information from its neighbors is used to detect clusters for which there may not be enough local support due to the artificially induced partition of the image.

Ostu's Method

In 1979, Ostu's [3] research shows that thresholding method is based on a very simple idea, which is to figure out the threshold that minimizes the weighted within-class variance. In the experiment, Ostu's method resulted in an advance in threshold-based technique by converting a gray scale image into a binary image by automatically.

Gaussian Mixture Method

Gaussian mixture approach for image segmentation is a method to estimate the number of components with their means and covariance sequentially without requiring any initialization as proposed by Nicole and Alexander in 2012 [4]. The experiment procedure starts from a single mixture component covering the whole data set and sequentially splits incrementally during the expectation maximization steps.

B. Region-Based

Region Growing

Region growing method can be accomplished by adding an offset and by scaling to transform all gray values to zero mean and unit-variance. As an alternative to work with intensities, a method which is storing the gradients' direction and strength, the latter is mapped non-linearly, this method proved to be better than the normalized intensity. The latter method proved especially useful in images with a strongly non-Gaussian distribution as encountered, e.g. in ultrasound images [5-7].

Region Splitting and Merging

Region splitting and merging technique is well known in region-based approach. This technique is a combination of region splitting and merging. Improvements involving simulated annealing and boundary elimination can also be

applied effectively in 3D or 2D MRI. The execution process is less time consuming [8].

C. Edge-Based

Edge Detection

In general edge detection methods are the process of identifying and locating sharp discontinuities in an image. Edge detection is important for the object recognition of human organs in medical images. In the years of 2006, Y.Q Zhang et al. [9] introduced basic mathematical morphological theory and operations, the novel mathematical morphological edge detection is proposed to detect the edge of lungs CT image with salt -and -pepper noise.

Prewitt Edge Detection

Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response [10-12].

Laplacian of Gaussian

Laplacian of Gaussian was firstly introduced by Marr and Hildreth in 1980 whom combined Gaussian filtering with the Laplacian technique. This algorithm is not often used in machine vision.

Watershed

Watershed is an image segmentation method which separates overlapping objects [13]. They proposed using mathematical morphology in image segmentation. The objective is to avoid the problem of over segmentation. This method involved two tools which are watershed transform and the homotopy modification.

D. Clustering-Based

Fuzzy C-Mean Clustering Method

The fuzzy set theory was introduced by Zadeh, and successfully applied in image segmentation. The fuzzy c-means algorithm was proposed by Bezdek in 1981 based on the fuzzy theory, it is the most widely studied and used algorithm in image segmentation for its simplicity and the ability to obtain more information from images. A fuzzy local information c-means (FLICM) is proposed to overcome the problem of setting parameters in the FCM-based methods. This algorithm uses both spatial and graylevel local information, and is fully free of parameter adjustment (except for the number of clusters)[14].

K-Means Clustering

According to Kaus et al. in 2004, [15] K-means Clustering Method is a process to classify a given data set through a certain numbers of K-clusters. After clustering all features into n classes with the k-means algorithm, each landmark is assigned to the cluster containing the largest number of training features from that point. In the research, the features sampled at a certain landmark only need to be compared with the assigned cluster.

Hierarchical Clustering

Hierarchical clustering is one of the edge based method to measure connectivity in functional MRI. This method is able to detect similarities of low-frequency fluctuations, and the results indicated that the patterns of functional connectivity can be obtained with hierarchical clustering that resembles known neuronal connections [16].

Mean-Shift

The mean-shift algorithm is designed to locate points of locally-maximal density in feature space. Feature vectors containing gray-scale or colour information as well as pixel coordinates are computed for each pixel [17-18].

E. Other Method

Artificial Neural Network

ANN becomes widely applied in image processing. An unsupervised method Kohonen's Self-Organizing Maps (SOM) form ANN and (Genetic Algorithm) GA were combined to identify the main featured present in the image [19].

Table I: Advantages and Limitation of Methodologies

Methodologies	Advantages	Limitations
Gray level thresholding -based	Easy to implement and efficient. No need prior information or calculation	Noisy and blurred edges. Lack of sensitivity and sharpness, hard to define, complex for Multidimensional.
Otsu's method	Able to extend to multilevel thresholding	False maxima may occur during optimization function.
Gaussian mixture approach	Minimizes classification error probability. Applicable to small-sizeclasses	Difficult to detect close and flat nodes.
Region growing	Perform better in noise image. Easy to compute	Costly
Region merging and splitting	The image can be split progressively according to demanded resolution	May produce blocky segments

Edge detection	Enclose large areas. Applicable to images with uneven illumination	Only applicable to simple background. closed contours are not guaranteed
Clustering based	Simple and easy to understand	Undefined optimal solution. Not compatible with noisy data
Neural network based	Applicable to a variety of problems. Easy to implement	Problem in choosing the best architecture.

The imaging modalities employed can be divided into two global categories: anatomical and functional. Images are presented in 2D as well as in 3D domain. In the 2D domain each element is called pixel, while in 3D domain it is called voxel [20]. Medical imaging is performed in various modalities as shown in Table II.

Table II: Recommended Methodologies

Modalities	Recommended method
	Thresholding and region-based Region-growing and watershed
3D MRI	ANN
MRI	Clustering-based
Ultrasound	Thresholding-based
X-ray	Edge-based and watershed

IV. CONCLUSION

This paper surveys on the existing methods of image segmentation and recommends image segmentation methods to be applied on CT scan, 3D MRI, MRI, ultrasound and X-Ray. The scope only includes digital watermarking in medical image. Each image segmentation method has its own limitations. Hence this paper can be used as a reference. However, there are certain limitations for image segmentation in digital watermarking for medical images. The accuracy of the segmentation remains the most concerned issue in determining critical cases such as detection of tumor via medical imaging. Recommendation for future works includes improving the accuracy and the speed of image segmentation for the digital watermarking in medical imaging.

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