An Improved Image Segmentation Method Using Three-dimensional Region Growing Algorithm

Qiao Wang[1,a], Xiaolong Song[1,b] and Zhengang Jiang[1,c]

[1]School of Computer Science and Technology, Changchun University of Science and Technology, No.7089, Weixing Road, Changchun, China

[a]jiaotangmaqiduoqq@gmail.com, [b]sxl@cust.edu.cn, [c]jiangzhengang@cust.edu.cn

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Abstract. As an important means of clinical diagnoses and treatment of liver diseases, CT scan of liver has been applied more widely. How to extract liver from CT image automatically and accurately is one of the hot topics in the field of medical image segmentation. Because of the diversity and complexity of medical image, traditional segmentation methods may cause errors. Therefore, this paper presents an improved image segmentation method based on three-dimensional region growing algorithm. The experimental results show that the proposed method is an effective way for improving the accuracy of liver segmentation.

Introduction

With the continuous development of computer technology, electronics and physics, modern medical imaging technology has been utilized widely in clinical applications [1]. It includes X-ray imaging techniques, computerized tomography (CT), magnetic resonance imaging (MRI), ultrasonic imaging, infrared thermal imaging (Thermal Imaging), endoscope imaging (Endoscope), micrograph imaging (Micrograph), positron emission tomography (PET), digital subtraction angiography (DSA) and so on.

As a key technique of medical imaging in computer aided medical application, medical image segmentation has been a hot topic of research and application. The task of image segmentation is to extract useful diagnostic information about anatomical structure from CT, MRI, PET and other medical images with the assistance of computer [2]. Because the medical image is complex and diverse, it is susceptible to various uncertainties in the image scanning process. Moreover, differences among individuals make medical image segmentation more difficult than general image. In recent years, CT image of liver has been widely applied in clinical applications. It has been an important way for liver function, pathological and anatomical studies [3]. It is necessary to focus on image segmentation methods in the field of medical applications.

Related Research

The previous medical image segmentation methods can be classified into region-based methods, edge detection methods, hybrid methods, fuzzy theory based methods and other segmentation methods [4]. The basic theory of region-based methods is to combine the regions which have similar characteristics. These methods include threshold segmentation [5], region growing segmentation [6], classifier segmentation [7] and clustering algorithms [8,9]. Edge detection method is to detect boundary between different regions. Since the hybrid method combines the advantages of the above two methods, sometimes it can get better results.

Because of different segmented object in medical images, the selected method is also bound to be different. How to choose a suitable method is determined by the specific situation. Traditional segmentation methods cannot complete the segmentation task very well. Therefore, for CT images of liver, this paper presents an improved image segmentation method based on three-dimensional region growing algorithm. The task of segmentation is to extract the preliminary three-dimensional segmentation of liver.

Proposed Method

In this work, we present an improved image segmentation method based on three-dimensional region growing algorithm. First, a growth rule is determined by the result of automatic scan. And then a seed point is selected in the corresponding area of liver. According to the growth rule, the three-dimensional region growing algorithm is used to obtain the initial three-dimensional edge of liver. At last, image morphology is used to optimize the segmentation results. The basic operations of image morphology are opening and closing.

Three-dimensional Region Growing Algorithm. In contrast with the two-dimensional image, target region of a liver is a three-dimensional area in CT image. CT image sequences may have hundreds of slices. Each slice image has a strong correlation, which contains a large amount of structural information. Therefore, if it is supposed to use the traditional 4-neighborhood of two-dimensional region growing algorithm (Fig. 1), the spatial information cannot be utilized in the growing process. Because it will cut off the link between the slices and ignore a lot of important information. Moreover, more than one seed points should be selected for every slice. To solve this problem, this paper adopts 18-neighborhood of three-dimensional region growing algorithm (Fig. 1). The seed point will grow to 18 neighborhood directions at the same time, so that the correlation between the slices can be fully utilized.

The growth rule is determined by the automatic detection. Compared with setting the threshold manually, automatic detection has a high accuracy and stability. All the pixels within the given range are scanned. As shown in Fig. 2(a), a frequency distribution graph of the pixel value has been drawn. The pixel value of the highest frequency is set to be the upper threshold. Then the threshold is determined by experiments.

Experiments show that the result of the three-dimensional region growing algorithm is better, when the number of pixels contained in the shaded area (Fig. 2(b)) is 55 percent of the total number contained in the given region. Namely, the threshold is 0.55.

As shown in the results of Fig.3, the threshold of Fig. 3(a) is 0.45; the threshold Fig. 3(b) is 0.55 and the threshold of Fig. 3(c) is 0.65.

Compared with Fig. 3(a) (n = 123 slice) with the threshold of 0.45, the threshold range of 0.55 has been widened. As shown in Fig. 3(b), the result has been grown more suitable points into the image. The initial result of the three-dimensional region growing contains more pixels.

Compared with Fig. 3(c) with the threshold of 0.65, the threshold range of 0.55 has been narrowed. Because the organs in human intra-abdominal have the similar density and structure, intensities are close to each other. If the threshold is too large, the result of three-dimensional region growing algorithm may include other organs as Fig. 3(c).

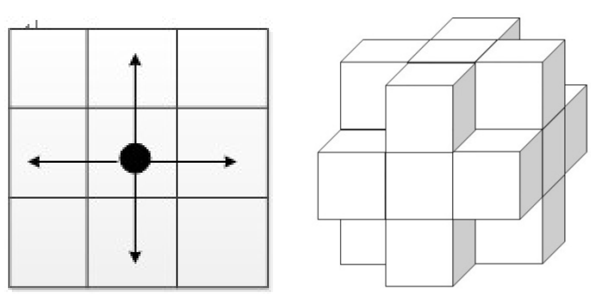
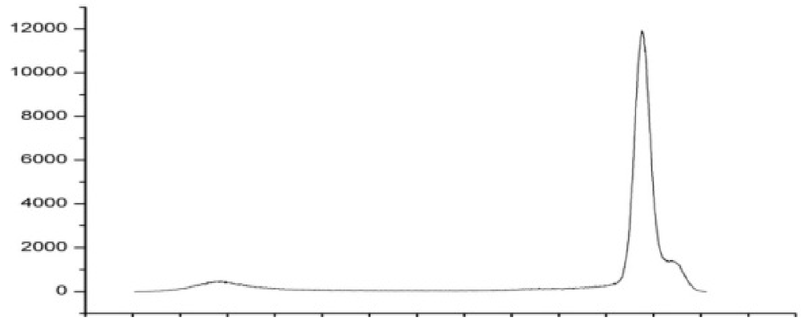
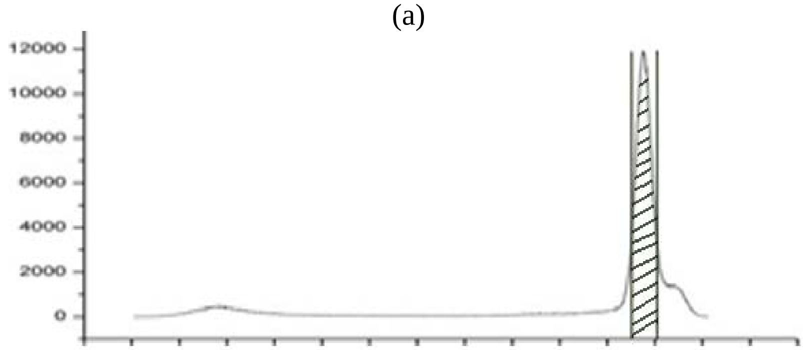


Fig. 1 4–neighborhood for two-dimensional image (left) and 18–neighborhood for three-dimensional image (right)

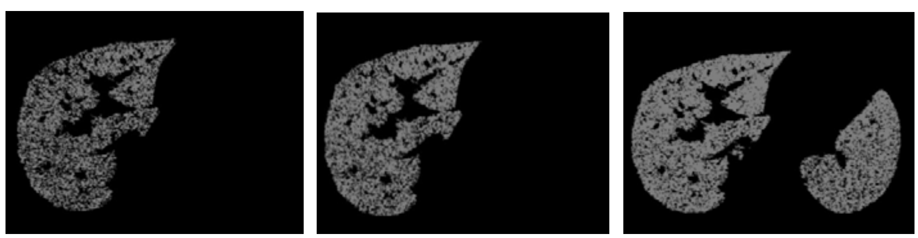


(a)



(b)

Fig. 2 Frequency of the voxel intensities



(a) (b) (c)

Fig. 3 Results of three-dimensional region growing algorithm in different threshold ranges

After the region growing procedure finishes, the initial three-dimensional segmentation results of liver will be extracted.

In order to optimize the results, image morphology is used to obtain the edge of liver clearer. The work adopts closing operation and takes expansion operation first. The structure element adopted in the expansion operation is 13*13*13, and 7*7*7 in corrosion operation. Experimental results show that the structure of this size works better.

Experimental Results

In order to verify the proposed method, some experiments were performed in this work. The testing data are a group of clinical CT image series. The purpose of segmentation is to extract preliminary three-dimensional segmentation of liver.

First, the CT images are sharpened using a three-dimensional Laplace transform. In this procedure, the area of pixel intensity changed sharply can be enhanced, and the area of pixel intensity changed smoothly can be reduced. Fig. 4 is the original abdominal CT image series. Fig. 5 is the result after the Laplace transform. The result was used to assist determining the boundary. Then the three-dimensional region growing algorithm was used to deal with the original abdominal CT image series.

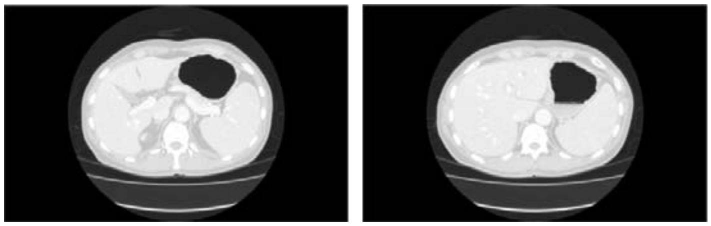
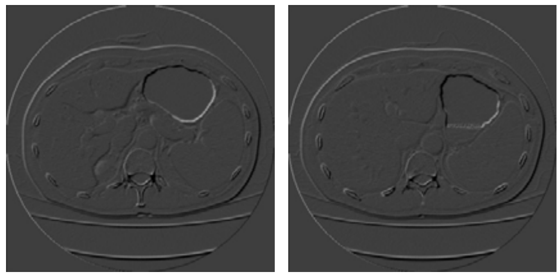
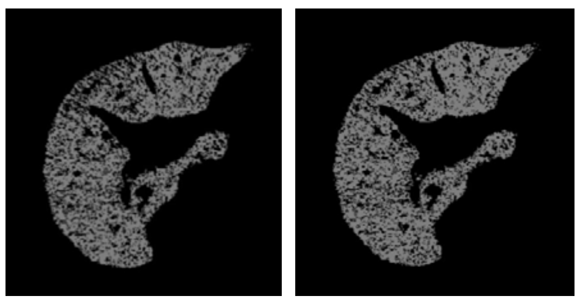


Fig.4 Original abdominal CT image series



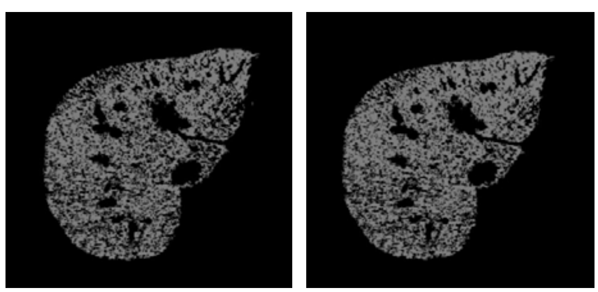
(a) (b)

Fig.5 Images after three-dimensional Laplace transform



(a) (b)

Fig.6 Results of the 143rd slice



(a) (b)

Fig.7 Results of the 103rd slice

Fig. 6(a) (n = 136 slice) is the result of setting threshold manually. Fig. 6(b) is the result of automatic detection. Fig. 7(a) (n = 71 slice) is the result of setting threshold manually. Fig. 7(b) is the result of automatic detection. Experiments show that the results of the above two methods are of little difference. Moreover, the result of automatic detection method is even better. Because setting threshold manually will be subject to many human factors, the result is of unstable accuracy.

Fig. 8 shows the results after image morphology. It is clear that the edge of liver is clearer than before.

(a) (b)

Fig. 8 Results after image morphology

Summary

This paper presents an improved image segmentation method based on three-dimensional region growing algorithm. The initial three-dimensional segmentation of liver has been extracted. Experimental results show that the proposed method can determine the growth rule by automatic detection and has a high accuracy. How to select the seed point automatically and extract liver more accurately are our future works.

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