The liver CT image sequence segmentation based on region growing

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Abstract. According to the serial correlation characteristics of liver CT images, in this paper, based on the morphology expansion and corrosion method, we put forward a liver CT sequence image segmentation method based on region growing algorithm. First conduct the smoothing denoising pretreatment to the sequence image[1], and then select an image, and the region growing algorithm was adopted to realize the liver parenchyma area division. We adopt expansion and corrosion to process the segmentation result. Later we take it as the seed point of the next image. Finally we finish all the liver CT sequence image segmentation. Experimental results show that this method can effectively conduct the liver sequence image segmentation, and fill the empty after sequence segmentation, greatly reducing the user interaction.

Introduction

Liver CT image is currently still the main method that doctor diagnosed liver disease. Especially in recent years, with the development of medical imaging technology and computer image processing technology, combined with 3-d reconstruction technology, establishing virtual models of liver provides great convenience to the doctor's diagnosis[2]. Accurate and fast segmentation of the image is the foundation of setting up virtual liver model. Using 64 row multilayer spiral CTs to scan liver area can produce 200 to 300 copies of CT images. So this needs to be able to quickly and less interact with a group of liver CT image sequence segmentation. Then we get a set of segmentation results, and we can build out patients' virtual liver model by 3-d reconstruction technology[3].

At home and abroad there are a lot of liver segmentation methods based on CT images, such as threshold segmentation, region growing, level set method and active contour, and so on[4]. Because the liver structure is very complex and noise is inevitably produced in the CT image, the segmentation of liver CT images often produces phenomenon of over-segmentation or under-segmentation. So, most of the research method is the improvement of existing methods or a combination of various methods along with all the preprocessing and post-processing operation[5].

In this paper, according to the characteristics of single liver image segmentation results, combined with morphological expansion and corrosion method, this paper proposes a liver image sequence segmentation method based on region growing algorithm. Because in liver CT sequence images, there exists a correlation between two adjacent images, and both liver areas are roughly same, and image grey values are roughly similar[6]. So we can get rough area of adjacent images through the expansion and corrosion process of the segmentation image. Taking corrosion processing results as segmented part of the adjacent images then as a seed point continues to segment. The expansion processing gains the biggest contour of adjacent images. It can not only improve the speed of segmentation, but also can reduce the phenomenon of over segmentation and under segmentation.

Expansion and corrosion

In computing method of morphology, expansion and corrosion transformation is the most common operation[7]. They are built in the foundation of aggregative Minkowski sum and difference, and it is the foundation of all complex morphological transform[8]. In this paper, according to the

characteristics of the liver images, and in order to avoid the over expansion situation when the gray image expand. We select the square flat structure operator[9], and length is 3, and the operator matrix are as follows:

$$\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

Through the above 3*3 structure operator, conduct the expansion processing to the image. Take the maximum value of the pixel values of all the points to assign within 3*3 neighborhood of the point[10]; Conduct the corrosion processing to the image. Take the minimum value of the pixel values of all the points to assign within 3*3 neighborhood of the point[10].

In the segmented image, the liver area will generate "empty". Usually it is caused by strong noise, and it will affect the result of segmentation, and it will also have a significant impact on the subsequent sequence segmentation and 3-d reconstruction[1]. In order to avoid this kind of phenomenon, this paper first fill the "empty" through expansion, then remove edge expansion part though corrosion. The flow chart of filling the image through expansion and corrosion is shown in Figure 1.

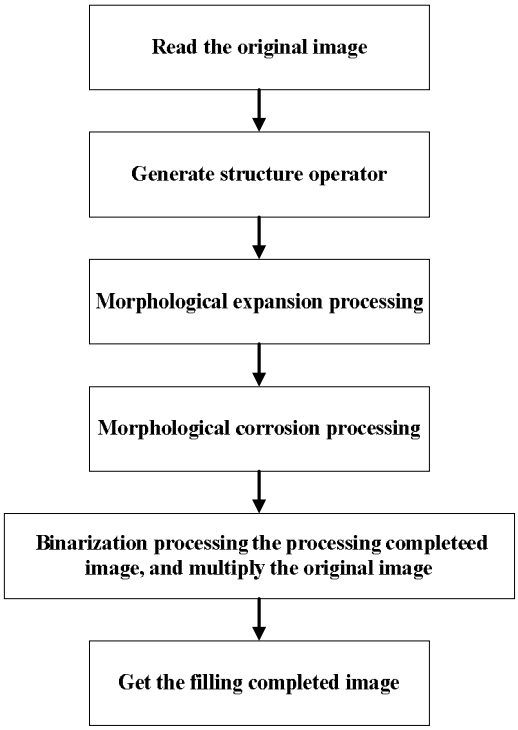


Figure 1 Image filling flow chart

Liver CT image sequence segmentation

In this paper, we study the liver image sequence segmentation based on single liver image segmentation region, and use the corrosion morphology of binary image and the correlation of adjacent images realize segmentation for the entire group sequence image.

A single segmentation mainly use region growing algorithm. The algorithm is that constitute the area by gathering together pixels with a certain similarity[11]. At first find one or more seed points in the area needing the segmentation, then expand to the surrounding through the seed points and merge the point meeting the conditions. And take the new merged points as new pixel point and continue to grow around until no more pixels meeting the constraint conditions can be included[12]. In the growth rule of the region growing algorithm, generally it is mainly depends on two parameters: the average gray degree and standard deviation[13]. This article uses the formula (1) as a constraint condition:

$$\bar{m} - l\,s < x < \bar{m} + l\,s \quad (1)$$

Among them: $\bar{m}$ is the local average gray degree, and it is average value of all pixels in the extension area the seed point in, s is the standard deviation for the target area,λ is adjustable parameter, and it is used to control the uniformity of the similarity threshold between pixels, and join the neighboring pixels meeting the formula into the seed region.

The correlation of adjacent images shows that the grayscale average of adjacent images liver part are the same and variance are close, and liver area sizes and locations are similar[14], so we can use data of the former segmented image as the segmentation parameter of the next region growing algorithm[15]. At the same time, we can use expansion and corrosion to effectively prevent the image over segmentation and under segmentation phenomenon. In the segmentation process, because of the influence of the noise point, image could split out the spare parts or less segmentation of liver area. Due to the similar adjacent images liver area we can use the front segmented image to determine the approximate scope by expansion, thus remove the part of under segmentation. Due to taking the former segmented image after corrosion as the seeds of the next point, these seed points, in fact, have already included most of the liver area. On one hand, the seed point number can increase the accuracy of the segmentation, on the other hand, as a seed point, most liver scope of the image have been segmented, thus it greatly reduces the under segmentation phenomenon. In order to make the sequence image segmentation effect best, firstly, select image with the biggest area that liver area occupies total abdominal (usually it is the image whose serial number is in the middle) for segmentation. Manually conduct the repair and image filling of the segmented image, and then conduct the expansion and corrosion processing about the segmentation results. After liver area proceeds several times of corrosion, we take it as the seeds points set of the next image segmentation (the more the seed points, the better the segmentation effect, the faster the segmentation speed), then conduct the adjacent images segmentation. After liver area proceeds several times of expansion, as the biggest range in the next image, and get the union set with the segmentation result, and remove the over-segmentation part. After such a segmentation end, then repeat the above process, until segment to the first or the last image, or ends until that the segmentation results is less than a certain range. This completes the whole group segmentation of the liver image. The flow chart of sequence segmentation is as shown in Figure 2:

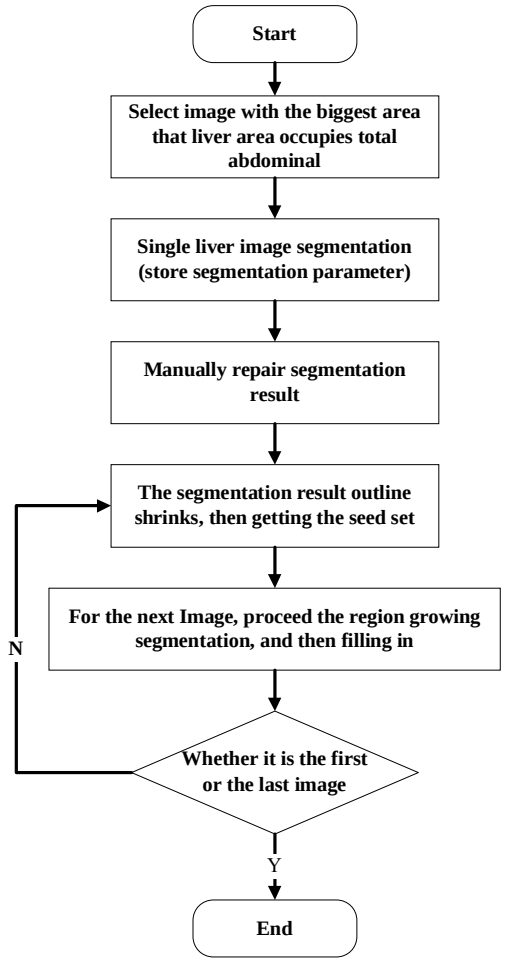
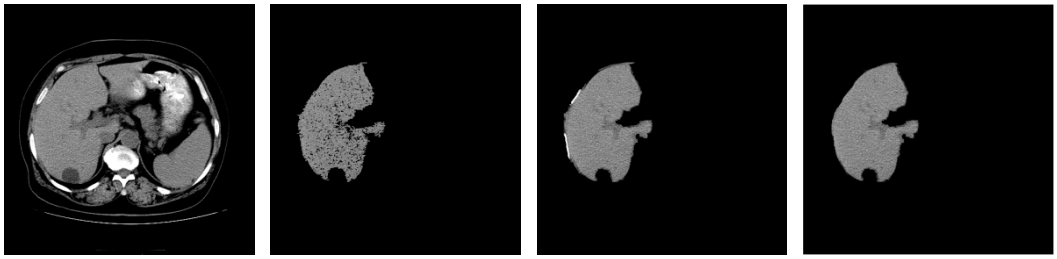


Figure 2 The flow chart of liver sequence segmentation

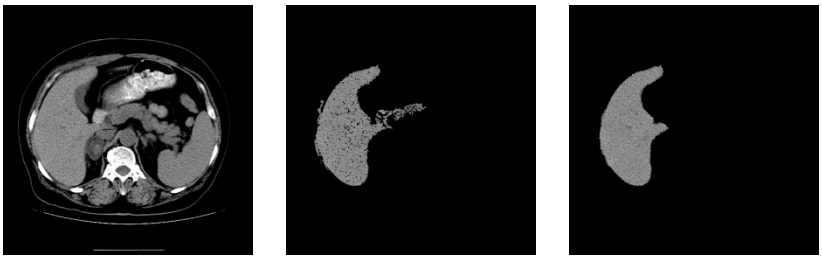
The experimental results and analysis



(a) Original image (b) Segmented image (c) Expansion after segmentation (d) First expansion then corrosion

Figure 3 The original image and segmented image and the image comparison after expansion and corrosion processing with the segmented image

We get Figure3-(b) after segmenting the original image 3-(a) by the region growing algorithm. We can clearly see that there are large amounts of "empty" in the image of Figure 3-(b). We get Figure 3-(c) after the expansion processing of the binary image. It effectively fills the "empty" in liver area. But because of the expansion operation, there exists the problem of edge expansion, which makes the outline of the liver area is not accurate. We get Figure3-(d) after the corrosion of the expansion image. From Figure 3-(d), we can clearly see that the "empty" in the original image is fully populated, but the image edge doesn't get extended. Through the first expansion then corrosion method of the original image, we can not only fill "empty" in the original image, but also can avoid the expansion of the image edge outline, which reaches the perfect effect.



(a) Original image (b) Over segmented image (c)Final segmentation result

Figure 4 The original image and over segmentation and comparison of final segmentation results

We get Figure4-(b) after segmenting the original image 4-(a) by the region growing algorithm. We can obviously see that image generates over-segmentation phenomenon affected by the noise. Figure 4-(c) effectively prevents the over-segmentation phenomena and fill the "empty" by expansion and corrosion.

This study also uses adding window, adaptive anisotropic filtering and region growing image segmentation algorithm based on RBF-CI, and expansion and corrosion. This study realizes liver image sequence segmentation based on the improved region growing algorithm. Figure 5 is segmentation results of a group of liver CT image sequence.

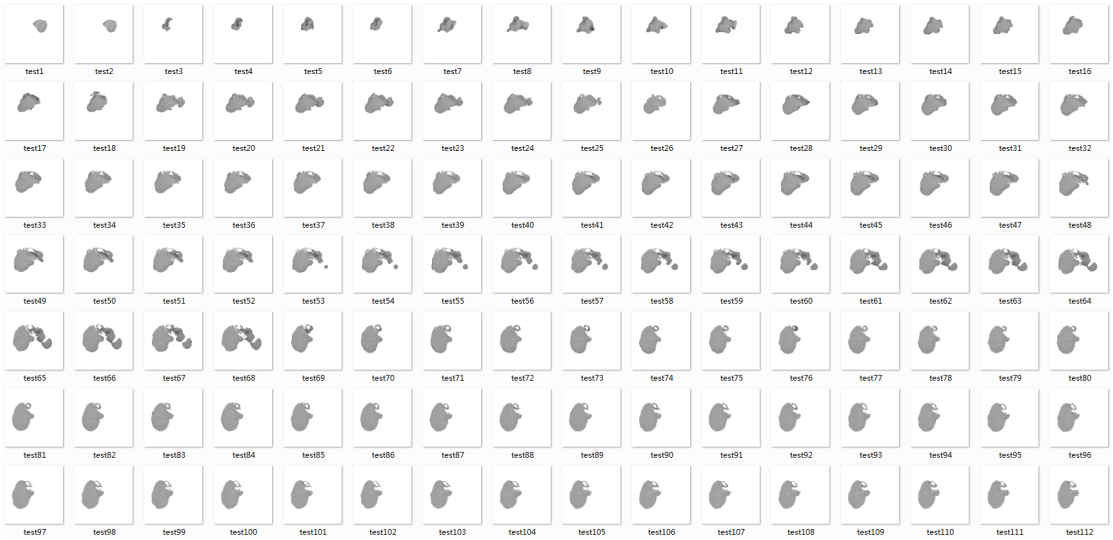


Figure 5 Liver image sequence segmentation

Summary

In this paper, based on window technology and denoising processing, according to the need of liver image sequence segmentation, the liver image sequence segmentation method is studied. For single liver image segmentation results, we first use expansion then the corrosion of filling method to reduce the image strong noise effect on the segmentation results, and combined with the traditional region growing algorithm to achieve the liver image sequence segmentation automatically. Experimental results show that the segmentation results of proposed liver sequence image segmentation method can meet the requirements of 3-d modeling, and greatly reduces the amount of user interaction. Because the automatic segmentation of liver sequence image technology is not mature enough, and the accuracy calculation of the segmentation results need medical professionals' cooperation to achieve, so this paper only identify the segmentation effect is good or bad according to the visual effect of the segmentation results. There is no quantitative calculation research of algorithm segmentation accuracy, and this is also our next research work.

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