A Plain Segmentation Algorithm Utilizing Region Growing Technique for Automatic Partitioning of Computed Tomography Liver Images

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***Abstract*—Medical image segmentation is quite significant, especially for diagnosis and treatment of diseases. In this study, similar and different tissues in computed tomography (CT) images of liver are decomposed by utilizing region growing method. The images are preprocessed before segmentation. First, gray scale CT images are smoothed with a median filter, and a coarse segmentation is done with four level uniform quantization. A pixel from each connected component of the quantized image is selected as a seed point and is employed by region growing algorithm to specify corresponding segment. The number of segments depends on the number of connected components. Experimental results show that this basic method has successfully segmented the liver.**

Keywords*—*Medical image segmentation, region growing method, computed tomography liver image.

I. INTRODUCTION

Medical image segmentation is a tool for assessment of the medical images to support physicians. The segmentation methods are required for detailed analysis of each region in the images and to identify healthy or unhealthy regions before a surgery. In this study, CT images of liver have been segmented. The liver has crucial tasks in our body and liver cancer causes death although it is not seen as common as other types of cancer. Many algorithms have been successfully performed for medical image segmentation in recent years. One of these algorithms implemented for liver segmentation is region growing [1]–[10]. Beside these works, in here, a simple and yet profitable approach has been proposed to segment liver images by employing region growing technique.

II. MATERIALS AND METHOD

A. Materials

The algorithm has been evaluated on 44 2-D gray level CT images of the liver. The CT images have been obtained from two different CT scanners in Radiology Department of Başkent University, Adana. The size of the images has been 512×512 and resolution has been 1.25 pixel/mm. The images have been scaled to 0-1 range (0: black and 1: white). The method has been implemented by using Matlab©. The region growing algorithm written in Matlab programming language by Dirk-Jan Kroon has been utilized [11].

B. Methods

The method consists of three main steps: 1. Smoothing and quantization, 2. Seed point specification 3. Region growing segmentation.

Cropping image. Firstly, blank regions surrounding the liver of a CT image is removed. The image is thresholded to isolate the liver (threshold level is 0.035). The image opening and then image closing operations are applied to remove region smaller than 5x5 pixels and to tear off regions connected with 5x5 pixels. The connected component with the biggest area is chosen and its bounding box is computed. The image is cut from this bounding box.

Smoothing and quantization. Smoothing and quantization is done to achieve a uniform gray level distribution for each partition in the image. A median filter with mask size 7x7 is employed for smoothing. And then four level uniform quantizer is applied. The quantization is done using equation: $Q = \lfloor I/64 \times 255 \rfloor$, where $\lfloor \cdot \rfloor$ is flooring operation. In here, the label zero corresponds to the background. The other labels are parts of the CT liver image.

Seed point specification. For each segment (labeled as 1, 2, and 3) connected components are determined. Next area of each connected component is computed. Following connected components which have lower than 196 pixels (14x14) are removed. Median of linear indices of each connected component provides address of the seed points. Notice that linear index of $Q(x, y)$ is $y \cdot N + x$, $x = 0, 1, \ldots, N-1$ and $y = 0, 1, \ldots, M-1$ where $N \times M$ is the size of the image Q. With this approach not only regions with dissimilar brightness are separated. The disjoint areas with similar mean intensities are also partitioned.

Image segmentation with region growing. Each seed point decided in the previous step is used in the region growing technique [12] to specify a segment in the image Q. Obviously, the number of the segments depends on the total number of

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connected components (equal or higher then four). The region growing algorithm has been summarized in the following.

Region growing:

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1) Choose the seed pixel $Q(x, y)$. Set mean intensity value of the region $Qm = Q(x, y)$.
2) Check the neighboring pixels (four neighbors) and add them to the region if they are similar to the seed. The four neighbors of $Q(x, y)$ are $Q(x-1, y)$, $Q(x+1, y)$, $Q(x, y-1)$, $Q(x, y+1)$. If $|Q(x-k, y) - Qm| < 0.2$ and $|Q(x, y-k) - Qm| < 0.2$ for $k = 0, 1$, then add these neighbor pixels to the region.
3) Using the expanded region update mean intensity value Qm. Repeat step 2 for each of the newly added pixels; stop if no more pixels can be added.

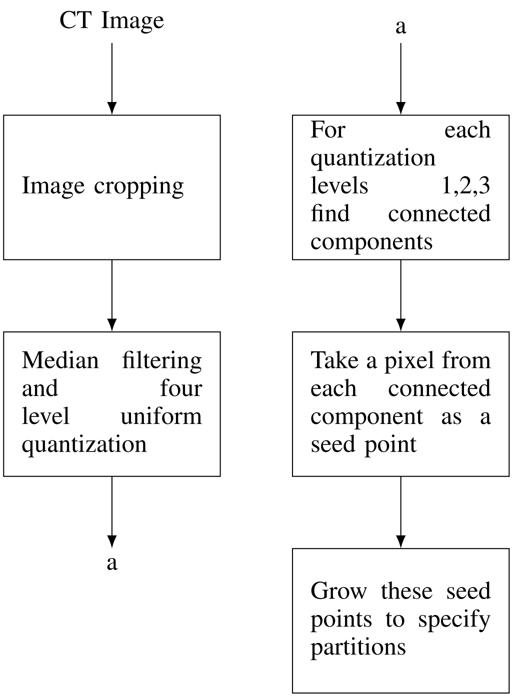


Figure 1: Block diagram of the segmentation algorithm

III. RESULTS AND DISCUSSIONS

The proposed methodology has been applied to 44 2-D CT images of the liver. The segmented images have been evaluated subjectively. If the liver and other tissues are partitioned clearly, it is marked as "good". When the liver is separated correctly but the other tissues are uncertain, it is rated as "fair". The result is poor if the segments obtained do not match tissues accurately. In the following a sample from each category has been reported.

Figure 2 is an example of successful segmentation. It is recognized visually that tissues (liver, vertebra, lesion/tumor, lining, and others) have been clearly identified. In figure 2c the green part is the tumorous area, the orange part corresponds to liver and, the navy blue part covers vertebra. The light green part screens lining and the olive green part contains the regions called others.

A case for fair segmentation is in figure 3. It is observed that some tissues have not been described correctly. Investigating figure 3c, it is seen that liver and vertebra are shown in purple and dark green, respectively. The orange part views lining and the olive green part corresponds to the others. The tumorous area could not be detected since the lesion has similar characteristic with soft tissues in the border of the liver. It is recognized that inadequate number of quantization levels causes error in the segmentation.

The figure 4 shows a poorly segmented image. In figure 4c, liver is shown in pink. The sea green part covers lining, the dark brown part corresponds to vertebra and the olive green part shows the others. The lesion could not detected and some regions are miss-classified due to adipose tissues or low-contrast in the liver image. The most of the tissues have not been detected properly. It is discovered that the order of smoothing should be higher to get better segmentation of the liver.

The partitioning achievement has been quantified as 1 if the result is good, as 2 when the decision is fair and as 3 if the image is poorly segmented. A radiologist has evaluated all 44 outcomes. The 23 results have been rated as "good", 18 segmented image have been labeled as "fair" and the remaining 3 of the outcomes have been scored as "poor". The average goodness of the results become $(23 \cdot 1 + 18 \cdot 2 + 3 \cdot 3)/44 \approx 1.5$, which is above "fair".

Therefore, tuning the parameters (filter order, number of quantization levels, similarity measure in the region growing procedure etc.) by maintaining a balanced trade off between clear and insufficient segmentation it may be possible to get more accurate results.

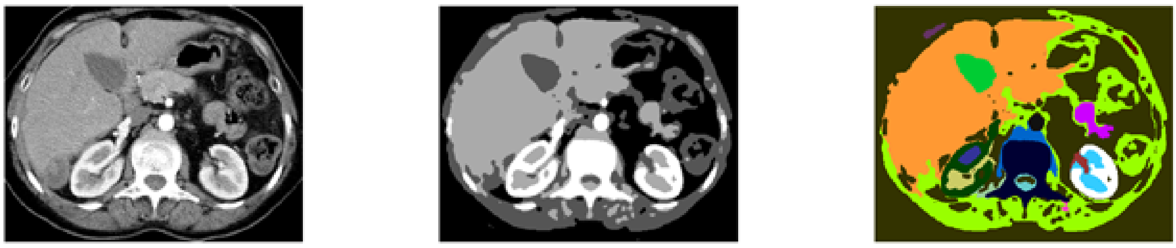
IV. CONCLUSION

In this study, automatic segmentation of 2-D CT images of the liver has been performed by utilizing region growing method. A CT image is first smoothed and quantized to get a coarse segmentation. The connected components in the quantized image are specified, and seed points from these regions are selected. The region growing algorithm makes use of these seeds to determine the partitions. The method is uncomplicated and easy to implement. However, its partitioning performance is profitable. The results of the study suggest that it might support physicians to segment and determine healthy and unhealthy tissues in CT liver images.

Future work of this study may be to extract features from each segment of the CT liver image to determine healthy, and unhealthy tissues if exist.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

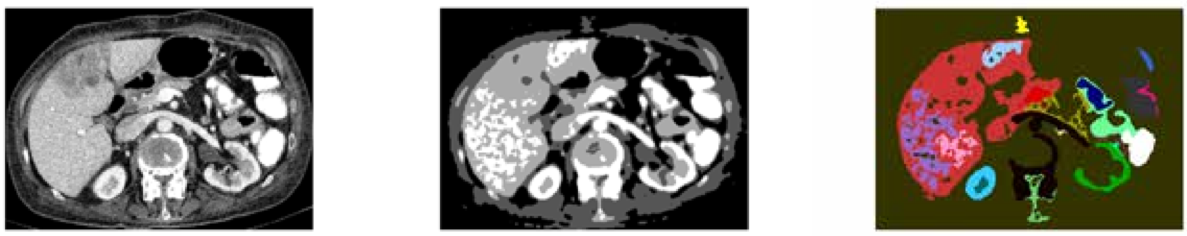


(a) Original (b) Quantized (c) Segmented

Figure 2: An example of good segmentation

(a) Original (b) Quantized (c) Segmented

Figure 3: An example of fair segmentation



(a) Original (b) Quantized (c) Segmented

Figure 4: An example of poor segmentation

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