Advanced Liver Segmentation by Using Pixel Ratio in Abdominal CT Image

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Abstract: In our study, by observing and analyzing normal liver in abdominal CT image, we estimated gray value range and generated binary image. In the binary image, we achieved the number of hole which is located between pixels. Depending on the ratio, we processed the input image to 4 kinds of mesh images to remove the noise part that has the different ratio. With the Union image of 4 kinds of mesh images, we generated the template representing general outline of liver and subtracted from the binary image so that we can represent the organ boundary to be minute. With the results of proposed method, processing time is reduced compared with existing method and we compared the result image to manual image of medical specialists.

1. Introduction

Each internal organ has its own gray value range. If we segment with only gray value[2][3], however, it is likely to mistake another organ for the targeted organ because several organs coexist in this gray value range. In the existing method, we used gray value and the location of the organ as information to segment the organ[1][3][4][5], and if necessary, we also used its size or shape and the shapes adjacent to other organs[6]. In addition to these methods, a clustering method[7] and the method using standard deviation have been studied. But because these methods are difficult to apply to the CT images which has the characteristics of the partial volume effect, we reduced the error of misunderstanding noise part with the use of pixel ratio which construct the organs.

2. Pixel ratio and template

Not considering the distribution of organ's pixel, existing method segmented all part of organ which have the same gray value with the target, and resulted in a wrong understanding of noise parts.

(a) (b)

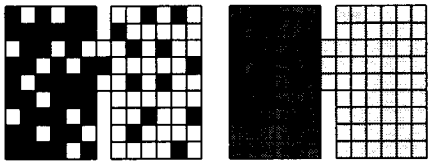
(c) (d)

Fig. 1. (a) ~ (d) Results of Wrong segmentation of noise parts

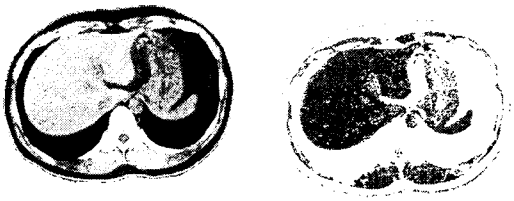
If a pixel is small, generally two objects with different distributions of gray value can be perceived as different ones with the naked eye. The organ discriminated with the naked eye in the equalized image, can be segmented also because it has the different distribution of pixel in the binary image even if it has the same gray value range with the noise.

we can discriminate targeted organ from noise when we use blurring effect because they have the different pixel distribution which is represented different gray value with mesh. The mesh role a part of discrimination between organ and noise by blurring the each pixel value artificially in the unit area.

(a)



(b) (c)



(d) (e)

Fig. 2. (a)Example of real image and blurred image perceived with naked eye (b) The example image of pixel distribution of the organ and the noise (c) Blurring of (b) image (d) Equalized input image (e) binary image

In this study, to discriminate between organ and noise that have the same gray value range with organ, we examine the pixel distribution and obtained the threshold. We compared the threshold with the binary image divided into mesh size and removed noise part. The selected mesh of which hole ratio is almost same with the standard value represent the mesh image and the template is from union image of four kinds of mesh image.

The template of this study means a lump to keep the whole shape of the organ to be segmented without noise of the other organs, does not outline the organ in details and is used as the frame of subtraction. Template determines the rough outline of the organ of a gray value distribution so that it improve existing method which has difficulty in removing larger size noise.

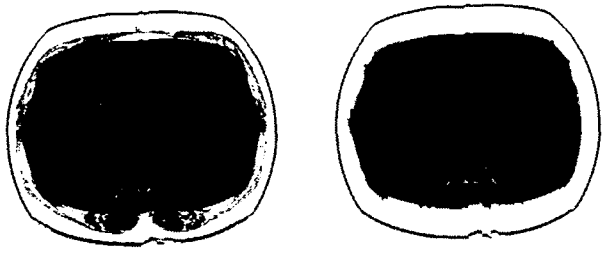
3. Organ segmentation

The whole process consisted of three process. In the first process, we examined a hole ratio which consists targeted organ and determined the threshold. The second process is to generate template to subtract from binary image. In the process, the template generated from union image of four kinds of mesh images. The third process is trimming process including subtraction and filling inside the organ.

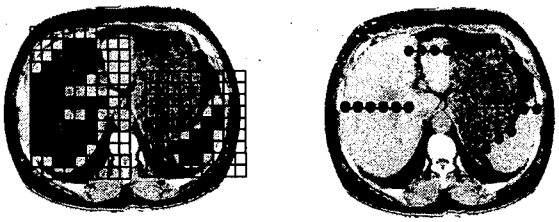
3.1 deciding the gray value range location searching

To examine the distribution of gray value, we estimated the gray value range which makes up of the organ, we set up the mesh of a regular size in an organ existing area, estimated the gray value range of it, and determined minimum and maximum value of it.

Location searching is a process in which we determine the location of the body of input data from each slice and the approximate locations of the liver and the spleen, and obtain coordinates.. Therefore, location searching coordinates were used to discover if the organ exists or not and to segment the separated organ exactly. If we discovered the corresponding pixel of the organ of a gray value, tracing the given direction in the location searching line, we set up the coordinates as a dot of the inside organ



(a) (b)



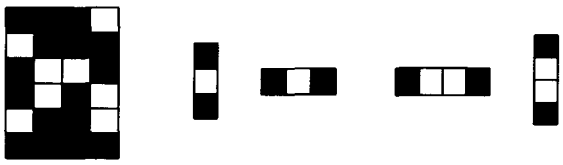
(c) (d)

Fig. 3. (a) Image of Fat layer and ribs removal (b) Image of muscle layer removal by tracing thickness of the irregular muscle layer (c) Image of deciding the gray value range represented with mesh (d) location searching with 3 location searching line

3.2 Deciding threshold of pixel ratio

To obtain the binary image , we imposed organ's gray value as a threshold. The binary image consists of black pixel which represent organ part and whit pixel which represent hole in the organ. Examining the hole ratio , we determined standard value and processed image by the hole distribution in unit area. The noise parts have different hole distribution from organ, they can be possibly eliminated.

The hole ration is the ratio of the number of organ's pixel to the number of holes in organ. The number of holes is the total number of white pixels between black pixels. Mesh image is from following way. That is, if the number of holes in unit mesh is more than threshold, all pixels included in mesh are processed to gray value 255, and then if the number of holes is less then threshold, gray value 0 is assigned to all pixels existed in mesh.

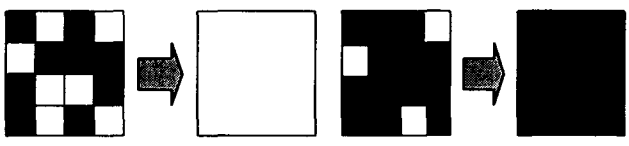


(a) (b) (c)

Fig. 4. (a) Example of hole ratio, Pixel = 24 ,hole = 8, Ratio = 34 % , b) 1pixel hole의 인식 , c) 2 pixel hole의 인식

3.3 Deciding four mesh image and template image

In mesh processing method, pixels included in one mesh area are processed by threshold. Since the ratio of holes existed in noise is larger than the ratio of organ, noise area can be removed by assigning 255 to that in which the nmber of holes per unit mesh is more than determined threshold. In other words, All of the pixels in unit mesh are assigned 0 or 255 gray value depending on the number of holes. Therefore, noise having larger hole ratio than threshold become 255 and can be eliminated. Each 4 mesh images are generated by moving half size of mesh the overall image to diagonal direction.



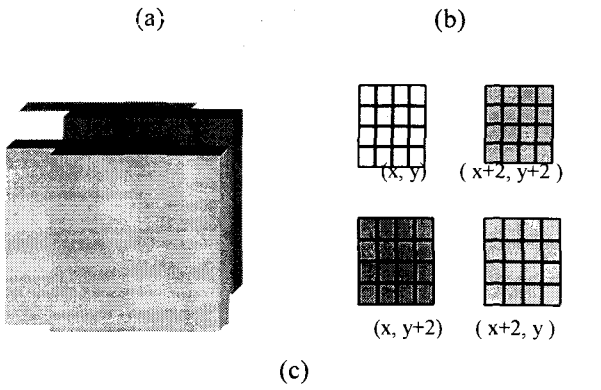


Fig. 5. (a) Unit mesh processed as gray value 255 in case of threshold is 5 (b) Unit mesh processed as gray value 0 (c) Example of four kind of mesh direction

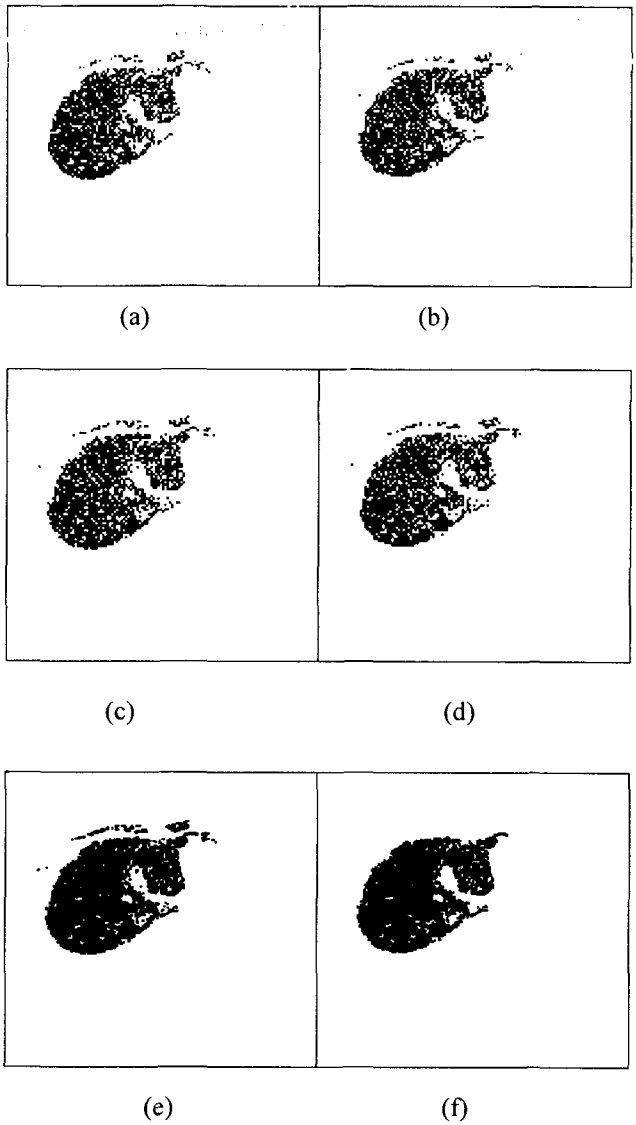


Fig. 6. (a) – (d) four kind of mesh images (e) Union image (f) closed area segmented image

3.4 Subtraction and filling

Since a template is used as a frame to subtract the organ to be segmented from the binary image, it should be big enough to include the outline of the targeted organ. Therefore we make the template image large with an opening. The existing opening had a defect—it took a long time to process because it used a structuring element.

The dilation algorithm, in this study, which is used to reduce the processing time is a contrast to the existing dilation. In the existing process, trimming process was done by using a structuring element and there can be a partial loss as well as a noise removal because the tips of the organ were misunderstood as noise. In this algorithm of the study, subtraction on the binary image is used to represent a more detail outline. This method helps to represent it without loosing information of an original image and to generate the natural outline.

Filling process also did not use the existing erosion, but used a filling method with perception of the space between pixels. With this method, we can exclude the inside hole of its own organ, by filling only the small inside holes of the organ, and express the detail outline, while we get the rough one with erosion algorithm.

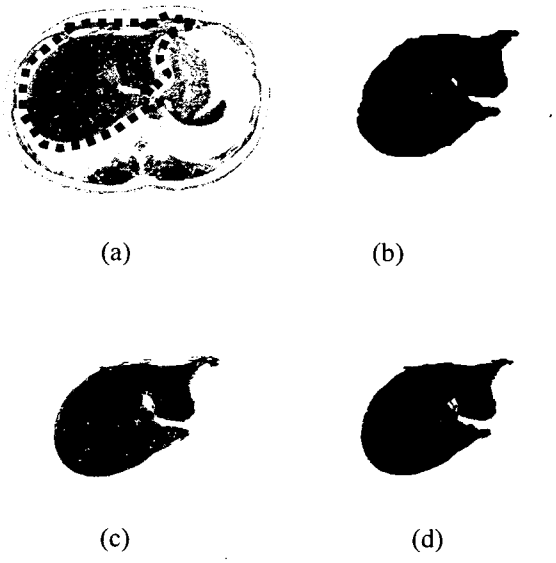


Fig. 7. (a) subtraction region in binary image (b) template from opened union image (c) subtracted image from binary image before filling process (d) result image

4. Results of image processing

The algorithms have been applied to the CT images of thirty persons. The following table shows the comparison results between the mean value of the image volume obtained by the method of the present treatise and the mean value of the image volume obtained by the manual method of the radiation medical specialists. The following table shows the comparison results between the mean value of the image volume obtained by the method of the present treatise and the mean value of the image volume obtained by the manual method of the radiation medical specialists.

Table 1. Comparison program volume with manual volume for liver

Volume by program	Volume by manual	Error
1.13543948	**1.12909536**	**3.41%**

5. Conclusion

As the result of processing, we reduced the processing time of the whole slice from about 12 minutes to 4 minutes approximately. The reduction of the processing time can be caused from the fact that we did not use the existing algorithm using the structuring element. The opening and the closing algorithms developed in this study made a great contribution to reducing the processing time.

We can discover that the value of the whole volume is more close to that of manual interface by a medical specialist because noise with large size is removed. From the point of accuracy of active processing, it makes good progress in that the tips of the organ can be represented without a loss, comparing with the manual image by a medical specialist or an the equalized image.

Mesh processing makes it possible to process easily and to reduce the processing time by performing the conditions that the algorithm suggests within a given size of mesh. Pixel ratio comparing method is also helpful removing the large size noise. It gave a reliable way not to include the noise part considering individual difference.

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