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Extracting Gall Bladders from Ultrasound Images

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Abstract Nowadays, the internal images of a human body can be easily provided by the ultrasound imaging, the X-ray CT, or the MRI device, among which the ultrasound imaging device has good resolution for soft tissues of a human body compared with the other devices. Furthermore, the use of ultrasound imaging devices will increase in future especially in the obstetrics territory, since it does not give harm to the human body.

Although several techniques have been investigated until now in order to extract organs from ultrasound images, very few of them have achieved satisfactory results because of low contrast and high noise nature of images. This paper proposes a technique for automatic extraction of the gall bladder area from ultrasound images. The proposed technique first extracts a small reliable area of a gall bladder from an ultrasound image employing smoothing, binarization, expanding and shrinking, and labeling, and then expands the area referring to the binarized version of the original image. The technique is examined its performance by real ultrasound images of a gall bladder and satisfactory results are obtained. Some problems to be solved are discussed finally.

keywords Medical image processing, Ultrasound image

1. INTRODUCTION

Nowadays, the internal images of a human body can be easily provided by the ultrasound imaging, the X-ray CT, or the MRI device, among which the ultrasound imaging device has good resolution for soft tissues of a human body compared with the other devices. Furthermore, the use of ultrasound imaging devices will increase in future especially in the obstetrics territory, since it does not give harm to the human body[1].

Although several techniques have been investigated until now in order to extract organs from ultrasound images, very few of them have achieved satisfactory results because of low contrast and high noise nature of images. This paper proposes a technique for automatic extraction of the gall bladder area from ultrasound images.

The proposed technique first extracts a small reliable area of a gall bladder from its ultrasound image employing several image processing techniques,and then enlarges the area referring to the binarized version of the original image.

2. SYSTEM CONFIGURATION

Figure 1 shows the configuration of the employed hardware system. In this system, the image obtained from ultrasound imaging devices is scanned by an image scanner and fed into an EWS through a personal computer, and the following extraction algorithm is applied.

Figure 2 shows the flow chart of extracting a gall bladders from ultrasound images. The proposed method is devided into two major stages. First, it extracts a small reliable area of a gall bladder from its ultrasound image employing smoothing, binarization, expanding and shrinking, and labeling. Second, the area is enlarged one pixel by one pixel referring to the binarized version of the original image.

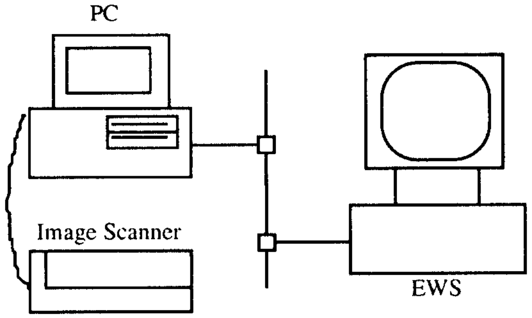


Fig.1 Employed hardware system

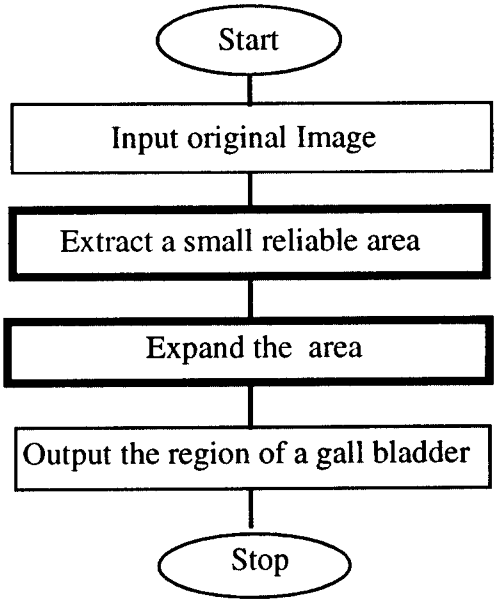


Fig.2 Flow chart of a gall bladder extraction

3. EXTRACTION METHOD

3.1 Pre-processing

In general, ultrasound image processing is difficult because the image is very noisy and especially there is speckle noise in the low contrast part[2]. In order to avoid noise influence, the proposed method contains smoothing by selective local averaging and binarization. By modified dynamic threshold selection which includes two subsidiary parameters k_1 and k_2, as shown in Eq(1), the speckle noise can be eliminated.

$$y_{ij}=\begin{cases}255 & x_{ij}>k_1 \quad or \quad x_{ij}\geq a_{ij}\\ 0 & x_{ij}<k_2 \quad or \quad x_{ij}<a_{ij}\end{cases} \qquad (1)$$

$$a_{ij}=\frac{1}{n}\left(\sum_{i=1}^{n}X_i\right)$$

Here y_{ij} is an output gray value, a_{ij} is a mean gray value in a specified area and x_{ij} is a gray value of a pixel concerned.

3.2 Extraction of a gall bladder area

3.2.1 Extraction of a small reliable area

As the first stage, a given ultrasound image is applied expansion and shrinking and resultant closed areas are assigned labels. Among them, the largest area is extracted as a reliable area of a gall bladder.

3.2.2 Extraction of a gall bladder area by expantion.

A reliable region which is considered as part of a gall bladder is extracted as the result of the former labeling procedure. Since this region is usually smaller than the original gall bladder, its boundary needs be expanded in some way.

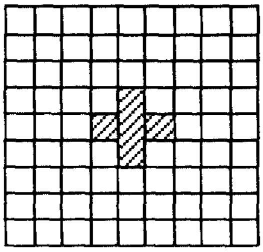
In the following algorithm, we consider this problem and propose an expansion method of the small reliable area.

In **Fig.3**,(a) is input image 1 containing the reliable area (the result of expansion and shrinking process), and (b) is input image 2 (the result of binarization process). We assume that K is a pixel outside of the gall bladder region.

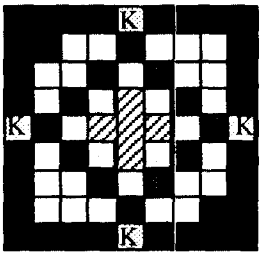
In general, shape of the gall bladder is like a balloon and it does not expand in only a single direction. We stack input image 1 on top of input image 2 and inflate input image 1. This procedure is iterated until the shape of a gall bladder appears on the input image 1. Here small pushed out areas such as four K pixels in **Fig.3**(b) should be excluded from the gall bladder area. The whole expansion algorithm is given in the following:

Expansion Algorithm

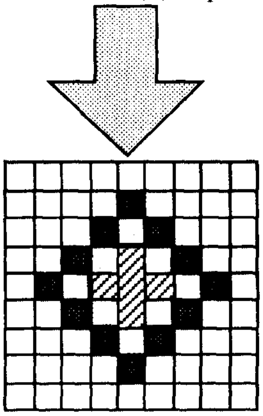
Step 1: Set the top left of the given image as a starting point of scanning, and set to zero the access counter and the success counter.



(a) Input image 1



(b) Input image 2



(c) Output image

Fig.3 Expansion Method

Step 2: Scan input image 1 and find a black pixel. If the procedure reach the bottom right of the image, go to step 7.

Step 3: If the black pixel has at least one white pixel within its four connected adjacent neighbors, then set the white pixel as a reference point and increase the access counter.

Step 4: Stack the reference point on the input image 2.

Step 5: If the corresponding pixel on the input image 2 is black, then the reference point is blacked. When the number of renewed reference point is more than one pixel, we assume that this procedure was success and increase the success counter.

Step 6: Set the image obtained from step 5 as input image 1. Go to step 2.

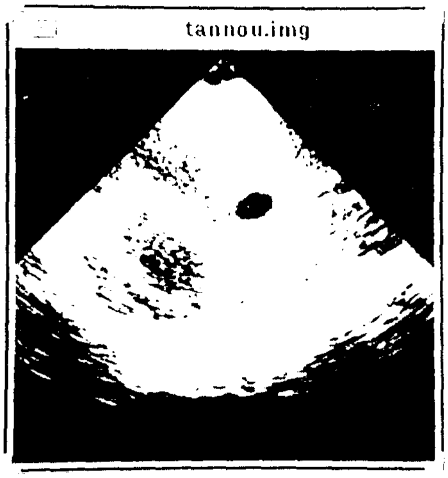
Step 7: If the ratio of the number in the success counter to the number in the access counter is less than a certain threshold value, the blacked pixels are renewed to white pixels and finish this procedure.

Step 8: Go to step 1.

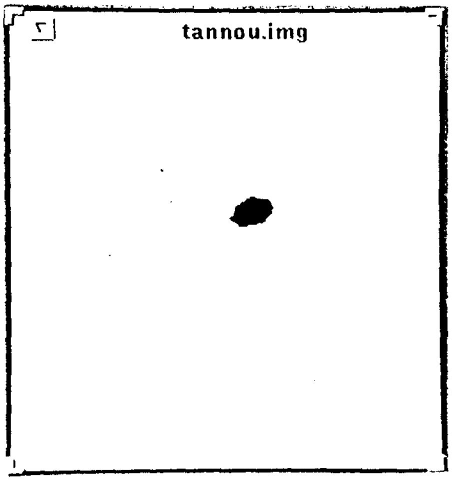
Step 7 contributes to excluding those areas/pixels like Ks in input image 2 from the expected area.

4. EXPERIMENTAL RESULTS

The proposed technique was applied to real ultrasound images of gall bladders provided by photographic films.The films are scanned by an image scanner and fed into an EWS through a personal computer, and finally converted into 256 by 256 digital images with 256 gray levels. The programs are written in C language. The average processing time is about 21 seconds.

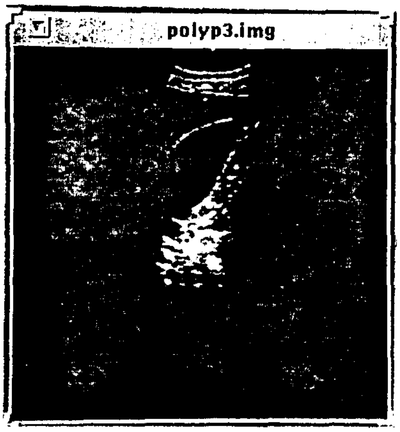


(a) Original image

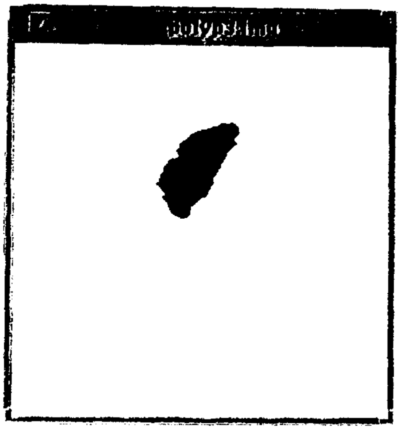


(b) Obtained gall bladder area

Fig.4 Experimental result 1



(a) Original Image



(b) Obtained gall bladder area

Fig.5 Experimental result 2

Two of the experimental results are given in **Figs.4** and **5**. Original ultrasound images and the obtained gall bladder areas are depicted there. The gall bladder of **Fig.4**(b) seems to have no medical problems, while a polyp is observed in the gall bladder of **Fig.5**(b). This was also confirmed medically.

5. DISCUSSION

The proposed method was applied to 12 ultrasound images of normal/abnormal gall bladders and satisfactory results were obtained. With respect to five abnormal cases, even small polyps were clearly extracted. However, at the moment, the employed images are rather those with good quality in the sense that the contours of gall bladders are almost visible, although they often contain discontinuous contour parts which yield small pushed out areas as illustrated in **Fig.3**(b). Applicability of the method to those images with low quality depends on the ratio defined in Step7 of Expansion Algorithm. This issue needs be further investigated. The employment of SNAKES[3] may be another way of extracting a gall bladder contour from its ultrasound image. This method necessitates specifying an initial position and, moreover, computation is enormous, both of which are overcomed by the proposed method. As for performance, however comparison remains to be done between the two methods.

6. CONCLUSION

This paper proposed a method of extracting a gall bladder from its ultrasound image. Basic image preprocessing techniques and an expansion technique of a reliable small area of a gall bladder were employed for the extraction. The method was examined by real medical ultrasound images and satisfatory results were obtained. Application of this method to those ultrasound images with lower quality needs to be investigated. Comparison with SNAKES technique also remains for further study.

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