Ultrasound Liver Image Enhancement Using Watershed Segmentation Method

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ABSTRACT
This paper proposed the ultrasound liver image enhancement based on watershed segmentation method. Image segmentation is an important problem in medical image processing fields. The focus of this study is to enhance the region of liver based on watershed algorithm of segmentation and visualization technique. The MATLAB is used as a tool for this study. The watershed segmentation entirely relay presented the good result base on the contrast of the image. In this study, an ultrasound image is transformed into a binary image using the threshold method, which means that the color of the output image appears only black and white. After the image is converted into binary, the image is modified using Watershed technique together with the visualization process. The result is really helpful in medical diagnostics.

Keywords **-** *Ultrasound liver image, image processing, watershed algorithm, image segmentation and visualization.*

I. INTRODUCTION
Nowadays, ultrasound imaging is an important diagnosis method in a medical analysis. It is important to segment out the cavities, different types of tissues and organs in the ultrasound image for effective and correct diagnosis. In the medical field, the human experts are very good in segmenting out the required region of the medical image. But humans lack efficiency when size of data set increases. The need of high reproducibility and need of increasing efficiency motivates the development of computer-assisted and automated segmentation. These automated procedures segment out different regions in medical images by applying different types of image segmentation methods. The main disadvantage of ultrasound images is the poor quality of images, which are also affected by speckle noise. Therefore, in general, many of the image segmentation methods may not be suitable in case of ultrasound images [2].

Image segmentation is a process to partition an image into non-overlap regions, which is an important step in the image processing area and is fundamental to the analysis and identification in image processing. Image segmentation is an important process for most of the medical image analysis tasks, which is basic for higher-level image comprehension and analysis. A good segmentation will benefit clinicians and patients as it provides important information for surgical planning, early disease detection and 3D visualization [1, 4].

In order to solve the problems of medical image segmentation, many practical methods have been advanced in this field. These include watershed segmentation, thresholding method, region-growing method, fuzzy cluster method and so on. The watershed algorithm is a classical and an effective segmentation method by which one-pixel-wide continuous edge can be extracted. The most effective methods in complex segmentation problems are watershed segmentation. The segmented region is obtained when the algorithm uses watershed transform applied to the image. However, segmentation of noisy ultrasound image using watershed transform always leads to over-segmentation [3]. There are many applications whether on synthesis of the objects or computer graphic images require precise segmentation. In general, image noise should be eliminated through image pre-processing [5, 6].

The overall objective of this study is to understand the concept of image processing in medical image analysis. A liver image is scanned by using a medical ultrasound. By using this image, this study involves improving the contrast of image by using histogram equalization techniques, converting the gray scale image to binary image by using thresholding, segmenting the image by using watershed algorithm and transforming the liver region to the color image in visualization technique.

II. LITERATURE REVIEW
An effective and correct diagnosis of ultrasound image is very important to avoid faulty in segmenting out cavities, tissues and organs which can lead to other problems in treating the patient. Thus, automated segmentation is a must to help clinicians and doctors make the diagnosis as the ultrasound images come out with poor quality of images due to the relatively low resolution and reduced contrast of the images. Some segmentation methods have been proven to be effective in handling the mentioned problem, such as Active Contour Model, Fuzzy C Means (FCM) and Graph-based method [3].
Fei Mao et. al. [5], describe a segmentation algorithm based on a discrete dynamic model approach with only one seed point to guide the initialization of the deformable model for each lumen cross-section. The initial contour of the deformable model is generated by using the entropy map of the original image and mathematical morphology operations with one seed. Meanwhile, the definition of the deformable model is the driven to fit the lumen contour by an internal force and an external force that are calculated respectively

with geometrical properties of deformed contour and with the image gray level features. To get to the result, seven images of the common, internal and external carotid arteries were chosen to test the segmentation algorithm. In their approach, they used an initial contour model and external and internal forces to deform the model, allows them to incorporate minimum user interactions, contextual information, and various image features. Although interactive mechanisms provide users with the control over the segmentation algorithm and the final result, they also introduce the potential for errors and variability. This requires an evaluation technique to estimate both the variability and accuracy of the interactive segmentation algorithm for the optimization during the algorithm development process and the final performance assessment.

Amr R. Abdel-Dayem et. al. [7], introduce a novel segmentation scheme for carotid artery ultrasound images. The proposed scheme is based on watershed segmentation algorithm. It consists of four major stages. These stages can be divided into preprocessing, watershed segmentation, region merging and finally boundary extraction. The proposed scheme also is tested using a set of carotid artery ultrasound images. Finally, the experimental results show that the proposed scheme can produce accurate and appropriate contours.

Vincent et. al., in [8], proposed the immersion simulation algorithm for watershed line calculation. Initially, the image gradient is calculated using the Sobel operator [9]. In the immersion simulation algorithm, the image is viewed as a surface and the gradient local minimum of each region as a hole from which the water will rise up.

Furthermore, the watershed segmentation defined in [6] is a morphological based method of image segmentation. The gradient magnitude of an image is considered as a topographic surface for the watershed transformation. Watershed lines can be found by different ways. The complete division of the image through watershed transformation relies mostly on a good estimation of image gradients.

III. METHODOLOGY

An experiment using MATLAB software has been performed using an ultrasound lower abdomen image scanned from a female sample. A lower abdomen ultrasound image gained from the ultrasound machine tested in the Biomedical Engineering Laboratory, Universiti Teknologi Malaysia, Johor, Malaysia has been processed for further liver watershed-based segmentation process.

Segmentation of an ultrasound image is one of the most difficult image processing operations because the ultrasound image contains strong speckle noise and attenuated artifacts. The watershed transform is often applied to this problem.

The procedure took for watershed segmentation is described details as follows:

A. Step 1: Convert image to grayscale and enhance the image contrast.

The original ultrasound image which is in RGB format was converted to grayscale because it needs further enhancement in its contrast and it is sufficient in grayscale image format.

B. Step 2: Use the Gradient Magnitude as the Segmentation Function.

The gradient magnitude is computed by applying the Sobel edge masks, filtering coefficients, and additional arithmetic. At the borders of the objects, the gradient is high but is low (mostly) inside the objects.

C. Step 3: Marking the Foreground Objects.

Foreground objects are marked due to the "oversegmentation" problem when watershed transform is applied directly to the image. Therefore, it is important to apply Morphological techniques called "opening-by-reconstruction" and "closing-by-reconstruction" to "clean" up the image so that the object can become flat after undergo these steps. Opening is a process involving erosion followed by dilation, while opening-by-reconstruction involves with erosion followed by a morphological reconstruction. The opening with a closing can remove the dark spots and stem marks. Therefore, a regular morphological closing and a closing-by-reconstruction are performed. The results of computing the regular and irregular morphological are discussed in section result and discussion.

D. Step 4: Compute Background Markers.

These are pixels that do not belong to any object. Thresholding operation is done to clean-up the image.

E. Step 5: Modify the Segmentation Function.

The segmentation function has to be modified so that it only has minimum at the foreground and background marker locations in order to avoid having background markers too close to the edges of the objects to be segmented. The background is thinned by computing the watershed functions.

F. Step 6: Compute the Watershed Transform of the Segmentation Function.

The function *"imimposemin"* is used to modify the gradient magnitude image so that only regional minima occur at foreground and background marker pixels. Finally watershed-based segmentation is computed.

G. Step 7: Visualize the Result.

One of the methods used to visualize the image after segmentation is to superimpose the foreground markers, background markers, and segmented object boundaries on the original image. Another method is by using transparency to superimpose this pseudo-color label matrix on top of the original intensity image.

IV. RESULTS AND DISCUSIONS

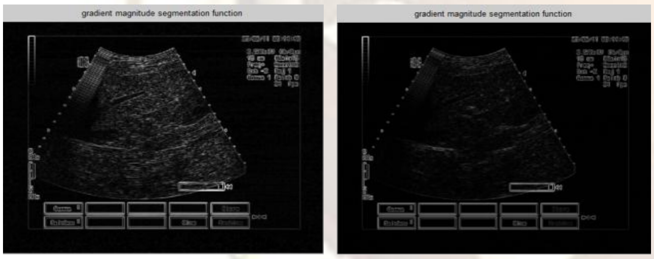
In this section, we present full results based on the step taken in methodology.

Figure 1 and Figure 2 shows the results of the original image after converting the RGB image into grayscale and enhancing the contrast of the image. This process is important as a starting point for further image analysis.

Fig. 1: Grayscale ultrasound image after been converted from RGB image.

Fig. 2: Grayscale ultrasound image after been applied contrast enhancement using "*adapthisteq"*.

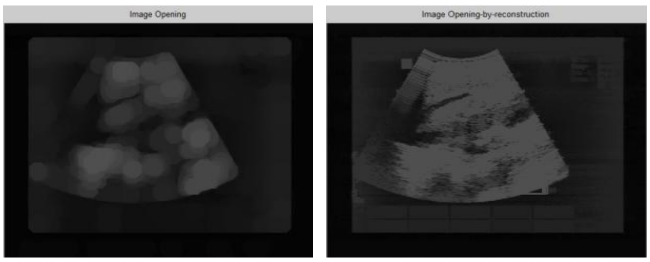
Figure 3(a) demonstrates a clearer image compared to image in Figure 3(b). This is due to adaptive histogram equalization applied to the grayscale ultrasound image. A clearer ultrasound image will be helpful in watershed segmentation as it will avoid over segmentation. Therefore, Figure 3(a) is chosen to be used in marking the foreground and background objects.



(a) (b)

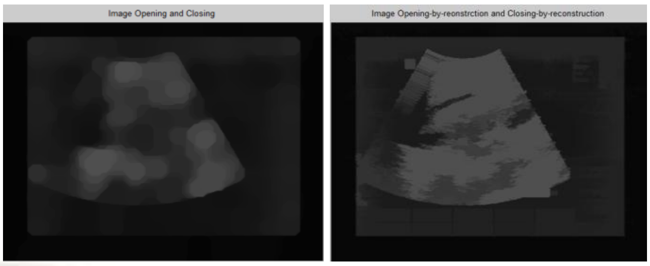
Fig. 3: Image whose dark regions are the objects to be segmented. (a) Image affected from contrast enhancement. (b) Image without applying contrast enhancement.

Next result is marking the foreground objects. This involves two functions *"imopen"* and *"imclose"* as an image opening as well as image closing. Figure 4(a) and 4(b) show the differences between image opening and image opening by reconstruction. After this process, the image is enhanced by using the closing by reconstruction for detail enhancement.



(a) (b)

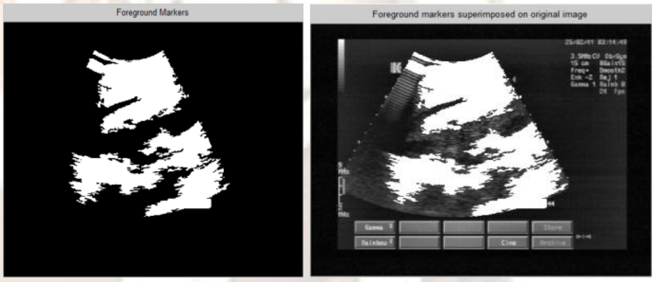
Fig. 4: (a) Image opening using function *"imopen"*. (b) Opening-by-reconstruction using function "*imerode"* and "*imreconstruct"*.



(a) (b)

Fig. 5: (a) Closing Image using function "*imclose"*. (b) Closing-by-reconstruction image using function "*imdilate"* followed by "*imreconstruct"*.

Comparing Figure 4 and Figure 5, reconstruction-based opening and closing are far more effective than standard opening and closing at removing small blemishes without affecting the overall shapes of the objects. By superimposing the original image with the image of foreground markers in Figure 6(a), it can be seen that some of the most-blocked and shadowed objects are not marked as shown in Figure 6(b). These unmarked objects show that they will not be segmented properly at the end of result. Also, the foreground markers in some objects go right up to the object's edge.



(a) (b)

Fig. 6: (a) Image of foreground markers. (b) Image of foreground markers superimposed on original image.

To have better results, the edges of the marker blobs of image are cleaned and shrank as shown in Figure 7.

Fig. 7: Advance foreground marked after applying "*bwareaopen"* function.

It is shown that the stray isolated pixels have been removed after applying the *"bwareaopen"* function. It removes all blobs that have less than a certain number of pixels. Next, the watershed transform is applied as a function of segmentation process. Figure 8 shows the markers and object boundaries that have been superimposed on the original image.

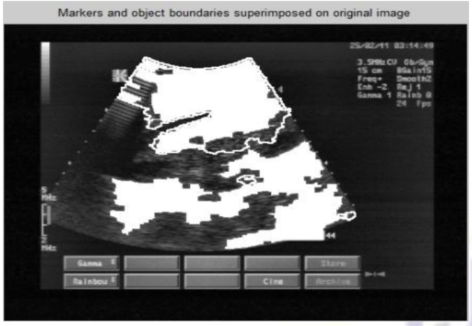


Fig. 8: Image of markers and object boundaries of superimposed on the original ultrasound image.

It can be clearly seen that the liver in the ultrasound image is almost been segmented properly. Figure 9 shows the yellow color been applied to the segmented region as in Figure 8 while Figure 10 shows the other way to visualize the segmented liver part on the original ultrasound image for better views.

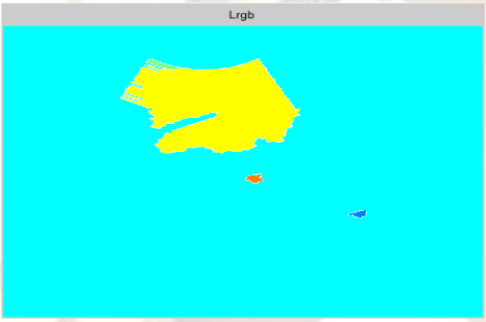


Fig. 9: Image of watershed-based segmentation of a liver (referring to the yellow shading).

Fig. 10: Final watershed-based segmented image after superimposed transparently on the original images.

V. CONCLUSION

Image segmentation system is a fundamental and is the most important step before any image processing method can be proceeded. An ultrasound liver image has low in contrast. Step like contrast enhancement seems necessary to make the image clearer before applying the watershed segmentation. After pre-processing step, the gradient of the image is found by converting the input image to grey scale. This gradient of image is used as the input image. The results of experiments show that the algorithm has a certain degree of adaptability and accuracy. The result also has provided a basis for visualization of the liver area in color transformation. In the thresholding process, it still has lacked a certain degree of accuracy and cannot obtain precise partition out of the liver region. Therefore, the eliminating the coupling between the image areas and extracting liver region accuracy are still the issue of study in the future. Future work should focus on the color transformation from grayscale to RGB color for medical image region of the ultrasound image such as liver, stomach and others possibly could be applied to enhance the ultrasound image.

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