

A User Friendly Guide for Spleen Ultrasound Image Enhancement

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Abstract: -

Spleen ultrasound screening was rarely used because usually people will scan their body thoroughly using CT scan or x-ray to observe any abnormalities. However, it is a fact that ultrasound machine is far safer than any other imaging modalities, and it can be used to scan any parts of the body except for hard tissue such as bone. In this paper, we proposed an approach to obtain spleen ultrasound image and perform image quality enhancement so that the image of spleen is clearer and easier to analyze. The used method is Region of Interest based image filtering using a MATLAB. The Graphical User Interface (GUI) of the work is also created to have user friendly analysis. This approach is really suitable for new learners to learn one of the biomedical image processing techniques. From the results, it shows that this method can enhance the image quality especially at the region of interest specified.

Keywords: - Spleen Ultrasound, Image Enhancement, MATLAB, Region of Interest, GUI

1 Introduction

Ultrasound is one of the diagnostic equipments to diagnose human internal organs, tendons, to capture their size and structure. Ultrasound is usually used for pregnancy, as the images for others' internal organs that are not very clear. Typically, the image of ultrasound is depending on the operator view. Hence, the purpose of this work is to help operator view to get a clear image of ultrasound and could be use not only for viewing the fetus in mother's womb but to view other soft organs or abnormalities in the human body. Since ultrasound is the safest imaging modalities compared to other image modalities, so it would be very safe to diagnose patient. This work will focus on spleen as a subject or soft tissue that taken from human via ultrasound. One of the problems of spleen ultrasound image is how to get a clear view of spleen since a normal size spleen is hard to be seen in the ultrasound image. It is good to examine with the patient rolled onto the right side at a 45-90° angle and in the left-side-up decubitus position. Region of Interest (ROI) mask, ROI Filter, Histogram Equalization and Active contour techniques from MATLAB is used to get a clearer spleen image.

2 Literature Review

The spleen is a soft, blood-rich organ that filters blood and the largest lymphoid organ in the body and interposed within the circulatory system. The spleen lies in left hypochondrium behind the stomach, above the left colic flexure and to the side (laterally) of the left kidney. It lies underneath the diaphragm, in front and to the side of the left 9th to 11th, sometimes 12th ribs. The size of spleen is about the size of a cupped hand. The length is approximately 10 cm, the width is approximately 5 cm and the spleen is about 3-4 cm thick. The weight of the spleen may vary between 150 to 200 grams (5 to 7 ounces) [1].

Enlarged Spleen (splenomegaly) is one of the spleen diseases. An enlarged spleen can be caused by infections, cirrhosis and other liver diseases, blood diseases characterized by abnormal blood cells, problems with the lymph system, or other conditions. It may be caused by Viral infections, such as mononucleosis, parasitic infections, such as toxoplasmosis, bacterial infections, such as endocarditis (an infection of heart's valves), Leukemia, Lymphoma (a cancer of lymph tissue, such as Hodgkin's disease), sickle-cell anemia, sarcoidosis, malaria, bacterial andocarditis, pernicious anemia, leishmaniasis, Banti's disease, hereditary spherocytosis, glandular fever and tumors. Figure 1(a) and (b) are the comparison between mild splenomegaly with normal spleen [1].



(a)



(b)

Figure 1: (a) Normal Spleen. (b) Longitudinal view of the spleen shows mild splenomegal (length 13cm) due to infectious mononucleosis and a typical splenunculus at the hilum.

Usually, a normal sized spleen is hard to be seen in ultrasound image however it is best examined with the patient rolled onto the right side at a 45-90° angle, in the left-side-up decubitus position [2-3].

3 Material and Methods

There were several processes involved in this work. Generally, Figure 2 describes the flow of methodology, from obtaining the image until the image being processed. First, few spleen images were taken from human body using ultrasound. The most suitable image was then selected as an image subject. After the image was obtained, the image is processed and enhanced using a MATLAB software. A few processes involved, which were loading the image, creating the mask in a spleen shape to be used for filtering, a few techniques of filtering, histogram equalization, and also an enhancement technique using active contour. One of the functions which is the localized segmentation is modified from [8].

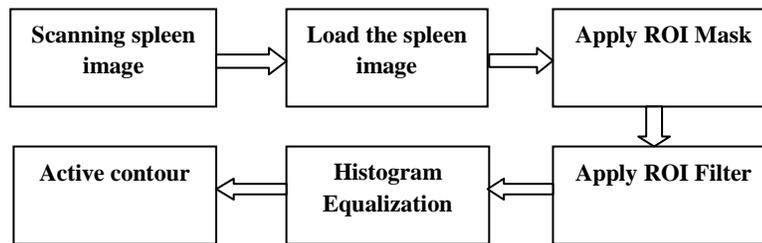


Figure 2: Flow chart of the methodology.

There are a lot of standard operation procedures for using ultrasound machine. Firstly, operator must decide the most suitable probe to use and to plug into the ultrasound machine. Normally, 3.5MHz or 5MHz probes frequency can be used to scan the spleen image. Current probes such as 7.5MHz probes provide adequate penetration of spleen. The most appropriate probe is sector or curvilinear probe as shown in Figure 3. Wide probe footprint allows accurate measurement thus useful in obtaining maximum length of spleen on the image. As a routine part of splenic assessment, color Doppler or amplitude imaging can be used to assess vascularity (appearance of veins through skin). The operator must sit or stand to sit comfortably in front of the machine so that you can reach the patient without bending sideways unnecessarily. After switching on the machine, operator must register for new patient data. Then, operator can start scanning for patient's spleen. Sufficient acoustic coupling gel must be used, especially on hairy patient to reduce the resistance between the probe and skin. The transducer must be held with the tips of right thumb and fingers. This is important as it allows the operator to roll the probe around its long axis. The transducer wire also must be arranged so that its weight does not drag on the hand holding the probe.



Figure 3: Curvilinear probe.

General approach to scan spleen is intercostals approach as the spleen is situated posteriorly and subcostally in the left upper quadrant. If the spleen was scanned via anterior approach, where the patient in a supine position, it will result in no visualization of spleen. This is because gas in the intervening stomach and splenic flexure will prevent sound transmission.

After the image has successfully obtained, a graphical user interface (GUI) was developed using MATLAB software. The purpose of this GUI is to provide user friendly environment for enhance the image quality so that the image can be analyzed easier. Next, selected image is load into Matlab for enhancement processes. Region of Interest (ROI) mask is applied to the image so that only the selected region is filtered using ROI filter. To enhance the contrast of the grayscale image, histogram equalization is applied to image using contrast-limited adaptive histogram equalization. Finally, an active contour technique is applied to outline the object or region of interest in the image. The example of MATLAB coding [9] for ROI mask, ROI filter, histogram equalization and active contour is shown in Table 1.

Table 1: Examples of MATLAB coding used in the program.

Process	Matlab Coding	Process	Matlab Coding
ROI mask	<pre>A=imread('mask2.jpg'); I = imresize(A,.5); figure, imshow(I), title('Fixed Mask Kidney');</pre>	Active Contour	<pre>image = getappdata(0,'MyImagePass'); image2 = rgb2gray(image); I = adapthisteq(image2); c = [140 325 160]; r = [70 75 300]; m = roipoly(image,c,r); I = imresize(I,.5); m = imresize(m,.5); (I, m, 80); axes(handles.axes2); imshow(imagepushbutton4);</pre>
ROI filter	<pre>BW = roipoly; I = imresize(BW,.5); figure, imshow(I); B = rgb2gray(image); h = fspecial('unsharp'); filteredimage = roifilt2(h,B,BW);</pre>		
Histogram Equalization	<pre>imagepushbutton2 = adapthisteq(filteredimage); imagepushbutton4 = adapthisteq(image2);</pre>		

The key point in this work is 'roipoly' and 'adapthisteq' because this function is not only enhance the contrast of the grayscale image which makes image clearer but it act as preparation of active contour so that the region of interest is easy to be selected. The function 'roipoly' also enable user to select region of interest themselves thus enhance the selected part of the image.



Figure 4: Spleen mask

Figure 4 shows the result of ROI Mask where the spleen mask is created. This process is necessary to select the region so that a portion in the shape could perform some other operations later. This mask is prepared beforehand, thus, when used for filtering this image is called using 'imread' function. The complete GUI system is shown in Figure 5.



Figure 5: GUI for the project using MATLAB.

After the desired region is masked, it is then being filtered using ROI Filter. Here, only the masked region (where the picture of spleen is covered by spleen mask) is filtered, and the rest is still in its original condition. Then the contrast of the image is adjusted using Histogram Equalization so that it becomes clearer and easier for active contour to select the region of interest. Finally, an active contour is applied to outline the object or region of interest in the image [4-8].

4 Result and Analysis

For both machines, images of spleen were obtained from different views and angles to find the best angle and position of the probe so that image obtained can fully and clearly show the spleen. Since all the subjects chosen have a normal spleen, thus, all spleen images that have been collected only consist of normal spleen image. After a GUI is developed, the program was tested on five different samples of spleen ultrasound image, which were obtained earlier using Kontron™ and Toshiba™ ultrasound machines. Table 2 shows the result obtained after using the filtering of ROI function.

Table 2: Results of GUI for 5 different images of spleen

Original Scanned Image	Results of Processed Image
	
	
	
	
	

This result obtained after loading the sample image and clicking the 'ROI Filter Freehand Mask' button. User must locate the ROI themselves after clicking the button by moving the pointer around the image of spleen so that the mask calculated will fit the spleen. After that, MATLAB function will enhance the selected ROI with 'unsharp' filter and perform histogram equalization to the image. The output image shows a clearer image than the original image scanned with the machine.

In GUI, there are also buttons for fixed mask. The advantage of this fixed mask function is that the image can be enhanced more than once, and the ROI of the image can be enhanced using various other functions such as Sobel filter and active contour function. However, using this function, only one image can be enhanced because the fixed mask created can only fit that particular image which is for single spleen image.

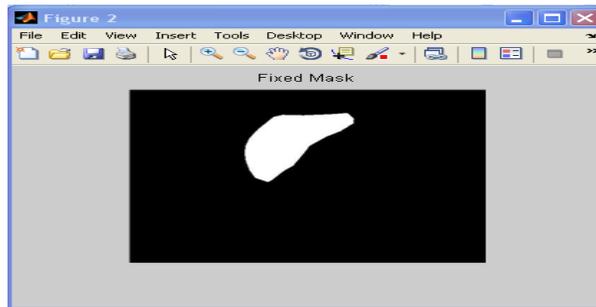


Figure 6: Fixed mask for the spleen

The fixed mask created as shown in the Figure 6 can only fit the image of spleen as in the Figure 7, thus, if this function is used for other images, the mask cannot overlap to the real position of spleen in that particular image. The ROI is enhanced at the fixed location. There is also a limitation to this function where the image and the mask must be in the same size. Otherwise, an error will occur and image processing cannot be continued.



Figure 7: Filtered image using Sobel filter.

There is also a function in the GUI which used a fixed mask as shown in Figure 8 for kidney so that the image of kidney will be blurred, thus, making the image of spleen look clearer. This function can be obtained by clicking 'ROI Filter Disk' button.

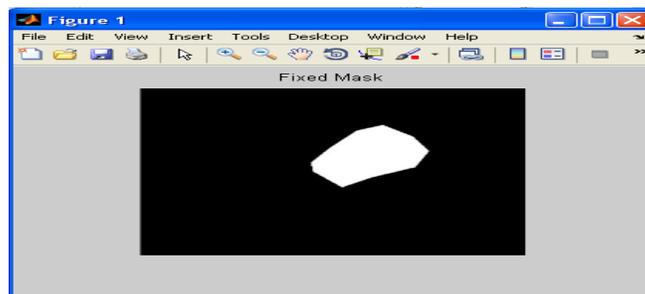


Figure 8: Fixed mask for Kidney.



Figure 9: Blurred image of Kidney.

The blurred image of kidney (Figure 9) is also used fixed mask of kidney, which also gives the same disadvantage. Only single spleen image can be used for this function. However, the filtered image shows a clear image of spleen when the image of kidney is blurred.

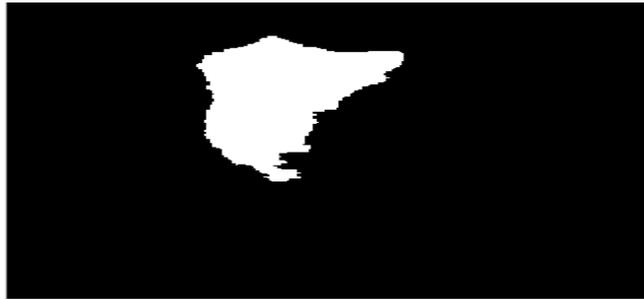


Figure 10: Final output of Active Contour function

Lastly, the other function of GUI created is an active contour function. For this function, the mask is also a fixed mask which is a predefined triangle. From the triangle mask, this function will find the region of interest automatically. The output of this function is in black and white form where black is the background while white is the region of interest as shown in Figure 10. Although the output cannot precisely locate the boundary of the spleen, we can see the output image obtained have similarities in the shape of a real spleen. This problem may be caused due to limited mask, and the number of iteration performed in the image. Further research is required to achieve a better mask that can automatically find the region of interest regardless the position of spleen in the image.

5 Conclusion

The ultrasound image of spleen has been successfully obtained using the allocated machine. The image was processed using MATLAB software to obtain a higher-quality image of spleen. GUI that has been created using MATLAB makes the image enhancement more users friendly and easier to analyze. Although the study is only focused on developing the user friendly interface, it is hope that new learners in biomedical image processing will learn and appreciate a simple tool to enhance the medical ultrasound image effectively.

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