

## Development of Cyst Detection System for Liver Ultrasound Images

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**Abstract:** Cystic liver diseases are relatively common and most identified incidentally on routine imaging. Ultrasound is used to detect liver cysts. Speckle artifact affects ultrasound images. Low-quality ultrasound images make diagnosing the cyst difficult. This paper proposes using ultrasound images and image processing to detect simple hepatic cysts. Current image segmentation techniques were evaluated to determine the best method for segmenting ultrasound images of simple hepatic cysts. This paper develops the system using MATLAB in which the GUI detects cysts. This graphical user interface (GUI) lets users select liver images from a database and check for cysts. The user can use the GUI segmentation method to detect the cyst's area in the pixel unit. The system was evaluated by measuring the area of detected liver cyst images and comparing them to the gold standard, manual segmentation. In boundary segmentation, the cyst was detected with 80% accuracy, in active contour with 100%, and in the watershed with 70%. This system can identify liver cyst ultrasound samples with 84% accuracy. Radiologists can use this system to analyse ultrasound images and detect cysts.

**Keywords:** Liver Cyst, Image Processing, Graphical User Interface (GUI)

### 1. Introduction

Liver cysts occur in approximately 5% of the population. In general, cysts are thin-walled structures that contain fluid [1]. Cystic liver diseases are relatively common conditions and most identified incidentally on routine imaging. However, in rare cases, they can be complicated and life-threatening [2]. Ultrasound remains the imaging modality of choice for investigating suspected liver cysts. Moreover, ultrasound scanning will reveal a calcified, spherical lesion with multiple septations [2]. Ultrasound is usually the first imaging modality in evaluating liver disease because it is easy to perform, widely available, relatively inexpensive, and cost-effective [3]. Image processing is the process of converting an image into a digital format and performing operations to obtain a better image or extract useful information. The main problem is that the low quality of ultrasound images makes it difficult to analyse and diagnose the cyst. Using several image processing techniques, the effectiveness of current image segmentation techniques will be assessed to determine the method best suited for medical image

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segmentation. The objectives of this paper are to analyse several image processing techniques for the detection of liver simple hepatic cysts Next, to develop a system for detecting the liver's simple hepatic cyst using ultrasound images. Finally, to assess the performance evaluation of the developed system by calculating the average area of the cyst to choose the best segmentation technique. The scope has been established to ensure that the study is done within and toward the objectives which the liver simple hepatic cyst images are taken from the website of [ultrasoundcases.info](http://ultrasoundcases.info) as the image source for the GUI system. Next, the GUI will be developed using MATLAB software to detect the presence of a simple hepatic cyst in a patient's liver. Furthermore, the performance of the liver cyst detection will be compared to manual segmentation. Last but not least, is to apply the image processing techniques used as image cropping, image enhancement, image binarization and image segmentation to detect the cyst by using ultrasound images

The liver is an essential organ that performs crucial processes such as hormone and drug detoxification, blood filtering for waste items, and protein manufacturing for blood coagulation. However, illnesses can strike without warning, and early identification can minimise cysts and is important to successful treatment [4]. The radiologist must carefully assess such imaging features, the nature of the cyst or cysts, and evaluate cyst complexity and associated findings [5].

There are various imaging modalities such as Computed Tomography (CT) scan, Ultrasound, and Magnetic Resonance Imaging (MRI) used to diagnose liver lesions [4]. Imaging findings are unique to each cyst type and can be used to differentiate simple and complex liver cysts. The finding may differ by imaging modality, with specific modalities more suited to visualised selected features. For instance, calcification is not seen on MRI but is well characterised on CT – scans and can be seen on ultrasound [6].

In a previous study written by L. Ali, et. Al about image pre-processing in MATLAB, in the image pre-processing step, they used two techniques: Image Normalisation and Image Enhancement. It also maps out each region based on the updated histogram values. Finally, it uses grey-level mapping to rebuild the final CLAHE image, which will be our improved image suitable for regions of interest (ROI) segmentation [7].

In boundary-based techniques, segmentation starts at a seed point, and the region grows to depend on the intensity value of the neighbouring pixels. The main disadvantage of region-growing-based techniques is the difficulties of selecting seed points. Manual selection of the seed point depends on the person's ability, and it might lead to erroneous results. Region growing techniques work best when the intensities of the object to be detected are uniform and different from the background. This method is more immune to noise but is less time efficient. It is a method for extracting a section of an image that is related based on predetermined criteria in region-based segmentation. The criterion might be based on picture intensity or an image edge [8].

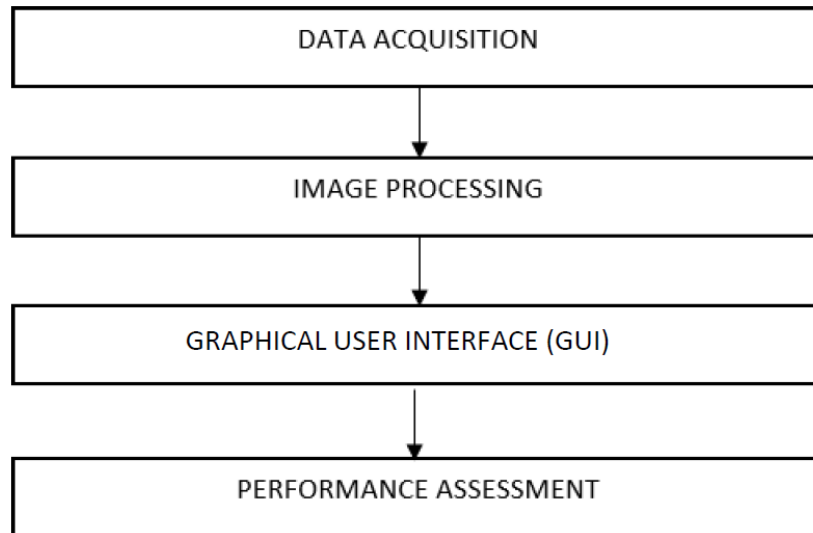
Active contour is a type of segmentation technique which can be defined as the use of energy forces and constraints for the segregation of the pixels of interest from the image for further processing and analysis. Active contour is described as an active model for the process of segmentation.

Watershed segmentation is a robust and quick approach for contour detection and region-based segmentation. Watershed segmentation, in theory, relies on ridges to accomplish appropriate segmentation, a condition that is often satisfied in contour detection, where the borders of the objects are depicted as ridges [9].

In this study, the advantage of choosing these three segmentations because for the boundary based the concept is simple in that the multiple stops of criteria can be chosen. As for active contour, it is robust, and self-adapting in search of a minimal energy state. Finally, the watershed ensures closed the region's boundaries.

## 2. Materials and Methods

A description was made of the method used to perform several image processing techniques using MATLAB software. The process of liver cyst detection uses several image processing methods, as described in detail using the flow chart illustration as shown in Figure 1.



**Figure 1: Block diagram for the proposed system**

### 2.1 Software Development

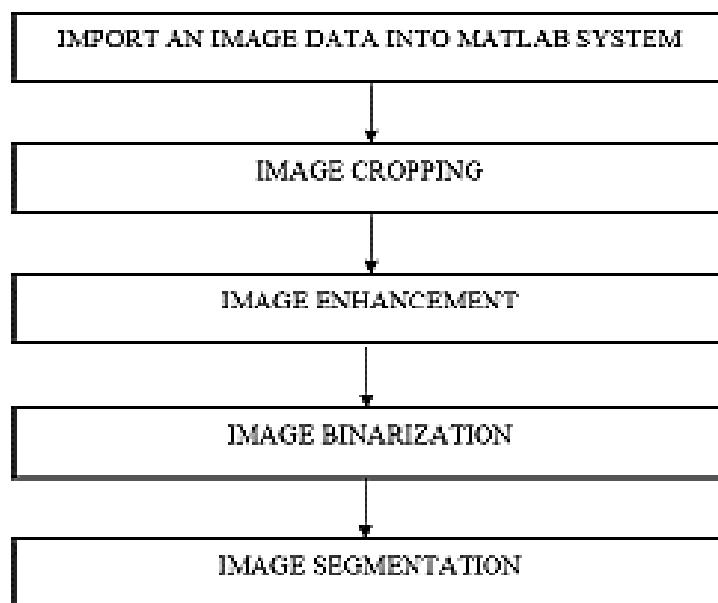
MATLAB software was used in this study. This software includes numerous functional toolboxes, such as Image Processing, which is the primary goal of this study. After conducting an extensive study on current image processing study similar to this topic, the software used in this study was chosen. MATLAB Software is software that offers numerous capabilities that aid in design, programming, project modelling, building an application, and many other aspects that were employed for this study.

### 2.2 Data Acquisition

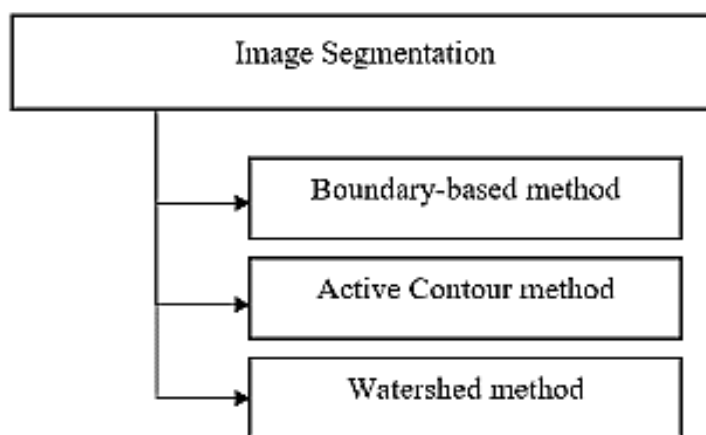
The data serve as the bases or raw material for analysis. No specific inferences can be drawn from the questions under study without analysing factual data. As for this study, the [ultrasoundcase.info](http://ultrasoundcase.info) website has been used; it contains feature images of ultrasound cysts inside the liver. Ultrasound images are generally in grayscale. On these websites, the data collection included ten images the type of the cyst is a simple hepatic cyst.

### 2.3 Image Processing

The process started by taking a sample image of the liver cyst. The sample image is then uploaded into the Guided User Interface (GUI) system in MATLAB for the system to load the image. The step for image processing is listed in Figure 2 for a clearer view of the technique used to extract an image. The system will be pre-processing the image on resizing, which is to crop to provide an accurate image for the next steps. The image enhancement process enhances the image and removes unwanted noise. Next, the segmentation process using a different algorithm as shown in Figure 3 will segment the cyst from the image. Once the system detects the liver cyst, it will display the output.



**Figure 2: Block diagram of the image processing**



**Figure 3: Types of methods of segmentation**

In Figure 3 as types of methods of segmentation that is used for this study is boundary-based segmentation, this segmentation the detected cyst on a liver image. Because the liver images are all in RGB colour, the image was segmented using a boundary-based to detect more easily. The boundary of an image is a contour, as opposed to an image edge which is typically defined as an abrupt variation in low-level image characteristics such as brightness in colour. The latter denotes a shift in pixel ownership from one surface to another. Furthermore, active contour segmentation will also detect the cyst. An active contour is a form of segmentation method that may be described as applying energy forces and restrictions to segregate the pixels of interest from the picture for further processing and analysis. Active contour is a type of image segmentation approach. Additionally, this method begins with extracting a specific background and foreground for watershed segmentation. It then uses markers to run the algorithm and determine the precise boundaries. This technique typically assists in recognising touching and overlapping items in images. This method determined the precise range of values for the cyst area in pixel. It evaluated the best technique by checking the accurate result of the cyst area that these three segmentation techniques have segmented.

## 2.4 Graphical User Interface (GUI)

For the output in this study, the Graphical User Interface (GUI) will allow the user to design a layout for their system. Widgets in MATLAB's graphical user interface (GUI) programmes include the likes of graphs, switch buttons, and other functions that may visually present output to the user. You may access this feature in the MATLAB programme by typing the command "guide" into the command window and selecting the GUI feature from the available options in the windows.

## 2.5 Performance of Evaluation System

To confirm the system's efficiency, performance was evaluated utilising the best technique segmentation by measuring the area of detected liver cyst images and comparing the values with the manual segmentation (ground truth). The performance test interface uses the script, function, and class-based unit testing interfaces. As a result, while evaluating code performance, tests may be run within the performance tests to ensure proper functional behaviour.

In the calculation of the system accuracy, it is defined in image processing as the percentage of error between the manual segmentation and the segmentation that has been made in the GUI system. The mathematical equation for error percentage is calculated as shown in Equation 1.





$$\text{error \%} = \frac{\text{segmentation} - \text{manual segmentation}}{\text{manual segmentation}} \times 100$$

## 3. Results and Discussion

The system of detecting liver cysts uses several image processing in Graphical User Interface (GUI) for each function. This study focuses on the image processing techniques in which each method's result will be shown to detect the cyst.

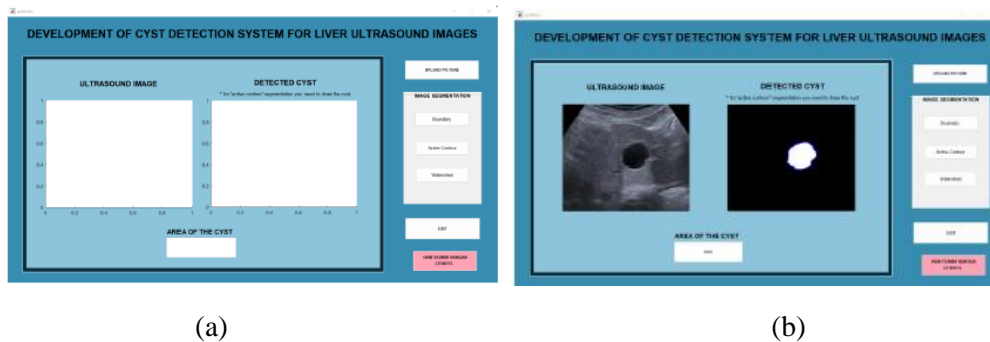
### 3.1 Results

The system's basic operation began with cropping and picture enhancement to make it less noisy than the ultrasound image and provide a clearer perspective of locating the cyst. The image sample is then binarized, converting the picture to black and white to provide a sharper view of the cyst in the ultrasound image. The purpose of region props is to detect the cyst for border segmentation. This method will automatically discover the cyst. Furthermore, using the enhancement method, the ultrasound sample image of the ultrasound image will go through the basic operation of image cropping and image filtering. Image binarization will be used to provide a more exact cyst image. In this study, the active-contour segmentation will require the user to draw on the cyst to detect the cyst since it uses an interactive mask to detect the cyst. The cyst will be detected manually by users in this method. Therefore, the basic operation of the watershed segmentation technique is the same as that of the previous boundary and active contour approaches. Furthermore, because it treats the surface where bright pixels are high and dark pixels are low, this approach is inaccurate in identifying cysts as shown in Figure 4.

No	Segment methods	Input images	Result that obtained
1	Boundary		
2	Active-Contour		
3	Watershed		

**Figure 4: Image segmentation on several methods**

In Figure 5 it is the results obtained in GUI formed. those are the result obtained from GUI when the images are uploaded and detect the cyst. The user will then press the button segmentation and choose the method available in GUI for them to test out for detecting the cyst and get to know the area of the cyst.



**Figure 5: (a) GUI development system. (b) Results obtained in GUI**

### 3.2 Discussions

As for the performance evaluation, this study will evaluate the best segmentation technique. The data average was observed using the cyst area on each ultrasound liver cyst sample image. The area of the cyst is intensity image in pixels. Table 1 shows the results of the cyst area in the pixel unit of the sample images.

**Table 1: Cyst area in pixel unit of samples images detected by the system**

Item	Boundary Method	Error %	Active-Contour Method	Error %	Watershed Method	Error %	Manual segmentation
1	1899	0.48	1889	-0.05	1720	-9	1890
2	2813	7.20	2592	-1.21	2910	10.9	2624
3	2609	0.46	2597	0	2154	-17	2597
4	2741	0.18	2732	-0.14	3202	17	2736
5	2447	1.95	291	-4.54	2004	-16	2400
6	2963	0.06	2961	0	2449	-17.3	2961

7	2756	0	2750	-0.22	2655	-3.66	2756
8	2911	6.28	2800	2.23	2701	-1.39	2739
9	2601	0.81	2574	-0.23	2881	11.67	2580
10	2847	-0.03	2842	-0.21	3210	12.71	2848

The cyst area's value for the methods and the value for manual segmentation. Based on the assessment of which segmentation technique is closest to the value of the manual segmentation method according to the percentage of the error which is 1.111% for the boundary segmentation method, -0.437% for the active-contour segmentation method, and -1.207% for the watershed method, the least error percentage method is the best segmentation approach for this study which is active-contour segmentation method. Because the current method uses the manual click design for this system to help the doctors, moreover, this system will help the doctors to give them a second option in detecting the images and analysing more of the image. Therefore, selecting the method closest to manual segmentation requires a segmentation outcome comparable to that of an expert in manual segmentation.

Table 2 shows that a total of 8 in the boundary segmentation method were detected clearly for the cyst, which gives the detection 80% accuracy. As for the active-contour method, the sample image detected 10, bringing the system accuracy to 100%. Finally, the watershed method detects 7 of the images, giving 70% of the system accuracy. It indicates that this system is able to identify the sample images of liver cyst ultrasound with an 84% success rate.

**Table 2: Liver cyst ultrasound images detected by the system**

Segmentation method	Total Number of Sample Images	Total Number of Images Detected
Boundary		8
Active-Contour	10	10
Watershed		7

#### 4. Conclusion

The conclusion that can be made from this study is to understand the concept and the coding of the image processing techniques for detecting cysts by using ultrasound images. This report focuses on the image processing techniques where the MATLAB coding at the early process is completed. Every three methods of image segmentation are wholly done without any error. This process will help the steps of image segmentation to detect the cyst more accurately. With the implementation of Graphical User Interface (GUI), this system will also provide a user -friendly to detect cyst. To confirm the best segmentation techniques, performance was evaluated using different liver cyst images and calculating the average cyst area of the sample images.

To make this study even more successful and serve as inspiration and guide for future work, specific area changes are being suggested once completed. For this study, improving the segmentation by improving the image quality in the filtering process for the segmentation procedure can give a good result. Then, the calculating area is in a pixel that needs to be changed in cm much more understandable. In conclusion, more study is required for image processing in MATLAB to broaden the concept and make evaluating the example images for this study more straightforward.

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