Enhancement of Liver and Kidney Ultrasound Images by Using Digital Image Processing Techniques

by

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Dissertation submitted in partial fulfilment of

the requirements for the

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CERTIFICATION OF APPROVAL

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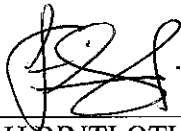Universiti Teknologi PETRONAS
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TRONOH, PERAK

JUNE 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

FAIZAH BINTI OTHMAN

ACKNOWLEDGEMENT

ABSTRACT

Liver and kidney are two important organs in human body. Both of them play a vital role in regulating life processes, especially in digestion and excretion system. However, both liver and kidney diseases persist as a very common disease across the nation. Annually, thousands of patients suffer from both diseases. In Malaysia itself, the statistics shows that average of 1,000 people die due to kidney problem in a year [15]. Today, with the rapid movement of technology, unnecessary measures like surgery can be avoided. Doctors and health practitioners can simply diagnose the mass or tumor by using Medical Imaging Techniques such as Computer Tomography (CT scan), Magnetic Resonance Imaging (MRI), Ultrasound Imaging and X-Ray.

The project involves on detecting liver and kidney diseases by using Ultrasound Imaging method. These days, doctors and radiologists have a difficulty in diagnosing raw ultrasound images of any internal organs that consist of soft tissue (i.e.: liver and kidney). Those unprocessed images cannot give patent image to doctors and radiologists in order for them to acquire essential information such as shape, texture and composition of tumors and cysts. The gist of the project is to enhance the images of both organs for a better outlook so that doctor can easily diagnose it. The principle of Digital Image Processing (DIP) and its application for liver and kidney ultrasound images has been selected as a field of research for this final year project. The objective of this project is to develop a technique in enhancing the imaging investigation of liver and kidney patients by using Ultrasound Imaging method. This method is safe, cheaper, faster and radiation free. A Digital Image Processing (DIP) fundamental was employed in achieving better quality of images. Literature review of both liver and kidney diseases was reviewed first before the images were processed. Besides, knowledge of Image Processing was mastered before the images were enhanced. Samples of 15 kidney images and 10 liver images from various type of disease were processed by using Matlab 6.1 software. The result was found satisfy since the quality of the new images was clearer compare to the raw images. Nevertheless, future work will continue by applying Neural Network system in order to get pattern recognition for the process image.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Liver Disease

Liver is the largest internal organ in the body. It is reddish-brown glandular in color located in the upper right portion of the abdominal cavity. It is essential in keeping the body functioning properly. It removes or neutralizes poisons from the blood, produces immune agents to control infection, and removes germs and bacteria from the blood. It makes proteins that regulate blood clotting and produces bile to help absorb fats and fat-soluble vitamins. Besides, it also synthesizes substances involved in the clotting of the blood, synthesizes vitamin A, detoxifies poisonous substances and breaks down worn-out erythrocytes.

Each year, more than 25 million people in America are afflicted with liver diseases. Amongst the most ordinary liver diseases are viral hepatitis, cirrhosis and liver disorders in children, gallstones and cancer. The diagnosis of liver diseases depends upon a combination of history, physical examination, laboratory testing, biopsy and radiological studies. Although surgical and cryosurgical treatments of liver cancer are the main curative options, but it still depend on excellent intraoperative ultrasound imaging to discover the full extent of the disease [6].

Frequently, lesions of the liver are very small in size. It is located either very superficially or very deep, which is near to the capsule of the liver. In such cases, it is very difficult to determine whether the liver lesions are caused by definitively benign lesions such as simple cysts (hemangiomas) or solid nodules which might represent liver metastases.
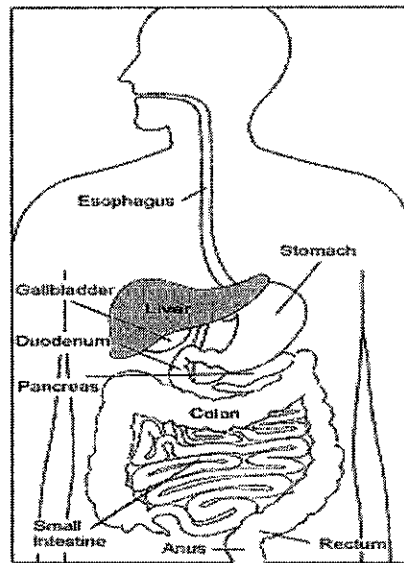
Figure 1.1: The digestion system

1.2 Kidney Disease

The kidney is a pair of bean-shaped organ located at the back of body about the level of waist. They receive their blood supply from the main artery of the body called the aorta. Each kidney measures 10 – 15 cm in length and weighs about 160 gm. The kidney is made up of 1 million units called nephrons. Each nephron consists of two-parts, the glomerulus which is bunch of capillaries with thin walls (serve as a filter), and a tubule which drains the glomerulus.

Kidney failure may be acute or chronic. Acute diseases develop very fast and it can be very serious. Although an acute disease may have long-lasting consequences, it usually lasts for only a short time and then goes away once the underlying cause has been treated. Chronic diseases, however, do not go away and tend to get worse over time. When the kidney stops working, doctors use a treatment called dialysis to remove waste products and extra water from patients with chronic kidney failure. Some common kidney diseases are glomerulonephritis, proteinuria, nephrotic syndrome and igA nephropathy.

In general population, slightly more than 30 people in every 100,000 people develop kidney failure each year. In the pediatric population age 19 and under, the annual rate is only one or two new cases in every 100,000 children [1]. In other words, adults are about 20 times more likely to develop kidney failure than children. The risk increases steadily with age.
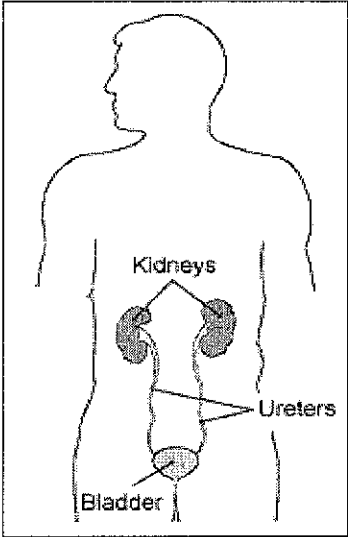
Figure 1.2: The excretion system
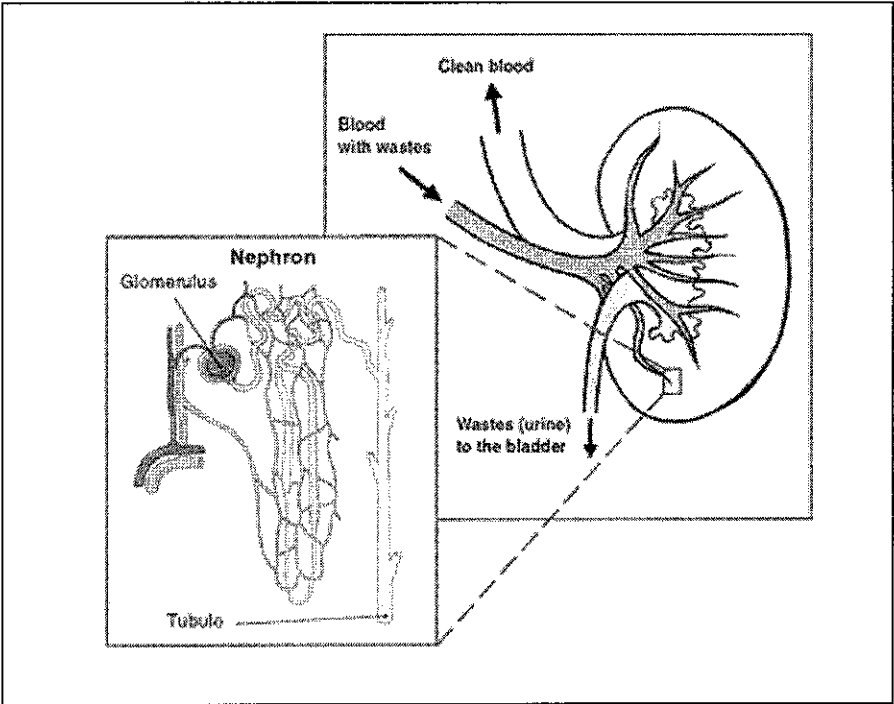
Figure 1.3: Structure of Kidney

1.3 Problem Statement

Liver and kidney diseases are two major diseases in Malaysia. Those patients who are found to have masses or lesion in their liver or kidney, an investigation has to be carried out. The first step of diagnosis procedures is by looking at patients' medical background. Then, physical examination and laboratory testing take place. At this stage, if doctors can detect the disease and also the cause, further investigation can be proceed without any biopsy or radiological studies.

In cases where the liver and kidney disease are crucial enough, further investigation has to be done. Radiological studies and biopsy are those two common studies at this level. Besides, before any surgical treatments available to liver and kidney patients, they have to depend on these two tests first.

The project involves on detecting liver and kidney disease by using one of the medical imaging technique, which is Ultrasound Imaging. Currently, raw images of liver and kidney cannot give a patent image to doctors and radiologist to diagnose the images. This make they hardly find the information on these two organs. Such important information; shape, texture and composition of tumors and cysts need to be revealed in order for the doctor to diagnose the actual disease. The gist of the project is to enhance the images of both organs for a better outlook so that doctor can easily diagnose it. A Digital Image Processing (DIP) fundamental is used in order to have better images. Hopefully with the better image, it can increase the degree of accuracy of the doctors in analyzing patients' disease. Yet, this will bring a credit for those patients who suffer from liver and kidney diseases.

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1.4 Objective

The objective of this project is to develop techniques in enhancing raw images of liver and kidney, which is taken by using Ultrasound Imaging method. By this, it could help specialists in diagnosing the ultrasound images. The technique produced is lined up with Digital Image Processing (DIP) principles by means of Matlab 6.1 software.

1.5 Scope of Study

The initial scope of the project revolves around looking into facts and details of liver and kidney diseases. Knowledge on these diseases is important on analyzing the images. The proceeding scope is to understand on how Ultrasound Imaging works. Once it is known, the technique of medical imaging can be narrowed down to a possible solution.

 The third scope is to master on techniques involve in medical image processing. This is because a basic understanding of Digital Image Processing techniques is required before liver and kidney images can be enhanced. Software such as Matlab 6.1 and Borland C++ are used in order to improve the quality of the images. At the final stage, enhancement of 25 samples of both diseases will be made by using the software. The result will be officially approved by the doctors or radiologists.

Basically, the first two scopes were done during the first half of the project time frame. The later scopes are targeted to be completed by the end of the project schedule. In essence, second half of time frame is more on application of Digital Image Processing theory via assessment the techniques on each image. Finally, output of the assessment is then analyzed with facilitation from doctors and radiologists from Hospital Selayang and Hospital Kuala Lumpur.

CHAPTER 2

2.0   LITERATURE REVIEW

There are several journals and projects that have been produced that show the application of Ultrasound Imaging in medical field.

2.1   Previous Work

From conventional ultrasound images, it is hardly to read on the actual symptoms due to the imbedded noise. To overcome the problem, Digital Image Processing techniques are applied. Such techniques are noise filtering, histogram equalization and image segmentation (region growing, thresholding and edge detection) [6].

2.1.1   Noise filtering

Before segmentation process taken into account, the image need to be filtered first so that noise speckle encountered in the image can be removed. By Alin Achim [16], imaging speckle is a phenomenon that occurs when coherent source are used to interrogate a medium, which is rough on the scale of wavelength. Speckle occurs especially in liver and kidney images whose underlying structures is too small to be resolved by a large wave ultrasound [16].

Peak-and-valley is one of the methods used to remove noise. It is considered as a nonlinear method. It reduces impulsive noise while modifying the gray levels of the image. The basic idea behind peak-and-valley method is to substitute the intensity value of local peak pixels with the local maximum value within edges. In further, it also fills the intensity values of local valley pixels with the local minimum value between edges.

Example of peak-and-valley algorithm:

Table 2.1: Algorithm of peak-and-valley method

$$P'(i+j) = \min(P(i-1), P(i+k))$$
$$\text{if } P(i+j) < P(i-1) \text{ and } P(i+j) < P(i+k) \qquad (1)$$
$$P'(i+j) = \max(P(i-1), P(i+k))$$
$$\text{if } P(i+j) > P(i-1) \text{ and } P(i+j) > P(i+k) \qquad (2)$$
$$P'(i+j) = P(i+j) \text{ else.} \qquad (3)$$
$$\forall j = 0, 1, 2, \ldots, k-1$$

2.1.2 Novel Bayesian Multiscale Method

This method is used in order to remove speckle that occurs on an image. Imaging speckle is a phenomenon that occurs when a coherent source and a noncoherent detector are used to interrogate a medium, which is rough on scale of the wavelength. Speckle occurs especially on images of the liver and kidney whose underlying structures are too small to be resolved by large wavelength ultrasound. The presence of speckle is undesirable since it degrades quality of the image. Thus, it affects the human diagnosis. This shows that speckle filtering is a critical preprocessing step before analysis and image recognition take place [16].

The main reason for the choice of multiscale bases of decompositions is that the statistics of many natural signals, when decomposed in such bases are significantly simplified. There are three main steps involve:

(i)   the raw data analysed by using wavelet transforms

(ii)   empirical wavelet coefficients are shrunk

(iii)   the denoised signal is synthesized from the processed wavelet coefficients through the inverse wavelet transform

Figure 2.1 shows steps involved in Novel Bayesian Multiscale method [16].

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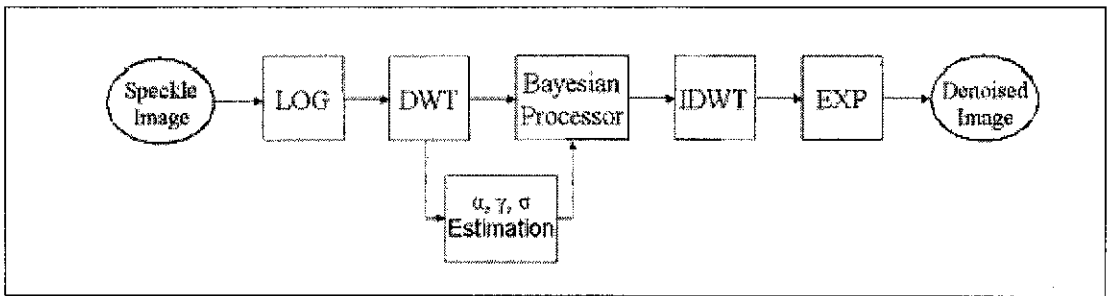
Figure 2.1: Block diagram of Novel Multiscale Bayesian-based algorithm [16]

2.1.3 Histogram Equalization

Histogram equalization is categorized under image enhancement techniques. It can be used to improve the visual appearance of an image. This technique deals with range gray levels of the images. Consequently, it can increase the contrast of the image by increasing the dynamic range of the gray levels. Generally, images have unique brightness histograms. Even images of different areas of the same sample (in which the various structures present have consistent brightness levels) will have different histograms. In fact, most real images display some variation in brightness within features.

Histogram equalization reassigns the brightness values of pixels based on the image histogram. Individual pixels retain their brightness order but the values are shifted, so that an equal number of pixels have their own brightness values. Histogram equalization will not "flatten" a histogram. It redistributes the intensity distributions. If the histogram of any image has many peaks and valleys, it will still have peaks and valley after equalization, but peaks and valley will be shifted. Due to this, "spreading" is a precise term than "flattening" to describe histogram equalization [3].

Because histogram equalization is a point process, new intensities will not be introduced into the image. Existing values will be mapped to new values but the actual number of intensities in the resulting image will be equal or less than the

original number of intensities. Figure 2.2 shows the example output of histogram equalization process [2].
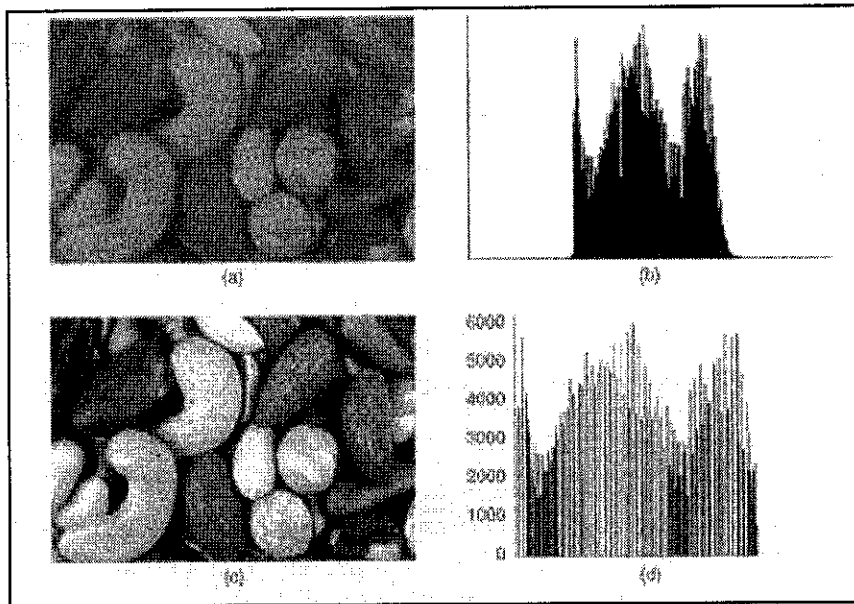
Figure 2.2 (a) Original image (b) Histogram of original image
(c) Equalized image (d) Histogram of equalized image.

Histogram Equalization Working Principle

Histogram modeling is usually introduced using continuous process functions, rather than discrete process functions. Suppose that the images of interest contain continuous intensity levels (in the interval [0, 1]) and the transformation function f which maps an input image A (x,y) onto an output image B (x,y) is continuous within this interval. Further, it will be assumed that the transfer law (which may also be written in terms of intensity density levels), as example:

$$D_B = f\,(D_A) \quad \text{...................................... [3]}$$

is single-valued and monotonically increasing (as is the case in histogram equalization) so that it is possible to define the inverse law $D_A = f^{-1}\,(D_B)$ [3]. An example of such a transfer function is illustrated in Figure 2.3.

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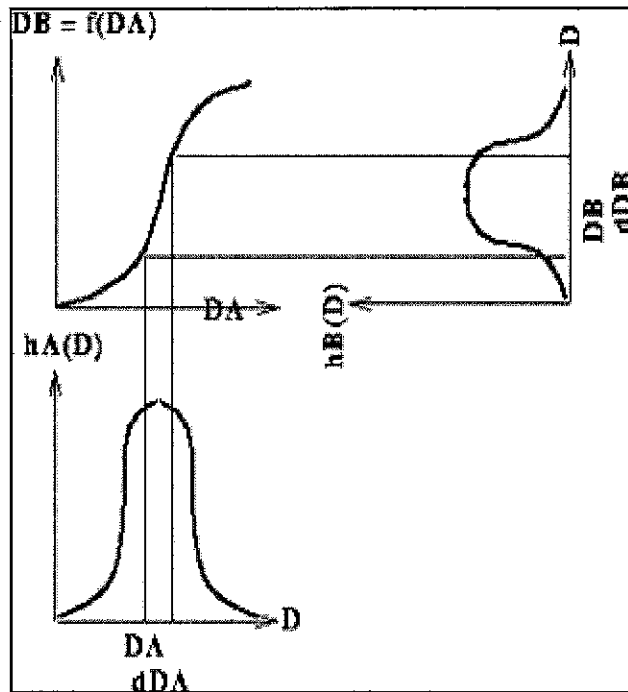
Figure 2.3: A histogram transformation function [3].

All pixels in the input image with densities in the region D_A to $D_A + dD_A$ will have their pixel values reassigned such that they assume an output pixel density value in the range from D_B to $D_B + dD_B$. The surface areas $h_A (D_A) dD_A$ and $hB(D_B) dD_B$ will therefore be equal, yielding:

$$h_B(D_B) = \frac{h_A(D_A)}{d(D_A)} \quad \text{.. [3]}$$

where
$$d(x) = \frac{df(x)}{dx} \quad \text{.................................... [3]}$$

This result can be written in the language of probability theory if the histogram h is regarded as a continuous probability density function p describing the distribution of the (assumed random) intensity levels:

$$p_B(D_B) = \frac{p_A(D_A)}{d(D_A)} \quad \text{...................................} \quad [3]$$

In the case of histogram equalization, the output probability densities should all be an equal fraction of the maximum number of intensity levels in the input image D_M (where the minimum level considered is 0). The transfer function (or point operator) necessary to achieve this result is simply:

$$d(D_A) = D_M \times p_A(D_A) \quad \text{...................................} \quad [3]$$

Therefore,

$$f(D_A) = D_M \int p_A(u)du = D_M \times F_A(D_A) \quad \text{...........................} \quad [3]$$

where $F_A D_A$ is simply the cumulative probability distribution (*i.e.* cumulative histogram) of the original image. Thus, an image which is transformed using its cumulative histogram yields an output histogram which is flat.

A digital implementation of histogram equalization is usually performed by defining a transfer function of the form:

$$f(D_A) = \max(0, round[D_M \times n_k / N^2)] - 1) \quad \text{.......................} \quad [3]$$

where N is the number of image pixels and n_k is the number of pixels at intensity level k or less [3].

In the digital implementation, the output image will not necessarily be fully equalized and there may be 'holes' in the histogram (*i.e.* unused intensity levels). These effects are likely to decrease as the number of pixels and intensity quantization levels in the input image are increased [4].

2.1.4 Segmentation

The process of forming a region-based image description is referred to as segmentation. Image segmentation involves the partitioning of an image into a number of disjoint regions based on the pixel gray level characteristics. Three main classes of image segmentation are thresholding, edge detection and region growing [6].

Region growing is a procedure that groups pixels into larger regions based on certain criteria. The basic approach is to start with sets of "seed" points and from these grow regions by appending to each seed those neighboring pixels that have similar to the seed. The selection of similarity criteria depends on not only on the problem under consideration, but also on the type of image data available [3].

For the segmentation of intensity images, four classical approaches have to be considered. The approaches are:

a) Threshold techniques

Threshold techniques are based on the thresholds that are usually selected from the image histogram. It is said that all pixels whose value (gray intensity, color, or other) is between two values of thresholds belong to one region. The fact that the thresholds are derived from the histogram says that these techniques don't take into account spatial information of the image and they have problems to cope well with the noise as well as with blurred edges on the image [3].

b) Edge-based methods

Edge based methods try to find the places of rapid transition from one to the other region of different brightness or color value. The basic principle is to apply some of the gradient operators convolving them with the image. High values of

the gradient magnitude are possible places of rapid transition between two different regions, what we call edges. After this step of finding edges on the image they have to be linked to form closed boundaries of the regions. To go from image edges to the image boundaries is very difficult task which has been studied a lot [6].

c) *Region-based methods*

Region-based methods are complementary to the edge-based methods. Here the point is to group pixels of the same or similar brightness or color to the regions according to the given criteria of homogeneity (look at the neighboring pixels of the given pixel and merge them into the region if criteria of homogeneity are satisfied). Homogeneity criteria is based on some threshold value, the choice of which is problematic, because we have usually to play a lot with the right choice of the thresholds, and thresholds always depend on the image data. Also, results are sensitive to the noise [6].

d) *Mixed, hybrid methods which combine edge and region methods*

There are lot definitions of such mixed methods. In the morphological watershed segmentation and variable surface fitting are given as an example. The watershed method is applied to the gradient of the image. This gradient of the image can be viewed as topography with boundaries between regions as ridges. Algorithm is simulation of flood, starting from the seed points and flooding the topography until the water is not stopped at the ridges of the valleys. Water from different valleys is not mixed between two neighboring valleys. Comparing with edge-based methods this method gives closed boundaries around the supposed regions, but it is sensitive to the noise in the regions and blurred edges between regions.

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The variable-surface fitting technique starts coarse segmentation of the image into several surface-curvature-sign primitives (e.g. pit, peak, ridge, etc.), which are then refined by an iterative region growing method based on variable-order surface fitting. The method is highly data driven with no scope to involve higher-level knowledge. It is computationally very expensive [7].

- *Seeded region growing algorithm*

Seeded region growing algorithm (SRG) is a new approach which is based on conventional postulate of region growing algorithms where the criteria of similarity of pixels is applied, but the mechanism of growing regions is closer to the watershed algorithm [7].

Instead of controlling region growing by tuning homogeneity parameters, SRG is controlled by choosing a usually small number of pixels, known as seeds. These seed pixels are chosen by user according to his own opinion what should be regions to extract on the image. So, we start with the number of seeds which have been grouped into n sets: A1, A2, ..., An. Sometimes individual sets could consist of single point. At each step of the algorithm we add one pixel to some of the sets Ai, i=1,...,n. Consider now the state of sets Ai, after m steps. Let T be the set of unallocated pixels which border at least one of the regions, what means that T is the set of all pixels which are on the borders of the, up to now, formed regions:

$$T = \left\{ x \notin \bigcup_{i=1}^{n} A_i \mid N(x) \bigcap \bigcup_{i=1}^{n} A_i \neq 0 \right\}$$ .... [7]

where N(x) is the set of immediate neighbors of the pixel x. In our case we consider 8-connectivity (for each pixel all its 8 neighbors). Each step in the algorithm takes one pixel from the T set and adds it to one of the regions with which neighbors N(x) of the pixel intersect, actually label it with the label of that region. Then we examine all pixels from N(x) and calculate distances from their

neighboring regions. According to that distance we put them into T set to be in increasing order, what will be explained in the part of implementation. The distance is simple measure which says how far the intensity of the regarded pixel is from the intensity mean value of those regions. It is defined as:

$$\delta(x) = g(x) - mean_{y \in A_i(x)} [g(y)]$$

.... [7]

If we have that our regarded pixel x has more than one neighboring region, then we have to decide to which region add our pixel x. After that, we simply calculate the distance from all its neighboring regions and add it to the region to which it is the closest. So, we can formulate its minimal distance from the neighboring regions as:

$$\delta(z) = \min_{x \in T} \{\delta(x)\}$$

.... [7]

- *Improved seeded region growing algorithm*

In [9], authors said that different order of processing pixels leads to the different final results. They noticed two types of order dependencies. First type they named inherent order dependencies, while the second is named implementation order dependencies.

a) Inherent order dependencies

Here are inherent pixel order dependencies:

- When several pixels x from T have the same value of delta, than the order of pixels processing is critical. If we chose, for example raster order, than the first chosen pixel will change running mean value of the region to which it has been added. This will further influence delta values of pixels x from T which will

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be processed in the next iteration. Figure 2.4 illustrates the process [7].

• When chosen pixel from T has the same delta value for several regions it borders, than the choice of region to which it will be added will influence running mean value of that region and final segmentation. For example, if the center pixel of Fig (d) had to be first processed.
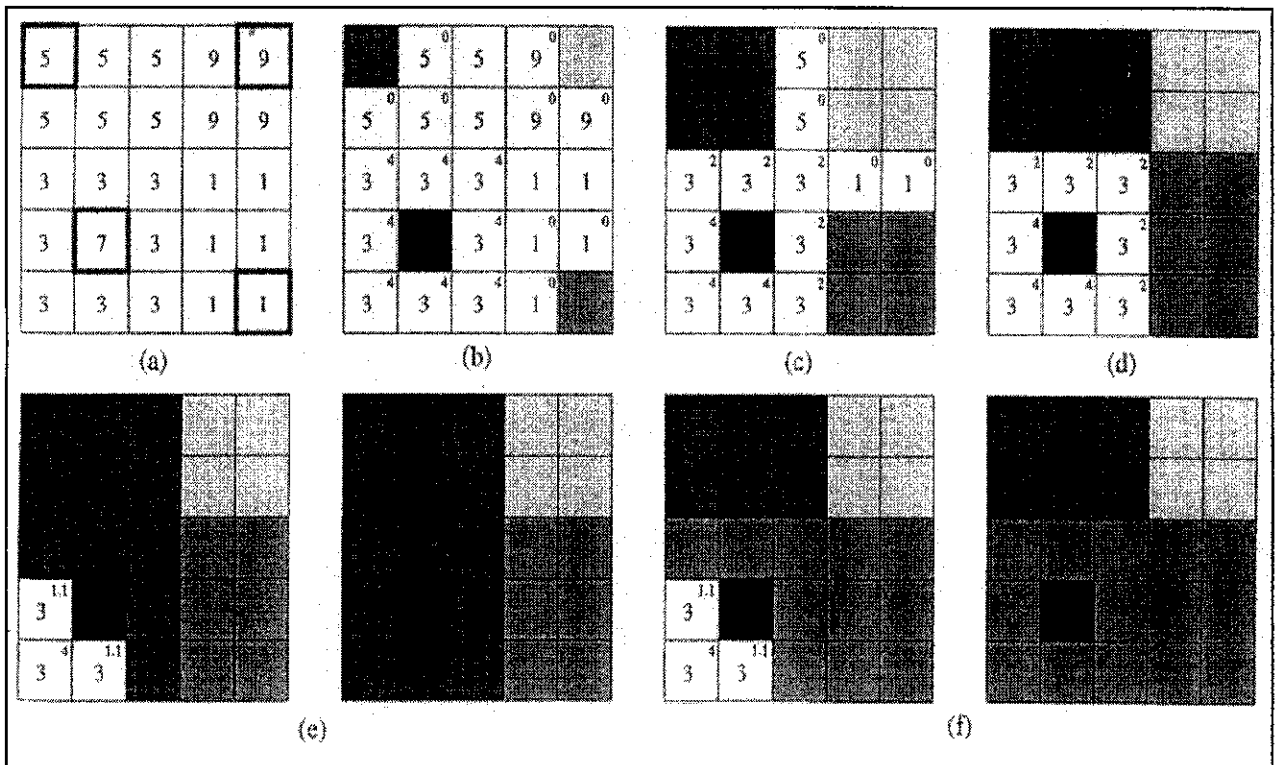
Figure 2.4: Order dependency of the SRG algorithm. (a) Gray value test image with four seeds marked (the initial {Aj}). (b) Each x from T is shown with its delta value as a superscript numeral. (c) Results after 9 iterations. (d) Result after 13 iterations. (e) Final result assuming that the "3"'s in (d) are scanned in raster order. (f) Final result assuming that the "3"'s are scanned in anti-raster order [7].

2.2 Theory

2.2.1 Ultrasound Principle

Ultrasound imaging is based on the same principles involved in the sonar used by bats, ships at sea, and anglers with fish detectors. As a controlled sound bounces against objects, its echoing waves can be used to identify how far away the object is, how large it is its shape and its internal consistency (fluid, solid or mixed) and also how uniform it is.

Ultrasound wave is a propagating mechanical disturbances of the matter through which it passes. The sound wave creates pressure disturbances that accelerate and displays the atoms in its path. [5]

Figure below shows example of Ultrasound equipment.
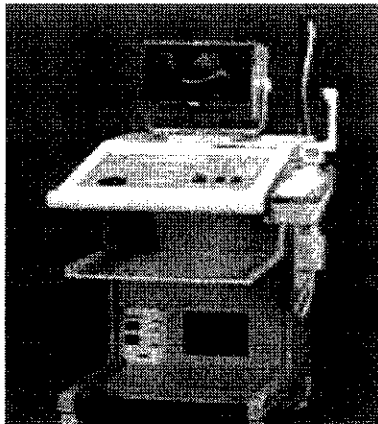
Figure 2.5: Ultrasound equipment

### 2.2.2 Basic Principles of Ultrasound Imaging System Design

By referring to Figure 2.6, the transducer of width a sends a short pulse with sonic energy of duration Δt into a tissue along narrow beam of width $\Delta \theta$. Imaging system will waits a time T before sending out another pulse. During this time T any echoes from obstacles in the path are reflected and received by the transducer.

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The velocity of sound in water and tissue is c = 1540 ms^{-1}. The delay with successive pulses is time T. The maximum range, r_{max} is r_{max} = cT / 2. Generally, it is desirable of ultrasound imaging system to have large axial range so that deep structures within the body may be imaged. Basically, there are two factors that may constrain on r_{max}:-

a) the larger r_{max}, the longer T will need to be

b) energy dissipation
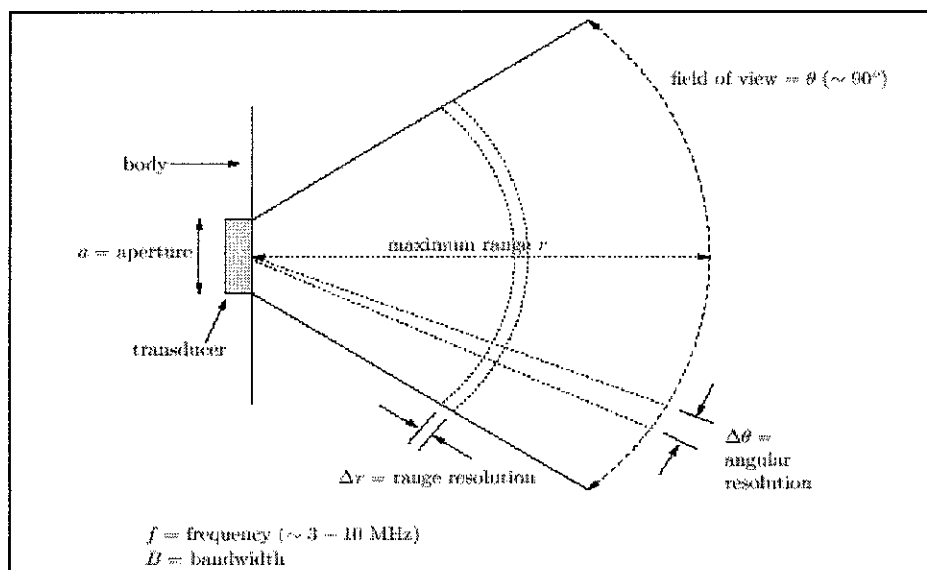
Figure 2.6: Basic engineering parameters of ultrasound system
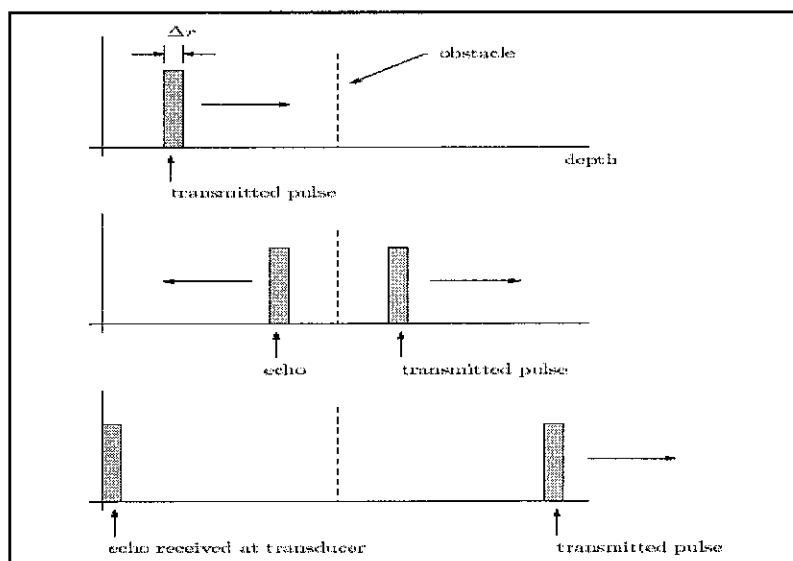
Figure 2.7: Ultrasound pulse transmission and reflection

2.2.3 Medical Ultrasound Imaging

Ultrasound imaging which also called as ultrasound scanning or sonography, is a method of obtaining images of internal organs by sending high-frequency sound waves into the body. The reflected sound waves' echoes are recorded and displayed as a real-time visual image. No ionizing radiation (x-ray) is involved in ultrasound imaging. A medical ultrasound image is a useful way of examining internal organs, including the liver, gallbladder, spleen, pancreas, kidneys, and bladder. Because ultrasound images are captured in a real time basis, the display on the ultrasound screen can show movement of internal tissues and also part of internal organs. This enable physicians to see blood flow. This can help to diagnose a variety of conditions and to assess damage caused by illness.

Figure 2.8: Patient undergo Ultrasound process

CHAPTER 3

3.0 METHODOLOGY

3.1 Procedure Identification

Towards the completion of the project, the student had followed some methodologies and appropriate procedures especially during information gathering, enhancement of the images and testing. Below are some of the methodologies applied for the project:

3.1.1 Problem identification and Image acquisition

At the earliest stage, problem statement of the project was analyzed. In hand, research on liver and kidney diseases together with ultrasound imaging system was done from many sources, such as journals, internet websites and related books.

Besides that, the important part of the first stage is to get an image samples of liver and kidney from Kuala Lumpur General Hospital (HKL) and Hospital Selayang. The number of samples taken is ten for liver and 15 for kidney. From these samples, the later part of the research can be proceed. Discern that images taken from HKL and Hospital Selayang are differ to each other. Means that images taken from HKL are in hard-copy type, which is still in film. Compare to Hospital Selayang, the images are in soft-copy which the images is in digitized-form.

The images which in film-type are digitized first by using scanner before it can be processed. This is because DIP techniques need a digitized-image for the image to be processed. Instead of taking the images only, a short-hand explanation on the images taken was given by respective radiologists in order for the students to get short overview of the disease.

3.1.2 Image enhancement process

There are five steps involve in image enhancement process:-

Table 3.1: Image enhancement steps

STEPS	PROCESS
1	Image Restoration
2	Pre-processing
3	Image Segmentation
4	Feature Extraction
5	Image Recognition

Step One: Image Restoration

The sample of liver and kidney images is stored inside the desktop where the action of enhancement process will be done. The sample consists of the raw ultrasound images taken from hospitals.

Step Two: Pre-processing

In this second-level, the need is to filter out all the noise. Besides, all unnecessary background of the image is removed. Adding and subtracting some of the image part also be done. All the needs accomplish by using Image Processing techniques such as histogram equalization, region seed-growing and edge detection.

Step Three: Image Segmentation

In Image Segmentation, 'Region drawing Technique" is introduced. Interested parts of images are concentrated. The interested region is focus to it. And it becomes bigger.

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Step Four: Feature Extraction

In this part, the tissue characteristics will be determined. It indicates whether the tissue goes for malignant or benign.

Step Five: Image recognition

After all the four processes above have gone through, the final section is to finalize whether the image process is successfully enhanced. The whole images will be recognizing.
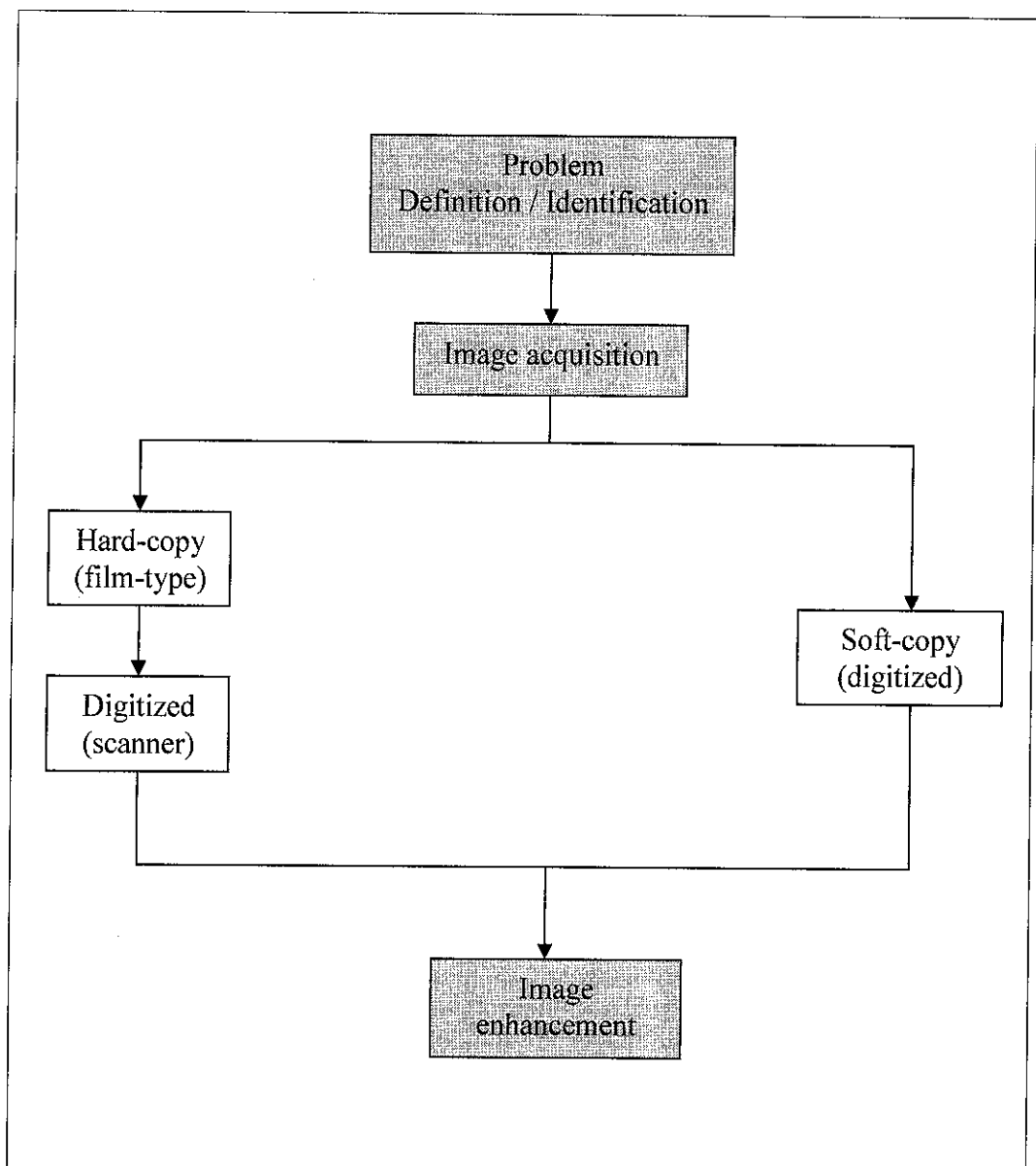
3.1.3 Overall Procedure
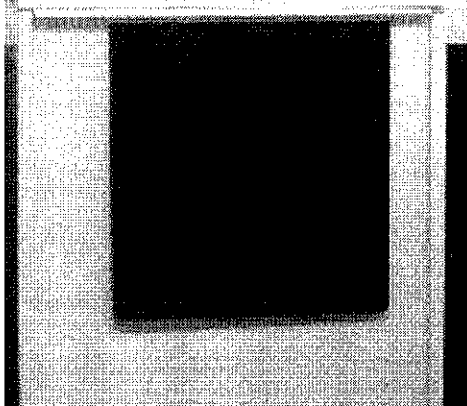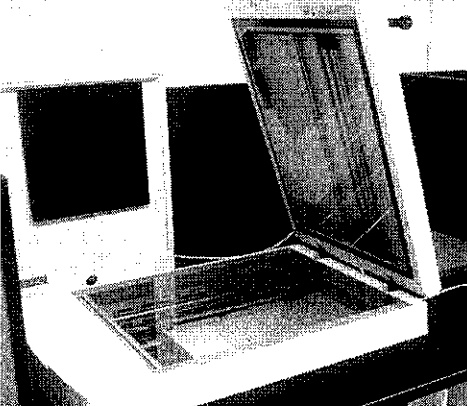

Figure 3.1: Overall project procedure

3.2 Tools

Throughout the project, student has been accessing several equipments to aid student to conduct the enhancement process. The initial work started from acquiring the image of liver and kidney. However, although in the first plan is to processed 50 images altogether for both liver and kidney, but due to technical problems, only 10 liver images and 15 kidney images can be acquired from respective hospitals.
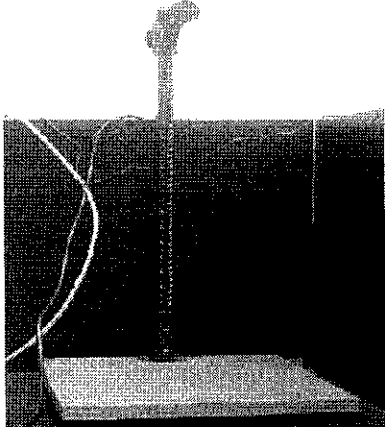
They are two category of tools used in this project:
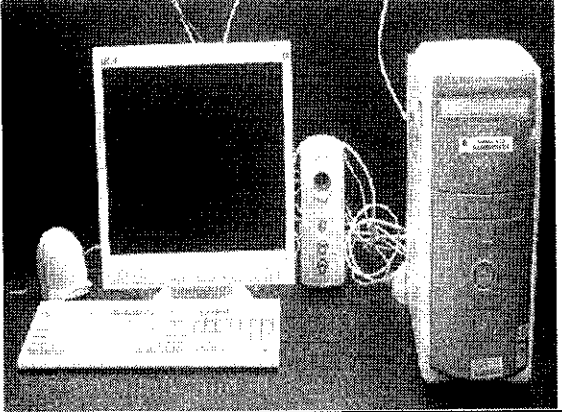
   a) Hardware – Scanner, Workstation, 10 liver images and 15 kidney images

   b) Software – Matlab 6.1, Borland C++

Table 3.2 shows the hardware equipment and its purpose.

Table 3.2: Hardware equipments

Equipment	Purpose	Figure
Ultrasound film	To diagnose patient disease	
Scanner (Microtek)	To convert ultrasound film image to digital image	

Workstation	To enhance the image by using Matlab 6.1 and Borland C++ software	
	To enhance the image by using Matlab 6.1 and Borland C++ software	
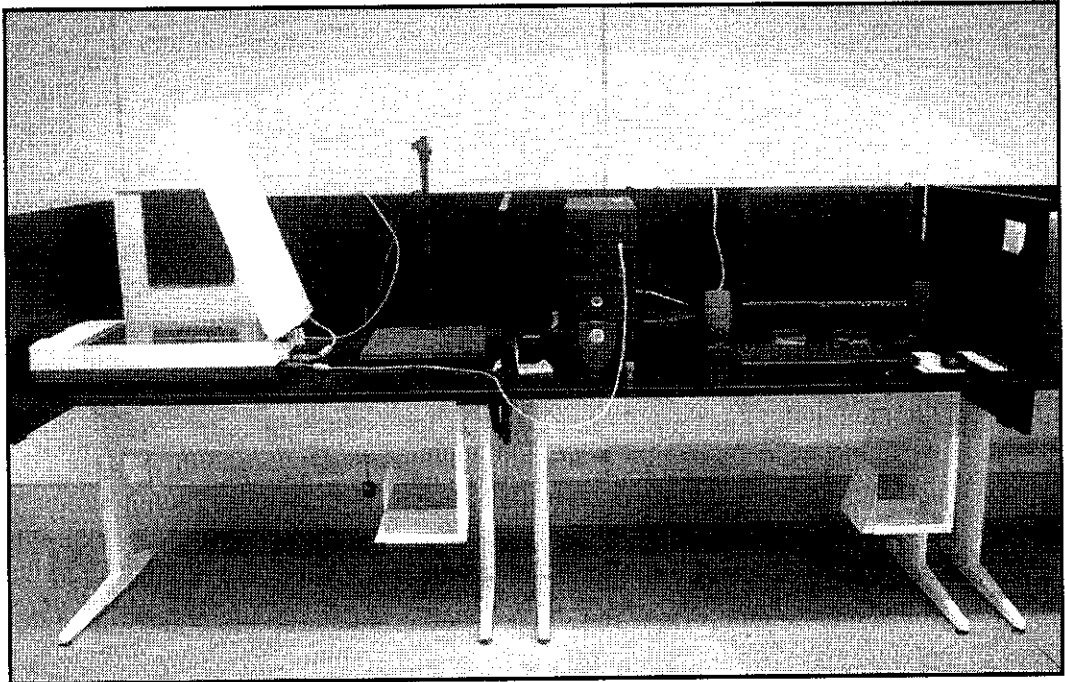
**Figure 3.2**: Equipments in Telemedicine Laboratory

CHAPTER 4

4.0 RESULT AND DISCUSSIONS

4.1 Findings and Analysis

4.1.1 Liver Disease

Based on the scope of study, the focus is more on application of Digital Image Processing (DIP) techniques. All the theories captured before hand are being utilized in order to enhance the images. At this point, ten images of liver have been processed from various kinds of diseases. The first image discuss is on Cirrhosis and second one is on Rectal Carcinoma.

Case 1: Cirrhosis
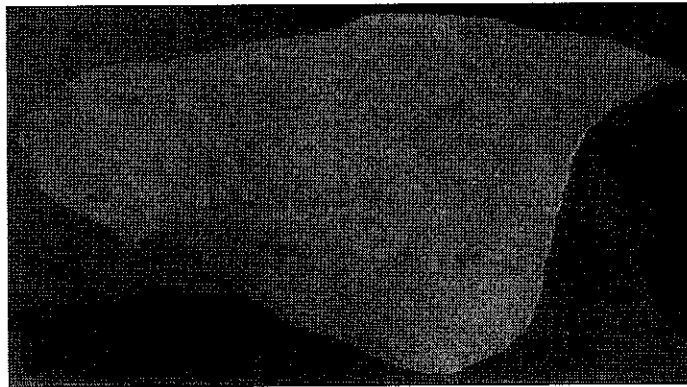
Figure 4.1: Liver image of Cirrhosis

For this type of liver failure, one image has been acquired and image enhancement process has taken place. Based on previous work [1], region growing technique offers several advantages over conventional image segmentation techniques. Hence, region growing technique is applied on the cirrhosis image. Figure 4.2 shows images of before and after process being done.

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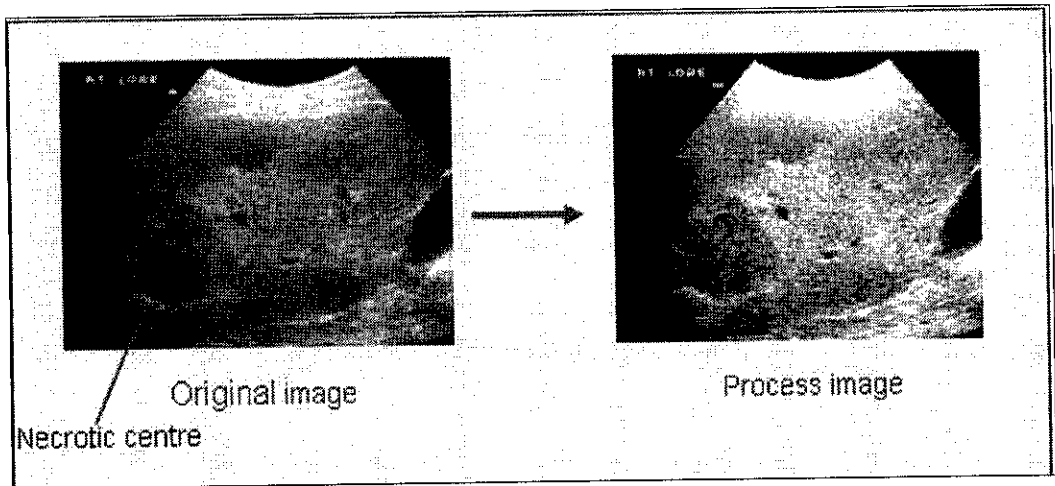
Figure 4.2: Raw image and processed image of Cirrhosis

The process of obtaining process image in Figure 4.1 is as shown in Figure 4.3.
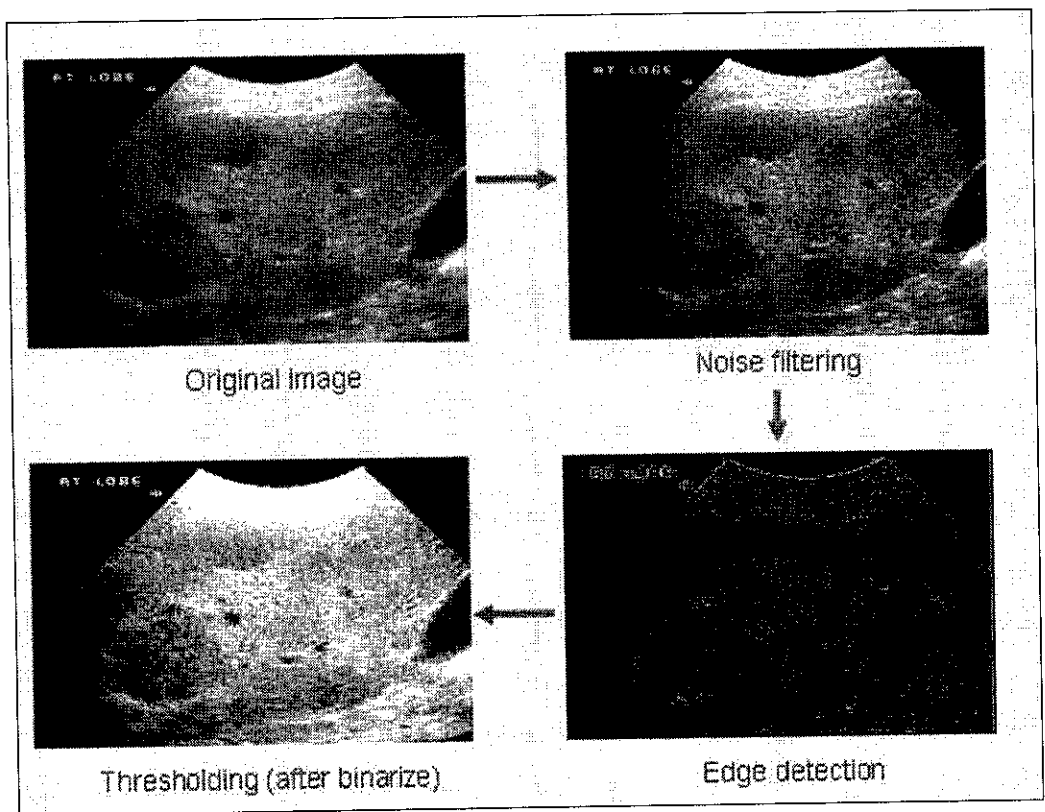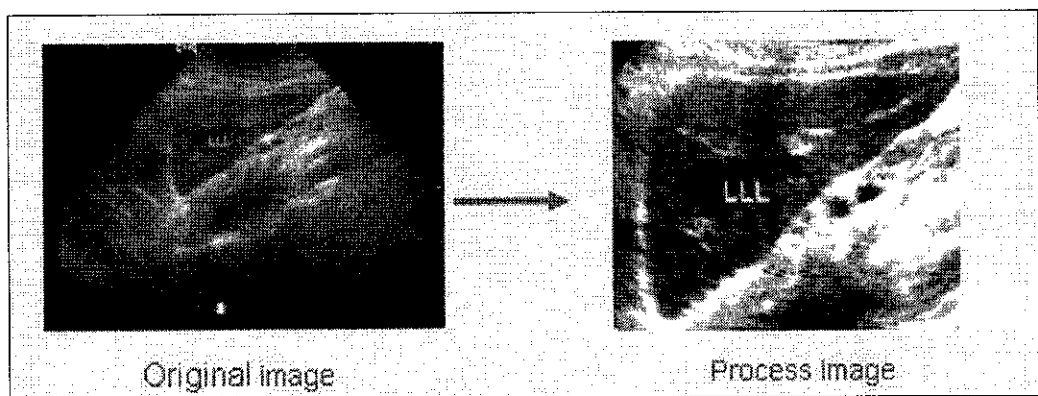

Figure 4.3: Image enhancement process techniques

From both images in Figure 4.2, the analysis shows that the gray level of part which the tumor suspected is much clearer, but the noise still embedded in the system. The image just only being equalized means that the gray levels of the raw image is distributed. The problem of the process image raise is that the other part of the liver is seems to be hidden. Practically, the background part should also brighten so that the tumor can be differentiation can be seen clearly.

The process involve in getting the image is based on filtering and image segmentation techniques. On image segmentation, edge detection and thresholding is chosen based on trial-error basis. Since it is simulate by using Matlab 6.1, only the technique can be applied.

Based on the radiologist, this cirrhosis image is clearer compare to the raw image.

Case 2: Rectal Carcinoma

Figure 4.4: Raw image and processed image of Rectal Carcinoma
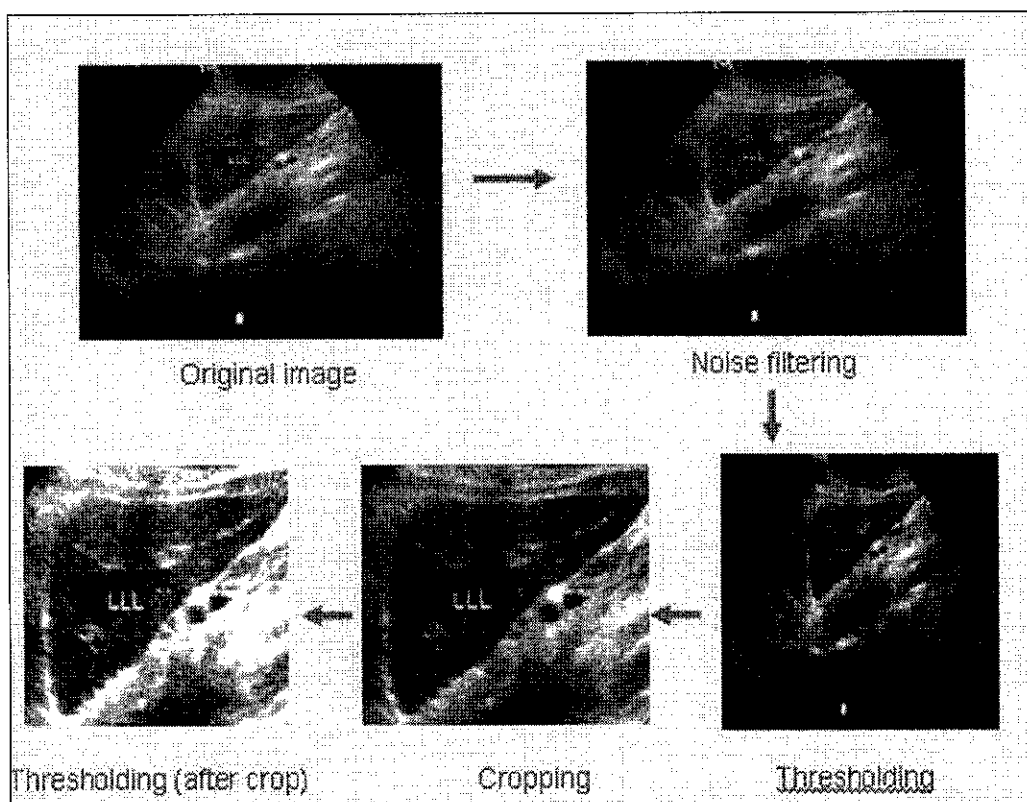
**Figure 4.5**: Image enhancement process techniques

From Figure 4.5, the final image is focus on part where the tumor or liver cysts are located. By comparing the original image and final results, the intensity of cyst can be accurately detected since the fourth process is cropping the part where doctors done the analysis.

Based on doctors indication, the enhancement process of this image is meets the requirement on detecting the intensity of the cysts.

4.1.2 Kidney Disease

Basically for kidney images, the techniques most currently used is on Image Segmentation. The findings display below shows the most currently diseases occur in patient in Malaysia: nephritic syndrome and Glomerulonephritis.
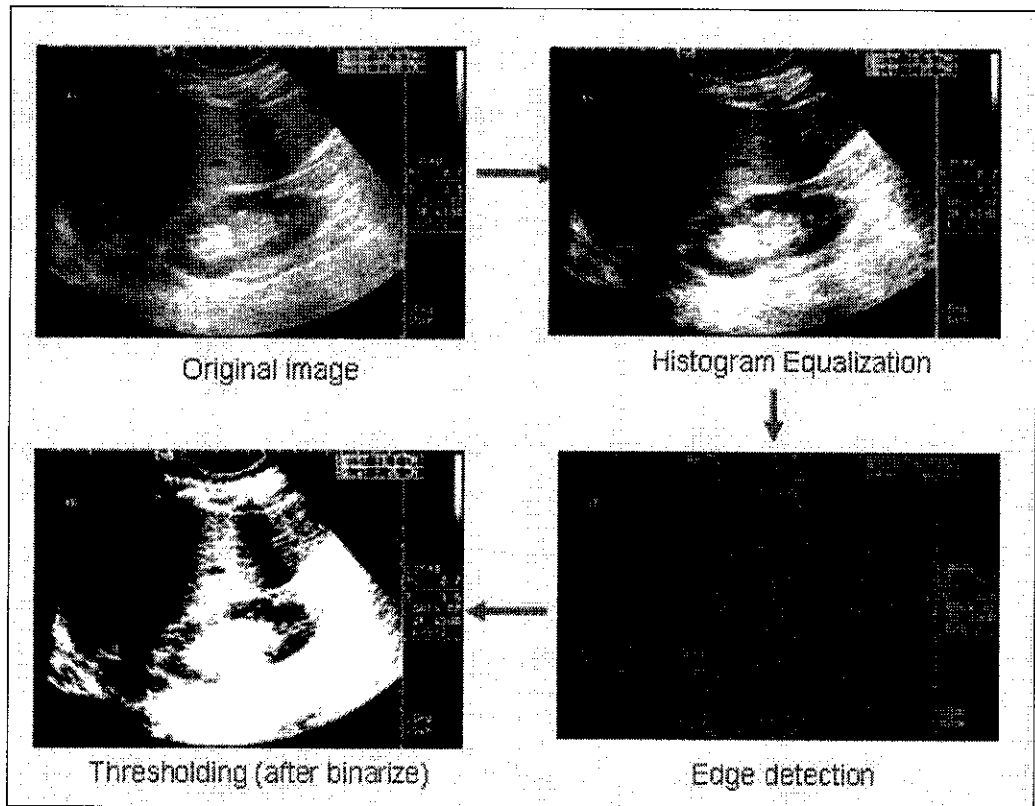
Case 1: Nephrotic Syndrome
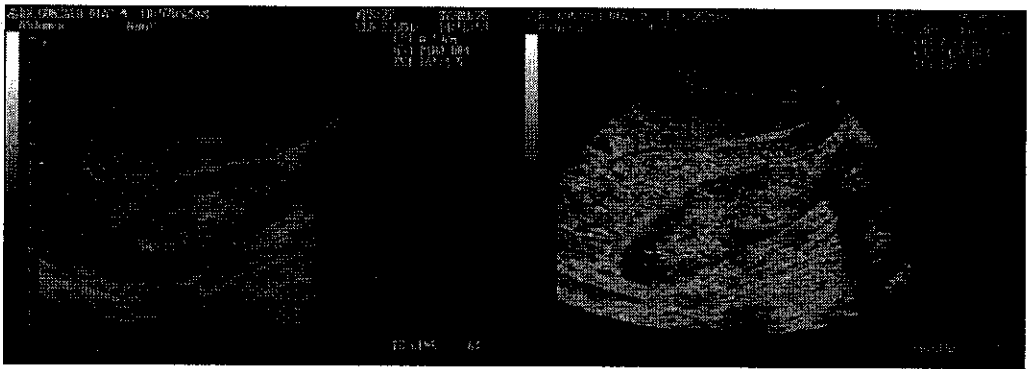
Figure 4.6(a): Nephrotic disease (binary); **Figure 4.6(b)** Colour image

Figure 4.7 shows the raw image of Nephrotic Syndrome and process image (after enhancement process being applied).
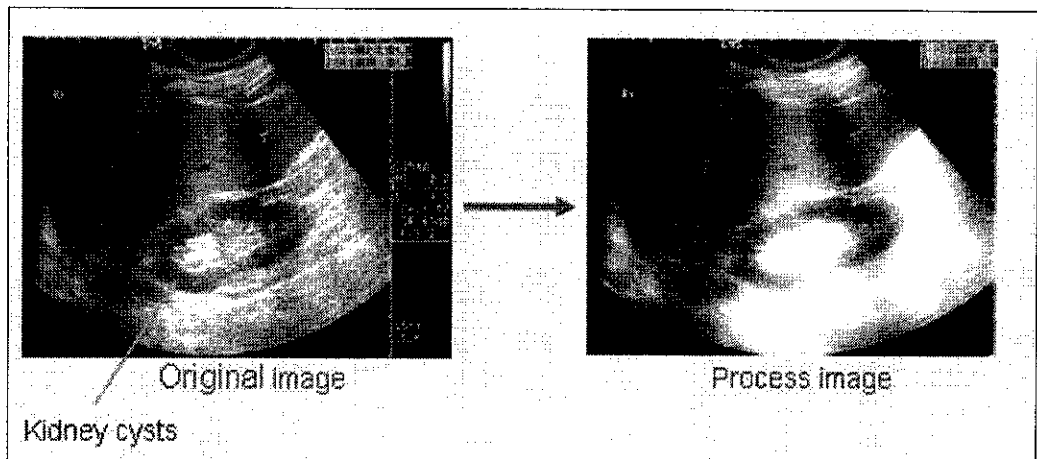
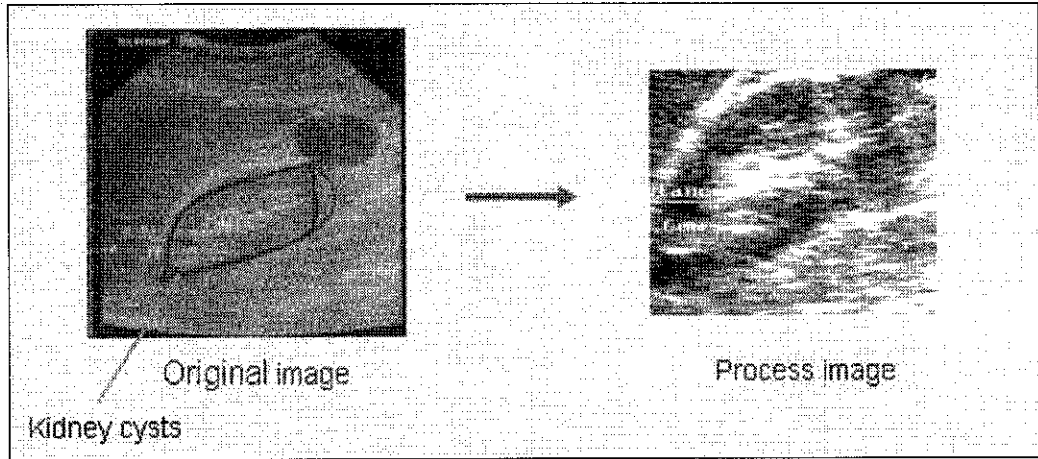**Figure 4.7:** Raw image and processed image of Nephrotic Syndrome

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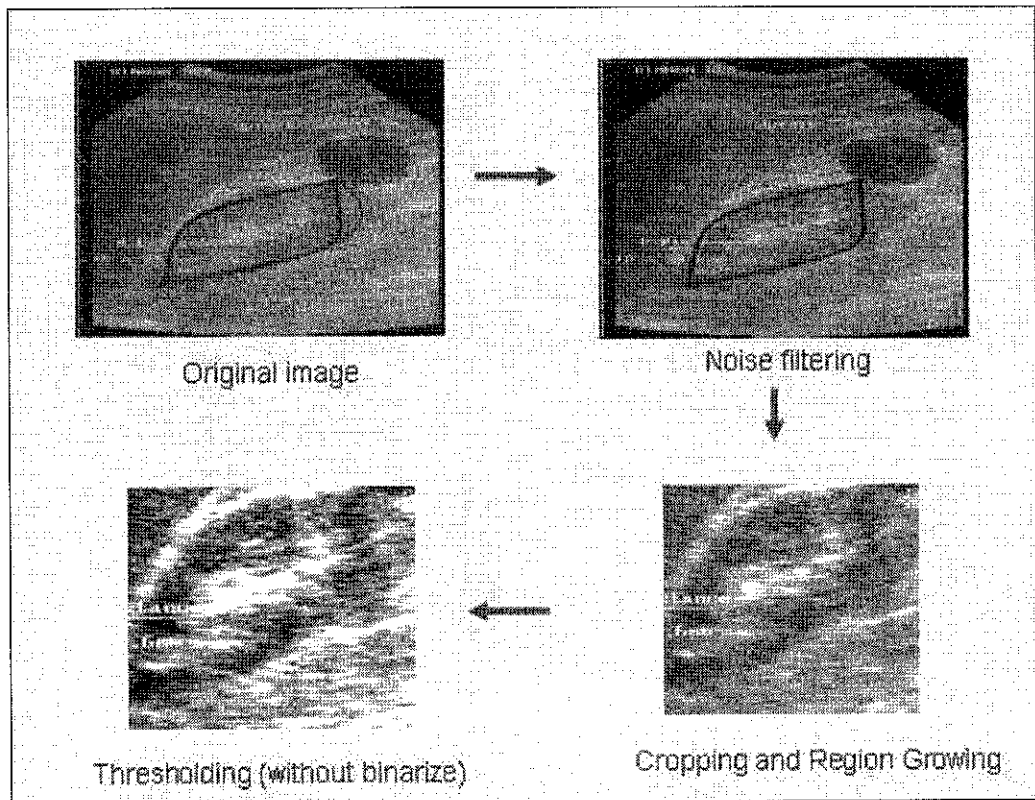**Figure 4.8**: Image enhancement process techniques

From Figure 4.8, there are three process was done during the enhancement process. Noticed that for kidney image, histogram equalization play a big role before segmentation part taken into account. This is because the resolution of the raw image on kidney tissue.

The value of thresholding on this case is 15. The value obtained is also based on trial-error basis, which is the trial starts with value of 5. Based on radiologists analysis, the process image is successfully enhanced. The suggestion made is to try out with bigger threshold value.

Case 2: Glomerulonephritis

Figure 4.10: Raw image and processed image of Glomerulonephritis

Figure 4.11: Image enhancement process techniques

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For case number two of kidney disease, it is called as glomerulonephritis disease. For this image, doctor has specifically detected the location of the cysts. In filtering the raw image, median filtering technique is used rather than peak-and-end valley method. This is because the resolution of the location in the cysts is very low. Besides, the background of the whole image is also low in resolution.

After cropping the desired part (location of the cysts), region growing method is applied. Based on the analysis of radiologist and nephrologists, the process image is successfully enhanced. This result based on the final image where the intensity of the part where cysts located can be identified.

4.2   Discussion of Results

From both the results of liver and kidney images, the results obtained are the visible output after Digital Image Processing (DIP) techniques being applied for various types of images. From the entire figure showing the before and after enhancement process, it shows that the DIP techniques can be used for enhancing images especially for images consist of soft tissue.

Based on the analysis, it shows that all the techniques used in enhancing the images are based on trial-and-error concept. It means that, different image will give different techniques in enhancing the image. This is because each image has different criteria. Based on this, four factors have been identified in order for determining the techniques used in enhancement process: resolution, size, technique in capturing image and ultrasound equipment used by the radiologists.

4.2.1   Resolution

Sampling is the principle factor determining the spatial resolution of an image. Resolution is the smallest discernible detail of an image. It simply refers to the smallest number of discernible line pairs per unit distance (example 100 line pairs per millimeter).By referring to the raw images of liver and kidney ultrasound images, it consists of two types of image: film-type (analog) image and digital image. Noticed that for different type has different value of resolution. Due to hardware considerations, the number of gray levels usually differ pertaining different hardware. Hence, in this project analysis, a basis technique in achieving the best result of enhanced image cannot be simply obtain since it uses two types of image.

Refer to Table 4.1 to see different resolution of image on liver disease.
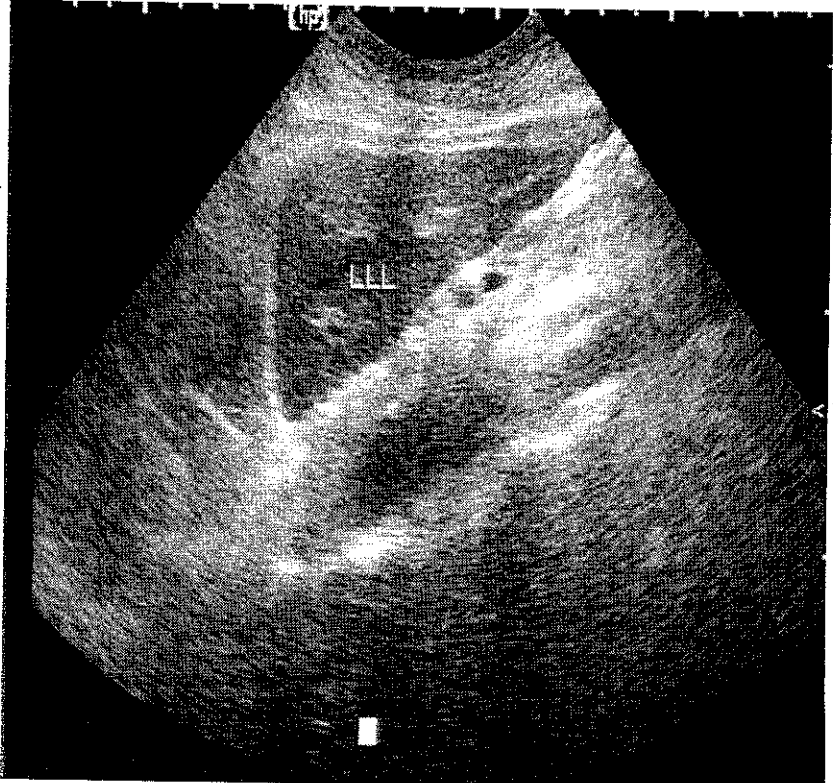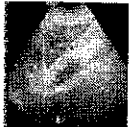
4.2.2   Size

Size of image does not give big impact to the analysis of the processed image. Hence, size does not play a vital role in determining the best technique in

acquiring best processed image. But, it yet still considered as one of the factor in determining the quality of the processed image.

4.2.3 Technique in capturing image

Basically, the quality of an image refers to the person who handles taking the ultrasound image. An image which is sharp is refers to high quality ultrasound image. So, this third factor relies on the experienced of those radiologists who captured the ultrasound image.
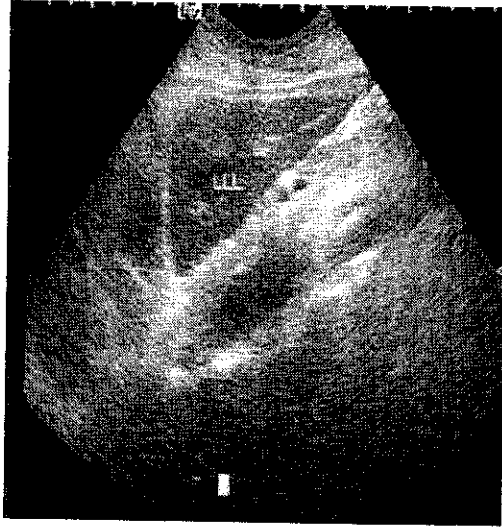
Table 4.1: Image size of 64*64, 128*128,256*256 and 512*512

Resolution /Pixels	Image
Original image	
64 * 64	
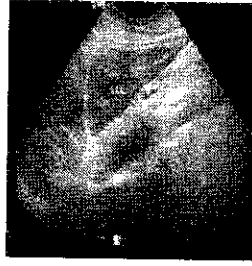
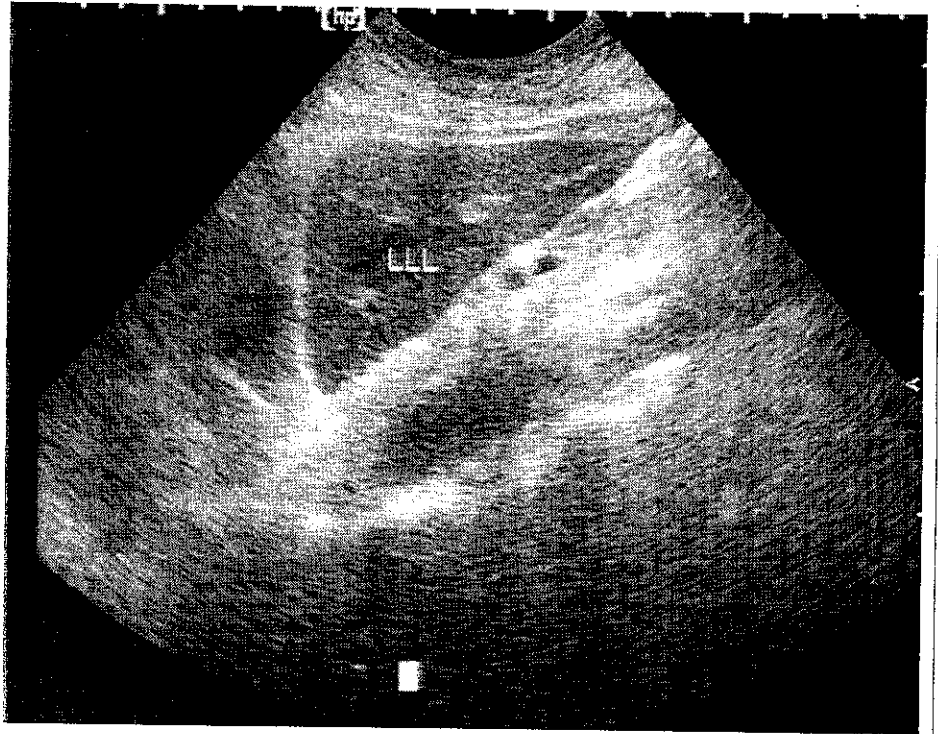| 128 * 128	
256 * 256	
512 * 512	

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1   Conclusion

This project has basically managed to cover the scope of study which is "Enhancement of Liver and Kidney Ultrasound Images by Using Digital Image Processing Techniques". The objective of this study is to apply the techniques of Image Processing in targeting of enhancing the quality of liver and kidney images. The simulation by using distinguishes software such as Matlab 6.1 and Borland C++ was done to establish a base case study which provides input in terms of quality of the process images. This input was used later to generate better liver and kidney images that provide a clearer image to doctors, radiologists as well as physicians, so that diagnostic of both diseases can be done easily.

From the simulation of the software, it was found that there was a difference results pertaining for different images. This is due to the different criterion such as resolution and size of each one of the images. Besides, different type of image gives different result. The best result was obtained by using Matlab 6.1 on the kidney image, but this does not means that others were not applicable. Yet, it shows that the study has to be prolonging in order to get the best result in the final stage.

In the stage of processing the images, Image Processing principles are used as a general background for the simulation. The analysis is used as a targeting tool rather than design the new coding. By having a Matlab 6.1 built-in simulation, the processing of the images can simply be done since both of them are easily accessible. Setting a total of 25 images of liver and kidney images can ensure that the final result is triumph or not. Respective doctors will analyze this later. This study has successfully applied some of the technique

of Image Processing in developing good-processed images. Up to now, all ten images of liver and fifteen images of kidney have been processed. The outcomes still need to be brush-out since the result is not applicable for all images. This shows that the specific imaging procedures may not be well matched at different type of image.

5.2   Recommendations

The simulation done in this study based on simple conceptual techniques of Digital Image Processing (DIP). Further improvement on the simulation of liver and kidney images is necessary in order to make the analysis more realistic. In prompt to that is to focus on enhancing all the images by using Neural Network system and Global Lab simulation.

In the future, as a continuation, it is highly recommended that this project is being pursuit by the integration of Electrical & Electronics Engineering student from UTP together with Radiologist Student from other universities to cover the field of study on the enhancement of ultrasound images. This is because the student found difficulty in analyzing the raw images and processed images.

Besides that, Universiti Teknologi PETRONAS should have a good collaboration with hospitals, especially personnel from Radiologist department. This is to ensure that the process of acquiring the image can be easily completed. In addition, the analysis of processed image can be conducted within two parties.

Knowledge on programming, especially in Java is very crucial since current technology on filtering noise of ultrasound image is mostly used Java Script. Consequently, in order to keep in pace with the latest technology, it is recommended the study continue with good knowledge in Java.

CHAPTER 6

6.0   REFERENCES

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APPENDICES

Appendix 1

```
function RMAP = region_grow(IN, RMAP, v, h, tolerance, center)

%get size of image

[a,b] = size(IN);

%find max of image and determine tolerange step

imax = max(max(IN));
tstep = tolerance*imax;

%grow the region

for j = -1:1,
  for k = -1:1,
    if (v+j) > 0 & (h+k) > 0 & (v+j) <= a & (h+k) <= b
        if RMAP(v+j, h+k) == .5
          diff = abs(IN(v+j, h+k) - center);
          if diff < tstep
            RMAP(v+j, h+k) = 1;
            RMAP = region_grow(IN, RMAP, v+j, h+k, tolerance, center);
          else
            RMAP(v+j, h+k) = 0;
          end
        end
    end
  end
end
```

Appendix 2

```
I = imread ('image1.jpg');
F = inline ('max(x ( : ))');
I2 = nlfilter (I,[3,3],f);
imshow (I)
figure, imshow (I2)
```

Appendix 3

```
I = imread ('image1.jpg');
h = fspecial ('average',5);
I2 = uint8(round(filter2(h,I)));
Imshow (I)
Figure, imshow (I2)
```

Appendix 4

```
imshow image2.tif
I = imcrop;
Imshow (I)
```

Appendix 5

```python
# histogram equalization

import operator

def equalize(h):

    lut = []

    for b in range(0, len(h), 256):

        # step size
        step = reduce(operator.add, h[b:b+256]) / 255

        # create equalization lookup table
        n = 0
        for i in range(256):
            lut.append(n / step)
            n = n + h[i+b]

    return lut

#
# test stuff

if __name__ == "__main__":

    import Image

    im = Image.open("/usr/iv/tip/images/clenna.im")

    # calculate lookup table
    lut = equalize(im.histogram())

    # map image through lookup table
    im = im.point(lut)

    im.save("out.ppm")
```
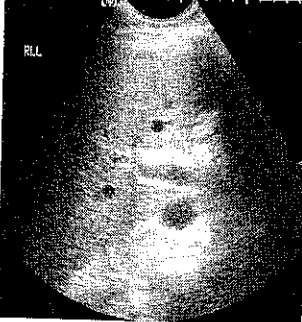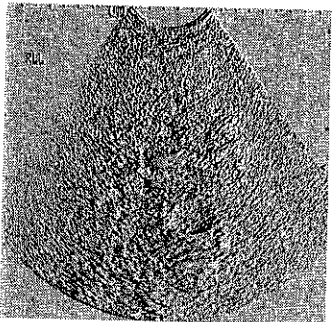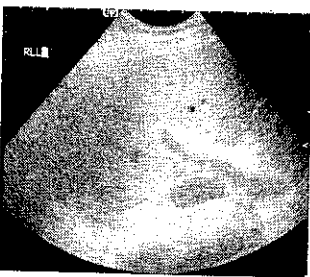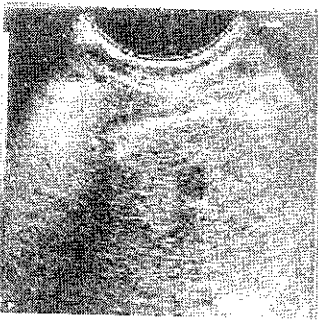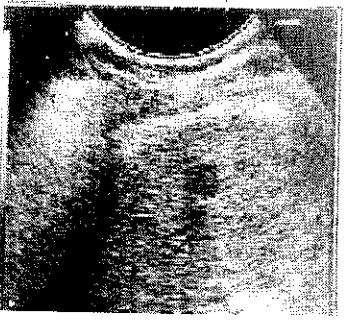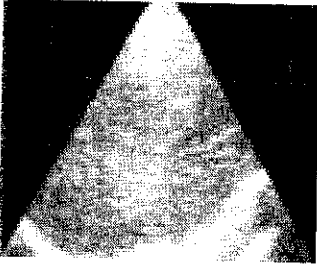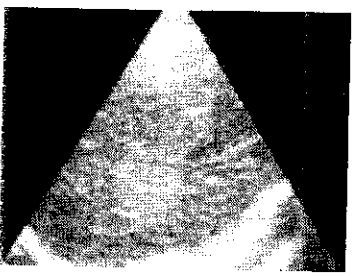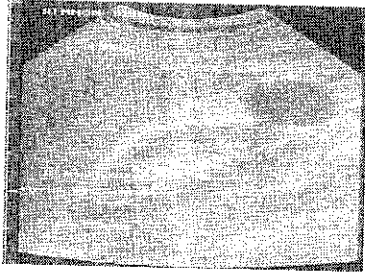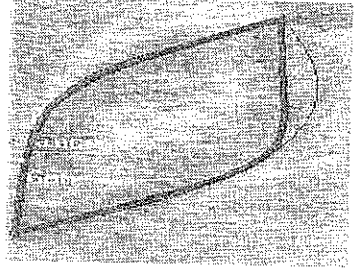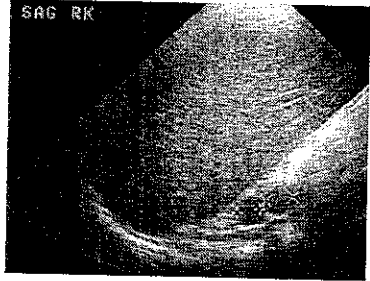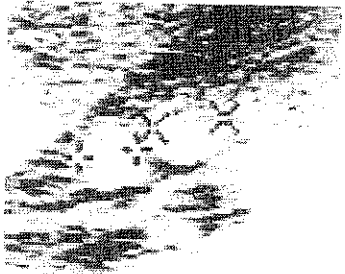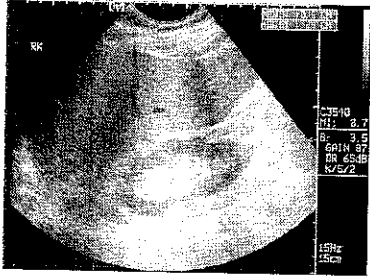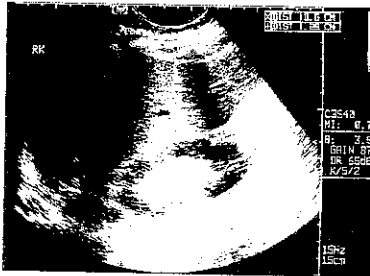
Appendix 6

Image	Description	Before	After
1	Liver: Rectal Carcinoma		
2	Liver: Rectal Carcinoma		
3	Liver: Cirrhosis		
4	Liver: Cirrhosis		

5	Kidney: Nephrotic Syndrome		
6	Kidney: Proteinuria		
7	Kidney: Glomerulonephritis		

NO	ACTIVITY / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Selection of Project Title	▓	▓	▓												
2	Preliminary research			▓	▓											
3	Submission of Preliminary Report				●											
4	Tools Identification					▓	▓	▓								
	- Liver and Kidney disease					▓	▓									
5	Image Processing principles familiarization					▓	▓	▓	▓	▓	▓	▓	▓	▓		
6	Ultrasound Principles									▓	▓	▓	▓	▓		
7	Image acquisition									▓	▓	▓	▓	▓	▓	▓
8	Submission of Interim Report													●		
9	Oral Presentation															●

▓ Process
● Submission

Gantt Bar Chart for Semester 2

NO	ACTIVITY / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Continue with Image Segmentation	▓	▓	▓	▓											
	- thresholding technique															
2	Novel Bayesian Method	▓	▓	▓	▓											
4	Multiscale Method:Noise filtering			▓	▓	▓	▓	▓								
5	Enhancing image	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
6	Progress Report I				●											
7	Progress Report II								●							
8	Exhibition and consult radiologists											●				
9	Final Report/Dissertation													●		
	Oral Presentation															●

▓ Process
● Submission