UNIVERSITI MALAYSIA PAHANG

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JUDUL: **ECHOCARDIOGRAM : LEFT VENTRICLE CHAMBER DETECTION USING IMAGE PROCESSING**

SESI PENGAJIAN: 2011/2012

Saya   THOIEBAH BINTI AHMAD MUKHTAR (880926-02-5892)
(HURUF BESAR)

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F-09-02 , PPR SRI SEMARAK, JALAN AYER KEROH, 53300 KUALA LUMPUR W.PERSEKUTUAN(KL).

CIK FARADILA NAIM

(Nama Penyelia)

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ECHOCARDIOGRAM: LEFT VENTRICLE CHAMBER DETECTION USING IMAGE PROCESSING

THOIEBAH AHMAD MUKHTAR

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Electronics)

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Universiti Malaysia Pahang

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

Signature   :

Name   : MISS FARADILA NAIM

Date   : 21. 6. 2010

Signature   : _____

Author   : THOIEBAH BINTI AHMAD MUKHTAR

Date   : 21st JUNE 2010

DEDICATION

Specially dedicated to

AHMAD MUKHTAR BIN MAHMUD
HASNAH BINTI DIN
HABSAH BINTI AHMAD MUKHTAR
ATIQAH BINTI AHMAD MUKHTAR
FATHIAH BINTI AHMAD MUKHTAR
THOLHAH BINTI AHMAD MUKHTAR
AMIRUL AMIN BIN AHMAD MUKHTAR
AMIRAH BINTI AHMAD MUKHTAR
AMIRUDIN ARIF BIN AHMAD MUKHTAR

lecturers

and

friends.

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ABSTRAK

Ventrikel kiri adalah salah satu daripada empat ruang di dalam jantung manusia. Ia menerima darah beroksigen daripada atrium kiri melalui injap mitral dan dipam ke dalam aorta melalui injap aorta. Kegagalan injap jantung boleh memberi kesan kepada produktiviti penghantaran darah ke bahagian lain tubuh manusia. Kesan kegagalan ini akan membawa kepada kematian. Ekokardiogram merupakan ujian diagnosis untuk mengesan penyakit yang berpunca daripada jantung. Kajian ini adalah berdasarkan video ekokardiogram yang telah diambil daripada Hospital Universiti Kebangsaan Malaysia (HUKM). Video yang diambil ini merupakan video pesakit injap jantung kiri. Kajian dilakukan dengan memproses video tersebut sehingga terhasilnya imej statik. Daripada imej statik tersebut, proses imej telah dilaksanakan untuk mendapatkan saiz ventrikel kiri jantung. Objektif bagi kajian ini adalah untuk mengesan sifat-sifat ruang jantung daripada imej ekokardiogram yang diambil daripada pesakit di HUKM. Dalam kajian ini, analisa saiz injap jantung telah dilakukan. Teknik pemprosesan imej digunakan untuk mengesan saiz atau diameter ruang ventrikel kiri. Hasil yang dijangka adalah untuk membangunkan antara muka pengguna grafik (GUI) yang berkebolehan mengimport imej ekokardiogram dan memaparkan parameter menggunakan simulasi MATLAB.

ABSTRACT

The left ventricle is one of the four chambers in the human heart. It receives oxygenated blood from the left atrium through the mitral valve and pumped into the aorta through the aorta valve. Heart valve failure could affect the productivity of the delivery of blood to other parts of the human body. The effect of this failure will lead to death. Echocardiogram is a diagnostic test to detect heart diseases. This study is based on the echocardiogram video taken from the Hospital Universiti Kebangsaan Malaysia (HUKM). This video is a video taken of patients left ventricle valves. The study was done with the video processing to generation of static images. From the static image, the image has been carried out to obtain the size of the left ventricle of the heart. The objective of this study was to detect the properties of cardiac chamber echocardiogram images taken from patients. In this study, an analysis of the size of the heart valves has been committed. Image processing techniques used to detect the size or diameter of the left ventricular chamber. Results are expected is to develop a graphical user interface (GUI) with the ability to import and display parameters echocardiogram images using MATLAB simulation.

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CHAPTER 1

INTRODUCTION

1.1   Overview

The left ventricle (LV) is the largest chamber of the heart. The chamber consists of two valve which is mitral valve and aortic valve. It receives oxygenated blood from the left atrium via the mitral valve, and pumps it into the aorta via the aorta valve. The failure of heart valve can give effect to unproductive of blood delivery to the other part of human body. A major problem of LV namely Mitral Valve Prolapse (MVP) where a condition in which the heart's mitral valve does not work well. The flaps of the valve are "floppy" and do not close tightly. These flaps normally help seal or open the valve. Much of the time, MVP does not cause any problems. Rarely, blood can leak the wrong way through the floppy valve. This can lead to palpitations, shortness of breath, chest pain, and other symptoms. Figure 1 below show the MVP condition.
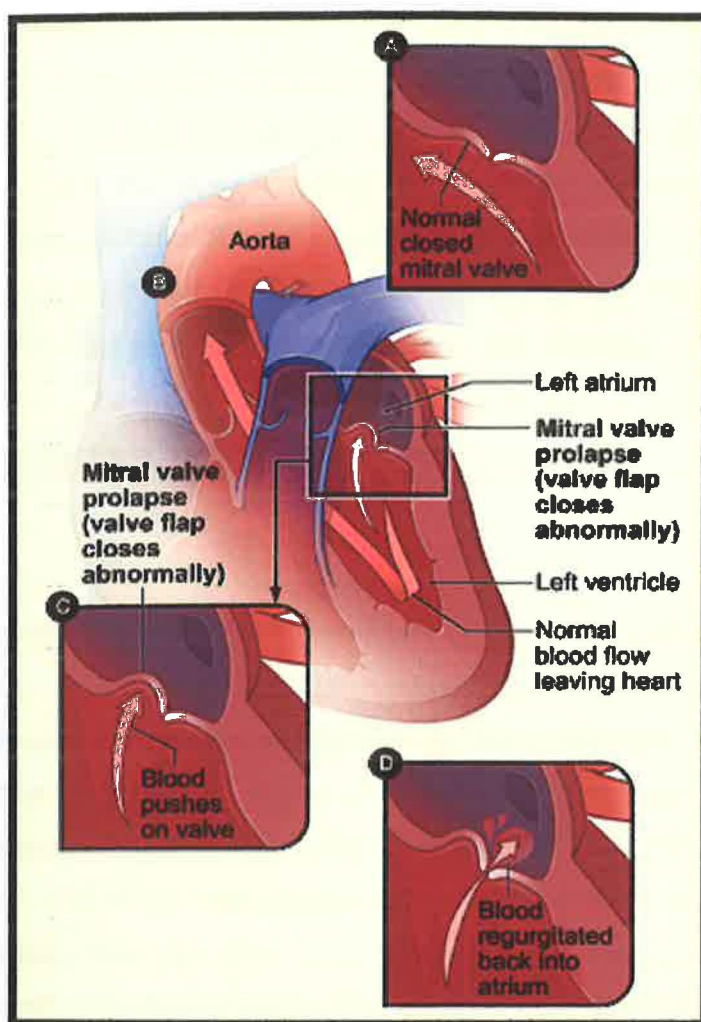
Figure 1.1: (A) A normal mitral valve. The valve separates the left atrium from the left ventricle. (B) A heart with mitral valve prolapses. (C) A close-up view of mitral valve prolapses. (D) A mitral valve that allows blood to flow back into the left atrium.

One of the methods to identify this problem is through an echocardiography (echo) also known as cardiac ultrasound. Echo is a painless test that uses sound waves to create moving pictures or video of heart. The pictures show the size and shape of heart. They also show how well heart chambers and valves are working. Echo also can pinpoint areas of heart muscle that are not contracting well because of poor blood flow or injury from a previous heart attack. A type of echo called Doppler ultrasound shows how well blood flows through heart chambers and valves. Echo can detect possible blood clots inside the heart, fluid buildup in the pericardium (the sac around the heart), and problems with the aorta.

This project is a part called *"Biomechanical Analysis and Prediction on Heart Valve Behavior by Fluid Structure Interaction Approach"* research done by the member of Faculty of Mechanical Engineering. The information obtained by the project based on the prediction can be made through engineering concept of fluid structure interaction. Based on this study, the concept will be applied by numerical simulation and next to be implemented into a software form to be used in the medicine practice. With this tool, medical practitioners can easily monitor and predict the current properties of heart valve so that they can decide on the prevention method. This study also will analyze the element of velocity, pressure, friction and strength of the cardiovascular system focusing to the heart valve.

To obtain the simulation concept using fluid structure interaction, the echo video need to processed. The echo video need to process because to get the static image before continue to the next step of image processing technique using Matrix Laboratory (MATLAB) simulation software. The software was used for image processing to detect and measure the diameter of the left ventricular area. The image processing technique and the basic mathematical calculation was applied to get clearer image and the size of left ventricle area. As a result, the size of area can be obtained and will be shown on graphical user interface.

1.2   Problem statement

This project is a part of a main project called *"Biomechanical Analysis and Prediction on Heart Valve Behavior by Fluid Structure Interaction Approach"* from Faculty of Mechanical Engineering research project. Researcher involved in providing data only, which is the size of the LV chamber. Researchers take the responsible for this project after getting echo video from the hospital and began to process until get the static image. The image processing technique and the basic mathematical calculation was used to get clearer image and the size of LV chamber area. The problem statement in this project is about how to detect the area of the LV chamber from an echo image and how to measure the size of LV chamber image processing technique.

1.3   Project Objectives

Each project must have the objective to state the purpose of the project or what you are trying to achieve through the investigation. So, for this project, there are two (2) main objectives which are;

   i.   To detect the area of left ventricle chamber from echocardiogram video taken from patient in Hospital Universiti Kebangsaan Malaysia (HUKM).
   ii.   To measure the size of left ventricle chamber using image processing technique.

1.4   Project Scopes

The project scope required to achieve the objectives of this project is to perform image processing. Researchers need to use MATLAB simulation to process one by one video image of the patient because they do not in similar circumstances. The result is a different size of LV chamber.

This project would focus on the image processing technique to measure the LV chamber size for echo images. The clearer image needs to choose so that the accurate size of LV chamber area will be obtained.

1.5   Significant of Study

The significances of study for this project are to facilitate the determination of the heart size for the project called "Biomechanical Analysis and Prediction on Heart Valve Behavior by Fluid Structure Interaction Approach". In addition, it can be used in medical application as a method to identify at an early stage of heart problems that may arise. The technique used is very effectively to get the size and the required parameters.

1.6 Thesis Outline

Chapter 1 contains explanation on the introduction of the project which consists of the review of the problem statement, objectives and scope of the project.

Chapter 2 is more focused on literature review which is the research and studies of this project.

Chapter 3 views the methods that are used in completing the project from the beginning to the end. This includes project flow, analysis and all programming used this project.

Chapter 4 is present full result and discussion of project.

Chapter 5 concludes the overall of the project and which includes the problem and future development.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

The purpose of literature review is to generate the knowledge and ideas that have been established on a topic and also about their strengths and weaknesses are. In this chapter, the researcher has several references that reviewed. The most topics from the references are about echocardiography image processing.

2.2   Heart failure

The term "heart failure" means that the heart isn't pumping as well as it should be. Our body is depends on the heart's pumping action to deliver oxygen and nutrient-rich blood to the body's cells. When the cells are nourished properly, the body can function normally. With heart failure, the weakened heart cannot supply the cells with enough blood. This results in fatigue and shortness of breath. Everyday activities such as walking, climbing stairs or carrying groceries can become very difficult. Heart failure is a serious condition, and usually there's no cure. The normal heart is a strong and the muscular pump a little larger than a fist. It pumps blood continuously through the circulatory system. [11]

2.3   Mitral Valve Prolapse

Mitral valve prolapse is a bulging of the mitral valve when the heart contracts (squeezes). The heart is divided into four (4) chambers. These chambers fill with blood, which is then pumped throughout the body to supply nourishment. Four valves open and close to assist this pumping action. This allows the blood to move in a forward direction. The mitral valve is a heart valve made of two (2) tissue flaps, called leaflets, which open and close. It is located between the upper chamber (atrium) and lower chamber (ventricle) on the left side of the heart. A deformity in the mitral valve can keep the leaflets from closing well. Sometimes it allows small amounts of blood to flow backward in heart. Most of the time, however, mitral valve prolapse causes no symptoms and no problems. [16]

2.4   Heart diagnose

Valve disorders can usually be diagnosed by listening to the heart with a stethoscope. When a valve is damaged and fails to close or open completely, blood will create a swirling current as it is squeezed through a narrow opening or regurgitated in the wrong direction, and a murmur is produced. An electrocardiogram (ECG) and chest X-ray are two diagnostic techniques that can provide important information about heart size and activity. They may, for example, reveal that the heart is enlarged, which is often a sign of heart valve or other cardiac disease. However, while both these methods are useful for detecting valve disorders, they are not especially helpful in making a specific diagnosis. A major diagnostic tool in assessing valve disorders is echocardiography, a noninvasive and painless procedure that has revolutionized the evaluation of heart diseases. In echocardiography, high-frequency sound waves (like sonar waves) are bounced off the heart's tissues, allowing physicians to visualize the shape and motion of the valves, the size of the valve's opening, and the thickness of chamber walls. One variety of this procedure, called Doppler echocardiography, makes it possible to measure the speed and flow of blood and is particularly helpful in assessing to what extent a valve is stenosis or leaky. While these procedures are more definitive, they are expensive and often not necessary for making a diagnosis. [13]

Although heart failure is a common clinical syndrome, especially in the elderly, its diagnosis is often missed. A detailed clinical history is crucial and should address not only current signs and symptoms of heart failure but also signs and symptoms that point to a specific cause of the syndrome, such as coronary artery disease, hypertension or valvular heart disease. It is important to determine whether the patient has had a previous cardiac event, in particular a myocardial infarction. The physical examination should include Valsalva's maneuver, a test that is highly specific and sensitive for the detection of left ventricular systolic and diastolic dysfunction in patients with heart failure. An electrocardiograph and a chest radiograph should also be obtained. Two-dimensional echocardiography of the heart

helps differentiate systolic from diastolic dysfunction. Coronary angiography is indicated in patients with heart failure and anginal chest pain and should be strongly considered in patients with an electrocardiogram suggestive of ischemia or myocardial infarction. [14]

An echocardiogram, which is an ultrasound of the heart, is the best way to diagnose mitral valve prolapse. The picture made by the sound waves shows the prolapse, any thickening of the valve leaflets, and any leakage of blood through the prolapsed valve. An echocardiogram can show if you have badly thickened and stretched valve leaflets, which may mean you have a higher risk of serious problems. [16]

2.5   Edge Detection Method

K Wang, AJ Sims and A Murray (2009) was compared the effects of 2D and 3D first order derivative edge detectors with similar size on accuracy and repeatability in six volume measurement methods of 3D echo images of a laboratory balloon phantom. Overall accuracy was better for 3D than 2D. 3D operators show potential for better performance with 3D echo images. 3D echocardiography offers great potential for accurate measurement, but many automated or semi-automated techniques suffer from acoustic noise which can be reduced by suitable choice of edge detectors.[1]

V Ahanathapillai, J.J. Soraghan and P. Sonecki (2009) said that the edge detection is performed using fuzzy logic based on center point detection and a subsequent radial search based fuzzy multi-scale edge detection. The edge obtained is used as the vertices for Delaunay triangulation for enhancement purposes. This method enhances the heart wall region in the echo image. This technique is applied to both synthetic and real image sets that were obtained from a local hospital. [5]

Sheila Chan and Gopalakrishnan Sainarayanan (2006) said that speckle noise and artifacts in echocardiogram may cause edges to manifest themselves in different manners. As a result, edges in echocardiogram are identified with ambiguous definitions and they pose challenges for conventional gradient approximations that typically characterize an edge as an abrupt change in gray-level. Therefore, an approach using fuzzy reasoning that works on a different notion from the typical edge definition is introduced to enhance the boundary of echocardiogram. The fuzzy reasoning employed in the proposed method defines edges by local image characteristics computed based on local statistics of the image. The proposed method addresses the challenge in two levels. Initially, noise suppression is applied without incurring over-blurring across the boundaries. Subsequently, fuzzy reasoning is employed to determine the edginess of each pixel of the enhanced echocardiogram to detect the boundaries. For performance measure, the results of the proposed method are compared to that of a conventional method, qualitatively and quantitatively. [15]

Kalpana Saini, M. L. Dewal, and Manoj Kumar Rohit (2010) were compared different edge detectors based on peak signal to noise ratio on Echocardiographic images. Edge detection is a critical element in image processing, since edges contain a major function of image information. The function of edge detection is to identify the boundaries of homogeneous regions in an image based on properties such as intensity and texture. They have taken Perwitt edge detector, Robarts edge detector, LoG edge detector, Canny edge detector, and Sobel edge detector for this comparison and study. [16]

2.6   Segmentation Method

Vladimir Zagrodsky, Vivek Walimbe, Carlos R. Castro-Pareja, Jian Xin Qin, Jong-Min Song and Raj Shekhar (2005) entitlement that Real-time three-dimensional (3-D) echocardiography is a new imaging process to visualize the complex 3-D shape and motion of the left ventricle. The researchers also introduce a new segmentation algorithm. Their algorithm was validated against expert –defined segmentation and demonstrated acceptable accuracy. An algorithm is fully automatic and has the potential to be used clinically together with real-time 3-D echocardiography for cardiovascular disease diagnosis improvement. [10]

Saulo Guerreiro Lacerda, Adson F. da Rocha, Daniel F. Vasconcelos, Joao L. A. de Carvalho, Iwens G. Sene Jr. and Juliana F. Camapum (2008) proposed a new left ventricle segmentation method in two-dimensional echocardiography images. They have combined two image processing technique with radial search and temporal information to extract the left ventricle boundary. The proposed method can be extracted the borders from sequential images and will present a curve illustrating the area within a cardiac cycle. The new sequential radial search algorithm improved the border extraction from long-axis ultrasound images, especially when the mitral valves were open. Segmentation errors due to low contrast were corrected in this paper. [11]

K. Y. Esther Leung, Marijn van Stralen, Gerard van Burken, Antonius F.W. van der Steen, Nico de Jong and Johan G. Bosch (2010) was developed a fully automated segmentation for 3-D echocardiography using 3-D Active Appearance Models (AAM). This method used ultrasound grey value normalization and employed both regular matching and jacobian tuning. The 3D AAM detected the endocardial contours accurately, even in the presence of large variations in left ventricular appearance and shape. The results show that fully automated AAM analysis is practically feasible in 3DE datasets of mixed origin and quality. [13]

2.7   Another method proposed

M.R.Hassanzadeh, G.R. Ardeshir, and M.R.Karami Mollaei (2009) was proposed two new algorithms for left ventricular (LV) endocardial and epicardial boundary detection from echocardiographic images are presented. The proposed algorithms are Center-Based approach in which the LV center point (LVCP) is estimated using a fuzzy-Based technique and then epicardial and endocardial edge points are searched on radial lines emanating from LVCP. A basic assumption in the first algorithm is that the boundary points of left ventricle are those with sharpest intensity changes, which can be detected as the global maximum wavelet transform modulus. In the second algorithm directional gradient with LVCP references are computed in all directions and all scales using wavelet transform. The images of gradient at different scales are then combined by logical operation to retain only possible boundary points. Mathematical morphology operations are applied to fill the dropouts in the resulting image. Radial search method is then used to find the boundary points. After de-noising by wavelet transform, cubic Bspline approximation method is used to achieve smooth and closed endocardia and epicedial boundaries. Sample experimental results are shown for endocardia and pericardial border identification in 2D short axis (SA) echocardiograms. [17]

2.8   Summary that related to project

Based on existing study, researcher got some idea to use doing this project. The researcher will be use two methods to process echocardiogram images which is using edge detection and segmentation object. Some image need to do hard processing because of the noise and also the blurring images. So, the steps for each image will be different. Besides, in this study, the 2D images were used so it will difficult to detect the edge. The researcher needs to find another solution for the images that have not have clear shape of the left ventricle chamber.

CHAPTER 3

RESEARCH METHODOLOGY

3.1   Introduction

Generally, the methodology provides guidelines to solve problems, with certain components such as phase, tasks, tools, techniques and tools. In this study, the echo videos need to be processed first to produce a lot of image. The image color from the video is RGB image. The images will be through the process of pre-processing image to get a clearer image (filtering) and the area required only (cropping) for detecting and measuring the left ventricle chamber area in echocardiogram image. Figure 3.1 shows the process of digital image processing that already done for this project.
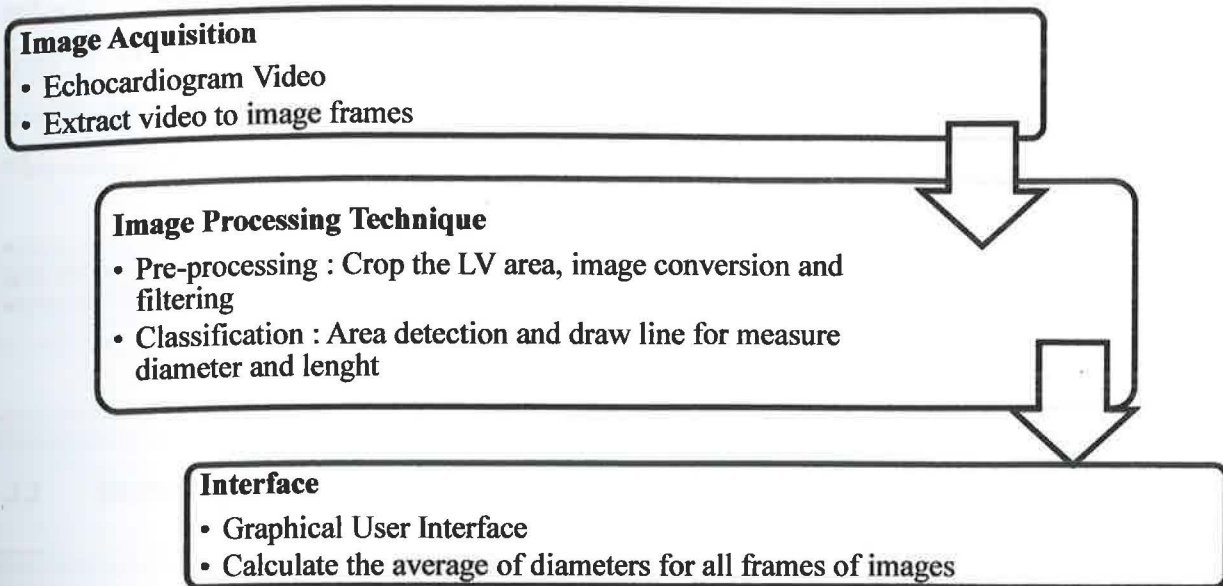
```
┌──────────────────────────────────────────────────────┐
│ Image Acquisition                                      │
│ • Echocardiogram Video                                 │
│ • Extract video to image frames                        │
└──────────────────────────────────────────────────────┘
      ┌──────────────────────────────────────────────────────┐
      │ Image Processing Technique                             │
      │ • Pre-processing : Crop the LV area, image conversion  │
      │   and filtering                                        │
      │ • Classification : Area detection and draw line for    │
      │   measure diameter and lenght                          │
      └──────────────────────────────────────────────────────┘
            ┌──────────────────────────────────────────────────────┐
            │ Interface                                              │
            │ • Graphical User Interface                             │
            │ • Calculate the average of diameters for all frames    │
            │   of images                                            │
            └──────────────────────────────────────────────────────┘
```

Figure 3.1: Digital Image Processing Process

3.2   Image Acquisition

Echocardiogram is a test to determine the movement of the heart through sound waves. Echocardiography is an invaluable tool in providing the doctor with important information about the size of the chambers of the heart, including the dimension or volume of the cavity and the thickness of the walls. The appearance of the walls may also help identify certain types of heart disease that predominantly involve the heart muscle. In patients with long standing hypertension or high blood pressure, the test can determine the thickness and "stiffness" of the LV walls. When the LV pump function is reduced in patients with heart failure, the LV and RV tends to dilate or enlarge. Echocardiography can measure the severity of this enlargement. Serial studies performed on an annual basis can gauge the response of treatment.

Echocardiogram video more easily seen as it can produce more images than x-ray test. Heart beating and heart valves can be examined in greater detail in this video. In this study, digital image processing was done starting from an

echocardiogram video obtained from the HUKM patients. Researchers have gained a total of 30 patients with different video. Echo video can be divided into several images depending on the length of the video recorded and the rates used per second. The coding below is to read the video is;

```
echo = VideoReader(filename);
get(echo)
echo = VideoReader('001.avi');
```

3.3   Image Pre-processing

3.3.1   Cropping

During the pre-processing, image should be to crop until got the LV chamber area without neglecting the existing size. Image need to be crop three times. First of all, the images should be to crop on the triangular region determined by length of heart.
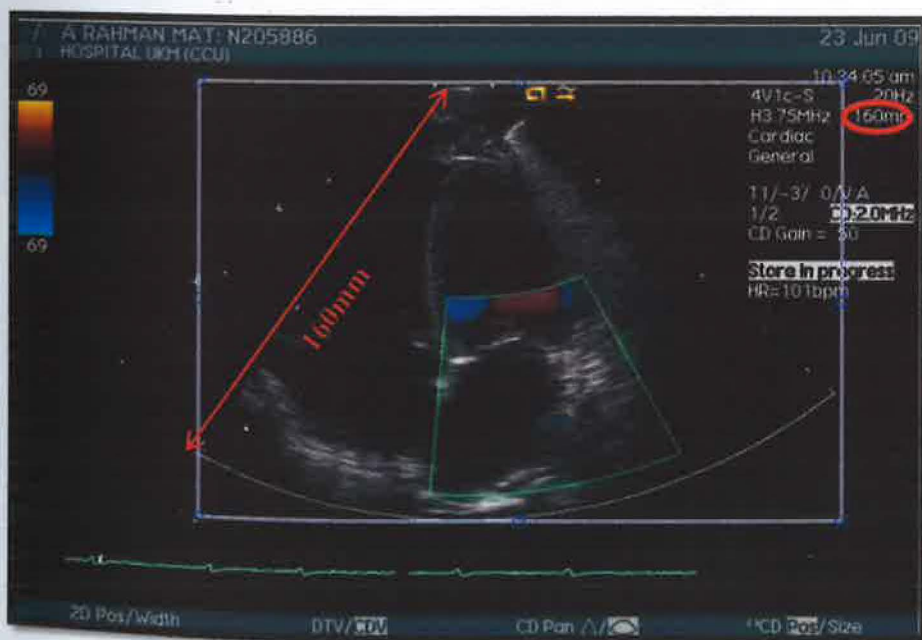

Figure 3.2: First crop image.

At the right corner of the image, it shows the input frequency length of this video. As example, the figure above shows that the image has 160mm input frequency length. Crop should be undertaken in the whole area of the triangle. Coding used is for cropping and rotating process are;

```
imCr1 = imcrop(Im);
imRt = imrotate(imCr1,45);
imCr2 = imcrop(imRt);
FullLen = size(imCr2,1); %The length equivalent to length
```

After that, the image will rotate until the length of the triangle above becomes horizontal.
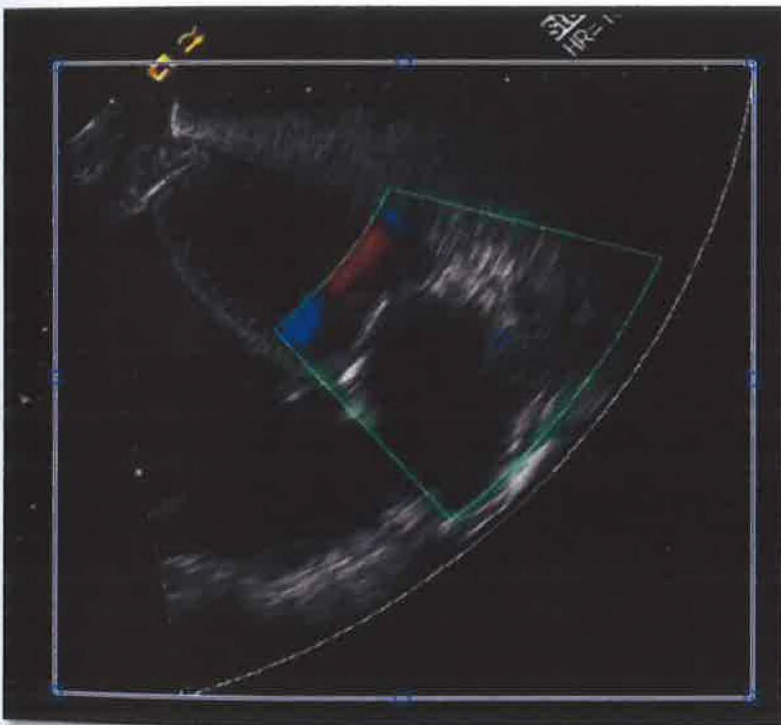

Figure 3.3: Second cropping area image

By using *imrotate (image,angle)* coding, the image will rotates by angle degrees in a counterclockwise direction around its center point. The angle for this image rotation is 45 degree counterclockwise direction from the actual state. Crop should be done again to get the required area only as shown by figure below.
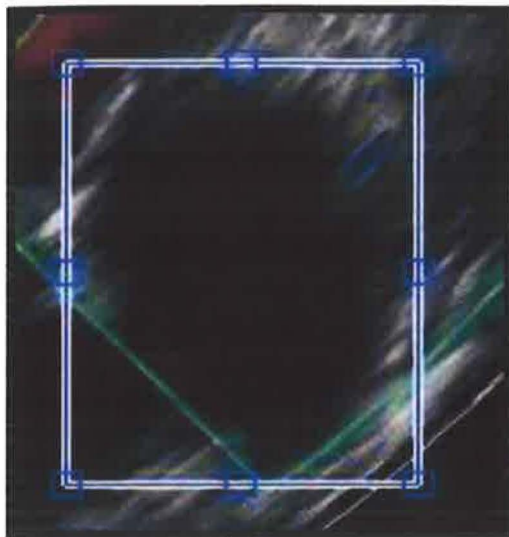

Figure 3.4: Last cropping

Size of each image is different after the images in crop due to a reduction of the original size. Original size is 576x768. First crop image size is 412x542. Then, the second crop image is 439x479 and the last crop image is 167x127.

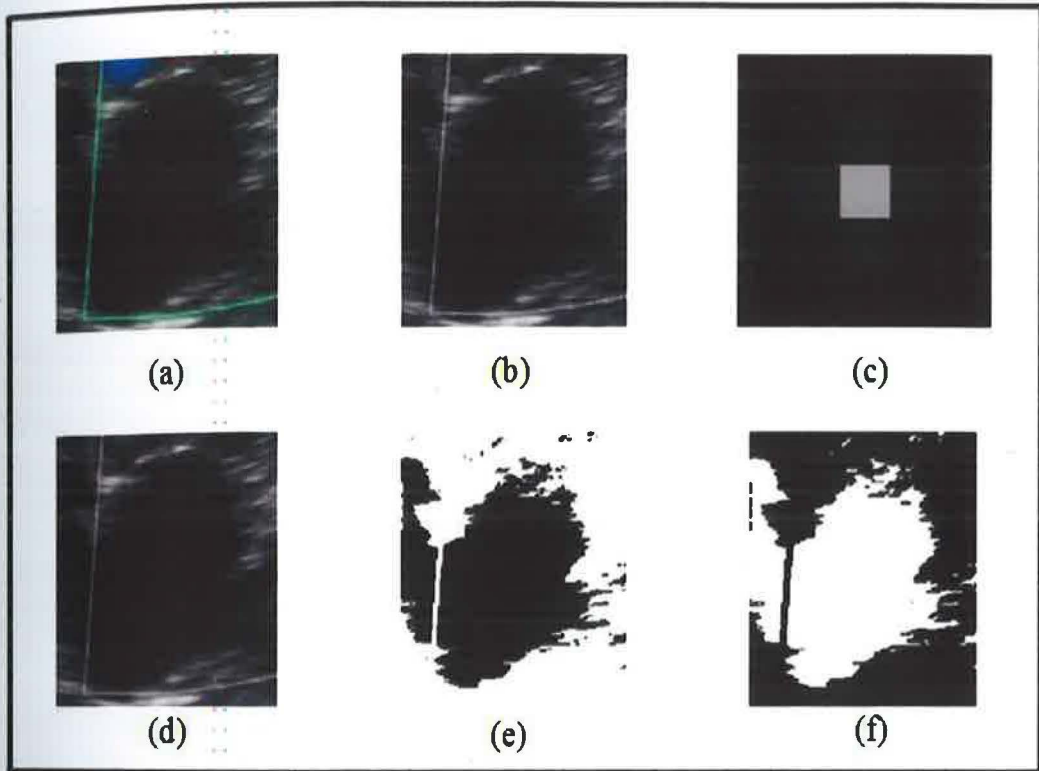### 3.3.2　Filtering

3.3.2.1　Colour conversion

Figure 3.5: Process of image filtering. (a) Original cropping image. (b) Converted image to grey-scale. (c) Filter mask used is Gaussian filter. (d) Filtered image. (e) Converted image. (f) Inverted image.

The first step to process the color conversion is to know the size of the picture. From figure 3.5, image (a) show the original image after the previous step. The image size is [y x z] = [163 145 3]. This image is RGB. So, the image needs to be converted into grayscale for the next process. The coding used for this conversion is *rgb2gray*. As a result, the color conversion can be seen in the image (b).

Next step for the image filtering is by using spatial filtering. Spatial filtering is a continuation of neighborhood operations where some calculation will be done in the neighborhood pixels with the corresponding sub image. This sub image is called by filter or mask or kernel. These sub images have various types that determine the

shape of filter such as average, disk, Gaussian, log, laplacian and many more. For image (c), it shows the filter using Gaussian low pass filter, 5x5 matrixes. The values for the image are shown in figure 3.6.

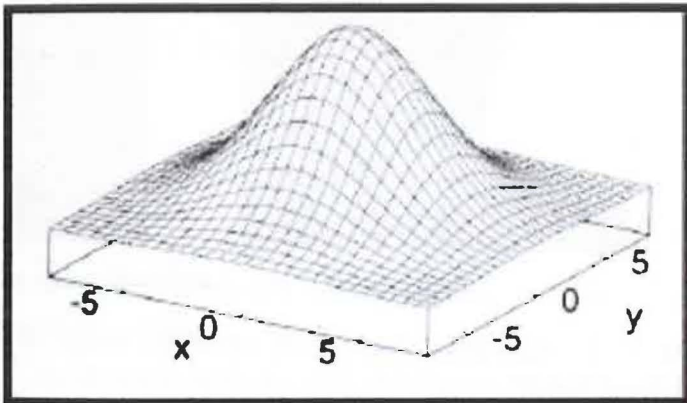| 0.0000	0.0000	0.0002	0.0000	0.0000
0.0000	0.0113	0.0837	0.0000	0.0000
0.0002	0.0837	0.6187	0.0837	0.0002
0.0000	0.0113	0.0837	0.0113	0.0000
0.0000	0.0000	0.0002	0.0000	0.0000

Figure 3.6: 5x5 matrices

Figure 3.7: 3-dimension graph of Gaussian filter 5x5 matrices

The calculation should be made to combine the image with the smoothing Gaussian filter that has been created by using this equation;

$$G_\sigma(x,y) \;=\; \frac{1}{2\pi\sigma^2}\,\exp^{-\frac{x^2+y^2}{2\sigma^2}} \qquad\qquad (\text{ Equation 1})$$

The image (d) is a result by the equation which is the combination of (b) and (c). The image look smoothen than (b).

The method of black white (bw) conversion have been done so that the image only have two value which is, 1 and 0. Image (e) shows the bw conversion. The last step is to get the area needed by invert the image. So, the two value will be changing. Image (f) show the inverting image from the previous image.

3.4 Object Classification

This section is about the object classification after image has been through colour and filtering processing. There have two process namely labelling and colouring the detected area. Besides, the calculated area also will be discussed in this section.

3.4.1 Labelling area

The inverted image has only two colours which is black and white. The process continued to detect the larger area. From the image shown in Figure 3.8, it can see larger area is at (1).
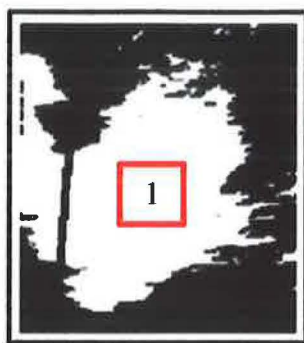

Figure 3.8: (1) The larger area labelled

The entire region will be labelled, before the region detected. The labelling is referring to their pixel value. For example, the inverting image, Figure 3.8 has 36 labels as shown in table below.

No. of label	Value of pixel
1	1814
2	2
3	1
4	1
5	8866
6	2
7	1
8	2
9	3
10	17

11	20
12	2
13	8
14	2
15	5
16	6
17	10
18	3
19	3
20	1
21	5
22	3

23	3
24	1
25	8
26	4
27	1
28	4
29	38

30	1
31	47
32	3
33	5
34	3
35	2
36	1

Table 3.0: Number of label and pixel value

From all labels shown in table 3.0, is seen that, the label that has a maximum value is the fifth label which is 8866. This shows the fifth label is the largest area. The area has been colored in green, after the largest area is detected.

As shown in figure 3.9, there are 6 frame images through the same video that colored in green which is the left ventricle chamber area is detected. The coding used ;

```
maxNumLabel = max(max(imLabel));

AreaLabel = zeros(maxNumLabel,1);
for i=1:maxNumLabel
     [x1,y1] = find(imLabel==i);
     tempA1 = size(x1);
     AreaLabel(i) = tempA1(1,1);
end

LVArea = find(AreaLabel == max(AreaLabel));
[LVr,LVc] = find(imLabel==LVArea);
f2 = f1;
LVlen = size(LVr,1);

for m = 1:LVlen

        f2(LVr(m),LVc(m),1) = 0;
        f2(LVr(m),LVc(m),2) = 255;
        f2(LVr(m),LVc(m),3) = 0;

end
```
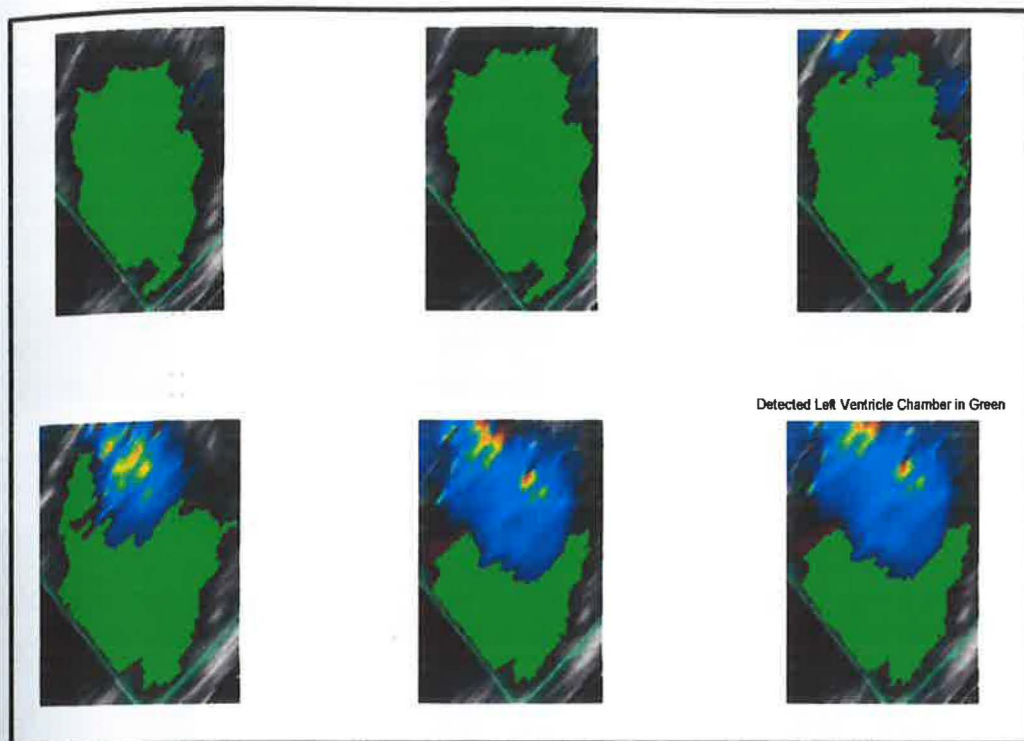
Figure 3.9: Six frames of image that colour in green which is the left ventricle chamber area was detect.

3.4.2   Calculate the Diameter

To calculate the diameter of the left ventricular chamber, the area will be divided to 10 parts. The image division can be as much as possible to get more accurate value. For this research, it only divided to 10 parts and the line is colored with red. A red line in Figure 3.7 shows that the green region was divided into 10 parts.

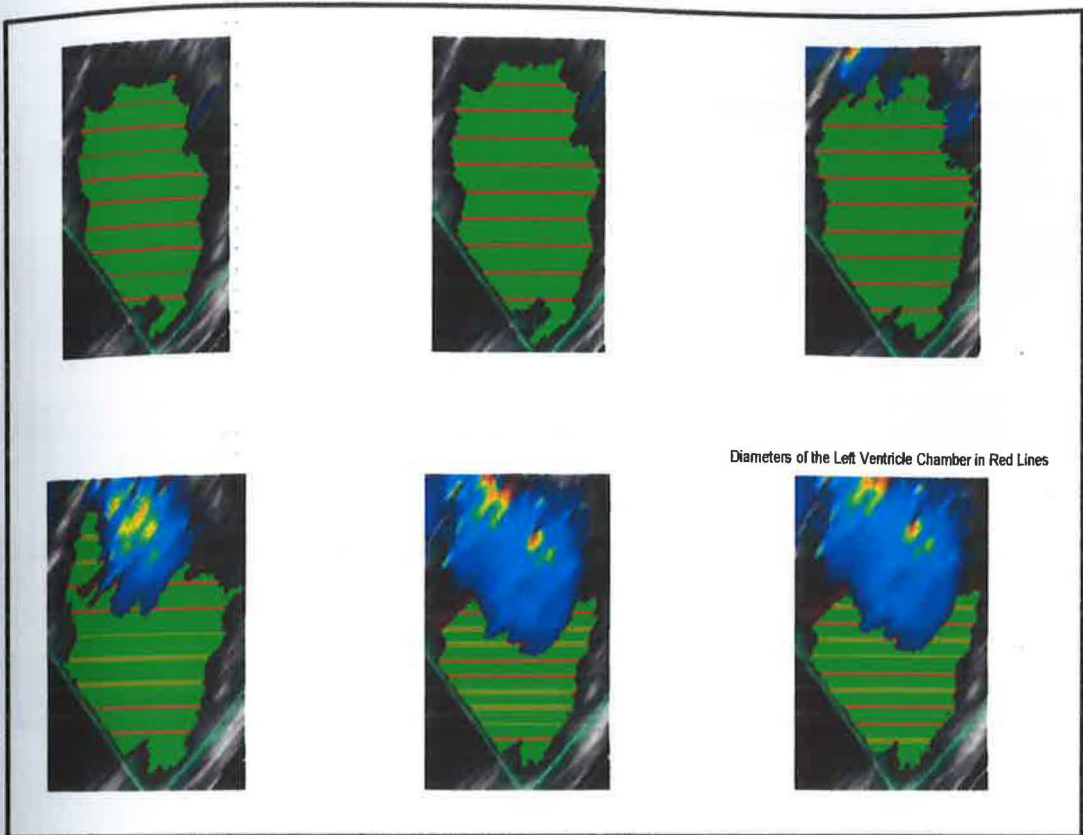Diameters of the Left Ventricle Chamber in Red Lines

Figure 3.10: Six frames of image in same video with red line

The coding used for this redline is;

```
div = 10;
sect = floor((max(LVr)-min(LVr))/10);
sect_div = [min(LVr):sect:max(LVr)]';

diam = zeros(1,div);
f3 = f2;
for w = 1:div
    diam(w) = size(find(LVr==sect_div(w)),1);
    rowLocation = find(LVr==sect_div(w));
    f3(LVr(rowLocation(1:end)),LVc(rowLocation(1:end)),1) = 255;
    f3(LVr(rowLocation(1:end)),LVc(rowLocation(1:end)),2) = 0;
    f3(LVr(rowLocation(1:end)),LVc(rowLocation(1:end)),3) = 0;
end
```
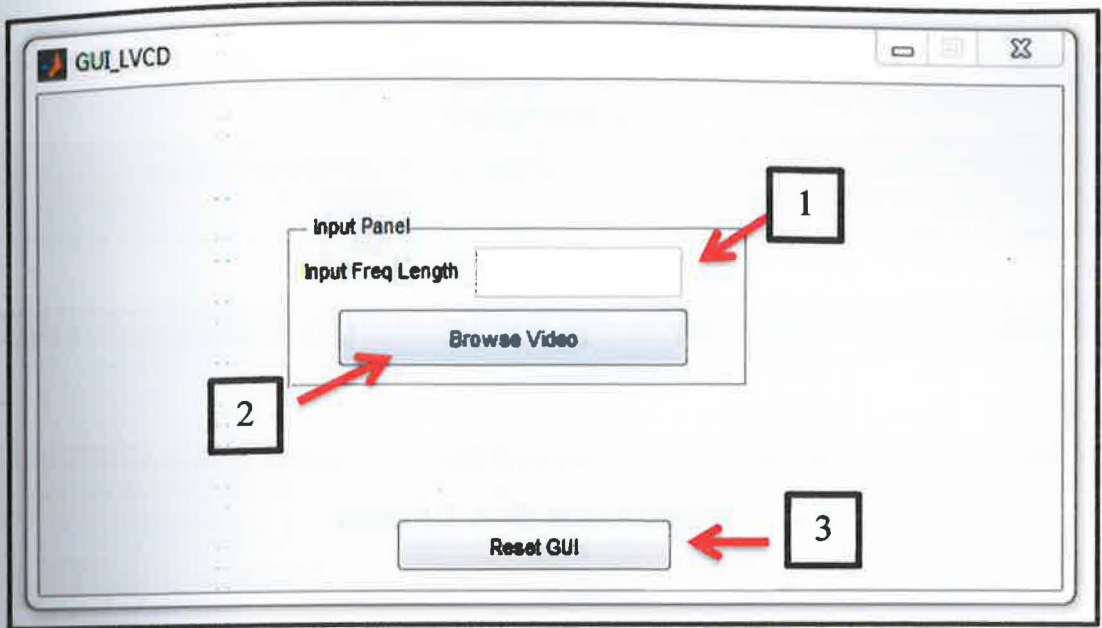
3.5 Interface

Figure 3.11: Graphical User Interface

Graphical User Interface has been developed so that the video can be found easily and images can be processed manually. First step is the input frequency length of video need to insert in space at (1). Secondly, the button Browse Video (2) need to pressed for find a video that has the same input frequency length as that has been inserted in (1). Automatically, a static image will come out, then, the cropping process have made for 6 frames (for example; more frames are processed, the more precise value obtained). In fact, the manual process is only to crop while other processes such as measuring diameter will be undertaken automatically.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter consists of discussions on the results obtained from MATLAB programming. The results will be analyzed with different methods to prove that the method chosen is the best technique. This chapter also shows the results for the whole project and the results are discussed here.

In this project, the method proposed is the simplest process which is based on pixel value to detect the largest area that will determine the left ventricle area. The second process is to measure the diameter.
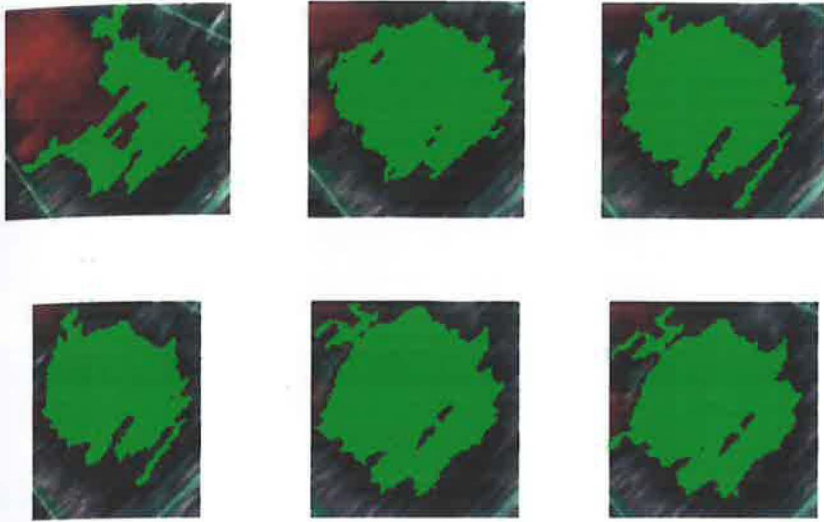
4.2 Detection Region

Figure 4.1: Left Ventricle chamber detected

Based on figure 4.1, the green colour is the detected left ventricle chamber area. According to the pixel value that labelled, the largest area will be colored by green. As a result, the objective to detect the left ventricle chamber for echo image was achieved. Researcher also have difficulty in obtaining clear video to be processed because there are some videos that have a less clear as the image, blurring, crooked and does not meet the required specifications. If the image is clear, sharp and complete the specification, all area of left ventricle chamber will detected with more clearly and accurately.
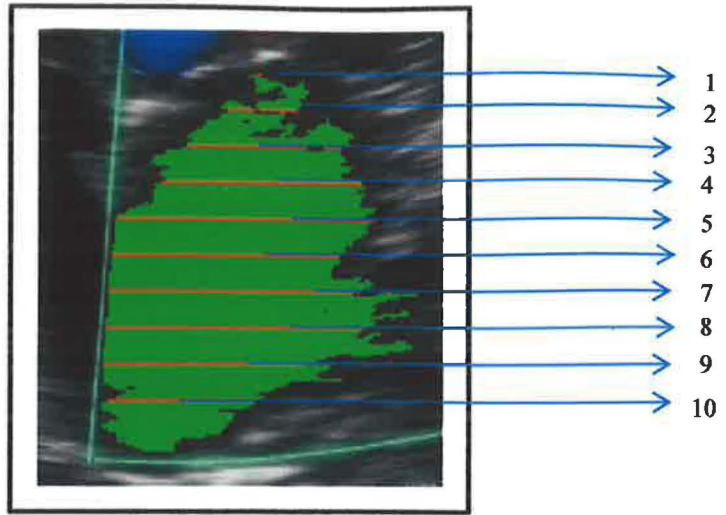
4.3 Left ventricle chamber measurement

Figure 4.2: Green region was divided by 10

To get the diameter of the left ventricle chamber, a green area should be divided into 10 parts as shown in figure 4.2. Each length will have different value. The average diameter has been calculated used this formula;

$$\text{Diameter} = \frac{L1+L2+L3+L4+L5+L6+L7+L8+L9+L10}{10} \qquad (\text{Equation 2})$$

To obtain more accurate results, the images must be processed by combining the results to another. Then, the average for the total frame is calculated by using the same formula.
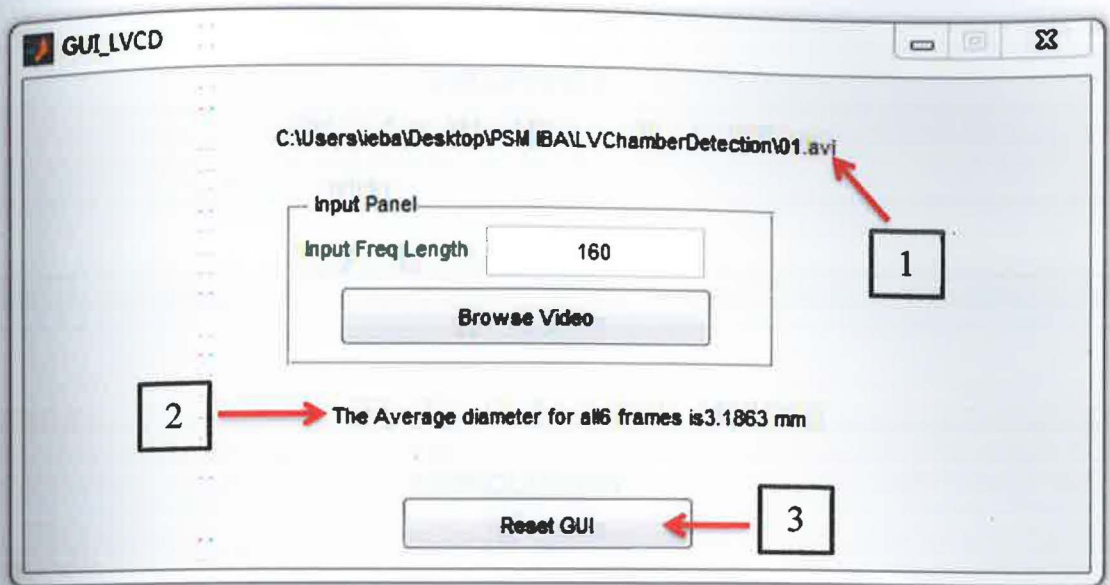
4.3   Interface

Figure 4.3: The diameter result

There have a few steps to use this graphical user interface to get the result. The result will be show as in figure 4.3. Firstly, the input frequency length must been added. The file location will be shown at the above of input panel (1). Then, browse the video that have the same input length. After finish crop all images appear, the result for the average diameter will automatically show at the below off input panel (2). If Reset GUI button was clicked, the process will reset to the original state again.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this final chapter, conclusions for the entire project will be explained here and also proposed to upgrade the system and to overcome any problems that arise during the completion of the project.

5.2 Conclusion

As part of the "*Biomechanical Analysis and Prediction of Behavior Heart Valve Fluid Structure Interaction by the Approach*" projects, image processing is very important because the data obtained the size of the left ventricle is the main factor to continue with an overview of the construction of simulated heart. The data

obtained after the simulation is to continue the implementation of mitral valve replacement in the human heart.

5.3 Recommendation

To obtain more precise results, the researchers would like to propose some suggestions. To the hospital or the medical part, the researcher wants to be stressed of the need to learn the proper way in retrieving the echo video. The videos that get from hospital are very disappointing. Just a little video that can be processed.

Researcher wants to recommend so that the result can save the entire database such as, the result of the length and the figure for each patient left ventricle chamber area.

5.4 Costing and Commercialization

This project can be commercialized to medical and biomechanical teams that want to construct the replacement of ventricle chamber. Where they can get the diameter of the chamber from this development of GUI and they can proceed to their full simulation using Fluid Structure Interaction.

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