Automatic Coronary Artery Detection in Cardiogram Image

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ABSTRACT

The Myocardium Infarction or generally known as MI, is the most dangerous and serious disease that effects the health of the human heart. MI usually attacks and damages the heart muscle by blocking the path of coronary artery. Echocardiography is a widely used imaging technique to examine myocardial function in patients with known or suspected heart disease. In clinical practice, the analysis mainly relies on visual inspection or manual measurements by experienced cardiologists. For researchers, the analysis of myocardium can be done with tissue samples taken from very small areas of interest manually. However, this manual process is tedious and time-consuming, and is vulnerable to error due to human weaknesses. Therefore, this project is aimed to automatically detect the wall of the coronary artery that separates the left and right chambers of the myocardium, so that it becomes much easier to analyze this particular area. In order to achieve this aim, a number of per-processing methods have been applied on the real medical image of the heart from the echocardiography which is performed in an offline manner. These pre-processing operations involved the use of binarizing, down sampling, median filtering, morphological erosion, morphological dilation, logical AND operation and morphological connected component labeling. The classification of the coronary artery area was done based on two features extraction. One is the height to width ratio and another is the label to image area ratio. The performance of the proposed method achieved 90% accuracy based on 10 test samples.

ABSTRAK

Myocardium Infraction atau pun lebih dikenali sebagai MI adalah salah satu penyakit jantung berbahaya yang dihidapi oleh manusia. MI umumnya menyerang dan merosakkan otot jantung dengan menutup laluan ke arteri koronari. *Echocardiography* ialah satu teknik memproses imej yang digunakan secara meluas untuk menguji fungsi *myocardial* seseorang pesakit yang dicurigai mempunyai sakit jantung. Kebiasaannya, analisis dilakukan secara visual dan pengukuran dilakukan secara manual oleh pakar kardiologi yang berpengalaman. Bagi para penyelidik pula, analisis myocardium boleh dilakukan dengan mengambil sampel tisu dari kawasan kecil yang berkenaan. Walaubagaimanapun, operasi manual ini adalah menyusahkan dan membuang masa, dan terdedah kepada kesilapan disebabkan kelemahan manusia. Oleh itu, projek ini adalah bertujuan untuk mencari dinding koronari arteri yang membezakan ruang kanan dan kiri jantung secara automatik, bagi menyenangkan analisis di kawasan ini. Untuk mencapai objektif ini, berberapa operasi pra-pemprosesan secara *offline* dilakukan ke atas imej medikal yang asal, iaitu imej yang diperolehi daripada *echocardiography*. Operasi pra-pemprosesan yang dilakukan antaranya ialah operasi binari, *down sampling*, penapisan penengah, operasi *morphology erosion*, *morphology dilation*, operasi logik DAN dan operasi *morphology connected component labeling*. Dalam projek ini, proses klasifikasi ke atas arteri koronari telah dilakukan berdasarkan dua ciri pilihan. Ciri pertama adalah nisbah antara tinggi dan lebar manakala ciri yang kedua adalah nisbah antara luas label terhadap luas imej. Projek ini didapati mempunyai ketepatan sebanyak 90% setelah ujian dilakukan ke atas 10 sampel terpilih.

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F(x, y)	Grayscale Image.
G(x, y)	Binary Image.
H(x, y)	Resized Image.
E(A,B)	Eroded Operation
D(A,B)	Dilated Operation.
$N_4(p)$	4 Neighborhood pixel relationship.
$N_8(p)$	8 Neighborhood pixel relationship.

LIST OF ABREVIATIONS

MI	Myocardium Infarction .
R1	Ratio of Label Area to Image Area.
R2	Height to Width Ratio.
V	Intensity Value.
B	Structuring Element.
A	Simple binary image.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The heart is the most active organ in the human body. Beating about every second throughout our lifetime, it continuously supplies the body with vital blood. The heart has always played a key role in medical science and has even become a major symbol for life. Its life-sustaining pumping function is realized by its powerful muscular structure the so-called myocardium. Its activity is kept up by an efficient circulatory system of coronary arteries that supplies the muscle with the essential oxygen and nutrients. Silent but progressive occlusion and hardening of the coronary arteries is the main cause for cardiac malfunction. It is caused by a build-up of fatty deposits in the lining of the artery walls a process known as atherosclerosis. The lack of blood supply the so-called ischemia reduces the heart's ability to contract normally. When one or more of the coronary arteries get completely occluded, blood to the heart muscle is cut off and the affected myocardial segments get seriously damaged or even die. This so-called myocardial infarction, also known as "heart attack", often occurs suddenly and may be life-threatening. Coronary artery disease specifically, heart attack is the main cause of long-term disability and death throughout the industrial world. In Europe, about four million people die of cardiovascular disease every year, which is claiming more lives than the next five leading causes of death altogether.

The heart is a restless working muscle that provides blood circulation to the whole human body. At an average rate of 72 times per minute, the heart beats about

100 000 times per day and 30 to 42 million times per year. This corresponds to a daily pumping capacity of about 7200 liters and 2.5 million liters per year. This enormous activity is due to the heart's highly optimized structure and functioning. To be able to understand the origin and symptoms of MI, the heart's basic anatomy and its associated terminology is reviewed in Section 1.2.

Several heart diseases affect the heart muscle and reduce its ability to contract normally The resulting loss in pumping efficiency leads to an undersupply of the vital oxygen to the body, which may seriously harm other organs. The most frequent. source for impaired wall motion is a process called atherosclerosis, which, in its worst case, may lead to a life threatening heart attack. The heart attack disease and its impact to cardiac function is summarized in Section 1.3.

In clinical routine, myocardial dysfunction can be diagnosed by a number of tools including physical examinations, electrocardiograms, blood tests, and, in particular, medical imaging techniques such as echocardiography (ultrasound image);The ultrasound imaging is summarized in Section 1.4

1.2 Basic Heart Anatomy

The heart is a muscular organ that is located between the lungs in the middle of the chest, behind and slightly to the left of the breastbone (sternum). It is surrounded by a double-layered membrane that is called the pericardium. The heart has four chambers as illustrated in Fig.1.1. The two upper chambers are called the left and right atria, and the lower chambers are called the left and right ventricles. The atria act as reservoirs for venous blood; they have a small pumping function to assist ventricular filling. The ventricles are the major pumping chambers that deliver blood to pulmonary (right ventricle) and systemic circulations (left ventricle). The heart's muscular walls are called myocardium. Its outer surface is called the epicardium and its inner lining the endocardium. The wall that separates the left and right atria and the left and right ventricles is called the septum. Four valves ensure that the blood flows only in one direction and prevent blood from leaking backwards

from one chamber to the upstream chamber (valvular regurgitation). The aortic and pulmonic valves are referred to as the semilunar valves and are located at the downstream sides of the left and right ventricle, respectively. The two atrioventricular valves, the mitral and tricuspid valve, are located between the atria and ventricles. The leaflets of the atrioventricular valves are connected to the papillary muscles that are, inturn, connected to the walls of the ventricles. The papillary muscles shorten during the contraction of the ventricles in order to prevent a bulging of the atrioventricular valves towards the atria that would lead to regurgitation**.** The anatomy of the human heart. anterior external view with coronary arteries and veins shows in Figure 1.1.(a) and the internal view shows in Figure 1.1.(b).

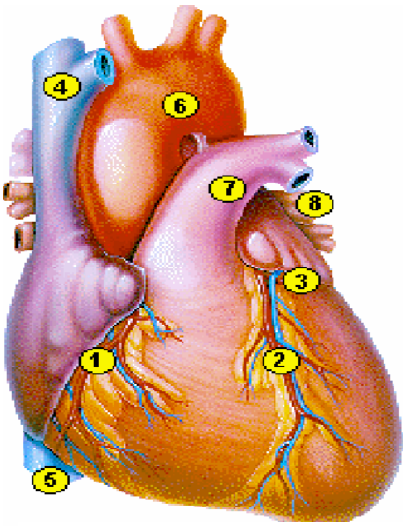

Figure 1.1(a): External View [35]

Parts of external view:

1. Right Coronary (RCA)
2. Left Anterior Descending (LAD)
3. Left Circumflex (LCX)
4. Superior Vena Cava
5. Inferior Vena Cava
6. Aorta
7. Pulmonary Artery
8. Pulmonary Vein

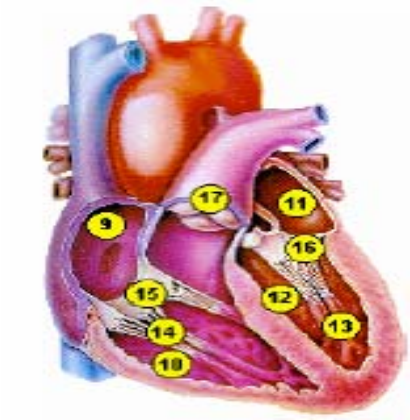

Figure 1.1(b): Internal View [35]

Parts of internal view:

9. Right Atrium
10. Right Ventricle
11. Left Atrium
12. Left Ventricle
13. Papillary Muscles
14. Chordae Tendineae
15. Tricuspid Valve
16. Mitral Valve
17. Pulmonary Valve

1.3 Myocardial Infarction (Heart Attack)

Myocardial infarction (MI) means that part of the heart muscle suddenly loses it's blood supply. Without prompt treatment, this can lead to damage to the affected part of the heart. MI is sometimes called a heart attack or coronary thrombosis.

1.3.1 Understanding the heart and coronary arteries

The heart is mainly made of special muscle. The heart muscle pumps blood into arteries (blood vessels) which take the blood to every part of the body. Like any other muscle, the heart muscle needs a good blood supply. The coronary arteries take blood to the heart muscle. The main coronary arteries branch off from the aorta. (The aorta is the large artery which takes oxygen-rich blood from the heart chambers to the body.) The main coronary arteries divide into smaller branches which take blood to all parts of the heart muscle. The following Figure shows how the blood got blocked during his cycle through coronary artery .

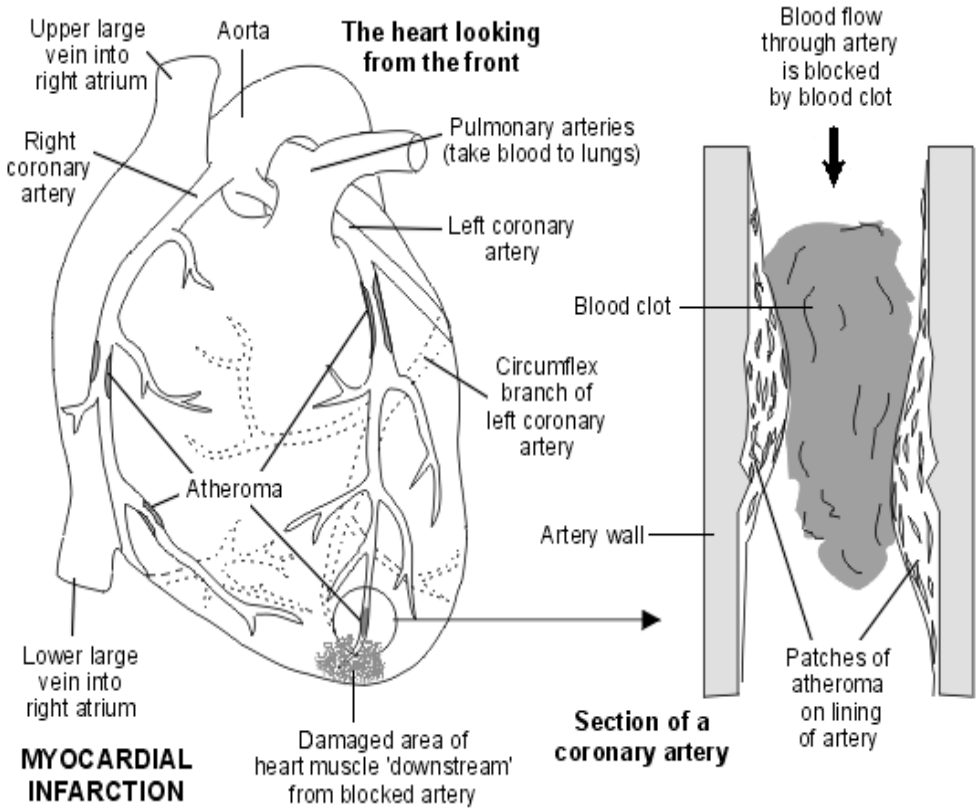

Figure 1.2. Coronary artery got blocked

1.3.2 What happens when someone has a myocardial infarction?

If someone has an MI, a coronary artery or one of it is smaller branches is suddenly blocked. The part of the heart muscle supplied by this artery loses it's blood (and oxygen) supply. This part of the heart muscle is then at risk of damage unless the blockage is quickly undone. (Strictly speaking, 'infarction' means death of some tissue due to a blocked artery which stops blood from getting past.)

If one of the main coronary arteries is blocked, a large part of the heart muscle is affected. If a smaller branch artery is blocked, a smaller amount of heart muscle is affected. In people who survive an MI, the part of the heart muscle which dies ('infarcts') is replaced by scar tissue over the next few weeks.

1.4 Ultrasound Image

1.4.1 Introduction

Ultrasound imaging, also called ultrasound scanning or sonography, is a method of obtaining images from inside the human body through the use of high-frequency sound waves. The reflected sound wave echoes are recorded and displayed as a real-time visual image. No ionizing radiation (x-ray) is involved in ultrasound imaging. Obstetric ultrasound refers to the specialized use of sound waves to visualize and thus determine the condition of a pregnant woman and her embryo or fetus.

Ultrasound is a useful way of examining many of the body's internal organs, including but not limited to the heart, liver, gallbladder, spleen, pancreas, kidneys and bladder. Because ultrasound images are captured in real time, they can show movement of internal tissues and organs and enable physicians to see blood flow and heart valve functions. This can help to diagnose a variety of heart conditions and to assess damage after a heart attack or other illness. The following Figures show the ultrasound machine and the echocardiography image of human heart.

Figure.1.3 (a):Ultrasound machine

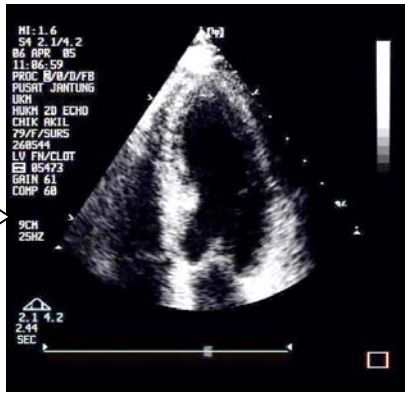

Figure.1.3 (b). Echocardiography image, atypical ultrasound image of human heart.

1.5 Objectives

Thus, the main objective of this project is to automatically detect the wall of the coronary artery that separates the left and right chambers of the heart , so that it becomes much easier to analyze this particular area.

1.6 Scope of Work

This project involves the following specific steps.

1. Sources are from ultrasound images of the heart – echocardiogram.
2. Image will be processed using 8-bit gray scale.
3. Image size is fixed at 767 x 575 as given from the system.
4. Processing will be done in an off line system.
5. Processing tool will be MATLAB Software

1.7 Problem statement

1. In clinical practice, the analysis mainly relies on visual inspection or manual measurements by experienced cardiologists.
2. For researchers, the analysis of the myocardium can be done with tissue samples taken from very small areas of interest manually (using mouse to extract the tissue samples from cardiogram image of the heart).

The manual methods are tedious and time-consuming, and visual assessment leads to qualitative and subjective diagnoses that suffer from considerable inter- and intra-observer variability. On the other hand, automatic detection method has the advantage of being, less time consuming, robust and does not suffer inter- and intra-observer variability.

1.8 Project outline

The project is organized into chapters. The outline is as following

Chapter 1-Introduction

This chapter discusses the objectives and scope of the project and gives a general introduction on basic heart anatomy, MI, and ultrasound images.

Chapter 2- Literature Review

This chapter reviews the previous methods which have been worked on myocardium image. Some of them have been related to texture analysis and the others related to motion of the myocardium.

Chapter 3-Methodolgy

This chapter presents the overall system methodology and discusses in details each step that has to be take into consideration for classification purposes.

Chapter 4-Rsults .

This chapter shows the results for each process(preprocessing) has done on the input image for this system and shows the result of the classification as well(detecting the wall of coronary artery).

Chapter 5-Conclusion

This chapter consists of conclusion and suggestion for future improvement.