HEART SOUND ACQUISITION SYSTEM

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This report is submitted in partial fulfillment of the requirements for the award of
Bachelor of Electronic Engineering (Computer Engineering) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

April 2009

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	**WIRELESS HEART SOUND DATA ACQUISITION SYSTEM**
Sesi Pengajian	:	**2008/2009**

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To my late mother, my dear father, sister, friends and colleagues, and lastly UTeM's lecturers.

ACKNOWLEDGEMENT

Firstly, I would like to take this opportunity to express my gratitude to my supervisor Miss Noor Shahida binti Mohd Kasim and my previous supervisor Miss Norhashimah Mohd Saad for their continuous guidance, advice and constant encouragement throughout the development of the project. For UTeM's lecturers who have taught me, thank you for giving me precious and valuable knowledge. Sincere appereciation to my friends for their guidance, help and coorperation in my project related knowledge, opinions and other activities throughout the project development.

ABSTRACT

Human heart sounds are very natural signals, which have been applied in the doctor's auscultation for health monitoring and diagnosis for many years ago. Auscultation techniques can be applied for diagnosing many heart disorders, which is the most reliable and successful tools for early diagnosis. For heart failure or any heart disease which can bring someone to death, heart sound acquisition is the most trustworthy tools. With no software to easily hear and record the patient's heart sound; this might be not helpful for doctors to observe the condition of their patient's heart especially for the patients with chronic cardiovascular decease. This project will be a helpful system to the doctors because the patient's heart sound can be recorded or heard from the personal computer sound system or their laptop speaker. The purpose of this project is to design a system using Visual Basic 6.0 software application which user can hear the similar sound heard at the stethoscope at the speaker, record the sound and can see the waveform of the sound for comparison or analysis. The Graphical User Interface (GUI) for this system have been designed for user friendly operation and making the software easy to use. The heart sound will be captured by electronic stethoscope and will be connected to the sound card in personal computer or laptop by using the phone jack. The sound that has been recorded can be saved for further analysis. This Heart Sound Acquisition System can be a useful tool for the doctors, health practice, educational purpose or and can be used by those who doing any cardiovascular health analysis or experiments.

ABSTRAK

Bunyi degupan jantung manusia adalah suatu isyarat semulajadi, dimana ia telah diaplikasikan oleh para doktor untuk mengawasi kesihatan dan mendiagnosis penyakit suatu ketika dahulu. Cara mendengar bunyi jantung boleh diaplikasi untuk diagnosis banyak penyakit jantung, iaitu cara yang paling berkesan dan berjaya untuk diagnosis awal. Untuk penyakit jantung yang boleh membawa maut ataupun penyakit kegagalan jantung, cara mendengar bunyi jantung adalah teknik yang boleh dipercayai pada masa kini. Dengan tiada alat atau perisian untuk mendengar dan merakam bunyi jantung pesakit, ini mungkin tidak menolong para doktor untuk memerhati keadaan penyakit pesakit jantung terutamanya bagi mereka yang menghidap penyakit jantung yang kronik. Projek ini mungkin akan menjadi projek yang dapat menolong para doktor kerana bunyi jantung pesakit dapat dirakam dan didengari daripada sistem bunyi komputer atau komputer riba. Tujuan projek ini adalah untuk merekabentuk satu sistem menggunakan perisian Visual Basic 6.0 dimana pengguna boleh mendengar bunyi yang sama jika menggunakan stetoskop pada pembesar suara, merakam bunyi tersebut dan boleh melihat gelombang bunyi tersebut untuk membuat perbezaan atau analisis. Paparan Pengguna Grafik (GUI) sistem ini telah direka bentuk untuk mesra pengguna dan menjadikan sistem ini suatu perisian yang mudah. Bunyi jantung akan diambil menggunakan stetoskop elektronik dan akan disambungkan pada kad bunyi komputer peribadi menggunakan "phone jack". Bunyi yang telah dirakam boleh disimpan untuk analisis. Sistem Mendengar Bunyi Jantung ini sangat berguna kepada para doktor, pengamal perubatan, tujuan pendidikan atau boleh digunakan oleh mereka yang menjalankan eksperimen atau analisis berkaitan kesihatan jantung.

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LIST OF ABBREVIATION

BPM	-	Beats per Minute
PSM	-	Projek Sarjana Muda
GUI	-	Graphical User Interface
PC	-	Personal Computer
PDA	-	Patent Ductus Arteriosus
VSD	-	Ventricular Septal Defects
AS	-	Aortic Stenosis
PS	-	Pulmonary Stenosis
MR	-	Mitral Regurgitation
TR	-	Tricuspid Regurgitation
AI	-	Aortic Insufficiency
PI	-	Pulmonic Insufficiency
MV	-	Mitral Valve
TV	-	Tricuspid Valve
LLSB	-	Left Lateral Sternal Border
DSP	-	Digital Signal Processing
ADC	-	Analog to Digital
DAC	-	Digital to Analog
STFT	-	Short Time Fourier Transform
BASIC	-	Beginners All-purpose Symbolic Instruction Code
TRS	-	Tip, Ring, and Sleeve
TS	-	Tip and Sleeve
TRRS	-	Tip, Ring, Ring and Sleeve
UK	-	United Kingdom
US	-	United States
IBM	-	International Business Machines Corporation
CD	-	Compact Disk

CHAPTER 1

INTRODUCTION

Generally, the heart sounds produced by the healthy hearts are identical and any abnormal sound always narrates with some abnormalities. Thus, the heart sounds are diagnostically useful, as it provides an indication of heart rate, blood pumping and valve action. Heart auscultation is the most important tool in monitoring and diagnosing human heart disease. It is a fundamental component in cardiac diagnosis. However, doing heart sound diagnosis is difficult and only experts can do this technique successfully. This technique can be applied to diagnose many heart disease and heart failures.

1.1 Introduction

Nowadays, heart sound data acquisition system existed for quite a long time in the market and it had been widely used in the medical field. However, there are few of the system that can be used wirelessly. Wireless heart sound data acquisition system provides a better environment when doing heart auscultations as it provide mobility.

1.2 Objective

1. To use Bluetooth technology to replace cable for interpreting between stethoscope and computer.
2. To develop software which user can use it to monitor heart sound waveform in real time, record/save the sound and furthermore to playback the sound for further analysis

1.3 Problem Statement

The method of interfacing stethoscope and computer using cable as the medium is not practical as it poses problems such as lack of mobility in taking the reading of heartbeats due to the cable. Besides that, there is possibility of current flow from computer to stethoscope through the cable which might poses danger to patient's health. Moreover, software that can be used to monitor and record patient's heartbeats are still limited. By developing this system using stethoscope and LabView8.6 GUI, anyone will be able to use the system to hear record and monitor the heartbeats.

1.4 Project Scope

Many kind of method can be used in developing this system and for this project, the project scope are:

1. Input for this system, human heartbeats sound (from the chest piece) using 3M Littman ® Electronic Stethoscope Model 4100.
2. Imply the interfacing between stethoscope and computer for data transferring using Bluetooth technology.
3. Monitoring the heartbeats waveform in real time using GUI developed using LabView 8.6.
4. Record and save the heartbeats.
5. Display and play the recorded heartbeats waveform for further analysis.

1.5 Methodology

The transferring signal from stethoscope to computer will be done through Bluetooth communication. Signal obtained from stethoscope will be inputted into ADC to convert signal to digital signal before the signal is transferred by Bluetooth Module. The interface of the system will be designed using LabView 8.6 where the system will be able to monitor heart sound waveform in real time, record/save the sound and furthermore to playback the sound for further analysis.

1.6 Thesis Outline

This thesis contains five chapters that will explain the details about this project. The first chapter is about the introduction of the project. This chapter will explain about the project overview, project objective, project scope and project problems. The explanations are made in the simplest way possible.

The second chapter will discuss the literature review of the project. Detailed explanations will be given about the heart itself, the processes occur inside the heart, heart sound, its components, stethoscope which is the device used for auscultation of heart sound, and the analysis which can be used to analyzed the heart sound.

The third chapter will discuss the methods that were used in the project. This section will cover all the processes from the beginning to completing the project. All these methodology should be followed for a better performance. Every detail that contributed in completing the project is inserted in this section. Related figures and tables were inserted for better understanding of the project.

Chapter IV will discuss the results which have been done for the project. The result consist figures with some explanation and covers the output for this project.

Lastly for Chapter V, it will discuss the conclusion form overall project including the study implementation which have been used and suggestion for future development and modification.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a comprehensive review about the theories and components used in this project are included. Theories involving heart sounds and component such as Bluetooth technology, stethoscope, PIC16f877a, and LabView are introduced.

2.1 Background Study

Heart sound data acquisition system existed for quite a long time in the market and it had been widely used in the medical field. However, there are few of the system that can be used wirelessly.

Below is a study which was done by T.W. Nam, J.M. Cho and H.J. Noh where they developed a wireless heart rate monitoring system for rehabilitation patients. Purpose of study is to develop a monitoring system that can monitor patients' heart rates so that it gives physical therapist early warning if necessary.

Author used a radio-frequency (RF) transmitter and receiver module to communicate with PC. A small foot-print microcontroller with a built-in analog-to-digital converter (ADC) was incorporated in the transmitter. The heart sound signal captured by a contact-type microphone is filtered by a band-pass filter and amplified to the level which corresponds to a full-scale input voltage range of the ADC built-in a microcontroller.

2.2 The Heart Sounds

The heart sounds are the noises (sound) generated by the beating heart and the resultant flow of blood through it. This is also called a heartbeat. In cardiac auscultation, an examiner uses a stethoscope to listen for these sounds, which provide important information about the condition of the heart.

Heart sounds are complex and highly non-stationary signals. The normal heart sound is typically has two sound components: Lub and Dub. Lub is the first heart sound which is usually softer and longer than the "dub" while dub is shorter and louder than the “lub” sound. They are also referred to as first and second heart sounds (S1 and S2). These sounds are produced by the turbulent flow against the closed AV valves and semilunar valves (aortic and pulmonary) respectively. There are always third and fourth heart sounds (S3 and S4) which might also be heard. Third heart sound, S3 occurs right after S2 and S4 occurs before S1. These sounds follow each other in a cyclic fashion.

2.2.1 First and Second Heart Sound (S1 and S2)

The first heart sound, or S1, forms the "lub" of "lub-dub". The sudden blockeage of reverse blood flow due to closure of the atrioventricular valves, i.e. mitral and tricuspid was the source of first heart sound. It occurs at the beginning of ventricular contraction, or also known as systole. When the pressure in the ventricles rises above the pressure in the atria, blood in both atria start to flow into the ventricles and causing the valve leaflets close in which preventing the flow of blood back into the atriums. The reverberation within the blood associated with the sudden block of flow reversal by the valves caused the first heart sound, S1.

The second heart sound, or S2, forms the "dub" of "lub-dub”. Unlike S1, S2 is caused by the sudden block of reversing blood flow due to closure of the aortic valve and pulmonary valve. This happens at the end of ventricular systole, i.e beginning of ventricular diastole. With the pressure in the ventricles dropped below the pressure in the aorta, blood that flowed though aorta quickly reverses back

toward the left ventricle, closing aortic valve leaflets which stop the flow of blood in aorta back to left ventricles. Similarly, as the pressure in the right ventricle falls below the pressure in the pulmonary artery, the pulmonary (outlet) valve closes. The reverberation within the blood associated with the sudden block of flow reversal by the valves caused the second heart sound, S2.

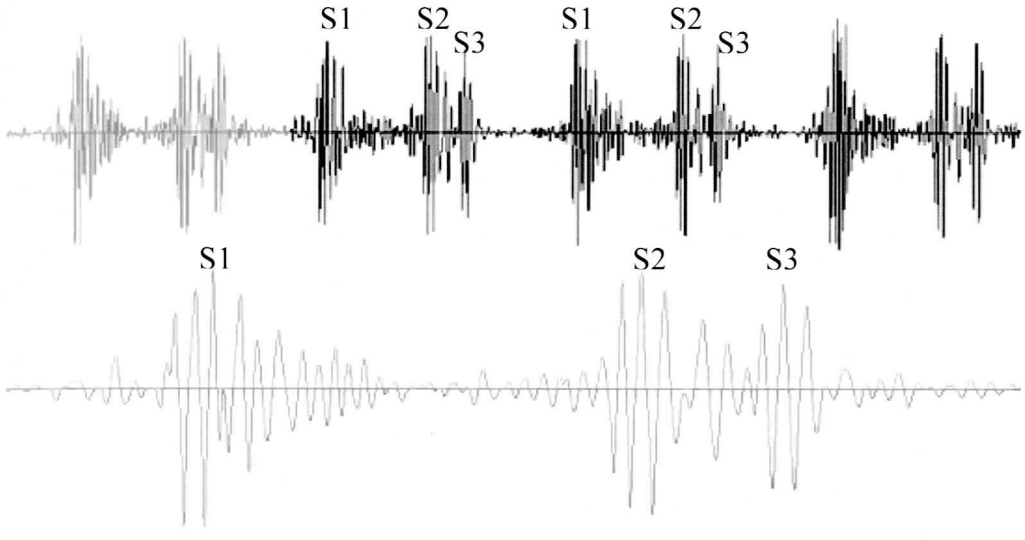

Figure 2.1: Heart sound waveform

Special recording techniques enable us to differentiate four components of the first heart sound. The first heart sound S1, consists of four components. The most remarkable components are two large, high amplitude deflections which called M1 that related to mitral valve closure and T1, related to tricuspid valve closure.

The major audible components are the related to the closure of the mitral and tricuspid valves. When mitral valve closes (M1), there are slightly higher in intensity and frequency; best heard at the apex while when tricuspid valve close (T1), there are less intensity and best heard at the left sternal border. The components of M1 and T1 are normally 20 - 30 milliseconds apart. A split of the first sound occurs when both events are separately noticeable. A split of the first sound is heard in about 70% of normal subjects, and is heard best at the left lateral sternal border (LLSB).

A physiological split occurs when both components of the second sound are separately distinguishable. Normally this split sound is heard on inspiration and become single on expiration. The A2 and P2 components of the physiological split

usually coincide, or are less than 30 milliseconds apart during expiration and often moved to around 50 to 60 milliseconds apart by the end of inspiration.

The physiological split is heard during respiration because it is during that respiratory cycle that intrathoracic pressure drops. This drop permits more blood to return to the right heart. The increased blood volume in the right ventricle results in a delayed pulmonic valve closure. At the same time, the capacity of the pulmonary vessels in the lung is increased, which results in a slight decrease in the blood volume returning to the left heart.

With less blood in the left ventricle, its ejection takes less time, resulting in earlier closing of the aortic valve. Therefore, the net effect of inspiration and a single second sound is heard during expiration.

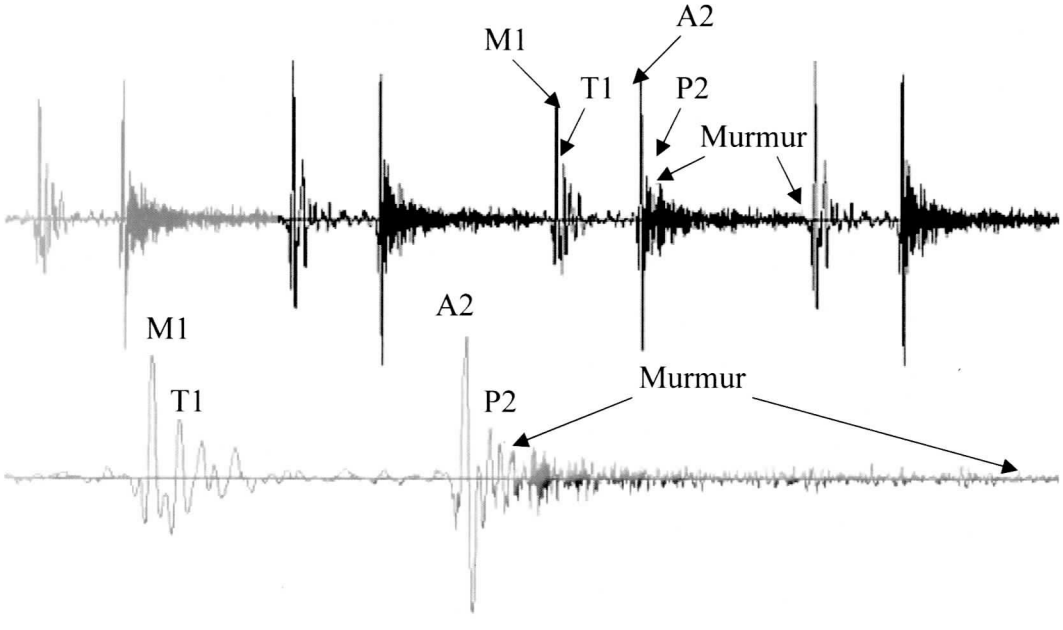

Figure 2.2: The first heart sound S1 components

Following the first heart sound, which is the second heart sound S2, is shorter and in high-pitched "dup", caused when the ventricles stop ejecting, relax and allow the aortic and pulmonary valves to close just after the end of ventricular systole. The time between the second sound and the following first sound called diastole which for ventricular filling. The second sound, S2 lasts about 0.12 second with the frequency about 50 Hz. The second heart sound also has two components called A2 and P2. The second sound will be split upon inspiration, and usually will be heard as

single on compensation. The physiological split second is audible at base left, with the diaphragm chest piece.

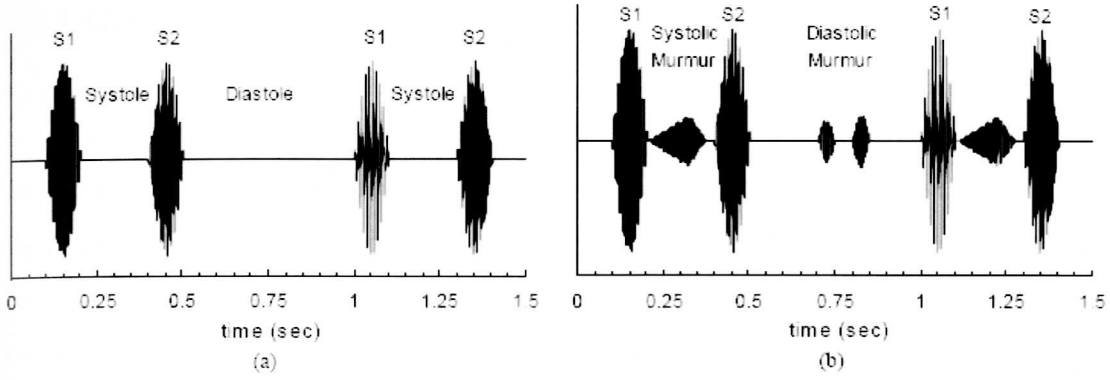

Fig. 1 Representative heart sounds for (a) a normal heart and (b) a heart with both systolic and diastolic murmurs.

Figure 2.3: Representative heart sounds for (a) a normal heart and (b) a heart with both systolic and diastolic murmurs

2.2.2 Third Heart Sound, S_3

Rarely, there may be a third heart sound also called a protodiastolic gallop, ventricular gallop, or informally the "Kentucky" gallop as an onomatopoeic reference to the rhythm and stress of S1, S2, and S3 together (S1=ken; S2=tuc; S3=ky). It occurs at the beginning of diastole after S2 and is lower in pitch than S1 or S2 as it is not of valvular origin. The third heart sound is benign in youth and some trained athletes, but if it re-emerges later in life it may signal cardiac problems like a failing left ventricle as in dilated congestive heart failure (CHF).

2.2.3 Fourth Heart Sound, S_4

The rare fourth heart sound is sometimes audible in healthy children and again in trained athletes, but when audible in an adult is called a presystolic gallop or atrial gallop. This gallop is produced by the sound of blood being forced into a stiff/hypertrophic ventricle. It is a sign of a pathologic state, usually a failing left ventricle. The sound occurs just after atrial contraction ("atrial kick") at the end of diastole and immediately before S1, producing a rhythm sometimes referred to as the "Tennessee" gallop where S4 represents the "tenn-" syllable. The combined presence