DESIGN AND DEVELOPMENT OF WIRELESS STETHOSCOPE
WITH DATA LOGGING FUNCTIONS

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ABSTRACT

Stethoscope is a special device to hear heartbeat sound and monitor pulmonary disease. The most type of stethoscope used these days is the acoustic stethoscope. However, the problem with this acoustic stethoscope is the sound level very low. It is hard to analyze the heart sound and difficult to be diagnosed by a medical doctor. Therefore, this project was developed to monitor and display heartbeat sound using wireless digital stethoscope. The condenser microphone is used as a sensor to capture the low sensitivity of heart sound signal and transmit the signal using Antenna Arduino ZigBee Pro Series 1. Microcontroller Arduino Nano and Arduino Mega were used as a platform to process the signal and sent the result to the computer. Graphical User Interface (GUI) was developed using MATLAB software to monitor real time electrocardiogram (ECG) waveform and for data logging purpose. The result shows that this device able to transmit and receive ECG waveform wirelessly. The ECG signal can be recorded through data logging application for further analysis by the medical personnel.

ABSTRAK

Stetoskop adalah alat khas untuk mendengar bunyi degupan jantung dan memantau penyakit paru-paru. Stetoskop yang kerap digunakan pada hari ini adalah stetoskop akustik. Walau bagaimanapun, stetoskop akustik ini mempunyai tahap bunyi yang sangat rendah. Ia amat sukar untuk menganalisis bunyi jantung untuk disahkan oleh doktor perubatan. Oleh itu, projek ini telah dibangunkan untuk memantau dan memaparkan bunyi degupan jantung dengan menggunakan stetoskop digital tanpa wayar. Mikrofon kondenser digunakan sebagai sensor untuk menangkap sensitiviti isyarat bunyi jantung yang rendah dan menghantar isyarat menggunakan Antena Arduino ZigBee Pro Siri 1. Mikropengawal Arduino Nano dan Arduino Mega telah digunakan sebagai platform untuk memproses isyarat dan menghantar hasil isyarat kepada komputer. Sistem penggunaan grafik (GUI) telah dibangunkan menggunakan perisian MATLAB untuk memantau masa sebenar gelombang elektrokardiogram (ECG) bertujuan untuk penyimpanan data. Hasil kajian menunjukkan bahawa alat ini mampu untuk menghantar dan menerima gelombang ECG tanpa wayar. Isyarat ECG boleh dirakam melalui aplikasi penyimpanan data untuk dianalisis dengan lebih lanjut oleh kakitangan perubatan.

TABLE OF CONTENTS

CHAPTER I   INTRODUCTION

CHAPTER II   LITERATURE REVIEW

CHAPTER III   METHODOLOGY

LIST OF FIGURES

3333333333

xi

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ASCII -   American Standard Co

BPM   -   Beats Per Minutes

DB   -   Decibel

ECG   -   Electrocardiogram

GND   -   Ground

GUI   -   Graphical User Interface

HB   -   Heart Beat

IDE   -   Intergrated Development Environment

LCD   -   Liquid Crystal Display

LED   -   Light Emitting Diode

mm Hg -   millimeters of Mercury

RX   -   Receive

TX   -   Transmit

WIFI   -   Wireless Local Area Network

XBee   -   ZigBee

CHAPTER I

INTRODUCTION

1.1 Introduction

The stethoscope comes from the Greek language for skope means chest and stethos means inspection. It is a very vital transducer for many medical practitioners. and used for end user like doctors, nurses and physicians detect the abnormalities of the heart and lung such as sounds of heart, lung rhythm, and vibration of the intestines and blood flow (Geddes 2005). Diaphragm of head stethoscope is the metal end that is placed on the chest to listen to the lungs and heart sound with the tubing to tapered inner bores. This structure is able to provide a better sound transmission while listening is known as a vacuum tube. The most type of stethoscope used these days is the acoustic stethoscope (Myint & Dillard 2001). However, the problem with this acoustic stethoscope is the sound level is very low make it hard to analyse and diagnose the heart sound by a medical doctor. This is why several forms of digital electronic stethoscope have been developed to replace the conventional acoustic stethoscope. Basically, the purpose of digital stethoscope is to improve the sound resolution, allow variable amplification, minimize interference noise and simplify the output signal.

The digital stethoscope can enhance the auscultation problem of acoustic stethoscope which is easily affected by the movement and noise surrounding. Several techniques with the functions like stethoscope have been widely used such as SPO2,

Sphygmomanometer and Electrocardiogram (ECG) (Francis E H Tay et al. 2009; Jokic et al. 2010).

1.2 Problem Statement

Sound detection of heart beat for the stethoscope is mainly problem that always occurs for medical doctors and physicians at hospital. This problem is in listening to heart sounds through the stethoscope when the signal level of detections is very low and cause very difficult to be analyzed. This is why some form of digital electronic stethoscope needs to be developed to replace the existing acoustic stethoscope. As the diagnosis part can be done by anybody except by an experiences medical doctor or physician for details of analysis, by developing the Digital Stethoscope where it will save the measured heart beat signal from a patient and the data input signal in voltage can easily be read by patient when they used it.This project will monitor the data with wireless transmissions and the result will be saved in real time.

1.3 Objective of Study

The main objective of this project is to Design and Develop a Wireless Stethoscope with Data logging Functions. The detail objective of this study as follow:

1. Develop a Digitalized Stethoscope Using Arduino Nano
2. Develop a Wireless Data Transmission System
3. Verify, Analyze and Compare the Digitalized Stethoscope with the current devices

1.4 Scope of Study

To design the circuit that will give a result for the heartbeats detection in digitalize stethoscope in number with the sensor circuit is to detect an input analog signal for heartbeats and convert into digital with Arduino Nano as a microprocessor.

Then continued by the development of Wireless Transmission using Antenna ZigBee Pro Series 1 it is to transmit and receive the data of signal from a communications system. The signal is sent directly to a personal computer that contains a data system to record important information about the patient to keep in the software system in real time wave to be analyzed received. Then this wireless stethoscope will be verified and shown the data of heartbeats as a result for the counting of heart rate per minute

Continue by create and design the Data Base of the heartbeat signal using Microsoft Excel for Data Logging information of patients and can be monitored in real time display with record for further analysis also to produce a portable device with a low cost wireless stethoscope

1.5 Significant of Study

Three categories is describe of Wireless Stethoscope study, first is develop a Digital Electronic Stethoscope, Wireless Transmission system and lastly is a verification on the Digital Stethoscope to detect the heartbeats.

To develop a system that can monitor the health of patients at home without having to commute to the hospital. Also can pleasant a doctor to monitor the health of patients with the information data storage system. Others are wireless device for this system can facilitate the patient to move go anywhere

Propose for this study is serves the others students as their reference or guide in creating new program that is related to the heartbeats. It will also help in computer communications system to identify the best communicate programming language that can be used.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Initial research was conducted to determine the types of heartbeats that are routinely measured during a visit by a doctor in hospital. This is a respiration rate of breathing that can give a total of heartbeats in heart rate per minute. One of the methods used to measure this heartbeat is by the auscultation method. These methods provide information about a variety of internal body sounds originated from the heart, lungs, bowel and vascular disorders (Khan et al. 2012). The ability to detect heart sounds may be influenced by a number of factors, including the presence of ambient noise or other sensory stimuli. This may result in inaccurate or insufficient information due to the inability of the user to discern certain complex, low-level, short duration or rarely encountered abnormal sounds (Jiang & Choi 2006). Therefore, only the skilled physician who is proficient in the skill of auscultation is likely to make accurate diagnoses upon cardiac auscultation. It is, thus, desirable to enhance the diagnostic ability by processing the auscultation signals electronically and providing a visual display and automatic analysis to the physician for a better comparison study.

2.2 Historical of Stethoscope

The expression of stethoscope is an examination that is an acoustic medical device for auscultation, or listening to the internal sounds of an animal body. It is often used to listen to lung and heart sounds as well as the intestines and blood flow in arteries and veins. In combination with a sphygmomanometer, it is commonly used for measurements of blood pressure and to detect small-scale acoustic signal in monitoring tasks. A stethoscope that intensifies auscultatory sounds is called phonendoscope. Acoustics Stethoscope is an evolution of a low cost active artificial ear or also known as ear pieces device to detect a sound frequency of the internal body (Scope n.d.).

(a)

(b)
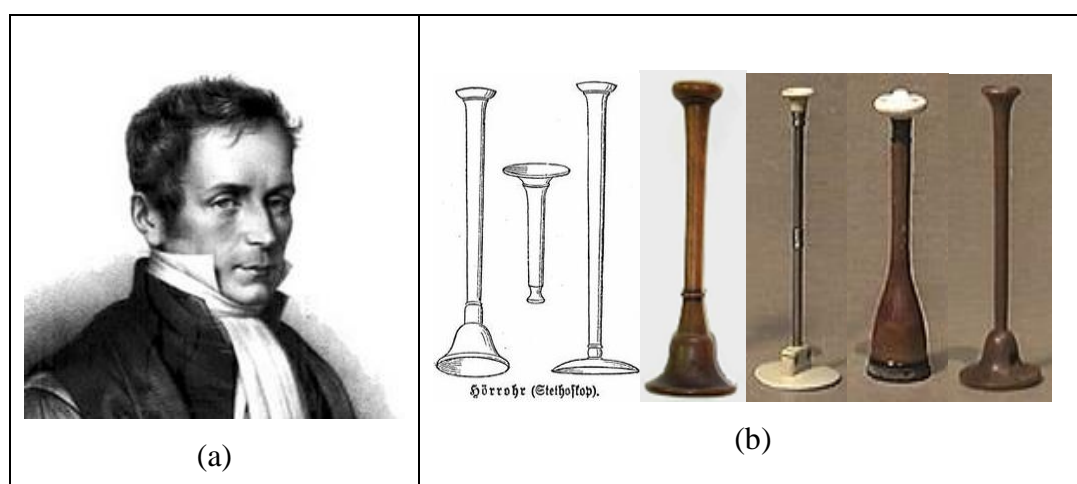
Figure 2.1: Early Stethoscope (a) Dr. Rene Laennec c. 1816

(b) Ear Trumpet Microphone

Stethoscope history began in 1816 with French physician called Doctor Rene Laennec at Necker-Enfants Malades Hospital in Paris. The stethoscope designed by Dr. Rene consisted of a wooden tube and was monaural design as shown in Figure 2.1. With this device which was similar to the common ear trumpet, a historical form of hearing aid; indeed, his invention was almost indistinguishable in structure and function from the trumpet call microphone.

Laennec said to have seen schoolchildren playing with long, hollow sticks in the days leading up to his innovation. The children held their ears to one end of the stick while the opposite end was scratched with a pin, the stick transmitted and

amplified the scratch. His skill as a flautist may also have inspired him. He built his first instrument as a 25 cm by 2.5 cm hollow wooden cylinder as shown in Figure 2.2, which he later refined to comprise three detachable parts (Ramon n.d.).
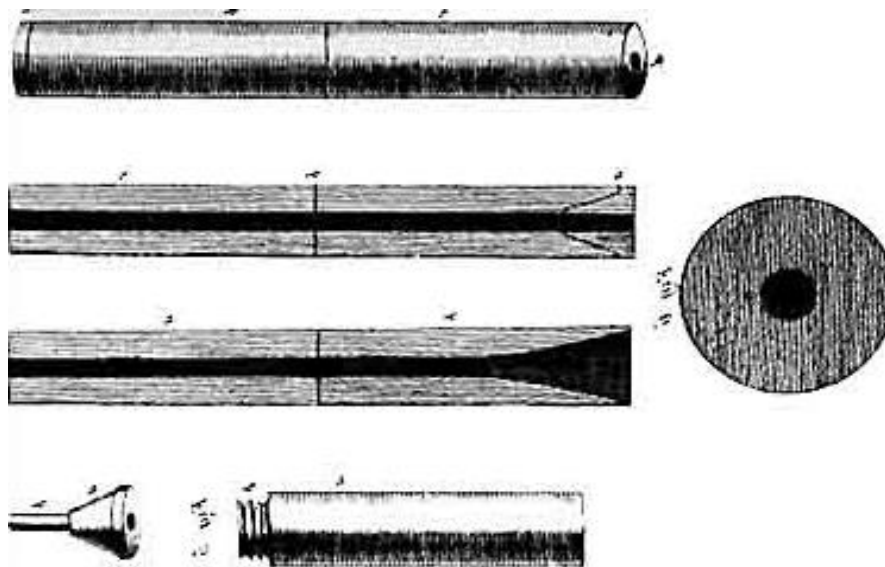
Figure 2.2: Stethoscope: History, Laennec's Invention Drawing

Inspired seen from schoolchildren playing with long, hollow sticks while the children held their ear to one end of the stick while the opposite end was scratched with a pin, the stick transmitted and amplified the scratch. Then he built his first instrument as a 25 cm by 2.5 cm hollow wooden cylinder, which later refined to comprise three detachable parts

Doctor Laennec spent the next three years perfecting his stethoscope's historical design and listening to the chest findings of patients with pneumonia, comparing what he heard to their autopsy lung findings. Then he published the first seminal work on the use of the stethoscope to listen to internal body sounds entitled De L'auscultation Mediatein in 1819 at thirty-eight years old. Ironically, Laennec himself died of tuberculosis on August 13th, 1826.

Stethoscope history further evolved to the binaural two ear stethoscope types in 1852 by Doctor George Cammann as a physician at the Northern Dispensary in New York City. He also creates a model of a soft metal and multiple designs for two people to listen at a same time.

Figure 2.3: Invention of Stethoscope (a) Dr. George Cammann c.1855 (b) Cammann Bianural Stethoscope

Figure 2.3 is the Cammann's model stethoscope, made with ivory earpieces connected to metal tube that were held together by a simple hinge joint, and tension was applied by way of an elastic band. Attached the two tubes covered by wound silk and converged into a hollow ball designed to amplify the sound, and then attached to the ball that was a conical or cone shaped, bell chest piece.

Table 2.1 shows the history of the main design of stethoscope from early development until 1900. The features enhance step by step when many inventions are created to make new stethoscope more reliable to be used nowadays.

Table 2.1: History of Stethoscope:

Years:	History Design
1829	Binaural Stethoscopes (two earpiece models) make their debut, but not with much success by a doctor in Dublin.
1860s	The Camman Stethoscope, a binaural model with a bell shaped chest piece is now considered the standard for superior "auscultation" to listen to sounds in the chest by American physicians. It would soon be followed by the Ford model.
1890s	A physician & surgeon supply catalog offers stethoscopes from 40 cents for a simple wooden monaural model up to $4.00 for a fancier binaural example.
1898	The Bowles Stethoscope with its diaphragm chest piece in a flattering shape appears. These would be joined by the "combination stethoscopes" in 1902 - having both bell & diaphragm chest pieces for better diagnosis.

Table 2.1 Continue

1900	The "Cardiophone" an early electronic instrument to help augment heart sounds arrives on the medical scene.

2.3 Previous Study For Digital Stethoscope

Table 2.2 shows the list of papers that focuses on Digital Electronic Stethoscope design. With several types of new features and characters that is being developed to make it more reliable and easy to be used by doctors, physicians and others end user.

Table 2.2: Project Development for others Electronics Stethoscope

Authors:	Title of Paper and Project Development
Jatupaiboon, N Pan-ngum, S Israsena, P Year: 2010	**Electronic Stethoscope Prototype with Adaptive Noise Cancellation** This electronic stethoscope prototype can filter frequency, reduce external noise and make real time digital signal processing with low cost product (Jatupaiboon et al. 2010).
Myint, W W Dillard, B Year: 2001	**An Electronic Stethoscope with Diagnosis Capability** This device can extract the heartbeat of sound cycle, also the murmur of data, time frequency analysis, with statistical metrics and diagnosis algorithms (Myint & Dillard 2001).
Rashid, Rb A Ch'ng, H S Alias, M A Fisal, N Year: 2005	**Real Time Medical Data Acquisition over Wireless Ad-Hoc Network** With real-time digital signal and can plot recording of body acoustic include standard audio data file. Have a multimedia computer with broadband, and a set of multimedia speakers is embedded inside the network with low cost (Rashid et al. 2005).
Reed, Todd R. Reed, Nancy E. Fritzson, Peter Year: 2004	**Heart Sound Analysis for Symptom Detection and Computer-Aided Diagnosis** This prototype system with heart sound analysis, based on a wavelet decomposition of the sound and a neural network-based on classifier for pathologies (T. R. Reed et al. 2004).

The papers mentioned above have different features in their project prototype development such as the filter on frequency noise and sound, the recording standard for the audio data file also the sound analysis.

2.4 Project Wireless Stethoscope

Table 2.3 shows the list of papers that focuses on wireless Stethoscope. There are several wireless communication techniques involved including Bluetooth and wireless local area network (Wifi).

Table 2.3: Project Development for others Wireless Stethoscope

Authors:	Title of the Paper with a Description:
Cho, Kyu Jin Asada, H Harry Years : 2002	**Wireless, Battery-Less Stethoscope for Wearable Health Monitoring** This system can capture and monitored the respiratory human body sound for asthma and other pulmonary diseases. The sensor and batteries are wireless to make it easy to attach at the skin (Kyu Jin & Asada 2002).
Luo, Yi Years: 2008	**Portable Bluetooth Visual Electrical Stethoscope Research** This project can separate the sound of cardiovascular sound based on the embedded system, Bluetooth, wireless transmission technology visualized and instrument. It can possess the features in real time display, playback and record the sound functions (Yi 2008).
B. Hok, V. Bythell, M. Bengtsson Years: 1988	**Development of a Wireless Stethoscope for Auscultatory Monitoring during Anaesthesia** Have microphone and battery operation with range 10 meters at operating theatre. The frequency is lower audible limit to ~20 Hz and the highest expected of the signal to ~ 1 kHz (U. 1988).
Hung, K B Choy, L Luk W H Tso, B Tai S K Years: 2004	**Multifunction Stethoscope for Telemedicine** This Bluetooth Wireless Communication can be used at home, by providing a video conferencing, remote auscultation, heart and lung sound separation, ECG recording, and automatic pre diagnosis for systems for doctors monitored the patients (Hung et al. 2004).
K. Hung, Y.T. Zhang Years: 2002	**Usage of BluetoothTM in Wireless Sensors for tele- Healthcare** Using power consumption of the radio module, with spread spectrum and short range transmission Bluetooth that is an attractive option in medical sensors. Using Powertrain Control Module (PCM) for a feasible solution for transmission of heart and lung sounds.

2.5 Human Physiology for Cardiovascular System

The cardiovascular system is a body comprised of the heart, the blood, and the blood vessels also known as the circulatory system and it is for transporting blood. As the cardiovascular system moves blood throughout the body, cells receive oxygen and nutrients while carbon dioxide and other wastes are removed from the body as well (Shin et al. n.d.).

2.5.1 Heart

The heart is a powerful muscle, about the size of a clenched fist, located at the left of the centre of the chest with the special type of muscle called the myocardium. Function of heart that has a rhythmic, automatically repeated beating and it is maintained by electrical impulse originating in the sinoatrial central node. It also known as a natural pacemaker that is to supply the blood and oxygen at all parts of the body. The heart is located in the chest cavity just posterior to the breastbone, between the lungs and superior to the diaphragm. Blood is pumped away from the heart through arteries and returns to the heart through veins. The major artery of the body is the aorta and the major veins of the body are the vena cavae (Sepehri et al. 2010). Figure 2.4 shows the heart of human.
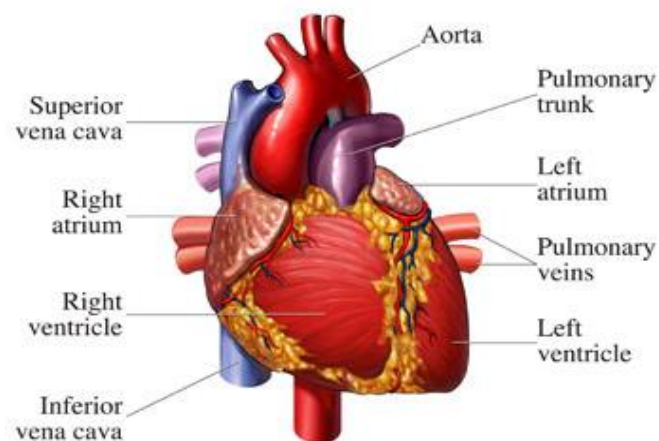
Figure 2.4: Human's Heart

2.5.2 Heart Beat Cycle

Heartbeat is a single pulsation of the complete cardiac cycle, when the electrical impulse is conducted and at the same time a mechanical contraction is occurs in muscle contraction and relaxation. This cardiac cycle is related to the flow or blood pressure that occurring from the beginning of one heartbeat to the beginning of the next (Nakajima et al. 1996).

For each beat of the heart involves five major stages. The first two stages, often considered together as the "ventricular filling" stage, involve the movement of blood from the atria into the ventricles. The next three stages involve the movement of blood from the ventricles to the pulmonary artery in the right ventricle and the aorta in the left ventricle (Übeyli 2007).

There are three separate and distinct phases make up the sequential beating of the heart. The relaxing of muscle and refilling of the chamber with blood during the first stage is followed by stages when the atria and then the ventricles contract, sending blood through the heart and out into the arteries. The cycle takes about four-fifths of second; during vigorous exercise, however in times of stress, this speed may increase to double (Maglaveras et al. 1998)(Bauer et al. 2008). The cycle of blood flow is shown in Figure 2.5 and can be simplified as:

1. Diastole – First phase of cycle, deoxygenated blood enters the right atrium and oxygenated blood enters the left atrium. The blood then flows through into the ventricles

2. Atrial Systole – Impulse from the sinoatrial node initiate the next phase of the cycle, during which the atria contract. This squeezes any blood remaining in the atria into the ventricles

3. Ventricular Systole – During this third phase of the heartbeat cycle, the ventricle contract. Valves at the ventricle exits open and blood is forced into the pulmonary artery and the aorta and this phase ends diastole start again. (Book 2001)
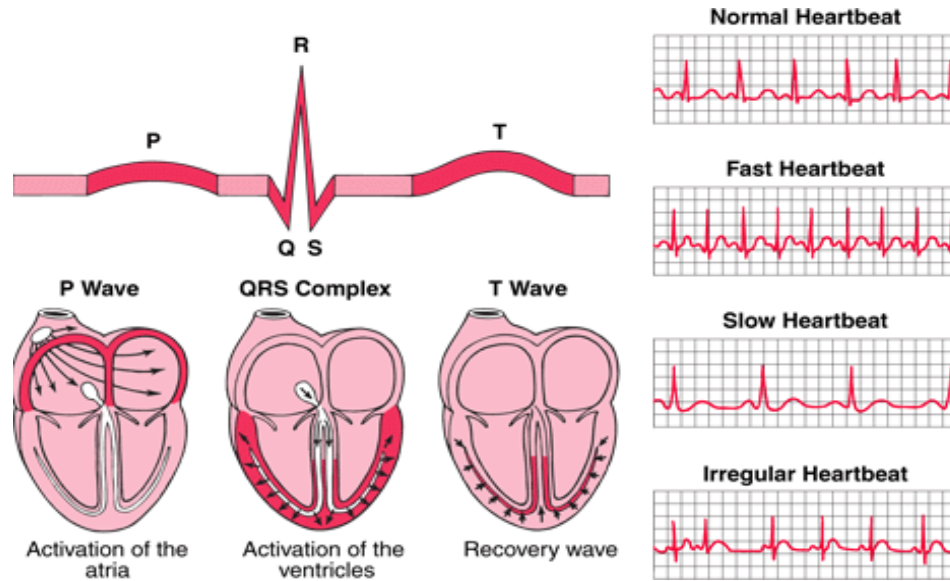
Figure 2.5: ECG Waveform

Table 2.5 shows the ECG Trace for the PQRST Waveform. There have 4 types of heartbeat that is a normal heartbeat, fast heartbeat, slow heartbeat and irregular heartbeat.

Table 2.4: ECG Trace for PQRST Wave

T wave	A ventricular repolarization is a positive deflection, since repolarization is in opposite direction
PR interval	The times is between 120-200ms beginning at P wave and ending of QRS complex
ST segment	The time between QRS complex and start of T wave at a plateau phase of cardiac muscle
QT interval	The time between ~400ms in beginning of QRS complex and end of T wave.
Normal	PT constant, but TP interval changes when HR changes

2.5.3 Heart Rate

Heart rate is same with the pulse rate and it is the number of heartbeats per unit of time, typically expressed as beats per minute (bpm). Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide changes, such as during physical exercise, sleep, illness, or as a result of ingesting drugs. Due to individuals having a constant blood volume, one of the physiological ways to deliver

more oxygen to an organ is to increase heart rate to permit blood to pass by the organ more often. Normal resting heart rates range from 60-100 bpm. Above is the average of the Heart Rate per Minute for the different ages consider situation of the physical characteristics is the total pumping of heart occurs. Table 2.5 from shows the normal heart rate based on age. As can be seen, the heart rate of baby and adult is quite high. (Bauer et al. 2008).

Table 2.5: Heart Rate Chart for Babies to Adults

AGE (years)	Beats Per Minute (BPM)
New born 0-3 Months Old	100-150
Infants or Babies 3-6 Months	90-120
Infants 6-12 Months	80-120
Children ages 1 - 10	70 – 130
Children age 10 + and Adults	60 – 100
Well-trained Adult Athletes	40 - 60
Adult 20 - 29	99-165
Adult 30 – 39	94-160
Adult 40 – 49	89-151
Adult 50 – 59	84-143
Adult 60 – 69	79-134
Adult 70 and above	75-128

2.5.4 Heart Sound

Heart sounds are the noises generated by the beating heart and the resultant flow of blood through artery (the turbulence created when the heart valves snap shut). In cardiac auscultation, an examiner may use a stethoscope to listen for these unique and distinct sounds that provide important auditory data regarding the condition of the heart (Yan et al. 2010b).

In healthy adults, there are two normal heart sounds often described as a lub and a dub or dup, that occur in sequence with each heartbeat. These are the first heart sound (S_1) and second heart sound (S_2), produced by the closing of the atrial ventricular valves and semilunar valves respectively(Amit et al. 2009). In addition to

these normal sounds, a variety of other sounds may be present including heart murmurs, adventitious sounds, and gallop rhythms S_3 and S_4(Yan et al. 2010a). Figure 2.6 shows the phonocardiograms on auscultation from normal and abnormal heart sounds.
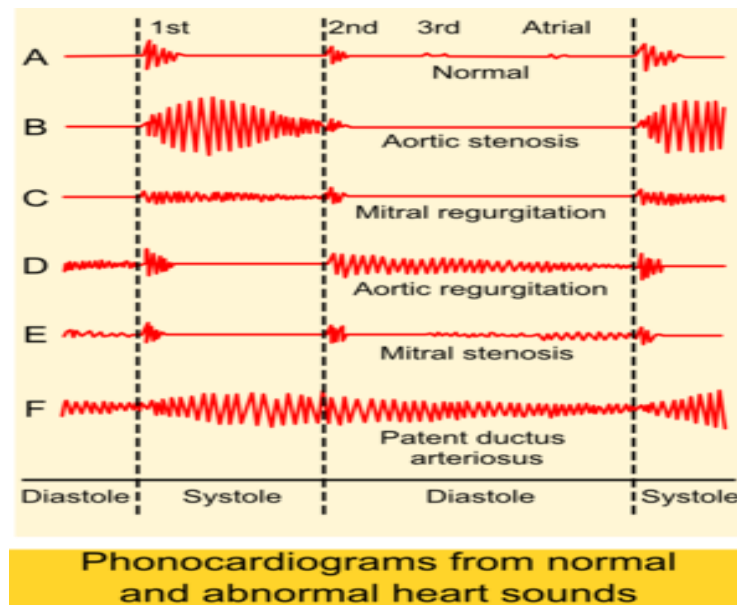
Figure 2.6: Auscultogram from Normal and Abnormal Heart Sounds

2.6 A Technique to Detect Heart Rate Condition

Several techniques have been used to detect heart rate. The techniques to detect the abnormalities at heart are based on Korotkoff sound, Blood Flow, Blood pressure, Systolic, Diastolic, Auscultation, Heart Murmurs, Arrhythmia, Tachycardia, and Bradycardia. The summary of the techniques are as shown in Table 2.6 contains 4 measurement.(M. A. Zaltum et all. 2010)

Table 2.6: List of the Techniques for Heart Rate Measurement

Korotkoff Sound	The technique is implemented by detecting the arterial sound using Blood Pressure Cuff or sphygmomanometer. The sound can be heard through a stethoscope which is put under the cuff at left armhole near heart. The first sound heard after release the cuff is known as systolic and the second sound is known as diastolic blood pressure.

Table 2.6 Continue

Auscultation	By listening to the heart beats using stethoscope and sphygmomanometer. Comprises and inflatable cuff place around upper arm.
Heart Murmurs	Generated by turbulent flow of blood sufficient to produce audible noise, which may occur inside or outside the heart. Murmurs may be physiological in benign or pathological at abnormal condition.
Arrhythmia	It is an irregular heartbeat with group of heart conditions which present with abnormal heartbeats like tachycardia and bradycardia.

2.7 Parameters of Heart Beat Measurement.

For analysis the heart rate of the human body, several parameters is involves refer to Table 2.7 Among these are the parameters for different types of heart beat measurement that is a Blood Flow, Blood Pressure, Systolic, Diastolic, Tachycardia and Bradycardia.

Table 2.7: The Parameters of Heart Beat Measurement

Blood Flow	The movement of blood through the vessels of the cardiovascular system
Blood Pressure	In a blood vessel, the force exerted by the blood against the vessel wall. This pressure caused by the pumping of the heart that keeps blood circulating. Blood pressure is recorded as 120/80 and read as "120 over 80."
Systolic	Systolic blood pressure refers to the pressure of blood in the artery when the heart contracts. It is the top (and higher) number in a blood pressure reading. Example: systolic pressure is 120 millimeters of mercury (mm Hg)
Diastolic	Diastolic blood pressure refers to the pressure of blood in the artery when the heart relaxes between beats. It is the bottom (and lower) number in a blood pressure reading. Example: diastolic pressure is 80 mm Hg and
Tachycardia	It is a fast or irregular heart rhythm, usually more than 100 beats per minute and as many as 400 beats per minute.
Bradycardia	It is a slow heartbeat means that the heart rate is slower than 60 beats per minute, either occasionally or all the time

Table 2.8: Characteristics of Systolic and Diastolic Blood Pressure

Characteristics	Diastolic	Systolic
Definition	It is the pressure that is exerted on the walls of the various arteries around the body in between heart beats when the heart is relaxed.	It measures the amount of pressure that blood exerts on arteries and vessels while the heart is beating.
Normal Range	60 – 80 mmHg (adults); 65 mmHg (infants); 65 mmHg (6 to 9 years)	90 – 120 mmHg (adults); 95 mmHg (infants); 100 mmHg (6 to 9 years)
Importance with age	Diastolic readings are particularly important in the monitoring blood pressure in younger individuals.	As a person's age increases, so too does the importance of their systolic blood pressure measurement.
Blood Pressure reading:	Diastolic represents the minimum pressure in the arteries with The lower number is diastolic pressure.	Systolic represents the maximum pressure exerted on the arteries with The higher number is the systolic pressure.
Ventricles of the heart for Vessel:	Fill with blood and Relaxed	Left ventricles contract and Contracted of B. Vessel.
Etymology	"Diastolic" comes from the Greek diastole meaning "a drawing apart."	"Systolic" comes from the Greek systole meaning "a drawing together or a contraction."

2.8 Electrocardiogram (ECG)

Electrocardiogram monitors are often used in many medical service centers and hospitals to diagnose and monitor a person's health status by measuring their cardiac activity. An ECG is a non-invasive monitor, to evaluate the heart electrical activity, measure the rate and regularity of heartbeats.

On an ECG, P, Q, R, S and T refer to the different spikes on the reading. P represents the depolarisation of the atria of the heart. Q, R and S represent the depolarisation of the ventricles. T represents the repolarisation of the ventricles.

Figure 2.7 shows that the condition when an ECG connection is attached to the patient with the ECG tracing paper to be analysed by the doctors. This is very

important so that the monitoring of the patient continuously to being measured to check the heart beats. This condition is commonly observed at the hospital.
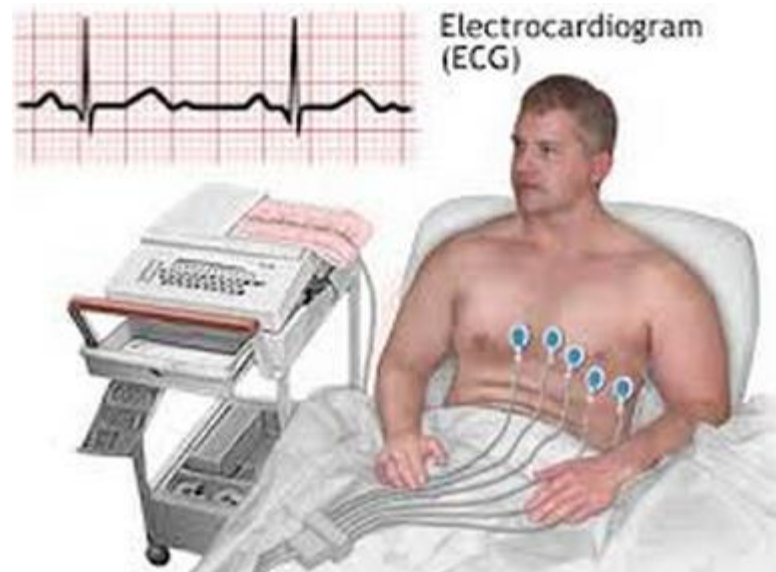
Figure 2.7: Connections with ECG Tracing Paper
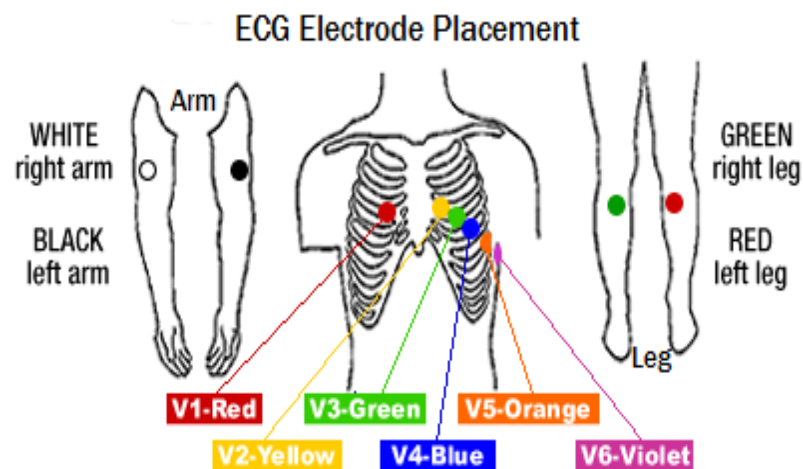
Figure 2.8: ECG placement for 10 electrodes

The standard ECG uses 10 cables to obtain 12 electrical views of the heart is shows in Figure 2.8. These wires break down into 2 groups that is first group for 6 chest leads and second are for 4 limb or peripheral leads with one of it is neutral. A lead is a view of the electrical activity of the heart from a particular angle across the body. The 10 electrodes give 12 pictures that are captured by a group of electrodes.

2.9 Hardware

This project has a hardware component to detect the heart beat is measurement which include sensor, microcontroller and the wireless communications system

2.9.1 Electrode Condenser Placement

Condenser is a capacitor to convert acoustical energy into electrical energy. It is an electronic component which stores energy in the form of an electrostatic field. They also generally have a louder output, but are much more sensitive to loud sounds, low decibel of sound and vibration (Shin et al. n.d.).

Condenser microphones require power from a battery or external source. This device works at a 1.5V operating supply and has a load resistance of 1 kohm.

(a)   (b)

Figure 2.9: Omnidirectional Condenser Microphone Sensor (a) C9767 (b) U8052

Figure 2.9 is an omnidirectional electret condenser microphone that is mountable on to a PCB or breadboard. Features of the Condenser Microphone Sensor with small size around 6.0 x 2.2 mm, high sensitivity type around ± 4dB until –35, impedance less than 2.2 k, maximum operation of voltage is 10 Volt and current consumption Max. 0.5 mA and lastly the sensitivity reduction within –3 dB at 1.5V(Anon n.d.). It is come with wavelength of sound at 10 kHz and the connection to the circuit include the term of output and grounding to get the result in voltage.

2.9.2 Arduino

Arduino is an open-source electronics prototyping platform based on flexible, simple microcontroller board. The development hardware is easy to use with software writing in the board. For this project by taking an inputs signal from the sensors, it also can control a LED, speaker and wireless communication Zigbee.

Referring to Figure 2.10, this project used Arduino Nano and Arduino Mega as a microcontroller to receive data and then transfer it through Zigbee Pro Series 1 for wireless communications. Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 have 14 digital pins with operate supply power at 5 volts. While for Arduino Mega also a microcontroller board based on the ATmega1280 has 54 digital input and output pins with same operate supply as Arduino Nano. Others for wireless connections is 8 pin used to receive (RX) and transmit (TX) at serial data for Arduino Mega while 2 pins TX and RX for Arduino Nano.
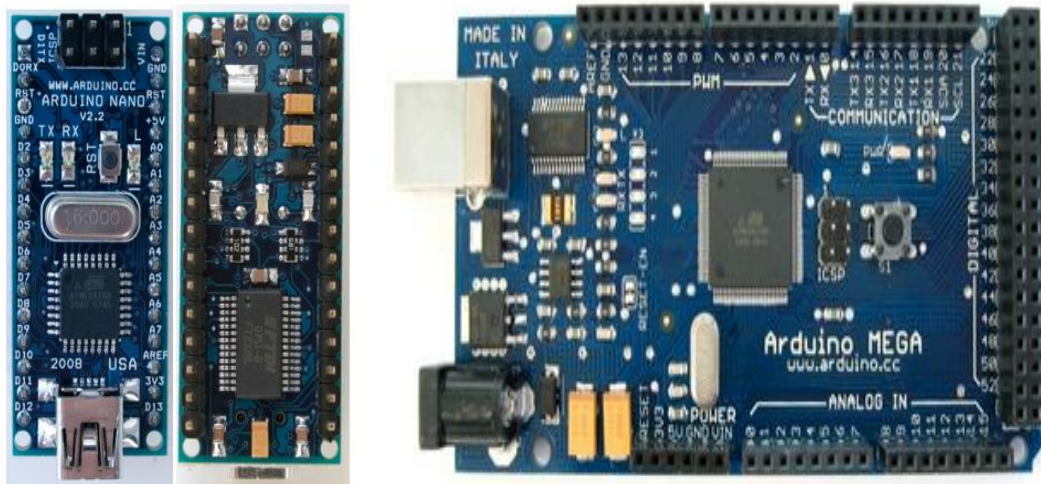
Figure 2.10: Schematic Diagram of Arduino Nano and Arduino Mega

2.9.3 Antenna Wireless Arduino ZigBee

Figure 2.11 is a ZigBee/XBee Pro Series 1 used to transfer the data between transmitter and receiver. It is based on an IEEE 802 standard that is IEEE 802.15.4 in networking protocol for fast point-to-multipoint or peer-to-peer networking. It is used in applications that require a low data rate, long battery life, and secure networking. That has a defined rate of 250 kilobits per second, transfer data or a sent the single signal transmission from a sensor or input device.

Figure 2.11: Wire Antenna Xbee Pro 60 mW Series 1(802.15.4)

The wireless communications using ZigBee can be performed by setting up their addressed using X-CTU programming. There are 4 importance pin that is used and according to the Table 2.9, the connections pin between Arduino and connections of the circuit can be referred.

Table 2.9: Pins for Wireless Communication at Antenna ZigBee

ZigBee or XBee	Arduino Pin	
VCC or 3.3V	3.3 Volt	
TX or D Out	RX or 0	
RX or D In	TX or 1	
Ground or GND	GND	

In the setting of wireless communications Figure 2.12 shows the two Antenna of Zigbee, pin NO.1 is for power supply from Arduino Nano 3.3 volt, pin NO.2 is for Transmit (TX) while pin NO.3 is for Receive (RX) and pin NO. 10 is Grounding (GND). After doing this setup, the suitable programming is needed to make 2 XBee communicate between each other as a transmit data input and receiver data output. Then the connections for Antenna on ZigBee Pro Series 1 are change into pin NO.3 for transmitter (TX) and pin NO.2 for receiver (RX). Two personal computer (PC) is needed to make the communications successful according to the address of the wireless that is based on the baud rate 9600.
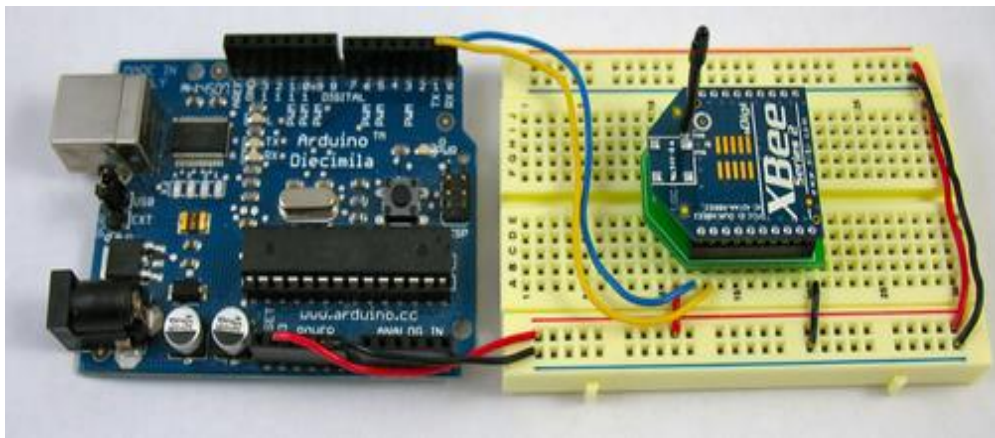
Figure 2. 12: Connection pins between Arduino Duemilanove and Antenna ZigBee

2.10 Software Method

Software that is needed to control this wireless stethoscope system can be monitored and analyzed the heartbeats by the doctors or physician. The system that is used for this method is capturing the input signal in voltage that is from condenser microphone sensor and then being read by the software programming system to convert from analog signal into digital signal for final result in the development of wireless stethoscope.

2.10.1 Arduino C++ Programming

The Arduino integrated development environment (IDE) is a cross-platform application written in Java. It is capable of compiling and uploading programs to the board with a single click. A language reference in Arduino programs that can be divided in three main parts that is structure, values for variables with constants, and functions. It runs machine code compiled from either C, C++, Java4 or any other language that has a compiler for the Arduino instruction set(Amir Hoshang Kioumars 2011).

2.10.2 Wireless Setup using X-CTU Program

X-CTU is a stand-alone tool for configuring ZigBee modules. By download the installation through internet, it will easily install in the personal computer. Then configure the Radio Frequency Modules that is launching the X-CTU software under PC setting by verify the Baud Rate in 9600. The baud rate of a data communications system is the number of symbols per second is transferred. They are simple devices that can use to set up serial communications between the applications. Once installed, it is ready for configuring the ZigBee it will construct a point-to-point network for two devices are going to communicate together. For this project two ZigBee is needed to transmission data and receiving data for wireless communications.

The Heart rate signal was send to the computer through serial communication. MATLAB software will show the result through GUI. Baud rate is set to 9600 to establish the communication between Matlab and serial communication. The 9600 baud means that the serial port is capable of transferring a maximum of 9600 bits per second of data.

$$1 \text{ sec} / 600 = 1.67\text{ms (Data in one Second)}$$

2.10.3 Matlab ASCII

MATLAB is a matrix laboratory that is numerical computing environment and fourth-generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran..

MATLAB has structure data types. MATLAB supports developing applications with graphical user interface features. MATLAB includes GUIDE (GUI development environment) for graphically designing GUIs. It also has tightly integrated graph-plotting features. It is a high-performance language for technical computing.

Table 2.10: ASCII character in Decimal Number

CHARACTER	BINARY	OCTAGON	DECIMAL	HEXAGON
0	00110000	060	48	30
1	00110001	061	49	31
2	00110010	062	50	32
3	00110011	063	51	33
4	00110100	064	52	34
5	00110101	065	53	35
6	00110110	066	54	36
7	00110111	067	55	37
8	00111000	070	56	38
9	00111001	071	57	39

ASCII stands for American Standard Code for Information Interchange. Computers can only understand numbers, so an ASCII code is the numerical representation of a character, text in computer, and communications equipment. Matlab is the user interface that only understands base on the Table 2.10 as shows is the ASCII code for 10 characters includes description numbers. It is an ASCII character for decimal number that will convert Arduino Data Input signal into ASCII code at MATLAB.

2.10.4 Graphical User Interface Design (GUI)

It is a graphical display in one or more windows containing controls, called components that enable a user to perform interactive tasks. It is created using MATLAB tools can also perform any type of computation, read and write data files, communicate with other GUIs, and display data as tables or as plots. . It is includes specifying the inputs, outputs, displays, and behaviours of the GUI and the application it controls shows is Figure 2.13. For this project, the pressing a screen button to get the waveform of hearbeats and key in the importance details data of patient (Y. Tang et al. 2010).
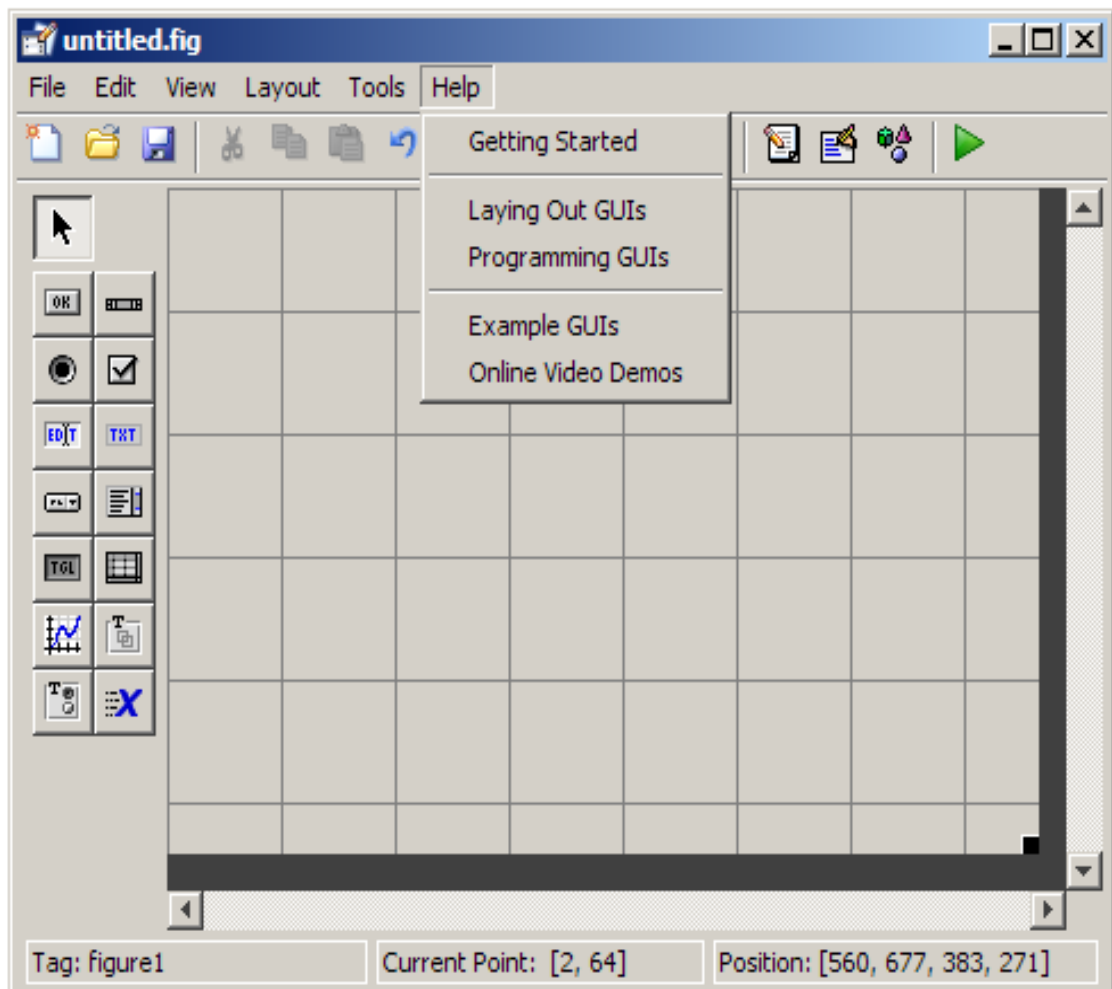

Figure 2.13: GUI Templates for Design System

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