ECG SIGNAL ANALYSIS BY JOINT- TIME FREQUENCY DISTRIBUTION

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SUPERVISOR APPROVAL

"I / We admit that to have read this report and it has follow the scope and quality in Partial Fulfillment of Requirements for the Degree of Bachelor of Electronic Engineering (Computer Engineering)"

Signature : 

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Date : 11/5/06

Special dedication to my loving ma Puan Mazni bte Hussin, my abah Mohamad bin Deraman, all my siblings, my kind hearted supervisor Cik Norhashimah binti Mohd Saad and my dearest friends.

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DECLARATION

"I, hereby declare that this thesis entitled, ECG Signal Analysis by Joint- Time Frequency Distribution is a result of my own research idea except works that have been cited clearly in the references."

Signature : 
Name : AHMAD NASAFI BIN MOHAMAD
Date : 5/5/06

ABSTRACT

A physician or cardiologist needs equipment that can analyze patient heart condition into the signal so that the cardiologist can know the patient's status prediction. The Electrocardiograph (ECG) is one of the medical equipment that investigates any heart disease or any cardiac abnormalities. Each portion of the ECG waveform or signal can obtain the patient's status prediction whether they are in good condition or not. This project is to design, analyze and simulate signal from ECG using Joint-Time-Frequency Distribution. All the formulas in Joint-Time-Frequency Distribution were rewrite into MATLAB 7.0 programming as source code. Data in *file.txt* were analyzed and simulated in MATLAB 7.0. The figure of the signal was appeared in MATLAB 7.0 based on data given. This project can help the cardiologist to know the patient's status prediction by referring the signal that has been simulated.

ABSTRAK

Ahli Fizik atau ahli Kardiologi memerlukan alat yang dapat menganalisa keadaan jantung pesakit ke dalam bentuk isyarat. Dari kaedah ini mereka dapat menjangkakan status keadaan pesakit. ECG adalah salah satu daripada alat- alat perubatan yang menyiasat apa sahaja jenis penyakit jantung atau ketidakseimbangan cardiac. Setiap bahagian pada isyarat dan gelombang ECG boleh mengenalpasti jangkaan status pesakit samada mereka berada dalam keadaan baik ataupun tidak. Projek ini adalah untuk merekabentuk, analisis dan simulasi isyarat dari ECG menggunakan Joint-Time Frequency Distribution. Semua formula dalam Joint- Time Frequency Distribution telah ditulis semula ke dalam program MATLAB 7.0 sebagai aturcara. Data di dalam *file.txt* (notepad) dianalisis dan kemudiannya disimulasi di dalam program MATLAB 7.0. Gambarajah isyarat yang telah muncul di dalam MATLAB 7.0 berdasarkan kepada data yang diberi. Projek ini dapat membantu ahli kardiologi mengetahui jangkaan status pesakit dengan merujuk isyarat yang disimulasi.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Nowadays, there are so many heart diseases that attack each person in this world. There is equipment in biomedical that can measure the heart rate and produce data from patient heart rate into a signal in piece of paper. This project is to analyze and simulate ECG waveform by using MATLAB 7.0 programming. The data were acquitted in *file. csv* format (Microsoft Excel). Data in *file. csv* then were converted into *file.txt* format (notepad). In the MATLAB, the data were analyzed and the figure of signal was appeared to represent the heart disease that its values had been analyzed by MATLAB.

The outputs were put in the GUI (Graphic User Interface) to make the user easy to use it. The signals were represented in 3 steps. First, it was presented in time- domain distribution. Second, in periodogram (frequency- domain distribution) and lastly spectrogram (time- frequency distribution). In this project, normal signal and heart block problems were focused. There were 6 types of heart block problems that had been analyzed in this project. Those heart block problems were listed at the scope of the project.

1.2 OBJECTIVE

The objectives are:

1. To know the patient condition based on the signal that had been analyzed.
2. To know the shape of normal signal and heart block signals.
3. To apply the combination knowledge of engineering technique in Digital Signal Processing (DSP), Joint-Time-Frequency Distribution and programming language such as MATLAB 7.0 software.

1.3 SCOPE OF THE PROJECT

1. Focused on type of signals; Normal and heart block signals that were analyzed using DSP algorithms
2. Type of ECG signals that had been analyzed in this project:

    a) Normal
    b) 1st degree block
    c) 2nd degree block 1
    d) 2nd degree block 2
    e) 3rd degree block
    f) Left bundle branch block
    g) Right bundle branch block

3. Method of signal analysis:

    a) Spectral Distribution (Periodogram Power Spectrum)

b) Joint-Time-Frequency Distribution (Spectogram Representation)

4. Using Matlab Version 7.0

1.4 RESEARH METHODOLOGY

Review of Literature:

Some studies had been made about all the things that related with the project. All things about Joint- Time Frequency Distribution, ECG and ECG signal itself. Beside that, some study and reference about the heart and heart disease based on the signal applied. To learn more about the ECG itself, some visit had been made at a biomedical company at Hospital Melaka.

Data Acquisition:

All ECG data were obtained from ECG simulator MEDSIM 300B that generates the 12- lead ECG waveforms. The data which was taken from lead II was sampled at sampling 500 Hz and saved in the *file .txt* format.

Data Transfer and Data Analysis:

Data in *file.txt* then were generated in MATLAB as source code.

1.5 THESIS OUTLINE

This thesis represented by 5 chapters. The following is the outline of ECG Signal Analysis Joint- Time Frequency Distribution in chapter by chapter.

Chapter I: This chapter discuss about the brief overview about the project such as introduction, objective, scope of study and research methodology.

Chapter II: This chapter discuss about the information that have in this project. This chapter discusses more about the heart itself, ECG signal and ECG itself, characteristics of normal signal and finally about heart blocks diseases.

Chapter III: This chapter discuss about theories that related with the project. The main theory was focused on Digital Signal Processing. In this theory, there were the other theories such as Discrete Fourier Transform, Fast Fourier Transform Spectogram and Periodogram. Simple formulas were used in this section.

Chapter IV: This chapter discuss about development of the project. Start from how the data was taken and how to convert the data from one format to another format. It is also explain about the Graphic User Interface (GUI) of the project.

Chapter V: This chapter describes about the project findings such as result and analysis of ECG signal analysis by joint- time frequency distribution using MATLAB. The result was presented by table, graph and figures.

Chapter VI: Conclusion and recommendation achieved in this project.

CHAPTER II

LITERATURE REVIEW

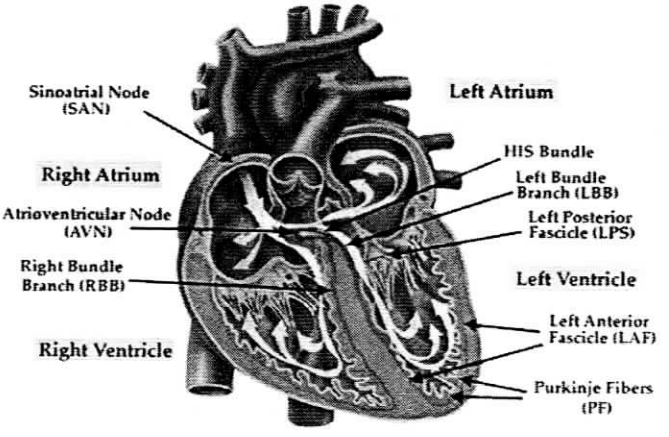

Figure 2.1: The heart diagram

2.1 THE ELECTRICITY OF THE HEART

Depolarization is contraction of any muscle is associated with electrical changes. These changes can be detected by electrodes attached to the surface of the body [1]. Since all muscular contraction will be detected, the electrical changes associated with contraction of the heart muscle will only be clear if the patient is fully relaxed and no skeletal muscles are contracting.

The heart has four chambers, two little ones (right and left atrium), and two large ones (right and left ventricles). The main role of the left and right atriums is to squeeze their walls when they are full with blood so they can fill the ventricles, which are downstream from them. Although the heart has four chambers, from the electrical point of view it can be thought of as having only two, because the two atria contract together and when the two ventricles contract together [1].

Assume the atria pump as a priming pump. By pouring its blood into the ventricle, it prepares it for pumping similar to pouring gasoline into a carburetor to prepare the engine for action. When the ventricles are full of blood their walls contract, and it imparts high pressure to the blood inside them. The blood from the right ventricle flows to the lungs and the blood from the left ventricle flows to the body.

The electrical discharge for each cardiac cycle normally starts in special area of the right atrium called the 'Sinoatrial (SA) node'. Depolarization then spreads through the atrial muscle fibres. There is a delay while the depolarization spreads through another special area in the atrium, the 'atrioventricular node' (also called the 'AV node', or sometimes just 'the node'). Thereafter, the electrical discharge travels very rapidly, down specialized conduction tissue: first a single pathway, the 'bundle if His', which then divides in the septum between the ventricles into right and left bundle branches [1]. The left bundle branch itself divides into two. Within the mass of ventricular muscle, conduction spreads somewhat more slowly, through specialized tissue called 'Purkinje fibres' [3].

The heart beat is basically an electric signal which is initiated by the Sinus Node. The Sinus Node is considered to be the main switch of the heart which initiates the electric impulse of the heart and terminates it. When the Sinus Node is turned on (electric switch is on) an electric current spreads to activate both right atrium and left atrium and then the AV Node (Atrial Ventrical Node).

The AV Node works like a delay station. When an electric impulse comes to the AV Node it is a little bit delayed before the electric impulse goes down to activate the ventricles. This is very important as during this time the Right Atrium and Left Atrium close their doors. The heart generates the electrical impulse that in turn makes the heart beat happen. The electric impulse originates high in the right atrium at the Sinoatrial Node (SA Node), a group of special cells. The impulse leaves the SA Node to spread across both the left and right atria causing them to contract simultaneously.

The SA Node is also known as the normal heart pacemaker, as it sets the pace of the heartbeat. It is responsible for the quickness and swiftness of the heartbeat. Like an electric turbine engine, the SA node generates electric impulses spontaneously all the time; however the rate of its electric impulse discharges is determined by the whole body's needs.

The signals then converge at the atrioventricular AV node, which is the relay station or electrical gate between the otherwise electrically isolated atria and ventricles. The delay provided by the AV node enables both atria to empty completely before the electrical impulse reaches the ventricles. The AV node slows down the impulse. The AV node connects at its lower end to specialized nerve fibers known as the His bundle (Bundle of His), that works like a tiny electric cable, carrying the electric impulse over the middle heart wall (septum).

The Bundle of His then divides into two branches; the right bundle branch and the left bundle branch. The right bundle branch goes to the right ventricle, and comes very close to the surface of the right ventricle muscle and then divides into a tremendous net work of tiny nerve fibers known as Purkinje fibers. The left bundle similarly, terminates into Purkinje fibers in the wall of the left ventricle.

The Purkinje fibers allow the electrical impulse to directly activate the ventricular muscle to contract, and so a heartbeat is generated, the blood from the right ventricle is pumped to the lungs, and the blood from the left ventricle is pumped to the body. The process of electric induction of the heart contraction is known as Electric-Mechanical Coupling.

After activating the heart muscle to contract, the electric impulse disappears, the heart muscle, then relaxes, and is waiting for the sinus node to generate a new electric impulse before it contracts again.

2.2 ELECTROCARDIOGRAPH SIGNAL

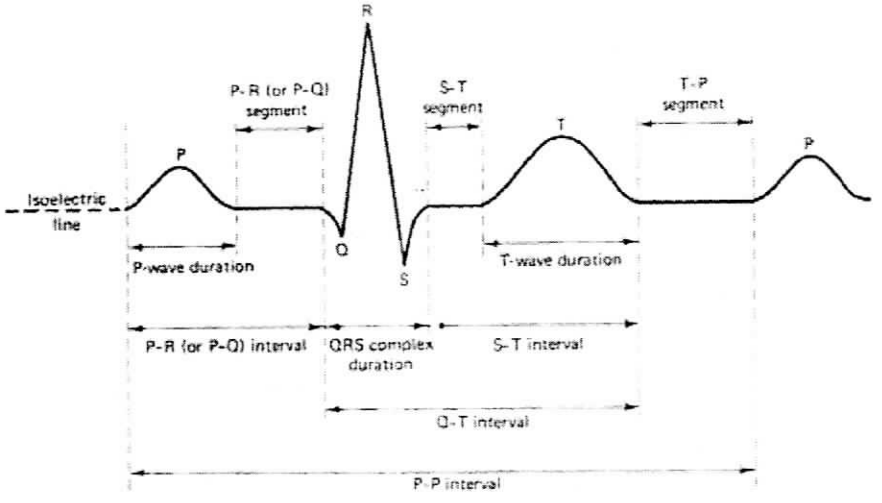

Figure 2.2: ECG Normal Signal

An electrocardiogram (ECG / EKG) is an electrical recording of the heart and is used in the investigation of heart disease. It is one of the Bio- Medical equipment that normally used in medical institution such as hospital and clinic. It comes in many brands and different additional functions.