ANALYSIS AND CLASSIFICATION OF ARRHYTHMIAS IN ECG SIGNALS

NUR AMALINA BINTI MHD IDROS

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

Faculty of Electronic and Computer Engineering
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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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70400 SEREMBAN,
NEGERI SEMBILAN

NORHASHIMAH BT MOHD SAAD
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM),
Karung Berkunci 1200,
Ayer Keroh, 75450 Melaka

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ABSTRACT

ECG (electrocardiograph) is a test that measures the electrical activity of the heart. In an ECG test, the electrical impulses were made while the heart is beating and then it records any problems with the heart's rhythm, and the conduction of the heart beat through the heart which may be affected by underlying heart disease. In this project, different signal processing techniques which are in Time-Frequency Domain and Auto-Correlation will be analyze and later, it will be classify to predict the patient's heart condition whether it is healthy or not. Apart of that, this project also used three types of method for automatic classifications which are Signal Analysis Technique, Pattern Recognition and Automatic Classification. MATLAB will be used as a computerized interpretation of ECG problems. In the MATLAB, the data were analyzed and the figure of the signal was appeared to represent the Arrhythmias.

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TABLE OF CONTENT

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LIST OF TABLES

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LIST OF FIGURES

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LIST OF ABBREVIATIONS

ECG	-	Electrocardiogram
BPM	-	Beats-Per-Minute
SA	-	Sinoatrial
AV	-	Atrioventricular
VT	-	Ventricular tachycardia
VF	-	Ventricular fibrillation
SAN	-	Sinoatrial Node
ICD	-	Cardioverter-Defibrillator
NSR	-	Normal Sinus Rhythm
AF	-	Atrial Fibrillation
SVT	-	Supraventricular Tachycardia
PAT	-	Paroxysmal atrial tachycardia
PVC	-	Premature Ventricular Contraction
FFT	-	Fast Fourier transform
$n_{\omega o}$	-	Length between the negative lag value and positive value in samples of the maximum when the amplitude equal to zero.
r_L	-	Defined as amplitude of first minimum side lobe at Negative maximum lag
n_L	-	Defined as the time occurrence in samples of first minimum side lobe at negative maximum lag.
r_H	-	Defined as the amplitude if first minimum side lobe at positive maximum lag.
n_H	-	Defined as the time occurrence in samples of first minimum side lobe at positive maximum lag.

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CHAPTER 1

INTRODUCTION

1.1 SYNOPSIS

The Electrocardiogram (ECG) is a non-invasive test that used to reflect underlying heart conditions by measuring the electrical activity of the heart. By positioning leads (electrical sensing devices) on the body in the standardized locations, information about many heart conditions can be learned by looking for characteristic patterns on the ECG.

The ECG is performed by ECG leads where the leads are attached to the body while the patient lies flat on a bed or table. Leads are attached to each extremity (4 totals) and to 6 pre-defined positions on the front of the chest. A small amount of gel is applied to the skin, which allows the electrical impulses of the heart to be more easily transmitted to the ECG leads. The leads are attached by the small suction cups, Velcro straps, or by small adhesive patches attached loosely to the skin. The test takes about 5 minutes and is painless. In some instances, men may require the shaving of chest hair to obtain optimal contact between the leads and the skin.

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1.2 OBJECTIVES

The objectives of this project are:

i) To analyze ECG signal processing algorithms
ii) To classify the signals to detect Arrhythmia problems based on the signal that had been analyzed.
iii) To know the shape of normal signal and the Arrhythmia signal.
iv) To built computerized interpretation of ECG problems for Arrhythmia detection using MATLAB.
v) To apply combination knowledge of engineering technique Digital Signal Processing (DSP) and programming language such as MATLAB software.

1.3 SCOPE OF THE PROJECT

Generally, all projects have their own scope or limitation as a guideline. The project scope for the implementation these projects are:

1. Only focused on Normal Signal and Arrhythmia Signals that were analyzed using different DSP algorithm.

2. The Arrhythmia subjects that were analyzed are:
   a) Normal
   b) Atrial Flutter
   c) Atrial Fabrillation
   d) Sinus Arrythmia
   e) Supraventricular Tachycardia
   f) Paroxysmal Atrial Tachycardia
   g) Bigeminy
   h) Trigeminy

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i) Ventricular Tachycardia

3. Using MATLAB software for analysis and simulation.

4. Three type of DSP algorithms used:
   a) Fast Fourier Transform (Periodogram)
   b) Time Frequency (Spectogram)
   c) Auto-Correlation Function

1.4 RESEARCH METHODOLOGY

1. Review of Literature:

   i) Studied made by reading from the Internet.
   ii) Reference notes from softcopy given by supervisor.
   iii) Reference from past-year PSM thesis.
   iv) E-Book

2. Data Acquisition

All ECG data were obtained from ECG simulator MEDSIM 300dB that generates that 12-lead ECG waveforms. The signal is transferred into a computer by using the PC-ECG card and for display and storage purpose. The data, which is taken from Lead II for further analysis is sampled at sampling frequency 500Hz and saved in the *file.txt* format.

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3. Data Analysis and Classification

    i) The signals were then computed in MATLAB for analysis (simulation) and then classified.
    ii) Using 3 Algorithms:
        a) Fast Fourier Transform (Periodogram)
        b) Time-Frequency (Spectogram)
        c) Correlation Function

1.5 PROBLEM STATEMENTS

Presently, many cardiologists face difficulty in making a correct diagnosis for heart diseases. An addition to this also, conventional technique of visual analysis is more complicated and requires experienced and time. Thus, the information obtained from an electrocardiogram can be used to discover different types of heart diseases. It may be useful for seeing how well the patient is responding to treatment. Therefore, by doing this project, a computerized interpretation of ECG problems will be built for analyze the Arrhythmias using MATLAB.

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CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF ECG

2.1.1 The Electrocardiogram (ECG)

The ECG is the electrical sign of the contractile activity of the heart, and can be recorded fairly easily with surface electrodes on the limbs or chest. The ECG is possibly the most commonly known, recognized, and used in biomedical signal. The rhythm of the heart in terms of beats-per-minute (bpm) may be easily estimated by counting the readily identifiable waves. More important is the fact reality that ECG wave shape is altered by cardiovascular disease and abnormalities such as myocarcial ischemia and infraction, ventricular hypertrophy, and conduction problems.

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2.1.2 Uses of ECG

Some of the important uses of ECG:

1) It can be use in the case of symptoms such as dyspnoea (difficulty in breathing), chest pain (angina), fainting, palpitations or when someone can feel that their own heart beat is abnormal.

2) The test can show evidence of disease in the coronary arteries . Unfortunately, in many people who have significant narrowing of the arteries supplying the heart muscle, the ECG recording made at rest is often normal. Therefore, if a significant narrowing is suspected, an ECG recording is often made when the patient is exercising (an exercise stress test) as this is more likely to reveal the problem.

3) An ECG can be used to access if the patient has had a heart attack or evidence of a previous heart attack.

4) An ECG can be used to monitor the effect of medicines used for coronary artery disease.

5) An ECG reveals rhythm problems such as the cause of a slow or fast heart beat.

6) To demonstrate thickening of a heart muscle (left ventricular hypertrophy), for example due to long-standing high blood pressure.

7) To see if there are too few minerals in the blood.

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2.1.3 ECG Normal Signal Intervals

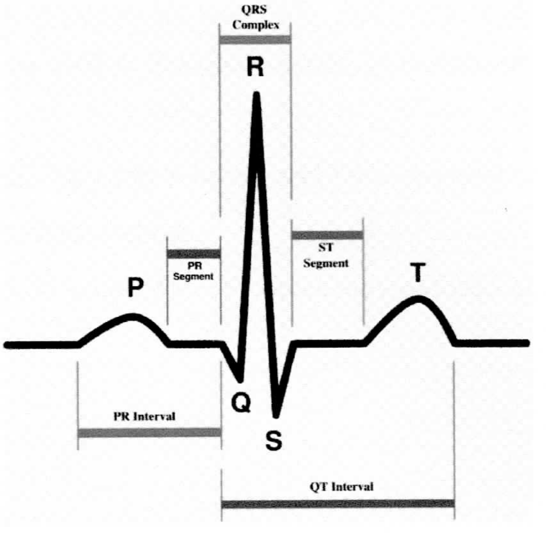

Figure 2.1: Schematic representation of Normal ECG

A typical ECG tracing of a normal heartbeat (or cardiac cycle) consist of a P wave, a QRS complex and a T wave. A small U wave is normally visible in 50% to 75% of ECGs. The baseline voltage of the electrocardiogram is known as the isoelectric line. Typically, the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave.[1]

2.1.4 Rhythm Analysis

There are some basic rules that can be followed to identify a patient's heart rhythm:

i) P wave

During normal atrial depolarization, the mean electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the EKG, which is upright in II, III, and aVF (since the general electrical activity is

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going toward the positive electrode in those leads), and inverted in aVR (since it is going away from the positive electrode for that lead). A P wave must be upright in leads II and aVF and inverted in lead aVR to designate a cardiac rhythm as Sinus Rhythm.

- The relationship between P waves and QRS complexes helps distinguish various cardiac arrhythmias.
- The shape and duration of the P waves may indicate atrial enlargement.

ii) PR Interval

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. It is usually 120 to 200 ms long. On an ECG tracing, this corresponds to 3 to 5 small boxes.

- A prolonged PR interval may indicate a first degree heart block.
- A short PR interval may indicate a pre-excitation syndrome via an accessory pathway that leads to early activation of the ventricles, such as seen in Wolff-Parkinson-White syndrome.
- A variable PR interval may indicate other types of heart block.
- PR segment depression may indicate atrial injury or pericarditis.
- Variable morphologies of P waves in a single ECG lead is suggestive of an ectopic pacemaker rhythm such as wandering pacemaker or multifocal atrial tachycardia

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iii) QRS Complex

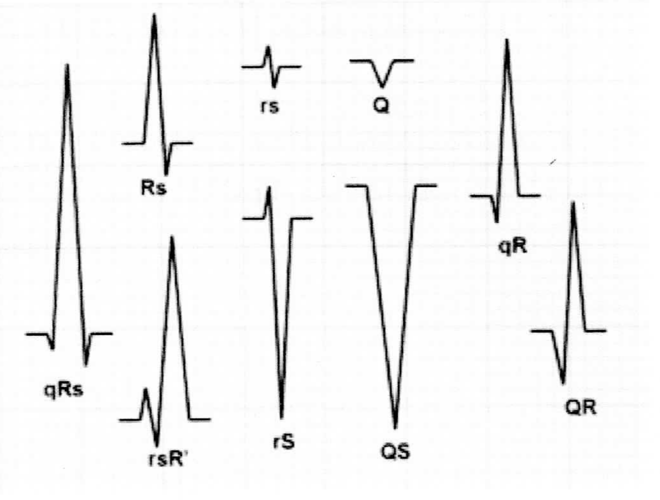

Figure 2.2: Various QRS complex with nomenclature

The QRS complex is a structure on the ECG that corresponds to the depolarization of the ventricles. Because the ventricles contain more muscle mass than the atria, the QRS complex is larger than the P wave. In addition, because the His/Purkinje system coordinates the depolarization of the ventricles, the QRS complex tends to look "spiked" rather than rounded due to the increase in conduction velocity. A normal QRS complex is 0.06 to 0.10 sec (60 to 100 ms) in duration.[2]

Not every QRS complex contains a Q wave, an R wave, and an S wave. By convention, any combination of these waves can be referred to as a QRS complex. However, correct interpretation of difficult ECGs requires exact labeling of the various waves. Some authors use lowercase and capital letters, depending on the relative size of each wave. For example, an Rs complex would be positively deflected, while a rS complex would be negatively deflected. If both complexes were labeled RS, it would be impossible to appreciate this distinction without viewing the actual ECG.

- The duration, amplitude, and morphology of the QRS complex is useful in diagnosing cardiac arrhythmias, conduction abnormalities, ventricular hypertrophy, myocardial infarction, electrolyte derangements, and other disease states.

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