CHARACTERIZATION OF VENTRICULAR TACHYCARDIA AND VENTRICULAR FIBRILLATION USING SEMANTIC MINING

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This thesis is dedicated to my wonderful parents, who have raised me to be the person I am today. You have been with me every step of the way, through good times and bad. Thank you for all the unconditional love, guidance, and support that you have always given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything I put my mind to. Thank you for everything.

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ABSTRACT

Ventricular tachycardia and ventricular fibrillation are ventricular cardiac arrhythmia that could be calamitous and life threatening. The ability to provide accurate predictions of ventricular tachycardia or ventricular fibrillation events can save lives. The purpose of this work was to investigate the possibility of using a semantic mining algorithm to predict the onset of ventricular tachycardia and ventricular fibrillation in electrocardiogram (ECG) signals. A total of eighteen subjects were obtained from Creighton University Ventricular Tachyarrhythmia Database and MIT-BIH Arrhythmia Database. Normal patient ventricular tachycardia, ventricular tachycardia, ventricular fibrillation for the same subject were classified based on annotations supplied by specialists at the Creighton University Cardiac Center. Based on these downloaded data damping ratios, natural frequencies and input parameters were developed using Semantic mining algorithm. The average value of the three developed parameters was determined. These average values were tabulated in sequence with time. Based on true observation, three ratios were taken: first, between the derivative of input parameter and natural frequency; second, between the input parameter and damping ratio; and third, between natural frequency and damping ratio. These ratios are characterized as new parameters and depending on the maximum amplitude for these new parameters, a threshold value is selected to predict the onset of ventricular tachycardia and ventricular fibrillation. In this study, it was found that the new parameters had different amplitude patterns with time according to conditions for the same subject, and the same patterns emerged for the same condition among different subjects. In addition, applying the selected threshold achieved successful result was one to four minute in the forecasting the onset of both Ventricular tachycardia and ventricular fibrillation. In brief this work provides a new method for advanced researches in distinguish and predict of heart disease.

ABSTRAK

Takikardia ventrikular dan fibrilasi ventrikel adalah ventricular cardiac arrhythmia yang boleh menjadi sangat merbahaya dan mengancam nyawa. Kemampuan untuk menyediakan ramalan tepat kejadian takikardia ventrikular atau fibrilasi ventrikel boleh menyelamatkan nyawa. Tujuan kajian ini adalah untuk menyelidik kemungkinan untuk menggunakan satu ekstrak algoritma semantik untuk meramal tanda-tanda awal takikardia ventrikular dan fibrilasi ventrikel pada isyarat elektrokardiogram (ECG). Sejumlah lapan belas subjek telah diperoleh daripada pengkalan data Ventricular Tachyarrhythmia Universiti Creighton dan pengkalan data MIT-BIH Arrhythmia. Pesakit biasa takikardia ventrikular, takikardia ventrikular, fibrilasi ventrikel di bawah subjek yang sama diklasifikasi berdasarkan keterangan yang diberi oleh pakar di Pusat Jantung Universiti Creighton. Berdasarkan maklumat nisbah redaman yang dimuat-turun, kekerapan asal dan parameter masukan telah dibangunkan dengan menggunakan ekstrak algoritma semantik. Nilai purata tiga parameter yang dihasilkan telah ditentukan. Nilai-nilai purata tersebut disusun dalam bentuk jadual mengikut urutan masa. Berdasarkan pemerhatian sebenar, tiga nisbah telah diambil: pertama, diantara terbitan parameter masukan dan frekuensi asal; kedua, diantara parameter masukan dan nisbah redaman; dan ketiga, diantara frekuensi asal dan nisbah redaman. Nisbah-nisbah ini digolongkan sebagai parameter-parameter baru dan bergantung kepada lebar ayunan maksimum untuk parameter-parameter baru ini, satu nilai genting dipilih untuk menentukan bermulanya takikardia ventrikular dan fibrilasi ventrikel. Dalam kajian ini, didapati bahawa parameter-parameter baru mempunyai pola lebar ayunan berbeza dengan masa menurut keadaan perkara yang sama dan pola sama timbul untuk keadaan yang sama diantara perkara yang berbeza. Selain itu, nilai genting terpilih yang digunakan telah berjaya mencapai keputusan yang bagus iaitu satu hingga empat minit dalam meramal permulaan kedua-dua takikardia ventrikular dan fibrilasi ventrikel. Secara ringkasnya kajian ini menyediakan kaedah baru untuk penyelidikan lanjutan dalam membezakan dan meramal penyakit jantung.

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ECG/ EKG	-	Electrocardiogram
VT	-	Ventricle Tachycardia
VF	-	Ventricular Fibrillation
CUdb	-	University Ventricular Tachyarrhythmia Database
CAD	-	Coronary artery disease
CPR	-	Cardio Pulmonary Resuscitation
FFT	-	Fast Fourier Transform
NN	-	Neural Network
WT	-	Wavelet Transforms
ANN	-	Artificial Neural Network
GRNN	-	Generalized Regression Neural Network
LVQ	-	Learning Vector Quantization
P	-	Input vector
IW	-	Weight vector
RMS	-	Root Mean Square
LDA	-	Linear Discriminate Analysis
CWT	-	Continuous Wavelet Transform
DWT	-	Discrete Wavelet Transform

CCU	-	Coronary Care Unit
NSRdb	-	Normal Sinus Rhythm
NP	-	Normal arrhythmia Patient
Z,W,U	-	Damping ratio, Natural frequency, Input parameter

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In [5] heart disease is defined as any disorder that affects the heart. The acknowledgment of the existence of heart disease spans several centuries. However, its causes, symptoms and effects did not specify until the 20th century according to [28]. Heart disease is in a class of medical conditions specified as cardiovascular disease (disorders of the heart or blood vessels).

According to [5] heart disease includes a number of problems affecting the heart and the blood vessels in the heart, where these diseases include:

The Coronary artery disease (CAD) is the most common type and is the leading cause of heart attacks. When you have CAD, your arteries become hard and narrow. Blood has a hard time getting to the heart, so the heart does not get all the blood it needs.

An Angina (an-JEYE-nuh), the angina is chest pain or discomfort that happens when the heart does not get enough blood.

It may feel like a pressing or squeezing pain, often in the chest, but sometimes the pain is in the shoulders, arms, neck, jaw, or back. It can also feel like indigestion (upset stomach). Angina is not a heart attack, but having angina means you are more likely to have a heart attack.

The second disease is Heart attack, the heart attack occurs when an artery is severely or completely blocked, and the heart does not get the blood it needs for more than 20 minutes, then heart failure occurs when the heart is not able to pump blood through the body as well as it should. This means that other organs, which normally get blood from the heart, do not get enough blood. It does not mean that the heart stops. Signs of heart failure include:

- ❖ Shortness of breath (feeling like you can't get enough air).
- ❖ Swelling in feet, ankles, and legs.
- ❖ Extreme tiredness Heart arrhythmias (uh-RITH-mee-uhz) are changes in the beat of the heart.

Most people have felt dizzy, faint, out of breath or had chest pains at one time. These changes in heartbeat are harmless for most people. As you get older, you are more likely to have arrhythmias.

Cardiac arrhythmias can reduce the function of the heart resulting in insufficient blood and oxygen to vital organs. Very serious cardiac arrhythmias can sometimes occur, resulting in sudden death.

In [28] they found around 4% of people in the US have atrial fibrillation; atrial fibrillation is one of cardiac arrhythmia types which could summarize according to [5] as follow:

- ❖ Premature beats: These are the most common type, are usually not harmful, and normally require no treatment.
- ❖ Atrial fibrillation: It tends to occur in older people, often as a result of some underlying heart disease. Atrial fibrillation can be associated with blood clots in the heart but cardiologists can usually identify those at higher risk of blood clot.
- ❖ Bradycardia: This means an unusually slow heart rate. It can cause fatigue, lightheadedness or rarely fainting.

- ❖ Tachycardia: This means an unusually fast heart rate. It can cause palpitations, a sensation of rapid heart action, dizziness, lightheadedness, or rarely fainting.
- ❖ Ventricular arrhythmias: they are Ventricular tachycardia (rapid heart rate arising in the ventricles) and ventricular fibrillation (ventricles begin to quiver and stop beating effectively), for that they are serious cardiac arrhythmias. If ventricular fibrillation is not corrected immediately (for example of an electric shock to the heart within 3-5 minutes), brain and heart damage and death will occur.

The previous paragraph which derived from [5] and [28] showed that Ventricle Tachycardia (VT) and Ventricle Fibrillation (VF) are the two main types of arrhythmia which lead to serious risks cause syncope or sudden cardiac death.

In [3] the Ventricular tachycardia (VT) was defined as general term referring to a rapid heart rhythm faster than 100-120 beats per minute, arising from the ventricles (bottom heart chambers) or the conduction pathway below the bundle of HIS, see figure 1.1. Monomorphic VT refers to a constant ventricular electrical circuit, whereas Polymorphic VT refers to a varying ventricular circuit.

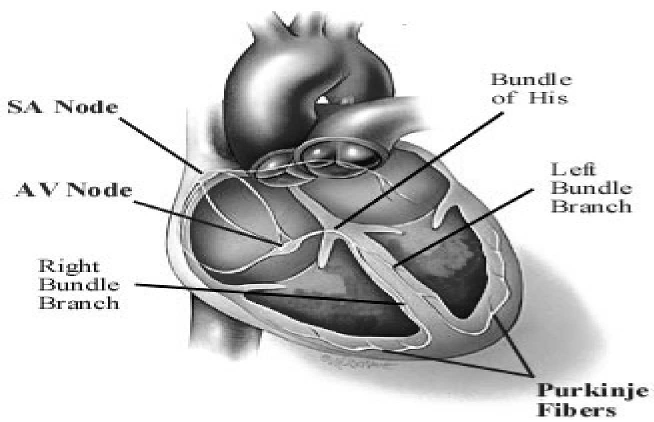

Figure 1.1 Electrical connections in the human heart [5]

In [16] mentioned that this (VT) condition is very dangerous because it could be degenerate further into a totally disorganized electrical activity known as VF. And Ventricular Fibrillation defined as a condition in which the heart's electrical activity becomes completely disordered. According to [5] when this happens, the heart's lower (pumping) chambers contract in a rapid, unsynchronized way, (The ventricles "flutter" rather than beat) then the heart pumps little or no blood, therefore it is crucial for the patient to receive immediate medical intervention when either VF or VT occurs else heart attack occur and lead to sudden death.

1.1.1 ECG Signal

An electrocardiogram (ECG / EKG) is an electrical recording of the heart and is used in the investigation of heart disease. So we calculate from high-resolution ECG recording variance parameters determined ventricular tachycardia, ventricular fibrillation and normal rhythm from patients.

1.2 problem statements

Cardiovascular or Heart disease is one of the main killers in Malaysia based on [29] where the death number keeps rising every year. In [5] heart diseases can be classified into two main classes which are congenital and acquired. Among acquired there are two dangerous types of arrhythmia Ventricular Fibrillation (VF) and Ventricular Tachycardia (VT), they can be described as life threaten by resulting heart fails that causes sudden death of patient, so in this case we need to do immediate treatment for patient in order to keep his life. In sustained VT, there are consecutive impulses that arise from the ventricles at a heart rate of 100 beats or more per minute until were stopped by drug treatment or electrical cardio version. This condition is very dangerous because it may degenerate further into a totally disorganized electrical activity known as VF. In VF, the heart's action is so disorganized that it quivers and doesn’t contract, thus failing to pump blood and will result in a sudden death of the patient. Therefore it is crucial for the patient to receive immediate medical intervention when either VF or VT occurs.

1.3 Research Objectives

The objectives of research work were:

❖ To acquire new parameters that can characterize ventricular fibrillation and ventricular tachycardia.

❖ To assess performance of the proposed parameter.

This research covered the distinguish among the three types of ECG train, i.e. Normal ventricular tachycardia, abnormal ventricular tachycardia and ventricular fibrillation depend on their characteristics in order to predict their occurrence even for a few seconds advance can potentially save one life.

1.4 Scope of Work

The general research scheme was characterized of VF and VT by using semantic mining algorithm. This algorithm provided three new parameters for VT and VF characterization, i.e. natural frequency, damping coefficient and input parameter, which used to derive three new parameters ($\frac{d\mu/_{dt}}{d\omega/_{dt}}$, $\frac{du/_{dt}}{d\zeta/_{dt}}$ and $\frac{d\omega/_{dt}}{d\zeta/_{dt}}$), where this last parameters used to achieve new threshold value used for prediction VT and VF.

This study used electrocardiogram (ECG) data with VF and VT that had been downloaded from MIT-BIH database [2].

All programming codes were developed using LABVIEW 8.2.

1.5 Significant of Study

The findings of this study are important to reduce the high percentage for sudden death via occurrence of Ventricular Fibrillation (VF) and Ventricular Tachycardia (VT), so by way of predicted them then we got the capability to give the necessary medical treatment to a patient in order to prevent (VF) or stop it before it kills the patient, e.g. one of the methods to stop (VF) is the defibrillation treatment. Finally, it is a novel issue to save patient life even for a few seconds in advance.

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