UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IOT BASED ELECTROCARDIOGRAPH (ECG) MONITORING SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Industrial Automation and Robotics) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Every day there is increasing population growth and hence the number of heart diseases. The contemporary hospital system becomes ineffective in treating conditions requiring immediate treatment. The focus then is on the centric hospital system and the patient center system. This project proposes a health surveillance system which monitors patients ' vital parameter using a Arduino mega and node mcu board heart rate sensor. The signals from AD8232 are converted to analog digital values by means of electrode pads. The heartbeat of the patient is recorded in the database and displayed with Blynk App on mobile phones. The intention of this projects to make health-related patients easier by designing and transmitting the physiological data from the body surface to the IoT cloud via wireless channels by using an AD8232 core rate sensor and single board computer. The project will provide wireless transmission. It is anticipated that the system will in future produce a thorough signal analysis and detect a specific disease.

ABSTRAK

Setiap hari terdapat peningkatan pertumbuhan penduduk dan begitu juga dengan bilangan penyakit jantung. Sistem hospital kontemporari menjadi tidak berkesan dalam merawat keadaan yang memerlukan rawatan segera. Tumpuannya adalah pada sistem hospital sentris dan sistem pusat pesakit. Projek ini mencadangkan sistem pengawasan kesihatan yang memantau parameter penting pesakit menggunakan sensor raspberry pi papan laju. Isyarat dari AD8232 ditukar kepada nilai digital analog dengan menggunakan elektrod pad. Denyutan jantung pesakit dirakam dalam pangkalan data dan dipaparkan dengan Blynk App pada telefon bimbit. Tujuan projek ini untuk menjadikan pesakit yang berkaitan dengan kesihatan lebih mudah dengan merancang dan menghantar data fisiologi dari permukaan badan ke awan IoT melalui saluran tanpa wayar dengan menggunakan sensor kadar jantung AD8232 dan komputer papan tunggal. Projek ini akan menyediakan penghantaran tanpa wayar. Diharapkan sistem ini pada masa akan datang menghasilkan analisis isyarat menyeluruh dan mengesan penyakit tertentu.

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Nevertheless, I gained a lot of precious knowledge and unforgettable experience by involving myself in exhibitions to widen my idea and analyse the feasibility of my project. I have learned a lot and really enjoyed while working for this thesis.

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LIST OF ABBREVIATIONS

ADC	Analog-to-Digital Converter
AFE	Analogue frontend
BPM	Beats per minute
CMRR	Common-Mode Rejection Ratio
DRL	"Driven Right Leg"
ECG	Electrocardiograph
FFT	Fast Fourier Tranform
GUI	Graphical User Interface
IFFT	Inverse Fast Fourier Transform
LA	Left Arm
LAN	Local Area Network
MoRE	Matrix of regularity
PHI	Public Health Institutions
RA	Right Arm
RL	Right Leg
SpO2	Blood Oxygen Saturation
WBASN	Wireless Body Area Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Project Background

Heart is an important part of the body that must be prioritized. Heart rate means the number of heart beat recorded in 60 seconds. The founder of galvanometer, Dr. Luigí Galvani who is an anatomist said electric current can be detected from skeletal muscles and this muscle contraction is caused by heart stimulation. A British physician Augustus D. Waller introduced human cardiograms later in 1887. Dr. Willem Einthoven produced his first electrocardiogram in the early 19th century recorded with a string- galvanometer. The magneto cardiogram was then invented, which employs the electromagnetic field created by Baule and McFee in 1963 by cardiac activity. Finally, a cardiologist from Denmark produced Electrocardiograph (ECG) wireless transmission for a patient in 2005 (AlGhatrif & Lindsay, 2012).

Now, in the 21st century, technological growth is experienced in our everyday lives. Today's developments take a short time to transform or innovate. These changes human beings in all respects, and so many new equipment is being developed in the medical field to improve the effectiveness of a disease. The ECG system is one of the main developments to be prioritized. Doctors use ECG for cardiac beat detection. Electric heart rhythm detection is therefore different. If these signals vary or are not consistent, then medical helpers can identify cardiac-related problems due to the

different signals produced. This really helps as it warns patients about cardiovascular attacks or other diseases like arrhythmias, congenital heart disease, and heart disease. There are mainly two terms to describe abnormal rhythm which are called tachycardia and bradycardia. When heart rate goes higher than normal, it is said tachycardia and vice versa is called bradycardia.

The standard way to perform ECG is shown in Figure 1.1. When the cardiac momentum passes through the cardiac muscle, electrical impulses are produced and spread over adjacent cardiac tissues. Little part of the current stretches across the body surface. Thus, the electrical potential can be recorded when electrodes are placed on the skin.

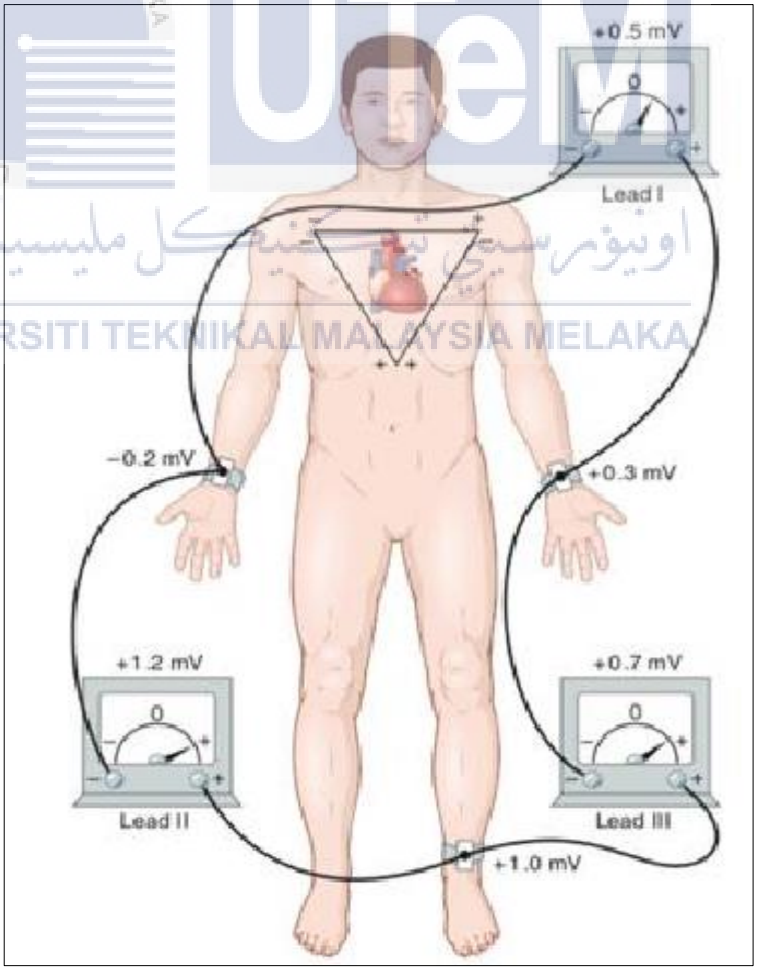

Figure 1.1 Conventional electrode registration system for electrocardiographic standard conducting

The standard ECG is comprised of P waves, QRS complexes, and T waves, as shown in Figure 1.2. The P wave is generated by electrical potential when the atrium depolarizes prior to atrial contraction. When the ventricles depolarize before contraction, that's the instant where QRS complex occurs. Therefore depolarization waves are both the P wave and the QRS complex components. The T-Wave is called repolarization wave and it has the potential to rebound from the depolarization state. The ECG consists of waves of depolarization as well as repolarization.

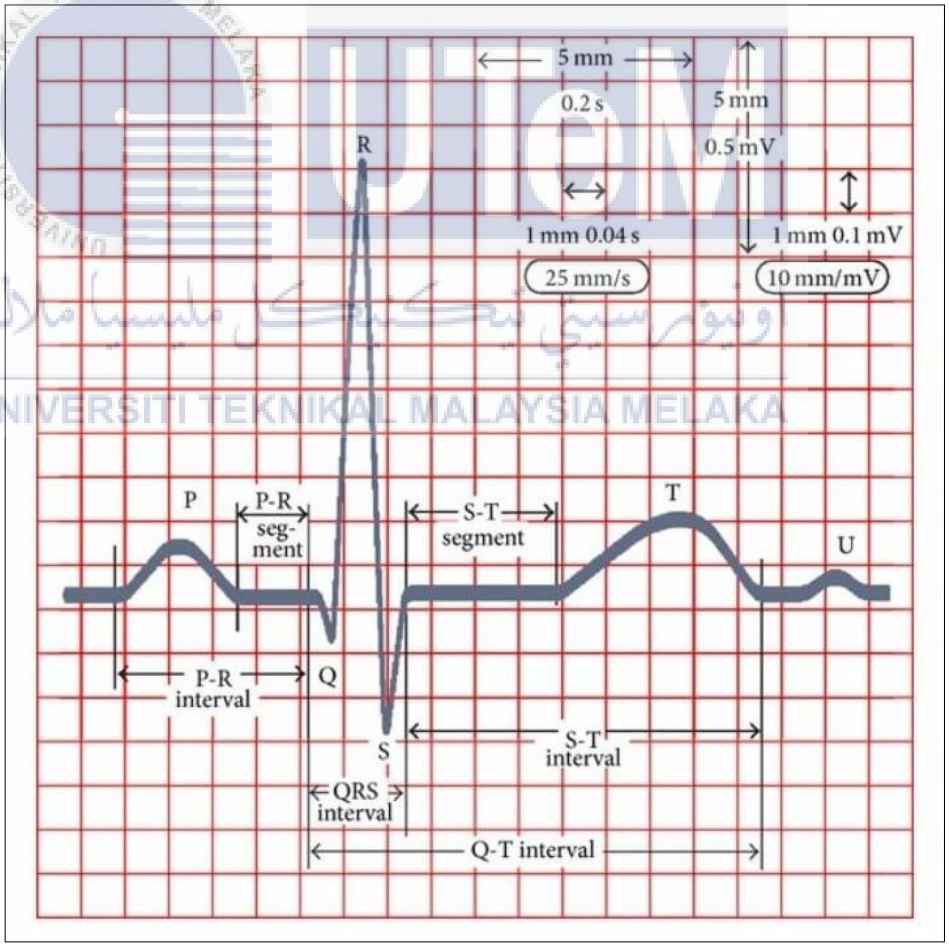

Figure 1.2 The P, QRS and T wave

1.2 Problem Statement

The traditional approach to cardiac monitoring means is that the patient always goes to the hospital to be examined by the cardiologist or the medical practitioner for any cardiac disease, particularly in rural areas. The signs of abnormality can also be intermediate, which means that the signs may disappear when you see the physician. In addition, there is no family member who can access patient health data since its confidential to health institutes, so monitoring and warning is difficult.

In medical institutions, the standard Electrocardiogram (ECG) machine used is costly and requires an expert in the management of the machine. The medical costs for the patients are high. The machine can show heartbeat in real time and is not moving, making it difficult for patients from far away. This makes it difficult for monitoring patient from time to time.

1.3 Objectives

I. To develop a portable ECG sensor that has little impact on the daily life of the user.

II. To analyse the heartbeat signal and detect abnormalities

III. To establish the wireless transmission between the physiological data from the body surface by wireless channel to the IoT cloud.

1.4 Scope of Study

In this study the heartbeat signal from the heart rate sensor is obtained and the noise is filtered by minimum design complexity. This project is to produce an ECG sensor that can be transported to the internet in real time

Cardiologist, patients and their families update the signal received from ECG sensors in real time. This helps to identify patients' problems. The real time signal obtained can be further analyzed to determine if the patient has heart disease.

This system can alert if abnormalities occur during the analysis of the heartbeat signals. The system can communicate the message or an e-mail to both the doctor and the patient. So, it will be helpful to create such a solution.

Data collected by the heart rate sensor will be uploaded to the respective hospital database, where the patient receives real-time treatment and care. Patient data can be accessed through mobile devices only by the physician and the patient circle as family members, close relatives or guardians. This ensures that patients are secured in detail. This allows patients to monitor their health at home.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Technology improvement has gone far beyond expectations and is still being upgraded for a better future. Considering issues related to world health, heart-related diseases are something crucial and threatening human life. The technology is chasing its way to replace the traditional method of using a machine with an electrocardiogram. The monitoring system of the electrocardiograph (ECG) basically means the constant observation even from home of the heartbeat of the patient. Author Henian Xia said the ECG monitoring system is intended to facilitate patient self-monitoring with internet assistance (Xia, Asif, & Zhao, 2013). Stefan expresses his perception of this system as IoT-based ECG monitoring improves the quality of heart beat signal recording for monitoring purposes and ECG diagnosis productivity (Gradl, Kugler, Lohmuller & Eskofier, 2012).

In addition, author Fernando agrees that ECG monitoring system is an uninterrupted observation of the patient's heartbeat while still waiting to be attended by a doctor. A patient's heart beat may suddenly deteriorate without being noticed by the nurses, according to Fernando (González et al., 2014). In overcrowded public health institutions, the use of ECG monitoring is vital. ECG tracking system in other words can be conveyed as mobile telemedicine devices (m-health) since it shows

patient health being assisted and monitored by a simple application installed on mobile devices.

The resulting fever also adds a high death rate to patients (Garmel and Gus 2012; Harry, 2015). The results are high body temperature. One of the key indicators of human health is body temperature (Rush and Wetherall, 2003). For example, an unusual increase in body temperature during ebola outbreak in Nigeria was one of the possible signs of a patient contracting the dreaded virus. A pain level monitoring cab should also be used after an operation (Jiann et al., 2007) for body temperature control. High body temperatures could also be a symptom of other conditions. High temperatures for children could lead to convulsion and death if not properly controlled. The human body's normal temperatures are around 370C and differ in age and climate depending on the person (Malhi et al., 2012).

2.1 Methods to read ECG signals

2.1.0 ECG Extraction Algorithm

There are mainly few methods used by research investigators to obtain the ECG signals produced by the heart rate sensor based on the research conducted. Author Henian Xia proposed the use of matrix method to merge quality indices. Regularity matrix (MoRE) calculates the degree of ECG irregularities. The largest magnitude of eigenvalues denoted by spectral radius of a matrix is calculated to represent the quality of the ECG records. Thus, a score of zero denotes the ECG has high signal quality and score of more than zero corresponds to a weak signal strength (Xia et al., 2013).

QRS detection using Pan-Tompkins algorithm is the most common technique used. By using this algorithm, Author Stefan (Gradl et al., 2012) said heart beats are

spotted with 99 percent accuracy. Rachim (Rachim & Chung, 2016) added that the overall result of the recorded ECG signal shows an error of less than 10 %. The ECG signal detection using Pan-Tompkins algorithm uses counters to calculate which is known as the beat classification algorithm (Nigam, Chavan, Ghatule & Barkade, 2016). Jiang reported the identification of heart rate using QRS peak detection by suggesting two methods, peak threshold and peak filter (Jiang, Dong, & Zhang, 2017). QRS complex is one of the key features of ECG signal detection and the detection of arrhythmia as those condition and measurements in this method might vary and outlook this method as a difficult one to perform, but it gives promising accuracy to the result (Singh Sachin & N. Netaji Gandhi, 2013).

Another method suggested by Ziran Peng is to use wavelet transform based on the Eigenvalue detection algorithm. In this method, ECG eigenvalues used by reversing the myocardial action potential to detect and diagnose heart rate signal abnormalities (Peng & Wang, 2017). Wavelet transform is an analysis of frequency-time in which the time and frequency frame may change. It is used to denoise the non-stationary ECG signal that could change in sudden (Banerjee & Mitra, 2014). Wavelet transformation is used to obtain ECG signal and to recognize abnormal heartbeat in which optimal wavelet is selected from the orthogonal and bi-orthogonal wavelet filter bank (Shalini et al., 2015).

2.1.1 Techniques for ECG parameters extraction

Several approaches have been targeted by researchers to have a better ECG signal. In circuit construction, Park (Park, Chou, Bai, Matthews, & Hibbs, n.d.) used insulated bioelectrodes. Park was able to measure the electrical potential on the skin without resistive and low-capacitive coupling by using low dielectric material.

Compared to the gold standard, this resulted in a 99 percent correlation.

SpO2 and pulse sensor are associated with mathematics using the modulation ratio (Rushambwa, Gezimati & Jeeva, 2017) to obtain SpO2 using pulse rate. A human's normal resting heartbeat is 60-100bpm, an adult average rate is 72bpm, athletes will have a lower rate than those less active in daily activities, and children will have about 90 beats per minute. The modulation ratio between red LED and infrared LED signals is the calculation method for SpO2 (Rushambwa et al., 2017) as shown in the formula below

$$R = (ACrms\_Red / DC\_Red) / (ACrms\_IR / DC\_IR) \quad (1)$$

Where "DC_Red" and "DC_IR" mean: "Average value overtime".

And "ACrms" means: alternating amount within the signal values overtime.

$$\% SpO2 = 110 - 25 \times R \quad (2)$$

Source : (Rushambwa et al., 2017)

The third technique uses Stefano's proposed Common-Mode Rejection Ratio (CMRR). Normally an ECG device consists of a signal processing unit and analogue frontend (AFE) circuit. CMRR is used to overcome the interference in common mode resulting from electromagnetic interference on the human body. This interference is caused by electrical systems such as electronic equipment, AC power lines and fluorescent lighting.

To repress the interference signal, "Driven right leg" (DRL) is used. AFE and DRL circuit combination is used to amplify the voltage of common mode and send the signal back to the body of the patient. At the input of the amplifier, the DRL subdue the amplitude of common-mode interference. Figure 1.3 shows the typical way of the

ECG analogue frontend circuit.

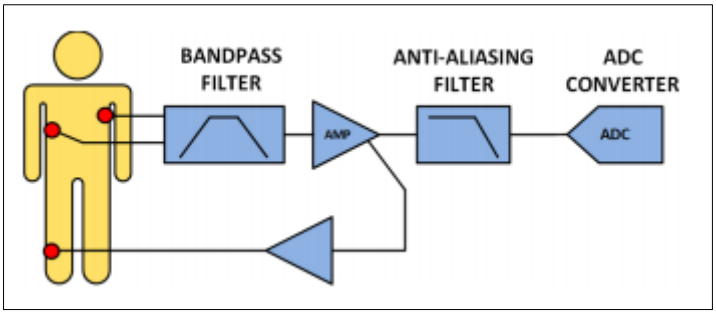

Figure 2.1 ECG AFE Method

2.2 Types of microcontroller

Arduino was used in Smart Health Monitoring by Adil (Adil Parvez & Bhosale, 2018). Arduino is a famous platform that provides low-cost IoT servers, according to Adil. Sanjay (Sanjay Kale & Bhagwat, 2016) said using Arduino provides good performance as it has a very high speed and greater memory space compared to other micro controllers.

Munyaradzi suggested using Arduino as it is more flexible and provides user mobility (Rushambwa et al., 2017). Hafid (Hafid et al., 2017) said Arduino allows fast prototyping because it is reasonably priced and compatible with most components. Arduino acts as a complete computer because it can be used as a personal server to save patient information and medication details (Rajkumar, Srikanth, & Ramasubramanian, 2017). Author Andrej conducted research on streaming pulse data to the cloud using 3 different modules primarily Bluetooth module (HC05), low-energy Bluetooth module and Wifi module ESP8266 (Škraba et al., 2016). The finding of Andrej states that if one were to strive for the complexity of the design, then ESP8266 is a choice as it consists of a module and a sensor, whereas if the priority is