Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF LOW-COST IOT BASED HEART RATE MONITORING SYSTEM FOR TELEMEDICINE APPLICATIONS USING ARDUINO

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SIEW MING HONG

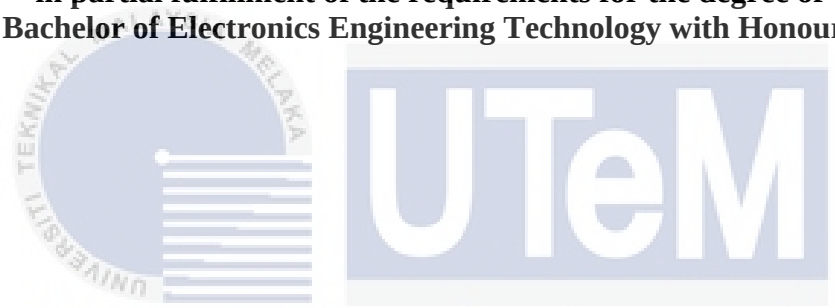
Bachelor of Electronics Engineering Technology with Honours

2021

DEVELOPMENT OF LOW-COST IOT BASED HEART RATE MONITORING SYSTEM FOR TELEMEDICINE APPLICATIONS USING ARDUINO

SIEW MING HONG

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology with Honours



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DEDICATION

I dedicate this report to my beloved,

Mother, ***WONG YOKE KAM****,*
and Father, ***SIEW TAI MUN****,*

whose always support and encourage me to reach this destination.
And along with all hard working and respected,

Supervisor, ***DR. VIGNESWARAN NARAYANAMURTHY****.*

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ABSTRACT

This research paper is related to the development of low-cost Internet of Things (IoT) based heart rate monitoring system for telemedicine applications using Arduino. A study had explored about the techniques and the technologies that used in this heart rate monitoring system, Photoplethysmography (PPG) is meaning that the light emits on the skin surface is used to detect heart rate. This main objective in the research is to develop a portable, cheap, functional monitoring system to obtain an accurate pulse or heart rate. With the improvement of living standards and the growth of economic pressure, people begin to pay attention to their own physical health. Research shows that in resting heart rate, children 10 years and older, and adults (including seniors) have a heart rate of about 60 to 100 beats per minute (bpm). The heart rate parameter can be obtained and show using a third-party application such as ThingSpeak or Blynk. It is easier to detect any heart-based disorders if the bpm is either lower or higher. Therefore, the implementation of a heart rate monitoring system is significant for people in order to make sure their health is in excellent condition.

Keywords: Heart rate, pulse, photoplethysmography, healthcare

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ABSTRAK

Kajian ini adalah berkaitan dengan pengembangan kos rendah sistem pemantauan denyut jantung berdasarkan Internet of Things (IoT) untuk aplikasi telemedicine menggunakan Arduino. Satu kajian telah meneroka tentang teknik dan teknologi yang digunakan dalam sistem pemantauan denyut jantung ini. Objektif utama penyelidikan ini adalah untuk mengembangkan sistem pemantauan yang ringan, murah dan berfungsi untuk mendapatkan denyutan nadi atau jantung dengan tepat. Dalam peningkatan taraf hidup dan pertumbuhan tekanan ekonomi ini, orang mula memperhatikan kesihatan fizikal mereka sendiri. Penyelidikan menunjukkan bahawa pada denyutan jantung dalam situasi berehat, kanak-kanak berumur 10 tahun ke atas, dan orang dewasa (termasuk warga emas) mempunyai kadar denyutan jantung sekitar 60 hingga 100 denyutan semini. Parameter denyut jantung dapat diperoleh dan ditunjukkan dengan menggunakan aplikasi pihak ketiga seperti ThingSpeak atau Blynk. Cara ini memudahkan pengesanan sebarang gangguan jantung jika denyutan jantung lebih rendah atau lebih tinggi. Oleh itu, pelaksanaan sistem pemantauan denyut jantung adalah penting bagi orang-orang untuk memastikan kesihatan mereka berada dalam keadaan yang sangat baik.

Kata kunci: Denyut jantung, pemantauan, *photoplethysmography*, kesihatan

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ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Vigneswaran Narayamurthy and Miss Bhuvaneshwari Shanmugavel for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) and Faculty of Engineering Technology (FTK) for the financial support through Bank Islam which enables me to accomplish the project. Not forgetting my fellow colleague, Muhammad 'Izzul Haziq bin Ibrahim and Revaithi A/P Kalithumu for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents, and family members for their love and prayer during the period of my study. An honourable mention also goes to my father, SIEW TAI MUN and my mother, WONG YOKE KAM for all the motivation and understanding.

Finally, I would like to thank all the staffs at the FTK, fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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LIST OF SYMBOLS

V	-	Voltage
Ω	-	Resistance
$O2$	-	Oxygen
%	-	Percentage
$>$	-	More than
$<$	-	Less than
A	-	Ampere
s	-	Second
h(rs)	-	Hour(s)

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LIST OF ABBREVIATIONS

WHO	-	World Health Organization
IoT	-	Internet of Things
PPG	-	Photoplethysmography
bpm	-	Beats per minute
LED	-	Light emitting diode
$WiFi$	-	Wireless Fidelity
PC	-	Personal computer
IMU	-	Inertial measurement unit
HR	-	Heart Rate
CAD	-	Coronary Artery Disease
CHD	-	Congenital Heart Disease
HF	-	Heart Failure
BMI	-	Body mass index
USA	-	United State America
$FYP\ /PSM$	-	Final Year Project (Project Sarjan Muda)
ADC	-	Analog-to-Digital Converter
IR	-	Infrared
IDE	-	Integrated Development Environment
$RISC$	-	Reduced Instruction Set Computing
TCP/IP	-	Transmission Control Protocol/Internet Protocol
USB	-	Universal Serial Bus
SNR	-	Signal-to-Noise
HEX	-	Hexadecimal
PCB	-	Printed Circuit Board
VCC	-	Voltage Common Collector
GND	-	Ground
RST	-	Reset
CH_PD	-	Chip Power-Down
RXD	-	Receive Data

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TXD	-	Transmit Data
$Op-Amp$	-	Operational Amplifier
IC	-	Integrated Circuit
$CO2$	-	Carbon dioxide
GPS	-	Global Positioning System
LCD	-	Liquid Crystal Display

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CHAPTER 1

INTRODUCTION

1.1 Background

Heart-based disorders are the top cause of death globally, approximately a 17.9millions of human beings had been taken from this disease. The factors that lead to heart disease usually high blood pressure, high blood cholesterol, raised blood lipids, overweight and obesity. According to World Health Organization (WHO), 4.9 million people die from lung cancer through nicotine from tobacco, 2.6 million are from obese people, 4.4 million dies from high cholesterol, and 7.1 million die from high blood pressure [1].

Over the past 10 years, consumers are very concerned about their health, especially in these 2 years due to COVID-19. In this case, heart rate is the easiest way that let consumers know about their health condition. Therefore, a heart rate monitoring system is needed to keep the eyes on health and to maintain good heart health.

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Why we need heart rate monitor? When athlete start to work out with exercise routine, keep an eye on the heart rate will help the athlete exercise more efficiently. Exercise smart but not exercise hard is very important to an athlete because they can exercise in a longer time without getting exhausted. Besides, as a normal people, we also can keep tracking our heart beats. If any unusual pulses tracked, we would get to know the first and get treatment as soon as possible.

Based on the Internet of Things (IoT) technology, this paper is going to develop a low-cost Internet of Things (IoT) based heart rate monitoring system for telemedicine applications using Arduino, which is used to realize the resting state of the heart rate, afterward transmit the data that can be monitored through applications. Therefore, this research is suitable to all kind of people especially for elderly, infant, patient as well as athlete that need other people to inspect and take care.

1.2 Problem Statement

I had found a few problems after did a few analyses and studies.

I. Different skin tones will lead to inaccuracy in obtaining the heart rate signal due to the ability of light absorption about the light.

II. Uncomfortable when wearing the monitoring device.

III. Much optical heart rate monitoring system today is located on the wrist and the place is one of the most inaccurate places to obtain the signal of heart rate by the sensor.

1.3 Project Objective

The main aim of this project is to develop a heart rate monitoring system that able to operate automatically for domestic users in affordable price. Below are the sub-objectives that were delivered.

a) To develop a real-time heart rate monitoring system.
   - To help individuals track their health condition even in a sleeping state.

b) To obtain an accurate heart rate pulse.
   - By comparing the prototype and the medical used, the error will be minimized.

c) To construct the designed heart rate monitoring system prototype.
   - To fulfill the main objective of this project, which is portable and cheap.

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1.4 Scope of Project

This project is a conceptual work. The scope of this project are as follows:

1. Case study about the technology and the development for this project in order to work accurately and correctly.

2. The prototype that was constructed will be compared with the blood pressure device and existing heart rate monitor to minimize the error.

3. Room conditions and other parameters that will affect the readings will be analyzed.

4. IoT analytics platform services such as ThingSpeak or Blynk will be used for real-time monitoring purposes.

1.5 Scope of Project

This thesis has a content that consists of five chapter.

1. INTRODUCTION

   Overview of this project which contains an introduction or background about the topic, problem statements, objectives, scopes, and the layouts.

2. LITERATURE REVIEW

   Contain the introduction about heart rate monitoring system, the article reviews about the applications, techniques and cardiovascular disease.

3. METHODOLOGY

   Specify for project activities and the experimental setup on hardware and software.

4. RESULT & DISCUSSION

   Present the initial results obtained by existing heart rate monitor and comparison about the prototype and the existing one.

5. CONCLUSION AND FUTURE WORKS

   Included some conclusion about the entire project and future recommendation that can be done to enhance the prototype performance.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The heart is one of the most important parts of our human body. It can behave as the voltage supply. The heart is an organ that pumps blood throughout the body via the circulatory system, supplying oxygen and nutrients to the tissues and removing carbon dioxide and other wastes. It helps to maintain the functionality of the body. [2]

Heart rate refers to the number of heart beats per minute of normal people in a quiet state, also called resting heart rate, generally 60 to 100 beats per minute (bpm), and individual differences can occur due to age, gender, or other physiological factors. Generally, the younger the age, the faster the heart rate. The heart rate of the elderly is lower than that of the young, and the heart rate of women is faster than that of men of the same age. These are normal physiological phenomena. In a quiet state, the normal heart rate of adults is around 72 beats per minute, and the babies have heart rates at around 120 beats per minute (bpm), while older children are about 90 beats per minute (bpm) [3].

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This study concentrates on the articles that are published between the year 2010 until the year 2020. The common keywords used for searching in this topic are “heart rate”, “pulse”, “photoplethysmography” and “healthcare”. Numerous articles that found these keywords and we sorted out few relevant articles and provided them in year-based order accordingly.

2.2 Applications

2.2.1 Heart Rate Monitoring System for Athlete

Mahmood et al. had proposed a wrist-type heart rate monitoring system for the athlete during their training session. Different color code of light-emitting diode (LED) is composited in a bracelet for a purpose of easier to let the user know what’s their heart rate range during training. The communication protocol of the color-coded heart rate monitoring system that

the team used is Zigbee and ANT+. Zigbee has a lesser power consumption, more power-efficient, and cheaper price. The size of Zigbee is also smaller compared to the Bluetooth protocol. However, ANT+ has a magnitude order that smaller than Zigbee and forty times smaller than Bluetooth protocol. This prototype is proposed to be non-invasive, portable, and comfortable for the athlete during training. This device benefits the coach that able to monitor the athlete's heart rate condition by monitoring only the LED signal. [4]

2.2.2 Heart Rate Monitoring in Sport Training.

Zulkifli et al. had planned a project of Xbee based wireless heart rate monitoring system. Xbee module is used in this project due to the power consumption is much lower (25% of standard Wi-Fi) and a lower data transfer rate (250kbit/s). Besides, the Xbee module also provided a wireless range of up to 100 meters of straight view and 30meters of indoor or urban range. In this project, a mesh wireless network will be proposed. The reason that mesh network is used instead of star topology is due to the better coverage which leads to a stronger wireless connection. With this feature, the coach can easily monitor multiple heart rates at the same time even the coach is far away. Overtrained athletes may lead to injury or lethargy. Therefore, effective training is needed for every athlete in order to get the best improvement and good performance during the competition. [5]

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2.2.3 Sports Bracelet Based on Internet of Things (IoT)

Xiao et al. had evaluated a project about wearable heart rate monitoring systems with IoT based. With the architecture of IoT, communication protocols or sensors such as Zigbee, Bluetooth, and others are able to transmit the data through cloud platform to any PC or mobile phones that connected to the platform. The IoT-based system also easy for storing data, analyze data, and real time monitoring. In this project, the cloud platform had gathered the health information of the user, then transfer the data to a mobile phone or PC through a communication protocol such as Bluetooth or Zigbee wireless transmitted network. Real-time parameters such as heart rate (bpm), blood pressure, body temperature, and others. This evolution based on IoT is significant to our daily health. [6]

2.2.4 Heart Rate Monitoring System for Senior Citizens

Huang et al. had proposed a project about a heart rate monitoring system for a senior citizen that is used in a senior center. The purpose of this project is able to monitor the heart rate signal of the senior citizen by the nurse station. Due to this monitoring system is designed for senior citizens, several designs are needed to ease the process of obtaining the heart rate value. Finger-ring type sensor is designed in this project due to the comfort and portable, which does not affect senior citizen's daily activities. This project also aimed for a long-term monitoring system to avoid over expenses for the senior center. In the real application, different people have different sizes of a finger, and smaller finger sizes will lead to the empty spaces of the ring sensor. In this case, they had measured the root mean square difference of the finger size and obtained the average value. However, the smaller finger size will definitely have a lesser accuracy in measuring heart rate. Regarding in select the connection protocol, they decided to pick Bluetooth, Wi-Fi, and ZigBee. This protocol allows the sensor to transmit the data obtained wirelessly to the nurse station. [7]

2.2.5 Real-Time Continuous Monitoring of Physical Activity

Taffoni et al. had proposed a wearable system that can be monitored continuously. This system is built with hardware modules which are respiratory frequency monitoring, heart rate monitoring, and motion cadence monitoring. Variable Orifice is used to save the stress drop and to determine the respiratory frequency. A photoplethysmography (PPG) sensor is used to detect the heart rate and collect the data. An inertial measurement unit (IMU) is used in this project to observe the body's force, angular rate, and body orientation. Several criteria are needed to satisfy the requirement of this project. This project ought to be a wireless system where it can connect the sensor synchronously and send the data to the cloud. After comparing the connection protocol, they decided to choose Bluetooth as it has a lower power consumption. [8]

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